UCLA
Institute of the Environment and Sustainability

Industrial Stormwater Regulatory Compliance in Los Angeles County

UCLA Senior Practicum Final Report 2015-2016

Team Members
Sarah Chiang
Marina Lindsay
Gabrielle Ruxin
Jacqueline Salem

Client
Los Angeles Waterkeeper

UCLA Faculty Advisor
Dr. Felicia Federico

LOS ANGELES WATERKEEPER®

Table of Contents

Executive Summary

Stormwater pollution from industrial facilities is a well-documented problem. Pollutants such as metals and hydrocarbons, can be carried by rain from exposed materials and process areas and enter water bodies through storm water runoff. Over the past two decades, the California State Water Resources Control Board (SWRCB), in partnership with federal authorities, has focused on increasing the regulation of industrial stormwater runoff under the Clean Water Act and supporting legislative programs.

Our research sought to assess the current state of these industrial stormwater pollution prevention programs at the municipal level, specifically in Los Angeles County. Administered under the Los Angeles Regional Water Quality Control Board (LARWQCB), Los Angeles County is home to 88 cities, 2277 facilities registered under the industrial program, as well as a dense concentration of industrial land use. We reviewed a representative sample of cities, using both targeted and random selection, stratified based on population and percent industrial land use. City programs were evaluated on a range of measures, including budget information, ease of accessing stormwater-specific information on the city website, and self-reported compliance with Municipal Separate Storm Sewer System (MS4) requirements for industrial/commercial facility inspection programs, based on annual reports for the year 2014-2015. We also looked at the number of registered facilities under the industrial general permit (IGP) per city and the number of violations per facility. Then, we compared this compliance data with the industrial program requirements in each municipality to see if any relationship existed between the two.

We found that municipal industrial stormwater pollution prevention programs vary greatly across the county in terms of compliance with MS4 requirements as well as level of information provided on the city website. Cities ranged from having 0-83% of the website and budget information, with no cities containing 100% of our city resources and communication analysis measures. From the MS4 requirement analysis, we found that the average city score was less than 50% for 4 out of our 6 “focus” requirements from the MS4. Three cities had MS4 “focus” requirement scores of 100%: Santa Monica, El Monte, and Los Angeles.

Our recommendations to improve these programs include: updating the Annual Report to correspond to the specific MS4 requirements for the Industrial/Commercial Facility Inspection Programs; requiring that the facility list be submitted with the Annual Report and made publicly accessible on line; providing a toolkit to cities (comprised of permit information, general stormwater facts, and website design features to support best management practices), improving databases content and search functionality.

Introduction

Communities across the nation are increasingly concerned with the state of their water quality and the potential for associated health conditions. This is most clearly expressed through the increase in State and Federal legislation aimed at protecting and regulating water resources and the control of pollutants. Stormwater runoff from industrial facilities is an important water quality concern due to the potential for contamination from exposed metals and chemicals. In urban areas especially, impervious surfaces (concrete sidewalks, paved roads, etc.) prevent stormwater infiltration and contribute to increased urban runoff (SWRCB, 2015). With limited ability to permeate surfaces, stormwater accumulates contaminants as it runs over roads, houses and buildings, and reaches water bodies untreated in areas with municipal separate storm sewer systems (Tang et al., 2013). A recent UCLA study (Gold et al, 2015) found that 40% of the studied waterbodies in Los Angeles are impaired due to runoff containing high concentrations of metal and metalloid pollutants.

Properly managing stormwater runoff can improve water body quality, benefit aquatic ecosystems, conserve water resources, protect public health, and help with flood control (US EPA). Stormwater management and water quality standards have been a matter of governmental policy and regulation since the 1972 Clean Water Act (CWA). This legislation established the authority of the United States Environmental Protection Agency (EPA) and the agency's ability to regulate water quality standards as well as initiate pollutant discharge control programs.

The U.S. policy framework for managing water quality operates at the federal, state, and local level. Authority, responsibility, and management of industrial stormwater are delegated from the federal government to states in most cases. Certain permits are required to discharge pollutants from a facility or business in the state of California. The two main permits we are investigating include the Los Angeles regional Municipal Separate Storm Sewer System permit (MS4) as well as the Industrial General Stormwater Permit (IGP). Currently, IGP permit registration and data collection processes rely heavily on individual facilities' self-reporting. Under the MS4 permit, municipalities have responsibility for inspecting industrial facilities to ensure IGP compliance. An evaluation of the effectiveness of these municipal programs for industrial inspections is the focus of our project.

Literature Review

In support of this investigation a comprehensive literature review was conducted. Topics that were reviewed included: sources and health impacts of pollutants in stormwater, urban hydrology, industrial pollution prevention programs, the California Industrial General Permit, the Los Angeles County MS4 permit and industrial stormwater pollution prevention programs and compliance records.

1. Stormwater Pollutants and Health Impacts

Stormwater can infiltrate into the soil, evaporate, or become runoff that flows into larger bodies of water. Urban areas tend to have higher volumes of stormwater runoff because impervious surfaces, such as concrete, do not allow water to naturally infiltrate into the ground. Stormwater runoff entrains debris and pollutants from urban surfaces, which can greatly affect the receiving waterbodies. Health risks due to pollutants in stormwater can be serious. Waterborne illnesses,

most often associated with fecal indicator bacteria, are a significant concern for humans. In addition, chemical toxicity of stormwater runoff is a major concern to the environment as well as human and wildlife health.

A. Metals

Metals are often found in stormwater pollution because of vehicle activity. Pollutants accumulate as cars drive over streets, parking lots, and highways. Zinc and copper are common metals found in highway runoff. (Herrera, 2007). Vehicles also contribute many other pollutants to road runoff, including heavy metals, oil, grease, and particulates (Kayhanian et al., 2003; Kim et al., 2007). Tire wear, motor oil and grease contribute to high concentrations of zinc, while engine wear introduces copper concentrations to stormwater runoff (Davis, Shokouhian & Ni, 2001; Herrera, 2007). Other pollutants from highway runoff, such as cadmium, chromium, iron, lead and nickel have also been documented (Grant et al., 2003).

Metals, including zinc and copper, have also been found in high concentrations at industrial sites (Duke, Buffleben & Bauersachs, 1998; Rule et al., 2006). A UCLA study found zinc and copper to frequently exceed water quality objectives at mass emission stations (Gold et. al, 2015). Also, all the watersheds studied during this time, except for Malibu Creek, had a high number of metal exceedances. A metal plating site in Los Angeles was found to have zinc and copper in 80% of runoff samples. Nickel, chromium, lead, cadmium and total organic carbon were among other prevalent pollutants that were found (Duke, Buffleben & Bauersachs, 1998). Many industrial sites conduct metal-intensive activities or have metals located on the site that can increase trace metals concentrations in stormwater runoff. Copper and zinc were the most common pollutants in runoff samples taken in North Carolina from five different types of industrial sites: auto salvage, metal fabrication, scrap and recycling, vehicle maintenance and wood preservation (Line et al., 1997).

Metal concentrations in stormwater have been found to have both deleterious environmental and human health effects. In Los Angeles, some of the metal plating facilities studied for stormwater runoff were found to have concentrations of mercury, cyanide, silver and arsenic. All of these are highly toxic and can have long term health impacts, even in small doses of exposure (Duke, 1998). Concentrations of cadmium, chromium, nickel, lead, and zinc were analyzed in two stormwater detention ponds in Sweden (Karlsson et al., 2010). In the studied stormwater detention ponds, incoming water from mixed land use and roadways exceeded many of the safe levels for heavy metals established by the Swedish EPA (which are evaluated based on Classes 1-5). Class 1 denotes no significant environmental effects, while class 5 demonstrates large deviations from reference values (Swedish EPA). At the pond inlet receiving runoff from residential and commercial/ industrial land use, lead exceeded the Class 5 threshold, while all of the incoming waters exceeded the copper values for class 4. In addition, the outgoing waters in both of the sites had copper, lead, and zinc numbers that met class 4 requirements. Inlet waters at the pond collecting stormwater from residential and commercial/industrial sites also exceeded US EPA marine life threshold values for copper and zinc (Karlsson et al., 2010). Toxic industrial contaminants, especially heavy metals, may also contribute to antibiotic resistance in humans, as indicated in a study evaluating contaminated waterways for antibiotic resistant microorganisms (McArthur et. al, 2015).

B. PAHs (Polycyclic Aromatic Hydrocarbons)

Vehicle exhaust and industrial sites are sources of PAHs (Brown & Peake, 2006; Herrera, 2007). Many industrial sites emit PAHs through stack emissions from combustion processes (Joshi & Balasubramanian, 2010). In addition, industrial PAHs can come from waste incineration. For example, medical waste incineration emits PAHs into the atmosphere (Lee et al., 2002). These emissions find their way into stormwater runoff through atmospheric deposition (Sabin et al., 2005). Other sources include biofuel (wood and coal) combustion, and petroleum refineries (Hwang & Foster, 2006; Zhang & Tao, 2009). PAHs also originate from refined coal tar, which can be found in certain sealants used on asphalt and pavement (Mahler et al., 2012). These sealants will eventually wash off into stormwater with road activity over time.

PAH contamination can cause significant harm to marine organisms such as fin erosion, liver abnormalities, cataracts, skin tumors, immune system damage, hindered reproduction, cell membrane degradation, and death (Mahler et al., 2012). These PAH contaminants' detrimental effects exceed many of California's state water quality standards based on health impacts of waterways. (SWRCB, n.d., Water Quality Objectives). In regards to human health, seven different PAH mixtures are listed by the US EPA as probable carcinogens (Mahler et al., 2012).

2. Regulatory Programs

A. The Federal Clean Water Act

Through the Clean Water Act (CWA), also known as the Federal Water Pollution Control Act Amendments of 1972, the United States Congress granted the US Environmental Protection Agency (EPA) authority over water management control programs at the federal level. The Clean Water Act established the EPA's authority to set industrial wastewater pollution standards, while simultaneously outlawing pollutant discharge from point sources into navigable waters without a permit, unless otherwise exempt from control (US EPA, 2015). One of the EPA administered programs includes the permitting and regulation of stormwater. The National Pollutant Discharge Elimination System (NPDES), a federal permitting program under the Clean Water Act, regulates these pollution sources with overarching standards, to be implemented and adjusted by individual states. Of the fifty states, the EPA has officially delegated regulatory power of NPDES permitting to forty-six of them, including California, which has complete delegated authority (ECOS, 2015). Federal powers to regulate and implement policy trickle down through state authorities; responsibilities are then assigned to municipalities and facilities through the permit system.

B. Overview of California State and Regional Regulations

California's Porter-Cologne Water Quality Act of 1969 predates the CWA and requires that the "highest quality water" that is "reasonable" be obtained in each respective water body. The SWRCB is the main authority for stormwater permitting and regulation, tasked with implementing both federal and state requirements, including the following stormwater-related permits: Industrial General Permit (IGP), Construction General Permit (CGP), and Municipal Separate Storm Sewer System (MS4). The SWRCB divides its authoritative power into nine regional water districts, including the Los Angeles Regional Water Quality Control

Board (LARWQCB). Within the LARWQCB, the Watershed Regulatory Unit focuses on municipal, industrial, and general permitting. The Industrial Unit writes and updates permits for facilities that are not discharging to a publicly-owned treatment works (i.e. sewage treatment plant). Facilities are required to self-register for the IGP or CGP. Detailed discussions of the IGP and MS4 permits are provided in the following sections.

C. California Industrial General Stormwater Permit

The twelve main categories of dischargers which are regulated under the industrial stormwater permit at the federal and state level are:

- Effluent discharges per 40 CFR,
- Heavy manufacturing,
- Coal and mineral mining,
- Oil and gas processing,
- Hazardous waste and waste treatment,
- Landfills and open dumps,
- Metal scrap yards,
- Steam and electric power generating plants,
- Transportation facilities,
- Treatment works treating domestic sewage,
- Construction that disturbs 5 acres of land, and
- Light manufacturing plants

These regulated categories have remained more or less fixed; however, certain requirements to the General Industrial Permit were recently updated. In 2014, the California General Industrial Stormwater Permit was updated from the previous 1997 version, which took effect in 2015 (SWRCB, 2016). The updates to the General Industrial Stormwater Permit were designed to improve water quality and compliance. Updates include a requirement for implementation of Best Available Technology Economically Achievable (BAT), Best Conventional Pollutant Control Technology (BCT). In 2016, the State updated on-site Stormwater Pollution Prevention Plan (SWPPP) requirements. In addition, site-specific sources of pollution should also be identified, recorded, and reported in the SWPPP. The SWPPP measure includes upwards of eighty specific criteria addressing the general categories: sitemap, list of industrial materials (storage, frequency, quantity), potential pollution sources, assessment of potential pollution sources, stormwater best management practices (minimum, advanced, and possible suspension), monitoring implementation plan, and the annual comprehensive facility compliance evaluation (SWRCB, 2016).

The General Permit also contains annual and instantaneous maximum Numeric Action Levels (NALs). NALs are derived from the U.S EPA 2008 Multi-Sector Permit for Stormwater Discharges Associated with Industrial Activity (SWRCB, 2014). If a permitted facility (which is permitted to discharge under the IGP rather than the MS4 which is for municipal authorities) exceeds the posted NALs they must file appropriate Exceedance Response Actions (ERAs), within the reporting year (SWRCB, 2014). The General Permit requires dischargers to begin collecting samples within four hours of start of discharge or four hours from start of scheduled facility operating hours (SWRCB, 2014).

The General Industrial Permit application includes requirements for two types of permit coverage: Notice of Intent (NOI) and No Exposure Certification (NEC) coverage (SWRCB, 2014). Facilities covered under the IGP must submit of Notice of Intent (NOI) to first begin the process of obtaining a permit (SWRCB, 2016). They must file for permit coverage at least seven days prior to starting their initial operations at their site. Permit filing fees as well as annual fees currently cost $1,632 and are paid to the SWRCB. Once a facility has filed for coverage, a Waste Discharge Identification (WDID) number is assigned to them. Permit holders are also supposed to report their discharge water testing and exceedances-- as described previously in regards to SWPPP, NALs, and sampling-- to the Stormwater Multiple Application and Report Tracking System (SMARTS) online database. SMARTS is used for registration of facility owners or managers (the Legally Responsible Person or LRPs) as well as the main source for reporting under the general permit (SWRCB, 2016). The process consists of registration, certification and indication of a NOI submission, an uploaded SWPPP, as well as an uploaded site map for the complete facility area. To discontinue coverage under the IGP, a facility must submit a Notice of Termination (NOT) to the RQWCB.

NEC coverage requires submission of a completed NEC form, NEC measure, and current site map. This requirement also asks for an Annual Comprehensive Compliance Evaluation accompanied by an annual fee in order to meet NEC coverage (SWRCB, 2014). If the polluting facility has submitted and completed all requirements for one of these forms of coverage, their permit will be granted. The SWRCB is the main permitting authority with submissions and payment sent to these offices. The Regional Water Quality Control Boards are responsible for inspections and varying levels of enforcement.

D. Los Angeles's MS4 Permit

Title 40 of the Clean Water Act Code of Federal Regulations (CFR) section describes the Municipal Stormwater Permitting Program, which regulates stormwater discharge from industrial facilities, construction sites, and municipal separate storm sewer systems (MS4s). Specifically, MS4s can refer to any stormwater conveyance system that is owned by a local or state government, which can include small ditches and concrete flood control channels. These typically discharge directly into streams, rivers, or other water bodies untreated (California Water Boards, 2004). MS4 permittees are individual municipalities who are required to adhere to waste discharge requirements listed in their specific MS4 permit.

Los Angeles is a Phase I municipality, with a population of over 250,000, and regulation and regular monitoring began in 1990. The current MS4 permit, Order Number R4-2012-0175, was issued by the LARWQCB, effective from November 8, 2012 to December 28, 2017. This MS4 permit regulates municipal discharges within the following watershed management areas:

- Santa Clara River Watershed

- Santa Monica Bay Watershed Management Area (including Malibu Creek and Ballona Creek Watershed)
- Los Angeles River Watershed
- Dominguez Channel, Greater Los Angeles and Long Beach Harbors Watershed Management Area
- Los Cerritos Channel and Alamitos Bay Watershed Management Area
- San Gabriel River Watershed
- Santa Ana River Watershed

At the time of its issuance, the permit covered the county plus 88 incorporated cities; the permit does not apply to the city of Long Beach, which is permitted separately. It is important to note that Long Beach did not have full industrial facility inspection program requirements until 2014. Additional areas that discharge into LA County's receiving waters but are not covered by this permit include 34 square miles of unincorporated area in Ventura County, nine square miles of Thousand Oaks, and 86 square miles in Orange County are also not included.

Part VI.D.6 of the MS4 permit details the Industrial / Commercial Facilities Program (ICFP), which states that permittees (i.e. designated permitting agency or municipality aka local authority) are required to prevent any illicit discharges into their MS4. Program components include tracking critical industrial and commercial sources, educating facility owners of BMP requirements, inspecting facilities, and enforcing program compliance. The following sections discuss each of these requirements in more detail.

i. Industrial and Commercial Facility Database

The MS4 permit calls for permittees to annually maintain a watershed-based database with details about each facility and its permit status (Table 6). Facilities of interest include restaurants, automotive service facilities and dealerships, retail gasoline outlets, nurseries, municipal landfills, and a few others outlined along with an umbrella term for any other facilities the permittee deems a significant pollutant contributor to the MS4.

ii. Education of Facility Owners

In addition to maintaining these records, each permittee must:

- Notify facility owners of applicable BMP requirements at least once during the MS4 permit period
- Implement a targeted Business Assistance Program for significant pollution-contributors, which includes:
- on-site assistance
- phone or email consultations
- distribution of educational materials

iii. Facility Inspections

Permittees are required to inspect all industrial facilities for compliance within 2 years of the renewal of the MS4 permit. The MS4 permit details a prescriptive inspection protocol that permittees can easily follow (Table 6).

iv. Enforcement

Each permittee is required to have progressive enforcement policies and a written plan to ensure that regulated industrial and commercial facilities are in compliance. Section VI also highlights the responsibility of permittees, requiring them to coordinate among internal departments and agencies to carry out the requirements of their MS4 permit, specifically mentioning intra-agency cooperation between agencies like the Fire Department, Public Health, Parks and Recreation, etc. (Table 6).

The MS4 grants the Regional Water Board the ability to fine those who are in violation of the permit, the permittees have not been explicitly granted the ability to fine and are limited to what their individual municipal ordinances allow. However, permittees are expected to support the Regional Water Board's enforcement actions by helping to identify site owners, providing staff for inspections with the Regional Water Board, and testifying in Regional Water Board enforcement hearings (LARWQCB, 2012).

LA's MS4 permit also allows permittees to voluntarily cooperate with each other on a watershed scale to address the management requirements of the MS4 permit (Los Angeles Regional Water Quality Control Board, n.d.). Watershed management plans detail a permittee's strategy and plan for protecting the water quality of their watershed, which may include site-specific hydrological information, monitoring details, and recommendations. The enhanced watershed management plans do not only include municipalities, but may also include non-governmental organizations and community stakeholders (LA Stormwater, n.d.).

E. Databases

Facility owners and managers, permitted under these industrial stormwater programs, are required by federal, state, and local authorities to submit and upload certain information to a variety of databases. The main databases associated with tracking industrial stormwater quality are detailed below along with a brief description of their history and accessibility.

i. California Integrated Water Quality System (CIWQS)

The California Integrated Water Quality System (CIWQS) is a database created and run by the State and Regional Water Boards to track environmental impact data, administer permits, track inspections, and manage violations of enforcement (SWRCB, 2016). Accessed publicly through the SWRCB website, individuals (the general public or registered submitters) may search CIWQS for facility compliance reports (as posted by county) or by violations. CIWQS is based on the following modules: party, place, regulatory measure, inspection, and violation. (Parties may be individuals or agencies such as the Regional Water Board.) Data is available publicly, through generated reports, once permittees have filed their data as required by their stormwater regulation program. At present, dischargers who were issued permits starting in 2006 are required to submit to CIWQS when asked to do so by the Water Board as listed in Attachment E, Section XI.B.1 of the officially issued permit. (http://www.waterboards.ca.gov/ciwqs/).

ii. Stormwater Multi-Application, Report Tracking System (SMARTS)

Enrollees under the state general industrial stormwater permit submit annual reports to the Stormwater Multi-Application, Report and Tracking System (SMARTS). SMARTS replaced the previous Stormwater Annual Reporting Module (SWARM) (SWRCB, 2016). The transition between SWARM and SMARTS occurred between 2009 and 2012. The actual transition date and initial implementation of the program was not found during our research. The SMARTS database contains information from Phase II small municipal, industrial, and construction stormwater permittee information and data (SWRCB, 2016). In order to access SMARTS a party must register and login as a Legally Responsible Person (LRP) indicating your authority as a manager or owner of a discharging facility (SWRCB, 2016). The public can also access generated reports available from a link on the login screen which compile the submitted data (https://smarts.waterboards.ca.gov/smarts/faces/SwSmartsLogin.jsp).

iii. Enforcement and Compliance History Online (ECHO)

ECHO is administered by the EPA and is accessible from the US EPA website. ECHO reports that they provide compliance and enforcement information for nearly 800,000 facilities nationwide (EPA, 2016). Unlike, CIWQS and SMARTS which are reported to directly, ECHO compiles reports from multiple databases across the country into one federally managed data portal. Possible searchable information includes permit data, inspection dates and findings, violations, enforcement actions, and penalties. The website database is designed to be used in four main ways: search by community, explore facilities, create maps, and analyze trends (EPA, 2016). ECHO is currently undergoing a "modernization" in order to ensure long continued use and accurate information. At present the most complete data on ECHO is that of air pollution. Although, a large percentage of industrial stormwater permit data is available, it is not necessarily more complete than CIWQS or SMARTS (https://echo.epa.gov/).

3. Previous Compliance Studies

Previous studies conducted in the mid-to-late 1990's found deficiencies in industry compliance with stormwater regulations (Duke and Beswick 1997, Duke and Chung 1995, Duke et al 1999 Pt I, Duke and Shaver 1999 Pt II). Of the facilities being monitored, a small proportion were actually in compliance with stormwater regulations (Duke and Beswick 1997). Many manufacturing facilities that should be monitored did not even file reports in the first few years after the permit was enacted (Duke et al Pt II). Enforcement of regulations may be lacking because there are no comprehensive databases with compliance information (Duke and Beswick 1997). In addition, there is little crossover between regional inventories of facilities with NPDES permits and compliance lists created by other regulatory agencies (Duke and Shaver Pt I).

Duke and Shaver (1999) evaluated compliance with industrial stormwater discharge regulations in Los Angeles and found that only about half of the facilities required to file under the Industrial General Permit had done so after the new policy had been in effect for five years. Their findings showed a lack of publicly available information on compliance, lack of facility responses, and inadequate reporting tools. At the time, compliance was estimated among only 30-42% of facilities, and one of their major findings was that publicly available databases were not accurately including all facilities in mandatory-compliance industries.

These industrial sites did not follow the best stormwater pollution prevention programs or best management practices. The main activities of concern for stormwater pollution include vehicle fueling, vehicle and equipment storage, and materials handling and storage (Duke and Chung 1995). These studies show a history of challenges related to industrial stormwater pollution prevention and enforcement.

Unfortunately, at present, the data available on serves such as CIWQS and SMARTS is still incomplete due to a lack of reporting from registered permittees and disjointed communication between regulating entities. Few significant changes have been made to address these database limitations, as described by Duke and Shaver, in the past few decades. Their findings showed a lack of publicly available information in compliance, lack of facility responses, and inadequate reporting tools. Throughout our research we found that these limitations are still present and serve as major barriers to properly using and accessing compliance data.

4. Best Management Practices

Implementing best management practices (BMPs) for stormwater management is required under both the Los Angeles MS4 permit and the IGP. There are two main categories of BMPs: structural BMPs and non-structural BMPs. Non-structural BMPs are practices that do not require a physical mechanism to reduce the level of pollutants in water. An example of a non-structural BMP is an educational program aimed at reducing pollutant discharge through changing people's behavior, such as anti-littering advertisements. Structural BMPs are physical systems that remove pollutants in stormwater or block pollutants from reaching the stormwater (BMP Handbook).

A type of structural BMP that can be used to reduce stormwater pollution is a filtration system. Types of filtration systems include sedimentation systems, detention ponds, wetlands and technological filtration (West et al., 2015). These systems filter pollutants from the water. Permeable pavement, such as porous asphalt, reduces runoff volumes as well as pollutants by allowing water to infiltrate into the soil below. These pavements are good for areas where there is little physical stress on surfaces from vehicle weight and driving frequency (SBCK, 2012). Permeable pavers are surfaces designed with crevices, such as tiles spaced apart, which allow water to infiltrate (Chau, 2009).

Other types of structural BMPs include green infrastructure and green landscaping. Green infrastructure is an interconnected system of natural features that provide ecosystem services (Chau, 2009). Green infrastructure can provide groundwater restoration, carbon sequestration, and water filtration. This infrastructure can also help efforts to maintain open space and can be designed to be aesthetically pleasing. Green landscaping includes swales that have dense vegetation and are designed to promote infiltration and remove particulate pollution. (Chau, 2009).

BMPs that specifically relate to industrial sites include covering materials and equipment in order to reduce exposure to rain. This reduces the amount of pollutants collected by stormwater. Examples of BMPs for auto recycling sites includes keeping vehicles and equipment indoors,

constructing barriers around the site and maintaining inventory of materials used at the site (BMP Handbook).

Methods

Overview

Our team reviewed the existing industrial facilities programs (IFP) in Los Angeles County. We selected a representative sample of cities from across the county based on city size and industrial land use. We evaluated different components of each city's program: one set based on the specific program elements required in the MS4 permit, and another that included additional indicators, including financial resources allocated to stormwater programs and website content. We evaluated city program effectiveness based on measures of compliance of industrial facilities within that city, based on CIWQS data, and then compared program indicators to program effectiveness to look for trends or correlations.

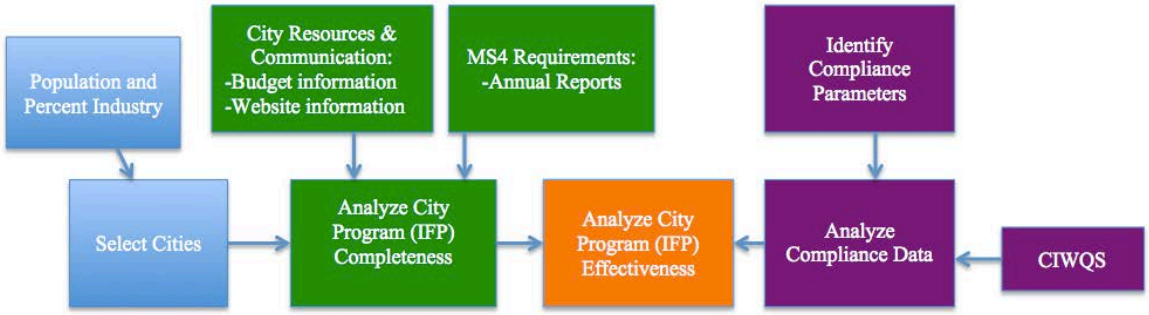

Figure 1: Methodology Flowchart

1. City Selection

We evaluated a subset of the 88 cities in Los Angeles County in order for our scope to be manageable within the project timeframe. To select a representative sample of cities, we first sorted them based on two criteria: (1) city size and (2) industrial land use percentage (Appendix A/B, Table 16 and Table 20). We used city population from the 2010 United States census data and calculated industrial land use percentages using Arc-GIS software.

Using land use datasets from the Southern California Association of Governments (SCAG), we overlaid city boundaries in Los Angeles County with industrial land use data, and used the ArcGIS join-relate function to calculate the area of industrial land use in each city. Because land use parcel boundaries did not coincide exactly with city boundaries, some cities' industrial land use summed to more than 100% of the total city land area. This only happened in the case of two cities, Maywood and Vernon. We visually checked these cities and made manual corrections to the percent industrial land use values. See Appendix B for a complete list of cities with industrial land use percentages (Table 20). We classified cities using percent industry range categories, calculated in R studio using histograms and distribution statistics.

To get a distribution of cities by size and percent industry, while focusing more on heavily industrial cities, we chose a certain number of the total cities per category as shown in Table 3 and Table 4. In total we analyzed twenty-eight municipalities as well as the county, accounting for a little over 30 percent of the total permittees under the MS4 permit. R Studio software was used to make histograms of both city size and industrial land use to sort cities into categories based on small, medium and large size and percent industrial for random selection (see Figure 2 and Figure 3). Outliers for city size and percent industry were excluded while making the respective histograms; these outliers were included in the study as targeted selections. The percent industry breakdowns are shown in Table 1, and the city size breakdowns are shown in Table 2. We targeted the four outliers based on city size and also included unincorporated Los Angeles County in our assessment. Twenty-four other cities were chosen randomly from the nine categories. Selected cities are shown in Table 4.

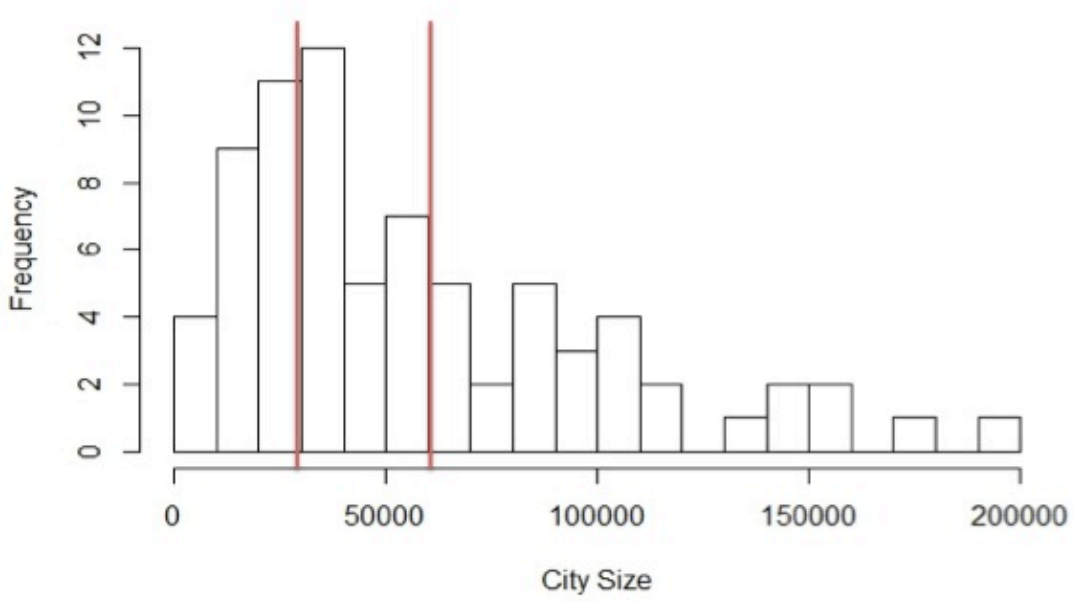

Figure 2: Histogram for LA County cities' population sizes (2010 Census data); outliers excluded. Red lines show approximate breaks. ***Note* cities without industrial land use data were not included***

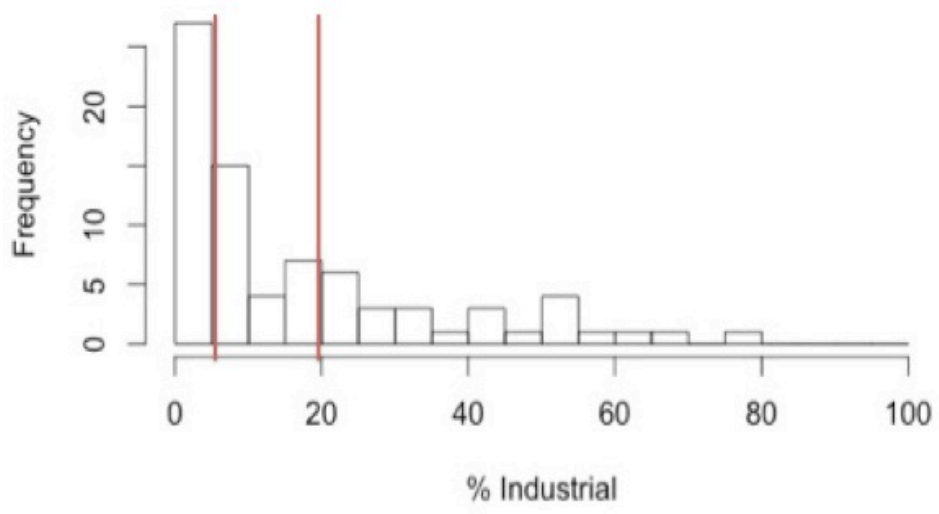

Figure 3: Histogram for % industry by city using 2005 SCAG land use data; outliers excluded. Red lines show approximate breaks. ***Note* cities without industrial land use data not included***

Table 1: Percent Industry Breakdowns

Categories	**Percent Industry**
Low	0-4.9%
Medium	4.96-19%
High	>19%

Table 2: City size breakdowns

Categories	**City Population Size**
Small Outliers	0-219
Small	1,048-27,395
Medium	29,172-62,500
Large	62,942-191,719
Large Outliers	462,257-3,792,621

Table 3: All LA County cities by category

City Size:			
Small	10 (LS)	5 (MS)	7 (HS)
Medium	11 (LM)	7 (MM)	10 (HM)
Large	5 (LL)	12 (ML)	9 (HL)
Outliers		2 (M)	2 (H)
% Industry:	Low	Medium	High

Table 4: Selected cities by category. Los Angeles County was also included in the study

City Size:			
Small	La Cañada Flintridge (1 LS)	Artesia (1 MS)	Cudahy, El Segundo, Commerce, Santa Fe Springs (4 HS)
Medium	Walnut (1 LM)	La Verne (1 MM)	Paramount, Azusa, Gardena, Bell (4 HM)
Large	West Covina, Glendale (2LL)	Santa Monica, Inglewood, Downey, Pomona, Burbank, Whittier (6 ML)	La Mirada, El Monte, Bell Gardens, Carson (4 HL)
Outliers		Los Angeles, Long Beach (2M)	Industry, Vernon (2H)
% Industrial:	Low	Medium	High

Note Long Beach has its own MS4 permit*

2. City Program Analysis

Our team conducted a preliminary survey of the stormwater management programs and city websites of the four largest cities, by land area, in Los Angeles County: Los Angeles, Palmdale, Lancaster and Santa Clarita. We researched these programs to find out what cities do to manage their industrial stormwater runoff and what information is available on each city's website. After conducting our initial research, our team created two sets of criteria with which we characterized cities and evaluated their industrial pollution prevention programs. They include the following elements:

Resources and Communication (Table 5):

- Website information: General Stormwater Information, link to stormwater permits, link to county/state website, advertisement of community outreach programs, languages information is available in, and contact information
- Budget information: Annual budget (General Fund) for municipality and budget of stormwater program
- Population size, percent of industrial land use, number of facilities with IGP and average income

MS4 Requirement Criteria (Table 6):

- MS4 permit requirements for Industrial / Commercial Facilities Programs (ICFP)

The resources and communication criteria is an overview of each city to see if there are any trends among different city sizes and resources. This first measure was completed through an initial web search (City Website, Public Works pages, public budget information etc.), followed by phone calls requesting information from the stormwater contact in each municipality as listed

in the MS4 permit. Demographic information was found through outside data sources: population size data as well as average income came from the 2010 census; percent industrial land use was found using Arc-GIS analysis as discussed above; and the number of facilities covered under the IGP was found through CIWQS searches. Answers were recorded as either a numerical value or Y/N (Yes/No) depending on whether or not the information could be found, with "Yes" being the preferred answer in each case. We tallied the total number of "Yes" counts out of total possible (6) and took this as a percentage of the criteria analyzed for each city website.

To obtain the budget information, we used the MS4 budget, taken from the annual report and the General Fund for each city. The General Fund was accessible through the cities' websites. We decided to use the General Fund for each city because it gives a good representation of each city's budget and is high quality data.

The list of required program components was taken from the Industrial/Commercial Facilities Program in Los Angeles County's MS4 permit. Our team read through each of our selected cities' required annual reports from the April 1, 2014-March 31, 2015 reporting year to complete this measure. The annual report is submitted to the Regional Water Quality Control Board, and is used to document each city's program implementation and also determine compliance with the MS4 permit. We filled our measure from that list with "Yes", "No", or N/A. We reached out over email and phone to attempt to obtain inspection protocols and fill in missing information.

Table 5: Website, Budget and additional city information

City Resources and Communication Criteria
1. Municipality Demographics
A. What is the population size?
B. What is the percent of industrial land use?
C. What is the number of facilities with IGP? (facilities reporting to CIWQS)
D. What is the average income?
2. Budget Information
A. What is the average budget for the municipality?
B. Is there a budget for a stormwater program? (Y/N)
C. If yes, what is the stormwater budget?
3. Ease of Accessing Information on Municipality Website
A. General Information about Stormwater? (Y/N)
B. Link to Stormwater Permits? (Y/N)
C. Link to County/State Website? (Y/N)
D. Any Community Outreach Programs Advertised? (Y/N)
E. Is the website offered in more than one language? (Y/N)
F. Contact information posted? (Y/N)

Table 6: IFP Requirements List

MS4 Requirements for the Industrial Facilities Program
1. Record Keeping
A. Facilities Database
1. Geographical Coordinates
2. Facility and Owner Name
3. Address
4. NAICS/SIC Code
5. Activity Description
6. Stormwater Exposure Status
7. Receiving Water Name
8. City is aware if facilities are a tributary to a 303(d) listed waterbody/TMDL water body
9. If the facility is known to have IGP coverage or any other NPDES permits
B. Annual Report
2. Legal Controls
A. Applicable ordinances, permits, contracts or orders allowing the permittee to control pollutant discharges into the MS4
B. Established system for fining violators
3. Inspection Programs
A. Provisions to inspect all industrial facilities for compliance within two years of the renewal of the MS4 permit
B. Inspecting Facility Elements
1. Do cities check if facilities have a Waste Discharge Identification number for the IGP or No Exposure Certification
1. Do cities check that facilities have Stormwater Pollution Prevention Plans
3. Do cities check that BMP implementation is up to municipal standards
C. Inspection Process Requirements
1. Do cities have a record of facilities not in compliance (after two follow-up inspections and two warning notices the permittee may refer the violation to the Regional Water Board)
2. Have cities referred any facilities to the Regional Water Board (if facilities are subject to an IGP, permittees may refer the violation to the Regional Water Board after only one inspection and one notice of violation)
3. Do cities have a protocol for having a second compliance inspection after 6 months for facilities without a No Exposure Certification
4. Has the city checked the SMARTS database? (ideally, cities are expected to check after the second and fourth year of the MS4 permit's effective date to determine if facilities have been already inspected by the Regional Water Board)
5. Have cities conducted second round inspections of at least 25% of facilities with a No Exposure Certification
6. Has the city indicated that they notified facilities without a current WDID or No Exposure Certification that they must obtain coverage and will be referred to the Regional Water Board
D. Do cities note that they plan to prioritize facilities for review (if any problems arose during inspection, etc.)
4. Best Management Practices
1. Structural
2. Non-Structural
5. Notification Process

A. Each permittee must notify facility owners of applicable BMP requirements at least once during the MS4 permit period, and implement a targeted
B. Does the city have a Business Assistance Program
6. Communication
A. Coordination among internal departments and agencies to carry out requirements
1. Intra-agency cooperation between agencies like the Fire Department, Public Health, Parks and Recreation, etc.
2. The Regional Water Board for: notification of illicit discharges into the MS4, through helping identifying site owners, providing staff for inspections with the Regional Water Board, and testifying in Regional Water Board enforcement hearings
B. Separate stormwater hotline (not the county's)

3. Industrial Facility Compliance

We would have liked to compare city programs to water quality as a measure of effectiveness, as improving water quality is the ultimate goal of these programs. Unfortunately, there are too many confounding variables to link a particular city's industrial inspection program to water quality in a nearby receiving body. (Factors such as multiple facilities discharging to the same conveyance or receiving waters even across city lines, under reporting of data, and unregistered facilities, to name a few. Note that discharging is not the same as "polluting" to these regulatory agencies, when a discharge exceeds the concentration standards of a certain pollutant it is then considered a polluting source for that exceedance.) As a result of these limitations, we decided to focus on the most proximate measure, which was the level of compliance of each municipality's industrial facilities.

Compliance data, regarding the industrial stormwater program specifically, was taken directly from the CIWQS database and consisted of recorded violations and enforcement actions. These violations included all classes and levels of severity sited in the past five years (See data obtainment process below for the exact entry search fields). CIWQS searches were conducted for Los Angeles County as a whole, by municipality, and by individual facility. The data used in our analysis was taken from the five-year period from January 1st, 2010 to December 31st, 2015. This five-year period was selected to account for variability between years of reporting, possibly affected by the most recently updated MS4 (2012) and IGP (2015) permits. We ended our observation window in 2015 (2014-2015 rather than 2015-2016) to remain comparable with the annual MS4 reports. The MS4 permit was recently updated for Region 4 in 2012 and therefore, previous annual reports will not yet reflect these changes.

In order to obtain the data we used for our evaluation the following search steps were conducted:

- Access ***CIWQS*** from the main page on SWRCB (http://www.waterboards.ca.gov/ciwqs/publicreports.shtml)
- Click on ***Facilities***
- Select the option entitled ***Interactive Regulated Facilities Report***
- Select SWRCB ***Region 4 -Los Angeles***
- Select ***Los Angeles County***
- Leave city blank
- Select program ***Storm Water***
- ***Active*** permits

- Select facility type ***Industrial***
- Leave Waste type blank
- Leave Agency type blank
- Then click ***Run Report***

(From this 2273 facilities were reported as registered under the Industrial Program with records of each facilities recorded violations and enforcement actions taken in the past 5 years.) Once completed, we clicked on ***Facilities Registered Under the Industrial Program*** and then exported to an excel file. In the excel file we converted the ***Facility Address*** column information into multiple columns, so that we could sort by city name.

CIWQS data was used to assess the number of active, registered facilities in each municipality, which was then compared to the violations. For each municipality, we calculated the ratio of facilities receiving violations in the past five years over the total number of facilities registered under the IGP. To accurately depict violation data, ideally we would have liked to express violations as a percentage of the total number of inspections carried across the years studied. However, this data was not available on the CIWQS server.

The inspection data that is available does not include total inspections on CIWQS, based on all of the searches we ran. In addition, this was not able to be extracted (as a search field) for any city or county data searches. This information could potentially be obtained from SMARTS; however, through our literature review research and professional consultations we found that the data available on SMARTS may be incomplete, unverifiable, and come from numerous sources. Also, communication between these two data sources has not always been possible and inspections from one may not translate to inspection violations in another.

Note that CIWQS does not specify exactly who is reporting inspection data or when they are reporting, other than four broad options (federal, state, local, and private). Since we are assessing municipality programs and facilities, which may be inspected by any of these entities, we chose to include all. In addition, inspections from certain entities such as state authorities may be infrequent or non-annual depending on their resources. Using all inspection fields reduces the possibility of a single bias for reporting entities.

Compliance data for the cities we studied was analyzed based on the total number of active facilities reporting to CIWQS under the IGP as well as the reported violations for each facility over the five years. This was done in an attempt to normalize the data and account for inspection biases and variability. Facilities may be inspected more or less frequently than others, thereby skewing tallied violation results due to unequal conditions.

4. City Measures and Violations Comparison

We used both the overview and MS4 criteria along with the violation records (any violation regardless of class sited under the stormwater program inspectors in the past five years) from CIWQS to determine Los Angeles County's MS4 Program effectiveness. We used the overview measure to analyze any trends among various city sizes and resources, and if any trends were correlated with having more complete MS4 requirements. We determined what percentage of

each city's total budget was allocated to stormwater compliance, and ranked them among each other.

We chose a targeted method to analyze our MS4 requirements as well. Our team determined which items on our MS4 measure were of high importance to ensuring compliance with the Industrial Facilities Program (IFP) subjectively based on a low, medium, high scale, and then further ranked those by reliability of our gathered data (some requirements in the IFP were not asked about in the annual report). Some of these include if cities have an inventory of critical sources (facilities) of stormwater pollution, if cities communicate with business owners about BMP requirements, etc. (Table 7). We then added up our total Yes answers each city had out of our total 31 items, and measured cities against each other. We used our MS4 measures to determine if a more complete program was correlated with having fewer violations.

In order to see how our weighted scores affected the outcome of our study, we also conducted a sensitivity analysis. We ranked each "focus" requirement equally, as well as with a low and high to see how the scores would turn out differently with different weights attached. This allowed us to see which requirements affected the "focus" requirement scores the most.

Table 7: Focus Requirements for MS4

MS4 Requirements for the Industrial Facilities Program
"Focus" Elements
1. Do they have a Critical Source Inventory?
2. Established system for fining violators?
3. Do cities check that BMP implementation is up to municipal standards?
4. Have cities notified facility owners of applicable BMP requirements at least once during the MS4 permit period?
5. Do cities have a Business Assistance Program?
6. Do cities have a separate stormwater hotline?

Results

City Program Analysis

1. Resources and Communication

A. Website Access and Information Content

The results for each city were recorded in Table 8. The average percentage of Yes answers out of the six questions was 29.3%. The maximum was 83.3% and the minimum was 0%.

Cities with the highest percentages included Long Beach and Santa Monica at 83.3%. Whereas, the cities of Artesia, Los Angeles, Whittier, La Mirada, Cudahy, Paramount, Bell Gardens, Gardena, and Santa Fe Springs had 0% of the criteria in the measure. None of the cities studied received a score of 100% based on the criteria we had selected (Table 9, Figure 4). To view the table of all city score percentages see (Table 9).

We then compared the percentages of "Yes" answers to the percentage of industrial land use for each city (Figure 5). The average percentage of completed criteria for each category (small, medium and large percent industry) for the cities studied was 16.7%, 39.7% and 22.2% respectively. Of the cities we studied, those with medium industrial land use, such as Santa Monica, La Verne, Long Beach and Pomona received higher percentages of "Yes" answers. On the other hand, some cities with high industrial land use such as Santa Fe Springs, Bell Gardens and Vernon garnered low percentages of the criteria.

After analyzing the total percentages, we looked at five specific questions, determined by our team to be the most important and beneficial criteria for each city to have on their website (Table 10). Of the cities studied, 34.5% had general information about stormwater, 24.1% had links to stormwater permits, 27.6% offered their city website in more than one language, 27.6% had a link to the State/County website and 44.9% had contact information posted for the individual in charge of their stormwater program.

Table 8: Yes/No Answers for Website Information Measures by City

Cities	A. General Information about Stormwater (Y/N)	B. Link to Stormwater Permits (Y/N)	C. Link to County/State Website (Y/N)	D. Any Community Outreach Programs Advertised? (Y/N)	E. Is the website offered in more than one language? (Y/N)	F. Contact information posted (Y/N)
SS La Canada Flintridge	N	N	N	N	N	Y
SM Walnut	Y	N	N	N	N	N
SL West Covina	N	Y	N	N	N	N
SL Glendale	N	N	N	N	Y	N
MS Artesia	N	N	N	N	N	N
MM La Verne	Y	N	N	Y	N	Y
ML Whittier	N	N	N	N	N	N
ML Santa Monica	Y	Y	Y	Y	N	Y
ML Pomona	Y	Y	Y	N	N	Y
ML Inglewood	N	N	N	N	Y	Y
ML Downey	N	N	N	N	Y	Y
ML Burbank	Y	N	Y	N	N	Y
LS Santa Fe Springs	N	N	N	N	N	N
LS El Segundo	N	N	N	N	N	Y
LS Cudahy	N	N	N	N	N	N
LS Commerce	Y	N	Y	N	N	Y
LM Paramount	N	N	N	N	N	N
LM Gardena	N	N	N	N	N	N
LM Bell	Y	N	Y	N	Y	Y
LM Azusa	Y	N	N	N	Y	Y
LL La Mirada	N	N	N	N	N	N
LL El Monte	N	Y	N	N	N	Y
LL Carson	N	N	N	Y	Y	Y
LL Bell Gardens	N	N	N	N	N	N
Small Outlier Vernon	Y	N	N	N	N	N
Small Outlier Industry	N	Y	Y	N	N	N
Large Outlier Long Beach	Y	Y	Y	N	Y	Y
Large Outlier City of LA	N	N	N	N	N	N
Outlier LA County	Y	Y	Y	N	Y	N

Table 9: Website Information Measures (Percent) by City

City (Low Industry)	Website Information Measures (Percent)	City (Medium Industry)	Website Information Measures (Percent)	City (High Industry)	Website Information Measures (Percent)	Outliers	Website Information Measures (Percent)
SS La Canada Flintridge	16.7	MS Artesia	0	LS Santa Fe Springs	0	Small Outlier Vernon	16.7
SM Walnut	16.7	MM La Verne	50	LS El Segundo	16.7	Small Outlier Industry	33.3
SL West Covina	16.7	ML Whittier	0	LS Cudahy	0	Large outlier Long Beach	83.3
SL Glendale	16.7	ML Santa Monica	83.3	LS Commerce	50	Large Outlier City of LA	0
		ML Pomona	67.7	LM Paramount	0	Outlier LA County	66.7
		ML Inglewood	33.3	LM Gardena	0		
		ML Downey	33.3	LM Bell	66.7		
		ML Burbank	50	LM Azusa	50		
				LL La Mirada	0		
				LL El Monte	33.3		
				LL Carson	50		
				LL Bell Gardens	0		

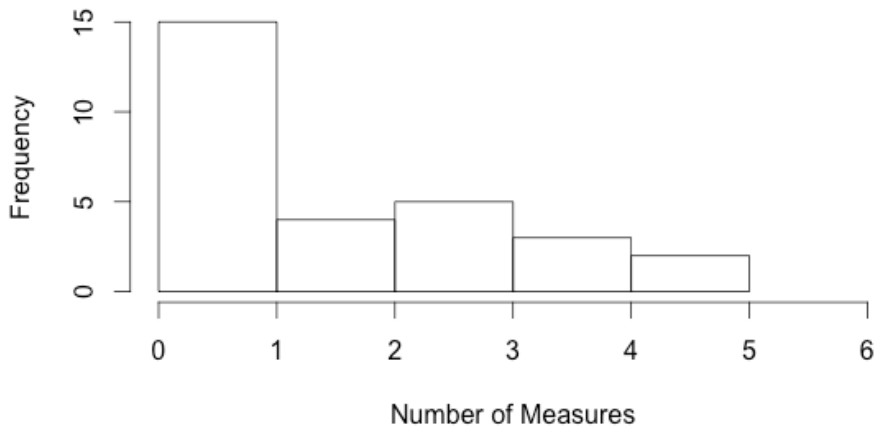

Figure 4: Histogram of the Number of Website Information Measures Per City

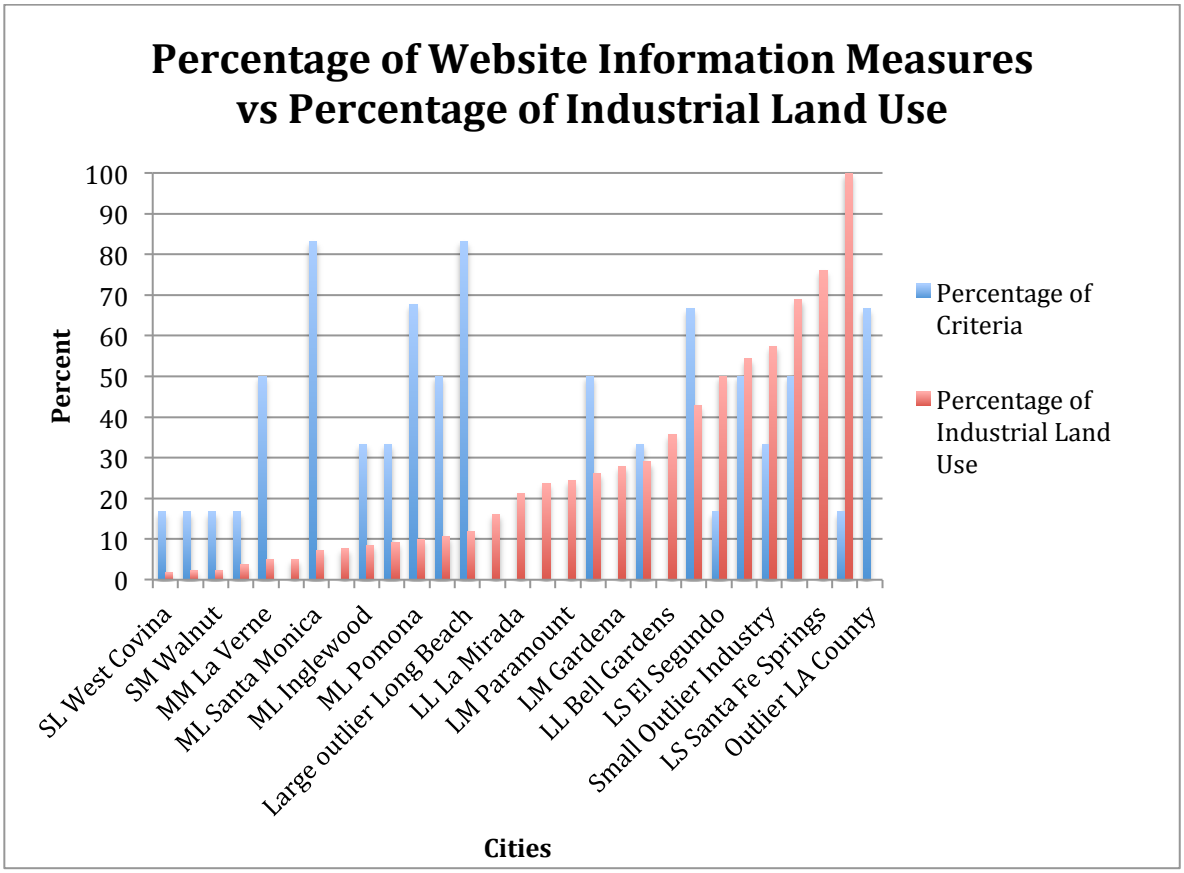

Figure 5: Percentage of Website Information Measures vs. Percentage of Industrial Land Use

Table 10: Summary of Most Important Website Information Measures

Question	Y	N	Y/ Total (Percent)
Is there general Information about stormwater? (Y/N)	10	19	35%
Are there links to stormwater permits? (Y/N)	7	22	24%
Is the website offered in more than one language? (Y/N)	8	21	28%
Is there a link to the County/State Website? (Y/N)	8	21	28%
Is stormwater contact information posted? (Y/N)	13	16	45%

B. Budget Information

As part of the resources and communication measures, we analyzed the resources available to each city using their budget information for the 2014 fiscal year for most cities. However, the 2015 fiscal year was for the City of Commerce and Industry, and the 2016 fiscal year was used for Paramount because these were the years available for the respective cities. We found the percentage of the General Fund budget that the MS4 budget made up for each city (Table 11).

Summary statistics for the budget percentages shows that the average percentage spent on the MS4 budget was 3.29%, and the range was 15.08%. The city with the highest percentage was Artesia with 15.28%, and the lowest percentage was Whittier with 0.01%. 48% of the cities spend less than 2.5% of their budget on MS4 compliance each year (Figure 6).

We then compared the percent budget to the percent industry splitting the cities by amount of industry. The average amount of industry for the small, medium and large industry cities was 1.82%, 5.93% and 2.19% respectively.

Table 11: MS4 Budget/General Fund (Percent) for Low, Medium, High Industry and Outliers

City (Small Industry)	MS4 Budget /General Fund	City (Medium Industry)	MS4 Budget /General Fund	City (Large Industry)	MS4 Budget /General Fund	City (Outliers)	MS4 Budget /General Fund
SL West Covina	1.3%	MM La Verne	6.8%	LL La Mirada	4.1%	Small Outlier Industry	10.4%
SS La Canada Flintridge	3.8%	MS Artesia	15.3%	LS Cudahy	3.4%	Small Outlier Vernon	1.1%
SM Walnut	1.0%	ML Santa Monica	4.5%	LM Paramount	1.3%	Large Outlier Long Beach	0.8%
SL Glendale	1.2%	ML Inglewood	14.3%	LM Azusa	1.2%	Large Outlier City of LA	1.9%
ML Whittier	0.9%	LM Bell	2.2%	LS El Segundo	3.6%	Outlier LA County	0.4%
		ML Downey	1.2%	LL Carson	2.1%		
		ML Pomona	2.1%	LS Commerce	3.7%		
		ML Burbank	2.3%	LS Santa Fe Springs	0.8%		
				LL El Monte	1.6%		
				LL Bell Gardens	2.2%		
				LM Gardena	0.2%		

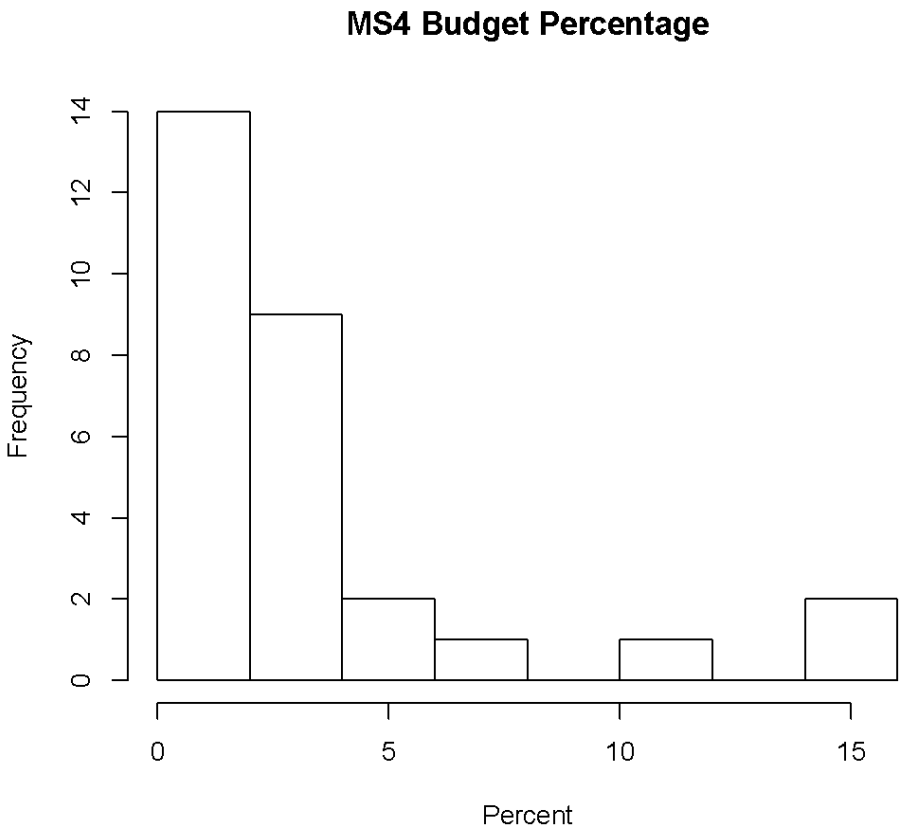

Figure 6: Histogram of MS4 Budget/General Fund (Percent)

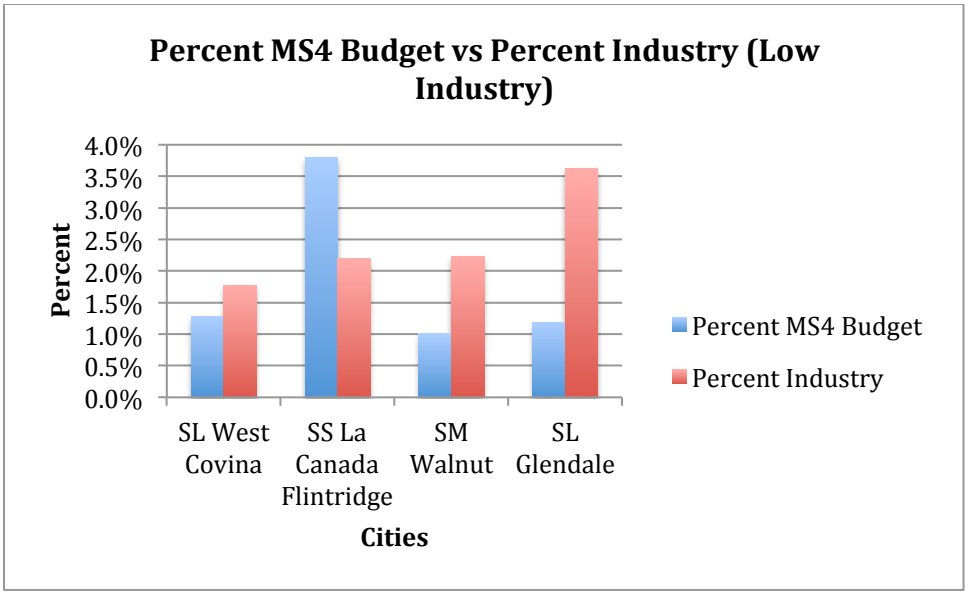

Figure 7: Percent MS4 Budget vs. Percent Industry for Low Industry

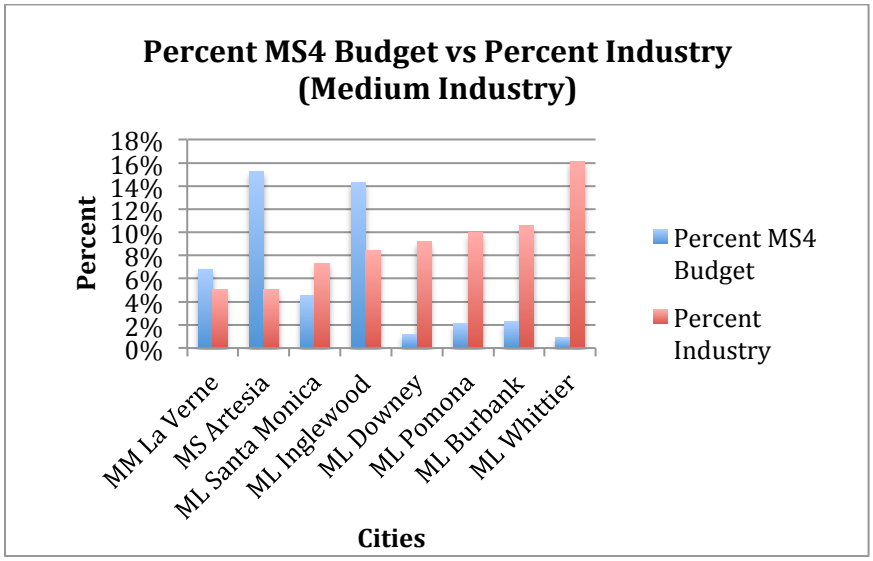

Figure 8: Percent MS4 Budget vs. Percent Industry for Medium Industry

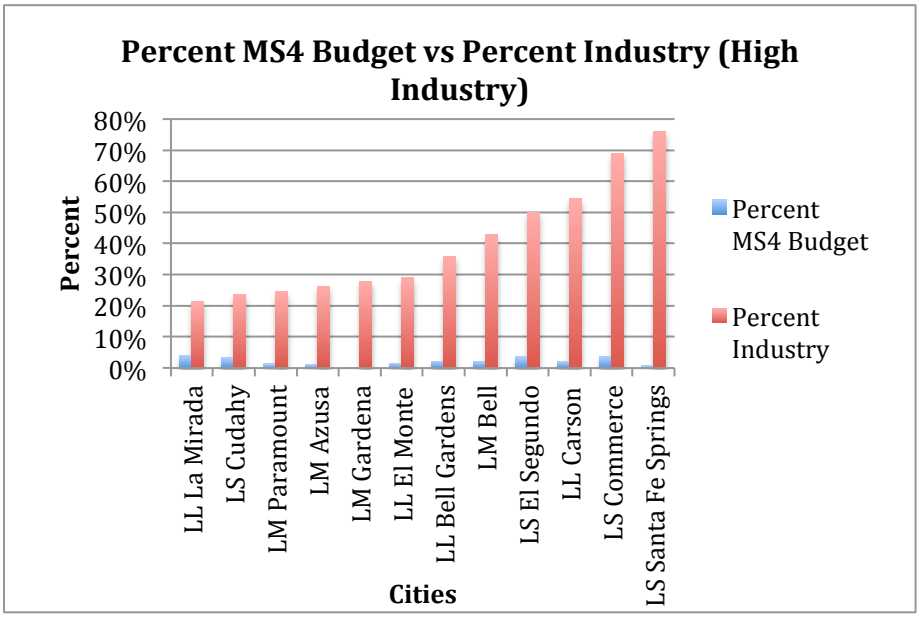

Figure 9: Percent MS4 Budget vs. Percent Industry for High Industry

2. MS4 Requirement List

Our MS4 requirement list was used to analyze city programs based on the MS4 permit requirements and compare the results with each city's annual stormwater report. This comparison allowed us to visualize which requirements each city was meeting and indicated how comprehensive their industrial stormwater pollution prevention programs are based on the information accessible to our team. Most of the information initially searched for on our measure and explicitly required by the MS4 permit was not available in the cities' annual reports, due to

missing fields in former annual report templates (2001 and 2003) and a lack of reporting structure. As a result, only some fields of our measure could be thoroughly analyzed.

Thus, we chose certain elements to analyze based on the quality of the data and their weighted importance to our study (Table 12). We first chose elements that seemed relevant to our study and that information had been available for. We did this by noting requirements that were clearly answered in the annual reports and then assessing whether this information was important to the industrial facilities program under the MS4. The quality of data and weighted importance to the study were each rated low, medium and high for each element (low=1, medium=3 and high=5). Then, these two scores were averaged together to find the overall score out of 5. To score each city numerically, we weighed the six chosen focus elements on a scale of 1-5 as well as added up the total number of Yes's per city based on the entire measure (a score out of 32). Figure 10 shows the score percentages for all cities analyzed. Figure 11, Figure 12, Figure 13, and Figure 14 show the score percentages of each city, categorized by their percent industry previously found from Arc-GIS. Figure 31, Figure 32, Figure 33 and Figure 34 are scatterplots of the same data categorized by size as well as percent industry. No strong correlations are found.

Our sensitivity analysis allowed us to determine how scores would be affected if weighted differently. To do this, we gave each focus requirement a score of 1 and 5 to see the variability based on the lowest and highest score possible. We also made each focus requirement the same weight to see how the scores would turn out differently if they were all weighted equally. Table 13 shows the weight given to each focus requirement in each scenario. Table 14 summarizes all of these different scenarios and how the total average focus requirement scores would differentiate from our chosen weighting scheme based on the average absolute value percent difference from the original scenario (the one used in our analysis). (See Appendix A for more detailed tables of focus requirement scores per city based on the different scenarios).

Table 12: "Focus" requirements analysis

"Focus" Requirement:	Critical source inventory	System for fining violators	Check BMPs are up to standards	Notify owners of BMP requirements at least once	Business Assistance Program	Separate Stormwater Hotline
Average Municipality Score:	2.8 (93.3%)	0.5 (24%)	3.3 (65.6%)	1.3 (44.7%)	1.9 (38%)	1.4 (34.5%)
Focus Requirement Score (weighted %):	5 (20.8%)	2 (8.3%)	5 (20.8%)	3 (12.5%)	5 (20.8%)	4 (16.7%)
• Data Quality Score:	5	1	5	3	5	5
• Requirement Importance Score:	5	3	5	3	5	3

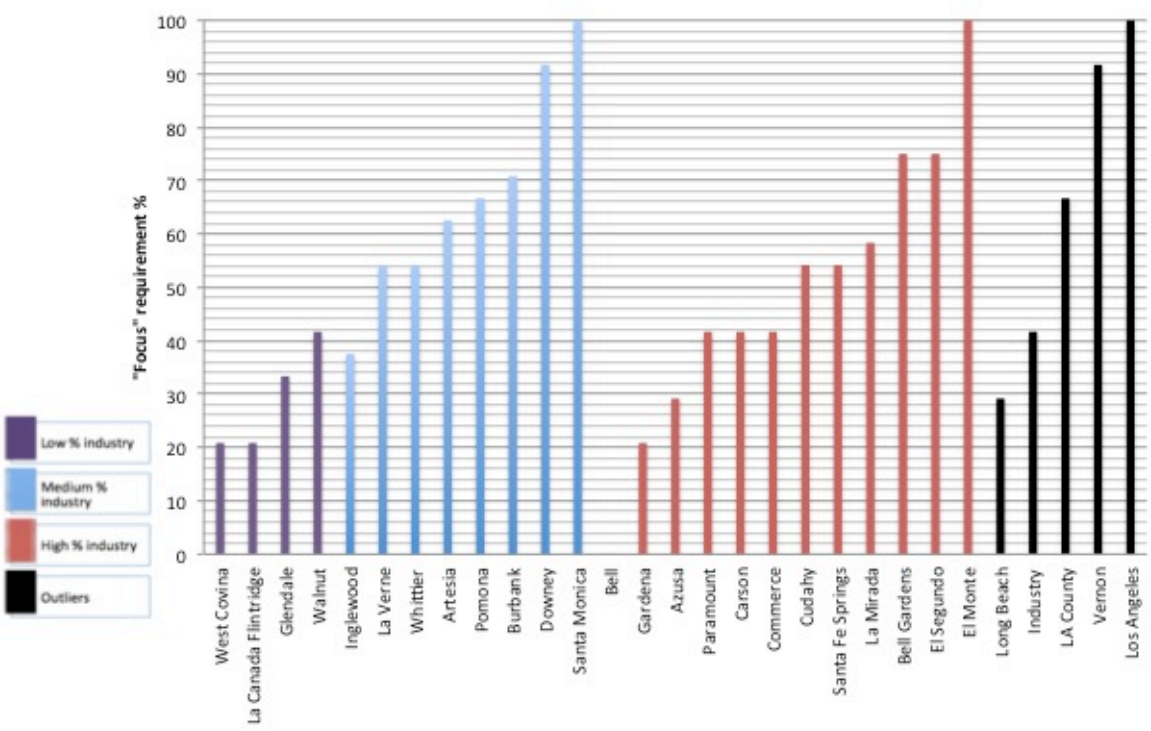

Figure 10: Focus requirement scores for all cities

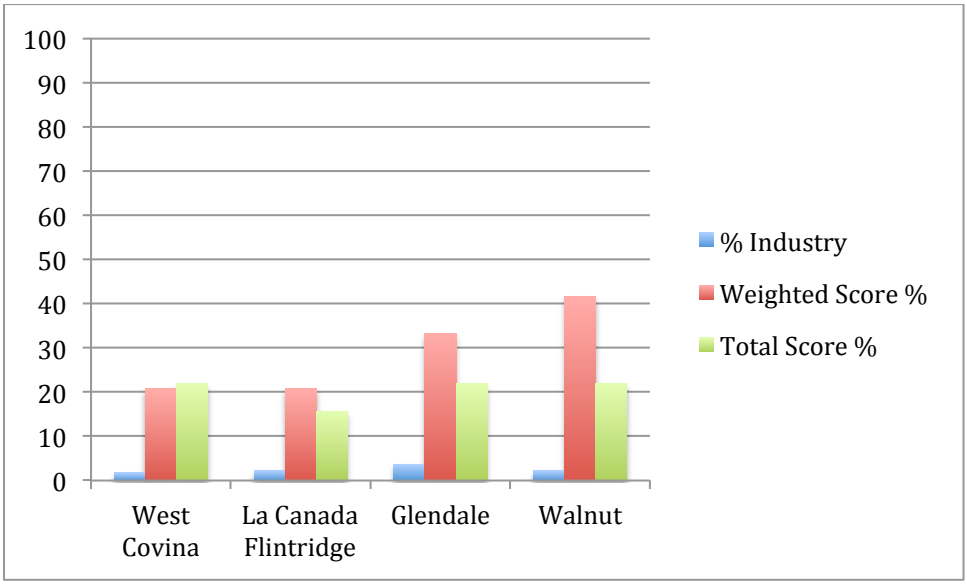

Figure 11: Small industry city scores for MS4 Requirements

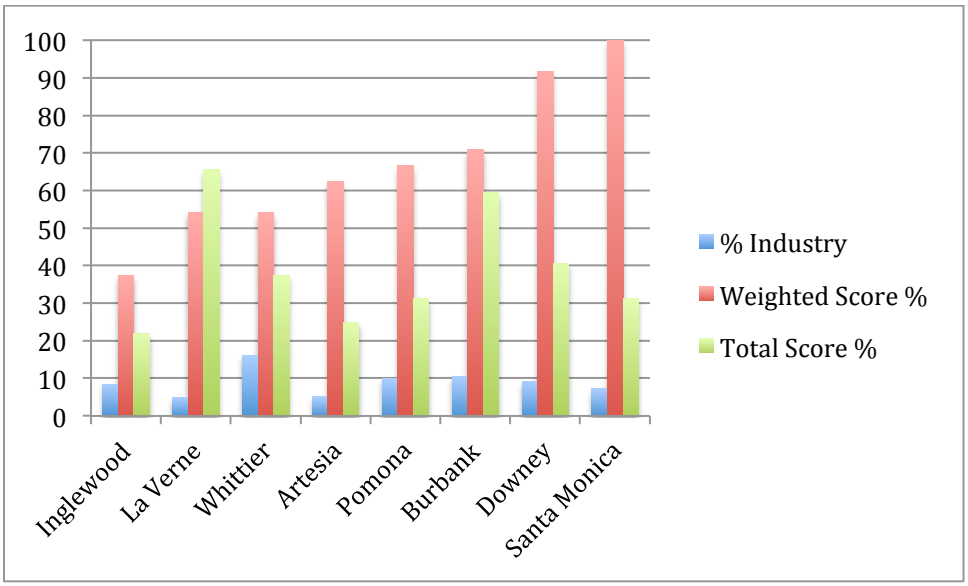

Figure 12: Medium industry city scores for MS4 Requirements

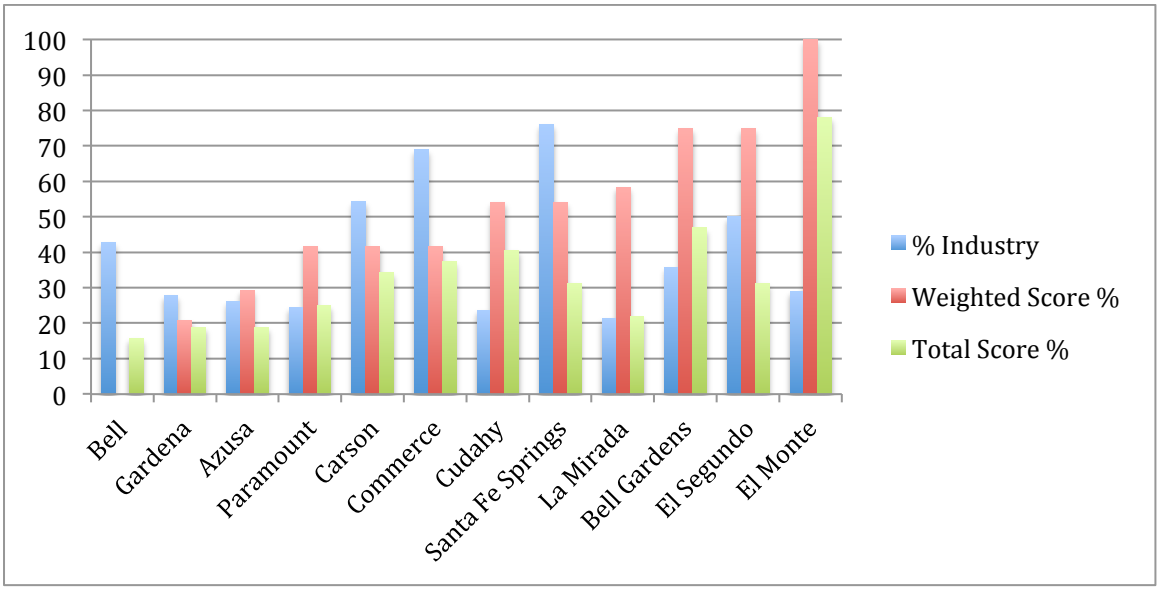

Figure 13: Large industry city scores for MS4 Requirements

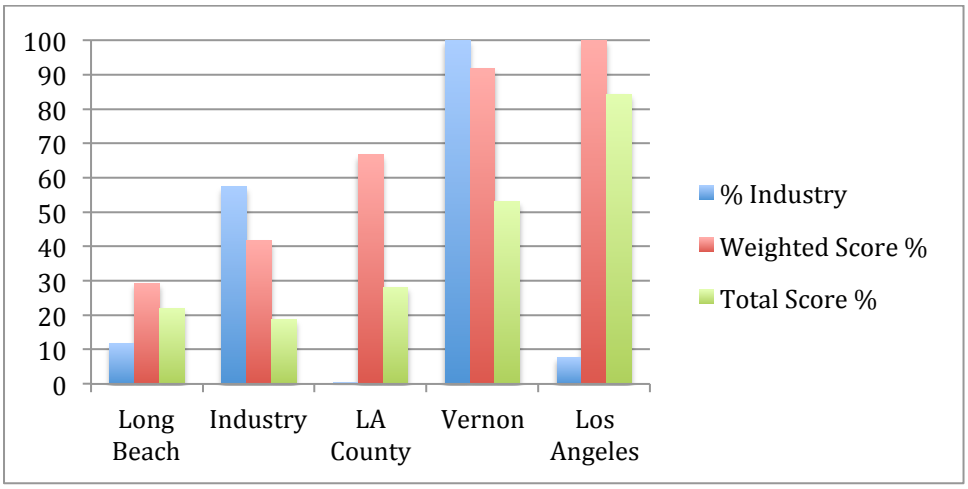

Figure 14: Outlier city scores for MS4 Requirements

Table 13: Weight of each Focus Element in Scenarios

Scenario:	Critical Source Inventory	System for fining Violators (Legal controls)	Check BMPs are up to standards	Notify owners of BMP requirements at least once	Business Assistance Program	Separate Stormwater Hotline	Total Possible Focus Requirement Score
Original	5 (20.8%)	2 (8.3%)	5 (20.8%)	3 (12.5%)	5 (20.8%)	4 (16.7%)	24
All equal	1 (16.7%)	1 (16.7%)	1 (16.7%)	1 (16.7%)	1 (16.7%)	1 (16.7%)	6
Critical Source Inventory =1	1 (5%)	2 (10%)	5 (25%)	3 (15%)	5 (25%)	4 (20%)	20
Critical Source Inventory =5	5 (20.8%)	2 (8.3%)	5 (20.8%)	3 (12.5%)	5 (20.8%)	4 (16.7%)	24
System for Fining Violators=1	5 (21.7%)	1 (4.3%)	5 (21.7%)	3 (13%)	5 (21.7%)	4 (17.4%)	23
System for Fining Violators=5	5 (18.5%)	5 (18.5%)	5 (18.5%)	3 (11.1%)	5 (18.5%)	4 (14.8%)	27
Check BMPs are up to Standards=1	5 (25%)	2 (10%)	1 (5%)	3 (15%)	5 (25%)	4 (20%)	20
Check BMPs are up to Standards=5	5 (20.8%)	2 (8.3%)	5 (20.8%)	3 (12.5%)	5 (20.8%)	4 (16.7%)	24
Notify owners of BMP requirements at least once=1	5 (22.7%)	2 (9.1%)	5 (22.7%)	1 (4.5%)	5 (22.7%)	4 (18.2%)	22
Notify owners of BMP requirements at least once=5	5 (19.2%)	2 (7.7%)	5 (19.2%)	5 (19.2%)	5 (19.2%)	4 (15.4%)	26
Business Assistance Program=1	5 (25%)	2 (10%)	5 (25%)	3 (15%)	1 (5%)	4 (20%)	20
Business Assistance Program =5	5 (20.8%)	2 (8.3%)	5 (20.8%)	3 (12.5%)	5 (20.8%)	4 (16.7%)	24
Separate Stormwater Hotline=1	5 (23.8%)	2 (9.5%)	5 (23.8%)	3 (14.3%)	5 (23.8%)	1 (4.8%)	21
Separate Stormwater Hotline=5	5 (20%)	2 (8%)	5 (20%)	3 (12%)	5 (20%)	5 (20%)	25

Table 14: Results of Sensitivity Analysis on "Focus" Requirement Analysis

Scenario:	Average absolute value % difference from original:
Original	0
All equal	10.7
Critical Source Inventory =1	22.4
Critical Source Inventory =5	0
System for Fining Violators=1	3.7
System for Fining Violators=5	9.5
Check BMPs are up to Standards=1	13.9
Check BMPs are up to Standards=5	0
Notify owners of BMP requirements at least once=1	7.4
Notify owners of BMP requirements at least once=5	6.3
Business Assistance Program=1	14.9
Business Assistance Program =5	0
Separate Stormwater Hotline=1	11.8
Separate Stormwater Hotline=5	3.3

Compliance Data Analysis

First, we determined how many facilities had violated their permit requirements in the past five years, regardless of how many times they had violated. These numbers were determined by counting each facility that had either one or more violations, regardless of violation class in the five years studied. The results of this analysis can be found in Appendix B, Table 21. Of the cities we studied, those with over 50% of their facilities found to be in violation included Bell, Cudahy, La Verne, and West Covina (Figure 15). The city of Bell was calculated to have 100% of its facilities in violation, the highest percent of violating facilities, with each of its 3 facilities found to be in violation. Due to the size and variation of these cities, we also separated the calculations for percent violating facilities based on their classified industrial percentage (large, medium, and small) for a more accurate comparison, as seen in Figure 16, Figure 17, Figure 18, and Figure 19. Of the cities classified as large industrial land-use percentage, the cities of Bell and Cudahy maintained the highest percentage of violating facilities. Of the cities classified as medium industrial land-use, La Verne had the highest percentage of violating facilities, although these medium cities were all relatively equal based on their violation percentages, with a range of around 20-50% of facilities found to have at least one violation. Of the small industrial land-use cities, West Covina was found to be the worst violator, by comparison. El Segundo, classified as large industrial, was the only one of the 24 cities studied with no violating facilities reported.

We then found the total percentage of violations (all violations reported including multiple violations for a single facility) using the total violations taken as a ratio over total facility count in each municipality (Figure 20). As seen in the scatterplot, Figure 21, cities who contained numerous violating facilities also received more violations per facility, indicating that the facility compliance level in that city could be improved on multiple fronts. The numerical totals of each municipalities' facility count, total violations, and total violating facilities can be seen in Figure 22, as well as Table 21.

In addition to evaluating our 24 cities we also looked at the compliance of our four outlier cities (Los Angeles, Long Beach, Vernon, and Industry) as well as Los Angeles County as a whole (Figure 19). Across Los Angeles County, the greatest percentages of violations are class 2, violations that pose a moderate, indirect, or cumulative threat to water quality (SWRCB, 2016). These violations are the result of ether negligence or noncompliance with the potential to cause an unauthorized discharge to occur (SWRCB, 2016). The descriptions of each violation class are found in Table 15. For a total breakdown of violation classes across Los Angeles County see Figure 23 and Figure 24.

Table 15: Violation Class Definitions as reported on CIWQS

Class 1	Violations that pose an immediate and substantial threat to water quality and that have the potential to cause significant detrimental impacts to human health or the environment. Violations involving recalcitrant parties who deliberately avoid compliance are also considered class I.
Class 2	Violations that pose a moderate, indirect, or cumulative threat to water quality. Negligent or inadvertent noncompliance with the potential to cause or allow the continuation of unauthorized discharge or obscuring past violations are also class 2 violations.
Class3	Violations that pose only a minor threat to water quality and include statutorily required liability for late reporting when such late filings do not result in causing unauthorized discharge or allowing one to continue. This class of violations should only include violations by dischargers who are first time or infrequent violators.
Unclassified	Violations entered by dischargers or data entry staff and not yet validated by technical staff.
Priority:	**No longer applicable after 5/20/2010.** Under the former Enforcement Policy, Water Boards ranked violations as either priority or not priority.

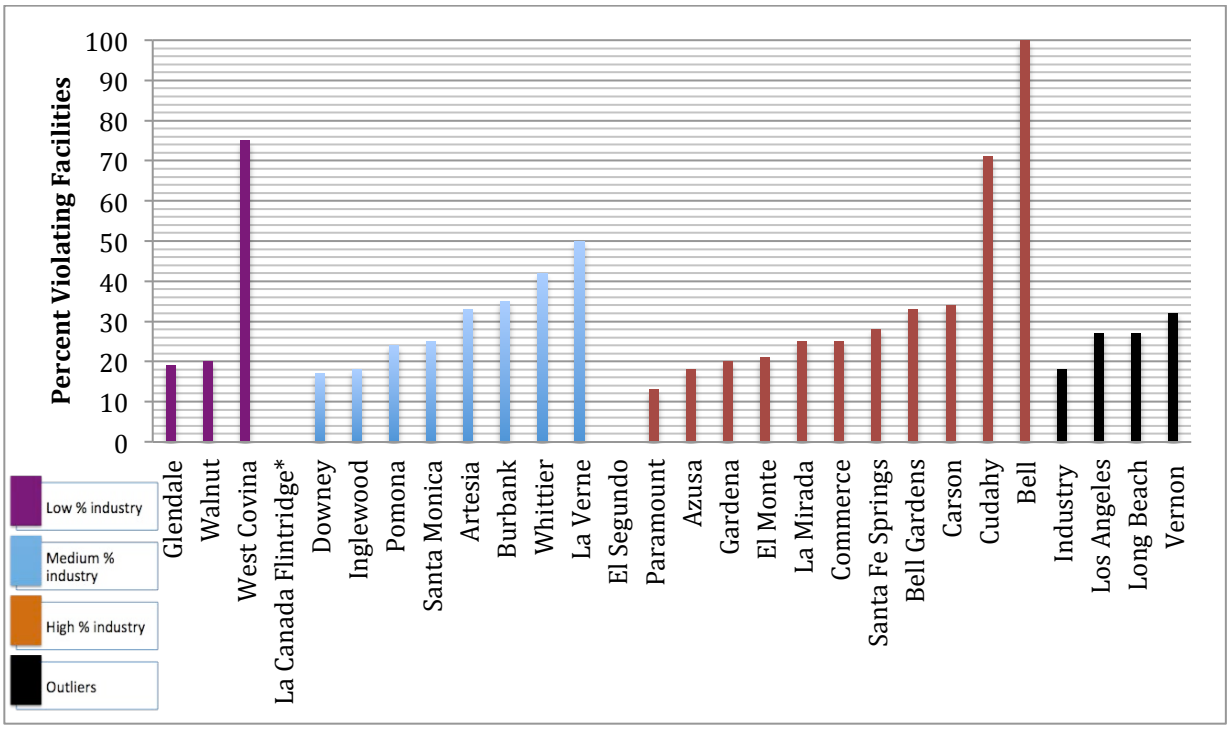

Figure 15: Total Facilities with at least one violation, taken as a percentage of Total Facilities recorded in each municipality studied. ***Note* No data was available for the city of La Canada Flintridge***

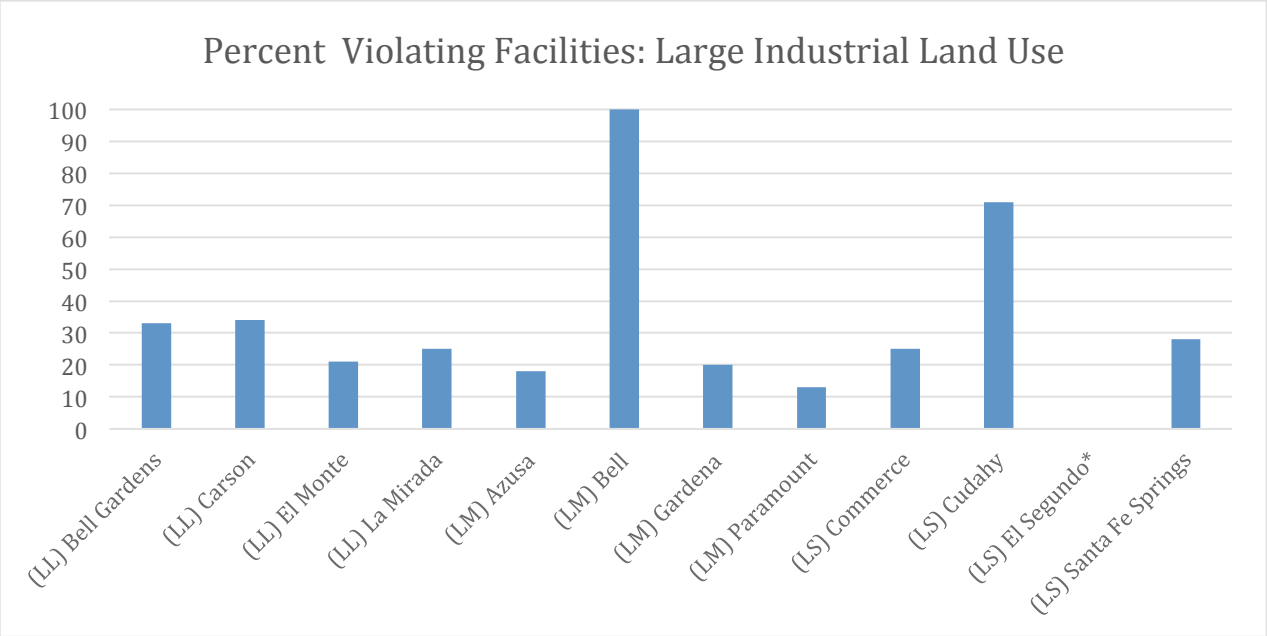

Figure 16: Percent Violating Facilities with Large Industrial Land Use. ***Note* El Segundo did not have any facilities in violation, data was present***

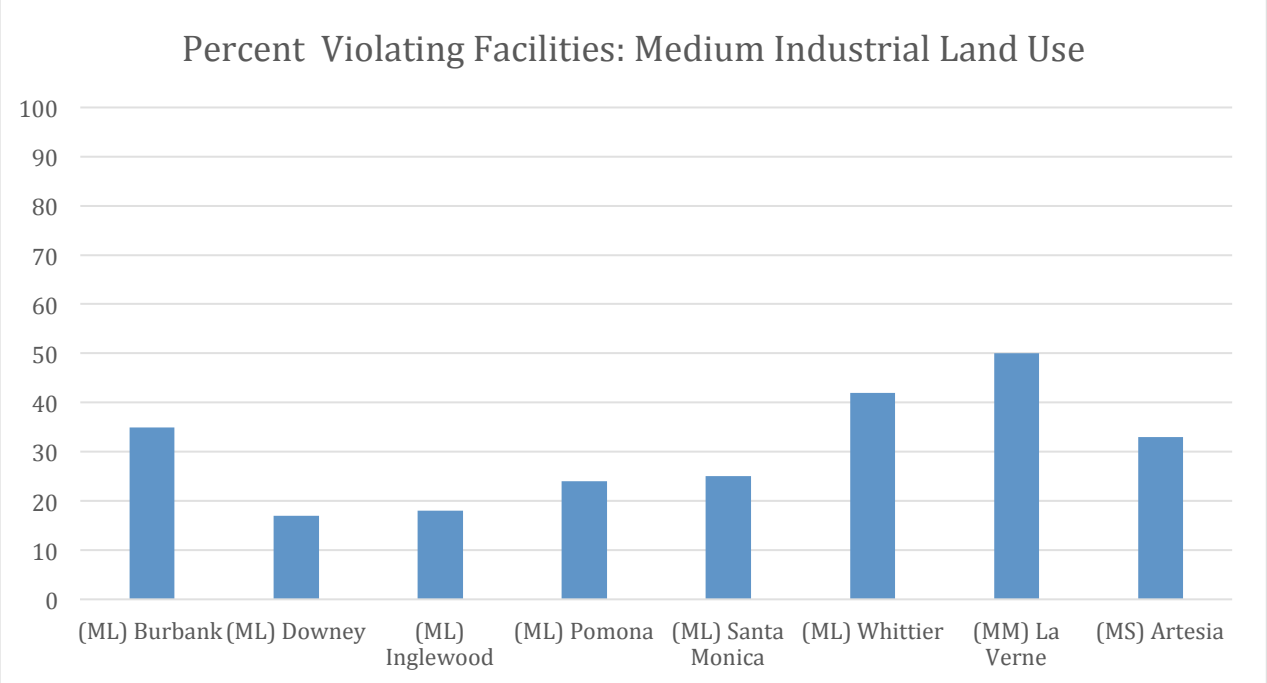

Figure 17: Percent Violating Facilities with Medium Industrial Land Use

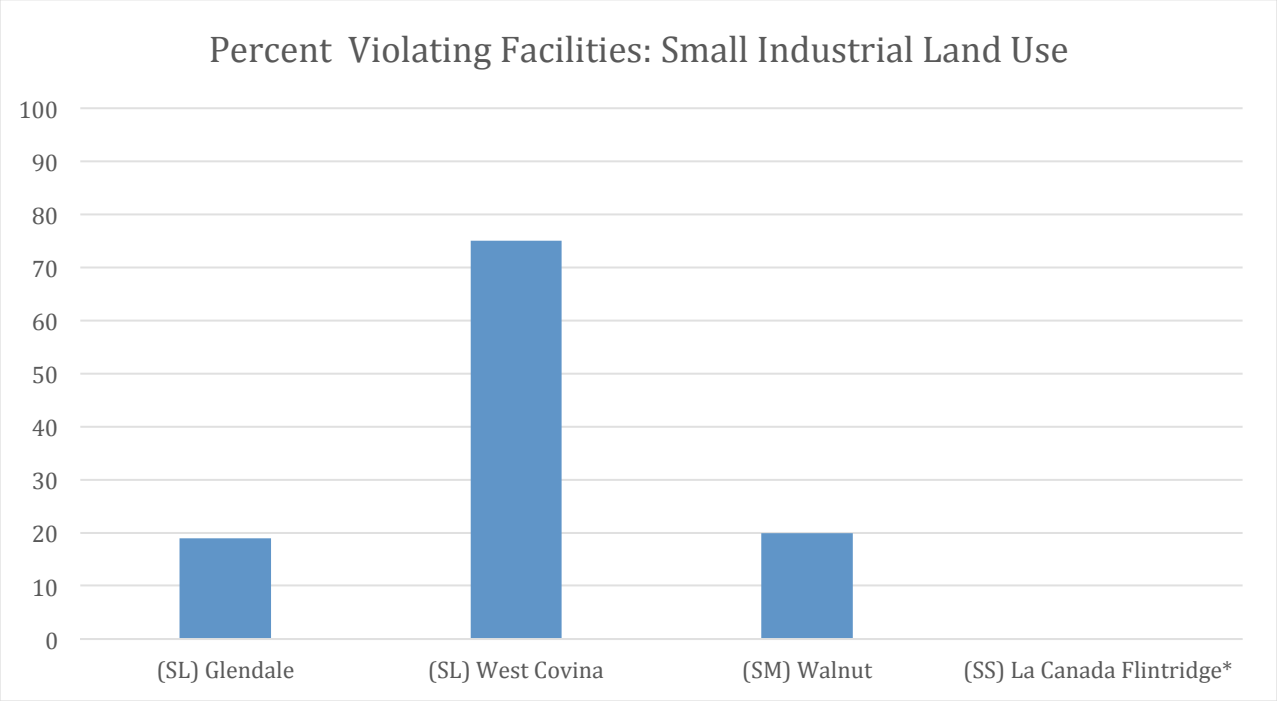

Figure 18: Percent Violating Facilities with Small Industrial Land Use

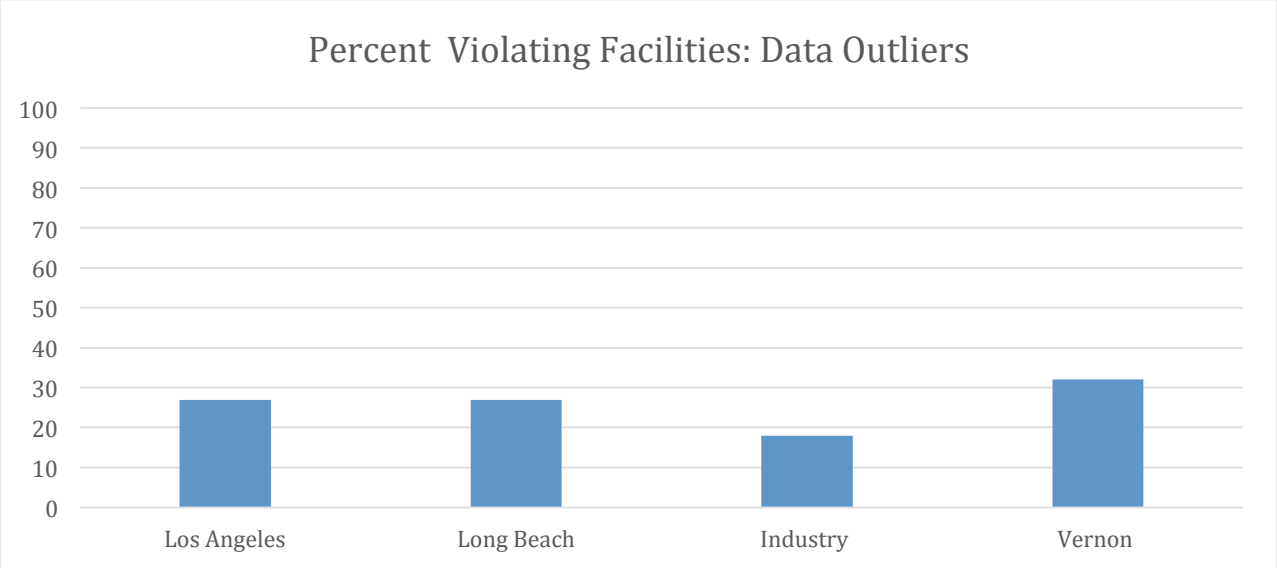

Figure 19: Percent Violating Facilities for the Outliers Studied

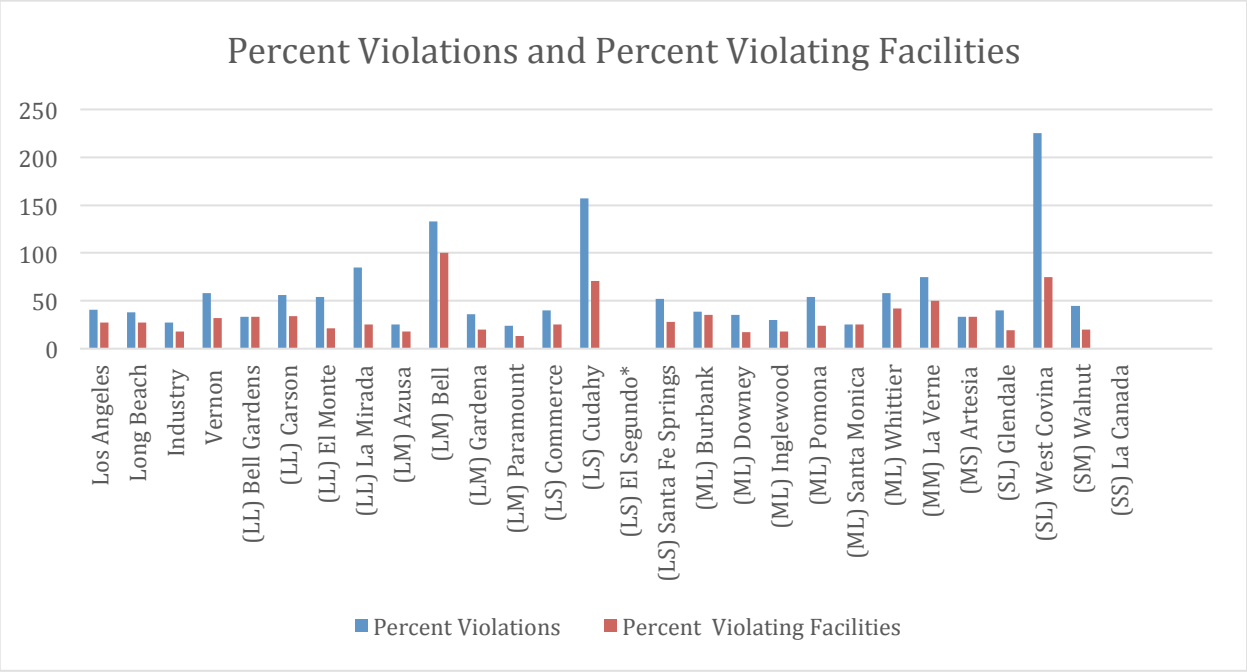

Figure 20: Percent violations (total violations over total facilities) and percent violating facilities. The axis is still a percentage table from 1-100% with all values over 100% indicating more violations than facilities present

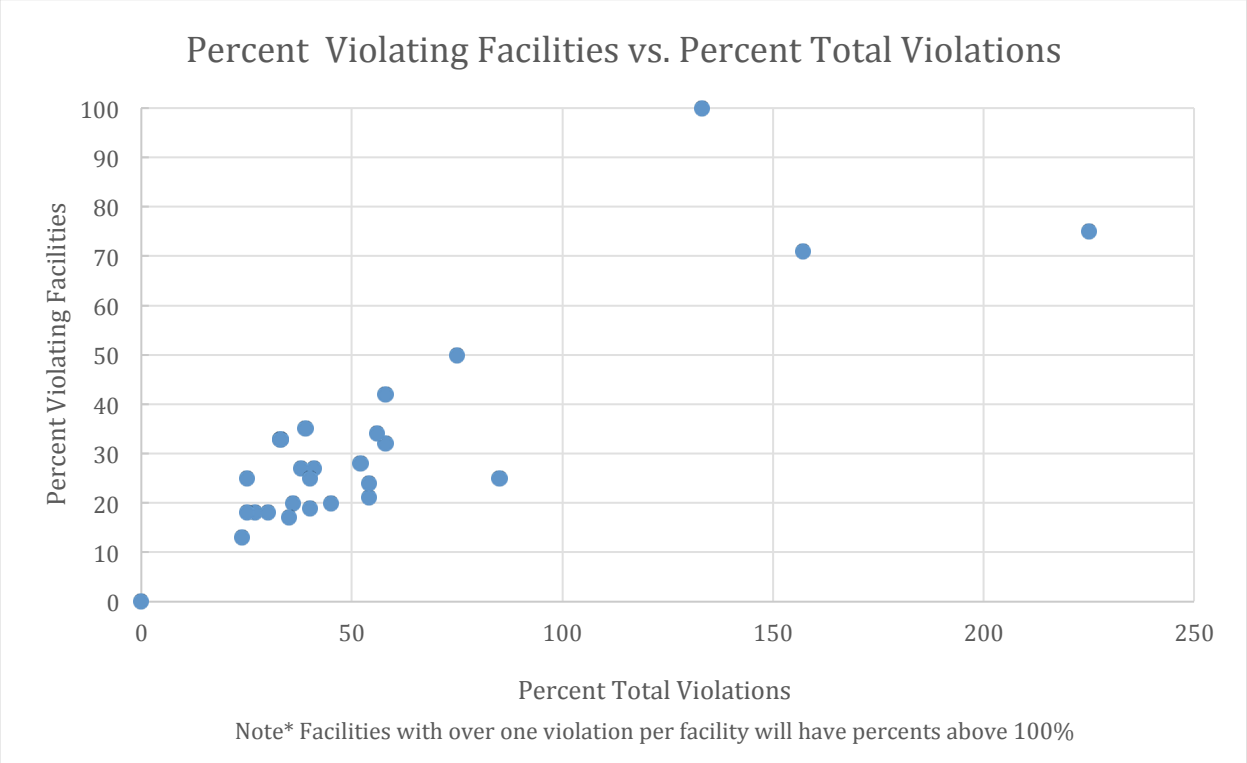

Figure 21: Scatterplot of facilities with cited violations and city percent total violations

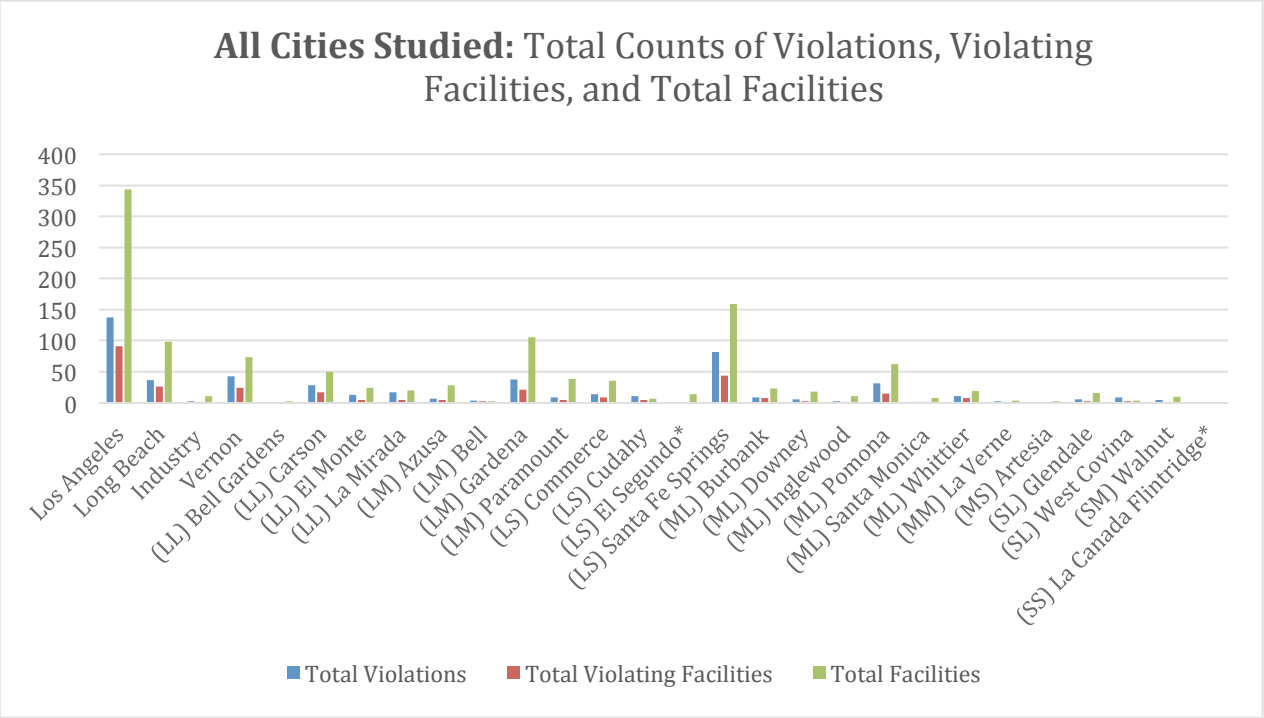

Figure 22: City total count of registered facilities, violations (including multiple citations for a single facility), and facilities found to be in violation (facilities with 1 violation or more). See Table 21

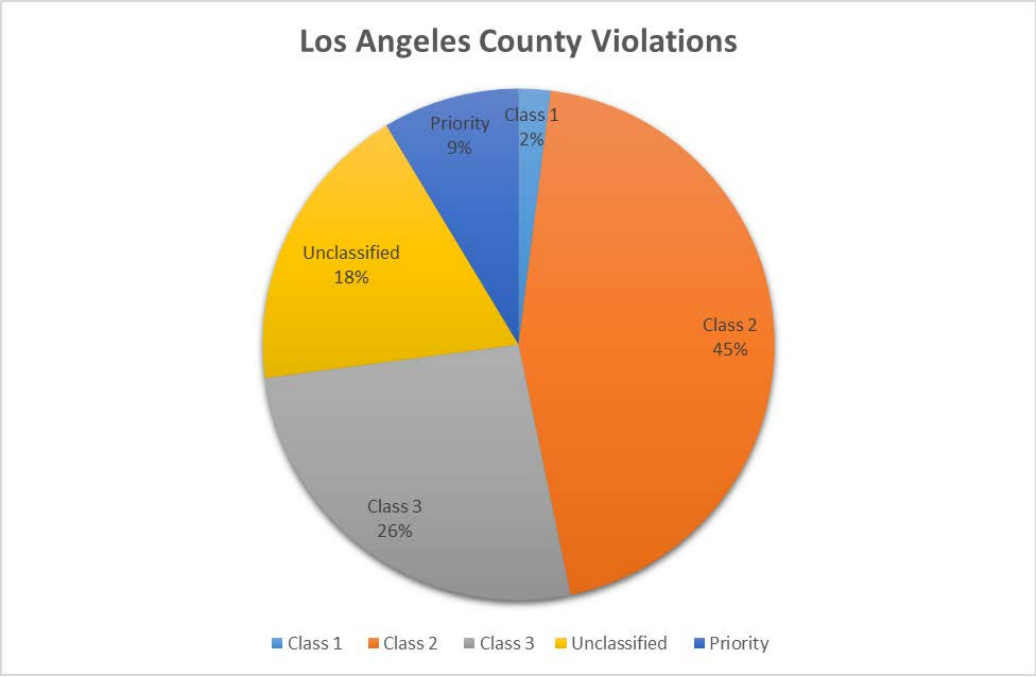

Figure 23: Violation Classes across Los Angeles County

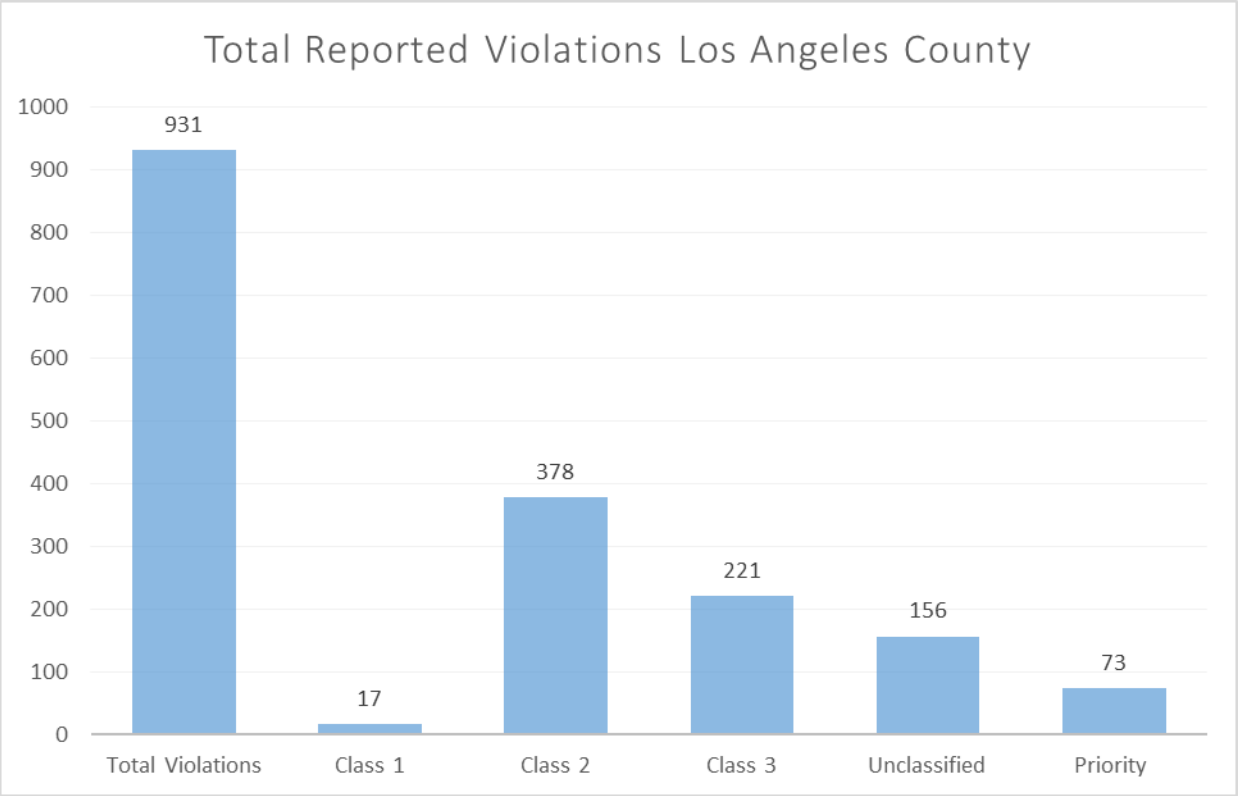

Figure 24: Total Count of Violation Classes across Los Angeles County

City Program and Compliance Analysis

We plotted each city's percentage scores of violating facilities against their percentage scores of completed IFP focus elements (See Figure 25). While there was not a strong enough correlation between the two measures, there was a general trend showing that those that had 60% of the MS4 requirements completed had less than 40% of their facilities in violation in the past 5 years. We also categorized each city to show their population size and industrial composition, but there was not a general trend, which could be attributed to having more medium and high industrial cities represented in our sample. Figure 26 shows the full scores from all of our cities and all three of our analyses to use as a reference. Figure 27 plots each city's full IFP requirements (see Table 6) score against their percentage scores of violating facilities. This did not reflect the same results as our IFP focus elements.

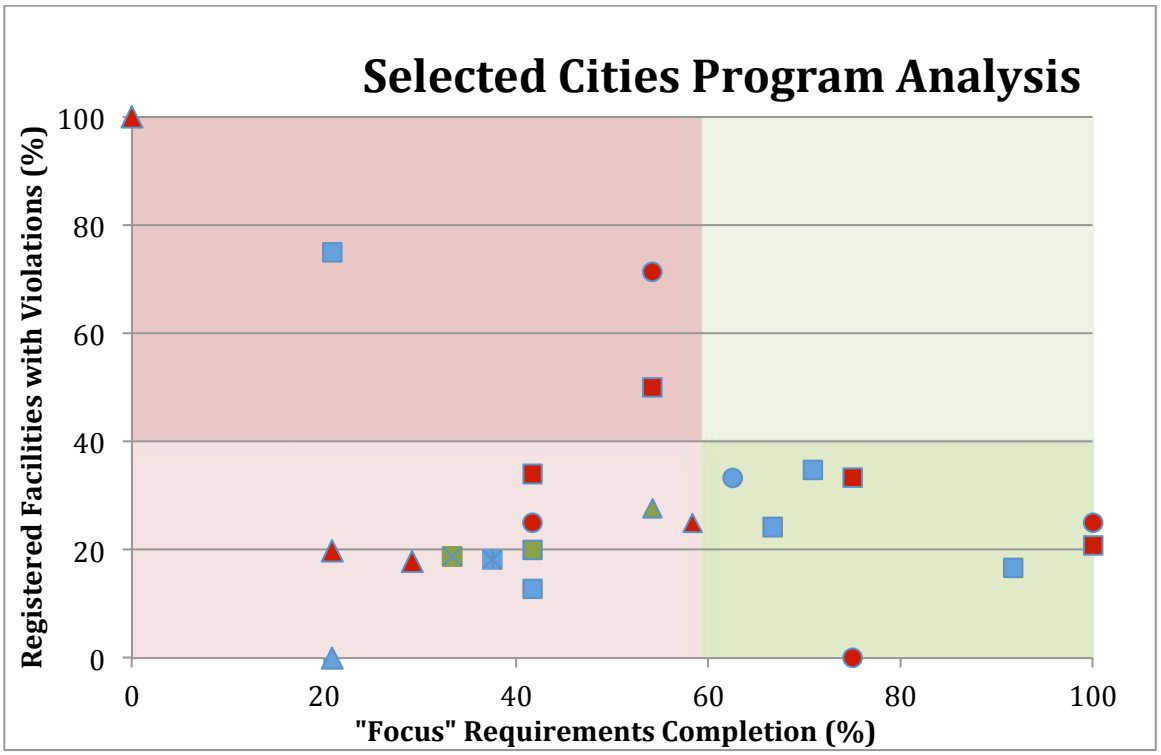

Figure 25: Plots of our selected cities to show the relationship between degree of completeness with key program requirements and the percentage of violating facilities.

Note* Excludes La Cañada Flintridge because they had no data in CIWQS

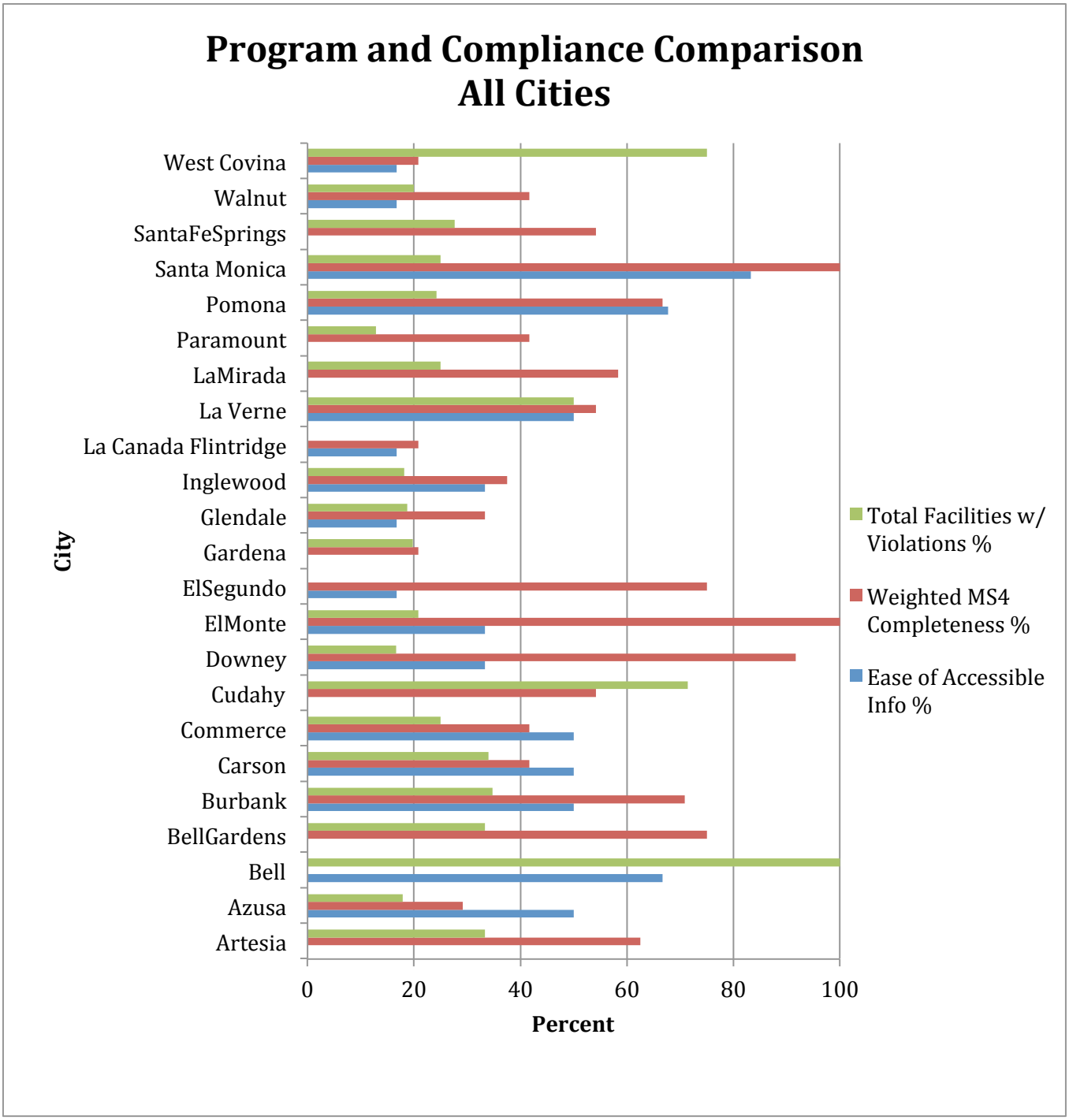

Figure 26: All cities with their scores from each of our analyses

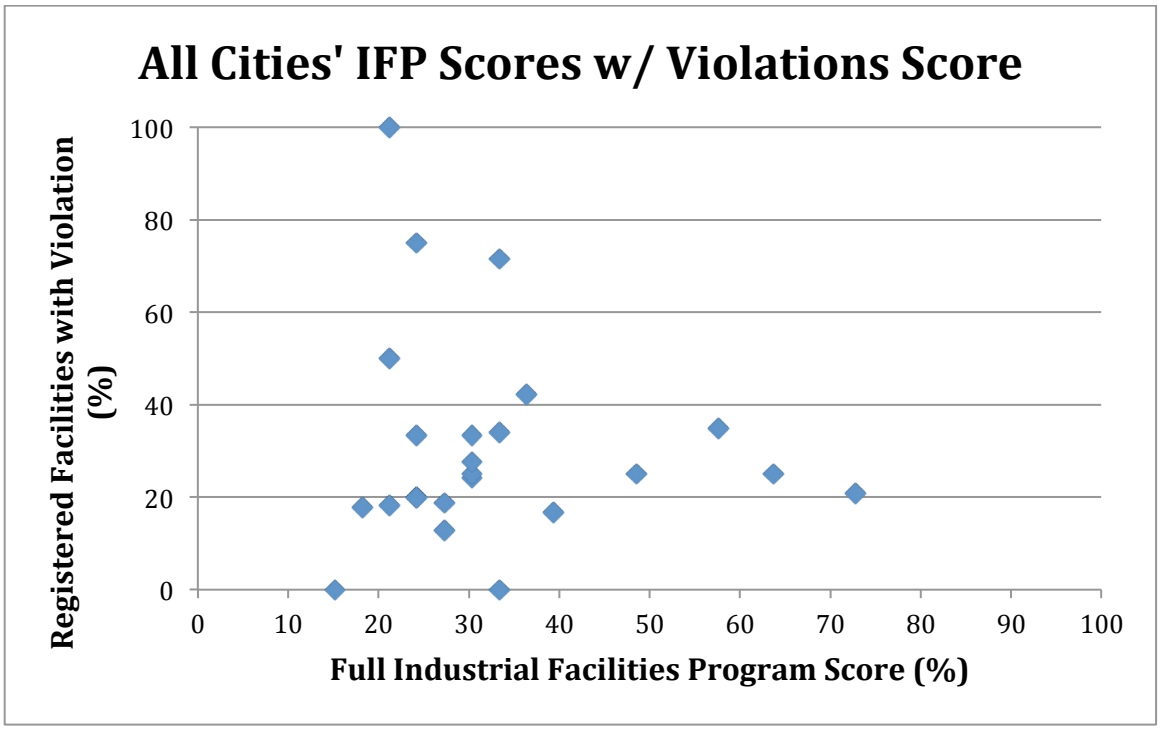

Figure 27: All Cities' Industrial Facility Program Scores and Facilities with Violations scatterplot

Discussion

City Resources and Communication Analysis

Comparing the percentage of website information criteria with the percentage of industrial land use for each city showed that in general the cities with a higher percentage of criteria were cities with a smaller amount of industry. The cities with medium industrial land use had the highest average percentage of criteria while the cities with high industrial land use had the lowest average of criteria. It is important for cities to have this information because it helps business owners understand the importance of stormwater pollution and what permits and resources they need for their business.

We looked at specific website measures more closely, due to their greater significance and more accurate data, and found that while almost half of the cities did post the information for their stormwater contact on their website, less than 25% had links to the stormwater permits business owners would need. The business owners are expected to have these permits but cannot go to their cities' website and find them. On top of that, less than 30% of the websites were offered in another language. Many people living in Los Angeles speak different languages and some business owners may not be able to understand the information on the website.

IFP Requirements Analysis

Analyzing the results of our IFP measure, we found that most of the cities (93.3%) had critical source inventories and 65.6% of cities checked that their BMPs were up to standards. All the other focus elements had scores below 50%, meaning that most cities did not have these elements or the information was not available in the annual report. Note that due to the difference between the Annual Report template and the requirements in the MS4 permit, there may be error associated with not having complete information about what each city is doing.

The total score percentages were almost always less than the weighted scores. Dividing the cities by percent industry, one can see that the cities with smaller industrial land use percentages have lower scores, while the medium and large industry cities have a range of scores. Santa Monica (ML), El Monte (LL), and Los Angeles (M) had the highest weighted score percentages with 100%. The weighted scores do not correlate with the total scores as many of the elements on the overall IFP measure simply could not be found in the annual reports and had to be marked N/A. Therefore, the quality of data for many of the elements on the measure was low. As a result, the total scores likely are not reflective of the quality of a city's industrial stormwater pollution prevention program. However, the range and variability of these scores indicates that a better, more standardized reporting protocol is needed to ensure that requirements are met.

Compliance Data Analysis

After our analysis of the available compliance data accessed on CIWQS, it is clear that improvements could still be made to the industrial stormwater program. Of all 24 cities studied, 23 out of 24 (96%) had facilities with cited violations in the past five years. While the largest percentage of violating facilities was recorded in the areas of greater industrial land-use, all categories of land-use percentage (large, medium, and small) were subject to high percentages of non-compliance. In addition, many facilities that received violations were issued more than one in the time period studied. Throughout our research and data collection, we were met with the same obstacles described in Duke and Shaver's report from 1999. CIWQS searches were often confusing with programed selections that did not yield a beneficial display of data. Sometimes multiple search results were consulted (in different sub-categories such as violations verses facilities) in order to identify the extent of the information CIWQS could provide as well as check the accuracy of such information. The information gathered on CIWQS was also at times contradictory where totals did not match the corresponding data, city names were misspelled in some entries, and some city data was missing entirely.

In 1999, Duke and Shaver found that an intensive search of facilities in the Los Angeles region (by means of multiple databases including CIWQS and Los Angeles County Fire and Sanitation) identified only 75% of the known facilities. Throughout their research, Duke and Shaver found that the information available from commercial databases showed little crossover with federal and state inventories. More public access, ease of use, and information sharing is needed to improve the SWRCB databases. Also, there should be greater connections between the required municipal databases and the regional and state inventories. Of the 24 cities we studied only one (El Monte) provided a full list of their known facilities, as obtained through their individual database. It is important to note that a list of facilities is not required in a municipalities annual MS4 report (which was the document used to reference program completeness), however, based

on the information we were able to obtain through public access channels very few cities showed that they had database software in place, regardless of how effectively they were using it. While CIWQS does provide an essential service, tracking facility identification and compliance, there are many areas that could still be improved upon and upgraded to promote greater regulatory action in the Los Angeles Region.

City Program and Compliance Analysis

There were 12 highly industrial cities, 8 medium-level industrial cities, and 3 low industrial cities represented in our analysis of program completeness and facility violations. There was not a trend among higher or lower industrial cities, but larger cities tended to have more representation in the quadrant where there were fewer facilities in violation and a more complete MS4 requirements list. We believe that this may be because they have more financial and personnel resources to allocate to managing industrial stormwater. Figure 26's full scoring graph did not show a relationship between violations and our IFP scoring requirements. However, this can be explained by the fact that our full IFP scoring system gave equal weight to each individual element and sub-element. Cities that did not have any of the sub-elements, such as knowing the geographic coordinates of each critical source, naturally had lower scores despite having the heading element (ex: critical source inventory). However, we chose to score them in this way because some cities did have multiple sub-elements, and ultimately showed that there is a lot of room for improvement in the IFP implementation.

Recommendations

Update MS4 annual report template to better reflect the new MS4 permit.

The current annual report template for the MS4 permit is outdated with questions dating back to 2003. Also, the annual report template does not reflect all of the requirements from the new MS4 permit. We have been told that the Regional Board has recently sent out an updated template to the Permittees for review, and are aware that this is being addressed. We were not able to obtain the updated version, and we do not know what has been changed. However, we suggest that the new template should follow along the lines of requirements in the MS4 permit so it is easier to see whether cities' programs follow the permit. Any new template should correspond with the new permit and include stricter guidelines for filling it out.

Require Facility Inventory to be Available Online and Updated Annually

Industrial facility inventories should be available in the annual reports as well as online in a user-friendly format. This is a critical component to support non-filer investigations and to allow public review.

Standardize how information is collected, presented and utilized on the city's website.

Although cities may differ in their industrial composition, all cites should present a basic set of standardized stormwater information such as where to file for permits, best practices to prevent excess stormwater discharge, and the most updated contact information to either report violations or track exceedances to allow business owners and residents easy access the information. In addition, having this information available and easily accessible will encourage residents and citizen reporting to help aid the regulatory efforts of these agencies.

To further support the implementation of this recommendation we asked another team at UCLA to design a stormwater toolkit. The information previously suggested including general stormwater information, applicable permit information and links, stormwater community outreach programs advertised and links to the county and state regional board websites is now available as a downloadable toolkit at the website they created. (http://www.stormwater.tk/). There is also a coded webpage template, which may be copied and transferred into existing city web structures. This information, regardless of whether or not a city uses this kit, should be easily accessible with very little searching on a city's website. In addition, websites should be offered in multiple languages to increase the accessibility to non-English speakers. This task is relatively easy to change by adding a "translate" button with the same functionality on each city's webpage.

Update CIWQS and other reporting databases.

At present, CIWQS, SMARTS and other regulatory databases are out-of-date considering their purposes. Data is not recorded with the name of the entity inspecting. Data entries are sometimes sloppy and misspelled. The information is not easy to access. In order to properly use these programs to pull out meaningful data, hours must be spent going through numerous configurations. To best improve this hindrance a few recommendations include

1) Marking all data entries with as much information as possible (ex: inspection agency, all violations recorded, etc.),

2) Improving and providing definitions (who is reporting to CIWQS, who has access, what does local, federal, state, or private entail in the context of inspectors), and

3) Allowing for one general search field, in addition to existing pre-sorted search fields, with all possible data entry options. These improvements will drastically help the functionality and continued use of CIWQS.

Other, yet more difficult improvements to carry out would include obtaining more data by digitizing older entries, registering non-filers, and communication between other reporting databases. Data accuracy and reliability are also matters of concern. By applying as much information as to where the data is coming from (which inspection source, etc.) as well as adding definitions thoroughly describing each type of data and source, accuracy and validity of data could be more properly accessed. Researchers would then have the choice to include only official inspection sources rather than a variety of undisclosed sources. Keeping databases, like CIWQs, up to date, is important in order to know which facilities and cities are in compliance. It is also important to keep these databases accurate. This may be achieved if the same regulatory agencies conduct all of the inspections and enforcement actions, however, by improving how data is entered and retrieved.

References

Brown, J. N., & Peake, B. M. "Sources of heavy metals and polycyclic aromatic hydrocarbons in urban stormwater runoff." *Science of the total environment* 359.1 (2006): 145-155.

Cagno, E., Trucco, P., & Tardini, L. (2005). Cleaner production and profitability: analysis of 134 industrial pollution prevention (P2) project reports. *Journal of Cleaner Production, 13* (6), 593-605.

California Regional Water Quality Control Board Los Angeles Region (2012). Order No. R4-2012-0175 as amended by State Water Board Order WQ 2015-0075 NPDES Permit No. CAS004001. http://www.waterboards.ca.gov/losangeles/water_issues/programs/stormwater/municipal/la_ms4/2015/OrderR4-2012-0175-FinalOrderasamendedbyOrderWQ2015-0075.pdf

California Stormwater Quality Association Stormwater Best Management Practice Handbook

California Waterboards (2004). National Pollutant Discharge Elimination System (NPDES) Stormwater Program Questions and Answers. http://www.waterboards.ca.gov/water_issues/programs/stormwater/docs/epa_q&a.pdf

California Water Resources Control Board (2013). Stormwater Programs: Municipal Program.

Chau, H. 2009. Green Infrastructure for Los Angeles: Addressing Urban Runoff and Water Supply Through Low Impact Development.

CIWQS. California Integrated Water Quality System (2009). SWRCB Fact Sheet. Accessed February 22nd from, http://www.waterboards.ca.gov/ciwqs/docs/ciwqs_factsheet.pdf

Davis, A. P., Shokouhian, M., & Ni, S. "Loading estimates of lead, copper, cadmium, and zinc in urban runoff from specific sources." *Chemosphere* 44.5 (2001): 997-1009.

Duke, D., Coleman, K.P., & Masek, B. (1999). Widespread Failure to Comply with U.S. Storm Water Regulations for Industry- Part I: Publicly Available Data to Estimate Number of Potentially Regulated Facilities. Environmental Engineering Science, 16 (4), 229-263.

Duke, D. & Beswick, P. G. (1997). Industry Compliance with Storm Water Pollution Prevention Regulations: The Case of Transportation Industry Facilities in California and the Los Angeles Region. Journal of the American Water Resources Association, 33 (4), 825-838.

Duke, D. & Jae Chung, Y. (1995). Industrial Storm Water Pollution Prevention: Effectiveness and Limitations of Source Controls in the Transportation Industry. Waste Management, 15 (8), 543-558.

Duke, L. D., Buffleben, M., & Bauersachs, L. A. "Pollutants in stormwater runoff from metal plating facilities, Los Angeles, California." *Waste management* 18.1 (1998): 25-38.

Environmental Council of the States (ECOS): States: Delegation by Environmental Act: State Delegations - Clean Water Act. (2015). Accessed November 30, 2015. http://www.ecos.org/section/states/enviro_actlist/states_enviro_actlist_cwa.

EPA Guidance Manual for Developing Best Management Practices. Accessed February 7, 2016. http://www3.epa.gov/npdes/pubs/owm0274.pdf

Federico, F., Kannan, S., Ng, S., Ng, W. & Shahbol, N. (2015). Compton Creek Watershed: An Assessment of Industrial Stormwater Pollution.

Grant, S.B., Rekhi, N.V., Pise, N.R., Reeves, R.L., Matsumoto, M., Wistrom, A., Moussa, L., Bay, S. and Kayhanian, M. (2003). A review of the contaminants and toxicity associated with particles in stormwater runoff. *Terminology*, *2*, 2.

Herrera Consulting Company. (2007). *Untreated Highway Runoff in Western Washington.* Web.

Hewitt, J. E., Anderson, M. J., & Thrush, S.F. (2005). Assessing and Monitoring Ecological Community Health in Marine Systems. *Ecological Applications, 15* (3), 942-953.

Hwang, H. M., & Foster, G. D. "Characterization of polycyclic aromatic hydrocarbons in urban stormwater runoff flowing into the tidal Anacostia River, Washington, DC, USA." *Environmental Pollution* 140.3 (2006): 416-426.

Joshi, U. M., & Balasubramanian, R. "Characteristics and environmental mobility of trace elements in urban runoff." *Chemosphere* 80.3 (2010): 310-318.

Karlsson, K., Viklander, M., Scholes, L., & Revitt, M. (2010). Heavy metal concentrations and toxicity in water and sediment from stormwater ponds and sedimentation tanks. *Journal of Hazardous Materials, 178* (1-3), 612-618.

Kayhanian, M., Singh, A., Suverkropp, C., and Borroum, S."Impact of annual average daily traffic on highway runoff pollutant concentrations." *Journal of Environmental Engineering* 129.11 (2003): 975-990.

Kim, L. H., Ko, S. O., Jeong, S., & Yoon, J. "Characteristics of washed-off pollutants and dynamic EMCs in parking lots and bridges during a storm." *Science of the total Environment* 376.1 (2007): 178-184.

LA Stormwater. Enhanced Watershed Management Program. Accessed Feb. 6, 2016. http://www.lastormwater.org/green-la/enhanced-watershed-management-program/

Lee, W. J., Liow, M. C., Tsai, P. J., & Hsieh, L. T. "Emission of polycyclic aromatic hydrocarbons from medical waste incinerators." *Atmospheric Environment* 36.5 (2002): 781-790.

Los Angeles Regional Water Quality Control Board. LARWQCB Programs. Accessed Feb. 6, 2016.
http://www.swrcb.ca.gov/losangeles/water_issues/programs/

Los Angeles Regional Water Quality Control Board. Watershed Management Programs. Accessed Feb. 6, 2016.
http://www.swrcb.ca.gov/losangeles/water_issues/programs/stormwater/municipal/watershed_management/index.shtml

Mahler, B. J., Van Metre, P. C., Crane, J. L., Watts, A. W., Scoggins, M., & Williams, E. S. (2012). Coal-Tar-Based Pavement Sealcoat and PAHs: Implications for the Environment, Human Health, and Stormwater Management. Environmental Science & Technology, 46 (6), 3039-3045.

McArthur, J.V., Flethcer, D.E., Tuckfield, R.C., & Baker-Austin, C. (2015). Patterns of Multi-Antibiotic-Resistant *Escherichia Coli* from Streams with No History of Antimicrobial Inputs. Environmental Microbiology. (1-11).

Monette, A. (n.d). Recent Developments in Water Quality Law in California and Their Fiscal and Operational Impacts on Municipalities. Accessed November 10, 2015.

Rule, K. L., Comber, S. D. W., Ross, D., Thornton, A., Makropoulos, C. K., & Rautiu, R. "Diffuse sources of heavy metals entering an urban wastewater catchment." *Chemosphere* 63.1 (2006): 64-72.

Sabin, L. D., Lim, J. H., Stolzenbach, K. D., & Schiff, K. C. "Contribution of trace metals from atmospheric deposition to stormwater runoff in a small impervious urban catchment." *Water research*39.16 (2005): 3929-3937.

Santa Barbara Channelkeeper (SBCK). 2012. "Reducing Stormwater Runoff and Pollution through Low Impact Development" A Review of Strategies in California and the West Coast.

State Water Resources Control Board. (n.d). National Pollutant Discharge Elimination System (NPDES) – Wastewater. Accessed November 12, 2015, from http://www.swrcb.ca.gov/water_issues/programs/npdes/#role.

State Water Resources Control Board. (n.d). Waterboards. CWIQS. Accessed Fevruary 22nd, 2016, from http://www.waterboards.ca.gov/ciwqs/

State Water Resources Control Board. (n.d). Waterboards. Industrial Stormwater Program. Accessed January 15th, 2016, from
http://www.waterboards.ca.gov/water_issues/programs/stormwater/industrial.shtml

State Water Resources Control Board. (2014). Waterboards. General Permit for Stormwater Discharges. Accessed February 22nd, 2016, from

http://www.waterboards.ca.gov/board_decisions/adopted_orders/water_quality/2014/wqo2014_0057_dwq_rev_mar2015.pdf

State Water Resources Control Board. (n.d). Waterboards. Stormwater Program. Accessed January 15th, 2016, from http://www.waterboards.ca.gov/water_issues/programs/stormwater/gen_const_faq.shtml

State Water Resources Control Board. (n.d). Waterboards. Water Quality Objectives. Accessed January 15th, 2016, from http://www.waterboards.ca.gov/sanfranciscobay/water_issues/programs/basin_plan/docs/bp_ch3+tables.pdf

Swedish Environmental Protection Agency. (2000). Environmental Quality Criteria. In *Environmental Quality Criteria- Lakes and Watercourses*. Report 5050. Retrieved from http://www.naturvardsverket.se/Documents/publikationer/620-6032-5.pdf

Tang, J.Y.M., Aryal, R., Deletic, A., Gernjak, W., Glenn, E., McCarthy, D., & Escher, B.I. (2013). Toxicity characterization of urban stormwater with bioanalytical tools. *Water Research, 47* (15), 5594-5606.

UCLA IoES Environmental Report Card for Los Angeles County, 2015. Accessed February 7, 2016. http://www.environment.ucla.edu/reportcard/

US EPA. ECHO: Enforcement and Compliance History Online. (2016) Accessed February 27, 2016 from. https://echo.epa.gov/?redirect=echo

US EPA, OW, OWM. (2015). NPDES State Program Information. Accessed December 3, 2015 from. http://www.epa.gov/npdes/npdes-state-program-information.

US EPA, OA, OP, ORPM, RMD. (2015). Summary of the Clean Water Act. Accessed November 13, 2015, from http://www2.epa.gov/laws-regulations/summary-clean-water-act.

West M., Wenzel M., Schwieiss B. 2015. Industrial Stormwater Best Management Practices Guidebook Version 1.1. Minnesota Pollution Control Agency (MPCA).

Zhang, Y., & Tao, S. "Global atmospheric emission inventory of polycyclic aromatic hydrocarbons (PAHs) for 2004." *Atmospheric Environment* 43.4 (2009): 812-819.

Appendix A

Table 16: City Sizes by category

City name	Population (2010 Census)							
Vernon	112	Small Outlier	Maywood	27,395	Medium	Monterey Park	60,269	Large
Industry	219	Small Outlier	Walnut	29,172	Medium	Montebello	62,500	Large
Bradbury	1,048	Small	La Verne	31,063	Medium	Pico Rivera	62,942	Large
Irwindale	1,422	Small	Lakewood	32,769	Medium	Redondo Beach	66,748	Large
Hidden Hills	1,856	Small	San Dimas	33,371	Medium	Lynwood	69,772	Large
Rolling Hills	1,860	Small	Beverly Hills	34,109	Medium	Baldwin Park	75,390	Large
Avalon	3,728	Small	West Hollywood	34,399	Medium	Bell Gardens	76,616	Large
La Habra Heights	5,325	Small	Claremont	34,926	Medium	La Mirada	80,048	Large
Rolling Hills Estates	8,067	Small	Manhattan Beach	35,135	Medium	Alhambra	83,089	Large
Westlake Village	8,270	Small	Bell	35,477	Medium	Hawthorne	84,293	Large
Sierra Madre	10,917	Small	Temple City	35,558	Medium	Whittier	85,331	Large
Signal Hill	11,016	Small	Monrovia	36,590	Medium	Santa Monica	89,736	Large
Malibu	12,645	Small	Culver City	38,883	Medium	Carson	91,714	Large
Commerce	12,823	Small	San Gabriel	39,718	Medium	South Gate	94,396	Large
San Marino	13,147	Small	Lawndale	39,816	Medium	Compton	96,455	Large
Palos Verdes Estates	13,438	Small	Rancho Palos Verdes	41,643	Medium	Burbank	103,340	Large
Hawaiian Gardens	14,254	Small	Bellflower	42,072	Medium	Norwalk	105,549	Large
Santa Fe Springs	16,223	Small	Azusa	46,361	Medium	West Covina	106,098	Large
Artesia	16,522	Small	Covina	47,796	Medium	Inglewood	109,673	Large
El Segundo	16,654	Small	Lancaster	48,527	Medium	Downey	111,772	Large
Hermosa Beach	19,506	Small	Cerritos	49,041	Medium	El Monte	113,475	Large
South El Monte	20,116	Small	Glendora	50,073	Medium	Pasadena	137,122	Large
La Canada Flintridge	20,246	Small	Rosemead	53,764	Medium	Torrance	145,438	Large
Lomita	20,256	Small	Paramount	54,098	Medium	Pomona	149,058	Large
Agoura Hills	20,330	Small	Diamond Bar	55,544	Medium	Palmdale	152,750	Large
Duarte	21,321	Small	Arcadia	56,364	Medium	La Puente	156,633	Large
Calabasas	23,058	Small	Huntington Park	58,114	Medium	Santa Clarita	176,320	Large
San Fernando	23,645	Small	Gardena	58,829	Medium	Glendale	191,719	Large
Cudahy	23,805	Small				Long Beach	462,257	Large Outlier

South Pasadena	25,619	Small				Los Angeles	3,792,621	Large Outlier
						County Total	9,818,605	

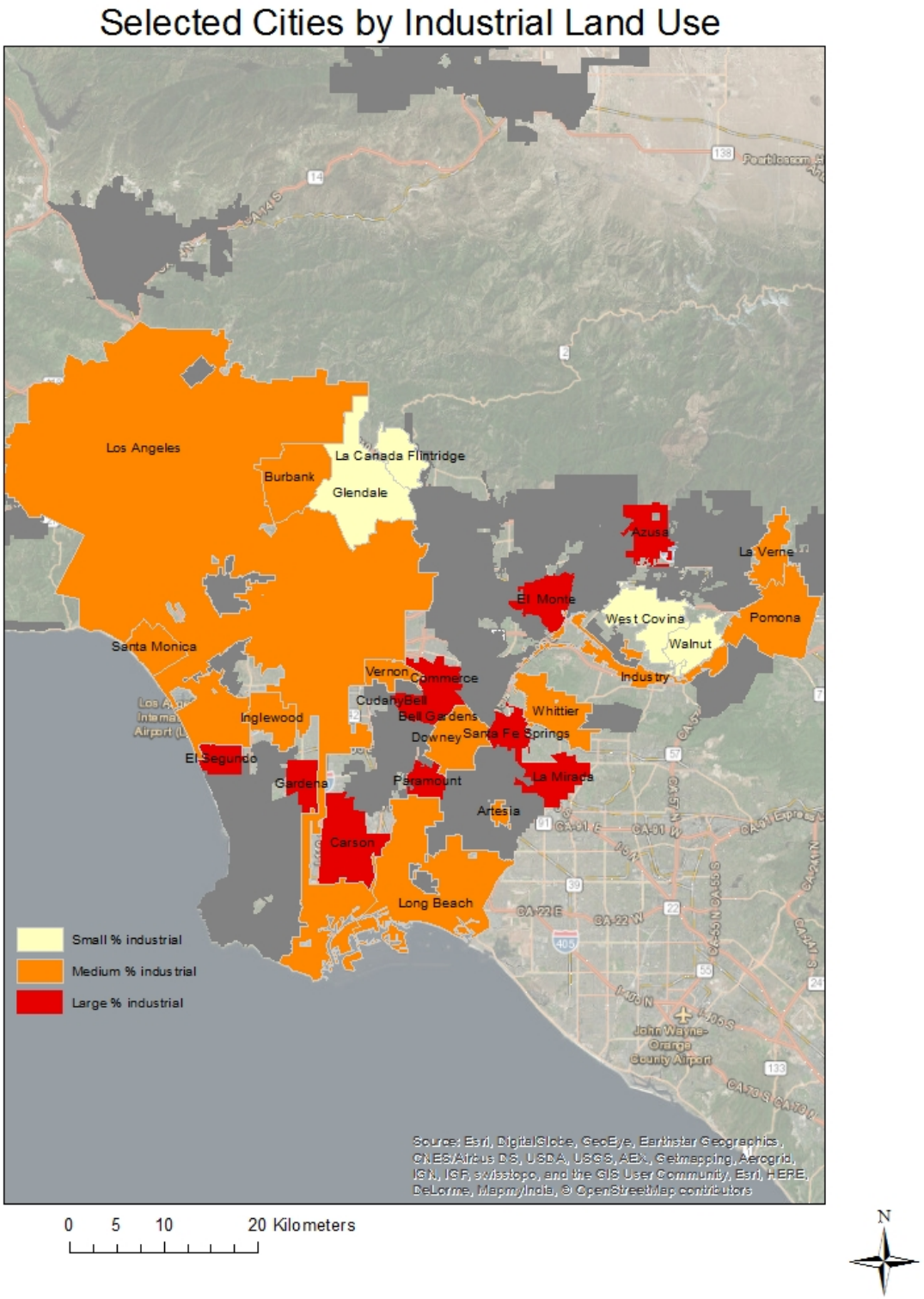

Figure 28: GIS map of selected cities by % industry

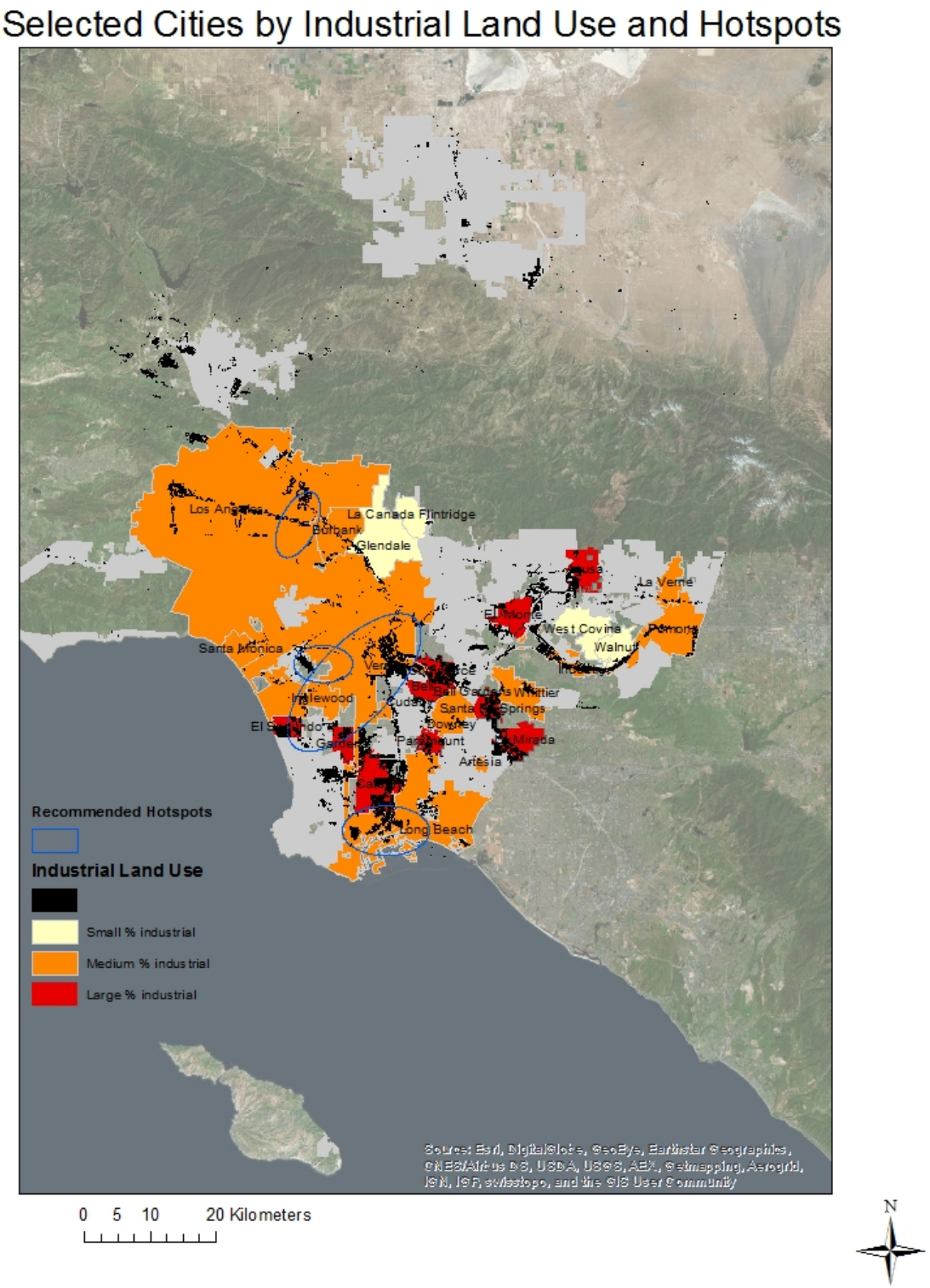

Figure 29: GIS map of selected cities, industrial land use % and recommended hotspots by LA Waterkeeper

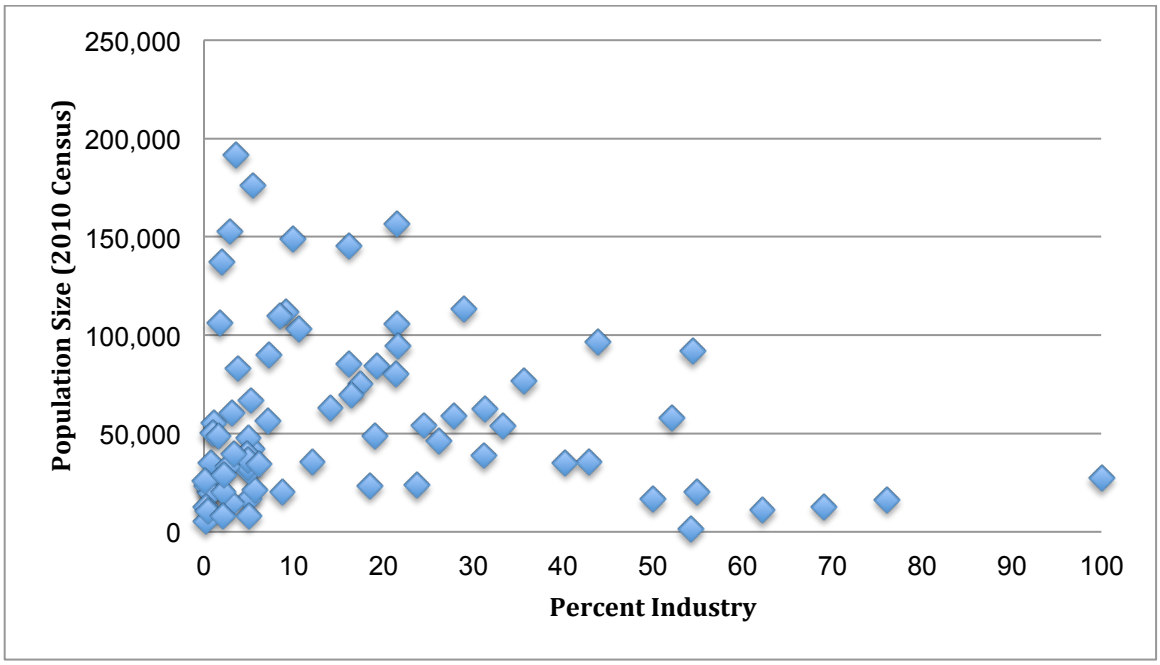

Figure 30: Scatterplot of distribution of all LA County cities with industrial land use and city population data (outliers excluded)

Table 17: MS4 Focus Requirement Scores for Selected Cities

City Name	Critical Source Inventory (5)	System for fining Violators (Legal controls) (2)	Check BMPs are up to standards (5)	Notify owners of BMP requirements at least once (3)	Business Assistance Program(5)	Separate Stormwater Hotline (4)	Total weighted score per city #/**24**	% of weighted score total
Artesia	5	0	5	0	5	0	15	62.5
Azusa	5	2	0	0	0	0	7	29.2
Bell	0	0	0	0	0	0	0	0
Bell Gardens	5	0	5	3	5	0	18	75
Burbank	5	2	5	0	5	0	17	70.8
Carson	5	0	5	0	0	0	10	41.7
Commerce	5	0	0	0	5	0	10	41.7
Cudahy	5	0	5	3	0	0	13	54.2
Downey	5	0	5	3	5	4	22	91.7
El Monte	5	2	5	3	5	4	24	100
El Segundo	5	0	5	3	5	0	18	75
Gardena	5	0	0	0	0	0	5	20.8
Glendale	5	0	0	3	0	0	8	33.3
Industry	5	0	5	0	0	0	10	41.7
Inglewood	5	0	0	0	0	4	9	37.5
La Canada Flintridge	5	0	0	0	0	0	5	20.8
La Mirada	5	0	5	0	0	4	14	58.3
La Verne	5	0	5	3	0	0	13	54.2
Long Beach	0	0	0	3	0	4	7	29.2
Los Angeles	5	2	5	3	5	4	24	100
Los Angeles COUNTY (unincorporated areas)	5	2	5	0	0	4	16	66.7
Paramount	5	0	5	0	0	0	10	41.7
Pomona	5	2	5	0	0	4	16	66.7
Santa Fe Springs	5	0	5	3	0	0	13	54.2
Santa Monica	5	2	5	3	5	4	24	100
Vernon	5	0	5	3	5	4	22	91.7
Walnut	5	0	0	0	5	0	10	41.7
West Covina	5	0	0	0	0	0	5	20.8
Whittier	5	0	5	3	0	0	13	54.2

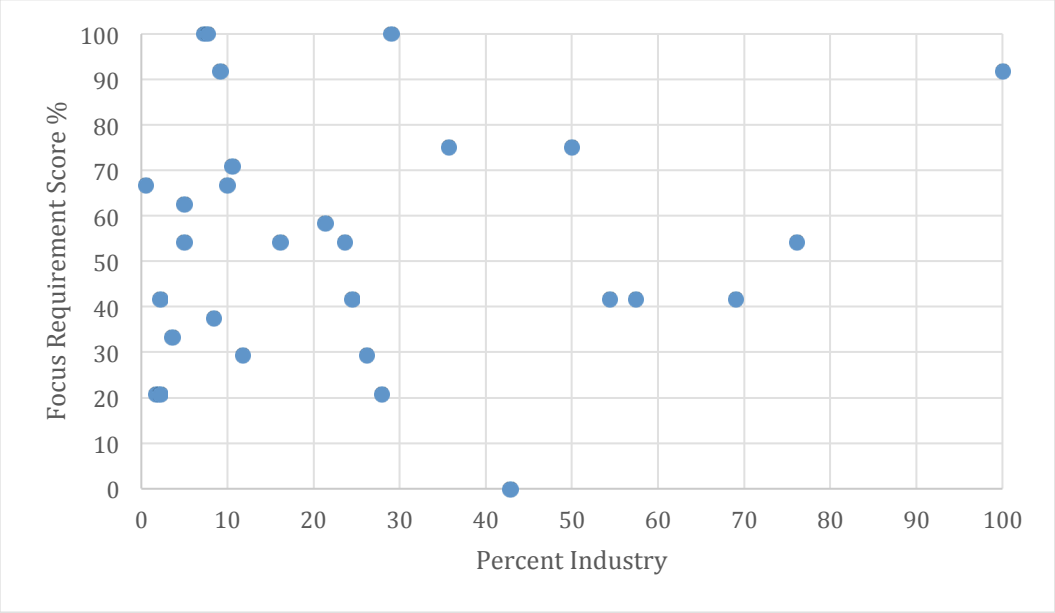

Figure 31: Weighted Score Correlation Scatterplot by Industry

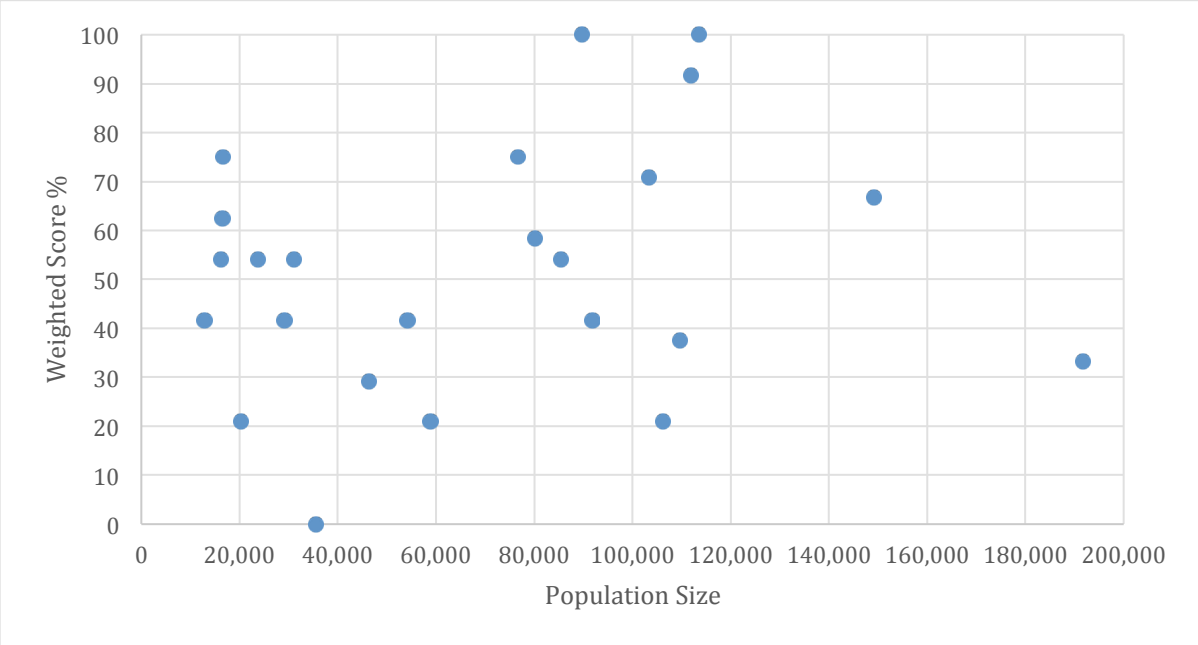

Figure 32: Weighted Score Correlation Scatterplot by Size. ***Note* Three large outliers excluded***

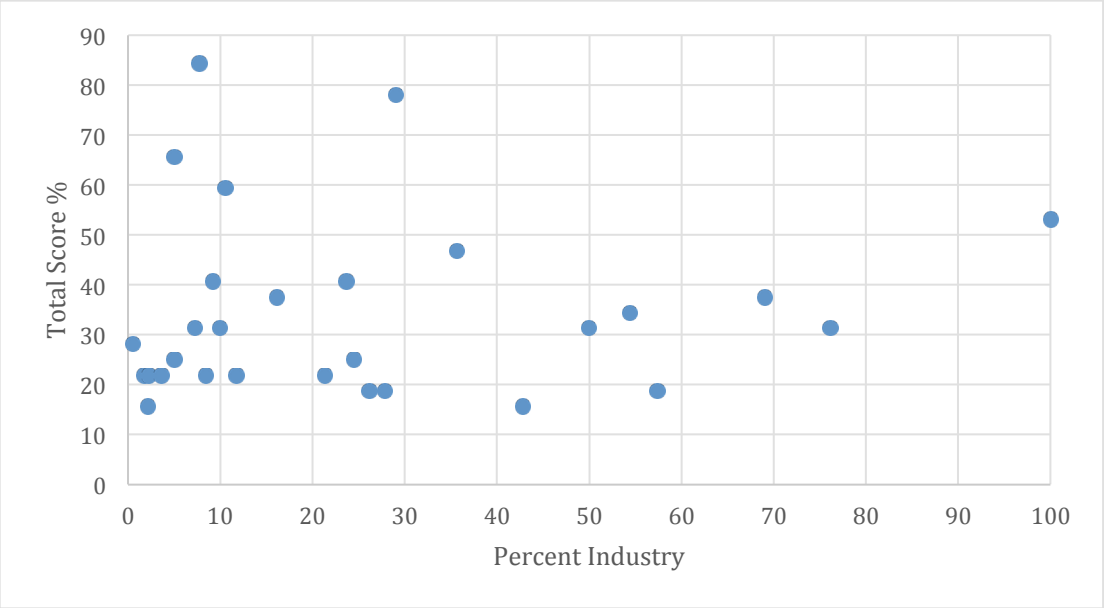

Figure 33: Total Score Correlation Scatterplot by Industry

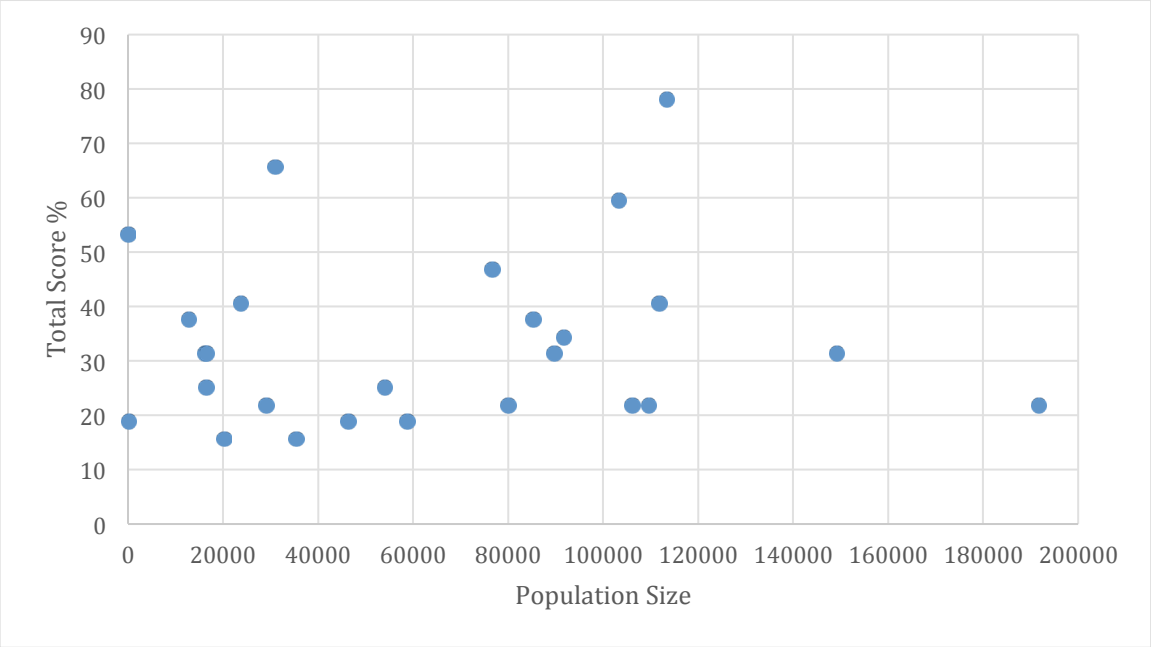

Figure 34: Total Score Correlation by Size. ***Note* Three largest outliers excluded***

Table 18: Percent of Focus Requirements met by each City under each Scenario

City	Original Scenario	All equal	Critical Source Inventory =1	System for Fining Violators=1	System for Fining Violators=5	Check BMPs are up to Standards=1	Notify owners of BMP requirements at least once=1	Notify owners of BMP requirements at least once=5	Business Assistance Program =1	Separate Stormwater Hotline=1	Separate Stormwater Hotline=5
Artesia	62.5	50	55	65.2	55.6	55	68.2	57.7	55	71.4	60
Azusa	29.2	33.3	15	26.1	37	35	31.8	26.9	35	33.3	28
Bell	0	0	0	0	0	0	0	0	0	0	0
Bell Gardens	75	66.7	70	78.3	66.7	70	72.7	76.9	70	85.7	72
Burbank	70.8	66.7	65	69.6	74.1	65	77.3	65.4	65	81	68
Carson	41.7	33.3	30	43.5	37	30	45.5	38.5	50	47.6	40
Commerce	41.7	33.3	30	43.5	37	50	45.5	38.5	30	47.6	40
Cudahy	54.2	50	45	56.5	48.1	45	50	57.7	65	61.9	52
Downey	91.7	83.3	90	95.7	81.5	90	90.9	92.3	90	90.5	92
El Monte	100	100	100	100	100	100	100	100	100	100	100
El Segundo	75	66.7	70	78.3	66.7	70	72.7	76.9	70	85.7	72
Gardena	20.8	16.7	5	21.7	18.5	25	22.7	19.2	25	23.8	20
Glendale	33.3	33.3	20	34.8	29.6	40	27.3	38.5	40	38.1	32
Industry	41.7	33.3	30	43.5	37	30	45.5	38.5	50	47.6	40
Inglewood	37.5	33.3	25	39.1	33.3	45	40.9	34.6	45	28.6	40
La Canada Flintridge	20.8	16.7	5	21.7	18.5	25	22.7	19.2	25	23.8	20
La Mirada	58.3	50	50	60.9	51.9	50	63.6	53.8	70	52.4	60
La Verne	54.2	50	45	56.5	48.1	45	50	57.7	65	61.9	52
Long Beach	29.2	33.3	35	30.4	25.9	35	22.7	34.6	35	19	32
Los Angeles	100	100	100	100	100	100	100	100	100	100	100
Los Angeles County (unincorporated areas)	66.7	66.7	60	65.2	70.4	60	72.7	61.5	80	61.9	68
Paramount	41.7	33.3	30	43.5	37	30	45.5	38.5	50	47.6	40
Pomona	66.7	66.7	60	65.2	70.4	60	72.7	61.5	80	61.9	68
Santa Fe Springs	54.2	50	45	56.5	48.1	45	50	57.7	65	61.9	52
Santa Monica	100	100	100	100	100	100	100	100	100	100	100
Vernon	91.7	83.3	90	95.7	81.5	90	90.9	92.3	90	90.5	92
Walnut	41.7	33.3	30	43.5	37	50	45.5	38.5	30	47.6	40

West Covina	20.8	16.7	5	21.7	18.5	25	22.7	19.2	25	23.8	20
Whittier	54.2	50	45	56.5	48.1	45	50	57.7	65	61.9	52

Note* 1 Scenarios not listed are the same as the original. These include Critical Source Inventory=5, Check BMPs are up to Standards=5, and Business Assistance Program=5

Table 19: Percent Difference for each Focus Requirement Between labeled Scenarios and Original Scenario used in our Analysis

City	Original Scenario	All equal	Critical Source Inventory =1	System for Fining Violators =1	System for Fining Violators =5	Check BMPs are up to Standards=1	Notify owners of BMP requirements at least once=1	Notify owners of BMP requirements at least once=5	Business Assistance Program =1	Separate Stormwater Hotline=1	Separate Stormwater Hotline=5
Artesia	0	-20	-12	4.3	-11.1	-12	9.1	-7.7	-12	14.3	-4
Azusa	0	14.3	-48.6	-10.6	27.0	20	9.1	-7.7	20	14.3	-4
Bell	0	0	0	0	0	0	0	0	0	0	0
Bell Gardens	0	-11.1	-6.7	4.3	-11.1	-6.7	-3.0	2.6	-6.7	14.3	-4
Burbank	0	-5.9	-8.2	-1.8	4.6	-8.2	9.1	-7.7	-8.2	14.3	-4
Carson	0	-20	-28	4.3	-11.1	-28	9.1	-7.7	20	14.3	-4
Commerce	0	-20	-28	4.3	-11.1	20	9.1	-7.7	-28	14.3	-4
Cudahy	0	-7.7	-16.9	4.3	-11.1	-16.9	-7.7	6.5	20	14.3	-4
Downey	0	-9.1	-1.8	4.3	-11.1	-1.8	-0.8	0.7	-1.8	-1.3	0.4
El Monte	0	0	0	0	0	0	0	0	0	0	0
El Segundo	0	-11.1	-6.7	4.3	-11.1	-6.7	-3.0	2.6	-6.7	14.3	-4
Gardena	0	-20	-76	4.3	-11.1	20	9.1	-7.7	20	14.3	-4
Glendale	0	0	-40	4.3	-11.1	20	-18.2	15.4	20	14.3	-4
Industry	0	-20	-28	4.3	-11.1	-28	9.1	-7.7	20	14.3	-4
Inglewood	0	-11.1	-33.3	4.3	-11.1	20	9.1	-7.7	20	-23.8	6.7
La Canada Flintridge	0	-20	-76	4.3	-11.1	20	9.1	-7.7	20	14.3	-4
La Mirada	0	-14.3	-14.3	4.3	-11.1	-14.3	9.1	-7.7	20	-10.2	2.9
La Verne	0	-7.7	-16.9	4.3	-11.1	-16.9	-7.7	6.5	20	14.3	-4
Long Beach	0	14.3	20	4.3	-11.1	20	-22.1	18.7	20	-34.7	9.7
Los Angeles	0	0	0	0	0	0	0	0	0	0	0
Los Angeles County (unincorporated areas)	0	0	-10	-2.2	5.6	-10	9.1	-7.7	20	-7.1	2
Paramount	0	-20	-28	4.3	-11.1	-28	9.1	-7.7	20	14.3	-4
Pomona	0	0	-10	-2.2	5.6	-10	9.1	-7.7	20	-7.1	2

Santa Fe Springs	0	-7.7	-16.9	4.3	-11.1	-16.9	-7.7	6.5	20	14.3	-4
Santa Monica	0	0	0	0	0	0	0	0	0	0	0
Vernon	0	-9.1	-1.8	4.3	-11.1	-1.8	-0.8	0.7	-1.8	-1.3	0.4
Walnut	0	-20	-28	4.3	-11.1	20	9.1	-7.7	-28	14.3	-4
West Covina	0	-20	-76	4.3	-11.1	20	9.1	-7.7	20	14.3	-4
Whittier	0	-7.7	-16.9	4.3	-11.1	-16.9	-7.7	6.5	20	14.3	-4

Note* 2 ***Scenarios not listed are the same as the original. These include Critical Source Inventory=5, Check BMPs are up to Standards=5, and Business Assistance Program=5***

Appendix B

Table 20: Cities by % Industry. *Note* For cities totaling over 100% industrial land use, percentiles were manually corrected to 100%*

City Name	Percent Industry	Category	City Name	Percent Industry	Category	City Name	Percent Industry	Category	No land use data available
South Pasadena	0.1	Low	Covina	5	Medium	Hawthorne	19.3	High	Avalon
La Habra Heights	0.2	Low	Rolling Hills Estates	5	Medium	La Mirada	21.3	High	Beverly Hills
Malibu	0.3	Low	La Verne	5	Medium	Norwalk	21.5	High	Bradbury
Calabasas	0.3	Low	Artesia	5	Medium	La Puente	21.5	High	Hidden Hills
Sierra Madre	0.5	Low	Redondo Beach	5.2	Medium	South Gate	21.6	High	Palos Verdes Estates
Agoura Hills	0.7	Low	Bellflower	5.4	Medium	Cudahy	23.7	High	Rancho Palos Verdes
Hermosa Beach	0.8	Low	Santa Clarita	5.5	Medium	Paramount	24.5	High	Rolling Hills
Claremont	0.8	Low	Duarte	5.7	Medium	Azusa	26.2	High	San Marino
Glendora	1	Low	West Hollywood	6.1	Medium	Gardena	27.9	High	
Diamond Bar	1.1	Low	Arcadia	7.2	Medium	El Monte	29	High	
Lancaster	1.6	Low	Santa Monica	7.3	Medium	Culver City	31.2	High	
West Covina	1.8	Low	Los Angeles	7.7	Medium	Montebello	31.3	High	
Pasadena	2	Low	Inglewood	8.4	Medium	Rosemead	33.3	High	
Westlake Village	2.1	Low	Lomita	8.7	Medium	Bell Gardens	35.7	High	
La Canada Flintridge	2.2	Low	Downey	9.2	Medium	Manhattan Beach	40.3	High	
Walnut	2.2	Low	Pomona	10	Medium	Bell	42.8	High	
San Dimas	2.7	Low	Burbank	10.6	Medium	Compton	43.8	High	
Palmdale	2.9	Low	Long Beach	11.8	Medium	El Segundo	50	High	
Monterey Park	3.1	Low	Temple City	12.1	Medium	Huntington Park	52.1	High	
Hawaiian Gardens	3.1	Low	Pico Rivera	14.1	Medium	Irwindale	54.2	High	
San Gabriel	3.3	Low	Whittier	16.2	Medium	Carson	54.4	High	
Glendale	3.6	Low	Torrance	16.2	Medium	South El Monte	54.9	High	
Alhambra	3.8	Low	Lynwood	16.5	Medium	Industry	57.4	High	
Lawndale	4.8	Low	Baldwin Park	17.4	Medium	Signal Hill	62.2	High	
Monrovia	4.9	Low	San Fernando	18.5	Medium	Commerce	69	High	
Lakewood	4.9	Low	Cerritos	19.1	Medium	Santa Fe Springs	76.1	High	
						Maywood	100	High	
						Vernon	100	High	

Table 21: Total Counts and Percentages for all cities studied including the four outliers. Categorization markers LL, LM, LS etc. indicate city size and city industrial percentage classifications

City Studied	Total Facilities	Total Violations	Percent Violations	Total Violating Facilities	Percent Violating Facilities
Los Angeles	343	138	41	91	27
Long Beach	98	37	38	26	27
Industry	11	3	27	2	18
Vernon	74	43	58	24	32
(LL) Bell Gardens	3	1	33	1	33
(LL) Carson	50	28	56	17	34
(LL) El Monte	24	13	54	5	21
(LL) La Mirada	20	17	85	5	25
(LM) Azusa	28	7	25	5	18
(LM) Bell	3	4	133	3	100
(LM) Gardena	106	38	36	21	20
(LM) Paramount	39	9	24	5	13
(LS) Commerce	36	14	40	9	25
(LS) Cudahy	7	11	157	5	71
(LS) El Segundo*	14	0	0	0	0
(LS) Santa Fe Springs	159	82	52	44	28
(ML) Burbank	23	9	39	8	35
(ML) Downey	18	6	35	3	17
(ML) Inglewood	11	3	30	2	18
(ML) Pomona	62	32	54	15	24
(ML) Santa Monica	8	2	25	2	25
(ML) Whittier	19	11	58	8	42
(MM) La Verne	4	3	75	2	50
(MS) Artesia	3	1	33	1	33
(SL) Glendale	16	6	40	3	19
(SL) West Covina	4	9	225	3	75
(SM) Walnut	10	5	45	2	20
(SS) La Canada Flintridge*	0- No Data				

Table 22: City Industrial Land Use Percentages for Los Angeles County. ***Note* For cities totaling over 100% industrial land use, due to ARC-GIS programming error with the SCAG data, percentiles were manually corrected to 100% indicating full industrial land use***

CITY	Industrial Area	City Total Area	Percent Industrial Land Use (a/b)	%
Maywood	4237197.9	3049200.8	1.4	139
Vernon	13738013.5	13462122.5	1	102
Santa Fe Springs	17485110.9	22975979.5	0.8	76.1
Commerce	11708482.6	16964783	0.7	69
Signal Hill	3525135.6	5669893.3	0.6	62.2
Industry	17876775.7	31158409.7	0.6	57.4
South El Monte	4051327.5	7376922.3	0.5	55
Carson	26674682.3	49028533.2	0.5	54.4
Irwindale	13512682.2	24935249.8	0.5	54.2
Huntington Park	4064928.8	7802950.6	0.5	52.1
El Segundo	7050052.4	14102421.4	0.5	50
Compton	11462318.3	26143093.4	0.4	43.8
Bell	2906373.2	6782921	0.4	42.8
Manhattan Beach	4111172.7	10210180.6	0.4	40.3
Bell Gardens	2277330.1	6380930	0.4	35.7
Rosemead	4458202.4	13391218	0.3	33.3
Montebello	6774497.2	21663778.3	0.3	31.3
Culver City	4148282	13293913	0.3	31.2
El Monte	7222012.6	24898529.6	0.3	29
Gardena	4225838.5	15160346.4	0.3	27.9
Azusa	6535717.1	24977389.5	0.3	26.2
Paramount	3058779.2	12479563.2	0.2	24.5
Cudahy	752861.2	3178395.7	0.2	23.7
South Gate	4120032.5	19033135.9	0.2	21.6
La Puente	1932959.7	8991322.4	0.2	21.5
Norwalk	5424164.6	25260375.6	0.2	21.5
La Mirada	4333980.8	20311844.5	0.2	21.3
Hawthorne	3039844.7	15770214.6	0.2	19.3
Cerritos	4373406.1	22903907.5	0.2	19.1
San Fernando	1135391.2	6134586.4	0.2	18.5
Baldwin Park	3055607.2	17542552.1	0.2	17.4
Lynwood	2062204.1	12535402.5	0.2	16.5
Torrance	8605912.2	53221768.5	0.2	16.2
Whittier	6130924.6	37957798.1	0.2	16.2
Pico Rivera	3239781.1	23047897.6	0.1	14.1
Temple City	1258370.6	10421161.9	0.1	12.1
Long Beach	15638522.8	133047377	0.1	11.8
Burbank	4768914.1	44956862.3	0.1	10.6

Pomona	5931532.6	59453057.5	0.1	10
Downey	2991623.0	32531211.1	0.1	9.2
Lomita	432501.8	4962227.5	0.1	8.7
Inglewood	1986040.5	23524695.1	0.1	8.4
Los Angeles	94382399.4	1224643047	0.1	7.7
Santa Monica	1570773.4	21613298.9	0.1	7.3
Arcadia	2067161.6	28757218.9	0.1	7.2
West Hollywood	297915.9	4900892	0.1	6.1
Duarte	977796.8	17289894.7	0.1	5.7
Santa Clarita	7440277.2	136341390.8	0.1	5.5
Bellflower	864125.3	16004239	0.1	5.4
Redondo Beach	843704.1	16070630.1	0.1	5.2
Artesia	212236.1	4203546.8	0.1	5
La Verne	1112723.1	22057020.3	0.1	5
Rolling Hills Estates	466753.1	9311431.2	0.1	5
Covina	904844.4	18224765	0.05	5
Lakewood	1200051.9	24466146.5	0.05	4.9
Monrovia	1744570.5	35595883.6	0.05	4.9
Lawndale	246080.2	5094335.2	0.05	4.8
Alhambra	756009.8	19756467.1	0.04	3.8
Glendale	2873656.9	79175162	0.04	3.6
San Gabriel	356399	10697296	0.03	3.3
Hawaiian Gardens	77789.1	2473034.4	0.03	3.1
Monterey Park	624625.6	20026157.4	0.03	3.1
Palmdale	7964500.1	274880733.3	0.03	2.9
San Dimas	1062972.1	39892613.7	0.03	2.7
Walnut	519027.2	23244415.1	0.02	2.2
La Canada Flintridge	493682.1	22386946.6	0.02	2.2
Westlake Village	299752.9	14249313.5	0.02	2.1
Pasadena	1190920.5	59886688.3	0.02	2
West Covina	740136.4	41608617.9	0.02	1.8
Lancaster	3969733.4	244615157.5	0.02	1.6
Diamond Bar	426163.9	38073321	0.01	1.1
Glendora	491281.4	50545789	0.01	1
Claremont	287639.8	34860657.6	0.01	0.8
Hermosa Beach	29508.8	3720159.3	0.01	0.8
Agoura Hills	137111.6	20245354.7	0.01	0.7
Sierra Madre	34898.4	7655114.5	0.0	0.5
Calabasas	97552.1	33597236.8	0.0	0.3
Malibu	136534.9	51274361	0.0	0.3
La Habra Heights	26931.4	15942104.9	0.0	0.2
South Pasadena	10462.1	8843073.9	0.0	0.1

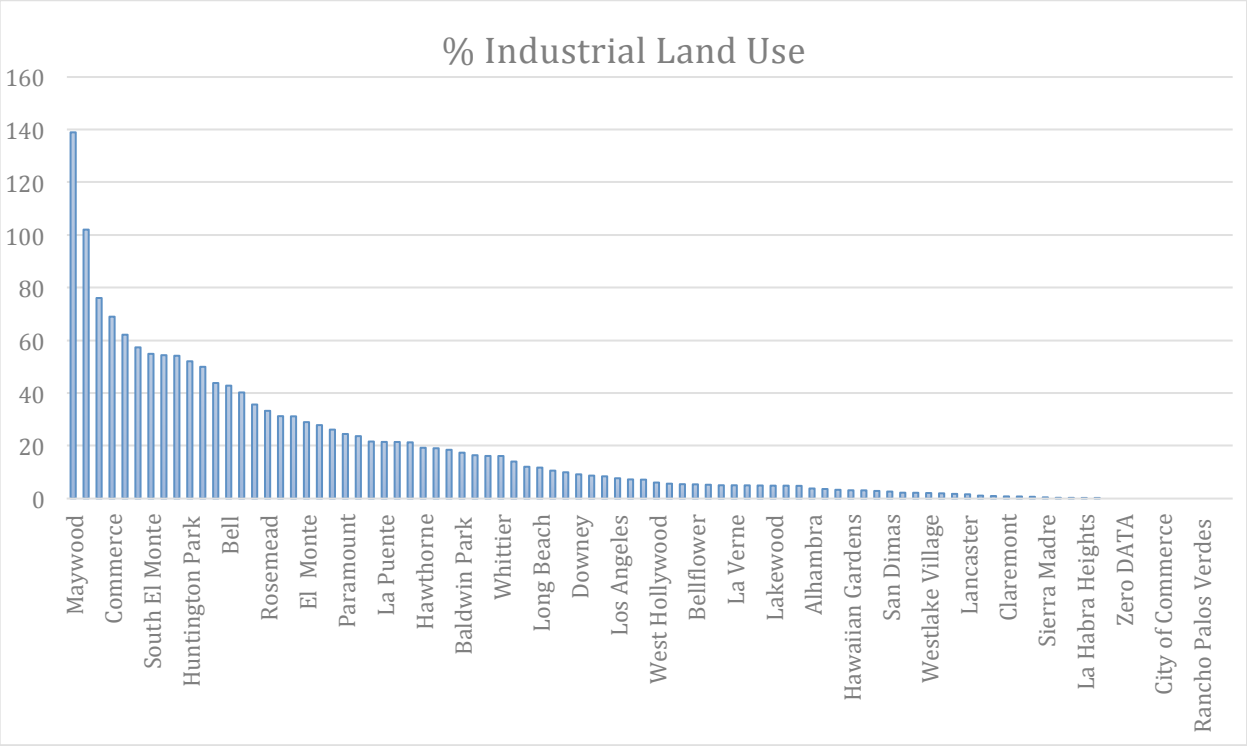

Figure 35: Industrial Land Use Distribution for Los Angeles County. ***Note* No data was found for the cities of Commerce and Palos Verdes***

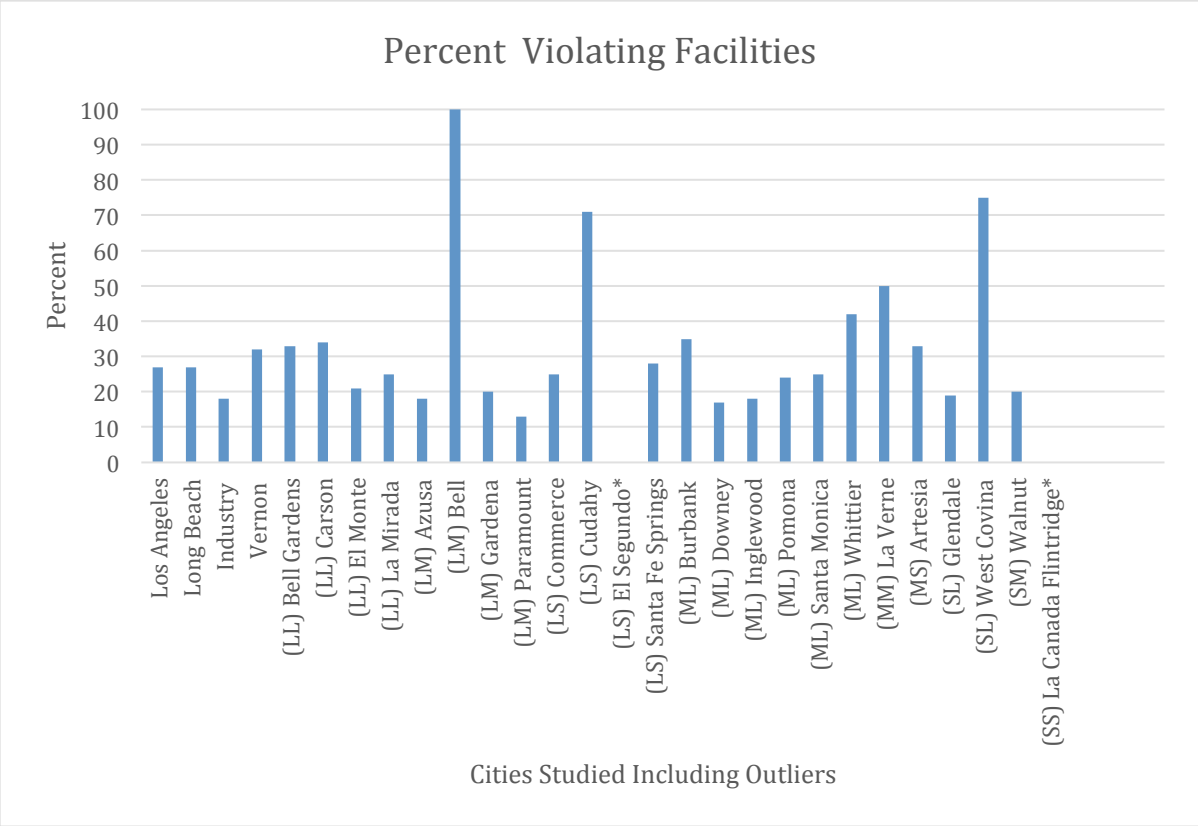

Figure 36: Percent Violating Facilities in Cities Studied (Ranked by Classification Rather than Violation Ratio)