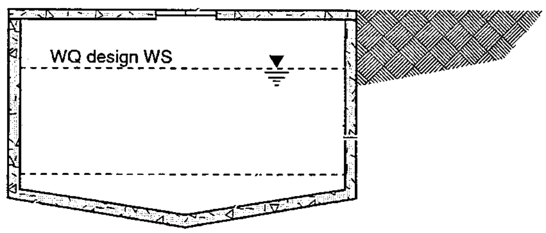
Wet Vaults



Description

A wet vault is a subterranean structure designed to provide temporary and permanent storage for stormwater runoff from a specified storm event. Wet vaults have a permanent pool of water which dissipates energy and improves the settling of particulate stormwater pollutants. Wet vaults are typically on-line, end-of-pipe BMPs. Wet vaults can be distinguished from grit chambers in two ways: 1) wet vaults are typically on-line structures (grit chambers are typically off-line) and 2) a wet vault's primary treatment feature is its permanent pool for sedimentation (acting essentially like an underground wet pond), whereas a grit chamber has a relatively smaller permanent pool as just one step in its treatment process (see the Grit Chamber BMP Section for more information). Figure 1 shows a typical wet vault design.

Pollutant removal mechanisms for particulate pollutants in wet vaults are similar to wet ponds. The primary pollutant removal mechanism in a wet vault is sedimentation. Significant loads of suspended pollutants, such as metals, nutrients, sediments, and organics, can be removed by sedimentation. However, in a wet vault, the permanent pool of water is covered by a lid which blocks sunlight from entering the facility, limiting light-dependent biological activity. Consequently, biological pollutant removal mechanisms that function in surface wet ponds are not a part of storm water treatment in a wet vault.

Wet vaults are typically used for commercial, industrial, or roadway projects if there are space limitations precluding the use of other treatment BMPs.

Wet vaults are not widely used and therefore little information has been published with regard to their design, applicability and usefulness.

Enhancement Options

Vault Shape: To avoid reducing the pollutant removal capability and to maximize travel distance, the inflow points of the wet vault should be as far from the outlet as possible. To maximize stormwater contact and residence time in the vault, a length to width ratio of 3:1 is recommended.

Purpose

Water Quantity	
Flow attenuation	◧
Runoff volume reduction	□
Water Quality	
Pollution prevention	
Soil erosion	**N/A**
Sediment control	**N/A**
Nutrient loading	**N/A**
Pollution removal	
Total suspended sediment (TSS)	■
Total phosphorus (P)	◧
Nitrogen (N)	◧
Heavy metals	◧
Floatables	■
Oil and grease	◧
Other	
Fecal coliform	□
Biochemical oxygen demand (BOD)	□

■	Primary design benefit
◧	Secondary design benefit
□	Little or no design benefit

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Advantages

- Good for areas with limited space for BMPs.
- Efficient removal of sediment and particulate pollutants.
- Pond sediment removal schedule is generally less frequent than for other BMPs.
- Can be designed to provide trapping of oils and floatables.
- Insulated from freezing

Limitations

- Considerably more expensive than many other BMPs.
- Wet vaults are believed to be ineffective in removing dissolved pollutants such as soluble phosphorus or metals such as copper.
- There is some concern that oxygen levels in a wet vault will decline, especially in warm summer months, because of limited contact with air and wind. However, the extent to which this potential problem occurs has not been documented.
- Maintenance of wet vaults requires special equipment.
- No biologic activity to increase stormwater treatment.
- Accumulated sediment and stagnant conditions may cause noxious gases to form and accumulate in the vault if regular maintenance is neglected.

Requirements

Design

Wet Vault Volume

As in wet pond design, the primary design factor that determines the removal efficiency of a wet vault is the volume of its permanent pool. In general, the larger the volume of the permanent pool, the higher the vault's potential for pollutant removal. The volume of the permanent pool in a wet vault can be calculated in the same manner as a wet pond, by defining a rainstorm event called the "water quality event". The runoff volume generated from the water quality event (called the "water quality volume") is equal to the volume of the permanent pool of the wet vault. Some authorities recommend a water quality volume that is three times the volume of runoff from the mean annual storm event (King County, 1998). Two other water quality event recommendations endorsed by the MPCA are the 1-year, 24-hour storm event (2-2.4" in Minnesota) and the 2.5", 24-hour storm event (Walker, 1987).

The volume of runoff from the water quality event is best predicted by a combination of monitoring existing conditions and modeling future conditions. However, local authorities will likely have their own methods for calculating runoff volume from storm events. For design purposes, the water quality volume should be considered an instant flow to the vault, not an inflow-outflow calculation. In other words, this volume should be considered to

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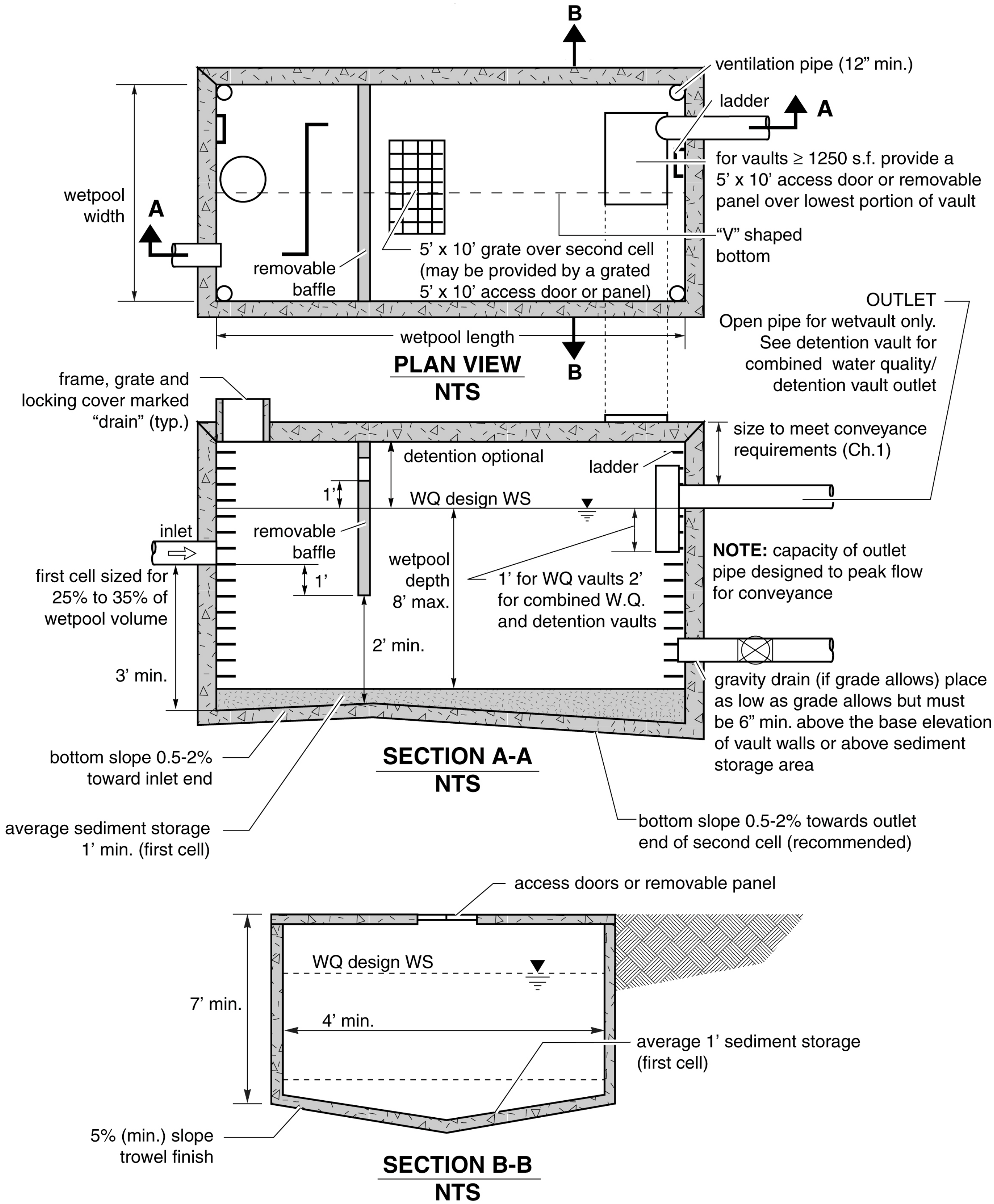

Figure 1: Schematic of a Typical Wet Vault
Source: King County, 1998

Design Requirements (continued)

arrive at the vault all at once, rather than over the course of several hours or days. The assumption of instant runoff is conservative, but it accounts for a great deal of the variability that occurs in both storm events and runoff conditions.

Avoidance of short-circuiting and the promotion of plug flow:

To prevent short-circuiting, water is forced to flow, to the extent practical, to all potentially available flow routes, avoiding "dead zones" (like corners) and maximizing the time water stays in the vault during the active part of a storm. Design features that encourage plug flow and avoid dead zones are:

- Providing a broad surface for water exchange across cells rather than a constricted area.
- Maximizing the flowpath between inlet and outlet, including the vertical path, also enhances treatment by increasing residence time.
- The ratio of flowpath length to width from the inlet to the outlet should be at least 3:1.
- All inlets should enter the first cell. If there are multiple inlets, the length-to-width ratio should be based on the average flowpath length for all inlets.
- Flow rates should be uniform to the extent possible and not increased between cells.

Vault Structure

The King County Surface Water Management Plan (1998) contains a detailed description of wet vault structure design, as follows:

- The vault should be separated into two cells by a wall or a removable baffle. If a wall is used, a 5 foot by 10 foot removable maintenance access should be provided for both cells. If a removable baffle is used, the following criteria apply:

1) The baffle should extend from a minimum of 1 foot above the design water surface to a minimum of 1 foot below the invert elevation of the inlet pipe.

2) The lowest point of the baffle should be a minimum of 2 feet from the bottom of the vault, and greater if feasible.

However, if the vault is less than 2,000 cubic feet (inside dimensions), or if the length to-width ratio of the vault pool is 5:1 or greater, the baffle or wall may be omitted and the vault may be one-celled.

- The bottom of the first cell should be sloped toward the access opening. Slope should be between 0.5 percent (minimum) and 2 percent (maximum). The second cell may be level (longitudinally) sloped toward the outlet, with a high point between the first and second cells. The intent of sloping the bottom is direct the sediment accumulation to the closest access point for maintenance purposes. Sloping the second cell towards the access opening for the first cell is also acceptable.
- The second cell shall be a minimum of 3 feet deep since planting cannot be used to prevent resuspension of sediment in shallow water as it can in open ponds.

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- The vault bottom shall slope laterally a minimum of 5% from each side towards the center, forming a broad "v" to facilitate sediment removal. Note: More than one "v" may be used to minimize vault depth. *Exception*: The vault bottom may be flat if removable panels are provided for openings over the entire vault. Removable panels should be at grade, have stainless steel lifting eyes, and weigh no more than 5 tons per panel.
- The highest point of a vault bottom should be at least 6 inches below the gravity drain outlet elevation to provide for sediment storage over the entire bottom.

Pond Inlet/Outlet Structures and Pipes

- The inlet to the wet vault shall be submerged with the inlet pipe invert a minimum of 3 feet from the vault bottom (not including sediment storage). The top of the inlet pipe should be submerged at least 1 foot, if possible. The submerged inlet is intended to dissipate energy of the incoming flow. The distance from the bottom is to minimize resuspension of settled sediments. Alternative inlet designs that accomplish these objectives are acceptable.
- Unless designed as an off-line facility, the capacity of the outlet pipe and available head above the outlet pipe should be designed to convey flows larger than the water quality design flow for developed site conditions without overtopping the vault. The available head above the outlet pipe should be a minimum of 6 inches.
- The outlet pipe should be back-sloped or have tee section, the lower arm of which should extend 1 foot below the water quality design water surface to provide for trapping of oils and floatables in the vault.
- A gravity drain for maintenance is recommended if grade allows. Gravity drains should be as low as the site situation allows; however, the invert shall be no lower than the average sediment storage depth. At a minimum, the invert shall be 6 inches above the base elevation of the vault side walls. This placement prevents highly sediment-laden water from escaping when the vault is drained for maintenance. A lower placement is allowed than for wet ponds since the v-shaped vault bottom will capture and retain additional sediments.
- Wet vaults may be constructed using arch culvert sections provided the top area at the design water surface is, at a minimum, equal to that of a vault with vertical walls designed with an average depth of 6 feet. This is to prevent decreasing the surface area available for oxygen exchange.
- Galvanized materials should be avoided whenever possible.
- Lockable grates instead of solid manhole covers are recommended to increase air contact with the wetpool.

Sediment Storage

The sediment storage in the first cell (Section B-B in Figure 1) should be limited to 1 foot. Because of the v-shaped bottom, the depth of sediment storage needed above the bottom of the side wall is roughly proportional to vault width according to the schedule at right.

Vault Width (feet)	**Sediment Depth** (inches from bottom of side wall)
15	10
20	9
40	6
60	4

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Requirements

Sequencing

- Wet vaults may be constructed in the early phases of a development project, in order to treat site runoff during construction.
- Sediment that has accumulated in the vault should be removed after construction in the drainage area is complete.

Construction

- Operational access to the valve that controls the gravity drain should be provided to the finished ground surface. The valve location should be accessible and well marked with one foot of paving placed around the box. It must also be protected from damage and unauthorized operation.
- Local permitting authorities may require a bypass/shutoff valve to enable the vault to be taken off-line for maintenance.

Maintenance

- Sediment should be removed when the 1-foot (average) sediment zone is full. Sediments should be tested for toxicants in compliance with current disposal requirements if land uses in the catchment include commercial or industrial zones, or if visual or olfactory indications of pollution are noticed.
- Facilities should be inspected annually. Floating debris and accumulated petroleum products should be removed as needed, but at least annually. The floating oil should be removed from wet vaults used as oil/water separators when oil accumulation exceeds one inch.
- Vault maintenance procedures must meet OSHA confined space entry requirements, which includes clearly marking entrances to confined space areas. This may be accomplished by hanging a removable sign in the access riser(s), just under the access lid.

Sources

1. King County Department of Natural Resources. 1998. *King County, Washington Surface Water Design Manual.* September 1998.
2. United States Environmental Protection Agency. 1999. *Preliminary Data Summary of Urban Storm Water Best Management Practices.* EPA-821-R-99-012. Washington, D.C.
3. Walker, 1987. “Design Calculations for Wet Detention Ponds”. Prepared for the St. Paul Water Utility and Vadnais Lake Area Water Management Association, St. Paul, Minnesota.
4. Washington State Department of Ecology. 1999. *Stormwater Management in Washington State – Volume V: Runoff Treatment BMPs.* Olympia.