Section 6 – Watershed Management Recommendations

STATEMENT OF NEED

The current standards of the ECWMC require that land development sites control storm runoff rates to existing levels for the 2, 10 and 100-year storm events. This is often accomplished with on-site detention basins that delay the release of stormwater to match the pre-development peak flow leaving the site. This common standard provides flood protection for downstream properties, but does not reduce the overall volume of runoff generated from new impervious surfaces. Increased runoff volume leads to more frequent bankfull flows in natural streams, therefore stream stability problems continue to accumulate in the watershed.

Based on field observations and management experience, it is apparent that many stream channels within Elm Creek Watershed have been impacted by land development. With current watershed management practices, continued development will perpetuate erosion of stream banks, loss of habitat and increased maintenance needs. Additional watershed management practices are necessary to address this concern.

STATEMENT OF GOALS

The following goals have been identified to guide these recommendations:

1. Effectively address the problem of stream impacts resulting from future land development,
2. Avoid placing an extraordinary burden on land owners,
3. Recognize technical limitations and avoid design complexity,
4. Minimize review complexity and administrative burden,
5. Coordinate and avoid conflicts with other management requirements,
6. Encourage preservation of pervious soils and natural areas
7. Encourage minimization of impervious surfaces.

ALTERNATIVES CONSIDERED

Streams respond to changes in hydrology, therefore the ideal channel protection practice mimics the hydrology that formed the stable stream, including the volume, peak and duration of storm runoff. Exact replication of hydrology is not possible in land development cases where unavoidable loss of infiltration, evaporation and transpiration lead to increased runoff volume. Effective stormwater management practices can be challenging to apply and expensive to implement. With these factors in mind, four prevailing watershed management approaches were considered and are discussed below.

OPTION 1 – IMPLEMENT LOW IMPACT DEVELOPMENT STANDARDS

Low impact development standards focus on reducing impervious surfaces and breaking the traditional pattern of directing storm runoff into concentrated flows. Impervious surfaces can be reduced by modifying zoning codes to set maximum impervious percentages, reduce minimum parking requirements, allow 'cluster development' or alternative allocation of density to preserve open space. 'Disconnected impervious surfaces' can be achieved through better site design practices such as turf channels and use of open space for stormwater infiltration. These concepts can be applied to the construction of public streets by implementing narrower street widths and cross-sections with grass channels.

Because the volume of stormwater runoff would be reduced, stream channel degradation within Elm Creek Watershed would be reduced through Option 1. Low impact development standards have been emerging on a nationwide scale for the past several years, and will continue to evolve with new technologies and approaches. The Minnesota Stormwater Manual, Chapter 4 - Better Site Design Techniques, focuses on the application of low impact development standards. Table 6.1 below lists the topics covered in that document.

Option 1 is strongly encouraged. Low impact development standards provide multiple benefits, including reduced pollutant load, conservation of resources and reduced runoff to receiving streams. With local planning code updates and agency coordination, this option will contribute to all of the stated stream protection goals.

TABLE 6.1 MINNESOTA STORMWATER MANUAL – LOW IMPACT DEVELOPMENT REFERENCE

Chapter 4: Better Site Design Techniques

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OPTION 2 – REDUCE RUNOFF VOLUME THROUGH ON-SITE INFILTRATION STANDARDS

On-site infiltration standards focus specifically on the problem of increased runoff volume from development. By specifying an amount of runoff that must be held and infiltrated into the ground (typically 0.5" to 1.0" of the runoff from impervious areas), infiltration can be very effective in eliminating the volume of runoff from small storms. The applicability of this approach is limited by soil permeability. Areas with heavy (clay) soils are not suitable for infiltration. Where soils are favorable, infiltration practices require careful design, construction and long-term maintenance to ensure operation. Chapter 3, Section 1.5.2 of the Minnesota Stormwater Manual focuses on the application of infiltration standards.

Option 2 is strongly encouraged where soils are favorable for this approach. Infiltration provides pollutant removal and runoff reduction benefits, which would result in reduced stream degradation within the watershed. In highly permeable soils, on-site infiltration contributes to all of the stated stream protection goals.

OPTION 3 – ANALYZE, DESIGN AND CONSTRUCT MODIFIED OUTLET CONTROL IN REGIONAL LAKES

This option proposes targeted projects to provide large scale detention storage of small storm events. A small increase in the depth of storm storage can result in a significant storage increase where the lake surface area is large. The efficiency of large storage areas would result in greatly reduced downstream flows from small storms.

This option does not effectively address the stated stream protection goals. Watershed-wide benefits would require modification to most of the dozens of larger water bodies within the watershed. This would be a lengthy and challenging process, requiring coordination with lake management plans, easements, flood protection and shoreland management. Therefore, this option is recommended only as a potential site specific approach to stream channel protection or restoration.

OPTION 4 – OFFSET INCREASED RUNOFF VOLUME THROUGH EXTENDED DETENTION STANDARDS

In most land development cases, unavoidable loss of infiltration, evaporation and transpiration will lead to increased runoff volume. The impacts of this increased runoff volume can be mitigated through on-site extended detention of small storm events. As an example, site runoff from the 2-year storm may be held and released over a two-day period. The greatly reduced release rate lowers the frequency of destructive stream flows immediately downstream from the site. Applied on a watershed scale, extended detention standards would reduce stream channel impacts in all open channels.

Extended detention builds upon traditional detention basin design concepts; therefore the application is basic and could also be applied to retrofit situations. Extended detention has been recommended as a stream channel protection practice in Maryland, New York, Vermont and Georgia. Chapter 10, Section 5 of the Minnesota Stormwater Manual discusses extended detention for channel protection. Extended detention is a basic standard to implement with watershed-wide benefits. Option 4 contributes to all of the stated stream channel protection goals and is strongly encouraged.

RECOMMENDATIONS

Three of the four options considered above will contribute to achieving the goals stated at the beginning of this section. The most effective watershed approach will be to implement performance standards that allow site specific application by the designer. The extended detention option provides a numerical format for defining the minimum performance standard to be met; therefore the following steps should be taken to implement channel protection standards within the watershed:

1. Implement an extended detention standard specific to the watershed.
2. Allow and encourage alternative compliance through low-impact development and on-site infiltration.

EXTENDED DETENTION STANDARD SPECIFIC TO THE WATERSHED

Extended detention can be combined with current detention methods by increasing the volume of storage dedicated to small storm events. Under current standards, small storms are released at a rate that matches existing conditions. In an extended detention design, small storms are released at a significantly lower rate to offset the downstream impacts of increased runoff volume.

Extended detention standards are defined by three parameters: design storm event, volume to be detained and length of storage time. Recommendations for each of these are provided below.

EXTENDED DETENTION STANDARD – DESIGN STORM

Channel protection can be effectively based on the 1-year, 1.5-year or 2-year events, with corresponding increases in extended detention storage volumes. The current MPCA Construction General Permit lists volume matching for the 1-year and 2-year events for permits discharging to special waters (trout streams, scenic rivers, wilderness areas.)[2] Examples at the end of this section demonstrate that the 24-hour, 2-year event may be reasonably implemented to provide channel protection in Elm Creek Watershed.

2. MPCA, General Permit, August 1, 2003, Appendix A, Section C.4

EXTENDED DETENTION STANDARD – VOLUME TO BE DETAINED

The extended detention storage volume required to provide channel protection has been referred to as the "channel protection volume" or Vcp. This volume is the difference between the predevelopment runoff volume and the developed runoff volume. The definition of "predevelopment" is a key factor in applying this approach. For channel protection purposes, the predevelopment condition should be as close to the natural or presettlement condition as possible. Figure 6.1 provides a graphical solution for determining Vcp for a site. This approach eliminates the need for site-specific modeling and simplifies the design and review process.

As an example, a development with 70% impervious cover (start at point 1) and C soils (move to point 2) in a 2-yr storm (move to point 3) has a runoff depth of 1.87" (point 4). The Channel Protection (CP) Target for C soils (start at point 5) in a 2-yr storm (move to point 6) has a runoff depth of 0.57" (point 7). The channel protection volume, Vcp is the 1.30" difference in runoff depth (1.87"-0.57") applied over the entire site.

FIGURE 6.1 CALCULATION OF CHANNEL PROTECTION VOLUME (VCP)

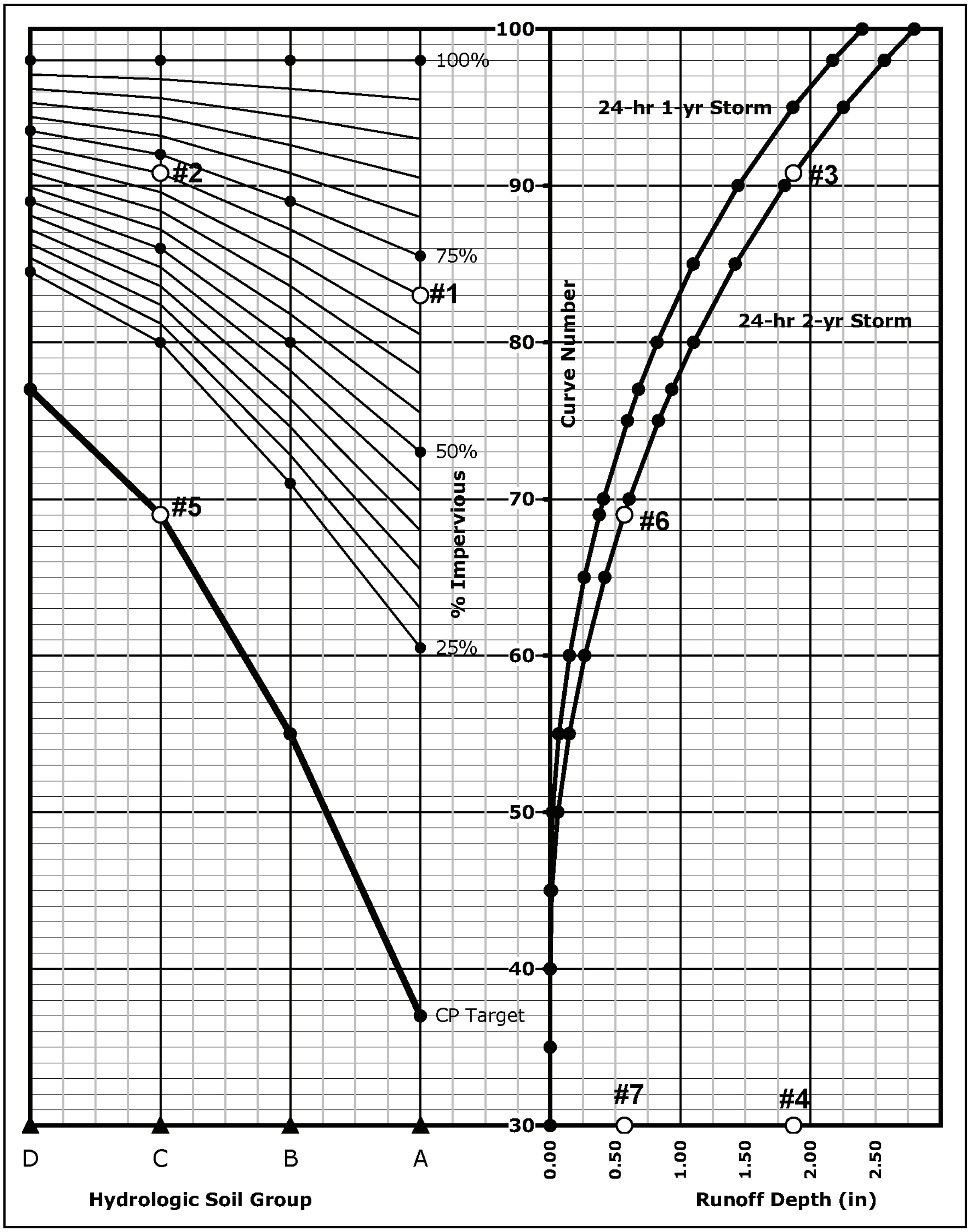


Figure 6.1 demonstrates two important points. First, the location of the 'CP Target' curve is a regulatory decision that reflects the definition of "predevelopment" conditions. Within Elm Creek Watershed, this condition can be characterized as a mix of woods and rangeland. Second, the predevelopment runoff volume is more pronounced in heavier soils. The proposed standard should reflect this to avoid unwarranted regulations.

Figure 6.2 shows the range of results from Figure 6.1 for the 2-year storm. On most development sites, the required channel protection volume Vcp will range from 0.5" to 1.5". The design process has been further simplified by listing these Vcp requirements in Table 6.2.

FIGURE 6.2 VCP VALUES CALCULATED FROM FIGURE 6.2 (24-HOUR, 2-YR STORM)

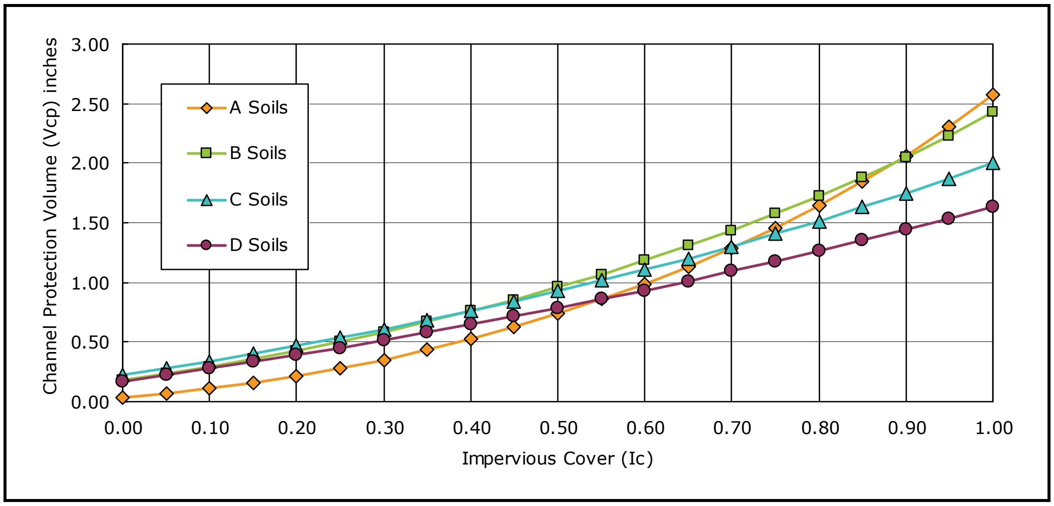


TABLE 6.2 REQUIRED STORAGE VOLUME VCP

Impervious Ratio	A Soils	B Soils	C Soils	D Soils
	Vcp (inches)			
0.00	0.03	0.18	0.22	0.17
0.05	0.07	0.23	0.28	0.22
0.10	0.11	0.29	0.34	0.28
0.15	0.16	0.36	0.40	0.33
0.20	0.21	0.43	0.47	0.39
0.25	0.28	0.50	0.54	0.45
0.30	0.35	0.58	0.61	0.51
0.35	0.43	0.67	0.68	0.58
0.40	0.53	0.76	0.76	0.65
0.45	0.63	0.85	0.84	0.71
0.50	0.74	0.96	0.93	0.79
0.55	0.86	1.07	1.02	0.86
0.60	0.99	1.18	1.11	0.93
0.65	1.13	1.30	1.20	1.01
0.70	1.29	1.44	1.30	1.09
0.75	1.46	1.58	1.41	1.17
0.80	1.64	1.72	1.52	1.26
0.85	1.84	1.88	1.63	1.35
0.90	2.06	2.05	1.75	1.44
0.95	2.30	2.23	1.87	1.54
1.00	2.57	2.42	2.00	1.63

EXTENDED DETENTION STANDARD – LENGTH OF STORAGE TIME

Extended detention storage time can be specified as the time between the center of masses of the inflow and outflow hydrographs. This parameter is fairly easy to design and review with current computer modeling methods. The release rate required to achieve this is dependent upon drainage area, time of concentration and basin dimensions.

Extended detention storage times can range from 24 to 48 hours. Longer storage times result in lower release rates and greater channel protection. Excessively low release rates may be limited by practical outlet dimensions. For maintenance reasons, a 3-inch diameter orifice is often considered the smallest opening that should be installed in a drainage control structure. Table 6.3 compares site drainage area for several examples designed with a 3" outlet orifice, a maximum depth of storage of 3', and extended detention of the 2-year storm for 24, 36 and 48-hour storage times.

TABLE 6.3 MINIMUM SITE DRAINAGE AREAS

Site Characteristics				Site Acreage		
Soil Group	Imperv Ratio	Vcp (inches)	Developed CN	24-hr ED	36-hr ED	48-hr ED
A	0.35	0.43	65	40	55	70
A	0.45	0.63	70	30	40	50
B	0.35	0.67	75	35	40	45
B	0.50	0.96	80	20	27	35
C	0.45	0.84	85	22	27	32
B	0.75	1.58	89	12	16	20
D	0.50	0.79	89	20	30	40
C	0.70	1.30	91	14	18	22

For sites with larger drainage area, channel protection volume can be managed with basic modifications to traditional detention practices. For smaller sites, storage and release will be difficult to implement due to physical outlet limitations. Designers will have to apply alternative methods to meet the channel protection standard in these cases. For example, channel protection volume on A and B soils could be eliminated with on-site infiltration. On C and D soils, extended release could be achieved using a filtration device as an outlet control structure. With these factors in mind, the recommended standard for channel protection in Elm Creek Watershed is a stepped approach based on site area, as shown in Table 6.4.

TABLE 6.4 REQUIRED STORAGE TIME

Site Area (acres)	Storage Time (hrs)
0 to 1	not required
1 to 30	24
30 to 40	36
40 +	48

PROPOSED RULE

Implementation of the proposed channel protection standard will require that Section A of the current Watershed Standards include the following:

1. Development and redevelopment projects shall provide extended detention and/or runoff volume reduction to protect stream channels in the watershed. The minimum runoff volume to be controlled shall be the channel protection volume (Vcp) in inches, obtained from Table 6.2.

2. Extended detention storage time is defined as the time between the center of mass of the inflow and outflow hydrographs. The minimum storage time shall be obtained from Table 6.4.

3. The minimum recommended outflow orifice diameter is 3". Lower release rates will require infiltration, filtration or alternative practices to provide control of the channel protection volume Vcp.

4. Infiltration, permanent storage or other volume reduction methods are encouraged and may be applied to reduce or eliminate the need for extended detention storage.

Current Elm creek standards require control of 2-year peak flows. The proposed standard will result in 2-year peak discharges that are far less than existing conditions; therefore sites meeting the proposed standard will not be required to demonstrate compliance with the current 2-year peak control standard.

FEASIBILITY AND IMPACT TO LANDOWNERS

Implementation of the proposed standard will require extended detention and/or runoff reduction on development sites. Extended detention can be combined with current detention methods by increasing the small storm storage zone. The design process follows these steps:

1. Define the area, curve number and time of concentration for the site draining to the detention basin.
2. Adjust the modeled 24-hr rainfall depth to produce runoff depth equal to Vcp (from Table 6.2).
3. Set the modeled time span long enough to model full outflow.
4. Route the site area through the basin and note the center of mass detention time.
5. Modify the detention storage area and outlet to achieve the required storage time.

The detention volume necessary to provide extended detention of the 2-year storm will be larger than the volume needed to meet the current 2-year peak flow standard. This increase in small storm storage will impact the 10-year and 100-year detention designs, leading to an increase in the overall detention basin volume and footprint. Table 6.5 compares detention basin size for the current and proposed standards for three example sites. The increase in detention basin footprint ranges from 12% to 15%.

The example sites make use of multi-stage outlets to achieve the optimum storage design. Extended detention is controlled by a simple orifice installed at the lowest storage elevation. 10-yr and 100-yr flows are routed through standard culvert pipes elevated above the extended storage zone.

TABLE 6.5 EXAMPLE DESIGNS AND COMPARISON OF BASIN FOOTPRINT

Example Site	1	2	3
Site Area	10 ac	30 ac	50 ac
Soil Group	B	B	B
Imperv Ratio	0.75	0.75	0.75
Vcp	1.58"	1.58"	1.58"
Existing CN	72	72	72
Developed CN	89	89	89
Rainfall for Vcp design	2.64"	2.64"	2.64"
Existing 2-yr (cfs)	6	12	17
Existing 10-yr (cfs)	14	32	46
Existing 100-yr (cfs)	27	60	86

Current Standards

Outlets	6" / 18"	12" / 24"	18" / 30"
Detention Volume (ac-ft)	1.38	4.48	7.48
Basin Footprint (ac)	0.301	0.731	1.149

Design to include 24-hr Extended Detention

Outlets	2" / 27"	4" / 42"	5" / 48"
Detention Volume (ac-ft)	1.70	5.20	8.96
Basin Footprint (ac)	0.347	0.818	1.289
Increase in footprint	15%	12%	12%

Design to include 36-hr Extended Detention

Outlets		3" / 42"	4" / 48"
Detention Volume (ac-ft)		5.28	9.07
Basin Footprint (ac)		0.828	1.302
Increase in footprint		13%	13%

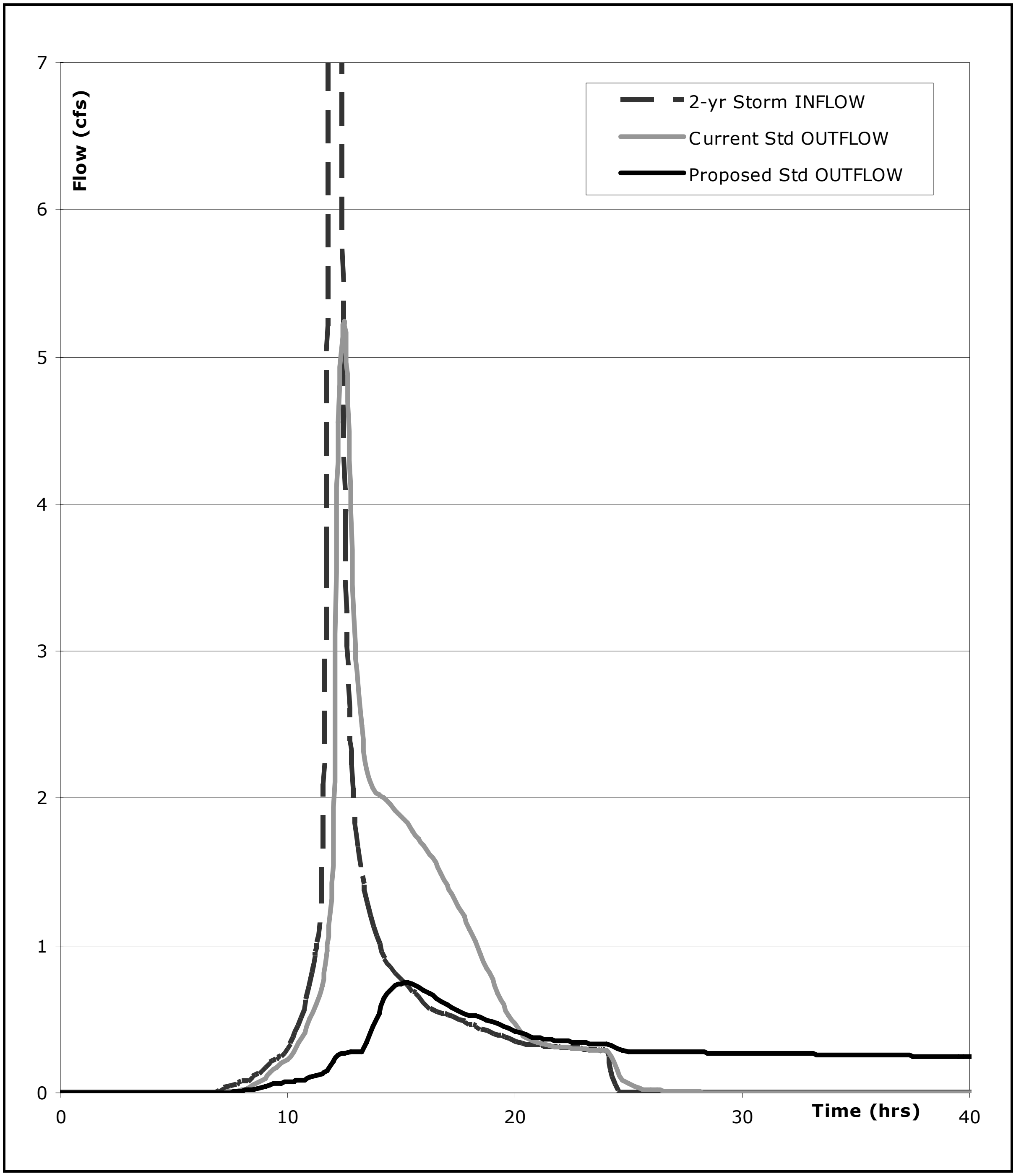
Design to include 48-hr Extended Detention

Outlets			3.5" / 48"
Detention Volume (ac-ft)			9.14
Basin Footprint (ac)			1.312
Increase in footprint			14%

DEMONSTRATED BENEFITS

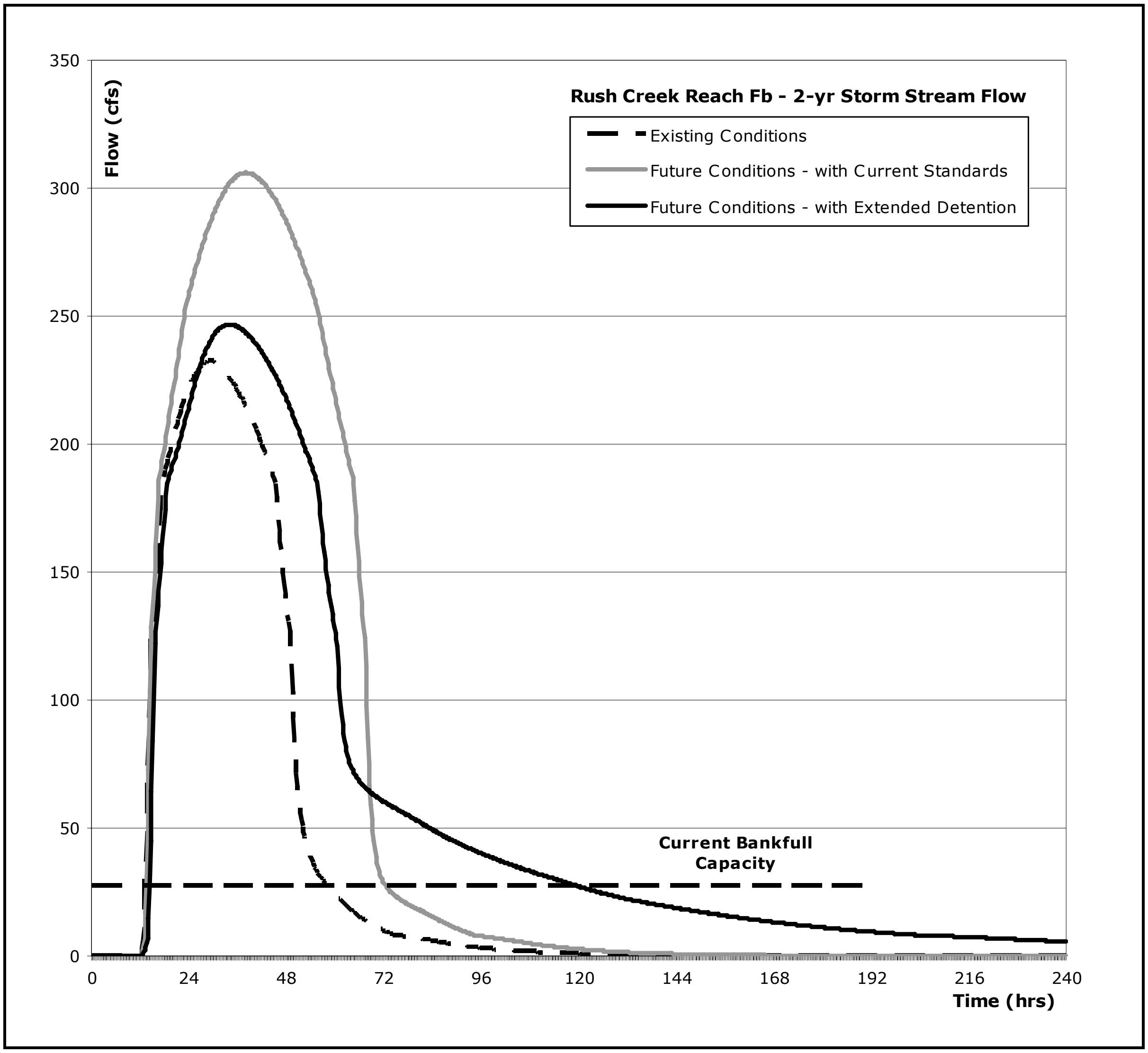
The benefits of extended detention are apparent in Figure 6.3, which shows the inflow and outflow hydrographs for a 2-year, 24-hour storm on example site #1. Flows to the receiving channel immediately downstream are greatly reduced for frequent small storm events.

FIGURE 6.3 SINGLE SITE HYDROGRAPH COMPARISON



The benefits of extended detention on a watershed-wide scale have been demonstrated using a portion of the hydrologic model created for this study. The 12,363 acre area draining to Rush Creek, Reach Fb was modeled to represent possible future development conditions with 30% overall impervious coverage. Figure 6.4 compares stream flow hydrographs for Reach Fb, for a 2-year, 24-hour storm.

FIGURE 6.4 WATERSHED HYDROGRAPH COMPARISON



Figures 6.3 and 6.4 do not include the additional benefit that would result from infiltration and on-site runoff reduction practices. At a minimum the proposed standard would result in the channel protection benefits indicated in these comparisons.

Figure 6.4 also demonstrates that the bankfull channel capacity is well below the calculated flows. Previous land use changes have increased the burden on most of the streams in the watershed. This condition emphasizes the need for on-site channel protection practices in new developments.

Section 7 – Conclusion

It is apparent that many stream channels within Elm Creek Watershed have been impacted by development. With current watershed management practices, continued development will perpetuate erosion of stream banks, loss of streamside habitat and increased maintenance needs. Communities are faced with a growing number of expensive stream stability projects and adverse impacts to natural resources. Additional watershed management practices are needed to address this concern.

Extended detention and runoff reduction practices should be implemented within the watershed to maximize channel protection. Section 6 establishes an extended detention design standard specific to the watershed, and demonstrates the feasibility and benefits of this approach. Low impact design techniques and infiltration practices should be encouraged wherever possible to reduce the need for extended detention and maximize the benefit to receiving streams.