GIS Weathers the New Stormwater Regulations

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Abstract: As part of a nationwide update mandated by the Environmental Protection Agency, local Departments of Environmental Protection are developing municipal stormwater regulation programs to address groundwater pollution issues in each state. The proposed changes will likely impact municipalities, public complexes (such as large public colleges), and highway systems (such as those operated by regional transportation authorities) for years to come. The implementation schedules, detailed documentation, public education materials and multiple mapping products needed for compliance with the new guidelines may seem daunting at first, but provide an ideal application for GIS technology. Municipalities and public works organizations nationwide can organize, analyze, manage and maintain their stormwater data more efficiently by implementing a GIS. This paper will explore all aspects of dealing with the stormwater regulation changes, from building an accurate digital base map foundation to creating a complete data management system.

Introduction: Stormwater rushing off roofs, across backyards and along roadways carries chemicals, animal waste, road salt and other pollutants along with it, and these unwanted additives can eventually contaminate our drinking water sources. The National Pollutant Discharge Elimination System (NPDES) Stormwater Program was implemented as part of the Clean Water Act to address the issue of stormwater runoff on our nation's waterways. Construction activity, industrial facilities and Municipal Separate Storm Sewer Systems are impacted by these regulations nationwide.

Municipal Separate Storm Sewer Systems, as the name implies, are a conveyance or system of conveyances separate from sanitary sewage systems. MS4s are designed and used specifically for collecting or conveying stormwater discharges directly into our nation's waterways.

Because these discharges are often untreated, the NPDES Stormwater Program requires the use of stormwater permits, stormwater pollution prevention plans, stormwater management programs and best management practices to reduce or eliminate polluted runoff into lakes, streams, rivers and other bodies of water. GIS technology can provide vital assistance with the documentation and implementation of these procedures for all states, municipalities, agencies, organizations and other public entities impacted by the new guidelines.

Stormwater Management Plan: According to the Environmental Protection Agency, the problem of stormwater pollution is twofold. First, there is increased volume and rate of runoff from impervious surfaces, such as roofs, parking lots or roadways, which do not allow the stormwater to be naturally filtered or absorbed. Second, there is an increased concentration of pollutants in the runoff itself. Approximately 40% of our nation's

waterways do not meet water quality standards, and stormwater runoff is one of the primary causes. Over time, water pollution destroys wildlife habitats and poses an increasing threat to public health. A Stormwater Management Plan is an important way to monitor and prevent these dangers.

Some of the goals stated in a typical Stormwater Management Plan may include:

- Reduce flood damage, including damage to life and property
- Minimize, to the extent practical, any increase in stormwater runoff from any new development
- Reduce soil erosion from any development or construction project
- Assure the adequacy of existing and proposed culverts and bridges, and other in-stream structures
- Maintain groundwater recharge areas
- Maintain the integrity of stream channels for their biological functions, as well as for drainage
- Minimize pollutants in stormwater runoff from new and existing development and government projects in order to restore, enhance and maintain the chemical, physical and biological integrity of the waters of the State, to protect health, to safeguard fish and aquatic life and scenic ecological values, and to enhance the domestic, municipal, recreational, industrial and other uses of water
- Protect public safety through the proper design and operation of stormwater management basins

There are a variety of GIS maps and associated databases that can graphically illustrate these stormwater management goals for all concerned.

- *Wetlands Maps* can show the boundaries of freshwater, coastal and/or stormwater wetlands, as applicable. Attributes can include block and lot information and dimensions.
- *Endangered Species Maps* can show habitat areas for wildlife, fish or birds by means of color-coding. Attributes can include estimated animal population in a particular area by year.
- *Soils Maps* can classify soils by type, making it easier to identify potential areas of poor drainage. Attributes can include block and lot information, or various soil components by percentage.

- *Flood Plain Maps* can show the areas around streams and waterways that allow the natural spread of water during flood events. Attributes can include previous flood dates, flood plain dimensions, and sediment levels.

- *Groundwater Aquifer Maps* can depict the location of groundwater deposits, aquifers, groundwater recharge rates and/or groundwater pollution. Attributes can include the surface area of the groundwater or recharge area, as well as any/all pollutants present.

- *Water Bodies Maps* can provide an overview of the surface water in the region, including lakes, rivers and streams. Attributes can include surface area, average depth, or flow direction.

- *Wellhead Protection Maps* can depict areas where underground sources of drinking water are being protected. Attributes can include wellfield area or contaminant levels.

- *Land Acquisition/Conservation Easement Maps* can depict land areas upstream of watershed or groundwater recharge areas that have been and/or can be acquired to prevent future drinking water contamination. Attributes can include land dimensions and ownership information (land trust, municipality, State, etc.).

- *Source Water Assessment Maps* can identify the area of land within a service area that most contributes to drinking water supplies. Attributes can include current and/or potential sources of pollution.

- *Watershed Maps* can show all the land area that drains to a specific point, such as a river, lake, stream, or portion thereof. Multiple watersheds in a specific region or service area can be prioritized for treatment and management of stormwater runoff. Attributes can reflect prioritization levels.

- *Water Quality Maps* can show the level of contamination on a percentage and/or color-coded basis. Attributes can include sampling dates and locations, as well as impurity or chemical levels. Graphs can be based on the tabular data and applied to the map for additional visual impact.

- *Surface Cover Maps* can show the type of surface coverage within a watershed or service area. Types of cover may include wooded, open field, farmed field, and impervious cover (such as parking lots or buildings). Attributes can include land area and types of vegetation.

- *Topographic Maps* can show the location of streams, floodplains, high water elevations, land elevations, steep slopes, and overall contour/grading. Attributes can include previous flood dates, erosion levels and runoff areas.

- *Impervious Surface Maps* can show the location of road surfaces, sidewalks, parking lots, developed areas, and other impervious land coverages by percentage in each

watershed. As impervious surface area increases, water quality decreases from associated runoff. Attributes can include levels of contaminants, debris, bacteria and sediment in streams and lakes impacted by surface alterations.

- *New Construction Maps* can depict the locations of municipal construction sites, where run-off controls are essential to reduce soil erosion and prevent its associated sediment from entering the stormwater system. Attributes can include block, lot and address information, construction type, site completion dates, and stormwater infrastructure features potentially impacted by the work.

In New Jersey, the Department of Environmental Protection offers grant funding to assist municipalities with Environmental Resource Inventory (ERI) Maps, which commonly include much of the data outlined above. These maps can often be reused for stormwater management purposes. Various grant programs are also available through ESRI.

Stormwater Pollution Prevention Plan: A typical Stormwater Pollution Prevention Plan addresses soil erosion, sediment control and waste disposal methods used at specific sites, particularly where new construction is involved. The goal of the Plan is to reduce the discharge of pollutants to the greatest extent possible, thereby protecting overall water quality. The Stormwater Pollution Prevention Plan must work in tandem with the Stormwater Management Plan, documenting how the general practices outlined in the latter will be applied to each individual site.

Typical existing sites to be included in the Stormwater Pollution Prevention Plan include salvage yards, recycling facilities, concrete plants, marinas and boatyards, transportation facilities and airports. Municipal maintenance yards will need to inventory all materials that may ultimately impact stormwater runoff, such as fuels, lubricants, solvents and de-icing materials.

Site descriptions, including maps, are generally required for Stormwater Pollution Prevention Plans. GIS mapping technology can assist with this process by allowing the user to highlight new construction sites within a region. Attributes can include site inspection schedules, proposed completion dates, block and lot information, pollution management practices being used on site, and the stormwater infrastructure features that will ultimately be impacted by the new construction.

A GIS can also be used to highlight municipal maintenance yard locations. Attributes can include the site inventory of potential pollutants. Another map might include the sites of any underground and/or above ground storage tanks utilized by the maintenance yards. Regular maintenance is critical to preventing leaks in these tanks, so the GIS attributes table can include past and future maintenance dates. A detailed site layout of each maintenance yard can also be attached to the GIS database as a separate image file. This will allow users a bird's eye view of the buildings, tanks and stormwater infrastructure features located on these sites.

Yard waste collection routes can also be mapped with GIS for inclusion in the Stormwater Pollution Prevention Plan. Yard waste collection programs are designed to keep leaves and other yard waste materials from entering the stormwater system, particularly during the critical autumn months. The schedules associated with each collection route can be used as attributes.

Inlet and Outfall Location Maps: The overall stormwater drainage infrastructure system for any municipality, authority or other public entity should be mapped in its entirety. A copy of this map can also be incorporated into the Stormwater Management Plan and/or Stormwater Pollution Prevention Plan.

The most cost effective and timely way to generate an accurate Stormwater GIS is by reusing as much existing information as possible. All available mapping data for the area in question should be inventoried, digitized, scaled, georeferenced and incorporated into the GIS database. Any stormwater infrastructure features not previously mapped can be located by conventional field inspections or GPS survey methods. Field survey work can also be used to document any systems located underground or in remote areas.

Aerial photography or municipal tax maps form an excellent base map for infrastructure data, since they allow the user to see the infrastructure features in relation to the homes, businesses, land areas and waterways they may impact. Aerial photography also allows the user to view and analyze impervious surface cover.

Illicit Connection Elimination Plan: Closely related to inlet and outfall mapping is the Illicit Connection Elimination Plan. A GIS map depicting the location of all outfall pipes that empty into a lake, ocean, river or stream can be an important part of this process. The location and name of the surface water bodies receiving the stormwater discharge must be noted on the map. Each outfall pipe must also be given an alphanumeric identifier, which must be included on the map.

All outfall locations must be investigated for dry weather flow, defined as flow that continues to occur more than seventy-two hours after a rainfall. All outfall pipes having dry weather flows must be further investigated, since this may indicate the discharge is something other than stormwater or other allowable runoff. The goal is to detect and eliminate illicit connections that pollute surface bodies of water.

GIS can be used to map the outfall locations, and to keep track of flow rates, chemical deposit levels, inspection schedules and violations. Photographs of the actual outfall and/or surrounding area can also be linked to the GIS to provide a complete record of any illicit connection activity.

By incorporating tax assessment data into the GIS database, it will also be possible to identify properties by land use classification, such as industrial or commercial, that could potentially be the source of any illicit connection discharge.

Zoning and Land Use Implications: Stormwater management can be greatly assisted by proper zoning and land use ordinances within a municipality or local service area. These can also be incorporated into an overall Master Plan to guide municipal growth and development. Working with local, regional and State planning departments to develop sound management practices prior to growth and development are generally less costly for stormwater management purposes than applying corrective measures later on.

The Association of New Jersey Environmental Commissions recommends consideration of the following zoning ordinances for New Jersey municipalities. These same guidelines can be applied to areas outside New Jersey as well:

- Impervious cover limitations to limit the amount of land within a particular zone that can be covered by buildings, parking lots, roads and other impervious surfaces.

- Large-lot zoning for ten or more acres to reduce the overall land disturbance area, thus simplifying and localizing stormwater management needs within a single lot.

- Lot-size averaging in individual zones to encourage natural resource protection. This type of ordinance allows some lots within a subdivision to be smaller than the standard minimum, as long as other lots are larger than the minimum to compensate. This is particularly important in environmentally sensitive areas, such as along waterways, and may require deed restrictions to prohibit subdivision of larger lots at a later date.

- Open space/cluster ordinances require that a certain percentage of a particular site be preserved as open space, thus allowing development to occur elsewhere on the site on smaller-than-minimum lots. A deed restriction should be placed on the open space area to preserve it for future generations.

- Noncontiguous cluster ordinances to encourage development in noncontiguous clusters, with open space areas preserved between them. Open space areas should be preserved by deed restriction.

- Overlay zoning establishes specific protection standards for resources that are located in multiple zones. These are particularly useful for maintaining continuous riparian or buffer requirements along waterways, which will remain unchanged no matter what zones the waterway passes through.

A GIS Zoning Map can graphically display the various zoning designations within a municipality or region by means of color-coding. The attributes table can reflect such information within each zone as minimum lot size, lot number limitations, deed restrictions, impervious cover limitations, overlay areas, and overall residential/commercial development requirements. An overall Zoning Map can be printed out as reference, and even mounted and/or laminated for public display purposes. The attributes table for each zone can also be printed out and distributed to developers or residents as reference.

The Association of New Jersey Environmental Commissions also recommends a variety of land use practices to assist with stormwater management or water quality improvement.

- Mimic natural stormwater behavior
- Minimize disturbance of site and retain natural features that provide stormwater drainage
- Minimize impervious surfaces
- Stagger impervious surfaces to enhance infiltration
- Use structural stormwater management facilities only in conjunction with non-structural facilities and practices
- Establish standards for calculating stormwater runoff and providing appropriately sized collection and conveyance methods, particularly for residential development
- Require submission of a stormwater maintenance plan with all new development applications
- Follow structural and non-structural best management practices wherever appropriate, such as
  - → Dispersion of flow to reduce velocity and allow for better infiltration
  - → Filtration of stormwater sediment through use of vegetation
  - → Retention of natural vegetation to promote good drainage
  - → Stream buffers to filter pollutants from runoff before it reaches a waterway
  - → Bioretention systems to remove pollutants and moderate runoff volume
  - → Dry wells to collect roof runoff
  - → Enhanced swales to promote infiltration
  - → Pervious pavement material, such as paving blocks and compacted gravel, to allow infiltration
  - → Sand filters to reduce stormwater pollutants before stormwater reaches the conveyance system

GIS can be used to map and keep track of specific land use requirements related to the stormwater management ordinance. It can also be used to highlight best management practice areas, problem areas or other areas of interest.

There are additional land use ordinances recommended by the Association of New Jersey Environmental Commissions for stormwater management and water resource protection:

- Critical area ordinances to provide important design standards for environmentally sensitive areas. These include steep slopes, flood plains, poorly drained soils, and aquifer recharge areas, among others.
- Aquifer recharge protection ordinances to identify recharge areas and prohibit land use that may adversely impact groundwater. Prohibited uses may include gas stations, dry cleaning operations and photographic development labs.

- Impervious cover requirements to reduce impervious land cover, similar to those outlined under zoning ordinances.

- Lot grading ordinances to limit negative impact on adjoining, off-site or off-tract properties.

- Pooper scooper ordinances to require pet owners to pick up after their pets. High levels of fecal coliform are often found in suburban and urban waterways, and this is directly related to pet waste.

- Setback requirement ordinances to reduce setbacks and thereby shorten driveway lengths.

- Shade tree protection ordinances to protect trees from unnecessary cutting and/or require replacement. Trees are an important part of the natural water cycle.

- Soil movement ordinances to minimize erosion.

- Steep slope ordinances to prevent development or disturbance to varying degrees of slope. This will minimize erosion and its associated sedimentation.

- Stream or riparian corridor ordinances to establish vegetated buffers from streams, lakes and other waterways. This will allow for filtration of stormwater runoff before it enters the waterways.

- Usable yard or lot area ordinances to define minimum area requirements that are outside flood plains, wetlands, wetland buffer areas, stormwater detention basins, utility easements, water courses and certain steep slopes.

- Wellhead protection ordinances to establish protected areas around wells to prevent pollutants from entering the groundwater.

A GIS Land Use Map can provide a general overview of the land use ordinances and/or land use classifications in a municipality or service area. When a GIS utilizes municipal tax maps for its base map foundation, land use can be studied on a block-by-block, lot-by-lot basis for in-depth analysis purposes.

Build-Out Analysis: GIS technology is not only helpful for showing how things are in the present, it is also helpful for showing how things could be in the future.

The Environmental Protection Agency recommends a build-out analysis to study the long-term effects of local land use and zoning practices. The build-out analysis lets a municipality visualize what would happen if all buildable land was developed in accordance with existing regulations. For stormwater management purposes, the following questions can be answered when studying the impact of growth:

- Will there be enough groundwater to support additional population following a build-out?
- Will the existing stormwater system be able to support a total build-out?
- Will new stormwater infrastructure need to be put in place? If so, where?
- Do additional regulations need to be adopted to better preserve open space and farmland?

Looking at land that has already been developed presents a different set of challenges. In order to perform the build-out analysis accurately, it will be necessary to look at maximum development possibilities for these properties as well. Some scenarios to consider include:

- Are there discrepancies between the current use of the property and its actual zoning status? For example, can any properties currently being used as residences ultimately be used for business or commercial purposes, and vice versa? If so, maximum potential development should be shown based on current zoning as opposed to current use.
- How many existing lots can be subdivided to allow for additional development? Again, the build-out analysis needs to consider all eventual development possibilities.
- Do current zoning and land use regulations allow any existing buildings to be enlarged? If so, show the maximum size allowed.
- Can any residential properties be converted into multi-family or apartment units under current zoning and land use regulations? If so, this must be taken into account in every possible instance.
- How close is a property to a college or university? Is there potential for any residence to be converted into student housing? This scenario must be taken into account wherever possible.
- Can any residences potentially become commercial or industrial sites, such as restaurants, schools, body shops, factories, landfills, hospitals, gas stations or funeral homes? How will these potential changes impact the stormwater infrastructure?

- How much bigger can an existing business grow?

- Can a low-impact business be converted to a higher-impact business? Could a small, family owned business grow into a mid- to large-size company with multiple employees and additional parking needs?

Once the worst-case scenarios have been determined for all properties, GIS will allow the user to study the impact of additional residential and/or commercial development on the existing stormwater system. Maximum growth can be averaged out over a period of years to create a progression of maps and data, or applied only to specific areas within a municipality where current development interest is highest.

ESRI offers many templates, models and schemas to assist in designing and implementing a build-out analysis.

Public Education and Involvement: The new stormwater regulations also include public education regarding topics related to water quality enhancement. GIS can be a tremendous resource tool for public education because of its innate ability to combine graphic and tabular data for display purposes.

GIS can be used to map trash and recycling routes, allowing the public to see when trash and recycling materials will be picked up in each neighborhood. Small copies of the maps can be handed out at public meetings, distributed door-to-door, or included in the annual mailings recommended in the draft permits. These maps can be accompanied by maps of the stormwater infrastructure features along each recycling route, allowing residents to see the relationship between improperly disposed pet wastes, litter and yard waste, and the storm drains that unwittingly conduit these materials into the stormwater system.

Many areas of the United States have experienced drought conditions in recent years. During these periods, it is often necessary to reduce water consumption by limiting lawn watering or car washing in residential areas. GIS can be used to create color-coded maps of the areas impacted by water restrictions, or areas where an odd/even lawn sprinkling schedule is permitted. These can be posted in public buildings or schools, printed in local newspapers, included in a special mailing, or distributed at public meetings.

The phrase “the grass is always greener” takes on new meaning in the suburbs. Those lush green lawns require fertilizers and pesticides that eventually seep into the stormwater system or groundwater. GIS can be used to study the impact of these chemicals on stormwater basins and groundwater recharge areas. Maps of the groundwater or area wells serving a particular area, accompanied by a breakdown of chemicals as seen in the attributes table, can be an eye-opening experience for residents. This can encourage the use of milder chemicals or more natural lawn enhancement practices that will be less invasive to the ecosystem. GIS maps, charts and tables can be provided to residents as part of an annual mailing, and would be particularly effective in early spring.

The use of aerial photography in GIS allows a true bird's eye view of a municipality or area. Depending on the scale and nature of the aerial photography, it may be possible to study the natural landscape, including the location of trees and other groundcover. Areas in need of additional landscaping and shade trees can be highlighted on the GIS aerial maps. The impact of planned development in an area already landscaped with large trees can also be studied. These aerial views can be displayed at public meetings to highlight areas of concern, or graphically present the relationship between the natural landscape and the stormwater infrastructure system. Web-based GIS maps can also be displayed over the Internet on a municipality's website for informational and public education purposes.

Earth Day is celebrated on April 22nd each year. If your hometown observes this international event, stormwater management practices would be an excellent topic for workshops, seminars or school presentations. GIS can be used for demonstrations or handouts at any of these proceedings.

Conclusion: In 1962, author Rachel Carson ignited the environmental movement with her landmark book, *Silent Spring.* In a time when the prevailing wisdom was that the needs and advancement of mankind were pre-eminent, Carson firmly believed that all living things were inextricably linked, and that damage imposed by chemicals on even the smallest portion of our natural world would ultimately harm every other facet of life as well. Shortly before her death in 1964, she remarked, "Man's attitude toward nature is today critically important, simply because we have now acquired a fateful power to alter and destroy nature. But man is a part of nature, and his war against nature is inevitably a war against himself…"

Forty years later, our society is still struggling to balance our need for technological control with our inherent obligation to protect the natural environment we all live in. The NPDES Stormwater Program exemplifies our ongoing determination to meet these challenges, and GIS can be an essential resource tool as we journey toward that elusive goal.

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