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REGULATING INDUSTRIAL STORMWATER: STATE PERMITS, MUNICIPAL IMPLEMENTATION, AND A PROTOCOL FOR PRIORITIZATION¹*Lindsay M. Cross and L. Donald Duke²*

ABSTRACT: This research evaluated the effectiveness of regulations for stormwater pollutants originating from industrial facilities. Industrial facilities discharging stormwater are subject to General Permits implemented by state and federal agencies, which require facility operators to identify themselves and to implement pollution prevention measures. An overlying system of permits require Municipal Separate Storm Sewer System operators to identify and inspect facilities in their jurisdictions capable of discharging substantial pollutant loads into stormwater conveyances, introducing more active regulation and strategic prioritization, but with unequal implementation in different urban regions. This research evaluated the interaction between the regulations and ways in which the regulations succeed, or fail, at protecting water quality. The research evaluated potential for pollutant discharges at 136 industrial facilities in Pinellas County, Florida, using telephone interviews; off-site facility visits; and on-site facility inspections, targeting four industrial categories: wood products; stone, clay, glass, and concrete products; fabricated metal products; and electronic products. **Results documented that a large proportion of facilities subject to General Permits conduct few or no activities likely to produce stormwater pollutants, indicating that the regulations' equal treatment of all facilities may constitute overregulation.** The research developed a methodology to assess facilities using intensity of industrial activities exposed to stormwater, a rational measurement that could regularize municipal agencies' requirements and prioritize implementation toward facilities with the potential to impact receiving water quality.

(KEY TERMS: nonpoint source pollution; water quality; NPDES permitting; industrial stormwater discharges; Municipal Separate Storm Sewer System (MS4); Clean Water Act.)

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INTRODUCTION

Stormwater runoff from industrial land usage has been identified as among the sources of pollutants in urban runoff since studies of the Nationwide Urban Runoff Program (Athayde *et al.*, 1983). Urban runoff

monitoring data have continued to document **substantial contribution of pollutant loads from industrial zones**, especially when compared by unit area to other land use types (e.g., Wong *et al.*, 1997). The 1987 reauthorization of the Clean Water Act (CWA) led to promulgation of two sets of regulations, effective in 1992, to attempt to reduce or control

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those pollutants. One set of regulations extended the National Pollutant Discharge Elimination System (NPDES), designed for industrial wastewater, to include **stormwater discharges “associated with industrial activities”** (USEPA, 1992). At the same time, NPDES regulations were adopted for discharges of stormwater through drainage conveyances in large urban areas, termed Municipal Separate Storm Sewer Systems (MS4s). Prior to 1992, local flood control agencies had few or no water quality responsibilities, but the reauthorized CWA required them to obtain NPDES permits, to identify potential sources of pollutant loads in their stormwater discharges, and to develop programs to reduce those loads (USEPA, 1996). These requirements have had implications for industrial discharges as well.

The direct regulations via general permits can be considered a universal regulation, in that all facilities within a specified set of industrial categories are required to comply. The U.S. Environmental Protection Agency (USEPA) has chosen to specify these direct regulations for industry in the form of a series of general permits. This is a departure from NPDES industrial wastewater regulations, where each covered facility receives an individualized permit based upon USEPA guidelines for pollutant controls. **Instead, the general permits specify that covered facilities should identify themselves, monitor runoff discharges, report regularly to the oversight agency, and implement pollutant control strategies if applicable.** In most parts of the United States (U.S.), the NPDES stormwater general permits are implemented by the states under delegated authority from USEPA (2005).

Facilities may comply in one of two ways: by filing a “No Exposure Certification” or by filing a “Notice of Intent” (NOI), which signifies the facility operator has accepted the obligation to complete the other General Permit requirements, such as monitoring runoff and implementing pollution prevention (P2) measures (USEPA, 1996, 1998, 2000; FDEP, 2001). A facility within the specified industry categories that fails to file one or the other of these forms is in violation of the CWA, a potentially serious violation, regardless of whether the facility implements P2 actions and regardless of whether it needs to do so. Filing an NOI, of course, is only a paper requirement and **does not guarantee a facility will implement P2 measures or that its runoff water quality will be improved.**

The General Permits emphasize a P2 approach, also a departure from the NPDES wastewater regulations that focus on end-of-pipe numeric limitations for listed pollutants. **The General Permit method delegates facility-level analysis, planning, and P2 choices to the regulated community. This adds considerable flexibility for industrial facility operators in**

identifying the most economically efficient means to address pollutants given their own particular operations, but also enormously increases the complexity of verifying facilities’ compliance, compared with numeric limits (Duke, 2001). Compliance is mandatory for facilities covered by the regulations, although the effectiveness of self implementation is questionable (Duke and Augustenborg, 2006).

U.S. Environmental Protection Agency guidelines specify that the General Permits cover all facilities that conduct “industrial activities typical of” the processes conducted at facilities within 11 industrial categories [(40 CFR 122.26 (b)(14)(i)-(xi)]. The categories are defined using the Standard Industrial Classification (SIC) system to target the regulated industrial facilities, a system devised for reporting economic and employment data to the Department of Commerce whereby each facility reports under the site’s single greatest revenue-producing activity (U.S. Census Bureau, 2005). This definition of a covered facility has long been recognized as a complication and a weakness of these regulations (Duke *et al.*, 1999a). The USEPA guidance regarding “activities typical of” industrial categories quite rationally exempts locations whose main source of income is within a category defined as industrial, but where the specific facility conducts no industrial activities. For example, an office building housing an electronics firm may report to the Department of Commerce under the industrial electronics-products SIC, but if no manufacturing is conducted at that site, then it quite reasonably need not comply with industrial stormwater regulations. Another weakness occurs when otherwise nonindustrial facilities conduct subsidiary industrial activities that should trigger compliance. For example, a facility whose primary income derives from sale of raw and finished lumber may identify itself with a “primary” SIC describing a commercial site; but if lumber is cut, shaped, or finished on-site, then the facility conducts some activities “typical of” a wood-products facility and should comply with the regulations. The regulations initially included a distinction between “heavy” industry, categories within which all facilities must comply, and “light” industry, which required compliance only for facilities where industrial activities were exposed to stormwater. That distinction was erased after a legal challenge by the Natural Resources Defense Council (NRDC, 1999).

The industrial aspects of the MS4 NPDES stormwater permits, implemented by municipal agencies, constitute a second, intentionally redundant set of requirements for industrial facilities. In the earliest MS4 permits, the industrial program in general was ancillary and not a major activity. The MS4 permittees’ roles were largely limited to disseminating

information about General Permits and listing existing facilities for outreach and enforcement by state agencies (e.g., CSWRCB, 1987). As the stormwater regulations matured, state agencies recognized that a large proportion of covered facilities had failed to comply with the General Permits (Duke *et al.*, 1999b). The MS4 permits began to include a more active role for MS4 agencies, including site inspections for a certain number of industrial facilities (e.g., CSWRCB, 1994). By the early 2000s, it had become common for USEPA and the states to specify in the MS4 permits that municipal agencies develop and submit for approval a plan to inspect industrial facilities for potential stormwater pollutants (e.g., FDEP, 2004).

The dual sets of regulations have in principle developed into a fully realized two-tier system that draws on the advantages of each agency. Local entities that hold and implement MS4 permits are presumably more familiar with local businesses, and thus are in a better position to identify, contact, inspect, and promote P2 at facilities with the potential to discharge pollutants in substantial amounts. The MS4 operators could serve as a first responder, providing personnel to conduct oversight of their industrial base and identify any problems of noncompliance. State entities can promulgate the General Permit requirements specifying the kinds of reporting, monitoring, and P2 that is expected of industrial facilities, and supply the enforcement that compels facility operators to comply. It is clear that the federal and state agencies intended to create this two-tier system (e.g., Radulescu, 2001; USEPA, 1995).

But the two sets of regulations do not interact as smoothly as this concept would suggest. The MS4 industrial requirements are not universal because not all facilities of a given type are necessarily addressed. Typical MS4 NPDES permit language specifies permit holders identify, prioritize, inspect, and monitor facilities in a “high risk” category, including some listed categories (municipal landfills, permitted hazardous waste treatment facilities, and facilities reporting under toxic release inventory requirements) and a broader category described as:

“The permit holders shall continue to implement a program to identify and control pollutants in stormwater discharges to the MS4 from...any other industrial or commercial discharge that the permit holders determine is contributing a substantial pollutant loading to the MS4... [T]he permit holders shall continue to identify all targeted facilities and determine priority sites. Inspection procedures and schedules for the identified facilities shall be implemented” (FDEP, 2004).

The intentionally vague permit language gives municipal agencies considerable latitude to select facilities for inspection. The clear intent of the “other”

category is to prioritize the inspections. Permit holders are encouraged to tailor the definition and approach to best meet their local conditions, such as particular receiving water body problems, nature of the industrial community, and available implementation resources. This broad latitude is characteristic of USEPA’s approach to developing new regulations. By allowing multiple regulated entities to develop a variety of possible approaches, USEPA can select those approaches that prove over time to be effective.

By the nature of the requirement, these are far more active interactions with industrial facilities: on-site inspections can observe daily activities, determine with some confidence whether activities have the potential to generate pollutants in stormwater runoff, and specify control measures the facility operator must undertake. This can be performed regardless of whether the facility is subject to the direct NPDES stormwater regulations for industry, in principle, capturing those facilities of concern neglected because they do not fall within industrial categories specified in the industry regulations. They could also, in principle, raise compliance with the industry NPDES regulations to 100%, at least among facilities determined to be sufficiently high in priority to receive inspections.

Facilities Regulated, Facilities Not Regulated, and Opportunities to Prioritize

In concept, it is possible to identify the ideal set of industrial or business facilities that should be regulated for pollutants in stormwater runoff. Regulations should address, and inspections should verify compliance for, those facilities discharging pollutants of concern in quantities that could cause harmful effects to receiving waters, or where those discharges could potentially occur in the absence of appropriate control actions that can be specified in the regulations.

The ways in which the ideal set relates to the set targeted by current regulations is illustrated in Figure 1. The circle on the left side of the diagram represents the ideal set of facilities to regulate: those capable of discharging pollutants in quantities of concern to receiving waters. The circle to the right represents facilities subject to industrial NPDES General Permits and the circle beneath represents those facilities inspected by MS4 permit holders. The circles contain some common area, indicating that the regulations succeed in reaching some of the intended regulated community. The areas that are not in common illustrate deficiencies.

Some facilities of concern are not included in the current regulations. For example, automotive repair operations are not considered “industrial” by the

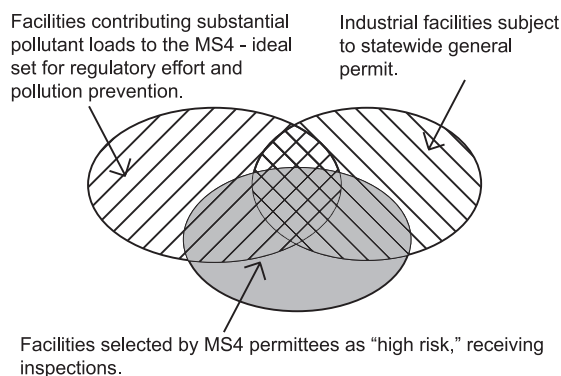


FIGURE 1. Facilities Subject to Overlapping Regulations for Industrial Stormwater Discharges and Ideal Set for Intensive Pollution Prevention Outreach.

regulatory definition, but are capable of discharging oils and grease, particulate metals, and other pollutants if careful control measures are not followed (Burton and Pitt, 2002). These may well be inspected by MS4 personnel, as the permit language encourages identification and inspection of "any other industrial or commercial discharge...contributing a substantial pollutant loading."

At the same time, the circle to the right includes some facilities that are subject to the regulations but do not discharge pollutants of concern under normal conditions. For example, photocopy shops are designated in the industrial category of "printers" even though they do not handle the chemicals, ink stock, binding glues, and other materials typical of traditional newspaper and book producers that, if poorly managed, could find their way into stormwater runoff. **Estimating the size of this regulated-but-not-polluting community was one of the goals of the present research:** if it is reasonably large, then the General Permit regulations are too broad and unnecessarily burden some businesses that do not discharge pollutants in stormwater in quantities of concern. The diagram does not indicate another failing of those regulations as implemented: that the proportion of compliance with those regulations is low. The circle on the right could be seen as porous, as **requirements are actually implemented by barely 20% of facilities for which they are intended** (Duke and Augustenborg, 2006).

The circle representing the MS4 industrial programs similarly shows some intersection with the ideal set of facilities and with the set of facilities subject to the General Permit. A certain number of facilities are inspected that ultimately prove to be neither subject to industrial NPDES regulations nor capable of discharging pollutants in quantities of concern. Those inspections occur because both the NPDES regulatory coverage and the potential to discharge

pollutants in many facilities can be determined only by the kind of site-specific assessment allowed by an inspection. The size and shape of that circle, and the degree to which it intersects the other two, varies enormously from one agency to another. Because of the latitude given in the permit language, agencies naturally choose a variety of approaches to satisfy the vague requirements. The methods implemented by MS4 agencies in separate urban drainage districts governs the effectiveness with which the two sets of regulations succeed in reducing pollutant discharges from industrial facilities, and the degree to which they impose an undue burden on businesses whose operations have little or no effect on receiving waters.

Research Objectives

The overall objective of this research was to critically evaluate the effectiveness of the current U.S. system of regulations for pollutants in industrial stormwater discharges. In particular, it examined the relative advantages, and potential synergies, of the dual system of regulations to which industrial facilities are subject: the direct NPDES General permits for industrial runoff and the MS4 NPDES permits that require local stormwater agencies to inspect facilities that may be contributing pollutants to urban drainage systems. The research was intended to identify features of the regulations that support or inhibit the goal of bringing into the regulatory system all stormwater discharges with the potential to convey pollutants in quantities of concern to receiving waters of the U.S. The research had three specific objectives.

The first specific objective was to investigate the ways in which the two regulatory systems interact. On one hand, the statewide General Permits have direct requirements for industrial facilities to self-implement pollutant reduction strategies designed individually for each facility. On the other hand, the agency-implemented inspections by MS4 permittees of stormwater dischargers, industrial facilities, and others determined to be "high risk" is an approach that embodies a prioritization concept absent from the General Permit method. The research identified advantages and disadvantages of the current two-tier system by evaluating how several selected MS4 permit holders implement their required programs for industry, especially regarding their effectiveness at supporting the statewide General Permit; and by evaluating the extent of compliance with the General Permit in one target urban region.

The second objective was to understand the range of potential impacts on water quality originating with stormwater runoff from industrial facilities in a typical urban region of the U.S. The research

characterized the industrial activities conducted at a sample of facilities subject to either or both of the stormwater regulatory systems in a selected case study region using telephone questionnaires, off-site inspections, and on-site inspections. One purpose was to determine whether there exists a substantial proportion of facilities that are subject to the General Permit but can be expected to discharge pollutants in very small amounts. Another purpose was to determine whether industrial facilities of separate categories exhibit systematic differences in the kinds or types of industrial activities exposed to stormwater. Many of the mechanisms proposed in the past to identify high-priority facilities for more intensive outreach have been structured to select particular industrial categories on the assumption that facilities in some industries are more important, and others less important, in their potential impacts on water quality. This research tested that assumption for a small number of industry categories in which facilities are widely found in U.S. urban regions.

The third objective was to attempt to develop a systematic method that could use the characterization of industrial activities to distinguish low-priority facilities from “high risk” facilities as defined in the MS4 permit language. A true and accurate measure of a facility’s potential impact on receiving water quality might require quantitative stormwater discharge monitoring for chemical constituents in its runoff. This research proposes a surrogate in the form of a rational scale of intensity of industrial activities exposed to stormwater. The research tests the applicability of the scale on the target sample of industrial facilities to determine whether it can draw meaningful distinctions among facilities of various industry categories. The scale could conceivably serve as a basis for MS4 permit holders to define “high risk” facilities in their jurisdictions in a rational, systematic fashion, and could be a basis for regularizing the inspection and compliance programs across multiple jurisdictions.

METHODS

The overall approach of the research was as follows. First, the researchers contacted MS4 personnel from nine selected Florida urban regions holding MS4 NPDES stormwater permits to investigate the methods currently used to implement the industrial portion of their permits. That analysis illustrated the kinds of approaches applied by the MS4 jurisdictions, in particular the extent to which they succeed in supporting the statewide General Permit (termed the

“Generic Permit” in Florida). The analysis was also designed to characterize the range of interpretations applied by Florida MS4 permit holders to define the term “high risk” used by USEPA and Florida Department of Environmental Protection (FDEP) to guide the permit holders’ industrial inspections.

The second portion of this research evaluated a sample of industrial facilities subject to General Permit requirements in one target MS4-permitted urban area – Pinellas County, Florida – within four selected industrial categories. Those evaluations first assessed the degree of compliance with the General Permit, to determine whether compliance is essentially complete under the existing state and county implementation efforts. The evaluations had the further purpose of characterizing the kinds of industrial activities conducted at facilities subject to the General Permit. Data were acquired by telephone interviews with a representative sample of facilities in selected industrial sectors, followed by firsthand site visits to a subset of the sample.

Third, the research developed and applied a relative scale of “intensity of industrial activities exposed to stormwater” that allowed the facilities to be compared with one another using information obtained from the questionnaires. The results provided an estimate of the proportion of facilities technically subject to the General Permit that appear to have little or no effect on water quality resulting from their stormwater discharges – those where intensity of industrial activities exposed to stormwater was nonexistent or minimal. Compliance requirements to self-identify, prepare pollution prevention efforts, monitor discharges, and submit annual reports at facilities of that type are of questionable importance. The results were also used to test the viability of the approach to identify facilities with high potential to discharge pollutants in quantities of concern, a method that could be used by MS4 permit holders to prioritize their required industrial inspections.

Developing a Comprehensive Industrial Facility List

The first step to identifying facilities regulated by the NPDES and MS4 industrial stormwater regulations was to compile a list of the universe of industries operating in Pinellas County. The need to develop lists in this way and the inadequacy of any single type of existing list for the purpose of stormwater regulations for industry was discussed in Duke *et al.* (1999a). Methods presented in that paper, that were applied here, established that efforts of this type succeed in identifying between 40 and 65% of all facilities in a given jurisdiction. Existing agency and publicly available databases were used to develop a

facility list, including those from various federal, state, and local government organizations; and a purchased database that was made available to the researchers by a local government agency. Examples included a USEPA database of facilities with Toxic Release Inventory data, lists maintained by USEPA and FDEP of facilities with current and/or expired General permits, dischargers to publicly owned treatment works, and facilities monitored by industrial pretreatment programs. The comprehensive list of Pinellas County industrial facilities that might need to comply with the industrial stormwater General Permit contained approximately 2,000 facilities, from which a subset was selected for primary data acquisition.

Selecting a Sample of Industrial Facilities for Data Acquisition

Four categories of industry were selected for data acquisition: SIC 24xx (lumber and wood products); SIC 32xx (stone, clay, glass, and concrete products); SIC 34xx (fabricated metal products); and SIC 36xx (electronics and other electrical equipment). In each of these four categories, there existed a large enough subset of facilities operating in Pinellas County to support statistical analyses. First, all four are manufacturing categories, which allowed the same questionnaire to be administered to each facility without the need to develop separate questions for commercial and service activities. Facilities such as landfills and hazardous waste treatment facilities, which the statewide permit identifies as required for inspection, were not selected for this research because prioritization is not relevant. Second, in all of these categories it was expected that facilities would occupy different physical facility types, ranging from large, outdoor sites to smaller, completely enclosed sites. Finally, these four categories encompass both “heavy” and “light” categories of industry according to General Permit definitions. This describes a meaningful physical difference in the kinds of indus-

trial activities that might be expected, although it is no longer a regulatory distinction in how the two categories need to comply (NRDC, 1999). Selection of these four categories within the industrial composition of Pinellas County constituted a stratified sampling effort.

The sample was further limited by selecting facilities within seven geographic areas within Pinellas County, defined by postal ZIP code. The selected areas were those in which facility inspections were currently being conducted by the Pinellas County Department of Environmental Management (PCDEM). This allowed the researcher to visit a subset of the contacted facilities in the company of PCDEM staff, as discussed below. The seven areas were chosen by PCDEM to be of high priority for inspections because six of the areas were within and around the watershed for an impaired water body known as Cross Bayou, and another was in an area of relatively dense industrial development in the northeastern section of the County. Selection of these geographic locations within Pinellas County constituted a cluster sampling superimposed upon the stratified sampling design. Facilities within the target regions can be assumed to be statistically representative of facilities in the County as a whole, because there is no reason to expect facilities in those areas are different in their industrial activity types, intensity of industrial activities exposed to stormwater, or requirement to comply with the industrial stormwater General Permit compared with the rest of the County.

Ultimately, facilities included in the telephone sample were not limited in all cases to the targeted geographic clusters. For some SIC categories the number of facilities within the target areas was small, fewer than 20 facilities, so facilities were randomly selected from other parts of Pinellas County in order to increase the sample sizes within the target SICs. The distribution among the target SICs of the ultimate call list is given in Table 1. That table also documents the distribution of facilities that completed the telephone questionnaire. Overall, just over 50% of

TABLE 1. Facilities Selected for and Completing Telephone Survey.

Industry Sector	Facilities in Database	Database Facilities in Target ZIPs (all contacted)	Facilities Contacted in Other ZIPs	Total Facilities Contacted	Facilities Completing Questionnaire	Facilities Subject to Statewide General Permit
Wood products	35	18	17	35	19	17
Stone, clay, glass, and concrete	46	15	25	40	27	21
Metal products	156	79	37	116	80	75
Electronics	65	32	16	48	31	23
Total	302	144	95	239	157	136

contacted facilities agreed to complete the questionnaire, yielding a sample of 136 facilities.

Telephone Survey Protocol

Facilities were contacted using a systematic telephone questionnaire. Full details of the methodology, including the complete phone transcripts, are available in Griffen (2005). Researchers administering the questionnaire were trained to administer it uniformly to all respondents, using the same language and with specified guidelines about how to follow up an initial response. The method was standardized in this way in order to minimize the chance for errors or inconsistencies in the way replies were elicited, and, at the same time, to encourage respondents to fully and accurately describe their facilities. Researchers were also trained in confidentiality protocols, and the survey was conducted in such a way as to preserve confidentiality. The identity of the participants was not connected to the responses and has not been released to the local MS4 agency, the state, or anyone outside the immediate research team. The researchers destroyed that portion of the questionnaire that could identify facilities or that could link a corporate name with a description of activities that could require compliance.

The focus of the questionnaire was to determine the type, frequency, and extent of industrial activities and associated equipment that were located on-site at each targeted industrial facility. The questions were designed to make minimal demands on the facility personnel, with each question answered by a simple “yes,” “no,” or “don’t know” response. For example, a typical question was phrased as “Do you manufacture a product at this facility? (IF YES), What products do you manufacture?”

For many of the questions, a “yes” response to an initial question led to additional questions designed to characterize the intensity of the activities. Intensity questions were generally related to the quantity of materials or equipment used, the size in area of the facility where they were conducted, or the frequency of occurrence of industrial activities. Questions also addressed whether the activities, materials, or equipment included exposure to precipitation or stormwater. The follow-up intensity-related questions were designed to differentiate facilities that perform activities frequently or on a larger scale from those that perform activities only occasionally or on a smaller scale. A summary of the questions addressing industrial characteristics, and the type of information requested for each of the participants, appears in Table 2.

The questionnaire was designed using specific information from the USEPA’s General Permit such

that a “yes” response to any question regarding exposure of an activity, process, or equipment to precipitation signified that the facility may need to comply with federal regulations. If any activities are exposed to stormwater, even infrequently or in very small amounts, then the facility is required to comply. “No” responses to all questions signified that the facility need not comply with the General Permit and may be eligible for the No Exposure Certification, even if it fell into one of the categories subject to the permit. While the questionnaire results could not definitively determine the need to comply, if the answers were accurate and truthful, they would cover nearly every condition in which a facility should comply. The detailed surveys were considered a reliable indicator of the need to comply with the General Permit and included information that could be evaluated for a greater degree of discrimination among facilities.

The questionnaire included a number of additional questions intended to illuminate the effectiveness of the regulations in a variety of ways. For example, the participants were asked if they knew whether their facility was subject to the statewide General Permit and, if so, whether the facility had already fulfilled the first stage of compliance by filing the NOI or No Exposure Certification. Participants were also asked whether the facility had been contacted by any federal, state, or local agencies specifically regarding industrial stormwater runoff.

Verification of Telephone Results: Site Visits to Industrial Facilities

Site visits were conducted by the researchers at 44 industrial facilities in Pinellas County, or about 32% of the facilities contacted by phone. The purpose was to validate, to some extent, the accuracy of the information acquired by the telephone questionnaires. Facilities were selected randomly from the list of facilities that had completed the telephone questionnaire. These site visits were conducted by the researchers from public property, sidewalks, or roadways, and termed “outside-the-fenceline” or “fence-line” observations because the researchers did not enter the facility property. No contact was made with facility employees and the visits were limited to observations of equipment and operations that were plainly visible from public areas. For that reason, the information gathered during the visits addressed only those parts of the phone questionnaire that could be viewed or ascertained from outside the facility fence-line, such as the size of the plant yard; the number of loading docks; the number of storage containers outdoors; the quantity of scrap material or waste products outdoors; the size of storage areas; and the

TABLE 2. Summary of Facility Characteristic Information Acquired by Phone Questionnaire.

	Form of Information Requested				Exposed to Stormwater?
	Yes/No/Do Not Know	Types	Quantity or Size	Frequency	
Industrial Nature of Facility per Stormwater Regulations					
Manufacture a product	X	X			
Store, process, and handle raw materials	X	X			
Blend, alter or modify materials, products, or chemicals	X	X			
Activities or Equipment That May Generate Stormwater Pollutants					
Perform process activities outdoors	X			X	X
Operate equipment outdoors (fixed and mobile)	X	X	X	X	
Operate forklifts and fork trucks	X	X	X	X	X
Operate shipping/receiving area	X		X		X
Maintain, fuel, and wash vehicles	X		X	X	X
Store materials outdoors: bulk dry raw materials, bulk liquid, liquid in smaller containers, waste liquid, dry bulk waste, completed or mid-stage products, and other	X		X		
Store scrap metal, disused equipment and other (boneyard)	X				
Store materials in underground tanks (including decommissioned tanks)	X		X		
Facility Layout					
Plant yard, access roads, and rail lines	X		X		
On-site area of former industrial activities	X		X		
Area of facility: Portion used for buildings, portions paved, and green space			X		

number of vehicles operating outdoors. The kinds of data acquired were reasonably complete for assessing extent of industrial activities but not able to judge frequency of activities or any types of activities that were not occurring at the moment of inspection. The research assumed that the accuracy or inaccuracy of facility operators' responses to those questions was indicative of their accuracy to the other parts of the telephone questionnaire.

The researchers accompanied PCDEM personnel during MS4 compliance inspections to a subset of 20 facilities. These allowed the researchers to more closely observe the facilities' equipment and layout, and to benefit from the inspector's observations and interviews with industry personnel. The visits were used to verify the accuracy of the outside-the-fenceline approach, by determining that the information acquired on-site for these 20 facilities was not substantially different from the information acquired by the fenceline visits.

Scoring Scheme for Facilities' Intensity of Industrial Activities Exposed to Stormwater

One of the main purposes of this research was to gain an understanding of the variation in the kind and amount of pollutants to be expected in runoff from the gamut of industrial facilities subject to USEPAs industrial stormwater NPDES permits. The

ideal way to assess that variation would be to measure the pollutants in runoff from a wide range of facilities and relate the pollutants to characteristics of the facilities. That information is not available. The best available monitoring data from the NPDES regulatory program has been demonstrated to be poorly correlated to any industry characteristics, which researchers have largely attributed to the loosely controlled sampling and reporting methods allowable under the permits (e.g., Lee and Stenstrom, 2005; Duke and Yeager, 1999). No other monitoring data of which we are aware has assessed facilities of a sufficiently large sample size to draw conclusions about the effect of particular on-site activities or P2 measures on pollution in runoff. Those few studies that have evaluated runoff constituents with rigorous sampling methods (e.g., Chang, 2001) have not identified any relationship between monitoring results and any reported or readily identified industry characteristics.

In place of direct evidence from monitoring data, this research applied a surrogate intended to capture the likely contribution of pollutants to runoff, which we term "intensity of industrial activities exposed to stormwater." The surrogate can be evaluated using information about a facility's physical layout and routine activities, the kind of information readily available to plant personnel but not to agencies until and unless they conduct a site inspection.

A point scale was developed from the phone questionnaire in order to further evaluate the sampled industrial facilities. Each question, or set of questions, was assigned a point value between zero and ten. Table 3 summarizes the point scale and demonstrates that the same activity may yield a different point value, depending on the frequency or magnitude of the occurrence. This scale was also utilized for the fenceline visits, with omissions of the questions that could not be answered from the public fenceline observations.

RESULTS

The results are organized into sections as follows. The research first investigated the mechanisms currently implemented by MS4 permit holders in Florida to meet their requirements to inspect “high risk” industrial facilities. The next section assesses compliance with the statewide permit, and awareness of compliance requirements, in a sample of industrial facilities in Pinellas County. Then the research evaluates the sampled Pinellas County facilities to characterize their on-site activities that have the potential to discharge pollutants in stormwater runoff. Results are presented for a telephone survey to the Pinellas County sample and for field verification of a subset of that sample. Those results are used to evaluate each facility for its intensity of industrial activities exposed to stormwater. The facilities are organized into groups according to their requirement to comply and their likely impact on receiving water quality judged by their on-site activities. The research used those findings to investigate the implications for water quality protection under existing stormwater regulations that specify identical requirements for all facilities under the statewide General Permits. A final section discusses the potential applicability of the intensity approach as a means to satisfy the MS4 permits’ regulatory requirement to inspect facilities considered “high risk,” and as a means to improve the current system of regulating industrial facilities by states throughout the U.S.

Approaches by Florida MS4 Permit Holders to Inspecting Industrial Facilities

The researchers contacted representatives of nine permitted MS4 agencies in Florida to identify relative strengths and limitations of their approaches to selecting and inspecting “high risk” industrial facilities as specified in their municipal NPDES storm-

TABLE 3. Scoring Scheme for Intensity of Industrial Activities Exposed to Stormwater.

0 Point	Small bulk waste, e.g., covered dumpster: area <100 m ² Hazardous waste: containers not exposed to precipitation
1 Point	Outdoor vehicle use: 1-2 vehicles, outdoors occasionally/never, not used in precipitation Vehicle washing outdoors: 1-2 vehicles, rarely or occasionally done
2 Points	Outdoor vehicles, e.g., forklifts: 1-2, outdoors occasionally/never, used in precipitation Outdoor vehicles, e.g., forklifts: 1-2, outdoors everyday, not used in precipitation Outdoor vehicles, e.g., forklifts: 3-4, outdoors occasionally/never, not used in precipitation Vehicle maintenance or re-fueling: 1-2 vehicles, rarely or occasionally done, outside Vehicle washing outdoors: 1-2 vehicles, regularly done Vehicle washing outdoors: ≥3 vehicles, rarely or occasionally done
4 Points	Storage of materials or products: area <100 m ² and/or < five 55-gallon drums Fixed outdoor equipment: 1-2 small or 1 large item(s) Outdoor vehicles, e.g., forklifts: 1-2, outdoors everyday, used in precipitation Outdoor vehicles, e.g., forklifts: 3-4, outdoors occasionally/never, used in precipitation Outdoor vehicles, e.g., forklifts: 3-4, outdoors everyday, not used in precipitation Outdoor vehicles: >5 or heavy, outdoors occasionally/never, not used in precipitation Uncovered shipping/receiving area: 1-2 docks Vehicle maintenance or re-fueling outdoors: 1-2 vehicles, regularly done Vehicle maintenance or re-fueling outdoors: ≥3 vehicles, rarely or occasionally done Vehicle washing outdoors: ≥3 vehicles, regularly done Plant yard, rail lines, access roads: ≤1,000 ft ² Small process equipment, e.g., compressors, generators: exposed to precipitation
6 Points	Outdoor vehicles, e.g., forklifts: 3-4, outdoors everyday, used in precipitation Outdoor vehicles, e.g., forklifts: >5 or heavy, outdoors occasionally, used in precipitation Outdoor vehicles, e.g., forklifts: >5 or heavy, outdoors everyday, not used in precipitation Vehicle maintenance or re-fueling outdoors: ≥3 vehicles, regularly done Plant yard, rail lines, access roads: ≥1,000 ft ²
8 Points	Storage of materials or products: area ≥100 m ² and/or ≥five 55-gallon drums “Boneyard” of scrap metal, disused equipment, similar Hazardous waste: containers exposed to precipitation Fixed outdoor equipment: ≥3 small or ≥2 large items Outdoor vehicles, e.g., forklifts: >5 or heavy, outdoors everyday, used in precipitation Uncovered shipping/receiving area: ≥3 docks Plant yard, rail lines, access roads: ≥5,000 ft ² Manufacturing activities, e.g., cutting, painting, coating materials: exposed to precipitation
10 Points	Storage of materials or products: area ≥500 m ² and/or ≥ ten 55-gallon drums

water permits. The researchers evaluated the extent to which those inspections, as designed and as implemented, succeed in supporting implementation of the state's General Permit. The nine selected agencies constituted a cross-section and not a representative sample, intended to capture the variety of approaches implemented by NPDES-permitted municipal agencies rather than to tabulate the proportion of Florida agencies that apply each approach. A variety of prioritization approaches have been developed and implemented in other states and various MS4-permitted regions. The researchers did not ask about the agencies' efforts to contact facilities for which inspection was required, such as landfills, but addressed only the undefined "high risk" categories. A more complete assessment of the full range of approaches would be valuable future research, but is beyond the scope of this paper.

In Florida, the state Department of Environmental Protection (FDEP) has responsibility for implementing the industrial stormwater NPDES General Permit (FDEP, 2000a). FDEP adopted the USEPA General Permit verbatim as its statewide NPDES permit for industrial stormwater discharges (FDEP, 2000b), and gave the regulations for the state of Florida the title of "Generic Permit" (FDEP, 2000c). The FDEP also issues MS4 permits to the local agencies under its NPDES authority through USEPA.

The municipalities' methods to select facilities for inspection varied widely. Table 4 summarizes the findings. The City of Jacksonville, City of Lakeland, and Polk County are examples of agencies with a broad definition of high-risk facilities. Those three municipalities used local business lists to identify facilities in industry sectors listed in the state's Generic Permit, not only those facilities that have actually identified themselves. These agencies did not limit inspections to the facilities that have filed NOIs, but actively sought other facilities that should be complying. They include every facility subject to the Generic Permit, and therefore inspect all facilities as potentially high risk. The City of Jacksonville had perhaps the most vigorous program, inspecting all listed facilities on a three-year cycle. Polk County applied similar rules on a five-year cycle, and the City of Lakeland envisioned implementing the same once its program is fully established.

Other MS4 agencies in Florida use some form of prioritization to select high-risk facilities, creating their own definitions of high risk as allowed under the MS4 permit language. In Miami-Dade County, the stormwater program conducts inspections of all facilities that report hazardous waste generation under the Small Quantity Generator (SQG) program. This includes a large number of facilities in that county – more than 8,000 individual facilities, each

inspected by stormwater inspectors once every three years, or more frequently if some problem is identified. But the SQG list is known to omit a potentially large number of facilities that could affect stormwater, even though they do not report under the hazardous waste system. For example, in industries such as stone products, most facilities do not generate or report hazardous wastes. However, some of these facilities, depending on their operations, could discharge pollutants, such as sediments, in stormwater runoff that could affect receiving waters substantially if uncontrolled.

The agencies in Hillsborough County and the City of Tallahassee both use the SQG lists, like the program in Miami-Dade County. In implementation, both Hillsborough's and Tallahassee's programs are less intensive than that of Miami-Dade County because they rely primarily on hazardous waste inspectors who include stormwater topics in their routine SQG inspections. In practice, those inspections may expend little attention on stormwater compliance or effective stormwater pollution prevention, since inspectors' time and effort are focused on hazardous waste generation, storage, handling, off-site transportation, and recordkeeping. Hillsborough County mitigates this limitation somewhat by inspecting a portion of the facilities in the unincorporated areas using a protocol explicitly designed for stormwater compliance and pollution prevention.

Pinellas County is an example of a jurisdiction where inspections are targeted based on facilities' likely impact on stormwater. The county selects industry types widely found in the county and expected to generate pollutants in stormwater runoff, and also focuses inspections on geographic areas that drain into receiving waters of particular concern. Inspectors with specific stormwater compliance and pollution-prevention training visit those facilities. Facilities that do not meet those criteria are deemed to be of lower priority and get no such attention. Pinellas County, therefore, has a less extensive definition of included facilities than some of the other example MS4 permit holders, but conducts a more intensive inspection than those jurisdictions that add stormwater concerns to a hazardous-waste inspection checklist.

Examples of less extensive programs are those of the City of St. Petersburg and the City of Largo. Both inspect a relatively small proportion of the jurisdictions' facilities. Largo inspects facilities identified in stormwater regulations as "heavy industry," the mandatory-compliance categories from the 1987 version of the regulations, and identifies facilities from the wastewater treatment utility's pretreatment list, an approach that has been shown to omit many facilities that should comply with stormwater requirements.

TABLE 4. Aspects of Industrial Facility Inspection Programs by Selected Florida MS4 Stormwater NPDES Permit Holders.

Criteria to Select Facilities for Inspection	Benefit for Improvement of Water Quality: As Designed	Benefit for Improvement of Water Quality: As Implemented	Support for Generic Permit Compliance
City of Jacksonville (Duval County) All facilities identified with SICs included in Generic Permit	Excellent: extensive facility list developed from multiple sources	Very good: extensive list of facilities to inspect. Are available resources sufficient to inspect all?	Good for number of facilities reached; but Generic Permit support limited to providing information to industrial personnel
Polk County All facilities identified with SICs included in Generic Permit; site characteristics	Very good: extensive list, refined using site characteristics to select high risk facilities	Very good: all facilities inspected once every five years	Good for number of facilities reached; but Generic Permit support limited to providing information to industrial personnel
City of Lakeland (Polk County) All facilities identified with SICs included in Generic Permit; site inspection observations used to identify high risk facilities	Very good: extensive list, refined using site characteristics to select high risk facilities	Initial stages – in process of adopting same approach as Polk County	Too early to determine
Miami-Dade County Hazardous waste Small Quantity Generator list	Good: SQG facilities inspected at least every three years; prioritization of SQG list facilities	Limited: Inspected list excludes many facilities that potentially generate stormwater pollutants	Marginal: Limited number of facilities reached-Generic Permit not mentioned during site visits
Pinellas County Location (impaired watershed, other sensitive area); industry type (selected sectors); citizen complaints; hazardous waste generator list	Good: Prioritization to facilities using hazardous materials and in impaired locations; on-site characteristics important	Initial stages – fewer than 40 facilities visited in first year. Planned increase in number as resources become available	Too early to determine
Hillsborough County Hazardous waste Small Quantity Generator (SQG) list	Marginal: Numerous facilities inspected through SQG program, most not by stormwater inspectors	Potentially Good: All facilities inspected once every five years	Limited number of facilities inspected, but strong information conveyance
City of Tallahassee (Leon County) Hazardous materials small quantity generator list plus 3 facility types given in MS4 permit	Marginal: Numerous facilities inspected through SQG program; most not by stormwater inspectors	Marginal: Over 25,000 facilities in City not considered “industrial” for inspections	Marginal: Over 25,000 facilities in City not considered “industrial” for inspections
City of Largo (Pinellas County) Industrial pretreatment list, only SICs considered “heavy industry”	Limited	Limited	Poor: excludes many facilities subject to Generic Permit
City of St. Petersburg (Pinellas County) EPCRA Title III, Section 313 Facilities (one MS4 permit category)	Limited	Limited	Poor: excludes many facilities subject to Generic Permit

St. Petersburg inspects only facilities reporting under the Emergency Planning and Community Right-to-Know Act of Superfund Title III, a list that has also been shown to be highly incomplete for stormwater purposes (Duke *et al.*, 1999a).

The variation in implementation strategies results in a wide range of the proportion of facilities inspected within the queried jurisdictions. The prioritization and the varying extent of the implementation methods can be seen as increasing efficiency of

resource allocation, protecting water quality to the extent desired by local populations and/or required by specific receiving waters within the agency's jurisdiction. For example, Pinellas County's decision to target facilities in known industrial areas or in impaired watersheds was a logical choice for meeting a variety of regulatory requirements facing the county, including supporting pollutant reduction plans for a number of expected Total Maximum Daily Load (TMDL) programs.

On the other hand, a large proportion of the interviewed MS4s' inspectors noted that their departments had not formally adopted a definition of "high risk," but instead relied on the judgment of the inspectors to identify facilities that deserved attention in the form of regular inspections. This suggests not only a flexibility of interpreting the regulations under local decision-making, but also that those decisions are not particularly rigorous, presumably due partially to a relatively casual oversight by FDEP, the permitting agency. Some inspectors reported they "got a feel" for a facility when they were on site. These inspectors concluded they could best gauge high-risk facilities by their behavior and attitude in conducting housekeeping, implementing best management practices, and other actions, in addition to direct observation of the intensity of on-site industrial practices and evidence of pollutant presence, such as oil stains and debris collecting in storm drainage channels.

Effect of MS4 Industrial Programs in Supporting the Statewide Generic Permit. In the view of many state-level regulators, one of the key purposes of the MS4 industrial facility inspection programs is to support the implementation of the statewide General Permits, as described by Radulescu (2001). However, that view has not been articulated in the MS4 stormwater permits. The permits are intentionally lacking guidance regarding how permit holders should select facilities for inspection, preserving flexibility to accommodate local conditions and preferences. As a consequence, the regulations do not instruct the permittees to enforce or in other ways implement the General Permit.

Table 4 includes a column assessing the effectiveness of the evaluated Florida programs for that purpose. Perhaps the most nearly successful in that role are agencies such as Jacksonville and Polk County that inspect a large number of facilities derived from a range of sources well beyond the NOI filers' list. **Because their inspectors visit many facilities not currently complying, the visits serve to spread awareness of the permit and its requirements. Permit holders that visit fewer facilities are less successful at that aspect.** Among the MS4 permit-holders interviewed for this research, none operate industrial out-

reach programs that are designed or implemented in a way that can be expected to have substantial effects on compliance with the statewide permit within their jurisdictions.

When the municipal agency representatives were asked about ways in which their implementation of the MS4 permit interacts with FDEP's implementation of the Generic Permit, none indicated an intent to take the lead in that role. For example, no permit holders identified their role as deliberately seeking nonfiling facilities and encouraging their compliance. No permit holder identified evaluation of the sufficiency of a facility's Generic Permit compliance documents as a component of a successful inspection. Representatives of the agencies in Pinellas County **and the City of Jacksonville referred to their function in relation to the Generic Permit as "educators," a sentiment echoed implicitly or explicitly by many of the other agencies.** This attitude indicates that Florida MS4 permit holders placed themselves firmly in the second tier of regulators for industry. **Those interviewed uniformly declined to take the lead, and clearly relied on FDEP as the primary** instrument for implementing the Generic Permit. Results of the phone questionnaire also demonstrate the limited outreach by both PCDEM and FDEP that has occurred to industrial facilities. Of the 157 participating in the research, only 10 facility personnel recalled being contacted by PCDEM, while nine recalled being contacted by FDEP specifically regarding the Generic Permit.

This finding is consistent with previous research that suggests MS4 permit holders nationwide have had little effect on compliance with the statewide General Permits. Duke and Augustenborg (2006) tabulated the proportion of facilities in compliance with the first-stage requirements (filing of an NOI) in four states, comparing compliance within MS4-permitted regions to compliance statewide. NOI ratios in MS4-permitted areas did not appear to be different from NOI ratios in other parts of the same states. Little variation was identified in the NOI ratios among different MS4 jurisdictions. That research suggested "few or no programs specific to MS4 permit holders have had powerful influences in promoting compliance among industrial facility operators." This is not surprising if MS4 permit holders typically decline or de-emphasize any role in promoting, enforcing, or supporting statewide permits.

It is not clear whether the large number of municipal agencies nationwide who hold MS4 permits have fully embraced an active regulatory role. These agencies were formed on an as-needed basis to provide engineering flood protection for urban regions, and consist of a range of structures including county public works agencies, special flood control districts with their own tax authority, and private or

independent public water supply districts that added flood control to their responsibilities. Most have gradually come to accept their role in water quality protection as they have been required to conform to the MS4 NPDES permit requirements to discharge urban runoff. However, many may remain reluctant to actively enforce the panoply of site-specific actions specified in the various states' General Permits. That kind of enforcement conflicts with the long-held view of these agencies as serving and protecting their constituents, not adding regulatory burdens for them.

Awareness of and Compliance With the Florida Generic Permit by Surveyed Facilities

The telephone survey of industrial facility operators began by asking about their compliance with, and understanding of, the specific requirements of the Florida statewide NPDES Generic Permit for industrial stormwater discharges. The facility operators' awareness and the compliance behavior of the surveyed facilities are summarized in Table 5.

Facilities That Need Not Comply. Facility personnel for 21 of the 136 surveyed facilities (about 15%) stated they conducted none of the industrial activities identified in the questionnaire as industrial in nature and potentially generating pollutants in stormwater runoff. This reflects the fact that databases organizing businesses by their "primary" SIC include a substantial portion of facilities identified by sector that actually conduct no activities requiring compliance with the General Permit. The 136 facilities were selected on the basis of information in public and agency databases that identified them with a primary SIC that would make them subject to the regulations if they conducted any activities "typical of" that SIC. This survey finding provides some evidence that a portion of these facilities do not fit the USEPA definition of the regulated community and, therefore, might not be required to either file an NOI or obtain a No Exposure Certification.

Facilities Required to Comply With the Generic Permit. There were 136 facilities in the sample that should have applied for a Generic Permit judging from the information they provided by phone. Only 14 of the sample facilities had filed an NOI for the Generic Permit, about 10% of those determined to be required to comply. None stated they had filed a No Exposure Certification. The proportion of NOI-filing facilities varied among sectors, with none of the 15 wood-products facilities and only five of the 75 metal-products facilities stating they had filed compliance paperwork. Among electronics-products facilities, three (or 13% of the sample) stated they had filed NOIs. Among the facilities in the stone-products industry, 29% of the 21 facilities stated they had filed NOIs.

Information from FDEP about facilities filing NOIs supports these estimates of low compliance. Table 5 tabulates the total number of facilities identified by this research to be conducting business in Pinellas County in each of the four target sectors during 2005, a total of 302 in the four sectors together. Table 5 then displays the proportion of those facilities that had filed NOIs, calculated using FDEP data current through 2005 (FDEP, 2005). The proportion filing NOIs was about 10%, almost precisely the same as the proportion of facilities in the surveyed sample that stated compliance during the phone survey. If the proportion of facilities county-wide that need not comply is similar to the results of the survey, then about 17% of those 302 facilities need not have filed NOIs, and the overall compliance rate would be about 12%.

Previous research also affirms the low compliance estimates. A site-inspection program in Los Angeles found that about 15% of manufacturing facilities required to comply with the statewide General Permit had completed first-stage requirements (Duke *et al.*, 2001). Statewide research in California (Duke *et al.*, 1999b) found compliance in the range of 10% to about 20% for separate sectors. Further research (Duke and Augustenborg, 2006) investigated the proportion of facilities completing first-stage compliance in four states (Florida, Texas, California, and

TABLE 5. Facilities in Pinellas County, Florida: Awareness and Compliance With Florida Generic Permit, Research Results, and FDEP Data.

Industry Sector	Facilities in Sample (research results)			Facilities in County (FDEP data)	
	Number of Facilities	Completed First-Stage Compliance (%)	Familiar With Permit (%)	Number of Facilities	Completed First-Stage Compliance (%)
Wood products	17	0	6	35	14
Stone, clay, glass, and concrete	21	29	38	46	24
Metal products	75	7	15	156	6
Electronics	23	13	35	65	6
Total	136	10	21	302	10

Oklahoma), and found even lower rates for statewide programs. While it is believed that the first-stage compliance is higher in MS4 service areas with targeted, extensive outreach programs implemented since 2001 (Swamikannu, 2006), the proportion complying in Pinellas County appears to be consistent with other regions nationwide evaluated by previous research.

If compliance with the statewide permit were substantially complete, then the role for the MS4 permit holders in reducing pollutants from industrial runoff could be prioritized toward facilities of the greatest interest locally and could focus on improving pollution prevention in support of, or beyond, the requirements of the statewide permit. But compliance with that permit is highly incomplete. The role for the MS4 agencies that may have the greatest impact on protecting water quality from industrial runoff may instead be to help increase compliance with the basic aspects of the statewide permit. MS4 permit holders in this case are needed to assist in roles such as identification of facilities, enforcement of requirements that those facilities enter the permitting structure, and support of monitoring actions (or penalizing inaction) to gather information about pollutants entering local water bodies.

Awareness of the Requirements for Stormwater Discharge Permits. Overall, only about 21% of the personnel answering the questionnaire stated they were familiar with the Generic Permit, as shown in Table 5. Results varied among the different industrial sectors, with very low proportions responding positively in the wood-products sector (about 6% of the 17 respondents) and in the metal-products sector (15% of the 75 respondents). Awareness was higher in the other two sectors – stone products and electronics products – each with just over 35% of respondents stating familiarity with the regulations. **Even in these better-informed sectors, more than half of the facilities' personnel responsible for environmental compliance stated they had no knowledge at all of the permit requirements for stormwater discharges associated with industrial activities.** The low proportion of facilities that were aware of the permit, at a point about 15 years after the permit became effective, **suggests that outreach efforts informing facilities of their duty to comply may produce higher compliance.** The variation among sectors may serve as a starting point to determine what kinds of information are available to some business categories that are absent in others. However, increased awareness by itself will not attain nearly complete compliance. Even among those facilities whose operators were aware of their regulatory duties, fewer than half of those surveyed fulfilled their requirement by filing for an NOI or a No Expo-

sure Certification. **This suggests that the penalties for noncompliance are not sufficiently strict to drive facilities to comply with requirements and, in fact, most facility operators who know of the regulations apparently do nothing to comply.**

Assessment of Facilities' Intensity of Industrial Activities Exposed to Stormwater

The telephone survey acquired detailed information about activities conducted on-site at each of the sample of 136 facilities. The researchers then developed a point scale that scored each facility based on the intensity of the industrial activities exposed to stormwater.

Results of the scoring were used to divide the 136 surveyed facilities into categories A, B, C, and D, in increasing order of intensity of industrial activities exposed to stormwater. The categories are designed to distinguish high-concern facilities from low-concern facilities, and not to make fine distinctions among facilities with similar characteristics. Facilities at which personnel answered "no exposure" for every kind of industrial activity are placed in category A, with the intent to identify truly no-exposure facilities.

Category B contains facilities where the minor activities exposed to stormwater are known to have minor impacts when properly operated, such as the lubricants that might wash off from housed air compressors and the particulates or lubricant leakage from fork trucks that operate outdoors only a few days annually. The evaluation was intentionally conservative in the distinction between Categories A and B: a facility was placed in Category B if it conducted virtually any activity, no matter how minor, from which residuals might be exposed to stormwater. That judgment is perhaps somewhat less well documented than the Category A grouping, because it relies to some extent on the researchers' judgment about the nature and frequency of industrial activities based on facility representatives' statements. However, facilities were placed in Category B only in the presence of convincing evidence that few or minor industrial activities were conducted on site, so it is reasonable to consider these "low intensity."

At the other extreme, facilities in Category D are those where everyday routines included significant outdoor processes or industrial activities where residuals may wash into storm drains. These may include: manufacturing prefabricated concrete structural members; collecting and sorting scrap and waste for recycling; and metal products manufacturing with substantial machining, painting, or storage and handling activities. The research made conservative

assumptions so that Category C became a catch-all category. Category C contains facilities where it was not clear that only minimal activities were conducted outdoors; and those where the interviewer was not certain about the kinds of activities described in the responses, such that a clear determination was not possible regarding whether the facility belonged in Category D.

This typology was sufficient to distinguish facilities with little or no potential for discharging pollutants associated with storm water from facilities that might discharge those pollutants. If the facility representatives' responses to questions were accurate, the survey data indicate that a high proportion of facilities in Pinellas County could be neglected in outreach and enforcement activities with minimal likelihood of causing water quality problems in receiving waters. The protocol was designed to produce consistently conservative results, in particular, by not assigning facilities to Category B without clear evidence that the intensity was low or minimal.

The facilities were divided into the four categories using point totals based on the criteria given in Table 3. Facilities were assigned to Category A if they were given 0 points; to Category B if their scores were between 1 point and 12 points; to Category C if their scores were between 13 and 24 points; and to Category D if their scores were 25 points or greater. Table 6 summarizes the results.

Facilities With Little or No Impact on Stormwater Pollutants but Subject to Statewide Regulations. Nearly 65% of the sample (75 facilities) were found to be in the no-intensity or low-intensity categories. A total of 34 facilities (25% of the sample) were placed in Category A, judged to have essentially no industrial activities exposed to stormwater. These facilities would qualify for the No Exposure Certification (FEDP, 2001; USEPA, 2000), although none had filed for the exemption. A slightly larger number, 41

facilities (30% of the sample) were placed in Category B, judged to have minimal or low intensity of industrial activities exposed to stormwater.

Difference in Intensity Results Among the Four Targeted Industry Sectors. The proportion of facilities in Category D, facilities judged to have high intensity of industrial activities exposed to stormwater, was slightly less than 25% of the sample. There were some notable differences among the four sectors: about 28% of the metal-products facilities were in Category D, compared with only 12% in the wood-products industry; while 53% of the wood-products facilities were in Category A, compared with only 19% of the metal-products industry.

More interesting is the variation in intensity observed within the industry sectors. Among the metal-products facilities, the largest group in the sample, 28% of facilities, fell into the highest intensity category, Category D. The other three industry sectors all had between 12 and 17% of their samples in Category D. If the intensity score is a valid indicator, then the survey data show that in this sample a facility's industry sector is not a good predictor of its discharge of pollutants in stormwater. A facility's assigned sector describes the products manufactured at a facility, whereas the kinds of activities routinely exposed to stormwater (storing and handling materials, loading and unloading products, operating and maintaining vehicles, and operating and maintaining other equipment) are not well described by the primary product(s) produced at a given facility. The data show these activities vary greatly within industry sectors, because a sizable proportion of facilities in all four sectors scored in Category A, while another sizable proportion in all four sectors scored in Category D.

This observation may be a partial explanation for the lack of correlation observed in previous studies between industry sector and pollutant load or concen-

TABLE 6. Proportion of Facilities in Each of Four Categories of Intensity of Industrial Activities Exposed to Stormwater, Four Industry Sectors, Pinellas County, Florida.

Industry Sector	Regulatory Interpretation				
	Not Subject to Permit	Entitled to File Notice of No Exposure	Subject to Full Requirements of Permit: Filing, Monitoring, Reporting, and Pollution Prevention		
	No Industrial Activities	A. No Activities Exposed to Stormwater	B. Low Intensity	C. Medium Intensity (or not determinable)	D. High Intensity
Wood products	2	9	4	2	2
Stone, clay, glass, and concrete	6	4	8	5	4
Metal products	5	14	24	16	21
Electronics	8	7	5	7	4
Total	21	34	41	30	31

tration, as reflected in routine stormwater discharge monitoring (e.g., USEPA, 1995; Lee and Stenstrom, 2005). The absence of the expected correlation has commonly been attributed to the poorly controlled nature of the data available under the monitoring system, especially in the Lee and Stenstrom study. However, there is no evidence to suggest that the concentration should vary in any statistically meaningful way between groups of facilities of different industry sectors.

Variation between industrial sectors has been clearly demonstrated in the data for wastewater discharges, where the manufacturing process that generates the wastewater generally governs chemical composition of the water samples. The present research suggests the possibility that no similar correlation is to be expected in stormwater discharges from facilities of varying industry sectors, even if the measurements of constituents in runoff were controlled to acceptable experimental standards. The load of pollutants typical of industrial activities might instead be correlated with the kind and intensity of activities exposed to stormwater. These factors, at present, are not well described by any features routinely reported or measured by industrial facilities, nor are they demonstrably related to manufacturing sector or SIC.

Verification of Phone Results With Field Observations

The researchers visited a subset of 44 of the telephoned facilities to determine whether the telephone data accurately describe the activities at the target facilities. The industrial facility representatives contacted by telephone were under no obligation to participate, understood their responses had no regulatory penalty for inaccuracy, and had nothing to lose if their responses were inaccurate. The responses could conceivably be inaccurate either because the facility representatives chose to expend little effort to reflect or verify their responses, or if they chose to intentionally mislead the interviewer.

The field verifications consisted of systematic observations from outside the facility property, without the participation of the facility personnel, using the methods described above. The site visits had the necessary limitation that observers could not include any activities that were not visible from public property. This affected only a small number of the targeted facilities and researchers made conservative assumptions about the potential nature of industrial activities hidden from view. A still smaller subset of 20 facilities was visited in the company of the PCDEM inspectors, allowing access to all parts of the facilities. Those results were not evaluated separately

in detail, but were used to gauge the effectiveness of the outside-the-fenceline observations. At none of those facilities did the researchers make observations during the inside-the-plant inspections that contradicted the scoring awarded to a facility during the outside-the-fenceline site visits.

The field inspection survey instrument was structured identically to those portions of the telephone survey instrument that could be observed in the field. The field inspection methodology omitted any features related to intensity of industrial activities that could not be observed from outside the property, notably any questions pertaining to frequency of industrial activities or routine operating practices of the facility. A total score was awarded for each visited facility using the same point values as for the telephone responses. Then a modified score was calculated for the telephone responses for only those questions that were also part of the site visit instrument. Each facility was then classified into Categories B, C, and D. No facilities were visited that had been placed in Category A using the telephone responses. This procedure produced an independent category ranking by each of the two methods – telephone survey and field visit – for each facility in the targeted subset, allowing a verification of the telephone survey results.

Table 7 displays the categorical rankings from the telephone survey and the site visits for the 44 facilities. The results showed a tendency of some facility personnel to understate to some extent the intensity of industrial activities exposed to stormwater. Of the 23 facilities judged from phone evidence to be in the low-intensity group, 11 appeared during site visits to be medium intensity and two to be high intensity. The conservative methods of the site visits might account for some of this, as some facilities were placed in the medium-intensity group if the researchers were uncertain of the evidence observed from outside the facility. For two facilities, there was sufficient visible evidence to support a determination of high intensity where the telephone survey concluded low intensity. Those are cases where the telephone respondent conveyed inaccurate information

TABLE 7. Field Verification of Intensity of Industrial Activities Exposed to Stormwater: 44 Facilities Evaluated by Site Visits and by Phone Survey.

Intensity as Evaluated by Site Visits	Intensity as Evaluated by Phone Survey		
	Low	Medium	High
<i>Number of Facilities</i>			
Low	10	3	0
Medium	11	6	0
High	2	2	10

on the phone, either because the respondent was misinformed about the facility's activities or chose to misrepresent the activities.

No facilities that were judged "high" intensity by phone were observed to be in either the low or medium categories from field data, so none of those facilities overstated their intensity during the telephone questionnaire. Of the 11 facilities judged medium-intensity by phone, most appeared to be medium intensity during the site visits, with three appearing to be low intensity and two appearing to be high intensity.

Results of the verification suggest that less than 10% of the facilities surveyed (4 of 44) understated the facility's intensity, leading to a miscategorization. The sample was too small to draw conclusions about the behavior of the regulated community in general, but sufficient to demonstrate that the potential inaccuracy of the telephone survey affects only a small portion of the sample. The telephone responses were reasonably accurate overall, so the proportion of facilities placed in each of the four categories can be judged to be a realistic estimate for this sample. The method was not intended to be used for regulatory decisions, and this method of verifying information given by phone is not claimed to be adequately reliable to allow any facilities to be relieved of their duty to comply, but was sufficient for the purposes of this research.

Implications for the Stormwater Regulatory System

Among the 136 facilities determined to be subject to the stormwater regulations, a total of 34 facilities (25%) were judged to have essentially no industrial activities exposed to stormwater, if information given in the phone survey was entirely correct. When combined, the two low-intensity categories, A and B, accounted for 75 facilities, or about 55% of the sample. The fact that more than half of the facilities evaluated fell into those categories is a powerful argument for the value of the prioritization step. The 30% of facilities in the B category, where exposure of activities was low or minimal, are at present obligated to comply with filing, pollution prevention, sampling, and reporting under the Generic Permit, although these results suggest they have little or no likelihood of impacting receiving waters.

The MS4 permits, by design, encourage municipal agencies to prioritize their compliance and enforcement activities for industry toward selected industrial dischargers. The prioritization aspect is explicitly not allowed in the statewide General Permits for industry; all facilities must comply, and all are in violation if they fail to comply or fail to specify why they qual-

ify for a No Exposure Certification. The prioritization aspect is embodied in the evaluated Florida MS4 permits as a requirement for inspection of high-risk facilities. The state agencies do not specify a definition of "high risk" in the MS4 permits they issue to local agencies, though the intent presumably is to focus on facilities that may generate high quantities of pollutants or facilities that may affect sensitive water bodies. The Florida MS4 agencies contacted for this research supported that definition in principle. In practice, the methods for choosing "high risk" facilities varied substantially among jurisdictions, and there is little evidence that the existing programs succeed in rigorously identifying and inspecting facilities with the greatest potential impact on water quality of receiving water bodies.

A prioritization option that specifies a lower level of effort for these facilities would better direct resources to the higher-intensity facilities, where the incremental effort to reduce pollutants would produce proportionally more protection for receiving water quality. Resources necessary for facilities to comply include paper reporting, runoff sampling and testing, and developing and implementing stormwater P2 plans. Resources for enforcement include the MS4 inspections and the state agencies' efforts to identify and bring into compliance facilities subject to the permit. Those resources may be expended unnecessarily on facilities where industrial activities exposed to stormwater are very infrequent, very unlikely to produce stormwater pollutants when conducted, or both. Furthermore, the persistently low proportion of facilities actually complying suggests that to attain full compliance would require substantially greater expenditure of enforcement resources than at present, an expenditure that is of little value for the more than one-half of facilities subject to the permit where little or no actual impact on water quality is to be expected should they fail to comply.

Potential Applicability of the Concept: Intensity of Industrial Activities Exposed to Stormwater

This research demonstrates the practicability of rating facilities according to the intensity of their industrial activities conducted on-site in a way that could generate pollutants in stormwater runoff. The method is not perfect, because it is not calibrated to actual pollutants in runoff. The assignment of points selected for this research is not based on a quantitative relationship to pollutants originating from those activities, but derives from best professional judgment and is open to discussion. It is sufficiently systematic to be replicable, and could be adjusted and fine-tuned by an agency that might wish to apply the

method. It is sufficiently precise to make an initial distinction among facilities within three or four separate categories of intensity, but not to distinguish the relative impact of a large number of facilities.

A perfect method of sorting facilities based on their potential for discharging pollutants in runoff may require sampling runoff from every facility during every storm event, testing for and quantifying chemical constituents in each sample, and reporting those samples to the regulatory agency to document the need (or lack thereof) for improved on-site pollution prevention. That is a far different monitoring system than is currently in place in any state (e.g., Lee and Stenstrom, 2005), and would be a far greater burden on the regulated community. That burden is not justified for the lower-polluting portion of the regulated community, a substantial number of facilities, which have little or no impact on receiving water quality. In the absence of rigorous monitoring data, the scale of intensity of industrial activities exposed to stormwater is proposed as a reasonable approximation for the relative loading of pollutants from a given facility if no pollution prevention measures are in place. That approximation may be sufficient to judge, which facilities should be given greatest scrutiny for compliance with the statewide permit and greatest priority for inspection by the MS4 agencies.

An MS4 agency could apply the scoring scheme from this phone method either by contacting facility operators by phone, or by conducting an initial site visit to all facilities in the jurisdiction. Facilities could be supplied with the ranking system and required to report any changes that may affect the ranking, under penalty of a fine for failure to report. That approach could be backed up with periodic re-visits to verify that the situation has not changed. Facilities scoring high on the scale could then be considered high-risk facilities under the MS4 permit and targeted for inspections. Every MS4 permit holder can decide how many facilities to inspect, and how far along the intensity scale those facilities are found, based on local preferences and the resources available to conduct inspections. For example, the permit holders might decide to inspect all facilities in Categories B through D in the watersheds of sensitive or impaired water bodies, or those subject to regulatory action such as TMDL plans; while inspecting only facilities in Category D for other parts of the jurisdiction. Table 8 shows how the categories applied in the present research relate to the General Permit requirements and how they might be adapted for use in a prioritized MS4 industrial program.

Prioritization approaches and ranking methods of various kinds have been applied in a number of states or regions in the U.S. A full analysis of methods applied across the nation is beyond the scope of

this research, but in brief, many of these are based on information about typical practices at facilities of broad industry categories (such as SIC) and the limited discharge constituent data that has been available. The proposed method improves those approaches by distinguishing among high-priority and low-priority facilities within a given SIC, a distinction this research demonstrates to be crucial.

Many of the interviewed MS4 permit holders stated an opinion that on-site inspections are needed in order to make reliable determinations about whether an industrial facility is potentially contributing pollutants, must apply for the Generic Permit, and/or should be defined as “high risk” for future MS4 agency attention. The results of the telephone survey support that perception, that a fairly large proportion of facilities (about 20% of this sample) fall into an in-between or indeterminate group, called Category C in this research. Inspectors could visit facilities and apply the intensity scale developed here to document the reasons for placing facilities into Categories B or D. Using their expertise, they may be able to allocate points for facilities in Category C that will make a reliable determination about whether they are high-intensity or low-intensity. The scale of intensity may be used to develop as many categories as an agency finds useful. The determination of a facility’s place relative to other facilities can be made using methods typically employed in agency inspections.

The method could also be applied to prioritize facilities currently subject to statewide NPDES General Permits for industrial stormwater discharges. The NPDES requirements could specify that facility operators conduct a categorization under agency guidelines as part of their self-identification and self-implementation requirements under those permits, subject to verification by agency inspections. That revised regulatory approach could more effectively target compliance efforts toward those facilities with the potential to discharge pollutants in quantities of concern, and could create a linkage between the intensity of on-site pollution prevention and agency enforcement effort with the degree to which each facility affects receiving water quality.

CONCLUSIONS

The current system of regulations for stormwater runoff associated with industrial activities in urbanized areas includes compliance and enforcement roles for two entities: federal or state-level water quality agencies with NPDES authority; and municipal stormwater dischargers that hold permits for MS4

TABLE 8. Categories of Intensity of Industrial Activities Exposed to Stormwater: Potential Relationship to Existing and Possible Regulatory Programs.

Intensity Category	Defined for this Research	NPDES General Permits	Possible Priority for MS4 Inspection	Potential Improved Permitting
Not Industrial	Determined using definition of industrial activities from USEPA regulations	Not subject; no action required	Commercial facilities must be considered if discharging substantial amounts of pollutants No inspection	Intensity scale could be used to include commercial facilities that could discharge pollutants Periodically re-certify no exposure
A: Industrial activities conducted at site (per stormwater definition); no activities exposed to stormwater	No industrial activities conducted in a way that could cause pollutants to enter stormwater in more than very small amounts	Eligible for Certificate of No Exposure, removing need for any further compliance actions		
B: Minimal intensity of industrial activities exposed to stormwater	Few and/or small-scale activities, conducted in a way that pollutants not expected to enter runoff in substantial quantities	Subject to full General Permit requirements: reporting, monitoring, P2, etc.	Inspect infrequently to verify no change in intensity	Specify minimal monitoring and reporting
C: Moderate intensity of activities exposed to stormwater	Includes facilities where evidence is insufficient for distinction between B and D	Subject to full General Permit requirements	Inspect initially to determine if Category D; if not, inspect less frequently to verify no change in intensity and stormwater P2 plan effectiveness	Optional inclusion in Category D depending on local preferences, impacts on water bodies of concern, etc.
D: High intensity of activities exposed to stormwater	In the absence of P2 or other controls, pollutants originating with industrial activities could enter stormwater in substantial amounts	Subject to full General Permit requirements	Inspect to verify stormwater P2 plan effectiveness and inclusion of all pollutant sources	Specify more frequent monitoring, vigorous stormwater P2 plan, regular reporting

discharges, permits issued by those same federal or state agencies. Under the current system, a large number of industrial facilities fail to comply with the statewide permit. In Pinellas County, Florida, the county targeted for this research, compliance in the four targeted industries was about 10% of the regulated community at a time nearly 15 years after the Florida General Permit took effect. That finding is consistent with previous research documenting low compliance with General Permits for industry in four evaluated states.

Municipal agencies' MS4 permits specify that they identify and work to control pollutant sources from industrial facilities. However, those requirements do not explicitly direct local agencies to integrate their efforts with statewide NPDES General Permits for industry and many of the agencies do not do so. The Florida MS4 agencies contacted for this research uniformly presented the position that implementation of the statewide Generic Permit for industry is not their responsibility. Not surprisingly, the municipal permits as currently implemented do little, if anything, to increase compliance with the statewide permit.

Among local drainage agencies of Florida urban regions, no consensus has yet emerged to define the intentionally vague USEPA permit language directing them to identify and inspect high-risk facilities capable of discharging pollutants of concern into the MS4 drainage systems. Municipal permit holders have chosen a wide range of approaches to identify facilities as candidates for inspections and to select high-priority facilities for inspection. Some agencies inspect only those facilities that have filed notices to comply with the Florida Generic Permit, demonstrated to be a very small proportion of facilities in a given region. Others aggressively identify a very large number of facilities as candidates, and assume all may be high priority until inspections prove otherwise. To date, both approaches have been accepted by the FDEP, the agency with NPDES authority.

The research evaluated the type and extent of industrial activities exposed to stormwater in a sample of 136 facilities of four target industries subject to the Florida statewide Generic Permits located in selected portions of Pinellas County. A total of 34 facilities were categorized as "zero intensity," forming 25% of the sample. Another 41 facilities were in the "low intensity" category, comprising 30% of the sample. Combining the two categories, more than half of the facilities evaluated were judged to present convincing evidence that their industrial activities would contribute few or no pollutants to stormwater runoff. High-intensity facilities – those that may benefit from periodic water quality sampling, inspections, and pollution prevention plans – accounted for less than 25% of the sample. The remaining 20% of facilities were

placed in the category of mid-range reported intensity or else did not present sufficient evidence to make a reliable determination between high and low intensity.

Those results documented the existence of a substantial proportion of facilities where industrial activities exposed to stormwater were so few, of such limited nature, and/or so seldom conducted that the runoff is highly unlikely to convey pollutants of a type and/or in a quantity that might pose a concern for water quality in receiving waters. In the Pinellas County sample, a total of 55% of facilities subject to the Generic Permit were classified in the two low-intensity categories. Including such a large number of low-intensity facilities in stormwater pollution prevention requirements may not be a good use of societal resources, either with respect to the effort of the agencies to enforce universal compliance or with respect to the compliance burden on those facilities. These low-intensity facilities can reasonably be given a less burdensome compliance requirement with minimal impact on water quality. Prioritization of this sort is an explicit part of the industrial inspection requirements on local MS4 agencies, but is explicitly prohibited in the statewide NPDES stormwater General Permits that directly regulate industry.

The research developed and demonstrated a method to systematically assess intensity of industrial activities exposed to stormwater at a given industrial facility. That qualitative measure could be an effective substitute to prioritize facilities for regulatory attention in the absence of detailed, burdensome monitoring data for all industrial facilities considered as possible high-priority sites. The scale can be directly applied by MS4 permit holders under current regulatory structures as a systematic, replicable, and meaningful method to identify "high risk" facilities, while preserving flexibility to accommodate local preferences, local agency resource allocations, and local efforts to protect sensitive or impaired water bodies. The scale could replace the current site-specific determination of the SIC sector to select those facilities that need to comply with the full suite of reporting, monitoring, and pollution prevention activities specified in the General Permit requirements, and could specify other groups of facilities for a reduced level of compliance effort.

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