SOUTH MIDDLETON TOWNSHIP

CUMBERLAND COUNTY, PENNSYLVANIA

ORDINANCE NO. 98-12
OF THE BOARD OF SUPERVISORS
OF SOUTH MIDDLETON TOWNSHIP, CUMBERLAND
COUNTY, PENNSYLVANIA

AN ORDINANCE OF AND BY THE BOARD OF SUPERVISORS OF SOUTH MIDDLETON TOWNSHIP, CUMBERLAND COUNTY, PA. PROVIDING FOR A WELLHEAD PROTECTION DISTRICT OVERLAY ON ANY ZONING DISTRICTS REGULATING LAND USES AND ACTIVITIES WITH POTENTIAL TO POLLUTE GROUNDWATER, ESTABLISH STANDARDS AND GUIDES FOR LAND DEVELOPMENT, STORMWATER MANAGEMENT, NUTRIENT MANAGEMENT, MAINTENANCE OF ON-LOT SEWAGE DISPOSAL AND PRESERVATION OF WETLANDS, WOODLANDS AND STEEP SLOPES; PROVIDE FOR SETBACKS AND BUFFER ZONES AROUND SINKHOLES, STREAMS, SPRINGS AND OTHER WATER BODIES; AND TO ALERT LANDOWNERS OF LEGAL RESTRICTIONS FOR CERTAIN LAND USES AND ACTIVITIES FOR THE PURPOSE OF PROTECTING THE WATER QUALITY OF THE WELLHEADS WITHIN THE TOWNSHIP.

IT IS HEREBY ENACTED AND ORDAINED by the Board of Supervisors of South Middleton Township, Cumberland County, Pennsylvania, as follows:

FINAL
March 4,1998

W-P Wellhead Protection District

Section 1 Purposes

The purpose of the Wellhead Protection District is to safeguard the public health, safety and welfare, by providing regulation of land use and the manufacture, use, storage, transport, or disposal of hazardous and other substances which pose a threat to the quality and quantity of groundwater being extracted from the South Middleton Township municipal wells. It is the further intent of this District to recognize and protect a uniquely vulnerable groundwater resource area, defined by a carbonate geologic formation which is prone to the development of sinkholes and fractures that allow rapid infiltration of contaminants to these wells.

The objective of this District as it applies to delineated wellhead protection areas are:

(1) To limit land uses and activities involving the generation, use, transport, or storage of hazardous substances;
(2) To regulate other land uses and activities with the potential to pollute groundwater;
(3) To assure appropriate nutrient management practices;
(4) To establish siting standards to guide development onto the least environmentally-sensitive portions of property;
(5) To preserve vegetated buffer areas and establish setbacks for uses around streams, water bodies, springs, and sinkholes;
(6) To provide for maximum lot coverage standards to minimize impervious surfaces and reduce storm water runoff;
(7) To provide for storm water management that maximizes groundwater recharge;
(8) To protect and enhance surface and groundwater quality from the impacts of development on storm water quality with Best Management Practices;
(9) To establish disturbance standards for wetlands, woodlands and steep slopes to minimize sedimentation of waters and to maximize water recharge;
(10) To require the regular maintenance of on-lot sewage disposal systems to minimize the potential for contamination of groundwater; and,
(11) To alert landowners, potential buyers, appraisers, assessors and lessees of the legal restrictions inherent in certain land uses and activities in this Overlay District.

Section 2 Statutory Authority

Section 1428 of the Federal Safe Drinking Water Act Amendments of 1986 requires the States to establish Wellhead Protection Programs to protect groundwater from contamination. In Pennsylvania, the responsibilities for development and implementation of Wellhead Protection Programs is shared between water suppliers, the Commonwealth and local municipal governments. The Pennsylvania Department of Environmental Protection (DEP) recognizes that, in Pennsylvania, DEP is responsible for regulating water suppliers and discharges of contaminants. DEP also recognizes that it is the responsibility of local governments to regulate land use. South Middleton Township is empowered, under the provisions of the Pennsylvania Municipalities Planning Code (MPC), as amended, 53 P.S. § 10101, to enact ordinances regulating development and land uses.

Section 3 Definitions

Abandonment of Well - An abandoned or unused well may be defined as one or more of the following:

a. A well, other than a monitoring well, which has been out of service continuously for one year or more, and does not meet the definition of a standby well.
b. A monitoring well from which no measurement or sample has been taken for a period of three years.
c. A well which is in such a state of disrepair that it cannot be made operational for its intended purpose.
d. A test hole or exploratory boring 24 hours after construction and testing work has been completed.
e. A cathodic protection well that is no longer functional for its original purpose.
f. Any boring that cannot be satisfactorily completed as a well.
g. An inactive geothermal groundwater heat exchange system.

Alteration of Natural Features - Any earth moving, clearcutting, filling, mining, dredging, grading, paving, excavating or drilling activities which require a permit or approval from Federal, State or local officials.

Best Management Practices (BMPs) - State-of-the-art recommended practices for controlling storm water runoff, or handling hazardous substances.

Carbonate- A sedimentary bedrock made up of limestone and/or dolomite which is highly permeable and prone to fractures, solution channels and the formation of sinkholes.

Closed Depression - In a limestone area, a distinctive bowl-shaped depression of varied sizes in the land surface. It is characterized by internal drainage, and an unbroken ground surface.

Community or Package Sewage Disposal System - A private sewage disposal system releasing treated effluent either into the ground or a surface water source. A large scale system is intended to serve over 25 equivalent dwelling units (EDUs); a small-scale system is intended to serve between 2 and 24 EDUs.

Detention Pond - A basin designed to retard storm water runoff by temporarily storing the runoff and releasing it at a predetermined rate through a defined outlet.

Existing Use - The use of a property as of the date this ordinance was adopted.

Fracture Trace - Natural, linear-drainage, soil-tonal and topographic alignments, usually visible on aerial photographs, which are commonly the surface manifestations of corresponding zones of fracture concentration within underlying bedrock. Particularly in soluble rocks (e.g., limestone and dolomite), fracture zones cause increased bedrock porosity and permeability, resulting in rates of groundwater movement that are greater than the surrounding bedrock.

Ghost Lakes - Transient surface water bodies formed in sinks and closed depressions after heavy precipitation, due to poor internal drainage. This poor drainage may be due to residual clay remaining after solution of limestone minerals.

Impermeable - Impervious, impenetrable to moisture.

Integrated Pesticide Management Plan - A plan which provides for the use of multiple pest management tactics which minimize the risk of undesirable environmental and health effects.

Junked Materials - The accumulation of used and/or discarded materials with the potential for leaching pollutants into the groundwater, including, but not limited to, trash, appliances, machinery, vehicles, or parts thereof, whether on the land surface, into a sinkhole or into a stream, wetland or other water body.

Karst - A type of topography characterized by closed depressions and/or sinkholes, caves, rock pinnacles, fracture traces, and underground drainage, resulting from solution of limestone and dolomite bedrock.

Nutrient Management Act - The PA Nutrient Management Act of 1993, which is applicable to agricultural operations with over 2,000 pounds of animal weight per acre which generate or utilize manure. The Act requires the development of a plan demonstrating that nutrients which are land applied do not exceed crop uptake.

Regulated Substance - A product or waste, or combination of substances that, because of the quantity, concentration, physical, chemical or infectious characteristics, if not properly treated, stored, transported, used or disposed of, or otherwise managed, would create a substantial present or potential threat to public health through direct or indirect introduction into groundwater resources and the subsurface environment. Such hazardous substances include, but are not limited to, substances regulated under Federal or State environmental, pollution control, hazardous substances, and drinking water laws and regulations.

Retention Pond - A basin designed to retard storm water runoff, by temporarily storing the runoff, which does not have a defined outlet structure and which empties through a combination of evaporation, transpiration and infiltration.

Sinkhole - A closed, generally circular, depression in the land surface of variable depth and width, characterized by a distinct breaking of the ground surface, and formed by solution of carbonate bedrock and downward movement of soil into bedrock voids or by collapse of underlying caves.

Storage Tank - Aboveground - A tank which contains hazardous or petroleum substances as regulated under the Storage Tank and Spill Prevention Act (STSPA), as amended, and which meets the following criteria: a stationary tank with 250 gallons or more of capacity with greater than 90% of its capacity above ground. Specific exceptions to this definition are included within the STSPA, and include, among others, on-premise heating fuel tanks, and farm or residential motor fuel tanks with a capacity of 1,100 gallons or less.

Storage Tank - Exempted - Any tank or container which contains hazardous or petroleum substances, either above or underground, which is otherwise unregulated by the Storage Tank and Spill Prevention Act (STSPA), as amended, to include exclusively the following: on premise heating fuel tanks, farm or residential motor fuel tanks with a capacity of 1,100 gallons or less,

and tanks, drums or containers with a capacity of less than 110 gallons which contain hazardous substances.

Storage Tank - Underground - A tank which contains hazardous or petroleum substances as regulated under the Storage Tank and Spill Prevention Act (STSPA), as amended, and which meets the following criteria: a tank with 110 gallons or more of capacity with 10% or greater of its capacity beneath the ground surface. Specific exceptions to this definition are included within the STSPA, and include, among others, on-premise heating fuel tanks, farm or residential motor fuel tanks with a capacity of 1,100 gallons or less.

Underground Injection Well - A bored, drilled, driven or dug well for the emplacement of fluids into the ground (except geothermal exchange systems and drilling muds and similar materials used in well construction).

Wellhead Protection Area (WHPA) - Zones 1, 2 and 3 adjacent to and surrounding a municipal water wellfield as delineated on maps set forth in the Wellhead Protection Study: "Production Wells 1, 2 and 3 (September, 1997), R. E. Wright Environmental, Inc. and included in Appendix A, which are hereby made a part of this Ordinance.

Section 4 General Provisions

General provisions relating to the Wellhead Protection District are as follows:

1. No area within the Wellhead Protection District shall hereafter be used without full compliance with the terms of this Article and other applicable regulations.

2. The Wellhead Protection District established hereby shall be an overlay on any zoning district(s) now or hereafter enacted to regulate the use of land in South Middleton Township.

   (a.) The Wellhead Protection District shall have no effect on the permitted uses in the underlying zoning district, except where said uses are intended to be located within the boundaries of the Wellhead Protection District, as defined herein, and said uses are in conflict with the permitted uses in the Wellhead Protection District.

   (b.) In those areas of the Township where the Wellhead Protection District applies, the requirements of the Wellhead Protection District, if more restrictive, shall supersede the requirements of the underlying zoning district(s).

   (c.) The land use restrictions and the land development regulations set forth herein have been carefully determined through engineering and scientific study to be the minimum restriction or regulation necessary to protect the future quality and quantity of this Township's public water supply. Therefore, there shall be no change in the underlying zoning districts or zoning regulations, such that density and impervious coverage limitations are affected, without further engineering and scientific study documenting that any such change will not adversely affect this Township's public water supply.

(d.) In the event of a judicial decision(s) which modifies, changes, or reduces any: (1) restriction on the use or development of land, (2) boundary for the zones or Wellhead Protection Districts, or (3) underlying zoning classifications within the Wellhead Protection Districts, such modification, change or reduction shall be to the minimum extent necessary to satisfy both the judicial objection and the purpose of this Ordinance.

3. The provisions hereof relating to the Wellhead Protection District shall not repeal, abrogate, or impair any existing easements, covenants, or deed restrictions. However, where the provisions relating to the Wellhead Protection District impose greater restrictions, such provisions shall prevail.

4. The following activities and land uses are exempt from the provisions of this District:

(a.) Retail sales establishments that store and handle hazardous substances for resale in their original, unopened containers.
(b.) Office use where storage and handling of hazardous substances is below threshold quantities as defined in Appendix B.
(c.) The transportation of any hazardous substance through the WHPAs provided the transporting vehicle is in transit.
(d.) Storage and use of hazardous substances in conjunction with municipal water supply and treatment activities.
(e.) Existing Land Uses - All lawfully existing land uses located within a Wellhead Protection Area at the time this Ordinance is adopted shall be exempt from the application of this Ordinance, except Section 6 (Reporting Requirements) and except as described in Section 8(2.)(c.). Nothing herein shall be deemed to exempt such existing land uses from compliance with any other statute, ordinance or rule of common law.

5. Disputes regarding boundary designations of or within the Wellhead Protection District or any zone shall be with the municipal engineer and the Zoning Hearing Board. All other disputes, and the authority for the administration and enforcement of this Ordinance, shall be with the governing body of the Township.

In any dispute arising under the provisions of this Ordinance, the burden of proof shall be on the person(s) challenging the Ordinance, or provisions therein, upon presentation of clear and convincing evidence. The governing body and the Zoning Hearing Board shall have the right to consult with independent consultants for purposes of testing, analysis, opinion, or the like. All costs associated with such consultation shall be shared equally by the parties to the dispute.

Section 5 **<u>Designation and Interpretation of District Boundary</u>**

1. The Wellhead Protection District consists of all lands located within Wellhead Protection Areas (WHPAs). The Wellhead Protection Area Zones are described in narrative form below. Where there may be a discrepancy between the narrative description of a Zone

and the maps referenced in Section 3 above, the maps shall be used to delineate the WHPA Zone.

(a.) Zone 1 is the protective area immediately surrounding each well. Because the location of all three wells is in carbonate geology, a minimum 400-foot radius from the wellhead was established. Zone 1 boundaries were extended an additional 400 feet along the fractures intersecting the perimeter of the 400-foot radius. Justification for a minimum 400-foot radius and extending the Zone 1 protection along these fractures is documented in the Wellhead Protection Study: "Production Wells 1, 2 and 3 (September, 1997), R. E. Wright Environmental, Inc.

(b.) Zone 2 is the area encompassing the portion of the aquifer through which water is diverted to a well. A minimum radius of 2,500 feet from the wellhead was established for Zone 2. Zone 2 boundaries were extended to encompass fracture traces intersecting wellheads, as well as clusters of fractures intersecting a fracture on which a well is located, and certain observation wells. Justification for extending the Zone 2 boundary to encompass fractures intersecting a fracture on which a well is located is documented in the Wellhead Protection Study: "Production Wells 1, 2 and 3 (September, 1997), R. E. Wright Environmental, Inc.

(c.) For purposes of regulating certain land uses and activities, a Zone 2 fringe area is hereby created which shall consist of a 200-foot radius beyond the Zone 1 boundary, within which a greater level of protection will be provided than for the remainder of the Zone 2 area. Justification for extending the Zone 1 protection is documented in the Wellhead Protection Study: "Production Wells 1, 2 and 3 (September, 1997), R. E. Wright Environmental, Inc.

(d.) Zone 3 is the area beyond Zone 2 that contributes surface water and groundwater to Zones 1 and 2. Zone 3 boundaries were determined using annual average recharge rates, maximum rated yield capacity and topographic drainage divides.

2. Boundary Interpretation

(a.) Each application for land development or subdivision containing land within the Wellhead Protection District shall be submitted in accordance with such other provisions of the ordinances of South Middleton Township as are applicable thereto. Any area of the Wellhead Protection District that falls within the subject lot or lots shall be shown on the site plan through shading of such area or areas.

(b.) Any party seeking land development and/or subdivision approval in what might be a Wellhead Protection District shall have the burden to present evidence of the boundaries of the District in the area in question. This presentation must include applicable geographic data with respect to the property and any other pertinent documentation for consideration. The municipal engineer, or other appointed agent, shall review the information and shall make determination regarding the boundaries of lands within a Wellhead Protection Area.

(c.) In situations where a property may have parts lying within more than one (1) WHPA Zone, each part of the property shall be governed by the restrictions applicable to the WHPA Zone in which that part of the property is located. The same rule shall apply to properties lying only partially within the Wellhead Protection District.

Section 6 Reporting Requirements

1. The record owner of a tract of land located within any Wellhead Protection Area, which contains a regulated land use or activity (see Section 7), whether existing or proposed, shall submit copies of the following applicable reports to the Zoning Officer within thirty (30) days of notification by the Township:

(a.) Copies of all Federal, State and County operational approvals, certificates, permits and applications, ongoing environmental reports and monitoring results, relating to environmental, pollution control, hazardous substance, and drinking water laws and regulations pertaining to such lot or tract of land, as and when required to be submitted to federal, state and county governmental authorities. These shall include an Environmental Hazard Survey Form, Hazardous Substances Survey Form, a PIP, PPC, SPCC, SPR, SARA Title III, Tier I and II Reports, as applicable.

The following tabulates various reports required for uses involving hazardous substances:

Table 1

HAZARDOUS SUBSTANCES FORMS, PLANS AND REPORTS		
Form, Plan or Report	**Authorizing Agency**	**Purposes**
Environmental Hazard Survey Form	PA Dept. of Labor & Industry PA Worker & Community Right-to-Know Act	Describes the hazardous substances emitted, discharged or disposed of from the workplace.
Hazardous Substance Survey Form	PA Dept. of Labor & Industry PA Worker & Community Right-to-Know Act	Provides a listing of all hazardous substances found in the workplace.
Pollution Incident Prevention (PIP) Plan	PA DEP Ch. 101	Emergency response plan for facilities which handle materials with potential for accidental pollution of the waters of the Commonwealth.
Preparedness, Prevention & Contingency (PPC) Plan	EPA, Federal Resource Conservation & Recovery Act, as amended PA DEP Ch. 260-270	Emergency response plan for facilities which generate, store, treat, or dispose of hazardous wastes.

Table 1 (Continued)

HAZARDOUS SUBSTANCES FORMS, PLANS AND REPORTS		
Form, Plan or Report	**Authorizing Agency**	**Purposes**
SARA Title III Off-Site Plan	EPA Federal Superfund Amendments & Reauthorization Act	Identities the transportation routes of extremely hazardous substances, a description of the workplace and a risk analysis of the operation to the surrounding community.
SARA Title III Tier I & Tier II Reports	EPA Federal Superfund Amendments & Reauthorization Act	Tier I lists the amounts and locations within the workplace of extremely hazardous substances by type of hazard (e.g., fire, explosion, acute health hazard). Tier II provides a listing of each specific extremely hazardous substances in the workplace and each specific hazardous substance exceeding 10,000 pounds on-site at any one time.
Spill Prevention Control & Countermeasure (SPCC) Plan	EPA Federal Clean Water Act 40 CFR 112	Emergency response plan for facilities which handle hazardous substances or petroleum products as defined in the Clean Water Act.
SpillPrevention Response (SPR) Plan	PA DEP PA Storage Tank & Spill Prevention Act	Emergency response plan for facilities with an above-ground storage tank exceeding a volume of 21,000 gallons.

(b.) In the event that any contaminants and/or substances regulated under federal, state or state environmental, pollution control, hazardous substance, and drinking water laws and regulations are released in reportable quantities on or from any lot or tract of land within any Wellhead Protection Area, copies of any and all notices, reports and documents which such owner filed with any Federal, State and/or County governmental authorities which relate to such release, as and when such notices, reports and documents are required to be filed with such governmental authorities;

(c.) Copies of all notices, orders, rules, decisions, recommendations, enforcement actions and similar documentation, as and when received by such record owner of any such lot or tract of land from any federal, state or county governmental authority in connection with the enforcement of environmental, pollution control, hazardous substance, and drinking water laws and regulations; and,

(2.) Failure to comply with the above requirements so as to permit the Township or any governmental agency to respond in a timely manner to prevent, minimize or contain damage to the groundwater and/or damage to the environment in the Wellhead Protection District shall be subject to the enforcement provisions of Section 9 of this Ordinance.

Section 7 <u>Regulated Land Uses and Activities</u>

The Table contained in this Section (Table 2 - Regulated Land Uses and Activities) sets forth various land uses/activities and the extent of regulation permitted in each of the Zones in the Wellhead Protection Areas. In the event of judicial decision affecting any of the land uses/activities or regulations set forth herein, it is the intent of this Ordinance that any provision found to be illegal shall be stricken, and the remaining provisions shall remain in full force and effect.

The land uses and activities set forth herein shall be considered conditional uses. Full authority for the administration/application of all criteria, terms and conditions of this Section shall be with the governing body. Land uses and activities shall be regulated as follows:

Table 2

REGULATED LAND USES AND ACTIVITIES			
Land Uses and Activities	**Zone 1**	**Zone 2**	**Zone 3**
1. Manufacture, Use or Storage of Hazardous Substances as a Principal Activity	Not Permitted	Not Permitted	Not Permitted
2. Open Burning of Materials Containing Hazardous Substances	Not Permitted	Not Permitted	Not Permitted
3. Quarries & Mining Operations	Not Permitted	Not Permitted	Not Permitted
4. Sanitary Landfills & Junkyards	Not Permitted	Not Permitted	Not Permitted
5. Junked Materials Whether on the Land Surface, in Sinkholes, Streams, Wetlands or Other Water Bodies	Not Permitted	Not Permitted	Not Permitted
6. Collection & Transfer Facilities for Solid Waster or Hazardous Substances, Including Battery & Drum Recycling & Reprocessing	Not Permitted	Not Permitted	Not Permitted
7. Commercial Truck or Rail Tanker Cleaning Operations Where Hazardous Substances Are Involved	Not Permitted	Not Permitted	Not Permitted
8. Commercial Slaughtering, Rendering, Tanneries	Not Permitted	Not Permitted	Not Permitted
9. Land Application of Sewage Sludge	Not Permitted	Not Permitted	Not Permitted
10. Sewage Treatment Plants & Large-scale Community or Package Sewage Disposal Systems (not including municipally-owned & operated pump stations or service lines)	Not Permitted	Not Permitted	Not Permitted
11. Underground Injection Wells	Not Permitted	Not Permitted	Not Permitted
12. Alteration of Natural Site Features Prior to Receiving All Required Permits & Approvals	Not Permitted	Not Permitted	Earth moving activities can be conducted prior to Township approval provided all required DEP and County Conservation District permits have been issued.
13. Liquid Petroleum Product Transmission Lines	Not Permitted	Not Permitted	Not Permitted
14. Commercial or Municipal Solid Waste Recycling & Composting Facilities	Not Permitted	Not Permitted	Storage facilities shall be designed to: a. Have an impervious storage & loading surface. b. Prevent infiltration of rain and surface water into storage areas. c. Provide diking to prevent runoff from storage & loading areas.
15. Cemeteries	Not Permitted	Not Permitted	All caskets shall be encased in concrete grave liners as defined by the Federal Trade Commission in regulations at Part 453, as amended.

Table 2 Continued

REGULATED LAND USES AND ACTIVITIES			
Land Uses and Activities	**Zone 1**	**Zone 2**	**Zone 3**
16. Industrial, Commercial or Institutional Facilities Which Use, Store, Transport, or Dispose of Hazardous Substances	Not Permitted	a. No such facilities shall be permitted within 200 feet of the WHPA Zone 1 boundary. b. All such facilities shall be connected to a public wastewater treatment facility. c. The use, storage and transportation of hazardous substances shall be in accordance with best Management practices. d. All storage of hazardous substances shall 1) be indoors, 2) comply with applicable storage tank requirements set forth in this table, and 3) be temporary only. e. On-site disposal of hazardous substances is prohibited.	(Same as for Zone 2,. b-d only)
17. Golf Courses	Not Permitted	Not Permitted	The Township encourages: a. Coordination with Penn State Cooperative Extension Service to develop and implement an Integrated Pest Management Plan. b. Coordination with the Cumberland County Conservation District to reduce any excess application of nutrients.
18. Small-scale Community or Package OLSDs	Not Permitted	Not Permitted	a. Testing, approval & reservation of second absorption field. b. Submittal of evidence of pumping of septic tanks every 3 years. c. Prior to the expansion or conversion of the land use, & prior to any transfer of property ownership, submittal of evidence by the SEO of inspection & any necessary repairs or maintenance.
19. Geothermal Exchange Systems (groundwater & ground loop)	Not Permitted	a. No such systems shall be permitted within 200 feet of the WHPA Zone 1 boundary. b. Submittal of evidence that 1) the landowner is aware that only food-based antifreeze may be used in piping, 2) professionally designed & installed piping will be encased to prevent leakage, & 3) the recommendations in DEP's Ground Source Heat Pump Manual for protecting water quality will be utilized.	(Same as for Zone 2, b only)
20. Above & Underground Storage Tanks[2]	Not Permitted	a. Underground storage tanks not permitted. b. No aboveground storage tanks permitted within 200 feet of the WHPA Zone 1 boundary. c. Submittal of an approved registration form indicating compliance with STSPA standards. d. All leaking tanks must be immediately emptied by the owner or operator & all released substances removed within 7 days of detection, or sooner if required by DEP.	Above and Underground Storage Tanks - (Same as for Zone 2, c & d only)

[1] For a listing of industrial, commercial and institutional uses which commonly generate use, store, or transport hazardous substances at greater than threshold quantities, see Appendix B. This Appendix conveys the threshold levels at which various substances are considered hazardous.

Table 2 - Continued

REGULATED LAND USES AND ACTIVITIES			
Land Uses and Activities	**Zone 1**	**Zone 2**	**Zone 3**
21. Exempted Storage Tanks	Not permitted	a. Underground tanks are prohibited. b. Aboveground tanks shall: 1) be stored; 2) be enclosed by a permanent dike of impermeable construction, the volume of which shall be equal to or greater than the capacity of the tanks within the dike, & 3) be covered by a roof adequate to prevent rainwater from entering the dike. c. All leaking tanks must be immediately emptied by the owner or operator & all released substances removed within 7 days of detection.	a. Only farm & commercial motor fuel tanks & commercial on-premise heating fuel tanks are permitted as underground tanks; these shall 1) be double-hulled steel or fiberglass encased, 2) be enclosed by a concrete vault, the volume of which shall be equal to or greater than the capacity of the tanks within the vault, & 3) utilize piping that is protected from internal & external corrosion. b. Aboveground tanks (same as for Zone 2) c. Leakage (same as for Zone 2)
22. Nonbagged Bulk (1+ ton) Storage & Application of Road Salt & De-icing Chemicals	Not permitted	a. The Township encourages the use of traditional snow & ice removal methods such as snow plow, hand shoveling & sand. The use of salt and de-icing chemicals should be used only as absolutely necessary. b. Storage is not permitted.	a. Same as for Zone 2. b. Storage facilities shall be designed 1) to have an impervious storage & loading surface, 2) to prevent infiltration of rain & surface water into storage areas, & 3) to provide diking to prevent runoff from storage & loading areas.
23. On-lot Sewage Disposal Systems (OLDS)	Not permitted	a. No such systems shall be permitted within 200 feet from the WHPA Zone 1 boundary. b. Testing approval & reservation of second absorption field. c. Submittal of evidence of pumping of OLDS every 3 years. d. Prior to the expansion or conversion of the land use, & prior to any transfer of property ownership, submittal of evidence by the SEO of inspection & any necessary repairs or maintenance.	(Same as for Zone 2, b-d only)
24. Agricultural Land Application of Manure, Fertilizer & Pesticides	Not permitted	a. a fifty foot (50') agricultural filter strip from the outermost edge of all streams, water bodies, springs, and sinkholes shall be maintained within which no nutrients or pesticides shall be applied. b. The Township encourages farmers having operations with over 2,000 lbs. of animal weight to work with the Cumberland County Conservation District toward compliance with the 1993 Nutrient Management Act. c. For operations with 2,000 lbs. of animal weight per acre or less, the Township encourages farmers to work with the Conservation District to reduce any excess application of nutrients to farm fields. d. For operations in which pesticides are used, the Township encourages farmers to work with the Penn State Cooperative Extension Service in the development & implementation of an Integrated Pest Management Plan. e. The Township encourages farmers to work with the Conservation District to develop a Conservation Plan.	(Same as for Zone 2)

[2] See Section 3 Definitions and Use 21 below.

Table 2 - Continued

REGULATED LAND USES AND ACTIVITIES			
Land Uses and Activities	**Zone 1**	**Zone 2**	**Zone 3**
25. Manure Storage Facility	Not permitted	Not permitted	Submittal of approved plan meeting the standards of U.S. Natural Resources Conservation Service.
26. Well Construction	Only municipal water supply wells may be constructed	Grouting shall be utilized and a sanitary seal shall be provided for all at- or below-grade well openings.	(Same as for Zone 2)
27. Abandonment of Wells	a. Wells shall be sealed within 30 days of abandonment b. A zoning permit demonstrating planned compliance with DEP's water well abandonment guidelines shall be required prior to the sealing of a well. c. Certification by a licensed well driller, professional engineer or registered professional geologist of the sealing of the well consistent with DEP guidelines shall be required.	(Same as for Zone 1)	(Same as for Zones 1 & 2)
28. The Withdrawal of 100,000 GPD or More of Water from Wells or Springs	Not permitted	Not permitted	a. The withdrawal of water for commercial water, soft drink or brewery bottling purposes is prohibited. b. The withdrawal of 100,000 GPD or more of water utilizing one or more wells for any single use is prohibited.
29. Residential Dwellings	Not Permitted	Public outreach and education programs to encourage the proper use of pesticides, herbicides, fertilizers and disposal of household hazardous waste.	Public outreach and education programs to encourage the proper use of pesticides, herbicides, fertilizers and disposal of household hazardous waste.

Section 8 <u>Design Standards</u>

(1.) <u>Intent</u>

The intent of the design standards set forth in subparagraph (3) herein is to minimize impervious surfaces and reduce storm water runoff; to provide for storm water management practices that maintain groundwater recharge; and, protect and enhance surface and groundwater quality from the impacts of development on storm water quality utilizing Best Management Practices. Where there may be conflict or confusion as to the application of these design standards, the governing body shall resolve such conflicts or confusion in the manner most consistent with the intent set forth above.

(2.) <u>Application</u>

(a.) The design standards herein are applicable to all land development in the Wellhead Protection District, WHPA Zones 1, 2 and 3 , except as set forth below in subparagraphs (b.) and (c.).

(b.) The design standards herein do not apply to land development outside of Zone 3 of the WHPAs. Nothing herein shall be construed so as to relieve such land development from the requirements of the Subdivision and Land Development Ordinance.

(c.) Since an existing use may contemplate expansion as part of its long-term plan, it is not the intent of this Section to impose new requirements or standards on an existing use that expands provided that:

(1) the expansion does not require the existing use to acquire additional land beyond its property boundary(ies) existing on the date this Ordinance was adopted. If the existing use changes, or is expanded beyond its property boundary(ies) existing on the date this Ordinance was adopted, then the use change or use expansion is subject to the requirements and standards contained herein; and,

(2) all expansions of existing uses must comply with the requirements of the Subdivision and Land Development Ordinance, and the requirements of any other applicable Ordinance, or imposed by the common law of the Commonwealth.

(3) The governing body may, at its discretion, require the installation of a groundwater monitoring well for expansions of existing uses to serve as advance warning of potential adverse water quality impacts.

(3.) **Land Development Design Standards**

(a.) **General Requirements**

(1) The subdivision of land within WHPA Zone 1 for any purpose other than for the specific protection of the groundwater within this area shall be prohibited;

(2) In WHPA Zones 2 and 3, land development projects shall comply with the following requirements:

A registered professional geologist shall review aerial photographs, soils, geologic and other available related data including the Wellhead Protection Study, as the data relates to the subject property. The geologist shall also conduct a site inspection of the property. Based on the above information, the professional shall prepare a map of the site showing the following:

(a) closed depressions
(b) open sinkholes
(c) outcrops of bedrock
(d) surface drainage into ground
(e) “ghost lakes” after rainfall

(f) lineaments, faults and fracture traces
(g) limonite excavations and quarries

(3) Based on the map prepared pursuant to Section 8(3.)(a.)(2.) above, and in conjunction with other mapping and information submitted for compliance with the requirements of the Subdivision and Land Development Ordinance, the geologist shall prepare a report demonstrating compliance with the requirements of this Section, including any recommended mitigating measures designed to ensure compliance;

(4) The municipal engineer, or other appointed agent, shall review the information and recommendations made by the geologist and shall then report to the planning commission and the governing body whether the proposal meets the design requirements of this Section;

(5) During construction activity, all excavations shall either be protected against storm water ponding or backfilled daily;

(6) All buildings, structures, impervious surfaces and utilities shall be situated, designed and constructed so as to minimize the risk of new sinkhole formation and of the accelerated introduction of contaminants and pollution into the wellhead protection area through existing or future sinkholes;

(7) Buildings, structures, impervious surfaces, utilities and swimming pools shall not be located within fifty feet (50') of any features identified in Section 8(3.)(a.)(2.) unless detailed geotechnical work shows that there will be no negative impact on groundwater recharge or quality;

(8) Salt or de-icing storage areas, gasoline or other chemical storage areas and blasting shall not be located within one hundred feet (100') of any features identified in Section 8(3.)(a.)(2.) unless detailed geotechnical work shows that there will be no negative impact on groundwater recharge or quality;

(9) Storm water facilities, including, but not limited to, detention basins, shall not be located within twenty five feet (25') any features identified in Section 8(3.)(a.)(2.) unless special precautions are taken to protect groundwater recharge and quality, including the installation of lines, impermeable beds and concrete pipe utilizing o-ring joints;

(10) Storm water retention facilities, french drains, and other areas of concentrated infiltration of storm water shall be prohibited; and

(11) Storm water shall not be directed into a sinkhole or closed depression.

(12) All subdivision and land development plans shall include a note holding the South Middleton Township Municipal Authority harmless for any

property damages which may be attributable to operation of the production wells.

(b.) **Siting**

Proposed development (excluding farm buildings) on properties that extend both inside and outside the WHPA Zone 3 boundary shall meet the following requirements:

(1) Where sufficient buildable land area exists on the portion of the property outside the WHPA Zone 3 area boundary to accommodate the proposed development, and where applicable setbacks permit, that area in its entirety shall be utilized before any land within the WHPA Zone 3 shall be used;

(2) Where insufficient buildable land area exists on the portion of the property outside the WHPA Zone 3 to accommodate the proposed development, as much of the proposed development as possible shall be sited outside the WHPA and the remainder sited just inside the WHPA Zone 3 boundary; and

(3) Proposed development (excluding farm buildings), located entirely within WHPAs Zones 2 and 3 should be grouped and sited at as great a distance on the subject parcel as possible from the wellhead and from streams, water bodies, sinkholes, and other karst features described in Section 8(3.)(a.)(2.) as buildable land area permits.

(c.) **Setback Requirements**

(1) A minimum of fifty percent (50%) of existing live trees and other brushy perennial vegetation within a one hundred foot (100') buffer of the outermost edge of all streams, water bodies, springs, and sinkholes shall be maintained;

(2) A minimum one hundred foot (100') development setback from the outermost edge of all streams, water bodies and springs shall be maintained; and

(3) Within WHPA Zones 1 and 2 only, a fifty foot (50') agricultural filter strip from the outermost edge of all streams, water bodies, springs, and sinkholes shall be maintained within which no nutrients or pesticides shall be applied.

(d.) **Lot Coverage** - As stated, the intent of these design standards is to minimize impervious surfaces and reduce storm water runoff; to provide for storm water management practices that maintain groundwater recharge; and, to protect and enhance surface and groundwater quality from the impacts of development on storm water quality with Best Management Practices. The Board of Supervisors

of South Middleton Township has studied the issue of impervious surface restrictions carefully and thoroughly. The Board believes that the following design requirements are equitable, in that they provide the greatest degree of wellhead protection and present the lowest potential for impacting existing and future land uses within the Township.

The percentage of the lot which may be covered by impermeable surfaces, including buildings, sidewalks, and parking lots and driveways shall be in accordance with Table 3.

Table 3

Well Number 1

Underlying Zoning District		Maximum Impervious Lot Coverage (Zones 1, 2 and 3)
Woodland Conservation	W-C	7%
Agricultural	A	15%
Village	V	60%
Commercial Office	C-O	60%

Well Number 2

Underlying Zoning District		Maximum Impervious Lot Coverage (Zones 1, 2 and 3)
Agricultural	A	15%
Low Density Residential	R-1	40%
Moderate Density Residential	R-2	50%
Commercial Office	C-O	60%

Well Number 3

Underlying Zoning District		Maximum Impervious Lot Coverage (Zones 1, 2 and 3)
Agricultural	A	15%
Low Density Residential	R-1	40%
Moderate Density Residential	R-2	50%
Commercial Office	C-O	60%

(a.) **Ground Cover and Landscaping** - Vegetative cover shall be provided on all disturbed land areas, excluding fallow agricultural fields, not covered by paving, stone or other solid material. The maintenance or use of native plant materials with lower water and nutrient requirements is encouraged;

(b.) **Erosion and Sedimentation** - All proposed development and land use activities which involve grading or excavation shall require the preparation of an Erosion and Sedimentation Control Plan, to be reviewed by the Cumberland County Conservation District. Such Plan shall conform to the requirements of Chapter 102, as amended, of the Rules and Regulations of the Department of Environmental Protection;

(c.) **Storm Water Management** - All proposed development and land use activities within WHPA Zones 1, 2 and 3 shall utilize innovative storm water management

techniques that incorporate Best Management Practices. Such practices shall be used to filter pollutants from surface runoff. Natural drainage systems shall be considered, including constructed wetlands, grassed swales, change in ground cover, and retention of woodlands and natural topography. Examples of acceptable BMPs are included in Appendix C.

(d.) **Sanitary Sewers** - Sanitary sewers constructed within one hundred feet of (100') closed depressions, open sinkholes, seasonal high water table indicators, surface drainage into ground, "ghost lakes", lineaments, faults and fracture traces shall be either encased in concrete or of ductile iron.

(e.) **Wetlands** - No development or land use activities or improvements which would entail encroachment into, the regrading of, or the placement of fill in wetlands in violation of State or Federal regulations is permitted. Applicants must submit evidence that, if wetlands are present on the site, the Pennsylvania Department of Environmental Protection (Bureau of Dams and Waterway Safety) and the U. S. Army Corps of Engineers have been contacted to determine the applicability of, and compliance with, State and Federal wetland regulations. Any replacement wetlands proposed to offset the filling of on-site wetlands shall be located within the same WHPA Zone;

(f.) **Woodlands** - Existing wooded areas shall be protected to prevent unnecessary destruction. Healthy trees with a caliper of six inches (6") or more as measured at a height of four and one-half feet (4½') above existing grade, shall not be removed unless their location interferes with a planned improvement that cannot be relocated. At least seventy-five percent (75%) of the number of trees (size described above) that exist at the time of plan submission shall be maintained or replaced immediately after construction. Replacement trees shall be of a native species and have a minimum trunk caliper of two inches (2") at a height of six inches (6") above finished grade and located within unbuildable sections of the site (i.e., floodplain, steep slope, and setback areas). Plans shall be submitted showing existing trees and proposed construction and which indicate conformance with this section;

(g.) **Steep Slopes** - Proposed development in areas having slopes of fifteen percent (15%) or greater shall meet the requirements of Section 1420, Steep Slope Conservation District, of the Zoning Ordinance. In addition, the applicant shall:

(1) indicate the methods that will be used to protect water quality on and around the site from the adverse effects of the proposed use;

(2) demonstrate how off-site impacts on karst features will be avoided (see Sections 8(3.)(a.)(2) and 8(3.)(a.)(3)); and

(3) provide a twenty-five foot (25') vegetative buffer consisting of native trees and other brushy perennial vegetation either along the boundary of the property with the lowest elevation, or at the foot of the sloped portion of the property if it lies interior to the boundary. Plans shall be submitted

showing existing vegetation and proposed new vegetation along this boundary. Any required new vegetation shall be established prior to the commencement of any other on-site earth disturbance activities; and

(h.) **Road Construction** - New roads and the widening of existing roads shall minimize impervious land cover.

Section 9 Modification/Waiver

(1.) The governing body may modify one or more provisions of this Ordinance provided that all of the following findings are made and such modification will not be contrary to the purpose and intent of this Ordinance:

(a.) strict compliance with or literal enforcement of the Ordinance will result in undue hardship because of peculiar conditions pertaining to the land in question;

(b.) the undue hardship alleged is not a hardship generally created by this Ordinance affecting all lands similarly situated;

(c.) the undue hardship was not created, or did not arise, subsequent to January 1, 1997;

(d.) the modification requested is the minimum necessary to afford relief and represents the least modification possible; and

(e.) the undue hardship alleged can not be reduced by development of adjoining land of the applicant or landowner.

(2.) The governing body may waive one or more provisions of this Ordinance when it is proved by clear and convincing evidence that there is no possibility that the property, together with any adjoining land of the applicant or landowner if applicable, can be developed in strict conformity with the Ordinance.

(3.) In granting any modification or waiver, the governing body may attach any conditions and safeguards as it may deem necessary.

(4.) All requests for a modification or waiver shall be in writing and shall accompany and be part of the application for subdivision or land development. The request shall address in full and with specificity the provisions in question and the grounds and facts being relied upon. The request shall also address each of the criteria raised herein and shall be signed by the applicant, and certified by an engineer.

Section 10 Enforcement

(1.) In addition to the fines and penalties set forth herein, and any other penalties existing under the law, any landowner and/or person responsible for violation of this Ordinance shall be liable for total remediation of the site where the violation occurs, as determined

by the governing body, and shall be liable for any and all damages arising from the violation.

(2.) Fines and Penalties

(a.) Violation #1 - property owner and/or person responsible for violation will be required to attend five (5) hours of Environmental Responsibility and Awareness Counseling, as determined by Township staff, plus all costs incurred by the Township, including, but not limited to, litigation costs, attorney fees, and consulting charges, if applicable; and any costs of remediation for contaminated sites.

(b.) Violation #2 - In addition to the other provisions hereof, a $500 fine for each violation.

(c.) Violation #3 - In addition to the other provisions hereof, a $1,000 fine for each violation.

(d.) Additional violations on a single site will be treated on an individual basis.

(e.) Failure to complete required counseling in the time as set forth by the Township staff will result in an additional $1,000 per-occurrence fine. Failure to initiate remediation as prescribed by the Township's Wellhead Protection Consultant within 24 hours of discovery of contamination will result in the Township completing said remediation and assessing a $2,500 fine plus all costs.

(3.) In addition to and notwithstanding the above, any and all persons who are determined to have delayed in reporting, or who are determined to have attempted to conceal a violation of this Ordinance such that the detrimental effects of the violation were not contained and/or minimized, shall pay an additional fine of $5,000.

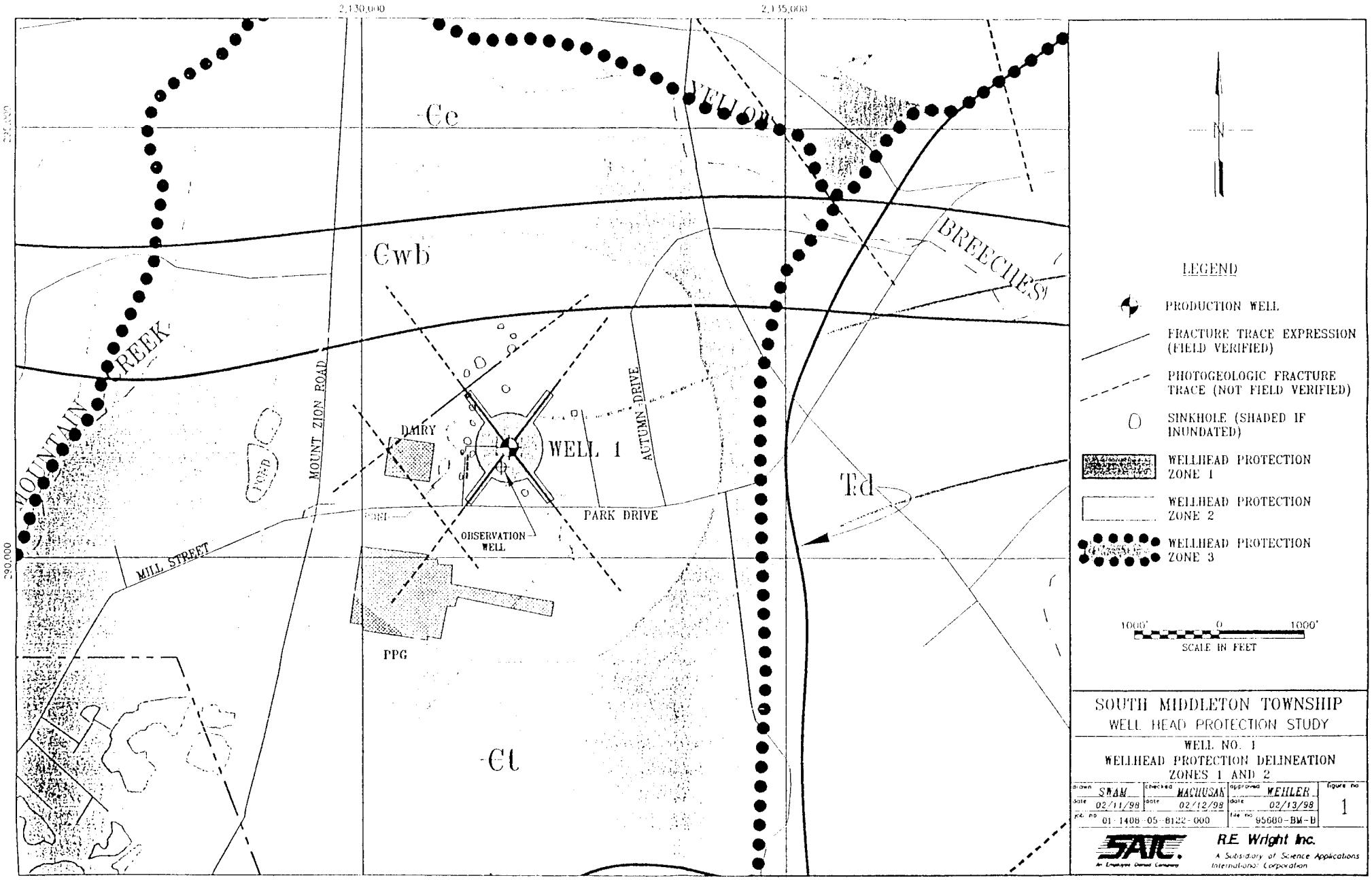
Section 11 <u>Repealer</u>

Any ordinance of the Township which is inconsistent with any of the provisions of this Ordinance is hereby repealed to the extent of the inconsistency only.

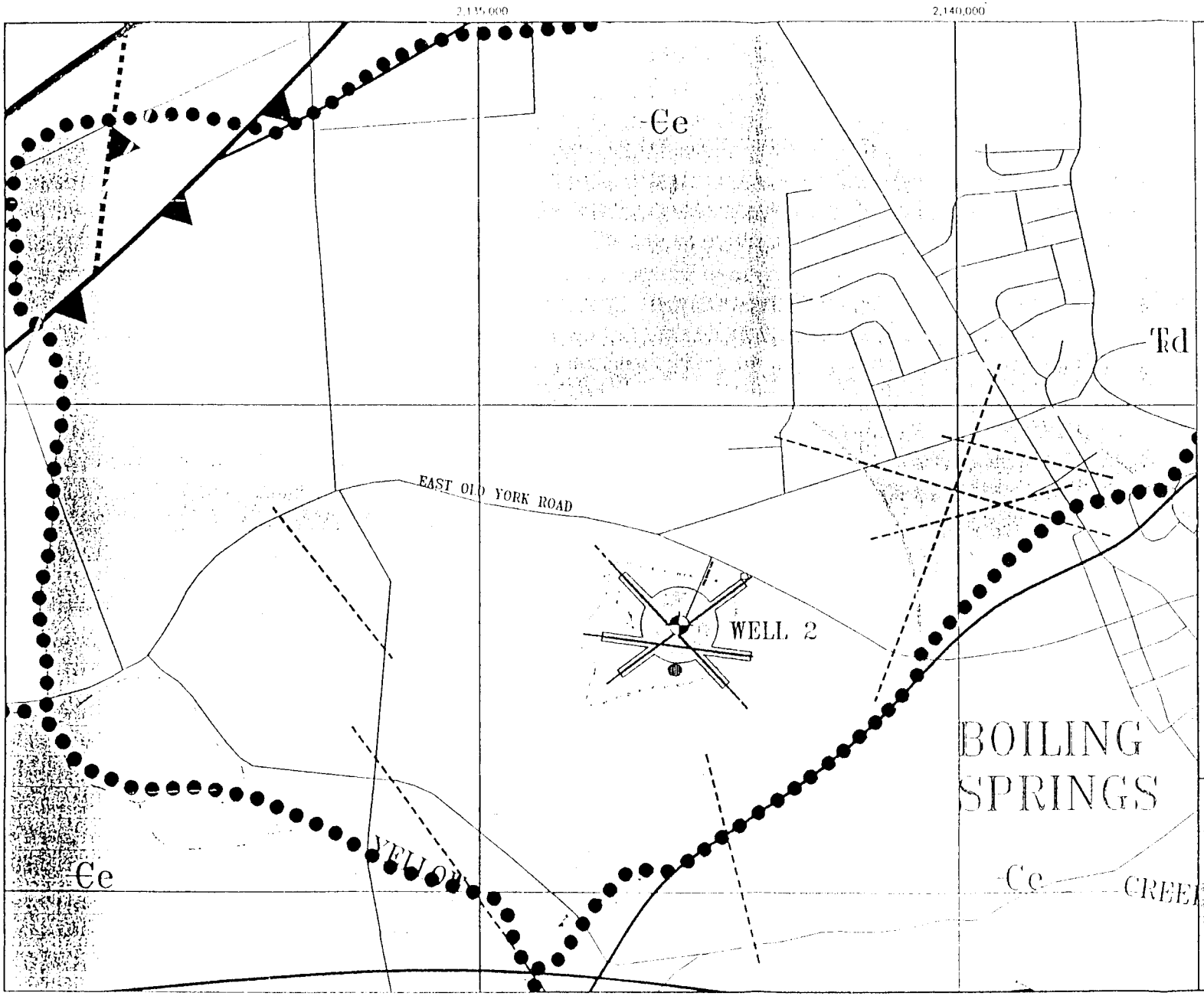
Section 12 <u>Severability</u>

Should any section or provision of this Ordinance be declared invalid by a court of competent jurisdiction, such decision shall not affect the validity of any of the remaining provisions of this Ordinance.

APPENDIX A



NOTE: SAIC/R. E. WRIGHT, INC. USED ORIGINAL USGS 7.5 MIN TOPOGRAPHICAL QUADRANGLE SHEETS FOR ALL TECHNICAL EVALUATIONS; GEOLOGY FROM BECHER AND ROOT, 1981.



N

LEGEND

- PRODUCTION WELL
- FRACTURE TRACE EXPRESSION (FIELD VERIFIED)
- PHOTOGEOLOGIC FRACTURE TRACE (NOT FIELD VERIFIED)
- SINKHOLE (SHADED IF INUNDATED)
- WELLHEAD PROTECTION ZONE 1
- WELLHEAD PROTECTION ZONE 2
- WELLHEAD PROTECTION ZONE 3

1000' 0 1000'
SCALE IN FEET

SOUTH MIDDLETON TOWNSHIP
WELL HEAD PROTECTION STUDY

WELL NO. 2
WELLHEAD PROTECTION DELINEATION
ZONES 1 AND 2

drawn	checked	approved	figure no
SWAN	MACHUSAK	WEHLER	2
date 02/11/98	date 02/12/98	date 02/13/98	
job no 01-1408-05-8122-000		file no 95680-DM-B	

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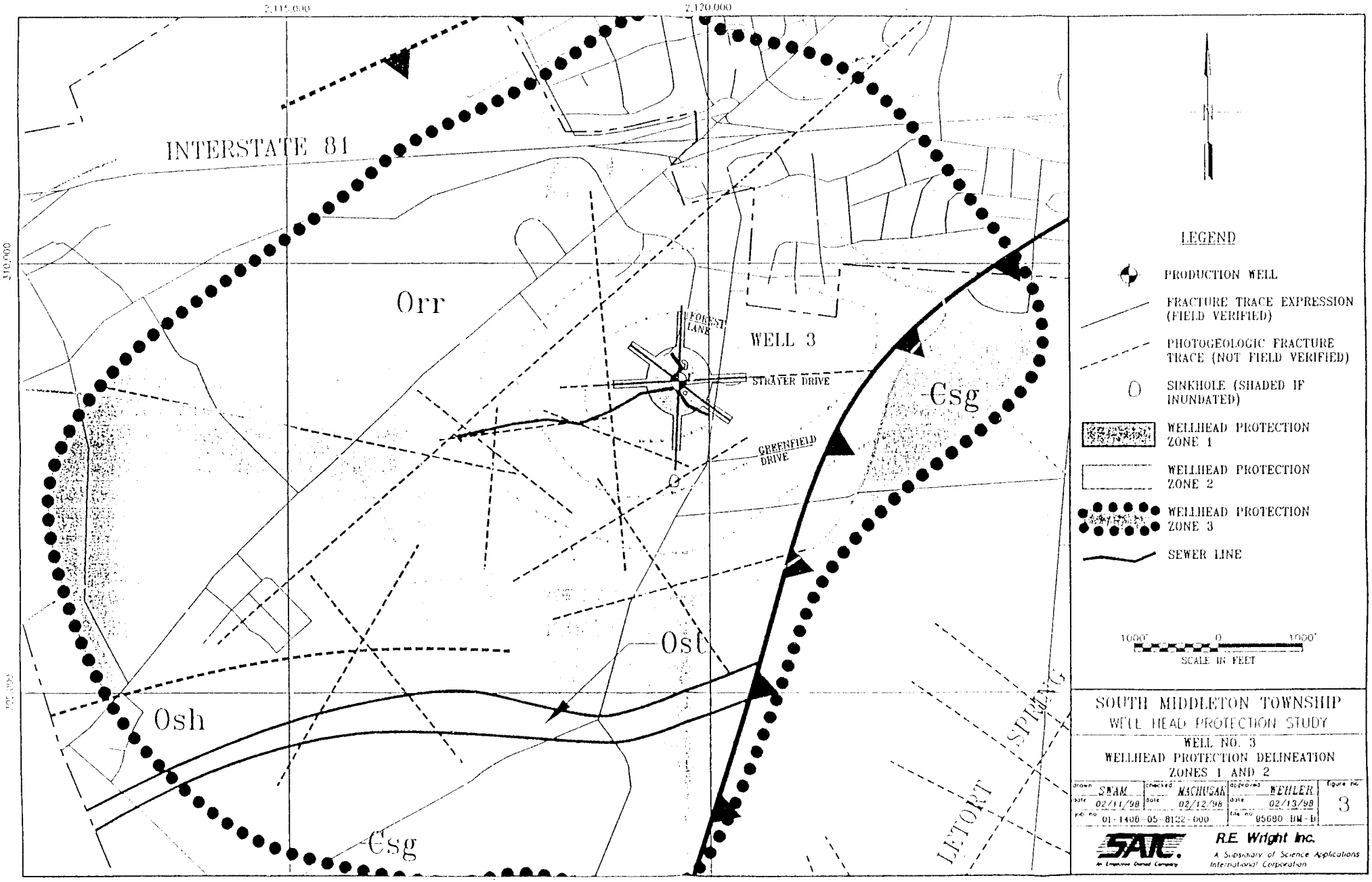

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APPENDIX B

APPENDIX B

This table is to be used in conjunction with the Wellhead Protection District with respect to permitted industrial, commercial or institutional facilities which generate, use, store, or transport hazardous substances. The table below conveys the threshold levels at which various substances which might be used by such facilities are considered hazardous.

HAZARDOUS SUBSTANCE ACTIVITIES			
Type of Business	**SIC Codes**	**Possible Hazardous Substances**	**Hazardous Threshold**
Agricultural Chemical Warehousing & Distribution	5191 2873 2874 2875 2879	Ammonium Nitrate Sulfate Chloride Pesticides & herbicides	1,600 lb as NH_4NO_3 370 lb as NH_4NO_3 3,000 lb as $(NH_4)_2SO_4$ 1,200 lb as KCl
Aluminum Rolling Mills	3353	Hydrocarbon solvents Methyl ethyl ketone 1,1,1-Trichloroethane Gasoline and diesel fuels Chloride salts Chromium salts	110 gal 105 gal 70 gal 110 gal 1,000 lb as NaCl 90 lb as $Na_2Cr_2O_7$
Aluminum Reduction	3334 3341	Fluoride salts Chromium salts Gasoline & diesel fuels Fluoride & Cyanide wastes	300 lb as AlF_3 90 lb as $Na_2Cr_2O_7$ 110 gal

Building Materials Production	2435 2436 2439 2491 2492	Pentachlorophenol Copper salts Chromium salts Phenolic resin glue Caustic soda	70 gal 5% soln. 90 lb as $CuSO_4$ 90 lb as $NaCr_2O_7$ 15 lb based on formaldehyde 850 lb
Chemical & Plastics Manufacturing	2813 2816 2819 282	All types of chemicals may be on site	
Chemical Warehousing & Distribution	5161	All types of chemicals may be on site	
Cleaning Supplies, Manufacturing & Distribution	2841 2869 5087 5161	Isopropyl alcohol Chlorinated phenols Dibutylphthalate	110 gal 20 lbs 3,000 gal
Dry Cleaning Establishments	7215 7217	Trichloroethene Tetrachloroethene Hydrocarbon solvents	2.5 gal 2.0 gal 110 gal
Educational Institutions	8221 8222	All chemicals may be present in laboratory quantities.	
Electrical & Electronic Products Manufacturing	3612 3641 3662 3674 3677 3679 3825 3993	Metal salts (Cu, Ni, Zn) Cyanide Methylene chloride 1,1,1-Trichloroethane Acetone Methyl ethyl ketone Formaldehyde	90 lb 150 gal 10% NaCN soln. 10 gal 70 gal 60 gal 105 gal 1 gal
Electroplating Operations	3471	Metal salts (Cr, Cu, Ni, & Zn) Cyanide Sodium phosphate Trichloroethene Tetrachloroethene Xylene Other solvents	90 lb 150 gal 10% NaCN soln. 300 gal 30% soln. 2.5 gal 2.0 gal 110 gal 110 gal
Foundries	3321 3322 3325 3361 3362 3369	Metal salts (Cr, Cu, Ni, & Zn) Cyanide Trichloroethene Isopropyl alcohol Caustic soda cleaning soln.	90 lb 125 lbs as NaCN 2.5 gal 110 gal 250 gal 35% soln.

HAZARDOUS SUBSTANCE ACTIVITIES			
Type of Business	**SIC Codes**	**Possible Hazardous Substances**	**Hazardous Threshold**
Furniture Refinishing	7641	Methylene chloride Acetone Hydrocarbon solvents Paint-related products	10 gal 60 gal 110 gal
Medical Facilities	0742 8062 8069 8071	Mono and Polycyclic Aromatic hydrocarbons Prescription drugs Biological contaminants	1 gal
Paint Manufacturing & Wholesale Distribution	2816 2865 5198	Metal salts (Cr, Pb, Sb & Zn) Phthalate esters Methylene chloride Methyl ethyl ketone Ethylene glycol Methyl alcohol	90 lb 10 gal 105 gal 7.5 gal 110 gal
Paint Shops	7535	Hydrocarbon solvents Xylene Methylene chloride	110 gal 110 gal 10 gal
Petroleum Products Production & Storage: Bulk Distribution of Petroleum Products	2992 5171 5172	Gasoline Diesel fuel & heating oil Lubricating oils Ethylene glycol Methyl alcohol	110 gal 110 gal 110 gal 7.5 gal 60 gal
Photo Processing	7333 7395	Silver salts Phenols Cyanide Aromatic hydrocarbons	50 lbs as $AgNO_3$ 10 lbs 125 lbs as NaCN 110 gal
Printing Establishments	2711 2751 2752 2761	Silver salts Aromatic hydrocarbons Phenols Cyanides Tetrachloroethene Hydrocarbon solvents	50 lbs as $AgNO_3$ 110 gal 10 lbs 125 lbs as NaCN 2.0 gal 110 gal
Gasoline Distribution	5541	Gasoline Diesel fuel Lubricating oils Ethylene glycol Methyl alcohol	110 gal 110 gal 110 gal 7.5 gal 60 gal
Metal Fabrication	3441 3442 3442 3444	Metal salts (Cr, Cu, Ni & Zn) Caustic cleaning solutions Hydrochloric acid Sulfuric acid Hydrocarbon solvents Xylene Caustic soda Sodium phosphate Sodium hydroxide	90 lb 250 gal 155 gal 150 gal 110 gal 110 gal 250 gal 35% soln. 300 gal 30% soln. 600 lb
Secondary Metals Refining	3341	Metal salts (Al, Cr, Zn) Chloride Sulfate	90 lb 1,000 lbs as NaCl 3,000 lbs as $(NH_4)_2SO_4$
Seed Cleaning & Treating	721	Hexachlorobenzene Other pesticides	1 gal
Solvent Recycling	2911	1,1,1-Trichloroethane Trichloroethene Tetrachloroethene	70 gal 2.5 gal 2.0 gal
Trucking Companies	4171 4172 4231	Gasoline & diesel Hydrocarbon solvents Ethylene glycol Caustic soda cleaning soln.	110 gal 110 gal 7.5 gal 250 gal 35% soln.

Source: Spokane County, Washington, 1983 Aquifer Sensitive Area Overlay Zone Ordinance.

APPENDIX C

Best Management Practices

Section Two

Stormwater Management *

RECOMMENDED BMP'S FOR STORMWATER MANAGEMENT

A variety of infiltration and exfiltration BMPs are currently in use to control stormwater runoff. The following discussion of stormwater management, adopted from the cited reference, is intended to provide an overview rather than comprehensive treatment of the topic.

New methods/structures are constantly being developed and tested such as the confined sand filter water quality control structure. All approaches, proven or experimental, must be evaluated on a case-by-case basis for application to special protection watersheds. At least one of the following BMP's (or a DER approved equivalent) must be employed in conjunction with the development of a special protection watershed. The BMP(s) must be tailored to the needs of the site and the anticipated characteristics of the stormwater generated. Infiltration techniques are preferred where environmentally sound and consistent with the protection of surface and ground waters because they eliminate the discharge to surface waters and consequently the need for an NPDES permit. The use of multiple practices in series or arranged in other ways designed to complement each other is encouraged. For example, filter strips or water quality inlets can be used to improve the efficiency of ponds or trenches.

Implementation of these stormwater management BMPs is authorized by either individual or general permit. When these permits cover activities in Exceptional Value watersheds a public hearing must be held before the permit can be issued. However, use of these practices (or DER approved equivalents) satisfies the antidegredation requirement to apply all cost effective and reasonable Best Management Practices as it relates to stormwater management. Therefore, this approach, when utilized in High Quality watersheds, is not subject to social or economic justification requirements.

	TDS	TSS	Nitrate	Total P	Atmos. Dep.
Detention Pond		X	X	X	
Wet Pond	X	X	X	X	
Infiltration Trench	X	X	X	X	
Infiltration Basin	X	X	X	X	
Porous Pavement	X	X	X	X	X

See next page for Pollutant removal efficiencies of various BMP's.

* Reference: Department of Environmental Programs, 1987. Controlling Urban Runoff. Metropolitan Washington Council of Governments, Washington, D.C. 275 p.

Comparative Pollutant Removal Of Urban BMP Designs

BMP/design	SUSPENDED SEDIMENT	TOTAL PHOSPHORUS	TOTAL NITROGEN	OXYGEN DEMAND	TRACE METALS	BACTERIA	OVERALL REMOVAL CAPABILITY
EXTENDED DETENTION POND							
DESIGN 1	◕	◔	◔	◔	○	⊗	MODERATE
DESIGN 2	●	◑	◔	◑	◕	⊗	MODERATE
DESIGN 3	●	◕	○	○	◕	⊗	HIGH
WET POND							
DESIGN 4	◕	○	◔	◔	◔	⊗	MODERATE
DESIGN 5	◕	○	◔	◔	◕	⊗	MODERATE
DESIGN 6	●	◕	○	○	◕	⊗	HIGH
INFILTRATION TRENCH							
DESIGN 7	◕	○	○	◕	◕	◕	MODERATE
DESIGN 8	●	○	○	◕	●	◕	HIGH
DESIGN 9	●	◕	◕	●	●	●	HIGH
INFILTRATION BASIN							
DESIGN 7	◕	○	○	◕	○	◕	MODERATE
DESIGN 8	●	○	○	◕	●	◕	HIGH
DESIGN 9	●	◕	◕	●	●	●	HIGH
POROUS PAVEMENT							
DESIGN 7	○	◕	○	◕	○	◕	MODERATE
DESIGN 8	●	◕	◕	◕	●	●	HIGH
DESIGN 9	●	◕	◕	●	●	●	HIGH
WATER QUALITY INLET							
DESIGN 10	○	⊗	⊗	⊗	⊗	⊗	LOW
FILTER STRIP							
DESIGN 11	◔	○	○	○	◔	⊗	LOW
DESIGN 12	●	◑	○	◕	●	⊗	MODERATE
GRASSED SWALE							
DESIGN 13	○	○	○	○	○	⊗	LOW
DESIGN 14	◔	◔	◔	◔	○	⊗	LOW

KEY:

- ○ 0 TO 20% REMOVAL
- ◔ 20 TO 40% REMOVAL
- ◑ 40 TO 60% REMOVAL
- ◕ 60 TO 80% REMOVAL
- ● 80 TO 100% REMOVAL
- ⊗ INSUFFICIENT KNOWLEDGE

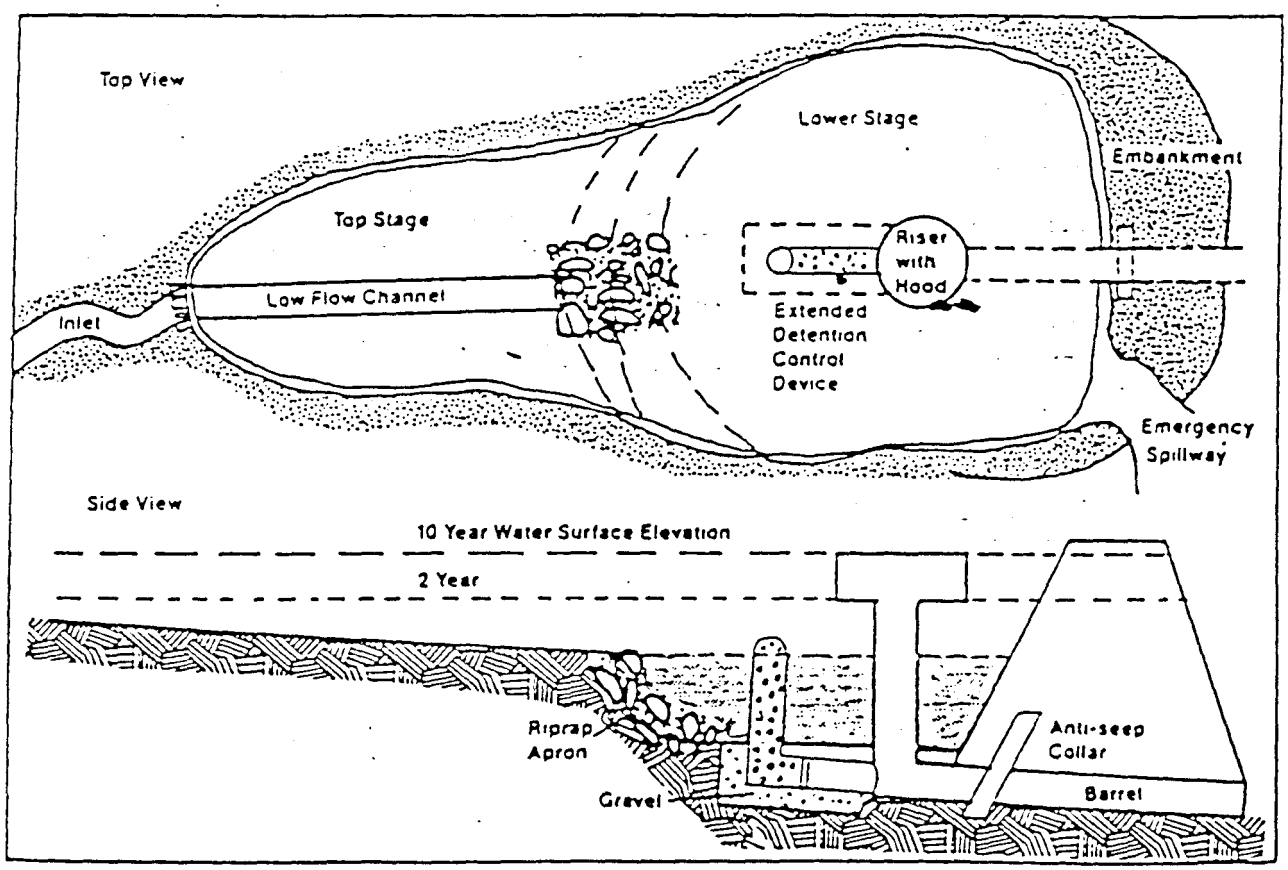
Design 1: First-flush runoff volume detained for 6-12 hours.
Design 2: Runoff volume produced by 1.0 inch, detained 24 hours.
Design 3: As in Design 2, but with shallow marsh in bottom stage.
Design 4: Permanent pool equal to 0.5 inch storage per impervious acre.
Design 5: Permanent pool equal to 2.5 (Vr); where Vr=mean storm runoff.
Design 6: Permanent pool equal to 4.0 (Vr); approx. 2 weeks retention.
Design 7: Facility exfiltrates first-flush; 0.5 inch runoff/imper. acre.
Design 8: Facility exfiltrates one inch runoff volume per imper. acre.
Design 9: Facility exfiltrates all runoff, up to the 2 year design storm.
Design 10: 400 cubic feet wet storage per impervious acre.
Design 11: 20 foot wide turf strip.
Design 12: 100 foot wide forested strip, with level spreader.
Design 13: High slope swales, with no check dams
Design 14: Low gradient swales with check dams

EXTENDED DETENTION PONDS

Extending the detention time of dry or wet ponds is an effective, low cost means of removing particulate pollutants and controlling increases in downstream bank erosion. If stormwater is detained for 24 hours or more, as much as 90% removal of particulate pollutants is possible. However, extended detention only slightly reduces levels of soluble phosphorus and nitrogen found in urban runoff. Removal of these pollutants can be enhanced if the normally inundated area of the pond is managed as a shallow marsh or a permanent pool.

Extended detention ponds significantly reduce the frequency of occurrence of erosive floods downstream, depending on the quantity of stormwater detained and the time over which it is released. Extended detention is extremely cost-effective, with construction costs seldom more than 10% above those reported for conventional dry ponds.

Schematic of a Dry Extended Detention Pond



Positive impacts of extended detention ponds include creation of local wetland and wildlife habitat, limited protection of downstream aquatic habitat, and recreational use in the infrequently inundated portion of the pond. Negative impacts include occasional nuisance and aesthetic problems in the inundated portion of the pond (e.g., odor, debris, and weeds), moderate to high routine maintenance requirements, and the eventual need for costly sediment removal. Extended detention generally can be applied in most new development situations, and also is an attractive option for retrofitting existing dry and wet ponds in older urbanized areas.

POLLUTANT REMOVAL

Settling is the primary pollutant removal mechanism associated with extended detention. As such, the degree of removal is dependent on whether a given pollutant is in particulate or soluble form. Removal is likely to be quite high if a pollutant is particulate, whereas very limited removal can be expected for soluble pollutants. Unfortunately, some of the urban pollutants of greatest concern occur primarily in soluble forms (e.g, nitrate and ortho-phosphorus). Removal of these soluble pollutants may be obtained if the lower stage of the extended detention pond is managed as a shallow wetland to utilize natural biological removal processes.

Settling Behavior of Urban Pollutants

The settling behavior of urban pollutants has been evaluated in a series of laboratory and field studies. Grizzard et al. (1986), Driscoll (1986), and Whipple and Hunter (1981) have utilized experimental settling column data to assess pollutant settling behavior over time. In each study, urban runoff was introduced into four to six foot deep plexiglass chambers and the change in pollutant concentration over time was measured at sampling ports located at different depths on the column. In addition, the long term pollutant removal performance of two extended detention ponds have been evaluated in local field monitoring efforts. During the Washington NURP study (MWCOG, 1983b) a dry pond (Stedwick) in Montgomery County, Maryland was modified to achieve 6-12 hours of extended detention, and monitored over a 18 month period. Interim results are also available for an extended detention pond (London Commons) monitored in suburban Northern Virginia (OWML, 1986a). Together, these studies provide a basis for estimating the detention time needed to obtain maximum possible removal for specific pollutants of interest listed below.

SEDIMENT

The settling column experiments indicated that 60-70% of urban sediments settle out within the first six hours. The remaining sediment may take as much as 2 days to settle out (Figure 3.6). Maximum removal rates after 48 hours of detention ranged from 80-90%. The rather slow sediment settling rates are primarily due to the very fine-grained particle distribution of sediment in urban runoff (OWML, 1983). Washington NURP field monitoring at the Stedwick extended detention pond generally supports the lab measurements. The pond was estimated to remove 65% of incoming sediment over the long term (MWCOG, 1983a), which is similar to the 6-12 hour removal rate reported in the settling column study (Figure 3.7). An average storm removal of approximately 65% was also reported for the London Commons pond (OWML, 1986a), which also experienced relatively brief detention times (estimated at 6-12 hours).

PHOSPHORUS

Both settling column studies indicated a maximum upper limit of about 40-50% removal for total phosphorus after 48 hours, with most of the removal occurring within the first 6 to 12 hours. The upper limit for phosphorus removal by settling is due to the fact that soluble forms comprise over half of all phosphorus found in urban runoff (Chapter 1). Nearly all the particulate phosphorus settled out in the OWML experiments, accounting for the majority of observed removal. In addition, a small fraction of soluble phosphorus adsorbed to sediment and eventually settled out during the experiments.

The field studies showed variable performance in removing phosphorus. Less than 15% of total phosphorus was removed at the Stedwick site over the long-term; whereas, initial results at the London Commons site indicated much higher average (70%) total phosphorus removal (OWML, 1986a). However, it is very likely that the long-term total phosphorus removal at the site is much lower, since very low (or even negative) removal rates were reported for larger storms. Resuspension of total phosphorus was cited as the likely cause.

NITROGEN

In the OWML (1983) settling column experiments, the upper limit on nitrogen removal achieved after 48 hours of detention was about 40%. Again, this is due to the predominance of soluble forms of nitrogen that comprise about 70-80% of the total nitrogen found in the Washington, D.C. area urban runoff (NVPDC, 1983). Field studies at the Stedwick extended detention pond suggested a long-term total nitrogen removal rate of about 25%, which compares well with the lab studies (Figure 3.7). Almost all of the particulate nitrogen settled out from the pond, but only limited settling of soluble nitrogen forms was reported. A higher average storm removal of total nitrogen was reported (52%) at the London Commons site (OWML, 1986a), although the long-term removal rates may not be as high.

ORGANIC MATTER

Organic matter, as measured by BOD in Whipple and Hunter (1981) and COD in OWML (1983), exhibited similar settling behavior in the column tests. Average maximum removal after 32 and 48 hours, respectively, was about 40-50%. Organic matter exhibited rapid settling rates over the first 6-8 hours, followed by gradual but steady removal thereafter. Long-term COD removal rates at the Stedwick site were on the order of 30%, which compare favorably to the six-hour detention removals observed in the lab (Figure 3.7).

TRACE METALS

Settling of most trace metals in the column tests was initially quite rapid. Lead, which has a close affinity with suspended sediment, exhibited essentially similar settling behavior (Figure 3.6) (Whipple and Hunter, 1981). Maximum average removal after 48 hours was greater than 90%, with about two-thirds of the settlement occurring within the first six hours. Long-term lead removal measured in the field was even greater, with 84% removal recorded after the first 6 hours. Maximum removal of zinc was much lower, averaging about 50% in the OWML experiments and about 30% in Whipple's. Unlike lead, most of the zinc (<70%) in urban runoff is in soluble form (NVPDC, 1983). However, a significant portion of the soluble zinc appears to adsorb to sediment particles and settle out of the water column. This appeared to be the case at the Stedwick site, where long-term removal rates were estimated to be near 60%, despite the fact that less than 20% of the incoming zinc was in particulate form at the site.

Positive impacts of extended detention ponds include creation of local wetland and wildlife habitat, limited protection of downstream aquatic habitat, and recreational use in the infrequently inundated portion of the pond. Negative impacts include occasional nuisance and aesthetic problems in the inundated portion of the pond (e.g., odor, debris, and weeds), moderate to high routine maintenance requirements, and the eventual need for costly sediment removal. Extended detention generally can be applied in most new development situations, and also is an attractive option for retrofitting existing dry and wet ponds in older urbanized areas.

POLLUTANT REMOVAL

Settling is the primary pollutant removal mechanism associated with extended detention. As such, the degree of removal is dependent on whether a given pollutant is in particulate or soluble form. Removal is likely to be quite high if a pollutant is particulate, whereas very limited removal can be expected for soluble pollutants. Unfortunately, some of the urban pollutants of greatest concern occur primarily in soluble forms (e.g, nitrate and ortho-phosphorus). Removal of these soluble pollutants may be obtained if the lower stage of the extended detention pond is managed as a shallow wetland to utilize natural biological removal processes.

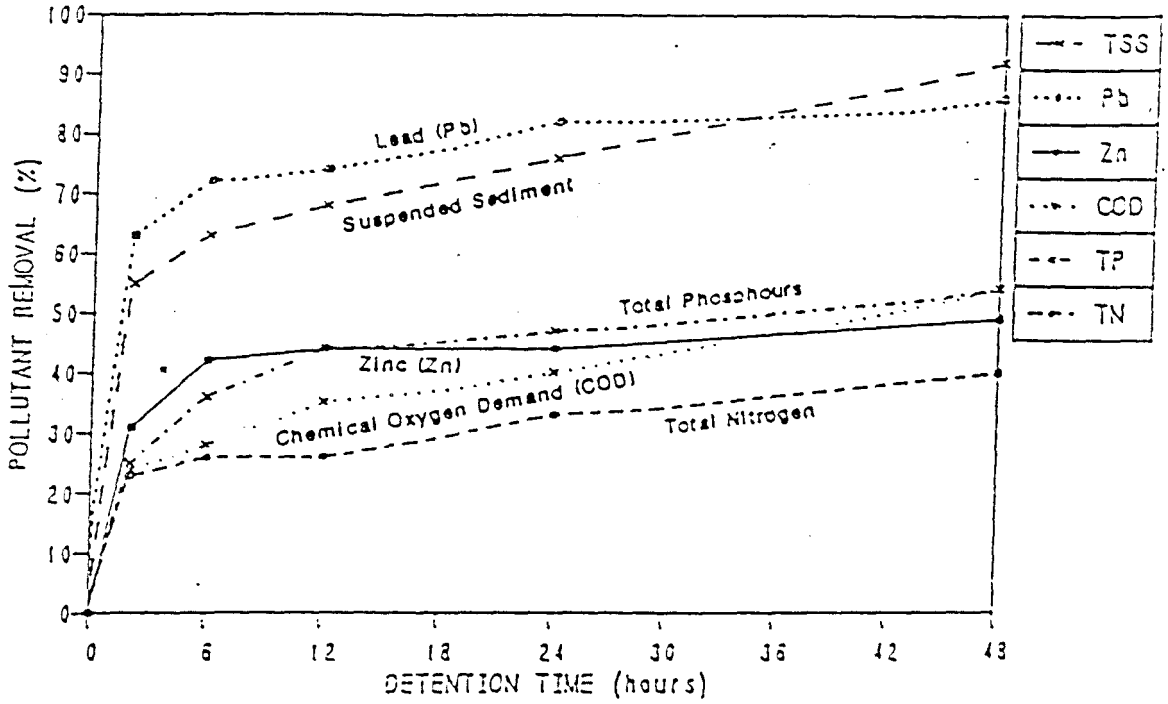
Settling Behavior of Urban Pollutants

The settling behavior of urban pollutants has been evaluated in a series of laboratory and field studies. Grizzard et al. (1986), Driscoll (1986), and Whipple and Hunter (1981) have utilized experimental settling column data to assess pollutant settling behavior over time. In each study, urban runoff was introduced into four to six foot deep plexiglass chambers and the change in pollutant concentration over time was measured at sampling ports located at different depths on the column. In addition, the long term pollutant removal performance of two extended detention ponds have been evaluated in local field monitoring efforts. During the Washington NURP study (MWCOG, 1983b) a dry pond (Stedwick) in Montgomery County, Maryland was modified to achieve 6-12 hours of extended detention, and monitored over a 18 month period. Interim results are also available for an extended detention pond (London Commons) monitored in suburban Northern Virginia (OWML, 1986a). Together, these studies provide a basis for estimating the detention time needed to obtain maximum possible removal for specific pollutants of interest listed below.

SEDIMENT

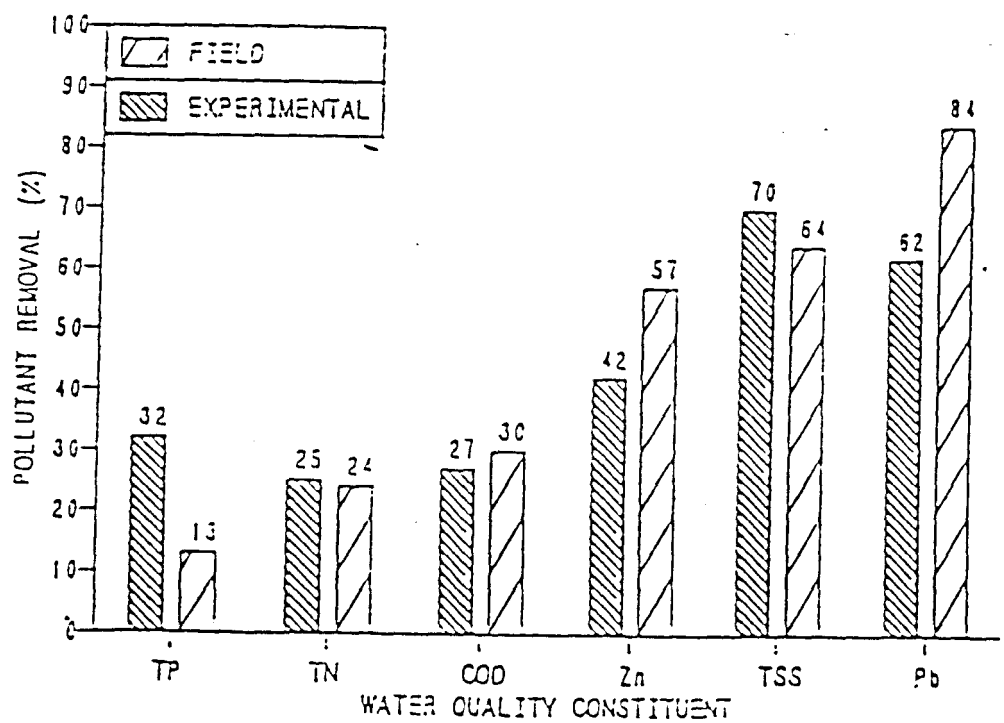
The settling column experiments indicated that 60-70% of urban sediments settle out within the first six hours. The remaining sediment may take as much as 2 days to settle out (Figure 3.6). Maximum removal rates after 48 hours of detention ranged from 80-90%. The rather slow sediment settling rates are primarily due to the very fine-grained particle distribution of sediment in urban runoff (OWML, 1983). Washington NURP field monitoring at the Stedwick extended detention pond generally supports the lab measurements. The pond was estimated to remove 65% of incoming sediment over the long term (MWCOG, 1983a), which is similar to the 6-12 hour removal rate reported in the settling column study (Figure 3.7). An average storm removal of approximately 65% was also reported for the London Commons pond (OWML, 1986a), which also experienced relatively brief detention times (estimated at 6-12 hours).

Figure 3.6: Removal Rate vs. Detention Time For Selected Pollutants



NOTE: Based on OWML (1983) settling column data. Average values for seven tests. Removal equivalent to 4 feet of settling.

Figure 3.7: Urban Pollutant Removal After 6 to 12 Hours Detention Time Comparison of Lab Studies and Field Measurements

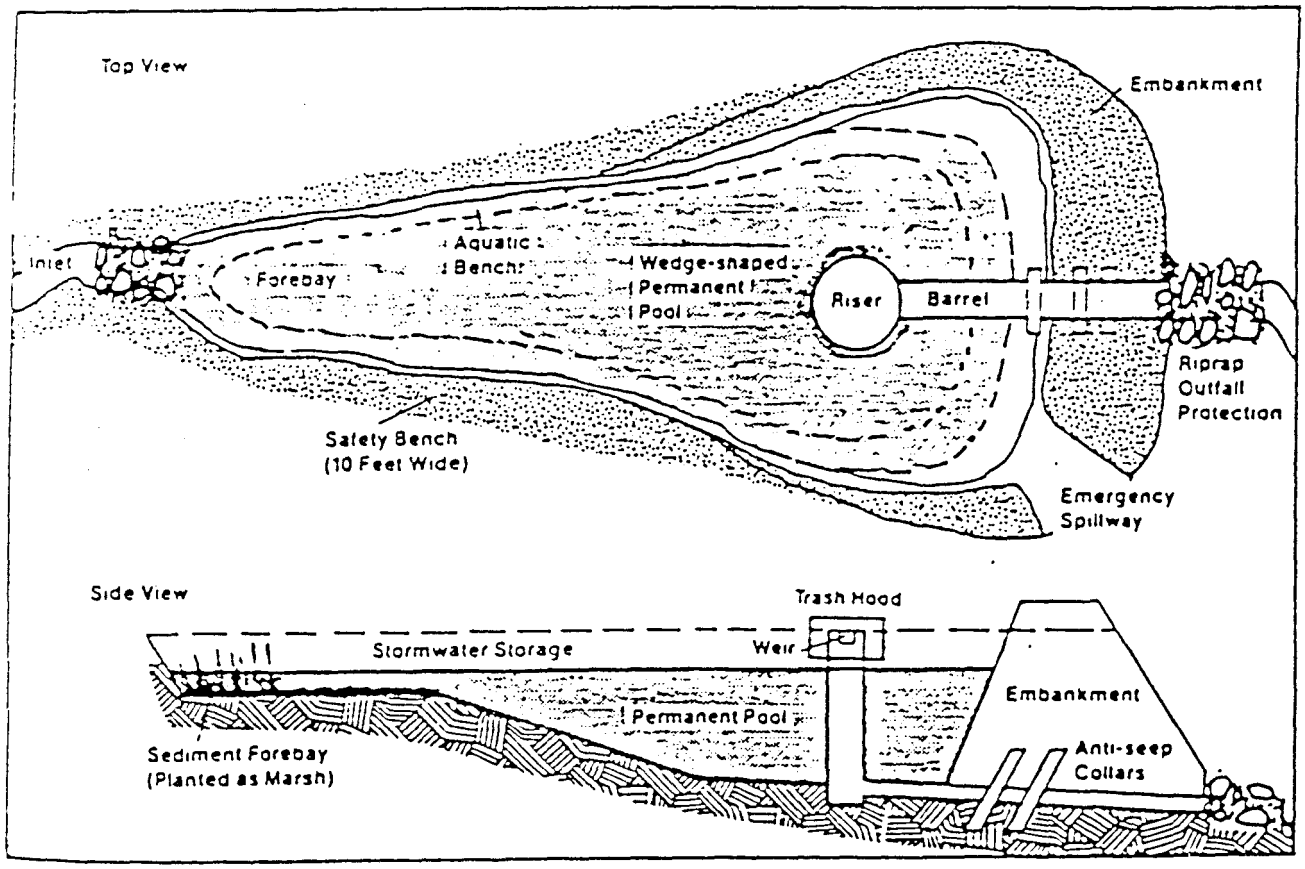


WET PONDS

Wet ponds, also known as retention ponds, are an extremely effective water quality BMP. If properly sized and maintained, wet ponds can achieve a high removal rate of sediment, BOD, organic nutrients and trace metals. Biological processes within the pond also remove soluble nutrients (nitrate and ortho-phosphorus) that contribute to nutrient enrichment (eutrophication). Wet ponds are most cost-effective in larger, more intensively developed sites. Positive impacts of wet ponds include: creation of local wildlife habitat, higher property values, recreation, and landscape amenities. Negative impacts include: possible upstream and downstream habitat degradation, potential safety hazards, occasional nuisance problems (e.g., odor, algae, and debris), and the eventual need for costly sediment removal.

Perhaps more than any other BMP, wet ponds require careful planning and thoughtful design, and regular maintenance. Competing objectives must be reconciled at every potential pond site, and the final design may never achieve all of them. However, wet ponds are unique in that they can truly be a multi-purpose BMP, by providing stormwater management, pollutant removal and landscaping/habitat improvement.

Schematic of a Wet Pond



POLLUTANT REMOVAL

The capability of wet ponds to remove pollutants borne in urban runoff has been demonstrated in local and national field studies (US EPA, 1983; MWCOG, 1983b). These studies have found pollutant removal to be variable from storm to storm, but generally high over the long-term, for well designed and maintained ponds. The degree of pollutant removal achieved by a pond is a function of the size and design of the permanent pool and the characteristics of individual urban pollutants.

Pollutant Removal Mechanisms in Wet Ponds

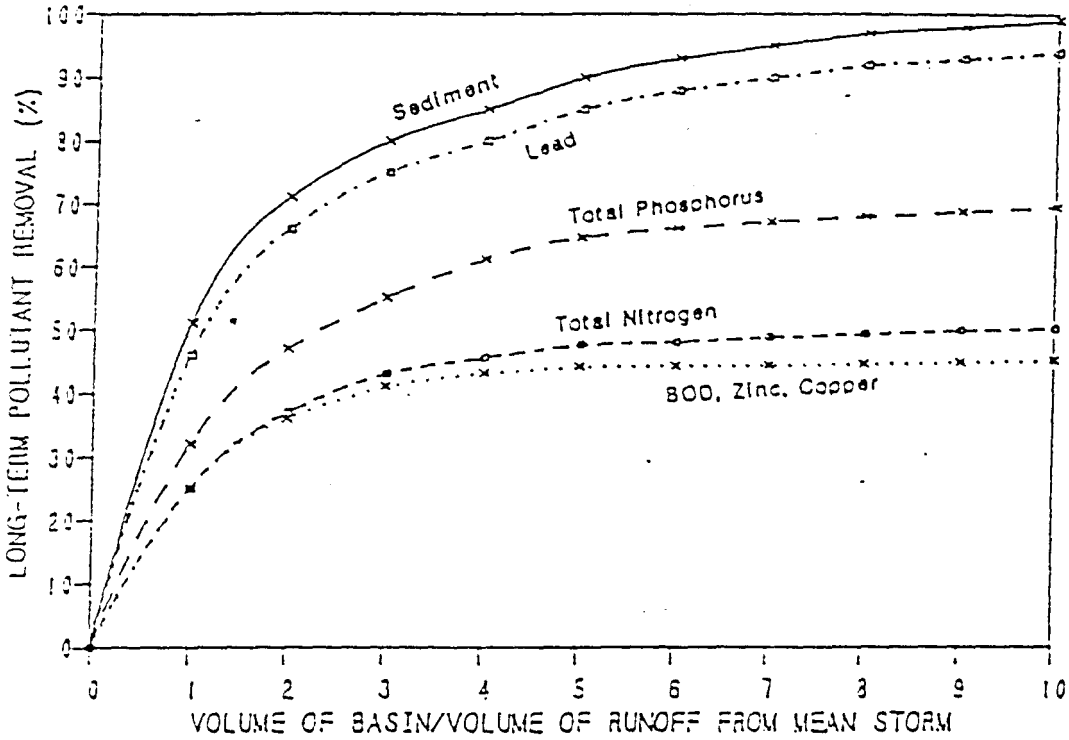
SEDIMENTATION

In theory, the incoming storm runoff displaces "old water" out of the pond and is then stored until the next storm. Suspended pollutants settle out from the water column to the pond sediments. Moreover, the permanent pool acts as a barrier to resuspension of deposited materials, improving removal performance over that achieved by dry ponds. The greatest initial settling often occurs near the inlet of the pond, where the velocity of the incoming runoff is dissipated by the still waters of the permanent pool. Settling in ponds during quiescent conditions can be modeled assuming Stokes Law Type I Sedimentation. Coarser materials are deposited first, followed by progressively finer-sized fractions. In practice, sedimentation is an effective pollutant removal mechanism unless short-circuiting occurs (i.e., incoming runoff passes through the pond without displacing the old water), or the volume of incoming runoff is greater than the volume of the permanent pool (in which case some portion of the runoff passes through the pond unmodified). As a result of these factors, pollutant removal rates often decline during larger storms in smaller ponds.

BIOLOGICAL UPTAKE

A unique feature of wet ponds is the presence of aquatic plants and algae that can remove significant amounts of soluble nutrients from the water column. Since soluble nutrients have minimal settling velocities, biological uptake represents an important removal pathway. In short, the plants convert the soluble nutrients into biomass which in turn can settle to the pond sediments. Once nutrients and organic materials are trapped in the sediments, they may be consumed by bacteria and removed from the system.

Estimated Removal of Selected Urban Pollutants as a Function of Permanent Pool Size



NOTE: Average results from U.S. EPA (1986), and adapted to reflect modifications of Walker (1986).

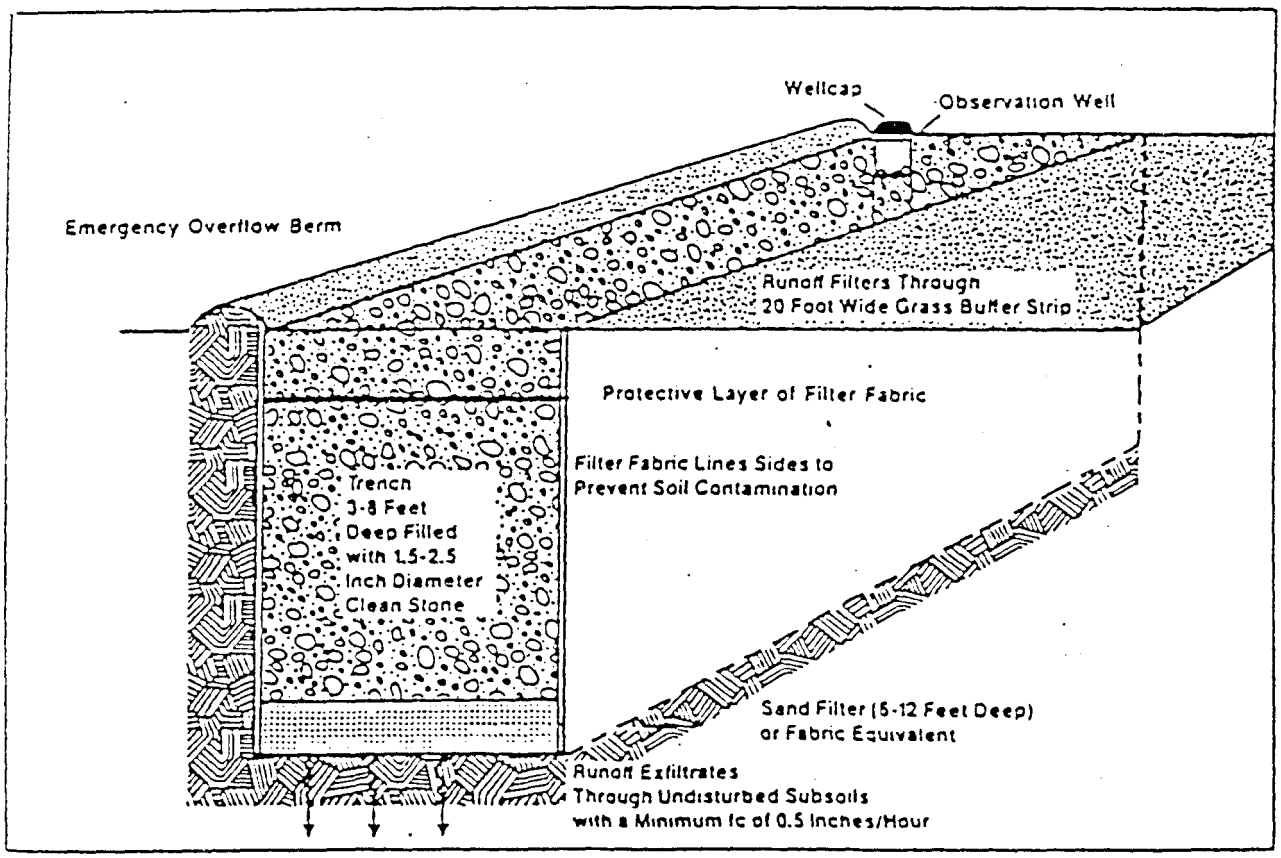
Summary of Wet Pond Pool Sizing Rules

SIZING RULE	SEDIMENT REMOVED	PHOSPHORUS REMOVED	EXTRA STORAGE (compared to 2 year dry pond)	EXTRA COST
RULE 1: 0.5 inch runoff per acre	60-90%	35-90%	35-200%	20-90%
RULE 2: 0.5 inch runoff per impervious acre	60%	35-40%	30%	20-25%
RULE 3: 0.1 to 0.8 inches depending on land use	55-80%	30-50%	30-70%	20-40%
RULE 4: 2.5 times the runoff of the mean storm	75%	55%	75%	40-50%
Rule 5: 4.0 times the runoff of the mean storm (=2 week retention)	85-90%	65%	200-250%	80-100%

INFILTRATION TRENCHES

Infiltration trenches are an adaptable BMP that effectively remove both soluble and particulate pollutants. As with other infiltration systems, trenches are not intended to trap coarse sediments. Grass buffers (for surface trenches) or special inlets (for underground trenches) must be installed to capture sediment before it enters the trench. Depending on the degree of storage/exfiltration achieved, trenches can provide groundwater recharge, low flow augmentation and localized streambank erosion control. Individual trenches are primarily an on-site control, and are seldom practical or economical on sites larger than 5 or 10 acres. Trenches are only feasible when soils are permeable and the water table and bedrock are situated well below the bottom of the trench. Aside from regular inspections and more rigorous sediment and erosion control, trenches have limited routine maintenance requirements. However, trenches will prematurely clog if sediment is not kept out before, during and after construction of a site. If a trench does become severely clogged, partial or complete replacement of the structure may be required.

Schematic of an Infiltration Trench



POLLUTANT REMOVAL

As with porous pavement BMPs (see Chapter 7), infiltration trenches are not really intended to provide much removal of coarse particulate pollutants. These must be removed by a pre-treatment device before they enter the trench. Fine particulates and soluble pollutants are effectively removed after exfiltrating through the trench and into the soil. Several decades of experience of land disposal of wastewater has shown that the soil layer is a highly effective and normally safe means of removing pollutants (MWCOG, 1979). Removal mechanisms involve sorption, precipitation, trapping, straining and bacterial degradation or transformation, and are quite complex. The actual removal rates for an individual pollutant depend on its solubility and biochemistry.

Full and Partial Exfiltration Trenches

Table 5.1 provides estimates of pollutant removal rates that might be expected for full exfiltration systems, based on field testing of similar rapid infiltration land treatment systems (NVPDC, 1979; US EPA, 1977).

Table 5.1: Estimated Long-Term Pollutant Removal Rate for Full Exfiltration Trenches

URBAN POLLUTANT	REMOVAL RATE	LIMITING FACTOR
SEDIMENT	99%	Should actually be trapped before reaching the trench.
TOTAL PHOSPHORUS	65-75%	Leaching of remineralized organic P.
TOTAL NITROGEN	60-70%	Leaching of soluble nitrate.
TRACE METALS	95-99%	Behavior similar to sediment.
BOD	90%	Leaching of dissolved organic matter.
BACTERIA	98%	Straining.

Water Quality Trenches

A significant portion of the annual runoff volume will bypass a water quality trench, and is not then subject to removal by exfiltration. Therefore, the pollutant removal capability of water quality trenches are somewhat lower than other designs. As noted earlier, there are two sizing rules for water quality trenches:

SIZING RULE 1: Trench storage volume should be equivalent to 0.5 inches of runoff per impervious acre in the contributing watershed (Md WRA, 1986b).

SIZING RULE 2: Trench storage volume should be capable of storing the runoff produced from a one inch storm over the contributing watershed (1.0*Rv*A) (see Chapter 1 for an explanation of variables).

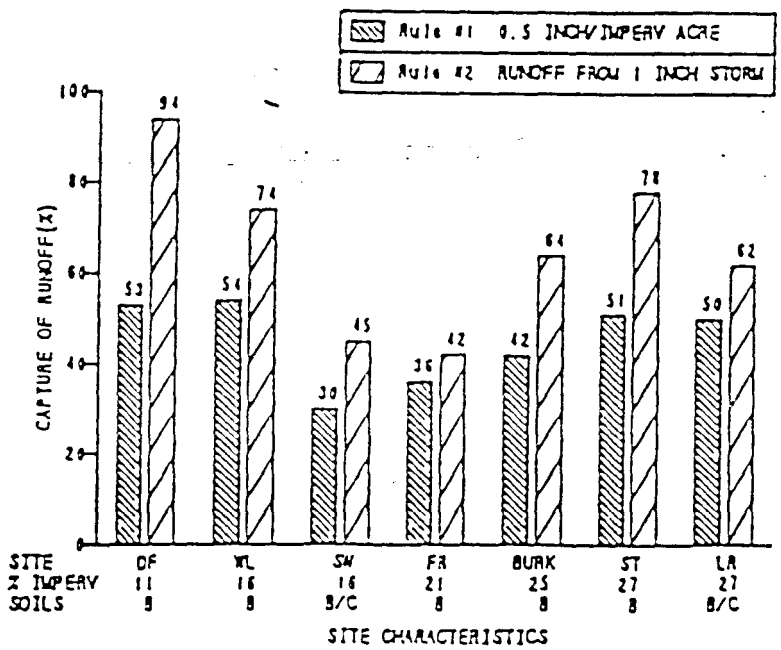
Actual pollutant removal rates in water quality trenches are slightly higher than the runoff volume capture efficiency, primarily because of the first flush phenomenon (Griffin et al., 1980; Md WRA, 1986b). That is, a greater portion of storm pollutant loads are delivered during the early part of storms due to the rapid wash-off of accumulated pollutants (Sartor and Boyd, 1977). Based on local modeling studies (NVPDC,1979) and field studies (Griffin et al., 1980) of the first flush effect, expected pollutant removal rates for water quality trenches are estimated in Table 5.2.

Table 5.2: Estimated Long-Term Pollutant Removal Rate (%) for Water Quality Trenches

POLLUTANT	SIZING RULE 1	SIZING RULE 2
SEDIMENT	75%	90%
TOTAL PHOSPHORUS	50-55%	60-70%
TOTAL NITROGEN	45-55%	55-60%
TRACE METALS	75-80%	85-90%
BOD	70%	80%
BACTERIA	75%	90%

The comparative runoff capture efficiency for each of these trench sizing rules was evaluated using observed runoff time-series for 300 storms at seven Washington, D.C. NURP sites (imperviousness: 11-27%, "B" soils). A series of calculations were made to determine the runoff volume diverted into, and bypassed over hypothetical trenches according to the water quality rules shown above. The results are shown in Figure 5.10. Under Rule 1 (0.5 inches/impervious acre), approximately 40-50% of storm runoff volumes is captured and exfiltrated over the long-term. For the more generous Rule 2 (runoff from one inch storm), capture efficiencies on the order of 65-75% of storm runoff volumes can be expected.

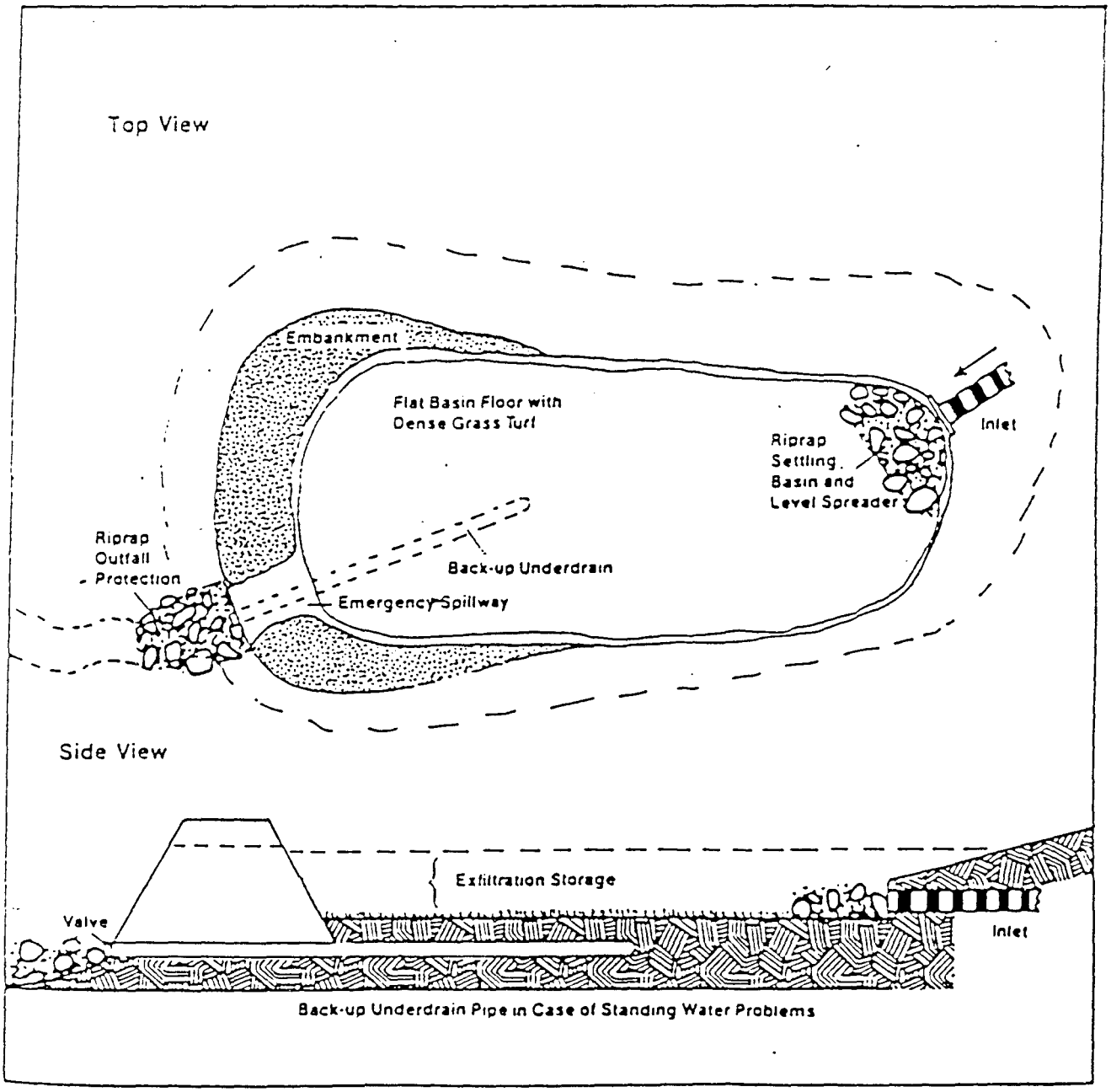
Figure 5.10: Runoff Capture Efficiency of Water Quality Trenches



INFILTRATION BASINS

Infiltration basins are effective in removing both soluble and fine particulate pollutants borne in urban runoff. Coarse-grained pollutants should generally be removed before they enter a basin. Unlike other infiltration systems, basins can be easily adapted to provide full control of peak discharges for large design storms. Also, basins can serve relatively large drainage areas (up to 50 acres). Depending on the degree of storage/exfiltration achieved in the basin, significant groundwater recharge, low flow augmentation and localized streambank erosion control can be achieved.

Schematic of an Infiltration Basin



POLLUTANT REMOVAL

The pollutant removal capability of infiltration basins has not been extensively tested in the field. As with other infiltration systems, pollutant removal is achieved by diverting stormwater runoff through the floor of the basin and into the soil. Limited field data from other infiltration systems, and several decades of experience in land disposal of wastewater suggest that the soil is a highly effective and normally safe filter for removing pollutants (MWCOG, 1979). Removal mechanisms involve sorption, precipitation, trapping, straining and bacterial degradation or transformation. Removal mechanisms are quite complex, and actual removal rates depend on the solubility and chemistry of each individual pollutant. Table 6.1 provides estimates of pollutant removal rates that might be achieved in various sized infiltration basins. The differences in estimated removal rates shown reflect differences in the amount of the annual runoff volume that passes through the basin without exfiltrating. Three frequently used basin sizing rules are defined below.

SIZING RULE 1: Basin sized to store and exfiltrate 0.5 inches of runoff per impervious acre in the contributing watershed (Md WRA, 1986b), with excess runoff only temporarily detained.

SIZING RULE 2: Basin sized to store and exfiltrate the runoff produced from a one inch storm over the contributing watershed (1.0*Rv*A) (see page 1.10), with excess runoff only temporarily detained.

SIZING RULE 3: Basin sized to store and exfiltrate runoff volumes up to and including the two year design storm runoff volume, with excess runoff volume associated with larger storms only briefly detained or bypassed entirely.

Table 6.1: Estimated Long-Term Pollutant Removal Rates (%) For Infiltration Basins

POLLUTANT	SIZING RULE 1 0.5 in/imperv acre	SIZING RULE 2 1.0 inch*Rv*A	SIZING RULE 3 2 yr runoff volume
SEDIMENT	75%	90%	99%
TOTAL PHOSPHORUS	50-55%	60-70%	65-75%
TOTAL NITROGEN	45-55%	55-60%	60-70%
TRACE METALS	75-80%	85-90%	95-99%
BOD	70%	80%	90%
BACTERIA	75%	90%	98%

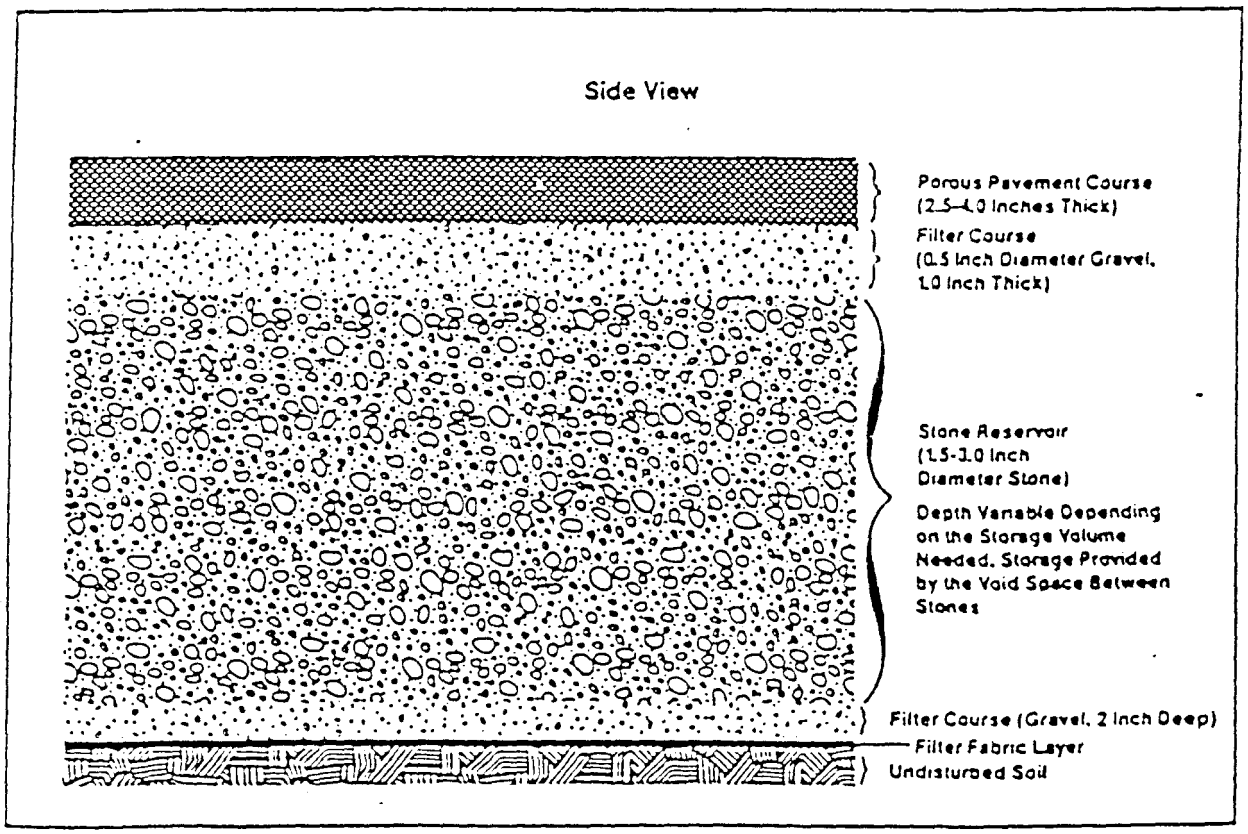
NOTE: Estimated removal efficiencies based on runoff capture efficiency of exfiltration storage (see Chapter 5, page 5.13 for derivation).

POROUS PAVEMENT

Porous pavement has a high capability to remove both soluble and fine particulate pollutants in urban runoff, and also provides groundwater recharge, low flow augmentation, and streambank erosion control. Its use is generally restricted to low volume parking areas, although it can accept runoff from rooftop storage or adjacent conventionally paved areas. As a BMP, porous pavement is only feasible on sites with gentle slopes, permeable soils, and relatively deep water table and bedrock levels. When these conditions are met, porous pavement is a reasonably cost-effective BMP, particularly if off-site runoff contributions are not great.

When properly designed and carefully installed, porous pavement has load bearing strength, longevity, and maintenance requirements similar to conventional pavement. Some other advantages of porous pavement are reduced land consumption, reduction or elimination of the need for curb and gutters and downstream conveyance systems, the preservation of the natural water balance at the site, and a safer driving surface which offers better skid resistance and reduced hydroplaning.

Figure 7.1: Schematic of Typical Porous Pavement Section



Source: City of Rockville (1984a)

The major drawback associated with porous pavement is that if it becomes clogged it is difficult and costly to rehabilitate. The risk of premature clogging of the pavement is fairly high, and can be prevented only if sediment is kept off of the pavement before, during and after construction. Other disadvantages include the need for extensive feasibility tests, inspections, very high levels of construction workmanship (which cannot always be assured), and a possible risk of groundwater contamination (probably slight).

METHODS USED FOR POROUS PAVEMENT

A typical cross-section of porous pavement is shown in Figure 7.1. Runoff rapidly infiltrates through the pores of the 2-4 inch porous asphalt layer into the void spaces of an underground stone reservoir. The reservoir is composed of two layers: a one-inch filter course of half-inch diameter gravel placed over a deeper reservoir course of 1.5-3.0 inch diameter stone. Runoff then exfiltrates out of the stone reservoir and into the underlying subsoil or is collected by perforated underdrain pipes and routed to an outflow facility. Thus, the storage capacity of porous pavement is primarily a function of the depth of the underground reservoir (plus any runoff lost via exfiltration through the subsoils).

Under normal conditions, the porous asphalt layer merely acts as a rapid conduit for runoff to reach the stone reservoir (typical infiltration rates for open-graded porous asphalt are in excess of 150 inches/hour). A less preferable alternative for directing runoff into the stone reservoir is to install drop inlets or drill holes through a layer of conventional asphalt.

Porous pavement designs fall into three basic categories, based on the runoff storage provided by the stone reservoir and the degree of reliance on exfiltration. These are described below.

Full Exfiltration System

With this design, the only way runoff can exit the stone reservoir is to exfiltrate through the underlying subsoil (i.e., there is no positive pipe outlet draining the stone reservoir). Consequently, the stone reservoir must be large enough to accommodate the entire increase in runoff volume for the design storm , less any runoff volume which is exfiltrated during a storm. The complete exfiltration system provides total peak discharge, volume, and water quality control for all rainfall events less than or equal to the design storm. An emergency overflow channel (such as a raised curb) is located above-ground to handle the excess runoff from storms greater than the design storm.

Partial Exfiltration System (stone filtration system)

It may not always be feasible or prudent to totally rely on exfiltration to dispose of runoff. For example, there may be concerns about the long term permeability of the underlying soils, downstream seepage, or clogging at the interface between the filter fabric and subsoil. In these situations, an underground drainage system can be installed, comprised of regularly spaced perforated pipes located in shallow depressions that collect the runoff and direct it to a central outlet. The size and spacing of the underdrain network is set to pass the two year storm. However, most of the runoff volume from smaller storms will still be exfiltrated before it is collected, thereby providing significant water quality control.

Pollutant Removal Mechanisms of Porous Pavement

Most of the pollutant removal in a porous pavement site is accomplished after the runoff has exfiltrated through the stone reservoir and into the underlying soil (except for the undesirable trapping of particulates in the asphalt pores or stone reservoir). Thus, the degree of pollutant removal achieved in porous pavement is closely related to the amount of runoff that is actually exfiltrated into the soil.

SORPTION

Some soluble forms of pollutants such as ortho-phosphorus and zinc become attached to binding sites on soil particles as they pass through the soil layer. Most of the sorption occurs within the first foot of soil, and is bound up for long periods of time (US EPA, 1977). The greatest sorption of nutrients and metals occurs in soils with a high content of clay and/or organic matter. Conversely, sandy soils exhibit much lower sorption rates. The same trend holds true for bacterial densities as well (US EPA, 1977). Unfortunately, soils that maximize sorption and bacterial growth also have low and sometimes unacceptable infiltration rates.

TRAPPING/STRAINING

Fine-grained particles eventually become trapped in the void spaces between soil particles as they percolate through the soil.

BACTERIAL REDUCTION

Aerobic bacteria within the soil consume and reduce organic matter. Thelen and Howe (1978) suggests that soil bacteria populations can thrive under porous pavement if the underlying soils get a chance to dry out every few days.

GROUNDWATER DIVERSION

Pollutants which have not been trapped, absorbed or reduced continue to move through the soil profile and into groundwater. This is not a desirable removal method, as it could lead to the contamination of drinking water supplies. Limited studies to date suggest that migration of urban stormwater pollutants through soils is normally not rapid nor deep (Nightingale, 1987; US EPA, 1983; OWML, 1983), except for extremely soluble pollutants such as nitrate or chloride.

Estimates of Porous Pavement Pollutant Removal Efficiency

Two long-term monitoring studies have been conducted in the Washington area on partial exfiltration systems by the OWML (1986b, 1983) in suburban Maryland and Virginia. In both cases, the pollutant export over a series of storms was monitored at a terminal underdrain, and compared to pollutant loads in the runoff from adjacent conventional pavement. Both partial exfiltration sites exhibited similar and quite high removal capabilities. Mass removal of solids was 85% at the Prince William County, Virginia site and 95% at the site in Rockville, Maryland. Approximately 65% of the total phosphorus and 75-85% of the total nitrogen load was removed at both sites. Removal of trace metals, such as zinc and lead, at the Rockville site approached 98%, and over 80% of the COD load was effectively removed (Table 7.2).

In some cases, increased export of the inorganic ions (such as Ca, Mg, K, and Na) has been observed from porous pavement, presumably from the dissolution or leaching of asphalt or stone aggregate (Gburek and Urban, 1980). However, these ions do not represent water quality problems.

Table 7.2: Pollutant Removal Rates Reported at Porous Pavement Sites (Partial Exfiltration Systems)

POLLUTANT	LONG TERM REMOVAL RATE (%)	
	Rockville, Md. Site	Prince William, Va. Site
Sediment	95	82
Total Phosphorus	65	65
Total Nitrogen	85	80
Chemical Oxygen Demand	82	-
Zinc	99	-
Lead	98	-

Sources: OWML, 1986b; MWCOG, 1983b

WATER QUALITY INLETS

Water quality inlets (also known as oil/grit separators) are designed to remove sediment and hydrocarbon loadings from parking lot runoff before they are conveyed to the storm drain network or to an infiltration BMP. Under current designs, water quality inlets only store a small fraction of the two year design storm volume, and because of their limited capacity, inlets play no role in modifying the post development peak discharge rate. The pollutant removal capability of these inlets has never been monitored in the field. However, since runoff is only briefly retained in the inlets, only moderate removal of coarse sediment, oil/grease, and debris can be expected. Even more limited removal is likely for fine-grained particulate pollutants such as silt, clay and associated trace metals and nutrients. Soluble pollutants probably pass through inlets without modification. Water quality inlets typically serve parking lots one acre or less in size, and are particularly appropriate for sites that are expected to receive a great deal of vehicular traffic or petroleum inputs (e.g, gas stations, roads, loading areas). Installation costs of standard sized water quality inlets are on the order of $5000-15,000. Routine maintenance costs are high since the inlets must be cleaned out at least twice a year to permanently dispose of trapped pollutants and to ensure proper inlet function.

Advantages of the water quality inlets lie in their unobtrusiveness, compatibility with the storm drain network, easy access, and capability to pretreat runoff before it enters infiltration BMPs. Disadvantages include their limited stormwater and pollutant removal capabilities, the need for frequent clean-outs (which cannot always be assured), and possible difficulties in disposing of accumulated sediments.

POLLUTANT REMOVAL

Current designs of water quality inlets appear to have low to moderate removal rates for particulate pollutants, and low to zero rates for soluble pollutants. Water quality inlets rely primarily on settling for removal, and given their small storage capacity and brief residence times, it is likely that only coarse grit, sand, and some silts will be trapped. Inlets do show some promise in removing hydrocarbons, such as oil, gas and grease, from runoff. Due to resuspension problems, however, pollutant removal can only be attained in water quality inlets if they are cleaned regularly.

Despite these design limitations, there is reason to believe that inlets can help to remove coarse-grained sediments from urban runoff. For example, settling column studies (Grizzard et al., 1986) indicate that initial settlement of urban sediment is quite rapid, with about 20-40% dropping out within the first hour, depending on the initial sediment concentration (Figures 8.1 & 8.2).

Also, the design of water quality inlets should provide moderate removal of hydrocarbons. Since oil and gas are less dense than water, they initially float on the water surface. However, since oil and gas have a strong affinity for sediment, they rapidly adsorb to particles in the water column, and can then settle out.

Figure 8.1: Schematic of a Water Quality Inlet, Montgomery County, MD. Three Chamber Design

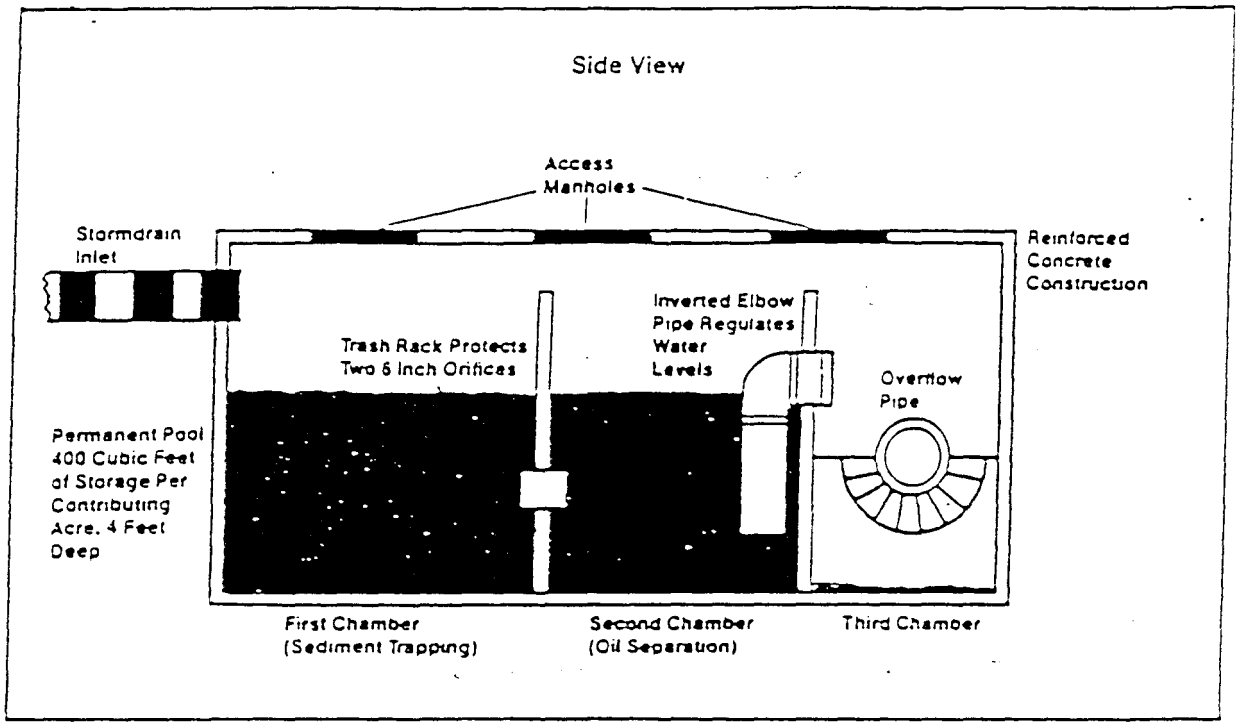
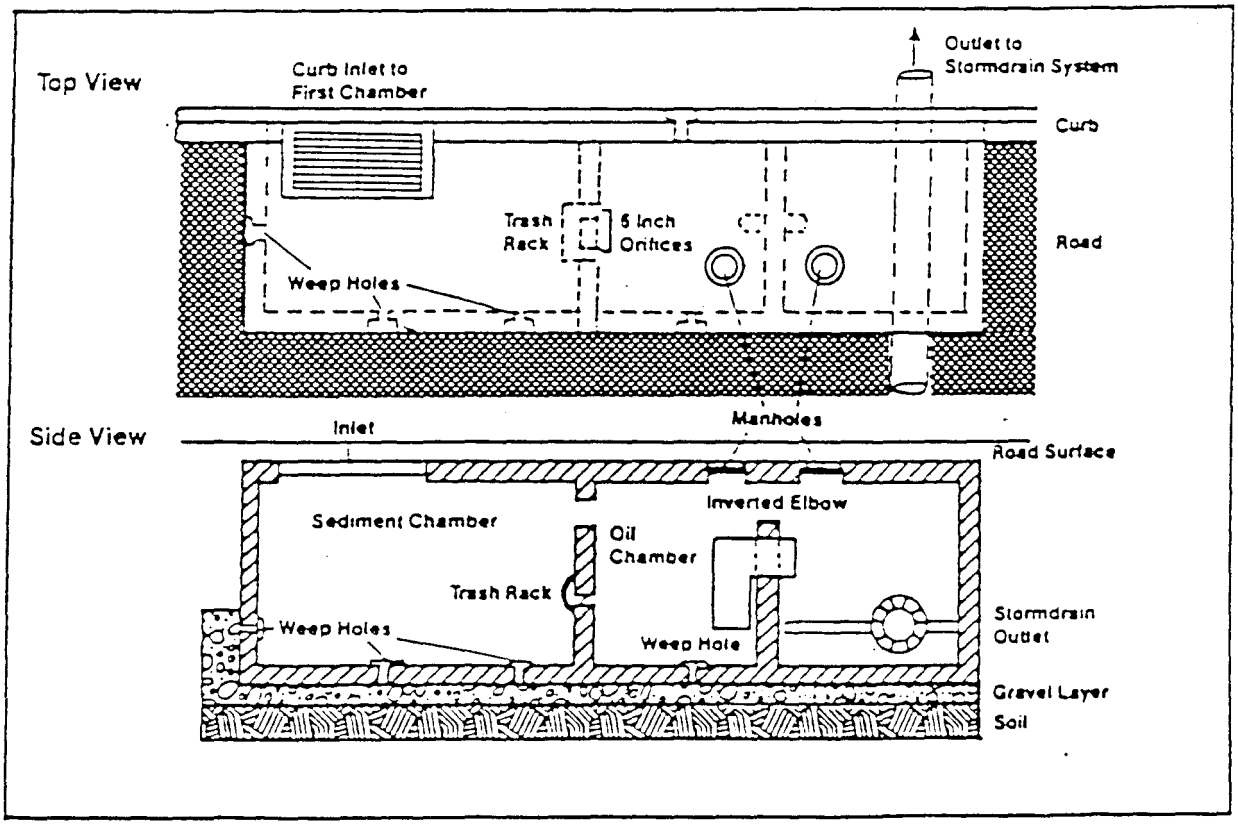


Figure 8.2: Schematic of a Water Quality Inlet, Rockville Percolating Inlet Design



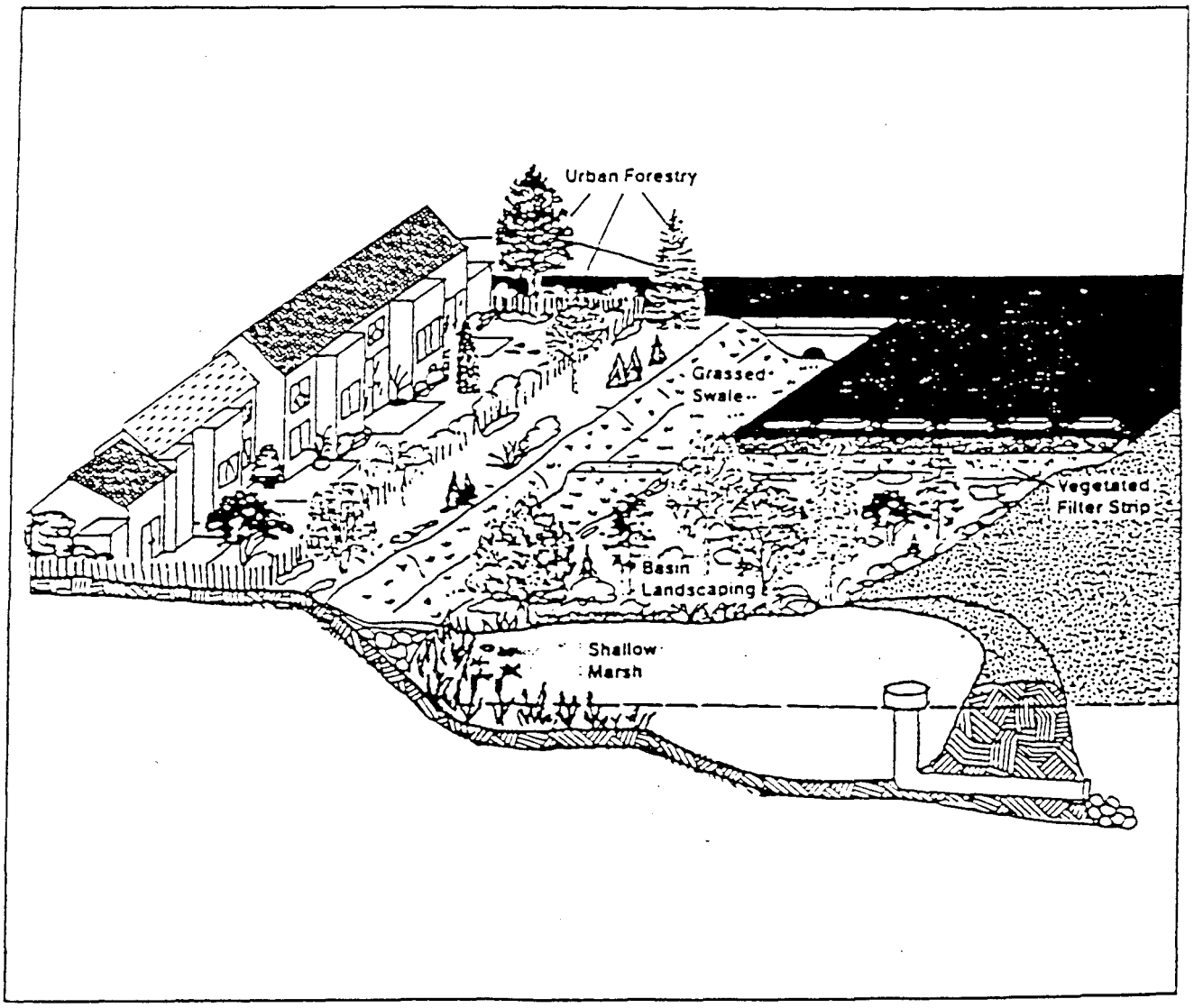
Source: City of Rockville (1984b)

VEGETATIVE BMPs

This section reviews a diverse series of landscaping practices that can be applied to portions of the urban drainage system, including:

- Grassed Swales
- Filter Strips
- Urban Forestry
- Basin Landscaping
- Shallow Marsh Creation

Vegetative BMPs for a Site



All of these practices rely on various forms of vegetation to enhance the pollutant removal, habitat value, or appearance of a development site. While each practice by itself is not generally capable of entirely controlling the increased runoff and pollutant export from a site, they can improve the performance and amenity value of other BMPs, and should be considered as an integral part of every site plan. Typically, the costs for vegetative BMPs are very small in relation to those incurred when constructing ponds and basins. Also, vegetative BMPs can usually be applied during any stage of development, and in some instances, are attractive retrofit candidates.

Each of the vegetative practices is briefly reviewed in the following section; more detailed design guidance is provided by reference. The section concludes with a general landscaping guide for stormwater management areas.

GRASSED SWALES

General

Grassed swales are typically applied in single family residential developments and highway medians as an alternative to curb and gutter drainage systems (Figure 9.2). Swales have a limited capacity to accept runoff from large design storms, and often must lead into storm drain inlets to prevent large, concentrated flows from gullying/eroding the swale. If check dams are placed across the flow path, swales can provide some stormwater management for small design storms (Md WRA, 1984) by infiltration and flow attenuation. In most cases, however, swales must be used in combination with other BMPs downstream to meet stormwater management requirements.

Some modeling efforts and field studies indicate that swales can filter out particulate pollutants, under certain site conditions. However, swales are not generally capable of removing soluble pollutants, such as nutrients. In some cases, trace metals leached from swale culverts and nutrients leached from intensive lawn fertilization may actually increase the export of these pollutants. Grassed swales are usually less expensive than the curb and gutter alternative. Swale maintenance is performed by adjacent homeowners, and basically involves normal lawn activities such as mowing, watering, and chemical applications.

Pollutant Removal

Pollutants are removed by the filtering action of the grass, deposition in low velocity areas, or by infiltration into the subsoil. Field monitoring has provided mixed results as to the extent of pollutant removal performed by swales. Kercher et al. (1983) and Yousef et al. (1985) reported moderate to high removal of particulate pollutants in low gradient, densely vegetated swales in Florida. In contrast, Oakland (1983) found low to moderate removal of particulate pollutants and negligible removal of soluble pollutants in a low-gradient swale, underlain by relatively impermeable soils in New Hampshire.

Figure 9.2: Schematic of a Grassed Swale

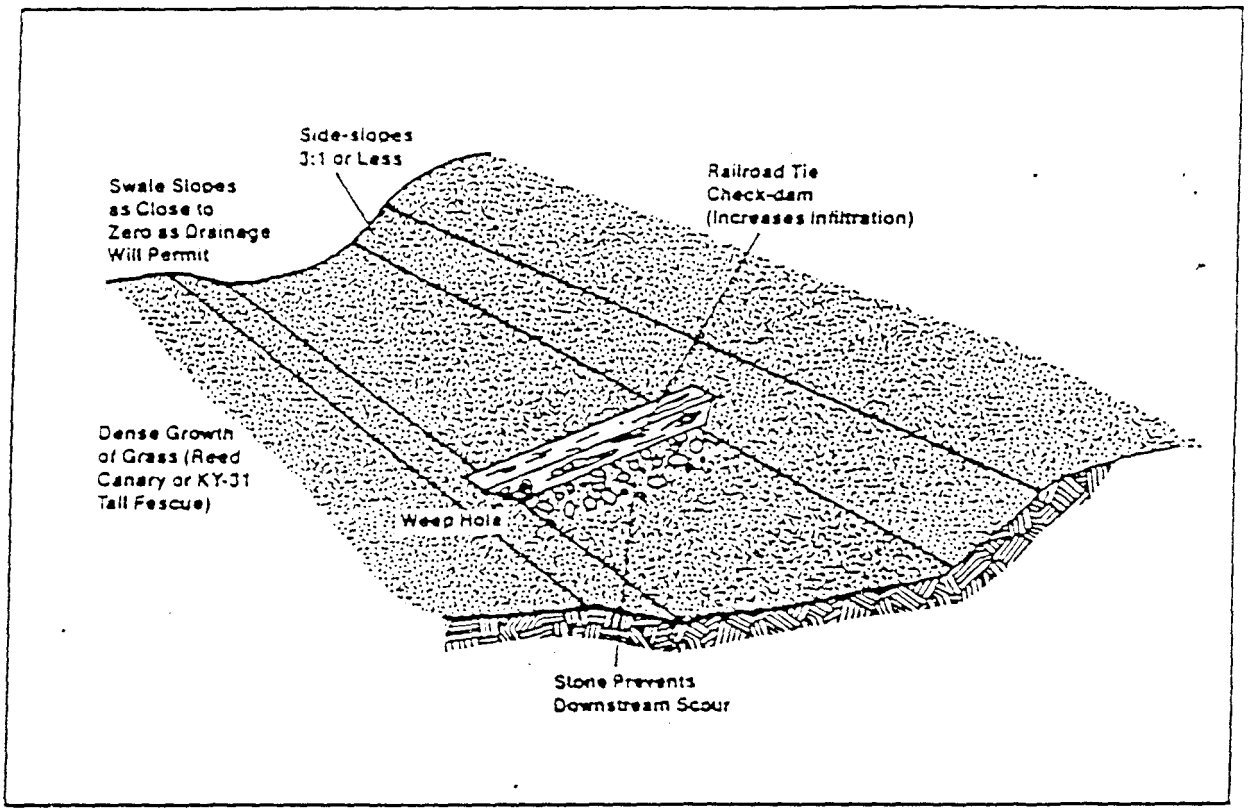
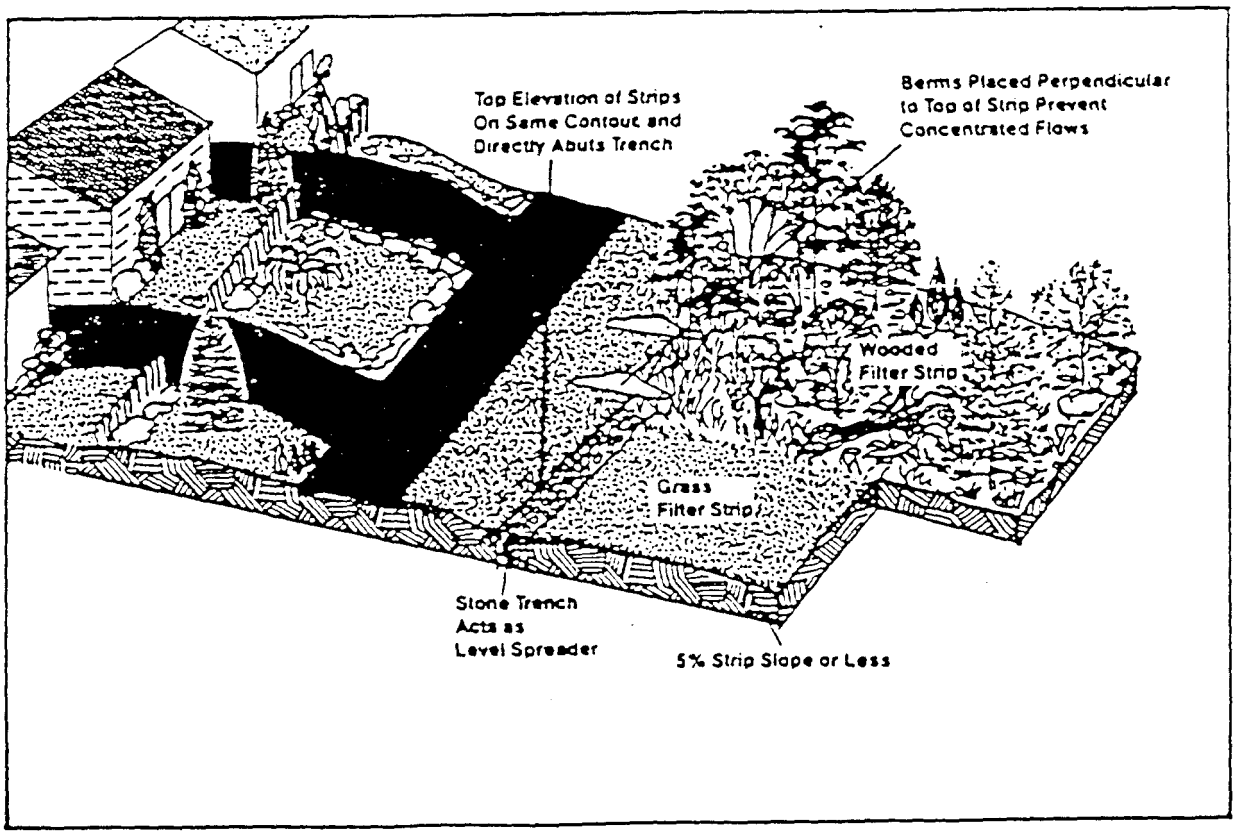


Figure 9.3: Schematic of a Filter Strip



FILTER STRIPS

General

Filter strips are similar in many respects to grassed swales (Figure 9.3), except that they are designed to only accept overland sheet flow. Runoff from an adjacent impervious area must be evenly distributed across the filter strips. This is not an easy task, as runoff has a strong tendency to concentrate and form a channel. Once a channel is formed, the filter strip is effectively "short-circuited" and will not perform as designed. Such short-circuiting is a common problem. For example, over 60% of agricultural filter strips installed in Virginia were reported to have been short-circuited (Dilhalla et al., 1986).

To work properly, a filter strip must be 1) equipped with some sort of level spreading device, 2) densely vegetated with a mix of erosion resistant plant species that effectively bind the soil, 3) graded to a uniform, even, and relatively low slope, and 4) be at least as long as the contributing runoff area. Modeling studies indicate that filter strips built to these exacting specifications can remove a high percentage of particulate pollutants (Wong and McCuen, 1982). Much less is known about the capability of filter strips in removing soluble pollutants. Filter strips are relatively inexpensive to establish, and cost almost nothing if preserved before the site is developed. A creatively landscaped filter strip can become a valuable community amenity, providing wildlife habitat, screening, and stream protection. Grass filter strips are also extensively used to protect surface infiltration trenches from clogging by sediment.

Pollutant Removal

Pollutant removal mechanisms in filter strips are similar to those discussed for grass swales. Results from some small test plots (Barfield et al., 1977) and several independent modeling studies (Wong and McCuen, 1982; Pitt, 1986, Overcash et al., 1981; Tollner et al., 1982) all suggest that filter strips are effective in removing particulate pollutants such as sediment, organic material and many trace metals. The rate of removal appears to be a function of the length, slope and soil permeability of the strip, the size of the contributing runoff area, and the runoff velocity.

URBAN FORESTRY

General

Urban forestry involves either preserving trees during construction, planting them after the site has been cleared, or homeowner landscaping after the site has been fully developed. With careful landscape design, as much as 50% of a residential lot can be converted into an attractive natural setting of trees, shrubs and ground covers. The amount of runoff generated from these landscaped areas is often 30-50% less than that produced from turf or lawns. Pollutant removal through urban forestry, on the other hand, is limited (with the notable exception of forested buffer strips). The cost and maintenance requirements for most urban forestry practices are quite low, yet the environmental amenity value is often very high.

Pollutant Removal

Urban forestry can help remove pollutants in a number of ways: by plant uptake and storage, by reducing the volume of storm runoff (and associated pollutants) delivered from the site, and by preventing soil erosion. However, the actual impact of urban forestry in reducing pollutant export from the site is limited because the bulk of the pollutant load from urban areas is generated from impervious areas, and not the pervious lawn areas that are the focus of urban forestry.

BASIN LANDSCAPING

General

Landscaping is a critical element in the design of stormwater basins, whether they are dry ponds, extended detention ponds, infiltration basins or wet ponds. Every basin design should be accompanied by a landscaping plan, as the form and species of plants used to stabilize a basin has a profound influence on its pollutant removal performance, appearance, habitat value and maintenance requirements well into the future.

SHALLOW MARSH CREATION

General

Wetland or shallow marsh creation is basically a form of basin landscaping. It is given special treatment here due to its important role in pollutant removal and the need for careful design. Wetlands can be established around the perimeter of a wet pond, the lower stage of an extended detention pond, or in a sediment forebay. The many benefits of wetlands have been summarized in earlier sections. Athanas (1986), Lakatos and McNemar (1986), and Md SCS (1986) have compiled design guidance for successful wetland establishment, which have been abstracted below:

SEVERABILITY

The provisions of this Ordinance shall be severable, and if any provision hereof shall be declared unconstitutional, illegal or invalid, such decision shall not affect the validity of any of the remaining provisions of this Ordinance. It is hereby declared as the legislative intent of the Township that this Ordinance would have been amended as if such unconstitutional, illegal or invalid provision or provisions had not been included herein.

REPEALER

All Ordinances or parts of Ordinances conflicting or inconsistent with the provisions of this Ordinance hereby adopted are hereby repealed.

ENACTED AND ORDAINED this 21st day of April, 1998.

BOARD OF SUPERVISORS

R. DUFF MANWEILER
CHAIRMAN

ATTEST:

BARBARA A. WILSON, SECRETARY