Chapter 25: Depression Storage

Introduction

Depression storage refers to the portion of rainfall that is temporarily retained in small surface depressions such as puddles, potholes, rills, and micro-topographic features before it either evaporates, infiltrates into the soil, or contributes to surface runoff. It is an important concept in surface hydrology as it plays a crucial role in determining initial abstraction losses and the amount of effective precipitation available for infiltration and runoff.

Understanding depression storage is essential for hydrologists, civil engineers, and watershed managers as it affects infiltration rates, flood peak estimations, and the overall hydrological response of a watershed. This chapter delves into the fundamental aspects, estimation techniques, and significance of depression storage in water resource planning and hydrologic modeling.

25.1 Definition and Concept

Depression storage is defined as the amount of water that collects in surface depressions during rainfall and does not contribute to surface runoff. It must be filled before any runoff can occur. It is considered part of **initial losses** in hydrological accounting.

- **Initial abstraction** = depression storage + interception + infiltration (before runoff starts).
- Typical examples: water in potholes, ploughed fields, ruts, low-lying areas, etc.

25.2 Factors Affecting Depression Storage

Several factors influence the magnitude of depression storage. These include:

25.2.1 Surface Topography

- Rough, uneven surfaces have more storage capacity.
- Micro-relief features such as mounds and pits increase depression storage.

25.2.2 Land Use and Land Cover

- Forested areas and agricultural fields with furrows and tillage features have higher depression storage.

- Urban areas with smooth impervious surfaces have minimal depression storage.

25.2.3 Soil Type and Surface Condition

- Clayey soils with low infiltration retain water longer.
- Compacted or crusted soils reduce depression storage.

25.2.4 Rainfall Intensity and Duration

- Short, low-intensity rain may get completely absorbed in depressions.
- High-intensity rain may quickly exceed depression storage capacity, leading to runoff.

25.2.5 Vegetative Cover

- Dense vegetation may help retain water in surface depressions and increase retention time.

25.3 Quantification of Depression Storage

25.3.1 Empirical Values

Different land uses have typical empirical values of depression storage derived from field experiments:

Land Use Type	Depression Storage (mm)
Forest	2 – 5 mm
Cultivated Land	1 – 3 mm
Grassland	1 – 2 mm
Urban Surfaces	~0 mm

25.3.2 Experimental Methods

- **Double ring infiltrometers** and **rain simulators** are used in laboratory or field to measure depression storage.
- LIDAR and photogrammetry are increasingly used to model micro-topography and calculate potential depression storage.

25.3.3 Analytical Methods

- Depression storage can be estimated using:
  - **SCS Curve Number Method**: Indirectly accounts for depression storage through the initial abstraction (Ia).

  - **Ia = 0.2S** where `S` is potential maximum retention after runoff begins.
  - In SCS method, `Ia` includes depression storage and interception losses.

25.4 Role in Hydrological Modelling

Depression storage is considered in various hydrologic models to simulate runoff accurately.

25.4.1 Conceptual Models

- Include depression storage as an initial loss.
- Models such as SWAT, HEC-HMS, and MIKE SHE allow explicit inclusion of depression storage.

25.4.2 Hydrologic Response Units (HRUs)

- In distributed models, HRUs help in estimating depression storage for each unit based on land use, soil, and slope.

25.5 Depression Storage and Urban Hydrology

Urban areas are typically considered to have negligible depression storage due to impervious surfaces. However:

- **Green Infrastructure (GI)** interventions like rain gardens, bio-swales, and permeable pavements are designed to increase depression storage and reduce peak runoff.
- Micro-topographic features in urban designs (e.g., recessed planting areas) can help simulate natural depression storage.

25.6 Estimation Using Digital Elevation Models (DEMs)

High-resolution **DEMs** (e.g., from drones or satellites) are used to compute depression storage:

- **Fill and pit removal algorithms** (e.g., Planchon-Darboux method) help identify depressions.
- Software such as ArcGIS and QGIS can model surface depressions and estimate potential depression storage.

25.7 Impact on Watershed Management

- **Flood mitigation**: Depression storage reduces peak discharge during storm events.
- **Soil erosion control**: Helps reduce flow velocities and prevents detachment of soil particles.
- **Groundwater recharge**: Enhances infiltration by increasing residence time of water on surface.

25.8 Case Studies and Field Observations

Several research studies have quantified depression storage across different terrains:

- **Agricultural Fields**: Furrow depth and row orientation significantly influence depression storage.
- **Deserts and Arid Lands**: Surface crusting reduces depression storage.
- **Tropical Forests**: Litter layer and fallen logs increase storage.

These studies validate the importance of accounting for depression storage in rainfall-runoff models.

25.9 Design Considerations in Engineering

Civil engineers must account for depression storage in the following designs:

- **Stormwater management systems**
- **Irrigation field layouts**
- **Watershed development structures**
- **Detention and retention basins**

Depression storage is often neglected in preliminary designs but can significantly influence performance and sustainability.
