United States
Environmental Protection
Agency

GroundWater Seepage Calculator (GWSC)

Steady-State Single-Event Non-Redistribution & Transient Single-Event Non-Redistribution.
Web-Based Tool
Version .01

User Manual

SCIENCE

IMPORTANT LINKS
https://groundwatercalculator.epa.gov/
https://github.com/USEPA/GSC_SSSENR

ORD QA TRACK #: G-LRPCD-0030041-MN-1-0

Software Name: GroundWater Seepage Calculator (GWSC)

Version Number: .01

Software Baseline Documentation

Project Tracking #:	G-LRPCD-0030041
Repository:	https://github.com/USEPA/GSC_SSSENR
Software Web Address:	https://groundwatercalculator.epa.gov/

ORIGINATED BY:	Daniel Young, Physical Scientist, U.S. EPA, NRMRL, LMMD, ECEB. Jacob Specht, Computer Engineer, Global Quality Corporation
Date:	12/11/2018

REVIEWED BY:	Bob Lien, Physical Scientist, U.S. EPA, NRMRL, LMMD, RTEB.
Date:	12/11/2018

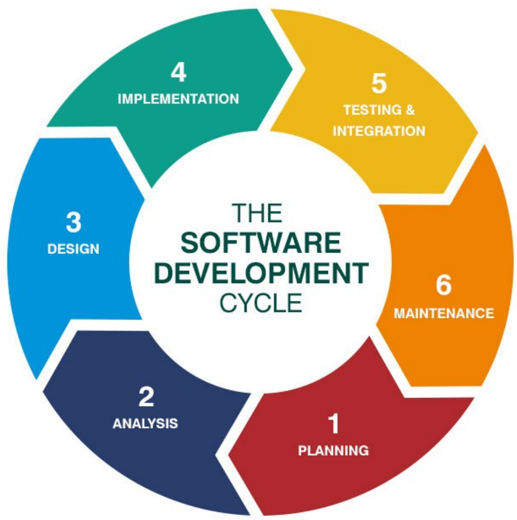
Office of Research and Development
National Risk Management Research Laboratory
Land and Materials Management Division
Emerging Chemistry and Engineering Branch
U.S. Environmental Protection Agency
Cincinnati, OH 45268

GroundWater Seepage Calculator (GWSC)

Version .01

Steady-State Single-Event Non-Redistribution & Transient Single-Event Non-Redistribution.
Web-Based Tool

Version 1.0



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User Manual
2018-12-11

DISCLAIMER

Approval Page

Written by:

Daniel Young Principal Investigator/Author LMMD, ECEB	Date
Jacob Specht Computer Engineer, Co-Author Global Quality Corporation	Date

Approved by:

Michael Gonzalez Branch Chief LMMD, ECEB	Date

Reviewed by:

Jill Hoelle, LMMD QAM	Date

National Risk Management Research
Laboratory Office of Research and
Development
U.S. Environmental Protection Agency
Cincinnati, OH 45268

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GroundWater Seepage Calculator (GWSC): Steady-State Single-Event Non-Redistribution and Transient Single-Event Non-Redistribution.

1.0 Introduction

This web application utilizes Steady-State Sediment and Transient Single-Event Non-Redistribution temperature profile to estimate groundwater seepage flux. Users are encouraged to familiarize with the theory beforehand. The only assumed parameters in the steady-state models are volumetric heat capacity of water (ρfcf) and thermal conductivity (k) of the saturated porous media. Solution of the analytical equations for steady-state conditions depends on input of values for the volumetric heat capacity of water and the thermal conductivity of sediment. The value of the volumetric heat capacity of water will vary between 4.19x106 and 4.12x106 J/m3-°C as a function of salinity from freshwater (salinity 0 ppt) to seawater (salinity 35 ppt) at 20°C. Sharqawy et al. (2010) provide a review of mathematical relationships that can be used to calculate values at other temperatures and salinity.

A description of the factors that influence sediment thermal conductivity has been summarized in Stonestrom and Constanz (2003). The grain size of sediment materials and the organic matter content are two important factors that influence the value of this parameter. Stonestrom and Constanz (2003) provided a review of measured or estimated values for a variety of porous materials and a commonly recommended default value for sediments is 1.84 J/m.s.°C. This value is representative of a sandy sediment with little or no organic matter. However, Duque et al (2016) have shown that use of this default value can lead to overestimation of calculated seepage flux by a factor of 30%, which can be significant in locations with seepage flux on the order of 1 cm/day or less.

The local surficial geology, sediment depositional environment, and the presence of vegetation or other sources of organic matter will influence characteristics of the sediment material. To provide an updated point of reference for selection of sediment thermal conductivity for a range of depositional systems for inland and coastal environments, a review was conducted of studies where sediment thermal conductivity was measured directly or specifically optimized during model calibration. These results are summarized in the table at left, which indicates that the common default value of 1.84 J/m.s. °C represents the high end of the distribution. The sediment origin, type and texture descriptors listed in the table can be used to select a value that seems appropriate for the investigated water body. Alternatively, measurements of thermal conductivity on sampled sediment cores can provide a more direct assessment of the value(s) to use for modeling.

1.1 Purpose

Ground Water Seepage Calculator (GWSC): Steady-State Single-Event Non-Redistribution and Transient Single-Event Non-Redistribution. This web application utilizes steady-state sediment temperature profile to estimate groundwater seepage flux as well as Transient Single-Event Non-Redistribution.

1.2 About the Tool

This application is based on the groundwater seepage calculator based on the analytical solutions from the following journal articles:

1.Bredehoeft, J.D. and Papadopulos, I.S., 1965. Rates of vertical groundwater movement estimated from the Earth's thermal profile. Water Resour. Res., 1(2): 325-328.

2.Schmidt, C., Conant Jr, B., Bayer-Raich, M. and Schirmer, M., 2007. Evaluation and field-scale application of an analytical method to quantify groundwater discharge using mapped streambed temperatures. Journal of Hydrology, 347(3–4): 292-307.

1.3 Servers

The GWSC web tool and stand-alone version has been developed primarily using Django web framework and PostgreSQL for database management. While we tested the site with Internet Explorer, Safari, Chrome, and Firefox, there are some sections of the site that may not look correct using Internet Explorer browsers. Firefox (https://www.mozilla.org/en-US/firefox/new/) is the recommended browser for use on the GEMM website.

The GWSC server is currently located on the following static IP addresses: https://134.67.216.102/

End section

2.0 Dashboard

2.1 GroundWater Seepage Calculator (GWSC) Scenario

2.1.1 Steady-State Models

2.1.1.1 Bredehoeft Model

Using the Bredehoeft worksheet. The example below in figure 1 demonstrates how to quantify groundwater discharge through a sandy stream bed when deciding to employ the steady-state temperature method. The Bredehoeft model (Bredehoeft and Papadopulos 1965){Bredehoeft, 1965 #17@@author-year;Bredehoeft, 1965 #17} requires steady-state sediment temperatures from three different depths, so figure 1 below demonstrates a snapshot temperature profile measurement at 15 cm, 45 cm, and 85 cm below the sediment-water interface. Based on his measurements, the user compiled the following input data for the Bredehoeft worksheet:

❶ TO, sediment temperature at the shallow depth = 19.87 (oC)

❷ TZ, sediment temperature at the middle depth = 17.53 (oC)

❸ TL, sediment temperature at the deeper depth = 16.21 (oC)

❹ Z, distance between the measurement points of TO and TZ = 0.30 (m)

❺ L, distance between the measurement points of TO and TL = 0.70 (m)

In addition, the user looked up the Parameter Metadata worksheet for the following estimated input parameter values he deemed appropriate for the particular site:

❻ k, thermal conductivity of saturated sandy sediment-water system = 1.56 (J m-1 s-1 C-1)

❼ ρfCf, heat capacity of water = 4.19x106 (J m-3 C-1)

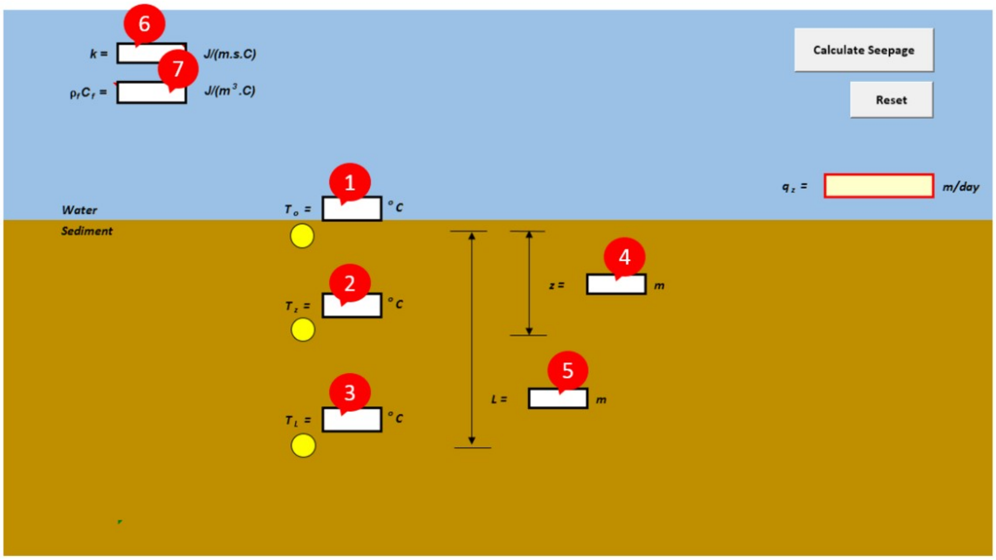

Figure 1: Designated input data space for the Bredehoeft worksheet

The user then entered each input value to its designated space in the Bredehoeft worksheet as shown in Error: Reference source not found, then clicked the Calculate Seepage button. Instantaneously, the seepage flux qZ was automatically calculated with an arrow indicator of the flow direction (Error: Reference source not found). The arrow indicator points upward when qZ is positive, points downward when qZ is negative. In situation of no flow, the arrow indicator will not appear.

User Tip: To start a new data set, simply overwrite the content(s) you want to replace or click the Reset button to start over blank.

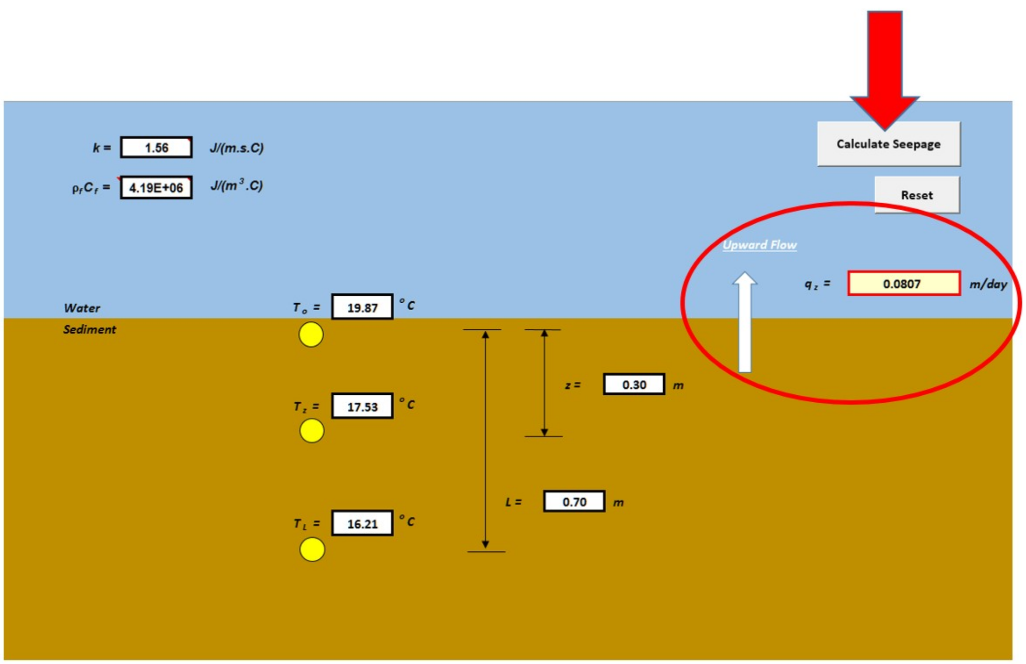

Figure 2: Example of an executed Bredehoeft worksheet

2.1.1.2 Schmidt Model

Using the Schmidt worksheet. At the request of the Jedi Order, Luke Skywalker traveled to the swampy world of Dagobah in an expedition to quantify groundwater seepage through a silty lakebed as part of his Jedi training. Limited by his rookie skill, Luke was only able to yield the Force to obtain a snapshot sediment temperature at depth 15 cm and 60 cm. From Master Yoda, Luke had learned that the Schmidt model ([Schmidt, Conant Jr et al. 2007]) only requires steady-state sediment temperatures from two different depths if the regional constant groundwater temperature is also known. So based on his measurements in addition to the groundwater temperature data provided by R2-D2, Luke compiled the following input data set for the Schmidt worksheet:

❶ TO, sediment temperature at the shallow depth = 25.36 (oC)

❷ TZ, sediment temperature at the middle depth = 16.11 (oC)

❸ Tgw, constant groundwater temperature of the region = 12.98 (oC)

❹ Z, distance between the measurement points of TO and TZ = 0.45 (m)

In addition, Luke looked up the Parameter Metadata worksheet for the following estimated input parameter values applicable to the site:

❺ k, thermal conductivity of saturated silty sediment-water system = 0.70 (J m-1 s-1 C-1)

❻ ρfCf, heat capacity of water = 4.19x106 (J m-3 C-1)

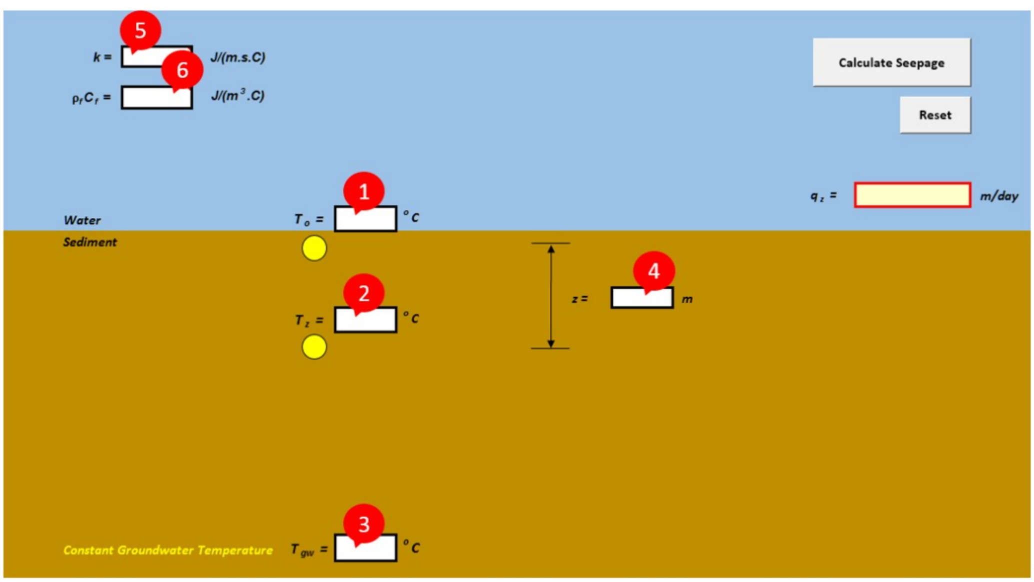

Figure 3: Designated input data space for the Schmidt worksheet

Luke typed in each input value to its designated space in the Schmidt worksheet as shown in Error: Reference source not found, then clicked the Calculate Seepage button. Instantaneously, the seepage flux qZ was automatically calculated with an arrow indicator of the flow direction (Error: Reference source not found). Note that the Schmidt model only yields positive qZ, hence the arrow indicator will always point to the upward direction. In situation of no flow, the arrow indicator will not appear.

Luke's Tip: To start a new data set, simply overwrite the content(s) you want to replace, or click the Reset button to start over blank.

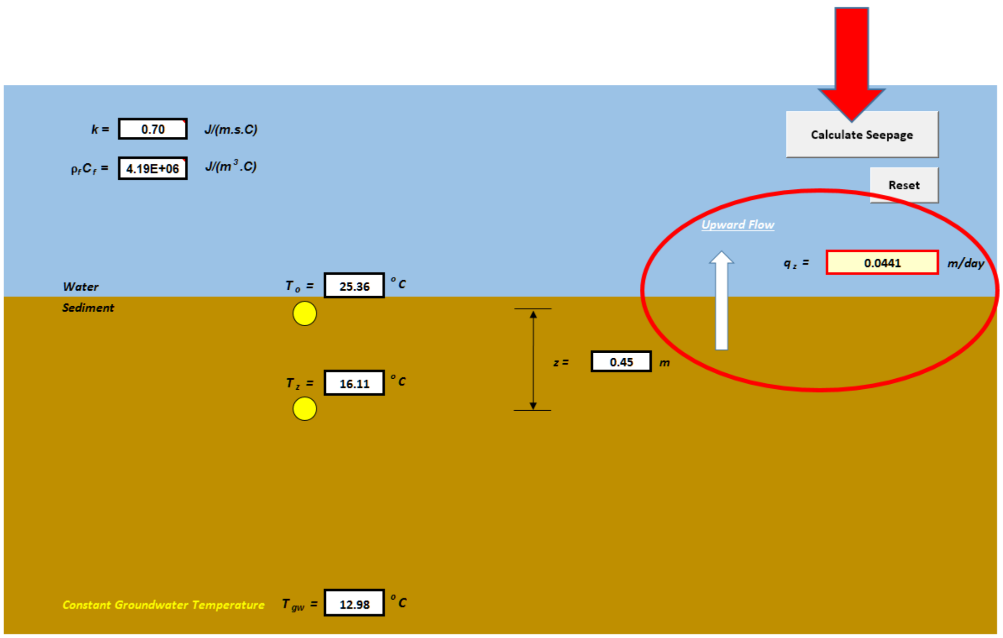

Figure 4: Example of an executed Schmidt worksheet

2.1.2 Transient Models

2.1.2.1 Hatch Model

2.1.2.2 McCallum Model

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Xxx

2.3 Export to Excel

End section

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References

Bredehoeft, J. D. and I. S. Papadopulos (1965). "Rates of vertical groundwater movement estimated from the Earth's thermal profile." Water Resour. Res. 1(2): 325-328.

Schmidt, C., B. Conant Jr, M. Bayer-Raich and M. Schirmer (2007). "Evaluation and field-scale application of an analytical method to quantify groundwater discharge using mapped streambed temperatures." Journal of Hydrology 347(3–4): 292-307.