ILLICIT DISCHARGE DETECTION AND ELIMINATION PROGRAM

Policies and Procedures

City of Bothell™

May 2020

Acknowledgments

The cities of Redmond, Kirkland, Woodinville and Bothell would like to thank the City of Bainbridge Island for generously sharing their *Illicit Discharge Detection and Elimination Program Manual*, April 2010, which became the base template from which this document was created.

The City of Bothell would like to extend additional gratitude to Snohomish County, King County, and the City of Kirkland for their extensive information-sharing regarding bacteria source tracing approaches and experiences.

Table of Contents

Section 1 – Introduction 5

1.1 Background 5

1.2 Summary of the IDDE Program 6

Section 2 – Storm System Map 7

2.1 Overview 7

2.2 Mapping Procedures 8

Section 3 – IDDE Ordinance 9

3.1 What is an Illicit Discharge? 9

3.2 What is an Illicit Connection? 9

3.3 City IDDE Ordinance 9

Section 4 – Illicit Discharge Detection Procedures 11

4.1 Overview 11

4.2 Routine Screening Inspections 11

4.2.1 Schedule 11

4.2.2 Responsibility 12

4.2.3 Field Equipment 12

4.2.4 Procedures 12

4.3 Incident Reporting 13

4.3.1 Contact Information 13

4.3.2 Problem Documentation 14

4.4 Incident Response 14

Section 5 – Follow-up Investigations 15

5.1 Purpose 15

5.2 Priority Levels 15

5.3 Tracing the Source 16

5.3.1 Open a Case Log 17

5.3.2 Method A – Storm Drain Network Investigations 17

5.3.3 Method B – Drainage Area Investigations 20

5.3.4 Equipment 21

5.3.5 Analytical Sampling (if needed 22

5.4 Follow-up Actions 23
Section 6 – Corrective Action 24
6.1 Purpose 24
6.2 Voluntary Compliance 24
6.2.1 Operational Problems 24
6.2.2 Structural Problems 24
6.3 Enforcement Actions 25
6.3.1 Enforcement Timeline 25
6.3.2 Potential Fines 26
6.3.3 Record Keeping 26
Section 7 – Public Education 27
Section 8 – Record Keeping 28
8.1 Data Sources 28
8.2 Record Storage Schedule 28
Section 9 – Staff Training 29
Section 10 – References 30

Appendices

Appendix A – Ecology's 2020 Illicit Connection and Illicit Discharge Field Screening and Source Tracing Guidance Manual

Appendix B – Spill Response Flow Chart

Appendix C – Spill Response Standard Operating Procedures

Appendix D – Long-Term Screening Program Plan

Section 1 – Introduction

1.1 Background

Surface Water Management staff work to protect and restore the physical, chemical and biotic integrity of surface water through the promotion of ecologically sound land use practices, reduction and elimination of stormwater impacts, the assurance of a high-performance level from current and future stormwater control systems, and education and outreach opportunities to foster healthy watershed stewardship.

According to the US EPA's 2000 National Water Quality Inventory, 39 percent of assessed river and stream miles, 46 percent of assessed lake acres, and 51 percent of assessed estuarine square miles do not meet water quality standards. The top causes of impairment include siltation, nutrients, bacteria, metals (primarily mercury), and oxygen-depleting substances. Polluted stormwater runoff, including runoff from urban/suburban areas and construction sites, is a leading source of this impairment. To address this problem, Environmental Protection Agency (EPA) established the National Pollutant Discharge Elimination System (NPDES) program as part of the Clean Water Act to regulate stormwater discharges.

In the State of Washington, EPA has delegated the NPDES program administration to the Department of Ecology. Ecology issued a Phase II Municipal Stormwater Permit to the City of Bothell. The Phase II Permit requires the City to have a stormwater management program (SWMP) for its municipal separate storm sewer system (MS4) with five major conditions. One of those conditions requires "The SWMP shall include an ongoing program to detect and remove illicit connections, discharges as defined in 40 CFR 122.26(b)(2), and improper disposal, including any spills…, into the municipal separate storm sewers owned or operated by the Permittee." (Permit Condition S5.C.3). The overarching program – known as Illicit Discharge, Detection, and Elimination (IDDE) – is implemented to locate and correct illicit discharges. For several cities, including Bothell, the Phase II Permit also contains special IDDE requirements to comply with Total Maximum Daily Load (TMDL) water quality cleanup plan(s) (Section 10) fecal coliform water quality standard exceedances in North Creek and Swamp Creek.

The City's Surface Water Management Team manages its IDDE program. Public Works Operations staff and construction site inspectors also play an important role identifying illicit discharge problems and responding to cleanup requests. Operations is primarily responsible for the initial field response. However, all Public Works, Community Development, Parks, Police, and Fire staff play a role in locating, identifying, and reporting potential illicit discharges.

1.2 Summary of the IDDE Program

The Phase II Permit requires the permittees to develop an IDDE program encompassing the elements listed below. Each element is addressed in the sections of this IDDE Program manual as follows:

• Develop a municipal storm system map	Section 2
• Adopt an ordinance to prohibit non-stormwater, illicit discharges, and/or dumping into the storm sewer system	Section 3
• Implement an ongoing program to detect and address non-stormwater discharges, spills, illicit connections, and illegal dumping	Sections 4, 5, and 6
• Educate employees, businesses, and the public about illicit discharge concerns	Section 7
• Adopt and implement procedures for program evaluation and assessment	Section 8
• Maintain records of all IDDE program activities	Section 8
• Provide IDDE training for municipal staff	Section 9
• Comply with applicable TMDLs	Sections 3 through 9

This manual is intended to assist City staff in implementing the IDDE program. It is to be used as a guidance document for staff in their day-to-day activities related to IDDE. This document can also be used as a training tool to ensure that staff are following the same procedures in responding to illicit discharge concerns.

Section 2 – Storm System Map

2.1 Overview

The first major component of the City's illicit discharge program is the mapping of the municipal stormwater drainage system. Maintaining an accurate map of the stormwater drainage system makes it easier for the City to track and locate the source of suspected illicit discharges.

Minimum information that the NPDES Phase II Permit requires the City to include on its municipal storm sewer system map is as follows:

a. Ongoing Mapping:

- Known MS4 outfalls and known MS4 discharge points.
- Receiving waters, other than groundwater.
- Stormwater treatment and flow control BMPs/facilities owned or operated by the Permittee.
- Geographic areas served by the Permittee's MS4 that do not discharge stormwater to surface waters.
- Tributary conveyances to all known outfalls and discharge points with a 24-inch nominal diameter or larger, or an equivalent cross-sectional area for non-pipe systems. The following features or attributes (or both) shall be mapped:

    (a) Tributary conveyance type, material, and size where known.

    (b) Associated drainage areas.

    (c) Land use.
- Connections between the MS4 owned or operated by the Permittee and other municipalities or public entities.
- All connections to the MS4 authorized or allowed by the Permittee after February 16, 2007.

b. New Mapping:

- No later than January 1, 2020, begin to collect size and material for all known MS4 outfalls during normal course of business (e.g. during field screening, inspection, or maintenance) and update records.
- No later than August 1, 2023, complete mapping of all known connections from the MS4 to a privately-owned stormwater system.

c. No later than August 1, 2021, the required format for mapping is electronic (e.g. Geographic Information System, CAD drawings, or other software that can map and store points, lines, polygons, and associated attributes), with fully described mapping standards.

d. To the extent consistent with national security laws and directives, each Permittee shall make available to Ecology, upon request, available maps depicting the information required in S5.C.4.a through c, above.

e. Upon request, and to the extent appropriate, Permittees shall provide mapping information to federally recognized Indian Tribes, municipalities, and other Permittees. This Permit does not preclude Permittees from recovering reasonable costs associated with fulfilling mapping information requests by federally recognized Indian Tribes, municipalities, and other Permittees.

In some cases, the City maps more than the minimum required structures listed above. The Department of Ecology requires the map be prepared in GIS format and the map must be made available to Ecology upon request.

2.2 Mapping Procedures

The City's GIS data layer for its surface and stormwater system is improved through various processes, which include data audits, data corrections from reported inconsistencies, and the addition of as-built plan data. The source of information for these data updates come from as-built data, graphical editing, and the use of a Trimble GPS unit.

In 2010, the Surface Water Management Team began field-collecting data for the surface and stormwater data layer with the assistance of a Trimble GPS unit. There have been periodic updates to this data layer in the subsequent years. Users are trained by the GIS department in the use of the units, and data collected conforms to the existing features and attributes in the data set.

When using the GPS unit for data collection, City staff locate drainage features and record the locations and feature attributes. The data is then downloaded, checked for accuracy, and imported into the City's GIS map.

The City has data for both the City's MS4 and private systems. Screening activities are done solely in the right-of-way. Data updates in the right-of-way are the highest priority; however, private systems are mapped and updated as data is available. New systems, both private and public, are routinely added through the development process.

Section 3 – IDDE Ordinance

3.1 What is an Illicit Discharge?

An illicit discharge is defined by the Department of Ecology as "…any direct or indirect non-stormwater discharge to the city's storm drain system, except as expressly allowed by this chapter." Examples of illicit discharges include (but are not limited to) the following:

- Disposal of vehicle maintenance fluids into a storm drain;
- Hosing or washing loading areas near storm drain inlets;
- Leaking dumpsters flowing into a storm drain inlet;
- Old and damaged sanitary sewer line leaking fluids into a cracked or damaged storm sewer line;
- Pouring paints or stains into a storm drain;
- Allowing wash water with soaps or detergents into a storm drain inlet; and
- Washing silt, sediment, concrete, cement or gravel into a storm drain.

3.2 What is an Illicit Connection?

An illicit connection is defined by the Department of Ecology as "Any [human]-made conveyance that is connected to a municipal separate storm sewer without a permit, excluding roof drains and other similar type connections." This generally includes pipes or connections to the separate storm sewer system not specifically intended to carry only stormwater or includes non-stormwater. Examples of illicit connections include (but are not limited to) the following:

- Sanitary sewer piping that is connected directly from a building to the stormwater system;
- A basement or shop floor drain that is connected to the stormwater system; or
- A cross-connection between the municipal sanitary sewer and the stormwater system.

3.3 City IDDE Ordinance

The City of Bothell developed, adopted, and implemented ordinances to address illicit discharges and illicit connections to the City's surface and stormwater system, which included enforcement provisions for the ordinance. These requirements are in the Bothell Municipal Code (BMC):

- BMC Title18, Utilities;
- BMC 11.20.010 (A) (3) Special Penalties for BMC Title 18, Utilities;

- BMC 6.16.011 Animal Waste; and
- BMC 8.60.240 Pets in Park Facilities.

Section 4 – Illicit Discharge Detection Procedures

4.1 Overview

Illicit discharges and connections are identified through citizen reporting, interdepartmental or interagency referral, or other IDDE-focused or routine MS4 inspection activities. The City relies on local citizens, field staff, and inspectors to detect potential problem areas quickly, so that they can be addressed before they cause significant water quality degradation. Outfalls that are flowing during dry weather or outfalls that have high turbidity, strong odors, or unusual colors can identify potential problem discharges.

Spill Hotline for reporting illicit discharges or spills:

425-806-6750

If a direct hazard to human health, call 911 immediately.

A spill hotline number is available 24 hours a day to call to report concerns. This number is forwarded to a third-party management company who intakes the call and directs it to the appropriate location and staff based on time of day and day of week. This convenience encourages residents and staff to participate in the reporting process and helps the City to receive timely information about problems like illegal dumping, spills, or strong odors. The City's related MS4 maintenance activities provide opportunities to document and identify potential problems that may not be obvious to the public.

4.2 Routine Screening Inspections

4.2.1 Schedule

The Phase II Permit required the City prioritize receiving waters for visual inspection to identify areas most likely to include illicit discharges. We identified receiving water priorities and completed screening in summers of 2010 and 2011. The City also conducted an Outfall Reconnaissance Inventory (ORI) to inspect outfalls from the City's stormwater drainage system and identify areas of obvious pollution or non-stormwater discharges.

Beyond the initial reconnaissance and 40% MS4 screening by December 31, 2017, the current Permit requires that 12% of the MS4 should be screened for illicit discharges and connections each year. Section 8 discusses the recording and tracking of this screening.

4.2.2 Responsibility

Public Works Operations staff complete inspections of the MS4 catch basins and inlets. IDDE information is collected through mapping efforts, staff observations, and customer calls. In all cases, field reports will be reviewed by a Surface Water Management Team member.

If inspection staff encounter a transitory discharge during inspection activities, such as a liquid or oil spill, the problem should be immediately referred to the appropriate agency or response contractor (i.e. NRC Environmental) for cleanup.

4.2.3 Field Equipment

Prior to conducting fieldwork, crews should assemble all necessary equipment (see Table 4-1) and review records from prior inspections in the same area to become familiar with the outfall locations and any potential inspection challenges. Field crews should prepare for consecutive days of fieldwork when possible.

Table 4-1
Field Equipment for Routine MS4 Screening

Minimum 2-person crew	
Safety gear: vest, work boots, cones, hard hats	Flashlight or headlamp
Field notebook/pencils	Tool box: hammer, tape measure, duct tape, zip ties
Map or aerial photo of inspection area	First Aid kit
Tablet equipped with Lucity	Clear sample bottles
Cell phone with charged battery	Wide-mouth container
Digital camera with charged battery	Catch basin hook

After long periods of heavy rain, field crews should allow at least 48 hours of a dry period before starting or resuming inspections, so that rainfall runoff has a chance to clear the storm drainage system.

4.2.4 Procedures

The Surface Water Management Team has developed a flow chart and procedures for spill responders to follow. This aids in timely response and accurate reporting. See Appendix B for IDDE Spill Response Flow Chart.

When screening MS4 catch basins and inlets, field crews should conduct visual and olfactory inspection of the structure and document the observations on the Lucity field tablet. Visual and olfactory inspections should be conducted according to normal safety measures and follow the

guidelines in the Spill Response Standard Operating Procedures available in Appendix C. See Appendix D for the Long Term Screening Program Plan.

Potential problems are indicated by outfalls that are flowing in dry weather and/or foul odors or discolored water in or around the outfall pipe. If an outfall with significant flow is encountered, field crews should attempt to first determine the source of the flow. If groundwater has been ruled out as the source of the flow, then a flowing outfall may indicate a potential illicit discharge concern.

When illicit discharge problems are identified, field crews will photograph the problem area and conduct a quick visual and olfactory inspection of the surrounding area to identify any obvious pollution sources. Staff should create a work request and a work order in Lucity, and update each for the investigation. For obvious illicit discharges, field crews should consider collecting samples of the discharge, if possible, and begin investigating the source of the pollutants as described in Section 5. These simple actions can give valuable direction to the upcoming IDDE inspection. Additional record keeping information is included in Section 8.

During field inspections, crews should also note whether the outfalls have maintenance issues, such as trash around the outfall or damaged infrastructure that should be brought to the attention of Public Works Operations staff. Observed spills or environmental hazards should be immediately reported to the Surface Water Management Team and the incident should be documented using a work request in Lucity. The Surface Water Management Team will work with the City's Maintenance and Operations Division or an appropriate vendor to clean up and properly dispose of the spilled material.

4.3 Incident Reporting

4.3.1 Contact Information

Citizens, field personnel, and outside agencies that suspect an illicit discharge, an illicit connection, or an illegal dumping action can call the City's Spill Hotline to report the incident, or submit a Customer Action Request.

During normal business hours (Monday thru Friday 8 a.m. to 5 p.m.) as well as after hours and on weekends, citizens, other City departments or outside agencies reporting incidents that have occurred within the city limits can call the Spill Hotline. A third-party call center will collect the caller's information and will contact the appropriate staff on the Surface Water Management Team and the City's Maintenance and Operations Division for timely response.

After hours, emergency water quality incidents are to be reported to the Spill Hotline and Operations on-call staff with be notified by the third-party call center.

4.3.2 Problem Documentation

When a staff member receives a water quality incident report, he/she should complete a work request in the tracking program Lucity, assign it to the primary Illicit Discharge Responder, and notify them for follow-up.

Once recorded, Lucity will generate a notification for staff to respond for further investigation. Staff will either follow the investigation procedures in Section 5 to identify the source of the problem or, if the source is known, the corrective action procedures outlined in Section 6 will apply.

4.4 Incident Response

When potential problem areas are identified, field crews should report the observations to the City's Spill Hotline. Based on the severity of the problem, the responsible team member will direct staff to open a case log and begin the investigation procedures outlined in Section 5. The responsible staff member will also determine if other City departments or outside agencies need to be involved. For example, polluted discharges that may be the cause of leaking septic tanks warrant contacting the appropriate Health District in either King or Snohomish County for assistance and follow-up.

Section 5 – Follow-up Investigations

5.1 Purpose

Potential illicit discharge problems can be revealed through screening activities or reports from staff, tenants, or the public as described in Section 4. When a concern is reported, the Phase II Permit requires that a follow-up investigation be initiated within seven days, on average. The follow-up investigation could include a site visit to look at the problem area, review of mapping information, review of past complaints or investigations at the location, or other data collection and review. Once a problem has been verified, the City will begin an official illicit discharge investigation, following the procedures outlined in this section.

When an illegal dumping or illicit discharge problem is directly observed by a member of the City staff, it is generally not necessary to follow these source-tracing procedures. In those scenarios, the source of the problem discharge is already known. Problems revealed through direct observation are referred directly to the corrective action information in Section 6. If a reported problem does not have a defined source, the procedures in this section should be followed to trace the source of the illicit discharge. Additional details are presented in the Spill Response Standard Operating Procedures in Appendix C.

5.2 Priority Levels

Table 5-1 outlines the priority levels to assist City staff in determining the appropriate response time for initiating a source investigation after a problem is identified in the field. Priority levels are based on the suspected pollutant source(s) of a reported problem. According to the Phase II Permit, illicit discharge investigations should begin within seven days of identifying a problem. In most cases, the City strives to respond more quickly than the required timeline.

Table 5-1 Source Investigation Priority Levels			
Priority Level	**Suspected Pollutants**		**Response Time (Work Days)**
1	• Alkalis • Automotive products • Bases • Cleaning products • Degreaser or solvent • Drain cleaner • Fertilizer • Flammable/explosive materials	• Herbicide • Metals • Painting products • Pesticide • Petroleum • Process wastewater • Sewage • Unknown chemicals	1-2
2	• Ammonia • Bacteria/ animal waste • Construction runoff (silt, sediment, gravel, settling tanks)	• Detergents • Food waste (fats, oils, grease) • Soap	3-5
3	• Car washing runoff • Pressure washing waste • Spa or pool water	• Steam cleaning waste • Yard waste • Potable water	5-7
4	• Animal carcasses • Construction materials • Debris	• Foam • Rust • Trash • Other	Within 10 days

Priority levels were determined based on the potential public health and/or water quality threat posed by a given pollutant. The response time indicates a target period for opening a case log and initiating a source investigation as described in Section 5.3. Contact Emergency Services (911) or the Surface Water Management Team immediately if the discharge poses a severe threat to human health or the environment.

5.3 Tracing the Source

This section outlines the basic procedures to trace the source of a suspected illicit discharge. The City uses Ecology's 2020 Illicit Connection and Illicit Discharge Field Screening and Source Tracing Guidance Manual as a reference document during screening follow-up investigations. See Appendix A.

Source tracing begins when a suspected problem area is identified through field screening or a complaint call/report. When the source of the non-stormwater discharge is not known, the

following methods can be used independently or in combination to locate the source of an illicit discharge:

- Method A – Storm Drain Network Investigations
- Method B – Drainage Area Investigations

The method(s) used will depend on the type of information collected or reported, level of understanding of the drainage network, and existing knowledge of operations and activities on the surrounding properties. All source tracing investigations should be documented and recorded in the Illicit Discharge category in Lucity.

5.3.1 Open a Case Log

When problems are identified, a Work Request and Work Order in Lucity should be opened and assigned a primary staff contact/investigator. A request is created listing the property name and person responsible (if known), and it should include all tracking information related to the observed or suspected problem. The investigator assigned to the case should keep an accurate log of labor, materials and costs associated with the investigation for invoicing the responsible party. The case log should be opened prior to completing any additional fieldwork unless the nature of the discharge necessitates immediate response.

In addition to filling out the electronic report, the file should include copies of the following, if applicable:

- GIS inspection map;
- Photographs;
- Field notes;
- Lab testing results;
- Compliance letters sent and responses received;
- Correspondence (mail, email, telephone logs);
- Proof of corrected problems (contract and invoice or clean field investigation report).

Any field investigations, photographs, corrective actions, or other activities associated with the suspected problem area should be documented in the case log. This becomes the City's official record of the IDDE investigation. Additional record keeping information is included in Section 8.

5.3.2 Method A – Storm Drain Network Investigations

The source of some illicit connections or discharges can be located by systematically isolating the area from which the polluted discharge originates. This method involves progressive investigation at maintenance access structures in the storm drain network to narrow down the

location where the illicit discharge is entering the drainage system. This method is best used to identify constant or frequent discharge sources such as an illicit connection from a sewer system or sink drain into the storm drainage network. One-time illicit discharges (such as a surface spill or intentional dumping into the storm drain system) should be investigated using Method B described later in this section.

Field crews should work progressively upstream from the outfall and inspect manholes until indicators reveal the discharge is no longer present. Maintenance access structures observations can be time-consuming, but they are generally a necessary step before conducting other tests. In particularly large storm drain systems, it may be helpful to first identify major branches of the system and test one maintenance access structure at the downstream end of each branch. This can help to reduce the area that must be investigated.

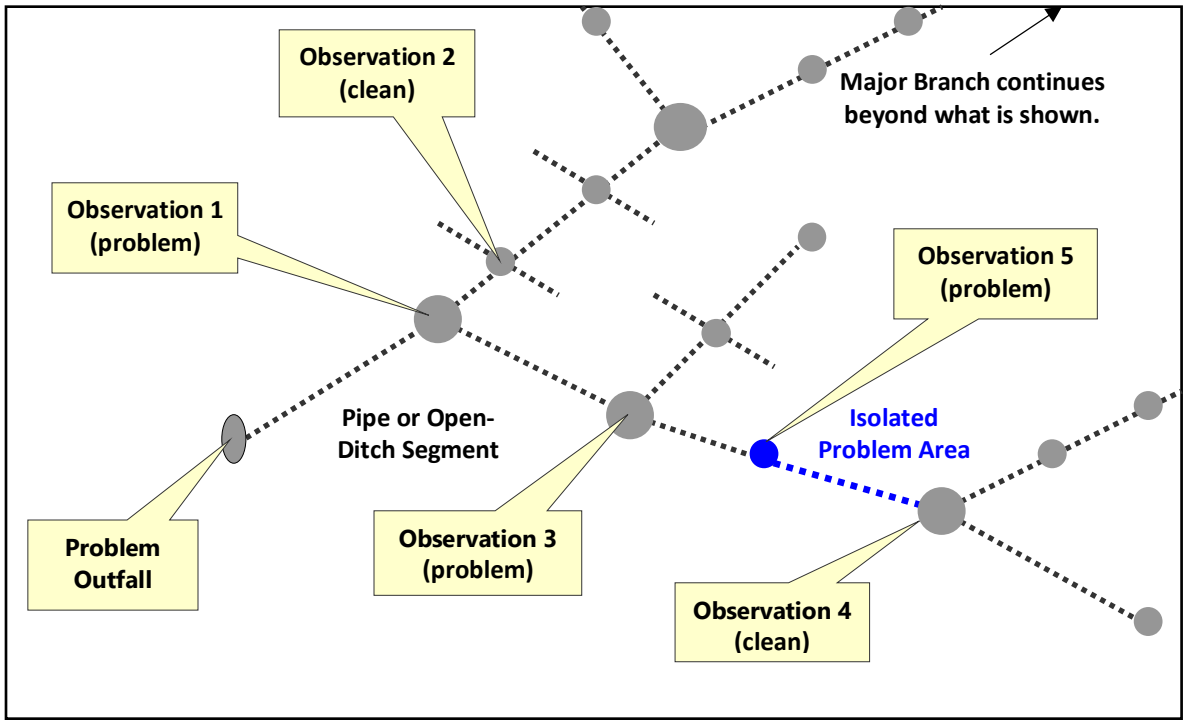
Storm drain network investigations include the following steps:

1. Consult the drainage system map (if available) and identify the major branches where multiple pipes meet at a junction maintenance access structure. If a drainage system map is not available or major branches cannot be identified, then sketches of the system should be made and the system should be identified in the GIS project queue for adding to the City's drainage system map.
2. Starting from the outfall, observe the next upstream junction to see if there is evidence of polluted discharge. As with the outfall inspections, field crews are looking for the presence of flow during dry weather, foul odors, colors or stained deposits, oily sheen, floatable materials, and/or other unusual observations.
3. Repeat observations at each upstream junction until a junction is found with no evidence of discharge; then check individual maintenance access structure between the junction with no evidence of discharge and the next downstream junction. The discharge source is likely located between the manhole with no evidence of pollution and the next downstream maintenance access structure.
4. Work downstream from the "clean" maintenance access structure to isolate the location where the polluted discharge is entering the storm drain system.
5. If discharge is evident from private property, initiate private property site entry procedures.

Document all findings in field notes and the Lucity case file.

Figure 5-1 shows the observation steps to isolate the location where an illicit discharge is entering the storm drainage network.

Figure 5-1. Storm Drain Network Observation Steps



Use visual and olfactory observations to isolate the source of the illicit discharge. If these observations are inconclusive, additional field tests can be performed. Field test applicability is site-specific and discharge-specific, and the field test selection should be conducted case-by-case based on the experience and best professional judgement of the field crew leads. Observed metrics of all field tests should be evaluated collectively to assess whether these combined metrics indicate a probable illicit discharge.

Possible field tests include:

- Dye testing
- Use of optical brighteners
- Closed-circuit video/camera/TV explorations and observations
- Smoke testing
- Indicator test strips
- Water sample collection for follow-up laboratory analysis

Confirmed illicit discharge sources should be referred for the follow-up actions and corrective action procedures described at the end of this section and in Section 6.

5.3.3 Method B – Drainage Area Investigations

The source of some illicit discharges can be determined through a survey or analysis of the drainage area of the problem outfall. Drainage area investigations are particularly useful when the discharge observed at the outfall has a distinct or unique characteristic that can allow field crews to quickly determine the type of activity or non-point source that is generating the discharge. However, drainage area investigations are generally not helpful in tracing sewage discharges, since they are not related to a specific land use.

Drainage area investigations should begin with a discussion between the field crews, inspectors, engineers, and other knowledgeable City staff to identify the type of site most likely to produce the observed discharge. Table 5-2 shows some of the activities or land uses most likely associated with specific discharge problems.

Staff should make a list of likely discharge sources and consult City land use and drainage system maps to identify areas of likely pollution sources near the storm drain network. Field crews should then conduct a windshield survey of the drainage area to confirm and identify potential sources of the discharge. Once potential discharge sites are identified, City staff should conduct individual site inspections to locate the specific source of the illicit discharge. Investigation resources in Appendix A should be used as applicable.

All drainage area investigations should be documented in field notes and entered in the Lucity case log.

Table 5-2 Common Discharges and Potential Sources	
Observed Discharge	**Potential Causes**
Clogging sediment	• Construction activity without proper erosion and sediment controls • Roadway sanding operations • Outdoor work areas or material storage areas
Thick algae growth	• Fertilizer leak or spill • Landscaping operations • Hydroseeding following construction • Failing or leaking septic system
Oil	• Refueling operations • Vehicle or machinery maintenance activities
Sudsy discharge	• Power washing of buildings • Vehicle or equipment washing operations • Mobile cleaning crew dumping • Laundry or cleaner • Household greywater discharge
Clogged grease	• Restaurant sink drain connection to stormwater system
Sewage	• Failing or leaking septic systems

5.3.4 Equipment

Prior to conducting field work, crews should assemble all required equipment (see Table 5-3) and review the outfall inspection records or water quality incident reports from the area to become familiar with the background information and potential pollution sources.

Table 5-3 Field Equipment for Source Investigations	
Tablet equipped with Lucity	Catch basin hook
Safety gear: vest, work boots, cones, hard hats	Flashlight or headlamp
Field notebook/pencils	Tool box: hammer, tape measure, duct tape, zip ties
Map or aerial photo of inspection area	First Aid kit
Digital camera with charged battery	Clear sample bottles
Cell phone with charged battery	Wide-mouth container

5.3.5 Analytical Sampling (if needed)

If illicit discharge sources cannot be identified based on a storm drain network investigation and/or drainage area investigation, the investigator may request that water samples be collected from potential problem discharges and sent to the lab for analytical testing. The results of lab tests may isolate the source or type of illicit discharge. Lab tests may also be important for documentation if an enforcement action must be taken against a tenant or property operator. Table 5-4 shows the recommended water quality testing parameters.

Table 5-4
Water Quality Test Parameters and Uses

Water Quality Test	Field or Lab Test	Use of Water Quality Test
Conductivity	Field	• Used as an indicator of dissolved solids • Used to distinguish between seawater and stormwater • Indicates the presence of dissolved ions or metals
pH	Field	• Extreme pH values (high or low) may indicate commercial or industrial flows
Temperature	Field	• Sanitary wastewater and industrial cooling water can substantially influence outfall discharge temperatures
Ammonia	Lab	• High levels can be an indicator of the presence of sanitary wastewater
Surfactants	Lab	• Indicates the presence of detergent (e.g. laundry, car washing)
Total Chlorine or Fluoride	Field	• Used to indicate inflow from potable water sources
Potassium	Lab	• High levels may indicate the presence of sanitary wastewater
Bacteria	Lab	• Indicates illicit discharges from sanitary wastewater or septic systems • Can potentially indicate runoff from areas of wildlife, domestic livestock, or pet activity

Results of any analytical testing should be recorded in Lucity. Testing results may lead to another round of field investigations using either Method A or B. All data should be recorded in the Lucity.

5.4 Follow-up Actions

Once the source of an illicit discharge has been identified, the investigator should initiate private property site entry procedures (if needed), notify the property owner or operator of the problem, and provide the appropriate educational materials and/or a notice of violation. This is an important first step in the corrective action process. The investigator completes the information in Lucity to document the findings. The investigator from the Surface Water Management Team can then begin working through the corrective action steps outlined in Section 6.

Section 6 – Corrective Action

6.1 Purpose

The City will respond to identified illicit discharges, illicit connections, or illegal dumping activities using progressive enforcement actions. Corrective actions will focus first on education to promote voluntary compliance and will escalate to increasingly severe enforcement actions if voluntary compliance is not obtained.

6.2 Voluntary Compliance

The preferred approach to address illicit discharge problems is to pursue voluntary compliance through property owner or responsible party education. Often, business operators and property owners are not aware of the existence of illicit connections or activities on their properties that may constitute an illicit discharge. In these cases, providing the responsible party with information about the connection or operation, the environmental consequences, and suggestions on how to remedy the problem may be enough to secure voluntary compliance.

Education begins during the site investigation when the operation or connection is first confirmed. Property owners and operators should be notified that the problems must be corrected in a timely manner and that the City will be conducting a follow-up site visit to verify compliance. Field staff should also provide the property operator with an educational brochure describing illicit discharge violations and a copy of the applicable City code. Field staff should also remind property owners of their obligation to report discharges to the proper agencies.

6.2.1 Operational Problems

Property owners are responsible for correcting operational problems that are leading to illicit discharges to the storm drainage system. This could include moving washing activities indoor or undercover, covering material storage areas, finding an appropriate discharge location for liquid wastes, or other operational modifications. Through site visits and education, the City can provide technical assistance to aid property owners in identifying the required modifications.

6.2.2 Structural Problems

Most illicit connection problems will require a structural modification to correct the problem. Structural repairs can be used to redirect discharges such as sewage, industrial, and commercial cross-connections. Such cross-connections must be rerouted to an approved sanitary sewer system. Correcting structural problems is the responsibility of the property owner, though the City may provide technical assistance throughout the process.

6.3 Enforcement Actions

When voluntary compliance does not produce the desired result, the City is required to pursue follow-up enforcement action.

All enforcement actions will be initiated by the Public Works Code Compliance Officer with assistance from the Surface Water Management Team and in conjunction with the Legal Department. Table 6-1 and Figure 6-1 outline the detailed enforcement steps. Violations that are more serious or continued non-compliance may warrant a more aggressive, enforcement-oriented approach.

Table 6-1
Illicit Discharge Enforcement Steps

Enforcement Step	Details	Responsibility
Step 1 – Initial Actions	• Issue Emergency Order with PW CCO only if necessary • Provide educational materials • Encourage voluntary compliance • Additional staff support or technical assistance • Request evidence of corrected problem (if applicable) • Site visit to verify compliance	Operations staff and Surface Water Management Team
Step 2 – Follow-up Actions	• Cease Activity notice to property owner regarding unresolved issues • Set second compliance date (determined on individual incident basis) • Site visit to verify compliance	Public Works Code Compliance Officer
Step 3 – Final Actions	• City may correct problems and send bill to property owner, if deemed appropriate by code	Public Works Code Compliance Officer

6.3.1 Enforcement Timeline

The timeline of corrective action procedures is highly dependent on the nature of the violation and the responsiveness and cooperation from the person(s) responsible. The urgency of addressing identified problems will be based on the nature of the pollutant in question and potential impacts to downstream waters. Compliance dates should be included in all violation notices.

The Phase II Permit requires identified problems to be corrected and illicit connections removed within 180 days of identifying the source. If property owners are not addressing problems in a timely manner, the City may step in (if deemed appropriate by code) and perform the repairs necessary to remove an illicit connection, eliminate an illicit discharge, and/or clean up a dumping incident. Property owners will be responsible for reimbursing the City for any costs occurred in correcting IDDE problems.

6.3.2 Potential Fines

See Bothell Municipal Code section 11.20.010 Penalties for schedule of penalties.

6.3.3 Record Keeping

Effective enforcement procedures require comprehensive record keeping and documentation to demonstrate all program steps have been followed. Throughout the problem investigation and corrective action activities, all information related to the incident or property in question should be documented in Lucity. Section 8 discusses illicit discharge record keeping in greater detail.

Section 7 – Public Education

The NPDES Phase II Permit requires the City to conduct outreach activities to educate the public and business community about water quality protection. Outreach activities focus on reducing pollutants at the source by educating the public and businesses about their ultimate impact on the natural environment, and by sharing BMPs that reduce stormwater pollution. Many members of the community are apt to modify behaviors once they understand the potential negative consequences.

The City has a well-established outreach and education program. The full program and plans for future activities are documented in the City's Surface Water Management Plan.

Section 8 – Record Keeping

The NPDES Phase II Permit requires the City to keep records of all stormwater program activities. Thorough record keeping is particularly important for a successful IDDE program. Records of past problems can help focus an investigation in the right direction or identify repeat offenders. Thorough record keeping is also critical to the enforcement process. Examples of the different types of information to be retained are included below.

Citizen Complaints – Recorded in Lucity.

Routine Screening Inspections – Logs include confirmation of catch basin visual and olfactory inspections even if no problem was detected. Maintain field maps and open Lucity case files for potential illicit discharges or connections.

Follow-up Investigations – Retain notes, photographs, conversation records, and lab testing results.

Corrective Action – In addition to the information collected during the investigation process, retain copies of compliance letters, correspondence with property owners, and proof of corrected problems (contract and invoice for completed work or clean field investigation report).

8.1 Data Sources

Routine Screening Inspections – Catch basin inspections are recorded on field tablets in Lucity.

Follow-up Investigations – Illicit discharge investigation records prior to February 2017 were logged in an Excel spreadsheet and investigation files saved in paper and/or electronic form. After February 2017, records are managed and tracked in the Lucity database. A Work Request and Work Order are created for each individual compliant. The system tracks actions completed by the investigator including education opportunities, technical assistance, communications, samples collected, and enforcement.

8.2 Record Storage Schedule

The NPDES permit requires that all IDDE program records be retained for a minimum of five (5) years. The City retains catch basin, inlet, and stormwater management facility inspections records for the perpetuity of the facility. Program documentation (such as plans, manuals, reports, data analysis, etc.) will be kept for at least ten (10) years, or longer as data storage availability allows. Follow-up investigation files are kept for six (6) years per state retention schedules.

Section 9 – Staff Training

The City has developed a comprehensive training schedule to meet the requirements of the NPDES Phase II Permit. Two primary trainings have been identified related to IDDE:

- Training for all staff that are routinely in the field to educate them on what constitutes an illicit discharge problem and how to report suspected problems.
- Training for illicit discharge responders on proper identification, investigation, cleanup, disposal, and reporting techniques for illicit discharges.

These trainings are generally conducted or reviewed by the Surface Water Management Team using materials developed for the IDDE program. The City has developed presentations that are used for conducting the overview training for all field staff. The City has met the permit requirement of developing a program to train all field staff, and the City will schedule follow-up trainings as needed to keep the information fresh or introduce new information acquired during implementation of the IDDE program.

Training for illicit discharge responders will primarily include distribution and review of this manual as well as a refresher on City spill response procedures. Follow-up trainings for illicit discharge responders may take the form of debriefings following significant IDDE incidents. Debriefings allow staff to review the actions taken and identify what worked well and what should be modified for future responses.

Section 10 – References

Illicit Discharge Detection and Elimination Program Manual, City of Bainbridge Island, April 2010.

Illicit Discharge Detection and Elimination: A Guidance Manual for Program Development and Technical Assessments. Center for Watershed Protection and Robert Pitt (University of Alabama), October 2004.

Illicit Discharge Detection and Elimination Manual: A Handbook for Municipalities, New England Interstate Water Pollution Control Commission, January 2003.

Investigation of Inappropriate Pollutant Entries into Storm Drainage Systems: A User's Guide, Robert Pitt, et al, EOA publication 600/R-92/238, January 1993.

Targeted Bacteria Source Identification and Elimination Procedures, Snohomish County Public Works, January 2017.

APPENDIX A

Ecology's 2020 Illicit Connection and Illicit Discharge Field Screening and Source Tracing Guidance Manual

ILLICIT CONNECTION AND ILLICIT DISCHARGE FIELD SCREENING AND SOURCE TRACING GUIDANCE MANUAL

MAY 2020 REVISION

Prepared for
King County
and
Washington State Department of Ecology

Prepared by
Herrera Environmental Consultants, Inc.
and
Aspect Consulting, LLC

Note:
Some pages in this document have been purposely skipped or blank pages inserted so that this document will copy correctly when duplexed.

ILLICIT CONNECTION AND ILLICIT DISCHARGE FIELD SCREENING AND SOURCE TRACING GUIDANCE MANUAL

MAY 2020 REVISION

Prepared for:
King County Department of Natural Resources
Stormwater Services Section
https://kingcounty.gov/services/environment/water-and-land/stormwater.aspx

and
Washington State Department of Ecology
Stormwater Action Monitoring Program
https://ecology.wa.gov/Regulations-Permits/Reporting-requirements/Stormwater-monitoring/Stormwater-Action-Monitoring

Prepared by:
Herrera Environmental Consultants, Inc.
Seattle, Washington 98121
www.herrerainc.com

and
Aspect Consulting, LLC
Seattle, Washington 98104
www.aspectconsulting.com

May 7, 2020

CONTENTS

Acknowledgements v
1. Introduction 1
   1.1. Background and Updates 1
   1.2. Scope of Manual 3
   1.3. Manual Organization 3
2. Definitions and Regulatory Requirements 5
   2.1. Definitions and Acronyms 5
   2.2. Regulatory Requirements 10
3. Field Screening Methodologies 13
   3.1. Selecting a Field Screening Methodology 13
   3.2. General Guidelines 16
      Data Management Recommendations 16
      Safety Considerations 18
      Costs 19
   3.3. Field Screening Methodology Pullout Sections 20
      Catch Basin/Manhole Inspections 21
      Ditch Inspections 27
      Outfall Inspections 33
      Video Inspections 37
      Other Field Screening Methodologies 41
4. Indicators 43
   4.1. Selecting an Indicator 43
   4.2. Selecting a Method 51
      Test Strips 51
      Test Kits 51
      Field Meter 51
      Multimeter 52
      Colorimeter 52
      Spectrophotometer 52
      Laboratory Analysis 52
   4.3. General Guidelines 53

Field Quality Assurance/Quality Control 53
Laboratory Analysis Quality Assurance/Quality Control 54
Safety Considerations 55
Costs 56
4.4. Indicator Pullout Sections 56
Flow 57
Ammonia 63
Color 69
Odor 75
pH 79
Temperature 85
Turbidity 89
Visual Indicators 95
Bacteria 105
Chlorine and Fluoride 111
Detergents/Surfactants 117
Hardness 121
Nitrate 125
Specific Conductivity 131
Total Petroleum Hydrocarbons (TPH) 135
Other Indicators 139
5. Source Tracing Methodologies 143
5.1. Selecting a Source Tracing Methodology 143
5.2. General Guidelines 146
Data Management Recommendations 146
Safety Considerations 147
Costs 148
5.3. Source Tracing Methodology Pullout Sections 148
Business Inspections 149
Catch Basin/Manhole Inspections 153
Ditch Inspections 157
Dye Testing 161
Septic System Inspections 167
Smoke Testing 171
Vehicle/Foot Reconnaissance 177
Video Inspections 181

Other Source Tracing Methodologies 185
6. References 187
7. Index 189

APPENDICES

Appendix A Field Screening, Source Tracing, and Indicator Sampling Equipment Costs
Appendix B Example Field Forms
Appendix C Case Studies
Appendix D Other Resources
Appendix E Other Field Screening Methodologies
Appendix F Other Indicators
Appendix G Other Source Tracing Methodologies

TABLES

Table 1.1. Key Changes in the 2020 IC-ID Field Screening and Source Tracing Manual. 2

Table 2.1. Requirements in the NPDES Municipal Stormwater Permits Related to Field Screening and Source Tracing. 11

Table 2.2. Requirements in the NPDES Municipal Stormwater Permits Related to Field Screening and Source Tracing for Secondary Permittees. 12

Table 3.1. Data Management Recommendations for Field Screening Methodologies. 17

Table 3.2. Options for Annual Field Screening Percentage Calculation. 18

Table 4.1. Primary Field Screening Indicator Observations and Follow-Up Indicator Recommendations Based on the Suspected Source of an Illicit Discharge. 49

Table 5.1. Source Tracing Methodology Recommendations Based on the Suspected Source of an Illicit Discharge. 145

Table 5.2. Data Management Recommendations for Source Tracing Methodologies. 147

FIGURES

Figure 3.1. Field Screening and Source Tracing Methodology Flow Chart. 15

Figure 4.1. Indicator Sampling Flow Chart (Urban Land Use). 45

Figure 4.2. Indicator Sampling Flow Chart (Rural Land Use). 47

ACKNOWLEDGEMENTS

We would like to thank the following people who worked on the team for developing the updated 2020 manual:

- Rebecca Dugopolski, Herrera Environmental Consultants
- James Packman, Aspect Consulting
- Jeanne Dorn, King County
- John Lenth, Herrera Environmental Consultants
- Katie Wingrove, Herrera Environmental Consultants
- Brian Hite, Aspect Consulting
- Will Guyton, Aspect Consulting

We also thank the following groups that provided valuable feedback on the updated 2020 manual:

- SWG Source ID Subgroup
- APWA Stormwater Managers Committee
- NPDES Coordinators Forum, Central Puget Sound

We also thank the following people and regional forums that provided valuable input on the original 2013 manual:

- Doug Navetski, King County
- Russ Connole, Spokane County
- Tanyalee Erwin, Washington Stormwater Center
- George Iftner, Herrera Environmental Consultants
- Anneliese Sytsma, Herrera Environmental Consultants
- Regional Operations and Maintenance Program (ROADMAP)

- Eastern Washington Stormwater Coordinators Group (EWSCG)

We would also like to thank the following people for providing photos and case studies for use in the manual:

- Russell Cotton-Betteridge and Maria Stevens, City of Bellevue
- Andy Loch, City of Bothell
- Daniel Smith, City of Federal Way
- Ryean-Marie Tuomisto, City of Kirkland
- Scott McQuary, City of Redmond
- Adam Bailey, City of Seattle
- Jennifer Keune and Jeanne Dorn, King County
- Anneliese Sytsma, Christina Avolio, Dan Bennett, George Iftner, Matt Klara, and Rebecca Dugopolski, Herrera Environmental Consultants

1. INTRODUCTION

1.1. BACKGROUND AND UPDATES

This Illicit Connection and Illicit Discharge Field Screening and Source Tracing Guidance Manual (Manual) was developed to serve as guidance for municipalities in Washington State that perform field screening and source tracing to address the illicit discharge detection and elimination (IDDE) program requirements in the National Pollutant Discharge Elimination System (NPDES) Phase I and Phase II Municipal Stormwater Permit. These municipalities currently use a wide variety of field screening and source tracing methodologies to identify illicit discharges and illicit connections, with varying levels of success. The goal of this manual is to provide a single, detailed source of information that municipal staff across Washington State can use for field screening and source tracing for illicit discharges and illicit connections in their storm drainage systems. Note that when the term illicit discharge (ID) is used in this manual, it is intended to also include illicit connections (IC).

This manual was originally developed in 2013 by King County, the Washington Stormwater Center, and Herrera Environmental Consultants using funding from a Grant of Regional or Statewide Significance (Grant No. G1200467) from the Washington State Department of Ecology (Ecology). A survey of Washington permittees was conducted to determine which methodologies and indicators were being used for field screening and source tracing of illicit discharges. A literature review was also performed to gather input from national IDDE programs as well as local IDDE programs. In addition to the survey and literature review, discussions regarding methodologies and indicators were also held at the Regional Operations and Maintenance Program (ROADMAP) and Eastern Washington Stormwater Coordinators Group (EWSCG) forums.

This 2020 update was developed by Herrera Environmental Consultants and Aspect Consulting for King County using funding from Western Washington permittees. This update was overseen by the Source Identification (Source ID) subgroup of the Stormwater Work Group (SWG) which is part of the Stormwater Action Monitoring (SAM) collaborative. Ecology manages the SAM program on behalf of the municipal stormwater permittees. The 2020 update included a survey of Washington permittees and two workshops (Aspect Consulting, 2019a), a literature review (Aspect Consulting, 2019b), and a data review (Aspect Consulting, 2019c) as well as input from the Source ID subgroup. The overall structure and technical content of the 2020 manual remains largely the same as the 2013 manual; however, there are several key changes that are noted that are summarized in Table 1.1.

Table 1.1. Key Changes in the 2020 IC-ID Field Screening and Source Tracing Manual.

Section	Subsection	Summary of Change
2.0 – Definitions and Regulatory Requirements	2.1 – Definitions and Acronyms	Added new definitions (conditionally allowable discharges and discharge point).
	2.2 – Regulatory Requirements	Updated tables to reflect the regulatory requirements in the 2019-2024 municipal NPDES permits.
3.0 – Field Screening Methodologies	3.1 – Selecting a Field Screening Methodology	Removed distinction between piped and ditch systems to streamline flow chart.
	3.2 – General Guidelines	Added a table describing options for calculating percent screened (related to the municipal NPDES permit field screening tracking requirements).
	3.3 – Field Screening Methodology Pullout Sections	Shifted Business Inspections and Stormwater BMP Inspections to Appendix E.
	Other Field Screening Methodologies	Added references for Automated Sampling.
4.0 – Indicators	4.1 – Selecting an Indicator	Streamlined flow charts. Removed A:P ratio and fecal coliform bacteria thresholds. Added new recommended threshold for specific conductivity.
	4.2 – Selecting a Method	Added a new section with generic language providing an overview of the various methods (e.g., test strips, test kits, field meters, etc.) used to evaluate indicators. Deleted this generic language from the individual indicator sections.
	Flow, pH, Temperature, and Chlorine	Added examples of conditionally allowable discharges to Description sections.
	Bacteria	Renamed Fecal Coliform Bacteria section as "Bacteria" and added detail for *Escherichia (E.) coli* and Bacteroidales DNA. Updated state water quality standards for fecal coliform bacteria. Added recommended threshold values for *E. coli* and Bacteroidales DNA.
	Total Petroleum Hydrocarbons (TPH)	Moved from the Other Indicators list to the Follow-up Indicators section and added detail related to indicator sampling. Added recommended threshold value for TPH.
	Other Indicators	Added numerous indicators to Other Indicators table.
5.0 – Source Tracing Methodologies	5.3 – Source Tracing Methodology Pullout Sections	Shifted Optical Brightener Monitoring and Sandbagging to Appendix G. Added example questions for neighboring homeowner or business owner/employee interviews.
	Other Source Tracing Methodologies	Expanded Continuous Monitoring description. Added Optical Brightener Monitoring and Sandbagging with a link to Appendix G.
Appendix A	Field Screening, Source Tracing, and Indicator Sampling Equipment Costs	Updated costs and added new equipment.
Appendix B	Example Field Forms	Incorporated new example field forms. Removed one outdated field form.
Appendix E	Other Field Screening Methodologies	New appendix that includes detailed information on Business Inspections and Stormwater BMP Inspections.
Appendix F	Other Indicators	New appendix that includes detailed information on Potassium indicator.
Appendix G	Other Source Tracing Methodologies	New appendix that includes detailed information on Business Inspections and Stormwater BMP Inspections.

1.2. SCOPE OF MANUAL

The intended audience for this manual includes local jurisdiction permit coordinators and field staff who implement illicit discharge field screening and source tracing in Washington State. Some of this guidance may also be useful for secondary permittees. This manual focuses on methodologies used for field screening a municipal separate storm sewer system (MS4) for illicit discharges as well as methodologies used for source tracing of potential illicit discharges. The most appropriate methodologies and indicators for any given jurisdiction will be determined based on their specific situation including the location and type of illicit connection or illicit discharge they are tracing, the skill set of and equipment available to their staff and/or contractors, and their priorities. This manual also identifies chemical and physical indicators that can be used to help identify illicit discharges and trace their sources.

1.3. MANUAL ORGANIZATION

The rest of this manual is organized into the following major sections:

- Section 2 – Definitions and Regulatory Requirements
- Section 3 – Field Screening Methodologies
- Section 4 – Indicators
- Section 5 – Source Tracing Methodologies
- Section 6 – References

2. DEFINITIONS AND REGULATORY REQUIREMENTS

The definitions, acronyms, and regulatory requirements for illicit connections and illicit discharges are included in this section. While most of the definitions and acronyms used here are consistent with the NPDES Municipal Stormwater permits or regulations, some are not. Users of this manual should always refer to their NPDES Municipal Stormwater permits and/or the appropriate regulations for specific definitions and requirements.

2.1. DEFINITIONS AND ACRONYMS

Conditionally allowable discharges – This regulatory mechanism may allow the following categories of non-stormwater discharges only if the stated conditions are met and such discharges are allowed by local codes and regulations:

- Discharges from potable water sources, including but not limited to water line flushing, hyperchlorinated water line flushing, fire hydrant system flushing, and pipeline hydrostatic test water. Planned discharges shall be dechlorinated to a total residual chlorine concentration of 0.1 parts per million (ppm) or less, pH-adjusted, if necessary, and volumetrically and velocity controlled to prevent re-suspension of sediments in the MS4.

- Discharges from lawn watering and other irrigation runoff. These discharges shall be minimized through, at a minimum, public education activities and water conservation efforts.

- Dechlorinated swimming pool, spa and hot tub discharges. The discharges shall be dechlorinated to a total residual chlorine concentration of 0.1 ppm or less, pH-adjusted and reoxygenized if necessary, and volumetrically and velocity controlled to prevent resuspension of sediments in the MS4. Discharges shall be thermally controlled to prevent an increase in temperature of the receiving water. Swimming pool cleaning wastewater and filter backwash shall not be discharged to the MS4.

- Street and sidewalk wash water, water used to control dust, and routine external building washdown that does not use detergents. The Permittee shall reduce these discharges through, at a minimum, public education activities and/or water conservation efforts. To avoid washing pollutants into the MS4, Permittees shall minimize the amount of street wash and dust control water used.

- Other non-stormwater discharges. The discharges shall be in compliance with the requirements of a pollution prevention plan reviewed by the Permittee, which addresses control of such discharges.

Continuous discharges – Discharges that occur most or all of the time. Examples of continuous illicit discharges include sewage cross-connections or failing septic fields. Examples of continuous discharges that are not considered illicit include groundwater flows.

Discharge point – A location where stormwater leaves the Permittee's MS4 by flowing overland to land owned by another entity, where the stormwater then infiltrates, or by infiltrating to ground from municipal stormwater facilities. Discharge points can include best management practices (BMPs) designed to infiltrate stormwater, and also underground injection wells designed to convey stormwater to the groundwater table.

Ditch system – A series of linear, shallow, and narrow excavations dug in the earth for drainage that are typically planted with grass and designed or used for collecting and conveying runoff.

Dry weather flow – Flowing water observed in a catch basin/manhole, ditch, or outfall after 48 hours without rain that can be composed of one or more of the following types of flow:

- **Sanitary wastewater or human/animal waste** flows are caused by sewer pipes that are illicitly connected to the MS4, failing or improperly plumbed septic systems, and improper storage of animal waste.

- **Washwater** flows are caused by illicit connections or improper source control from residential gray water (for example, laundry), commercial carwashes, commercial or municipal fleet washing, commercial laundry, and commercial/industrial floor washing to shop drains.

- **Liquid waste** refers to illegal dumping of materials such as oil, paint, and process water (for example, radiator flushing water, winemaking residue, food product residual fluids) into the MS4.

- **Tap water** flows can be observed in the MS4 if leaks and losses are occurring in the drinking water supply system.

- **Irrigation overspray** flows occur when excess potable water used for residential or commercial irrigation ends up in the MS4.

- **Groundwater and spring water** flows occur when the local water table rises and enters the MS4 through infrastructure cracks and joints, or where open channels or pipes intercept seeps and springs.

Field screening methodology – Techniques that are used to proactively investigate large sections of a drainage area or storm drainage system (for example, ditches, pipes, catch basins, and manholes) to determine if illicit discharges are present.

Illicit connection (IC) – An illicit connection is defined by the NPDES Phase I and Phase II Municipal Stormwater Permits as any infrastructure connection to the MS4 that is not intended, permitted, or used for collecting and conveying stormwater or non-stormwater discharges allowed as specified in the permit. Examples include sanitary sewer connections, floor drains, channels, pipelines, conduits, inlets, or outlets that are connected directly to the MS4.

Illicit discharge (ID) – An illicit discharge is defined by the NPDES Phase I and Phase II Municipal Stormwater Permits as any discharge to a MS4 that is not composed entirely of stormwater or of non-stormwater discharges allowed as specified in the permit.

Illicit Discharge Detection and Elimination (IDDE) – An ongoing program required by the NPDES Phase I and Phase II Municipal Stormwater Permits designed to prevent, detect, characterize, trace, and eliminate illicit connections and illicit discharges into the MS4.

Indicator – Water quality parameter or visual/olfactory observation used to determine the presence or absence of an illicit discharge or natural phenomenon.

Intermittent discharges – Illicit discharges that occur over a few hours per day or a few days per year. Examples of intermittent illicit discharges include cross connections between washing machines, which only discharge while they are running, to the MS4.

Land use – The type of development based on visual observations of a drainage basin or as defined by city/county/town zoning maps. For illicit discharge investigations, land use types are divided into the following classifications:

- **Urban** – Land that is composed of areas of intensive use with much of the land covered by buildings and paved surfaces. This category includes cities, towns, villages, commercial strip developments along major roads and highways, shopping centers, industrial and commercial complexes, and institutions.

- **Rural** – Development outside of designated urban areas and that are not in long-term resource use areas. This category includes agricultural and rural residential land uses and forested land uses.

- **Agricultural** – Land that is used primarily for the commercial production of food and fiber. This category includes cropland, pasture, orchards, groves, vineyards, nurseries, ornamental horticultural areas, confined feeding operations, livestock holding areas, farmsteads, horse farms, and farm lanes and roads.

- **Commercial** – Land that is used primarily for the sale of products and services. This category includes central business districts, shopping centers, office parks, public institutions, and commercial strip developments along major roads and highways.

- **Industrial –** Land that is used primarily for light and heavy manufacturing, distribution, and warehouse uses. This category includes design, assembly, finishing, processing, and packaging of products (light manufacturing). This category also includes steel mills, pulp and lumber mills, electric power generating stations, oil refineries and tank farms, chemical plants, and brick making plants (heavy manufacturing).

- **Mining** – Land that is used or was formerly used for strip mining, quarries, and gravel pits. This category includes inactive, unreclaimed, and active strip mines, quarries, borrow pits, and gravel pits until another land cover or land use has been established.

- **Residential** – Land that is used primarily used for housing. This category includes single family (houses, mobile homes) and multi-family (apartments, condominiums, dormitories, townhouses) development.

Municipal separate storm sewer system (MS4) – A MS4 is defined by the NPDES Phase I and Phase II Municipal Stormwater Permits as a conveyance, or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, manmade channels, or storm drains):

i. Owned or operated by a state, city, town, borough, county, parish, district, association, or other public body (created by or pursuant to state law) having jurisdiction over disposal of wastes, stormwater, or other wastes, including special districts under State law such as a sewer district, flood control district or drainage district, or similar entity, or an Indian tribe or an authorized Indian tribal organization, or a designated and approved management agency under Section 208 of the Clean Water Act that discharges to waters of Washington State.
ii. Designed or used for collecting or conveying stormwater.
iii. Which is not a combined sewer;
iv. Which is not part of a Publicly Owned Treatment Works (POTW) as defined at 40 CFR 122.2.; **and**
v. Which is defined as "large" or "medium" or "small" or otherwise designated by Ecology pursuant to 40 CFR 122.26.

National Pollutant Discharge Elimination System (NPDES) – NPDES is defined by the NPDES Phase I and Phase II Municipal Stormwater Permits as the national program for issuing, modifying, revoking, and reissuing, terminating, monitoring and enforcing permits, and imposing and enforcing pretreatment requirements, under sections 307, 402, 318, and 405 of the Federal Clean Water Act, for the discharge of pollutants to surface waters of the state (waters defined as "waters of the United States" in 40 CFR Subpart 122.2 within the geographic boundaries of Washington State and "waters of the state" as defined in

chapter 90.48 RCW, which includes lakes, rivers, ponds, streams, inland waters, underground waters, salt waters and all other surface waters and water courses within the jurisdiction of the State of Washington) from point sources. These permits are referred to as NPDES permits and, in Washington State, are administered by Ecology.

Outfall – An outfall is the point where an approved discharge leaves the Permittee's MS4 and enters a surface receiving water body or surface receiving waters. Outfalls do not include pipes, tunnels, or other conveyances that connect segments of the same stream or other surface waters and are used to convey primarily surface waters (such as, culverts). This point source definition of an outfall is from the NPDES Phase I and Phase II Municipal Stormwater Permits; 40 CFR 122.2.

Permittee – A Permittee is defined by the NPDES Phase I and Phase II Municipal Stormwater Permits as, unless otherwise noted, includes city, town, or county Permittee, port Permittee, Co-Permittee, Secondary Permittee, and New Secondary Permittee.

Piped system – A series of metal, plastic, or concrete pipes that are designed or used for collecting and conveying stormwater. Access to piped systems is provided through manholes, catch basins, and vaults. Piped systems are typical in urban areas and less typical in rural areas.

Quality Assurance/Quality Control (QA/QC) – A set of activities designed to establish and document the reliability and usability of measurement data and the routine application of measurement and statistical procedures to assess the accuracy of measurement data.

Receiving water body or receiving waters – Defined by the NPDES Phase I and Phase II Municipal Stormwater Permits as naturally and/or reconstructed naturally occurring surface water bodies, such as creeks, streams, rivers, lakes, wetlands, estuaries, and marine waters, or groundwater, to which a MS4 discharges.

Source tracing methodology – Focused techniques that are used to investigate smaller sections of a drainage area or storm drainage system (for example, ditches or pipes) to isolate the source of a confirmed or suspected illicit discharge.

Transitory discharges – Illicit discharges that occur in response to singular events. Examples of transitory illicit discharges include vehicle accidents, spills, ruptured tanks, sewer main breaks, and illegal dumping.

Visual indicators – This manual describes the following visual indicators: deposits and staining, fish kills, floatables, sewage bacteria, structural damage, surface scum or sheen, trash and debris, and abnormal vegetation. Color, odor, and flow are listed separately from visual indicators due to their importance in illicit discharge investigations.

Water quality standards – Defined by the NPDES Phase I and Phase II Municipal Stormwater Permits as Surface Water Quality Standards, Chapter 173-201A WAC, Ground Water Quality Standards, Chapter 173-200 WAC, and Sediment Management Standards,

Chapter 173-204 WAC. This manual focuses on the Surface Water Quality Standards, Chapter 173-201A WAC.

2.2. REGULATORY REQUIREMENTS

Table 2.1 briefly summarizes the requirements for IC and ID field screening and source tracing in the 2019–2024 NPDES Municipal Stormwater permits (Ecology 2019a, 2019b, and 2019c). Table 2.2 briefly summarizes the requirements for IC and ID field screening and source tracing for secondary permittees. For a summary of reporting requirements for sections G3 and S4.F of these permits, refer to Ecology's Focus on Municipal Stormwater: General Condition G3 Reporting (Ecology 2019d) and Reporting and Notification Requirements webpage <https://ecology.wa.gov/Regulations-Permits/Guidance-technical-assistance/Stormwater-permittee-guidance-resources/Municipal-stormwater-permit-guidance/Reporting> or more recent documentation (if available).

Table 2.1. Requirements in the NPDES Municipal Stormwater Permits Related to Field Screening and Source Tracing.

Category	Phase I Permit (2019-2024)	Western Washington Phase II Permit (2019-2024)	Eastern Washington Phase II Permit (2019-2024)
Field Screening Requirements	The program shall include implementation of a field screening methodology appropriate to the characteristics of the MS4 and water quality concerns.		Field assessment activities, including visual inspection of outfalls, discharge points, or facilities serving priority areas during dry weather.
Field Screening Methodologies	Screening for illicit connections may be conducted using this updated Manual, the 2013 version of this Manual, or another methodology of comparable or improved effectiveness.		Not specified in permit, but Permittees must develop procedures (see Field Screening Performance Measures below)
Business Inspections	Each Permittee shall update their source control inventory at least once every five years; 20% of these businesses and/or properties shall be inspected annually.	Each Permittee shall develop a source control inventory; 20% of these businesses and/or properties shall be inspected annually starting in 2023.	Permittee shall locate priority areas likely to have illicit discharges, including, at a minimum: evaluating land uses and associated business/industrial activities present; areas where complaints have been registered in the past; and areas with storage of large quantities of materials that could result in illicit discharges, including spills.
Field Screening Performance Measures	Each Permittee shall implement an ongoing field screening program of, on average, 12% of the Permittee's known MS4 each year and track total percentage of the MS4 screened beginning August 1, 2019.	All Permittees shall complete field screening for an average of 12% of the MS4 each year and track total percentage of the MS4 screened beginning August 1, 2019.	Field assessing at least 12%, on average, of the MS4 within the Permittee's coverage area each year to verify outfall locations and detect illicit discharges. Permittees shall track total percentage of the MS4 assessed beginning August 1, 2019.
Source Tracing	The program shall include procedures for tracing the source of an illicit discharge; including visual inspections, and when necessary, opening manholes, using mobile cameras, collecting and analyzing water samples, and/or other detailed inspection procedures.		

Table 2.2. Requirements in the NPDES Municipal Stormwater Permits Related to Field Screening and Source Tracing for Secondary Permittees.

Category	Phase I Permit Secondary S6.E Permittees (Port of Seattle and Port of Tacoma) (2019–2024)	Phase I Permit Secondary S6.D Permittees (2019-2024)	Western Washington Phase II Permit Secondary Permittees (2019–2024)	Eastern Washington Phase II Permit Secondary Permittees (2019–2024)
Field Screening Requirements	Implementation of a field screening methodology appropriate to the characteristics of the MS4 and water quality concerns.	Conduct field inspections and visually inspect for illicit discharges at all known MS4 outfalls and discharge points.		
Field Screening Methodologies	Not specified in permit, but Permittees must develop procedures (see Field Screening Performance Measures below).			
Business Inspections	Each Permittee shall maintain a list of sites covered by Stormwater Pollution Prevention Plans (SWPPPs); at least 20% the listed sites shall be inspected annually.	Not specified in permit.		
Field Screening Performance Measures	Each Permittee shall conduct field screening of at least 20% of the MS4 each year.	Visually inspect at least one third (on average) of all known MS4 outfalls and discharge points each year beginning no later than 2 years from the initial date of permit coverage.		
Source Tracing	Implement procedures to identify and remove any illicit discharges and illicit connections.	Implement procedures to identify and remove any illicit discharges.		

3. FIELD SCREENING METHODOLOGIES

As described in the previous section, each permittee must implement a methodology or multiple methodologies for illicit discharge field screening. The field screening methodologies summarized in this manual are listed below. Several field screening methodologies can also be used to trace the source of an illicit discharge in addition to being used for field screening. Specific information related to field screening is included in this section of the manual. Details on two additional field screening methodologies that are commonly used for other aspects of stormwater management programs, but not commonly used for field screening (Business Inspections and Stormwater BMP Inspections) are included in Appendix E. Specific information related to source tracing for these methodologies is included in Section 5.0 – Source Tracing Methodologies.

Field Screening Methodologies	Field Screening and Source Tracing Methodologies
• Catch basin/manhole inspections • Ditch inspections • Outfall inspections • Video inspections	• Catch basin/manhole inspections • Ditch inspections • Video inspections

3.1. SELECTING A FIELD SCREENING METHODOLOGY

Since illicit discharge field screening is a proactive technique for detecting illicit connections and illicit discharges, the field screening methodology or methodologies should be selected based on the system type. The field screening methodologies that are included in this manual are summarized below with their applicable system type:

Piped Systems	Ditch Systems
• Catch basin/manhole inspections • Outfall inspections • Video inspections	• Catch basin/manhole inspections • Ditch inspections • Outfall inspections

An IDDE program manager should select one or more field screening methodologies to screen a portion of their MS4 each year. The methodology or methodologies should be selected based on what each jurisdiction determines to be the most appropriate depending on their priorities; however, some general guidelines are provided below:

- **Incorporate work that is already underway:** For example, if your jurisdiction is already performing business inspections (see Appendix E) as part of the NPDES municipal stormwater permit requirements (Phase I and western Washington Phase II) jurisdictions) or voluntarily (either through the local source control program or as part of your stormwater management program),

incorporate that field screening methodology into your IDDE program. If you are planning on conducting video inspections to assess the condition of your stormwater pipes, review the videos to look for indicators of illicit connections as well.

- **Incorporate IC and ID identification into daily work activities:** For example, in the course of routine public and private stormwater facility operation and maintenance (O&M) inspections, questions can be added to standard catch basin/manhole inspection forms to trigger an IDDE investigation if a color, odor, or visual indicator is observed.

- **Review your storm drainage system information:** Do you have 50, 500 or 5,000 outfalls? If you have fewer outfalls that cover large drainage areas, outfall inspections during dry weather may be the most cost-effective approach for your jurisdiction. Although outfall inspections may be the most cost effective, they may not result in finding all the illicit connections or illicit discharges in a drainage basin and should be combined with one or more other field screening methodologies such as business inspections (see Appendix E) or video inspections. If you have numerous outfalls, strategic catch basin/manhole inspections may be more cost effective than outfall inspections.

- **Contracting out IC and ID field screening work:** If sufficient staff time, equipment, or skills are not available to perform a particular field screening methodology, a private contractor can be hired to perform the work. It is important that the selected contractor has the required expertise to perform the field screening methodology and that they follow the appropriate safety protocols.

Refer to the Field Screening Methodology Pullout sections for additional information on the pros and cons and applications of each methodology to select the most appropriate field screening methodologies to use for your situation. Once you have selected one or more field screening methodologies, follow the methods outlined in the Field Screening Methodology Pullout sections or modify them as appropriate to meet the unique characteristics of your jurisdiction.

Conduct the field screening during dry weather, typically defined as 48 hours or more without rainfall, if possible to narrow down the potential sources that may be present in any discharge that you observe. Follow-up investigations (using Source Tracing Methodologies) can be conducted during dry and/or wet weather. Figure 3.1 can be used as a guide to determine the next steps in the illicit discharge identification process. If you already know which source tracing methodology that you would like to use, you can skip this flow chart.

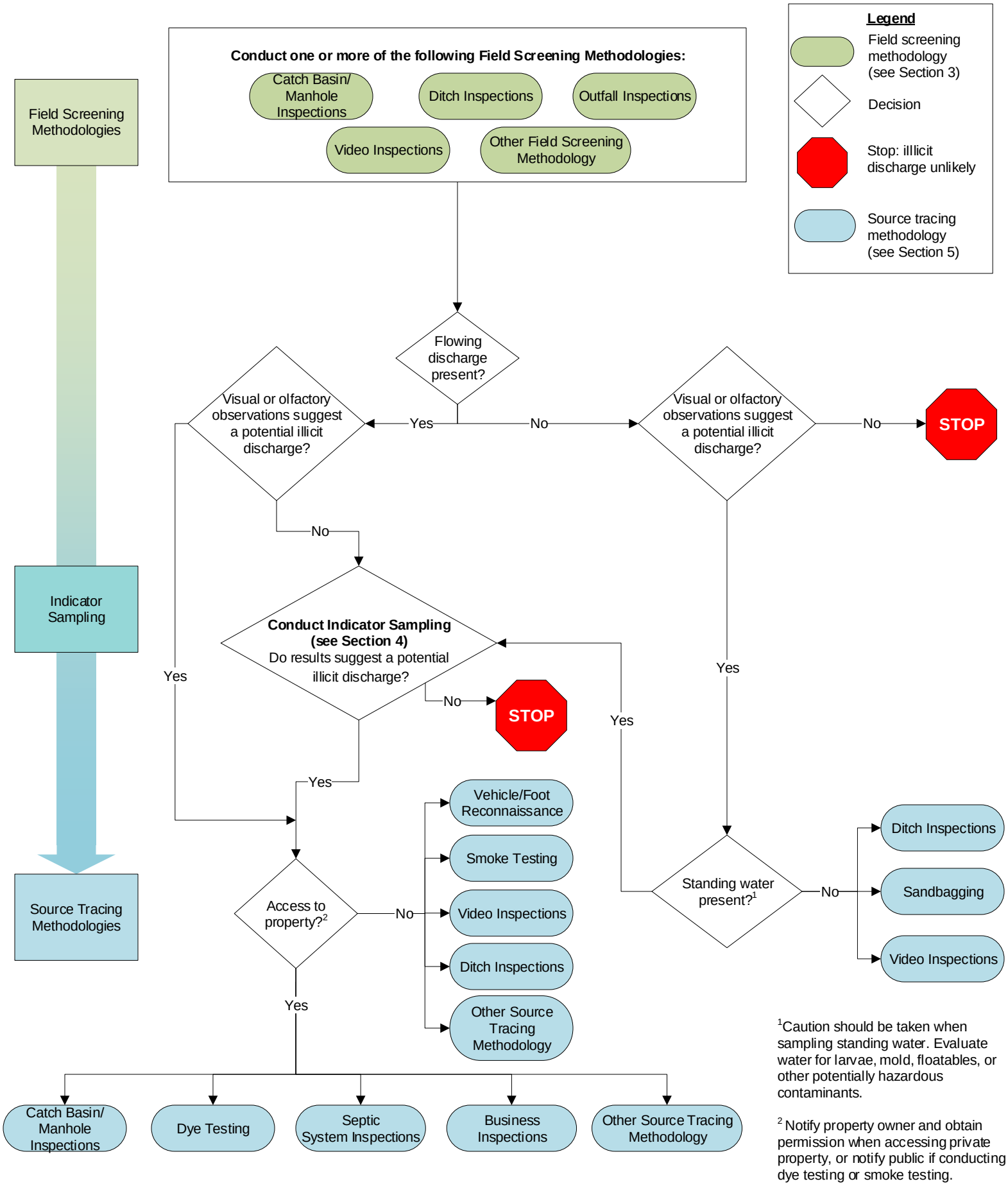


Figure 3.1. Field Screening and Source Tracing Methodology Flow Chart.

3.2. GENERAL GUIDELINES

The following guidelines for data management recommendations, safety considerations, and costs apply to all the field screening methodologies summarized in this section.

Data Management Recommendations

The NPDES Municipal Stormwater Permits reissued in 2019 included an updated and prescriptive reporting requirement for IDDE programs. The reporting must include information addressing 12 questions on key details of each ID incident found:

1. Jurisdiction name and permit number
2. Date incident discovered or reported
3. Date of beginning of response
4. Date of end of response
5. How was the incident discovered or reported?
6. Discharge to MS4?
7. Incident location
8. Pollutants identified
9. Source or cause
10. Source tracing approach(es) used
11. Correction/elimination methods used
12. Field notes, explanations, and/or other comments

The IDDE reporting questions and the recommended verbiage for the answers are the same for all permittees and are listed in Appendix 14 of the NPDES Phase I Municipal Stormwater Permit, Appendix 12 of the NPDES Phase II Municipal Stormwater Permit for Western Washington, and Appendix 7 of the NPDES Phase II Municipal Stormwater Permit for Eastern Washington.

Related to these reporting requirements, a spatially referenced data management system (for example, an ArcGIS geodatabase, Cartegraph, Cityworks, a Microsoft Access database, a custom database, or a combination of these) is an important component of any IDDE program. Regular updates to the system with IC/ID field screening information will reduce level of effort for annual reporting to Ecology. The information stored in the data management system should be evaluated on an annual basis at a minimum to adjust the IDDE program as needed. Table 3.1 provides a summary of the some of the information that should be tracked in relation to each

field screening methodology for this purpose. This table includes basic guidance on tracking and reporting recommendations, but is not intended to provide an exhaustive list of all of the information that should be tracked for an IDDE program. If an app is used for data collection, then the scanning and recording of data recorded on a hard copy paper form can be skipped and the electronic data can be compiled directly into a spreadsheet or database.

Table 3.1. Data Management Recommendations for Field Screening Methodologies.

Field Screening Methodology	Tracking and Reporting Recommendations for the 2019–2024 Permits
Catch basin/manhole inspections	• Location of inspection (address/intersection, city, and zip or latitude/longitude) • Number of catch basins/manholes inspected • Area that drains to each catch basin/manhole • Number and types of illicit discharges or illicit connections identified (address 12 questions in the NPDES permit) • Catch basin/manhole inspection forms (or electronic database) • Digital photographs • Indicator sampling data • Follow-up sampling data • Flow data (if collected)
Ditch inspections	• Location of inspection (address/intersection, city, and zip or latitude/longitude) • Linear feet of ditch inspected • Area that drains to each ditch • Number and types of illicit discharges or illicit connections identified (address 12 questions in the NPDES permit) • Ditch inspection forms (or electronic database) • Digital photographs • Indicator sampling data • Follow-up sampling data • Flow data (if collected)
Outfall inspections	• Location of inspection (address/intersection, city, and zip or latitude/longitude) • Number of outfalls screened • Area that drains to each outfall • Number and types of illicit discharges or illicit connections identified (address 12 questions in the NPDES permit) • Outfall inspection forms (or electronic database) • Digital photographs • Indicator sampling data • Follow-up sampling data • Flow data (if collected)
Video inspections	• Linear feet of pipe videotaped and reviewed • Pipe network area that drains to each pipe segment • Number and types of illicit discharges or illicit connections identified (address 12 questions in the NPDES permit) • Video labeling and archiving

Table 3.2 provides recommendations on calculating the 12 percent annual field screening requirement in the NPDES Municipal Stormwater Permits. Ecology does not specify how this percentage should be calculated but only specifies that permittees shall screen 12 percent on average of their MS4, and new permittees shall screen at least 12 percent of their MS4 by December 31, 2023. Options for determining the number, length, and area of screening locations are listed in Table 3.2. If combining multiple methodologies, either length or area should be used.

Table 3.2. Options for Annual Field Screening Percentage Calculation.

Field Screening Methodology	Number	Length (feet or miles)	Area (square miles)
Catch basin/manhole inspections	Number of catch basins/manholes inspected	Calculation metric may be applied[a]	Areas that drains to each catch basin/manhole
Ditch inspections	Not applicable	Linear feet of ditch inspected	Area that drains to each ditch
Outfall inspections	Number of outfalls screened	Calculation metric may be applied[a]	Area that drains to each outfall
Video inspections	Not applicable	Linear feet of pipe videotaped and reviewed	Pipe network area that drains to each pipe segment

[a] A jurisdiction may be able to assign a linear metric such as 0.2 miles of linear conveyance to each catch basin or outfall for "conveyance screening purposes."

Safety Considerations

Safety is an important factor when conducting field screening investigations. General safety considerations include the following:

Manholes

- Having a field crew of at least two people.
- Properly lifting manhole covers to reduce the potential for back injuries.
- Testing for presence of flammable or toxic fumes in manholes.
- Testing for oxygen levels in manholes.
- Only entering a manhole when necessary. If entering a manhole, confined space entry training and equipment is necessary. Equipment must be in good working order and must be properly utilized whenever confined space entry is performed.

Surrounding Environment

- Having a field crew of at least two people.
- Being aware of the environment of the facilities field crews will enter and taking proper precautions (for example, forklifts, hazardous materials exposure, hearing, eye, and respiratory protection).
- Using appropriate traffic control equipment and clothing (for example, traffic cones and safety vests) when working in or near the road right-of-way. The Manual on Uniform Traffic Control Devices, Part 6 (Federal Highway Administration 2012) establishes flagger responsibilities and methods of operations. If the decision is made that traffic control flagging is needed, guidance provided in the "Traffic Control Flagger Certification" handbook (Evergreen Safety Council 2012) should be followed.
- Reviewing local codes for information related to private property access and confirming policies with internal managers.
- Notifying landowners and obtaining permission before accessing private property. Inspectors should be familiar with drainage system maps and private and public property lines. Inspectors should refer to the jurisdiction's protocols for requesting access to private properties when access to private property is needed. Contact information for the private property owner should be collected at the time of inspection or prior to inspection if inspection of the property is anticipated. Follow-up correspondence with property owners may be required.

Prevention

- Vaccinating field staff for Tetanus and Hepatitis B if crews will be working near metal equipment or accessing waters suspected to be contaminated with sewage discharges.
- Wearing sturdy boots or belted waders.

Costs

Costs for representative field screening equipment and materials are summarized in Appendix A. The authors and clients or any other governmental agency referenced in this manual do not promote, endorse, or otherwise recommend any of the companies, individuals, or organizations presented in Appendix A. Rather, costs and equipment are provided for informational purposes only and do not represent a complete list of vendors or equipment.

3.3. FIELD SCREENING METHODOLOGY PULLOUT SECTIONS

Each of the following field screening methodology pullout sections contains the following information:

- **Description:** Field screening methodology definition
- **Applications:** Lists the applicable storm drainage system types (pipes and ditches), land use types (urban, rural, agricultural, commercial, industrial, mining, and residential), and weather conditions (dry and wet)
- **Equipment:** Checklist for field crews to determine what materials and supplies to bring to the field
- **Methods:** Generic standard operating procedures for conducting each field screening methodology
- **Pros and cons:** List of the positive and negative aspects of the field screening methodology

Catch Basin/Manhole Inspections

Description

Catch basin/manhole inspections are a field screening methodology that involves removing catch basin and manhole lids and observing if flow, odor, color, or visual indicators are present during dry weather. One option for implementing catch basin/manhole inspections is to train stormwater maintenance staff on how to identify illicit discharges during routine inspections and to add tracking information regarding illicit discharges to related inspection forms. If flowing water is observed during dry weather, likely sources are groundwater inflow or an illicit discharge or connection, and the structure should be flagged for follow-up investigation. Catch basin/manhole inspections can also be used as a source tracing methodology once a suspected illicit discharge has been found to track the illicit discharge to its source (refer to Catch Basin/Manhole Inspections in the *Source Tracing Methodologies* section).

Applications

Catch basin/manhole inspections can be used to screen branches of the storm drainage system for illicit discharges. Catch basin/manhole inspections can be used for field screening if a larger drainage area is divided into branch or segments containing 10 to 20 structures or fewer.

Storm Drainage System Types	Land Use Types	Weather Conditions
• Pipes • Small drainage areas (20 structures or fewer)	• Rural • Urban • Agricultural • Commercial • Industrial • Mining • Residential	• Dry • Wet

Equipment

The following suggested staffing and equipment apply to catch basin/manhole inspections:

- ☐ Two or more field staff
- ☐ Cell phones or 2-way radios
- ☐ Detailed maps of the storm drainage and sanitary sewer system
- ☐ Field laptop/tablet (with charged battery) and/or clipboard, field forms (customized with line items for illicit discharge observations), and pen/pencil

- ☐ GPS unit
- ☐ Camera, phone, or other device for taking pictures (with date and time stamp)
- ☐ Dry erase board and pen for labeling catch basins or manholes (optional)
- ☐ Tape measure
- ☐ Traffic control signs and orange cones
- ☐ Confined space entry equipment (if needed)
- ☐ Various catch basin/manhole cover removal hooks and wrenches (including 7/16-inch hexagonal Allen key for standard manhole cover bolts)
- ☐ Sledge hammer for loosening lids
- ☐ Safety equipment (for example, hard hats, work gloves, ANSI 107-1999 labeled safety vests, steel-toe boots, ear protection, gas monitor)
- ☐ Primary field screening indicator equipment (see Flow, Ammonia, Color, Odor, pH, Temperature, Turbidity, Specific Conductivity and Visual Indicators sections)

Notes:

1) Only staff with confined space entry training should enter manholes or other confined spaces.

2) Use traffic control and orange cones near catch basins/manholes to protect you and pedestrians from harm.

Methods

The methods for conducting catch basin/manhole inspections as well as the format of the inspection form used can be modified by each jurisdiction as needed. Two general methods for conducting catch basin/manhole inspections for field screening are provided below.

Monitoring Node Approach

1. Office Investigation:

    a. Identify pairs of staff who will work together. The buddy system is recommended for field work for health and safety reasons. Review the Safety Considerations in Section 3.2 of this manual. Consider traffic control and confined space entry needs before heading into the field. Staff should carry a current ID and business cards when conducting field work.

Manhole inspection (Photo Credit: City of Seattle).

b. Review GIS field maps of the drainage basin or subbasin that will be investigated.

c. Identify the storm drainage mainline and strategic monitoring nodes/intersections where several branch lines connect to the mainline.

d. Select monitoring nodes where field inspection and sampling, if needed, might quickly eliminate large portions of the drainage basin.

2. On-Site Investigation:

a. Assess nearby traffic and potential hazards to pedestrians at each catch basin/manhole to be inspected. Set up signs and cones as needed. Washington State Flagger Certification is required if placing cones in traffic; traffic flagging regulations must be followed.

b. Check the atmosphere within the manhole structure if you suspect that explosive or toxic gases may be present. Use a gas monitor (as you would during confined space entry).

c. Assign a unique number or identifier and record the latitude and longitude of the structure using a GPS unit if this has not previously been done.

d. Document any visual, olfactory, or auditory indicators observed using a field notebook, customized catch basin/manhole maintenance inspection form, or a drop-down menu (for example, data dictionary) on a GPS unit.

e. Check for dry weather flow from any of the pipes into the catch basin/manhole, and document the pipe location and direction that the flow is coming from.
   i. Collect a sample if dry weather flow is observed and record values for the other primary field screening indicators (pH, temperature, turbidity, conductivity, and ammonia). Refer to the Indicators section for additional detailed information regarding how these samples should be collected and analyzed.
   ii. Take a photograph if an illicit discharge is suspected. Optional: Use a dry erase white board next to the structure and include the date, time, structure ID, and inspector(s) initials.
   iii. Trace flow using source tracing methodologies if visual indicators suggest that an illicit discharge is present.

f. Continue to the next monitoring node and repeat steps 2a through 2e.

3. Follow internal notification procedures to ensure proper reporting to other agencies and appropriate timely follow up if an illicit discharge is identified.

4. Return to the office and make sure that documentation from the field work is completed and downloaded. This includes hardcopy field forms, photographs, GPS data, and storm drainage system mapping updates delivered to GIS staff.

Routine Maintenance Approach:

Revise the field form or GPS data dictionary that staff use to document routine catch basin/manhole inspections. The following fields are recommended for describing potential illicit discharges that may require follow-up investigation:

- Color
- Odor
- Turbidity
- Visual indicators:
    - Deposits and staining
    - Fish kills
    - Floatables
    - Sewage bacteria
    - Structural damage
    - Surface scum or sheen
    - Trash and debris
    - Vegetation

Use the following steps during routine maintenance inspections:

1. Evaluate the following:
    a. Water inside of a catch basin/manhole for evidence of color, odor, turbidity, and visual indicators
    b. The condition of the structure for the following visual indicators: deposits and staining, structural damage, and vegetation
    c. The area immediately surrounding the structure for signs of visual indicators
2. Document any visual, olfactory, or auditory indicators observed using a field notebook, field form, or a drop-down menu (for example, data dictionary) on a GPS unit.
3. Follow internal notification procedures to ensure proper reporting to other agencies and appropriate timely follow up if an illicit discharge is identified.

Pros and Cons

Pros	Cons
• Quick and inexpensive • Can eliminate branches of a storm drainage network from screening if no flow or visual indicators are present • Can test multiple storm drainage system branches that flow to a single manhole • Effective if storm drainage network is already mapped • Highly efficient if used in combination with routine catch basin/manhole inspections	• Some manholes will have flow continuously year-round due to groundwater inflow • Traffic hazards and danger to pedestrians when accessing some catch basins/manholes • Potential for toxic or flammable pollutants and hazards if confined space entry is necessary • Can be time consuming and difficult if storm drainage map is unavailable or incomplete • Less effective in wet weather than dry weather • Wet weather safety considerations for confined space entry

Ditch Inspections

Description

Inspections of ditches and similar open channels or swales can be used as a field screening methodology to help identify illicit discharges, especially in rural areas that do not have piped stormwater conveyance systems. In addition to conveying stormwater flows from the municipal separate storm drainage system, ditches also receive flows with potential illicit discharges from adjacent private property via straight pipes, swales, or seepage from failing septic systems. Ditches may also convey natural flow and can be identified by their flow patterns and historical drainage patterns:

- If a ditch only flows during storm events or periods of site discharges and/or was specifically built to convey stormwater or discharge water, then it is not typically considered to be a ditch that conveys natural flow.

- If a ditch is located in an area where there historically was a stream, then it is likely that the ditch still conveys some natural flows.

One option for implementing ditch inspections is to train stormwater maintenance staff on how to identify illicit discharges during routine maintenance and to add tracking information regarding illicit discharges to related inspection forms. Ditch inspections can also be used as a source tracing methodology once a suspected illicit discharge has been found to track the illicit discharge to its source (refer to Ditch Inspections in the *Source Tracing Methodologies* section).

Applications

Ditch inspections are most commonly conducted in rural areas, but can also be used in urban areas that do not have piped storm drainage systems. Ditch inspections are one of the best field screening methodologies to use in agricultural and rural residential settings with large drainage areas when performed using a combination of driving and walking.

Storm Drainage System Types	Land Use Types	Weather Conditions
• Ditches • Large drainage areas	• Rural • Urban • Agricultural • Commercial • Industrial • Mining • Residential	• Dry • Wet

Equipment

The following recommendations for staffing and equipment apply specifically to ditch inspections:

- ☐ Two field staff
- ☐ 1 to 2 vehicles
- ☐ Cell phones or 2-way radios
- ☐ Detailed maps of the storm drainage and sanitary sewer systems
- ☐ Field laptop/tablet and/or clipboard, field forms, and pen/pencil
- ☐ GPS unit (optional)
- ☐ Camera, phone, or other device for taking pictures (with date and time stamp)
- ☐ 25′ or 50′ flexible tape measure, string, or twine
- ☐ Sturdy boots or belted waders
- ☐ Safety equipment (for example, hard hats, work/leather gloves, ANSI 107-1999 labeled safety vests)
- ☐ Machete and/or loppers
- ☐ Primary field screening indicator equipment (see Flow, Ammonia, Color, Odor, pH, Temperature, Specific Conductivity, Turbidity, and Visual Indicators sections)

Notes:

1) As a general rule, do not enter private property without permission from the landowner.

Methods

The methods for conducting ditch inspections as well as the format of the inspection forms used can be modified by each jurisdiction as needed. Two general methods for conducting catch basin/manhole inspections for field screening are provided below.

Vehicle/Foot Reconnaissance Approach:

1. Identify pairs of staff who will work together. The buddy system is recommended for field work for health and safety reasons. Review the Safety Considerations in Section 3.2 of this manual. Consider property access before heading into the field. Staff should carry a current ID and business cards when conducting field work.

2. Review GIS field maps of the drainage basin or subbasin that will be investigated.

3. Select a driving route that includes a majority of the drainage basin or subbasin being investigated and highlights specific focus areas based on adjacent land uses that have a higher potential for illicit discharges. Driving through a drainage area can help to screen larger drainage areas that would be difficult to survey solely by foot.

4. Drive the route slowly and stop frequently to record observations and to take photographs. If two staff are present, one can record observations while the other focuses on driving.

5. Perform a walking survey at the confluence of several ditches where they come together at nodes near road intersections.

6. Record observations of the following indicators: color, odor, turbidity, visual indicators (deposits and staining, floatables, abnormal vegetation, sewage bacteria, etc.) and auditory indicators. Refer to the Indicators section for additional detailed information regarding how to evaluate these observations.

Ditch inspection (Photo Credit: Herrera).

7. Check for dry weather flow from any of the pipes into the ditch (if inspection is occurring during dry weather) and document the pipe location and direction that the flow is coming from.

8. Record observations of other items of interest such as invasive vegetation, ditch areas in need of maintenance, damaged culverts under roads, etc.

9. Document evidence of the following:

   a. Discharge locations: pipe diameter and material or ditch/channel width
      i. Cheater pipes (pipes that bypass the drain field of a septic system)
      ii. Other private drainage ditches or open channels

Cheater pipe (Photo Credit: unknown).

   b. Impacting Land Uses and Activities: visual observations
      i. Pastures with grazing animals, horse and livestock corrals, and animal feed lots
      ii. Adjacent landscaping
      iii. Parking lots
      iv. Engine/mechanical repair shops
      v. Other land uses that could generate illicit discharges, especially those with outdoor operations and activities

c. Dump sites: approximate area, distance to ditch, and type of debris
   i. Small debris (for example, bottles, cans, and trash)
   ii. Large debris (for example, shopping carts, abandoned cars, appliances, large quantities of yard waste [grass and yard clippings, piles of leaves], and/or miscellaneous pieces of junk)
   iii. Trash or improvised latrines from homeless encampments

10. Record the location of each item of interest in steps 4 and 5 on a field map or using a GPS unit.

11. Take photographs of each item of interest.

12. Collect a sample if dry weather flow is present and record values for the other primary field screening indicators (pH, temperature, turbidity, specific conductivity, and ammonia). Refer to the Indicators section for additional detailed information regarding how these samples should be collected and analyzed.

13. Trace flow using source tracing methodologies if visual indicators suggest that an illicit discharge is present.

14. Fill out a field form or use a GPS unit with drop-down menus (for example, data dictionary) to document all observations from the ditch inspection.

15. Follow internal notification procedures to ensure proper reporting to other agencies and appropriate timely follow up if an illicit discharge is identified.

16. Return to the office and make sure that documentation from the field work is completed and downloaded. This includes hardcopy field forms, photographs, GPS data, and storm drainage system mapping updates delivered to GIS staff.

Routine Maintenance Approach

Revise the field form or GPS data dictionary that staff use to document routine ditch inspections. The following fields are recommended for describing potential illicit discharges that may require follow-up investigation:

- Color
- Odor
- Turbidity
- Visual indicators:
  - Deposits and staining

- Fish kills
- Floatables
- Sewage bacteria
- Structural damage
- Surface scum or sheen
- Trash and debris
- Vegetation

Use the following steps during routine maintenance inspections:

1. Evaluate the following:
   a. Water floating in ditch for evidence of color, odor, turbidity, and visual indicators
   b. The condition of the ditch for the following visual indicators: deposits and staining, structural damage, and vegetation
   c. The area immediately surrounding the ditch for signs of visual or auditory indicators
2. Document any visual, olfactory, or auditory indicators observed using a field notebook, field form, or a drop-down menu (for example, data dictionary) on a GPS unit.
3. Follow internal notification procedures to ensure proper reporting to other agencies and appropriate timely follow up if an illicit discharge is identified.

Pros and Cons

Pros	Cons
• Can be used to locate unknown outfalls and update mapping • Can quickly detect illicit connections or illicit discharges if present • Can be used to identify other issues (for example, invasive vegetation or maintenance needs) • Highly efficient if used in combination with routine ditch inspections or road maintenance activities	• Ditches can be difficult and even hazardous to access when vegetation is thick and/or when sides slopes are steep • Dense vegetation can make visual observations and finding outfalls or cheater pipes difficult • Access to ditches may be limited by permission to enter private property • Less effective in wet weather than dry weather

Outfall Inspections

Description

Outfall inspections can be used as a field screening methodology to identify illicit discharges when flow is present or when visual, olfactory, or other indicators (for example, a greasy film) are observed. Outfall inspections are best conducted during dry weather and periods of low groundwater flow, generally at least 48 to 72 hours following the last runoff-producing rainfall event. If outfalls still have flow during dry weather, the flow should be investigated further to determine if the source is groundwater inflow to the storm drainage system or an illicit discharge or illicit connection.

Applications

Outfall screening applies to all storm drainage system and land use types. When flow is observed in an outfall pipe, primary field screening indicator sampling should be conducted.

Storm Drainage System Types	Land Use Types	Weather Conditions
• Pipes • Ditches	• Rural • Urban • Agricultural • Commercial • Industrial • Mining • Residential	• Dry • Wet

Equipment

The following recommendations for staffing and equipment apply specifically to outfall inspections:

- ☐ Two field staff
- ☐ Cell phones or 2-way radios
- ☐ Detailed maps of the storm drainage and sanitary sewer systems
- ☐ Field laptop/tablet and/or clipboard, field forms, and pen/pencil
- ☐ GPS unit
- ☐ Camera, phone, or other device for taking pictures (with date and time stamp)

- ☐ Dry erase board and dry erase marker for labeling outfalls
- ☐ High-powered lamps or flashlights/headlamps with batteries
- ☐ Tape measure
- ☐ Safety equipment (for example, hard hats, work gloves, ANSI 107-1999 labeled safety vests, steel-toe boots)
- ☐ Primary field screening indicator equipment (see Flow, Ammonia, Color, Odor, pH, Temperature, Specific Conductivity, Turbidity, and Visual Indicators sections)
- ☐ Machete and/or loppers

Notes:

1) *Only staff with confined-space entry training should enter an outfall or other confined space.*

2) As a general rule, do not enter private property without permission from the landowner.

Methods

The methods for conducting outfall inspections as well as the format of the inspection forms used can be modified by each jurisdiction as needed. The following general guidance is suggested for completing outfall inspections.

1. Identify pairs of staff who will work together. The buddy system is recommended for field work for health and safety reasons. Review the Safety Considerations in Section 3.2 of this manual. Consider traffic control, confined space entry needs, and property access before heading into the field. Staff should carry a current ID and business cards when conducting field work.

2. Drive or walk to the outfall to be inspected. Refer to your storm drainage system map to determine if the outfall has been previously documented. Assign a unique number or identifier to the outfall if the outfall has not been previously documented. Note that if the outfall is not accessible, the nearest catch basin(s) upstream of the outfall can be considered to be used as 'proxies' for the outfall (See Catch Basin/Manhole Inspections section).

3. Record the latitude and longitude of the outfall at the end of the pipe using a GPS unit if this has not previously been done.

4. Use a dry erase board to record down the date, time, outfall number, and inspector(s) initial. Photograph the white board next to the outfall.

Outfall inspection (Photo Credit: Herrera).

5. Record the following information on an outfall inspection form or using drop-down menus (for example, data dictionary) on a GPS unit:

    a. Background Data: Receiving water, outfall ID, land use, etc.

    b. Outfall Description: location (closed pipe or open swale/ditch), material type, shape, and dimensions, and whether the outfall is submerged.

    c. Flow Measurements: (such as, quantitative characterization) for flowing outfalls only.

    d. Physical Indicators: color, odor, turbidity, and visual indicators (for example, deposits and staining, floatables, abnormal vegetation, sewage bacteria in pool below outfall, etc.). Refer to the Indicators section for additional detailed information regarding how to evaluate these observations.

    e. Overall Outfall Characterization: unlikely illicit discharge, potential illicit discharge, obvious/likely illicit discharge

    f. Data Collection: collect a sample if dry weather flow is observed in an outfall pipe and record values for the other primary field screening indicators (pH, temperature, turbidity, and ammonia). Refer to the Indicators section for additional detailed information regarding how these samples should be collected and analyzed.

    g. Trace flow using source tracing methodologies if visual indicators suggest that an illicit discharge is present.

6. Follow internal notification procedures to ensure proper reporting to other agencies and appropriate timely follow up if an illicit discharge is identified.

7. Return to the office and make sure that documentation from the field work is completed and downloaded. This includes hardcopy field forms, photographs, GPS data, and storm drainage system mapping updates delivered to GIS staff.

Pros and Cons

Pros	Cons
• Relatively quick and inexpensive • Testing at an outfall can quickly screen flows from large portions of a storm drainage basin or subbasin	• Many outfalls flow continuously year-round due to groundwater inflow • An illicit discharge may be too diluted to be detected by the time it reaches an outfall • Outfalls can be difficult to access when vegetation is thick and/or terrain is steep/rough • Access to outfalls is often limited by permission to enter private property • Less effective during wet weather than dry weather

Video Inspections

Description

Video inspections are used as a field screening methodology to assess the condition of pipes and structures over a large area of the storm drainage system. Along with this condition assessment, indicators of illicit connections or illicit discharges can be recorded that will trigger follow-up source tracing investigations in smaller sections of the storm drainage system. Video inspections can also be used as a source tracing methodology once a suspected illicit discharge has been identified to track the illicit discharge to its source (refer to Video Inspections in the *Source Tracing Methodologies* section).

Applications

Video inspections are effective in large drainage areas to perform a coarse screening and assessment of the condition of pipes and structures in the storm drainage system. Sewer cameras are typically used to determine if there are cracks, leaks, or cross connections in sewer pipes. The same methodology used for televising sewer lines can be applied to storm drainage systems for screening branches of the system for illicit discharges or illicit connections. This methodology is most effective for identifying continuous or intermittent discharges or connections by working up the storm drainage system and inspecting larger mainline storm drainage pipes.

Storm Drainage System Types	Land Use Types	Weather Conditions
• Larger diameter pipes (>3 or 4 inches) • Large drainage areas	• Rural • Urban • Commercial • Industrial • Residential	• Dry • Wet

Equipment

Different types of video equipment are used based on the diameter of storm drainage pipe being inspected. A site visit should be conducted prior to purchasing any video inspection equipment to determine the most appropriate video camera size, material, capabilities, and accessories. Equipment specific to video inspections includes:

- ☐ Closed-Circuit Television (CCTV), capable of radial view and in color. Camera options include:
  - Mini cameras (1.5-inch to 4-inch diameter pipes)
  - Lateral cameras (3-inch to 8-inch diameter pipes)

- Mainline crawler/tractor cameras (4-inch to 10-inch diameter pipes)
- Pull cameras

☐ 200 to 400-foot push reel

☐ Tractor or crawler unit for camera

☐ Skid unit for camera

☐ Raft for camera (if water is present in storm pipe)

☐ Field laptop/tablet and/or clipboard, field forms, and pen/pencil

☐ Television system (truck, van, or utility trailer)

☐ High-powered lamps or flashlights

☐ Various catch basin/manhole hooks and wrenches (including hexagonal Allen key)

☐ Sledge hammer for loosening lids

☐ Safety equipment (for example, hard hats, work gloves, ANSI 107-1999 labeled safety vests, ear protection, steel-toe boots, traffic control equipment, gas monitor)

Methods

Each video camera and video inspection system will have different instructions depending on its manufacturer, intended application, and capabilities. It is important to read the instructions for each component of the video inspection system closely, as equipment is expensive and potential damage to equipment should be minimized as much as possible. In general, field crews should implement the following steps during and prior to a video inspection:

1. Determine the condition of the pipe segment being tested (such as, diameter, water ponding). If excessive debris or other material in the pipe is suspected, the pipe should be cleaned prior to conducting a video inspection.

2. Select an appropriately sized camera and camera navigation system for the pipe segment (for example, tractor or crawling unit, skid unit, raft).

3. Orient the CCTV to keep the lens as close as possible to the center of the pipe.

4. Record a video with an audio voice over as the camera is guided through the pipe to document significant findings for future review and evaluation.

Pros and Cons

Pros	Cons
• Pinpoints exact location of breaks, infiltration, cross connections between manhole structures • Safer than confined space entry • Does not require intrusion on members of public	• Expensive, rig including cameras, monitors, trailers and associated equipment can be expensive • Only captures continuous discharges from pipes that are not submerged • Requires field crew training to operate equipment • May require line cleaning before equipment can be used • Specialized equipment needed for smaller diameter pipes • Debris and other obstructions can block off storm drainage pipe and restrict camera usage • Less effective in wet weather than in dry weather

Other Field Screening Methodologies

The following field screening methodologies were not included in this manual due to the high cost of implementation and the specialized nature of these methodologies. However, IDDE program managers may want to develop and use these methodologies on a case-by-case basis:

Other Field Screening Methodologies	Description
Automated Sampling	This methodology uses automated sampling equipment installed in catch basins or manholes, or near outfalls to sample intermittent flows. Laboratory testing is performed on the collected samples. Ecology (2018) has developed standard operating procedures and the USGS (2014) has developed a field manual that may be useful references when implementing automated sampling.
Business Inspections	Business inspections are performed to identify pollutant-generating sources at commercial, industrial, and multifamily properties and enforce implementation of required BMPs that prevent pollutants from discharging into storm drainage systems. Business inspections can also be used as a source tracing methodology. See Appendix E for more details.
Canine Scent Tracking	Methodology using trained dogs (for example, a canine "K-9" unit) to perform scent tracking.
Infrared Color Aerial Photography	This methodology uses color as an indicator to detect changes in plant growth, differences in soil moisture content, and the presence of standing water on the ground to identify failing septic systems.
Infrared Thermography	This methodology uses the temperature difference of sewage as a marker to locate failing septic systems. It can be employed as a field screening methodology on a landscape scale using aerial photography systems, and also as a source tracing methodology on an in-pipe scale using video inspection systems.
Intensive Sampling	Intensive sampling can also be performed with automated sampling equipment or sampling conducted during base flow or storm events.
Sediment Trap Sampling	This methodology uses sediment traps to trace and locate sources of contamination that have adhered to storm solids and sediment (such as, polychlorinated biphenyls [PCBs] and polycyclic aromatic hydrocarbons [PAHs]). Grab samples of settled stormwater solids from catch basin/manhole sumps can also be analyzed and used to trace such sources.
Stormwater BMP Inspections	Stormwater BMPs include detention facilities such as ponds and vaults, stormwater treatment facilities such as stormwater wetlands and biofiltration swales, and low impact development (LID) facilities such as bioretention and permeable pavement. Stormwater maintenance staff can be trained to identify illicit discharges during routine maintenance, inspection, or repair activities. See Appendix E for more details.
Stream Walks	Stream walks involve walking along or wading in a stream and identifying outfall locations, indicators of potential illicit discharges, illegal dumping, and streambank erosion. This type of assessment can also be performed along the shore of a lake, pond, inlet, strait, or Puget Sound using a boat (for example, canoe, kayak, or motorboat). Stream walks are best conducted during dry weather (generally at least 48 to 72 hours following the last runoff-producing rainfall event) and after leaves have fallen (dense vegetation can make it difficult to locate outfalls and obtain accurate GPS coordinates). Local jurisdictions may have specific requirements for obtaining permission from adjacent property owners prior conducting a stream walk.

4. INDICATORS

Indicator sampling is a useful tool to determine the presence and potential threat to public health and the environment. Some illicit discharges are fairly obvious and have distinct colors, odors, sounds of flow or visual indicators and can be identified during field screening. Other illicit discharges, however, may not be as easy to detect using visual and olfactory observations and require additional steps to indicate what is being discharged.

If flow is present during dry weather, then indicator sampling or evaluation should be conducted for the primary field screening indicators listed below. These indicators were selected since they are typically quick and easy to observe or measure to determine if an exceedance of a recommended threshold is present. Recommended thresholds for the primary field screening indicators are summarized in Figure 4.1 and Figure 4.2 and in the indicator pullout sections. Exceedances of the recommended primary field screening indicator thresholds indicate that an illicit discharge may be present and trigger further sampling of one or more follow-up indicators listed below.

Primary Field Screening Indicators	Follow-Up Indicators
• Ammonia • Color • Odor • pH • Temperature • Turbidity • Visual indicators[a]	• Bacteria • Chlorine • Detergents/Surfactants • Fluoride • Hardness • Nitrate • Specific conductivity • Total petroleum hydrocarbons

[a] Visual indicators include floatables, debris, vegetation, deposits and staining, structural damage, sewage bacteria, surface scum or sheen, fish kills.

4.1. SELECTING AN INDICATOR

As summarized above, the primary field screening indicators should typically be evaluated in all situations where flow is present during dry weather. Indicator sampling will typically occur using the methods specified in one of the following field screening methodology sections (see Figure 3.1):

- Catch basin/manhole inspections
- Ditch inspections
- Outfall inspections

The exact location of the indicator sampling depends on where the suspected illicit discharge was observed. If the suspected illicit discharge was observed during an outfall inspection, then indicator sampling should occur at the outfall. If exceedances are measured, successive source tracing methodologies should be conducted back up through the storm drainage network. The storm drainage network could include either pipes or ditches, which should be sampled from catch basins/manholes or from ditches.

Once a sample has been collected, the inspector should follow the Figure 4.1 flow chart if indicator sampling has occurred in an urban area or the Figure 4.2 flow chart if indicator sampling has occurred in a rural area. For indicators that will be analyzed in the field, the field quality assurance/quality control (QA/QC) procedures summarized in the *General Guidelines* section below should be followed. For indicators that will be analyzed in the lab, the laboratory QA/QC procedures summarized in the *General Guidelines* section below should be followed.

The flow charts provided in Figure 4.1 and Figure 4.2 assume that the source of illicit discharge is unknown until indicator sampling is conducted. There are certain cases; however, in which the presence of an illicit discharge can be determined based on results from the primary field screening indicators and observations of the surrounding area. In these cases, it is helpful to select an indicator or multiple indicators to confirm the suspected source of the illicit discharge. Table 4.1 lists follow-up indicators that can help to confirm the type and source of an illicit discharge based on the suspected source and primary field screening indicator observations.

In some cases, additional indicator sampling, land survey, or specialized investigation may be necessary. Refer to the Other Indicators section at the end of this section for other indicators that may be used for these cases. The case studies included in Appendix C may also provide some useful guidance in determining what the source of a potential illicit discharge may be.

If sufficient staff time, equipment, or skills are not available to perform indicator sampling, a private contractor can be hired to perform the work. It is important that the selected contractor has the required expertise to perform the indicator sampling and that they follow the appropriate safety protocols.

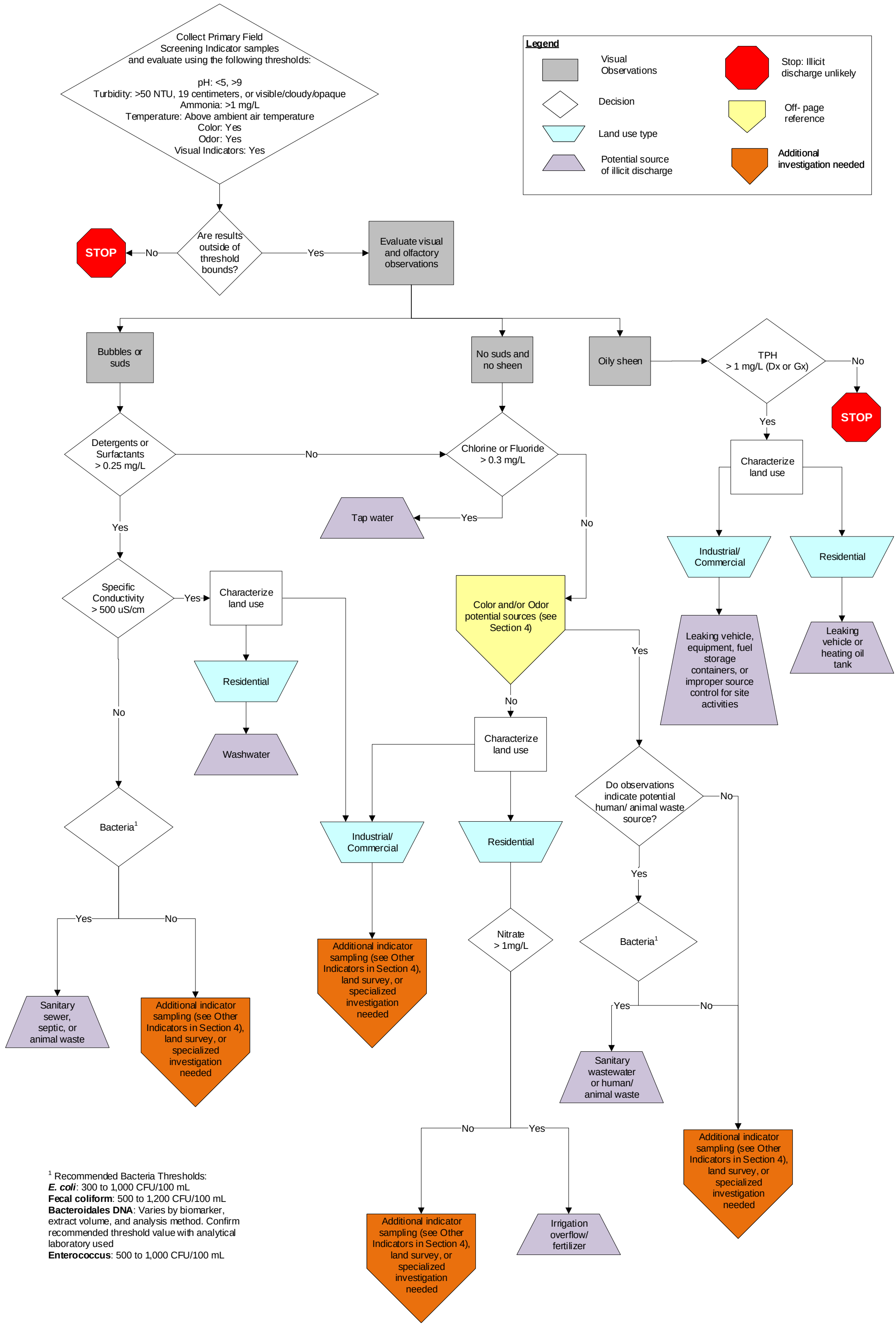


Figure 4.1. Indicator Sampling Flow Chart (Urban Land Use).

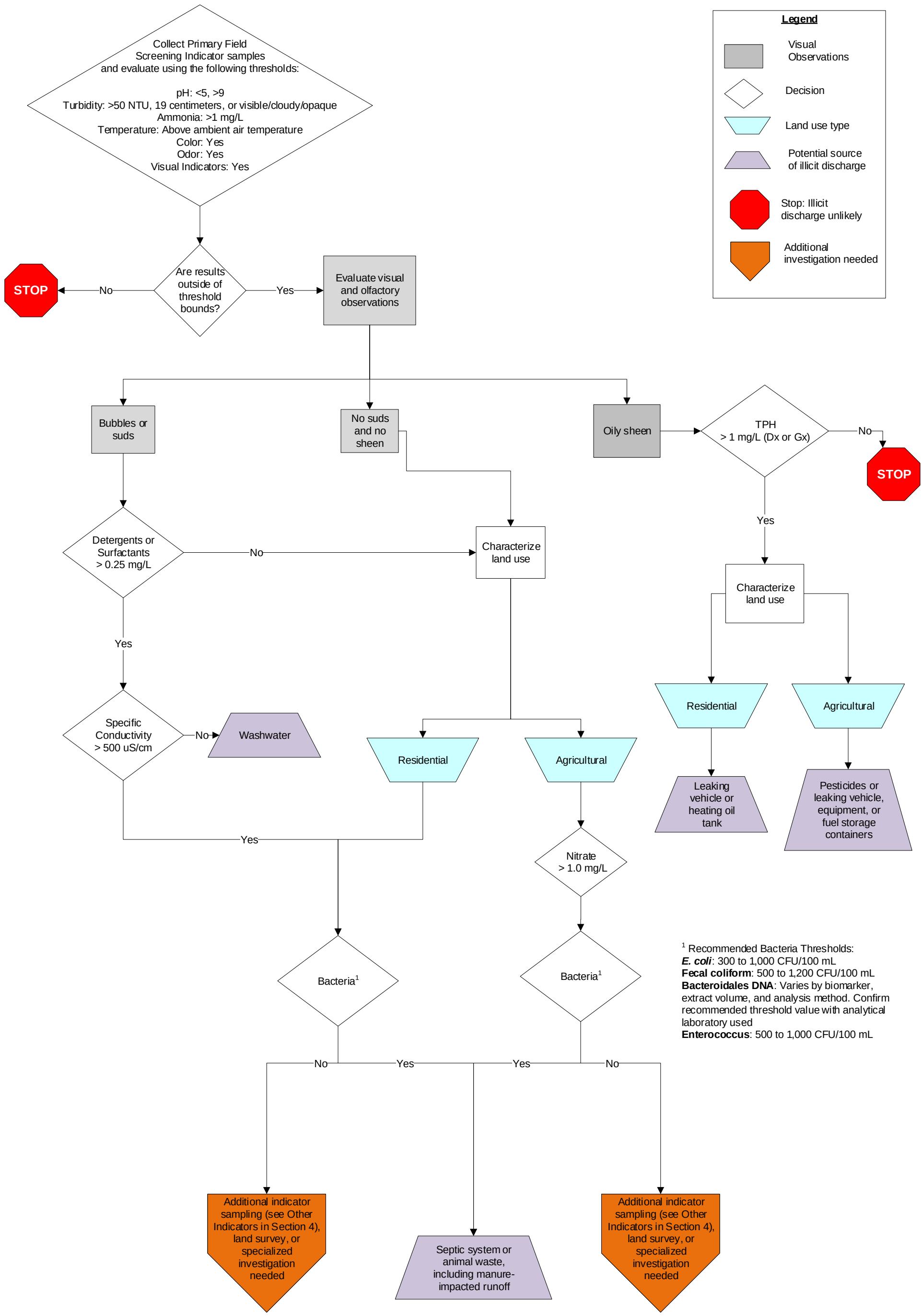


Figure 4.2. Indicator Sampling Flow Chart (Rural Land Use).

Table 4.1. Primary Field Screening Indicator Observations and Follow-Up Indicator Recommendations Based on the Suspected Source of an Illicit Discharge.

Suspected Source	Examples	Primary Field Screening Indicator Observations	Follow-Up Indicator(s)
Construction site runoff	• Failing erosion and sediment control BMPs	• Color: Tan to brown • Turbidity: >50 NTU	• Specific Conductivity
Construction site runoff	• Concrete slurry	• Color: Milky white, gray • pH: >9	• Specific Conductivity
Gasoline, vehicle oil, or grease	• Leaking vehicle • Oil change • Leaking storage tank • Improper material storage	• Odor: petroleum • Visual Indicators: ○ Surface sheen (petroleum sheen)	• Total Petroleum Hydrocarbons

Human/ animal waste	• Illicit connection
	• Sewage overflow
	• Improper disposal of animal waste
	• Runoff or direct discharge from homeless encampments
		• Ammonia: >1 mg/L
		• Odor:
		  ○ Rotten egg/ hydrogen sulfide/ natural gas
		  ○ Musty
		• Temperature above ambient air temperature
		• Visual Indicators:
		  ○ Fungus and algae (*Sphaerotilus natans*)
		  ○ Floatables (toilet paper, sanitary waste)
			• Bacteria
			• Nitrate

Industrial process water	• Illicit connection
	• Overflow
		• Temperature above ambient air temperature
		• Visual Indicators:
		  ○ Structural damage (spalling, chipping)
		  ○ Surface sheen (petroleum sheen)
			• Hardness
			• Specific Conductivity

Industrial operations	• Illicit connection • Overflow • Improper material storage • Leaking storage tank • Improper waste disposal	• Temperature above ambient air temperature • Color: highly variable (see Color section) • Odor: highly variable (see Odor section)	• Hardness • Specific Conductivity

Table 4.1 (continued). Primary Field Screening Indicator Observations and Follow-Up Indicator Recommendations Based on the Suspected Source of an Illicit Discharge.

Suspected Source	Examples	Primary Field Screening Indicator Observations	Follow-Up Indicator(s)

Nutrient rich discharge	• Excessive irrigation
	• Excessive fertilization
	• Hydroseeding following construction
		• Visual Indicators:
		  ○ Excessive vegetation
		  ○ Fungus and algae (white mat-like growth or algal blooms)
			• Nitrate

Sanitary wastewater or sewage	• Illicit connection
	• Sewage overflow
	• Septic system discharge
		• Ammonia: >1 mg/L
		• Color:
		  ○ Blue green/brown green
		  ○ Black
		• Odor: Rotten egg/ hydrogen sulfide/ natural gas
		• Temperature above ambient air temperature
		• Visual Indicators:
		  ○ Fungus and algae (*Sphaerotilus natans*)
		• Floatables (toilet paper, sanitary waste)
			• Bacteria
			• Nitrate

Tap water	• Illicit connection • Fire hydrant flushing • Swimming pool, hot tub, and spa drainage • Water main break	• Color: Blue green/brown green • Odor: Chlorine	• Chlorine or Fluoride

Washwater	• Car washing
	• Pressure washing
	• Mobile cleaning
		• Color:
		  ○ Blue green/brown green
		  ○ Gray to milky white
		• Odor: Soapy/ perfume
		• Temperature above ambient air temperature
		• Visual Indicators: Surface scum, bubbles, suds
			• Detergents/Surfactants
			• Specific Conductivity

4.2. SELECTING A METHOD

In order to evaluate an indicator, a measurement should be taken using a test strip, test kit, field meter, multimeter, colorimeter, spectrophotometer, or collecting a sample for laboratory analysis. Some indicators may also be evaluated using visual or olfactory observations. This section provides an overview of the different methods described in each of the indicator subsections.

Test Strips

Test strips are small pieces of paper or plastic with one or more test pads on the end of the strip. The test pads react with a water sample to cause a color change. The basic steps for using test strips include collecting a water sample, dipping the test strip in the water sample, removing the strip, and matching the color(s) that appear on the test pad to a color scale. The specific steps for using test strips vary depending on the brand of test strip being used.

Test Kits

Test kits are typically packaged in plastic or cardboard containers and are designed to determine the concentration or quantity of an indicator. Test kits typically include reagents (such as, a substance used in a chemical analysis), sample vials (such as, to hold a given sample amount), and a user's manual or instruction sheet. Standard solutions with known concentrations are typically used to verify that a test kit is reporting the correct results for a given indicator. Some test kits also use a water sample without the addition of a reagent as a "blank" or control sample to compare to a sample that has the reagent added.

The basic steps for using a test kit include collecting a water sample, adding one or two reagents to the water sample, waiting for a reaction to occur, and comparing the water sample to a color scale or control sample. The specific steps for using test strips vary depending on the brand of test strip being used.

Field Meter

A field meter is an electronic instrument that operates using batteries and can be used to measure one or more water quality indicators using a probe or sensor typically attached to a cable. Field meters used for water quality sampling are typically durable and waterproof, but should be stored in a hard case lined with foam to protect the meter when not in use.

The basic steps for using field meters typically include collecting a water sample, immersing the probe or sensor attached to the field meter in the sample, and reading the value that appears on the display screen. Alternatively, some field meters can determine indicator concentrations if a small amount of the water sample is placed on the field meter sensor.

Multimeter

A multimeter is an electronic instrument that operates using batteries and can be used to measure multiple water quality indicators using various probes or sensors. Multimeters used for water quality sampling are typically durable and waterproof, but should be stored in a hard case lined with foam to protect the meter when not in use.

The basic steps for using a multimeter typically include collecting a water sample, immersing the probe or sensor attached to the multimeter in the sample, and reading the value that appears on the display screen. The specific steps for using multimeters vary depending on the brand of multimeter being used.

Colorimeter

A digital colorimeter is an instrument that measures the absorbance of a particular wavelength of light by a sample. The basic steps for using a colorimeter typically involves collecting a water sample, adding one or two reagents to the water sample, waiting for a reaction to occur, placing the prepared sample into the colorimeter, and comparing the prepared sample to a "blank" or control sample. Some reagents include hazardous or toxic chemicals or form hazardous or toxic byproducts when they react with a water sample that may require special handling or disposal. The specific steps for using a colorimeter will vary depending on the brand of colorimeter being used.

Spectrophotometer

A spectrophotometer is a digital instrument that is related to a colorimeter, but measures the transmittance or reflectance of a sample and can scan across a spectrum of wavelengths instead of focusing on a single wavelength of light. The basic steps for using a spectrophotometer typically include collecting a water sample, adding one or two reagents to the water sample, waiting for a reaction to occur, and placing the prepared sample into the spectrophotometer. The specific steps for using a colorimeter will vary depending on the brand of spectrophotometer being used. The field crew should read the user's manual and practice using the spectrophotometer prior using it in the field to become familiar with its operation.

Laboratory Analysis

Water samples can also be collected in the field and taken to an analytical laboratory for analysis. Laboratory analyses are typically more accurate than in field measurements, but can be more expensive and results are not available immediately. Laboratory analyses can also be less expensive than investing in a field meter, especially for infrequently used follow-up parameters. A single water sample can be analyzed for multiple indicators at an analytical laboratory; however, you should verify the required volume for each analysis in order to ensure that you collect enough sample volume in the field.

4.3. GENERAL GUIDELINES

The following guidelines for field QA/QC, laboratory QA/QC, safety considerations, and costs apply to all the indicators summarized in this section.

Field Quality Assurance/Quality Control

Basic QA/QC procedures for sample bottles, test strips, field meters, and buffers or standard solutions are summarized below.

Sample Bottles

Clean, sterile sample bottles should be obtained from an analytical laboratory or local wastewater treatment plant. Spare sample bottles should be carried by field personnel in case of breakage or possible contamination. Sample bottles and preservation techniques will follow Code of Federal Regulations [40 CFR 136] guidelines. Refer to the indicator pullout sections for information on recommended sample bottles.

Test Strips

Test strips should be stored at room temperature and should not be exposed to light when not in use. Test strips should be replaced according to the schedule specified by the manufacturer. For example, pH test strips should be replaced every 3 to 5 years.

Field Meters

Proper calibration is essential to obtaining accurate results. Field meters should be calibrated before heading out in the field. If the meter has been turned off for an extended period of time during the day, a calibration and battery check should be performed.

Buffer or Standard Solutions

Buffer or standard solutions should be labeled with the date that they were opened and replaced according to the schedule specified by the manufacturer. For example, pH buffer solutions should be replaced every 3 to 6 months once opened. Unopened pH buffer solutions can be stored for up to 2 years.

Laboratory Analysis Quality Assurance/Quality Control

Basic QA/QC procedures for sample bottles, sample identification and labeling, chain-of-custody, sample transport, and laboratory quality control are summarized below.

Sample Bottles

Clean, sterile sample bottles should be obtained from an analytical laboratory or local wastewater treatment plant. Depending on what is being sampling, bottle material may be glass, polyethylene, Teflon, or other plastic. Spare sample bottles should be carried by field personnel in case of breakage or possible contamination. Sample bottles and preservation techniques will follow Code of Federal Regulations [40 CFR 136] guidelines. Refer to the indicator pullout sections for information on recommended sample bottles and contact the laboratory for specific information on bottle types, filling techniques and analyte-specific information.

Sample Identification and Labeling

All sample bottles will be labeled with the following information, using indelible ink and placed on dry sample bottles with labeling tape:

- Location ID
- Date of sample collection (month/day/year)
- Time of sample collection (military format)
- Sample type (grab)
- Requested analytes for lab testing

Chain-of-Custody

After samples have been obtained and the collection procedures properly documented, a written record of the chain-of-custody of each sample should be made. This is recommended to ensure that samples have not been tampered with or compromised in any way and to track the requested analysis for the analytical laboratory. Information necessary in the chain-of-custody includes:

- Name(s) of field personnel
- Date and time of sample collection
- Location of sample collection
- Names and signatures of field personnel and laboratory personnel handling the samples

- Laboratory analysis requested and control information (for example, duplicate or spiked samples) and any special instructions (for example, time sensitive analyses)

Sample custody will be tracked in the laboratory through the entire analytical process, and the signed chain-of-custody forms and analytical results returned to the investigator.

Sample Transport

Samples should be placed in a storage container (for example, cooler) in an ice bath or packed tightly with an ice substitute to keep them at 4°C (40°F) or less, and delivered to the laboratory as soon as possible.

Laboratory Quality Control

Accuracy of the laboratory analyses will be verified using blank analyses, duplicate analyses, laboratory control spikes and matrix spikes in accordance with the EPA methods employed. The analytical laboratory selected for the analysis will be responsible for conducting internal quality control and quality assurance measures in accordance with their own quality assurance plans.

Water quality results will be reviewed at the laboratory for errors or omissions. Laboratory quality control results will be reviewed by the laboratory to verify compliance with acceptance criteria. The laboratory will also validate the results by examining the completeness of the data package to determine whether method procedures and laboratory quality assurance procedures were followed. The review, verification, and validation by the laboratory will be documented in a case narrative that accompanies the analytical results.

Safety Considerations

Safety is an important factor when conducting indicator sampling. Refer to the safety considerations included in the Field Screening Methodology section. Additional safety considerations for indicator sampling include:

- Wearing nitrile gloves and safety glasses when handling samples to protect yourself from potential contaminants
- Considering the handling and disposal of hazardous test kit, colorimeter, and spectrophotometer reagents
- Determining the best method for collecting a sample (Do you need to enter a fast moving stream or river or perform confined space entry or can you collect a sample using a claw grabber or telescoping sampling pole?)

Costs

Costs for indicator sampling equipment and materials are summarized in Appendix A. The authors do not promote, endorse, or otherwise recommend any of the companies, individuals, or organizations presented in Appendix A.

4.4. INDICATOR PULLOUT SECTIONS

Each of the following indicator pullout sections contains the following information:

- **Description:** Indicator definition.
- **Applications:** Lists the applicable storm drainage system types (pipes and ditches), land use types (urban, rural, agricultural, commercial, industrial, mining, and residential), and weather conditions (dry and wet).
- **Equipment:** Checklist for field crews to determine what materials and supplies to bring out in the field.
- **Methods:** Generic standard operating procedures for collecting an indicator sample for analysis using a variety of methods (for example, test strips, a test kit, a digital colorimeter, a field meter, or laboratory analysis).
- **Thresholds:** Recommended measurements or observations that trigger further investigation. Recommended thresholds were selected based on the values that Washington jurisdictions are currently using for IC and ID investigations as well as values that were found during the literature review. Thresholds may be modified for use based on local knowledge or observations. Surface water quality standards (if applicable) are provided for reference only and are not intended to be used as thresholds in storm drainage systems.
- **Pros and cons:** List of the positive and negative aspects of the indicator.
- **Common sources:** Lists potential sources in relation to observations of color, odor, visual indicators, or concentration of a chemical indicator (such as, high or low in comparison to the recommended threshold value).

Flow

Description

Flow during dry weather is an indicator that a water source other than stormwater is flowing through the storm drainage system. The source of the flow could be groundwater or natural flow, but could also be a sanitary sewer cross-connection, potable water, or illegal dumping.

The following discharges are examples of allowable and conditionally allowable according to the NPDES Municipal Stormwater Permits:

Allowable Discharges	Conditionally Allowable
• Diverted stream flows • Uncontaminated or rising groundwater • Foundation drains • Air conditioning condensation • Comingled irrigation and urban stormwater • Springs • Uncontaminated water from crawl space pumps • Footing drains • Flows from riparian habitats and wetlands • Flows authorized by another discharge permit • Emergency firefighting activities	• Potable water sources, such as water line testing and fire hydrant system flushing (residual chlorine of 0.1 parts per million [ppm] or less, pH adjusted if necessary, and volumetrically and velocity controlled to prevent resuspension of sediments) • Irrigation runoff, minimized through conservation efforts • Dechlorinated swimming pool, spa, and hot tub discharges (residual chlorine of 0.1 ppm or less, pH adjusted and reoxygenated if necessary, temperature controlled, and volumetrically and velocity controlled to prevent resuspension of sediments) • Street and sidewalk wash water, dust control water, and building wash water without detergents, minimized through conservation efforts

Note: Local codes and regulations may be more restrictive than allowable and conditionally allowable discharges listed in table. Allowable and conditionally allowable discharges may require a G3 report to Ecology.

Ditches may convey natural flow and can be identified by their flow patterns and historical drainage patterns:

- If a ditch only flows during storm events or periods of site discharges and/or was specifically built to convey stormwater or discharge water, then it is not typically considered to be a ditch that conveys natural flow.

- If a ditch is located in an area where there historically was a stream or is in a known area where groundwater seeps and springs are present, then it is likely that the ditch still conveys some natural flows.

Indicator sampling should be conducted at every ditch, outfall, or manhole where dry weather flow is observed that is not attributable to groundwater, natural flow, or other allowable discharges. When no flow is present, but visual observations suggest the potential of an illicit

discharge, source tracing methodologies such as sandbagging (see Appendix G) can be used to block flow to allow for indicator sampling.

Applications

The presence of flow is used as a trigger for primary field screening indicator sampling, and applies to all storm drainage system and land use types.

Presence of flow in a pipe, ditch, or outfall during dry weather may indicate an illicit discharge (if not attributable to groundwater or other allowable discharges), while the rate and frequency of flow can help to determine the source. Classifying the frequency of flow as continuous, intermittent, or transitory (see Definitions and Regulatory Requirements section) can help to pinpoint specific actions that may be causing the illicit discharge.

Storm Drainage System Types	Land Use Types	Weather Conditions
• Pipes • Ditches	• Rural • Urban • Agricultural • Commercial • Industrial • Mining • Residential	• Dry

Equipment

Refer to the equipment list in the Field Screening Methodology section for the methodology you have selected. Equipment specific to flow observations and/or testing includes:

- ☐ Bucket, tracing dye, or floatable item (for example, cork, orange, rubber ball, or stick)
- ☐ Alternative flow measurement device (for example, flow meter)
- ☐ Stopwatch
- ☐ Tape measure
- ☐ Field laptop/tablet and/or clipboard, field forms, and pen/pencil
- ☐ Safety equipment (for example, hard hats, ANSI 107-1999 labeled safety vests)
- ☐ Nitrile gloves
- ☐ Sturdy boots or belted waders

Methods

Dry weather flow should be assessed qualitatively or quantitatively in the field using visual and auditory observations or quantitative measurement techniques. Although the quantitative measurement of flow is not always necessary, it can be useful for determining pollutant loading rates. Flow measurements in streams can be collected using a flow meter; however, it can often be difficult to measure the flow in a pipe with a flow meter due to the depth of a catch basin/manhole structure or shallow flow. This manual describes general procedures for two simple methods that can be used to measure flow quantitatively: the bucket method and the float method. Refer to Figure 4.1 or Figure 4.2 for additional indicator sampling after obtaining results.

Bucket Method

The bucket method requires a large enough space and water depth to accommodate a bucket or container of known volume, and is best suited for open pipes, ditches, or outfalls when the outfall is not submerged.

1. Wear nitrile gloves to protect yourself from potential contaminants.
2. Time how long it takes to fill the bucket
    a. If the bucket has incremental volume markings, hold the bucket under the flow for 1 minute.
    b. If only the total volume of the bucket is known, hold the bucket under the flow until it fills completely.
3. Calculate the flow rate (flow rate = volume of bucket/amount of time to fill the bucket).
4. Repeat steps 1 through 3 at least three times and calculate an average flow rate.
5. Record the average flow rate on your field data sheet, notebook, or field laptop/tablet.

Float Method

The float method requires downstream access to catch basins, manholes, ditches, or streams, and a measurable distance between the two locations. This method is therefore more appropriate for relatively short branches of the storm drainage system. One important consideration of the float method is the presence of debris or uneven substrate, which can impede the movement of the floatable material downstream. If a large amount of debris is present, consider using dye instead of a floatable object. Refer to Dye Testing and local regulations for appropriate dye testing notification procedures prior to injecting dye into the storm drainage system.

1. Wear nitrile gloves to protect yourself from potential contaminants.

2. For piped systems:

   a. Measure the distance between outfall and the first upstream catch basin or manhole.

   b. Drop floatable object (for example, cork, orange, rubber ball, or stick) or inject dye into upstream manhole and start the stopwatch.

   c. Stop timing when the object or dye reaches the outfall being investigated.

   d. Estimate the cross-sectional area of the pipe.
      i. Measure the diameter of pipe and depth of flow in pipe using a tape measure
      ii. Cross-sectional area of pipe = (3.1415 x diameter of pipe^2) / 4
      iii. Cross-sectional area of flow = (depth of flow/diameter of pipe)^2 x cross-sectional area of pipe

3. For ditch systems:

   a. Measure a known distance of at least 20 to 30 feet upstream of the outfall being investigated, preferably with a length of 10 times the width of the ditch.

   b. Drop floatable object (for example, cork, orange, rubber ball, or stick) or inject dye into upstream manhole or in the ditch upstream of the outfall (refer to Dye Testing) and start the stopwatch.

   c. Stop timing when the object or dye reaches the outfall being investigated.

   d. Estimate the cross-sectional area of the wetted ditch section.
      i. Measure width of flow using a tape measure
      ii. Measure depth of flow at three different locations along the width of the ditch. Take the average of these measurements.
      iii. Cross-sectional area = width of wetted ditch x average depth in ditch

4. Calculate the flow rate (velocity = distance/time, flow rate = velocity x cross-sectional area).

5. Repeat procedure at least three times and calculate an average flow rate.

6. Record the average flow rate on your field data sheet, notebook, or field laptop/tablet.

Flow Meter Method

A flow meter is an electronic instrument that operates using batteries and can be used to measure the velocity of water using a propeller and sensor attached to the end of a wand. The velocity is read from an "indicator unit" attached to the cable. The basic steps for using a flow/velocity meter typically include taking incremental velocity measurements along the width

of the stream of water. Some velocity/flow meters automatically record depths, widths, angles, and date/time, but others only record velocity measurements. With these instrument types, it is important to use a wand with measurement markings on the sides so the depth of flow can be determined. The specific steps for using velocity/flow meters vary depending on the brand of meter being used. Refer to the user's manual with your meter for more detailed information. Velocity/flow meters are most effective in areas where the depth of flow is significant, otherwise the propeller or probe may not be submerged completely. The following steps are generally common to velocity/flow meters:

1. **Check Meter:** Prior to taking meter in the field, confirm that the meter is working properly and sufficient battery life is left.

2. **Calibrate Meter:** Manufacturers typically recommend that meter calibration be checked regularly. Refer to the user's manual for the recalibration frequency and procedures.

3. **Field Measurements:**

    a. Remove sensor cap and connect wand to the Indicator control unit

    b. Place the sensor in the stream with the propeller facing into the flow

    c. Press and release the reset button to zero the display.

    d. Read the velocity, flow rate, depth, and/or time on the indicator control unit.

    e. Measure the depth of flow in this area if it is not recorded by your instrument

    f. Record the information in your field data sheet, notebook, or field laptop/tablet.

4. **Meter Storage:** Clean the surface of the indicator control unit with a solution designed for plastics. Wipe off the solution before storage. Store the meter and Indicator unit in a case between uses.

Thresholds

The following flow observation is recommended for triggering further investigation and additional indicator sampling. This threshold may be modified for use based on local knowledge or observations.

Recommended Threshold for Further Investigation and Additional Indicator Sampling
Any presence of flow during dry weather

Pros and Cons

Pros	Cons
• Inexpensive • Time efficient • Can help prioritize outfall investigations • Can be used to calculate pollutant loading rates	• Methods for estimating flow are not exact • Excessive debris or uneven substrate can affect movement of floatable material downstream • Bucket method is nonfunctional if end of pipe is submerged

Common Sources

Flow may be associated with a variety of sources and land use types. While the presence of flow or the flow rate alone is not enough to determine the source of the potential illicit discharge, the presence of flow is a prerequisite condition for primary field screening indicator sampling. Flow measurements should be used in combination with other parameters, such as color, odor, and visual indicators. Characterization of land use can help to narrow down the potential sources of illicit discharges based on flow rate and frequency.

Flow Frequency	Flow Rate	Potential Source
Continuous	High flow	• Construction site dewatering • Leaking tanks and pipes • Industrial processes water • Sanitary wastewater • Septic tank effluent • Washwater
	Low flow	• Groundwater seepage • Leaking potable water pipes
Intermittent	High flow	• Commercial liquid dumping • Industrial process water • Leaking tanks and pipes • Sanitary wastewater • Swimming pool, spa, or hot tub discharge • Washwater
	Low flow	• Irrigation overflow • Household chemical discharges • Septic system cross connection • Tap water
Transitory	High flow	• Illegal dumping • Outdoor washing activity • Ruptured tank • Single industrial spill • Sewer break • Vehicle accident • Firefighting activities

Ammonia

Description

Ammonia (also known as ammonia nitrogen or NH_3) is produced by the decomposition of plant and animal proteins and is also a main ingredient in fertilizers. The presence of ammonia in surface water usually indicates contamination from fertilizers, sanitary wastewater, or a commercial/industrial source. Trace amounts of ammonia over time can be toxic to fish and higher ammonia concentrations can result in low dissolved oxygen concentrations and fish kills.

Applications

Ammonia is used as a primary field screening indicator, and applies to all storm drainage system and land use types when flow is present. Ammonia concentrations may be diluted if samples are collected during wet weather.

Storm Drainage System Types	Land Use Types	Weather Conditions
• Pipes • Ditches	• Rural • Urban • Agricultural • Commercial • Industrial • Mining • Residential	• Dry • Wet

Equipment

Refer to the equipment list in the Field Screening Methodology section for the methodology you have selected. Equipment specific to ammonia testing includes:

- ☐ Ammonia field test kit, ammonia test strips, or ammonia ion probe on a multimeter
- ☐ Ammonia reagent set (if ammonia field test kit is selected)
- ☐ Ammonia standard solution (if ammonia field test kit is selected)
- ☐ Laboratory grade cleaning wipes
- ☐ Tap water (for first rinse)
- ☐ Distilled water (for final rinse)
- ☐ Wash bottle (for rinsing with distilled water)

- ☐ Clean, sterile sample bottles (glass or plastic)
- ☐ Containers for waste sample water and used reagent solution
- ☐ Field laptop/tablet and/or clipboard, field forms and pen/pencil
- ☐ Safety equipment (for example, hard hats, ANSI 107-1999 labeled safety vests)
- ☐ Nitrile gloves
- ☐ Sturdy boots or belted waders
- ☐ Claw grabber or telescoping sampling pole (for collecting samples)

Methods

Ammonia can be measured using ammonia test strips, a field test kit, an ion probe on a multimeter, or at an analytical laboratory. General procedures for each type of equipment are outlined below. Refer to Figure 4.1 or Figure 4.2 for additional indicator sampling after obtaining results.

Ammonia Test Strips

The specific steps for using test strips vary depending on the brand of test strip being used. Refer to the container holding your test strips for more detailed information. The following steps are generally common to all test strips:

1. Wear nitrile gloves to avoid sample contamination and protect yourself from potential contaminants.
2. Collect the sample to be analyzed in a clean, sterile sample bottle made of glass. Avoid collecting sediment with the water sample.
3. Remove one strip from the test strip container and replace the cap tightly.
4. Dip the strip into your sample and move back and forth for the specified amount of time. Make sure that the test pad(s) are always submerged.
5. Remove the strip and gently shake off any excess liquid.
6. Wait the specified amount of time for the color change to occur.
7. Match the color(s) on the test pad(s) as closely as possible to the color scale on the test strip container.
8. Record the value(s) on your field data sheet, notebook, or field laptop/tablet.

9. Dispose of sample back to source.

10. Store test strips at room temperature and avoid exposure to light when not in use. Replace test strips after 3 to 5 years.

Ammonia Test Kit

The specific steps for using test kits vary depending on the brand of test kit being used. Refer to the user's manual or instruction sheet with your test kit for more detailed information. The following steps are generally common to all test kits:

1. Wear nitrile gloves to avoid sample contamination and protect yourself from potential contaminants and test kit reagents.

2. Collect the sample to be analyzed in a clean, sterile sample bottle made of glass. Avoid collecting sediment with the water sample.

3. Follow the steps in the user's manual included with your test kit to prepare and analyze the sample.

4. Record the value on your field data sheet, notebook, or field laptop/tablet.

Ammonia Ion Probe on a Multimeter

The specific steps for using multimeters vary depending on the brand of multimeter being used. Refer to the user's manual with your multimeter for more detailed information. Note: Ion probes are available for detecting both ammonia (NH_3) and ammonium (NH_4); users should be careful to select the appropriate probe for measuring ammonia. The following steps are generally common to multimeters:

1. **Check Meter:** Prior to taking meter in the field, confirm that the meter and probes are working properly and sufficient battery life is left.

2. **Probe Calibration**: Manufacturers typically recommend that probes be checked at least once a year. Refer to the user's manual for the recalibration frequency and procedures.

3. **Field Measurements**:

    a. Wear nitrile gloves to avoid sample contamination and protect yourself from potential contaminants. Do not touch the inside of the lid or bottle.

    b. Collect a field sample in a clean, sterile sample bottle made of either glass or plastic. Avoid collecting sediment with the water sample.

    c. Pour some of the water sample over the probe to remove residue from the probe and avoid cross contamination of the sample.

d. Dip the probe in the water sample. Stir gently for a few seconds. Allow up to 1 minute for the readings to stabilize.

e. Record the ammonia concentration shown on the multimeter on your field data sheet, notebook, or field laptop/tablet.

f. Rinse the probe with distilled water and dry with a laboratory grade cleaning wipe between each reading and before storage.

g. Dispose of sample back to source.

4. **Meter Storage:** Clean the surface of the probe with a laboratory grade cleaning wipe and distilled water. Wipe off the distilled water before storage. Refer to the user's manual for specific storage recommendations.

Ammonia Laboratory Analysis

The following steps should be followed to collect samples for laboratory analyses:

1. Wear nitrile gloves to avoid sample contamination and protect yourself from potential contaminants. Do not touch the inside of the lid or bottle.

2. Rinse the clean, sterile sample container bottle three times with sample water before collecting the sample. Make sure to empty the sample water either downstream or away from your sampling location to avoid stirring up sediment and to avoid collecting sediment with your water sample.

3. Fill the bottle completely to the top after the third rinse.

4. Label the bottle with the sample location, date, and time.

5. Keep the samples at 4°C (40°F) or less by placing them in an ice-filled cooler.

6. Fill out a chain-of-custody form and submit to a laboratory. The samples must be analyzed within 28 days of sample collection.

Thresholds

The following ammonia level is recommended for triggering further investigation and additional indicator sampling. This threshold may be modified for use based on local knowledge or observations. Washington State does have surface water quality standards for ammonia; however, the standard varies with pH, temperature, and the presence/absence of salmonids (see WAC 173-201A-240).

Recommended Threshold for Further Investigation and Additional Indicator Sampling	State Water Quality Standards [a]
>1.0 mg/L	Fresh water: varies with pH, temperature, and presence/absence of salmonids Marine water: 0.233 mg/L (acute), 0.035 mg/L (chronic)

[a] Surface water quality standards are provided for reference only and are not intended to be used as thresholds in storm drainage systems.

Pros and Cons

Pros	Cons
• Good indicator of sanitary sewage • Test strips are easy to use • Field test kits are relatively easy to use	• Must take additional measures to account for interferences with saltwater, chlorine, iron, sulfides, and hardness • Concentrations may be too low to measure and may be diluted if samples are collected during wet weather • Cannot distinguish between human and non-human sources (pets or wildlife) • Aqueous ammonia volatilizes to ammonia gas at the air/water interface when pH >9.0 • Field test kits are sensitive to contamination • Need to properly dispose of reagents if using an ammonia test kit • Some reagents used with the field test kits are harmful if swallowed, inhaled, or absorbed through skin and may also cause eye, skin, or respiratory tract irritation • Ammonia may be present if irrigation water is comingled with stormwater

Common Sources

High concentrations of ammonia can be caused by the following sources:

High Ammonia
• Application of fertilizer, pesticides, or manure • Industrial or commercial liquid wastes (including petroleum refining and chemical industries, synthetic fibers and dyes, and pharmaceuticals) • Runoff or direct discharge from homeless encampments • Sanitary wastewater • Septic system discharge • Washwater

Color

Description

The color of water is influenced by the presence or absence of substances such as metallic salts, organic matter, dissolved or suspended materials. Color can indicate when stormwater has been contaminated by an illicit discharge or illicit connection, but not all illicit discharges will have a color. Color is assessed qualitatively by field staff using simple visual observations. Polluted stormwater often exhibits colors similar to the dissolved chemicals or materials that caused the contamination. Field staff should be aware that natural phenomena, as well as tracing dyes, can discolor stormwater, and may not be associated with an illicit discharge (see examples in *Common Sources* section).

Applications

Color is used as a primary field screening indicator, and applies to all storm drainage system and land use types.

Storm Drainage System Types	Land Use Types	Weather Conditions
• Pipes • Ditches	• Rural • Urban • Agricultural • Commercial • Industrial • Mining • Residential	• Dry • Wet

Equipment

Refer to the equipment list in the Field Screening Methodology section for the methodology you have selected. Equipment specific to color observations and/or testing includes:

- ☐ Clean, sterile sample bottles (clear glass or plastic)
- ☐ Color test kit (optional)
- ☐ Tap water (if using color test kit)
- ☐ Distilled water (if using color test kit)
- ☐ Field laptop/tablet and/or clipboard, field forms and pen/pencil
- ☐ Plain white paper or dry erase board (optional)

- ☐ Safety equipment (for example, hard hats, ANSI 107-1999 labeled safety vests)
- ☐ Nitrile gloves
- ☐ Sturdy boots or belted waders
- ☐ Claw grabber or telescoping sampling pole (for collecting samples)
- ☐ Camera, phone, or other device for taking pictures (with date and time stamp)

Methods

Color is typically assessed qualitatively in the field using visual observations of how severely a sample is discolored. Qualitative color observations (for example, brown, reddish brown, light green, etc.) are subjective and depend on the inspector. Color can also be assessed quantitatively in the field using a color test kit and reagents, but this method is generally unnecessary and not recommended unless documenting stormwater pollution related to a specific site is needed to support a code enforcement action. General procedures for these two methods of assessing color are outlined below. Refer to Figure 4.1 or Figure 4.2 for additional indicator sampling after obtaining results.

Visual Observations

1. Wear nitrile gloves to protect yourself from potential contaminants.
2. Collect the sample to be analyzed in a clean, sterile sample bottle made of either clear glass or plastic using a claw grabber or telescoping sampling pole. Avoid collecting sediment with the water sample.
3. Raise the sample up to a natural light source to observe the color and how severely the sample is discolored. Place the sample against a plain white piece of paper or dry erase board (or similar neutral background) if available. Consider taking a photograph to document the color. If a second inspector is available, have them verify your observations and/or record their own observations since color can be subjective. (Note: Depth, sediment accumulation, aquatic plant growth, and weather conditions can influence your perception of the color. Do not try to assess the color by looking into a catch basin, manhole, or water body.)
4. Write "NA" (not applicable) on your field data sheet, notebook, or field laptop/tablet, if no color was observed.
5. Record the color if one was observed, and its intensity or severity (for example, 1 – low, 2 – moderate, or 3 – high) on your field data sheet, notebook, or field laptop/tablet. A low color severity is assigned when there is a faint color in a sample bottle; moderate severity is assigned when a color is clearly visible in a sample bottle; and high severity is

used when a strong discoloration is clearly visible in the water in a flowing stream, ditch, or outfall.

Color Test Kit

The specific steps for using test kits vary depending on the brand of test kit being used. Refer to the user's manual or instruction sheet with your test kit for more detailed information. The following steps are generally common to all test kits:

1. Wear nitrile gloves to avoid sample contamination and protect yourself from potential contaminants and test kit reagents.
2. Collect the sample to be analyzed in a clean, sterile sample bottle made of glass. Avoid collecting sediment with the water sample.
3. Follow the steps in the user's manual included with your test kit to prepare and analyze the sample.
4. Record the value on your field data sheet, notebook, or field laptop/tablet.

Thresholds

The following color observations are recommended for triggering further investigation and additional indicator sampling. This threshold may be modified for use based on local knowledge or observations. Washington State does not have surface water quality standards for color.

Recommended Threshold for Further Investigation and Additional Indicator Sampling
Any discoloration not attributed to natural phenomena (*refer to examples in* ***Common Sources*** *section*)

Pros and Cons

Pros	Cons
• Quick and inexpensive • Fairly easy to track through a drainage system	• May be difficult or impossible for staff who are color blind • May be difficult to assess at night or without a good source of natural light • Can be subjective—one person's gray may be another person's off-white. Use of color standards is important. • Not all illicit discharges will have a color that can be traced

Common Sources

Colors may be associated with a variety of sources and land use types. Examples of potential illicit discharges and natural phenomena (that are not considered illicit discharges) are provided below in two separate tables.

Potential Illicit Discharges

Color	Potential Sources	Photo Examples
Tan to brown	• Construction site runoff • Sediment from soil erosion (sometimes a natural phenomenon) • See Natural Phenomena table for other potential sources	 Sediment (Photo Credit: City of Federal Way)
Brown to reddish brown	• Decomposing food or meat products • Grain mill products • Paint • Rusting metal • Stone, clay, glass, and concrete product manufacturing • See Natural Phenomena table for other potential sources	 Grocery store compactor leakage (Photo Credit: City of Redmond)
Brown to black	• Automotive dealers, garden or building product suppliers • Bakery products, fats and oils • Decomposing food or dumpster liquids from restaurants • Metals, rubber, wood chemicals, and plastics manufacturing • Paint • Ink from paper and cardboard manufacturing	 Restaurant grease (Photo Credit: City of Federal Way)
Black	• Paint • Septic wastewater • Sulfuric acid • Turnover of oxygen depleted water • Oil • Fabric dye	 Oil (Photo Credit: King County)

Color	Potential Sources	Photo Examples
Gray to milky white	• Concrete washwater • Dairy products • Drywall compound • Grease • Lime (limestone) • Paint • Phosphate fertilizer manufacturing • Washwater from commercial/industrial or domestic sources	 Latex paint (Photo Credit: King County)
Orange-red	• Iron deposits • Paint • Tracing dye • See Natural Phenomena table for other potential sources	Most orange-red discharges are related to natural iron bacteria (see Natural Phenomena table)
Dark red or purple	• Blood from meat packing/processing facilities • Diesel fuel or hydraulic fluid • Fabric dye • Heating oil • Paint • Paper ink	 Heating oil discharge (Photo Credit: City of Kirkland)
Blue green/brown green	• Algae blooms (sometimes a natural phenomenon) • Fertilizer runoff • Paint • Portable toilet waste • Sewage • Tracing dye • Vehicle wash water • See Natural Phenomena table for other potential sources	 Paint (Photo Credit: City of Redmond)
Yellow to bright green	• Algae blooms (sometimes a natural phenomenon) • Chlorine chemical manufacturing • Paint • Radiator fluid (anti-freeze) • Tracing dye • See Natural Phenomena table for other potential sources	 Radiator fluid (Photo Credit: City of Federal Way)

Natural Phenomena (not illicit discharges)

Color	Potential Sources	Photo Examples
Tan to brown	Sediment from natural soil erosion	None provided
Brown to reddish brown	Naturally occurring tannins and lignins caused by the decomposition of organic matter; can cause water to look brown or tea-colored	None provided
Orange-red	Iron bacteria can produce orange-red deposits or staining	Iron bacteria (Photo Credit: Herrera)
Blue green/ brown green	Algae blooms	Brown green algae growth (Photo Credit: Herrera)
Yellow to bright green	Algae blooms	Non-toxic filamentous algae bloom (Photo Credit: City of Federal Way)

Odor

Description

Odor can often indicate when stormwater has been contaminated by an illicit discharge or illicit connection since clean stormwater typically has no odor. However, not all illicit discharges will have an odor to trace. Odor is typically assessed qualitatively by field staff using their sense of smell. Polluted stormwater can exhibit odors similar to the dissolved chemicals or materials that caused the contamination.

Applications

Odor is used as a primary field screening indicator, and applies to all storm drainage system and land use types.

Storm Drainage System Types	Land Use Types	Weather Conditions
• Pipes • Ditches	• Rural • Urban • Agricultural • Commercial • Industrial • Mining • Residential	• Dry • Wet

Equipment

Refer to the equipment list in the Field Screening Methodology section for the methodology you have selected. Equipment specific to odor observations include:

- ☐ Clean, sterile sample bottles (glass or plastic)
- ☐ Field laptop/tablet and/or clipboard, field forms and pen/pencil
- ☐ Safety equipment (for example hard hats, ANSI 107-1999 labeled safety vests)
- ☐ Nitrile gloves
- ☐ Sturdy boots or belted waders
- ☐ Claw grabber or telescoping sampling pole (for collecting samples)

Methods

Odor should be assessed qualitatively in the field using your nose to determine if a water sample has a distinct smell. Odor observations are subjective and may include descriptions such as a petroleum, sewage, or chemical odor. Odor observations are typically documented by describing the intensity or severity of odor based on a scale of 1 to 3 (faint, moderate, or strong). A faint odor is barely noticeable, a moderate odor is easily detectable, and a strong odor can be detected from several feet away. General procedures for assessing odor are outlined below. Refer to Figure 4.1 or Figure 4.2 for additional indicator sampling after obtaining results.

1. Wear nitrile gloves to protect yourself from potential contaminants.
2. Collect the sample to be analyzed in a clean, sterile sample bottle made of either glass or plastic using a claw grabber or telescoping sampling pole. Avoid collecting sediment with the water sample.
3. Wave your hand across the water sample (instead of smelling it directly) to determine if there is a distinct odor.
4. Write "NA" (not applicable) on your field data sheet, notebook, or field laptop/tablet, if no odor was detected.
5. Record the odor (for example, petroleum, musty, acrid) if one was detected, and its intensity or severity (for example, 1, 2, or 3) on your field data sheet, notebook, or field laptop/tablet. If a second inspector is available, have them verify your observations and/or record their own observations since odor can be subjective.

Thresholds

The following odor observations are recommended for triggering further investigation and additional indicator sampling. This threshold may be modified for use based on local knowledge or observations. Washington State does not have surface water quality standards for odor.

Recommended Threshold for Further Investigation and Additional Indicator Sampling
Any odor (refer to examples in **Common Sources** section)

Pros and Cons

Pros	Cons
• Quick and inexpensive • Typically fairly easy to track through a drainage system	• The sense of smell of field staff may become desensitized over the course of a shift, limiting their ability to detect odors • Variability between field staff's senses of smell can make comparisons difficult • Difficult to assess under certain conditions (for example very windy or rainy) • Not all illicit discharges will have an odor that can be traced • Inhalation of hazardous or toxic substances may be a safety consideration

Common Sources

Odors may be associated with a variety of sources and land use types. Some examples are provided below:

Odor	Potential Sources
Musty	• Partially treated sewage • Livestock waste • Algae
Rotten egg	• Raw sewage • Sulfuric acid • Anaerobic stagnant water in pipes, ditches, or wetlands • Decomposing organic matter • Rubber and plastics manufacturing
Rotten, spoiled, and/or rancid	• Restaurant food waste • Leaking dumpster • Dead fish/animals
Foul, rotten, and/or fecal	• Raw sewage
Natural gas	• Natural gas leak
Chlorine	• Broken drinking water line • Swimming pool, spa, or hot tub flushing • Wastewater treatment plant discharge • Industrial discharge • Rubber and plastics manufacturing
Sharp, acrid, and/or pungent	• Chemicals, pesticides, antifreeze, or solvents • Paper or associated products manufacturing
Soapy and/or perfumy	• Commercial or home laundry or dry cleaner discharge • Commercial or charity car wash
Pungent sweet, fruity, and/or musty	• Grain mill products • Soaps, detergents, and cleaning products • Phosphate fertilizers • Commercial or charity car wash
Beer or wine, alcohol, and/or yeasty	• Beverage production at wineries, breweries, or distilleries
Fishy	• Decaying algae
Petroleum and/or gasoline	• Oil spill or leak • Vehicle maintenance facilities • Petroleum refining

pH

Description

pH measures the hydrogen ion activity on a scale from 1 to 14. Water with a pH below 7.0 is acidic and water with a pH above 7.0 is alkaline or basic. pH values that are lower than 6.5 or higher than 8.5 may be harmful to fish and other aquatic organisms. A low pH can cause heavy metals to leach out of stream sediments, resulting in an increase in dissolved metals concentrations. A high pH can produce a toxic environment, in which ammonia becomes more poisonous to aquatic organisms.

The following discharges are examples of allowable and conditionally allowable according to the NPDES Municipal Stormwater Permits:

Allowable Discharges	Conditionally Allowable
• Flows authorized by another discharge permit	• Potable water sources, such as water line testing and fire hydrant system flushing (residual chlorine of 0.1 parts per million [ppm] or less, pH adjusted if necessary, and volumetrically and velocity controlled to prevent resuspension of sediments) • Dechlorinated swimming pool, spa, and hot tub discharges (residual chlorine of 0.1 ppm or less, pH adjusted if necessary, temperature controlled, and volumetrically and velocity controlled to prevent resuspension of sediments)

Note: Local codes and regulations may be more restrictive than allowable and conditionally allowable discharges listed in table. Allowable and conditionally allowable discharges may require a G3 report to Ecology.

Applications

pH is used as a primary field screening indicator, and applies to all storm drainage system and land use types.

Storm Drainage System Types	Land Use Types	Weather Conditions
• Pipes • Ditches	• Rural • Urban • Agricultural • Commercial • Industrial • Mining • Residential	• Dry • Wet

Equipment

Refer to the equipment list in the Field Screening Methodology section for the methodology you have selected. Equipment specific to pH testing includes:

- ☐ pH meter or pH test strips
- ☐ Buffer solutions (pH = 4.01, 7.00, and 10.01; if using a meter)
- ☐ pH electrode storage solution (or pH 4.01 buffer; if using a meter)
- ☐ Laboratory grade cleaning wipes
- ☐ Tap water (for first rinse)
- ☐ Distilled water (for final rinse)
- ☐ Wash bottle (for rinsing)
- ☐ Clean, sterile sample bottles (glass or plastic)
- ☐ Field laptop/tablet and/or clipboard, field forms, and pen/pencil
- ☐ Safety equipment (for example, hard hats, ANSI 107-1999 labeled safety vests)
- ☐ Nitrile gloves
- ☐ Sturdy boots or belted waders
- ☐ Claw grabber or telescoping sampling pole (for collecting samples)

Methods

pH can be measured using either a field meter or test strips. General procedures for each type of equipment are outlined below. Refer to the user's manual with your field meter or the container holding your test strips for more detailed information. Refer to Figure 4.1 or Figure 4.2 for additional indicator sampling after obtaining results.

pH Field Meter

The specific steps for using field meters (defined in Section 4.2) vary depending on the brand of field meter being used. Refer to the user's manual with your field meter for more detailed information. The following steps are generally common to pH field meters:

1. **Check Meter:** Prior to taking meter in the field, confirm that the meter and probe are working properly, storage solution is present in the probe cap, and sufficient battery life

is left. It is normal to see potassium chloride (KCl) crystals around the cap. They are easily removed when rinsing the probe will distilled water.

2. **Calibrate Meter:** Proper calibration is essential to obtaining accurate results. Field meters should be calibrated before heading out in the field. If the meter has been turned off for an extended period during the day, a calibration check should be performed.

    a. Remove the storage cap from the pH probe, rinse with distilled water, and remove excess moisture with a laboratory grade cleaning wipe.

    b. Choose a set of buffer solutions. If the field samples to be analyzed are expected to be slightly acidic (samples from wetlands for example), calibrate with pH 4.01 and pH 7.00 buffer solutions. If samples may be basic (samples associated with concrete for example), calibrate with pH 7.00 and pH 10.01 buffers.

    c. Pour pH 7.00 buffer solution into a clean sample bottle. Rinse the probe tips with the buffer solution. Next, submerge the probe in the solution so that approximately 1.5 inches of the probe is submerged. If the meter has a temperature probe as well as a pH probe, submerge both probes in the buffer solution. Gently stir for a few seconds.

    d. Confirm the first buffer value.

    e. Pour pH 4.01 or 10.01 buffer solution into a second clean sample bottle. Remove the probe from the first buffer solution. Rinse the probe tips with distilled water, remove excess water with a laboratory grade cleaning wipe, and rinse the probe tips with the second buffer solution. Submerge the probe in the second buffer solution and gently stir for a few seconds. If the meter has a temperature probe as well as a pH probe, submerge both probes in the buffer solution.

    f. Confirm the second buffer value.

    g. Dispose of buffer solutions appropriately

3. **Field Measurements:**

    a. Wear nitrile gloves to avoid sample contamination and protect yourself from potential contaminants.

    b. Collect a field sample in a clean, sterile sample bottle made of either glass or plastic; avoid collecting sediment with the water sample.

    c. Pour some of the water sample over the pH probe to remove residue from the probe and avoid cross contamination of the sample.

d. Dip the probe in the water sample. If the meter has a temperature probe as well as a pH probe, submerge both probes in the water sample. Stir gently for a few seconds. Allow up to 2 minutes for the probes to adjust to the sample temperature and the readings to stabilize.

e. Record the pH value shown on the meter on your field data sheet, notebook, or field laptop/tablet.

f. Rinse the probe tips with distilled water and dry with a laboratory grade cleaning wipe between each reading and before storage.

g. Dispose of sample back to source

4. **Meter Storage:** Cover the sensor on the pH probe with the protective cap (partially filled with storage solution or pH 4.01 buffer), turn off pH meter, and place it back in its protective case. Storing the pH probe in distilled water can damage it by causing the ions in the pH probe to leach out. Buffer solutions should be replaced every 3 to 6 months once opened (unopened buffer solutions can be stored for up to 2 years).

pH Test Strips

The specific steps for using test strips (defined in Section 4.2) vary depending on the brand of test strip being used. Test strips that are specific to pH are recommended; 5-in-1 test strips typically do not have a wide enough pH range for illicit discharge detection. Refer to the container holding your test strips for more detailed information. The following steps are generally common to all test strips:

1. Wear nitrile gloves and safety glasses to avoid sample contamination and protect yourself from potential contaminants.

2. Collect the sample to be analyzed in a clean, sterile sample bottle made of glass. Avoid collecting sediment with the water sample.

3. Remove one strip from the test strip container and replace the cap tightly.

4. Dip the strip into your sample and move back and forth for the specified amount of time. Make sure that the test pad(s) are always submerged.

5. Remove the strip and gently shake off any excess liquid.

6. Wait the specified amount of time for the color change to occur.

7. Match the color(s) on the test pad(s) as closely as possible to the color scale on the test strip container.

8. Record the value(s) on your field data sheet, notebook, or field laptop/tablet.

9. Dispose of sample back to source.

10. Store test strips at room temperature and avoid exposure to light when not in use. Replace test strips after 3 to 5 years.

Thresholds

The following pH levels are recommended for triggering further investigation and additional indicator sampling. These thresholds may be modified for use based on local knowledge or observations. Washington State water quality standards for pH in fresh and marine water are designated for protection of fish spawning, rearing, and migration habitats and the general aquatic environment.

Recommended Threshold for Further Investigation and Additional Indicator Sampling	State Water Quality Standards [a]
pH <5 or >9	Fresh water: pH <6.5 or >8.5 Marine water: pH <7 or >8.5

[a] Surface water quality standards are provided for reference only and are not intended to be used as thresholds in storm drainage systems.

Pros and Cons

Pros	Cons
• Test strips are inexpensive and easy to use • Field meters are slightly more expensive than test strips, but can provide more accurate results	• Not useful in determining presence of sanitary wastewater • Not conclusive by itself but it can identify potential illicit discharges that merit follow-up investigations using more effective indicators • Test strips must be kept dry and should be replaced after 3 to 5 years • Test strips can detect extreme pH levels, but are not as accurate as field meters in determining an exact pH value • Field meters require routine calibration and proper storage • Buffer solutions must be replaced frequently; bottles last for 2 years if they are unopened and 3 to 6 months if they have been opened • Proper buffer solution disposal needed

Common Sources

Low and high pH values can be caused by the following sources:

Low pH[a,b,c]	High pH[a,b,c]
• Dairy products • Fabricators • Fertilizers and pesticides • Metal finishers • Pharmaceutical manufacturers • Resin producing companies • Wineries	• Disinfectants and sanitizer • Latex paint • Metal plating and steel mills • Poured or recycled concrete, cement, mortars, and other Portland cement or lime-containing construction materials • Rubber or plastic producers • Soaps and detergents

[a] Brewery effluent typically contains spent grains, waste yeast, spent hops, and grit and the pH can range from 3 to 12, resulting in either a low, high, or even a neutral pH. Other indicators such as color, odor, and floatables may be more useful than pH for determining if brewery effluent is an illicit discharge.

[b] Textile mills can either have a high or low pH. Other indicators such as color and odor may be more useful than pH for determining if textile mill waste is an illicit discharge.

[c] pH of sediments can vary depending on the pH of source soils.

↑	0		
	1	Battery acid	Acid rain = 1 to 5
	2	Lemon juice	
	3	Vinegar	
Increasing Acidity	4	Beer and wine	
	5		Precipitation = 5 to 6
	6	Milk	Streams and stormwater = 6.5 to 8.5
Neutral	7		Pure water = 7.0
	8		Seawater = 8.3
	9		
Increasing Alkalinity	10		
	11	Ammonia	
	12	Soapy water	
	13	Bleach, oven cleaner	
↓	14	Drain cleaner, caustic soda	

Temperature

Description

Temperature extremes can threaten the health and survival of fish and other aquatic species in many life stages including embryonic development, juvenile growth, and adult migration. Water temperature can be useful in identifying contamination by sanitary wastewater or industrial cooling water. Household and commercial sewage produces heat due to microbial activity during anaerobic decomposition, while industrial cooling water is heated as it is circulated through heat exchangers. Water temperature measurements are typically the most useful for IDDE when indicator sampling is being conducted during cold weather and temperature differences can be significant.

The following discharges are examples of allowable and conditionally allowable according to the NPDES Municipal Stormwater Permits:

Allowable Discharges	Conditionally Allowable
• Flows authorized by another discharge permit • Emergency firefighting activities	• Dechlorinated swimming pool, spa, and hot tub discharges (residual chlorine of 0.1 ppm or less, pH adjusted if necessary, temperature controlled, and volume controlled)

Note: Local codes and regulations may be more restrictive than allowable and conditionally allowable discharges listed in table. Allowable and conditionally allowable discharges may require a G3 report to Ecology.

Applications

Temperature is used as a primary field screening indicator, and applies to all storm drainage system and land use types.

Storm Drainage System Types	Land Use Types	Weather Conditions
• Pipes • Ditches	• Rural • Urban • Agricultural • Commercial • Industrial • Mining • Residential	• Dry • Wet

Equipment

Refer to the equipment list in the Field Screening Methodology section for the methodology you have selected. Equipment specific to temperature testing includes:

- ☐ Temperature probe or other temperature measuring device
- ☐ Laboratory grade cleaning wipes
- ☐ Tap water (for first rinse)
- ☐ Distilled water (for final rinse)
- ☐ Wash bottle (for rinsing with distilled water)
- ☐ Clean, sterile sample bottles (glass or plastic)
- ☐ Field laptop/tablet and/or clipboard, field forms, and pen/pencil
- ☐ Safety equipment (for example hard hats, ANSI 107-1999 labeled safety vests)
- ☐ Nitrile gloves
- ☐ Sturdy boots or belted waders
- ☐ Claw grabber or telescoping sampling pole (for collecting samples)

Methods

Temperature can be measured using a temperature probe (often included with a pH meter or multimeter). A standard thermometer or a continuous water temperature data logger can also be used as an alternative to a temperature probe (methods not provided in this section). Refer to Figure 4.1 or Figure 4.2 for additional indicator sampling after obtaining results.

The specific steps for using field meters (defined in Section 4.2) vary depending on the brand of field meter being used. Refer to the user's manual with your field meter for more detailed information. The following steps are generally common to temperature probes:

1. **Check Meter:** Prior to taking meter in the field, confirm that the meter and probe are working properly and sufficient battery life is left.
2. **Probe Calibration**: Manufacturers typically recommend that temperature probes be recalibrated at least once a year.

3. **Field Measurements**:

   a. Wear nitrile gloves to avoid sample contamination and protect yourself from potential contaminants. Do not touch the inside of the lid or bottle.

   b. Collect a field sample in a clean, sterile sample bottle made of either glass or plastic. Avoid collecting sediment with the water sample.

   c. Pour some of the water sample over the temperature probe to remove residue from the probe and avoid cross contamination of the sample. Note: temperature should be measured as soon as possible after the sample has been collected.

   d. Dip the probe in the water sample and stir gently for a few seconds. Allow up to 1 minute for the probe to adjust to the sample temperature and the readings to stabilize.

   e. Record the temperature value shown on the meter on your field data sheet, notebook, or field laptop/tablet.

   f. Rinse the probe tips with distilled water and dry with a laboratory grade cleaning wipe between each reading and before storage.

   g. Dispose of sample back to source.

Thresholds

The following temperature level is recommended for triggering further investigation and additional indicator sampling. This threshold may be modified for use based on local knowledge or observations. Washington State water quality standards for temperature in fresh water and marine environments are designated for protection of fish spawning, rearing, and migration habitats and the general aquatic environment. The fresh water quality standard depends on the aquatic life use category and ranges from a 7-day maximum value of 12 to 20 degrees Celsius depending on the fish species that use the receiving water. The marine water quality standard depends on the aquatic life use category and ranges from a 1-day maximum value of 13 to 22 degrees Celsius depending on the fish species that use the receiving water. Refer to WAC 173-201A-200 for further information on fresh water criteria and WAC 173-201A-210 for further information on marine water criteria.

Recommended Threshold for Further Investigation and Additional Indicator Sampling	State Water Quality Standards[a]
Above ambient air temperature	Fresh water: 12°C (53.6°F) to 20°C (68°F) 7-day maximum (depends on aquatic life use category) Marine water: 13°C (55.4°F) to 22°C (71.6°F) 1-day maximum (depends on aquatic life use category)

[a] Surface water quality standards are provided for reference only and are not intended to be used as thresholds in storm drainage systems

Pros and Cons

Pros	Cons
Inexpensive (if included with pH field meter or multimeter) Easy to measure	Most useful in cold weather when temperature difference is significant from the likely higher temperatures of illicit discharges

Common Sources

Lower or higher temperature values, relative to ambient, can be caused by the following sources:

Lower Temperature	Higher Temperature
• Large pond or lake discharge (not an illicit discharge) located in a cool climate • Groundwater (not typically an illicit discharge) • Cold storage facility discharge	• Small pond or lake (not an illicit discharge) located in a warm climate • Industrial cooling water • Sanitary wastewater • Potable water sources

Turbidity

Description

Turbidity is a measure of how transparent or clear water is based on the amount of sediment or suspended particulates. Large amounts of suspended material can affect fish growth and survival by impairing their vision, gill function, and affecting egg and larval development. Higher turbidity can also increase temperature and thereby decrease dissolved oxygen concentrations in water bodies, affecting the growth of both aquatic animals and plants. High turbidity in water can be contributed to many different sources including soil erosion, construction activities, sanitary wastewater, excessive algal growth, or industrial processes.

Applications

Turbidity is used as a primary field screening indicator and applies to all storm drainage system and land use types. For purposes of illicit connection and illicit discharge field screening, turbidity assessments can be based on visual observations, using a turbidity meter, or using a turbidity tube. However, for source tracing, code enforcement and other site-specific issues, quantitative turbidity measurements may be either required by regulatory agencies and/or useful; turbidity meters or turbidity tubes will be needed in these instances.

Storm Drainage System Types	Land Use Types	Weather Conditions
• Pipes • Ditches	• Rural • Urban • Agricultural • Commercial • Industrial • Mining • Residential	• Dry • Wet

Equipment

Equipment specific to turbidity testing includes:

- ☐ Turbidity meter or turbidity tube
- ☐ Turbidity standard solutions (for turbidity meter)
- ☐ Laboratory grade cleaning wipes (for turbidity meter)
- ☐ Tap water (for first rinse when using turbidity meter)
- ☐ Distilled water (for final rinse when using turbidity meter)

- ☐ Wash bottle (for rinsing with distilled water when using turbidity meter)
- ☐ Sheet of white paper or a white binder (when using turbidity tube)
- ☐ Clean, sterile sample bottles (clear glass or plastic)
- ☐ Field laptop/tablet and/or clipboard, field forms, and pen/pencil
- ☐ Safety equipment (for example, hard hats, ANSI 107-1999 labeled safety vests)
- ☐ Nitrile gloves
- ☐ Sturdy boots or belted waders
- ☐ Claw grabber or telescoping sampling pole (for collecting samples)

Methods

Turbidity can be measured qualitatively using visual observation or quantitatively using a turbidity meter. It is important to understand the difference between turbidity and color if relying on visual observations. Refer to Figure 4.1 or Figure 4.2 for additional indicator sampling after obtaining results.

Visual Observations

1. Wear nitrile gloves to avoid sample contamination and protect yourself from potential contaminants.
2. Collect a field sample in a clear, clean, sterile sample bottle made of either clear glass or plastic. Avoid collecting sediment with the water sample.
3. Hold the sample bottle up to a light source and visually observe how easily light is able to penetrate through the sample bottle. Do not confuse the turbidity (cloudiness) of the water with its color (tint or intensity of color observed).
4. Assign a turbidity severity ranking (1 = slight cloudiness, 2 = cloudy, and 3 = opaque) and record this on your field data sheet, notebook, or field laptop/tablet.
5. Dispose of sample back to source.

Turbidity Meter

The specific steps for using field meters (defined in Section 4.2) vary depending on the brand of field meter being used. Refer to the user's manual with your field meter for more detailed information. The following steps are generally common to turbidity field meters:

1. **Check Meter:** Prior to taking meter in the field, confirm that the meter is working properly and sufficient battery life is left.

2. **Calibration Check**: Check that the meter is reading properly by using a standard turbidity solution at the beginning of each use. Turbidity field meters should also be calibrated according to the manufacturer's instructions once every 3 months.

    a. Wipe the outside of the sample vial with a laboratory grade cleaning wipe to remove fingerprints.

    b. Insert the sample vial with the standard solution into the turbidity meter, close the lid, and take a reading. Do not hold the meter while making measurements.

    c. Record the turbidity value shown on the meter on your field data sheet, notebook, or field laptop/tablet.

    d. Repeat steps a through c with a second standard every 3 months. Performing a single point calibration is sufficient once a day before use.

3. **Field Measurements:**

    a. Place the turbidity meter on a level, stationary surface.

    b. Wear nitrile gloves to avoid sample contamination and protect yourself from potential contaminants. Do not touch the inside of the lid or bottle.

    c. Collect a field sample in a clean, sterile sample bottle made of either glass or plastic. Avoid collecting sediment with the water sample.

    d. Remove the cap from a sample vial and triple rinse the vial with the water sample.

    e. Fill the sample vial to the fill line and place the cap back on the vial.

    f. Wipe the outside of the sample vial with a laboratory grade cleaning wipe to remove fingerprints.

    g. Insert the sample vial into the turbidity meter, close the lid, and take a reading. Do not hold the meter while making measurements.

    h. Record the turbidity value shown on the meter on your field data sheet, notebook, or field laptop/tablet.

    i. Dispose of sample back to source.

4. **Meter Storage:** Close sample compartment lid to prevent dust and dirt from entering.

Turbidity Tube

A turbidity tube (also known as a transparency tube or Secchi tube) is a transparent tube that is typically 60 to 120 centimeters long with a Secchi disk (black and white symbol) at the bottom of the tube. Some turbidity tubes have a valve at the bottom of the tube and others do not.

1. Place the turbidity tube on a level, stationary surface. It may be helpful to place a sheet of white paper or a white binder underneath the tube.

2. Wear nitrile gloves to avoid sample contamination and protect yourself from potential contaminants. Do not touch the inside of the lid or bottle.

3. Collect a field sample in a clean, sterile sample bottle made of either glass or plastic. Avoid collecting sediment with the water sample.

4. Pour the field sample into the turbidity tube gradually until the Secchi disk (black and white symbol) at the bottom of the tube is no longer visible. Some turbidity tubes have a valve at the bottom, so you can fill the tube and then slowly let the water out of the bottom until the Secchi disk marking at the bottom of the tube just becomes visible.

5. Read the gradation (marking) on the turbidity tube corresponding to the height of the sample in the tube.

6. Convert the height (in centimeters) to nephelometric turbidity units (NTU) using the following table (based on tube length of 60 centimeters). Alternatively, turbidity can be calculated using the following equation and the tube depth (in centimeters):

   Turbidity (NTU) = 2198.1 * (Tube Depth^(-1.2765))

7. Dispose of sample back to source.

Distance from the Bottom of the Turbidity Tube (centimeters)	Nephelometric Turbidity Units (NTU)
<6	>250
10	116
15	69
20	48
25	36
30	29
35	23
40	20
45	17
50	15
55	13
>60	<12

Source: Ecology (2005)

Thresholds

The following turbidity level is recommended for triggering further investigation and additional indicator sampling. This threshold may be modified for use based on local knowledge or observations. Washington State water quality standards for turbidity in fresh water and marine environments are designated for protection of fish spawning, rearing, and migration habitats and the general aquatic environment. Turbidity units of measurement are mostly commonly expressed as nephelometric turbidity units (NTU). The fresh and marine water quality standards depends on the aquatic life use category and range from 5 to 10 NTU above background levels (when background levels are 50 NTU or less) or a 10 to 20 percent increase (when background levels are more than 50 NTU) depending on the fish species that use the receiving water. Background levels are measured up-gradient or outside the area of influence of the discharge. Refer to WAC 173-201A-200 for further information on fresh water criteria and WAC 173-201A-210 for further information on marine water criteria. The Construction Stormwater General Permit also includes a benchmark value of 25 NTU (or 33 centimeters) and a phone reporting trigger value of 250 NTU (or 6 centimeters).

Recommended Threshold for Further Investigation and Additional Indicator Sampling	State Water Quality Standards[a]
All land use types: >50 NTU, 19 centimeters, or visible/cloudy/opaque	Fresh and marine water: 5 to 10 NTU above background when background is ≤50 NTU; or 10 to 20% above background if background is >50 NTU

[a] Surface water quality standards are provided for reference only and are not intended to be used as thresholds in storm drainage systems

Pros and Cons

Pros	Cons
• Taking note of the composition of the turbidity (for example, soil particles, algae, plankton, microbes, sewage, industrial waste) may help to identify the source • Readings taken using a turbidity meter or turbidity tube can be useful for code enforcement	• Cannot identify whether multiple sources are present • Qualitative visual observations and turbidity tube measurements can be somewhat subjective • No single turbidity meter works well for all turbidity levels • The detailed (3-point) calibration of turbidity meters once every 3 months can be time consuming • Regional variations in soil properties may affect the readings turbidity meter readings and the correlation between NTU and centimeters • Turbidity tube results can be imprecise for water column depths of 6 centimeters or less

Common Sources

High turbidity can be caused by the following sources:

High Turbidity	
• Chemical manufacturing processes (for example, inorganic pigments, plastic and synthetic materials, pharmaceuticals, soaps and detergents, paints and varnishes, wood chemicals, and petroleum refining) • Coal steam electric power processes • Construction activities • Industrial washwater • Landscaping activities • Leaking underground storage tanks • Metal fabrication processes • Sanitary wastewater • Soil erosion • Stone/tile cutting • Textile mill discharges • Waste products from different food processing industries (for example, meat, dairy, vegetable, grains, oil, or bakeries)	 A turbid discharge was observed to a catch basin (see above photo). The source was identified as a failed temporary erosion and sediment control swale overflowing to the slope above the rockery (see photo below). The contractor employed Baker Tanks and pumps to eliminate the turbid flows. Photo Credits: Russell Cotton-Betteridge (City of Bellevue)

Visual Indicators

Description

Visual indicators other than color, odor, and flow can often indicate when stormwater has been contaminated by an illicit discharge or illicit connection; however, not all illicit discharges will have visual indicators. Visual indicators are assessed qualitatively by field staff using simple visual observations. The following visual indicators are described in this section:

Visual Indicator	Description
Abnormal vegetation	Excessive vegetation or dead vegetation near an outfall can indicate an illicit discharge.
Algae, bacteria, and fungus	*Sphaerotilus natans* is a white or grayish bacterial growth that can be found in flowing sewage.. Whitish mat-like growth can also occur in stormwater systems and is a combination of fungus, algae, and organic debris. Brownish algae growth can also occur in natural systems.
Deposits and staining	Deposits and staining are coatings that remain on the streambank or on the outfall structure after a non-stormwater discharge has ceased.
Fish kills	Fish kills are the number of dead fish observed in a stream or other water body where an illicit discharge is suspected.
Floatables	Floatables can include animal fats, food products, oils, solvents, sawdust, foams, packing materials, fuel, fecal matter, and toilet paper.
Structural damage	Structural damage such as pitting or spalling of concrete outfall structures can be caused by abnormal pH from an industrial discharge.
Surface film	Surface film can include pollen.
Surface scum	Surface scum can include bubbles, soap suds or natural foaming.
Surface sheen	Surface sheen can include petroleum or organic sheens.
Trash and debris	Trash and debris are typically listed as a prohibited discharge in illicit discharge codes and ordinances; however, tracking and enforcement can be difficult. Excessive amounts of trash and debris can indicate that illegal dumping is occurring, which may involve other pollutants.

Applications

Visual indicators are used for primary field screening, and apply to all storm drainage system and land use types.

Storm Drainage System Types	Land Use Types	Weather Conditions
• Pipes • Ditches	• Rural • Urban • Agricultural • Commercial • Industrial • Mining • Residential	• Dry • Wet

Equipment

Refer to the equipment list in the Field Screening Methodology section for the methodology you have selected. Equipment specific to visual indicator observation includes:

- ☐ Field laptop/tablet and/or clipboard, field forms, and pen/pencil
- ☐ Camera, phone, or other device for taking pictures (with date and time stamp)
- ☐ Safety equipment (for example, hard hats, ANSI 107-1999 labeled safety vests)

Methods

Visual indicators should be assessed qualitatively in the field using visual observations. Visual observations are subjective and may include descriptions such as toilet paper, petroleum sheen, suds, or dead fish. These observations are also typically documented either by noting their absence or presence and using a severity index of 1 to 3 (few/slight, many/moderate, or numerous/obvious) if observed. The descriptions documented will depend on the format of data forms used. General procedures for assessing visual observations are outlined below. Specific observations for sewage bacteria and surface scum or sheen are also highlighted below. Refer to Figure 4.1 or Figure 4.2 for additional indicator sampling after obtaining results.

1. Observe the condition of the water surface, flowing water, outfall or catch basin/manhole structure integrity, and the surrounding area.
2. Write "NA" (not applicable) on your field data sheet, notebook, or field laptop/tablet, if no visual indicators were observed.
3. Record the visual indicators if any were present, and the presence or severity (for example, 1, 2, or 3) on your field data sheet, notebook, or field laptop/tablet.
4. Take a photograph to document the visual observations.

Algae, Bacteria, and Fungus Observations

Record observations of the type of algae, bacteria, and fungus growing based on color and flow:

1. White or grayish growth in flowing water is typically *Sphaerotilus natans*, a bacterium that can be found in flowing water and in sewage and wastewater treatment plants (*see photo example in Common Sources section*). It "breaks up into nothing" when touched with a stick. This growth disappears quickly after sewage discharge is eliminated.
2. Dried white mat-like growth residue is typically a combination of fungus, algae, organics, and detritus and is a dry, thin coating on solid surfaces (*see photo example in Common Sources section*).

3. Green or brown algae growth is typically a natural phenomenon, but can sometimes indicate an elevated level of nutrients. Green algae (*Cladophora* and *Rhizoclonium*) form long, coarse filaments in flowing water and can also form thick mats if excessive nutrients are present. Lighter green algae (*Spirogyra* or watersilk) feels silky and is typically found in still or stagnant water. Brown algae is formed by masses of diatoms that grow on rocks, sand, plant roots, and other surfaces and typically feels slimy when touched.

4. Algae blooms are extensive areas of tiny algae, or phytoplankton, accumulated on the surface of a water body. They typically are caused by elevated levels of nutrients in fresh or marine waters, and can be either a natural occurrence or illicit discharge related. Colors of algae blooms include red, orange green, yellow, or brown. These blooms are most common during the spring and summer when temperatures rise, and increased sunlight allows the algae to photosynthesize more rapidly near the surface of the water body. Most algae blooms are harmless, but some blooms, called Harmful Algae Blooms (or HABs), can be harmful or toxic if ingested. Note: Illicit discharges are one source of excessive nutrients that may cause an algae bloom; however, many other factors such as stormwater runoff and overland flow are also possible sources.

Surface Scum Observations

Record observations of the type of surface scum based on color:

1. Bubbles or suds from a washwater discharge contain a rainbow-like sheen on the surface of the bubbles; refer to Detergents/Surfactants section for additional indicator testing.

2. Natural foaming results from the natural die-off of aquatic plants that release oils. Natural foam often has a partial brownish tint and can include organic debris.

3. Fats, grease, and oils

Surface Sheen Observations

Record observations of the type of surface sheen based on color and the "pencil test" (tapping the surface of the sheen with a pencil or a stick).

1. Petroleum sheen typically has an iridescent rainbow pattern (*see photo example in Common Sources section*) and does not separate when disturbed by poking; when pencil or stick is removed, petroleum sheen will quickly coalesce.

2. Organic sheen is a natural phenomenon that that occurs when bacteria create oil-like iridescent films when they attach themselves to the water surface. Sunlight bounces off the films, giving them an oily appearance (*see photo example in Common Sources section*). Organic sheens separate into plates or sheets on the surface of still water when disturbed by poking. When the pencil or stick is removed, organic sheens typically do not coalesce quickly. Organic sheens will often be accompanied by organic or rusty looking water.

Thresholds

The following visual indicator observations are recommended for triggering further investigation and additional indicator sampling. These thresholds may be modified for use based on local knowledge or observations. Washington State does not have surface water quality standards for visual indicators. Trash and debris are typically listed as a prohibited discharge in illicit discharge codes and ordinances.

Recommended Threshold for Further Investigation and Additional Indicator Sampling
Any visual indicator not attributed to natural phenomena (*refer to examples in **Common Sources** section*)

Pros and Cons

Pros	Cons
• Quick and inexpensive • Fairly easy to track through a drainage system	• Sometimes conclusive by itself, but often requires follow-up investigation using more effective indicators

Common Sources

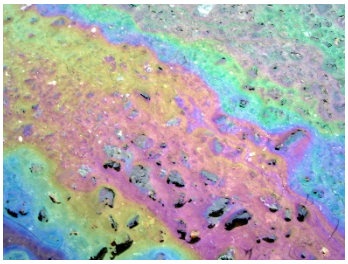
Visual indicators may be associated with a variety of sources and land use types. Natural phenomena that are not considered illicit discharges and do not need to be traced are provided below.

Potential Illicit Discharges

Visual Indicator	Potential Sources	Photo Examples
Abnormal vegetation	• Excessive nutrients (lush vegetation growth during dry weather) • Stormwater pollutant toxic to vegetation (dead vegetation with adjacent healthy vegetation)	 Dead vegetation (Photo Credit: City of Seattle)

Visual Indicator	Potential Sources	Photo Examples
Deposits and staining	• Black or gray staining from a sanitary source • Dark staining from petroleum hydrocarbons • Orange-red staining from iron bacteria • Powdery residues from chemicals • See Natural Phenomena table for other potential sources	 Stained outfall pipe (Photo Credit: Herrera)
Fish kills	• Pesticides • Pollutant toxic to aquatic organisms • See Natural Phenomena table for other potential sources	 Fish kill (Photo Credit: King County)
Floatables (toilet paper, other sanitary waste)	• Sewage discharge • Wind-blown surface litter	 Toilet paper and floatables in catch basin. Illicit connection was confirmed by dye testing. (Photo Credit: City of Redmond)

Visual Indicator	Potential Sources	Photo Examples
Floatables (food waste)	• Restaurants and dumpsters, warehouses, grocery stores • Roadside fruit stands, commercial fruit processing facilities • Mobile food vendors	 Soybeans spilled at warehouse (Photo Credit: City of Bellevue)
Algae, bacteria, and fungus (*Sphaerotilus natans*)	Sewage discharge	 White growth, likely *Sphaerotilus natans*, from a failing septic system drain field. High *E. coli* and human waste-related DNA confirmed the illicit discharge. (Photo Credit: King County)
Algae, bacteria, and fungus (white mat-like growth residue)	Excessive nutrients	 Dried white mat-like growth residue on dry substrate of a stormwater pond (Photo Credit: King County)
Algae, bacteria, and fungus (algae blooms)	Excessive nutrients	 Algae bloom (Photo Credit: Herrera)

Visual Indicator	Potential Sources	Photo Examples
Structural damage (spalling, chipping)	• Corrosive discharges from industrial or commercial sites • Natural deterioration associated with old infrastructure (not considered to be from an illicit discharge)	 Structural damage of old infrastructure (Photo Credit: Herrera)
Surface sheen (petroleum sheen)	• Gasoline, diesel fuel, motor oil • Lubricating oil or hydraulic oil from construction equipment • Heating oil from underground or aboveground storage tanks	 Petroleum sheen (Photo Credit: Herrera)
Surface scum (bubbles or suds)	Washwater containing detergents or soaps	 Washwater (Photo Credit: Herrera)
Surface scum (fats, grease, and oils)	Fats, grease, and oils from food waste, mobile food vendors, or restaurants	 Restaurant grease (Photo Credit: City of Federal Way)

Visual Indicator	Potential Sources	Photo Examples
Trash and debris	• Illegal dumping • Wind-blown litter	 Cigarette butts in a catch basin (Photo Credit: City of Redmond)

Natural Phenomena

Visual Indicator	Potential Sources	Photo Examples
Algae, bacteria, and fungus (green or brown algae growth)	Algae or diatom growth	 Brown green algae growth (Photo Credit: Herrera)
Algae, bacteria, and fungus (algae blooms)	Algae blooms	 Non-toxic filamentous algae bloom (Photo Credit: City of Federal Way)
Deposits and staining	Iron oxidizing bacteria can produce orange-red deposits or staining	 Iron bacteria (Photo Credit: Herrera)

Visual Indicator	Potential Sources	Photo Examples
Fish kills	Die off due to low oxygen levels or high temperatures	Fish kill (Photo Credit: City of Federal Way)
Surface film (pollen)	Pollen from pine, cedar, and oak can form a yellow, brown, or black film on the surface (especially in ponds or slow-moving water)	None provided
Surface sheen (organic)	Iron oxidizing bacteria can produce an organic sheen (typically found in standing or stagnant waters)	Organic sheen (Photo Credit: Herrera)
Surface scum (natural foaming)	Natural foam from organic matter decomposition (can increase after storm events and collect along shorelines or streambanks)	Natural foaming (Photo Credit: Herrera)

Bacteria

Description

There are four types of bacterial indicators addressed in this manual:

- Fecal coliform bacteria
- *E. coli* bacteria (a subset of fecal coliform bacteria)
- Bacteroidales DNA
- Enterococci

Fecal coliform bacteria and ***E. coli* bacteria** have been typically-used as indicators of fecal contamination of stormwater and natural waters, as they are present in the fecal waste of warm-blooded animals, including humans. A relatively elevated test result for fecal coliform bacteria or *E. coli* bacteria may indicate an illicit discharge or illicit connection associated with sewage or a failing septic system. However, it may indicate waste related to large domestic animals (such as cows, llamas, etc.), pets, or wild animals. Fecal coliform bacteria and *E. coli* bacteria are both tested using a culture (growth) analysis that is typically performed in a laboratory setting.

Bacteroidales DNA can be tested by quantitative polymerase chain reaction (qPCR), which is not a culture (growth) analysis but rather a method related to cloning and counting DNA fragments. This method is one of the most common techniques used in Microbial Source Tracking (MST), also called bacterial or fecal source tracking. Bacteroidales tests have been successfully used to track down and identify confirmed or suspected sources of human waste and other kinds of animal waste. DNA biomarkers specific to humans and a few other animal groups, such as ruminants (such as sheep, goats, and cows) and dogs, may be analyzed in a laboratory setting.

Enterococci are a subgroup of the fecal streptococci, indicate the presence of fecal contamination by warm-blooded animals, and are not known to multiply in the environment like fecal coliform bacteria. There is a Washington State surface water quality standard for enterococcus bacteria, but only in marine waters. This bacterial indicator is not commonly used in fresh water.

Applications

Bacteria are used as follow-up indicators, and apply to all storm drainage system and land use types.

Storm Drainage System Types	Land Use Types	Weather Conditions
• Pipes • Ditches	• Rural • Urban • Agricultural • Commercial • Industrial • Residential	• Dry • Wet

Equipment

Refer to the equipment list in the Field Screening Methodology section for the methodology you have selected. Equipment specific to bacteria sampling includes:

- ☐ Clean, sterile sample bottles (usually amber glass or plastic with sodium thiosulfate preservative provided by the laboratory, unless using Coliscan© Easygel©)
- ☐ Field laptop/tablet and/or clipboard, field forms, and pen/pencil
- ☐ Safety equipment (for example, hard hats, ANSI 107-1999 labeled safety vests)
- ☐ Nitrile gloves
- ☐ Sturdy boots or belted waders (if needed)
- ☐ Claw grabber or telescoping sampling pole (if needed for collecting samples)
- ☐ Coliscan© Easygel© supplies and equipment (nutrient bottles, pipettes, and pipette tips for field; Petri dishes and poultry egg incubator for office)

Methods

Bacteria by culture methods can be measured using Coliscan© Easygel© (Easygel©) or to an analytical laboratory for analysis. General sample collection and handling procedures are outlined below. Easygel© nutrient bottles should be stored in a freezer at -18°C (0°F) until use. Refer to Figure 4.1 or Figure 4.2 for additional information pertaining to interpreting results.

Coliscan© Easygel© Sampling and Culturing Method

The Easygel© method can be used to sample water and measure *E. coli* bacteria. The following steps should be followed:

1. Remove the frozen Easygel© nutrient bottles from the storage freezer the night before the sampling day and thaw them at room temperature overnight. (Note: If this step is forgotten, the bottles may be thawed by placing them in a pocket or on a warm vehicle dashboard).

2. Wear nitrile gloves in the field to avoid sample contamination and protect yourself from potential contaminants. Do not touch the inside of the Easygel© nutrient bottle or cap.

3. Pipette the sample (typically 5 mL) directly from the flowing water or from a sampling container, such as a ladle or bailer. When pipetting from a bailer, rinse it three times with the water being sampled (e.g., from a stormwater ditch or catch basin, or a stream) before collecting the sample to be sure that only the flowing water is being sampled. Make sure to empty the rinse water either downstream or away from your sampling location, to not disturb streambed or other bottom sediments.

4. Pipette the aliquot of sample directly into the Easygel© nutrient bottle.

5. Tightly screw the lid back on the Easygel© nutrient bottle.

6. Keep the samples (now in the Easygel© nutrient bottles) at 4°C (40°F) by placing them in an ice-filled cooler; return them to the office within 6 hours of sampling.

7. Record all information, including date, time, sample location name, and any relevant information on a paper field form or digitally.

8. Label the tops of the Easygel© Petri dishes with appropriate sample names back in the office, using a permanent marker.

9. Transfer the samples (contained in the Easygel© nutrient bottles) carefully to the bottom plates of the Petri dishes.

10. Ensure that the nutrient/sample mix is distributed evenly on the Petri dish bottom; typically just by pouring carefully.

11. Place the labeled Petri dish tops onto the dishes, and place them into an incubator, being careful not to slosh or disrupt them. The gel in the bottom of the dishes will solidify in about an hour.

12. If an incubator is available, incubate at 95ºF (35ºC) for 24 hours. If an incubator is not available, incubate at room temperature for 48 hours. Note: An incubator is recommended for improved control, temperature consistency, and faster incubation.

13. Remove Petri dishes from incubator (if applicable).

14. Inspect the Petri dish.

a. Count all the easily-seen **dark blue** or **dark purple-blue** colonies on Petri dishes to quantify *E. coli* bacteria present.

b. Disregard light blue-green, red or pink colonies or irregularly shaped, light-colored growths. Disregard any "pinprick" size colonies. However, if in serious doubt as to whether a colony color is "blue," "purple-blue," or "blue-green," it is acceptable to err on the side of caution and count "ambiguous" colonies as *E. coli* bacteria.

c. Report the results in terms of colony forming units (CFU) per 100 mL of water. Multiply the plate count by the appropriate multiplier to obtain *E. coli* bacteria CFU/100 mL. For example, for 5 mL sample aliquots, the multiplier is 20.

d. Photograph the plates, typically with a completed plate count template, for documentation and for future reference if needed.

e. Dispose Easygel© bottles by throwing them directly into the trash.

f. Disinfect the bottom plates of the Petri dishes by placing them into a sink, pouring straight bleach or a 50/50 bleach/water mix into them, letting them sit for 5 minutes, carefully draining them, bagging them into a plastic bag, and placing the bag in the trash.

Bacteria Laboratory Analysis (Culture Methods and qPCR DNA)

Laboratory analysis can be used for fecal coliform and *E. coli* bacteria culture analyses and qPCR DNA analyses. The following steps should be followed to collect samples for laboratory analyses:

1. Wear nitrile gloves in the field to avoid sample contamination and protect yourself from potential contaminants. Do not touch the inside of the bottle or the lid

2. Label the bottle with the sample location, date, and time. (It is easier to label the bottle before sampling, since it is dry.)

3. Directly fill a sterile sample bottle (typically 500 or 1000 ml in size) from the flow and tightly replace the screw-top cap. (If using a sampling device such as a ladle or bailer to obtain the sample, be sure to pre-rinse the bailer three times with the water being sampled. Be sure to empty rinse water downstream of the sampling location, to not disturb bottom sediments.)

4. Keep the samples at 4°C (40°F) by placing them in an ice-filled cooler.

5. Record all information, including date, time, sample location name, and any relevant information on paper field form or digitally.

6. Follow the laboratory's chain-of-custody procedures. Submit samples to the laboratory within 6 hours of sample collection. The samples must be analyzed within 24 hours of sample collection.

Thresholds

The following bacteria concentrations are recommended for triggering further investigation and additional indicator sampling. Thresholds may be modified for use based on local knowledge or observations. Fecal coliform bacteria and *E. coli* bacteria are typically reported in colony forming units per 100 milliliters (CFU/100 mL). DNA is reported in gene copies/mL.

Fecal coliform bacteria (FC) has a fresh water surface water quality standard in Washington state; however, it will be phased out by the end of 2020. Many streams and rivers in Washington are listed on Ecology's 303(d) list for fecal coliform bacteria impairment or have had a fecal coliform total maximum daily load (TMDL) imposed on them due to reported exceedances of the state fecal coliform bacteria standard. At time of manual writing, it remains to be seen exactly how these fecal coliform bacteria impairments and TMDLs will be addressed by the state due to the switch to the fresh water *E. coli* bacteria standard (below). For saltwater, fecal coliform bacteria will continue to be used to regulate marine shellfish harvesting. Refer to WAC 173-201A-200 for further information on fresh water criteria and WAC 173-201A-210 for further information on marine water criteria.

***E. coli* bacteria** has a fresh water surface water quality standard adopted in February 2019 and will be phasing out the use of fecal coliform bacteria as a surface water quality indicator for fresh water by the end of 2020. Refer to WAC 173-201A-200 for further information on fresh water criteria.

Enterococcus bacteria has a marine water surface water quality standard in Washington state. This bacterial indicator is not commonly used in fresh water.

There are no regulatory standards for **Bacteroidales DNA**.

Type of Bacteria	Recommended Range for Further Investigation and Indicator Sampling [b]	State Water Quality Standards [a]	
		Geometric Mean	Single Value
E. coli	300 to 1,000 CFU/100 mL	100 CFU/100 mL	320 CFU/100 mL
Fecal coliform	500 to 1,200 CFU/100 mL	100 CFU/100 mL (fresh water) 14 CFU/100 mL (marine water)	200 CFU/100 mL (fresh water) 43 CFU/100 mL (marine water)
Bacteroidales DNA	Varies by biomarker, extract volume, and analysis method. Confirm recommended threshold value with analytical laboratory used.	Not applicable	Not applicable
Enterococcus[c]	500 to 1,000 CFU/100 mL	30 CFU/100 mL (marine water)	110 CFU/100 mL (marine water)

[a] Surface water quality standards are provided for reference only and are not intended to be used as thresholds in storm drainage systems.

[b] Bacterial results are highly context specific. Results can be influenced by factors such as weather, seasonality, antecedent dry or wet periods, and sampling location characteristics (for example, land use, presence of septic systems, formal or informal drainage, etc.). For this reason, relative ranges may be more useful than an absolute threshold. For a sampling event that occurs at multiple sites on the same day, an illicit discharge may have occurred if one site has significantly higher results.

[c] This bacterial indicator applies to marine water and is not commonly used in fresh water.

Pros and Cons

Pros	Cons
• Possible indicator of fecal waste pollution sources • Fecal coliform and *E. coli* bacteria culture methods are fairly inexpensive • Easy sampling techniques • Fecal coliform laboratory analysis can often be performed for free or low cost by a City/County wastewater treatment plant	• Samples must be transported to the laboratory within 6 hours • Minimum of 24-hour wait time for results from laboratory analysis and Coliscan© Easygel© analysis • Sterile sample handing procedures necessary • Results may be ambiguous

Common Sources

High bacteria values can be caused by the following sources:

High Bacteria (human sources)	High Bacteria (animal sources)
• Illicit sanitary sewer to stormwater drainage system cross-connections • Failing septic systems discharging to stormwater drainage systems or natural waters • Leaking sanitary sewer mainlines or side sewers • Municipal wastewater treatment plant effluent discharges • Runoff or direct discharge from homeless encampments	• Pets • Livestock (for example, manure storage, manure application, entering unfenced waterbodies) • Mammals and other wildlife (for example, larger populations in parks, traveling through animal migration zones) • Birds (for example, waterfowl in stormwater ponds, bird roosting areas)

Chlorine and Fluoride

Description

Chlorine and fluoride are both added to most potable water supplies in Washington State; notable exceptions include areas served by private wells. Residual chlorine in potable water supply systems is typically present at concentrations around 1.0 milligram per liter (mg/L). Fluoride is added to potable water to improve dental hygiene, typically at concentrations ranging from 0.8 to 1.35 mg/L. Most jurisdictions test for either chlorine or fluoride depending on factors such as whether potable water is chlorinated or fluoridated in their area, staff experience testing for these indicators, and whether locally elevated concentrations of fluoride occur naturally in groundwater.

The following discharges are examples of allowable and conditionally allowable according to the NPDES Municipal Stormwater Permits:

Allowable Discharges	Conditionally Allowable
• Emergency firefighting activities	• Potable water sources, such as pipeline testing and fire hydrant system flushing (residual chlorine of **0.1 parts per million [ppm]** or less, pH adjusted if necessary, and volume controlled) • Dechlorinated swimming pool, spa, and hot tub discharges (residual chlorine of **0.1 ppm** or less, pH adjusted if necessary, temperature controlled, and volume controlled)

Note: Local codes and regulations may be more restrictive than allowable and conditionally allowable discharges listed in table. Allowable and conditionally allowable discharges may require a G3 report to Ecology.

Applications

Chlorine or fluoride are used as follow-up indicators, and apply to piped storm drainage systems in urban, commercial, industrial, and residential land use types. Concentrations may be diluted if samples are collected during wet weather. These indicators are not useful in areas that do not chlorinate or fluoridate potable water.

Storm Drainage System Types	Land Use Types	Weather Conditions
• Pipes	• Urban • Commercial • Industrial • Residential	• Dry • Wet

Equipment

Refer to the equipment list in the Field Screening Methodology section for the methodology you have selected. Equipment specific to chlorine or fluoride testing includes:

- ☐ Chlorine test strips, test kit, or digital colorimeter
- ☐ Chlorine reagent (if using chlorine test kit or digital colorimeter)
- ☐ Fluoride test kit, field meter, or digital colorimeter
- ☐ Fluoride standard solution (if using fluoride field meter)
- ☐ Fluoride reagent (if using fluoride field meter or digital colorimeter)
- ☐ Laboratory grade cleaning wipes
- ☐ Tap water (for first rinse)
- ☐ Distilled water (for final rinse)
- ☐ Clean, sterile sample bottles (glass preferred since plastic bottles may have a large chlorine demand)
- ☐ Field laptop/tablet and/or clipboard, field forms, and pen/pencil
- ☐ Safety equipment (for example, hard hats, ANSI 107-1999 labeled safety vests)
- ☐ Nitrile gloves
- ☐ Sturdy boots or belted waders
- ☐ Claw grabber or telescoping sampling pole (for collecting samples)

Methods

Chlorine can be measured using test strips, a test kit, or a digital colorimeter. Fluoride can be measured using a field meter or a digital colorimeter. General procedures for each type of equipment are outlined below. Refer to Figure 4.1 or Figure 4.2 for additional indicator sampling after obtaining results.

Total Chlorine Using Test Strips

The specific steps for using test strips (defined in Section 4.2) vary depending on the brand of test strip being used. Refer to the container holding your test strips for more detailed information. The following steps are generally common to all test strips:

1. Wear nitrile gloves to avoid sample contamination and protect yourself from potential contaminants.
2. Collect the sample to be analyzed in a clean, sterile sample bottle made of glass. Avoid collecting sediment with the water sample.
3. Remove one strip from the test strip container and replace the cap tightly.
4. Dip the strip into your sample and move back and forth for the specified amount of time. Make sure that the test pad(s) are always submerged.
5. Remove the strip and gently shake off any excess liquid.
6. Wait the specified amount of time for the color change to occur.
7. Match the color(s) on the test pad(s) as closely as possible to the color scale on the test strip container.
8. Record the value(s) on your field data sheet, notebook, or field laptop/tablet.
9. Dispose of sample back to source.
10. Store test strips at room temperature and avoid exposure to light when not in use. Replace test strips after 3 to 5 years.

Total Chlorine Using a Test Kit

The specific steps for using test kits (defined in Section 4.2) vary depending on the brand of test kit being used. Refer to the user's manual or instruction sheet with your test kit for more detailed information. The following steps are generally common to all test kits:

1. Wear nitrile gloves to avoid sample contamination and protect yourself from potential contaminants and test kit reagents.
2. Collect the sample to be analyzed in a clean, sterile sample bottle made of glass. Avoid collecting sediment with the water sample.
3. Follow the steps in the user's manual included with your test kit to prepare and analyze the sample, and for proper hazardous material disposal, if needed.
4. Record the value on your field data sheet, notebook, or field laptop/tablet.

Total Chlorine Using a Digital Colorimeter

Samples are prepared for total chlorine analysis using a digital colorimeter (defined in Section 4.2) by using a N, N-diethyl-p-phenylenediamine (DPD) reagent either contained in a powder pillow or an ampoule. The DPD reagent is not known to be hazardous; however, if

samples are treated with sodium arsenite for manganese or chromium interferences, this substance is known to be toxic and corrosive. The final solution will contain arsenic in sufficient concentrations to be regulated as a hazardous waste under the Resource Conservation and Recovery Act (RCRA). Refer to the Safety Data Sheet (SDS) for safe handling and disposal instructions.

The specific steps for using a colorimeter will vary depending on the brand of colorimeter being used. Refer to the user's manual with your colorimeter for more detailed information. The following steps are generally common to all colorimeters:

1. Wear nitrile gloves and safety glasses to avoid sample contamination and protect yourself from potential contaminants and colorimeter reagents.

2. Collect the sample to be analyzed in a clean, sterile sample bottle made of glass. Avoid collecting sediment with the water sample.

3. Follow the steps in the user's manual included with your colorimeter to prepare and analyze the sample.

4. Record the value on your field data sheet, notebook, or field laptop/tablet.

Fluoride Field Meter

The specific steps for using field meters (defined in Section 4.2) vary depending on the brand of field meter being used. Refer to the user's manual with your field meter for more detailed information. The following steps are generally common to fluoride field meters:

1. **Prepare Meter:** Prior to taking meter in the field, confirm that the meter and electrode sensor are working properly, water is present in the electrode sensor cap, and sufficient battery life is left.

2. **Calibrate Meter:** Proper calibration is essential to obtaining accurate results. Field meters should be calibrated before each new measurement batch or if more than 12 hours has elapsed since the last calibration.

    a. Pour 15 to 30 milliliters (mL) of fluoride standard solution into sample cup

    b. Rinse the electrode sensor with distilled water, wipe with laboratory grade cleaning wipe, and place into fluoride standard solution

    c. Wait for the reading to stabilize (should take approximately 30 seconds)

3. **Field Measurements:**

    a. Wear nitrile gloves to avoid sample contamination and protect yourself from potential contaminants.

b. Collect a field sample in a clean, sterile sample bottle made of either glass or plastic. Avoid collecting sediment with the water sample.

c. Pour some of the water sample over the electrode sensor and then dip the sensor in the water sample to remove residue from the probe and avoid cross contamination of the sample.

d. Stir gently for a few seconds. Allow up to 1 minute for the readings to stabilize.

e. Record the value shown on the meter on your field data sheet, notebook, or field laptop/tablet.

f. Rinse the electrode sensor with distilled water and dry with a laboratory grade cleaning wipe between each reading and before storage.

4. **Meter Storage:** Wipe the sensor with a laboratory grade cleaning wipe. Store the electrode sensor in distilled water. Replace protective caps. The fluoride sensor will need to be replaced once the automatic calibration no longer sufficiently calibrates the meter. Standard solutions should be replaced every 6 to 12 months once opened (unopened standard solutions can be stored for up to 2 years).

Fluoride Using a Digital Colorimeter

Samples are prepared for fluoride analysis using a digital colorimeter (defined in Section 4.2) by using a sodium 2-(parasulfophenylazo)-1,8-dihydroxy-3,6-naphthalene disulfonate (SPADNS) reagent either contained in a powder pillow or an ampoule. The SPADNS reagent contains sodium arsenite and is known to be toxic and corrosive. The final solution will contain arsenic in sufficient concentrations to be regulated as a hazardous waste under RCRA. Refer to the SDS for safe handling and disposal instructions.

The specific steps for using a colorimeter will vary depending on the brand of colorimeter being used. Refer to the user's manual with your colorimeter for more detailed information. The following steps are generally common to all colorimeters:

1. Wear nitrile gloves to avoid sample contamination and protect yourself from potential contaminants and colorimeter reagents.

2. Collect the sample to be analyzed in a clean, sterile sample bottle made of either glass or plastic. Avoid collecting sediment with the water sample.

3. Follow the steps in the user's manual included with your colorimeter to prepare and analyze the sample.

4. Record the value on your field data sheet, notebook, or field laptop/tablet.

Thresholds

The following threshold for total chlorine and fluoride is recommended for triggering further investigation and additional indicator sampling. This threshold may be modified for use based on local knowledge or observations. Washington State does have state water quality standards for chlorine, but does not have surface water quality standards for fluoride; however, a discharge is considered to be illicit by the Municipal Stormwater NPDES Permits if the chlorine concentration is greater than 0.1 mg/L.

Recommended Threshold for Further Investigation and Additional Indicator Sampling	State Water Quality Standards[a]
>0.3 mg/L total chlorine or fluoride	Fresh water: 19 mg/L (acute), 11 mg/L (chronic) Marine water: 13 mg/L (acute), 7.5 mg/L (chronic)

[a] Surface water quality standards are provided for reference only and are not intended to be used as thresholds in storm drainage systems

Pros and Cons

Pros	Cons
• Chlorine testing is quick and easy • Fluoride can be a good indicator of tap water discharges or leaks and illicit connections, in areas that are known to be served by fluoridated domestic water supplies • Fluoride testing using the meter is quick and easy	• Chlorine is a poor indicator for sanitary wastewater because it quickly combines with organic compounds. • Chlorine quickly off-gases, so is a negative test result does not guarantee the water is not due to an illicit tap water discharge • The reagents used in the chlorine test kit and with the fluoride colorimeter are hazardous wastes that must be disposed of properly • Fluoride testing is not useful in areas with high concentrations naturally occurring in groundwater, or in areas that are not served by fluoridated domestic water

Common Sources

High concentrations of chlorine or fluoride can be caused by the following sources:

Chlorine	Fluoride	Chlorine or Fluoride
• Laundries • Paper mills • Pesticide manufacturing • Textile bleaching	• Ceramic plants • Chemical manufacturing • Fertilizer manufacturing • Glass etching • Gas and coke manufacturing • Metal refining • Transistor manufacturing	• Broken drinking water line • Commercial/industrial liquid waste • Fire hydrant flushing water • Irrigation water (in urban areas with potable water) • Swimming pool, spa, or hot tub flushing • Washwater

Detergents/Surfactants

Description

Surfactants are a main component of laundry detergents and dishwashing soaps that help remove dirt, food, and stains by reducing the surface tension of water. Surfactants are often referred to as "detergents" because of the analytical method used to detect them. Surfactants are often accompanied by suds observed on the water surface. A field test for surfactants can help distinguish between an illicit discharge and natural foam caused by the decomposition of organic matter.

Applications

A surfactants test is used as a follow-up indicator and applies to all storm drainage system and land use types. Concentrations may be diluted if samples are collected during wet weather.

Storm Drainage System Types	Land Use Types	Weather Conditions
• Pipes • Ditches	• Rural • Urban • Agricultural • Commercial • Industrial • Mining • Residential	• Dry • Wet

Equipment

Refer to the equipment list in the Field Screening Methodology section for the methodology you have selected. Equipment specific to surfactants testing includes:

- ☐ Surfactant test kit or colorimeter
- ☐ Clean, sterile sample bottles (amber glass bottle for test kits and colorimeters, glass or plastic for laboratory analysis)
- ☐ Field laptop/tablet and/or clipboard, field forms, and pen/pencil
- ☐ Safety equipment (for example, hard hats, ANSI 107-1999 labeled safety vests)
- ☐ Nitrile gloves
- ☐ Sturdy boots or belted waders

- ☐ Claw grabber or telescoping sampling pole (for collecting samples)

Methods

Surfactants can be measured using a field test kit, colorimeter or at an analytical laboratory. General procedures for each type of equipment are outlined below. Refer to Figure 4.1 or Figure 4.2 for additional indicator sampling after obtaining results.

Surfactant Test Kit

Surfactant test kits (defined in Section 4.2) typically use a methylene blue extraction method. Tests typically take 3 to 5 minutes per sample. Detergents in the sample react with methylene blue to form a blue complex that is directly related to the concentration of "methylene blue active substances" present in the sample. Surfactant test kits typically contain chloroform and sulfuric acid, which are both known to be toxic. Chloroform is also a possible carcinogen to humans and animals and sulfuric acid is harmful to aquatic organisms. Refer to the Safety Data Sheet (SDS) for safe handling and disposal instructions. The shelf life of a surfactant test kit is typically 8 months.

The specific steps for using test kits vary depending on the brand of test kit being used. Refer to the user's manual or instruction sheet with your test kit for more detailed information. The following steps are generally common to all test kits:

1. Wear nitrile gloves to avoid sample contamination and protect yourself from potential contaminants and test kit reagents.

2. Collect the sample to be analyzed in a clean, sterile sample bottle made of glass. Avoid collecting sediment with the water sample.

3. Follow the steps in the user's manual included with your test kit to prepare and analyze the sample.

4. Record the value on your field data sheet, notebook, or field laptop/tablet.

Surfactants Using a Digital Colorimeter

Samples are prepared for detergent/surfactant analysis using a digital colorimeter (defined in Section 4.2) by the Crystal Violet method. One of the steps in this method involves adding benzene. Benzene should only be used in a well-ventilated area. Benzene solutions are regulated as a hazardous waste under the Resource Conservation and Recovery Act (RCRA). Refer to the SDS for safe handling and disposal instructions. It should be noted that detergent/surfactant digital colorimeters are prone to false positive results, in which the test indicates slight contamination where none is actually present. To account for this tendency, a sample with no detergent/surfactant contamination can be tested with the detergent/ surfactant colorimeter and the resulting color can serve as a basis for correcting any false positive results.

The specific steps for using a colorimeter will vary depending on the brand of colorimeter being used. Refer to the user's manual with your colorimeter for more detailed information. The following steps are generally common to all colorimeters:

1. Wear nitrile gloves to avoid sample contamination and protect yourself from potential contaminants and colorimeter reagents.
2. Collect the sample to be analyzed in a clean, sterile sample bottle. Avoid collecting sediment with the water sample.
3. Follow the steps in the user's manual included with your colorimeter to prepare and analyze the sample.
4. Record the value on your field data sheet, notebook, or field laptop/tablet.

Surfactants Laboratory Analysis

The following steps should be followed to collect samples for laboratory analyses:

1. Wear nitrile gloves to avoid sample contamination and protect yourself from potential contaminants. Do not touch the inside of the lid or bottle.
2. Rinse the clean, sterile sample container bottle three times with sample water before collecting the sample. Make sure to empty the sample water either downstream or away from your sampling location to avoid stirring up sediment and to avoid collecting sediment with your water sample.
3. Fill the bottle completely to the top after the third rinse.
4. Label the bottle with the sample location, date, and time.
5. Keep the samples at 4°C (40°F) by placing them in an ice-filled cooler.
6. Fill out a chain-of-custody form and submit to a laboratory. The samples must be analyzed within 48 hours.

Thresholds

The following surfactant level is recommended for triggering further investigation and additional indicator sampling. This threshold may be modified for use based on local knowledge or observations. Washington State does not have surface water quality standards for surfactants.

Recommended Threshold for Further Investigation and Additional Indicator Sampling
>0.25 mg/L

Pros and Cons

Pros	Cons
• Results can clearly indicate an illicit discharge or illicit connection • Generally more reliable than testing for detergents using boron or optical brightener monitoring traps	• Preparing samples for analysis in the field can be time consuming • The reagents used in the test kit and colorimeter are a hazardous waste that must be disposed of properly • False positive results may occur when using the test kit (from passing the tip of the test ampoule through the methylene blue solution), but should only have a slight blue tinge and are typically less than the recommended threshold value

Common Sources

High concentrations of surfactants can be caused by the following sources:

High Surfactants
• Washwater (residential) • Commercial laundry facilities • Firefighting foam • Washwater from temporary (charity care washes) or fixed-facility car washes (commercial car washes, rental car facilities, and auto dealerships) • Washwater from mobile cleaning businesses (carpet cleaning or floor cleaning) • Sewage from a broken sewer line or illicit connection • Septage from a failing septic system

Hardness

Description

Hardness is a measurement of the dissolved mineral content (primarily calcium and magnesium) of water. Hard water contains a high mineral content and soft water contains a low mineral content. In areas where hardness levels are elevated due to local geology, hardness can help distinguish between natural groundwater flows and tap water. Tap water is typically "soft" with a low hardness. Very high or low hardness values can also be associated with certain industrial discharges. High hardness values can increase or decrease the toxicity of metals in runoff, depending on the aquatic species that is exposed. Natural sources of hardness include limestone (which introduces calcium into percolating groundwater) and dolomite (which introduces magnesium).

Applications

Hardness is used as a follow-up indicator that applies to piped storm drainage systems, urban areas, and commercial/industrial land uses.

Storm Drainage System Types	Land Use Types	Weather Conditions
• Pipes	• Urban • Commercial • Mining • Industrial	• Dry • Wet

Equipment

Refer to the equipment list in the Field Screening Methodology section for the methodology you have selected. Equipment specific to hardness sampling includes:

- ☐ Hardness test strips or hardness test kit (if a field method is selected)
- ☐ Hardness buffer solution(s) (if a field method is selected)
- ☐ Clean, sterile sample bottles (glass or plastic)
- ☐ Field laptop/tablet and/or clipboard, field forms, and pen/pencil
- ☐ Safety equipment (for example, hard hats, ANSI 107-1999 labeled safety vests)
- ☐ Nitrile gloves
- ☐ Sturdy boots or belted waders

- ☐ Claw grabber or telescoping sampling pole (for collecting samples)

Methods

Hardness can be measured using test strips, a test kit, or at an analytical laboratory. General procedures for each type of equipment are outlined below. If shallow groundwater is suspected as a source, you should also test for elevated pH above 8.5. Refer to Figure 4.1 or Figure 4.2 for additional indicator sampling after obtaining results.

Hardness Test Strips

The increments of hardness that correspond to a color on the color scale differ depending on the type of test strip used. Generally, a test strip with more increments will provide more accurate results. Hardness is typically measured in milligrams per liter (mg/L) as calcium carbonate ($CaCO_3$). Test strips with large measuring ranges (0 to 1,000 mg/L) use larger increments, and while they are useful for obtaining an approximation of water hardness, their accuracy is compromised by the larger increments. Test strips with small measuring ranges (0 to 425 mg/L) can provide more accurate results, and can be used after the hardness of the water sample has been narrowed down to a smaller range.

The specific steps for using test strips (defined in Section 4.2) vary depending on the brand of test strip being used. Refer to the container holding your test strips for more detailed information. The following steps are generally common to all test strips:

1. Wear nitrile gloves to avoid sample contamination and protect yourself from potential contaminants.
2. Collect the sample to be analyzed in a clean, sterile sample bottle made of either glass or plastic. Avoid collecting sediment with the water sample.
3. Remove one strip from the test strip container and replace the cap tightly.
4. Dip the strip into your sample and move back and forth for the specified amount of time. Make sure that the test pad(s) are always submerged.
5. Remove the strip and gently shake off any excess liquid.
6. Wait the specified amount of time for the color change to occur.
7. Match the color(s) on the test pad(s) as closely as possible to the color scale on the test strip container.
8. Record the value on your field data sheet, notebook, or field laptop/tablet.
9. Dispose of sample back to source.

10. Store test strips at room temperature and avoid exposure to light when not in use. Replace test strips after 3 to 5 years.

Hardness Test Kit

The specific steps for using test kits (defined in Section 4.2) vary depending on the brand of test kit being used. Refer to the user's manual or instruction sheet with your test kit for more detailed information.

Hardness test kits are available, but include hazardous reagents and involve a complicated series of steps. Hardness tests are best performed in the field using test strips or in a laboratory (either using a test kit or at an approved analytical laboratory).

Hardness Laboratory Analysis

The following steps should be followed to collect samples for laboratory analyses:

1. Wear nitrile gloves to avoid sample contamination and protect yourself from potential contaminants. Do not touch the inside of the lid or bottle.
2. Rinse the clean, sterile sample bottle three times with sample water before collecting the sample. Make sure to empty the sample water either downstream or away from your sampling location to avoid stirring up sediment and to avoid collecting sediment with your water sample.
3. Fill the bottle completely to the top after the third rinse.
4. Label the bottle with the sample location, date, and time.
5. Keep the samples at 4°C (40°F) by placing them in an ice-filled cooler.
6. Fill out a chain-of-custody form and submit to a laboratory. The samples must be analyzed within 6 months of sample collection.

Thresholds

The following hardness concentrations are recommended for triggering further investigation and additional indicator sampling. This threshold may be modified for use based on local knowledge or observations. Washington State does not have surface water quality standards for hardness; however, the toxicity of several heavy metals (for example, copper, lead, zinc) is hardness dependent and uses a conversion factor based on the measured hardness (WAC 173-201A-240).

Recommended Threshold for Further Investigation and Additional Indicator Sampling
Commercial/Industrial only: Hardness ≤10 mg/L as $CaCO_3$ or ≥1,000 mg/L as $CaCO_3$

Pros and Cons

Pros	Cons
• Hardness test strips are quick and easy to use and can confirm extremely low or high concentrations	• Not conclusive by itself but it can identify potential illicit discharges that merit follow-up investigations using more effective indicators • Hardness test strips are not as accurate as the other test methods listed • Presence of metals can interfere with hardness tests and result in false positive tests results

Common Sources

Very low and high hardness values can be caused by the following sources:

Low Hardness (≤10 mg/L as $CaCO_3$)	High Hardness (≥1,000 mg/L as $CaCO_3$)
• Radiator flushing	• Industrial plating baths

Other sources such as sewage, septage, laundry washwater, car washwater, tap water, groundwater, and landscaping irrigation water are considered to be soft or moderately hard (typically in the range of 40 to 70 mg/L as $CaCO_3$) and are difficult to identify using a hardness test. If a water sample has high hardness and high specific conductivity, it is possible that the presence of metals has interfered with the hardness measurement, and a sample should be submitted to a laboratory for individual laboratory analyses of these parameters.

For reference to what is typically considered soft and hard water, the following table provides these classifications:

Hardness Concentration (mg/L as $CaCO_3$)	Classification	Natural Source
0 to 60	Soft	Erosion from mineral-poor soil (e.g., glacial deposits)
61 to 120	Moderately hard	
121 to 180	Hard	
>180	Very hard	Erosion from mineral-rich soil (e.g., limestone, dolomite)

Nitrate

Description

Nitrate (NO_3-) (often expressed as nitrate+nitrite nitrogen, or NO_3- plus NO_2-) is a concern in fresh water because it may contribute to an overabundant growth of aquatic plants and to a decline in diversity of the biological community.

Applications

Nitrate is used as a follow-up indicator, and applies to all storm drainage system and land use types. Concentrations may be diluted if samples are collected during wet weather.

Storm Drainage System Types	Land Use Types	Weather Conditions
• Pipes • Ditches	• Rural • Urban • Agricultural • Commercial • Industrial • Mining • Residential	• Dry • Wet

Equipment

Refer to the equipment list in the Field Screening Methodology section for the methodology you have selected. Equipment specific to nitrate sampling includes:

- ☐ Nitrate test strips, nitrate ion probe on multimeter, or spectrophotometer (if a field method is selected)
- ☐ Clean, sterile sample bottles (glass or plastic)
- ☐ Field laptop/tablet and/or clipboard, field forms, and pen/pencil
- ☐ Safety equipment (for example, hard hats, ANSI 107-1999 labeled safety vests)
- ☐ Nitrile gloves
- ☐ Sturdy boots or belted waders
- ☐ Claw grabber or telescoping sampling pole (for collecting samples)

Methods

Nitrate can be measured using test strips, a digital colorimeter, a nitrate ion probe on a multimeter, or at an analytical laboratory. General procedures for each method are outlined below. Refer to Figure 4.1 or Figure 4.2 for additional indicator sampling after obtaining results.

Nitrate and Nitrite Test Strips

The specific steps for using test strips (defined in Section 4.2) vary depending on the brand of test strip being used. Refer to the container holding your test strips for more detailed information. The following steps are generally common to all test strips:

1. Wear nitrile gloves to avoid sample contamination and protect yourself from potential contaminants.
2. Collect the sample to be analyzed in a clean, sterile sample bottle made of either glass or plastic. Avoid collecting sediment with the water sample.
3. Remove one strip from the test strip container and replace the cap tightly.
4. Dip the strip into your sample and move back and forth for the specified amount of time. Make sure that the test pad(s) are always submerged.
5. Remove the strip and gently shake off any excess liquid.
6. Wait the specified amount of time for the color change to occur.
7. Match the color(s) on the test pad(s) as closely as possible to the color scale on the test strip container.
8. Record the value on your field data sheet, notebook, or field laptop/tablet.
9. Store test strips at room temperature and avoid exposure to light when not in use. Replace test strips after 3 to 5 years.

Nitrate Ion Probe on a Multimeter

The specific steps for using multimeters (defined in Section 4.2) vary depending on the brand of multimeter being used. Refer to the user's manual with your multimeter for more detailed information. The following steps are generally common to multimeters:

1. **Check Meter:** Prior to taking meter in the field, confirm that the meter and probes are working properly and sufficient battery life is left.
2. **Probe Calibration**: Manufacturers typically recommend that probes be checked at least once a year. Refer to the user's manual for the recalibration frequency and procedures.

3. **Field Measurements**:

   a. Wear nitrile gloves to avoid sample contamination and protect yourself from potential contaminants. Do not touch the inside of the lid or bottle.

   b. Collect a field sample in a clean, sterile sample bottle made of either glass or plastic. Avoid collecting sediment with the water sample.

   c. Pour some of the water sample over the probe to remove residue from the probe and avoid cross contamination of the sample.

   d. Dip the probe in the water sample. Stir gently for a few seconds. Allow up to 1 minute for the probe to adjust to the sample temperature and the readings to stabilize.

   e. Record the nitrate concentration shown on the meter on your field data sheet, notebook, or field laptop/tablet.

   f. Rinse the probe with distilled water and dry with a laboratory grade cleaning wipe between each reading and before storage.

   g. Dispose of sample back to source.

4. **Meter Storage:** Clean the surface of the probe with a laboratory grade cleaning wipe and distilled water. Wipe off the distilled water before storage. Refer to the user's manual for specific storage recommendations.

Nitrate Using a Spectrophotometer

Samples are prepared for nitrate analysis using a spectrophotometer (defined in Section 4.2) by using a reagent typically contained in a power pillow. Suspended matter and debris in a sample can interfere with spectrophotometer results, and should be removed prior to testing using filtration. Refer to the user's manual with your spectrophotometer for more detailed information. The following steps are generally common to collecting and preparing a sample for a spectrophotometer,:

1. Wear nitrile gloves to avoid sample contamination and protect yourself from potential contaminants and reagents.

2. Collect the sample to be analyzed in a clean, sterile sample bottle made of either glass or plastic. Avoid collecting sediment with the water sample.

3. Follow the steps in the user's manual included with your spectrophotometer to prepare and analyze the sample.

4. Record the value on your field data sheet, notebook, or field laptop/tablet.

Nitrate and Nitrite Laboratory Analysis

The following steps should be followed to collect samples for laboratory analyses:

1. Wear nitrile gloves to avoid sample contamination and protect yourself from potential contaminants. Do not touch the inside of the lid or bottle.

2. Rinse the clean, sterile sample bottle three times with sample water before collecting the sample. Make sure to empty the sample water either downstream or away from your sampling location to avoid stirring up sediment and to avoid collecting sediment with your water sample.

3. Fill the bottle completely to the top after the third rinse.

4. Label the bottle with the sample location, date, and time.

5. Keep the samples at 4°C (40°F) by placing them in an ice-filled cooler.

6. Fill out a chain-of-custody form and submit to a laboratory. The samples must be analyzed within 28 days of sample collection.

Nitrate Using a Digital Colorimeter

Samples are prepared for nitrate analysis using a digital colorimeter (defined in Section 4.2) by using either a NitraVer5 reagent either contained in a powder pillow or an ampoule. The NitraVer5 reagent contains cadmium in sufficient concentrations to be regulated as a hazardous waste under the Resource Conservation and Recovery Act (RCRA). Refer to the Safety Data Sheet (SDS) for safe handling and disposal instructions.

The specific steps for using a colorimeter will vary depending on the brand of colorimeter being used. Refer to the user's manual with your colorimeter for more detailed information. The following steps are generally common to all colorimeters:

1. Wear nitrile gloves to avoid sample contamination and protect yourself from potential contaminants and colorimeter reagents.

2. Collect the sample to be analyzed in a clean, sterile sample bottle made of either glass or plastic. Avoid collecting sediment with the water sample.

3. Follow the steps in the user's manual included with your colorimeter to prepare and analyze the sample.

4. Record the value for nitrate on your field data sheet, notebook, or field laptop/tablet.

Thresholds

The following nitrate and nitrite concentrations are recommended for triggering further investigation and additional indicator sampling. This threshold may be modified for use based on local knowledge or observations. Washington State does not have surface water quality standards for nitrate. Nitrate is typically measured in milligrams per liter (mg/L).

Recommended Threshold for Further Investigation and Additional Indicator Sampling
>1 mg/L

Pros and Cons

Pros	Cons
• Nitrate and nitrite test strips are quick and easy to use and can confirm extremely low or high concentrations	• Not conclusive by itself but it can identify potential illicit discharges that merit follow-up investigations using more effective indicators • Test strips are not as accurate as the other test methods listed for nitrate and nitrite • The reagents used in the colorimeter are a hazardous waste that must be disposed of properly • Nitrate may be present if irrigation water is comingled with stormwater

Common Sources

High nitrate and high nitrite values can be caused by the following sources:

High Nitrate	High Nitrite
• Biological waste in agricultural runoff • Compost • Fertilizer in irrigation runoff • Fertilizer in residential irrigation overspray • Runoff from nurseries and garden supply stores	• Corrosion inhibitors in industrial process and cooling water • Preservatives in food

Specific Conductivity

Description

Specific conductivity, also referred to as specific conductance, is a measure of how well water can conduct an electrical current based on ionic activity and content. Specific conductivity is an indicator of dissolved solids from potential pollutant sources such as sewage and washwater, and can help distinguish groundwater from illicit discharges and identify commercial/ industrial liquid waste if used in combination with another parameter such as Hardness, Turbidity, or Detergents/Surfactants. Specific conductivity can also be used in combination with caffeine or pharmaceuticals (see Other Indicators) to indicate sanitary wastewater.

Applications

Specific conductivity is used as a follow-up indicator, and applies primarily to piped storm drainage systems in urban, commercial, and industrial land use types when flow is present. As an indicator, specific conductivity depends on whether concentrations are elevated in "natural" or clean waters. For example, seawater naturally has a high specific conductivity due to its high concentration of ionic constituents (salt). For this reason, specific conductivity testing is not recommended for detecting illicit discharges in marine outfalls or areas near marine waters.

Storm Drainage System Types	Land Use Types	Weather Conditions
• Pipes	• Urban • Commercial • Mining • Industrial	• Dry • Wet

Equipment

Refer to the equipment list in the Field Screening Methodology section for the methodology you have selected. Equipment specific to specific conductivity sampling includes:

- ☐ Conductivity meter (if field meter is used)
- ☐ Conductivity standard solutions (if field meter is used)
- ☐ Thermometer (if field meter is used)
- ☐ Laboratory grade cleaning wipes (if field meter is used)
- ☐ Tap water (for first rinse)
- ☐ Distilled water (for final rinse)

- ☐ Wash bottle (for rinsing with distilled water)
- ☐ Clean, sterile sample bottles (glass or plastic)
- ☐ Field laptop/tablet and/or clipboard, field forms, and pen/pencil
- ☐ Safety equipment (for example, hard hats, ANSI 107-1999 labeled safety vests)
- ☐ Nitrile gloves
- ☐ Sturdy boots or belted waders
- ☐ Claw grabber or telescoping sampling pole (for collecting samples)

Methods

Specific conductivity can be measured using a conductivity field meter or at an analytical laboratory. General procedures for using a field meter and collecting a sample for laboratory analysis are outlined below. Refer to the user's manual with your field meter for more detailed information. Refer to Figure 4.1 or Figure 4.2 for additional indicator sampling after obtaining results.

Specific Conductivity Field Meter

The specific steps for using field meters (defined in Section 4.2) vary depending on the brand of field meter being used. Refer to the user's manual with your field meter for more detailed information. The following steps are generally common to specific conductivity field meters:

1. **Check Meter:** Prior to taking meter in the field, confirm that the meter and probe are working properly and sufficient battery life is left.
2. **Calibrate Meter**:
    a. Verify the meter's internal temperature sensor against a thermometer and note any differences.
    b. Rinse probe with distilled water and blot dry with a laboratory grade cleaning wipe.
    c. Immerse the probe in the first standard solution and calibrate; follow with additional standards if appropriate (rinsing with distilled water between each standard).
    d. Record post calibration readings and recalibrate if necessary.

3. **Field Measurements:**

    a. Wear nitrile gloves to avoid sample contamination and protect yourself from potential contaminants.

    b. Collect a field sample in a clean, sterile sample bottle made of glass or plastic. Avoid collecting sediment with the water sample.

    c. Immerse the probe in the sample (or place a drop of the sample on the sensor) and allow the meter to stabilize.

    d. Record the temperature and the conductivity value shown on the meter on your field data sheet, notebook, or field laptop/tablet. If the meter does not automatically compensate for temperature, it is important to document the temperature so that the appropriate adjustments can be made.

    e. Rinse the probe with distilled water and dry with a laboratory grade cleaning wipe between each reading and before storage.

4. **Meter Storage:** Rinse the conductivity sensor with clean water after each use. To clean to conductivity sensor, dip the sensor in a foaming acid tile cleaner and agitate for 2 to 3 minutes. Use a small nylon brush to remove any contaminants from the inside of the electrode chamber. Repeat above steps until sensor is completely clean, then rinse with distilled water. Store in the meter storage chamber.

Specific Conductivity Laboratory Analysis

The following steps should be followed to collect samples for laboratory analyses:

1. Wear nitrile gloves to avoid sample contamination and protect yourself from potential contaminants. Do not touch the inside of the lid or bottle.

2. Rinse the clean, sterile sample bottle three times with sample water before collecting the sample. Make sure to empty the sample water either downstream or away from your sampling location to avoid stirring up sediment and to avoid collecting sediment with your water sample.

3. Fill the bottle completely to the top after the third rinse.

4. Label the bottle with the sample location, date, and time.

5. Keep the samples at 4°C (40°F) by placing them in an ice-filled cooler.

6. Fill out a chain-of-custody form and submit to a laboratory. The samples must be analyzed within 28 days of sample collection.

Thresholds

The following specific conductivity concentration is recommended for triggering further investigation and additional indicator sampling. This threshold may be modified for use based on local knowledge or observations. Background specific conductivity concentrations can vary and are strongly influenced by local geology, ambient temperature, and dilution from stormwater runoff. Washington State does not have surface water quality standards for specific conductivity, but drinking water standards for specific conductivity in Washington State are set at > 700 microsiemens per centimeter (µS/cm).

Recommended Threshold for Further Investigation and Additional Indicator Sampling
>500 µS/cm

Pros and Cons

Pros	Cons
• Easy and quick measurements	• Naturally occurring • Ineffective in saline waters • High specific conductivity may be present if irrigation water is comingled with stormwater • Moderately elevated specific conductivity (400-500 µS/cm) may not necessarily indicate an illicit discharge; additional indicator sampling may be needed to verify the source

Common Sources

High specific conductivity can be caused by the following sources:

High Specific Conductivity (Industrial/Commercial)	High Specific Conductivity (Residential)
• Commercial/industrial waste • Plating bath water • Radiator flushing water • Food manufacturing • Wood products • Shallow groundwater	• Sanitary wastewater • Washwater (laundry) • Washwater (vehicle) • Shallow groundwater

Low specific conductivity could result from the presence of tap water or spring water.

Total Petroleum Hydrocarbons (TPH)

Description

Total petroleum hydrocarbons (TPH) is a term that is used to describe a family of several hundred chemical compounds, primarily composed of hydrogen and carbon (hydrocarbons), that originate from crude oil. Some of the chemicals found in TPH include benzene, toluene, xylene, hexane, naphthalene, and fluorene. In Washington, the analytical laboratory analysis (NWTPH) groups these compounds into Dx (motor oil and diesel) and Gx (gasoline) fractions. The Dx fraction includes jet fuels, kerosene, diesel oils, hydraulic fluids, mineral oils, lubricating oils, and fuel oils. The Gx fraction includes aviation and automotive gasolines, mineral spirits, Stoddard solvent, and naphtha.

Applications

TPH is used as a follow-up indicator and applies to applies to all storm drainage system and land use types.

Storm Drainage System Types	Land Use Types	Weather Conditions
• Pipes • Ditches	• Rural • Urban • Agricultural • Commercial • Industrial • Mining • Residential	• Dry • Wet

Equipment

Refer to the equipment list in the Field Screening Methodology section for the methodology you have selected. Equipment specific to TPH sampling includes:

- ☐ Clean, sterile sample bottles (typically amber glass)
- ☐ Field laptop/tablet and/or clipboard, field forms and pen/pencil
- ☐ Safety equipment (for example, hard hats, ANSI 107-1999 labeled safety vests)
- ☐ Nitrile gloves
- ☐ Sturdy boots or belted waders
- ☐ Claw grabber or telescoping sampling pole (for collecting samples)

Methods

Laboratory analysis is recommended for TPH detection. General procedures for collecting a sample for laboratory analysis are outlined below. Field test kits may also be available for screening for presence or absence of TPH in the field; however, since the authors of this manual did not have direct experience using field test kits for TPH detection (or oil screening), they were not added to this manual for this update. Refer to Figure 4.1 or Figure 4.2 for additional indicator sampling after obtaining results.

TPH Laboratory Analysis

TPH samples are typically submitted to an analytical laboratory for analysis. A single water sample can be analyzed for multiple indicators at an analytical laboratory; however, you should verify the required volume for each analysis in order to ensure that you collect enough sample volume in the field. The following steps should be followed to collect samples for laboratory analyses:

1. Wear nitrile gloves to avoid sample contamination and protect yourself from potential contaminants. Do not touch the inside of the lid or bottle. For TPH samples, glass bottles are required (TPH will stick to the sides of plastic bottles).

2. Label the bottle with the sample location, date, and time. It is easier to pre-mark a dry bottle prior to sample collection.

3. Rinse the clean, sterile sample bottle three times with sample water before collecting the sample. Make sure to empty the sample water either downstream or away from your sampling location to avoid stirring up sediment and to avoid collecting sediment with your water sample.

4. Fill the bottle completely to the top after the third rinse.

5. Keep the samples at 4°C (40°F) by placing them in an ice-filled cooler.

6. Fill out a chain-of-custody form and submit to a laboratory. The samples must be analyzed within 14 days of sample collection (or within 7 days if unpreserved).

Thresholds

The following TPH concentration is recommended for triggering further investigation and additional indicator sampling. This threshold may be modified for use based on local knowledge or observations. Washington State does not have surface water quality standards for TPH, but does have surface water quality standards for some of the components of TPH (for example, benzene). The state has developed Model Toxics Control Act (MTCA) cleanup values for TPH present in groundwater. TPH measurements are measured in units of milligrams per liter (mg/L).

Recommended Threshold for Further Investigation and Additional Indicator Sampling
1 mg/L (Dx or Gx)

Pros and Cons

Pros	Cons
• Laboratory analysis is relatively inexpensive • Test result should be unambiguous	• Wait time for results from laboratory analysis • Laboratory analysis does not distinguish between the various types of hydrocarbons • Field test kit does not provide a TPH concentration, just the presence or absence of TPH

Common Sources

High TPH can be caused by the following sources:

High TPH
• Heating oil leaks from underground or aboveground storage tanks • Leaking vehicles and equipment • Leaking construction equipment • Leaks from improper fuel storage containers (tanks, drums, etc.) • Service stations • Engine or automobile repair shops • Automotive dealerships • Municipal garages • Washing down or degreasing vehicles and equipment • Abandoned or converted service station fuel tanks • Fleet operators (e.g., taxicab and vehicle rental companies) • Industrial plants, including refineries, terminals, and bulk plants • Airports • Pipelines • Abandoned oil and gas wells • Pesticides

Other Indicators

The following indicators are not described in detail in this manual, but may be used for specialized investigations on a case-by-case basis. Recommended threshold values (or ranges) are included if they were specified in the references reviewed for the literature review for this project, but were not available for all indicators.

Other Indicators	Description	Recommended Threshold Value
Alkalinity	Alkalinity is a measure of the buffering capacity (ability to neutralize acids and bases) of a water body. It can be used along with pH, hardness, temperature, and conductivity, as an indicator of an industrial wash water discharge.	NG
Biochemical oxygen demand (BOD)	BOD is a measure of the amount of oxygen required or consumed for the microbiological decomposition (oxidation) of organic material in water. High BOD values may indicate industrial, domestic, or agricultural sources of organic matter, which may cause low dissolved oxygen levels. It is often used in combination with COD.	>30 mg/L[i]
Boron	Boron is added as a water softener to washing powders and detergents and may indicate sewage or washwater discharges. It can also be added to swimming pools (in the form of borate) to stabilize pH.	>0.35 mg/L for wastewater or washwater[a,b,c] <0.35 mg/L for tap or irrigation water[b,c]
Caffeine	Caffeine can be used to indicate the presence of sanitary sewage. Caffeine is best used in combination with other indicators such as pharmaceuticals, specific conductivity, and temperature. Lower values of specific conductivity in water that tests positive for caffeine may indicate dilution of the water being tested and highlight the need for further investigation moving upstream.	NG
Chemical oxygen demand (COD)	COD is a measure of the amount of oxygen required or consumed for the microbiological decomposition (oxidation) of organic material in water. High COD values may indicate residual food and beverage waste from cans and bottles, antifreeze, or emulsified oils, which may cause low dissolved oxygen levels. It is often used in combination with BOD.	>120 mg/L[i]
Dissolved oxygen (DO)	DO is an important parameter for salmonids and other aquatic organisms. Low dissolved oxygen levels can be harmful to larval life stages and respiration of juveniles and adults. DO depends on local hydraulic conditions affecting the oxygenation of the discharge. For this reason, DO is not a widely useful indicator for illicit discharges.	<6 mg/L[d]

Other Indicators	Description	Recommended Threshold Value
Fecal sterols	Fecal sterols have been used as chemical indicators of fecal pollution in many parts of the world. The primary sterol found in human feces is coprostanol. Fecal sterols can be used to indicate the presence of sanitary sewage, but are not specific to human waste. They are best used in combination with other fecal indicators if confirmation of human fecal pollution is desired.	NG
Fluorescence	Fluorescence is an analytical technique that can identify a wide range of organic compounds. Optical brighteners use fluorescence by changing the reflective wavelength of material exposed to brightener chemicals, which are often used in laundry detergents to make fabrics appear whiter or brighter. In addition to portable optical brightener pads for in-situ detection (see Appendix G), portable fluorometers can also be used to detect brighteners in water samples. Some fluorometers have multiple "channels" that can be used to detect different wavelength ranges to indicate a range of organic compounds, turbidity, cyanobacteria, chlorophyll *a*, toxicity to cellular organisms, as well as detecting dye used for dye testing (see Section 5).	NG
Glycol	Glycol or ethylene glycol is the main component of automotive antifreeze. It can also be found in hydraulic brake fluids, deicing solutions, stamp pad ink, ballpoint pens, and print shops. Ethylene glycol is used to make some plastics and textiles.	>0.5 mg/L[e] >1.5 mg/L[f] >5 mg/L[d]
Metals	Metals are inorganic substances that occur naturally. Typical metals measured as water quality parameters include copper, lead, and zinc. At higher concentrations copper can become toxic to aquatic life. At low concentrations, copper can negatively affect olfaction in salmonids that plays a key role in species recognition, migration, reproduction, and predator avoidance.	>0.025 mg/L (copper)[g] >0.1 mg/L (copper)[h] >0.1 mg/L (lead)[e] >0.2 mg/L (nickel)[e]
Pharmaceuticals	Pharmaceuticals, such as colfibric acid, aspirin, ibuprofen, steroids, and illegal drugs, can be used to indicate the presence of sanitary sewage. Pharmaceuticals are best used in combination with caffeine and specific conductivity.	NG

Other Indicators	Description	Recommended Threshold Value
Phenol	Phenols are organic compounds that are produced for various industrial processes. Phenol is also produced by the natural degradation of organic wastes including benzene. Phenols are can be toxic to both humans and aquatic organisms. Sources of phenol include cleaning compounds, coal tar, wastewater from manufacturing (resins, plastics, fibers, adhesives, iron, steel, aluminum, leather, rubber), effluents from synthetic fuel manufacturing, paper pulp mills, and wood treatment facilities. Phenol can also be found in wastewater treatment plant effluent and sewage overflows.	>0.1 mg/L[g] >1.0 mg/L[h]
Phosphate	Phosphate (or phosphorus) is a concern in fresh water because high levels can lead to accelerated plant growth, algal blooms, low dissolved oxygen, decreases in aquatic diversity, and eutrophication.	>0.5 mg/L[e] >1.5 mg/L[d] ≥5.0 mg/L[f]
Potassium	Potassium is a naturally occurring element that can be found widely in the environment and in natural waters. High concentrations of potassium are found in sewage and commercial/industrial discharges. See Appendix F for more detail on this indicator.	>5 mg/L
Orthophosphate	Orthophosphate (also known as soluble reactive phosphorus or SRP) is an inorganic fraction of phosphorus that is produced by natural processes, but also can be measured in municipal sewage. Additional sources of orthophosphate are similar to those for phosphate such as septic system failure, animal waste, decaying vegetation and animals, and fertilizer runoff.	NG
Oxygen stable isotopes	Naturally occurring oxygen is composed of three stable isotopes: ^{16}O, ^{17}O, and ^{18}O. Oxygen stable isotopes are used to identify major sources of water such as drinking water and groundwater.	NG
Salinity	Salinity is the saltiness or dissolved inorganic salt content of water. The Pacific Ocean has an average salinity of 34 parts per thousand (ppt) compared to 29 ppt in Puget Sound.	NG
Semi-volatile organic compounds (SVOCs)	SVOCs are used and produced in the manufacturing industry (for example, in plastic, pharmaceutical and pesticide manufacturing)	NG
Tannins and lignins	Tannins and lignins are released during the decomposition of wood and tend to make water look dark brown or tea-colored.	NG
Total dissolved solids (TDS)	Total dissolved solids reflect the amount of dissolved material in water and strongly affect conductivity; most often used to detect industrial discharges.	NG

Other Indicators	Description	Recommended Threshold Value
Total Kjeldahl nitrogen (TKN)	TKN is a combination of organically bound nitrogen and ammonia. TKN can be used as an indicator of pollution from industrial sources and municipal sewage.	>3 mg/L[d]
Toxicity screening tests	Toxicity screening tests are short-term tests performed in a laboratory to assess the relative toxicity of a water sample to a selected test organism.	NG

CFU/100 mL = colony forming units per 100 milliliters

mg/L = milligrams per liter

MPN/100 mL = most probable number per 100 milliliters

NG = no guidance provided in literature review

[a] Source: CWP (2004)

[b] Source: Lower Charles River (2004)

[c] Source: Snohomish County (2010)

[d] Source: King County (2011)

[e] Source: North Central Texas (2011)

[f] Source: Kitsap County (2011)

[g] Source: Lake County (2009)

[h] Source: Wayne County (1996)

[I] Source: Grand Island, Nebraska (2016)

5. SOURCE TRACING METHODOLOGIES

Once a potential illicit discharge has been detected using one or more of the field screening methodologies (Section 3 of this manual) and/or identified by one or more indicator tests (Section 4 of this manual), a source tracing methodology can be used to locate the source of the illicit discharge. Source tracing methodologies can also be utilized to respond to referrals through the IDDE/spill hotline, citizen complaints, or staff reports. The source tracing methodologies that are included in Section 5 of this manual are summarized below with their applicable system type:

Piped Systems	Ditch Systems
• Business inspections • Catch basin/manhole inspections • Dye testing • Septic system inspections • Smoke testing • Vehicle/Foot Reconnaissance • Video inspections	• Business inspections • Catch basin/manhole inspections • Ditch inspections • Septic system inspections • Vehicle/Foot Reconnaissance

5.1. SELECTING A SOURCE TRACING METHODOLOGY

Figure 3.1 shows the process of selecting a source tracing methodology for the following situations:

- Flow is not present, but visual/olfactory observations suggested a potential illicit discharge
- Flow is present, indicator sampling suggested a potential illicit discharge, and the investigator has access to the property where the illicit discharge is suspected to be originating from
- Flow is present, indicator sampling suggested a potential illicit discharge, and the investigator does not have access to the property where the illicit discharge suspected to be originating from

An IDDE program manager should select the most appropriate source tracing methodology depending on the location and type of illicit connection or illicit discharge that they are tracing, and the skill set of their staff and/or contractors. The methodology or methodologies should be selected based on what each jurisdiction determines to be the most appropriate; however, some general guidelines are provided below and in Table 5.1:

- **Equipment and staff availability:** Is an illicit connection suspected based on the indicators observed and measured? Do your staff frequently perform dye testing, smoke testing, or have access to video inspection equipment to conduct a video inspection?

- **Weather:** Most source tracing methodologies can be performed in dry or wet weather; however, video inspections tend to work better in dry weather. Sandbagging and optical brightener traps (see Appendix G) are also installed during dry weather if visual and/or olfactory observations suggest an illicit discharge, but no flow is present.

- **Drainage area size:** Most source tracing methodologies are easier to conduct on a small drainage area. Follow-up business inspections (see Appendix E) are typically performed if the source of an illicit connection or illicit discharge has been narrowed down to a few businesses or properties. Dye testing and septic system investigations are more cost effective if the potential area has been narrowed down to less than 10 properties.

- **Coordination and investigation:** If your City/County has a business inspection program, follow-up with them to find out the results of past business inspections on properties where a suspected illicit connection or illicit discharge may have been identified. The inspectors may also assist with follow-up source tracing inspections and/or enforcement actions. Contact your local health department to find out the results of past septic system inspections and coordinate with them to inspect properties where failing septic fields are suspected. Consult planning/development departments for recent permit activities (such as, building, plumbing, side sewer permits) that may require follow up investigations.

- **Contracting out IC and ID source tracing:** If sufficient staff time, equipment, or skills are not available to perform a particular source tracing methodology, a private contractor or another jurisdiction can be hired to perform the work. It is important that the selected contractor or jurisdiction has the required expertise to perform the source tracing methodology and that they follow the appropriate safety protocols.

Table 5.1. Source Tracing Methodology Recommendations Based on the Suspected Source of an Illicit Discharge.

Suspected Source	Examples	Recommended Source Tracing Methodologies
Cleaning chemicals	• Improper material storage • Improper waste disposal	• Business inspections • Vehicle/foot reconnaissance
Construction site runoff	• Failing erosion and sediment control BMPs • Concrete slurry • Oil sheen from leaking equipment or spills of fuel	• Catch basin/manhole inspections • Vehicle/foot reconnaissance • Video inspections
Gasoline, vehicle oil, or grease	• Leaking vehicle • Oil change • Leaking storage tank • Improper material storage	• Catch basin/manhole inspections • Vehicle/foot reconnaissance
Human/animal waste	• Illicit connection • Sewage overflow • Improper disposal of animal waste • Runoff or direct discharge from homeless encampment	• Catch basin/manhole inspections • Septic system investigation • Vehicle/foot reconnaissance
Industrial operations	• Illicit connection • Overflow • Improper material storage • Leaking storage tank • Improper waste disposal	• Catch basin/manhole inspections • Vehicle/foot reconnaissance • Video inspections
Industrial process water	• Illicit connection • Overflow	• Catch basin/manhole inspections • Vehicle/foot reconnaissance • Video inspections
Nutrient rich discharge	• Excessive irrigation • Excessive fertilization • Hydroseeding following construction	• Ditch inspections • Vehicle/foot reconnaissance
Sanitary wastewater or sewage	• Illicit connection • Sewage overflow • Septic system discharge	• Catch basin/manhole inspections • Dye testing • Smoke testing • Vehicle/foot reconnaissance • Video inspections
Tap water	• Illicit connection • Fire hydrant flushing • Swimming pool, hot tub, and spa drainage • Pressure washing for cleaning, paint removal, or stripping • Water main break	• Catch basin/manhole inspections • Ditch inspections • Vehicle/foot reconnaissance
Washwater	• Car washing • Pressure washing • Mobile cleaning	• Business inspections • Catch basin/manhole inspections • Vehicle/foot reconnaissance

5.2. GENERAL GUIDELINES

The following guidelines for data management recommendations, safety considerations, and costs apply to all the source tracing methodologies summarized in this section.

Data Management Recommendations

The NPDES Municipal Stormwater Permits reissued in 2019 included an updated and prescriptive reporting requirement for IDDE programs. The reporting must include information addressing 12 questions on key details of each ID incident found. Information required includes location of the ID incident, response dates, how the incident was reported, if the discharge reached the MS4, what pollutants were identified, what the source was and was source tracing approaches were used, and what correction and elimination methods were used. The IDDE reporting questions are the same for all permittees and are listed in Appendix 14 of the NPDES Phase I Municipal Stormwater Permit, Appendix 12 of the NPDES Phase II Municipal Stormwater Permit for Western Washington, and Appendix 7 of the NPDES Phase II Municipal Stormwater Permit for Eastern Washington.

Related to these reporting requirements, a spatially referenced data management system (for example, ArcGIS geodatabase, Cartegraph, CityWorks, Microsoft Access database, or a specialized database) is an important component of any IDDE program. Regular updates to the system with IC/ID field screening information will reduce level of effort for submission to Ecology. The information stored in the data management system should be evaluated on an annual basis at a minimum to adjust the IDDE program as needed. Table 5.2 provides a summary of the some of the information that should be tracked in relation to each source tracing methodology for this purpose. This table includes basic guidance on tracking and reporting recommendations, but is not intended to provide an exhaustive list of all of the information that should be tracked for an IDDE program.

Table 5.2. Data Management Recommendations for Source Tracing Methodologies.

Source Tracing Methodology	Tracking and Reporting Recommendations
Business inspections	• Location of inspection • Parcel size • Business contact information • Number and types of illicit discharges or illicit connections identified • Number and types of BMPs in use to manage or treat runoff or process water • Business inspection forms • Digital photographs
Catch basin/manhole inspections	• Location of inspection • Number of catch basins/manholes inspected • Number and types of illicit discharges or illicit connections identified • Catch basin/manhole inspection forms • Digital photographs • Indicator sampling data • Follow-up sampling data • Flow data (if collected)
Dye testing	• Property owner contact information • Number and types of fixtures tested • Number and types of illicit discharges or illicit connections identified • Detailed sketch or map of facility showing fixtures tested • Dye testing forms • Dye color used • Digital photographs
Septic system inspections	• Property owner contact information • Number of inspections conducted • Number and type of retrofit recommendations made • Septic system investigation forms • Follow-up inspection/code enforcement
Smoke testing	• Length of storm drainage pipe network or drainage basin area • Number and types of illicit discharges or illicit connections identified
Video inspections	• Linear feet of pipe videotaped and reviewed • Number and types of illicit discharges or illicit connections identified • Video labeling and archiving
Vehicle/foot reconnaissance	• Location of survey • Length of roadway driven • Approximate size of drainage basin observed • Number and types of illicit discharges or illicit connections identified • Digital photographs

Safety Considerations

Safety is an important factor when conducting source tracing investigations. Refer to the general safety considerations summarized previously in Section 3 – Field Screening Methodologies.

Costs

Costs for representative source tracing equipment and materials are summarized in Appendix A. The authors do not promote, endorse, or otherwise recommend any of the companies, individuals, or organizations presented in Appendix A.

5.3. SOURCE TRACING METHODOLOGY PULLOUT SECTIONS

Each of the following source tracing methodology pullout sections is organized in the same format as the field screening methodologies and contains the following information:

- **Description:** Source tracing methodology definition
- **Applications:** Lists the applicable storm drainage system types (pipes and ditches), land use types (urban, rural, agricultural, commercial, industrial, mining, residential), weather conditions (dry and wet), and complementary source tracing methodologies
- **Equipment:** Checklist for field crews to determine what materials and supplies to bring out in the field
- **Methods:** Generic standard operating procedures for conducting the source tracing methodology
- **Pros and cons:** List of the positive and negative aspects of the source tracing methodology

Business Inspections

Description

Business inspections can be used as a source tracing methodology once field screening has identified the presence of an illicit discharge, and the illicit discharge is suspected to be originating at a business or private property. When used for source tracing, business inspections will require a detailed investigation of potential cross connections and illicit discharge sources from materials stored and used at a business or private property.

Applications

Business inspections can be used for source tracing once the likely source of an illicit discharge has been narrowed down to a small drainage area (a few businesses or private properties).

Storm Drainage System Types	Land Use Types	Weather Conditions	Complementary Source Tracing Methodologies
• Pipes • Ditches	• Urban • Agricultural • Commercial • Industrial • Mining • Residential	• Dry • Wet	• Catch Basin/Manhole Inspections • Dye Testing • Septic System Inspections • Smoke Testing • Video Inspections

Equipment

Equipment specific to business inspections includes:

- ☐ Local stormwater code or manual
- ☐ Best Management Practices (BMP) handouts and outreach materials (brochures, posters, etc.)
- ☐ Camera, phone, or other device for taking pictures (with date and time stamp)
- ☐ Site plans (if available)
- ☐ Maps of sanitary and storm drainage systems
- ☐ Facility/property owner contact information
- ☐ Various catch basin/manhole hooks and wrenches (including hexagonal Allen key) (for both types of inspections)

- ☐ Sledge hammer for loosening lids
- ☐ Field laptop/tablet and/or clipboard, field forms, and pen/pencil
- ☐ Safety equipment (for example, hard hats, eye protection, work gloves, ANSI 107-1999 labeled safety vests, ear protection, steel-toe boots, traffic control equipment)
- ☐ Equipment for other source tracing methodologies to be used

Methods

Field crews should implement the following steps during business inspections for source tracing:

1. **In-office Investigation:**
   a. Review storm drainage and sanitary sewer maps to identify lateral sewer connections and access points including building sanitary sewer as-built drawings.
   b. Review results of previous investigations.
   c. Communicate with the site owner to gather information about the types of activities that occur on site.
2. **Onsite investigation:**
   a. Notify the property owner if required according to jurisdiction protocols (for example, using a notification letter).
   b. Walk and discuss site operations and BMPs in use with a property owner, manager, or other representative familiar with the site.
   c. Investigate material storage areas and handling and storage practices if hazardous or polluting materials are found on site.
   d. Ensure that there are no connections or discharges to the storm drainage system that contain anything other than stormwater. Check for dry weather flow in downstream catch basins/manholes or stormwater BMPs.
      i. Check to see if there are floor drains in any work areas on the site. If so, determine whether polluting fluids could enter the drain, and if the drain discharges to the sanitary sewer or storm system. Catch Basin/Manhole Inspections, Dye Testing, Septic System Inspections, Smoke Testing, or Video Inspections can be used to verify that floor drains and other indoor plumbing connections are not connected to the storm drainage system.
   e. Record any issues observed in field data sheet, notebook, or field laptop/tablet.

> ***Notes:***
>
> *1) As a general rule, do not enter private property without permission from the business owner.*

3. Conduct a second round of indicator sampling using Catch Basin/Manhole Inspections, Ditch Inspections, or Outfall Inspections to confirm initial results if business inspection does not lead to the source of the discharge.

4. Return to the office and make sure that documentation from the field work is completed and downloaded. This includes hardcopy field forms, photographs, GPS data, and storm drainage system mapping updates delivered to GIS staff.

Pros and Cons

Pros	Cons
• Can be used in combination with other source tracing methodologies to confirm drainage connections • Can be used as a public education and outreach tool to help prevent future illicit discharges • Effective during wet and dry weather • Can be combined with other NPDES permit requirements to reduce overall number of inspections	• Coordination with property owner, site visits, communication after the site visit, and follow-up can be time consuming • Private property access can be difficult if the property owner is not responding to notification letters or calls • Follow up source tracing methodologies may have limited effectiveness in wet weather

Catch Basin/Manhole Inspections

Description

Catch basin/manhole inspections can be used as a source tracing methodology once a suspected illicit discharge has been found to track the illicit discharge to its source. Catch basin/manhole inspections can be used any time of year when attempting to trace an illicit discharge back to a source.

Applications

Catch basin/manhole inspections can be used to trace a specific illicit discharge that was observed or reported back to its source. This methodology is most effective in urban environments with piped systems for source tracing when the likely source of an illicit discharge has been narrowed down to a small drainage area (20 structures or fewer).

Storm Drainage System Types	Land Use Types	Weather Conditions	Complementary Source Tracing Methodologies
• Pipes	• Rural • Urban • Agricultural • Commercial • Industrial • Mining • Residential	• Dry • Wet	• Dye Testing • Smoke Testing • Video Inspections

Equipment

The following suggested staffing and equipment apply to catch basin/manhole inspections:

- ☐ 2 field staff
- ☐ Cell phones or 2-way radios
- ☐ Detailed maps of the storm drainage and sanitary sewer system
- ☐ Field laptop/tablet and/or clipboard, field forms (customized with line items for IDDE observations), and pen/pencil
- ☐ GPS unit
- ☐ Camera, phone, or other device for taking pictures (with date and time stamp)

- ☐ Dry erase board and pen for labeling catch basins or manholes (optional)
- ☐ Tape measure
- ☐ Traffic control signs and orange cones
- ☐ Confined space entry equipment (if needed)
- ☐ Various catch basin/manhole hooks and wrenches (including hexagonal Allen key)
- ☐ Sledge hammer for loosening lids
- ☐ Safety equipment (for example, hard hats, work gloves, ANSI 107-1999 labeled safety vests, ear protection, steel-toe boots, gas monitor)
- ☐ Follow-up indicator sampling equipment (see Flow, Ammonia, Specific Conductivity, Color, Odor, pH, Temperature, and Visual Indicators sections)

Methods

The methods for conducting catch basin/manhole inspections as well as the format of the inspection form used can be modified by each jurisdiction as needed. The general methods for conducting catch basin/manhole inspections for source tracing are provided below.

> ***Notes:***
>
> *1) Only staff with confined space entry training should enter manholes or other confined spaces.*
>
> *2) Use traffic control and orange cones near catch basins/manholes to protect you and pedestrians from harm.*

1. Review maps and active construction permits to determine the area of the drainage basin where the illicit discharge might be originating from.
2. Select monitoring nodes where field sampling might quickly eliminate large portions of the drainage basin from further sampling while tracing the illicit discharge to its source.
3. Assess nearby traffic and potential hazards to pedestrians at each catch basin/manhole to be inspected. Review the Safety Considerations in Section 3.2 of this manual. Set up signs and cones as needed. Washington State Flagger Certification is required if placing cones in traffic; traffic flagging regulations must be followed.
4. Check the atmosphere within the manhole structure if you suspect that explosive or toxic gases may be present. Use a gas monitor (as you would during confined space entry).
5. Assign a unique number or identifier and record the latitude and longitude of the structure using a GPS unit if this has not previously been done.

6. Document any visual or olfactory indicators observed using a field notebook, customized catch basin/manhole maintenance inspection form, or a drop-down menu (for example, data dictionary) on a GPS unit.

7. Collect a sample if dry weather flow is observed and record values for follow-up field screening indicators selected based on Figure 4.1 and Figure 4.2. Refer to the Indicators section for additional detailed information regarding how these samples should be collected and analyzed.

8. Take a photograph if visual indicators are present. *Optional:* Use a dry erase white board next to the structure and include the date, time, structure ID, and inspector(s) initials.

9. Continue to the next monitoring node and repeat steps 3 through 8.

10. Return to the office and make sure that documentation from the field work is completed and downloaded. This includes hardcopy field forms, photographs, GPS data, and storm drainage system mapping updates delivered to GIS staff.

11. Conduct a second round of indicator sampling to confirm initial results if catch basin/ manhole inspection does not lead to the source of the discharge.

Pros and Cons

Pros	Cons
• Quick and inexpensive • Can test multiple storm drainage system branches that flow to a single manhole • Effective if storm drainage network is already mapped	• Some manholes will have flow continuously year round due to groundwater inflow • Traffic hazards and danger to pedestrians when accessing some catch basins/manholes • Potential for toxic or flammable pollutants and hazards if confined space entry is necessary • Can be time consuming and difficult if storm drainage map is unavailable or incomplete • Less effective in wet weather than dry weather • Wet weather safety considerations for confined space entry

Ditch Inspections

Description

Inspections of ditches and similar open channels or swales can help identify the source of illicit discharges, especially in rural areas that do not have piped stormwater conveyance systems. In addition to conveying stormwater flows from the municipal separate storm drainage system, ditches also receive flows with potential illicit discharges from adjacent private property via straight pipes, swales, or seepage from failing septic systems. Ditches may also convey natural flow and can be identified by their flow patterns and historical drainage patterns:

- If a ditch only flows during storm events or periods of site discharges and/or was specifically built to convey stormwater or discharge water, then it is not typically considered to be a ditch that conveys natural flow.
- If a ditch is located in an area where there historically was a stream, then it is likely that the ditch still conveys some natural flows.

Applications

Ditch inspections are most commonly conducted in rural areas, but can also be used in urban areas without piped storm drainage systems. Ditch inspections can be used in smaller drainage areas (up to two adjacent properties or at a road intersection where one or more ditches intersect) for source tracing.

Storm Drainage System Types	Land Use Types	Weather Conditions	Complementary Source Tracing Methodologies
• Ditches	• Rural • Urban • Agricultural • Commercial • Industrial • Mining • Residential	• Dry • Wet	• Septic System Inspections • Vehicle/Foot Reconnaissance

Equipment

The following recommendations for staffing and equipment apply specifically to ditch inspections:

☐ 2 field staff

- ☐ 1 to 2 vehicles
- ☐ Cell phones or 2-way radios
- ☐ Detailed maps of the storm drainage and sanitary sewer systems
- ☐ Field laptop/tablet and/or clipboard, field forms, and pen/pencil
- ☐ GPS unit (optional)
- ☐ Camera, phone, or other device for taking pictures (with date and time stamp)
- ☐ 25' or 50' flexible tape measure, string, or twine
- ☐ Sturdy boots or belted waders
- ☐ Safety equipment (for example, hard hats, work gloves, ANSI 107-1999 labeled safety vests, ear protection)
- ☐ Sledge hammer for loosening lids
- ☐ Machete and/or loppers
- ☐ Follow-up indicator sampling equipment (see Indicators section)

Methods

The methods for conducting ditch inspections as well as the format of the inspection forms used can be modified by each jurisdiction as needed. The following general guidance is recommended for completing ditch inspections.

> ***Notes:***
>
> *1) As a general rule, do not enter private property without permission from the landowner.*

1. Identify pairs of staff who will work together. The buddy system is recommended for field work for health and safety reasons. Review the Safety Considerations in Section 3.2 of this manual. Consider property access before heading into the field. Staff should carry a current ID and business cards when conducting field work.

2. Review GIS field maps of the properties or road intersections that will be investigated. Review active construction permits in the vicinity of the inspection area.

3. Walk along a ditch that is being inspected. It may be helpful to inspect the confluence of several ditches where they come together at nodes near road intersections.

4. Collect a sample if dry weather flow is observed and record values for follow-up indicators selected based on Figure 4.1 or Figure 4.2. Refer to the Indicators section for

additional detailed information regarding how these samples should be collected and analyzed.

5. Document evidence of the following:

   a. Discharge Locations:
      i. Cheater pipes (pipes that bypass the drain field of a septic system)
      ii. Other private drainage ditches or open channels

   b. Impacting Land Uses and Activities: visual observations
      i. Horse corrals and animal feed lots
      ii. Landscaping adjacent to ditches
      iii. Parking lots
      iv. Pastures with grazing animals adjacent to a ditch
      v. Other land uses that could generate illicit discharges

   c. Dump Sites: approximate area, distance to ditch, and type of debris
      i. Small debris (for example, bottles, cans, and trash)
      ii. Large debris (for example, shopping carts, abandoned cars, appliances, large quantities of yard waste [grass and yard clippings, piles of leaves], and/or miscellaneous pieces of junk)
      iii. Trash or improvised latrines from homeless encampments

Ditch inspection (Photo Credit: Herrera).

Cheater pipe (Photo Credit: Herrera).

6. Record the location of each item of interest in step 5 on a field map or using a GPS unit.

7. Take photographs of each item of interest.

8. Fill out a field form or use a GPS unit with drop-down menus (for example, data dictionary) to document all observations from the ditch inspection.

9. Follow internal notification procedures to ensure proper reporting to other agencies and appropriate timely follow up if an illicit discharge is identified.

10. Return to the office and make sure that documentation from the field work is completed and downloaded. This includes hardcopy field forms, photographs, GPS data, and storm drainage system mapping updates delivered to GIS staff.

11. Conduct a second round of indicator sampling to confirm initial results if ditch inspection does not lead to the source of the discharge.

Pros and Cons

Pros	Cons
• Can be used to locate unknown outfalls and update mapping • Effective in wet weather as well as dry weather	• Ditches can be difficult and even hazardous to access when vegetation is thick and/or when sides slopes are steep • Dense vegetation can make visual observations and finding outfalls or cheater pipes difficult • Access to ditches may be limited by permission to enter private property

Dye Testing

Description

Dye testing is a source tracing methodology typically used to pinpoint or isolate illicit connections in a smaller section of the storm drainage system, and may include testing the storm drainage system or plumbing fixtures at an individual facility. Dye testing is typically performed on all plumbing fixtures within a building (such as, sinks, toilets, and floor drains) using colored dyes. Dye is available in liquid, powder, strip, wax cakes and donuts, and tablet forms. The most commonly used color is fluorescent yellow-green; other colors include fluorescent red, orange, blue, and violet. Any dyes used for surface water testing must be non-toxic and biodegradable. Fluorescent dyes are easily detected with field fluorometer.

Applications

Dye testing is the most effective in small drainage areas (fewer than 10 properties). It is typically used once the likely source of an illicit discharge has been narrowed down to a few houses or businesses. This methodology is most effective for identifying continuous or intermittent discharges or connections. As an in-pipe methodology, dye testing can be complemented with the use of other in-pipe methodologies as noted in the table below.

Storm Drainage System Types	Land Use Types	Weather Conditions	Complementary Source Tracing Methodologies
• Pipes	• Urban • Commercial • Industrial • Residential	• Dry • Wet	• Catch Basin/Manhole Inspections • Smoke Testing • Video Inspections

Equipment

Equipment specific to dye testing includes:

- ☐ 2 or more staff
- ☐ 2-way radios or cell phones
- ☐ Dye (multiple colors; liquid powder, strip, wax, or tablet form)
- ☐ High-powered lamps or flashlights
- ☐ Field fluorometer with a rhodamine sensor (optional)
- ☐ Hose (optional)

- ☐ Camera, phone, or other device for taking pictures (with date and time stamp)
- ☐ Various catch basin/manhole hooks and wrenches (including hexagonal Allen key)
- ☐ Sledge hammer for loosening lids
- ☐ Activated charcoal packets (optional)
- ☐ Site utility plan (if available)
- ☐ Maps of storm drainage and sanitary sewer systems
- ☐ Field laptop/tablet and/or clipboard, field forms, and pen/pencil
- ☐ Facility/property owner contact information
- ☐ Safety equipment (for example, hard hats, work gloves, ANSI 107-1999 labeled safety vests, ear protection, steel-toe boots, traffic control equipment, gas monitor)

Methods

Prior to Testing

Field crews should implement the following steps prior to dye testing:

1. Review storm drain and sanitary sewer maps to identify lateral sewer connections and access points including building sanitary sewer as-built drawings.
2. Notify property owners to obtain permission to enter home/facility at least 2 weeks prior to dye testing. Provide the following information:
    a. Date(s) that dye testing will occur
    b. Reason for dye testing
    c. Numbers to call regarding any questions related to the dye testing
3. Notify agencies to avoid wasted efforts should the dye testing result in complaints or reports of discoloration in the receiving water body. The following agencies should be notified regarding when and where dye testing will be occurring, dye color(s) being used, and which water body the dye may end up in:
    a. The agency responsible for operating the sewage system (either the local sewer district or the local public health department)
    b. City and/or County water quality or Public Works staff and/or spill hotline

c. The Washington State Department of Ecology spill hotline

d. Any other agency that could be involved in spill reporting and clean-up (for example, City/County Roads Maintenance Division)

4. Obtain a site utility plan (if available) and identify fixtures that will be tested.

5. Identify form of dye (such as, tablets, liquid, strips, powder, wax cakes, wax donuts) that will be used.

During Testing

Field crews should implement the following steps during dye testing:

1. Review the Safety Considerations in Section 3.2 of this manual. Consider traffic control, confined space entry needs, and property access before heading into the field. Staff should carry a current ID and business cards when conducting field work.

2. Designate field staff positions (such as, dye tester and field verifier) and follow the steps outlined below:

> ***Notes:***
>
> *1) Only staff with confined space entry training should enter manholes or other confined spaces.*
>
> *2) Use traffic control and orange cones near catch basins/manholes to protect you and pedestrians from harm.*
>
> *3) As a general rule, do not enter private property without permission from the landowner.*

a. **Field verifier**: Select the closest sanitary sewer manhole for visual observations. Follow the field procedure for removal of manhole covers found in the Catch Basin/Manhole Inspections methodology. Monitor the manhole for toxic or flammable fumes before removing the lid completely.

b. **Dye tester:** Flush or wash dye down the fixture or manhole being tested and then contact the field verifier using a 2-way radio or cell phone. A different dye color should be used for each fixture and structure being tested. If dye tablets are being used, they can be dissolved before use in the fixture by being placed in a partially-filled water bottle and shaken. Use two tablets per bottle per dye test. Approximate dosages for several forms of dye are provided below. Refer to the instructions from the dye manufacturer for specific dosage information.

Form of Dye	Approximate Dosage
Liquid	1 oz per 500 gallons
Powder	1 lb per 16,000 gallons
Strips	1 strip per 500 gallons (or per toilet)
Wax cake	1 cake per up to 3,600 gallons (Bright Dyes)
Wax cone	1 cone per up to 12,000 gallons (Bright Dyes)
Wax donuts	1 donut per 8,000 gallons (Norlab) 1 donut per up to 93,000 gallons (Bright Dyes)
Tablets	2 tablets per test

Record the time the dye was introduced to the fixture on the site utility plan or a dye testing field form.

i. Residential: Flush dye down the toilet. Flush quickly and repeatedly to prevent staining. Run a nearby sink/bathtub for 5 to 10 minutes to ensure the dye is washed to the monitored sanitary manhole. Alternatively, dye can be placed in the sewer cleanout for the house and washed down using a hose connected to a nearby hose bib. Note that the dye may need to be flushed for up to 1 hour if sumps are present in the storm drainage system.

Dye test from a home thought to be illicitly connected to the storm drainage system (Photo Credit: City of Seattle).

ii. Commercial and Industrial: Flush dye down a restroom toilet, janitor's sink, and floor drains. Flush quickly and repeatedly with water to prevent staining. Run a nearby sink for 5 to 10 minutes to ensure that dye is washed down to the monitored sanitary manhole. Note that the dye may need to be flushed for up to 1 hour if sumps are present in the storm drainage system.

iii. Sanitary Sewer: Choose a sanitary manhole upstream of the stormwater outfall or upstream of where the sanitary sewer line crosses the storm drain line

Notes:

Dye tests typically last 20 to 30 minutes, but can last over an hour if sumps are present in the storm drainage system.

c. **Field verifier**: Use a high-powered lamp or flashlight or field fluorometer with a rhodamine sensor to check if the dye appears; take photographs if possible. If dye appears in the sanitary sewer manhole, immediately call the dye tester to relay this information and the time the dye was observed. This is a correct sanitary sewer connection. The dye tester should note the correct connection and immediately move on to the next dye test location.

d. **Field verifier**: If no dye is detected in the sanitary sewer manhole after 15 minutes of continuous water flow to the fixture, either an illicit sewage-to-stormwater connection may be present, or the fixture may be connected to another sanitary sewer main.

e. **Field verifier**: Attempt to locate the dye by checking downgradient storm drains or outfalls for the presence of dye, determining if the sewer line is clogged, and verifying that the facility is not connected to a septic system or to another sewer main. The fixture may need an additional round of dye testing conducted, since the dye may have already passed through the stormwater conveyance section by the

time the field verifier checks it. Make sure to use a different dye color and document the time of the second dye test.

i. For dark light conditions where it may be hard to see the dye, it is recommended to use fluorescent dye with a field fluorometer to verify the presence of dye.

ii. If dye does not surface in the storm drain after two or more dye tests at the same fixture, or if the field staff cannot wait for the dye to surface, secure activated charcoal packets any place where dye is expected to surface. Leave the activated charcoal packets in place for a week or two, then retrieve and analyze. Activated charcoal packets can be disposed of in the garbage or recharged for future use. Use of activated charcoal packets for dye testing may require additional training.

f. **Dye tester**: Record the date, time, dye color, and the fixtures that were tested on a site utility plan (if available) or develop a detailed sketch of the facility with this information.

3. Verify that all water has been turned off after testing fixtures and all manholes have been closed. Collect all testing equipment.

4. Notify the property owner(s) of the results of the dye testing

5. Conduct a second round of indicator sampling to confirm initial results if dye test does not lead to the source of the discharge.

Pros and Cons

Pros	Cons
• Dye is water soluble, biodegradable, stable, and has low toxicity • Dye is inexpensive • Effectively locates specific illicit connections • Quick (typically 20-30 minutes per test) • Easy to implement and to train staff to implement	• May be difficult to gain access to some properties • Time consuming in low flow conditions • May require follow up site visit if flow is too low at the time of the dye test • Can be difficult to see dye in high flow or turbid conditions • Requires notifying local public health and state water quality staff • Less effective during wet weather than dry weather

Pros and cons of various forms and colors of dye include the following:

Form/Color of Dye	Pros	Cons
Liquid	• Disperses quickly • Easy to use • Works well with moderate to large volumes of water (>20,000 gallons) • Input can be metered	• Potential for spilling and staining ground, equipment, and clothing.
Powder	• Works well with moderate to large volumes of water (>50,000 gallons) • Can be premixed in 5-gallon pails of water prior to usage in high wind environments and indoors	• Messier than liquid and strips, especially in high wind environments and indoors • Not effective unless dissolved completely • Moderate rate of dispersion
Strips	• Less cumbersome than liquid dye • Ideal for cold weather applications (will not freeze) • Ideal for indoor applications (nothing to spill) • Provides a measured dosage (individually packaged)	• Multiple strips may need to be used in a larger volume of flow
Wax cakes or donuts	• Works well with moderate to large volumes of water (20,000-50,000 gallons) • Can be suspended in water from a line, string, or mesh bag	• Slow to moderate rate of dispersion (approximately 3 to 5 hours)
Tablets	• Dissolves quickly (3 to 5 minutes) • Can release dye over a longer period of time than some of the other forms of dye • Works well with small volumes of water (<20,000 gallons)	• May need to be dissolved in a small amount of water prior to use
Yellow-green	• Typically provides the greatest contrast in murky water • Easier to see than non-fluorescent blue dye • Typically takes 2 to 3 days to degrade/fade	• Can be difficult to see in sunlight
Red	• Easier to see than yellow-green dye if large amounts of algae are present • Easier to see than non-fluorescent blue dye	• Typically takes 5 to 7 days to degrade/fade
Orange	• Easier to see than yellow-green dye if large amounts of algae are present • Easier to see than non-fluorescent blue dye	• Can be difficult to see if water contains significant amounts of naturally occurring orange or brown substances, such as iron bacteria or tannins
Blue	• Best used in high-light environments and in clear water • Color may be more aesthetically acceptable to the public than fluorescent dyes	• Typically takes 2 to 3 weeks to degrade/fade • Not as readily visible in dark water and against dark background, such as metal pipes.
Violet	• Best used in high-light environments and in clear water • Color may be more aesthetically acceptable to the public than fluorescent dyes	• Not as readily visible in dark water and against dark background, such as metal pipes.

Septic System Inspections

Description

Septic system inspections are a source tracing methodology that can be used to detect failing septic systems and locate illicit discharges in drainage basins with elevated concentrations of bacteria or nutrients. Failing septic systems produce an illicit discharge of sanitary wastewater, commonly called septage, through a breakout at the ground surface from a septic drain field or a straight pipe discharge (cheater pipe) where a property owner has intentionally bypassed the drain field of a septic system.

Applications

Septic system inspections are most commonly performed in rural areas, but also in some urban settings where homes are not connected to the sanitary sewer system. Detailed system inspections are often performed by County health department inspectors or private contractors, but City staff may conduct homeowner interviews or yard inspections. Some jurisdictions may have developed Pollution Identification and Correction (PIC) programs and Onsite Sewage System (OSS) Monitoring and Maintenance programs that refer to local regulations and authorities to address pollution caused by on-site septic systems. PIC Programs can help a jurisdiction prioritize and address water quality problem areas by educating owners and residents regarding proper septic system maintenance and corrective actions. Septic system inspections are the most effective for IDDE in small drainage areas (less than 10 properties) once the likely source of an illicit discharge has been narrowed down to a few houses or businesses. This methodology is most effective for identifying intermittent discharges or connections.

Storm Drainage System Types	Land Use Types	Weather Conditions	Complementary Source Tracing Methodologies
• Ditches	• Rural • Urban • Commercial • Industrial • Residential	• Dry • Wet	• Ditch Inspections • Dye Testing • Smoke Testing • Vehicle/Foot Reconnaissance

Equipment

Equipment specific to septic system inspections includes:

- ☐ 1 or 2 staff
- ☐ Camera, phone, or other device for taking pictures (with date and time stamp)

- ☐ Nitrile gloves
- ☐ Site plans (if available)
- ☐ Maps of nearby natural drainage systems
- ☐ Various catch basin/manhole hooks and wrenches (including hexagonal Allen key)
- ☐ Sledge hammer for loosening lids
- ☐ Field laptop/tablet and/or clipboard, field forms, and pen/pencil
- ☐ Safety equipment (for example, hard hats, work gloves, ANSI 107-1999 labeled safety vests, steel-toe boots, ear protection, safety glasses, traffic control equipment, gas monitor)

Methods

Four methods used to identify failing septic systems include: 1) homeowner interview and yard inspection, 2) detailed system inspection, and 3) canine scent tracking. Each method is briefly summarized below.

Homeowner Interview and Yard Inspection

The table below provides example questions for conducting a homeowner interview and questions that can be used as part of a checklist for performing a yard inspection. Appendix B also includes example septic system survey forms and questions. If property access is granted by the homeowner, both sets of questions can be used during the same site visit. It is helpful to compare the system capacity against water usage for the entire household to determine if the system may be overloaded. Typical water usage rates range from 50 to 100 gallons per day per person and a septic tank should be large enough to hold 2 days' worth of wastewater.

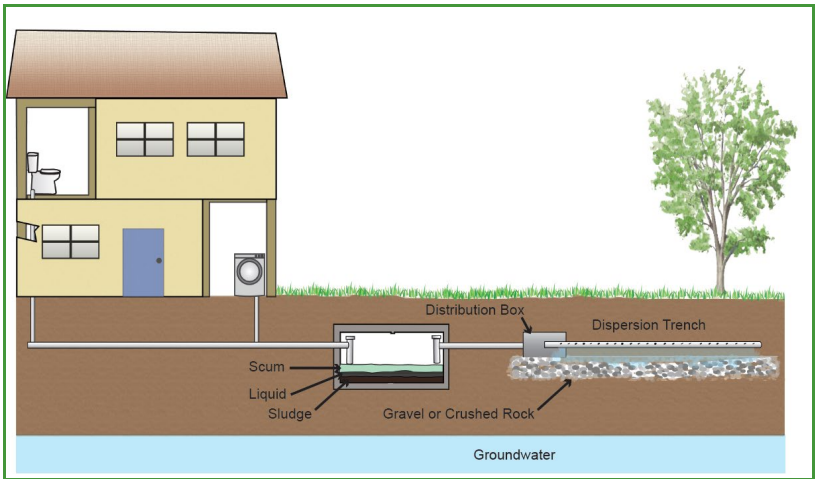
> ***Notes:***
>
> *1) As a general rule, do not enter private property without permission from the landowner.*

Homeowner Interview Questions	Yard Inspection Checklist Questions
How many years old is the septic system?	Is there visible liquid on the ground surface above the drain field (for example, surface breakouts)?
What is the septic tank capacity?	Are any obvious pipes installed to bypass a failing drain field?
When was the system last cleaned or maintained?	Are there wet, soft spots, sewage odors, lush green grass, or dead grass in the yard near the drain field?
Do the drains in the house empty slowly or not at all? Do toilets back up frequently?	Are any cars, boats, or other heavy objects located over the drain field that could crush lateral pipes?
How many people live at the residence?	Are there any cave-ins or exposed system components?
Is the septic tank effluent piped so it drains to a roadside ditch, storm drain, stream, or farm drain tile?	Is there an algae bloom or excessive weed growth in an adjacent ditch or stream?

Homeowner Interview Questions	Yard Inspection Checklist Questions
How many water-using machines do you have in your home (for example, washing machine, garbage disposal, dish washer, water softener, whirlpool tub)?	How many feet away from the drain field is the shore of a lake, stream, and/or stormwater ditch?
Do you have a sump pump that discharges to the septic system?	Have elevated levels of fecal coliform bacteria (or other bacterial indicators) been detected downstream from the home or in a nearby ditch and/or stream?
Do you have roof drains or floor drains that discharge to the septic system?	Are the maintenance holes accessible?

Detailed System Inspection

Homeowners can hire a certified professional to inspect their septic system if they notice odors, backups, or their system is not functioning properly. A typical inspection includes checking the integrity of the entire septic system to observe any leaks, broken pipes, or blockages. An inspection also includes measuring the depth of solids, estimating the distance to surface water and groundwater, and Dye Testing the system.



Components of a standard septic system that would be inspected during a detailed system inspection.

Canine Scent Tracking

Some jurisdictions in the United States use trained dogs to detect septage and surfactants in illicit discharges from failing septic systems. The dogs are typically trained as puppies and most dogs can learn to differentiate between fecal waste from animals versus from humans.

Pros and Cons

Pros	Cons
• Homeowner interviews and yard inspections are inexpensive and easy to perform • The results of interviews and inspections can often identify obvious illicit discharges • Using trained dogs, if available, can quickly and accurately identify an illicit discharge • Effective in wet weather as well as dry weather	• Homeowner interviews may be inconclusive if the homeowner is not knowledgeable about their septic system • Site-specific inspections require permission to access a property • A detailed system inspection can be expensive and time consuming to perform • Trained dogs are expensive to either contract with or to keep on hand.

Smoke Testing

Description

Smoke testing is a source tracing methodology that involves forcing a non-toxic, artificially-created smoke through a storm drainage system using a smoke blower or fan to find leaks and illicit connections to the system. Plumes of smoke will form where leaks or connections are present. Smoke testing has been used historically to identify areas of inflow or infiltration into the sanitary sewer system; however, its application to IDDE investigations of the storm drainage system is relatively new. While smoke testing can determine the source of direct discharges and connections, it is ineffective in identifying any indirect discharges to the storm system, such as spills or dumping.

Applications

Smoke testing is most effective when the illicit discharge has been isolated to a small drainage area (the upper reaches of the storm drainage network). It is useful when pipe diameters are too small for video inspections and gaining access to multiple properties makes dye testing an infeasible option. This methodology can be used to identify continuous, intermittent, or transitory discharges or connections.

Storm Drainage System Types	Land Use Types	Weather Conditions	Complementary Source Tracing Methodologies
• Pipes	• Urban • Commercial • Industrial • Residential	• Dry • Wet	• Business Inspections • Catch Basin/Manhole Inspections • Dye Testing • Vehicle/Foot Reconnaissance • Video Inspections

Equipment

Equipment specific to smoke testing includes:

- ☐ 2 or more staff
- ☐ Smoke source (smoke candle or liquid smoke)
- ☐ Smoke blower or fan (smoke candle blower or liquid smoke blower)
- ☐ Sewer plugs (sandbags or expandable plugs)
- ☐ Bucket and rope (if using smoke candle)

- ☐ Camera, phone, or other device for taking pictures (with date and time stamp)
- ☐ Handheld video camera (for documenting test, including views of all homes/businesses in range of test)
- ☐ Nitrile gloves
- ☐ Site plans (if available)
- ☐ Maps of storm drainage and sanitary sewer system
- ☐ Various catch basin/manhole hooks and wrenches (including hexagonal Allen key)
- ☐ Sledge hammer for loosening lids
- ☐ Field laptop/tablet and/or clipboard, field forms, and pen/pencil
- ☐ Safety equipment (for example, hard hats, work gloves, ANSI 107-1999 labeled safety vests, ear protection, steel-toe boots, traffic control equipment, gas monitor)

Smoke testing engine and liquid smoke in place during smoke test (Photo Credit: City of Seattle).

Methods

Prior to Testing

Field crews should implement the following steps prior to smoke testing.

Smoke test reveals connections to the storm drainage system (Photo Credit: City of Federal Way).

Different colored smoke candles used in a manhole (Photo Credit: Herrera).

1. Notify the public by letter at least 2 weeks prior to smoke testing. Provide the following information:
    a. Date(s) that smoke testing will occur
    b. Reason for smoke testing
    c. Methods to prevent smoke from entering homes
    d. Action to take if smoke enters homes
    e. Numbers to call and relay any health concerns regarding smoke testing
2. Notify the local fire and police departments of smoke testing at least 1 week before testing to warn them of potential calls from the public.
3. Remind the fire and police departments of smoke testing again on the day of testing; personnel from these departments may wish to be present at the smoke test.
4. Notify the public by door hanger notice the day or two prior to actual smoke test. Door-to-door visits by staff with pictures of smoke testing can also help to prepare the public, especially in neighborhoods where English is not the primary language. Provide same information specified above and included on the initial notification letter.
5. Conduct a second round of indicator sampling to confirm initial results if smoke testing does not lead to the source of the discharge.

During Testing

Field crews should implement the following steps during smoke testing.

> ***Notes:***
>
> *1) Only staff with confined space entry training should enter manholes or other confined spaces.*
>
> *2) Use traffic control and orange cones near catch basins/manholes to protect you and pedestrians from harm.*
>
> *3) As a general rule, do not enter private property without permission from the landowner.*

1. Review the Safety Considerations in Section 3.2 of this manual. Consider traffic control, confined space entry needs, and property access before heading into the field. Staff should carry a current ID and business cards when conducting field work.

2. Identify type of smoke (such as, smoke candle, liquid smoke) and type of blower (such as, smoke candle blower or liquid smoke blower) that will be used

3. Open the catch basin or manhole that leads to the branch of the storm drainage system suspected of an illicit connection

4. Seal off all storm drainage branches except one branch by using sandbags. See Sandbagging methodology (Appendix G) for more information on sandbag placement.

5. Set up the smoke blower by pointing it into the open catch basin or manhole

6. Designate field staff positions (such as, smoke tester and field verifier) and follow the steps outlined below:

    a. **Field Verifier:** Turn on the smoke blower.

    b. **Smoke Tester:** If using a smoke candle, light the candle and lower the it into the open catch basin using a bucket and aim the smoke candle blower into the open catch basin or manhole.

    c. **Smoke Tester:** If using liquid smoke, inject liquid smoke into the hot exhaust of the liquid smoke blower and aim blower into the open catch basin or manhole.

    d. **Field Verifier:** Observe the surrounding area for smoke escaping from leaks, internal plumbing fixtures, or sewers.

    e. **Field Verifier:** Document any visual evidence of smoke using a field notebook, customized smoke testing form, or using a drop-down menu (for example, data dictionary) on a GPS unit. Differentiate the source of smoke on building exteriors and roof tops. Smoke from gutters and downspouts indicate normal stormwater connections. Smoke from a soil stack (plumbing vent), floor drains, sinks, or interior plumbing fixtures indicates an illicit connection.

7. Conduct a second round of indicator testing to confirm initial results if smoke testing does not lead to the source of the discharge.

Additional considerations for smoke testing include:

- Online postings, community meetings, and news reports can be an effective way of notifying the public.
- Smoke escaping from floor drains, sinks or other plumbing fixtures inside buildings or from exterior soil stacks (plumbing vents that typically extend above the building roof) are indications of illicit sewer-to-stormwater conveyance connections. Note that many plumbing connections will have water standing in their P-traps (fitting outside the U-bend); this water typically prevents smoke from entering the fixture from the stormwater system if there is an illicit connection. However, neglected floor, sink or shower drains may have dried out P-traps that will allow smoke to pass through. A toilet with a bad wax ring may allow smoke to enter the house if an illicit connection is present. Exterior soil stacks (plumbing vents) should allow smoke to pass if an illicit connection is present.
- Smoke leaving gutters and downspouts of houses/businesses are indications of normal downspout-to-stormwater conveyance system connections and are **not** evidence of illicit connections. It is also normal for smoke to escape from storm drainage manholes, catch basins, or any structure intended for storm drainage conveyance.
- Smoke blowers can weigh up to 100 pounds.
- Any smoke testing equipment purchased for IDDE purposes can also be used to evaluate maintenance needs and check for leaks or damage of sanitary sewers or storm drainage pipes.

Pros and Cons

Pros	Cons
• Useful for finding cross connections from the sanitary sewer system • Can be used to verify mapping • Can identify other underground sources caused by storm drainage damage • Quick (about 30 minutes) • Inexpensive • Effective in wet weather as well as dry weather	• Must notify public in advance (2 weeks recommended) prior to smoke testing • More effective in inflow and infiltration investigations for sanitary sewer systems than in detecting illicit connections to storm drainage system • May cause irritation of respiratory passages • Not effective in identifying indirect discharges

Pros and cons of various forms of smoke include the following:

Form of Smoke	Pros	Cons
Liquid	• Easier to control than smoke candles • No shelf life • Less expensive to run per minute of smoke • Produces smoke for 45 to 60 minutes	• Not as visible as smoke candles • Does not travel as far as smoke candles • Petroleum-based oil • Requires a liquid smoke blower or liquid smoke conversion kit on a smoke candle blower
Candles	• Produces a denser smoke than the liquid form • Less expensive equipment than the liquid form • Compact • Can be biodegradable • Can be daisy-chained to lengthen tests (for example, 6, 9, or 12 minutes of smoke)	• Should be stored in a dry location • Has a shelf life of 1 to 2 years • Only generates smoke for approximately 3 minutes

Vehicle/Foot Reconnaissance

Description

Vehicle/foot reconnaissance is a source tracing methodology that can be used during dry or wet weather when attempting to trace an illicit discharge back to a source.

This methodology is most effective when used after a field screening methodology has narrowed down the drainage area to a smaller area or properties suspect of illicit discharge or illicit connections. As a source tracing methodology, foot reconnaissance relies on walking and investigating specific areas identified in the screening process.

Applications

Vehicle/foot reconnaissance is the most effective as a source tracing methodology in small drainage areas (a few businesses or properties) where the field crew is familiar with surrounding business operations. Vehicle/foot reconnaissance is typically followed by another source tracing methodology to confirm the source of any suspected illicit discharges.

Storm Drainage System Types	Land Use Types	Weather Conditions	Complementary Source Tracing Methodologies
• Pipes • Ditches	• Rural • Urban • Agricultural • Commercial • Industrial • Mining • Residential	• Dry • Wet	• Catch Basin/Manhole Inspections • Ditch Inspections • Dye Testing • Septic System Inspections • Smoke Testing • Video Inspections

Equipment

Equipment specific to vehicle/foot reconnaissance include:

- ☐ Vehicle
- ☐ Camera, phone, or other device for taking pictures (with date and time stamp)
- ☐ GPS unit
- ☐ Detailed maps of the storm drainage and sanitary sewer systems
- ☐ Field laptop/tablet and/or clipboard, field forms, and pen/pencil

Methods

Field crews should implement the following steps during a vehicle/foot reconnaissance survey.

1. Review maps and active construction permits to determine the area of the drainage basin where the illicit discharge might be originating from.

2. Walk by the businesses suspected in the drainage area for obvious illicit connections or discharges.

3. Document any visual, olfactory, or auditory indicators observed using a field notebook, customized vehicle/foot reconnaissance form, or using a drop-down menu (such as a data dictionary) on a GPS unit. Take photographs of potential sources of illicit discharges at businesses and residences in the drainage basin.

4. Interview neighboring homeowners or business owners/employees regarding their observations. Homeowner interviews can be conducted when the source of the illicit connection or illicit discharge is suspected to be originating in a residential area. On sites where property access has not been granted or the property owner is reluctant to talk, surrounding homeowners or business owners/employees can often be a good source of information. The table below provides example questions for conducting an interview with a neighboring homeowner or business owner/employee.

Neighboring Homeowner Interview Questions	Neighboring Business Owner/Employee Questions
Have you noticed any illegal dumping or improper storage of construction materials and household hazardous waste in your neighborhood?	Have you noticed any illegal dumping or improper storage of materials and hazardous waste at [the adjacent business]?
Have you noticed any issues with overfertilizing or overwatering in your neighborhood?	Have you noticed any issues with overfertilizing or overwatering at [the adjacent business]?
Have you noticed any leaking vehicles, garbage, or yard waste management problems in your neighborhood?	Have you noticed any issues with disposal of trash or dumping of oil, cleaning fluids, or other potentially toxic materials at adjacent businesses?
Have you observed any mobile contractors working in your neighborhood recently?	Are you aware of a new owner or new employees at [the adjacent business]?
Have you observed any new construction or remodeling occurring in your neighborhood recently?	Have you observed any new construction or remodeling occurring at [the adjacent business] recently?

5. Follow up with Dye Testing, Smoke Testing, or Video Inspections for obvious discharges that match the discharge downstream (for example gasoline discharge from a gas station; soapy discharge from a charity car wash or Laundromat).

6. Collect a sample using the methods outlined in the Catch Basin/Manhole Inspections or Ditch Inspections if the specific connection is not clear.

7. Conduct a second round of indicator sampling to confirm initial results using Catch Basin/Manhole Inspections, Ditch Inspections, or Outfall Inspections if vehicle/foot reconnaissance does not lead to the source of the discharge.

Pros and Cons

Pros	Cons
• Can quickly identify and direct resources to cleaning up illicit discharges if the potential source has been isolated to a few businesses • Uses existing staff and experienced field crews • Low cost • Can identify compounded discharges (for example, illegal paint dumping and pressure washing) • Can be combined with temporary mitigation measures (for example, sandbagging)	• Not very precise or conclusive by itself • Detects only the obvious illicit discharges • Always requires follow up with another source tracing methodology • Only useful if the discharge has unique characteristics that pertain to directly certain business activities • Limited usefulness for detecting illicit discharges in piped systems

Video Inspections

Description

Video inspections are typically used as a source tracing methodology when looking for an illicit connection (typically a sanitary sewer) between two manhole structures or along an isolated segment of the storm drainage system. Video inspections are performed using a sewer inspection camera to record activity and condition of the storm drainage system segment. Video inspections provide documentation of actively flowing illicit connections, grease buildup, and other deposits or conditions caused by illicit discharges. They are particularly helpful when an illicit connection from the sanitary sewer system is suspected in a smaller reach of the storm drainage system or when used to inspect potential cross connections from a single business. Video inspections can be used in smaller sections of a piped storm drainage system to identify the source of an illicit discharge or illicit connection after indicator sampling has triggered a follow-up investigation.

Storm Drainage System Types	Land Use Types	Weather Conditions	Complementary Source Tracing Methodologies
• Larger diameter pipes (>3 or 4 inches)	• Rural • Urban • Commercial • Industrial • Residential	• Dry • Wet	• Business Inspections • Catch Basin/Manhole Inspections • Dye Testing • Smoke Testing

Applications

Video inspections are the most effective in small drainage areas (section of the storm drainage system that flows to a single node) or at a single business and are typically used once the likely source of an illicit discharge has been narrowed down and when access to property is limited. This methodology is most effective for identifying continuous or intermittent discharges or connections. If an illicit discharge is suspected in a smaller reach of a piped system but the pipe diameter is too small for a video camera, Smoke Testing or Dye Testing should be considered as alternative source tracing methodologies.

Equipment

Different types of video equipment are used based on the diameter of storm drainage pipe being inspected. A site visit should be conducted prior to purchasing any video inspection equipment to determine the most appropriate video camera size, material, capabilities, and accessories. Equipment specific to video inspections includes:

- ☐ Closed-Circuit Television (CCTV), capable of radial view and in color. Camera options include:
  - Mini cameras (1.5-inch- to 4-inch-diameter pipes)
  - Lateral cameras (3-inch- to 8-inch-diameter pipes)
  - Mainline crawler/tractor cameras (4-inch- to 10-inch-diameter pipes)
- ☐ 200-to 400-foot push reel
- ☐ Tractor or crawler unit for camera
- ☐ Skid unit for camera
- ☐ Raft for camera (if water is present in storm pipe)
- ☐ Field laptop/tablet and/or clipboard, field forms, and pen/pencil
- ☐ Television system (truck, van, or utility trailer)
- ☐ High-powered lamps or flashlights
- ☐ Various catch basin/manhole hooks and wrenches (including hexagonal Allen key)
- ☐ Sledge hammer for loosening lids
- ☐ Safety equipment (for example, hard hats, work gloves, ANSI 107-1999 labeled safety vests, ear protection, steel-toe boots, traffic control equipment, gas monitor)

Methods

Each video camera and video inspection system will have different instructions depending on its manufacturer, intended application, and capabilities. It is important to read the instructions for each component of the video inspection system closely, as equipment is expensive and potential damage to equipment should be minimized as much as possible. In general, field crews should implement the following steps during and prior to a video inspection:

> ***Notes:***
>
> *1) Only staff with confined space entry training should enter manholes or other confined spaces.*
>
> *2) Use traffic control and orange cones near catch basins/manholes to protect you and pedestrians from harm.*
>
> *3) As a general rule, do not enter private property without permission from the landowner.*

1. Review the Safety Considerations in Section 3.2 of this manual. Consider traffic control, confined space entry needs, and property access before heading into the field. Staff should carry a current ID and business cards when conducting field work.

2. Determine the condition of the pipe segment being tested (such as, diameter, water ponding). If excessive debris or other material in the pipe is suspected, the pipe should be cleaned prior to conducting a video inspection.

3. Select an appropriately sized camera and camera navigation system for the pipe segment (for example, tractor or crawling unit, skid unit, raft). For smaller areas and pipes to single businesses, a smaller camera (mini camera) is recommended.

4. Orient the CCTV to keep the lens as close as possible to the center of the pipe.

5. Record a video with an audio voice over as the camera is guided through the pipe to document significant findings for future review and evaluation.

6. Follow the potential illicit discharge or connection up the storm drainage system using system maps

7. Notify the business or property owner of connection if a potential illicit discharge or connection is found.

8. Conduct a second round of indicator sampling using Catch Basin/Manhole Inspections, Ditch Inspections, or Outfall Inspections to confirm initial results if video inspection does not lead to the source of the discharge.

Pros and Cons

Pros	Cons
• Pinpoints exact location of breaks, infiltration, cross connections between manhole structures • Safer than confined space entry • Does not require intrusion on members of public	• Expensive, rig including cameras, monitors, trailers and associated equipment can be expensive • Only captures continuous discharges from pipes that are not submerged • Requires field crew training to operate equipment • May require line cleaning before equipment can be used • Specialized equipment needed for smaller diameter pipes • Debris and other obstructions can block off storm drainage pipe and restrict camera usage • Less effective in wet weather than in dry weather

Other Source Tracing Methodologies

The following source tracing methodologies are included in this manual with brief descriptions for reference and alternatives. Many of these have high cost of implementation and a specialized nature of the investigation, but can be researched by the investigator for usefulness and used on a case-by-case basis:

Other Source Tracing Methodologies	Description
Continuous Monitoring	This methodology can be used to track intermittent or unpredictable illicit discharges such as sewer cross connections, draining storage tanks, and swimming pools as well as to capture the variability in discharges over time. In this context, continuous monitoring refers to water quality monitoring using unattended, preprogrammed automated instruments (such as a sonde, cold flush technology, or data loggers) in catch basins, manholes, and/ or outfalls to measure temperature, pH, specific conductivity, and/or dissolved oxygen, among other parameters. The results can complement automated sampling and help to determine if a location has an illicit connection or illicit discharge or if further indicator testing is needed. With cellular, satellite, or another telemetry connection, data from continuous monitoring can be viewed in real-time (or near real-time) if an instrument is programmed to send data to a cloud-based network platform.
Optical Brightener Monitoring	Optical brighteners are fluorescent white dyes that are used in laundry soaps and detergents to enhance the appearance of fabric and paper. Optical brightener monitoring involves anchoring an absorbent pad in a pipe, catch basin, manhole, or inlet to capture intermittent dry weather flows to determine if detergents are present. See Appendix G for details.
Pressure Testing	Pressure testing can be helpful in limited circumstances where a leak or break is suspected in a pressured pipe, such as a water or irrigation pipe, that could be contributing to dry weather (and wet weather) flow in a storm drainage pipe.
Sandbagging	Sandbagging is used to catch intermittent discharges by sealing off flow in the storm drain, followed by sampling. In addition to sandbags, other materials (for example, beach balls, expandable plugs, or caulk dams) can be used to block flow. See Appendix G for details.

6. REFERENCES

Aspect Consulting. 2019a. Technical memo: IC-ID Feedback Workshops and Survey, Illicit Connection and Illicit Discharge Field Screening and Source Tracing Guidance Manual Update. May.

Aspect Consulting. 2019b. Technical memo: IC-ID Literature Review, Illicit Connection and Illicit Discharge Field Screening and Source Tracing Guidance Manual Update. June.

Aspect Consulting. 2019c. Technical memo: IDDE Data Review, Illicit Connection and Illicit Discharge Field Screening and Source Tracing Guidance Manual Update. August.

CWP. 2004. Illicit Discharge Detection and Elimination – A Guidance Manual for Program Development and Technical Assessments. Center for Watershed Protection, Ellicott City, Maryland. October.

Ecology. 2005. Stormwater Quality Survey of Western Washington Construction Sites, 2003-2005. Publication 05-03-028. Prepared by the Washington State Department of Ecology. August.

Ecology. 2018. Standard Operating Procedure for Automatic Sampling for Stormwater Monitoring. Publication No. 18-10-024. Prepared by the Washington State Department of Ecology. July.

Ecology. 2019a. Phase I Municipal Stormwater Permit, effective date August 1, 2019. Prepared by the Washington State Department of Ecology.

Ecology. 2019b. Western Washington Phase II Municipal Stormwater Permit, effective August 1, 2019. Prepared by the Washington State Department of Ecology.

Ecology. 2019c. Eastern Washington Phase II Municipal Stormwater Permit, effective August 1, 2019. Prepared by the Washington State Department of Ecology.

Ecology. 2019d. Focus on Municipal Stormwater: General Condition G3 Reporting. Publication No. 07-10-089 (revised November 2019). Prepared by the Washington State Department of Ecology Water Quality Program. November.

Evergreen Safety Council. 2012. Traffic Control Flagger Certification Handbook, Fourth Edition. Prepared by the Evergreen Safety Council of Seattle, Washington.

Federal Highway Administration. 2012. Manual on Uniform Traffic Control Devices for Streets and Highways. 2009 edition (including Revision 1 dated May 2012 and Revision 2 dated May 2012). May.

King County. 2011. King County Dry Weather Outfall Reconnaissance Inventory (ORI) Standard Operating Procedures (SOP). SOP ID No. 2011-01. Prepared by King County Department of Natural Resources and Parks, Water and Land Resources Division, Stormwater Services Section. January.

Kitsap County. 2011. Illicit Discharge Detection and Elimination Program Summary Report 2000–2010: A Comparison of Outfall Screening, Reporting, and Inspection Programs. Prepared by Kitsap County Department of Public Works Surface and Stormwater Management Program, Kitsap County, Washington. July.

Lake County. 2009. Stormwater Management Program Plan. Prepared by The Lake County Stormwater Management Commission, The Village of Mundelein, and Bleck Engineering Company, Inc. April 20.

Lower Charles River. 2004. Lower Charles River Illicit Discharge Detection & Elimination (IDDE) Protocol. November.

North Central Texas. 2011. Illicit Discharge Detection & Elimination (IDDE) Field Investigation Guide.

Pitt, R. 2001. Methods for Detection of Inappropriate Discharges to Storm Drainage Systems Background Literature and Summary of Findings. November.

Snohomish County. 2010. Dry Weather Outfall Screening Manual. Prepared by Snohomish County Public Works, Surface Water Management Division, Snohomish County, Washington.

USGS. 2014. National Field Manual for the Collection of Water Quality Data (Chapter A2: Selection of Equipment for Water Sampling). Prepared by the United States Geological Survey. April.

Wayne County. 1996. Summary of Illicit Connection Detection Programs in Michigan Technical Memorandum. Prepared by the Rouge River Project, Wayne County, Michigan. February 19.

7. INDEX

Suspected Source	Primary Field Screening Indicator(s)	Follow-Up Indicator(s)	Recommended Source Tracing Methodologies
Cleaning chemicals	Odor	Detergents/ Surfactants	• Business inspections • Vehicle/foot reconnaissance
Construction site runoff	• Color • pH • Turbidity	Specific Conductivity	• Catch basin/manhole inspections • Vehicle/foot reconnaissance • Video inspections
Gasoline, vehicle oil, or grease	• Odor • Visual Indicators	Total Petroleum Hydrocarbons	• Catch basin/manhole inspections • Vehicle/foot reconnaissance
Human/animal waste	• Ammonia • Odor • Temperature • Visual Indicators	• Bacteria • Nitrate	• Catch basin/manhole inspections • Septic system investigation • Vehicle/foot reconnaissance
Industrial operations	• Color • Odor • Temperature	• Hardness • Specific Conductivity	• Catch basin/manhole inspections • Vehicle/foot reconnaissance • Video inspections
Industrial process water	• Temperature • Visual Indicators	• Hardness • Specific Conductivity	• Catch basin/manhole inspections • Vehicle/foot reconnaissance • Video inspections
Nutrient-rich discharge	Visual Indicators	Nitrate	• Ditch inspections • Vehicle/foot reconnaissance
Sanitary wastewater or sewage	• Ammonia • Color • Odor • Temperature • Visual Indicators	• Bacteria • Nitrate	• Catch basin/manhole inspections • Dye testing • Smoke testing • Vehicle/foot reconnaissance • Video inspections
Tap water	• Color • Odor	Chlorine or Fluoride	• Catch basin/manhole inspections • Ditch inspections • Vehicle/foot reconnaissance
Washwater	• Color • Odor • Temperature • Visual Indicators	• Detergents Surfactants • Specific Conductivity	• Business inspections • Catch basin/manhole inspections • Vehicle/foot reconnaissance

APPENDIX A

Field Screening, Source Tracing, and Indicator Sampling Equipment Costs

FIELD SCREENING, SOURCE TRACING, AND INDICATOR SAMPLING EQUIPMENT COSTS

This appendix includes costs specific to the field screening methodologies, source tracing methodologies, and indicator sampling included in the Illicit Connection and Illicit Discharge Field Screening and Source Tracing Guidance Manual. These costs are based on a preliminary assessment of equipment vendors and suppliers, and further research should be conducted to obtain costs more specific to each jurisdiction's needs. Equipment, vendors, and costs are expected to change over time and more recent data should be used in the future. The authors and clients or any other governmental agency referenced in this appendix do not promote, endorse, or otherwise recommend any of the companies, individuals, or organizations presented here. Costs and equipment are provided for informational purposes only and does not represent a complete list of vendors or equipment.

FIELD SCREENING AND SOURCE TRACING METHODOLOGY EQUIPMENT COSTS

The following standard items are not included in the equipment costs summarized in this appendix, but may be required for a field screening or source tracing methodology:

- Local stormwater code or manuals
- Best Management Practices (BMP) handouts and outreach materials
- Inspection and maintenance checklists/forms (see examples in Appendix B)
- Camera, phone, or other device for taking pictures
- Site plans
- Maps of sanitary and storm drainage systems
- Various wrenches (including hexagonal Allen key)
- Field laptop/tablet (with charged battery) and/or clipboard, field forms (customized with line items for illicit discharge observations), and pen/pencil
- Facility/property owner contact information

- Safety equipment (for example, hard hats, work gloves, ANSI 107-1999 labeled safety vests, steel-toe boots, traffic control equipment, gas monitor)
- Cell phones or 2-way radios
- GPS unit
- Dry erase board and pens
- Tape measure
- Traffic control and orange cones
- Vehicles
- Hose
- Machete and/or loppers
- Rope
- Batteries for electronic devices

Tables A-1 and A-2 display the approximate cost of equipment specific to each field screening methodology and source tracing methodology, respectively, along with the name and website uniform resource locator (URL) for potential vendors.

Table A-1. Field Screening Methodology Equipment Costs.					
Field Screening Methodology	**Equipment Type**	**Quantity/ Description**	**Equipment Cost (in 2020)[a]**	**Vendor Name(s)**	**URL**
Catch Basin/ Manhole Inspections	High powered lamps or hand-held spotlights	Various	$30–80	Amazon Dicks Sporting Goods Home Depot	www.amazon.com www.dickssportinggoods.com www.homedepot.com
	Mirror and pole	Extendable 4 to 12-foot pole with mirror	$100	Heavy Duty Supplies	https://heavydutysupplies.com
	Manhole cover hook or lid lifter	24- to 42-inch length	$20–100	Grainger	www.grainger.com
Ditch Inspections	No special equipment required (standard items only)				
Outfall Inspections	High powered lamps or hand-held spotlights	Various	$30–80	Amazon Dicks Sporting Goods	www.amazon.com www.dickssportinggoods.com
Video Inspections	Refer to Table A-2				

[a] Equipment costs do not include sales tax or shipping costs.

Table A-2. Source Tracing Methodology Equipment Costs.					
Source Tracing Methodology	**Equipment Type**	**Quantity/ Description**	**Equipment Cost (in 2020)[a]**	**Vendor Name**	**URL**
Business Inspections	No special equipment required (standard items only)				
Dye Testing	Liquid dye	1 gallon	$80–140	Bright Dyes Norlab Inc.	www.brightdyes.com www.norlabdyes.com
	Powder dye	1 lb.	$70–120	Bright Dyes Cole-Parmer Norlab Inc.	www.brightdyes.com www.coleparmer.com www.norlabdyes.com
	Dye wax cakes	2-oz cakes, 10 pack	$100–130	Bright Dyes USA Blue Book	www.brightdyes.com www.usabluebook.com
	Dye strips	100 strips	$112	Norlab Inc.	www.norlabdyes.com
	Dye tablets	200 tablets	$55–70	Bright Dyes USA Blue Book	www.brightdyes.com www.usabluebook.com
	Dye wax donuts or forms	32 oz.	$150–200	Bright Dyes Grainger USA Blue Book	www.brightdyes.com www.grainger.com www.usabluebook.com
	High powered lamps or hand-held spotlights	Various	$30–80	Amazon Dicks Sporting Goods	www.amazon.com www.dickssportinggoods.com
	Charcoal packets	1,500 2-gram packets	$80	Adsorbents & Desiccants Corporation of America	www.adcoa.net

Table A-2 (continued). Source Tracing Methodology Equipment Costs.					
Source Tracing Methodology	**Equipment Type**	**Quantity/ Description**	**Equipment Cost (in 2020)[a]**	**Vendor Name**	**URL**
Septic System Inspections	No special equipment required (standard items only)				
Smoke Testing	Smoke candles	30 seconds (12 candles) 1 minute (12 candles) 2–3 minutes (12 candles)	$65 $70 $120	USA Blue Book	www.usabluebook.com
	Liquid smoke (or "smoke fluid")	1 gallon 5 gallons 55 gallons	$60 $225 $1,500	USA Blue Book	www.usabluebook.com
	Smoke blower	For smoke candles	$40–350	Home Depot	www.homedepot.com
		For liquid smoke	$2,000	USA Blue Book	www.usabluebook.com
	Sewer plugs	Pneumatic or test-ball pipe plug	$60–220 (varies based on size)	Grainger	www.grainger.com
Vehicle/Foot Reconnaissance	No special equipment required (standard items only)				
Video Inspections	Closed-Circuit Television (CCTV)	Push camera with 200-foot push rod	$8,000–13,000	Ultimate Washer Inspector Tools Fiberscope	www.ultimatewasher.com www.inspectortools.com www.fiberscope.net
	Pole camera	Quickview airHD camera mounted on extendable pole (up to 16 feet)	$15,000; laser measurement add-on for $1,600	Envirosight	www.envirosight.com
	Crawler unit and camera	Crawler camera and crawler unit, extendable cable	$15,000–32,000	Owen Equipment Envirosight Insight Vision	www.owenequipment.com www.envirosight.com www.insightvisioncameras.com
	Skid unit for camera	Universal roller skid for 6- to 12-inch lines	$440	Fiberscope	www.fiberscope.net

Table A-2 (continued). Source Tracing Methodology Equipment Costs.					
Source Tracing Methodology	**Equipment Type**	**Quantity/ Description**	**Equipment Cost (in 2020)[a]**	**Vendor Name**	**URL**
Video Inspections (cont'd)	Portable mainline systems	CCTV inspection workstation *Note: unit can be mounted on truck or ATV, not included in price	TBD	Subsite Electronics	www.subsite.com
	High powered lamps or hand-held spotlights	Summer: 3 million candle power, rechargeable	$30–80	Amazon Dicks Sporting Goods	www.amazon.com www.dickssportinggoods.com
Other Source Tracing Methodologies (Continuous Monitoring)	TidbiT® waterproof temperature data logger	Records more than 42,000 12-bit measurements, waterproof to 1,000 feet	$133	Forestry Suppliers MicroDAQ	www.forestry-suppliers.com www.microdaq.com
Other Source Tracing Methodologies (Sandbagging)	Sandbags	Empty woven 14" x 26" polypropylene sandbags (per bags)	$0.35–0.85 each	Home Depot Salmon Bay Sand and Gravel	www.homedepot.com www.sbsg.com

Table A-2 (continued). Source Tracing Methodology Equipment Costs.					
Source Tracing Methodology	**Equipment Type**	**Quantity/ Description**	**Equipment Cost (in 2020)[a]**	**Vendor Name**	**URL**
Other Source Tracing Methodologies (Optical Brightener Monitoring)	Absorbent, unbleached cotton pads	Pack of 100 (4" x 4")	$27	VWR International	us.vwr.com/store
	Wire or monofilament fishing line	yards	$15–25	Cabelas	www.cabelas.com
	4- to 6-watt ultraviolet fluorescent light	6-watt long wave (365nm) hand-held UV lamp	$390	Fisher Scientific	www.fishersci.com
	Plastic or vinyl coated wire bin, box, or cage (or window screen and PVC pipe)	1/2" mesh (approx. 5" x 5")	$10	Container Store Home Depot Lowe's	www.containerstore.com www.homedepot.com www.lowes.com
	Plastic mesh	1/2" mesh (3' x 15' roll)	$30	Home Depot	www.homedepot.com

[a] Equipment costs do not include sales tax or shipping and handling costs.

Lb: pound

Nm: nanometer

Oz: ounce

Sf: square feet

TBD: to be determined

UV: ultraviolet

Indicator Sampling Costs

The following items are not included in the equipment costs summarized in this appendix, but may be required for indicator sampling:

- Stopwatch
- Flexible tape measure
- Camera, phone, or other device for taking pictures
- Field laptop/tablet (with charged battery) and/or clipboard, field forms (customized with line items for illicit discharge observations), and pen/pencil
- Labels for sample bottles
- Safety equipment (for example, hard hats, ANSI 107-1999 labeled safety vest)
- Sturdy boots or belted waders
- Telescoping sampling pole
- Tap water
- Distilled water
- Containers for waste sample water and used reagent solution

Tables A-3 and A-4 display the approximate cost of equipment specific to each primary field screening or follow-up indicator, respectively, along with the name and web site uniform resource locator (URL) for potential vendors. Certain indicator tests are more expensive or difficult to conduct. In these cases, it may be more efficient to send samples to the laboratory to be analyzed; analytes for laboratory analyses may include bacteria, (*E. coli* and fecal coliform) specific conductivity, total petroleum hydrocarbons, nitrate/nitrite, surfactants, and hardness, for example. Information and guidance on selecting an accredited environmental laboratory in Washington State can be found here: <https://ecology.wa.gov/Regulations-Permits/Permits-certifications/Laboratory-Accreditation>.

Note; however, that although the sample will be analyzed in the laboratory, the sample must be collected in the field and therefore the general indicator sampling equipment summarized in Tables A-3 and A-4 is still recommended.

Table A-3. Primary Field Screening Indicator Sampling Equipment Costs.

Indicator	Equipment Type	Quantity/Description	Equipment Cost (in 2020)[a]	Vendor Name	URL
General Indicator Sampling	Nitrile gloves	Disposable nitrile gloves (100 count)	$15	Home Depot	www.homedepot.com
	Claw grabber	48-inch (or longer) claw grabber	$20–40	Amazon Home Depot	www.amazon.com www.homedepot.com
	Swing sampler/telescopic dipper	Extendable 12-foot fiberglass pole with bottle holder (up to 1,000 mL)	$90–130	Forestry Suppliers CONBAR	www.forestry-suppliers.com www.conbar.com
	Laboratory grade cleaning wipes	140 sheets per box (Kimwipes), also available in other quantities and sizes	$10	Staples (and various other vendors)	www.staples.com
	Wash bottle	250 or 500 mL, leakproof wide mouth polypropylene	$8–10	Forestry Suppliers (and various other vendors)	www.forestry-suppliers.com
	Sample bottles	250 or 500 mL, clear plastic, wide mouth bottles (24 or 12 per case) or clear or amber glass, wide mouth bottles (12 per case)	$20–30	Environmental Sampling Supply	www.essvial.com
Flow	Bucket	5-gallon	$3	Home Depot	www.homedepot.com
	Tracing dye	Refer to dye testing equipment costs in Table A-2			
	Floatable item	Cork, orange, rubber ball, or stick (minimal or no cost)			
	Flow meter	Flow (or velocity/depth) meter, datalogger, and telescoping wand or top set wading rod	$2,100–6,000	Swoffer Instruments, Inc. Hach	www.swoffer.com www.hach.com
Ammonia	Ammonia field test kit (Salicylate method)	Measures 0–2.4 mg/L (or 3.0 mg/L), 100 tests	$100	Hach Hanna	www.hach.com www.hannainst.com
	Ammonia field test kit (Hydroxybenzyl Alcohol [HBA] method)	Measures 0–4 and 0–80 mg/L (or 0–125 and 0–2,500 mg/L), 30 tests Test kit refills, 30 ampoules	$60–80 $30	CHEMetrics, Inc.	www.chemetrics.com
	Direct-readout photometer (or alternative spectrophotometer)	Instrumental HBA method with Ammonia Vacu-vials® Kit (0–3 and 0–60 ppm), 30 tests	$1,410	CHEMetrics, Inc.	www.chemetrics.com
	Ammonia test strips	Measures 0–6.0 mg/L, 25 tests	$25	Hach	www.hach.com
	Ammonia ion probe (with multimeter)	Multimeter with ammonia ion probe and 1-meter cable, measures 0–200 mg/L	$2,500	YSI	www.ysi.com
Color	Color test kit	Measures color in Platinum Cobalt Units (PCU)	$100	Hach	www.hach.com
Odor	No special equipment required				
pH	pH meter and accessories	–	$330–500	Cole Parmer YSI	www.coleparmer.com www.ysi.com
	pH test strips (0–14 range)	Measures pH 1–14, 100 strips per pack	$30	Hach	www.hach.com
	Buffer solutions	500 mL each of pH 4.01, 7.00, and 10.01	$30	Hach	www.hach.com
	pH electrode storage solution	60 mL, package of 5 bottles	$70	Cole Parmer	www.coleparmer.com
Temperature	Temperature probe only (does not include multimeter)	Measures 0–80°C	$205–260	Hach	www.hach.com
Turbidity	Turbidity (or Secchi) tube	60 cm	$50	Forestry Suppliers	www.forestry-suppliers.com
	Turbidity meter	Measures 0–1,000 NTU	$1,120–1,340	Hach Forestry Suppliers	www.hach.com www.forestry-suppliers.com
	Turbidity standard solutions	500 mL of 4,000 NTU	$40	Hach	www.hach.com
		60 mL of 0 NTU	$40	Forestry Suppliers	www.forestry-suppliers.com
Visual Indicators	No special equipment required				

[a] Equipment costs do not include sales tax or shipping and handling costs.

°C: degrees Celsius ft: feet mg/L: milligrams per liter mL: milliliter NTU: nephelometric turbidity units

this page blank for back of 11 x 17 table

Table A-4. Follow-Up Indicator Sampling Equipment Costs.

Indicator	Equipment Type	Quantity/Description	Equipment Cost (in 2020)[a]	Vendor Name	URL
General Indicator Sampling	Nitrile gloves	Disposable nitrile gloves (100 count)	$10–15	Home Depot	www.homedepot.com
	Claw grabber	48-inch (or longer) claw grabber	$20–40	Amazon Home Depot	www.amazon.com www.homedepot.com
	Swing sampler	Extendable fiberglass pole (6' to 24') with bottle holder (up to 1,000 mL)	$140–170	Forestry Suppliers	www.forestry-suppliers.com
	Telescopic dipper	Extendable aluminum sampling poles (8' to 24'); swivel adapter and ladles can be added	$80–140	CONBAR	www.conbar.com
	Laboratory grade cleaning wipes	140 sheets per box (Kimwipes), also available in other quantities and sizes	$10	Staples (and various other vendors)	www.staples.com
	Wash bottle	250 or 500 mL, leakproof wide mouth polypropylene	$8–10	Forestry Suppliers (and various other vendors)	www.forestry-suppliers.com
	Sample bottles	250 or 500 mL, clear plastic, wide mouth bottles (24 or 12 per case) or clear or amber glass, wide mouth bottles (12 per case)	$20–30	Environmental Sampling Supply	www.essvial.com
Bacteria (*E. coli*)	*E. coli* laboratory test	–	$90	Various laboratories	NA
	Coliscan© Easygel©	Coliscan© Easygel© test kit (medium in bottles and petri dishes)	$2–3/test	Micrology Labs Weber Scientific	www.micrologylabs.com www.weberscientific.com
	Poultry egg incubator	Hova Bator Little Giant Egg Incubator 9300 without (or with) circulated fan	$50–80	Incubator Warehouse	www.incubatorwarehouse.com
	Pipette(s)	5 mL, plastic disposable (package of 500)	$30	eNasco	www.enasco.com
		5 mL, mechanical (1 pipette) Disposable pipette tips for mechanical pipette (250 tips)	$300 $40	Pipettes.com, Inc.	www.pipettes.com
	E. coli test kit	Lamotte® Total Coliform and E. coli Test Kit, presence/absence, 5 tests	$20	Forestry Suppliers	www.forestry-suppliers.com
Bacteria (Fecal Coliform)	Fecal coliform bacteria laboratory test	–	$40	Various laboratories	NA
Chlorine and Fluoride	Chlorine test strips	Measures 1–10 mg/L, 50 test strips	$20	Hach	www.hach.com
	Chlorine test kit	Measures 0.02–0.7 mg/L or 0–10 mg/L, 100 tests	$140	Hach	www.hach.com
	Chlorine digital colorimeter	Measures 0–2.0 mg/L	$1,500	Hach	www.hach.com
	Chlorine standard solution	Pack of 25 ampules (for 0–2.0 mg/L)	$30	Hach	www.hach.com
	Chlorine reagent	10 mL, pack of 100	$25	Hach	www.hach.com
	Fluoride test kit	Measures 0–2.0 mg/L, 50 tests	$75	Cole Parmer	www.coleparmer.com
	Fluoride field meter	Measures 0–2.0 or 0.1–10.0 mg/L	$50–250	Grainger Industrial Supply Hanna	www.grainger.com www.hannainst.com
	Fluoride digital colorimeter	Measures 0–2.0 mg/L	$1,500	Hach	www.hach.com
	Fluoride standard solution	500 mL of 0.5 mg/L or 1 mg/L	$25–40	Hach Labchem	www.hach.com www.labchem.com
	Fluoride reagent	Pack of 25 ampules (for 0–2.0 mg/L) for digital colorimeter	$40	Hach	www.hach.com
Detergents/Surfactants	Surfactant test kit	Measures 0–3.0 mg/L, 20 tests	$100	CHEMetrics	www.chemetrics.com
	Surfactant digital colorimeter	Measures 0–2.0 mg/L	$1,500	Hach	www.hach.com
	Surfactants laboratory analysis	–	$50	Various laboratories	NA
Hardness	Hardness test strips	Measures 0–25 mg/L and 0–425 mg/L, 50 tests	$15	Hach	www.hach.com
	Hardness test kit	Low range (0–20 mg/L), or high range (20–40 mg/L), 100 tests	$35–70	Hach	www.hach.com
	Hardness buffer solution	100 mL	$20	Hach	www.hach.com
	Hardness laboratory analysis	–	$20–65	Various laboratories	NA

blank for back of 11 x 17 table

Table A-4 (continued). Follow-Up Indicator Sampling Equipment Costs.

Indicator	Equipment Type	Quantity/Description	Equipment Cost (in 2020)[a]	Vendor Name	URL
Nitrate	Nitrate test strips	Measures nitrate 0–3 mg/L and nitrite 0–50 mg/L, 25 tests	$25	Hach	www.hach.com
	Nitrate probe (with multimeter)	Multimeter with nitrate probe and 1-meter cable, measures 0–200 mg/L	$2,260	YSI	www.ysi.com
	Nitrate standard	500 mL of 1 mg/L for use with multimeter	$90	YSI	www.ysi.com
	Nitrate + Nitrite laboratory analysis	–	$20–25	Various laboratories	NA
Specific Conductivity Total Petroleum Hydrocarbons	Conductivity standard solutions	Various standard solutions, from 147 to 18,000 µS/cm	$20–60	Hach	www.hach.com
	Conductivity meter	0.01–200,000 µS/cm (200 mS/cm)	$600–1,700	Hach YSI	www.hach.com www.ysi.com
	Specific conductivity laboratory analysis	–	$10–20	Various laboratories	NA
	TPH laboratory analysis	–	$50–145	Various laboratories	NA
Multiple Parameters	5-in-1 Water Quality Test Strips	Intended to measure free chlorine (0–10 mg/L), total chlorine (0–10 mg/L), total hardness (0–425 mg/L), pH (6.2–8.4); 50 tests	$20	Hach	www.hach.com
	Multimeter	Field meter with probe for measuring pH, specific conductivity, dissolved oxygen, and temperature	$1,900	Hach	www.hach.com
	Digital colorimeter	Measures over 40+ parameters including chlorine, fluoride, and detergents/surfactants	$1,400–1,500	CHEMetrics, Inc. Hach	www.chemetrics.com www.hach.com
Total Petroleum Hydrocarbons	Spectrophotometer	Measures over 40+ parameters including chlorine, fluoride, and detergents/surfactants	$3,640	Hach	www.hach.com

[a] Equipment costs do not include sales tax or shipping and handling costs.

Ft: feet
g/L: grams per liter
mg/L: milligrams per liter
mL: milliliters
M: Molar
NA: not applicable
µs/cm: microsiemens per centimeter

blank for back of 11 x 17 table

Basic, Intermediate, and Advanced Sampling Equipment Recommendations

Three groupings, or tiers, of equipment are provided here to help jurisdictions consider basic, intermediate, and advanced "toolboxes" of equipment for IDDE programs. Jurisdictions that already have developed their IDDE programs can continue with their current approach if it appears to be working well. Equipment can be selected from various tiers or replaced with comparable sampling equipment or laboratory analysis summarized in the main text of this manual or in Tables A-1 through A-4 included in this appendix.

The following three tiers are based on the cost for purchasing equipment for field screening, source tracing, and indicator sampling in-house. It should be noted; however, that a different cost may be associated with contracting out IDDE work than is estimated for implementing the IDDE work in-house. This appendix does not include costs for contracting out IDDE work, but these costs should be considered if purchasing IDDE related equipment and materials is not feasible.

Tier 1 – Basic IDDE Equipment List

Tier 1 assumes a basic IDDE program with equipment for sampling the primary field screening indicators, one follow-up indicator (detergents/surfactants), and one source tracing technique (dye testing). Turbidity sampling is assumed to be performed using visual observations. Table A-5 identifies the specific equipment required for a basic "toolbox" of equipment for IDDE programs. The approximate cost for purchasing all the equipment summarized in Table A-5 ranges from $900 to $1,400. Note the equipment listed on the standard items list at the beginning of this appendix is not included in the recommended equipment list provided in Table A-5.

Table A-5. Basic IDDE Equipment List.

Field Screening and Source Tracing Methodology Sampling Equipment	Indicator Sampling Equipment
• High-powered lamp (rechargeable spotlight) • Mirror and pole • Dye testing supplies (200 tablets [low end of range] to wax donuts and activated charcoal packets [high end of range])	• Ammonia test strips (25 tests) • pH field meter (with pH and temperature probes) • Surfactant test kit (20 tests) • Nitrile gloves (box of 100) • Claw grabber • Swing sampler or telescoping dipper • Laboratory grade cleaning wipes (box of 140) • Wash bottles (2) • Sample bottles (12)

Tier 2 – Intermediate Equipment List

Tier 2 assumes a more robust or intermediate IDDE program with equipment for sampling the primary field screening indicators, one follow-up indicator (detergents/surfactants), and one source tracing techniques (dye testing). Turbidity sampling is assumed to be performed using a turbidity meter. Table A-6 identifies the specific equipment required for an intermediate "toolbox" of equipment. The approximate cost for purchasing all the equipment summarized in Table A-6 ranges from $2,100 to $2,800. Note the equipment listed on the standard items lists above is not included in the recommended equipment list provided in Table A-6.

Table A-6. Intermediate IDDE Equipment List.

Field Screening and Source Tracing Methodology Sampling Equipment	Indicator Sampling Equipment
• High-powered lamp (rechargeable spotlight) • Mirror and pole • Dye testing supplies (200 tablets [low end of range] to wax donuts and activated charcoal packets [high end of range])	• Ammonia test strips (25 tests) • pH probe (with temperature probe) • Turbidity meter • Surfactant test kit (20 tests) • Nitrile gloves (box of 100) • Claw grabber • Swing sampler or telescoping dipper • Laboratory grade cleaning wipes (box of 140) • Wash bottles (2) • Sample bottles (12)

Tier 3 – Advanced IDDE Equipment List

Tier 3 assumes an advanced IDDE program with equipment for sampling the primary field screening indicators, multiple follow-up indicators (detergents/surfactants, chlorine/fluoride, and *E. coli*), and two source tracing techniques (dye testing and video inspections). Multiple primary field screening and follow-up indicators are addressed through the use of a multimeter. Turbidity sampling is assumed to be performed using a turbidity meter. Table A-7 identifies the specific equipment required for an advanced "toolbox" of equipment. The approximate cost for purchasing all the equipment summarized in Table A-7 ranges from $20,000 to $50,000. Note the equipment listed on the standard items lists above is not included in the recommended equipment list provided in Table A-7.

Table A-7. Advanced IDDE Equipment List.

Field Screening and Source Tracing Methodology Sampling Equipment	Indicator Sampling Equipment
• High-powered lamp (rechargeable spotlight) • Mirror and pole • Dye testing supplies (200 tablets [low end of range] to wax donuts and activated charcoal packets [high end of range]) • Dedicated video camera rig (pole camera [low end of range] or crawler unit and camera with skid [high end of range])	• Dedicated multimeter with pH, temperature, specific conductivity, and dissolved oxygen probes • Ammonia test strips (25 tests) • Turbidity meter • Surfactant test kit (20 tests) • Chlorine test strips [low end of range] or colorimeter [high end of range] • Coliscan© Easygel© test kits (for *E. coli*), pipette and disposable tips, and poultry egg incubator • Total Petroleum Hydrocarbon (TPH) laboratory analysis (20 samples) • Nitrile gloves (box of 100) • Claw grabber • Swing sampler or telescoping dipper • Laboratory grade cleaning wipes (box of 140) • Wash bottles (2) • Sample bottles

APPENDIX B

Example Field Forms

Example Field Forms

Field forms are recommended for all field screening and source tracing methodologies, as well as any indicator sampling conducted during illicit connection and illicit discharge investigations. A well organized, thorough, and user-friendly field form can improve data management activities by streamlining the process of collecting measurements and observations in the field and analyzing the data in the office.

The intent of including example field forms in this manual is to provide templates or ideas for field forms but should be tailored for use according to each jurisdiction's internal processes and methods. This appendix provides example field forms for the following field screening methodologies, source tracing methodologies, and indicator sampling procedures:

General Category	Methodology/Indicator Name	Source
Field Screening Methodology	Outfall Inspections	●City of Mercer Island ●Snohomish County ●Center for Watershed Protection
Field Screening Methodology	●Business Inspections ●Catch Basin/Manhole Inspections ●Ditch Inspections ●Outfall Inspections ●Stormwater BMP Inspections ●Video Inspections	City of Snoqualmie
Source Tracing Methodology	Dye Testing	King County
Source Tracing Methodology	Optical Brightener Monitoring	Dave Sargent and Wayne Castonguay
Source Tracing Methodology	Septic System Inspections	●University of Minnesota ●New Hampshire ●Kitsap County
Source Tracing Methodology	Smoke Testing	City of Baton Rogue
Indicators	General Water Quality Indicator Sampling	●King County ●Snohomish County

Field forms were not readily available for all of the field screening and source tracing methodologies included in this manual, but may be modeled after these field forms. Field forms that are available in Microsoft Word or Excel format are posted on the Washington Stormwater Center website (www.wastormwatercenter.org/illicit-connection-illicit-discharge).

Additional helpful resources can be found at the following websites:

- Maryland Department of Natural Resources Stream Corridor Assessment Survey: https://dnr.maryland.gov/education/Pages/StreamCorridorAssessment.aspx
- Center for Watershed Protection Online Watershed Library: https://owl.cwp.org

Field Screening Methodologies

City of Mercer Island - Dry Weather Outfall Reconnaissance Inspection Form

Section 1: Background Data

Watershed name:	Outfall ID:	
Date:	Time (Military):	
Outdoor air temperature:	Inspector(s):	
Amount of precipitation in the past 48 hours (inches):	Photos taken (Y/N):	If yes, photo numbers:
Land use in drainage area (Check all that apply): ☐ Industrial ☐ Residential ☐ Commercial ☐ Open Space ☐ Institutional Other: _____	Known Industries: _____	

Section 2: Outfall Description

Location	Material	Shape		Dimensions (inches)	Submerged
Storm sewer (closed pipe)	☐ RCP ☐ CMP ☐ PVC ☐ HDPE ☐ Steel ☐ Clay/drain tile ☐ Other: _____	☐ Circular ☐ Elliptical ☐ Box ☐ Other: _____	☐ Single ☐ Double ☐ Triple ☐ Other:_____	Diameter/ dimensions: _____	In Water: ☐ No ☐ Partially ☐ Fully With Sediment: ☐ No ☐ Partially ☐ Fully
Open drainage (swale/ditch)	☐ Concrete ☐ Earthen ☐ Rip-rap ☐ Other: _____	☐ Trapezoid ☐ Parabolic ☐ Other: _____		Depth: _____ Top width: _____ Bottom width: _____	

Section 3: Physical Indicators for All Outfalls

Indicator	Yes	No	Description	Comments
Outfall damage	☐	☐	☐ Spalling, cracking, or chipping ☐ Peeling paint ☐Corrosion	
Deposits/stains	☐	☐	☐ Oily ☐ Flow line ☐ Paint ☐ Other: _____	
Abnormal vegetation	☐	☐	☐ Excessive ☐ Inhibited	
Poor pool quality	☐	☐	☐ Odors ☐ Colors ☐ Floatables ☐ Oil sheen ☐ Suds ☐ Excessive algae ☐ Other: _____	
Pipe algae/growth	☐	☐	☐ Brown ☐ Orange ☐ Green ☐ Other: _____	
Do physical indicators suggest an illicit discharge is present? ☐ Yes ☐ No				
Flow Present?	☐ Yes ☐ No		**If No, complete Section 4 and skip Sections 5-7.** **If Yes, continue with Sections 4 through 7.**	
Flow Description	☐ Trickle ☐ Moderate ☐ Substantial			

Section 4: Any Non-Illicit Discharge Concerns (e.g., trash or needed infrastructure repairs)?

City of Mercer Island - Dry Weather Outfall Reconnaissance Inspection Form

Section 5: Physical Indicators for Flowing Outfalls

Indicator	Yes	No	Description	Relative Severity Index (1-3)		
Odor	☐	☐	☐ Sewage ☐ Rancid/sour/rotten ☐ Sulfide ☐ Petroleum/gas ☐ Laundry ☐ Other: _____	☐ 1 – Faint	☐ 2 – Easily detected	☐ 3 –Noticeable from a distance
Color (color chart)	☐	☐	☐ Clear ☐ Brown ☐ Gray ☐ Yellow ☐ Green ☐ Orange/Red ☐ Multi-color ☐ Other: _____	☐ 1 – Faint colors in sample bottle	☐ 2 – Clearly visible in sample bottle	☐ 3 – Clearly visible in outfall flow
Floatables (does not include trash)	☐	☐	☐ Sewage ☐ Soap suds ☐ Oil sheen ☐ Other: _____ ☐ Grease	☐ 1 – Few/ slight; origin not obvious	☐ 2 – Some; indications of origin	☐ 3 – Some; origin clear
Natural phenomena	☐	☐	☐ Organic sheen ☐ Foam ☐ Tannins ☐ Algae ☐ Iron bacteria ☐ Other: _____			
Do physical indictors (flowing outfalls) suggest an illicit discharge is present? ☐ Yes ☐ No						

Section 6: Water Quality Sampling – Primary Screening

Primary Screening Parameter	Field Test Result	Trigger for Further Investigation	Investigate Further for Illicit Discharge?	Equipment
pH		< 6.5 or > 8.5	☐ Yes ☐ No	Field meter
Temperature		>10° F warmer than normal for that waterbody	☐ Yes ☐ No	Field meter
Turbidity		>25 NTU	☐ Yes ☐ No	Field meter
Ammonia		>3 mg/L	☐ Yes ☐ No	Field test strips
Potassium		>5 mg/L	☐ Yes ☐ No	Field meter
Detergents/surfactants		> 0.5 mg/L	☐ Yes ☐ No	Field test kit
Do primary screening results suggest an illicit discharge is present? ☐ Yes ☐ No				

Section 7: Water Quality Sampling – Follow-up (See IDDE Plan for applicability)

Secondary Follow-up Parameter	Test Result (field or lab)	Trigger for Further Investigation	Investigate Further for Illicit Discharge?	Equipment
Bacteria (fecal coliform, *E. coli*)		>5,000 CFU/100 mL	☐ Yes ☐ No	Laboratory test
Chlorine		>0.2 mg/L	☐ Yes ☐ No	Low level colorimeter
Sample collected for laboratory analysis?		☐ Yes ☐ No		
If yes, collected from:		☐ Flow ☐ Pool		

2010 Outfall Field Form **Page___**

Date/Time:_____ Location ID:_____

Crew:_____ File Name:_____

Photo Taken (circle one): Yes No

Location Type (circle one): Outfall Conveyance point for OF ID_____ Unknown

Location information (describe structure's physical location):_____
_____
_____

Physical Description (describe structure type and physical condition):_____
_____
_____

Visual and Olfactory Indicators Present (describe indicators):_____
_____
_____

Flow (circle all that apply): Yes No Standing

Water Quality Parameters

Parameter	Result	Parameter	Blank Result	Final Result	Adjusted Result*
Dissolved O_2	mg/L	**Ammonia**	mg/L	mg/L	mg/L
Temperature	C	**Potassium**	mg/L	mg/L	mg/L
pH		**Surfactants**	mg/L	mg/L	mg/L
Turbidity	NTU	**Fluoride**	mg/L	mg/L	mg/L
Conductivity	uS/cm		mg/L	mg/L	mg/L
Azimuth			mg/L	mg/L	mg/L

***Adjusted Result= Final result – Reagent Blank Result. The reagent blank result can be found in the Outfall Field Notebook**

WQ samples taken for lab (circle one): Yes No

QA/QC samples taken (circle all that apply): Blank Duplicate None

Additional Notes and Diagrams:

OUTFALL RECONNAISSANCE INVENTORY/ SAMPLE COLLECTION FIELD SHEET

Section 1: Background Data

Subwatershed:		Outfall ID:	
Today's date:		Time (Military):	
Investigators:		Form completed by:	
Temperature (°F):	Rainfall (in.): Last 24 hours: Last 48 hours:		
Latitude:	Longitude:	GPS Unit:	GPS LMK #:
Camera:		Photo #s:	

Land Use in Drainage Area (Check all that apply):

- ☐ Industrial
- ☐ Ultra-Urban Residential
- ☐ Suburban Residential
- ☐ Commercial
- ☐ Open Space
- ☐ Institutional
- Other: _____
- Known Industries: _____

Notes (e.g., origin of outfall, if known):

Section 2: Outfall Description

LOCATION	MATERIAL	SHAPE		DIMENSIONS (IN.)	SUBMERGED
☐ **Closed Pipe**	☐ RCP ☐ CMP ☐ PVC ☐ HDPE ☐ Steel ☐ Other: _____	☐ Circular ☐ Eliptical ☐ Box ☐ Other: _____	☐ Single ☐ Double ☐ Triple ☐ Other: _____	Diameter/Dimensions: _____	In Water: ☐ No ☐ Partially ☐ Fully With Sediment: ☐ No ☐ Partially ☐ Fully
☐ **Open drainage**	☐ Concrete ☐ Earthen ☐ rip-rap ☐ Other: _____	☐ Trapezoid ☐ Parabolic ☐ Other: _____		Depth: _____ Top Width: _____ Bottom Width: _____	
☐ **In-Stream**	**(applicable when collecting samples)**				
Flow Present?	☐ Yes ☐ No ***If No, Skip to Section 5***				
Flow Description (If present)	☐ Trickle ☐ Moderate ☐ Substantial				

Section 3: Quantitative Characterization

FIELD DATA FOR FLOWING OUTFALLS				
PARAMETER		**RESULT**	**UNIT**	**EQUIPMENT**
☐Flow #1	Volume		Liter	Bottle
	Time to fill		Sec	
☐Flow #2	Flow depth		In	Tape measure
	Flow width	_____' _____"	Ft, In	Tape measure
	Measured length	_____' _____"	Ft, In	Tape measure
	Time of travel		S	Stop watch
Temperature			°F	Thermometer
pH			pH Units	Test strip/Probe
Ammonia			mg/L	Test strip

Outfall Reconnaissance Inventory Field Sheet

Section 4: Physical Indicators for Flowing Outfalls Only

Are Any Physical Indicators Present in the flow? ☐ Yes ☐ No *(If No, Skip to Section 5)*

INDICATOR	CHECK if Present	DESCRIPTION	RELATIVE SEVERITY INDEX (1-3)		
Odor	☐	☐ Sewage ☐ Rancid/sour ☐ Petroleum/gas ☐ Sulfide ☐ Other:	☐ 1 – Faint	☐ 2 – Easily detected	☐ 3 – Noticeable from a distance
Color	☐	☐ Clear ☐ Brown ☐ Gray ☐ Yellow ☐ Green ☐ Orange ☐ Red ☐ Other:	☐ 1 – Faint colors in sample bottle	☐ 2 – Clearly visible in sample bottle	☐ 3 – Clearly visible in outfall flow
Turbidity	☐	See severity	☐ 1 – Slight cloudiness	☐ 2 – Cloudy	☐ 3 – Opaque
Floatables -Does Not Include Trash!!	☐	☐ Sewage (Toilet Paper, etc.) ☐ Suds ☐ Petroleum (oil sheen) ☐ Other:	☐ 1 – Few/slight; origin not obvious	☐ 2 – Some; indications of origin (e.g., possible suds or oil sheen)	☐ 3 - Some; origin clear (e.g., obvious oil sheen, suds, or floating sanitary materials)

Section 5: Physical Indicators for Both Flowing and Non-Flowing Outfalls

Are physical indicators that are not related to flow present? ☐ Yes ☐ No *(If No, Skip to Section 6)*

INDICATOR	CHECK if Present	DESCRIPTION	COMMENTS
Outfall Damage	☐	☐ Spalling, Cracking or Chipping ☐ Peeling Paint ☐ Corrosion	
Deposits/Stains	☐	☐ Oily ☐ Flow Line ☐ Paint ☐ Other:	
Abnormal Vegetation	☐	☐ Excessive ☐ Inhibited	
Poor pool quality	☐	☐ Odors ☐ Colors ☐ Floatables ☐ Oil Sheen ☐ Suds ☐ Excessive Algae ☐ Other:	
Pipe benthic growth	☐	☐ Brown ☐ Orange ☐ Green ☐ Other:	

Section 6: Overall Outfall Characterization

☐ Unlikely ☐ Potential (presence of two or more indicators) ☐ Suspect (one or more indicators with a severity of 3) ☐ Obvious

Section 7: Data Collection

1. Sample for the lab?	☐ Yes	☐ No	
2. If yes, collected from:	☐ Flow	☐ Pool	
3. Intermittent flow trap set?	☐ Yes	☐ No	If Yes, type: ☐ OBM ☐ Caulk dam

Section 8: Any Non-Illicit Discharge Concerns (e.g., trash or needed infrastructure repairs)?

Source Tracing Methodologies

City of Snoqualmie – Illicit Connection & Illicit Detection Inspection Form

Section 1: Background Data

Drainage basin name:	Catch basin, ditch, or outfall ID:	
Date:	Time (Military):	
Ambient air temperature:	Inspector(s):	
Amount of precipitation in the past 48 hours (inches):	Photos taken (Y/N):	If yes, photo numbers:

Section 2: Selection of a Field Screening Methodology

System Type	Field Screening Methodology (circle one)				
Piped System	Business Inspections	Catch Basin / Manhole Inspections	Outfall Inspections	Stormwater BMP Inspections	Video Inspections
Ditch System				Ditch Inspections	

Section 3: Visual and Olfactory Observations

Indicator	Yes	No	Description	Comments
Color	☐	☐	☐ Tan to brown ☐ Brown to reddish brown ☐ Brown to black ☐ Black ☐ Gray to milky white ☐ Orange-red ☐ Dark red or purple ☐ Blue green/brown green ☐ Yellow to bright green ☐ Other: _____	
Odor	☐	☐	☐ Musty ☐ Rotten egg, hydrogen sulfide, natural gas ☐ Rotten/spoiled ☐ Sewage ☐ Chlorine ☐ Sharp, acrid, or pungent ☐ Soapy/perfume ☐ Pungent sweet/musty ☐ Rotten eggs, kerosene, or gasoline ☐ Beer, wine, alcohol, or yeast ☐ Rotten egg or chlorine ☐ Other: _____	
Visual Indicators	☐	☐	☐ Excessive vegetation ☐ Dead vegetation ☐ Deposits and staining ☐ Fish kills ☐ Sewage fungus (white or grayish growth) ☐ Dried white mat-like residue ☐ Green or brown algae growth ☐ Algae blooms ☐ Bubbles or suds with a rainbow sheen ☐ Fats, grease, and oils ☐ Petroleum sheen ☐ Other: _____	
Do visual and olfactory observations suggest an illicit discharge is present? ☐ Yes ☐ No				

City of Snoqualmie – Illicit Connection & Illicit Detection Inspection Form

Section 4: Flow

Flow Present?	☐ Yes ☐ No
Flow Description	☐ Trickle ☐ Moderate ☐ Substantial

Section 5: Primary Screening Indicator Sampling (if dry weather flow is observed)

Primary Screening Indicator	Test Result	Trigger for Further Investigation	Investigate Further for Illicit Discharge?	Field Equipment Used or Laboratory Analysis
pH		< 5 or > 9	☐ Yes ☐ No	☐ Field test strips ☐ Field meter
Turbidity		> 50 NTU or visible/cloudy/opaque	☐ Yes ☐ No	☐ Field meter ☐ Visual observation
Ammonia		> 1 mg/L	☐ Yes ☐ No	☐ Field test strips ☐ Field test kit ☐ Ion probe (multimeter) ☐ Laboratory analysis
Temperature		Above ambient air temperature	☐ Yes ☐ No	☐ Field meter
Do primary field screening indicator results suggest an illicit discharge is present? ☐ Yes ☐ No				

Section 6: Follow-up Indicator Sampling (if triggered by primary screening indicator results)

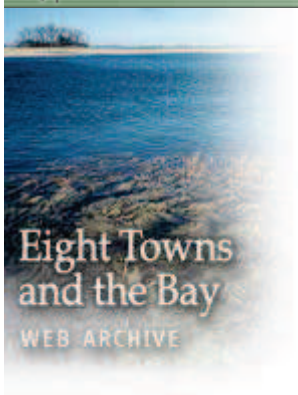
Follow-up Indicator	Test Result	Trigger for Further Investigation	Investigate Further for Illicit Discharge?	Field Equipment Used or Laboratory Analysis
Chlorine		> 0.3 mg/L	☐ Yes ☐ No	☐ Field test strips ☐ Field test kit ☐ Digital colorimeter
Detergents/surfactants		> 0.25 mg/L	☐ Yes ☐ No	☐ Field test kit ☐ Digital colorimeter ☐ Laboratory analysis
Fecal coliform bacteria		> 5,000 CFU/100 mL during wet weather > 500 CFU/100 mL during dry weather	☐ Yes ☐ No	☐ Laboratory analysis
Hardness		Commercial/industrial only ≤ 10 mg/L as $CaCO_3$ or ≥ 1,000 mg/L as $CaCO_3$	☐ Yes ☐ No	☐ Field test strips ☐ Field test kit ☐ Laboratory analysis
Nitrate		> 1 mg/L	☐ Yes ☐ No	☐ Field test strips ☐ Digital colorimeter ☐ Ion probe (multimeter)
Potassium		> 5 mg/L Ammonia/Potassium ratio > 1 or <1	☐ Yes ☐ No	☐ Field meter ☐ Spectrophotometer

Illicit Connection Investigation Field Form

Project Name		***Date***	
Project #		***Weather***	
Staff			

Address	Name & Phone	Bus/ Res	Dye Color	Time In	Fixture	Dye Seen	Manhole Type	Time Seen	Manhole Location
		Bus Res	Y B R		Toilet Sink Floor	Yes No	Storm Sanitary		
		Bus Res	Y B R		Toilet Sink Floor	Yes No	Storm Sanitary		
		Bus Res	Y B R		Toilet Sink Floor	Yes No	Storm Sanitary		
		Bus Res	Y B R		Toilet Sink Floor	Yes No	Storm Sanitary		
		Bus Res	Y B R		Toilet Sink Floor	Yes No	Storm Sanitary		
		Bus Res	Y B R		Toilet Sink Floor	Yes No	Storm Sanitary		
		Bus Res	Y B R		Toilet Sink Floor	Yes No	Storm Sanitary		

Legend: Business, Residential – Bus/Res Dye Color. Yellow - Y, Blue - B, Red - R



Appendix A

Optical Brightener Data Sheet

Drainage Area _____ Collected by _____
Page __ of __

Remarks
_____

Location	Placed	Pulled	No. days	Volume	O.B. +/-	Total Rain

Next: **Appendix B**

Text/art: Eight Towns and the Bay
Web site: Nature Compass LLC - Some rights reserved
A Nature of Place Project
Current 8T&B Web site

Top

UNIVERSITY OF MINNESOTA

Homeowner Survey – Onsite Septic System

These questions help septic system professionals determine the best level of care for your septic system. The questions can also help troubleshoot problems, address needed upgrades or changes, or other issues.

Name_____ Phone Number_____

Address_____

County/Township_____Permit No._____

Information about the home and residents:

1. The house/cabin is used _____ full time, year-round _____ seasonal or part-time
2. Number of people living in the home: _____adults _____children age 0 – 11 _____ children age 12 & up
3. Current number of bedrooms _____ number of bedrooms in original design_____

   number of bathrooms: _____full _____three-fourths _____half
4. Do you have an in-home business? _____ If yes – what is it?_____

Information about the Septic System: *italicized answers best protect your system.*

5. Number of septic tanks or chambers in tanks:_____ capacity of tanks in gallons_____ _____ unknown
6. Date of last pumping or evaluation: _____ How many tanks pumped_____ _____ unknown
7. Are there risers on the septic tank maintenance holes? _____*yes* _____no _____unknown
8. Are the risers insulated for freezing protection, and well secured for safety? _____*yes*_____no_____unknown
9. Is there an effluent screen on the outlet baffle of the tank? _____*yes* _____no _____unknown
10. If an effluent screen is present, do you maintain it? _____the pumper checks it _____ yes _____unknown
11. Do you know how old your septic system is? _____no _____yes, installed in _____
12. Are you aware of any problems or repairs? _____ Describe:_____

    _____
13. Has the system ever frozen? _____Yes, specify where_____ _____no___unknown
14. Do you use septic tank or system additives? _____*no* ___yes, we have added_____
15. Have you noticed any odors?_____ Where?_____
16. We have: ____in-ground soil treatment area ___above ground___other_____
17. We mow the grass over the drainfield regularly _____*yes* _____no
18. We keep all vehicles, snowmobiles, dirt bikes, 4-wheelers, other items off our drain field area ____*yes* ____no
19. Pumps: ___yes, our system has pumps ___no ___unknown Gallons/dose _____ Doses/day_____
20. Alarms: ___alarms are present for pumps and/or effluent screen. _____Alarms do not work

    ___unknown _____we do not have any alarms.
21. Well: _____yes _____no Well casing depth_____feet Distance from drainfield_____feet
22. Is this your first home with a septic system? _____

    Are you familiar with the "dos and don'ts" of a septic system? _____

    Do you have a copy of the *Septic System Owner's Guide* from the University of Minnesota? _____

UNIVERSITY OF MINNESOTA

Homeowner Survey – Onsite Septic System

Household product and use information: *italicized answers best protect your system.*

23. **Garbage Disposal:** (*circle*) _____*no* _____yes, and use it ___often _____rarely _____never
24. **Dishwasher:** _____no _____yes _____loads per week

    we use _____*gel* or _____ powdered detergents. _____ we read labels for phosphorus content.

    Does it discharges to the septic system? _____yes _____ *no*
25. **Clothes Washer:** _____no _____yes, _____and wash _____ loads/week. _____We wash more than 1 load/day.

    We have: _____an older agitator top loading washer _____suds-saver washer ____front loading washer

    We use ___ *liquid* or ___ powdered laundry detergents. Lint screen on the washer? _____*Yes* ___ no

    Amount of laundry bleach used in one week:_____ Type? _____

    Does it discharge to the septic system? _____yes _____ no
26. **Water Softener:** _____no _____yes, and it discharges to the septic system __yes ___ *no*
27. **Other water treatment filter:** what:_____ it discharges to the septic system __yes ___ *no*
28. **Whirlpool bathtub**: _____no _____yes, and it discharges to the septic system __yes ___ no
29. **Sump Pump**: _____no _____yes, and it discharges to the septic system __yes ___ *no*
30. **Floor, roof or other drains**: _____no _____yes, and it discharges to the septic system __yes ___ *no*
31. **Skin care products:** _____bath and shaving oils, creams, moisturizers: ____yes, we use these, times/week: _____
32. **Anti-bacterial soaps, cleansers**: _____yes, we use these _____*no, we do not use anti-bacterials.*
33. **Cleaning products**: indicate those used:_____ Every-flush toilet cleaners ____after-shower door cleansers

    _____drain cleaners _____bleach-based kitchen and bathroom cleansers.

    List other commonly used cleaning products:_____
34. **Toilet Paper**: number of rolls used per week _____
35. **Prescription Drugs used long-term**: _____no ____yes,

    _____type of medicine

    _____type of medicine
36. We dispose of un-needed prescription drugs by_____
37. Please attach system sketch if available. Include: footing drains, surface drainage and system replacement area

What questions do you have?

© 2009, Regents of the University of Minnesota. All rights reserved. For additional copies or for Americans with Disabilities Act accommodation, please call(800) 322-8642. University of Minnesota is an equal opportunity educator and employer.

Anonymous Septic System Survey (Example)

Dear _____ Watershed Property Owner:
(Lake Name)

In order to assess the threats to the quality of our lake, the lake association is sending each property owner in the watershed a septic system survey. We ask that this survey be completed by a member of each household. This information will help us better understand the state of the septic systems in the watershed and the impact that these systems may be having on the quality of the lake. Because these issues are sometimes sensitive, we have decided to conduct an anonymous survey. You only need to fill out the questions that are asked below and you do not need to include your name, address, or lot number. We encourage you to be honest in your responses, as this will assist us in better understanding the threats to our lake and how to protect our lake. Remember, as the lake quality declines, property values along the lake and the recreational values of the lake will decline as well.

If you have any comments, or would like to include your name and address, please feel free to include this information on the back of the survey in the indicated location.

Thank you for participating!

Sincerely,

_____ Association
(Lake Name)

---

1. Is there a septic system on your property?

Yes No

2. How old is your septic system (in years)?

1 – 10 10 – 15 15 – 20 20 – 25 I don't know

3. How many feet from the shore of the lake is your septic system located?

10 – 20 20 -50 50 – 75 Greater than 75 feet

4. Is the property used year round or seasonally?

Year round Seasonally

5. If you are a seasonal resident, how many months out of the year do you spend in your lake home? _____

6. In what condition is your septic system?

Good Moderate Poor I don't know

7. Do you have any problems with your septic system (odors, surface discharge, clogging)?

Yes No

8. Have you made any repairs to your septic system?

Yes No

9. How often do you have your septic system tank pumped?

Every 1 – 3 years Every 3 – 5 years Every 10 years Never

10. What size lot do you own?

¼ acre ½ acre 1 acre greater than 1 acre

11. How far away from the lake edge is your home located?

10 – 20 feet 20 – 50 feet 50 – 75 feet greater than 75 feet

12. How far away from the edge of the nearest tributary to the lake is your home located?

10 – 20 feet 20 – 50 feet 50 – 75 feet greater than 75 feet

13. What is your drinking water source?

Dug Well Drilled Well Public Water Bottled Water I don't know

14. How many bedrooms does your home/cottage have?

1 2 3 More than 3

15. How many people typically occupy your lot? _____

16. Which of the following water-using machines do you have on your lake-front dwelling?

Washing Machine Garbage Disposal Dishwasher Water Softener Other:_____

17. Other Comments (optional):

_____

When this form is complete, please mail it to:

_____

(include lake association address)

For more information, contact: _____

(Include contact person and phone number)

APPENDIX F: Pollution Identification & Correction (PIC) Inspection Form

TAX ID:

PROJECT AREA	**ADDRESS**
OWNER NAME	**PHONE**
OCCUPANT NAME	

PROPERTY SURVEY INFORMATION:

Occupancy type	System type	Records on file	#Bedrooms	
__ Commercial __ Single family __ Multi-family	__Standard gravity __Pressure __Drip irrigation __Glendon __Other _____ __M & M contract	__BSA __Permit __As built		__Marine shoreline __Fresh shoreline __Upland Distance to OSS
Survey date(s)	Staff	OSS rating	Farm rating	Date last pumping
Roof drains __ OK __ needs improvement	Curtain drains __ OK __ needs improvement	Bulkhead drains __ OK __ needs improvement	Pets present (# and type)	Livestock present (# and type)

Animal waste management: ___ OK ___ Needs improvement ___ Violation

Notes/Comments on OSS and/or other property conditions

OSS EDUCATION CHECKLIST:

___ Water usage: (Hydraulic Loading, Plumbing leaks, laundry, use of low flow fixtures, runoff, sprinklers)

___ Waste strength: (Use of Additives, Chemical drain cleaners Bleach, Fabric softener, Meds, Fats/Oils/Greases)

___ Physical damage: (Driving over drainfield, bldgs/structures, heavy equipment etc.)

___ Inspect system regularly (pump/inspect frequency, warning signs of failing OSS)

___ Educational materials provided circle 1 or more (Fact Sheet, OSS manual, Repair brochure, Pet waste)

ANIMAL WASTE CHECKLIST:

___ Pet waste

___ Manure from livestock

___ Referral to Kitsap Conservation District _____

Complete the Following:

In the box below, indicate sources/areas of animal waste, surface water flows, locations of OSS and where samples/dye tests were collected/placed on the property. For consistency, indicate distances and directions on the drawing (Not To Scale).

Notes:_____

_____

_____

Dye Test Date: **Dye Used:**

Location Number	Control (BAC)			Pack Week #1 (F1)			Pack Week #2 (F2)			Pack Week #3 (F3)		
	Placed	Retrieved	Result	Placed	Retrieved	Result	Placed	Retrieved	Result	Placed	Retrieved	Result
1												
2												
3												

WATER SAMPLE DATA: **(FC per 100mL)**

Water Sample Taken: Date:_____ Inspector:____ Result:_____ Location:_____

Water Sample Taken: Date:_____ Inspector:____ Result:_____ Location:_____

Water Sample Taken: Date:_____ Inspector:____ Result:_____ Location:_____

Water Sample Taken: Date:_____ Inspector:____ Result:_____ Location:_____

Smoke Inspection Test

Contractor's Smoke Testing Form

Project No. _____

Contractor _____

Technician _____

Date _____

Length _____

Predominate Surface Cover _____

Manhole Number	SAND BAGGED	BLOWER	Manhole Number	SAND BAGGED	BLOWER
UPSTREAM			DOWNSTREAM		
	Y / N	Y / N		Y / N	Y / N

OBS No.	Source Address/Location (All Positive and Suspect)	Distance from UPS MH	Distance from mainline Left	Distance from mainline Right	Result	Status	Source Type	Smoke	Area Ft	Area Ft	Run Off	TV Y / N	DVD NO.
1													
2													
3													
4													
5													
6													
7													
8													
9													
10													

SKETCH

RESULT CODES
- 1 POSITIVE
- 2 SUSPECT
- 3 NEGATIVE
- 4 CONNOT TEST

STATUS CODES
- 1 PRIVATE
- 2 PUBLIC

SOURCE TYPE CODES
- 1 SERVICE LATERALS
- 2 TRANSITIONAL JOINT
- 3 DRIVEWAY DRAIN
- 4 WINDOW WELL DRAIN
- 5 STAIRWELL DRAIN
- 6 AREA DRAIN
- 7 DOWNSPOUT
- 8 DOWNSPOUT DRAIN
- 9 FOUNDATION DRAIN
- 10 BUILDING INSIDE
- 11 CATCH BASIN
- 12 STORM DITCH
- 13 STORM MANHOLE
- 14 MAIN SEWER
- 15 UPSTREAM MANHOLE
- 16 CLEANOUT
- 17 OTHER

SMOKE CODE
- 1 LIGHT
- 2 MEDIUM
- 3 HEAVY

RUNOFF CODES
- 1 0% PAVED
- 2 25% PAVED
- 3 50% PAVED
- 4 75% PAVED
- 5 100% PAVED

Other Leaks or Comments:

Revised: Mar-08

Indicators

Water Quality Sampling Data Sheet
King County Illicit Connection/Illicit Discharge Elimination Program

Outfall ID #	OF_____	Personnel	_____
Date	___/___/___	Camera	_____
Military time	____:____	Photos?	_____

Flow present?	Y / N	Lab sample taken?	Y / N
Screening performed?	Y / N	Lab duplicate taken?	Y / N
Duplicate screening performed?	Y / N	Field blank taken?	Y / N

Sample ID(s):	Parameters to analyze in laboratory (circle)		
	Ammonia	Nitrate +Nitrite	TKN
	Fecal coliform	Potassium	Total P
	Fluoride	Surfactants	TPH
	Hardness	sVOC	Total metals (specify)

Field observations

Other notes

Field analyses

Temperature		degrees C	Hydrolab
Dissolved oxygen		mg/L (ppm)	Hydrolab
Spec. conductivity		µS/cm	Hydrolab
pH		pH units	Hydrolab
Ammonia		mg/L (ppm)	Hach single
Total hardness		mg/L as CaCO3	Hach 5-in-1
Alkalinity		mg/L as CaCO3	Hach 5-in-1
Total chlorine		mg/L (ppm)	Hach 5-in-1
Free chlorine		mg/L (ppm)	Hach 5-in-1
Total copper		mg/L (ppm)	Hach single
Phosphate		mg/L (ppm)	Hach single
Turbidity		NTU	Turbidimeter
Surfactants		mg/L (ppm)	Chemetrics

(Office use only) SiteVisitID:	King County DNRP-WLRD-SWS 201 S. Jackson St Seattle, WA 98104	

Snohomish County Ambient Water Quality Monitoring – Field Instrument Calibration Checks

Date:	Sample Run:	Personnel:

Data quality criteria for Hydrolab/Hach Calibration Checks

HYDROLAB Daily Calibration Checks	Standard	Measured	% Diff or Std. Unit	A/Q/R	HACH Daily Turbidity Calibration Checks	Standard NTU	Measured NTU	% Diff.	A/Q/R
	pH 4* / Temp								
Skipper, Professor, L'il Buddy	pH 7* / Temp				(#1 or #3)				
	Cond. 0 us/cm				---------- Date of last Calibration				
	Cond.* us/cm / Temp								
	DO% sat. 100.0								

*Standard pH & Conductivity is measured during the Calibration process and is set base upon the room temperature of the conductivity solution at the time of calibration.

How to Calculate Percent Difference

Method

Step 1: Divide the New Value by the Standard (you will get a decimal number)

Step 2: Convert that to a percentage (by multiplying by 100 and adding a "%" sign)

Step 3: Subtract 100% from that

Note: if the result is positive it is a percentage increase, if negative, just remove the minus sign and cal it a decrease.

Use the Table below to evaluate % difference & assign qualifier
A = Accept, Q = Qualify, R = Reject

Data quality criteria for Hydrolab/Hach Calibration Checks

Parameter	Units	Accept	Qualify	Reject
pH	std. units	< or = ± 0.25	> ± 0.25 and < or = ± 0.5	> ± 0.5
Conductivity*	µS/cm	< or = ± 5%	> ± 5% and < or = ± 15%	> ± 15%
Dissolved Oxygen**	% saturation	< or = ± 5%	> ± 5% and < or = ± 10%	> ± 10%
Turbidity	NTU	< or = ± 5%	> ± 5% and < or = ± 10%	> ± 10%

* Criteria expressed as a percentage of readings; for example, buffer = 100.2 µS/cm and Hydrolab = 98.7 µS/cm; (100.2-98.7)/100.2 = 1.49% variation, which would fall into the acceptable data criteria of less than 5**%.**

APPENDIX C

Case Studies

This appendix describes various scenarios in which illicit connections and illicit discharges were detected using the methodologies and indicators described in the Illicit Connection and Illicit Discharge Field Screening and Source Tracing Guidance Manual. These examples represent actual illicit connection and illicit discharge (IC and ID) experiences provided by the City of Bellevue (Case Studies #1 through #3), King County (Case Study #4), City of Federal Way (Case Studies #5 through #8), City of Bothell (Case Study #9), and City of Seattle (Case Study #10). While many different scenarios are possible during IC and ID investigations, the following scenarios represent common situations that may be encountered in Washington.

CASE STUDY #1 – FOAMING OUTFALL

Photo Credit: Russell Cotton-Betteridge (City of Bellevue)

Notification: Resident complained of foam near outfall to Lake Sammamish.

Field Screening Methodology: Not applicable

Source Tracing Methodology: Not applicable (recent rainstorms made source tracing infeasible)

Indicators: Odor and visual indicators

Source: Source was believed to be residential roof and patio pressure washing where Simple Green was employed by the gallon in an automatic dispenser over a half mile away. Waste washwater traveled through storm drainage system (1,250 feet), a natural drainage channel (1,000 feet), and a detention area with flow control before discharging to the lake.

Type of Discharge: Transitory

Follow-up: No responsible party was identified, and specific source was not traceable due to the transitory nature of the discharge. A notification letter explaining the illegal discharge was sent to 30 to 40 residents in the tributary area asking for assistance in finding the responsible party. The letter did not result in identification of the responsible party, but it did serve as an education/outreach opportunity and generated multiple calls for clarification of the law. Many people in the area were concerned that this kind of activity around their home could generate pollution in the lake and expressed gratitude for bringing this to their attention.

Case Study Description Credit: Russell Cotton-Betteridge, City of Bellevue

CASE STUDY #2 – SEWAGE SMELL

Notification: Patrons of a local grocery store complained of a sewage smell as they entered the store from the parking area.

Photo Credit: Russell Cotton-Betteridge (City of Bellevue)

Field Screening Methodology: Not applicable

Source Tracing Methodologies: Business inspection, catch basin/manhole inspection, and dye testing

Indicators: Odor and visual indicators

Source: Pavement cuts showed recent sewer service remodel. Initially, the source was believed to be a cross connection between a storm drainage and sanitary sewer line that occurred during the remodel. Dye testing was conducted on the toilets and sinks, and dye was observed in the sewers outside but not in the storm drainage system; therefore, a cross connection was eliminated as a possible source. A drainage system inspection was conducted, in which all manholes and catch basins on site were opened and investigated. The drainage system inspection led to a leaking dumpster discharging to a catch basin behind the facility. This leaking dumpster was identified as the source of the sewage small that initiated the complaints.

Type of Discharge: Intermittent

Follow-up: The property manager was notified of the incident, and a letter was sent out requiring the manager to repair the leaky dumpster and clean the storm system completely within a relatively short time frame. Once these actions were completed, the odor seemed to be eliminated. However, follow-up inspections will be conducted on a regular basis to ensure the grocer does not place large amounts of liquids in the compactor or that it has started to leak again.

Case Study Description Credit: Russell Cotton-Betteridge, City of Bellevue

Case Study #3 – High Fecal Coliform Bacteria

Notification: City staff identified this discharge while traveling to investigate another IDDE incident.

Field Screening Methodology: Not applicable

Source Tracing Methodology: Catch basin/manhole inspection

Indicators: Fecal coliform bacteria

Source: Upstream and downstream catch basin sampling showed that high fecal coliform bacteria concentrations were originating from a horse pasture discharging to the City's municipal storm drainage system.

Type of Discharge: Intermittent

Follow-up: The City's IDDE Code was cited in a letter to the property manager. The property manager was very cooperative and supportive in the City's efforts to mitigate the contamination problem. A City Engineer met multiple times with the property owner to develop a plan that included adding grass to the site to prevent soil erosion and reduce stormwater runoff. In addition, conveyance features were installed to route stormwater runoff to an infiltration pit on site. The property owner was also invited to view sampling results that demonstrated reductions in fecal coliform contamination had occurred after the runoff controls were implemented on the property.

Runoff channel leaving pasture and contributing to downstream contamination (top). Site mitigation solution (bottom).

Photo Credit: Maria Stevens (City of Bellevue)

Case Study Description Credit: Maria Stevens, City of Bellevue

Case Study #4 – Side Sewer Cross Connection

Notification: High fecal coliform bacteria in a lake, and high *Bacteroides* concentrations in stormwater manholes upstream of the lake.

Field Screening Methodology: Not applicable

Source Tracing Methodology: Dye testing

Indicators: Fecal coliform bacteria, visual indicators, odor, flow, *Bacteroides*

Note:

Fecal coliform bacteria can indicate waste from animals or humans. Bacteroides is a group of bacteria that resides in the human gut to aid digestion and can be used to differentiate between human and animal waste. Finding high concentrations of Bacteroides in the stormwater manholes in this case study helped the staff identify the specific sources of bacteria.

Source: Two illicit sewage-to-stormwater pipe connections were identified. One was from a small dog wash business, and the other was from a commercial laundry. In addition to observing dye in the stormwater manhole, staff noticed visual indicators, flow, and odor in the manhole. These observations included floatables (bits of paper), occasional and marked surges of flow when no recent rainfall had occurred, occasional odors of soap, and warm air occasionally rising from the stormwater manhole.

Type of Discharge: Intermittent

Follow-up: As soon as County staff identified the illicit connections, they notified the local sewer district. The sewer district took responsibility to correct the illicit connections and within weeks both of these illicit connections were fixed. County staff ran dye into one of these repaired connections and confirmed that the plumbing had been properly connected to the sanitary sewer mainline.

Photo Credit: Jeanne Dorn (King County)

Case Study Description Credit: Jeanne Dorn, King County

CASE STUDY #5 – LATEX PAINT DISCHARGE

Notification: City staff were notified by field inspection staff of an unknown white discharge in a ditch that was part of the City's storm drainage system.

Photo Credit: Dan Smith (City of Federal Way)

Field Screening Methodology: Ditch inspection

Source Tracing Methodology: Catch basin/manhole inspection

Indicators: Color

Source: Traced the source of the discharge using catch basin/manhole inspections to a nearby apartment complex. City Staff found latex paint impacting a large portion of the private storm drainage system, including a number of catch basins and pipes. The paint was dumped into the on-site storm drainage system during an exterior painting project during the summer and migrated downstream during a storm event several months later.

Type of Discharge: Transitory

Follow-up: City staff immediately notified the on-site apartment manager. The property management firm (located in California) was emailed a Notice of Violation within an hour after inspection, which stated a high level of urgency due to a major winter weather system that was approaching Western Washington, and the proximity of the discharge to Puget Sound (less than a half mile away). The storm eventually produced over 2 inches of rain during the following 48 hours. The property owner dispatched a Vactor truck later that day, and all of the waste (more than 500 gallons) was removed from the storm drainage system.

Case Study Description Credit: Dan Smith, City of Federal Way

CASE STUDY #6 – UTILITY SINK ILLICIT CONNECTION

Notification: City staff alerted by complaints concerning odors in a catch basin in a residential area.

Photo Credit: Dan Smith (City of Federal Way)

Field Screening Methodology: Catch basin/manhole inspection

Source Tracing Methodologies: Smoke testing, dye testing, homeowner interviews

Indicators: Odor and visual indicators

Source: City staff initially began by documenting the presence of wastewater and odors in a residential catch basin emanating from a 6-inch corrugated plastic drainpipe connected to the catch basin. City staff interviewed adjacent residents about their water usage after soapy discharge began appearing in the catch basin. When no upstream source was immediately determined during the interviews, City staff decided to try smoke testing to determine the source. While City staff walked the neighborhood to distributed smoke test notices, a suspicious connection was observed at the front of a house located only two doors down from the suspected catch basin: a one-inch PVC pipe directly tied-in to a roof drain. Smoke testing of the catch basin was inconclusive. However, the next day City staff contacted the owner of the suspicious pipe and learned that it was connected to a utility sink in the garage. Follow-up dye testing confirmed that the sink was illegally connected to the downstream catch basin in question (via roof drainage), and it was the cause of the observed transitory discharge.

Type of Discharge: Transitory

Follow-up: Pursuant to the requirements of a Notice of Violation, the homeowner disconnected the drain from the utility sink.

Case Study Description Credit: Dan Smith, City of Federal Way

CASE STUDY # 7 – COMMERCIAL GREASE BUILD UP

Notification: Long term investigation of grease in a storm drainage system on a commercial property.

Field Screening Methodology: Catch basin/manhole inspections

Source Tracing Methodology: Business inspections, dye testing, video inspections

Indicators: Visual indicators

Source: The City began documenting the presence of grease during routine O&M inspections of a commercial storm drainage system. Public education and eventual enforcement action targeted several restaurants for what appeared to be non-point sources originating from poor implementation of outdoor management of grease.

Although outdoor management of grease improved, the discharges continued for months. A thorough review of the drainage maps provided by the property owner began to implicate point source discharges from a particular restaurant; however, a comprehensive dye testing of all sinks, floor drains, and restrooms at this business (in coordination with the local sanitary sewer utility) did not lead to any conclusions. A grease plug eventually caused stormwater to back up onto the roof. Follow-up dye testing at a second restaurant was more productive and determined that both the restroom and the kitchen were illegally connected to the roof drain.

Additional video inspection documented that the sanitary waste had been discharging into a buried catch basin not indicated on the property owner's site plans,; thus, only grease was detected in downstream catch basins. The video inspection showed that the storm drainage pipes were heavily impacted by grease build-up.

Initial investigation of grease management (top), grease build-up catch basin sump (middle), and grease build up in pipes found during video inspection (bottom). Photo Credit: Dan Smith (City of Federal Way)

Type of Discharge: Transitory

Follow-up: A Notice of Violation compelled the property owner to disconnect the pipe and properly clean the storm drainage system.

Case Study Description Credit: Dan Smith, City of Federal Way

Case Study #8 – Commercial Grease Blockage

Notification: City staff were notified of sewer gas-like odors at the entrance to a major well-known restaurant chain

Field Screening Methodology: Catch basin/manhole inspections

Source Tracing Methodologies: Business inspections, smoke testing

Indicators: Odor and visual indicators

Source: Initially, the local sanitary sewer utility could not locate an improper connection or sewage leak. A follow up smoke test of the storm drainage system found a large downstream plug of rotting grease, which had become septic to the point of generating sewer gas-like odors that traveled back upstream nearly 50 yards to the restaurant, drifted up through the roof drains, and then down to the front door to generate the complaints.

Type of Discharge: Intermittent

Follow-up: During an extended investigation, water quality sampling was used to document the presence of restaurant-related stormwater contaminants. This information established the groundwork for enforcement. A Notice of Correction was issued to the restaurant requiring the development of a SWPPP with proper implementation of BMPs (outdoor management of food wastes). However, when those efforts failed, the establishment owner was required to make structural improvements to effectively eliminate the discharge, including installing a grease recovery system, tying in surface drainage to the storm drainage system, and covering for the dumpster area.

Case Study Description Credit: Dan Smith, City of Federal Way

Smoke testing detects large grease plug in stormwater system (top), grease and food wastes documented to be chronically contaminating the on-site storm system (middle), and retrofit installation of covered dumpster enclosure with interior grease recovery system.

Photo Credit: Dan Smith (City of Federal Way)

CASE STUDY # 9– COOLANT LEAK

Notification: The City received a report of a pollutant spill into a local creek in a commercial area.

Field Screening Methodology: Not applicable

Source Tracing Methodology: Business inspections, dye testing, smoke testing

Indicators: Odor visual indicators, temperature, dissolved oxygen, pH, and specific conductivity

Source: City staff traced the source of pollution to a footing drain located under a commercial building. The property owner was notified of a possible spill of unknown material from the building, and the City conducted a follow-up inspection of the interior area of the building and the roof. The follow up investigation was not successful in identifying the source of the discharge. The property owner then hired a contractor to conduct an investigation of possible pollutant sources. The investigation used dye testing and smoke testing to determine if any part of the facility was the source of the illicit discharge. The dye testing and smoke testing were also inconclusive.

Photo Credit: Andy Loch (City of Bothell)

A few months later, a routine maintenance inspection of the onsite coolant system detected a leak in the system. At this time, it was determined that the source of the pollutant was the onsite coolant system. It was estimated that the leak had released nearly 49 tons of pollutants (including propylene glycol, ethylene glycol, and sodium nitrate) over the course of about 5 months.

Type of Discharge: Continuous—the pollutant was constantly being picked up by the building's footing drain causing heavy bacteria and mold growth.

Follow-up: The business will not be fined for coolant discharge to the storm drainage system and surface waters.

Case Study Description Credit: Andy Loch, City of Bothell

Case Study #10 – Dialysis Cross Connection

Notification: City inspectors observed dry weather flow in a storm drainage manhole.

Field Screening Methodology: Catch basin/manhole inspections

Source Tracing Methodology: Catch basin/manhole inspections, video inspections, dye testing

Indicators: Specific conductivity, potassium, fluoride, ammonia, fecal coliform bacteria, *E. coli* bacteria

Source: Indicator sampling showed elevated concentrations of specific conductivity and potassium and levels of fluoride consistent with municipal tap/drinking water; however, the discharge contained no visual indicators of sewage and had low fecal coliform bacteria and *E. coli* bacteria concentrations. City inspectors isolated the flow to a smaller drainage area and performed indicator sampling and a video inspection of the storm drainage pipe. Results of the source tracing led the inspectors to believe that the discharge was originating from an adjacent hospital.

Side sewer flow into storm drainage mainline (top) and dialysis port configuration (bottom). Photo Credit: Adam Bailey (City of Seattle)

The City inspectors discussed their findings with hospital staff and the hospital staff implemented dye testing. Dye testing did not successfully identify the source of the discharge due to the size of the hospital and restricted access to some areas of the hospital.

Upon further research, the City inspectors realized that sodium was present in the discharge. Elevated concentrations of potassium, sodium and specific conductivity were consistent with the chemical composition of dialysate waste. Dye testing was refocused on areas of the hospital where dialysis was being performed. Hospital staff determined that the source was from four fixtures serving dialysis machines (estimated 1,500 to 2,000 gallons per week).

Type of Discharge: Intermittent

Follow Up: Upon the discovery of the illicit connection, the City sent the hospital a Notice of Violation letter with instruction to locate and repair the illicit connection within a specified time frame. Once the discharge was located the repair was made shortly after.

Case Study Description Credit: Adam Bailey, City of Seattle

APPENDIX D

Other Resources

APPENDIX D – OTHER RESOURCES

This appendix includes other resources that are not referenced in the main text of this document, but that may be useful when developing and refining an IDDE program.

CWP. 2005. A User's Guide to Watershed Planning in Maryland. Prepared for the Maryland Department of Natural Resources, Watershed Services by the Center for Watershed Protection, Ellicott City, Maryland. December. <https://owl.cwp.org/mdocs-posts/a-users-guide-to-watershed-planning-in-maryland>.

CWP. 2011. Illicit Discharge Detection and Tracking Guide. Center for Watershed Protection, Maryland. December. <http://owl.cwp.org/mdocs-posts/idde-and-tracking-guide>.

CWP. 2017. Illicit Discharge Detection and Elimination Field Guide for the Coastal Plain: How to Identify and Quickly Report Pollution Problems. Prepared for the Hampton Roads Planning District Commission MS4 Communities by the Center for Watershed Protection, Ellicott City, Maryland. April. <https://owl.cwp.org/mdocs-posts/illicit-discharge-detection-and-elimination-field-guide-for-the-coastal-plain-how-to-identify-and-quickly-report-pollution-problems>.

CWP. Undated. Isolating and Fixing Illicit Discharges. Prepared for Lake County Stormwater Management by the Center for Watershed Protection, Ellicott City, Maryland. <https://owl.cwp.org/mdocs-posts/isolating_fixing_id>.

Galveston County. 2002. A Guidance Manual for Identifying and Eliminating Illicit Connections to Municipal Separate Storm Sewer Systems (MS4). Prepared by the Galveston County Health District Pollution Control Division. August. <www.tceq.texas.gov/assets/public/comm_exec/pubs/gbnep/ms4.pdf>.

Haverhill. 2018. Illicit Discharge Detection and Elimination (IDDE) Manual. City of Haverhill, Massachusetts. January. <www.haverhillma.gov/Haverhill%20IDDE%20Manual%20Revision%203_%20January%202018%20EPA%20Submittal.pdf>.

King County. 2011. King County Illicit Connection/Illicit Discharge Detection and Elimination (IC/IDDE) Field Screening, Sampling and Analysis Program Sampling and Analysis Plan. SAP No. 2011-02. Prepared by King County Department of Natural Resources and Parks, Water and Land Resources Division, Stormwater Services Section. July.

Kitsap County. 2013. Pollution Source Identification and Correction: Protocol Manual. Prepared by Kitsap County Public Health. April 4. <www.kitsapcountyhealth.com/environment/2012_PIC_Protocol.pdf>.

McLellan, S.L., and D.K. Dila. 2014. Greater Milwaukee Watersheds Stormwater Report. March 19, 2008 through October 23, 2012. Prepared by the University of Wisconsin-Milwaukee School of Freshwater Sciences. May. <http://home.freshwater.uwm.edu/mclellanlab/files/2014/05/2008-2012-SW-Report.pdf>.

New England Interstate Water Pollution Control Commission. 2003. Illicit Discharge Detection and Elimination Manual: A Handbook for Municipalities. New England Interstate Water Pollution Control Commission. January. <http://click.neiwpcc.org/neiwpcc_docs/iddmanual.pdf>.

New Hampshire. Undated. Anonymous Septic System Survey (Example). <http://des.nh.gov/organization/divisions/water/wmb/vlap/documents/septic_system_survey.pdf>.

Sargent, D., and W. Castonguay. 1998. Water Quality Sampling an Optical Brightener Handbook. Prepared for The Eight Towns and the Bay Committee. <http://nature.thecompass.com/8tb/sampling/index.html>.

Seattle. 2010. IDDE Dry Weather Screening Procedure. Seattle Public Utilities, Seattle, Washington. May 27.

Seattle. 2014. Illicit Discharge Detection and Elimination Program Quality Assurance Project Plan. City of Seattle, Washington. June. <www.seattle.gov/util/cs/groups/public/@spu/@drainsew/documents/webcontent/1_037854.pdf>.

University of Minnesota. 2009. Homeowner Survey-Onsite Septic System. Prepared by the University of Minnesota. August 5. <www.septic.umn.edu/sites/septic.umn.edu/files/homeowner_survey.pdf>.

Valdosta. 2016. Illicit Discharge Detection and Elimination Guidance Manual. Prepared by the City of Valdosta, Georgia. May. <www.valdostacity.com/Data/Sites/1/media/depts/engineering/idde-guidance-manual-.pdf>.

Wayne County. 1995. Illicit Connection Control Program: Field Inspection Procedures. Prepared by the Rouge River Project.

Wayne County. 2004. "Sherlocks of Stormwater" Effective Investigation Techniques for Illicit Connection and Discharge Detection. Prepared by D.C. Tuomari and S. Thompson, Wayne County Department of Environment Watershed Management Division, Wayne County. Michigan. <https://owl.cwp.org/mdocs-posts/tuomari_2004_sherlocks_of_stormwater>.

Wayne County. 2007. Comparison Analysis of Alternatives for Finding Illicit Discharges to Storm Water Systems. Prepared by the Rouge River Project and Alliance of Rouge Communities, Wayne County, Michigan. February. <www.allianceofrougecommunities.com/PDFs/technical/RPO-WMGT-TR66.pdf>.

Wayne County. 2016. Illicit Discharge Elimination Program (IDEP). Prepared by the Charter County of Wayne, Michigan. April. <www.waynecounty.com/documents/environmental/wqmd-app-e-wc-idep-app-items-7-26.pdf>.

APPENDIX E

Other Field Screening Methodologies

This appendix includes detailed information on two field screening methodologies (Business Inspections and Stormwater BMP Inspections) that were included in the 2013 Illicit Connection and Illicit Discharge Field Screening and Source Tracing Guidance Manual. These methodologies were moved to an appendix based on feedback obtained for the updated manual because of their less common use. These methodologies can still be helpful for field screening to identify illicit connections and illicit discharges.

Business Inspections

Description

Business inspections are performed to identify pollutant-generating sources at commercial, industrial, and multifamily properties and enforce implementation of required best management practices (BMPs) that prevent pollutants from discharging into storm drainage systems. General business inspections focus on material storage and site activities and should utilize the local stormwater code and source control program requirements (if applicable), which aim to prevent and control pollutants related to business operations before they reach the storm drainage system or a receiving water. Business Inspections can also be used as a source tracing methodology once a suspected illicit discharge has been found (refer to Business Inspections in the *Source Tracing Methodologies* section).

Applications

Business inspections are commonly used to identify pollution-generating activities and sources but can also be used as a field screening methodology to identify potential illicit connections or illicit discharges.

Storm Drainage System Types	Land Use Types	Weather Conditions
• Pipes • Ditches	• Urban • Agricultural • Commercial • Industrial • Mining • Residential	• Dry • Wet

Equipment

Equipment specific to business inspections includes:

- ☐ Local stormwater code or manual
- ☐ BMP handouts and outreach materials (brochures, posters, etc.)
- ☐ Camera, phone, or other device for taking pictures (with date and time stamp)
- ☐ Site plans (if available)
- ☐ Maps of sanitary and storm drainage systems
- ☐ Facility/property owner contact information

- ☐ Various catch basin/manhole hooks and wrenches (including hexagonal Allen key) (for both types of inspections)
- ☐ Sledgehammer for loosening lids
- ☐ Field laptop/tablet and/or clipboard, field forms, and pen/pencil
- ☐ Safety equipment (for example, hard hats, eye protection, work gloves, ANSI 107-1999 labeled safety vests, ear protection, steel-toe boots, traffic control equipment)

Method

Field crews should implement the following steps during business inspections.

1. **In-office Investigation:**
   a. Review storm drainage and sanitary sewer maps to identify lateral sewer connections and access points including building sanitary sewer as-built drawings.
   b. Review results of previous investigations.
   c. Communicate with the site owner to gather information about the types of activities that occur on site.
2. **Onsite investigation:**
   a. Notify the property owner according to jurisdiction protocols (for example, using a notification letter).
   b. Walk and discuss site operations with property owner, manager, or other representative familiar with the site.
   c. Investigate material storage areas and handling and storage practices if hazardous or polluting materials are found on site.
   d. Ensure that there are no connections or discharges to the storm drainage system that contain anything other than stormwater. Check for dry weather flow in downstream catch basins/manholes.
      i. Check to see if there are floor drains in any work areas on the site. If so, determine whether polluting fluids could enter the drain, and if the drain discharges to the sanitary sewer or storm system. Dye Testing or Smoke Testing can be used to verify that floor drains and other indoor plumbing connections are not connected to the storm drainage system.

e. Conduct indicator sampling using one of the following field screening methodologies if a potential illicit discharge is observed and sampling is allowed by the local stormwater code: Catch Basin/Manhole Inspections, Ditch Inspections, Outfall Inspections, or Stormwater BMP Inspections (see Appendix E).

f. Record any issues observed in field data sheet, notebook, or field laptop/tablet.

g. Return to the office and make sure that documentation from the field work is completed and downloaded. This includes hardcopy field forms, photographs, GPS data, and storm drainage system mapping updates delivered to GIS staff.

Pros and Cons

Pros	Cons
• Can locate the source of an illicit discharge due to improper storage or handling of materials • Can locate the source of an illicit discharge due to leaky vehicles and equipment • Can be used in combination with dye testing or smoke testing to confirm drainage connections • Can be used as a public education and outreach tool to help prevent future illicit discharges • Effective during wet and dry weather	• Coordination with property owner, the site visit, and communication after the site visit can be time consuming • Need to train staff to recognize proper material storage and handling consistent with local source control requirements or inspection and maintenance criteria • Private property access can be difficult if the property owner is not responding to notification letters or calls • Follow up source tracing methodologies may have limited effectiveness in wet weather

Stormwater BMP Inspections

Description

Stormwater best management practices (BMPs) are stormwater treatment and flow control facilities that are part of the MS4. Stormwater BMPs include detention facilities such as ponds and vaults, stormwater treatment facilities such as stormwater wetlands and biofiltration swales, and low impact development (LID) facilities such as bioretention and permeable pavement. Routine stormwater BMP inspections include filling out an operation and maintenance checklist for the BMP and developing recommendations for maintenance or repair based on inspection criteria. One option for implementing stormwater BMP inspections is to train stormwater maintenance staff on how to identify illicit discharges during routine inspections and to add tracking information regarding illicit discharges to related inspection forms.

Applications

Stormwater BMP inspections are used to identify maintenance needs, but can also be used as a field screening methodology to identify potential illicit connections or illicit discharges.

Storm Drainage System Types	Land Use Types	Weather Conditions
• Pipes	• Urban • Agricultural • Commercial • Industrial • Mining • Residential	• Dry • Wet

Equipment

Equipment specific to stormwater BMP inspections includes:

- ☐ Camera, phone, or other device for taking pictures (with date and time stamp)
- ☐ As-built drawings or site plans (if available)
- ☐ Maps of sanitary and storm drainage systems
- ☐ Facility/property owner contact information
- ☐ Various catch basin/manhole hooks and wrenches (including hexagonal Allen key) (for both types of inspections)
- ☐ Sledgehammer for loosening lids

- ☐ Field laptop/tablet and/or clipboard, field forms, and pen/pencil
- ☐ Safety equipment (for example, hard hats, eye protection, work gloves, ANSI 107-1999 labeled safety vests, ear protection, steel-toe boots, traffic control equipment)
- ☐ Primary field screening indicator equipment (see *Flow*, *Ammonia*, *Color*, *Odor*, *pH*, *Specific Conductivity*, *Temperature*, *Turbidity*, and *Visual Indicators* sections)

Methods

Revise the field form or GPS data dictionary that staff use to document routine stormwater BMP inspections. The following fields are recommended for describing potential illicit discharges that may require follow-up investigation:

- Color
- Odor
- Turbidity
- Visual indicators:
  - Deposits and staining
  - Fish kills
  - Floatables
  - Sewage bacteria
  - Structural damage
  - Surface scum or sheen
  - Trash and debris
  - Vegetation

Use the following steps during routine stormwater BMP inspections:

1. <u>Evaluate</u> the following:
   a. Water inside of a stormwater BMP for evidence of color, odor, turbidity, and other visual indicators

b. The condition of the stormwater BMP for the following visual indicators: deposits and staining, structural damage, and vegetation

c. The area immediately surrounding the stormwater BMP for signs of other visual indicators

d. Consistency with the as-built drawings or site plans (if available)

2. Document any visual, olfactory, or auditory indicators observed using a field notebook, field form, or a drop-down menu (for example, data dictionary) on a GPS unit.

3. Follow internal notification procedures to ensure proper reporting to other agencies and appropriate timely follow up if an illicit discharge is identified.

Pros and Cons

Pros	Cons
• Quick and inexpensive • Can eliminate sections of a storm drainage network from further screening if no flow or visual indicators are present • Effective if storm drainage network is already mapped • Highly efficient since it is combined with routine stormwater BMP inspections	• Some stormwater BMPs will have flow continuously year-round due to groundwater inflow or BMP design • Traffic hazards and danger to pedestrians when accessing some stormwater BMPs • Potential for toxic or flammable pollutants and hazards if confined space entry is necessary • Can be time consuming and difficult if storm drainage map is unavailable or incomplete • Less effective in wet weather than dry weather • Wet weather safety considerations for confined space entry

APPENDIX F

Other Indicators

This appendix includes detailed information on one indicator (Potassium) that was included as a follow-up indicator in the 2013 Illicit Connection and Illicit Discharge Field Screening and Source Tracing Guidance Manual. This indicator was moved to an appendix based on feedback obtained for the updated Manual because it is less commonly used than the other follow-up indicators. This indicator can still be helpful for source tracing to identify illicit connections and illicit discharges.

Potassium

Description

Potassium is an essential element for proper function of human, animal and plant cells. In natural waters, potassium concentrations range from 0.4 to 15 milligrams per liter (mg/L), although typical concentrations are less than 5 mg/L (Pitt 2001). Potassium is found at high concentrations in sewage and commercial/industrial discharges.

Applications

Potassium can be used for all storm drainage system and land use types. As a stand-alone field screening parameter, potassium testing has the potential to indicate industrial cooling water discharge.

Storm Drainage System Types	Land Use Types	Weather Conditions
• Pipes • Ditches	• Rural • Urban • Agricultural • Commercial • Industrial • Mining • Residential	• Dry • Wet

Equipment

Refer to the equipment list in the Field Screening Methodology section (Section 3) for the methodology you have selected. Equipment specific to potassium sampling includes:

- ☐ Potassium field meter or spectrophotometer
- ☐ Potassium reagent set (if spectrophotometer is selected)
- ☐ Potassium standards (if field probe method is selected)
- ☐ Laboratory grade cleaning wipes
- ☐ Tap water (for first rinse)
- ☐ Distilled water (for final rinse)
- ☐ Wash bottle (for rinsing with distilled water)
- ☐ Clean, sterile sample bottles (glass or plastic)

- ☐ Field laptop/tablet and/or clipboard, field, forms, and pen/pencil
- ☐ Safety equipment (for example, hard hats, ANSI 107-1999 labeled safety vests)
- ☐ Nitrile gloves
- ☐ Sturdy boots or belted waders
- ☐ Claw grabber or telescoping sampling pole (for collecting samples)

Methods

Potassium can be measured using a field meter or a spectrophotometer. General procedures for each type of equipment are outlined below. Refer to Figure 4.1 or Figure 4.2 for additional indicator sampling after obtaining results.

Potassium Field Meter

The specific steps for using field meters vary depending on the brand of field meter being used. Refer to the user's manual with your field meter for more detailed information. The following steps are generally common to potassium field meters:

1. **Check Meter:** Prior to taking meter in the field, confirm that the meter and probe are working properly and sufficient battery life is left.

2. **Calibrate Meter:**

    a. Wipe the sensor pad clean with distilled water and a laboratory grade cleaning wipe, dry the sensor pad with a laboratory grade cleaning wipe, and repeat several times.

    b. Place a sampling sheet onto the sensor pad and drip 2 to 5 drops of standard solution on it. Standard solution can also be applied directly to the sensor pad without a sampling sheet.

    c. Adjust the calibration dials as specified in the user's manual.

    d. Repeat steps a through c with a second standard solution for monthly calibration. Performing a single point calibration is sufficient once a day before use.

3. **Field Measurements:**

    a. Wear nitrile gloves to avoid sample contamination and protect yourself from potential contaminants.

    b. Collect a field sample in a clean, sterile sample bottle made of either glass or plastic. Avoid collecting sediment with the water sample.

c. Wipe the sensor pad clean with distilled water and a laboratory grade cleaning wipe and dry the sensor pad with a laboratory grade cleaning wipe.

d. Place a sampling sheet moistened with the sample onto the sensor pad. The sample can also be applied directly to the sensor pad without a sampling sheet.

e. Record the value shown on the meter on your field data sheet, notebook, or field laptop/tablet.

f. Wipe the sensor pad clean with distilled water and a laboratory grade cleaning wipe and dry the sensor pad with a laboratory grade cleaning wipe between each reading and before storage.

4. **Meter Storage:** Clean the surface of the sensor pad with a sampling sheet or laboratory grade cleaning wipe and distilled water. Wipe off the distilled water before storage. Place a seal over the sensor if the meter will be stored for a long time.

Potassium Using a Spectrophotometer

Samples are prepared for potassium analysis using a spectrophotometer by using a sodium tetraphenylborate reagent typically contained in a power pillow. The reagent is not known to be hazardous. Suspended matter and debris in a sample can interfere with spectrophotometer results and should be removed prior to testing using filtration. Refer to the user's manual with your spectrophotometer for more detailed information. The following steps are generally common to collecting and preparing a sample for a spectrophotometer:

1. Wear nitrile gloves to avoid sample contamination and protect yourself from potential contaminants and reagents.

2. Collect the sample to be analyzed in a clean, sterile sample bottle made of either glass or plastic. Avoid collecting sediment with the water sample.

3. Follow the steps in the user's manual included with your spectrophotometer to prepare and analyze the sample.

4. Record the value on your field data sheet, notebook, or field laptop/tablet.

Thresholds

The following potassium concentration triggers further investigation and indicator sampling. Washington State does not have surface water quality standards for potassium.

Threshold for Further Investigation and Indicator Sampling
Potassium > 5 mg/L

Pros and Cons

Pros	Cons
• Potassium can be used as an initial screening indicator for industrial waste	• Potassium field meters are unable to measure low concentrations of potassium (< 35 to 40 mg/l) • Need to use two separate analytical techniques depending on the concentration • Calcium and magnesium can interfere at high concentrations

Common Sources

Presence of potassium can be caused by the following sources:

High Potassium	
• Automotive manufacturer • Car wash water • Industrial process water • Metal plating bath water	• Poultry supplier • Radiator flush water • Uniform manufacturing

APPENDIX G

Other Source Tracing Methodologies

This appendix includes detailed information on two source tracing methodologies (Optical Brightener Monitoring and Sandbagging) that were included in the 2013 Illicit Connection and Illicit Discharge Field Screening and Source Tracing Guidance Manual. These methodologies were moved to an appendix based on feedback obtained for the updated manual because of their less common use. These methodologies can still be helpful for source tracing to identify illicit connections and illicit discharges.

Optical Brightener Monitoring

Description

Optical brighteners are fluorescent white dyes that are used in many laundry soaps and detergents to enhance the appearance of fabric and paper. Presence of optical brighteners in surface water indicates ineffective removal through adsorption in septic systems or wastewater treatment or an illicit connection. Optical brightener monitoring is a source tracing methodology that involves anchoring an absorbent pad in a pipe, catch basin, manhole, or inlet to capture intermittent dry weather flows and can be used to determine if detergents (containing optical brighteners) are present. Other source tracing methodologies used to identify intermittent discharges in piped systems include Sandbagging (also in Appendix G) and Video Inspections.

Applications

Optical brightener monitoring can be used in pipe or ditch systems, but is typically applied in small drainage areas (section of the storm drainage system that flows to a single node) when the visual inspection of a non-flowing outfall, catch basin, manhole, or inlet indicates that an illicit connection may be present. This methodology is most effective for identifying continuous or intermittent discharges or connections.

Storm Drainage System Types	Land Use Types	Weather Conditions	Complementary Source Tracing Methodologies
• Pipes • Ditches	• Urban • Commercial • Industrial • Residential	• Dry	• Catch Basin/Manhole Inspections • Dye Testing • Smoke Testing • Video Inspections

Equipment

Refer to the equipment list in the *Field Screening Methodology* section for the methodology you have selected. Equipment specific to optical brightener sampling includes:

All Applications

- ☐ Absorbent, unbleached cotton pad
- ☐ Wire or monofilament fishing line (for anchoring)
- ☐ Hook or popsicle stick (for anchoring)
- ☐ Unexposed labels (dark manila envelopes)

- ☐ Plastic bags with zipper enclosures
- ☐ Field laptop/tablet and/or clipboard, field forms, and pen/pencil
- ☐ Nitrile gloves
- ☐ Sturdy boots or belted waders
- ☐ Safety equipment (for example, hard hats, ANSI 107-1999 labeled safety vests, work gloves, steel-toe boots)
- ☐ 4–6 watt ultraviolet fluorescent light with 2 bulbs (for use in lab or office after field investigation)

Installation in a Pipe or Stream:

- ☐ 1/2 inch plastic or vinyl coated black wire cage, approximately 5 inches by 5 inches
- ☐ Elastic bands

Installation in a Catch Basin, Manhole, or Inlet:

- ☐ 1/2 inch plastic mesh bag
- ☐ Stapler and staples
- ☐ Rocks or stones to anchor mesh bag
- ☐ Various catch basin/manhole hooks and wrenches (including hexagonal Allen key)

Methods

Optical brightener monitoring can be used to detect presence of optical brighteners in catch basins, manholes, inlets, pipes, or streams. General procedures for using this methodology are outlined below.

1. Wear nitrile gloves to avoid sample contamination and protect yourself from potential contaminants.
2. Set up optical brightener monitoring trap during an expected period of dry weather.
    a. Test the unbleached cotton pad under long wave ultraviolet fluorescent light for presence of optical brighteners prior to use.
    b. **Pipe or stream sampling**:
        i. Place unbleached cotton pad in plastic wire cage and close with elastic band.

ii. Secure the plastic mesh cage with a monofilament fishing line tied to a branch, rock, or spike.

c. **Catch basin, manhole, or inlet sampling**:
   i. Staple unbleached cotton pad to mesh bag.
   ii. Place small stones or rocks in the bottom of the bag.
   iii. Tie the fishing line to the top of the plastic mesh bag.
   iv. Lower the plastic mesh bag into the catch basin, manhole, or inlet using a monofilament fishing line.
   v. Tie the other end of the fishing line to a hook or popsicle stick and wedge it into the side of the grate or lid cover.

d. **Flag or document** the location of optical brightener monitoring trap for easier retrieval.

3. Leave the optical brightener monitoring trap in place during dry weather for approximately 48 hours.

4. Retrieve optical brightener monitoring trap.

5. Prepare optical brightener monitoring trap for analysis.

   a. Rinse cotton pad in sampling water to remove sediment.

   b. Squeeze cotton pad to remove water.

   c. Label cotton pads with a piece of dark manila envelope. Labels should specify location, day of placement, and day of removal. *Do not* use white paper labels as these may contain optical brighteners.

   d. Place cotton pad and label in a plastic bag with a zipper enclosure and store in a dark area while collecting other optical brightener monitoring traps.

6. Analyze optical brightener monitoring traps

   a. Dry each cotton pad overnight on a monofilament fishing line.

   b. Place cotton pads on a table in a dark room and view under a long wave ultraviolet fluorescent light. Ensure that no ambient light enters the room.

   c. Compare the fluorescence of each sample with a non-exposed sampling pad (control pad). Determine qualitative test results:
      i. Positive: obvious glow compared to control
      ii. Negative: noticeably drab compared to control
      iii. Retest: any other result

7. Repeat steps 1 through 6 using Sandbagging (also in Appendix G) if cotton pad was not completely submerged.

8. Conduct a second round of indicator sampling to confirm initial results if optical brightener monitoring results do not lead to the source of the discharge.

Additional considerations for optical brightener monitoring include:

- Deploy for use during dry weather
- Hide device from public view to avoid tampering
- Ensure that cross contamination of cotton pads does not occur

Pros and Cons

Pros	Cons
• Inexpensive supplies • Animal/human waste differentiation • Laboratory test not required to obtain results • A single person can complete all steps	• Rainfall and groundwater can dilute optical brighteners; less effective during wet weather than dry weather • Only detects high concentrations of optical brighteners • Humic and fulvic acids (natural substances in the environment formed by the microbial degradation of dead plant matter) can mimic the fluorescence of laundry detergent and lead to inaccurate results • Sediment and debris can affect the results • Can be time consuming; requires two or more site visits • Results not available immediately • Optical brighteners are not included in all laundry detergents

Sandbagging

Description

If visual and olfactory indicators suggest the potential of an illicit discharge but no flow is present, the discharge may be intermittent, and another method is needed to sample the flow when it occurs. Sandbagging is a source tracing methodology used to catch intermittent discharges by sealing off flow in the storm drain. Although sandbags are the most commonly used material, other materials such as beach balls, expandable plugs, or caulk dams can also be used to block flow. Any flow collected behind the sandbags can be used for visual or indicator sampling. While sandbagging can be used as a source tracing methodology by itself, it is also used in conjunction with other source tracing methodologies such as Dye Testing, Smoke Testing, Optical Brightener Monitoring (also in Appendix G), or Video Inspections.

Applications

Sandbags are typically placed at junctions in the storm drainage network. If no flow is captured, it can be used to eliminate branches of the network from further consideration or investigation.

Storm Drainage System Types	Land Use Types	Weather Conditions	Complementary Source Tracing Methodologies
• Pipes • Ditches	• Urban • Commercial • Industrial • Residential	• Dry	• Catch Basin/Manhole Inspections • Ditch Inspections • Dye Testing • Smoke Testing • Video Inspections

Equipment

Equipment specific to sandbagging includes:

- ☐ Sandbags (beach balls, expandable plugs, or caulk dams can also be used)
- ☐ Rope
- ☐ Digital camera (with date and time stamp)
- ☐ Confined space entry equipment (only if entering manhole)
- ☐ Various catch basin/manhole hooks and wrenches (including hexagonal Allen key)
- ☐ Sledgehammer for loosening lids
- ☐ Field laptop/tablet and/or clipboard and pen/pencil

- ☐ Safety equipment (for example, hard hats, work gloves, ANSI 107-1999 labeled safety vests, ear protection, steel-toe boots, traffic control equipment, gas monitor)
- ☐ Primary field screening indicator equipment (see *Flow*, *Ammonia*, *Color*, *Specific Conductivity*, *Odor*, *pH*, *Temperature*, *Turbidity*, and *Visual Indicators* sections)

Methods

Field crews should implement the following steps during sandbagging:

1. Identify which manhole junction in storm drainage network to block off.
2. Lower sandbags on a rope through the manhole to form a dam on the bottom of the storm pipe. Form as many dams as needed at the network junction (such as, if three pipes are flowing into the junction, form three dams upstream of the junction). Confined space entry may be required to ensure that a complete seal is achieved.
3. Leave sandbags in place for 48 hours.
4. Return to the site and inspect each sandbag for accumulation of water on the upstream side. If no flow was captured, the discharge was likely transitory, and it may not be possible to determine its source. If the sandbag has captured flow, there may be a potential illicit discharge upstream of its respective storm drainage pipe. If sandbag has leaks or gaps between bags, discharge may have flowed through, in which case look for water stains on the bags.
5. Document any visual or olfactory indicators observed using a field notebook, customized catch basin/manhole maintenance inspection form, or using a drop-down menu (for example, data dictionary) on a GPS unit.
6. Collect a sample if water has accumulated behind the sandbag dam and record values for the other primary field screening indicators (pH, temperature, turbidity, and ammonia). Refer to the *Indicators* section for additional detailed information regarding how these samples should be collected and analyzed.
7. Remove sandbags after the water sample has been collected.
8. Move up the branch of the junction with captured flow to further isolate the intermittent discharge. Repeat sandbagging at the next junction or use an alternate source tracing methodology such as Dye Testing, Smoke Testing, Optical Brightener Monitoring (also in Appendix G), or Video Inspections. Sandbags can be reused between locations.
9. Conduct a second round of indicator sampling to confirm initial results if sandbagging does not lead to the source of the discharge.

Additional considerations for sandbagging include:

- Sandbags should be placed in the storm drainage system after 48 hours of dry weather and should only be used when at least 48 more hours of dry weather is predicted.

- Sandbags should be removed prior to a heavy rainstorms as they may cause a blockage in the storm drain or be washed downstream.

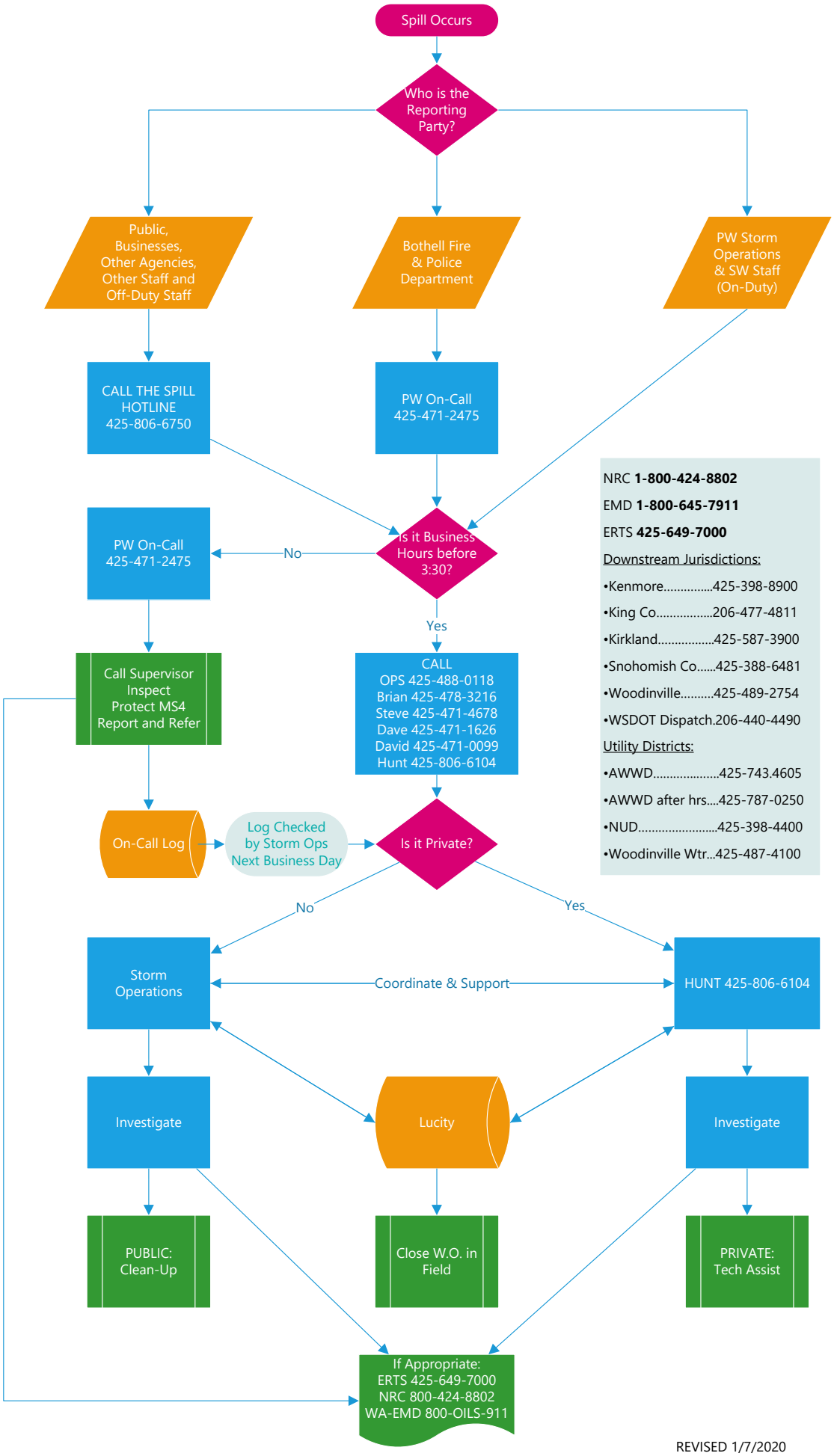
- Sandbagging can be used to block off storm drainage systems prior to using other source tracing methodologies such as Catch Basin/Manhole Inspection, Ditch Inspections, Dye Testing, Smoke Testing, or Optical Brightener Monitoring (also in Appendix G). If this is the intent, Steps 1 and 2 should be followed in addition to the methods for the source tracing methodology selected.

Pros and Cons

Pros	Cons
• Isolates intermittent flows • Sandbags are small enough that they do not block the outlet pipe(s) • Can be used in combination with other source tracing methodologies	• Requires at least two trips to each manhole • Requires a 96-hour period of dry weather (two 48-hour periods) • If it rains while sandbags are in place, interference from stormwater will make the results inconclusive or difficult to interpret; less effective during wet weather than dry weather • Potential for toxic or flammable pollutants and hazards if confined space entry is necessary

APPENDIX B

Spill Response Flow Chart



REVISED 1/7/2020

APPENDIX C

Spill Response Standard Operating Procedures

Spill Response

Spill response is everyone's responsibility. Public Works Operations responds to all spills on private and public property.

After hours response to spills

Respond to all public and private spills.

Duties include:

1. Containment to prevent discharge to City of Bothell storm system or surface water.
2. Contact with the business or property owner, and request that the person or business responsible clean up the spill.
3. Contact Department of Ecology if spill enters the storm system.
4. In the event that we cannot make contact with the business or property owner or there is a refusal to clean up and the spill is going to affect our storm system, you are required to contact your manager then BEGIN CONTAINMENT AND CLEAN UP. WE WILL NEED TO MAKE CONTACT WITH THE PRIVATE PROPERTY OWNER TO CLEAN UP.
5. In all cases, track all staff hours, equipment hours, and disposal costs. The City will back bill the business or person reasonable.
6. See below for **Spill Response** steps. SpillReport@Bothellwa.gov

Reporting - Nothing but rain down the drain

You are expected to call and report to Department of Ecology any discharge to the storm system within 24 hours of the discharge. This could include catch basin, ditch, rain garden, vault, creek, wetland, stream or river.

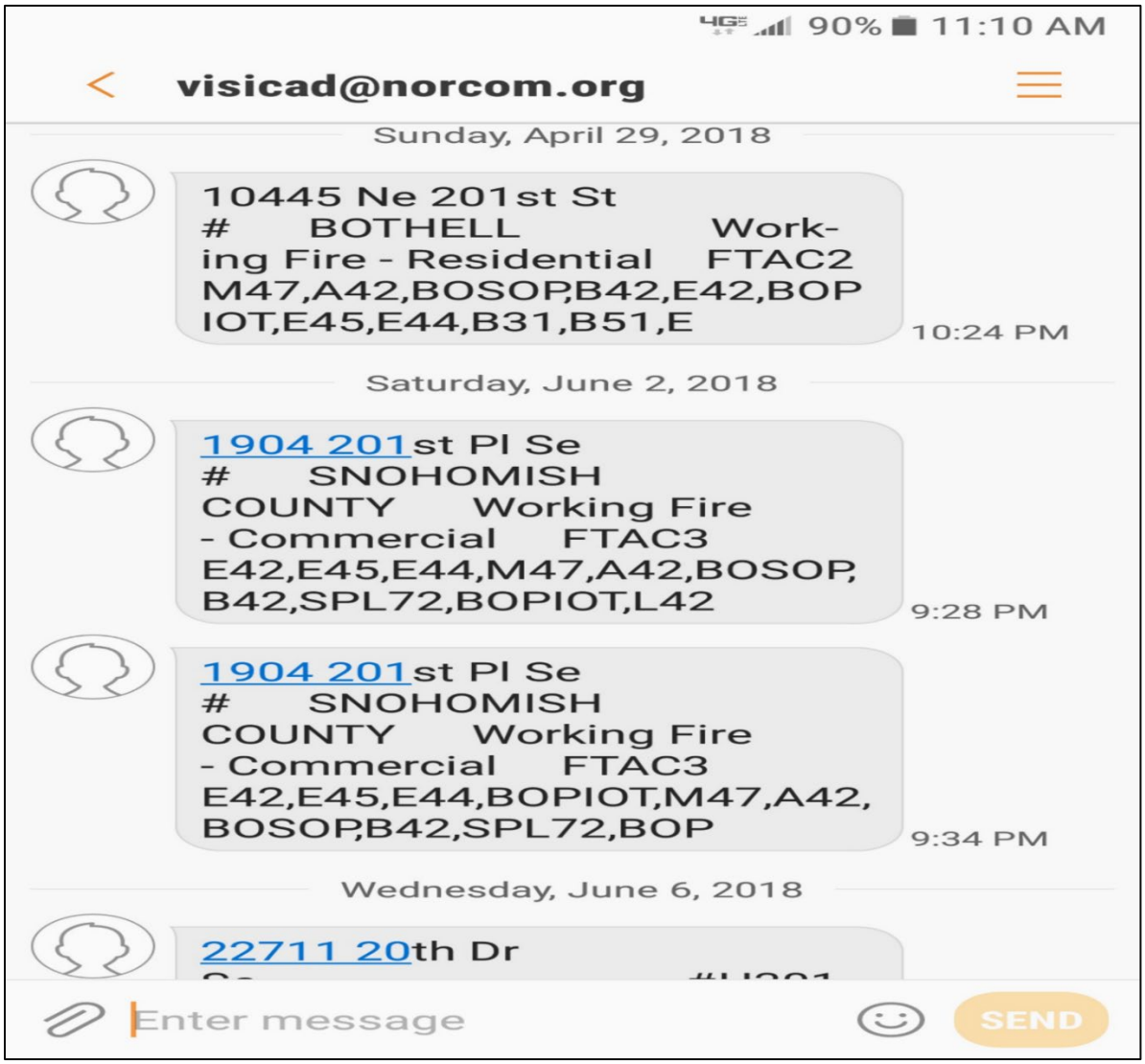
Fire Discharge Process

In the event that Fire Department discharges water or foam, the Fire Department is required to contact Surface Water or Storm in one of the following ways. In both cases, we will respond and report accordingly.

1. Norcom dispatch will send a text from visicad@norcom.org to the 24-hour Public Works On-call 425-471-2475 for a working structure fire at residential, commercial, or multi-family.
2. Fire staff will contact the 24-hour Public Works On-call 425-471-2475 anytime they discharge class A or B foam or water to a non-structure fire. This includes car fire, brush fire or potable water discharge for training.
3. Public Works On-call staff will be responsible for assessing the storm system and notifying Ecology of the discharge.
4. Public Works Operations staff will email Spill Report to report the incident and assist as necessary with subsequent reporting to Ecology.

5. Public Works Operations staff will follow-up with cleaning the system per the requirements.

Below is an example of a text from visicad@norcom.org . On-Call Staff is required look up the address and, if it is within the city limits, to respond, contain and report, as needed.



Power Pole Transformer Spills

DO NOT CLEAN UP TRANSFORMER LEAKS. Some transformers can contain a chemical called polychlorinated biphenyl (PCB). The recommendation is that you close that section of roadway. The power utility provider, Puget Sound Energy (PSE) or Snohomish Public Utility District (Sno PUD) is required clean up transformer spills.

Staff Person

Spill Response

1. Evaluate safety of scene and material.
2. Contain the material.
3. Call your Manager immediately.
4. During business hours, call the Surface Water Hunt Group **425-806-6104. This will notify Surface Water. If the spill is on private property, ask an inspector to assist.**
5. Clean up and properly dispose of material.
6. If spill reaches the **public storm system** contact Ecology. Ecology-ERTS 425-649-7000 (within 24-hours for all non-storm water discharges).
7. **If the spill is oil or hazardous material** and on public property or for non-responsive private property call- NRC 1-800-424-8802 and the EMD 1-800-OILS-911.
8. Does it drain to another jurisdiction? Call them (as soon as practical).
9. After-action reporting **LUCITY.** (Every IDDE needs both a Work Request and Work Order to be a complete report. The **REQUEST** triggers the email to notify Surface Water of the incident)

All incident and ERTS numbers are required to be documented under notes in your work order.

All three numbers are required to have notification including location, quantity spilled, and what was spilled is required. **See step 8 above**

It is required Surface Water is notified during hours of 7 am to 5 pm, Monday through Friday**.**

In the event of a spill on the weekend or after hours, Surface Water must be notified the following business day. It is your responsibility as the on call to send an email to SpillReport@Bothellwa.gov stating that you have responded and the spill is contained and cleaned up this will notify **your** Supervisor and Surface water

Keep in mind: Cleaning the storm system in a neighborhood in the middle of the night is not recommended. HOWEVER, IF REQUIRED WE WILL DO SO.

In the event of a large spill - contact additional Storm Operations staff for assistance.

Sound Telecom

Sound Telecom Answering Service monitors the Spill Hotline. The answering service takes the incoming calls 24 hours a day, seven days a week, and relays the information to City of Bothell personnel.

1. The answering service is instructed to keep calling until a live person answers or responds to "Clear" a message left for them. Clearing the call means that the answering service has conveyed the information to a City of Bothell Employee on the spill report.
    a. During office hours, they have a call list that includes nine office staff and then the On-Call number.
    b. After office hours, weekends and holidays the call list is the On-Call number only. They keep calling until they have spoken to a person.

2. Write down all the information provided when receiving a call from the Spill Hotline Answering Service.
3. Call 1-800-452-1908 to respond to messages left by the answering service.
4. Enter all Spill Hotline calls as Work Requests in Lucity.
5. Calls that report spills outside City Limits are reported to the appropriate jurisdiction.

On call, staff will be responsible for determining location/jurisdiction
On call, staff will be responsible to call jurisdiction

Untreated Storm water

City of Bothell storm drains do not connect to the sewer system, so anything that enters our storm drains can pass directly to the nearest pond, stream, or wetland without treatment. This is why it is so important to keep all pollutants out of our storm water system.

.

What are PCBs and why are they bad?
PCBs have been used as coolants and lubricants in transformers, capacitors, and other electrical equipment because **they** do not burn easily and are good insulators. The manufacture of **PCBs** was stopped in the U.S. in 1977 because of evidence **they** build up in the environment and can cause harmful health effects.

APPENDIX D

Long-Term Screening Program Plan

719 2ND AVENUE, SUITE 200 | SEATTLE, WA 98104 | P 206.394.3700

LONG-TERM PLAN | ILLICIT DISCHARGE & BACTERIA SCREENING PROGRAM

Programmatic Components	Field Screening and Analytical Methods
YEAR 1 *(Goal: full implementation within 1 year following plan adoption)*	
1. Utilize field presence of available City staff (public works crews, police, fire, animal control, interns, etc.). · Conduct regular training and coordination on visual and olfactory illicit discharge markers · Streamline internal reporting procedures · Utilize electronic asset management database (Lucity) and field tablets for cross-department coordination 2. Conduct public outreach and education for pollutant prevention and reduction (pet owner education, school programs, urban wildlife deterrents, etc.)	1. Conduct visual and olfactory IDDE checks during drainage system maintenance, cleanings, and other inspections 2. Potential illicit discharge signs reported to surface water staff for upstream source tracing 3. Identify possible sources and potential for leaks using desktop analysis based on inspections, complaints, or other currently available information 4. Use MS4 junctions identified in IDDE plan to conduct upstream field source tracing 5. Conduct initial project area reconnaissance visits, community outreach and inspection notification, and fecal coliform pollution identification & correction 6. Use visual and olfactory markers to conduct field inspections of potential sources 7. Evaluate need for additional screening tools on a per-event basis: · Dye testing · Optical brighteners · Additional bacteria sampling 8. If additional bacteria sampling warranted: · Desktop analysis and field recon prior to any sampling · Rank bacteria sampling results based on Snohomish County Targeted Bacteria Source Identification and Elimination Procedures to prioritize upstream source tracing

Programmatic Components	Field Screening and Analytical Methods
YEARS 2 and 3 *(Goal: full implementation within 3 years following plan adoption)*	
Increase IDDE database inventory of local businesses for reference in potential pollutant-source identification	1. Continue to map and log bacteria sampling results to build a data baseline of the MS4. 2. Compare in-stream sampling results against those collected in a correlating outfall (if available based on source-tracing sampling conducted in MS4) 3. Supplement source-tracing monitoring with sampling in areas of MS4 that have not been evaluated to expand data baseline. 4. Time supplemental sampling throughout seasonal periods. Dry weather flows do not always indicate illicit connection due to base flows and bacteria levels in seasonal first-flush are typically higher.
YEARS 4 and 5 *(Goal: full implementation within 5 years following plan adoption)*	
On-going reduction in bacteria sources and pathways as part of overall stormwater management program, including: · Watershed management · Additional source control · Capital projects · Regional treatment retrofits	Review/re-evaluate emerging bacterial screening technologies