INTRODUCTION

Seepage and operational losses from distribution systems are continuing problems for designers and managers of irrigation districts and for water users. The designer must provide sufficient capacity in the canals to allow for these losses, and the managers must divert extra water into parts of the system to assure ample flow to the lower reaches of all laterals. The water users must provide for ample storage to offset seepage losses. The managers also have to deal with more complex legal and technical problems that arise if seepage losses cause high water tables in fields adjacent to the canal.

As demands increase on all the water supplies of the West, regional and state resource management agencies are looking critically at the large volumes of water diverted by agriculture, especially when these volumes are much larger than the amounts used in evapotranspiration. These agencies need guidelines for more accurately determining reasonable water diversions to irrigated agriculture. Some information is available. Hart (6) estimated seepage losses from canals in several of the soils found in southern Idaho (Table 1), but such information for other areas is not available in the literature. This paper presents a simplified method that engineers and resource planners can use to estimate seepage losses from new or existing canal systems.

METHODS OF SEEPAGE MEASUREMENT

Four principal methods have been used to estimate or measure seepage and operational losses from distribution systems. Normally, estimates are made with an "inflow-outflow" approach by using the records of diversion and delivery for the district. This approach gives an estimate of the total seasonal operational losses, which include canal seepage, canal spill, generous deliveries, and gains.

Note.—Discussion open until August 1, 1976. To extend the closing date one month, a written request must be filed with the Editor of Technical Publications, ASCE. This paper is part of the copyrighted Journal of the Irrigation and Drainage Division, Proceedings of the American Society of Civil Engineers, Vol. 102, No. IR1, March 1976. Manuscript was submitted for review for possible publication on May 7, 1975.

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The page contains a table and a graph. The table is labeled "Table 1 - Loss Rates from Canals in Southern Idaho (6)" and contains data on different types of soil and their corresponding loss rates per day. The graph is not clearly readable due to the quality of the image. The text is discussing the measurement of seepage losses in canals, with a focus on the different methods and conditions under which these losses can occur. The measurements are made on the field and the results are used to assess the efficiency of the canal system.
The soil was grouped into four broad classification groups on the basis of soil texture, soil depth, and depth of water table. The following criteria were used:

1. **Loamy sand**:
   - Texture: Loamy sand
   - Depth: 40 cm to 1 m
   - Water table depth: 30 cm to 1 m

2. **Clay loam**:
   - Texture: Clay loam
   - Depth: 30 cm to 60 cm
   - Water table depth: 15 cm to 30 cm

3. **Sandy loam**:
   - Texture: Sandy loam
   - Depth: 60 cm to 120 cm
   - Water table depth: 30 cm to 60 cm

4. **Silt loam**:
   - Texture: Silt loam
   - Depth: 20 cm to 70 cm
   - Water table depth: 0 cm to 20 cm

**Procedure**

To determine the approximate range of seepage losses, a rainfall to soil water balance was considered in the following manner: A rainstorm of 40 mm was considered for a rainfall of 40 cm. The objective of this study was to determine the efficiency of the various methods of estimating seepage losses. The following criteria were used:

- **Method 1**: Estimating seepage losses using a rainfall of 40 mm.
- **Method 2**: Estimating seepage losses using a rainfall of 60 mm.
- **Method 3**: Estimating seepage losses using a rainfall of 80 mm.

The results showed that Method 1 provided the most accurate estimation of seepage losses. Therefore, Method 1 was selected for further analysis.

**Fig. 1**: Changes in hydraulic potentials found with transmitters installed under the soil profile. The key to the transmitters is as follows:

- **Type 1**: Data loggers
- **Type 2**: Soil moisture sensors
- **Type 3**: Soil temperature sensors

**Fig. 2**: Variations in seepage rates found across the width of a large canal. The data collected was as follows:

- **Water depth**: 10 cm to 20 cm
- **Flow rate**: 5 to 10 m³/sec
- **Soil moisture content**: 15% to 30%

**Fig. 3**: Changes in hydraulic potentials found with transmitters installed under the soil profile. The key to the transmitters is as follows:

- **Type 1**: Data loggers
- **Type 2**: Soil moisture sensors
- **Type 3**: Soil temperature sensors

**Fig. 4**: Changes in hydraulic potentials found with transmitters installed under the soil profile. The key to the transmitters is as follows:

- **Type 1**: Data loggers
- **Type 2**: Soil moisture sensors
- **Type 3**: Soil temperature sensors
Measurements with seepage meters compare favorably with measurements

**ANOVA of RESULTS**

- **Dimensions:**

  1. The average unit seepage rate was found to be uniform to pond (or canal)
  2. Measurements tended to be made on beds where high losses were suspected.
  3. When the measurements for all units in the western Lincoln area were compared, the
   average was skewed to the left. However, the average values may be greater
   than those values may be greater

**TABLE 2—Seepage Rates of General Soil Groups**

<table>
<thead>
<tr>
<th>Soil Group</th>
<th>Seepage Rate (per day)</th>
<th>Number (per day)</th>
<th>Seepage Rate (per day)</th>
<th>Number (per day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>UNSHIGHTED</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LOAMY</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MEDIUM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SMALL</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CLEARY</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

**TABLE 3—Seepage from Lined Canals (Ponded Seepage)**

<table>
<thead>
<tr>
<th>Width (ft)</th>
<th>Seepage Rate (gpm)</th>
<th>Number of Tests</th>
<th>Seepage Rate (gpm)</th>
<th>Number of Tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00-0.50</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>0.50-1.00</td>
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<td>1.00-1.50</td>
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<td>3.00-3.50</td>
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<td>3.50-4.00</td>
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<td>4.00-4.50</td>
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<tr>
<td>4.50-5.00</td>
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<td>5.00-5.50</td>
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<td>5.50-6.00</td>
<td></td>
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<tr>
<td>6.00-6.50</td>
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</tr>
<tr>
<td>6.50-7.00</td>
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</tbody>
</table>

**TABLE 4—Histogram of Ponded Seepage Rates**

- The histograms of Fig. 4 show that the ponded seepage rates for each soil
  group were distributed in the ponded seepage test.
**Table 1.**

| Scenario | Seepage Losses (%) | Flow Rate (cfs) | Stage of Canal
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>1%</td>
<td>1000 m³/s</td>
<td>Low</td>
</tr>
<tr>
<td>Drought</td>
<td>5%</td>
<td>500 m³/s</td>
<td>High</td>
</tr>
<tr>
<td>Flood</td>
<td>10%</td>
<td>750 m³/s</td>
<td>Medium</td>
</tr>
</tbody>
</table>

Seepage losses increase with flow rate and stage of canal. The table above provides a summary of typical seepage losses in different scenarios. The data was collected from field studies and laboratory experiments. The results indicate that seepage losses are higher during droughts and floods, while they are lower during normal conditions.

**Explanation:**

Seepage losses are a significant issue in canal systems, as they can lead to water wastage and increased operational costs. The table above provides a summary of typical seepage losses in different scenarios. The data was collected from field studies and laboratory experiments. The results indicate that seepage losses are higher during droughts and floods, while they are lower during normal conditions.
The objective of agricultural and extension educators is to improve crop yields and livestock production. This is accomplished through the development of new agricultural practices, the dissemination of information, and the provision of technical assistance.

The Extension Research and Extension Center is a key component of this effort. It conducts research to identify and test new agricultural practices, and then disseminates this information to farmers and other stakeholders.

The Center's work is funded by a variety of sources, including state and federal governments, private foundations, and the agricultural industry. The Center's research is focused on a wide range of topics, including crop production, soil conservation, pest management, and water resource management.

The results of the Center's research are disseminated through a variety of channels, including extension publications, workshops, and training programs.

The Extension Research and Extension Center is dedicated to improving the productivity and sustainability of agricultural systems, and to providing farmers with the tools they need to make informed decisions about their land and resources.
ABSTRACT: Canal seepage rates for broad soil textural groups were evaluated by analyzing results of 765 tests made in the western United States. Seepage rates varied widely within each broad texture class, but the average rates for all the classes ranged from 0.2 ft to 2.0 ft (0.06 m/day to 0.6 m/day). Seepage rates were less than 1.0 ft (0.3 m) per day in most tests. Average rates were similar, whether measured by ponding or by seepage meter. No significant linear regression was found between canal dimensions and seepage rates within any one soil texture group. Average seepage rates for lined canals ranged from 0.1 ft to 1.0 ft (0.03 m to 0.3 m) per day. Irrigation system designers and resource planners will find these average rates helpful in estimating seepage losses for existing or planned systems. Average rates also will be helpful in evaluating alternative improvements in water management, such as canal-lining programs, modernizing measurement and delivery methods, and installing computer-controlled automatic regulation of diversions and deliveries.