

**Clackamas County Service District No. 1**  
**SURFACE WATER MANAGEMENT PROGRAM MASTER**  
**PLAN**

August 23, 2005

**TECHNICAL MEMORANDUM NO. 8**

**TITLE: Stormwater Regulations and Design Standards Review**

## **Conclusions**

This assignment reviewed the District's February 2005 Rules and Regulations. This technical memorandum's conclusions and recommendations incorporate the lessons learned from District experiences implementing stormwater policy and from development of the District Surface Water Management Program Master Plan (SWMPMP).

This study resulted in the following observations and conclusions.

1. The existing rules and regulations are substantially on the 'right track'. For example there is general recognition that frequent small storm events cause harmful geomorphic changes. As a response, the District revised the rules and regulations mandating that detention basins release at 1/2 the 2-year pre-developed condition rates. This shows progressive thinking and a desire to approach problems with an open mind. Even so, based on the SWMPMP update studies, it was determined that there are additional innovative and progressive techniques that could further enhance the District's standards which would move the District towards achieving its underlying objective to create a more sustainable surface water management program.
2. This study concluded that the most promising approach to mitigating degrading watershed health caused by complex stormwater related issues, was adopting integrated watershed management. Integrated stormwater management is a holistic approach to surface water management for spatially large but related areas. Further discussion is provided in subsequent sections.
3. The District could also use Geographical Information System (GIS) more intensively as the primary instrument for organizing and coordinating the District's day-to-day information management operations. For example, GIS could be used as the primary interface to retrieve archived information such as record drawings, hydrologic and hydraulic models, drainage reports and infrastructure information, etc.. The District already uses Geographical Information Systems (GIS). Therefore, if GIS were used in a new role, the time it would take to learn the new system could be reduced.

4. The study found that there is a need for the District to more clearly convey which design methods and procedures it wants followed. One recommendation is that the District develop stormwater drainage design manuals, technical design memorandum outlining specific procedures and comprehensive checklists to facilitate review and record keeping. Additionally, PWR advocates for a District wide certification plan for engineers designing and building stormwater facilities. This would raise the quality and consistency of work performed in the District.
5. In principle, PWR advocates for the use of low impact development (LID) practices. Some LID techniques offer promise as a viable runoff source control that has the advantage of impacting the surrounding environment less intensively. The District should carefully evaluate LID practices prior to adoption.
6. In general it was found that traditional conveyance systems such as lined channels and stormwater pipes are detrimental to watershed stream stability and aquatic biology. It is proposed that systems such as naturally lined and mildly sloped swales along with flow spreaders be used instead. Downspout disconnects should be done as much as possible to reduce the effective impervious areas which have been shown by others to cause detrimental hydromodification effects. The goal is to mimic the natural routing processes as much as possible. Doing this effectively reduces peak flows and more closely matches natural flow durations.
7. In the course of this study it was found that traditional single event hydrology is flawed. The District's hydrology is based on the SCS Type IA storm. It was found that the SCS design methodology overestimates peak flows especially when the hydrology is uncalibrated. It was also found that the SCS rainfall distribution does not accurately model the more typical rainfall patterns observed in the District. Fundamentally, single event modeling also makes it difficult to address the full range of flows (smaller frequent storm events to rarer more extreme storms) encountered by stormwater infrastructure. These limitations stress the need for a better hydrologic modeling approach.
8. It has been determined by the District previously and confirmed by studies conducted for the SWMPMP, that existing detention facilities allow flows generated by smaller more frequent storms to pass through unimpeded. Traditional focus has been on controlling larger more extreme storms since these caused damage to property. However, small storm runoff intensified by urbanization causes substantial damage to the ecosystem and is not effectively controlled by the existing storm water systems.
9. The objective of revising water quantity regulations that address the currently perceived stormwater issues is to create developed (urbanized) hydrologic patterns that more closely match the pre-urbanization processes. In order to accomplish this, PWR has found that the District should adopt a flow duration standard to size detention basins, use more accurate single event based calibrated hydrology (HEC-HMS) models for the design of conveyance structures and possibly use LID practices. The District's water quantity rules and regulations should be revised accordingly.

## Background

Clackamas County Service District No. 1 Water Environmental Services (WES) is revising their Surface Water Management Program Master Plan (SWMPMP). One of the objectives of the revision is to update the Surface Water Management Rules and Regulations and to implement new policy in order to meet WES District No. 1 goals and objectives as stated below:

The objective of this ordinance is: (a) to prevent or minimize the introduction of pollutants to surface waters; (b) to meet Federal National Pollutant Discharge Elimination System (NPDES) permit requirements; (c) to establish policies which prevent future pollution and erosion through implementation of Best Management Practices; (d) to provide for the equitable distribution of the costs of the surface water management program; and (e) to better manage and control surface water within Clackamas service District No. 1.

It is believed that the District's existing regulations are progressive and point the District in the right direction. The current regulations reflect an able and evolving understanding of natural watershed processes. The District standards identify and address sediment migration (erosion and sedimentation), water quality and the detrimental geomorphic impacts of frequent smaller storm events. The District has expressed a desire to incorporate new scientific knowledge, verified in the field and balanced against the necessity for social/economic considerations, to create innovative non-structural solutions to stormwater issues. The study team has attempted to continue the momentum begun by the District and presents in the following paragraphs recommendations for possible revisions and enhancements to the current set of regulations.

The scope of this technical memorandum is to recommend revisions and updates to the February 2005 District's "Surface Water Management Rules and Regulations for Clackamas County Service District No. 1" based on knowledge and understanding acquired in the course of preparing the Surface Water Management Program Master Plan (SWMPMP) update. The following discussion concerning revisions to the standards and regulations includes the practical experience of District personnel. A significant portion of the material presented in this memorandum was developed as a result of conversations with Tim Finley, Mike Nacrelli, and Mike Bickerton of the District. The results of these conversations were initially compiled by Lew Scholl in November 2004. The study team is grateful for their help and insight in the synthesis of this technical memorandum's recommendations.

The standards review was performed in light of District experience implementing stormwater policy, new scientific understanding, availability of new regulatory methods and computer tools and the availability of new stormwater technology for use in the field. The review focused on the following areas:

- Evaluation of the District's overall approach to stormwater management
- Evaluation of the District's document control process including the expectations for level of competency as well as standards defining proper engineering design submittal requirement.
- Evaluation of the use of Low Impact Development techniques in the District
- Evaluation of the conveyance control policy in the District

- Evaluation of the District flow quantity control standards and policy

As a follow on activity to this review, the District may consider establishing a standards and regulations revisions work group. The work group should be composed of a diverse group of professional disciplines and technical functions to insure that all pertinent viewpoints are represented. The purpose of the group would be to formulate an implementation scheme for revising and reissuing the current standards and regulations based on the SWMPMP work. The work group could then establish subgroups that further evaluate and implement the specific recommendations contained in this technical memorandum.

In the course of performing the SWMPMP, PWR reviewed a multitude of issue papers, technical publications, design manuals, stormwater management plans and other pertinent documents. A full literature review is outside the scope of this memorandum and in any case, reference to many works used to form initial premises and final conclusions may be found in the SWMPMP Final Report.

It has become clear that jurisdictions nationwide are implementing new regulations and procedures that emphasize:

- Sustainable development
- Integrated/comprehensive watershed management planning and regulation
- Hydrologic/hydraulic criteria and methodology with the goal of creating systems that more closely mimic the natural hydrologic processes

PWR advocates that in general the District adopt these approaches and incorporate them into the surface water management program. Stormwater municipalities have moved to these approaches to address stringent Federal regulations (e.g. NPDES II) and because there is a deepening understanding that population growth and urbanization cause sometimes irreversible damage to the biological and fluvial geomorphic balances found in the watershed ecosystem. This new understanding brings a realization that mitigating the effects of urbanization is an immediate and pressing concern and, due to the complexity of the problem, will require the insights and contributions from many stake holder groups.

The remainder of this technical memorandum shall discuss the ‘thought process’ behind the review recommendations and provide a summary of general and specific revisions/additions to the rules and regulations. This technical memorandum will focus on the District’s philosophy for surface stormwater management; how the District performs information and document processing; how LID techniques could affect District design and construction practices and address changes in policy and methodology with respect to stormwater conveyance and water quantity controls.

## Discussion

### District Philosophy, Goals and Objectives

It has become apparent that watersheds are being dramatically degraded by urbanization. As development increases and spreads into previously rural or forested areas, biological health is significantly altered and reduced. Watershed health issues are complicated and interrelated. They demand a mitigation program, which is correspondingly broad and multi-objective, yet at the same time, is focused enough to solve problems decisively. Confronting these watershed issues requires that the District change some of the ways it currently approaches its 'business' of stormwater management.

First, a broad understanding is required of the underlying problems. To accomplish this, the insights of multiple professional disciplines and scientific communities must be shared and exchanged. A facilitator may be useful in order to guide the discussion and keep the focus on the goal of creating a sustainable solution resulting in a healthy watershed habitat.

Comprehensive and effective mitigation planning requires that planners, hydrologists, engineers, geologists and biologists combine skills and share their unique perspectives. The long-term solution must balance social and economic benefits while safeguarding the pre-urbanization habitat function. This sustainability is the only way to insure that the watershed is viable as a place for present and future generations to live on.

A possible approach to maintaining watershed health and bio-diversity while maintaining the contemporary level of development and economic growth, the District could adopt integrated watershed management. This methodology centralizes the various aspects of how surface stormwater management has been performed in the past. This includes consolidating and directing the functions of planning, engineering, permitting and review, maintenance and community stewardship. The latest scientific understanding and engineering practice should be integrated in an adaptive and dynamic manner.

Previously this would have been hampered by a lack of computer tools to adequately model and inventory large areas and tie them together in an efficient and effective manner. With the advent of Geographical Information Systems (GIS) and hydrologic and hydraulic computer programs that can model large numbers of disparate nodes, integrated and comprehensive modeling is now feasible if not pain free. The development of adequate computational tools coincided with the engineering and scientific community's convergence in understanding more completely the natural processes found in a watershed ecosystem. With these things in place, it is now possible to take an integrated watershed management approach to stormwater.

Urbanization of an undeveloped watershed creates a range of damaging cumulative effects. Much like fatigue failure, cumulative effects caused by repeated actions over time, when combined have a magnified additive effect. The repeated use of current site development practices such as creation of

impervious areas and increased drainage network density, may ‘trip’ a threshold point that causes disproportionate damage to the watershed health.

To mitigate cumulative effects, it is proposed that the District should approach watershed protection on a ‘tiered’ basis. Three (3) levels, protection, restoration and stewardship make up this multi-layer approach. The level of protection that can be applied to a watershed depends on the degree to which it has been urbanized as well as the number and richness of the biological resources to be protected. Definitions are presented below (“Specific CCSD#1 SWM Rules and Regulations” Section 2 discussion) and further description can be found in Chapter 6 of the SWMPMP Final Report.

The SWMPMP update report also suggested in Chapter 6 categorizing watershed management activities/strategies in terms of a flow continuum approach. For example, activities that mitigate water quality issues should be applied to small storm events defined in terms of relatively shallow rainfall depths (0 to 1.25 inches of rainfall over 24 hours). The approach as presented in the SWMPMP update report also recognizes and distinguishes between the two predominant human impact characteristics reflected by the existing District and expansion areas. The method is useful because it establishes a quantifiable way to choose different management strategies for different situations encountered. Table 1 is reproduced from the one in Chapter 6 and summarizes the flow continuum approach to determining applicable watershed management strategies.

As a final reiteration, it is stressed that the essence of a successful surface water management program is responsiveness and flexibility. These both allow for a culture of adaptive management. Understanding watershed processes (for example geomorphology of waterways and hydrology of pre-urbanized drainage areas) is continuously being expanded upon and updated. The District itself is continually learning how its policies are affecting watersheds (e.g. increased erosion or flashiness at receiving waters, etc.). An adaptive approach includes continuing education and awareness of the changes in the science upon which stormwater policy is based. In this light, the District should institute a policy of continuous review of the evolving science and validate with actual field observations.

Table 1 Flow Continuum Approach to Watershed Management Strategies

~ 24-hr Rainfall Depth (inches)

	0	1.25	2.5	5.0
	Water Quality Flows	Channel Forming Flows	Flood Hazard Flows	
Existing District	<ul style="list-style-type: none"> <li>• Install Selected Treatment Facility Retrofits Using BMPs</li> <li>• Optimize Maintenance Practices</li> <li>• Encourage Impervious Area Reduction using Low Impact Development (LID) Techniques on Redevelopment</li> <li>• Promote Tree Planting</li> <li>• Promote Native Vegetation Planting</li> <li>• Encourage Downspout Disconnection in Appropriate Soils</li> </ul>	<ul style="list-style-type: none"> <li>• Perform Habitat Inventory and Assessment for Identifying Potential Rehabilitation Areas</li> <li>• Perform Strategic Stream Rehabilitation Projects</li> <li>• Perform Stewardship Functions Where Appropriate</li> <li>• Implement Fish Passage Projects Where Habitat Stability Permits</li> <li>• Perform Stream Bank Stabilization as Suggested by Habitat Assessments</li> <li>• Establish Stewardship Programs for Stream Side Land Owners</li> </ul>	<ul style="list-style-type: none"> <li>• Implement a Willing Seller Program for Frequently Flooded Areas</li> <li>• Determine Opportunities for Multi-Objective Projects Using Purchased Floodplain Areas and Habitat Assessments</li> <li>• Update Flood Management Regulatory Instruments and Hazards Maps</li> <li>• Implement Strategic Floodplain Reconnection Projects</li> <li>• Implement Appropriate Conveyance Improvements for Assuring Public Safety</li> <li>• Implement Appropriate Detention Retrofits</li> </ul>	
Expansion Areas	<ul style="list-style-type: none"> <li>• Establish Regional Water Quality Treatment Facilities in Conjunction with Quantity Control Facilities</li> <li>• Promote Low Impact Development Techniques</li> <li>• Encourage Sheet Flow/ Discourage Concentrated Flow</li> <li>• Encourage Tree Plantings and Native Vegetation Management</li> </ul>	<ul style="list-style-type: none"> <li>• Identify High Quality Biologic Resources</li> <li>• Establish Areas Requiring Protection and Rehabilitation</li> <li>• Implement Regional Detention Facilities Using Flow Duration Standards</li> <li>• Establish Adequate Buffers Based on Biological Productivity and Diversity</li> </ul>	<ul style="list-style-type: none"> <li>• Protect and Restore Natural Floodplain Processes</li> <li>• Establish Vertical Buffer Sufficient for Maintaining Natural Flood Plain Processes</li> <li>• Identify Erosion/Stability Issues and Prioritize for Rehabilitation</li> <li>• Identify and Protect Meander Zones</li> <li>• Prepare Mapping of Hazardous Areas</li> <li>• Maintain Tree Cover</li> </ul>	

## Information Management – Document Creation and Processing

Administering information effectively is critical to the District's goal of implementing successful surface water management. Additionally, in order that the information is useful, it is vital that the District convey its expectations for acceptable levels of engineering competency, use of proper methodologies and procedures and required information content for submittals.

In the course of preparing the SWMPMP update, PWR performed comprehensive hydrologic and hydraulic analysis on a 'Pilot Basin'. The Pilot Basin analyses required accurate drainage inventory information (such as physical location and size, etc.) as well as background information (design flows and facility rating curves, for example). Obtaining this information was difficult because:

- Information was not centralized and easily accessible.
- Information was not complete. For example plan sheets were physically missing or often the reports did not discuss important topics.

During the SWMPMP update study, information necessary to construct accurate hydraulic and hydrologic models was often unavailable on the record drawings in the District archives. Significant resources were expended tracking down or making 'educated guesses' as to what the proper elevations should be.

The District has found that inconsistent document format, clarity and comprehensiveness has hindered stormwater review (Scholl, 2004). PWR has also observed that drainage reports often lacked complete and concise assumption and result summaries as well. This made it difficult or impossible to draw firm conclusions on design intent or intended structure performance. Additionally, drainage reports were often unavailable and the sole documentation of the site design was the record drawings themselves. Without having access to design reports it is useful to have drainage related information on the record drawings themselves. Some of the information that could be provided is:

- Datums used to set infrastructure elevations
- Stage-storage relationships for detention ponds
- Design flows and storm recurrence interval
- Design HGLs

The simple expedient of having available 'scanned in' drainage reports archived in a central 'clearinghouse' would have aided Pilot Basin study significantly.

Although understandable, PWR also found that that drainage reports often overlooked the site drainage in the larger context of the surrounding watershed and its integration and impact on it. The subjects of fluvial geomorphic and water quality impacts were lacking (or minimal) since addressing these topics has not been emphasized in the rules and regulations.

It seems apparent that to address these issues, the District should:

- Develop a more centralized data management system
- Develop a data management system that is comprehensively integrated into the functional processes of the agency.
- Provide definitive guidance on:
  - Information required from the District as part of a submittal package
  - Proper engineering methods and procedures to be used in design
  - Appropriate hydrologic/hydraulic/ fluvial geomorphic considerations to address in the report documentation

Geographical Information Systems (GIS) could be used to centralize stormwater information management and processing. Although promising, it should be pointed out that realizing GIS's full potential may be hindered by such concerns as:

- The fact that the underlying GIS data bases are not always structured in a uniform manner. For example some GIS databases have superfluous data such as multiple identities. This is quite confusing and probably contributes to large file sizes. The underlying databases may need to be 'cleaned up'.
- The District's GIS drainage structure inventory (stormwater facilities) database is not complete. A process must be defined so that the base information is useful and that preprocessing of the GIS information is not a prerequisite when used in hydrologic or hydraulic modeling.
- District regulatory computer programs such as HEC-HMS and EPA SWMM do not seamlessly integrate with GIS. Currently GIS and other computer programs are somewhat difficult to integrate and use together.
- Intensive GIS memory and hardware requirements hinder its use. This makes use of GIS expensive.

However, using GIS is promising and its limitations seem to be outweighed by its potential. The strengths of GIS as the "tie in" solution to various District functions (planning, engineering, regulation, etc.) are:

- GIS is an inherently visual tool. The adage that a picture is worth a thousand words is applicable here. Being visual can allow more efficient information processing.
- GIS is currently used by almost all departments of the District and therefore is familiar. Retraining personnel to use the new implementation of GIS should therefore be minimal.
- GIS databases can be shared and updated relatively easily. This presumes that access to the software is fairly widespread.
- GIS could facilitate the integration of a 'central clearing house' for information used by planners, engineers, etc.

As a practical matter, electronic data formats need to be standardized and a central repository for electronic submittals should be set up. This central network location could be accessed manually (by 'pathing' to it) or through the GIS system itself.

Standardizing engineering document submittals could be aided by providing a set of checklists to guide from. The main types of checklists that could be provided by the District and referenced by the rules and regulations are:

- Engineering design submittal checklist – provides what documents are required for District review and archiving purposes
- Drainage/stormwater report topics checklist – indicates what topics should be addressed in a stormwater drainage report. The checklist should also stress the importance of presenting data in a clear and concise manner. Topics usually overlooked in stormwater drainage reports are:
  - Overall watershed/regional impact
  - Fluvial geomorphic considerations and impacts
  - Effect of small frequent storms
- Record drawing information checklist –will include what should be shown on the design plan drawings such as datums and design flow information.
- List of acceptable hydrologic and hydraulic methodologies and resources though not ostensibly a checklist - indicates District accepted hydrologic and hydraulic design computer programs and methodologies.

As supplemental to the District's rules and regulations incorporating checklists, the District could consider providing example plans and stormwater drainage reports that represent samples of 'good work'. Examples often convey more than does a 'laundry list' of requirements. They could be posted on the Internet and periodically updated.

It should still be emphasized that the goal of the 'checklist' approach is to provide a comprehensive collection of guidance material while at the same time underscoring the need for flexible and a 'common sense' interpretation of these guidelines. Flexibility is 'built in' by making the guidelines/checklists specific enough to cover the most important topics but should not become too specific which may constrain independent thought and creative solutions. The checklist should also emphasize that these are guidelines only and not 'gospel'. 'The element of 'common sense' is hopefully attained by emphasizing freedom of action outside the guidelines if the need arises and by making clear that the checklists can be superceded by outside considerations.

Checklist/guidelines help assure that the subject matter is at least touched upon and that the designer is made aware of certain aspects that the District often finds to be important – for example fluvial geomorphic stability. However, the designer has the freedom to consider and evaluate each project on a case-by-case basis. Of course the designer may be 'called' on something, if the District disagrees. Ultimately, the checklist/guidelines are the beginning. The designer uses their experience and judgment to proceed from there.

Conversely, the reviewer can use the checklists as a guide to check a project submittal and see if it meets the requirements of the District. However, it is also up to the reviewer to step outside the guidelines when necessary and not to fall into a pattern or 'dotting the Is and crossing the Ts'. Reviewers need to take a 'big picture' approach to analyzing a project's impacts and to make sure that the proper level of engineering competency is met. The checklist is useful to make sure that other considerations are not overlooked. Checklists are not to be a substitute for engineering

judgment or experience. To instill experience, training, mentorship and exposure to actual design and construction are required.

During the process of preparing the SWMPMP update, it became apparent that the design methodology and procedures utilized on projects located in the District was variable and often inconsistent. It appeared that lack of definite standards on the subject contributed to this situation. For example, the District has found in the course of regulating development that there is confusion as to the proper methodology to be used to calculate allowable flows and ‘total’ developed condition flows (Scholl, 2004). In the short term, a memorandum could be written outlining the District preferred methods and procedures for calculating the flows. Ultimately, to insure that the District conveys what methods and procedures it wants followed, a District stormwater drainage manual would be invaluable. The out-dated 1991 Design Guide referenced in Section 5.3 may have useful methods, procedures, details and definitions that can be drawn from and used in future District publications (Scholl, 2004). The 1991 Design Guide could be reviewed carefully in light of new technology and information (particularly in the area of LID – e.g. porous pavement). The manual could integrate the subjects of storm water quality and quantity, erosion control and consider the impact from the full spectrum of storm events.

Finally, a District sponsored certification program for engineers could be useful for establishing a uniform (and higher) standard of practitioner proficiency. It is suggested that a minimum 1-day course be given that introduces engineers to the District’s goals and objectives and makes them aware of District expectations and acceptable design methodologies and level of competency expected on a job. The course can also teach techniques for determining the reasonableness of an answer generated by a ‘black box’ (i.e. a computer program). It was found through the course of this study that erroneous results could have been avoided if the designer or the reviewer was able to do a quick ‘sanity check’ on the results. Many times getting a sense of the reasonableness of results only comes with experience, which must be taught or learned through trial and error. The value of experience lends credence to a certification program.

## Low Impact Development

The goal of LID in the context of surface water management is to limit the amount of human impact by creating engineered systems which protect the human population while attempting to maintain the pre-urbanization hydrologic and hydraulic regimes. This approach has become a popular way to mitigate such issues as erosion/sedimentation and reduced stream health in urbanized watersheds. It is now accepted that the best way to prevent unintended impacts is to match nature’s function and processes as much as possible.

Undisturbed natural land surfaces absorb most rainfall at the point where it falls to the ground. The natural storm/runoff processes include much more evaporation, transpiration and infiltration than does the altered urbanized environment. Trees, underbrush and naturally mulched topsoil are replaced by buildings and pavements, which create substantially more runoff. The runoff is often contaminated with chemicals and silts. The result is contamination and reduction in stream biological health. LID is designed to reduce human development impact on the natural environment by mimicking and preserving the natural hydrologic and hydraulic functions found in an undeveloped watershed.

The basic hydrologic and hydraulic objectives of 'LID practices are:

- Reducing runoff at the source
- Reducing the amount of concentrated flows and maintaining a more natural sheet flow patterns
- Increasing the travel times of runoff in the contributing drainage area in order to reduce peak flows

One way that runoff is reduced or eliminated at the source by removal of total impervious areas such as roads or parking lots and replacing them with porous surfaces (such as porous pavers and pervious concrete pavements, etc.). Additionally, soils amendments can emulate the function of the natural 'spongy' cover of the original forest floor. Effective impervious areas, or areas connected directly to a drainage network, are reduced by disconnecting downspouts and eliminating the pipes themselves. Other examples of LID that reduce runoff at the source are green roofs, rainwater cisterns and planter boxes.

The current practice of stormwater management for land development is to collect and concentrate runoff as soon as possible. Stormwater runoff outfalls at points that previously did not experience such high flows volumes and flow velocities. Philosophically, LID takes the approach that stormwater should be allowed to flow in more of a sheet like pattern for longer periods of time until being concentrated in numerous smaller tributaries which route to the receiving waters. This is generally how runoff is naturally conveyed in an undeveloped watershed. LID promotes the use of flow spreaders to 'gently' handle runoff just as it starts its travel to the outfall. Smaller and more numerous grass lined swales are utilized to convey storm water to larger outfall streams and creeks. Catch basins, curbs and 'hard' channels should be avoided, since these traditional drainage structures concentrate runoff.

The District's current standards and regulations do not include provisions for the use of LID practices. Although the technology is relatively new, the project team has found that LIDs do offer sufficient promise to recommend at least considering its use as a viable water quantity control methodology. LIDs also offer intrinsic water quality benefits since they mimic natural processes such as filtration and natural chemical break down. For example, porous pavements provide a media for growing bacteria that digest hydrocarbons (Scholl, 2004). Due to the newness of the technology, the exact quantitative benefits (i.e. how much runoff is eliminated via a certain device) are not well defined. However, several studies are being performed in the Pacific Northwest with the goal of quantifying LID performance data. As more information becomes available it is anticipated that LID techniques can be incorporated into future updates to drainage design methods and procedures.

PWR developed HEC- HMS LID scenarios as part of the analysis of the District watersheds. It was assumed in the (future condition) models that amended soils would be used extensively to reduce surface runoff. The infiltration and storage effect of amended soils were modeled by adjusting the soil storage capacity in each developed subbasin. Model results indicated that amended soils were quite beneficial. If the District adopts amended soils as part of a larger implementation of LID, it should be noted that 12 to 15 inches of soil amendments would be required to achieve the modeled

results. Additionally, soil amendments should consist of stabilized leaf compost or similar organic material, necessary to achieve proper absorptive capacity.

The existing District infiltration policy is confusing and is difficult to implement due to the unique soil conditions of the area (Scholl, 2004). Vagueness on what exactly constitutes impermeable soils as well as inaccurate infiltration measurement sometimes contributes to infiltration being ineffective as a stormwater control. Urbanization also facilitates the ‘wash down’ of fines within the watershed and these tend to accumulate in the bottom of detention ponds. This process ‘glazes’ over or occludes the basin bottoms further reducing percolation and infiltration rates. It was concluded that LID application in the District that rely on infiltration might not be practical. Infiltration techniques should, therefore, be approached with caution, even if geotechnical reports suggest their use.

Individual site rain cisterns were evaluated as a possible source control. One of their attractions is that they do not rely on infiltration to function. They may be uniquely suited to the District needs because the soil composition in much of the District is primarily SCS type C and D - soils with high runoff potential, and low infiltration capacity. This is because much of the underlying soil is glacier till, with high clay content and which tend to have a high degree of compaction. Infiltration in the natural condition is poor and urbanization only worsens it.

Water stored in cisterns may be used for irrigation and as a gray water for household use. Cisterns could provide the source water for drip irrigation systems and/or as a potable water replacement for toilets. It is envisioned that a ‘smart’ cistern could be designed that is fully automatic. Water storage sensors and a small electric pump could regulate water levels in the tank. Emergency overflow could be to the streets. Although the site storm cistern could be expensive to install, the benefits both to the region and the individual owner could justify the expenditure.

Green roofs offer another potential way to absorb rainfall without relying on infiltration of the underlying soils. However, at the time of this writing, it appears that both capital and recurring maintenance costs may be prohibitively high and the benefits not that great.

If the District chooses to pursue the use of LID, several issues will have to be addressed. They are:

- **LID’s purpose, intent and scope.** The District will have to determine how fully it will embrace the LID concept. Will LID techniques be permissible as fully replacing traditional flow control measure or will they be supplemental? A combination thereof?
- **Applicability.** Will the District permit LID use for all development or reserve it for residential developments only? Also, some LID techniques that attain their effect through increased infiltration may not be as useful in areas with highly impermeable subsurface soils. For example, glacier till and other soils high in clay content or with underlying impervious bedrock will not be good candidates for LID infiltration techniques.
- **Peak rate credits.** Will the District institute a peak flow rate credit for LID used on a site?
- **Incentives.** Will LID use be favored by District incentives? Will the District award ‘special credits’ to developers who use LID to reduce stormwater runoff or to protect biodiversity?
- **Standards.** The District will have to develop LID design standards. This means that the District will have to undertake further study on LID performance and develop new hydrologic and hydraulic design procedures. The experience of others implementing LID should be studied and lessons applied to the District’s unique conditions. PWR recommends that the

District exercise caution before accepting LID for maintenance and/or upon contemplating any substantial implementation.

## Conveyance Controls

The District's approach to the function and implementation of conveyance controls could be reviewed. LID practices and updated thinking gained through reexamination of the science and lessons gained from practical District experience could be used to enhance the existing conveyance standards.

Conveyance facilities are required when excess surface water runoff becomes concentrated runoff. Traditional conveyance devices concentrate flows. Concentrated flows have significant adverse environmental consequences. As noted above, concentrated flow is more detrimental at a given point than sheet flow. Once concentrated this energy is difficult to dissipate. Concentrated flows are responsible for significant erosion, which disrupts the sediment transport regime of receiving waters.

Examples of traditional conveyance controls include:

- Engineered channels, ditches and swales
- Pavement drainage features such as curbs, storm drain pipes, inlets and culverts

Traditionally designed conveyance facilities:

- Increase the speed at which surface runoff leaves a site
- Concentrates runoff at specific points
- Reduces watershed response time (i.e. the time of concentration or tc) to storm events increasing the flashiness of flows into receiving waters

The timing and sediment transport characteristics associated with conveyance facilities produce significant adverse impacts on receiving waters and their associated biology. For these reasons, the use of conveyance facilities should be avoided or minimized to the greatest practical extent.

If conveyance controls are actually required, use of milder sloped and more 'natural' conveyance devices should be used. As stated above this means exchanging pipes and 'hard' channels for milder sloped vegetated swales. Any runoff that develops should be allowed to sheet flow as long as possible (or as it did naturally) before being intercepted by a swale/ditch etc.

## Quantity Controls

The recommended Surface Water Management policy changes discussed above necessitate that stormwater quantity regulations be altered significantly. Stormwater quantity controls include structural and non structural elements. The purpose of the controls is to maintain ‘safe’ flow patterns on and off a site.

Design standards and details describe the methods and procedures that should be used in order to meet ordinances, rules and regulations. Rules and regulations are ‘non-structural’ water quantity controls meant to define the ‘safe’ stormwater conditions that should be matched. ‘Structural controls’ include devices such as detention ponds and control manholes that meter out flows at the ‘safe’ rate. Revisions to stormwater quantity controls primarily affect:

- Hydrologic and hydraulic design methods and procedures
- Detention and infiltration facility design requirements

Traditionally the focus has been on protecting people and property from rare and intense flood events without fully considering other factors such as water quality and biological health of receiving waters. Partially because of this, the current stormwater issues have developed as described above. As a response, PWR advocates adopting procedures and methodologies that result in flow patterns similar to what was experienced before urbanization. The underlying assumption and reason for adopting this approach is that by matching pre-urbanized flow durations, the negative effects caused by traditional modes of stormwater management can be mitigated most effectively.

PWR determined that a flow duration standard results in outflows from ‘structural’ systems that more closely match the pre-development hydrologic patterns. Flow duration is accurate because it is based on a long period of gauged data and simulates the most significant surface, subsurface and ground water processes. The Environmental Protection Agency’s (EPA) Hydrologic Simulation Program – Fortran (HSPF) was used to create several continuous runoff time series (RTS) representing different land uses and conditions within the District. Using the PWR developed WES-RTS spreadsheet tool, flow duration simulation can then be used to size flow control facilities such as detention basins.

In the course of developing a new stormwater management approach for the District, it became necessary to define exactly what the hydrologic pre-development target condition was. It is accepted that the Pre-Lewis and Clark condition of heavy forest no longer exists. Farmers long ago cleared the land. Thus, the District’s watersheds were radically impacted by the agricultural use. Recently, as urbanization has taken hold, the previous hydrologic balances were changed once again, continuing and accelerating detrimental geomorphic and biological impacts seen in today’s developing areas (e.g. Happy Valley). Therefore PWR, believed that the appropriate target condition was not the Pre-European land-use. For the study purposes, predevelopment flow control target for new development, was established in terms of a pre-urbanized land use. Studies undertaken as part of the SWMPMP update, indicate that a rural condition of pastures and small stands of forest as seen in 1930’s era aerial photographs constitutes the hydrologic and geomorphically most stable pre-urbanized/predevelopment condition. There is literature to suggest that a period of several decades is sufficient for a watershed to stabilize after major land use change. From the 1930’s photos it is

apparent that much of the District spend several generations as agricultural prior to urbanization. Therefore the 1930's condition was adopted as the ideal/new construction target design condition.

Establishing the pre-developed condition for new infill development/redevelopments in highly urbanized areas is a bit more complex. Adhering to the 1930's target flows and durations may not be feasible or scientifically defensible. For areas that have been developed approximately 20 years or more, it has been found by others that the streams have established geomorphic stabilization and adapted to the urban flow rates and flow durations. Therefore, when determining the pre-development target condition flows and durations it is more important to consider the stable condition prior to development. It should be emphasized that a thorough fluvial geomorphic and watershed assessment should be conducted to insure that waiving the 1930's condition as a standard is the correct thing to do. The goal is to ensure that additional geomorphic instability does not occur as a result of development or that any harm comes to the receiving waters, as a result of development.

Although continuous hydrology modeling is deemed the best way to match the pre-urbanization natural hydrology, from a practical side, some infrastructure will still need to be designed using traditional single event methods. Continuous modeling was found to result in detention basin sizes that were 3-5 times (on average) larger than a comparable basin designed using present methodology. The existing District area is already heavily developed and lacks large tracts of open area, limiting the possibilities for installing a properly designed detention facility.

Further, it is in the District's interest that continuous modeling is done on the regional scale. Flow duration is primarily applicable to detention basin design. Very small drainage areas are difficult to simulate and impractical to maintain.

Single event conventional hydrologic methodologies include the rational and Santa Barbara Unit Hydrograph (SBUH) techniques. The King County computer program HYD or HEC-HMS are often used for SBUH modeling. The rational method is used for sizing pavement drainage type inlets and storm drain laterals. SBUH is typically used to size detention basin facilities.

The District's current set of single event modeling has several drawbacks that contribute to the problems seen today. The District's SBUH methodology is inherently conservative and leads to gross overestimation of existing and developed condition peak flows. This results in 'existing condition' flows that are actually much higher than reality. This leads to release of damaging low flows – and channel incision. Part of the reason that the SCS storm is so conservative is that it uses a Type 1A rainfall distribution. This is a 24-hour single peak hydrograph which does not statistically match the District (and regions) observed temporal and areal distribution for more common rainfall. As part of the SWPMP update, a new 72-hour storm with a rainfall distribution that more closely matches District rainfall patterns was developed. PWR has also created calibrated HEC-HMS models of the District that use a 72-hour rainfall (see TM2) and more accurate physical parameters as input to the models. These models will be useful as the starting point for future design and planning projects.

PWR and the District have determined that the most common storms (small recurrence periods  $\frac{1}{2}$  the 2-year for example) cause significant geomorphic and biological stream damage. While urbanization has increased the severity and intensity of all return interval storm runoff, increased small event

runoff was not seen as capable of causing significant damage, and attention to controlling small storm runoff was neglected. Over time, it was found that this perspective was fundamentally flawed. While rarer events are more dramatic, the smaller storms achieve 'channel forming' potential by exposing channel bed and bank materials to long term stresses due to increased flow rates and the time the elevated flows are exposed to the stream (flow duration). The frequent flow recurrence 'wears down' channel bank and bed stability over time. This is the reason that from a fluvial geomorphology standpoint, small storms can cause as much or more change, as the intense but very rare storm event.

To compound the problem, the SWMPMP determined that smaller storm flows pass unhindered by existing detention control structures. This is because traditional design practice has emphasizes the extreme storm events (5-year and higher). And as noted above, low flows were substantially over estimated. The result is that existing flow control devices do not attenuate smaller storm runoff to pre-developed flow rates and durations. In fact, since detention basins concentrate flow from an area and meter it out after a storm event, the basins actually increase the duration of high flows experienced by the receiving waters, relative to the pre-development conditions.

Existing onsite detention basins have been found to be cost ineffective as a means for reducing peak flows at the receiving waters of large complex drainage basins. It was found that the detention basin effectiveness diminishes dramatically as one moves downstream from the onsite basin. The SWMPMP study also found that the effect of multiple detention basins is minimal at the downstream receiving waters. For example, the Pilot Basin study found that for a contributing area of 235 acres with approximately 40% of the area being detained, the peak reduction due to detention (at Mount Scott Creek) was only 7 and 11 percent for the 2-year and 25-year storm events respectively. It was concluded that the cost of such facilities is high with respect to capital and recurring operation and maintenance costs, for the benefit they provide. As a result, the SWMPMP study determined that an alternative regional detention basin could be a more efficient use of resources than multiple onsite detention basins. .

With respect to District stormwater runoff policy, it was found that a flow duration standard should be used for sizing regional detention. Conveyance facilities such as large pipes and channels should be designed using the new rainfall distribution and the regionally calibrated HEC-HMS models , since these more closely match available observations. The exception to using HEC-HMS flows would be for the design of pavement conveyance systems. Here the rational method along with the current District intensity duration frequency (IDF) curves should be employed.

## General Recommendations

The following section summarizes the general recommendations for revising the District's standards and policies.

### District Philosophy Goals and Objectives

- Adopt an Integrated Watershed Management Policy. The concepts of integration and watershed perspective are explained below.

- Integration is a more holistic approach to stormwater management made necessary by the requirement to solve complex and often times cumulative stormwater problems faced by the District. This solution approach emphasizes an assemblage of diverse perspectives, dynamic flexibility and multi-layered response mechanisms. The disparate elements are centralized so that they can be collectively focused on solving stormwater problems.
- A watershed perspective approach is a response to the realization that natural processes and human interactions occur over spatially large areas and most often create complex and negative ecological changes. Solving the observed stormwater problems must not be done in a piecemeal fashion but rather a ‘big picture’ approach solution should be taken.
- Watershed management should be adaptive with 3 levels of effort to preserve watershed biological diversity and health. The three (3) levels of effort are “Protection”, “Restoration” and “Stewardship”. The definitions for these terms are given in the following section “Specific CCSD#1 SWM Rules and Regulations Recommendations”, Section 2 discussion.
- The District should adopt a science based and multi-discipline approach to stormwater management. This assures that management is continuously dynamic and improving.
- A flow continuum approach for choosing applicable watershed management strategy could be a practical planning and District programming tool.
- Stormwater infrastructure should be master planned. As part of this approach, regional stormwater facilities should be built prior to development. This approach is modeled on how sanitary and sewer water systems are implemented and makes feasible a more logical and efficient layout to the stormwater system.
- The District should adopt an equitable long-term cost-sharing financial plan for funding stormwater and its new capital improvement projects (CIPs).

## Information Management – Document Creation and Processing

- The District should ‘GIS center’ the information management process as much as possible. Since most departments in the District use GIS separately, it would be advantageous to integrate the GIS programs already in use and to centralize data access.
- The District should standardize electronic file formats. For example, the District could request drainage analyses results be submitted as a GIS layer, drainage reports be in pdf format and that record drawings be in pdf and/or AutoCAD drawing formats.
- The District could collect electronic computer models (especially input parameters) as part of the review process and store in a centralized ‘clearing house’ to be used by subsequent developers and District personnel.
- Consistent yet flexible guidelines for document creation and processing should be made available. The goal would be to expedite District reviews and to allow use of the information for future planning, design and regulation activities. In order to accomplish this task, a series of checklists could be created that set baseline requirements. For example:
  - An **engineering design submittal checklist**. The checklist would include specific plan sheets and design report documents to include for review and record keeping purposes.

- A **drainage/stormwater report checklist**. District personnel shall be ultimately responsible for generating a list of requirements, but PWR recommends that the District require stormwater drainage reports address the following subjects not historically given much consideration:
  - Project watershed/regional impacts
  - Fluvial geomorphic stability considerations both onsite and areas offsite that are affected by the subject development
  - Analysis of smaller storm events (e.g. less than the 2-year) and their impact (e.g. stream stability analysis) to downstream receiving waters.
- A **record drawing information checklist**. This checklist would indicate what should be included on plan drawings – for example, project datum used.
- A **list of acceptable hydrologic and hydraulic methodologies and resources** to be used in the District. PWR recommends that the Federal Highways Administration (FHWA), US Corps of Engineers (in particular HEC) and Western Washington/King County design manuals be utilized for design in the District. A future District drainage manual would be very useful for conveying what methods and procedures should be used. However developing a specific manual is costly and adopting the standards of another jurisdiction may be more cost effective
- It is recommended that further guidance be provided outlining District expectations of proper engineering design methods and procedures. To accomplish this, the rules and regulations could mandate that engineers complete a certification program to practice in the District. A certifications program would be used to introduce District goals, design policy and accepted procedures.

## Low Impact Development

- The use of source controls should be explored by the District as viable option for storm quantity runoff control. Special consideration should be given to using LID source controls such as compost amended soils and rain water cisterns.
- Possible update the WES Erosion Prevention Manual (BMPs) to include LID practices.

## Conveyance Controls

- Traditional ‘hard’ conveyance facilities that tend to concentrate and increase the energy of flow should be avoided.
- Every effort should be made at the site level to maintain sheet flow characteristics and avoid concentration of storm runoff.
- Design standards should give preference to using grass lined swales rather than pipes.
- Where flow does become concentrated the outlet of the conveyance facility should be protected by a properly designed energy dissipater.

## Quantity Controls

- The District could redefine the definition for pre-development condition (see specifics below)

- The District could state in the rules and regulations that LID techniques may be a viable alternative to reduce the quantity of flow generated from development. The District should also state that LID will be accepted only on a case by case basis. Concerns include maintenance features and modeling approaches.
- The District could update the standards to indicate that sizing conveyance facilities such as channels and large pipe trunklines should be performed using 25-year, 72-hour calibrated HEC-HMS model flows
- Only onsite detention basin design method are included in the rules and regulations. The rules and regulations should be revised to include and favor regional detention basins
- New detention basin design policy should emphasize the following approaches:
  - Integrated watershed based management techniques (discussed above)
  - Where feasible, the District could construct regional detention basins in lieu of numerous on site detention basins
  - Regional detention basins could be designed to fulfill multiple functions such as:
    - Water quantity and water quality control
    - Community recreational opportunities
    - Aesthetics
    - Reduce West Nile virus vector habitat where possible
    - Consider upland headwater baseflow areas and not be a temperature source
    - Integrate into the natural surroundings
  - Detention basins should be designed using a flow duration approach (see TM6 and the WES RTS)
  - Detention basin design should:
    - If site based and event based, utilize the 72-hour design storm and where possible match both peaks of the pre-developed conditions hydrograph.
    - Reviewed with a focus on small storm events and an eye to ensure that the design does not use excessively conservative assumptions
    - Include a fluvial geomorphologic evaluation of the downstream receiving waters. Where deficiencies arise, mitigation measures should be included.
- Where feasible, the existing infrastructure should be retrofitted to the standards of new construction. However where retrofitting existing detention basins to the level of new construction is not feasible or cost effective, existing detention basins or infill projects should be retrofitted/ designed to better control small storm inflows. Based on PWR study findings, existing detention basin retrofits appear to be feasible (because of inadequate volume) for controlling up to the water quality storm depth (0.9 inches). District accepted routing methods (e.g. level pool) using calibrated HEC-HMS hydrographs should be used to size the basin and its outlet works. Special attention should be paid to the downstream conveyance capacities. If modification to a water quality pond creates conveyance issues downstream, the retrofit should not be implemented.
- Stormwater drainage for infill (in urbanized areas) and redevelopments– should utilize or integrate into the regional stormwater system.
- Downstream analysis should be performed from the project site to a District identified major watershed waterway.
- In developed areas of the District, downspout disconnects could be performed where feasible. This program could be modeled after a similar initiative conducted by the City of Portland.

- As discussed previously, LID could be a viable method for stormwater quantity reduction and a substitute for conventional ‘pipe’ based conveyance solutions.
- It may be beneficial to construct demonstration projects with pervious pavement: asphalt, concrete, and paver blocks to demonstrate performance and maintenance issues over time.

## Specific CCSD#1 SWM Rules and Regulations Recommendations

The following section details revision recommendations to specific sections of the existing rules and regulations. The sections cited in italics were identified because they were directly related to the review recommendations discussed above. Below the italics are suggested changes which should be viewed as a basis for discussion only. The District shall establish final rules and regulation revisions (if any).

### SECTION 1 – PURPOSE AND OBJECTIVES

#### 1.1 Purpose and Objectives

The District could expound on the proposed approaches to surface water management (as outlined above), such as:

- Emphasizing a watershed perspective approach
- Leveraging all available resources by adopting an integrated management philosophy
- Addressing the cumulative (and detrimental) effects of multiple developments
- Utilizing an adaptive management approach
- Emphasizing the importance of pre-development master planning and the placement of regional stormwater infrastructure before development
- Stressing the importance of scientific basis both in surface water management decision making and in design practices
- Stating importance of public awareness and fostering community stewardship

#### 1.2 Adoption of New or Amended rules and Regulations

- A statement should be included indicating how often the District intends to re-examine the ‘state of the art’ in applicable scientific fields (e.g. continually, annually, etc.)
- Detail should be provided discussing a mechanism to update the regulations and practices due to technology change and adaptive management process

### SECTION 2 – DEFINITIONS

The definitions section could be updated to include the following definitions. The District is ultimately responsible for deciding on proper terminology which best serves its purposes, however, the design team provides the following definitions as a beginning point for further discussion.

- **Sustainable development** – Development which maintains both the existing quality of life of present and future residents by preserving as much as possible the natural habitats and resources of the surrounding area.
- **Integrated watershed management** - The coordinated and unified management of all watershed planning, development, monitoring, regulatory services and associated assets. Coordinated management strategies are created by utilizing both scientific and community inputs.
- **Adaptive watershed management** – A process of continual and dynamic refinement of how a watershed is managed. This includes continual education of personnel on the latest science and engineering techniques as well as continual communication between the community and those concerned with the maintenance and functionality of watershed stormwater facilities.
  - **“Protection”** The first of a three level concept for watershed asset management, which includes long-term conservation including land acquisition. Buffers between development and sensitive biological and water resources should be increased and floodplain exclusions should be fully enforced and expanded to protect the watershed and its intrinsic values.
  - **“Restoration.”** The second of a three level concept for watershed asset management is applicable for watersheds whose biological condition is moderately to severely degraded. Improvements to the biological condition of these streams are possible but usually limited due to existing land use and stormwater management methods.
  - **“Stewardship”** The third in a three level concept for watershed asset management is called for where urbanization is essentially complete and the negative biological impacts are fully developed (and ongoing). These stream reaches experience substantial pollutant and sediment loads, which significantly limit their potential for improvement. In these areas the greatest benefits may result from cleaning up, removing non-native vegetation, and/or replanting. Such improvements can improve local biological health, community aesthetics and minimize adverse impacts downstream.
- **Low Impact Development** – A development approach with the goal of maintaining or mimicking the natural (pre-urbanization) condition hydrologic and other physical processes and functions while meeting the traditional human requirements of land development.

2.1.46 Pre-developed – *“Conditions at the site immediately before application for development. Man-made site alterations or activities made without an approved development permit will not be considered as pre-developed conditions.”*

This definition should be changed to reflect that the proposed pre-developed condition is the rural or agricultural condition. In areas where urbanization has been established for sometime (20 years or more as a rule of thumb) and the streams have been ‘hardened’ (based on field evaluation) for the new urbanized flows, the pre-developed condition target could be adjusted.

2.1.55 Redevelopment - The threshold for requiring water quality and water quantity improvements for redevelopment is if the redevelopment impact is 800 square feet or greater of impervious area. This requirement seems inequitable because new development is required to provide such enhancements when the development impervious area impacts are 5000 square feet or greater (Scholl, 2004). District personnel have indicated that the intent of the redevelopment definition may have been for the 800 square feet threshold applying to erosion control only.

It was recommended by District personnel that this issue be reexamined and the criteria clarified.

### **SECTION 3 – DISCHARGE REGULATIONS**

No revisions recommendations at this time.

### **SECTION 4 – ENVIRONMENTAL PROTECTION AND EROSION CONTROL RULES and**

#### **4.2.3 General Requirements –**

Mention of LID techniques could be given in this section. BMP's could be mentioned for dual use as longer-term source controls. The BMPs may have to be modified so that they can be used for longer periods of time. Note: LID techniques should be implemented only on a case-by-case basis. Consideration should be given to maintenance aspects and proposed hydrologic modeling approaches.

### **SECTION 5 – ADDITIONAL SURFACE WATER MANAGEMENT STANDARDS**

A 'blanket' statement could be included which states that all the planning and design decision-making processes should be based on firm scientific principles.

If a 'master planned' paradigm for infrastructure placement is adopted, this section could be updated to reflect this fact. It should be emphasized that regional storm water facilities will be built prior to development.

These sections could be updated to include a statement mandating that plans and design documents be the responsibility of an engineer who has been uniquely certified by the District to perform work in their jurisdiction. The process and requirements of the certification should be established by the District.

5.1.11 *“As-built plans of facilities, easements for all facilities, and approved maintenance plans shall be provided to the District upon completion of construction.”*

The District could add additional clarification to this section. For example, exact sheets to be submitted and in what format. Possible formats include pdf, dwg and GIS layers. A checklist with this information could be developed so that the rules and regulations do not have to include this detail.

The District's publication *Surface Water Management Administrative Procedures* could incorporate stormwater submittal checklists as mentioned and described above.

5.1.14 **PLAN REVIEW** – *“All plans and calculations should be stamped and signed by a civil engineer licensed by the State of Oregon and meet the Standards of the District”*

If a certification program is adopted, this section could include specification that the engineer is certified as approved by the District for performing these types of designs.

5.1.17- *“All developments and redevelopments shall provide water quantity, water quality and infiltration systems to meet Sections 5.2 and 5.3.”*

This could be updated to reflect the fact that the District will be responsible for constructing major stormwater facilities (such as detention facilities). Developments would be required to coordinate with the District for partially funding the regional systems (via some fee structure) and for integrating their site infrastructure into the overall system. Infiltration systems must be implemented with extreme care due to the problems of ‘glazing’ over and the unique soil conditions of the District.

5.2.1 Water Quantity Standards- *Surface water collection systems with the potential to serve areas up to 10 acres of land must be sized for the post-developed 10-yr storm, using the Rational Method. All other surface water conveyance systems shall be sized for post-developed conditions in accordance with the following criteria:*

If the new 72-hour, HEC-HMS calibrated hydrology models are adopted by the District, section 5.2 should be considered for revision. Specific possible revisions follow.

5.2.1.1 *Storm sewer and outfall pipes draining less than 640 acres: 25-yr, 24-hr design storm*

It is recommended that the 25-yr, 72 hour design storm developed for the SWMPMP be used. District supplied HEC-HMS calibrated models should be used as the starting point for determining design flows to be used to size these facilities.

5.2.1.2 *Storm sewer and outfall pipes draining greater than 640 acres: 50-year, 24-hour design storm*

It is recommended that the 50-yr, 72 hour design storm developed for the SWMPMP be used. District supplied HEC-HMS calibrated models should be used as the starting point for determining design flows to be used to size these facilities.

5.2.1.3 *Creek or stream channels draining less than 250 acres: 25-year, 24-hour design storm*

It is recommended that the 25-yr, 72 hour design storm developed for the SWMPMP be used. District supplied HEC-HMS calibrated models should be used as the starting point for determining design flows to be used to size these facilities.

5.2.1.4 *Creek or stream channels draining greater than 250 acres: 50-year, 24-hour design storm*

It is recommended that the 50-yr, 72 hour design storm developed for the SWMPMP be used. District supplied HEC-HMS calibrated models should be used as the starting point for determining design flows to be used to size these facilities.

5.2.1.5 *Creek or stream channels draining greater than 640 acres: 100-year, 24-hour design storm*

It is recommended that the 100-yr, 72 hour design storm developed for the SWMPMP be used. District supplied HEC-HMS calibrated models should be used as the starting point for determining design flows to be used to size these facilities.

*“...Areas draining greater than 10 acres of land may use alternate methods such as SBUH, HEC-1, HSPF, or SWMM, or others approved by the District”*

The District should revise the list of acceptable District hydrologic methodologies in light of the SWMPMP update emphasis on flow duration standards and continuous flow modeling. Also, this section should include a list of FHWA and USACE HEC manuals and models be used by designers. The use of the SBUH and Type IA SCS rainfall distributions should be discontinued.

5.2.3 *“Where a drainage system of catch basins and pipes is available, all drains that extend to the curb must be directly connected to the storm system. No drainage will be allowed into the street or roadway where a drainage system is available.”*

The District should consider revising this section by allowing an alternative to tying into a storm drain system, **if feasible**. The goal would be to reduce the overall effective impervious area as well as the density of pipes in a contributing area. Recommendations regarding source controls (LID) could replace the roof drains outfalling to stream tributaries for example.

5.2.4 Onsite Detention Design Criteria - *“Onsite storm quantity detention facilities shall be designed to capture and detain runoff as follows:*

*2 year, 24-hour post-developed runoff rate to a ½ of the 2 year, 24-hour pre-developed discharge rate. In areas with limited downstream capacity that cannot be upgraded, (see Standards for maps of specific areas), detention shall be designed to reduce the 25 year, 24 hour post-developed runoff rate to a 2 year 24-hour pre-developed discharge rate, and, 2 year, 24-hour post-developed runoff rate to a ½ of the 2 year, 24-hour pre-developed discharge rate.”*

Section 5.2.4 should be redefined as “Detention Design Criteria”. Regional detention should be addressed in greater detail. It should be stated that tying into master planned regional detention basins (or the collector system of one) is the preferred method of disposing of excess runoff generated due to development.

In substantially developed basins, the criterion to use the premier continuous modeling method may be relaxed to appropriate single event methods which meet the same rigors set for the District's HEC-HMS calibrated models.

A flow duration standard using continuous flow modeling is the preferred method of sizing detention basins. The WES-RTS spreadsheet tool should be used to size a detention basin which will meter out flows at the pre-development flow duration rates from ½ the 2-year to the 10-year return intervals.

*Downstream analysis shall demonstrate adequate conveyance capacity where the project site contributes less than 15% of the upstream drainage area OR a minimum of 1,500 feet downstream of the project, whichever is greater. If the downstream analysis crosses the jurisdictional boundary of another surface water management agency, that agency must be notified by the Developer or Owner and given the opportunity to review and comment on the analysis.*

It is proposed that downstream analysis be performed to major creeks serving District identified watersheds (e.g. Mount Scott Creek, etc.). An appropriate hydraulic and fluvial geomorphic evaluation should be performed with the goal of averting or mitigating downstream degradation caused by a proposed development.

*For residential subdivisions and partitions of parcels with the potential to create more than two lots as currently zoned, and for developments having more than 5,000 square feet of impervious surface, on-site stormwater detention, treatment, and infiltration facilities shall be required....*

The District may want to revisit the 5,000 square feet requirement. Clarification may be needed for what sort of onsite stormwater and treatment facilities are actually required given the new emphasis on regional stormwater planning.

#### 5.2.5 Onsite Detention Design Method

*The procedure for determining the detention quantities is set forth in Chapter 4.4, Retention/Detention Facility Analysis and Design, King County, Washington, Surface Water Design Manual Version 4.21 (ibid), except subchapters 4.4.5 Tanks, 4.4.6 Vaults and Figure 4.4.4G Permanent Surface Water Control Pond Sign. This reference shall be used for procedure only. Local rainfall data and information shall apply. The design criteria shall be as noted herein. Engineers desiring to utilize a procedure other than that set forth herein shall obtain the approval of SWMACC prior to submitting calculations utilizing the proposed procedure.*

The District may revise this section to 'Detention Design Method'. Specific detention basin criteria that may be considered for incorporation into the rules and regulations is stated below:

- New detention basins should be sized using a flow duration standard - continuous flow modeling. HSPF is and the WES-RTS spreadsheet tool or comparable methods as

- approved by the District should be used to size the detention basin. The flow durations should match the pre-developed (rural/agricultural) condition for range of ½ the 2-year to the 10-year event estimated by the new WESRTS model
- Detention should be designed to achieve pre-treatment removal of the largest sediment from the main settling area of a ponds via either a pre-settling forebay or a water quality manhole upstream
    - A ‘dead’ storage should be provided within the detention area to retain the water quality storm (0.9 inches in 72-hours). The detention basin should be designed such that it is not prone to becoming a mosquito breeding area. To facilitate this, the bottom should be mildly sloped to ensure positive drainage and prevent areas of ponding.
    - The dead storage should be designed to drain entirely post event. and should include proper outlet structures to drain the retained flows in the water quality pool (brim full to half empty) in 1/3 of the total draw time (16 hours for a 48 draw down time) and the bottom half drains should drain in 2/3 of the total draw down time. See recommendations from the water quality consultant for more details.
  - Inlet and outlet pipes in a detention basin water quality forebay should be located at opposite ends (upstream to downstream) to prevent short-circuiting.
  - Detention basins should contain a live storage component to meet the ½ the 2-year to the 10-year flow duration requirements (using HSPF and WES-RTS for design)
  - Detention should have a primary outlet structure capable of meeting the full spectrum storm criteria.
  - Detention facilities should be provided with an energy dissipater capable of preventing downstream erosion caused by detention basin releases. The design flows should be HEC-HMS generated and calibrated flows. Both primary and emergency overflow structures should have appropriately sized energy dissipation facilities.
  - Sediment build up in detention basins and water quality facilities is a maintenance concern for the District. The primary mechanism for dealing with this is by properly sizing the forebay. It should be realized that the methods available to accomplish this are imprecise at best. The District could mitigate this by indicating that detention basin design provide access ramps with a maximum 4:1 slope for the purpose of track-hoe access or other excavation equipment into open ponds to remove sediment (Scholl, 2004). Additionally, adequate on site area should be provided for drying accumulated material.
  - Should consider treatment train approach and utilize unit operations (e.g., wetpond, bioswale, etc.) and processes (i.e., physical (sedimentation); chemical (sorption); and biological (uptake)).
  - Incorporate comprehensive planting plans to achieve all various forms of treatment processes (as noted above) within various treatment areas of the detention pond (e.g., sediment forebay, low flow channel, permanent pool, berms, and side slopes).

### 5.2.6 *Infiltration systems...*

The District should clarify the meaning of “impermeable soils” for the purpose of waiving infiltration (Lew Scholl, 2004). It would also be useful to require on-site infiltration testing for most sites. Sites with fine soils, may require the use of a “double ring infiltrometer” as is done in Portland. Pit tests could be used to determine infiltration capacity for coarser soils. On very coarse soils the “soil characterization” methods (based on particle gradation) may be preferred. The pre-treatment requirement for infiltration systems could be based on the gradation or permeability of the soil. The District could require more pre-treatment where soils are highly permeable to protect groundwater. The District could waive the infiltration requirement wherever slopes are greater than 10 or 15% (Portland uses 10%). Also clarify other geotechnical reasons to waive the requirement such as high groundwater (define the allowable depth to GW) or slopes that would be unstable at less than 10 or 15% slopes.

PWR’s opinion is that infiltration in the bottom of detention basins is ineffective and should not be considered when sizing basins. It is stressed that all infiltration facilities necessitate an especially high level of detail during the design phase and subsequently require post construction monitoring – to insure adequate functionality.

## **SECTION 6 – RATES FOR SURFACE WATER SERVICE**

The District should update the fee structures necessary for a master planned approach which emphasizes constructing stormwater infrastructure before development takes place. Additionally, the rates should also allow for the capital improvement programs recommended in the SWPMP update.

## **SECTION 7 – COLLECTION PROCEDURES**

The same comment applies to this section as stated in Section 6.

## **SECTION 8 - ENFORCEMENT**

No revisions recommendations at this time.

## **SECTION 9 - APPEALS**

No revisions recommendations at this time.

## **SECTION 10 – SUPPLEMENTARY RULES**

No revisions recommendations at this time.