SOURCE WATER PROTECTION GUIDELINES

APPENDIX A

SUPPLEMENTAL INFORMATION ON PROJECT DESIGN BMPS

This Appendix provides narrative explanations to accompany Decision Guide A: Project Design BMPs. In addition, the Internet links to BMPs provided in this appendix are provided as reference material for the user. Although this appendix supplies a number of possible approaches to designing your project to better manage runoff, the contents do not represent an exhaustive information search. The project applicant is encouraged to further research appropriate water quality management approaches beyond those presented here.

The inclusion of any vendor-supplied BMPs, instruments, equipment, systems, and/or materials does not constitute an endorsement by the San Diego Water Department.

Decision Guide A – Supporting Information

PROJECT DESIGN CONSIDERATIONS

The overall objective of project design considerations is to minimize the increase in the project's runoff volume (as compared to pre-development conditions). Reducing the amount of runoff required to be captured and infiltrated and/or treated may be achieved by applying the following design philosophies during the planning and design stage of development:

- Manage Impervious Areas
- Minimize Direct Connection of Impervious Areas
- Incorporate Zero Discharge Areas
- Include Self-Treatment Areas
- Maximize Runoff-Reduction Areas

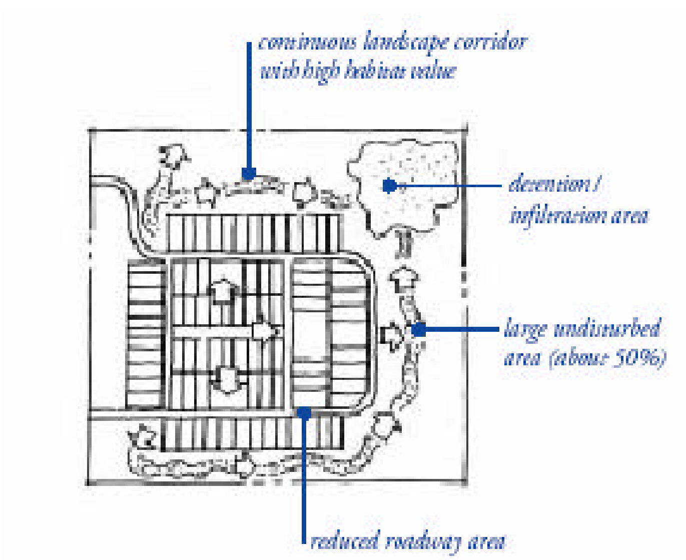
These storm water management techniques are sometimes referred to as low impact development, or LID, practices. An overview of LID practices is presented below.

More detailed information regarding project design considerations and LID may be found on the following websites:

- http://www.lowimpactdevelopment.org
- http://www.ci.san-jose.ca.us/planning/sjplan/counter/stormwater/startatsource.pdf

Manage Impervious Areas

Impervious areas are any surfaces that do not readily absorb water and that impede the natural infiltration of water into the soil. Common examples include roofs, concrete or asphalt streets, driveways, parking areas, sidewalks, patios, and decks. Extensive research by the Center for Watershed Protection has found that increased percentage of paved surfaces and rooftops (or impervious cover) in a watershed results in increased non-point source pollution that degrades the water quality of streams and other water bodies.



Source: http://www.scvurppp-w2k.com/basmaa_satsm.htm

Management strategies for minimizing the total amount of impervious surface in a new development include:

- Setting aside open space and sensitive resource areas
- Considering designs that minimize land conversion (e.g., clustering)
- Limiting road widths, parking lot and driveway areas spaces
- Using permeable materials for surfaces such as bicycle paths, parking spaces, pedestrian areas

Minimize Direct Connection of Impervious Areas

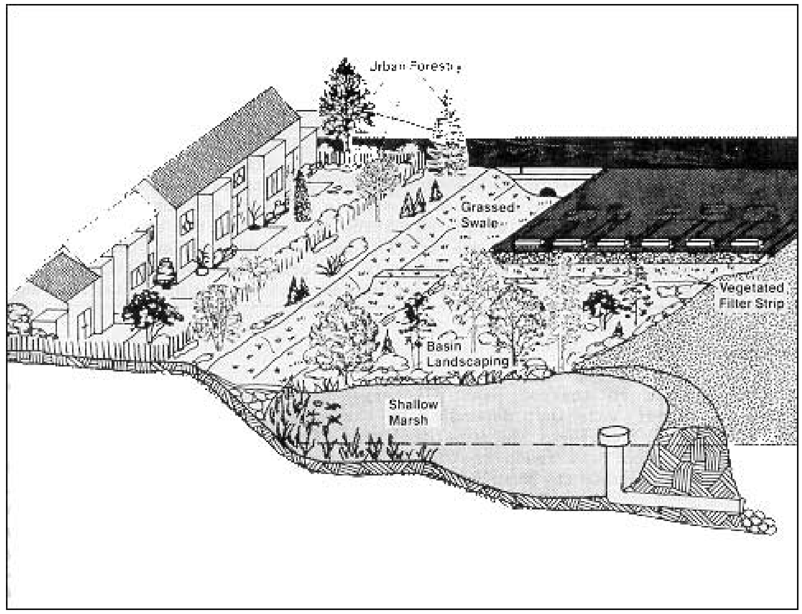
Any impervious surface that drains into a catch basin, area drain, or other conveyance structure is a "directly connected impervious area" (DCIA). Directly connected impervious areas (DCIA) are the impervious areas such as roofs and paving that drain directly to the street drainage system in an urban area. As storm water runoff flows across parking lots, roadways, and paved areas, the oils, metals, sediments, and other pollutants are picked up in the flow. In addition, the volume and velocity of the flow tend to increase, requiring larger capacity storm drain systems, and increasing flood and erosion potential. Minimization of DCIAs is considered to be one of the most effective methods of storm water quality and discharge control available. The benefits of reducing DCIAs include reduced storm water peak discharge rates and volumes, improved water quality by increased filtration through vegetation and reduced erosion, and enhanced groundwater recharge by maximizing infiltration.

Source: http://www.ecocreto.com/default2.htm

Strategies for minimizing DCIAs focus on limiting overall impervious surface coverage and/or directing runoff from impervious areas to pervious areas for infiltration, retention/detention, or filtration. This can be achieved using strategies such as:

- Taller, narrower buildings rather than lower spreading ones
- Sod or vegetative "green roofs" rather than conventional roofing materials
- Pervious pavement for light duty roads, parking lots and pathways
- Vegetated swales
- Vegetated basins (ephemeral- seasonally wet)
- Constructed ponds and lakes (permanent- always wet)
- Crushed stone reservoir base rock under pavements or in sumps
- Cisterns and tanks to capture roof drainage

- Infiltration basins
- Drainage trenches
- Dry wells

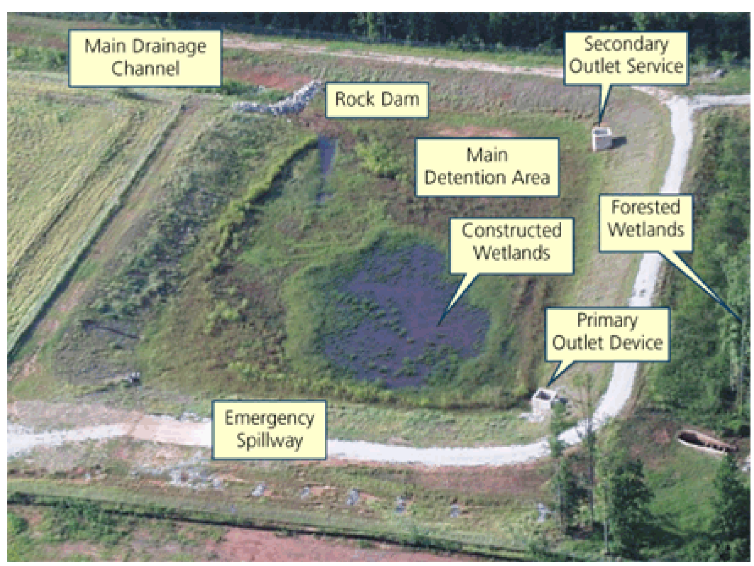


Source: http://www.cmhc-schl.gc.ca/en/imquaf/himu/wacon/images/Image9.jpg)

Unlike conveyance storm drain systems that convey water beneath the surface and work independently of surface topography, a drainage system for storm water infiltration can work with natural landforms and land uses to become a major design element of a site plan. Solutions that reduce DCIA prevent runoff, detain or retain surface water, attenuate peak runoff rates, benefit water quality and convey storm water. Site plans that apply storm water management techniques use the natural topography to suggest the drainage system, pathway alignments, optimum locations for parks and play areas, and the most advantageous locations for building sites. In this way, the natural landforms help to generate an aesthetically pleasing urban form integrated with the natural features of the site.

Incorporate Zero-Discharge Areas

An area within a development or redevelopment project can be designed to completely infiltrate or retain the volume of runoff requiring treatment from that area. In such a case, the term “zero discharge” applies at storm water treatment design storm volumes.



Source: http://www.forester.net/sw_0106_north.html

“Zero discharge” areas such as wet ponds, retention ponds, and infiltration areas can be designed to provide treatment over and above the storm volume captured and infiltrated. For example, after a wet pond area has captured its required storm volume, additional storm volume may be treated via settling prior to discharge from the pond. In this case, the "zero discharge" area converts automatically into a treatment device for runoff from other areas, providing settling for storm volumes beyond treatment requirements. Another example is a grassy infiltration area that converts into a treatment swale after infiltrating its area-required treatment volume. The grassy infiltration area in this example becomes a treatment swale for another area within the development.

Site design strategies for zero-discharge areas include:

- Retention/Detention Pondshttp://www.ecocreto.com/default2.htm
- Wet Ponds
- Infiltration Areas
- Large Fountains
- Retention Rooftops
- Green roofs

Infiltration areas, ponds, fountains, and green/blue roofs can provide "dual use" functionality as storm water retention measures and development amenities. Retention ponds and infiltration areas can double as playing fields or parks. Wet ponds and infiltration areas can serve dual roles when meeting landscaping requirements, such as creating habitat, creating active or passive recreation, and improving aesthetics.

Include Self-Treatment Areas

Developed areas may provide "self-treatment" of runoff if they are properly designed and drained. Self-treating site design strategies include:

- Conserved Natural Spaces
- Large Landscaped Areas (including parks and lawns)
- Grass/Vegetated Swales
- Turf Block Paving Areas

Example of Turf Block
Source:
http://www.nscc.govt.nz/Waterinfo/stormwater/swenviro-f.htm

The infiltration and bio-treatment inherent to such areas provides the treatment control necessary. These areas therefore act as their own BMP, and no additional BMPs to treat runoff should be required. Site drainage designs must direct runoff from self-treating areas away from other areas of the site that require treatment of runoff. Otherwise, the volume from the self-treating area will only add to the volume requiring treatment from the impervious area. Likewise under this philosophy, self-treating areas receiving runoff from treatment-required areas would no longer be considered self-treating, but rather would be considered as the BMP in place to treat that runoff. These areas could remain as self-treating, or partially self-treating areas, if adequately sized to handle the excess runoff addition.

Maximize Runoff-Reduction Areas

Using alternative surfaces with a lower runoff coefficient helps reduce runoff from developed areas. The runoff coefficient is a representation of a surface's ability to produce runoff. Surfaces that produce higher volumes of runoff are represented by higher runoff coefficients, such as paved surfaces. Surfaces that produce smaller volumes of runoff are represented by lower runoff coefficients, such as landscaped areas. See Appendix B for the various runoff coefficients in San Diego County. By incorporating more pervious, lower runoff coefficient surfaces into a development, lower volumes of runoff are produced. Lower volumes and rates of runoff translate directly to lower treatment requirements and smaller size treatment control facilities.

Site design strategies may be used to reduce the runoff coefficient of a developed area, reducing the amount of runoff requiring treatment, including:

- Pervious Concrete
- Pervious Asphalt
- Turf Block
- Brick (un-grouted)
- Natural Stone
- Concrete Unit Pavers
- Crushed Aggregate
- Cobbles
- Wood Mulch

Example of Porous Paving
Source: http://www.nscc.govt.nz/Waterinfo/stormwater/swenviro-f.htm

Other site design techniques such as disconnecting impervious areas, preservation of natural areas, and designing concave medians may be used to reduce the overall runoff coefficient of new development sites.

SOURCE WATER PROTECTION GUIDELINES

APPENDIX B

SUPPLEMENTAL INFORMATION ON SOURCE CONTROL BMPS

This Appendix provides narrative explanations to accompany Decision Guide B: Source Control BMPs. In addition, the Internet links to BMPs provided in this appendix are provided as reference material for the user. Although this appendix supplies a number of possible approaches to designing your project to better manage runoff, the contents do not represent an exhaustive information search. The project applicant is encouraged to further research appropriate water quality management approaches beyond those presented here.

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Decision Guide B – Supporting Information

SOURCE CONTROL BMPS

The overall objective of source controls is to minimize the exposure and introduction of pollutants in urban runoff (storm water and dry-weather runoff).

Prevent Runoff Contact

The best source control is to keep runoff from contacting pollutants in the first place. Strategies for preventing contact between runoff and potential pollutants include: proper containment measures, spill prevention and cleanup, waste reduction, public education, illegal dumping controls, and illicit connection controls. These methods, which can result in significant water quality benefits, prevent pollutants from coming into contact with storm water and dry-weather runoff in a cost effective manner.

Example of Secondary Containment
Source: http://www.interstateproducts.com/fuel_containment.htm

Secondary containment is a means of surrounding storage containers to collect chemicals or other fluids that may be released in the event a spill or leak. Examples of secondary containment include dikes or berms, curbing, drainage systems, or sumps. Berms and curbing create a physical barrier between the chemical storage area and a possible runoff area. Drainage systems and sumps provide a means of collecting and transporting runoff or spills to a more appropriate site.

Another method of preventing runoff from outside storage areas from entering the storm water collection system is to prevent rain from entering the storage area. Overhead coverages and roofs serve this purpose. Permanent structures such as galvanized metal roofs or temporary tents are examples of overhead structures.

Minimize Sources of Potential Pollutants

Alternatives currently exist for most products including chemical fertilizers, pesticides, cleaning solutions, janitorial chemicals, automotive and paint products, and consumables (batteries, fluorescent lamps). The use of these alternatives is encouraged as a pollution prevention measure.

Key to the prevention of all environmental degradation and pollution is promoting efficient and safe housekeeping practices (storage, use, and cleanup), while responsibly managing potentially harmful materials like fertilizers, pesticides, cleaning solutions, paint products, automotive products, and swimming pool chemicals.

Minimize Dry-Weather Flows

Dry-weather flows are discharges of runoff that originate from sources other than storm events. They may include natural sources such as springs, but in urbanized areas they often result from human activities such as excessive irrigation, car washing, and hosing off of pavement. These flows often contain high concentrations of pollutants such as nutrients (from lawn fertilizers), detergents (from car washing), and organics (e.g., pesticide). Some strategies for minimizing dry weather flows include:

- Installing automatic shutoff valves on irrigation systems
- Planting drought-tolerant plants that require less water (e.g., native plants)
- Directing car wash water onto vegetated areas where it can infiltrate, or collect and re-use it

Drought Tolerant
Concha California Lilac
Source:
http://www.bewaterwise.com/gardensoft/plant_description.aspx?PlantID=1368

SOURCE WATER PROTECTION GUIDELINES

APPENDIX C

SUPPLEMENTAL INFORMATION ON TREATMENT CONTROL BMPS

This Appendix provides narrative explanations to accompany Decision Guide C: Treatment Control BMPs. In addition, the Internet links to BMPs provided in this appendix are provided as reference material for the user. Although this appendix supplies a number of possible approaches to designing your project to better treat runoff, the contents do not represent an exhaustive information search. The project applicant is encouraged to further research appropriate water quality management approaches beyond those presented here.

The inclusion of any vendor-supplied BMPs, instruments, equipment, systems, and/or materials does not constitute an endorsement by the San Diego Water Department.

Be aware that most structural BMPs or other control devices that are used to divert, treat, or store storm water runoff may require some degree of engineering design or understanding for proper implementation, operation, and maintenance.

Refer to the Treatment BMP Technologies Matrix presented earlier for the applicability and typical uses of the structural BMPs referenced.

Decision Guide C & Treatment BMP Effectiveness Matrix – Supporting Information

FILTRATION SYSTEMS

Media filtration devices usually consist of a settling basin as a pretreatment component of the BMP to all gross pollutant capture and heavy-sediment settling before filtration through a filter. Sand filters are usually two-chambered stormwater treatment practices; the first chamber is for settling, and the second is a filter bed filled with sand or another filtering media. As stormwater flows into the first chamber, large particles settle out, and the finer particles and other pollutants are removed as stormwater flows through filtering media. There are several modifications of the basic sand filter design, including the Austin or surface sand filter, underground sand filter, Delaware or perimeter sand filter, organic media filter, and the Multi-Chamber Treatment Train (MCTT). All of these filtering practices operate on the same basic principle. Designers need to carefully consider conditions at the site level before using a sand or organic filter, and should incorporate design features to improve the longevity and performance, as well as minimizing their maintenance burden (http://www.stormwatercenter.net).

Sand Filters

Types of Sand Filters:

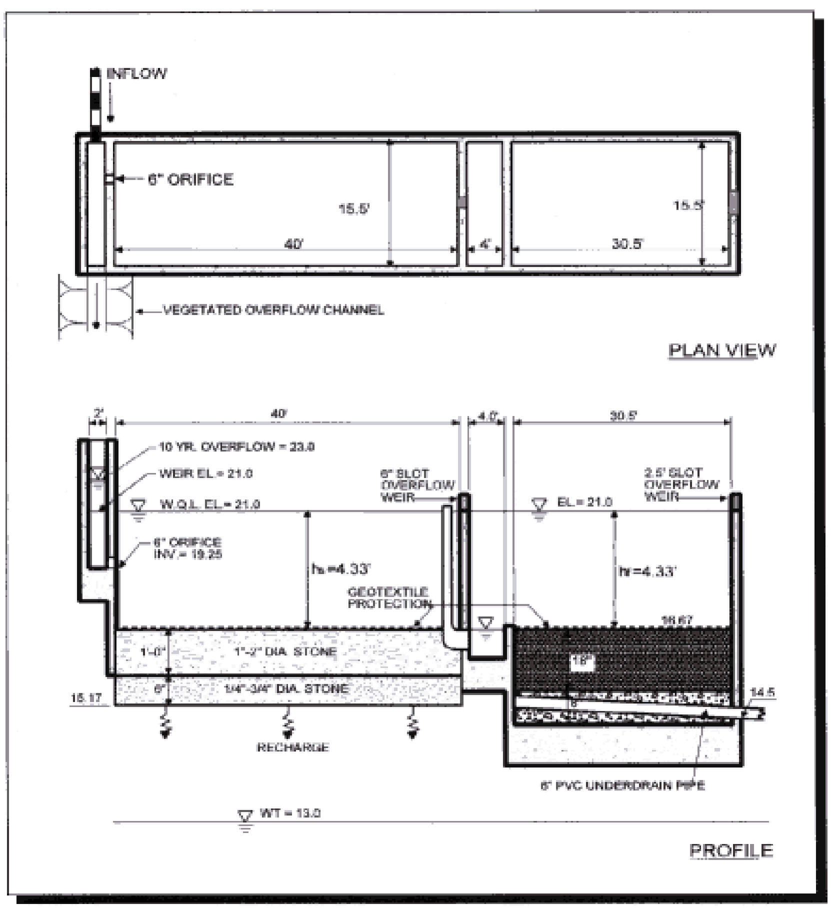
Austin – Field research done in Austin, Texas found that sand filters have a removal efficiency of suspended solids that is comparable to wet ponds and extended detention.

Delaware – For small catchments of a few acres, the underground "linear" filter used in Delaware is suitable.

Washington, D.C. This underground design accepts concentrated flow and utilizes a wet vault or water quality inlet as the pretreatment device.

Sources of Information:
http://www.cabmphandbooks.com/Documents/Development/TC-6.pdf

http://www.stormwatercenter.net

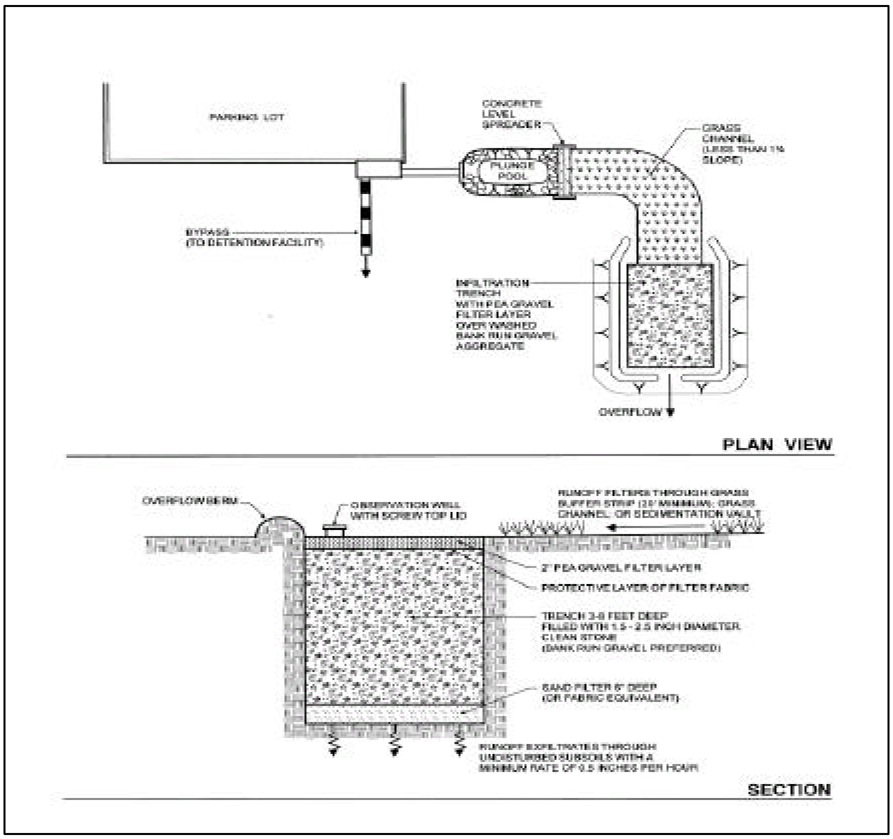


INFILTRATION SYSTEMS

BMPs that use infiltration properties require careful consideration when proposing candidate sites for implementation. These BMPs, which may rely on the filtering properties of gravel-filled trenches or vaults, wide grassy buffer strips, catchment basins, porous pavement, dry wells, and concrete grids must ultimately consider subsurface soils geology for percolation. In clay-rich soils, these BMPs perform less effectively than in areas where fast-draining, sandy soils reside. However, the infiltration of pollutant-laden runoff into subsurface soils can threaten groundwater quality in areas where the groundwater table is shallow. There are also strict regulations governing the siting of these types of units, the types of flow they can accept and treat, and design characteristics.

Infiltration Trench

An infiltration trench is a long, narrow, rock-filled trench with no outlet that receives storm water runoff. Runoff is stored in the void space between the stones and infiltrates through the bottom and into the soil matrix. Infiltration trenches perform well for removal of fine sediment and associated pollutants. Pretreatment using buffer strips, swales, or detention basins is important for limiting amounts of coarse sediment entering the trench which can clog and render the trench ineffective.

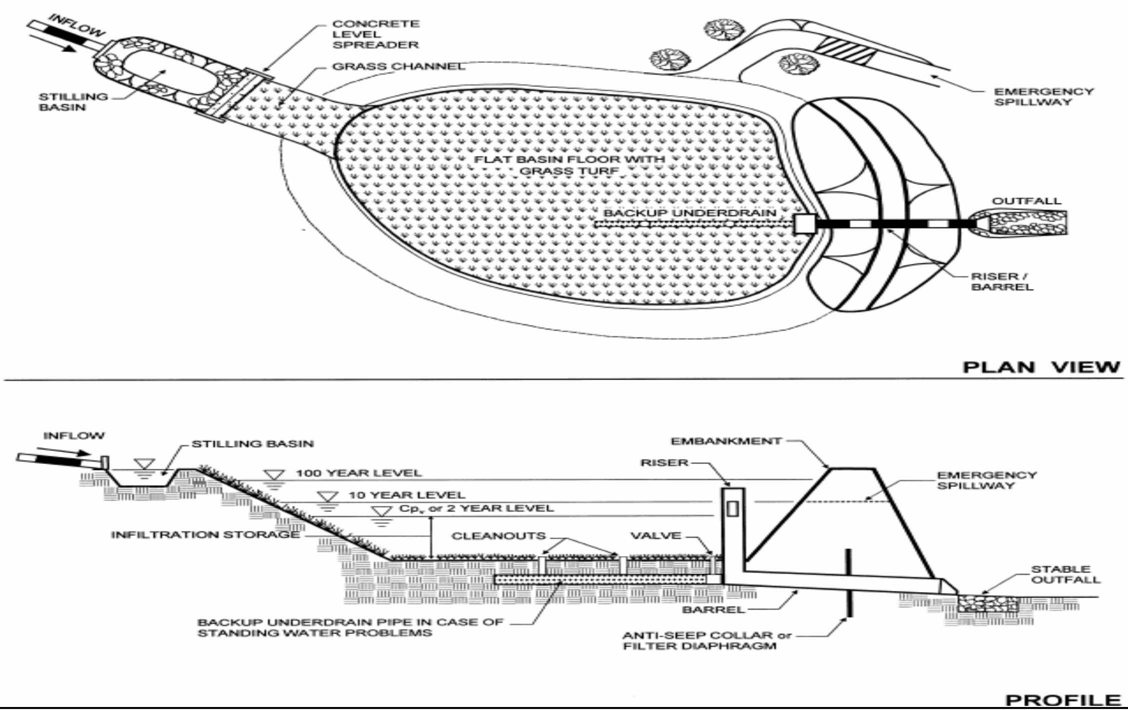


Sources of Information:
http://www.cabmphandbooks.com/Documents/Development/TC-10.pdf
www.stormwatercenter.net

Infiltration Basin

An infiltration basin is a shallow impoundment that is designed to infiltrate storm water. Infiltration basins use the natural filtering ability of the soil to remove pollutants in storm water runoff. Infiltration facilities store runoff until it gradually exfiltrates through the soil and eventually into the water table. This practice has high pollutant removal efficiency and can also help recharge groundwater, thus helping to maintain low flows in stream systems. Infiltration basins can be challenging to apply on many sites, however, because of soils requirements. In addition, some studies have shown relatively high failure rates relative to other BMPs.

Sources of Information:
http://www.stormwatercenter.net
http://cabmphandbooks.com



Porous Pavement

A substitute for conventional pavement designed to increase infiltration and minimize surface runoff. There are two basic designs of porous pavement , as follows:

Composed of asphalt or concrete which lacks the finer sediment found in conventional cement. This mixture is usually laid over a thick base of granular material.

Formed with modular, interlocking open-cell cement blocks placed over a base of coarse gravel. A geo-textile fabric placed under the gravel prevents the migration of soil upward into the gravel bed.

Use of porous pavement requires permeable soils with a deep water table. Traffic must be restricted to exclude heavy vehicles. It is not recommended for areas that are expecting high levels of sediment input and use of chemicals.

Sources of Information:
http://www.cabmphandbooks.com/Documents/Development/SD-20.pdf
http://h2osparc.wq.ncsu.edu/estuary/rec/urbstorm.html

DETENTION/SETTLING SYSTEMS

Extended Detention Basins

Dry extended detention basins are dry between storms. The basin fills during a storm, and a bottom outlet releases the stormwater slowly to give time for sediments to settle. Extended detention basins and vaults can work well in California because they do not require a dry-weather base flow to maintain water levels, such as wet ponds and constructed wetlands.

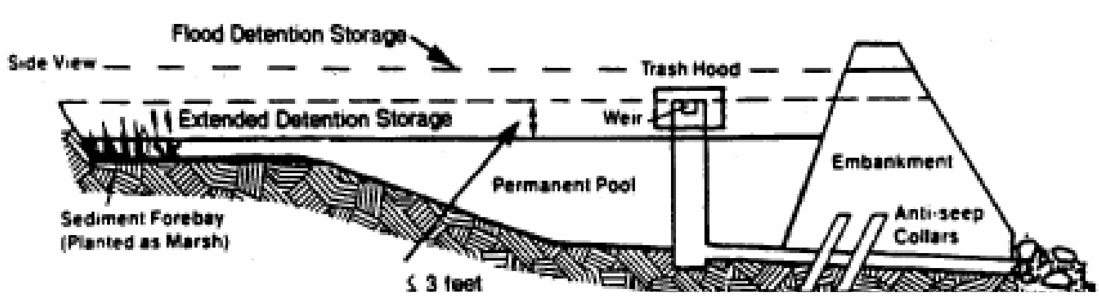
Sources of Information:
http://cabmphandbooks.com
http://www.udfcd.org/fhn2001/cover.htm

A wet extended detention basin combines the pollutant removal effectiveness of a permanent pool of water with the flow reduction capabilities of an extended storage volume. Wet extended detention ponds require careful planning in order to function correctly.

Sources of Information:

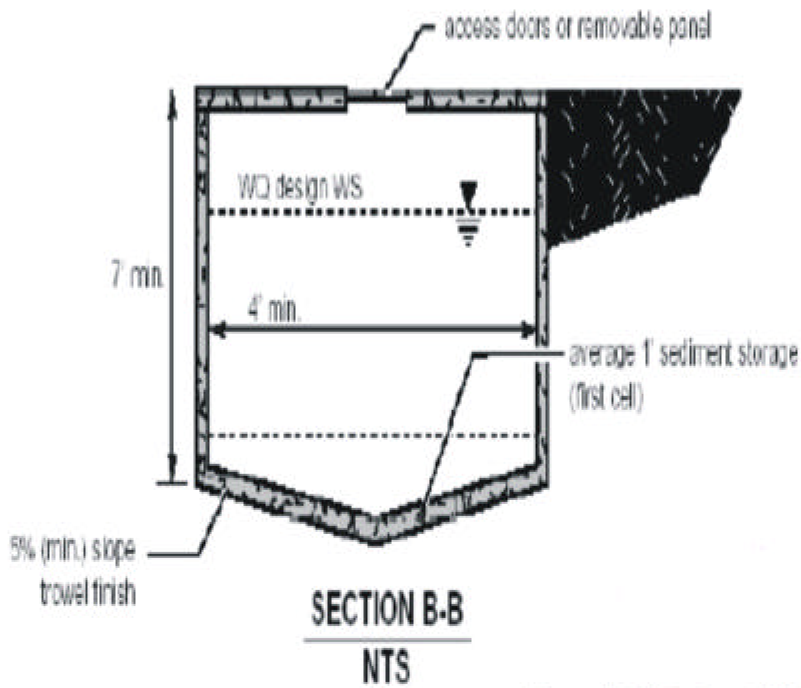
http://www.deq.state.id.us/water/stormwater_catalog/doc_bmp47.asp

http://www.ci.gresham.or.us/departments/des/stormwater/kmhpdfs/Section_4.pdf



Wet Vault/Tank/Underground Detention

A wet vault is a vault with a permanent water pool, generally 3 to 5 feet deep. The vault may also have a constricted outlet that causes a temporary rise of the water level (i.e., extended detention) during each storm. This live volume generally drains within 12 to 48 hours after the end of each storm. Wet vaults can't provide the equivalent level of treatment accomplished by wet ponds because neither biological uptake nor vegetative filtration are available as pollutant removal mechanisms; however, re-use of storm water runoff for landscaping purposes does provide a beneficial nutrient treatment mechanism. As wet vaults are underground, they can be more difficult to inspect and maintain.



Source: 1998 King County Water Quality Manual

Sources of Information:
http://cabmphandbooks.com
http://www.ci.gresham.or.us/departments/des/stormwater/kmhpdfs/Section_4.pdf
http://www.deq.state.id.us/

BIOFILTRATION SYSTEMS

Constructed Wetlands

Constructed wetlands are built expressly for treating stormwater runoff. They are not meant to be mitigation for the loss of natural wetlands. For constructed wetlands, a considerable percentage of the land is covered by wetland vegetation. The simplest form of a constructed wetland is comprised of a rectangular basin with a forebay and wetland vegetation area.

Sources of Information:
http://www.cabmphandbooks.com
http://www.epa.gov/owow/wetlands/construc/martinez/12marsh.html

Biofilters

Biofilters are of two different types: swale and strip. A swale is a vegetated channel that treats concentrated flow. It is comparable to but wider than a ditch, and is sized only to convey flow. A strip treats sheet flow and is placed parallel to the contributing surface. It is placed along the pavement edge.

Sources of Information:
http://cabmphandbooks.com

Bioretention

The bioretention best management practice (BMP) functions as a soil and plant-based filtration device that removes pollutants through a variety of physical, biological, and chemical treatment processes. These facilities normally consist of a grass buffer strip, sand bed, ponding area, organic layer or mulch layer, planting soil, and plants. The runoff's velocity is reduced by passing over or through buffer strip and subsequently distributed evenly along a ponding area. Exfiltration of the stored water in the bioretention area planting soil into the underlying occurs over a period of days.

Source of Information:
http://cabmphandbooks.com

Vegetated/Grass Swale

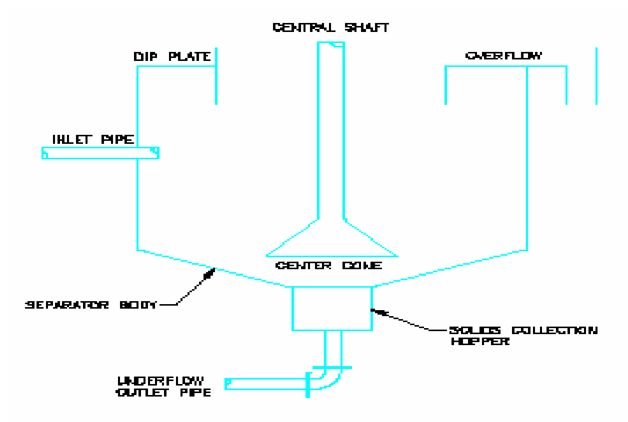
Vegetated swales are open, shallow channels with vegetation covering the side slopes and bottom that collect and slowly convey runoff flow to downstream discharge points. They are designed to treat runoff through filtering by the vegetation in the channel, filtering through a subsoil matrix, and/or infiltration into the underlying soils. Swales can be natural or manmade. They trap particulate pollutants (suspended solids and trace metals), promote infiltration, and reduce the flow velocity of stormwater runoff. Vegetated swales can serve as part of a storm water drainage system and can replace curbs, gutters and storm sewer systems.

Sources of Information:
http://cabmphandbooks.com

MISCELLANEOUS BMPS

Vortex-Type Separators

These units utilize hydrodynamic forces for separating solids and floatable material. When water enters the unit on a tangential plane, a circular flow pattern is established by the cylindrical shape of the unit, creating a vortex (tornado-like flow). The flow at the outer edge of the tank moves at a higher velocity than the flow in the center, and thus is more turbulent. As the flow spirals inward and upward the velocity slows down and becomes more stable. In general, the vortex flow tends to move denser material downward in the center, whereas floatables rise towards the surface on the outside of the flow.



Sources of Information:
http://www.wrc.org.za
http://cabmphandbooks.com
http://www.epa.gov/owm/mtb/hydro.pdf

Multi-Chambered Treatment Trains (MCTTs)

The MCTT was primarily developed for treating stormwater at significant source areas with limited space (i.e., vehicle service facilities, parking areas, and fueling stations). The MCTT utilizes three treatment mechanisms in three different chambers. The initial chamber is a catch basin, which functions primarily as a screening process for the other two chambers. The settling chamber is the primary treatment area for removing settleable solids and associated constituents. Sorbent pads can also remove oil and grease. The media filter chamber is for final polishing of the effluent using a combination of sorption and ion exchange.

Sources of Information:

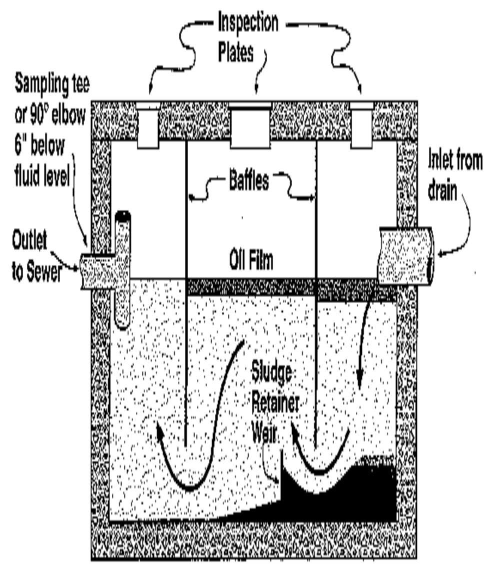
http://www.dot.ca.gov/hq/env/stormwater/ongoing/pilot_studies/bmps/details/mctt/rec/urbstorm.html

Oil/Water Separators

Oil/water separators are mechanical devices produced by various industrial equipment manufacturers. These devices use various mechanisms to separate oil from stormwater, which is then discharged to a treatment plant or to receiving water. Oil-water separators typically call for support from the manufacturer and are best used where they can be properly maintained and frequently inspected, such as at industrial sites.

Another type of oil and grease removal device is the oil and grease trap catch basin (or oil and grit separator). These underground devices are used to remove oils, grease, other floating substances and sediment from stormwater before the pollutants can enter the storm sewer system. They are typically placed in such a way that they catch the oil and fuel that leak from automobiles and trucks in parking lots, service stations, and loading areas.

A third type of device is a simple skimmer and control structure used at the outlet of a sediment basin (forebay), frequently used prior to discharge into a larger detention device.



Sources of Information:
http://h2osparc.wq.ncsu.edu/estuary/rec/urbstorm.html

http://dnr.metrokc.gov/wlr/indwaste/oilfact.htm

Gross Solids Removal Devices (GSRDs)

Litter capture devices designed to remove litter and vegetative debris (otherwise known as 'gross pollutants' and 'gross solids') from stormwater discharge. Different types of GSRDs include linear radial, baffle boxes, and inclined screens. The image on the right is known as a linear radial GSRD.

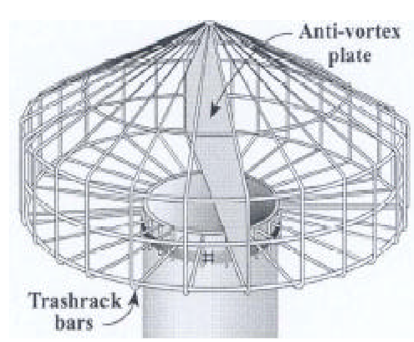
Sources of Information:
http://www.dot.ca.gov/hq/env/stormwater/workshop/online_presentations/12_01/pdfs/berger.pdf

Screens and Trash Racks

Screens and trash racks are made of a series of horizontal and vertical bars or wires that catch floatables while letting water pass through the openings between the bars or wires.

Sources of Information:

http://www.in.gov/dnr/water/dam_levee/inspection_man/pdf/Part4-FactSheets/03-13DesignandMaintOfTrashRacks.pdf



Nets

Two types of netting are typically used in capturing floatables: in-line netting, and floating units.

In-line netting can be mounted at strategic locations throughout the combined sewer system (CSS). The nets are installed in underground concrete vaults that hold one or more nylon mesh bags and a metal frame and guide system to support the nets. The nylon mesh bags are changed after every storm event.

Floating units are made up of an in-water containment area that channels CSO flow through a series of large nylon mesh nets.. The nets are for single use and are discarded after an overflow.

Sources of Information:

http://www.epa.gov/region1/assistance/ceitts/stormwater/techs/trashtrap.html

Booms

Booms are containment systems that employ specially fabricated flotation devices with suspended curtains made to capture buoyant materials. They can also be designed with oils and grease in mind. Booms are usually anchored to a shoreline structure and they can be located downstream of one or more outfalls. They are sized according to the expected volume of floatables that occur during a storm event.

Sources of Information:
http://www.epa.gov

http://www.stormwater.com

APPENDIX D

SUPPLEMENTAL INFORMATION ON PRE-TREATMENT & POST-TREATMENT BMPS

This Appendix provides narrative explanations to accompany Decision Guide D: Pre-Treatment and Post-Treatment BMPs. Although this appendix supplies a number of possible approaches to designing your project to better manage and treat runoff, the contents do not represent an exhaustive information search. The project applicant is encouraged to further research appropriate water quality management approaches beyond those presented here.

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Decision Guide D – Supporting Information

On-site controls, or SUSMPs, are required regardless of the location of the project, environmental effectiveness, availability of land for treatment, environmental sensitivity, or costs. Moreover, on-site controls may work in certain situations, but they are not uniformly effective, especially in treating many toxic pollutants restricted by TMDLs. In some cases, regional storm water facilities, which use infiltration, wetlands or "treatment trains," employing several mechanisms in a series to remove pollutants may offer more effective, reliable solutions (BC/CICWQ 2003).

TREATMENT-TRAIN SYSTEMS

A treatment train, or multiple treatment system, uses two or more BMPs (such as a swale, detention basin, or an infiltration basin) in series or by stacking vertically.

Some series systems that have been used are:

Extended detention basin - sand filter. A settling basin should be used in order to evade excessive maintenance on the sand filter.

Detention basin - sand filter - wetland. These BMPs are used for settling, filtration, and absorption.

Wet pond – wetland. If an unusually high loading of sediment is probable, a full size wet pond, rather than just a forebay in the wetland, could be the answer in reducing the sediment reaching the wetland, where it is more expensive to remove.

Biofilter – wet pond. Used often in order to enhance reliability.

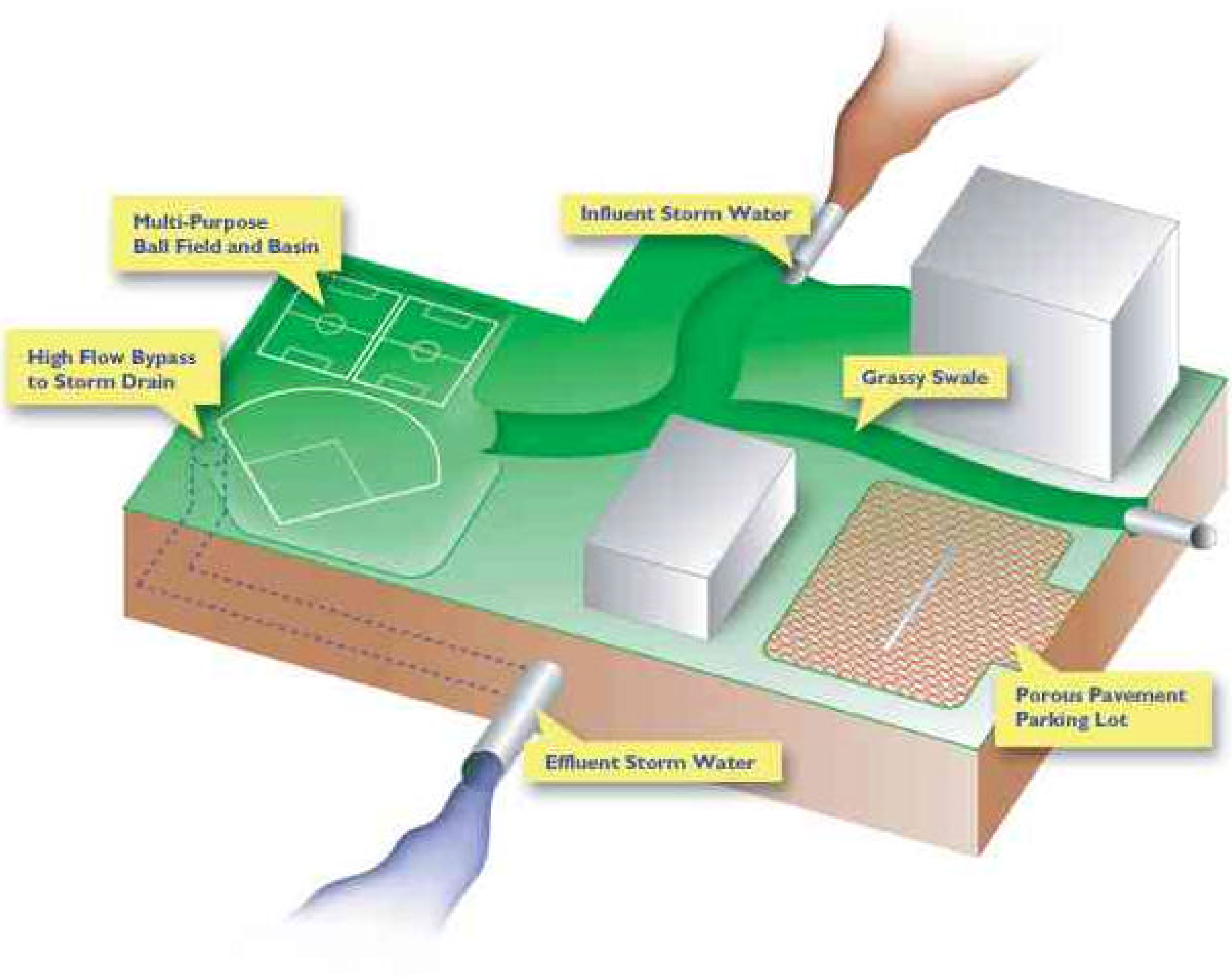
Biofilter – infiltration trench. The storm water is treated before it enters the infiltration system.

Oil/water separator – wetland or biofilter. The vegetated treatment system is protected against high concentrations of oil through the oil/water separator.

Examples of vertically stacked systems are:

Extended detention above wet pond. This treatment train is recommended because of the ambiguous performance of wet ponds.

Wet pond above sand filter. This treatment train is used due to the clogging of the sand filter by settleable solids.



Example of Multi-Purpose Regional BMP System

Source of Information:

BC/CICWQ 2003

APPENDIX E

BMP MAINTENANCE CONSIDERATIONS

When considering BMPs for implementation, carefully consider the expected maintenance that would be required. General maintenance requirements of BMPs are summarized in Table E-1 below.

Table E-1. Example Maintenance Requirements of Selected BMPs

BMP	Maintenance
Wet Detention Basins/Ponds	Inspect after the first rain event during the first few months after construction, and annually thereafter. Inspect, clean, and remove litter and floating materials after each rain event. Provide supplement water supply during dry season. Inspect condition of aquatic life, if any.
Vegetated Swales and Strips	Trim vegetation regularly to avoid woody growth and increase of vegetation density. Excessive vegetation may hinder infiltration.
Dry Ponds	Inspect regularly during rain season and remove trash, litter, debris, and other solid materials that hinder infiltration. Re-vegetate any eroded areas.
Infiltration Trenches	Inspect infiltration trench surface if evidence of clogging exists. Clear and remove litter and debris from the trench surface after each rain event. If an observation well is installed, measure groundwater depth before and after rain season.

BMP	Maintenance
Catch Basin Inserts	Inspect before rain season starts, remove trash and debris, inspect filter media and replace before start of rain season or as necessary. Service or replace defective system parts. Inspect after the first rain event and perform similar steps as above. After rain season, remove trash, debris, or oil accumulation from the insert manifold.
Media Filtration	Replace filter media/material at the beginning of rain season or as necessary when saturated with pollutants.
Vortex Type Separators	Inspect system for clogging before rain season starts and remove trash, debris, and other solids. Service or replace defective system parts. Inspect after the first rain event and perform similar steps as above. After rain season, remove trash, debris, or oil accumulation from the system.

An additional maintenance issue that is common to all BMPs that store storm water is vector control. Vector control seeks to monitor small animals and insects that spread disease. The primary vectors of interest for storm water BMPs are mosquitoes. Mosquitoes transmit diseases such as malaria and West Nile virus, requiring water to complete there life cycles. Vector controls for storm water BMPs include inspecting sites, sampling the mosquito population present, and possibly applying environmentally benign pesticides. Often the local health department or vector control district will implement the control measures on a fee basis. The additional cost of the inspections should be taken into consideration when selecting a BMP.

Additional maintenance information can be found in Section 6 of the New Development and Redevelopment volume of the California Stormwater BMP Handbook (www.cabmphandbooks.com).

APPENDIX F

RUNOFF ESTIMATES METHODOLOGIES AND BMP SIZING CRITERIA

Estimates of storm water runoff are needed to size and design facilities for two purposes: 1) to safely capture, detain, and convey storm water flows (i.e., drainage quantity or flood control considerations); and 2) to provide treatment through the application of various structural Best Management Practices (i.e., urban runoff quality considerations). Runoff estimates for quantity considerations generally focus on peak runoff flows to ensure effective flood control, while BMP sizing criteria focus on capturing and treating a certain proportion of the total annual flow volume or certain flow rates.

A brief overview of existing and recommended methodologies for runoff estimates is presented below for both quantity (drainage) and quality (BMP sizing) criteria. The purpose of this section is to summarize the methodologies that are already being applied within the San Diego Water Department source water watersheds and to support greater consistency in the future among the relevant jurisdictions, but also flexibility to encourage more innovative approaches to improve water quality.

Drainage Design Criteria - Quantity

Numerous existing engineering methodologies are widely applied for the design of drainage facilities to control quantities of storm water runoff. Several drainage design guidance documents apply within the jurisdictions of the City of San Diego, the City of Chula Vista, the City of Escondido, and the County of San Diego, including the following.

- City of San Diego Municipal Code Land Development Manual, Storm Water Standards – A Manual for Construction & Permanent Storm Water Best Management Practices Requirements, Revised May 30, 2003.
- San Diego County Hydrology Manual, County of San Diego Department of Public Works Flood Control Section, August 2003.

- City of Chula Vista Subdivision Manual, General Design Criteria, Section 3-200, Hydrology/Drainage/Urban Runoff, July 1, 2002.
- City of Escondido Design Standards for the Design of Public Work Improvements, June 23, 1999 (Resolution 99-123).

The San Diego County Hydrology Manual provides particularly extensive and detailed guidance on runoff estimate methodologies.

Traditionally, drainage facilities for new developments have been required to provide on-site detention such that post-development flow rates for a given design storm size do not exceed pre-development flow rates out of the area to be developed. Within the study area, design storms have been defined as the 100-year frequency event for major drainage areas (e.g., over one square mile) and the 50-year frequency event for smaller tributary areas.

Rational Method. A number of methods are available to estimate peak runoff flow rates to size drainage facilities, as referenced in the documents for each jurisdiction listed above. In general, the rational method equation is the simplest approach, and can be applied to estimate peak runoff as follows.

$$Q = CIA$$

Where:

- Q = peak runoff flow (cubic feet per second)
- C = runoff coefficient, or proportion of rainfall that runs off the surface (no units)
- I = rainfall intensity (inches/hour)
  - Calculated as the rainfall intensity for a duration equal to the time of concentration for the area, or the time required for storm water runoff to flow from the most remote part of the watershed to the outlet point under consideration
  - Calculated as a function of the design storm size (e.g., 100-year or 50-year event) and generally for the 6-hour precipitation duration
- A = drainage basin area (acres)

Note – the unit conversion coefficient for this equation is negligible.

Other Methods. More complicated methods to estimate peak runoff are also available and may be appropriate for larger, more complex watersheds. For example, continuous simulation methods have been shown to be more accurate in determining capture volumes and peak runoff rates, which can be over-estimated using simpler methods (Stormwater Management Manual for Eastern Washington, Washington Department of Ecology, June, 2003).

BMP Design Criteria – Quality

Design criteria for water quality BMPs vary, depending on the design approach and objectives. Within the study area, the San Diego County storm water permit provides the primary guidance for BMP sizing criteria. The permit includes specific numeric sizing criteria for standard urban storm water management plans (SUSMPs) to address storm water quality from new development and re-development areas (San Diego County Municipal Stormwater Permit, February 21, 2001). The SUSMP sizing criteria from the permit have also been reflected in the Model SUSMP and the City of San Diego Land Development Manual Storm Water Standards (Revised May 30, 2003).

The San Diego County permit provides several sizing criteria options for volume-based BMPs (e.g., detention/retention ponds or other types of facilities that provide storage), and for flow-based BMPs (e.g., swales, filters, or other types of facilities that provide no storage). The SUSMP-related sizing requirements specify levels of treatment, as a function of the quantity or portion of storm water runoff to be captured and treated, rather than as a function of treated water quality concentration. In other words, the SUSMPs are not designed to meet specific water quality objectives or numeric targets, but are rather technology-based requirements. The SUSMPs also focus on wet-weather discharges and do not particularly address dry-weather flows.

Volume-based criteria. The county permit requires that volume-based BMPs be sized to mitigate the volume of runoff from the 24-hour 85^{th} percentile storm event (approximated by the 0.6 inch storm event for the San Diego area). Another means can also be applied, based on unit storage volume, to ensure the capture and treatment of 90% of the total annual runoff volume.

Flow-based criteria. The county permit generally requires that flow-based BMPs be sized to mitigate the maximum flow rate from a rainfall intensity of 0.2-inch rainfall. This can also be approximated as the 85^{th} percentile hourly rainfall intensity multiplied by a factor of two. Documents such as the ASCE Manual of Practice and California Stormwater Best Management Practices Handbook are also referenced by the county permit for more details on runoff estimate methodologies.

Equivalent criteria. The county permit also allows for "any equivalent method" to calculate the volume of flow to be mitigated or numeric sizing criteria, given approval of the San Diego Regional Water Quality Control Board.

Runoff Coefficients

One important runoff estimate factor that varies considerably among the various jurisdictions is the runoff coefficient. As summarized in Table 1 below, the jurisdictions use different land use considerations to determine runoff coefficients (e.g., impervious area, categories of development and/or slope and vegetation conditions).

Table F-1. Summary of Land Use Considerations Used to Determine Runoff Coefficients in San Diego County Jurisdictions

Runoff Coefficient	San Diego County (see note below)		City of Chula Vista	City of Escondido
	% Impervious	Land Use		
0.25	0	Permanent Open Space		Open space, parks, golf courses, cemeteries
0.30	0-10	Low residential (max 1.0 DU/A)	Parks, golf courses	
0.35	10-20	Low residential (max 2.0 DU/A)	Farm land	
0.40	20-25	Low residential (max 2.9 DU/A)		
0.45	25-30	Low-Medium residential (max 4.3 DU/A)	Vegetated slopes, flat	Rural, over ½-acre lots Undeveloped land
0.50	30-40	Medium residential (max 7.3 DU/A)	Vegetated slopes, rolling	
0.55	40-45	Medium residential (max 10.9 DU/A)	Vegetated slopes, hilly –or- Suburban property (RE)	Single family
0.60	45-50	Medium residential (max 14.5 DU/A)	Vegetated slopes, steep	
0.65	55-60		Barren slopes, flat -or- Normal residential (R1)	Mobile home
0.70	65-70	High residential (max 24.0 DU/A)	Barren slopes, rolling	Multiple units
0.75	75-80	High residential (max 43.0 DU/A) Neighborhood commercial	Barren slopes, hilly -or- Dense residential (R2, R3)	
0.80	85	General commercial	Barren slopes, steep	
0.85	90	Office professional/ commercial	Commercial area	Commercial
0.90	90-95	Limited industrial	Paved surface	
0.95	95	General industrial		Industrial

Notes:

For the purposes of this summary, representative conditions are presented for San Diego County, combining four categories of soil types .

The City of San Diego Storm Water Standards do not recommend specific runoff coefficients, but rather refer to the County Hydrology Manual.

Accounting for effective impervious area. In determining the runoff coefficient for a proposed development, the Water Department recommends considering effective impervious area, rather than relying on standard assumptions about runoff coefficients for various types or densities of development. Effective impervious area reflects only the impervious portion of the site that is directly connected to the storm sewer system and discounts areas that are not directly connected (e.g., roofs that drain to infiltrate on-site versus being transported off-site). The runoff coefficient for a basin should also be a weighted, or composite value, made up of the many different runoff coefficients for sub-areas of the basin, using the following equation.

$$\frac{CA = C_1A_1 + C_2A_2 + C_2A_2 + C_nA_n}{n}$$

Where:

C_n = runoff coefficient for a given sub-area

A = area for given sub-area

n = number of different runoff coefficients considered

Encouraging Low Impact Development. The City of San Diego Water Department encourages the use of Low Impact Development (LID), as sustainable source control measures to limit adverse impacts of urban runoff on water quality by reducing runoff flows from new development. Such low impact development alternatives, are based on managing rainfall where it falls through enhancing infiltration and/or routing impervious runoff across pervious areas to allow for infiltration. To encourage source control techniques like low impact development, the Water Department recommends that effective impervious area be evaluated on a site-specific basis to determine runoff coefficients.

For example, if there were a medium density residential area that has applied LID techniques and can achieve lower effective impervious area than a standard assumed value of 40% or 45% (see Table F-1), then the developer should be able to calculate site-specific, effective impervious area and the associated runoff coefficient. The County of San Diego Drainage Design Manual could be used as a guide, while it presents runoff coefficients for various percent impervious levels. Allowing for site-specific effective runoff coefficients will provide incentive for developers to apply LID, as it can allow them to save costs by supporting the use of lower runoff coefficients and smaller size drainage facilities and BMPs.

Recommended Approaches

For the purposes of these Source Water Protection Guidelines for New Development, the San Diego Water Department recommends the use of consistent methodologies for estimating peak runoff flows and volumes to size treatment BMPs, where possible. The Water Department also recommends flexibility for equivalent methods to reflect site-specific conditions and to encourage more innovative approaches like low impact development and regional, multi-use treatment facilities. Composite runoff coefficients should be calculated to reflect effective impervious area, wherever possible, to encourage minimization of directly connected impervious areas, thus reducing runoff from new development areas.

Given that the SUSMP requirements are currently applied consistently throughout the county, the Water Department recommends that the numeric sizing criteria in the SUSMP continue to be applied as a default. However, on a site-specific basis, jurisdictional agencies may want to require more specific sizing criteria to achieve specific discharge quality objectives, especially where total maximum daily loads (TMDLs) might be required to improve the quality of impaired waters. The Water Department also encourages consideration of regional facilities, versus the on-site approach generally dictated by SUSMPs. Such regional approaches are allowed by the Localized Equivalent Area Drainage or LEAD approach, outlined in the County of San Diego's model SUSMP, and can provide greater water quality benefits, while also supporting other uses such as recreation and habitat.

APPENDIX G

REFERENCES AND ACKNOWLEDGEMENTS

Additional References

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Water Quality Control Plan for San Diego Basin (Basin Plan), RWQCB – San Diego Region, September 1994.

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