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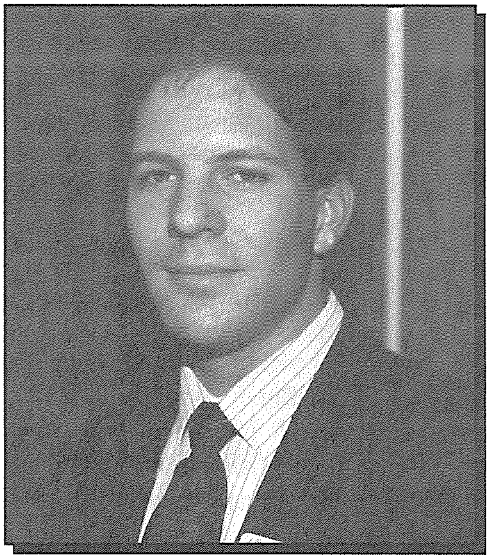

USING A WATERSHED-BASED APPROACH TO MANAGE AND PROTECT WATER RESOURCES IN THE BEAR CANYON WATERSHED, ALBUQUERQUE, NEW MEXICO

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Depending upon how people use land in a watershed, whether it be farming, livestock grazing, timber harvesting, mining, urbanization, or even recreation, all have significant impacts on the water moving through that watershed. This paper will focus on the urban watershed and how stormwater runoff from urbanization affects erosion, sedimentation, and water quality. I also will explore the potential of a watershed as the basis for managing and protecting water resources. Watershed-based management offers a clear look at how land-use changes affect not only water quality but also erosion and sedimentation; in addition, this approach develops preventive strategies to restore those affected water and land resources.

The preventive strategies I use for this watershed can be applied to other New Mexico urban watersheds. This paper is divided into three parts. The first part shows how past and present land-use activities affect erosion, sedimentation, and water quality in the Bear Canyon arroyo system. The second part provides solutions to the problems of soil erosion and stormwater pollution in the urban areas through government intervention. The third part discusses how Best Management Practices (BMPs) can be used to limit or reduce stormwater pollution in residential and industrial areas.

PAST AND PRESENT LAND USE EFFECTS ON LAND AND WATER RESOURCES

From its highest elevation of 9300 feet, the Bear Canyon watershed extends westerly eleven miles from the Sandia Mountains to the North Diversion Channel at an elevation of 5100 feet. The Bear Canyon arroyo runs almost due east-west across the northeast quadrant of Albuquerque with numerous tributaries flowing in from the northeast. Typical of the arroyo pattern in Albuquerque, it has a relatively narrow, very long watershed which has been channeled, diverted, and concrete lined. In addition, since the establishment of the Albuquerque Metropolitan Arroyo Flood Control Authority (AMAFCA) in 1963, the metropolitan arroyos have been treated as primary elements in Albuquerque's flood control system.

Before the land surrounding the Bear Canyon watershed was grazed or urbanized, the arroyo channels meandered within its floodplains, shifting the locations of the floodplains themselves in response to storm runoff. Like most arroyos, it was dry for most of the year. Summer thundershowers produced intermittent streams in its channels which flowed only long enough to carry away runoff from the basins it drained. Severe summer thunderstorms produced high flows which eroded the channels, dramatically changing the slope and paths of the arroyo. When the stream stopped flowing, it deposited sediment, choking the channel. When the next severe thunderstorm came, the existing channel could not accommodate the flow and would overflow its banks, thereby cutting a new channel (City 1986).

This channel cutting was an ongoing process for a 4,000 to 5,000 year-period after the Ice Age when the climate became drier. However, this natural condition ended in the period between 1880 to 1900, when an increase in intensity of summer storms combined with intensive grazing accelerated the erosion processes, concentrating the water flow and entrenching the arroyo channels. It is quite invisible to the tourist who finds this wrecked landscape colorful and charming (as indeed it is, but it has a scant resemblance to what it was in 1848) (Leopold 1966).

As urbanization encroached along the lower portions of the watershed, it altered the natural drainage system. Where the rain once fell on soil and vegetation, it now falls on the impervious surfaces of rooftops, driveways, parking lots, sidewalks, streets, and the concrete-lining of the arroyos themselves. These surfaces allow almost no infiltration of water into the ground and shed water faster than the soil and vegetation they have replaced.

Generally, arroyos in urban areas are required to accommodate more water in a shorter time than would be the case under natural conditions. This rapid surge of discharge water increases the available energy in the stream, making it capable of doing more damage to its channel and to the surrounding land. In addition, runoff from an urbanized watershed may pick up only small amounts of sediment as it passes over hard surfaces. However, when this water reaches an unlined channel, it picks up more sediment while eroding the channel (City 1986).

For example, there is a concrete-lined conduit that opens up into the unlined channel near the base of the Sandia Mountains; the concrete blocks laid down to dissipate the energy of the water are unsuccessful in preventing gully erosion. The channel has degraded because the water coming out of the conduit is *sediment-deprived*; thus, the water is capable of picking up more sediment as it comes down the channel.

Not only does erosion degrade the land but also the quality of water as a form of stormwater pollution. Sediment is a medium for transport of other pollutants, including phosphorus, metals, and organic chemicals, such as pesticides which can run off into storm drains leading straight to the Rio Grande untreated. For example, chemical compounds used in construction materials can contaminate the loose soil; if protective measures are not employed, the contaminated soil can be carried off either by wind or water. In addition, sediment also can clog storm drains and cause local flooding.

The best solution for controlling soil losses from construction sites is to prevent it in the beginning. Because the major problem is caused by the clearing of construction sites and road cuts, one obvious method of control is to maintain as much of the original vegetation and topsoil as possible. One method is to revegetate at the same time that the land surface is being stripped by mulching (covering the ground surface with organic debris such as manure, hay, straw, or compost), or even covering it temporarily with matting, netting, or polyethylene sheets (Dunne 1978). Another method is through good site planning that takes advantage of the natural features of the site rather than obliterating them. This method also reduces soil loss and, thus, the problems with sedimentation.

Sediment is not the only form of stormwater pollution. The impervious surfaces from the paving of natural surfaces and the installation of drainage systems influence the water quality of urban runoff because of the contaminants it accumulates. Each time it rains, runoff from streets and arroyos carries with it street litter, grass clippings and leaves from fertilized lawns and gardens, pet wastes, antifreeze, motor oil, and other pollutants from automobile deposits, and detergents, solvents, paint, and other various chemicals people put down the storm drains. Moreover, according to the U.S. Environmental Protection Agency (EPA), runoff pollution has been found to be largely unaffected by frequent street cleaning activities that occurs in both downtown areas and in suburban settings (Tourbier 1994).

The problems with stormwater pollution described above are defined as nonpoint-source pollution, pollution that occurs over a wide area and is usually associated with such land use activities as agricultural cultivation, grazing, forest management practices, and urban runoff. Unlike point-source pollution, whereby pollutants are discharged to natural waters through a pipe or ditch and can be measured and treated at a point, nonpoint-source pollution presents problems to resource managers from the standpoint of processes involved and in developing procedures to eliminate or to minimize impacts (Brooks et al. 1991). According to the National Water Quality Inventory 1988 Report to Congress, urban and suburban stormwater runoff is the single biggest source of water pollution, limiting the full use of one third of the nation's waters (Tourbier 1994).

INTERVENTION MEASURES

The problems of stormwater pollution from urbanization can be a direct result of how cities zone their land-use activities. Today, with rare exception, Euclidean or conventional zoning exists in the cities, villages, and counties of this country which have adopted zoning. Although the history of Euclidean zoning in America spans more than six decades, its promise as an effective land use measure for the implementation of plans has not been fulfilled. Zoning has failed to protect the environment: forests have been felled, floodplains and marshes have been filled (often with serious flooding consequences), and agricultural land has been destroyed.

In the case of Albuquerque, the importance of the arroyos as natural drainage systems has not always been recognized, and in some areas of the city, arroyos have been obliterated by development. Actions of this sort have taught us a very expensive lesson—that arroyos can be eradicated, but stormwater runoff cannot. Millions of public dollars have been spent for underground storm sewers, open channels, and stormwater detention facilities in the areas where the arroyos were destroyed.

The failures of traditional zoning indicate a need to explore alternative ways of regulating land-use development. Intervention measures can be used as an alternative to traditional zoning. Intervention measures exert direct governmental influence on the course of events in the watershed, especially on the way that land and waterways are used. The following section concentrates on how local government can use performance zoning and transfer of development rights to induce public and private watershed users to undertake appropriate physical controls.

Concept of Performance

Regulatory measures are the backbone of almost any land use management program, including most watershed protection programs. In fact, any effort to plan to manage the environment rests on a concept regarding how the environment should perform. When plans are formulated, the objective is either to guide and structure future change in order to avoid undesirable performance and/or to improve performance in an environment, setting, or system whose existing performance is judged to be inadequate.

In watershed management planning, performance goals must be set early in the program. The process of formulating performance goals usually begins with the identification of the riparian areas and the local watershed land users' values, attitudes, and polices as well as the communities and riparian areas downstream. Downstream communities and riparian areas must be included because water flows downhill, and what happens on the land and the effects on the water upstream affects what happens downstream. Furthermore, in setting performance goals, the carrying capacity of the watershed must be considered (Marsh 1991). For example, performance goals based on the "carrying capacity" of the parcel of land, are defined as the amount of development it can support without experiencing irreversible harm to the surrounding land, water, flora, and/or fauna.

Once performance goals have been formulated, performance standards and controls have to be defined. Performance standards are the specific levels of performance that must be met if goals are to be achieved. For instance, to deal with stormwater pollution, many communities have passed ordinances that place stringent performance standards on developers, requiring that post-development runoff peaks not exceed pre-development peaks. This means that the rate of release across the border of a site can be no greater after development than before (Tourbier 1994). Performance controls are the rules and regulations used to enforce the standards and goals. These may be specific ordinances limiting the percentage of impervious surface requirements for site plan review and approval, or incentives such as tax breaks for restoring open space. Controls are necessary because without them the plan has no real "teeth" and thus no regulatory strength (Marsh 1991).

Performance zoning sets standards for acceptable levels of side effects, such as the quantity, velocity, and pollutant level of stormwater runoff, rather than specifying the acceptable uses for the site or the specific design measures that must be taken. Attention is thereby focused on acceptable levels of environmental impact while allowing the market and the developer to determine the appropriate use and the appropriate site measures to meet impact standards. Performance zoning would set standards for each zone rather than setting the list of allowable uses. For example, criteria might address the control of hazardous substances, stormwater runoff, and on-site waste disposal (Burby et al. 1983).

Performance standards, while permitting more flexibility, are more difficult to administer because they require those who review and approve development and those who inspect and enforce development standards to have a good technical grasp on environmental processes and the wide range of runoff control techniques, and to have the ability to exercise good judgment in determining whether a measure is best for a particular piece of land (Burby et al. 1983).

Good Design Through Site Analysis

In reducing the amount of damage to a site before development, performance standards can be applied through good design. Good design begins with an analysis of the natural and environmental assets and liabilities of a site. Variables such as topography, drainage, vegetation, views, amenities, and access should be considered. Performance standards can set the parameters of how and where development may be permitted, rather than a fixed minimum lot size permitted virtually anywhere and everywhere on the site. Generally the designer begins by working with the site analysis to determine areas best suited to certain uses and to develop major circulation routes (Kendig 1980).

An example of using site analysis to determine areas best suited for development in the Bear Canyon watershed is the High Desert Development. This property is located on the northeast side of Albuquerque on an alluvial fan at the base of the western slope of the Sandia Mountains at an elevation of 6,000 to 6,300 feet. When analyzing the High Desert Development site, The High Desert Corporation had engineers analyzing variables such as topography, drainage, and vegetation; they performed an environmental assessment which included overviews and analyses of a variety of physical, biological, and cultural resources.

The fundamental tenet of the plan is the combination of urban development with the preservation and enhancement of the natural arroyos connecting the city to the mountains; thus, all of the major arroyo floodplains and vegetation in them are preserved. In addition, impact on areas of arroyo sideslope greater than 10 percent will be minimized through limitations on building siting, area, and construction methods (High Desert 1993).

Through these actions on High Desert, fully 40 percent of the gross land area (1,000 acres) of the site is protected as public open space, private open space, or lands left in their natural state (High Desert 1993). The result is a site plan that fits the site rather than fights it, still seeking to maximize profits by, for example, providing a mix of dwelling-unit types that results in much the same density as would have resulted from a cookie cutter approach (Kendig 1980).

Good design is also predicated on freedom, flexibility, and creativity. Albuquerque can use performance zoning to require the designer to implement these values. The increased flexibility of performance zoning enables the landowner to work within the constraints of the site and to buffer adjoining uses and roads; it also provides a necessary protection for the welfare of the community without depriving the developer of a profitable return (Kendig 1980).

To determine the siting of major circulation routes, the designer can refine the siting of streets along the ridgelines of a site. Ridgelines tend to slope more gently than the hillsides or valleys, requiring less grading. In addition, by staying on the ridgeline, costly drainage structures can be avoided. Moreover, in most cases following the ridgeline allows a more effective use of the natural drainage system. Finally, from an aesthetic point of view, streets that follow the ridge blend well with the site rather than becoming unsightly scars slashing across the topography. Unfortunately, not all sites have a ridge located in just the right place. In these cases, street corridors should run with or at a diagonal to the contours where slopes in excess of 4 percent are encountered. Running streets perpendicular to the contours usually result in drainage and access problems to the abutting properties. These general rules are not law, but ignoring them without good reason usually leads to grading problems and higher site development cost (Landphair and Motloch 1985).

Site Capacity and Land Use Intensity

Performance standards also can be applied to determine the capacity and intensity of a development site. Current zoning districts within the City provide for the establishment of building setbacks based upon standard dimensions from front, rear, and side property lines as prescribed in the City code. Albuquerque should look at the High Desert Development as an example of specifying developmental limits on a resource-by-resource basis. For example, in order to limit encroachment of buildings into the major arroyos of the site, to respond to site topography, and to preserve existing vegetation, High Desert's residential zones will establish a building envelope. The variables considered in these building envelopes include existing drainages, vegetation, and topography, as well as views to and from adjacent lots. In addition, floor area ratios which limit the size home that can be built on each lot have been established to preserve a balance between the built area and the open area on each site. Moreover, all construction, including all non-native landscaping installations, must take place within the enclosed areas of the envelope, thus preserving the rest of the lot surface in its native state. Outside the envelope, only native plant material can be used, thus enhancing the natural landscape and minimizing the use of irrigation water (High Desert 1993).

Albuquerque should also look at the High Desert Development when establishing stormwater management performance goals. The stormwater management system at High Desert was derived directly from environmental criteria calling for the preservation of the natural landscape of the arroyos and the enhancement of natural vegetation in arroyos. To accomplish these stormwater management goals, the development can be divided into four major land use areas employing different drainage management concepts. These major land use areas consist of varying degrees of intensity ranging from undeveloped open areas to commercial and institutional development.

For example, in the floodplain zone which are those areas that could potentially be inundated in a 100-year storm, separate parcels for public and private use will be set aside for open space and stormwater management purposes; in addition, no development is proposed for the floodplain zones other than recreational uses (High Desert 1993). In the Urban Residential Zones, in contrast, historic flows will be removed from the arroyos. Arroyo flows will be collected in sedimentation basins and conveyed to crossing structures at Tramway Boulevard via major storm drain lines. However, the arroyos will continue to remain in a natural condition and will be enhanced through the use of water harvesting techniques. These techniques collect stormwater from developed area runoff and irrigate the arroyo in order to sustain higher densities of animal and plant life. The High Desert Sector Plan (Volume I, Section 7) contains general descriptions of the various land use areas and their associated drainage management concepts.

Transferable Development Rights: Application of Compensatory Powers

The second general category of governmental powers is the power to pay compensation for property being affected by watershed management. Often referred to as land acquisition or purchase of property rights, compensation enables restrictions on watershed uses and practices that go beyond legal limits of the police power (Burby et al. 1983).

Transfer of development rights (TDRs) allow the acquisition of development rights in environmentally critical parts of the watershed, or conceivably all of the watershed, by the private sector rather than the public. The basic concept underlying TDRs is that ownership of land is a bundle of rights, each of which may be separated from the rest and transferred to someone else. TDR allows transfer of a detachable development right to another piece of land, preferably to a particularly suitable piece of land where development would not be detrimental to the quality of water supply (Burby et al. 1983).

In the TDR approach, the watershed or particularly vulnerable sections of it are designated as restricted development or conservation zones, where use of the land is severely constrained. The landowner there is allowed to sell the unusable development rights to a landowner in a receiving zone designated as suitable for development more dense than would otherwise be allowed by zoning and other land use controls. Development at the increased intensity in the receiving zone requires the developer of that land to have purchased the necessary development rights from a landowner in a conservation zone. The TDR is a hybrid approach combining regulations by which restrictions are placed on the conservation zone land and compensation by which restricted landowners are compensated for loss of their development rights (Burby et al. 1983).

In terms of protecting the natural environment, conventional zoning is not "environmentally sensitive." In other words, a single Euclidean zone may encompass a variety of environmental conditions but there are not provisions for reflecting these variations in the requirements. Performance zoning and TDRs offer an opportunity to structure the pattern of environmentally destructive sprawling subdivisions by protecting vegetation and wildlife. As long as the development does not perform in a manner detrimental to the resource, the land potential for development can be maximized. What needs protection is protected and, conversely, development is permitted to the extent that the land is capable of sustaining the land use (Stockman 1974).

BEST MANAGEMENT PRACTICES

This section provides options to manage stormwater pollution through the use of Best Management Practices (BMPs). BMPs consist of structural, vegetative, or management systems that operators can perform or install to control the discharge of pollutants in stormwater runoff. Residential BMPs can be used to prevent stormwater pollution caused by lawn and garden chemical pollutants. BMPs also are necessary for those cities and their industries required to obtain a National Pollutant Discharge Elimination System (NPDES) permit. This section also describes how a Geographic Information System (GIS) can be used to identify nonpoint source polluters.

Design Principles for Residential Stormwater Pollution Prevention

Urban and suburban landscapes are difficult to imagine as pollution sources. However, with each rain or lawn/garden watering the storm sewer may transport lawn and garden chemical pollutants. Common residential practices may result in runoff which may carry bacteria, nutrients from pet wastes, sediment from eroding areas, and spilled oil, grease, or solvents. The cumulative impact of pollutants from lawn and driveways may be significant (USEPA 1994).

The key to a landscape design that prevents nonpoint source pollution is understanding the site to be designed and the resources to be protected. The EPA recommends six basic landscape design principles that can reduce potential nonpoint-source pollution. The first is to work with the hydrology instead of altering the site. The common resource intensive approach drains wet areas, alters water flow patterns, and irrigates dry areas. However, incorporating site hydrology into the landscape design can meet design objectives while controlling pollution and saving money. The landscape design for a residential property should allow offsite runoff to move across the property without damaging the site or adding pollution to the runoff. Using areas that carry runoff as part of the landscape design integrates the hydrology of the area into the landscape plan. For example, small on-site detention or retention basins and gravel-filled seepage pits can hold water to increase infiltration or slow rapid runoff to a non-erosive rate (USEPA 1994).

The second principle is the use of buffer zones and riparian protection areas. Properly designed and vegetated buffer zones are highly effective in intercepting and filtering pollution in runoff. In protecting critical areas with buffer zones, a mixture of trees, shrubs, and ground cover is a more effective design than one with a single species. If soil conditions are suitable, these buffer zones may operate like a seepage trench (a soil-covered, gravel-filled trench) or Dutch drain (a surface drain that consists of a shallow, gravel-lined trench with curbing and a grate) by improving infiltration and slowing runoff velocity. Most small suburban lots (less than a quarter-acre) cannot accommodate a buffer designed to control pollution from a large drainage but may be sufficient to control on-site runoff (USEPA 1994).

The third principle is to limit impervious areas. Research in urban and suburban watersheds shows that once a watershed exceeds 12 percent imperviousness, stormwater flow and pollutant loadings increase proportionally. On a typical 100 by 75-foot lot with a 2,000-square-foot home, a driveway, and a garage, the site is approximately 33 percent developed. Since roof area generally cannot be reduced, other methods to reduce site imperviousness will help control pollution. For example, nonsolid decking, porous pavements, organic mulch, sand walkways, and crushed gravel within curbing are efficient methods that limit the total impervious surface (USEPA 1994).

The fourth principle is to manage runoff and pollution from impervious surfaces. Driveways, sidewalks, and gutters which drain to well-vegetated areas may assist in the control of nonpoint source pollution. Sloping, crowning, or redirecting water flow to infiltration trenches or improving the soil infiltration capacity may serve to offset the impact of impervious areas (USEPA 1994).

The fifth principle is to select resource efficient plants. A resource efficient landscape should include attractive plants suited to the site requiring minimal fertilizer, pesticides, and irrigation to thrive. Each area of the country has a wealth of resource efficient "native" trees, shrubs, ground cover, grasses, and flowers (USEPA 1994).

The sixth principle is to replace areas of high maintenance with adapted or resource efficient landscape. The largest consumer of water, time, fertilizers, and other resources is a high-maintenance landscape. Research at Texas A&M University in Dallas shows selection of low maintenance plants results in significantly reduced nutrient concentrations in runoff. Portions of the high-maintenance landscape can be replaced with resource efficient ground cover, shrubs, and trees. Establishing native grass and herbaceous flowering plants in a meadow setting is an excellent alternative for high-maintenance landscapes unsuited for shrubs or ground cover (USEPA 1994).

Resource efficient landscapes can be designed to require minimum maintenance and to prevent pollution. Existing landscapes without resource efficient plants can be managed more efficiently to provide protection for water resources. Key management principles to prevent pollution include the following:

- **Manage water efficiently.** Simple methods to conserve water and prevent runoff consider both irrigation quantity and timing.
- **Use mulch.** The infiltration rate in mulched areas is often more than double that of unmulched areas because the mulch intercepts the impact of raindrops and prevents the soil from developing a less permeable crust. Mulch also controls weeds, and therefore reduces the need for herbicides.
- **Manage nutrients wisely.** All plants require nitrogen, phosphorus, potassium, and various micronutrients to grow. The key to water quality protection through proper nutrient management is to test the soil and plants to determine the missing nutrients, select the least mobile form of the nutrient available, and apply the nutrient to coincide with growth

cycles. Avoid applying fertilizer just before rainfall, place fertilizer only when and where it is needed, and avoid overwatering.

- **Begin pest management with plant selection.** Site-adapted and native plants may be more pest resistant than introduced species. A disease or insect problem is best addressed through the least toxic, pest-specific pesticide, selection of the least mobile pesticide with the shortest residual time, and application according to label directions (USEPA 1994).

Industrial Stormwater Pollution Prevention

In November 1990, the EPA issued a final rule to implement Section 402 of the Clean Water Act, federal legislation aimed at preserving the quality of America's waters. The final rule requires cities with populations greater than 100,000 and with separate storm sewer systems to obtain a National Pollutant Discharge Elimination System (NPDES) permit. Cities must apply for this permit to ensure the EPA that their stormwater systems are operating as efficiently and as cleanly as possible. All stormwater discharges associated with industrial activity that discharge through municipal separate storm sewer systems or that discharge directly to waters of the U.S. are required to obtain NPDES permit coverage. Facilities with stormwater discharges associated with industrial activity include: manufacturing facilities; construction operations disturbing 5 or more acres; hazardous waste treatment, storage, or disposal facilities; landfills and certain sewage treatment plants; recycling facilities; powerplants; mining operations; some oil and gas operations; airports; and certain other transportation facilities (Tourbier 1994).

The volume and quality of stormwater discharges associated with industrial activity depend on the following factors: the type of industrial activity, the nature of precipitation, and the degree of site imperviousness. Illicit connections, spills, and other improperly dumped materials may increase the pollutant loads from separate municipal storm sewers. The sources of pollutants in stormwater discharges differ with the type of industry operation and specific facility features. For example, air emissions may be a significant source of pollutants at some facilities, material storage operations at others, and still other facilities may discharge stormwater associated with industrial activity with relatively low levels of pollutants (USEPA 1992).

All facilities covered by current NPDES general permits for stormwater discharges associated with industrial activity must prepare and implement a Storm Water Pollution Prevention Plan (SWPPP). The pollution prevention approach focuses on three major objectives: (1) to identify the sources of pollution potentially affecting the quality of stormwater; (2) to describe and implement practices to minimize stormwater pollutants; and, (3) to comply with the terms and conditions of the permit. The SWPPP requirements direct the operator of the industrial facility to evaluate the potential pollution sources of the site and implement BMPs.

One of the steps that cities must take in filing for an NPDES permit is identifying possible sources of pollutants. The City of Albuquerque currently is identifying vehicle and equipment maintenance facilities; these include ground transportation and rail transportation facilities that have vehicle and equipment maintenance shops such as vehicle and equipment rehabilitation, mechanical repairs, painting, fueling and lubrication and equipment cleaning operations. Upon inspection of the site, they are informing facility operators or owners that they need a NPDES permit. In addition, the City provides a complimentary guidance manual for stormwater pollution prevention which simplifies the process. The City also gives those owners or operators a list of BMPs commonly used at ground transportation facilities to comply with the NPDES permit.

Identifying Nonpoint Source Pollution Using GIS

By definition, nonpoint source pollution is a problem associated with extensive geographic areas. Understanding of the causes and impacts of nonpoint source pollution requires the integration and display of several types of geographic information. A GIS is particularly suited to the task. The GIS approach can assist all municipalities in meeting the stormwater requirements.

The City has identified those facilities mentioned above on a metropolitan wide basis using GIS. A GIS was used to locate land use activities by Standard Industrial Classification codes in the Bear Canyon watershed which are required to have a

NPDES permit. Those activities located will be required to implement as many as eight EPA recommended BMPs. A GIS also was used to identify land use activities that are not required to obtain a NPDES permit but could potentially contribute to stormwater pollution. For those land-use activities such as auto repair shops and photo developing labs which are not required to have permits, the City can recommend *traditional stormwater management practices* that contain, control, direct, and/or treat stormwater runoff.

Although this permit application is only required for cities with populations larger than 100,000, all other cities, towns, and counties should be aware of the problems caused by nonpoint source pollution. Local rivers and streams often receive pollutants that can damage the water quality of any size town. The government is doing what it can to decrease water quality problems, but it is largely up to the people of our country to tackle nonpoint source pollution. Municipalities now have an opportunity to formulate an approach enabling stormwater management to function as a tool to help structure growth.

CONCLUSION

With growth must come sustainable development, which implies that we maintain natural systems without impairing their capability for self renewal. Stormwater is an essential component of the water cycle, and management practices should ensure that natural processes are being maintained (Tourbier 1994). In a planning and management program aimed at water quality, basically two approaches may be employed: preventive and corrective. The corrective approach is used to address an unsatisfactory condition that has already developed. The strategies discussed, such as performance standards and best management practices, are preventive approaches which involve limiting or reducing the contributions of nutrients and other pollutants from the watershed by controlling on-site sources of pollution and limiting the transport of those pollutants from the watershed to the river. To be effective and sustainable, we must take a more holistic approach to future water policy decisions by taking into account the impacts of water and land use upon water quality.

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