Emergency Services and Storm Water Management

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Many communities are interested in reducing environmental impacts of storm water by changing local infrastructure. They recognize the importance of accomplishing this without compromising essential community services such as fire safety. To identify the needs of emergency service (ES) personnel (primarily fire marshals) and the constraints city/county planners, elected and other municipal officials face when making land-use decisions related to storm water management, we convened two focus groups and organized personal interviews with representatives of these groups in both Northern and Southern California. The purpose of this fact sheet is to help communities address storm water runoff problems while maintaining excellent public health and safety services. The main findings from our work are summarized, highlighting the benefits and drawbacks of alternative site designs for storm water management from the perspectives of ES personnel, planners and municipal officials.


Craig Allyn Rose, City of San José Fire Department

Emergency Safety Needs

- Easy/quick access to buildings
- Maneuverability
- Structural integrity of access ways
- Quick access to hoses and equipment

Environmental Impact of Storm Water and LID

Urban storm water runoff is the predominant cause of water quality decline and erosion/sedimentation in streams, lakes and estuaries (Arnold & Gibbons, 1996; USEPA, 1996). Toxic materials found in storm water such as heavy metals, nutrients, pesticides and pathogens can degrade the environment and impact human health (Booth & Jackson, 1997; Pitt, Clark & Field, 1999). A key factor contributing to the contamination and flow of storm water runoff is hardscape or impervious surface areas, such as roads, parking lots and rooftops (Arnold & Gibbons, 1996; Schueler, 1994).

The United States Environmental Protection Agency (U.S. EPA) and state regulatory agencies are requiring a reduction in both the volume and rate of urban runoff. Communities interested in reducing storm water runoff by limiting expansive development are using "Smart Growth" strategies, which are often used to protect sensitive areas, reduce hardscape by encouraging redevelopment and higher population densities, and encourage walkability and bike ridership through narrower street widths (USEPA, 2004). Another way to achieve a reduction in urban runoff is by directing it to pervious surfaces (such as porous asphalt and cement), infiltration landscape areas (such as biorention basins, rain gardens and swales, which treat storm water by allowing it to percolate into the ground), wetland ponds and green roofs (Stoner, Kloss & Calarusse, 2006).

Collectively, these strategies are often called Better Site Design or Low Impact Development (LID). Some of these new storm water management strategies potentially conflict with essential public health and safety services that communities provide including: waste management, public transportation, flood fighting, fire fighting and other emergency services (Ewing, Stevens & Brown, 2007). Changing community design and development practices to accommodate new storm water management systems provides challenges and opportunities for ES providers and government officials.

Concerns of Emergency Service Professionals

ES professionals are understandably wary of alternative approaches to storm water treatment that may affect their professional responsibilities. Site design features that cause the greatest amount of concern include: narrow streets, pervious surfaces and bioretention basins. The overriding concerns about these features expressed by ES professionals are limitations to access, maneuverability, structural support for vehicles, and maintenance of infiltration areas. Any of these factors may hinder access in an emergency situation or affect response time.

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Narrow Streets

Benefits: Reduced amount of impervious surface area, reduced storm water runoff, more intimate community character, better walkability, slower traffic, safer for children to play.

Drawbacks: Reduced maneuverability, potential for delay in response time to emergencies.

Residential street design professionals believe residential streets have a greater function than providing access, street parking and conveyance of traffic. They suggest that traffic in residential areas should be minimized to reduce noise and accommodate bicycle and pedestrian traffic. Residential streets can provide a sense of space and community, and often function as meeting places for neighbors and play areas for children. Street widths should be based on the neighborhood function while providing for suitable access in emergency situations. They contend that 24–26 foot-wide streets, are suitable for most local streets and can include parking on both sides (Kulash, 2001).

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The International Fire Code (IFC) guidelines (California Building Standards Commission, 2007) adopted by the state of California recommend a minimum of 20-foot wide streets with no parking[1]. This allows enough room for two trucks to pass each other or one truck to get around another at the emergency scene. The IFC also allows exceptions to their guidelines[2] if the alternative follows the "intent of the provisions of the codes and are at least equivalent of that prescribed in quality, strength, effectiveness, fire resistance, durability and safety." Generally, jurisdictions require wider lanes than the minimum IFC guidelines to allow traffic maneuverability and access for services.

Typically, a two-lane highway will have a minimum of 12-foot (24 feet total) travel lanes (Cheu, 2006). There is not a clear requirement for parking lane widths in California's codes; however, most jurisdictions use 8 feet for parking and 15 feet if the lane is to be used for both parking and biking (7 feet for parking spaces and 8 feet for the bike lane). Parking areas are designed to accommodate the size of the vehicle and enough room for door opening and maneuvering, although the size may vary according to the traffic function and flow in an area. On a busy street, for example, widths for maneuverability and safe access are greater than on a quiet residential street.

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Reducing Fire Engine Size

Benefits: Greater maneuverability, ability to access narrower streets, and tight turning radius.

Drawbacks: Reduced pumping capacity (less water available to fight a large blaze), may not be able to carry all the equipment needed in an emergency.

There are two main factors that determine fire engine size: storage and pumping capacity. Since fire safety personnel are first responders to many situations where there are risks to public health and safety, fire engines are "rolling tool boxes" storing a large amount of equipment. The primary factor that determines the width of the fire engine is the engine size and the water pump it drives. Fire engines in the United States have large pumps capable of delivering 1,250–2,000 gallons per minute. To maximize the energy transfer from the engine through the transmission and into the pump, the pump is placed directly behind the transmission. The location of the pump dictates that the pumping station and the operator needs to be positioned on the side of the truck directly behind the cab (Potter, 2008). The fire engine length is a factor of the size of the cab, the pump, and the equipment storage area (for hoses and other tools and supplies).

Recently, the width of most fire engines increased from 96 inches (8 feet) to a maximum of 102 inches (8.5 feet). This resulted from new clean air regulations on diesel emissions that required engines to burn hotter to reduce particulate matter. To deal with the excess heat needed for complete combustion, trucks have larger engines (300–500 hp) and cooling systems. Since the size of the engine and radiator affect truck width, cleaner burning trucks, with larger, hotter engines and bigger cooling systems, are wider. New trucks are built to the maximum allowable width, and with mirrors adding 10 inches to both sides the total permissible truck width is 122 inches (10 feet, 2 inches).

[1] IFC 503.2.2 Fire Apparatus Access Roads Specifications—Dimensions

[2] IFC 104.9 Alternative Materials and Methods

A Swiss fire apparatus with pumping station in the rear and compact design for maneuverability and access of narrow streets.

Innovative Neighborhood Design

In Davis, California, the Village Homes community, built in 1975, is an example of innovative neighborhood design. To instill community character and minimize impervious cover, the streets are curvy, only 18–24 feet wide without on-street parking (off-street parking is allowed), and end in cul-de-sacs. Three fires have occurred in this development and the city has benefited from the valuable lessons they provided. The curvy streets can be problematic when fire hoses are charged since hoses tend to straighten and not follow the curvature of the street. This and the lack of on-street connectivity (due to cul-de-sacs) can restrict access to other emergency personnel after water is delivered to the fire. If a development similar to Village Homes were proposed today the design would look substantially different. Currently local officials try to work with developers to meet the goals of the community. Any new development is reviewed on a case-by-case basis. Twenty four-foot wide streets with parking on one side and 16-foot streets without parking may be acceptable with inter-connecting streets (without cul-de-sacs). This flexible approach in Davis is a good model for finding a balance in meeting environmental concerns and emergency service requirements.

Smaller Trucks

Some proponents of narrower streets suggest that smaller trucks would resolve the concerns presented by emergency service professionals (Ewing, et al., 2007). They argue that in European cities, where narrow streets are common, smaller fire engines are used. Newer U.S. trucks have already adopted some of the common features from the European design, such as roll-up doors for quick and easy access in confined areas. The main difference between European and U.S. fire apparatus is the location of the pump. European fire engines use a power take-off system with the pump located in the rear of the truck, allowing fire fighters to work the pump from the back end, a necessity on narrower streets. Energy transfer between the engine and the pump at the rear of the truck results in a 30% energy loss, substantially reducing the pumping capacity. European fire engines typically have a pumping capacity of around 1,600 liters per minute (413 gallons/minute), well below the U.S. standard. It would take three to four European fire engines to match the pumping capacity of one U.S. fire engine (Potter, 2008).

The length of a fire engine is also a concern since it affects maneuverability. The turning radius, which varies between vehicles, is based on wheelbase, steering gear geometry, axle placement and other factors. Many communities use single axle trucks less than 30 feet in length, which generally have a shorter turning radius. There is a trend toward using commercial chassis, including greater use of foreign chassis, on which to mount fire apparatus body work. Likely, this trend will result in shorter wheelbase trucks and U.S. apparatus will resemble European designs to a greater degree (Calderone, 2005).

Village Homes Community

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Low Impact Development Principles

Infiltration of storm water • More permeable surfaces
Less hardscape • Narrower streets

Pervious Pavement

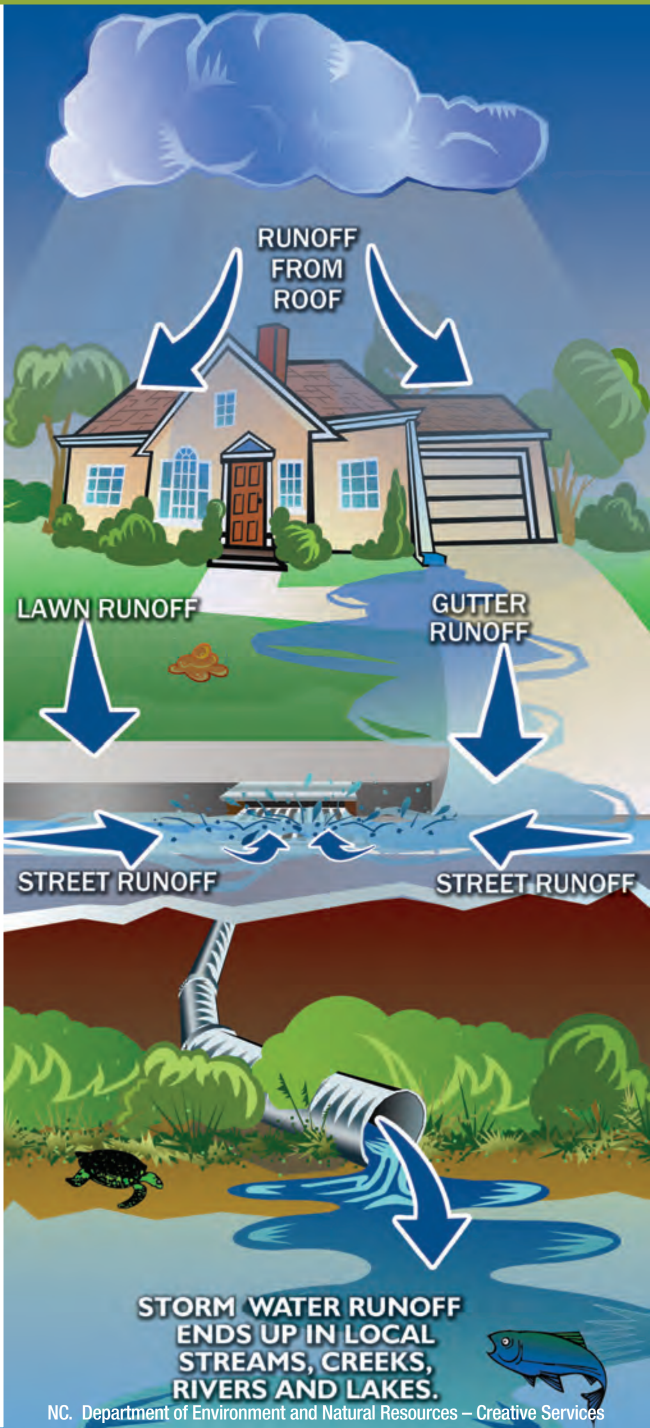
Benefits: Allows storm water to infiltrate into the ground, reduces flooding, helps save trees, can improve stopping ability of vehicles, and may sequester carbon thereby reducing greenhouse gases.

Drawbacks: More rustic looking, requires maintenance (vacuum/sweeping), can unravel, and currently difficult to find qualified contractors to install.

The use of pervious cement and asphalt concrete for infiltration can substantially reduce the storm water runoff from streets, parking lots and driveways. ES professionals expressed concern about the structural integrity of these surfaces when used in public access ways. The 2007 California Fire Code[3] states that access roads should be of asphalt, concrete, or other approved driving surface capable of supporting a truck weighing at least 75,000 pounds. California allows fire engines to have a single axle weight of 23,000 pounds on the steering axle (2 tires/steering axle) and 24,000 on the drive axle. Tandem axles can be up to 48,000 pounds and tridem axles up to 54,000 pounds[4]. All fire engine drive axles have dual tires (4 total/axle), so each steering tire can support up to 13,500 pounds (54,000 ÷ 4).

Another key area of concern for ES providers is the braking ability of vehicles on different surfaces. ES vehicles need to be able to make "panic stops," and skid resistance properties are important. Pervious overlays are often used to enhance highway safety and traffic flow. Tests show that porous asphalt maintains tire friction in both wet and dry weather conditions. Pervious pavement meets or exceeds the friction value for grooved, dense concrete and exceeds dense asphalt by a factor of four in wet conditions (Ferguson, 2005). These are important considerations that may provide an extra benefit for using pervious concrete. Based on these data, it does not appear that properly installed pervious concrete is an impediment to emergency service.

[3] D102.1 Required Access–Access and loading
[4] CFR Title 21 (Public Works)–Division 2 (DOT)–Chapter 7 (Transport Permits–1411.7 (fire engines)



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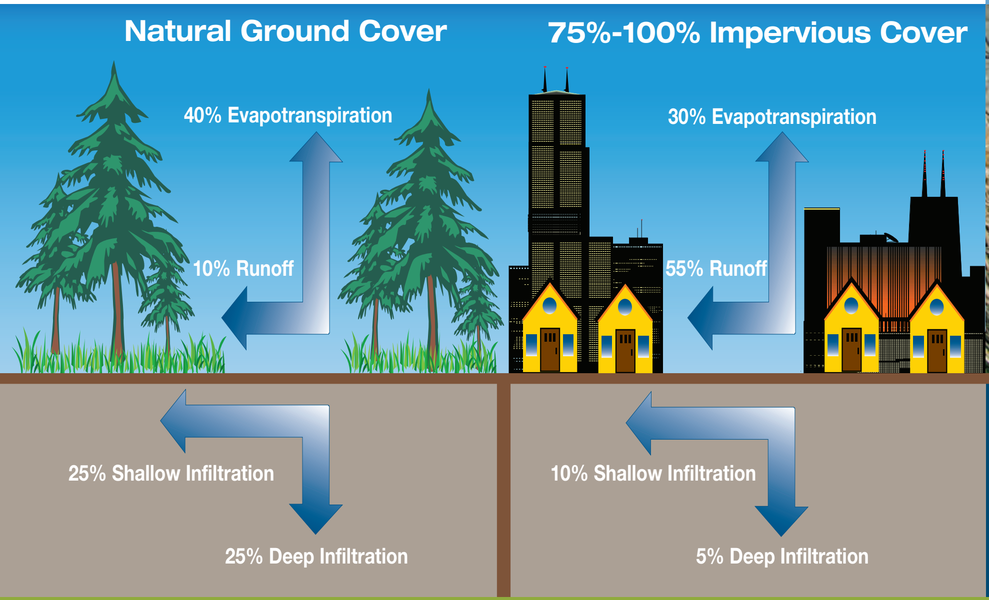


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Relationship between impervious cover and surface runoff. Impervious cover in a watershed results in increased surface runoff. As little as 10% impervious cover in a watershed can result in stream degradation.

Porous concrete in Santa Monica, CA allows access and infiltration.

Gravel infiltration trenches within a subdivision in Davis, CA.

Infiltration Systems

Benefits: Storm water infiltration, provides attractive green features.

Drawbacks: Maintenance requirement, need for structural support along the edges.

Landscape infiltration areas improve the aesthetics of a community and help slow traffic in residential areas. These areas usually are not a cause of major concern to ES providers as long as they are placed in areas away from fire access lanes and intersections and conform to rules governing access way requirements. When located along street shoulders, they should be properly maintained and adequately marked with a defined edge, which allows inflow of storm water but provides a visual or structural traffic barrier. Some jurisdictions define the edge of the street with a mountable curb or concrete edge that clearly delineates the edge of the street. Installing easily recognizable demarcation or "access safe" signage, and incorporating this into ES training, may help lessen problems and win approval of these systems. Developing a universal standard that is incorporated into firefighter-training programs should be a part of alternative storm water implementation programs.

Weight Distribution of Emergency Vehicles on Porous Concrete

Porous concrete mixtures are suitable for a wide range of applications. Mixtures can develop compressive strength between 500–4,000 pounds per square inch (psi), with typical values of 2,500 psi. The general rule for porous pavement to handle occasional truck traffic is 6 inches of base (compacted to 95%) and 6 inches of concrete with an average pore space of 15–20%. Determining the support capability of any surface is based on the displacement of the weight over the surface area in direct contact with the vehicle tires. The contact surface area can vary by tire size, brand and inflation pressure. An example of the weight distribution of a fire engine in psi for a tire commonly found on fire engines is the Goodyear G286 12R22.5. Inflated to 90 psi, the average surface area of tire contact is 95 in^2 (613 cm^2)[5]. The weight displacement for each tire, if the maximum allowable load on a steering axle is 12,500 pounds or 357.14 psi, gives a 7-fold safety factor for a typical pervious concrete pavement rated at 2,500 psi.

[5] Source–Goodyear Tire, Inc.

Runoff from the rooftop, driveway and paths in this suburban home in Contra Costa County are directed into a beautifully landscaped bioretention area.

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Even in this highly urbanized area of Emeryville, downspouts are directed into landscaped areas.

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Conclusions

Local jurisdictions face a difficult situation when addressing storm water runoff requirements and ES needs. The appropriate balance requires open and early dialog with local ES providers. It also requires all parties to have an understanding of the issues and concerns other departments face in meeting storm water reduction objectives. The information provided here may be helpful when finding resolution in roadway sizing, use of alternative surface materials and infiltration basins. There is no one-size-fits-all solution; it is up to each community to determine the best approach based on their individual circumstances.

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In an emergency situation, whether responding to a fire, life threatening traffic accident, chemical spill, medical emergency, or natural disaster, time is of critical importance. Quick response and adequate access are necessary to protect public health and safety, and to minimize property damage. In the long term, protection of the environment and water quality are important considerations. Through the use of innovative approaches and community design, it is possible to achieve both objectives.

Acknowledgements:

We thank the fire, planning, storm water and engineering department personnel who participated in the focus group events and Cris Johnson who recorded the dialogues. Susan Zaleski from USC Sea Grant, Jessica D'Ambrosio from Ohio NEMO, Kathleen Van Velsor from ABAG, and Eileen Keenan from NY Sea Grant graciously reviewed this document.

This project was supported by the National Sea Grant College Program of the U.S. Department of Commerce's National Oceanic and Atmospheric Administration under NOAA Grant #NA08OAR4170669, project number A/AE-1, through the California Sea Grant College Program. The views expressed herein do not necessarily reflect the views of any of those organizations.