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Select Techniques for Detecting and Quantifying Seepage from Unlined Canals

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Mission Issue

Water Infrastructure
Canal Seepage Detection and Quantification.

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Problem

Canal seepage losses affect the ability of water conveyance structures to maximize efficiency and can be a precursor to canal failure. Identification and quantification of canal seepage out of unlined canals is a complex interaction affected by geology, canal stage, operations, embankment geometry, siltation, animal burrows, structures, and other physical characteristics. Seepage out of unlined canals can be coarsely estimated using a mass balance-type approach (water in minus water out with the difference assumed to be a combination of seepage and evapotranspiration). More sophisticated methods are used in some instances but are typically limited efforts aimed at quantifying seepage in a specific location.

Installing field equipment in the Truckee Canal outside of Reno, Nevada.

Solution

Seepage is generally broken out into two categories: diffuse and concentrated (or focused) seepage. Diffuse seepage is where the seepage discharges relatively constant over a given area, whereas concentrated (point discharge source) seepage discharges along preferentially focused areas. Diffuse seepage typically occurs in homogeneous conditions where the amount of water flowing into the subsurface is controlled by soil permeability and canal stage. Conversely, concentrated seepage occurs in areas of heterogeneous conditions where water flows into bedrock fractures, rodent burrows or other pre-existing discrete flow-paths. Concentrated seepage can also develop in the advent of sudden or excessive increases in hydraulic gradient which can lead to heaving, cracking, and development of backward erosion piping flow-paths. Concentrated and diffuse seepage can lead to seeps, in this case, a surface expression of water fed by irrigation water on canal embankment or at distal regions away from the canal.

"Canal sustainability is a priority issue for Reclamation and the Western U.S. water management community. Reclamation and partners have constructed over 8,000 miles of canal to service water deliveries. As canals age, water managers seek efficient and affordable ways to inspect frequently, identify seepage areas, and analyze areas of interest to inform response."

Levi Brekke
Program Manager,
R&D Office

More Information

https://www.usbr.gov/research/projects/detail.cfm?id=19144

This report focuses on work funded by the Research and Development Office from Fiscal Year 2016 through 2021 and the references provided pertain primarily to those efforts. This report also provides a generalized framework for how and when to investigate seepage out of an unlined canal based on the type of seepage, level of understanding about the seepage locations, geology, and knowledge of the subsurface conditions. The various methods used to locate seeps and quantify canal seepage are discussed in further detail, with references provided for the reader.

Direct Application

The following seepage investigation scenarios are discussed within the report:

1. Idealized workflow insensitive to time with highest quality data required
2. General workflow sensitive to time with highest quality data required
3. General workflow insensitive to time with lowest cost items preceding more costly techniques
4. Newly developed concentrated seep(s), concern about consequences (time sensitive)
5. Newly developed or rapidly increasing diffuse seepage, concern about consequences (time sensitive)
6. Existing concentrated seep(s), limited concern about consequences, poor geologic understanding
7. Existing concentrated seep(s), limited concern about consequences, good geologic understanding
8. Existing diffuse seepage, limited concern about consequences, poor geologic understanding
9. Existing diffuse seepage, limited concern about consequences, good geologic understanding

A workflow is given for each scenario which details recommended steps and the order in which those steps should be taken to maximize efficiency and data quality. The various seepage investigation techniques and estimated costs are discussed in detail to provide the reader with the required background.

Future Plans

The next step is to take the data collected from the various methods and incorporate them into canal operations models to optimize deliveries. This step could also include the development of 3D seepage models to better understand the larger-scale groundwater-surface water interactions and how they are affected by the water delivery system.

Future research will be proposed for this upscaling and synthesizing of the data to create a complete seepage model. The future research will likely focus on already acquired data as a proof-of-concept but will be presented in a manner which allows for widespread application of the techniques.