iNUX Interactive Documents: **Overview and Examples for Basic Hydrogeology**

15. December 2025; v1.0

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Disclaimer

This document represents a static snapshot of the *iNUX Interactive Documents Overview and Examples for Basic Hydrogeology* at the time of publication.

The most recent online version is available at the gw-inux GitHub repository:

https://github.com/gw-inux/iNUX-Handbook/tree/main/Examples_Basic_Hydrogeology

Content

1. Purpose and Scope

This report provides a concise overview of active interactive documents hosted in the iNUX GitHub repository and documented through the iNUX Web Catalog (Reimann et al. 2025; see access link below). The focus is on resources that are currently accessible and in use, including interactive Streamlit applications and other digital learning materials that deal with topics related to Basic Hydrogeology

The report aims to:

- document the availability and usage of interactive documents for the broader topic 'Basic Hydrogeology' (i.e., typically suitable for undergraduate education),
- summarize usage statistics for Streamlit applications (as of the end of December 2025),
- and highlight a small selection of the most frequently accessed examples.

The complete overview of the interactive documents is provided by the iNUX Catalog

→ https://gw-inux.github.io/iNUX-Interactive-Documents/

and the GitHub repositories

→ https://github.com/gw-inux/iNUX-Interactive-Documents

→ https://github.com/gw-inux/Jupyter-Notebooks

2. Usage Statistics for Streamlit Applications

For interactive documents deployed as Streamlit applications, usage statistics are available as unique access counts provided by the Streamlit hosting platform. A large part of the iNUX interactive documents is available as Streamlit application and hosted through the Streamlit community cloud. An overview about the available Streamlit applications is available under

- https://share.streamlit.io/user/thoreimann
- https://share.streamlit.io/user/thoreimann-0432

Table 1 lists the applications with their categorization index and the number of unique accesses since deployment (the number of accesses is typically higher due to returning users). These statistics provide an indicator of global usage and visibility.

Number	Name of the app	Number of unique users in Streamlit Community Cloud	Access	iNUX Catalog ID
1	Pumping test analysis Module	1790	https://gwp-pumping-test-analysis.streamlit.app/	06-04-001
2	Well capture zone	521	https://gwp-wellcapture.streamlit.app/	07-03-001
3	Analytical solution for 1D unconfined flow with two defined head boundaries	342	https://gwf-1d-unconf-analytic.streamlit.app/	03-03-001
4	Theis drawdown prediction – fitting formation parameter to measured data	332*	https://theis-inverse-ddown.streamlit.app/	06-04-006*
5	Mass balance for a decay chain	311	https://radioactive-decay.streamlit.app/	05-06-001
6	1D Transport with advection and dispersion	288	https://transport-1d-ad.streamlit.app/	05-05-001
7	Introduction to Boundary Conditions	123	https://gwp-boundary-conditions-intro.streamlit.app/	08-01-001
8	Analytical solution for 1D unconfined flow with one no-flow boundary and one specified head/head-dependent boundary - Understanding model calibration	52	https://gwf-1d-unconf-noflow-calib.streamlit.app/	08-07-003
9	Infiltration capacity	42	https://horton-infiltration-intro.streamlit.app/	04-05-002
10	Transient flow towards wells and superposition	40	https://flow2well-transient-confined-superposition.streamlit.app/	03-05-006

** A variant of the app account also for measured/own data; this app has 294 unique users; see Catalog index 06-04-007*

Table 1: Streamlit applications and number of unique accesses

3. Selected Examples: Most Popular Documents

As a complement to the overview, this report includes the ten most frequently accessed interactive documents at the time of reporting (see Table 1). The selection is mainly based on access statistics and does not imply a qualitative ranking.

For each selected example, an overview document based on the iNUX catalog is attached, providing standardized insights and descriptions of the most popular resources:

- 06-04-001: Pumping test analysis Module
- 07-03-001: Well capture zone
- 03-03-001: Analytical solution for 1D unconfined flow with two defined head boundaries
- 06-04-006: Theis drawdown prediction – fitting formation parameter to measured data
- 05-06-001: Mass balance for a decay chain
- 05-05-001: 1D Transport with advection and dispersion
- 08-01-001: Introduction to Boundary Conditions
- 08-07-003: Analytical solution for 1D unconfined flow with one no-flow boundary and one specified head/head-dependent boundary - Understanding model calibration
- 04-05-002: Infiltration capacity
- 03-05-006: Transient flow towards wells and superposition

Acknowledgment

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References

Reimann, T., Sinha, N., Liedl, R., Giese, M., Barthel, R., Grießer, E., Birk, S., Bertran, O., Fernandez-Garcia, D. (2025). iNUX Interactive Documents: Web Catalog of Digital Learning Resources. Available under https://github.com/gw-inux/iNUX-Handbook/tree/main/Catalog

The Pumping Test Analysis Module

Topic: 06 Experimental Techniques and Methods → 04 Aquifer Characterization
Language: English

1. Basic information

Resource type	Streamlit app
URL	https://gwp-pumping-test-analysis.streamlit.app/
Time required	2 hours

2. Pedagogical overview

Short description

Pumping tests are one of the most important methods for acquiring information about groundwater systems. A pumping test provides values of aquifer transmissivity T and storativity S and in some settings, other hydraulic parameter values. This module is designed to introduce the evaluation of pumping tests for confined, unconfined, and leaky aquifers. The Pumping Test Analysis Module is provided by The Groundwater Project and developed in cooperation with the iNUX project. The module forms part of a broader initiative to create interactive, open-access educational resources for groundwater science and engineering.

Overview of the module: This module combines theoretical explanations with interactive applications and exercises. Quizzes inside the module allow you to assess your understanding. The underlying theory is provided as a concise overview at the beginning. First, the general response of aquifers to groundwater abstraction is explained as a cone of water-level drawdown expanding outward from a well over time. Then we explore how pumping test data can be evaluated to estimate hydraulic parameters such as transmissivity and storativity for: confined, leaky, and unconfined aquifers. Opportunities are offered to explore the evaluation methods with a few different synthetic and idealized data that originate from textbooks, as well as measured data from the Varnum test site in Sweden, the Viterbo test site in Italy, the Pirna test site in Germany, and you can also use your own data in the Pumping Test Analysis section.

Keywords: Theis, Neuman, Hantush-Jacob, Pumping test
Best suited for: self learning, exam preparation

3. Technical details

Multipage app	approximately 7 page(s)
Interactive plots	10 interactive plot(s)
Assessments	28 question(s)
Videos	1 video(s)

4. Educational fit

Time required	2 hours
Prerequisites	Basic Hydrogeology
Best suited for	self learning, exam preparation

5. Authors & references

Authors

• Thomas Reimann (TU Dresden)
• Eileen Poeter (Colorado School of Mines)

References

– https://zenodo.org/records/16789736

6. Figures and illustrations

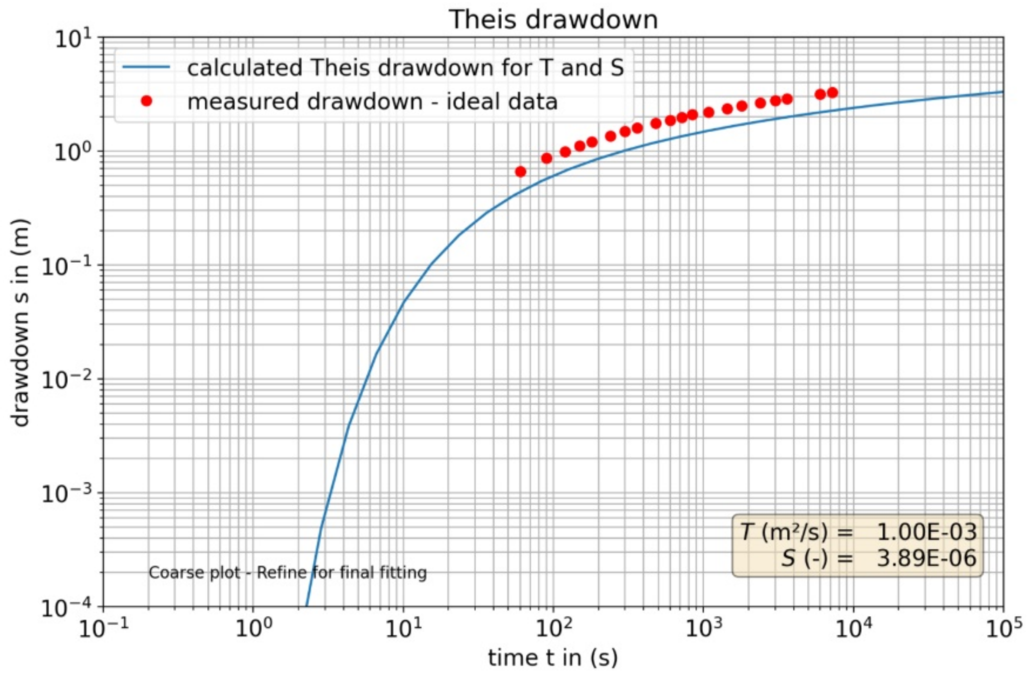

Figure 1. Curve fitting with the Theis solution (Screenshot)

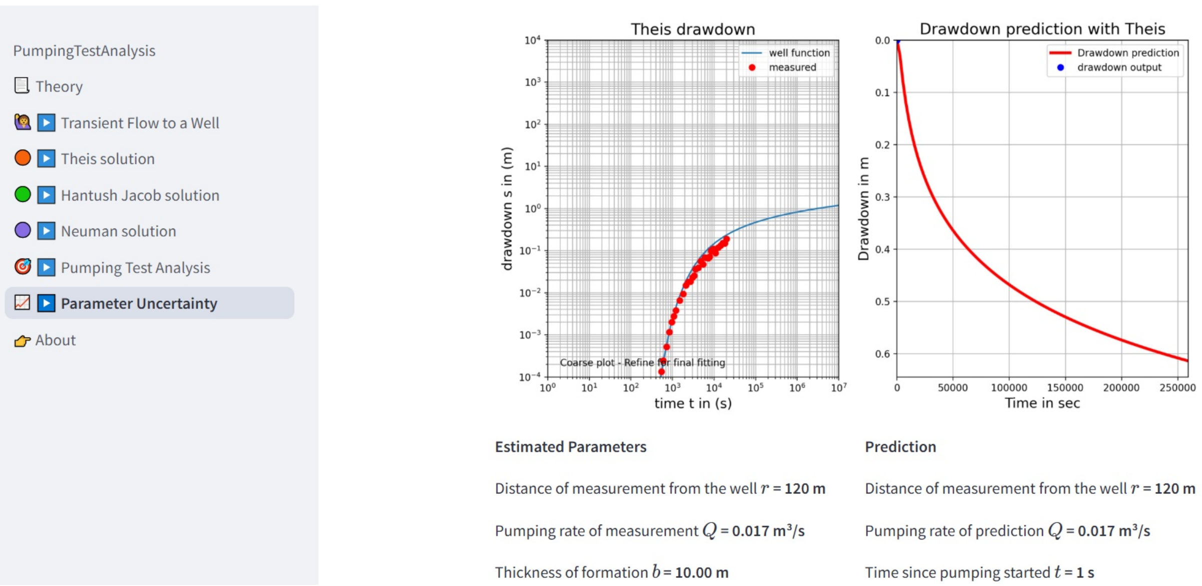

Figure 2. An applied exercise with the Pumping Test Analysis Module - Theis curve fitting with random data and prediction. (Screenshot)

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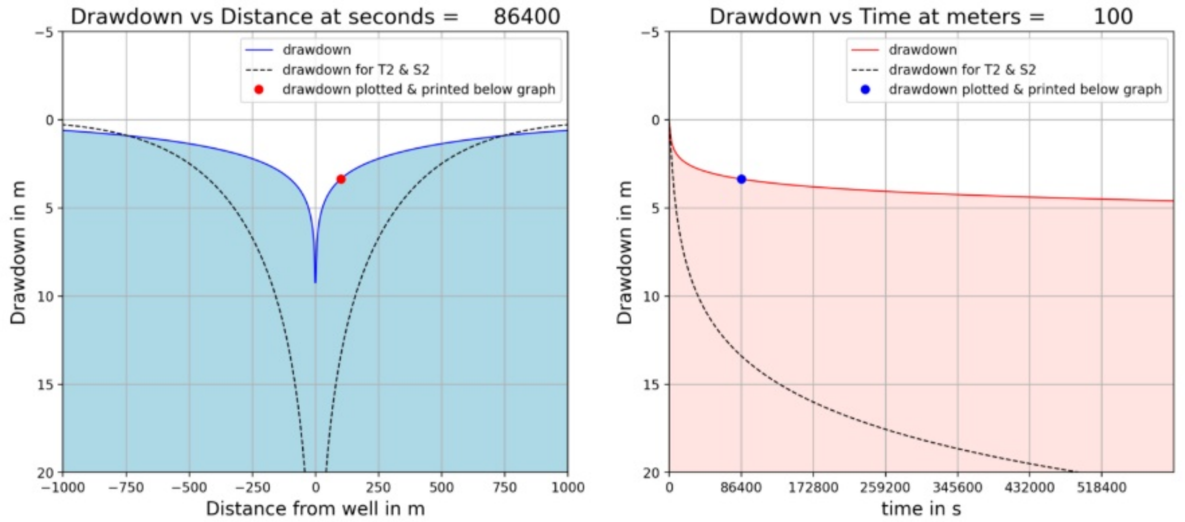

Drawdown = 3.36 m at distance = 100.00 m and time = 86400 sec

Figure 3. Prediction of drawdown with Theis. Evaluation of different datasets (Screenshot)

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Well Capture App

Topic: 07 Applied Hydrogeology → 07-03 Groundwater in Water Supply
Language: English

1. Basic information

Resource type	Streamlit app
URL	https://gwp-wellcapture.streamlit.app/
Time required	15–30 minutes

2. Pedagogical overview

Short description
This interactive app visualizes the well capture zone (capture width and dividing streamlines) for a single pumping well in a confined aquifer subject to regional uniform groundwater flow.

Users adjust the pumping rate, hydraulic conductivity, aquifer thickness, and regional hydraulic gradient (with log-scaled sliders) and immediately see how these parameters control the shape and extent of the capture zone in plan view.

In addition to plotting the separating streamlines, the app reports two key diagnostic quantities: the total capture-zone width 2y_max and the culmination point x_0, which together provide a compact characterization of the contributing area feeding the well under steady-state conditions.

This tool supports conceptual understanding of wellhead protection and capture-zone sensitivity in confined aquifers and complements the theory section of the multipage well-capture module.

Keywords: well capture, capture zone, water protection zone, well catchment
Best suited for: self learning, online teaching, classroom teaching

3. Technical details

Multipage app	approximately 4 page(s)
Interactive plots	1 interactive plot(s)

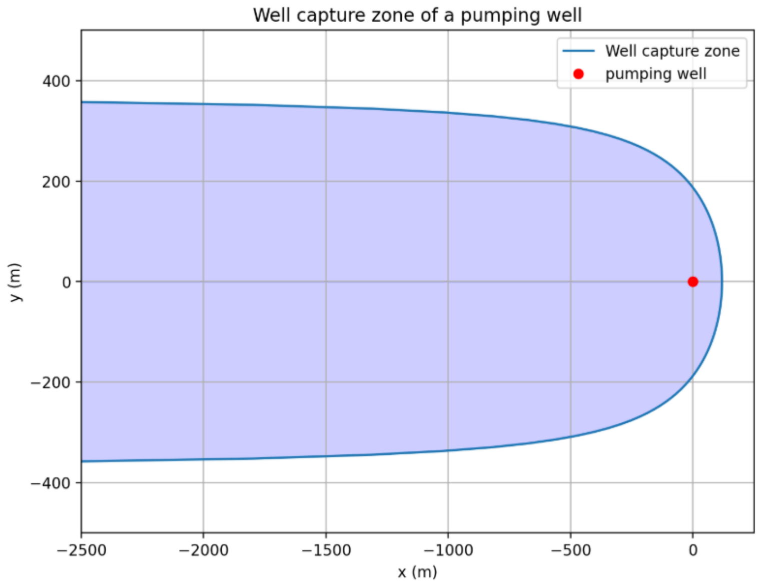
4. Educational fit

Time required	15–30 minutes
Prerequisites	Basic hydrogeology, Aquifer parameters
Best suited for	self learning, online teaching, classroom teaching

5. Authors & references

Authors
• Thomas Reimann (TU Dresden)

6. Figures and illustrations



Width of capture zone (m): 750.00

Culmination point x_0 (m): 119.37

Figure 1. The computed well capture zone (Screenshot)

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Analytical solution for 1D unconfined flow with two specified head boundaries

Topic: 03 Basic Hydrogeology → 03-03 Steady Groundwater Flow
Language: English

1. Basic information

Resource type	Streamlit app
URL	https://gwf-1d-unconf-analytic.streamlit.app/
Time required	5–15 min

2. Pedagogical overview

Short description
This app illustrates the analytical solution for one-dimensional groundwater flow in an unconfined aquifer subject to two specified head boundaries and uniform recharge. The conceptual model assumes a homogeneous and isotropic aquifer with a horizontal base, bounded by fixed hydraulic heads at the inflow and outflow boundaries.

Users can interactively explore the influence of recharge, hydraulic conductivity, aquifer length, and boundary heads on the resulting hydraulic head distribution. The visualization highlights characteristic features such as groundwater divides and recharge effects, making the app well suited for teaching fundamental concepts of steady unconfined groundwater flow and boundary-controlled systems.

Keywords: groundwater flow, 1D flow, unconfined flow
Best suited for: classroom teaching, online teaching

3. Technical details

Interactive plots	1 interactive plot(s)

4. Educational fit

Time required	5–15 min
Prerequisites	Darcy law, boundary conditions, groundwater flow equation
Best suited for	classroom teaching, online teaching

5. Authors & references

Authors
• Thomas Reimann (TU Dresden)

6. Figures and illustrations

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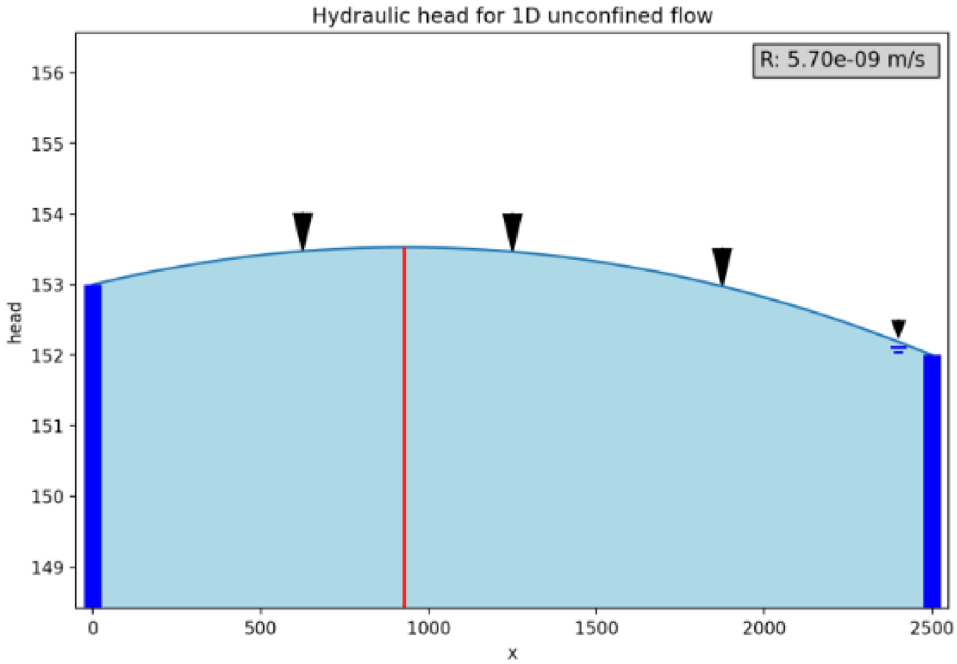

Figure 1. 1D groundwater flow with two specified heads. The red line indicate a groundwater divide. (Screenshot)

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Theis drawdown prediction - Fitting Formation parameter to measured data

Topic: 06 Experimental Techniques and Methods → 06-04 Aquifer Characterization Techniques
Language: English

1. Basic information

Resource type	Streamlit app
URL	https://theis-inverse-ddown.streamlit.app/
Time required	15–30 minutes

2. Pedagogical overview

Short description
This interactive app supports pumping-test evaluation in confined aquifers using the classical Theis solution. Measured drawdown data are compared to the analytical well function, allowing users to interactively fit transmissivity (T) and storativity (S) through type-curve matching and direct numerical evaluation of the Theis equation.

The app combines two complementary views:

* (1) a logarithmic Theis type-curve plot with measured data points, and
* (2) a time–drawdown plot showing both fitted results and forward predictions at user-defined distances, pumping rates, and time horizons.

By adjusting aquifer parameters in real time, users can explore parameter sensitivity, understand the inverse problem of pumping-test interpretation, and immediately assess how estimated parameters influence drawdown predictions. The tool is intended for teaching and self-learning in hydrogeology and complements theoretical material on transient radial flow to wells.

Keywords: Theis, prediction, curve fitting, prediction uncertainty
Best suited for: self learning, classroom teaching, online teaching

3. Technical details

Interactive plots	2 interactive plot(s)

4. Educational fit

Time required	15–30 minutes
Prerequisites	Basic hydrogeology, Aquifer parameters
Best suited for	self learning, classroom teaching, online teaching

5. Authors & references

Authors
• Thomas Reimann (TU Dresden)
• Rudolf Liedl (TU Dresden)

6. Figures and illustrations

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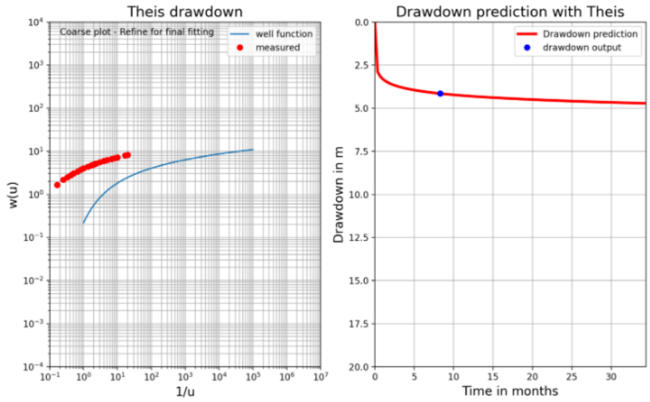

Parameter estimation

Distance of measurement from the well (in m): 120

Pumping rate of measurement (in m^3/s): 0.005

Thickness of formation b = 8.50 m

Transmissivity T = 1.00E-03 m^2/s

(Hydr. cond. K) = 1.18E-04 m^2/s

Storativity S = 1.00E-04 [-]

Prediction

Distance of prediction from the well (in m): 120

Pumping rate of prediction (in m^3/s): 0.005

Time since pumping start (in s): 21748446

Time since pumping start (in months): 8.27

Predicted drawdown at this distance and time (in m): 4.15

Figure 1. The Theis type curve fitting (left side) and the resulting prediction (right side). (Screenshot)

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Mass balance for a decay chain - Decay of Species A to B and species B to C

Topic: 05 Hydrogeochemistry and Contaminant Transport → 05-06 Reactive Solute Transport
Language: English

1. Basic information

Resource type	Streamlit app
URL	https://radioactive-decay.streamlit.app/
Time required	5–15 min

2. Pedagogical overview

Short description
This interactive app illustrates the mass balance of a simple decay chain (A → B → C) using a time-discrete numerical approach. It demonstrates how the decay of one species leads to the production of subsequent species while conserving total mass.

Users can modify initial masses and decay rates and explore the temporal evolution of all three species through interactive plots. The example is motivated by radioactive decay but is formulated generically, making it applicable to a wide range of first-order transformation processes relevant to hydrogeochemistry and reactive solute transport.

The app is primarily intended as a conceptual teaching tool to support the understanding of coupled decay and production processes, mass conservation, and dynamic system behavior in environmental and groundwater-related contexts.

Keywords: solute transport, decay, half-time, reactive transport, mass balance
Best suited for: self learning, classroom teaching, online teaching

3. Technical details

Interactive plots	1 interactive plot(s)

4. Educational fit

Time required	5–15 min
Prerequisites	basic chemistry
Best suited for	self learning, classroom teaching, online teaching

5. Authors & references

Authors
• Thomas Reimann (TU Dresden, Institute for Groundwater Management)
• Rudolf Liedl (TU Dresden, Institute for Groundwater Management)

6. Figures and illustrations

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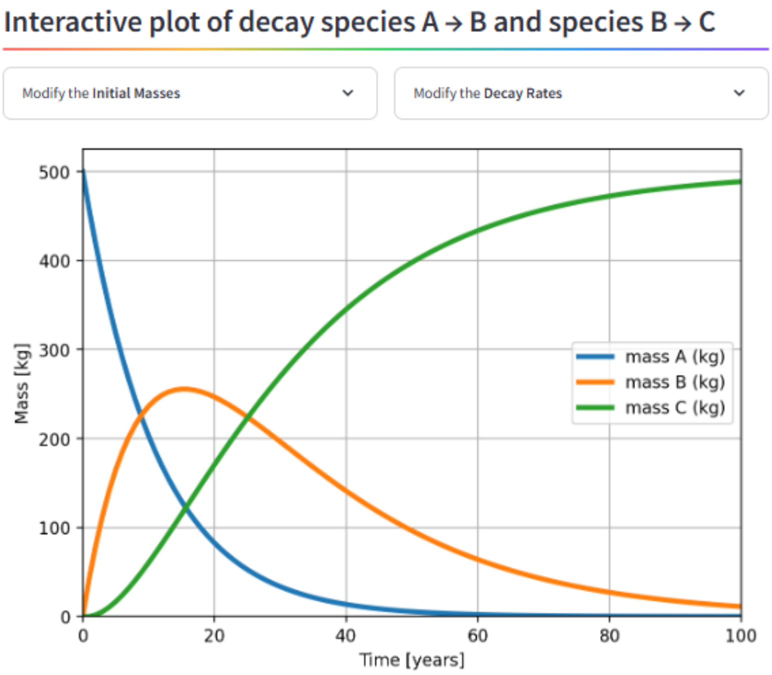

Figure 1. The interactive plot of the mass balance for radioactive decay. (Screenshot)

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1D Transport with advection and dispersion

Topic: 05 Hydrogeochemistry and Contaminant Transport → 05-05 Conservative Solute Transport Processes
Language: English

1. Basic information

Resource type	Streamlit app
URL	https://transport-1d-ad.streamlit.app/
Time required	15–30 minutes

2. Pedagogical overview

Short description
This interactive app illustrates one-dimensional solute transport under steady groundwater flow, focusing on the combined effects of advection and longitudinal dispersion. A finite-duration pulse input is applied at the source, and the app computes and plots the resulting breakthrough curve (concentration versus time) at a user-defined observation distance.

Users can vary key transport parameters such as porosity and longitudinal dispersivity, and compare alternative representations by toggling between advection-only transport and the advection–dispersion solution. An optional set of example measurements can be displayed for visual comparison with the simulated breakthrough curve. The app supports conceptual understanding of plume spreading, travel times, and parameter sensitivity in 1D transport problems and is suited for teaching and self-study in hydrogeology and contaminant transport.

Keywords: solute transport, advection, dispersion, analytical solution
Best suited for: self learning, online teaching, classroom teaching

3. Technical details

Interactive plots	1 interactive plot(s)

4. Educational fit

Time required	15–30 minutes
Prerequisites	Basic hydrogeology, Aquifer parameters
Best suited for	self learning, online teaching, classroom teaching

5. Authors & references

Authors
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• Rudolf Liedl (TU Dresden)

6. Figures and illustrations

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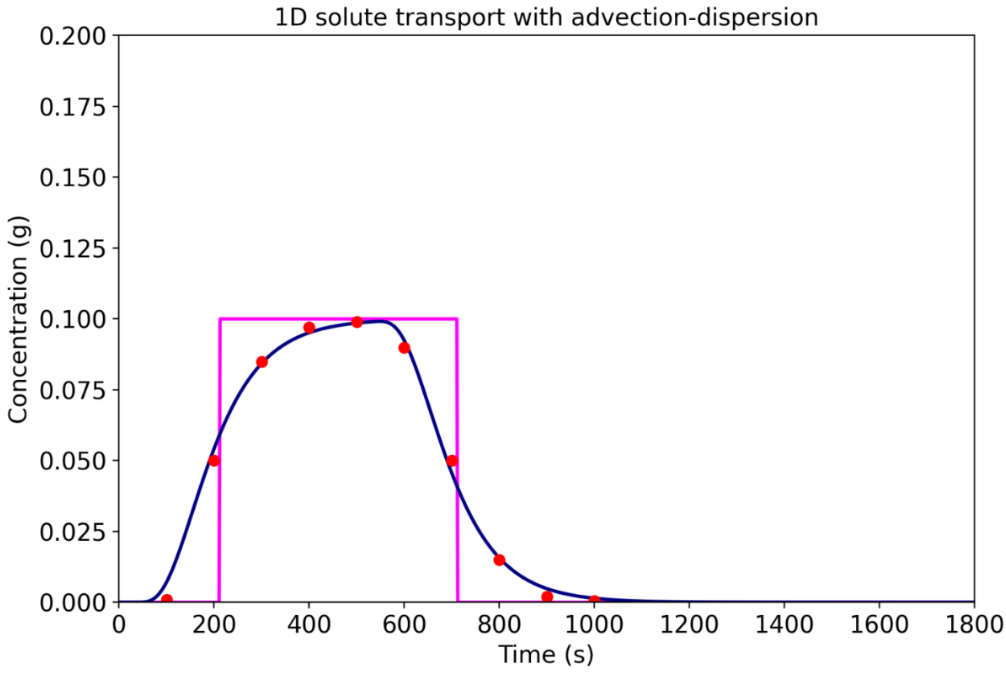

Figure 1. The computed breakthrough curve for 1D advective-dispersive transport, together with (Screenshot)

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Introduction in Boundary Conditions

Topic: 08 Groundwater Modeling → 01 Conceptual Model Development
Language: English

1. Basic information

Resource type	Streamlit app
URL	https://gwp-boundary-conditions-intro.streamlit.app/
Time required	30–45 minutes

2. Pedagogical overview

Short description
Boundary conditions define how the groundwater system interacts with its surroundings. They describe whether water enters or leaves the model domain, for example, through recharge, rivers, lakes, wells, or impermeable barriers. It is essential to understand the concept behind the different boundary conditions. This understanding is required to 'translate' physical and hydrological elements of the real world into model elements.

With this application you can build intuition for how Type I/II/III boundaries behave, and how this behavior can be described by discharge-head relations (Q–h-plots). You can learn how boundary conditions reflect system characteristics, and gain an understanding of the general characteristics of groundwater–surface water interaction.

This application is an excellent introduction for the Module: Boundary Conditions for Groundwater Modeling.

Keywords: Boundary conditions, groundwater modeling, conceptual model
Best suited for: self learning, classroom teaching, online teaching

3. Technical details

Interactive plots	4 interactive plot(s)
Assessments	8 question(s)

4. Educational fit

Time required	30–45 minutes
Prerequisites	Basic hydrogeology
Best suited for	self learning, classroom teaching, online teaching

5. Authors & references

Authors
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• Eileen Poeter (Colorado School of Mines)

6. Figures and illustrations

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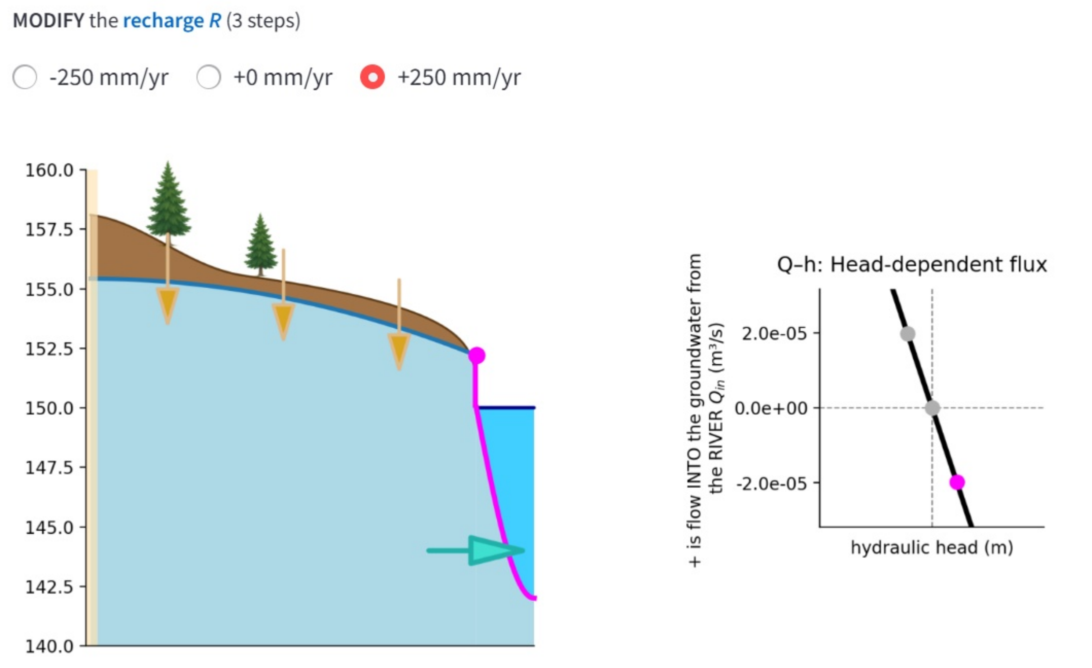
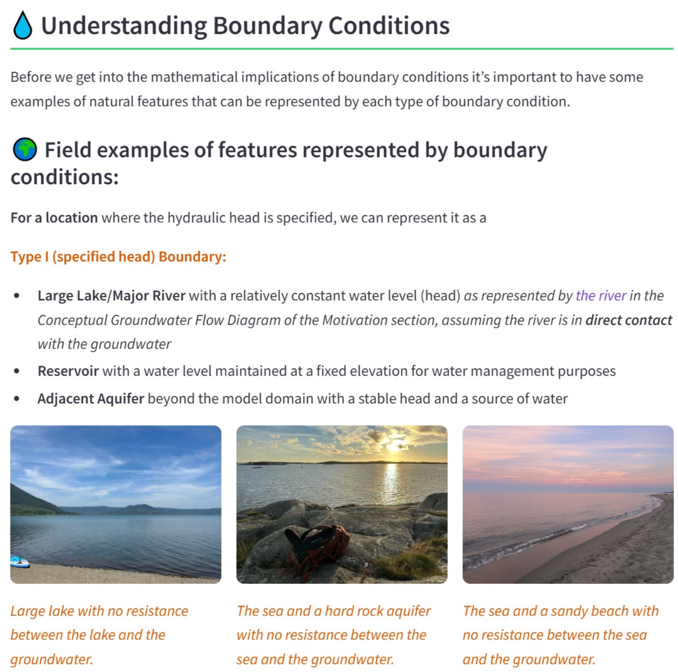


Figure 1. Interactive plot of for a boundary condition including the discharge-head relationship. (Screenshot)



Understanding Boundary Conditions

Before we get into the mathematical implications of boundary conditions it's important to have some examples of natural features that can be represented by each type of boundary condition.

Field examples of features represented by boundary conditions:

For a location where the hydraulic head is specified, we can represent it as a

Type I (specified head) Boundary:

- **Large Lake/Major River** with a relatively constant water level (head) *as represented by the river in the Conceptual Groundwater Flow Diagram of the Motivation section, assuming the river is in* ***direct contact*** *with the groundwater*
- **Reservoir** with a water level maintained at a fixed elevation for water management purposes
- **Adjacent Aquifer** beyond the model domain with a stable head and a source of water

Large lake with no resistance between the lake and the groundwater.

The sea and a hard rock aquifer with no resistance between the sea and the groundwater.

The sea and a sandy beach with no resistance between the sea and the groundwater.

Figure 2. Insight of the app that combines explanations, figures, interactive plots, and assessments. (Screenshot)

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Analytical solution for 1D unconfined flow with one no-flow boundary and one specified head/head-dependent boundary - Understanding model calibration

Topic: 08 Groundwater Modeling → 08-07 Parameter Estimation & Calibration
Language: English

1. Basic information

Resource type	Streamlit app
URL	https://gwf-1d-unconf-noflow-calib.streamlit.app/
Time required	15–30 minutes

2. Pedagogical overview

Short description
This app extends the 1D unconfined flow calibration exercise by introducing a no-flow boundary on one side and, on the other side, either a specified-head boundary or a head-dependent (river-type) boundary. The conceptual model assumes a homogeneous, isotropic aquifer with a horizontal impermeable base and uniform recharge over the entire model length.

Users can generate synthetic calibration datasets (regular or irregular sampling, optionally with noise) and then estimate model parameters by adjusting recharge and hydraulic conductivity. In the head-dependent scenario, an additional boundary parameter (river conductance) is included, allowing learners to experience how boundary formulation increases calibration complexity and parameter non-uniqueness. Model performance can be evaluated using an optional scatter plot and basic error metrics (ME, MAE, RMSE), and the app can reveal the “true” parameter values for self-assessment.

Keywords: groundwater flow, 1D flow, unconfined flow, gamification, calibration, uncertainty
Best suited for: self learning, classroom teaching, online teaching

3. Technical details

Interactive plots	2 interactive plot(s)

4. Educational fit

Time required	15–30 minutes
Prerequisites	Darcy law, boundary conditions, groundwater flow equation
Best suited for	self learning, classroom teaching, online teaching

5. Authors & references

Authors
- Thomas Reimann (TU Dresden)

6. Figures and illustrations

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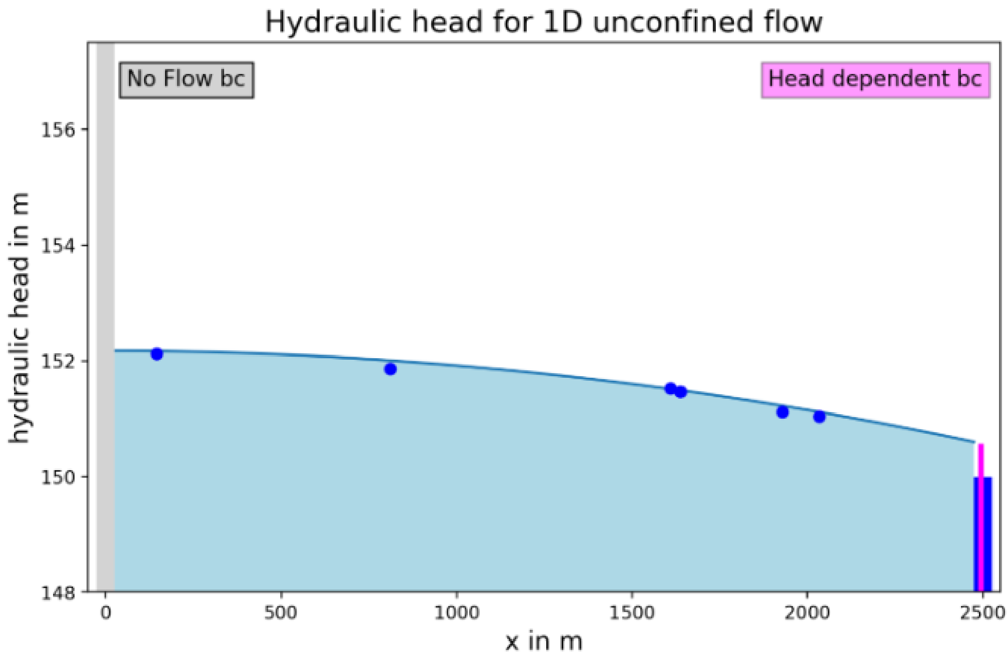

Figure 1. Computed heads with measurements for calibration. (Screenshot)

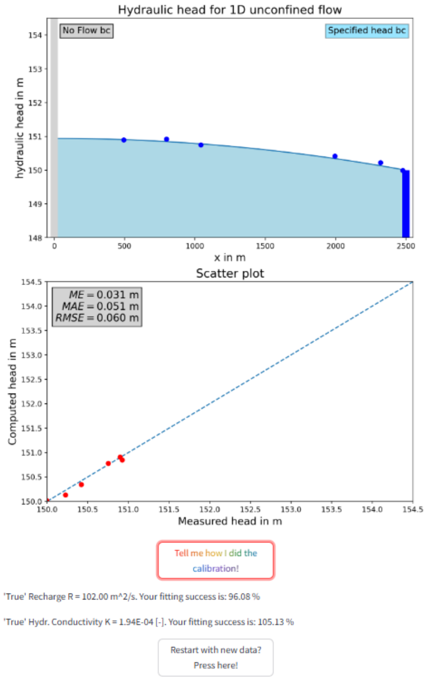

Figure 2. The user interface with the model, the scatter plot, and the results of the calibration. (Screenshot)

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Horton Infiltration Introduction

Topic: 04 Vadose Zone Physics → 04-05 Infiltration
Language: English

1. Basic information

Resource type	Streamlit app
URL	https://horton-infiltration-intro.streamlit.app/
Time required	15–30 minutes

2. Pedagogical overview

Short description
This interactive application illustrates the Horton infiltration model and its role in explaining infiltration-excess (Hortonian) overland flow during intense rainfall events. Users explore how infiltration capacity decreases over time from an initial value toward an equilibrium rate and how this behavior controls the partitioning of rainfall into infiltration and surface runoff.

The app allows interactive modification of the key Horton parameters—initial infiltration capacity f_0, equilibrium infiltration capacity fc, and decay constant k, as well as rainfall intensity. The resulting time evolution of infiltration capacity is visualized and compared with precipitation, enabling users to identify conditions under which overland flow occurs.

Integrated initial and final assessment questions support self-learning and conceptual understanding. The application is suitable for undergraduate and graduate teaching, self-study, and professional training, providing an intuitive introduction to infiltration processes in basic hydrology.

Keywords: Infiltration, unsaturated zone
Best suited for: self learning, classroom teaching, online teaching, exam preparation

3. Technical details

Interactive plots	1 interactive plot(s)
Assessments	8 question(s)

4. Educational fit

Time required	15–30 minutes
Prerequisites	Basic hydrology, basic hydrogeology
Best suited for	self learning, classroom teaching, online teaching, exam preparation

5. Authors & references

Authors
• Markus Giese (University of Gothenburg)
• Thomas Reimann (TU Dresden)

6. Figures and illustrations

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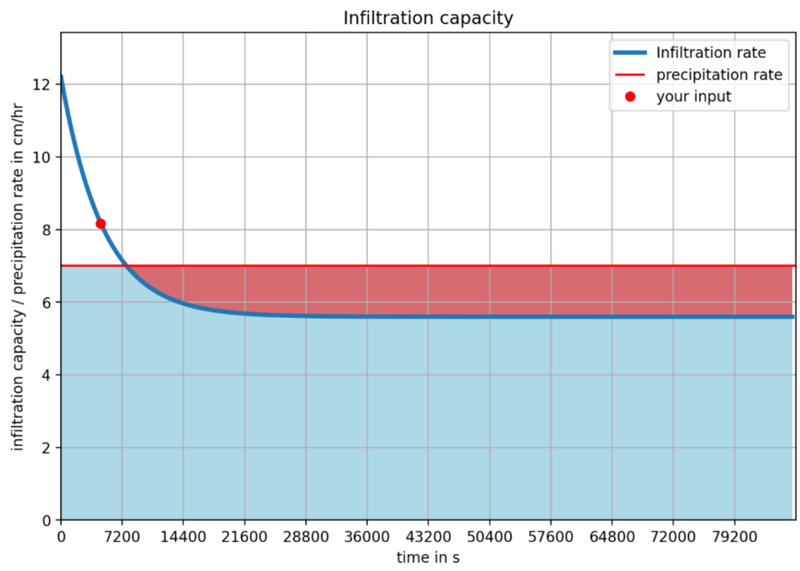

Time after beginning of precipitation: 4680

Infiltration rate in cm/hr: 8.18

Figure 1. The interactive plot with Horton infiltration. (Screenshot)

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Transient Flow towards wells and superposition

Topic: 03 Basic Hydrogeology → 03-05 Flow to Wells
Language: English

1. Basic information

Resource type	Streamlit app
URL	https://flow2well-transient-confined-superposition.streamlit.app/
Time required	15–30 minutes

2. Pedagogical overview

Keywords: Superposition, Theis, pumping test, infiltration well, imaginary well
Best suited for: self learning, classroom teaching, online teaching

3. Technical details

Interactive plots	1 interactive plot(s)

4. Educational fit

Time required	15–30 minutes
Prerequisites	Basic Hydrogeology, Flow to well, Theis
Best suited for	self learning, classroom teaching, online teaching

5. Authors & references

Authors
• Thomas Reimann (TU Dresden)

6. Figures and illustrations

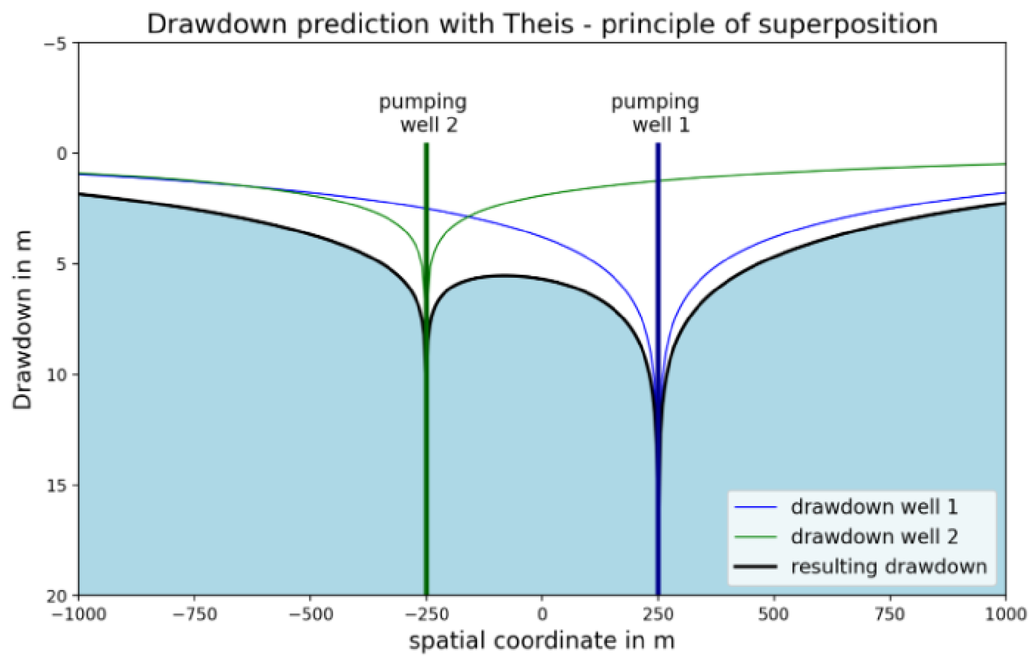

Figure 1. Computed drawdown for two pumping wells with different abstraction rates. (Screenshot)

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