INAPPROPRIATE DISCHARGE DETECTION AND ELIMINATION WHAT PHASE I COMMUNITIES ARE DOING TO ADDRESS THE PROBLEM

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Abstract

Inappropriate connections to storm drain systems account for significant annual pollutant loads from urban areas. Inappropriate discharge detection and elimination (IDDE) are important elements of any effective stormwater quality management program. Since 1990, under US EPA's National Pollutant Discharge Elimination System (NPDES) Phase I Storm Water Program, cities and counties with populations of 100,000 or more that operate a municipal separate storm sewer system (MS4) were required to obtain discharge permit coverage. An element of NPDES Phase I, Part I was that regulated MS4s were required to perform discharge characterization by screening outfalls for inappropriate connections to MS4s. NPDES Phase I, Part II required regulated MS4s to demonstrate adequate legal authority to control discharges, prohibit inappropriate discharges, require compliance, and carry out inspections, surveillance and monitoring (EPA, 1996). As a result, 173 cities and 47 counties (Glanton *et al*., 1992) were required to develop IDDE programs.

In 2001, the Center for Watershed Protection (CWP) and Dr. Robert Pitt from the University of Alabama obtained a multi-year grant from US EPA to research the most cost-effective and efficient techniques that can be employed to identify and correct inappropriate discharges, and write a "Users Guide" geared toward use by NPDES Phase II communities and citizen volunteers. One element of the research is investigating and compiling data and methods that have been employed in pursuit of IDDE by NPDES Phase I MS4s. CWP conducted a survey of 24 NPDES MS4s representing various geographic and climatic regions in the U.S. to research what these communities have been doing on the IDDE front. Surveys requested information about: community characterization; system characterization; IDDE program characterization; legal authority; system mapping; procedures used for inappropriate discharge identification, confirmation, source identification and correction; education and outreach; and other programmatic features or references. This paper presents the findings of the survey and provides inferences that can be drawn about the collected data.

Introduction

The Center for Watershed Protection (CWP) and Dr. Robert Pitt, University of Alabama, are working under a multi-year grant from the US EPA to research the most cost effective and efficient techniques that can be employed to identify and correct inappropriate discharges, and to develop a "Users Guide" for use by National Pollutant Discharge Elimination System (NPDES) Phase II jurisdictions and citizen volunteers. One element of the research is investigating and compiling data and methods that have been employed in pursuit of inappropriate discharge detection and elimination (IDDE) by NPDES Phase I MS4s.

A survey was developed and submitted to over 50 local jurisdictions representing various geographic and climatic regions in the United States that have implemented IDDE programs. The intent of the survey was to

determine the current state of practices utilized by local governments, and to identify practical, low cost, and effective techniques that have been implemented in the field and laboratory for inappropriate discharge detection and elimination. The survey information will be used in the preparation and development of the Users Guide. This paper summarizes the results of the survey.

Design of Survey

The survey was designed to elicit detailed information on existing IDDE programs and to gain insight on the following topics: (A copy of the survey can be accessed from www.cwp.org)

1. Community Characterization
2. System Characterization
3. Inappropriate Discharge Detection Elimination (IDDE) Program Characterization and Cost
4. Legal Authority
5. System Mapping
6. Methods to Identify and Confirm Inappropriate Discharges
7. Inappropriate Discharge Corrections Program
8. Education, Outreach, and Pollution Prevention Programs

The target audience for the survey included jurisdictions that have implemented IDDE programs, primarily those subject to NPDES Phase I requirements. Jurisdictions selected for the survey represent a variety of geographic and climatic regions. The EPA stormwater coordinators for each region of the country were contacted for recommendations on jurisdictions to include in the survey. A variety of jurisdiction sizes were targeted on the basis of population, IDDE program service area, and land use. The ages and reputations of the program were also considered. The survey was sent to 57 jurisdictions, with 24 jurisdictions (42%) from 16 states completing the survey (Figure 1).

Surveys were supplemented by on-site interviews of IDDE program staff in seven jurisdictions: Baltimore City, MD; Baltimore County, MD; Boston, MA; Cambridge, MA; Dayton, OH; Raleigh, NC; and Wayne County, MI, witnessing field operations when possible.

Survey Results

Community Characterization

Of the 24 jurisdictions that completed the survey, 18 are NPDES Phase I jurisdictions, one was awaiting the issuance of its Phase I permit, two are Phase II jurisdictions, two operate under a Stormwater General Permit, and one is a Special Purpose District servicing both Phase I and Phase II jurisdictions (Table 1). Of the 24 respondents, only 21 have fully implemented IDDE programs. Alexandria and Falls Church, Virginia, are both currently developing programs as part of their NPDES Phase II requirements. Seattle, Washington, currently addresses inappropriate connections via water quality complaints and a routine business inspection program. Seattle's Phase I NPDES permit is currently being updated, and the next permit cycle will require the implementation of a full inappropriate discharge reduction program. Even

though these three jurisdictions have not fully implemented their programs, they have each implemented some elements. Therefore, data reported throughout this paper reflects varying numbers of responses to different survey questions.

Overall, the respondents included five counties, 18 cities, and one Special Purpose District. Land use was varied, but tended towards ultra-urban, urban, and suburban. The population density ranged from 175 to 15,000 people per square mile, with a median of 2,600 people per square mile. The jurisdictions also vary in service area, with ranges from 2 to 498 square miles, and a median of 70 square miles.

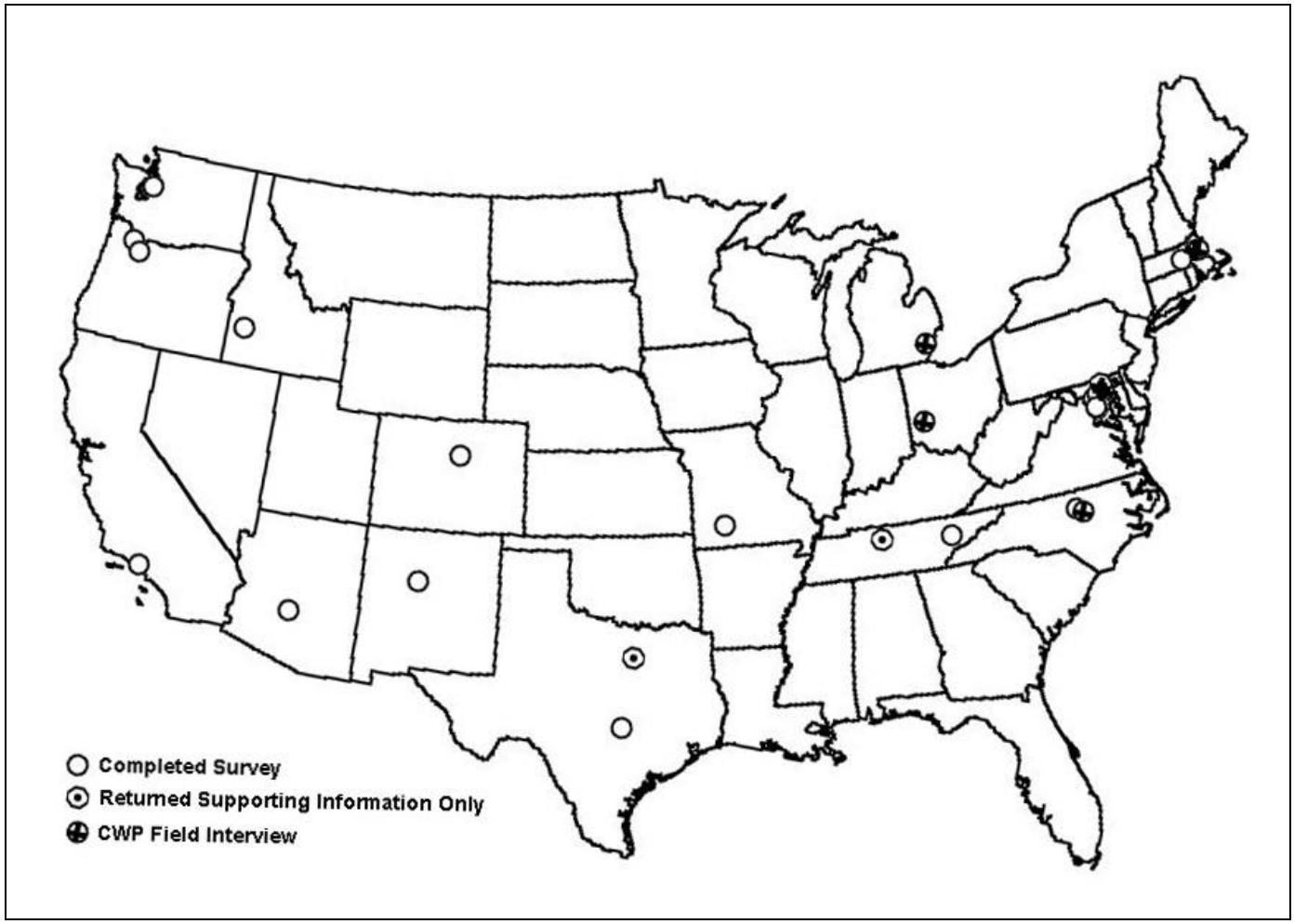

Figure 1: Jurisdictions that Participated in the IDDE Survey

System Characterization

To help determine the relative scale of the programs, the survey requested information that would characterize the jurisdictions drainage systems in addition to population density, service area, and land use. Specifically, information on length of storm drain network, number of major outfalls, and the ratio of outfalls to miles of storm drain were compiled (Table 1).

Table 1: Characterization of Jurisdictions that Participated in the IDDE Survey

Jurisdiction	Form of Government	NPDES Status	Land Use (%)					Population Density (people/mi2)	Service Area (mi2)	Total Length of Storm Drainage Network (mi)	# of Major Outfalls	Outfall / Mile of Drainage Network
			Ultra-Urban	Urban	Sub-urban	Rural	Forest/ Undev'd					
Ada County Highway District (ACHD), ID	Special Purpose District	Phase I, Phase II	12	23	28	11	26	1,070	69.73	351	65	0.19
Albuquerque, NM	City	Phase I	-	90	-	-	10	2,400	181	582	6	0.01
Alexandria, VA	City	Phase II	100	-	-	-	-	8,000	15.75	N/R	N/R	N/A
Arlington Co., VA	County	Phase I	10	9	47	-	33	7,149	20	400.5	100	0.25
Austin, TX	City	Phase I	1	25	54	20	-	2,745	238	600	250	0.42
Baltimore City, MD	City	Phase I	-	71	-	-	29	7,173	92	726	345	0.48
Boston, MA	City	Phase I	-	85	-	-	15	12,271	48	542	94	0.17
Cambridge, MA	City	Phase II	85	15	-	-	-	15,000	6.25	81	11	0.14
Clackamas Co., OR	County	Phase I	10	15	60	5	10	181	22	N/R	22	N/A
Dayton, OH	City	Phase I	20	50	10	5	15	3,115	52	600	300	0.50
Durham, NC	City	Phase I	4	20	43	5	28	1,950	92	2,690	890	0.33
Falls Church, VA	City	Phase I	10	50	39.5	-	0.5	5,000	2	N/R	N/R	N/A
Howard Co., MD	County	Gen. Permit	15	25	53	6	-	972	255	300	365	1.22
Knoxville, TN	City	Phase I	10	20	55	5	10	1,750	100	324	1,004	3.10
Lakewood, CO	City	Phase I			N/R			3,225	44	N/R	204	N/A
Montgomery Co., MD	County	Phase I	-	30	12	30	28	1,762	496	2,597	7,165	2.76
Phoenix, AZ	City	Phase I	-	30	60	10	-	2,537	473	3,500	322	0.09
Portland, OR	City	Phase I	-	-	-	-	-	3,534	47	562	110	0.20
Raleigh, NC	City	Phase I	5	20	40	10	25	1,800	120	3,200	1400	0.44
Seattle, WA	City	Phase I	100	-	-	-	-	6,706	84	630	200	0.32
Springfield, MO	City	Phase I	5	50	30	-	15	2,000	70	500	6	0.01
Thousand Oaks, CA	City	Phase I	-		33	10	47	2,142	58	N/R	N/R	N/A
Wayne Co., MI	County	Gen. Permit	33	6	41	13	7	175	498	3,265	2,000	0.61
Worcester, MA	City	Phase I			N/R			4,600	37.6	347	250	0.72
Median			**10**	**25**	**41**	**10**	**15**	**2,600**	**70**	**582**	**250**	**0.33**

Notes: N/A = Not applicable; N/R = Not reported

Program Characterization

Staff time dedicated to the IDDE programs surveyed ranged from 0.08 to 10 person-years, with a median of 1.5 person-years (Table 2). It was difficult for many of the jurisdictions to quantify actual staff time dedicated to IDDE activities since the responsibilities are spread among many departments, or because the staff who work on IDDE also perform other un-related tasks.

Table 2: Staff Time Dedicated to IDDE Program Annually

Jurisdiction	Staff Time (person-years) Dedicated to IDDE Program Annually (n = 21)			Ratio of Field to Total
	Field Staff	Office Staff[1]	Total Staff	
Wayne Co., MI	6	4	10	60%
Baltimore City, MD	6	2.25	8.25	73%
Phoenix, AZ	5	2	7	71%
Knoxville, TN	2	1.5	3.5	57%
BWSC, MA	2	1.25	3.25	62%
Worcester, MA	2	1	3	67%
Durham, NC	2.1	0.5	2.6	81%
ACHD, ID	1	1.5	2.5	40%
Montgomery Co., MD	2	0.5	2.5	80%
Cambridge, MA	1[2]	0.50	1.50	66%
Albuquerque, NM	Note 3	1.5	1.5	N/A
Austin, TX	1	0.35	1.35	74%
Raleigh, NC	1	0.3	1.3	77%
Thousand Oaks, CA	0.9	0.3	1.2	75%
Springfield, MO	0.5	0.5	1.0	50%
Howard County, MD	N/R	0.6	0.6	N/A
Portland, OR	0.22	0.11	0.33	67%
Clackamas Co., OR	0.1	0.1	0.2	50%
Dayton, OH	0.1	0.05	.15	67%
Arlington Co., VA	0	0.1	0.1	0%
Lakewood, CO	0.04	0.04	0.08	50%
Median	**1.0**	**0.5**	**1.5**	**67%**

Notes:
1. Includes administrative and professional office staff.
2. Additional 1.75 person-years spent by professional consultant performing sampling, inspection work.
3. Field monitoring subcontracted to a consultant.

For similar reasons, it was also difficult for jurisdictions to accurately report the full IDDE program budget, as well as costs associated with different related activities (Table 3). Annual IDDE program expenditure ranged from $3,500 to $613,561, with a median of $121,825.

Table 3: Annual IDDE Program Expenditure

Jurisdiction	Staff Total		Office Computer / Software		Field Equipment		Lab Equipment / Testing		Other[1]		Total Annual
	($)	(% of total)	($)	(% of total)	($)	(% of total)	($)	(% of total)	($)	(% of total)	($)
Wayne Co., MI	460,672	75%	3,760	0.6%	319	0.1%	7,500	1%	141,273	23%	613,561
Phoenix, AZ	500,003	84%	-	-	15,665	2.6%	13,840	2%	64,571	11%	593,134
Cambridge, MA	100,200	25%	1,000	0.2%	3,000	0.7%	10,000	2%	297,200	73%	406,400
Baltimore City, MD	298,750	75%	-	-	10,000	2.5%	87,000	22%	-	-	395,750
Albuquerque, NM	110,000	28%	-	-	14,000	3.6%	20,000	5%	250,000	63%	394,000
Worcester, MA	160,000	57%	-	-	-	-	15,000	5%	100,000	36%	280,000
Montgomery Co., MD	200,000	97%	-	-	5,500	2.7%	-	-	-	-	205,500
BWSC, MA[2]	142,000	73%	200	0.1%	1,000	0.5%	500	0%	50,000	26%	193,700
Durham, MA	156,600	89%	2,500	1.4%	3,500	2.0%	8,000	5%	4,600	3%	175,000
ACHD, ID	160,450	100%	-	-	-	-	-	-	-	-	160,450
Thousand Oaks, CA	60,000	72%	-	-	10,000	12.0%	5,000	6%	5,000	6%	83,200
Raleigh, NC	53,000	64%	5,000	6.0%	6,000	7.2%	12,000	14%	7,000	8%	83,000
Springfield, MO	70,000	84%	5,000	6.0%	5,000	6.0%	1,000	1%	2,000	2%	83,000
Austin, TX	67,500	82%	1,000	1.2%	4,000	4.8%	5,000	6%	-	-	82,500
Knoxville, TN	33,000	55%	1,000	1.7%	500	0.8%	15,000	25%	10,000	17%	59,500
Portland, OR	15,000	58%	-	-	-	-	10,000	38%	1,000	4%	26,000
Clackamas Co., OR	16,000	100%	-	-	-	-	-	-	-	-	16,000
Arlington Co., VA	7,000	95%	-	-	50	0.7%	300	4%	-	-	7,350
Lakewood, CO	3,500	57%	300	4.9%	1,600	26.0%	500	8%	250	4%	6,150
Howard Co., MD	3,000	86%	-	-	-	-	500	14%	-	-	3,500
Median	**$85,100**	**75%**	**$1,000**	**1%**	**$4,000**	**3%**	**$8,000**	**5%**	**$10,000**	**11%**	**$121,825**

Notes:

1. Typical costs included in the “other” category include education, training, travel, consultants, and contractors.
2. The annual budget information provided by BWSC does not include the costs associated with corrections, nor the costs associated with special drainage system studies.

Legal Authority

Ninety-six percent of the surveyed jurisdictions have some type of regulation that prohibits inappropriate discharges from entering the MS4. Discharge prohibitions typically come under at least one of three regulations:

1) A stormwater ordinance that addresses inappropriate discharges to the storm sewer system or receiving waters;
2) A plumbing code that addresses illegal connections to the storm sewer system; or
3) A health code that regulates the discharge of harmful substances to the storm sewer system or receiving waters.

Most jurisdictions surveyed have the legal authority necessary to inspect private properties for illegal discharges, but based on our interviews, few seem to have found it necessary to invoke that authority. Communities noted that owners are usually cooperative with respect to property inspections by jurisdictions investigating inappropriate discharges, and that achieving compliance is not usually problematic.

Mapping Capabilities

Over 80% of the jurisdictions surveyed utilize Geographic Information Systems (GIS) to track outfalls and record site data. Despite the convenience and power of the digital maps, many communities still relied on supplemental information provided on paper maps, particularly where information transfer to the GIS was not complete or was unverified. Based on interviews with select jurisdictions, preferences for paper or digital mapping varied. For instance, Baltimore City field crews expressed a preference for paper mapping, which they felt to be easier to interpret than printouts from the digital mapping system. In addition, for areas where sewer mapping either does not exist, they have often turned to historic topographical maps to determine possible pre-development stream locations.

A primary use of mapping in an IDDE program is to prioritize areas for outfall screening or dye testing. In addition, it is useful for tracking areas that have been investigated versus those that still need to be investigated. Table 4 displays the IDDE program mapping elements that surveyed jurisdictions use.

Based on interviews, other key areas that are useful to map include:

- Certain industries by SIC code
- Historic complaints
- Sanitary and storm sewers in close or in common manholes
- "Gaps" in sanitary mapping
- Licensed businesses, SIC codes, industrial permittees
- Areas with businesses with night hours (e.g., bars and restaurants)

Table 4: Common IDDE Program Mapping Elements

Elements Mapped by Jurisdictions	% of Jurisdictions Responding (n = 24)
Storm sewers	96%
Waters of the US receiving discharges from outfalls	83%
Outfalls	79%
Open channels (conveyance channels)	71%
Land use	67%
Sanitary sewers	63%
Industrial discharge permit holders	33%
Building connections to storm sewers	25%
Connections to adjacent systems / communities	25%
Building connections to sanitary sewers	21%
Watershed, outfall drainage area boundaries	13%
Hotspot areas	13%

Methods to Identify and Confirm Potential Inappropriate Discharges

Table 5 displays the procedures utilized by the surveyed jurisdictions to determine the presence of a suspected inappropriate discharge. Most of the jurisdictions used several different methods and there was no apparent trend based on geographical location. The top three procedures selected were: 1) pollution reporting hotline (86%); 2) regular inspection of outfalls by jurisdiction (76%); and 3) water quality monitoring of receiving waters (71%).

Some of the jurisdictions found that the initial outfall screening conducted was very successful at identifying chronic problems, but that the following screening was less useful. For sporadic discharges, jurisdictions are relying more heavily on telephone hotlines and cross-training inspection and maintenance staff than on monitoring or field screening.

Table 5: Investigative Procedure(s) Used to Determine the Presence of a Suspected Inappropriate Discharge to a MS4 or Receiving Water

Investigative Procedure	% of Respondents (n = 21)
Pollution reporting hotline for citizens to call	86%
Regular inspection of outfalls by jurisdiction	76%
Water quality monitoring of receiving waters	71%
Regular inspection of storm sewers	62%
Regular inspection of sanitary sewers	48%
Dye- or smoke-testing of buildings in problem areas	48%
Sporadic outfall inspection by watershed/citizen organization	38%
Regular outfall inspection by watershed/citizen organization	24%

Sporadic inspection of outfalls by jurisdiction	24%
Dye- or smoke-testing of buildings at the time of sale	5%
Water quality monitoring of discharge waters	5%
Septic system inspection at time of sale	5%

Sources of Discharges Typically Found

Common sources of discharge found by jurisdictions responding to the survey are displayed in Table 6. While certain sources are random and may occur anywhere, such as illegal dumping, other sources can often be associated with specific factors within a community or subwatershed. These include:

- Land use (e.g., industrial discharges, restaurant grease, failing septic systems)
- Type and age of sewer system (e.g., pump station failures, inflow/ infiltration, SSOs)
- Historic plumbing codes (e.g., connection of floor drains to storm sewers)
- Recreational facilities (e.g., chlorine from swimming pool discharges, sewage from marina pumpouts)

No significant relationship was apparent relating sources of discharge to geographic location.

Table 6: Sources of Inappropriate Discharges Typically Found

Sources of Inappropriate Discharge	% of Respondents (n = 21)
Illegal dumping practices	95%
Broken sanitary sewer line	81%
Cross-connections	71%
Connection of floor drains to storm sewer	62%
Sanitary sewer overflows	52%
Inflow / infiltration	48%
Straight pipe sewer discharge	38%
Failing septic systems	33%
Improper disposal of wastes from recreational vehicles	33%
Pump station failure	14%

Outfall Monitoring

All but two of the jurisdictions surveyed conduct some sort of outfall monitoring program. Most conduct outfall monitoring on a regular basis, per NPDES Phase I requirements.

Jurisdictions reported that beyond initial outfall screening, continued outfall monitoring was less useful in finding intermittent or one-time discharges. For instance, Wayne County, MI, noted that outfall monitoring is not the most effective method for identifying inappropriate connections due to the potential for dilution, the periodic nature of some discharges, and the time delay between discharge into the system and discharge from the outfall. This is supported by survey results that indicate the periodic nature of discharges is the biggest impediment to identifying inappropriate discharges.

Jurisdictions seem to place a heavy reliance on physical indicators of discharges, as opposed to chemical outfall screening, even in light of a 30% false positive identification rate (Lalor, 1993). The most common approach to outfall screening involves conducting a visual inspection of the outfall and a qualitative

assessment of any flow present, including observation of water color, odor, turbidity, floatables, and sedimentation. In some cases, if the flow is suspected to be inappropriate, a follow-up grab sample is taken for quantitative analysis. Many jurisdictions bypass the quantitative tests and immediately move upstream to find the source of the discharge.

In-Stream Monitoring

Some jurisdictions utilize in-stream monitoring to enhance or supplement outfall monitoring. In-stream monitoring is used to identify trends that may lead toward characterization of inappropriate discharges. The City of Raleigh, NC has conducted baseline monitoring on nine streams for basic parameters, some of which are used to detect sewer leaks including fluoride, fecal coliform, ammonia, sodium, and conductivity. Deviation from the baseline for these parameters observed during regular in-stream monitoring prompts further investigation of possible inappropriate discharges. Baltimore City conducts weekly screening of receiving waters using a hydrolab or equivalent and field test kits for ammonia. When a threshold value is exceeded, sampling continues upstream until the source is located. To address chronic problems, a monthly sampling program is conducted using an extensive variety of laboratory-analyzed chemical parameters at approximately 40 receiving water stations. When long-term medians exceed a certain percentile based on the entire database, investigations are conducted by sampling further upstream in the storm drain network.

Citizen Hotlines

Citizen hotlines are a common method for indicating the presence of a suspected inappropriate discharge. Nineteen (90 %) of the surveyed jurisdictions have pollution reporting hotlines, and 18 of these track the number of complaints that have been received and corrected to help determine IDDE program success. Montgomery County, MD, noted that the success of their IDDE program is directly related to their water quality outreach, complaint, and enforcement system, not to their outfall-screening program. On average, County staff identify and correct about six inappropriate discharges per year as a result of regular screening. By contrast, over 185 inappropriate discharges are corrected each year as a direct result of citizen complaints and calls to the hotline.

Public education and labeling of outfalls and other storm drain infrastructure is an important element of establishing a successful citizen hotline. Boston Water and Sewer Commission (BWSC) has labeled outfalls along the Charles River so that citizens can identify outfalls from the water. Dayton has labeled outfalls along the City's popular riverfront, and recommends labeling catch basins and manhole covers.

Tracers and Methods Used

The majority of surveyed jurisdictions utilize tracers to confirm the presence of a suspected inappropriate discharge (Table 7). Emphasis is on quick and simple tests that do not require extensive and time-consuming laboratory analysis. Qualitative physical parameters are the most widely used tracers, including color, odor, deposits and stains, temperature and presence of floatable matter. When chemical tracers are used, communities tend to focus on a single parameter such as bacteria, ammonia, or detergents so that field and lab equipment costs are controlled. However, using only one parameter as a tracer can leave unanswered questions about other sources of inappropriate discharges. This uncertainty can be reduced somewhat when sampling is conducted in conjunction with land use data analysis. In addition, there are

certain situations where a single source is known to dominate the inappropriate discharges to a watershed and a single tracer is warranted. For example, Baltimore, MD, has chronic sewage infrastructure problems and makes the assumption that sewage is the likely dominant inappropriate discharge in many of its subwatersheds. Consequently, Baltimore often uses ammonia as a sole tracer to track inappropriate discharges.

Table 7: Tracer Parameters Used to Confirm the Existence of Inappropriate Discharges

Tracer Parameter	Physical or Chemical	% of Respondents (n = 21)
Color	P	95%
Odor	P	95%
Deposits and stains	P	90%
Floatable matter	P	86%
pH	C[1]	86%
Temperature	P	86%
Chlorine	C	76%
Turbidity	P	76%
Changes in flow	P	62%
Specific conductivity	C	62%
Vegetation change	P	62%
Ammonia / ammonium	C	52%
Structural damage	P	52%
Surfactants	C	48%
Fecal coliform	C	33%
Fluoride	C	33%
Copper	C	29%
Florescence	C	24%
Phenols	C	14%
Potassium	C	14%
Detergents	C	10%
Dissolved oxygen	C	10%
Grease / oil	P	10%
Hardness	C	10%

[1] Some chemical parameters can be measured in the field with probes or test strips. These methods are often not as sensitive as those that would be used in a laboratory analysis.

Inappropriate Discharge Corrections Program

Some jurisdictions simply bear the cost of inappropriate connection repairs and bill the owners after the repairs have been completed. Ada County, ID and Raleigh, NC use this method as a last resort to gain compliance. Worcester, MA pays half of repair costs and bills the owner for the remainder.

Most jurisdictions reported that diplomacy, trust, reasoning and education are the primary people skills required to successfully perform their jobs effectively. Diplomacy and trust are important when trying to gain access to private property for plumbing inspections and dye testing. Reasoning and education are necessary when explaining to property owners that a problem exists on their property when trying to get the owners to make required connections. The bottom line is that different tactics and approaches work to gain compliance from different people. Wayne County, MI mentioned that the publicity surrounding the Rouge River Project helped open doors for them, because property owners had heard enough about programs to clean the river prior to having IDDE inspectors knock on their doors.

Education, Outreach, and Pollution Prevention Programs

Nineteen of the IDDE programs surveyed include some type of education and outreach elements. Of these, all target residents, 75% target the commercial sector, 63% target the industrial sector, and 50% target the government sector. In some cases, educational messages relating to inappropriate discharges are incorporated into campaigns developed for other departments or programs within the jurisdiction. Other jurisdictions run very targeted IDDE education programs.

Resident Education

For jurisdictions that rely heavily on citizen hotlines as a means of identifying potential inappropriate discharges, residential education is an important program component. Some common forms of residential education identified through the surveys include storm drain stenciling or marking; signage at outfalls; educational brochures or newsletters in utility bills; and promotion of citizen hotlines.

Schoolchildren Education

Some communities such as Dayton, OH and Phoenix, AZ have educational programs geared towards schoolchildren. Dayton's inappropriate discharges education is part of a larger schoolchildren educational effort that includes regular visits to schools and the "Children's Water Festival." This one-day event for 3,000 students from the 4th-6th grade levels offers a series of presentations, games, experiments, and exhibits on groundwater, surface water, conservation, land use, and other water related topics. Phoenix noted that the school presentations made to third and fourth graders are an effective part of their stormwater program. City stormwater inspectors give presentations to the children and distribute Storm Drain Dan coloring books, pencils, erasers, rulers (all bearing the City's stormwater logo and phone number) and Storm Drain Dan dolls. They have found this to be particularly helpful in lower income neighborhoods where school supplies are in high demand. The children are reported to be enthusiastic and motivated to keep the environment clean.

Commercial and Industrial Education

In most cases, jurisdictions have developed targeted commercial or industrial education programs based on specific local problems, land uses, or "hot spot" activities likely to contribute specific types of problems. For example, several jurisdictions have developed educational programs regarding grease handling and disposal at restaurants. Clackamas County, OR has developed educational brochures for contractors regarding concrete and mortar management. Both land use mapping and a historical record of problems and complaints help jurisdictions to identify areas to focus on in these types of educational campaigns, which tend to be accomplished through one-on-one contact as opposed to mass distribution of educational materials used for residential education.

Public Employee Education

Several jurisdictions identified cross training of public employees as an important means of identifying potential inappropriate discharges. For example, Wayne County, MI currently trains field crews of the Division of Public Works, County Drains, and Recreation and Parks on inappropriate discharge detection to increase both awareness and the number of "eyes" looking for problems. Effective training typically includes presentations, videos, and problem-solving activities.

Conclusions

Several conclusions were developed from the surveys and interviews regarding IDDE program development. Typically, 67% of program staff time is dedicated field staff. As program staffing increased, this ratio stayed fairly consistent. Also, several program directors noted that experienced field staff are a valuable asset, while several others noted that the lack of staff expertise and experience is a top problem in identifying inappropriate discharges. Accurate mapping resources can improve the efficiency of a program in the identification of outfalls and prioritization of problem areas. The wide range of program budgets can be attributed to the methods used by the programs to identify potential inappropriate discharges. The five programs with the highest annual expenditures dedicate significant portions of their budgets to support intensive outfall screening, continuous in-stream monitoring, and targeted area investigations. Their budgets support larger field staffs or consultants who conduct these investigations; the purchase of more sophisticated lab and field equipment; and targeted educational programs. IDDE programs have invoked legal authority using one or more of three mechanisms: 1) a stormwater ordinance that prohibits illicit discharges to the drainage network; 2) a plumbing code that prohibits illegal connections to the drainage network; or 3) a health code that regulates the discharge of harmful substances to the drainage network.

Drawing from these conclusions, there are several program development challenges that will likely be faced by NPDES Phase II communities and potential ways to alleviate them. The range of responses with regard to program characterization questions indicates a defined need for relatively simple guidance for performing inappropriate discharge investigations. The guidance should provide programmatic recommendations as well as recommendations for field methods and anticipated costs. A lack of staffing resources may prove to be a significant hindrance to implementing a successful IDDE program. Phase I communities rely heavily on the expertise of their field staff – expertise that has been largely developed as the programs were being developed. Methods or approaches recommended for Phase II communities should be less dependent on professional judgment. Many communities do not have current mapping. Focus should be placed on mapping storm sewers, open drainage channels, waters of the US, outfalls, and land use. This will provide field staff the minimum data necessary to conduct field investigations, and will serve as a basis for prioritizing field investigations.

Outfall screening can require significant staff and equipment resources. An efficient approach that examines a limited number of parameters at each outfall is necessary. In addition, more effective and reliable tracers and associated analytical techniques are needed to reduce the uncertainty (i.e., number of false negatives and false positives). When examining equipment needs, Phase II programs should communicate with other jurisdictional programs that utilize the same types of field equipment and examine the possibility of sharing

purchase expenses. Model ordinance language should be provided to Phase II communities to ensure that all potential sources of inappropriate discharges are prohibited; and that the community is provided with the necessary legal authority to inspect private properties and to enforce corrections. Effective IDDE programs need to have a balanced approach involving field screening, hotspot targeting, hotlines, public education, and municipal employee cross-training.

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