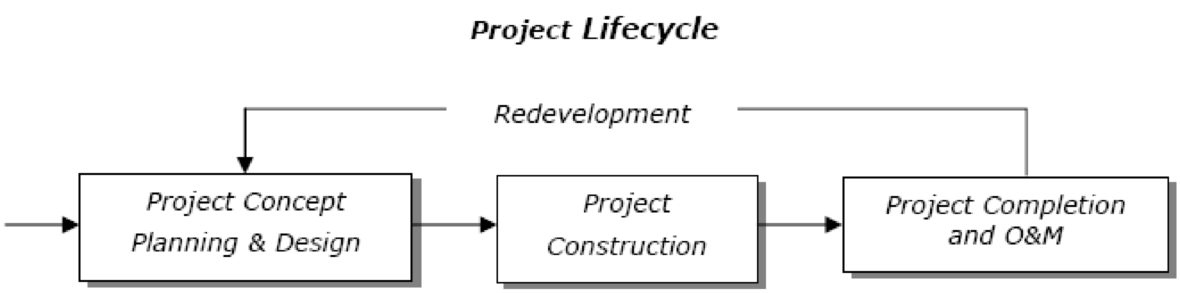
2A-2 Planning and Design Principles

A. Project scope and analysis

Iowa has implemented individual Phase II Stormwater NPDES permits for selected jurisdictions in the State (see Section 2A-3). The Phase II programs require BMPs to be implemented by developers, property owners, and public agencies engaged in new development or redevelopment activities. Understanding new development and redevelopment in the context of the project life cycle is important for proper selection and implementation of BMPs as shown in Figure 1. The concept, planning, and design phases of a project may be spread over a period of months to many years. BMPs incorporated into the concept, planning, and design phase are much more cost-effective than the retrofit of BMPs.

Figure 1: Project lifecycle



Source: California Stormwater BMP Handbook

An effective mechanism for documenting the incorporation of stormwater quality controls into new development and redevelopment projects on a site, regional, or watershed basis is to develop a written plan known as a Stormwater Management Plan, or SMP. An effective SMP clearly sets forth the means and methods for long-term stormwater quality protection.

B. Developing a stormwater management plan

Developing an effective stormwater management plan depends on making effective BMP choices. This section describes the basic steps and processes used to develop a plan with appropriate BMPs. Such a plan would include reviewing the full suite of BMPs that are available and identifying the dominant site factors that should go into the decision-making process. Assessment of the regional area, specific site conditions, site constraints, site hydrology, and project type are central to successful planning to minimize pollutants during development as well as during the life of the project. The basic steps in the stormwater management plan process are:

- Assess site and watershed conditions
- Understand hydrologic conditions of concern
- Evaluate pollutants of concern
- Identify candidate BMPs
- Develop the plan for BMP Maintenance

The specific requirements of a Stormwater Management Plan are usually specified by the local jurisdiction based on requirements in their MS4 permit or as part of a local design requirement for project development. A number of jurisdictions in Iowa use a Project Drainage Report format, as discussed in more detail in Section 2A-5.

The three phases of the project planning process are:

1. **Phase 1: Collection and analysis:**

    a. Identify resource problems, opportunities, and concerns in the planning area.

    b. Identify the project scope, objectives, and engineering design tasks.

    c. Inventory the existing conditions at the project site and any specific economic and/or social constraints.

    d. Complete an analysis of the pre-development and post-development site conditions related to soils, topography, and existing hydrology.

2. **Phase 2: Decision support:**

    a. Develop a set of alternative solutions that meet the project objective and meet the design criteria established for the project.

    b. Evaluate the alternatives to determine their relative effectiveness, technical and economic feasibility, and life-cycle considerations for operation and maintenance.

    c. Select the alternative that meets owner and jurisdiction requirements and establish a final design and construction cost estimate.

3. **Phase 3: Project implementation and evaluation:**

    a. Provide a final design and specification for project implementation.

    b. Conduct post-construction maintenance and performance evaluation.

A more detailed procedure related to stormwater management is provided below:

1. **Assess site conditions.** Site and watershed assessment includes assessing and describing the pre- and post-development site conditions and how the site fits into the overall watershed or drainage area. The assessment should include sufficient detail to allow for assessment of the need for and application of stormwater BMPs. Information typically required is listed below:

    a. **Site information:**
        1) Historic features
        2) Existing features
        3) Planned features
        4) Drainage patterns
        5) Discharge locations

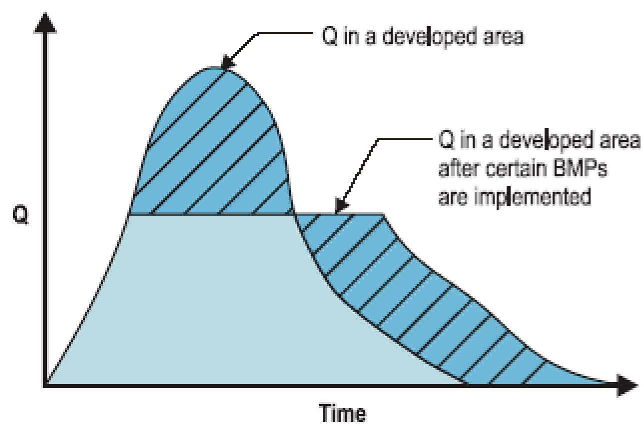
    b. **Vicinity information:**
        1) Major roadways

2) Geographic features or landmarks
3) Area surrounding the site
4) General topography
5) Area drainage

c. **Watershed or drainage area information:**
1) Received waters
2) Watershed drainage

2. **Understand hydrologic conditions of concern.** Development in urban areas increases the amount of impervious areas and changes the landform, and therefore the runoff hydrograph. Modifications to the runoff hydrograph change downstream hydrology. New development typically results in more runoff volume and higher rates of runoff. Many BMPs, such as detention basins which detain volume, effectively remove the top part of the hydrograph, but extend the duration of flow as illustrated in Figure 2.

Figure 2: Hydraulic alteration after traditional detention



Source: California Stormwater BMP Handbook

Over the last 12-15 years, the emerging consensus is that while such actions mitigate peak flows, the increased duration associated with these actions has impacts as well. Problems include washing out habitat, eroding streambed and banks, and changing downstream ecosystems. In addition to volume, rate, and duration, other factors, such as the amount of energy in the water and peak flow, impact downstream conditions. A comprehensive understanding of these factors is necessary to develop meaningful stormwater management plans. To be effective, these solutions must be done on an individual watershed basis.

Ideally, the runoff hydrograph that exists after construction would parallel the pre-construction hydrograph. It is difficult to ask upstream developers to be concerned about what is happening several miles below them in a watershed. On the other hand, stormwater planners and policy makers must ask what can be done to make the watershed more stable, and what enhancements are needed to balance impacts to the watershed from development. A downstream assessment should be completed to make qualitative predictions concerning channel impacts due to changes in runoff or sediment loads within the watershed.
The best way to resolve the watershed stability and balance issues is through a comprehensive drainage master plan. A formal drainage study considers the project area's location in the larger watershed, topography, soil and vegetation conditions, percent impervious area, natural and

infrastructure drainage features, and any other relevant hydrologic and environmental factors. As part of the study, the drainage report includes:

- Field reconnaissance to observe downstream conditions
- Computed rainfall and runoff characteristics, including a minimum of peak flow rate, flow velocity, runoff volume, time of concentration, and retention volume
- Establishment of site design, source control, and treatment control measures to be incorporated and maintained to address downstream conditions of concern

3. **Evaluate pollutants of concern.** The stormwater management plan should identify anticipated pollutants of concern. Pollutants frequently identified in the 303(d) list for surface waters in Iowa include sediment, nitrogen, phosphorous, indicator bacteria (i.e., fecal coliform), and pesticides. For urban stream segments, additional pollutants of concern are loading of metals and gross pollutants (trash, debris, and floatables). With respect to metals, the most commonly listed metals are mercury, copper, lead, selenium, zinc, and nickel.

   The procedures should include, at a minimum, consideration of:
   - Receiving water quality (including pollutants for which receiving waters are listed as impaired under Clean Water Act section 303(d)
   - Land use type of the development project and pollutants associated with that land use type
   - Pollutants expected to be present on site
   - Changes in stormwater discharge flow rates, velocities, durations, and volumes resulting from the development project
   - Sensitivity of receiving waters to changes in stormwater discharge flow rates, velocities, durations, and volumes

   Pollutants of concern for a water body can extend beyond those pollutants listed in a 303(d) list as causing impairment. For example, trash is a pollutant of concern in most communities, yet very few, if any urban stream segments in Iowa are presently listed as impaired by trash. A pollutant need not be causing an immediate impairment to be considered when developing a stormwater management plan.

4. **Identify candidate BMPs.** Selecting BMPs based on pollutants of concern is a function of site constraints, constituents of concern, BMP performance, stringency of permit requirements, and watershed specific requirements such as TMDLs. Pollutants of concern are especially important in water-limited stream segments and must be carefully reviewed in relationship to BMP performance. BMP performance is discussed further in Part 2D. When no specific pollutant has been targeted for removal, local jurisdiction requirements may address pollutant removal through flow- and/or volume-based requirements. Under these circumstances, cost can become an important criterion in BMP selection.

   Large reductions in treatment BMP size and investment can be made by:
   - Reducing runoff that needs to be captured, infiltrated, or treated
   - Controlling sources of pollutants

   These two strategies are the most effective in managing stormwater. A third strategy includes implementation of treatment BMPs. The principles and methodologies for incorporating these strategies into site facility planning and design are discussed in Part 2D.

5. **Determine BMP size/capacity.** Based on the selected BMPs, the capacity and primary design sizing criteria must be established using a combination of local hydrology, project drainage characteristics (e.g., percent imperviousness or runoff coefficient), and the local permit and jurisdictional sizing requirements. BMPs will be either volume-based or flow-based, as discussed in more detail later in this manual and must be able to effectively treat the design quantity.

   Peak storm event flows must also be taken into account if the BMP is a flow-based BMP, or a volume-based BMP that must also safely pass the design storm (e.g., an in-line detention basin). The volume-based BMP can safely pass the design peak event while maintaining its water quality functions up to the water quality design volume.

6. **Develop plan for BMP ownership and maintenance responsibility.** BMP maintenance arrangements take should place during the planning phase of development and redevelopment projects. A permittee is committed to providing for water quality protection by requiring that a mechanism for ongoing, long-term maintenance of BMPs is in place. To ensure that BMP maintenance will take place, permittees should require evidence that project proponents have executed an approved method of BMP maintenance, repair, and replacement before construction approvals are issued. Mechanisms used by permittees to assign responsibility for maintenance to public and private sector project proponents include:
   - Covenants
   - Maintenance agreements
   - Conditional use permits
   - Deed restrictions
   - Other legal agreements

   The jurisdiction may also require an Operation and Maintenance (O&M) plan be prepared by the project proponents if the ownership of the stormwater management BMPs remains with the project owner or designated successor legal entity. These plans are normally attached to approved maintenance agreements and describe a designated party to manage:
   - BMPs
   - Employee training program and duties
   - Operating schedule
   - Maintenance frequency
   - Routine service schedule
   - Specific maintenance activities
   - Copies of resource agency permits
   - Funding
   - Other necessary activities

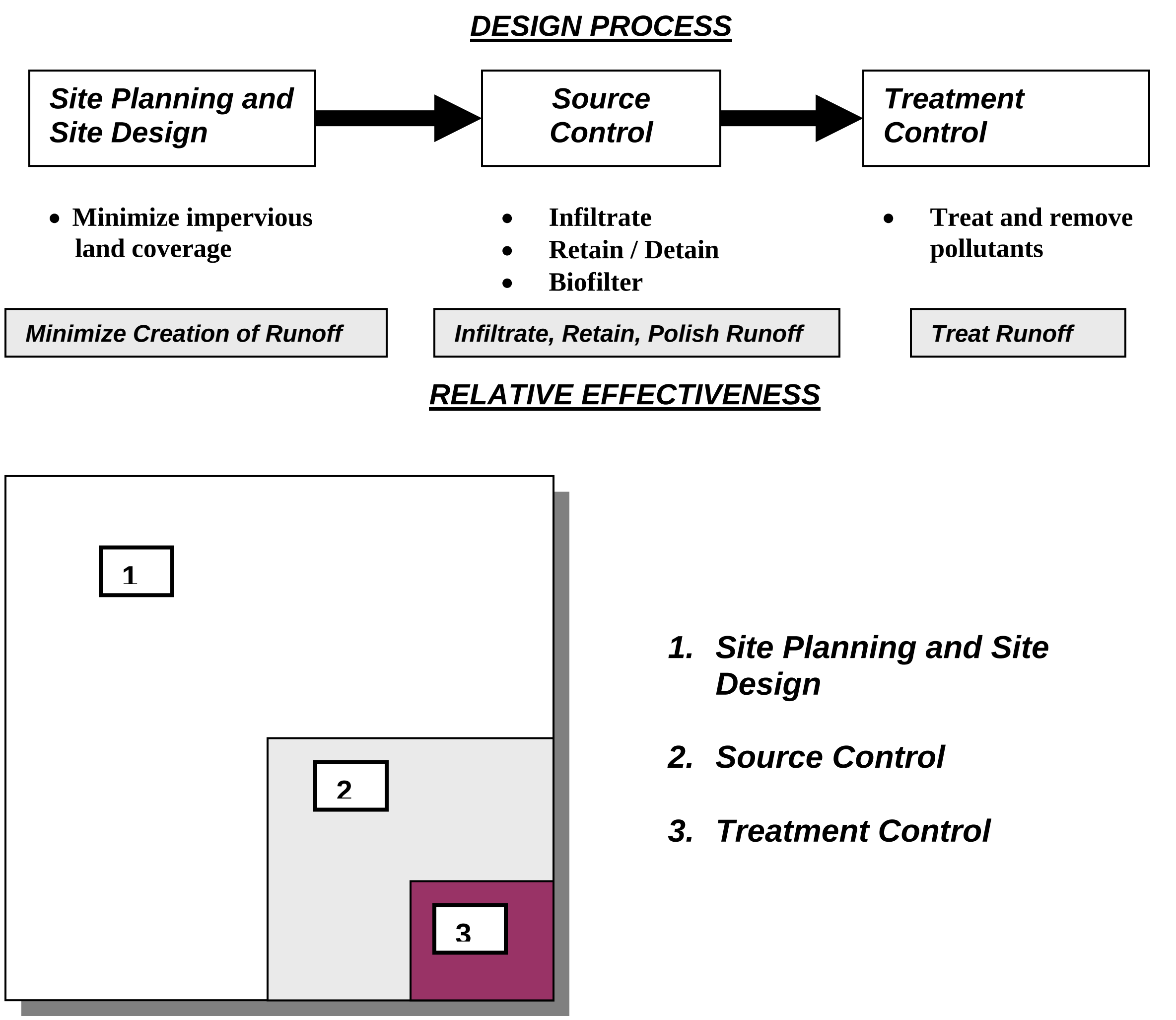
   Permittees often require annual inspection and servicing of all BMPs within maintenance agreements, and O&M forms documenting all required maintenance activities. The party responsible for the O&M plan may be required to retain O&M forms for at least five years. A BMP maintenance plan is particularly valuable during ownership transitions. For example, when a developer transitions maintenance to a homeowners association, or when a developer turns over maintenance to a new owner. The BMP maintenance plan is also important when valuating properties for acquisition, allowing long-term costs associated with BMPs to be factored into the property purchase agreement.

C. Planning and design principles

Planning and design for water quality protection employs three basic strategies in the following order of relative effectiveness (See Figure 3):

- Reduce post-project runoff
- Control sources of pollutants
- Treat contaminated stormwater runoff before discharging it to natural water bodies

Figure 3: Planning principles



These principles are consistent with the typical permit and local program requirements for projects that require a consideration of a combination of source control BMPs (that reduce or eliminate runoff and control pollutant sources) and treatment control BMPs with specific quantitative standards. The extent to which projects can incorporate strategies that reduce or eliminate post project runoff will depend upon the land use and local site characteristics of each project. Reduction in post project runoff offers a direct benefit by reducing the required size of treatment controls to meet the requirements included in the local permit. Therefore, project developers can evaluate tradeoffs between the incorporation of alternative site design and source control techniques that reduce runoff and pollutants, and the size of required treatment controls either included as part of the project or as a commitment to an offsite watershed-based program.

1. **Reduce runoff.** The principle of runoff reduction begins by recognizing that developing or redeveloping land within a watershed inherently increases the imperviousness of the areas and therefore the volume and rate of runoff and the associated pollutant load; and outlines various approaches to reduce or minimize this impact through planning and design techniques. The extent of impervious land covering the landscape is an important indicator of stormwater quantity and quality and the health of urban watersheds. Impervious land coverage is a fundamental characteristic of the urban and suburban environment -- rooftops, roadways, parking areas and other impenetrable surfaces cover soils that, before development, allowed rainwater to infiltrate. The results of the NURP studies in the 1980's indicated a predictable relationship between runoff volume and the % imperviousness of the drainage area (US EPA 1983). Without these impervious coverings, inherent watershed functions would naturally filter rainwater and prevent receiving water degradation.

   Impervious surfaces associated with urbanization can cause adverse receiving water impacts in the following ways:
   - Rainwater is prevented from filtering into the soil, adversely affecting groundwater recharge, and reducing base stream flows.
   - Because it cannot filter into the soil, more rainwater runs off, and runs off more quickly; causing increased flow volumes, accelerating erosion in natural channels, and reducing habitat and other stream values. Flooding and channel destabilization often require further intervention. As a result, riparian corridors are lost to channelization, further reducing habitat values.
   - Pollutants that settle on the impervious pavements and rooftops are washed untreated into storm sewers and nearby stream channels, increasing pollution in receiving water bodies.
   - Impervious surfaces retain and reflect heat, increasing ambient air and water temperatures. Increased water temperature negatively impacts aquatic life and reduces the oxygen content of nearby water bodies.

   Techniques for reducing runoff range from land use planning on a regional scale by local jurisdictions (permittees) or other local planning agencies, to methods that can be incorporated into specific projects. These techniques include actions to:
   - Manage watershed impervious area
   - Minimize directly connected impervious areas
   - Incorporate reduced discharge areas
   - Include self-treatment areas
   - Consider runoff reduction areas.

   a. **Manage watershed impervious area.** Land use planning on the watershed scale is a powerful tool to manage the extent of impervious land coverage. This planning has two elements. First, identify open space and sensitive resource areas at the regional scale and target growth to areas that are best suited to development; and second, plan development that is compact to reduce overall land conversion to impervious surfaces and reliance on land-intensive streets and parking systems.

Impervious land coverage is a practical measure of environmental quality because:

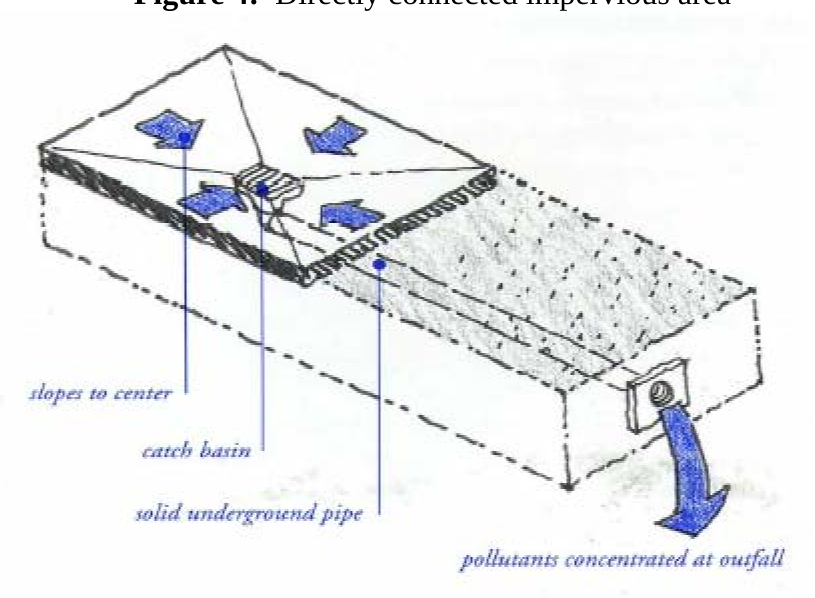
- It is quantifiable, meaning that it can be easily recognized and calculated.
- It is integrative, meaning that it can estimate or predict cumulative water resource impacts independent of specific factors, helping to simplify the intimidating complexity surrounding non-point source pollution.
- It is conceptual, meaning that water resource scientists, municipal planners, landscape architects, developers, policy makers, and citizens can easily understand it.

Water resource protection at the local and regional level is complex. A wide variety of regulatory agencies, diverse sources of non-point source pollution, and a multitude of stakeholders make it difficult to achieve a consistent, easily understandable strategy for watershed protection. Impervious land coverage is a scientifically sound, easily communicated, and practical way to measure the impacts of new development on water quality.

b. **Minimize directly connected impervious areas (DCIA).** Any impervious surface that drains into a catch basin, area drain, or other conveyance structure is a "*directly connected impervious area*." As stormwater runoff flows across parking lots, roadways, and paved areas, the oils, sediments, metals and other pollutants are collected and concentrated. If this runoff is collected by a drainage system and carried directly along impervious gutters, into surface or curb intake openings, or in closed underground pipes; it has no opportunity for filtering by plant material or infiltration into the soil. It also increases in speed (reducing the runoff time of concentration) and volume, which may cause higher peak flows downstream, and may require larger capacity storm drain systems, and increasing flood and erosion potential.

Impervious areas directly connected to the storm drain system are the greatest contributor to non-point source pollution. The first effort in site planning and design for stormwater quality protection is to minimize the directly connected impervious area, as shown in Figure 4.

Figure 4: Directly connected impervious area



Source: California Stormwater BMP Handbook

Minimizing directly connected impervious areas can be achieved in two ways:

- Limiting overall impervious land coverage
- Directing runoff from impervious areas to pervious areas for infiltration, detention, or filtration

Strategies for reducing impervious land coverage include:

- Cluster rather than sprawl development
- Taller narrower buildings rather than lower spreading ones
- Sod or vegetative “green roofs” rather than conventional roofing materials
- Narrower streets rather than wider ones
- Pervious pavement for light duty roads, parking lots and pathways

Example strategies for infiltration, retention/detention, and bio-filtration include:

- Vegetated swales
- Vegetated basins (ephemeral – seasonally wet)
- Constructed ponds and lakes (permanent- always wet)
- Crushed stone reservoir base rock under pavements or in sumps
- Infiltration trenches
- Infiltration basins
- Bioretention areas and raingardens

Unlike conventional storm drain systems that convey water beneath the surface and work independently of surface topography, a drainage system for stormwater 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 stormwater. Site plans that apply stormwater 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. This planning approach is often referred to as the “better site design” methodology.

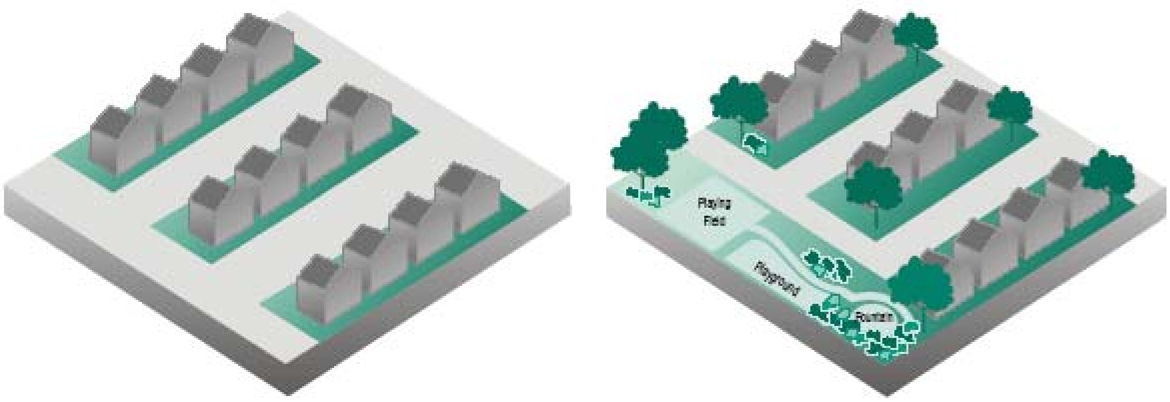
c. **Incorporate reduced discharge areas.** An area within a development project can be designed to infiltrate, retain, or detain the volume of runoff requiring treatment from that area. The term “reduced discharge” in this philosophy applies at stormwater treatment design storm volumes. For example, consider an area that functionally captures and then infiltrates the 80th percentile storm volume. If permits require treatment of the 80th percentile storm volume, the area generates no treatment-required runoff.

Site design techniques available for designing areas that could produce no treatment-required runoff include:

- Retention/detention ponds
- Wet ponds
- Infiltration areas
- Large fountains
- Retention rooftops
- Green roofs (roofs that incorporate vegetation)

Infiltration areas, ponds, fountains, and green roofs can provide dual functionality as stormwater retention measures and development amenities. Detention ponds and infiltration areas can double as playing fields or parks. Wet ponds and infiltration areas can serve dual roles when meeting landscaping requirements. When several reduced discharge areas are incorporated into a development design, significant reductions in volumes requiring treatment may be realized. Figure 5 illustrates a residential tract, and a tract incorporating reduced discharge area techniques (infiltration areas). The reduced discharge area-designed tract represents a design to infiltrate (i.e., achieve reduced discharge from) a portion of the tract’s runoff, reducing total runoff from the tract. The application of reduced discharge methodology in site design requires a careful consideration of the overall site characteristics, local jurisdiction planning and design requirements, and overall acceptance of the site features and individual BMPs by the residents in the development.

Figure 5: Use of reduced discharge areas to reduce runoff volume

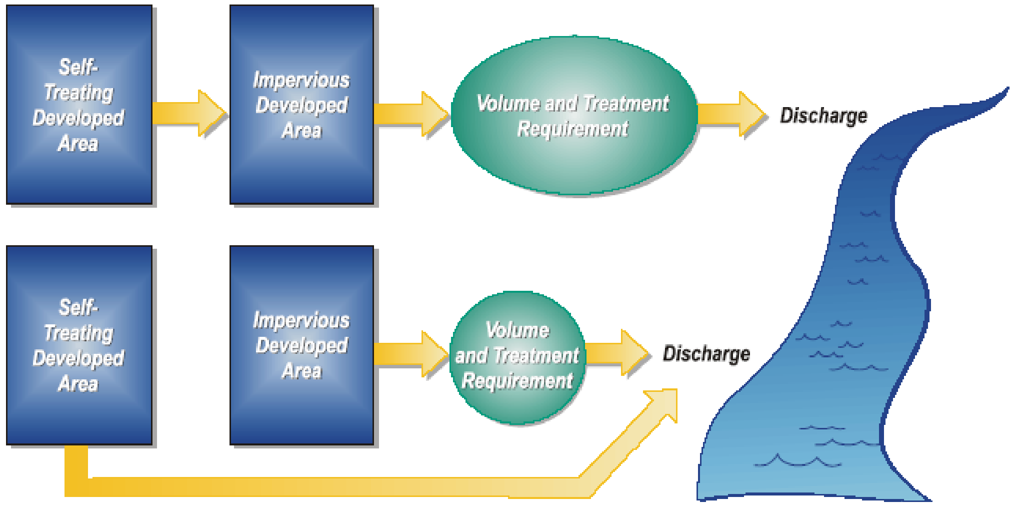


Source: California Stormwater BMP Handbook

d. **Include self-treatment areas.** Developed areas may provide self-treatment of runoff if properly designed and drained. Self-treating site design techniques include:
   - Conserved natural spaces
   - Large landscaped areas (including parks and lawns)
   - Grass/vegetated swales
   - Turf block paving areas

   The infiltration and bio-treatment inherent to such areas may provide the treatment control necessary. These areas therefore act as their own BMP, and no additional BMPs to treat runoff should be required. As illustrated in Figure 6, site drainage designs 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 self-treating or partially self-treating areas, if adequately sized to handle the excess runoff addition.

Figure 6: Use of self-treatment areas to reduce runoff volume



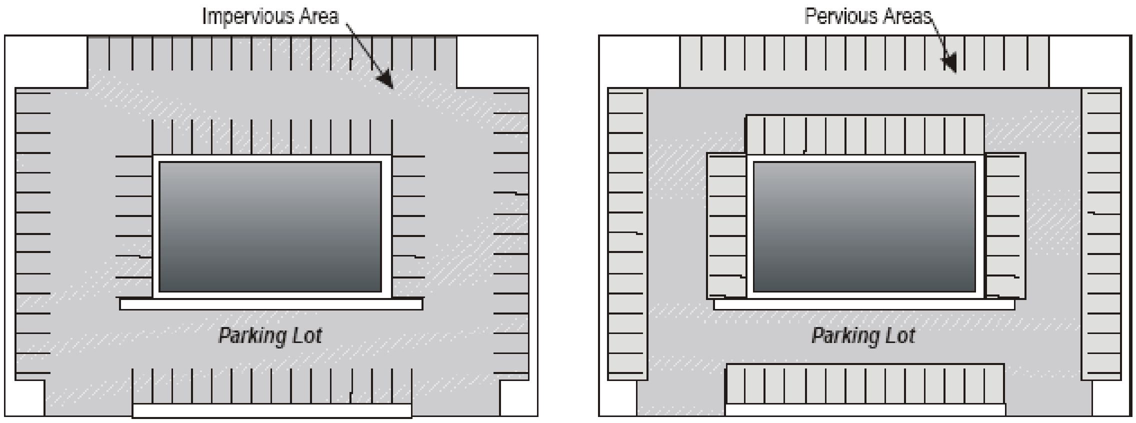
Source: California Stormwater BMP Handbook

e. **Consider runoff reduction areas.** Using alternative surfaces with a lower coefficient of runoff or C-Factor may reduce runoff from developed areas. The C-Factor is a representation of the surface's ability to produce runoff. The runoff coefficient C is used in the rational method to predict peak runoff rate from a drainage area. Other coefficients of runoff include the CN used in the NRCS TR-55 method, and the volumetric runoff coefficient Rv used in the calculation of the Water Quality Volume (WQv). Surfaces that produce higher volumes of runoff are represented by higher C-Factors, such as impervious surfaces. Surfaces that produce smaller volumes of runoff are represented by lower C-Factors, such as more pervious surfaces. Table 1 compares the C-Factors of conventional paving surfaces to alternative, lower C-Factor paving surfaces. By incorporating more pervious, lower C-Factor surfaces into a development (see Figure 7), lower volumes of runoff may be produced. Lower volumes and rates of runoff translate directly to lower treatment requirements.

Table 1: Conventional paving surface small storm C-factors vs. alternative paving C-factors

Conventional Paving Surface C-Factors	Reduced C-Factor Paving Alternatives
Dense PC Concrete Patio/Plaza (0.80 to 0.97)	Decorative Unit Pavers on Sand (0.10)
Asphalt Parking Area (0.73 to 0.95)	Turf Block Overflow Parking Area (0.15)
	Pervious Concrete (0.4)
	Porous Asphalt (0.55)
	Open jointed blocks w/0.8 to 0.2 aggregate fill (0.30 to 0.50)
	Crushed Aggregate (0.3 to 0.7)
	Turf, grass cover > 50% (0.05 to 0.53)

Figure 7: Impervious parking lot vs. parking lot with some pervious surfaces



Source: California Stormwater BMP Handbook

Site design techniques that incorporate pervious materials may be used to reduce the C-Factor of a developed area, reducing the amount of runoff requiring treatment. These materials include:

- Portland cement pervious concrete
- Porous asphalt
- Turf block
- Brick (un-grouted)
- Natural stone
- Concrete unit pavers
- Crushed aggregate
- Cobbles
- Wood mulch

Other site design techniques, such as disconnecting impervious areas, preservation of natural areas, and designing concave medians may be used to reduce the overall C-Factor of development areas. A summary list of site design and landscaping techniques is included in Table 2 and indicates whether they are applicable for use in reduced discharge areas, self-treating areas, and runoff reduction areas. Several different techniques can be implemented within the same design philosophy. Where feasible, combinations of multiple techniques may be incorporated into new development and redevelopment projects to minimize the amount of treatment required.

Table 2: Site design and landscaping techniques

Site Design and Landscape Techniques	Design Criteria		Design Philosophy		
	Volume-Based Design	Flow-Based Design	Reduced Discharge	Self – Treating	Runoff Reduction
Permeable Pavements	X				X
Pervious concrete	X				X
Porous asphalt	X				X
Turf block	X			X	X
Un-grouted brick	X				X
Un-grouted natural stone	X				X
Un-grouted concrete unit pavers	X				X
Unit pavers on sand	X				X
Crushed aggregate	X				X
Wood mulch	X				X
Streets					
Urban curb/swale system	X	X			X
Rural swale system	X	X			X
Dual drainage system	X	X			X
Concave median	X	X	X		X
Pervious island	X	X			X
Parking Lots					
Hybrid surface parking lot	X				X
Pervious parking surface	X				X
Pervious overflow parking	X			X	X
Driveways					
Not directly connected impervious driveway		X			X
Paving only under wheels	X			X	X
Landscape					
Grass/vegetated swales	X	X		X	X
Extended detention (dry) basins	X		X	X	X
Wet ponds	X		X	X	X
Bioretention areas	X		X	X	X

Adapted from California Stormwater BMP Handbook

2. **Control sources of pollutants.** There are a number of items that can be routinely designed into a project that function as source controls once a project is completed. They include such items as marking new drain inlets and posting informational signs, improving landscape planning and efficient irrigation methods, using water quality-friendly building materials, implementing roof runoff controls, properly designing outdoor material and trash storage areas, and permanently protecting slopes and channels from erosion. They also include design features for specific workplace or other activity areas, such as vehicle washing areas, outdoor processing areas, maintenance bays and docks, and fueling areas.

   Design of BMPs to control workplace exposure to pollutants is guided by three general principles:

   a. **Prevent water from contacting work areas.** Work and storage areas should be designed to prevent stormwater runoff from passing through shipping areas, vehicle maintenance yards, and other work places before it reaches storm drains. The objective is to prevent the discharge of water laden with grease, oil, heavy metals, and process fluids to surface waters or sensitive resource areas.

b. **Prevent pollutants from contacting surfaces** that come into contact with stormwater runoff. Precautionary measures should be employed to keep pollutants from contacting surfaces that come into contact with runoff. This means controlling spills and reviewing operational practices and equipment to prevent pollutants from coming into contact with storm or wash water runoff.

c. **Treat water before discharging it to the storm drain.** Treatment of polluted runoff should be employed as a last resort. If source control options are not possible, treatment measures that comply with NPDES permit requirements must be adopted.

d. **Community programs to educate** homeowners and commercial facilities on protocols to improve management of fertilizer application on lawns, and associated controls for managing the use of other pollutants can be effective as well.

3. **Treat runoff.** In the traditional sense, stormwater and street design systems were designed to achieve a single objective – to convey water off-site as quickly as possible. The primary concern of conveyance systems is to protect property from flooding during large, infrequent storms. Drainage systems designed to meet this single volume control objective fail to address the environmental effects of non-point source pollution and increases in runoff volume and velocity caused by development. Future drainage systems must meet multiple purposes: protect property from flooding, control stream bank erosion, and protect water quality. To achieve this, designers must integrate conventional flood control strategies for large, infrequent storms with stormwater quality control strategies.

   There are several basic water quality strategies for treating runoff:
   - Convey runoff slowly through vegetation, infiltrate into the soil
   - Retain/detain runoff for later release with the detention providing treatment
   - Treat runoff on a flow-through basis using various treatment technologies

   Solutions should be based on an understanding of the water quality and economic benefits associated with design and construction of systems that utilize or mimic natural drainage patterns.

   Site designs should be based on site conditions and use them as the basis for selecting appropriate stormwater quality controls. The drainage system design process considers variables such as local climate, the infiltration rate and erosion potential of the soils, and slope. Many of the negative impacts associated with urban development can be alleviated if policy alternatives encourage developers to protect and restore habitat quality and quantity, include measures to improve water quality, and provide buffers between development and stream corridors.

   Unlike conveyance models, which are assessed by simple quantitative measures (flood control volumes and economics), water quality designs must optimize for a complex array of both quantitative and qualitative standards, including engineering worthiness, environmental benefit, horticultural sustainability, aesthetics, functionality, maintainability, economics, and safety.

D. Planning and design conditions

1. Planning and design data provided by the Engineer should demonstrate that investigations include:

    a. Documentation of the pre-existing site conditions and site hydrology. Characterization of the development site with respect to soils (HSG), topography, and existing natural drainage.

    b. The function of the proposed and/or existing streets as part of the storm water system, including level of anticipated flooding of street surfaces and encroachment into driving lanes.

    c. Gutters and intakes are adequate to prevent excessive flooding of streets and right-of ways.

    d. Culverts and storm pipes are designed to sufficient size (flow-based design).

    e. Adequate overland relief with proper easements for storms larger than the design storm for local flooding (see Part 2B).

    f. Street grades are coordinated with lot drainage; lot drainage slopes will not be less than 1-1/2% to minimize ponding, and not excessive to cause uncontrollable erosion.

    g. Spot elevations should be listed at each rear lot corner, at the mid-point of the side yard line, and along the proposed drainage ways and easements.

2. The Engineer should evaluate the management alternatives to handle the runoff and select the optimum design that will strike a balance between initial capital costs, maintenance costs, and public protection. Consideration should also be given to safety, environmental protection, and maintenance of the drainage system. Care should be exercised in developing drainage systems that depend solely on a specified protection level. Designers need to keep in mind that rainfall and runoff events seldom, if ever, occur at a specified frequency or duration. Therefore, at critical locations, additional protection should be considered, depending upon the drainage basin characteristics and the degree of protection necessary downstream.

    The following are examples that include but are not limited to, situations where damage can occur on the specified design frequency and duration in which emergency spillways or outlets are not made available.

    - Surface water flow conveyances between buildings, such as housing, and in backyards
    - Enclosed storm sewers adjacent to private property, where a single inlet could be plugged, resulting in significant damage to adjacent property
    - Single-lot or multiple-lot storm water detention

3. In addition to the potential damage in these particular areas, maintenance of stormwater BMPs and conveyance systems needs to be considered. Private-owner or homeowner association maintenance has the advantage of simplified responsibilities, without direct cost to the general taxpayer. The disadvantage is when the homeowner or association is not capable of maintaining a stormwater system on a continuous basis. Other options to be considered are delayed transfer of ownership from builder to homeowner’s association, to ensure proper stormwater conveyance system operation; or the issuance of a performance or maintenance bond by the builder, valid for a specified period of time. When the stormwater conveyance system is significant enough that the normal individual or group of individuals does not have the means for continuous maintenance, other maintenance alternatives need to be developed that involve Jurisdiction-

owned facilities. This would involve construction and maintenance by the Jurisdiction, funded through:

- A one-time charge to the developer that is placed into a stormwater escrow account for immediate or future stormwater improvements
- A stormwater utility assessment (either a one-time lump sum or monthly charge)
- Construction of the stormwater facility BMPs by the developer to meet the local jurisdictions post-construction runoff control requirements (i.e. ordinance) that would be owned and maintained by the Jurisdiction (similar to streets, water mains, and sanitary sewer infrastructure)

4. Runoff analysis should be based upon proposed land use, and should take into consideration all contributing runoff from areas outside of the study areas.

5. For previously undeveloped land, the recommended land use for determination of pre-development runoff discharge is meadow/pasture in good condition.

6. All undeveloped land lying outside of the study area should be considered as fully developed based upon the Jurisdiction's comprehensive plan. The designer should check with the Jurisdiction regarding upstream conditions.

7. If future land use of a specific undeveloped area is unknown, the runoff coefficient should be established on a conservative basis. The probable future flow pattern in undeveloped areas should be based on existing natural topographic features (existing slopes, drainageways, etc). Average land slopes in both developed and undeveloped areas may be used in computing runoff. However, for areas in which drainage patterns and slopes are established, these should be utilized.

8. Flows and velocities that may occur at a design point when the upstream area is fully developed should be considered. Drainage facilities should be designed such that increased flows and velocities will not cause erosion damage.

9. The primary use of streets should be for the conveyance of traffic. The computed amount of runoff in streets should not exceed the requirements set forth herein.

10. The use of detention and natural drainage-ways is recommended and encouraged whenever possible. The changing of natural drainage-way locations may not be approved unless such change is shown to be without unreasonable hazard and liability, substantiated by thorough analysis and investigation.

11. Restrictive covenants, surface flowage easements, and impoundment easements may be required to be executed and recorded to provide for the protection and maintenance of grassed drainage swales and grassed drainage detention areas within build-up areas.

12. If the Engineer's approval is given to the use of existing natural flow conveyances, the Project Engineer should show that the project will have minimum disruption of the existing environment (see requirement for downstream channel protection under unified sizing criteria – Cpv) and covenants may be required to be executed and recorded to provide protection. The Engineer may allow changes in the flow channel, provided state and federal guidelines and regulations will be followed.

13. In the design of storm drainage systems, consideration should be given to both surface and subsurface sources. Subsurface drainage systems should be designed where required. The

discharge from such underdrain systems should not flow over sidewalks or onto streets after completion of the project.

14. Land grading of the project site should be performed to take advantage of existing contours and minimize soil disturbance. Better site design techniques should be used to preserve or minimize the impact to the existing site hydrology. Steep slopes should be avoided. If steep slopes are necessary, an attempt should be made to save natural grasses, shrubs, and trees on these slopes and re-establish ground cover and permanent erosion control measures as soon as possible.

15. During construction grading phases, temporary diversions, contour furrows, terraces, and other remedial conservation practices should be used to reduce erosion and excessive water drainage to downstream adjacent properties. Sediment traps and basins should be used at the lower end of the drainageways and provisions should be made for their maintenance.

    An erosion control plan should be developed according to the design guidelines provided in Chapter 7 of this manual. Additional information on construction site runoff control can be found in the "Iowa Construction Site Erosion Control Manual," (Iowa DNR, 2006). An on-line electronic erosion and sediment planning guide is also available (http://dhn.iihr.uiowa.edu/runoff).

16. Acquire stormwater discharge permits from the Iowa Department of Natural Resources (http://www.iowadnr.com/water/stormwater/forms.html#manuals) for construction sites exceeding one acre in area. If the local jurisdiction maintains a stormwater NPDES permit, there may be additional local requirements.

17. The planning and design of drainage systems should be such that problems are not transferred from one location to another. Outfall points and velocities should be designed in such a manner that will not create flooding hazards downstream.

18. Where a master drainage plan for a Jurisdiction is available, the flow routing for both the minor storm and major storm runoff should conform to said plan. Drainage easements conforming to the master plan will be required and should be designated on all drainage drawings and subdivision plats. (See Part 2P).

19. Any proposed building or construction of any type of structure including retaining walls, fences, etc., or the placement of any type of fill material which will encroach on any utility or drainage easement, requires written approval of the Jurisdiction. Such structure will not impair surface or subsurface drainage from surrounding areas.

20. The design for stormwater management BMPs and conveyance systems should be in conformance with the following, if applicable:

    a. The jurisdictional MS4 post-construction runoff control regulations ("stormwater ordinance"), and supplemental guidelines, minimum standards, and applicability criteria established by the Iowa Department of Natural Resources.

    b. Iowa Statewide Urban Design Standards and Urban Standard Specifications for Public Improvements.

    c. Jurisdiction Plumbing Code.

E. Floodplain management

1. Although not a direct element of the municipal stormwater conveyance design, floodplain management should be considered along with the overall stormwater management plan to manage the floodplain as it relates to the various stormwater conveyance means, pipes, culverts, streams, and open channels.

2. According to *Municipal Stormwater Management, Second Edition*, "This duty (to manage the floodplain) is assigned by virtue of need and federal, state, and local regulations. The Floodplain Management Act of 1978 requires the floodplain manager to perform a number of duties."

   Furthermore, it states "FEMA (1986) provides an overview of the pertinent details of floodplain management and provides a conceptual framework for floodplain management that stands on four important legs:

   - Reduce flood losses and threats to health and safety
   - Preserve and restore the natural and beneficial uses of floodplains
   - Take a balanced view that minimizes exposure to loss rather than one that promotes either floodplain abandonment, or intense floodplain development
   - Develop and use the tools available to provide careful and technically sound consideration of all information and alternative uses of floodplains

   Floodplain management, when integrated with the overall stormwater management program, provides a regulatory means to improve the surface water system throughout the municipality."