4.28 Underground Detention

~~Detention~~
~~Structural Stormwater Control~~

Description: Detention storage located in underground tanks or vaults designed to provide water quantity control through detention and/or extended detention of stormwater runoff.

LID/GI Considerations: Underground detention facilities do not provide runoff reduction of water quality treatment and are not generally considered limited impact development or green infrastructure.

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KEY CONSIDERATIONS

DESIGN CRITERIA

- The maximum contributing drainage area to be served by a single underground detention vault or tank is 25 acres
- Detention vaults should be constructed with a minimum 3,000 psi structural reinforced concrete
- All construction joints must be provided with water stops
- Cast-in-place wall sections must be designed as retaining walls
- The maximum depth from finished grade to the vault invert should be 20 feet
- The minimum pipe diameter for underground detention tanks is 36 inches
- Underground detention vaults and tanks must meet structural requirements for overburden support and traffic loading if appropriate
- Riprap, plunge pools or pads, or other energy dissipators are to be placed at the end of the outlet to prevent scouring and erosion
- A high flow bypass is to be included in the underground detention system design to safely pass the extreme flood flow

ADVANTAGES / BENEFITS:

- Ideal for highly urbanized areas where land is limited.
- Can be used for stormwater quantity control downstream of other runoff reducing or water quality treating BMPs.
- Some designs require minimal drop between inlet and outlet

DISADVANTAGES / LIMITATIONS:

- Not designed to provide storm water quality benefits.
- Underground installation may make these systems difficult to maintain
- Frequent maintenance required
- Performance dependent on design and frequency of inspection and cleanout of unit
- Some designs may require a confined space entry for maintenance and repairs

ROUTINE MAINTENANCE REQUIREMENTS:

- Adequate maintenance access must be provided for all underground detention systems
- Remove any trash/debris and sediment buildup in the underground vaults or tanks
- Perform structural repairs to inlet and outlets

POLLUTANT REMOVAL

~~8~~0%	**Total Suspended Solids**
~~50%~~20%	**Nutrients** - Total Phosphorus / Total Nitrogen removal
~~5~~0%	**Metals** - Cadmium, Copper, Lead, and Zinc removal
~~7~~0%	**Pathogens** – Fecal Coliform

STORMWATER MANAGEMENT SUITABILITY

- ☐ **Runoff Reduction**
- ☑ **Water Quality**
- ☑ **Channel Protection**
- ☑ **Overbank Flood Protection**
- ☐ **Extreme Flood Protection**

☑ = suitable for this practice
☐ = may provide partial benefits

IMPLEMENTATION CONSIDERATIONS

L **Land Requirement**

M **Capital Cost**

L **Maintenance Burden**

Residential Subdivision Use: *Yes*

High Density/Ultra-Urban: Yes

Roadway Projects: Not Recommended

Soils: Geotechnical testing for the structural load bearing capacity of subsurface soils may be required prior to underground detention installation.

Other Considerations: Install as an off-line device unless the underground detention can be sized to handle a small drainage area. Install manhole on downstream side to provide easy access for sampling of effluent.

L=Low **M**=Moderate **H**=High

Runoff Reduction Credit: Minimal Runoff Reduction is provided by underground detention. A pretreatment BMP or downstream regional facility should be used if runoff reduction is desired

~~SPECIAL APPLICATIONS~~

~~**Pretreatment**~~

~~**High Density/Ultra-Urban**~~

~~**Other:**~~

~~**Residential Subdivision Use**: *No*~~

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~~3.4.3.1 General~~4.27.1 General Description

Detention vaults are box-shaped underground stormwater storage facilities typically constructed with reinforced concrete~~.~~. Detention tanks are underground storage facilities typically constructed with large diameter metal or plastic pipe~~.~~. Both serve as an alternative to surface dry detention for stormwater quantity control, particularly for space-limited areas where there is not adequate land for a dry detention basin or multi-purpose detention area.

Both underground vaults and tanks can provide channel protection through extended detention of the channel protection volume (CP_v), and overbank flood Q_{p25} (and in some cases extreme flood Q_f) control through normal detention~~.~~. Basic storage design and routing methods are the same as for detention basins except that the bypass for high flows is typically included.

Underground detention vaults and tanks are not intended for water quality treatment and must be used in a treatment train approach with other ~~structural control~~BMPs that provide treatment of the WQ_v (see Section 4.1.6)~~3.1)~~. This will prevent the underground vault or tank from becoming clogged with trash or sediment and significantly reduces the maintenance requirements for an underground detention system.

Prefabricated concrete vaults are available for commercial vendors~~.~~. In addition, several pipe manufacturers have developed packaged detention systems. Figures 4.28-1 and 4.28-2 show example design schematics for underground detention systems.

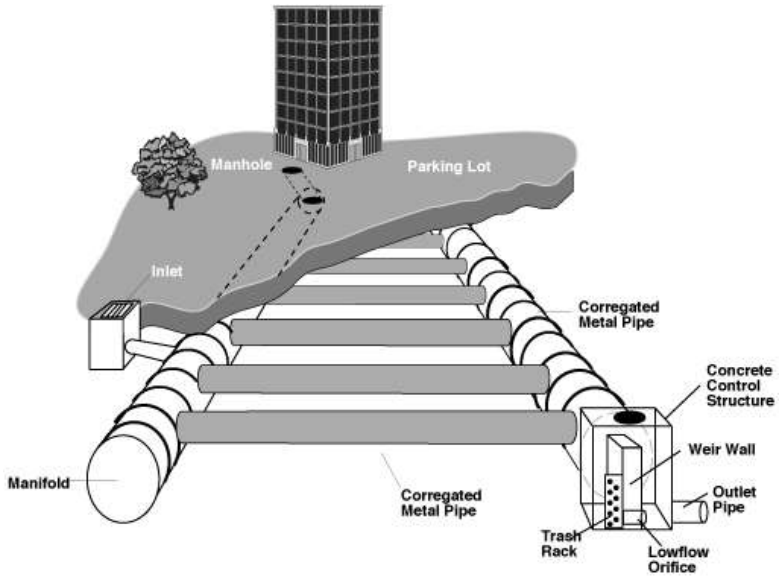
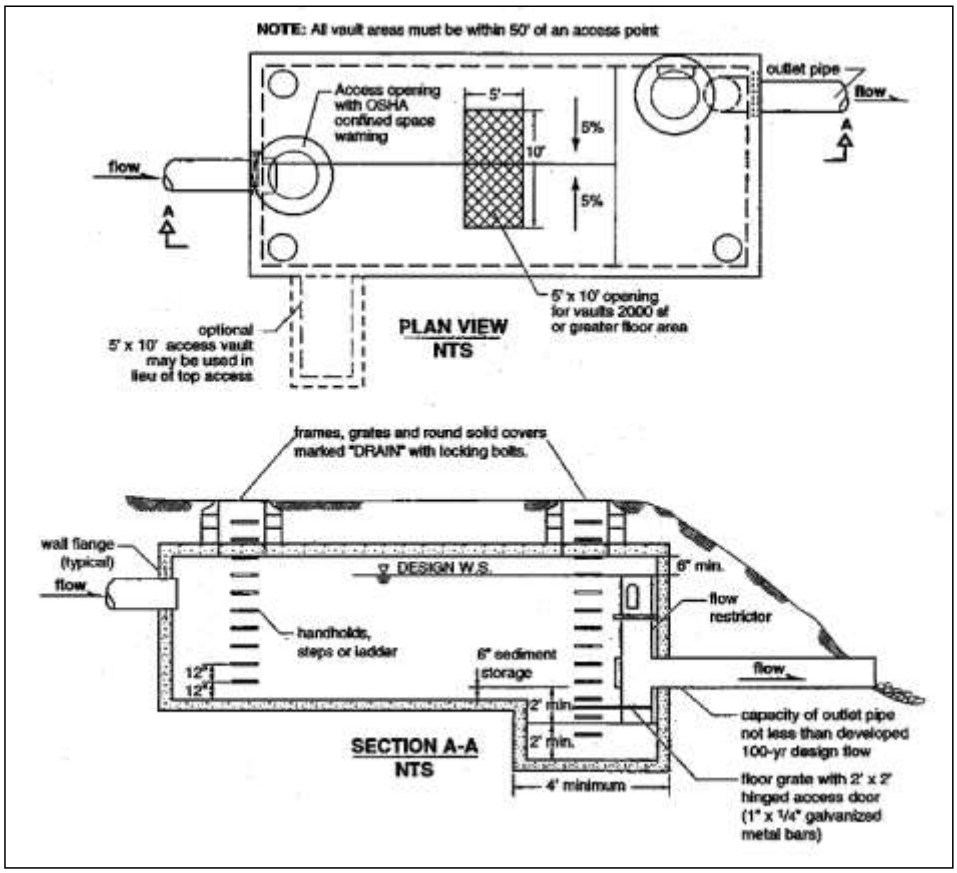


Figure 4.28-1 Example Underground Detention Tank System
(Source: WDE, 2000)



4.28-2 Example Underground Detention Tank System
(Source: WDE, 2000)

4.10.2 Stormwater Management Suitability

- Runoff Reduction

Underground detention provides minimal stormwater volume runoff reduction. Another BMP should be used in a treatment train with underground detention to provide runoff reduction. See section 4.1.6 for more information about using BMPs in series.

- Water Quality

Underground detention provides minimal water quality volume (WQv) treatment. Another BMP should be used in a treatment train with underground detention to provide WQv treatment. See section 4.1.6 for more information about using BMPs in series.

- Channel Protection

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Underground detention can be sized to store the Channel Protection volume (CP_v) and to completely drain over 24-72 hours, meeting the requirement of extended detention of the 1-year, 24-hour storm runoff volume.

- Overbank Flood Protection

Underground detention is intended to provide overbank flood protection (peak flow reduction of the 25-year storm, Qp_{25})

- Extreme Flood Protection

Underground detention can be designed to control the extreme flood (100-year, Q_f) storm event.

4.10.3 Pollutant Removal Capabilities

Underground detention does not provide measurable total suspended solids, nutrient, metals or organic matter removal

4.10.4 Application and Site Feasibility Criteria

Underground detention systems are sized to provide extended detention of the channel protection volume over 24 hours and temporarily store the volume of runoff required to provide overbank flood (Q_{p25}) protection (i.e., reduce the post-development peak flow of the 25-year storm event to the pre-development rate). Due to the storage volume required, underground detention vaults and tanks are typically not used to control the 100-year storm (Q_f) except for very small drainage areas (<1 acre).

General Feasibility

- Suitable for Residential Subdivision Usage – YES
- Suitable for High Density/Ultra Urban Areas – YES
- Regional Stormwater Control – YES

Physical Feasibility – Physical Constraints at Project Site

- Drainage Area – The maximum contributing drainage area to be served by a single underground detention vault or tank is 25 acres
- Space Required – Underground detention is installed underground; therefore, minimal surface area is required for the device.
- Adequate maintenance access to each chamber must be provided for inspection and cleanout of an underground detention unit.
- Site Slope – Underground detention may be installed on sites with slopes up to 15%.
- Minimum Depth to Water Table – 2 feet
- Minimum Head – 4 - 8 feet
- Soils – Structural load bearing capacity of subsurface soils must be adequate to support the detention device and stormwater runoff.
- Check with manufacturer recommendations for additional site design constraints.

Other Constraints / Considerations

- Hot spots – Underground detention is well-suited for hot spot runoff
- Damage to existing structures and facilities:
  - Underground detention should not be used in areas where their operation may create a risk for basement flooding, interfere with subsurface sewage disposal systems, or affect other underground structures.
  - Underground detention should be designed so that overflow drains away from buildings to prevent damage to building foundations.

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- Trout Stream –Underground detention is will not reduce thermal impacts of stormwater runoff, suspended solids, or soluble pollutants impacts. Therefore, they are not considered an effective means of protecting trout streams.

Coastal Areas

- Poorly Drained Soils—Poorly draining soils do not inhibit an underground detention's ability to temporarily store and treat stormwater runoff.
- Flat Terrain—Flat terrain and low site slopes do not interfere with the operation of underground detention.
- Shallow Water Table— Review manufacturer's instructions regarding groundwater elevation. Anti-flotation calculations may be required when large open chambers are installed at or below the water table.

~~3.4.3.2 Design~~4.28.5 Planning and Design Criteria ~~Criteria and Specifications~~

Before designing the underground detention system, the following data is necessary:

- Existing and proposed site, topographic and location maps, and field reviews.
- Impervious and pervious areas. Other means may be used to determine the land use data.
- Roadway and drainage profiles, cross sections, utility plans, and soil report for the site.
- Design data from nearby storm sewer structure.
- Water surface elevation of nearby water systems as well as the depth to seasonally high groundwater.

*The following criteria are to be considered **minimum** standards for the design of an underground detention system. Consult with the local review authority to determine if there are any variations to these criteria or additional standards that must be followed.*

4.28.5.1 Location and Layout

~~**Location**~~

- Underground detention systems are to be located downstream of other ~~structural stormwater control~~BMPs providing runoff reduction and/or treatment of the water quality volume (WQ_v)~~.~~. See Section 4.1.6~~3.1~~ for more information on the use of multiple ~~structural control~~BMPs in a treatment train.

~~The maximum contributing drainage area to be served by a single underground detention vault or tank is 25 acres.~~

4.28.5.2 General Design

~~General Design~~

~~Underground detention systems are sized to provide extended detention of the channel protection volume over 24 hours and temporarily store the volume of runoff required to provide overbank flood (Q_{p25}) protection (i.e., reduce the post-development peak flow of the 25-year storm event to the pre-development rate). Due to the storage volume required, underground detention vaults and tanks are typically not used to control the 100-year storm (Q_f) except for very small drainage areas (<1 acre).~~

- The maximum contributing drainage area to be served by a single underground detention vault or tank is 25 acres.
- Routing calculations must be used to demonstrate that the storage volume is adequate~~.~~. See Section 3.3~~2.2~~ (*Storage Design*) for procedures on the design of detention storage.
- Detention Vaults: Minimum 3,000 psi structural reinforced concrete may be used for underground detention vaults~~.~~. All construction joints must be provided with water stops~~.~~. Cast-in-place wall sections must be designed as retaining walls~~.~~. ~~The maximum depth from finished grade to the vault invert should be 20 feet.~~

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~~Detention Tanks: The minimum pipe diameter for underground detention tanks is 36 inches.~~

- Underground detention vaults and tanks must meet structural requirements for overburden support and traffic loading if appropriate.

- Adequate maintenance access must be provided for all underground detention systems~~.~~. Access must be provided over the inlet pipe and outflow structure~~.~~. Access openings can consist of a standard frame, grate and solid cover, or a removable panel~~.~~.

- Vaults with widths of 10 feet or less should have removable lids.

4.28.5.3 Physical Specifications / Geometry

- Detention Tanks: The minimum pipe diameter for underground detention tanks is 36 inches.
- The maximum depth from finished grade to the vault invert should be 20 feet.

4.28.5.4 Pretreatment \ Inlets

~~Inlet and Outlet Structures~~

- A separate sediment sump or vault chamber sized to 0.1 inches per impervious acre of contributing drainage should be provided at the inlet for underground detention systems that are in a treatment train with off-line water quality treatment ~~structural control~~BMPs.

- For CP_v control, a low flow orifice capable of releasing the channel protection volume over 24 hours must be provided. The channel protection orifice should have a minimum diameter of 3 inches and should be adequately protected from clogging by an acceptable external trash rack~~.~~. The orifice diameter may be reduced to 1 inch if internal orifice protection is used (i.e., an overperforated vertical stand pipe with 0.5-inch orifices or slots that are protected by wirecloth and a stone filtering jacket)~~.~~. Adjustable gate valves can also be used to achieve this equivalent diameter.

4.28.5.5 Outlet Structures

~~For overbank flood protection, an additional outlet is sized for Qp_{25} control (based upon hydrologic routing calculations) and can consist of a weir, orifice, outlet pipe, combination outlet, or other acceptable control structure.~~

- See Section 3.4~~2.3~~ (*Outlet Structures*) for more information on the design of outlet works.

- Riprap, plunge pools or pads, or other energy dissipators are to be placed at the end of the outlet to prevent scouring and erosion~~.~~. ~~See Section 4.5, *Energy Dissipation Design*, for more guidance.~~

- A high flow bypass is to be included in the underground detention system design to safely pass the extreme flood flow.

4.28.5.6 Safety Features

Maintenance activities for an underground detention device may require a confined space entry. Vaults that are greater than 4 feet deep should be equipped with a safety ladder.

4.28.5.7 Construction Considerations

- Newly installed underground detention should be inspected prior to being placed in service. Remove sediment and debris that may have been collected during delivery and installation.
- A minimum 20-foot wide maintenance right-of-way or drainage easement shall be provided for the underground detention.

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4.28.5.8 Construction and Maintenance Costs

- Material and installation costs for underground detention systems and vaults can vary based on the size, location, treatment requirements, and manufacturer.
- Typically, underground detention systems can range from approximately $12,000 for a small pipe and manifold system to over $50 - $60,000 for a multiple-chamber, high volume, high flow device.

4.28.6 Design Procedures

In general, site designers should perform the following design procedures when designing underground detention.

Step 1. Determine the goals and primary functions of the underground detention

- Underground detention can be designed to provide 24-hour detention of the channel protection volume (CP_v), and provide Overbank Flood (Qp_{25}) and Extreme Flood (Q_f) protection.
- Check with local officials and other agencies to determine if there are any additional restrictions and/or surface water or watershed requirements that may apply. In addition, consider if the underground detention has any special site-specific design conditions or criteria. List any restrictions or other requirements that may apply or affect the design.

Step 2. Determine if the development site and conditions are appropriate for the use of underground detention

Consider the application and site feasibility criteria in this chapter. In addition, determine if site conditions are suitable for underground detention. Create a rough layout of the underground detention dimensions taking into consideration existing trees, utility lines, and other obstructions.

Step 3. Determine underground detention location and preliminary geometry

Ensure that there is adequate site area for the installation of the underground detention and maintenance access to the vault.

Step 4. Compute runoff control volumes and rates

Calculate CP_v, Qp_{25}, and Qp_f, in accordance with the guidance presented in Section 3.3.

Step 5. Determine pretreatment volume

A separate sediment sump or vault chamber sized to 0.1 inches per impervious acre of contributing drainage area should be provided at the inlet for underground detention systems that are in a treatment train with off-line water quality treatment BMPs.

Step 6. Calculate CP_v release rates and water surface elevations

Set up a stage-storage-discharge relationship for the control structure for the 1-year, 24-hour storm orifice. Size and determine the invert elevation of the CPv orifice to ensure that the channel protection volume is stored for at least 24 hours within the underground detention.

Step 7. Calculate Qp_{25} and Qp_f release rates and water surface elevations

Set up a stage-storage-discharge relationship for the control structure for the 25- and 100-year, 24-hour storm orifices.

~~3.4.3.3 Inspection~~4.27.7 Inspection and Maintenance Requirements

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For some underground detention vaults, inspection and maintenance is conducted from the surface access cover, eliminating the need for confined space entry into a vault-style underground detention. Often an inspection orifice is provided.

Table 4.283.4.3-1 Typical Maintenance Activities for Underground Detention Systems

Activity	Schedule
•	Prior to Placing in Service
• Remove any trash/debris and sediment buildup in the underground vaults or tanks.	Annually
• Perform structural repairs to inlet and outlets.	As needed, based on inspection

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3.4.3.4 Example Schematics

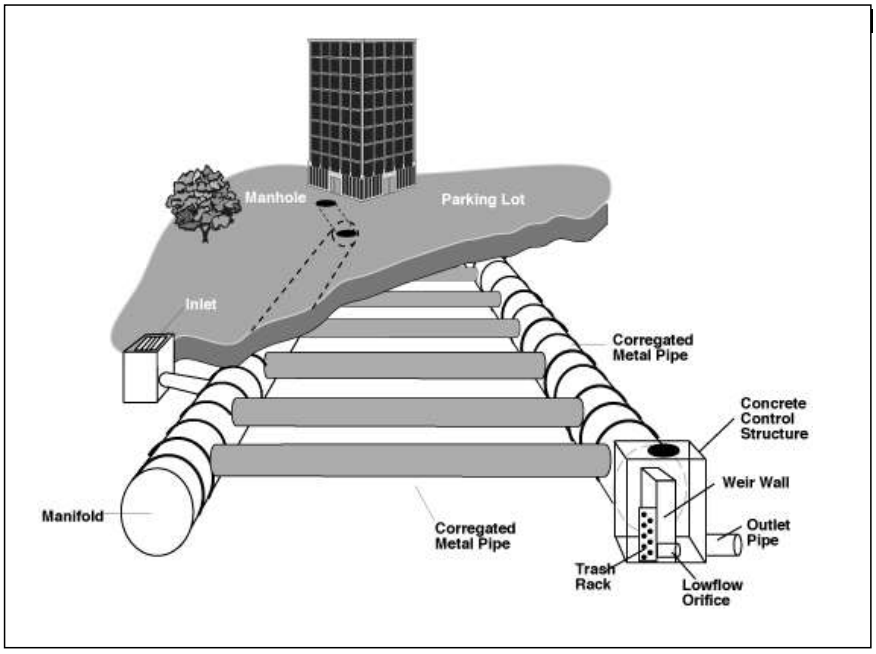
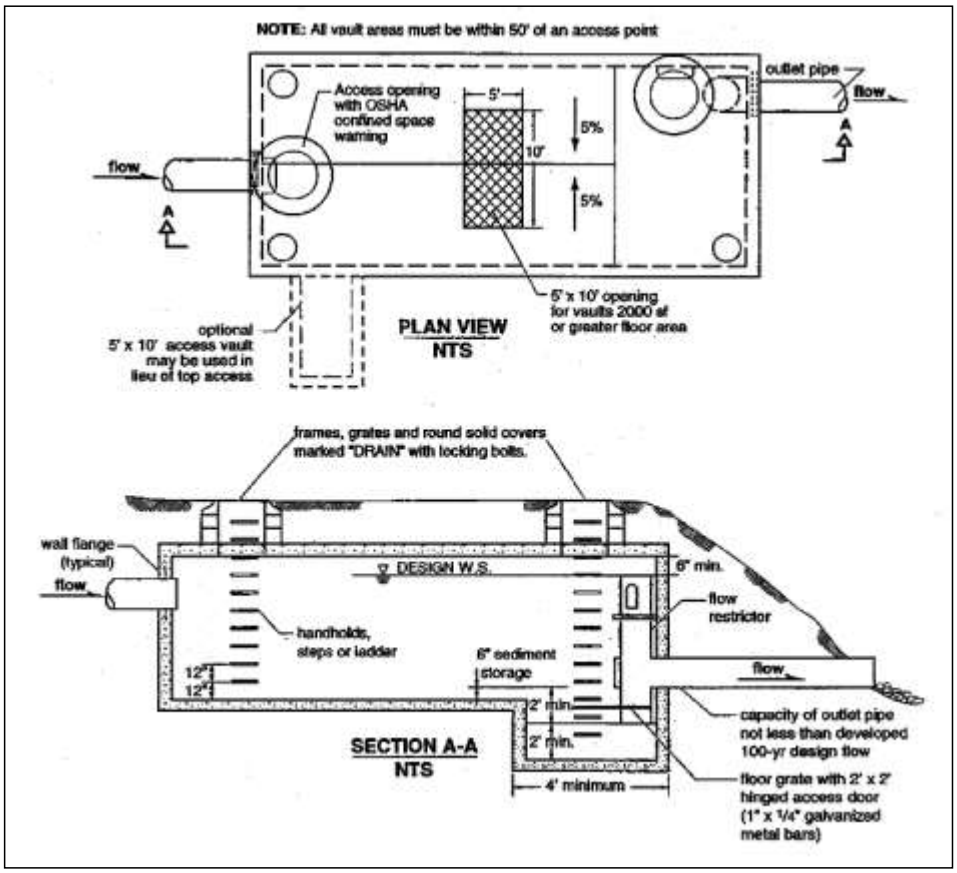


Figure 3.4.3-1 Example Underground Detention Tank System



~~Figure 3.4.3-2 Schematic of Typical Underground Detention Vault~~
~~(Source: WDE, 2000)~~