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# Definition of the data for comprehensiveness in scenario analysis of near-surface nuclear waste repositories

E. Tosoni [a,b,*], A. Salo [a], J. Govaerts [c], E. Zio [b,d,e]

[a] Department of Mathematics and Systems Analysis, Aalto University, Finland
[b] Energy Department, Politecnico di Milano, Italy
[c] SCK•CEN, Studiecentrum voor Kernenergie - Centre d'Étude de l'Énergie Nucléaire, Belgium
[d] MINES ParisTech/PSL Université Paris, Centre de Recherche sur les Risques et les Crises (CRC), Sophia Antipolis, France
[e] Eminent Scholar, Department of Nuclear Engineering, Kyung Hee University, South Korea

A R T I C L E I N F O

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A B S T R A C T

This article provides data on the near-surface repository for nuclear waste in the associated Research article "Comprehensiveness of scenarios in the safety assessment of nuclear waste repositories" [1].We illustrate i) the parameters of the COMSOL Multiphysics model for calculating the radiological impact of the repository, ii) the set of scenarios analyzed following a pluralistic approach, and iii) nodes, experts' beliefs and prior probabilities for the scenario analysis based on Bayesian networks.



## Specifications Table

| | |
|---|---|
| Subject | Engineering |
| Specific subject area | Risk and reliability analysis |

(*continued on next page*)

* Corresponding author.
*E-mail address:* edoardo.tosoni@aalto.fi (E. Tosoni).

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| | |
|---|---|
| Type of data | Tables<br>Figure |
| How data were acquired | Authors' assumptions and computational simulations |
| Data format | Raw |
| Parameters for data collection | Data are part of the modelling of a near-surface nuclear waste repository |
| Description of data collection | The figure with the schematization of the repository, the simulation-model parameters and most probabilities for the Bayesian network were supplied by the authors based on their assumptions.<br>The prior values of the conditional probabilities for the dose rate were derived from the results of computer simulations. |
| Data source location | Aalto University, Espoo, Finland - 60°11′11.9"N 24°49′41.9"E<br>Politecnico di Milano, Milan, Italy - 45°30′10.6"N 9°09′21.8"E<br>SCK•CEN, Studiecentrum voor Kernenergie - Centre d'Étude de l'Énergie Nucléaire, Mol, Belgium - 51°13′07.7"N 5°05′40.9"E |
| Data accessibility | With the article |
| Related research article | E Tosoni, A Salo, J Govaerts, E Zio, Comprehensiveness of scenarios in the safety assessment of nuclear waste repositories. Reliability Engineering & System Safety, 188 (2019) 561-573. |

## Value of the Data

- This data makes it possible to reproduce the results in the associated Research article.
- Data provides a benchmark for researchers who plan to investigate alternative assumptions concerning, for instance, the probabilities in the Bayesian network or prior probabilities in computational simulations.
- Data supports further developments outlined in the associated Research article, including the calculation of risk importance measures

## 1. Data Description

Table 1 lists the model parameters of COMSOL Multiphysics [2]. This software was used for calculating the radiation dose to the public due to exposure to radionuclides leaked from the repository studied in Tosoni et al. (2019) [1], as represented in Fig. 1. Table 2 reports the COMSOL parameter values for the characterization of scenarios which were formulated following a pluralistic approach.

Table 3 illustrates the Features, Events and Processes (FEPs) and the safety target of the Bayesian network for the probabilistic scenario analysis (second column), the corresponding consistent model parameters (third column), and their discrete states (fourth to sixth columns). Specifically, the earthquake can be either a beyond-design-basis (*BDBE*, return period of 20,000 y) or a *major* one. The other FEPs are associated with continuous ranges whose bounds characterize opposite pluralistic scenarios (e.g., "low" versus "high").

Table 4–12 present illustrative assignments to the probabilities for the FEPs of the BN. Lastly, Table 13 reports the prior probabilities of the violation state at the safety target (columns 9 and 18), conditioned on subscenarios (columns 1 through 8, and 10 through 17) associated with the states of the FEPs *Water flux, Crack aperture, Diffusion coefficient, Distribution coefficient, Chemical degradation, Barrier degradation, Monolith degradation* and *Hydraulic conductivity*.

## 2. Experimental Design, Materials, and Methods

The associated research paper [1] presents a novel methodology for scenario analysis, which uses imprecise probability values obtained from expert judgments and computer simulations. Simulations have been utilized to derive the prior probabilities in Table 13 (following the procedure described at the end of the section). The probability assignments of Tables 4 –12 are

**Table 1**
Parameters of COMSOL Multiphysics and their units of measurements.

| Parameter | u.m. | Parameter | u.m. |
|---|---|---|---|
| Initial water flux | m $s^{-1}$ | Diffusion coefficient of embankment | $m^2$ $s^{-1}$ |
| Degraded water flux | m $s^{-1}$ | Diffusion coefficient of cracks | $m^2$ $s^{-1}$ |
| Initial hydraulic conductivity of module | m $s^{-1}$ | Initial longitudinal dispersivity of concrete | m |
| Degraded hydraulic conductivity of module | m $s^{-1}$ | Degraded longitudinal dispersivity of concrete | m |
| Initial hydraulic conductivity of monolith | m $s^{-1}$ | Initial transverse dispersivity of concrete | m |
| Degraded hydraulic conductivity of monolith | m $s^{-1}$ | Degraded transverse dispersivity of concrete | m |
| Hydraulic conductivity of embankment | m $s^{-1}$ | Longitudinal dispersivity of concrete | m |
| Hydraulic conductivity of cracks | m $s^{-1}$ | Transverse dispersivity of concrete | m |
| Initial crack aperture | $\mu$m | Barrier degradation | y |
| Degraded crack aperture | $\mu$m | Monolith degradation | y |
| Initial porosity of concrete | - | Distribution coeff. in concrete, State I (*) | l $kg^{-1}$ |
| Degraded porosity of concrete | - | Distribution coeff. in concrete, State II (*) | l $kg^{-1}$ |
| Initial porosity of mortar (grout in monolith) | - | Distribution coeff. in concrete, State IV (*) | l $kg^{-1}$ |
| Degraded porosity of mortar | - | Distribution coeff. in embankment, State I (*) | l $kg^{-1}$ |
| Porosity of embankment | - | Distribution coeff. in embankment, State II (*) | l $kg^{-1}$ |
| Initial bulk density of concrete | kg $m^{-3}$ | Distribution coeff. in embankment, State IV (*) | l $kg^{-1}$ |
| Degraded bulk density of concrete | kg $m^{-3}$ | $t_i$ | y |
| Initial bulk density of mortar | kg $m^{-3}$ | $t_{ii}$ | y |
| Degraded bulk density of mortar | kg $m^{-3}$ | $t_{ii1}$ | y |
| Bulk density of embankment | kg $m^{-3}$ | $t_{ii2}$ | y |
| Initial diffusion coefficient of concrete | $m^2$ $s^{-1}$ | $t_{iii}$ | y |
| Degraded diffusion coefficient of concrete | $m^2$ $s^{-1}$ | Geotransfer factor | - |
| Initial diffusion coefficient of mortar | $m^2$ $s^{-1}$ | Bioconversion factor (*) | Sv $Bq^{-1}$ |
| Degraded diffusion coefficient of mortar | $m^2$ $s^{-1}$ | (*) Radionuclide-specific | |

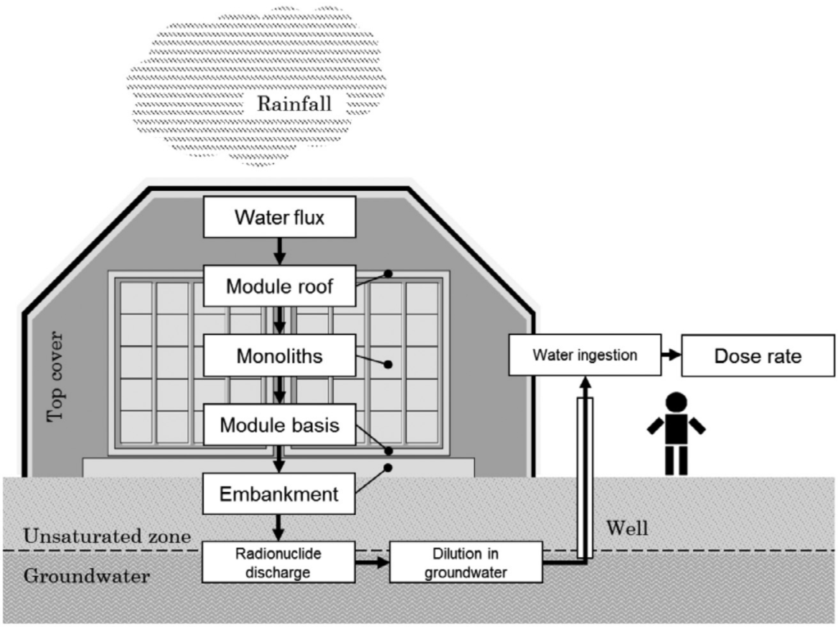


**Fig. 1.** Conceptual representation of near-surface disposal, and flowchart of the human dose-exposure model in COMSOL (white boxes).

**Table 2**
Values of COMSOL parameters (rows, units of measurement from Table 1) in the pluralistic scenarios (columns).

| Parameter | Base | Low sorption | High sorption | Fast chemical degradation | Slow chemical degradation | High conductivity | Low infiltration | High diffusion | Uncracked basis | Bathtubbing | Fast monolith degradation | Major earthquake | Major earthquake also affecting monolith | Cover disappearance |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Initial water flux | 3.4E-12 | | | | | 4.58E-11 | 3.4E-12 | | | 4.73E-12 | 3.4E-12 | | | |
| Degraded water flux | 1.31E-08 | | | | | | 3.17E-09 | 1.31E-08 | | | | | | 3.00E-08 |
| Init. hyd. cond. mod. | 1.75E-12 | | | | | 4.58E-11 | 1.75E-12 | | | | | | | |
| Init. hyd. cond. mon. | 1.42E-13 | | | | | 2.91E-11 | 1.42E-13 | | | | | | | |
| Degr. crack aperture | 300 | | | | | | | | 1 | 300 | | | | |
| Init. diff. coeff. con. | 3.83E-11 | | | | | | | 2.03E-10 | 3.83E-11 | 7.01E-11 | 3.83E-11 | | | |
| Init. diff. coeff. mor. | 8.46E-12 | | | | | | | 1.75E-10 | 8.46E-12 | 1.56E-11 | 8.46E-12 | | | |
| Barrier degradation | 466 | | | | | | | | | | | 50 | | 466 |
| Monolith degradation | 1,350 | | | | | | | | | | 1 | 1,350 | 50 | 1,350 |
| Distr. coeff. con. St. I 129I | 1.50E-01 | 0 | 4.50E01 | 1.50E-01 | | | | | | | | | | |
| Distr. coeff. con. St. II 129I | 1.50E00 | 0 | 1.50E02 | 1.50E00 | | | | | | | | | | |
| Distr. coeff. con. St. IV 129I | 1.50E-01 | 0 | 4.00E00 | 1.50E-01 | | | | | | | | | | |
| Distr. coeff. emb. St. I 129I | 5.00E-02 | 0 | 1.50E01 | 5.00E-02 | | | | | | | | | | |
| Distr. coeff. emb. St. II 129I | 5.00E-01 | 0 | 5.00E01 | 5.00E-01 | | | | | | | | | | |
| Distr. coeff. con. St. I 239Pu | 3.00E02 | 1.50E02 | 1.50E05 | 3.00E02 | | | | | | | | | | |
| Distr. coeff. con. St. II 239Pu | 4.50E03 | 1.50E02 | 1.50E05 | 4.50E03 | | | | | | | | | | |
| Distr. coeff. con. St. IV 239Pu | 5.00E01 | 3.00E01 | 1.50E05 | 5.00E01 | | | | | | | | | | |
| Distr. coeff. emb. St. I 239Pu | 1.00E02 | 5.00E01 | 5.00E04 | 1.00E02 | | | | | | | | | | |
| Distr. coeff. emb. St. II 239Pu | 1.50E03 | 5.00E01 | 5.00E04 | 1.50E03 | | | | | | | | | | |
| $t_i$ | 10 | | | 5 | 20 | 10 | | | | | | | | |
| $t_{ii}$ | 2,061 | | | 1,030 | 4,122 | 2,061 | | | | | | | | |
| $t_{ii1}$ | 6,100 | | | 3,050 | 12,200 | 6,100 | | | | | | | | |
| $t_{ii2}$ | 19,400 | | | 9,700 | 38,800 | 19,400 | | | | | | | | |
| $t_{iii}$ | 34,339 | | | 17,170 | 68,678 | 34,339 | | | | | | | | |

**Table 3**
FEPs and safety target of the Bayesian network with their consistent COMSOL parameters (if any) and states, possibly derived from discretization of continuous ranges (units of measurement from Table 1; *Dose rate* is normalized, hence dimensionless).

| | Node | Parameter | States | | | Discretization | | |
|---|---|---|---|---|---|---|---|---|
| FEPs | Earthquake | - | BDBE | Major | | - | | |
| | Water | Initial water flux | Low | High | | $[a^{IWF}, m^{IWF})$ | $[m^{IWF}, K_{eff}^{stack}]$ | |
| | flux | Degraded water flux | | | | [3.17E-09, 1.31E-08) | [1.31E-08, 3.00E-08] | |
| | Crack aperture | Degr. crack aperture | Micro | Macro | | [1,100) | [100,300] | |
| | Diffusion | Init. diff. coeff. con. | Low | High | | [3.83E-11, 8.82E-11) | [8.82E-11, 2.03E-10] | |
| | coefficient | Init. diff. coeff. mor. | | | | [8.46E-12, 3.85E-11) | [3.85E-11, 1.75E-10] | |
| | Distribution | Distr. coeff. con. St. I 129I | Low | High | | [0, 2.12E-01) | [2.12E-01, 4.50E01] | |
| | coefficient | Distr. coeff. con. St. II 129I | | | | [0, 3.87E-01) | [3.87E-01, 1.50E02] | |
| | | Distr. coeff. con. St. IV 129I | | | | [0, 6.32E-02) | [6.32E-02, 4.00E00] | |
| | | Distr. coeff. emb. St. I 129I | | | | [0, 1.22E-01) | [1.22E-01, 1.50E01] | |
| | | Distr. coeff. emb. St. II 129I | | | | [0, 2.24E-01) | [2.24E-01, 5.00E01] | |
| | | Distr. coeff. con. St. I 239Pu | | | | [1.50E02, 4.74E03) | [4.74E03, 1.50E05] | |
| | | Distr. coeff. con. St. II 239Pu | | | | [1.50E02, 4.74E03) | [4.74E03, 1.50E05] | |
| | | Distr. coeff. con. St. IV 239Pu | | | | [3.00E01, 2.12E03) | [2.12E03, 1.50E05] | |
| | | Distr. coeff. emb. St. I 239Pu | | | | [5.00E01, 1.58E03) | [1.58E03, 5.00E04] | |
| | | Distr. coeff. emb. St. II 239Pu | | | | [5.00E01, 1.58E03) | [1.58E03, 5.00E04] | |
| | Chemical | $t_i$ | Fast | Slow | | [5, 10) | [10, 20] | |
| | degradation | $t_{ii}$ | | | | [1,030, 2,061) | [2,061, 4,122] | |
| | | $t_{ii1}$ | | | | [3,050, 6,100) | [6,100, 12,200] | |
| | | $t_{ii2}$ | | | | [9,700, 19,400) | [19,400, 38,800] | |
| | | $t_{iii}$ | | | | [17,170, 34,339) | [34,339, 68,678] | |
| | Barrierdegradation | itself | Fast | Slow | | [50, 150) | [150, 466] | |
| | Monolithdegradation | itself | Very fast | Fast | Slow | [0, 50) | [50, 250) | [250, 1,350] |
| | Hydraulic | Init. hyd. cond. mod. | Low | Medium | High | [1.75E-12, 2.12E-12) | [2.12E-12, 1.00E-11) | [1.00E-11, 4.58E-11] |
| | conductivity | Init. hyd. cond. mon. | | | | [1.42E-13, 1.94E-13) | [1.94E-13, 2.43E-12) | [2.43E-12, 2.91E-11] |
| Safety target | Dose rate | - | Respect | Violation | | [0, 1) | $[1, +\infty)$ | |

**Table 4**
Assumptions on the probabilities for the FEP *Earthquake*

| Earthquake<br>State | Assumption 1 | Assumption 2 |
|---|---|---|
| BDBE | 9.954E-01 | 9.908E-01 |
| Major | 4.600E-03 | 9.200E-03 |

**Table 5**
Assumptions on the probabilities for the FEP *Water flux*

| Water flux<br>State | Assumption 1 | Assumption 2 |
|---|---|---|
| Low | 0.631 | 0.864 |
| High | 0.369 | 0.136 |

**Table 6**
Assumptions on the probabilities for the FEP *Crack aperture*

| Crack aperture<br>State | Assumption 1 | Assumption 2 |
|---|---|---|
| Micro | 0.807 | 0.869 |
| Macro | 0.193 | 0.104 |

**Table 7**
Assumptions on the probabilities for the FEP *Diffusion coefficient*

| Diffusion coefficient<br>State | Assumption 1 | Assumption 2 |
|---|---|---|
| Low | 0.500 | 0.750 |
| High | 0.500 | 0.250 |

**Table 8**
Assumptions on the probabilities for the FEP *Distribution coefficient*

| Distribution coefficient<br>State | Assumption 1 | Assumption 2 |
|---|---|---|
| Low | 0.500 | 0.750 |
| High | 0.500 | 0.250 |

**Table 9**
Assumptions on the probabilities for the FEP Chemical degradation

| Chemical degradation<br>State | Expert 1 | Assumption 2 | Assumption 3 |
|---|---|---|---|
| Fast | 0.500 | 0.750 | 0.550 |
| Slow | 0.500 | 0.250 | 0.450 |

**Table 10**
Assumptions on the probabilities for the FEP *Barrier degradation*

| Barrier degradation | | | |
|---|---|---|---|
| Subscenario<br>Earthquake | State | Assumption 1 | Assumption 2 |
| BDBE | Fast | 0.250 | 0.058 |
| | Slow | 0.750 | 0.942 |
| Major | Fast | 0.490 | 0.360 |
| | Slow | 0.510 | 0.640 |

**Table 11**
Assumptions on the probabilities for the FEP *Monolith degradation*

| Monolith degradation | | | |
|---|---|---|---|
| Subscenario Earthquake | State | Assumption 1 | Assumption 2 |
| BDBE | Very fast | 0.295 | 0.001 |
| | Fast | 0.292 | 0.033 |
| | Slow | 0.413 | 0.966 |
| Major | Very fast | 0.295 | 0.001 |
| | Fast | 0.425 | 0.345 |
| | Slow | 0.280 | 0.654 |

**Table 12**
Assumptions on the probabilities for the FEP *Hydraulic conductivity*

| Hydraulic conductivity | | | |
|---|---|---|---|
| Subscenario Crack aperture | State | Assumption 1 | Assumption 2 |
| Micro | Low | 0.814 | 0.667 |
| | Medium | 0.109 | 0.189 |
| | High | 0.077 | 0.144 |
| Macro | Low | 0.109 | 0.189 |
| | Medium | 0.814 | 0.667 |
| | High | 0.077 | 0.144 |

based on authors' assumptions rather than on a formal process of expert-judgment elicitation, which is outside the scope of the methodological work. The same is true for the rest of the data (Fig. 1 and Tables 1–3). The data, then, serve the purpose of illustrating the application of the scenario-analysis methodology through a case study which does not represent an actual safety assessment.

Fig. 1 represents the conceptual flowchart of the human exposure to the radiation dose [3] as modeled in COMSOL Multiphysics. In particular, a two-dimensional column of monoliths is assumed to contain the entire radionuclide inventory. The migration of radionuclides across this physical domain is simulated to calculate the time-dependent radionuclide discharge beneath the embankment in [Bq $y^{-1}$]. The discharge is multiplied by a dimensionless geotransfer factor and a bioconversion factor in [Sv $Bq^{-1}$], to account for the dilution in groundwater and the radiation dose per unit activity ingested, respectively. The final output is the time-dependent dose rate to the public in [Sv $y^{-1}$]. Table 1 was built by listing the model parameters through which this conceptual flowchart is implemented quantitatively.

The scenarios in Table 2 were formulated according to the pluralistic approach described in Tosoni et al. [1]. The goal was to replicate the scenarios analyzed in a previous study on the same nuclear waste repository [4].

The nodes in Table 3 include the same parameters that characterize the scenarios of Table 2; they are, then, utilized in the probabilistic approach. The continuous ranges of corresponding parameter values were discretized into intervals (seventh to ninth columns) to capture *low, high, fast, slow*, etc., states of the consistent FEPs. Intervals were split at values for the *Base* scenario of Table 2, or at "milestone" percentages (e.g., 50%) using logarithmic scales for a balanced discretization of wide ranges. A flexible discretization (Table 3, third row) ensures that the *Initial water flux* does not exceed the initial effective hydraulic conductivity of the barriers, because this would cause numerical instability when very high water fluxes encounter very low hydraulic conductivities (details in the appendix). The normalized *Dose rate* was discretized at 1.

The probability assignments for the FEP states in Tables 4–12 were specified by the authors to produce illustrative values based on given assumptions. In a realistic application, these prob-

**Table 13**
Prior probabilities of the violation state conditioned on the subscenarios of the safety target.

| Water flux | Crack aperture | Diffusion coefficient | Distribution coefficient | Chemical degradation | Barrier degradation | Monolith degradation | Hydraulic conductivity | Prior conditionalviolation probability | Water flux | Crack aperture | Diffusion coefficient | Distribution coefficient | Chemical degradation | Barrier degradation | Monolith degradation | Hydraulic conductivity | Prior conditionalviolation probability |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Low | Micro | Low | Low | Fast | Fast | Very fast | Low | 0.000 | Low | Micro | Low | Low | Fast | Slow | Fast | Medium | 0.333 |
| High | Micro | Low | Low | Fast | Fast | Very fast | Low | 0.500 | High | Micro | Low | Low | Fast | Slow | Fast | Medium | 0.333 |
| Low | Macro | Low | Low | Fast | Fast | Very fast | Low | 0.250 | Low | Macro | Low | Low | Fast | Slow | Fast | Medium | 0.000 |
| High | Macro | Low | Low | Fast | Fast | Very fast | Low | 0.500 | High | Macro | Low | Low | Fast | Slow | Fast | Medium | 0.667 |
| Low | Micro | High | Low | Fast | Fast | Very fast | Low | 0.333 | Low | Micro | High | Low | Fast | Slow | Fast | Medium | 0.333 |
| High | Micro | High | Low | Fast | Fast | Very fast | Low | 0.667 | High | Micro | High | Low | Fast | Slow | Fast | Medium | 0.500 |
| Low | Macro | High | Low | Fast | Fast | Very fast | Low | 0.333 | Low | Macro | High | Low | Fast | Slow | Fast | Medium | 0.000 |
| High | Macro | High | Low | Fast | Fast | Very fast | Low | 0.500 | High | Macro | High | Low | Fast | Slow | Fast | Medium | 0.333 |
| Low | Micro | Low | High | Fast | Fast | Very fast | Low | 0.000 | Low | Micro | Low | High | Fast | Slow | Fast | Medium | 0.000 |
| High | Micro | Low | High | Fast | Fast | Very fast | Low | 0.000 | High | Micro | Low | High | Fast | Slow | Fast | Medium | 0.000 |
| Low | Macro | Low | High | Fast | Fast | Very fast | Low | 0.000 | Low | Macro | Low | High | Fast | Slow | Fast | Medium | 0.000 |
| High | Macro | Low | High | Fast | Fast | Very fast | Low | 0.000 | High | Macro | Low | High | Fast | Slow | Fast | Medium | 0.000 |
| Low | Micro | High | High | Fast | Fast | Very fast | Low | 0.000 | Low | Micro | High | High | Fast | Slow | Fast | Medium | 0.000 |
| High | Micro | High | High | Fast | Fast | Very fast | Low | 0.333 | High | Micro | High | High | Fast | Slow | Fast | Medium | 0.000 |
| Low | Macro | High | High | Fast | Fast | Very fast | Low | 0.000 | Low | Macro | High | High | Fast | Slow | Fast | Medium | 0.000 |

(*continued on next page*)

**Table 13** (*continued*)

| Water flux | Crack aperture | Diffusion coefficient | Distribution coefficient | Chemical degradation | Barrier degradation | Monolith degradation | Hydraulic conductivity | Prior conditionalviolation probability | Water flux | Crack aperture | Diffusion coefficient | Distribution coefficient | Chemical degradation | Barrier degradation | Monolith degradation | Hydraulic conductivity | Prior conditionalviolation probability |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| High | Macro | High | High | Fast | Fast | Very fast | Low | 0.000 | High | Macro | High | High | Fast | Slow | Fast | Medium | 0.000 |
| Low | Micro | Low | Low | Slow | Fast | Very fast | Low | 0.000 | Low | Micro | Low | Low | Slow | Slow | Fast | Medium | 0.333 |
| High | Micro | Low | Low | Slow | Fast | Very fast | Low | 0.750 | High | Micro | Low | Low | Slow | Slow | Fast | Medium | 0.500 |
| Low | Macro | Low | Low | Slow | Fast | Very fast | Low | 0.000 | Low | Macro | Low | Low | Slow | Slow | Fast | Medium | 0.000 |
| High | Macro | Low | Low | Slow | Fast | Very fast | Low | 0.667 | High | Macro | Low | Low | Slow | Slow | Fast | Medium | 0.333 |
| Low | Micro | High | Low | Slow | Fast | Very fast | Low | 0.333 | Low | Micro | High | Low | Slow | Slow | Fast | Medium | 0.000 |
| High | Micro | High | Low | Slow | Fast | Very fast | Low | 0.500 | High | Micro | High | Low | Slow | Slow | Fast | Medium | 0.500 |
| Low | Macro | High | Low | Slow | Fast | Very fast | Low | 0.000 | Low | Macro | High | Low | Slow | Slow | Fast | Medium | 0.000 |
| High | Macro | High | Low | Slow | Fast | Very fast | Low | 0.667 | High | Macro | High | Low | Slow | Slow | Fast | Medium | 0.000 |
| Low | Micro | Low | High | Slow | Fast | Very fast | Low | 0.000 | Low | Micro | Low | High | Slow | Slow | Fast | Medium | 0.000 |
| High | Micro | Low | High | Slow | Fast | Very fast | Low | 0.500 | High | Micro | Low | High | Slow | Slow | Fast | Medium | 0.000 |
| Low | Macro | Low | High | Slow | Fast | Very fast | Low | 0.000 | Low | Macro | Low | High | Slow | Slow | Fast | Medium | 0.000 |
| High | Macro | Low | High | Slow | Fast | Very fast | Low | 0.000 | High | Macro | Low | High | Slow | Slow | Fast | Medium | 0.000 |
| Low | Micro | High | High | Slow | Fast | Very fast | Low | 0.000 | Low | Micro | High | High | Slow | Slow | Fast | Medium | 0.000 |

(*continued on next page*)

**Table 13** (*continued*)

| Water flux | Crack aperture | Diffusion coefficient | Distribution coefficient | Chemical degradation | Barrier degradation | Monolith degradation | Hydraulic conductivity | Prior conditionalviolation probability | Water flux | Crack aperture | Diffusion coefficient | Distribution coefficient | Chemical degradation | Barrier degradation | Monolith degradation | Hydraulic conductivity | Prior conditionalviolation probability |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| High | Micro | High | High | Slow | Fast | Very fast | Low | 0.333 | High | Micro | High | High | Slow | Slow | Fast | Medium | 0.000 |
| Low | Macro | High | High | Slow | Fast | Very fast | Low | 0.000 | Low | Macro | High | High | Slow | Slow | Fast | Medium | 0.000 |
| High | Macro | High | High | Slow | Fast | Very fast | Low | 0.000 | High | Macro | High | High | Slow | Slow | Fast | Medium | 0.000 |
| Low | Micro | Low | Low | Fast | Slow | Very fast | Low | 0.500 | Low | Micro | Low | Low | Fast | Fast | Slow | Medium | 0.333 |
| High | Micro | Low | Low | Fast | Slow | Very fast | Low | 0.333 | High | Micro | Low | Low | Fast | Fast | Slow | Medium | 0.750 |
| Low | Macro | Low | Low | Fast | Slow | Very fast | Low | 0.000 | Low | Macro | Low | Low | Fast | Fast | Slow | Medium | 0.000 |
| High | Macro | Low | Low | Fast | Slow | Very fast | Low | 0.000 | High | Macro | Low | Low | Fast | Fast | Slow | Medium | 0.333 |
| Low | Micro | High | Low | Fast | Slow | Very fast | Low | 0.000 | Low | Micro | High | Low | Fast | Fast | Slow | Medium | 0.500 |
| High | Micro | High | Low | Fast | Slow | Very fast | Low | 0.333 | High | Micro | High | Low | Fast | Fast | Slow | Medium | 0.667 |
| Low | Macro | High | Low | Fast | Slow | Very fast | Low | 0.333 | Low | Macro | High | Low | Fast | Fast | Slow | Medium | 0.333 |
| High | Macro | High | Low | Fast | Slow | Very fast | Low | 0.000 | High | Macro | High | Low | Fast | Fast | Slow | Medium | 0.500 |
| Low | Micro | Low | High | Fast | Slow | Very fast | Low | 0.000 | Low | Micro | Low | High | Fast | Fast | Slow | Medium | 0.000 |
| High | Micro | Low | High | Fast | Slow | Very fast | Low | 0.000 | High | Micro | Low | High | Fast | Fast | Slow | Medium | 0.000 |
| Low | Macro | Low | High | Fast | Slow | Very fast | Low | 0.000 | Low | Macro | Low | High | Fast | Fast | Slow | Medium | 0.000 |

(*continued on next page*)

**Table 13** (*continued*)

| Water flux | Crack aperture | Diffusion coefficient | Distribution coefficient | Chemical degradation | Barrier degradation | Monolith degradation | Hydraulic conductivity | Prior conditionalviolation probability | Water flux | Crack aperture | Diffusion coefficient | Distribution coefficient | Chemical degradation | Barrier degradation | Monolith degradation | Hydraulic conductivity | Prior conditionalviolation probability |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| High | Macro | Low | High | Fast | Slow | Very fast | Low | 0.000 | High | Macro | Low | High | Fast | Fast | Slow | Medium | 0.000 |
| Low | Micro | High | High | Fast | Slow | Very fast | Low | 0.000 | Low | Micro | High | High | Fast | Fast | Slow | Medium | 0.000 |
| High | Micro | High | High | Fast | Slow | Very fast | Low | 0.000 | High | Micro | High | High | Fast | Fast | Slow | Medium | 0.000 |
| Low | Macro | High | High | Fast | Slow | Very fast | Low | 0.000 | Low | Macro | High | High | Fast | Fast | Slow | Medium | 0.000 |
| High | Macro | High | High | Fast | Slow | Very fast | Low | 0.000 | High | Macro | High | High | Fast | Fast | Slow | Medium | 0.000 |
| Low | Micro | Low | Low | Slow | Slow | Very fast | Low | 0.000 | Low | Micro | Low | Low | Slow | Fast | Slow | Medium | 0.667 |
| High | Micro | Low | Low | Slow | Slow | Very fast | Low | 0.333 | High | Micro | Low | Low | Slow | Fast | Slow | Medium | 0.667 |
| Low | Macro | Low | Low | Slow | Slow | Very fast | Low | 0.000 | Low | Macro | Low | Low | Slow | Fast | Slow | Medium | 0.000 |
| High | Macro | Low | Low | Slow | Slow | Very fast | Low | 0.333 | High | Macro | Low | Low | Slow | Fast | Slow | Medium | 0.333 |
| Low | Micro | High | Low | Slow | Slow | Very fast | Low | 0.000 | Low | Micro | High | Low | Slow | Fast | Slow | Medium | 0.333 |
| High | Micro | High | Low | Slow | Slow | Very fast | Low | 0.667 | High | Micro | High | Low | Slow | Fast | Slow | Medium | 0.667 |
| Low | Macro | High | Low | Slow | Slow | Very fast | Low | 0.000 | Low | Macro | High | Low | Slow | Fast | Slow | Medium | 0.000 |
| High | Macro | High | Low | Slow | Slow | Very fast | Low | 0.000 | High | Macro | High | Low | Slow | Fast | Slow | Medium | 0.667 |
| Low | Micro | Low | High | Slow | Slow | Very fast | Low | 0.000 | Low | Micro | Low | High | Slow | Fast | Slow | Medium | 0.000 |
| High | Micro | Low | High | Slow | Slow | Very fast | Low | 0.000 | High | Micro | Low | High | Slow | Fast | Slow | Medium | 0.333 |

(*continued on next page*)

**Table 13** (*continued*)

| Water flux | Crack aperture | Diffusion coefficient | Distribution coefficient | Chemical degradation | Barrier degradation | Monolith degradation | Hydraulic conductivity | Prior conditionalviolation probability | Water flux | Crack aperture | Diffusion coefficient | Distribution coefficient | Chemical degradation | Barrier degradation | Monolith degradation | Hydraulic conductivity | Prior conditionalviolation probability |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Low | Macro | Low | High | Slow | Slow | Very fast | Low | 0.000 | Low | Macro | Low | High | Slow | Fast | Slow | Medium | 0.000 |
| High | Macro | Low | High | Slow | Slow | Very fast | Low | 0.000 | High | Macro | Low | High | Slow | Fast | Slow | Medium | 0.000 |
| Low | Micro | High | High | Slow | Slow | Very fast | Low | 0.000 | Low | Micro | High | High | Slow | Fast | Slow | Medium | 0.000 |
| High | Micro | High | High | Slow | Slow | Very fast | Low | 0.000 | High | Micro | High | High | Slow | Fast | Slow | Medium | 0.333 |
| Low | Macro | High | High | Slow | Slow | Very fast | Low | 0.000 | Low | Macro | High | High | Slow | Fast | Slow | Medium | 0.000 |
| High | Macro | High | High | Slow | Slow | Very fast | Low | 0.000 | High | Macro | High | High | Slow | Fast | Slow | Medium | 0.000 |
| Low | Micro | Low | Low | Fast | Fast | Fast | Low | 0.667 | Low | Micro | Low | Low | Fast | Slow | Slow | Medium | 0.500 |
| High | Micro | Low | Low | Fast | Fast | Fast | Low | 0.667 | High | Micro | Low | Low | Fast | Slow | Slow | Medium | 0.667 |
| Low | Macro | Low | Low | Fast | Fast | Fast | Low | 0.000 | Low | Macro | Low | Low | Fast | Slow | Slow | Medium | 0.000 |
| High | Macro | Low | Low | Fast | Fast | Fast | Low | 0.000 | High | Macro | Low | Low | Fast | Slow | Slow | Medium | 0.333 |
| Low | Micro | High | Low | Fast | Fast | Fast | Low | 0.500 | Low | Micro | High | Low | Fast | Slow | Slow | Medium | 0.500 |
| High | Micro | High | Low | Fast | Fast | Fast | Low | 0.750 | High | Micro | High | Low | Fast | Slow | Slow | Medium | 0.667 |
| Low | Macro | High | Low | Fast | Fast | Fast | Low | 0.500 | Low | Macro | High | Low | Fast | Slow | Slow | Medium | 0.000 |
| High | Macro | High | Low | Fast | Fast | Fast | Low | 0.333 | High | Macro | High | Low | Fast | Slow | Slow | Medium | 0.333 |
| Low | Micro | Low | High | Fast | Fast | Fast | Low | 0.000 | Low | Micro | Low | High | Fast | Slow | Slow | Medium | 0.000 |
| High | Micro | Low | High | Fast | Fast | Fast | Low | 0.500 | High | Micro | Low | High | Fast | Slow | Slow | Medium | 0.000 |
| Low | Macro | Low | High | Fast | Fast | Fast | Low | 0.000 | Low | Macro | Low | High | Fast | Slow | Slow | Medium | 0.000 |
| High | Macro | Low | High | Fast | Fast | Fast | Low | 0.000 | High | Macro | Low | High | Fast | Slow | Slow | Medium | 0.000 |
| Low | Micro | High | High | Fast | Fast | Fast | Low | 0.000 | Low | Micro | High | High | Fast | Slow | Slow | Medium | 0.000 |
| High | Micro | High | High | Fast | Fast | Fast | Low | 0.000 | High | Micro | High | High | Fast | Slow | Slow | Medium | 0.000 |
| Low | Macro | High | High | Fast | Fast | Fast | Low | 0.000 | Low | Macro | High | High | Fast | Slow | Slow | Medium | 0.000 |
| High | Macro | High | High | Fast | Fast | Fast | Low | 0.000 | High | Macro | High | High | Fast | Slow | Slow | Medium | 0.000 |
| Low | Micro | Low | Low | Slow | Fast | Fast | Low | 0.333 | Low | Micro | Low | Low | Slow | Slow | Slow | Medium | 0.500 |
| High | Micro | Low | Low | Slow | Fast | Fast | Low | 0.500 | High | Micro | Low | Low | Slow | Slow | Slow | Medium | 0.667 |
| Low | Macro | Low | Low | Slow | Fast | Fast | Low | 0.333 | Low | Macro | Low | Low | Slow | Slow | Slow | Medium | 0.000 |

(*continued on next page*)

**Table 13** (*continued*)

| Water flux | Crack aperture | Diffusion coefficient | Distribution coefficient | Chemical degradation | Barrier degradation | Monolith degradation | Hydraulic conductivity | Prior conditionalviolation probability | Water flux | Crack aperture | Diffusion coefficient | Distribution coefficient | Chemical degradation | Barrier degradation | Monolith degradation | Hydraulic conductivity | Prior conditionalviolation probability |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| High | Macro | Low | Low | Slow | Fast | Fast | Low | 0.667 | High | Macro | Low | Low | Slow | Slow | Slow | Medium | 0.000 |
| Low | Micro | High | Low | Slow | Fast | Fast | Low | 0.667 | Low | Micro | High | Low | Slow | Slow | Slow | Medium | 0.333 |
| High | Micro | High | Low | Slow | Fast | Fast | Low | 0.500 | High | Micro | High | Low | Slow | Slow | Slow | Medium | 0.500 |
| Low | Macro | High | Low | Slow | Fast | Fast | Low | 0.000 | Low | Macro | High | Low | Slow | Slow | Slow | Medium | 0.000 |
| High | Macro | High | Low | Slow | Fast | Fast | Low | 0.667 | High | Macro | High | Low | Slow | Slow | Slow | Medium | 0.000 |
| Low | Micro | Low | High | Slow | Fast | Fast | Low | 0.000 | Low | Micro | Low | High | Slow | Slow | Slow | Medium | 0.000 |
| High | Micro | Low | High | Slow | Fast | Fast | Low | 0.333 | High | Micro | Low | High | Slow | Slow | Slow | Medium | 0.000 |
| Low | Macro | Low | High | Slow | Fast | Fast | Low | 0.000 | Low | Macro | Low | High | Slow | Slow | Slow | Medium | 0.000 |
| High | Macro | Low | High | Slow | Fast | Fast | Low | 0.333 | High | Macro | Low | High | Slow | Slow | Slow | Medium | 0.000 |
| Low | Micro | High | High | Slow | Fast | Fast | Low | 0.000 | Low | Micro | High | High | Slow | Slow | Slow | Medium | 0.000 |
| High | Micro | High | High | Slow | Fast | Fast | Low | 0.000 | High | Micro | High | High | Slow | Slow | Slow | Medium | 0.000 |
| Low | Macro | High | High | Slow | Fast | Fast | Low | 0.000 | Low | Macro | High | High | Slow | Slow | Slow | Medium | 0.000 |
| High | Macro | High | High | Slow | Fast | Fast | Low | 0.000 | High | Macro | High | High | Slow | Slow | Slow | Medium | 0.000 |
| Low | Micro | Low | Low | Fast | Slow | Fast | Low | 0.000 | Low | Micro | Low | Low | Fast | Fast | Very fast | High | 0.000 |
| High | Micro | Low | Low | Fast | Slow | Fast | Low | 0.000 | High | Micro | Low | Low | Fast | Fast | Very fast | High | 0.667 |
| Low | Macro | Low | Low | Fast | Slow | Fast | Low | 0.000 | Low | Macro | Low | Low | Fast | Fast | Very fast | High | 0.667 |
| High | Macro | Low | Low | Fast | Slow | Fast | Low | 0.500 | High | Macro | Low | Low | Fast | Fast | Very fast | High | 0.500 |
| Low | Micro | High | Low | Fast | Slow | Fast | Low | 0.000 | Low | Micro | High | Low | Fast | Fast | Very fast | High | 0.333 |
| High | Micro | High | Low | Fast | Slow | Fast | Low | 0.500 | High | Micro | High | Low | Fast | Fast | Very fast | High | 0.667 |
| Low | Macro | High | Low | Fast | Slow | Fast | Low | 0.000 | Low | Macro | High | Low | Fast | Fast | Very fast | High | 0.000 |
| High | Macro | High | Low | Fast | Slow | Fast | Low | 0.500 | High | Macro | High | Low | Fast | Fast | Very fast | High | 0.333 |
| Low | Micro | Low | High | Fast | Slow | Fast | Low | 0.000 | Low | Micro | Low | High | Fast | Fast | Very fast | High | 0.000 |
| High | Micro | Low | High | Fast | Slow | Fast | Low | 0.000 | High | Micro | Low | High | Fast | Fast | Very fast | High | 0.667 |
| Low | Macro | Low | High | Fast | Slow | Fast | Low | 0.000 | Low | Macro | Low | High | Fast | Fast | Very fast | High | 0.000 |
| High | Macro | Low | High | Fast | Slow | Fast | Low | 0.000 | High | Macro | Low | High | Fast | Fast | Very fast | High | 0.333 |
| Low | Micro | High | High | Fast | Slow | Fast | Low | 0.000 | Low | Micro | High | High | Fast | Fast | Very fast | High | 0.000 |
| High | Micro | High | High | Fast | Slow | Fast | Low | 0.000 | High | Micro | High | High | Fast | Fast | Very fast | High | 0.000 |
| Low | Macro | High | High | Fast | Slow | Fast | Low | 0.000 | Low | Macro | High | High | Fast | Fast | Very fast | High | 0.000 |
| High | Macro | High | High | Fast | Slow | Fast | Low | 0.000 | High | Macro | High | High | Fast | Fast | Very fast | High | 0.000 |
| Low | Micro | Low | Low | Slow | Slow | Fast | Low | 0.000 | Low | Micro | Low | Low | Slow | Fast | Very fast | High | 0.333 |
| High | Micro | Low | Low | Slow | Slow | Fast | Low | 0.333 | High | Micro | Low | Low | Slow | Fast | Very fast | High | 0.667 |
| Low | Macro | Low | Low | Slow | Slow | Fast | Low | 0.000 | Low | Macro | Low | Low | Slow | Fast | Very fast | High | 0.667 |

(*continued on next page*)

**Table 13** (*continued*)

| Water flux | Crack aperture | Diffusion coefficient | Distribution coefficient | Chemical degradation | Barrier degradation | Monolith degradation | Hydraulic conductivity | Prior conditionalviolation probability | Water flux | Crack aperture | Diffusion coefficient | Distribution coefficient | Chemical degradation | Barrier degradation | Monolith degradation | Hydraulic conductivity | Prior conditionalviolation probability |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| High | Macro | Low | Low | Slow | Slow | Fast | Low | 0.333 | High | Macro | Low | Low | Slow | Fast | Very fast | High | 0.500 |
| Low | Micro | High | Low | Slow | Slow | Fast | Low | 0.000 | Low | Micro | High | Low | Slow | Fast | Very fast | High | 0.000 |
| High | Micro | High | Low | Slow | Slow | Fast | Low | 0.333 | High | Micro | High | Low | Slow | Fast | Very fast | High | 0.667 |
| Low | Macro | High | Low | Slow | Slow | Fast | Low | 0.000 | Low | Macro | High | Low | Slow | Fast | Very fast | High | 0.000 |
| High | Macro | High | Low | Slow | Slow | Fast | Low | 0.000 | High | Macro | High | Low | Slow | Fast | Very fast | High | 0.333 |
| Low | Micro | Low | High | Slow | Slow | Fast | Low | 0.000 | Low | Micro | Low | High | Slow | Fast | Very fast | High | 0.000 |
| High | Micro | Low | High | Slow | Slow | Fast | Low | 0.000 | High | Micro | Low | High | Slow | Fast | Very fast | High | 0.000 |
| Low | Macro | Low | High | Slow | Slow | Fast | Low | 0.000 | Low | Macro | Low | High | Slow | Fast | Very fast | High | 0.000 |
| High | Macro | Low | High | Slow | Slow | Fast | Low | 0.333 | High | Macro | Low | High | Slow | Fast | Very fast | High | 0.000 |
| Low | Micro | High | High | Slow | Slow | Fast | Low | 0.000 | Low | Micro | High | High | Slow | Fast | Very fast | High | 0.000 |
| High | Micro | High | High | Slow | Slow | Fast | Low | 0.000 | High | Micro | High | High | Slow | Fast | Very fast | High | 0.000 |
| Low | Macro | High | High | Slow | Slow | Fast | Low | 0.000 | Low | Macro | High | High | Slow | Fast | Very fast | High | 0.000 |
| High | Macro | High | High | Slow | Slow | Fast | Low | 0.333 | High | Macro | High | High | Slow | Fast | Very fast | High | 0.250 |
| Low | Micro | Low | Low | Fast | Fast | Slow | Low | 0.667 | Low | Micro | Low | Low | Fast | Slow | Very fast | High | 0.000 |
| High | Micro | Low | Low | Fast | Fast | Slow | Low | 0.667 | High | Micro | Low | Low | Fast | Slow | Very fast | High | 0.500 |
| Low | Macro | Low | Low | Fast | Fast | Slow | Low | 0.000 | Low | Macro | Low | Low | Fast | Slow | Very fast | High | 0.000 |
| High | Macro | Low | Low | Fast | Fast | Slow | Low | 0.500 | High | Macro | Low | Low | Fast | Slow | Very fast | High | 0.000 |
| Low | Micro | High | Low | Fast | Fast | Slow | Low | 0.667 | Low | Micro | High | Low | Fast | Slow | Very fast | High | 0.333 |
| High | Micro | High | Low | Fast | Fast | Slow | Low | 0.667 | High | Micro | High | Low | Fast | Slow | Very fast | High | 0.500 |
| Low | Macro | High | Low | Fast | Fast | Slow | Low | 0.000 | Low | Macro | High | Low | Fast | Slow | Very fast | High | 0.250 |
| High | Macro | High | Low | Fast | Fast | Slow | Low | 0.667 | High | Macro | High | Low | Fast | Slow | Very fast | High | 0.000 |
| Low | Micro | Low | High | Fast | Fast | Slow | Low | 0.000 | Low | Micro | Low | High | Fast | Slow | Very fast | High | 0.000 |
| High | Micro | Low | High | Fast | Fast | Slow | Low | 0.000 | High | Micro | Low | High | Fast | Slow | Very fast | High | 0.333 |
| Low | Macro | Low | High | Fast | Fast | Slow | Low | 0.000 | Low | Macro | Low | High | Fast | Slow | Very fast | High | 0.000 |
| High | Macro | Low | High | Fast | Fast | Slow | Low | 0.000 | High | Macro | Low | High | Fast | Slow | Very fast | High | 0.000 |
| Low | Micro | High | High | Fast | Fast | Slow | Low | 0.000 | Low | Micro | High | High | Fast | Slow | Very fast | High | 0.000 |
| High | Micro | High | High | Fast | Fast | Slow | Low | 0.000 | High | Micro | High | High | Fast | Slow | Very fast | High | 0.000 |
| Low | Macro | High | High | Fast | Fast | Slow | Low | 0.000 | Low | Macro | High | High | Fast | Slow | Very fast | High | 0.000 |
| High | Macro | High | High | Fast | Fast | Slow | Low | 0.000 | High | Macro | High | High | Fast | Slow | Very fast | High | 0.000 |

(*continued on next page*)

**Table 13** (*continued*)

| Water flux | Crack aperture | Diffusion coefficient | Distribution coefficient | Chemical degradation | Barrier degradation | Monolith degradation | Hydraulic conductivity | Prior conditionalviolation probability | Water flux | Crack aperture | Diffusion coefficient | Distribution coefficient | Chemical degradation | Barrier degradation | Monolith degradation | Hydraulic conductivity | Prior conditionalviolation probability |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Low | Micro | Low | Low | Slow | Fast | Slow | Low | 0.667 | Low | Micro | Low | Low | Slow | Slow | Very fast | High | 0.000 |
| High | Micro | Low | Low | Slow | Fast | Slow | Low | 0.667 | High | Micro | Low | Low | Slow | Slow | Very fast | High | 0.000 |
| Low | Macro | Low | Low | Slow | Fast | Slow | Low | 0.000 | Low | Macro | Low | Low | Slow | Slow | Very fast | High | 0.000 |
| High | Macro | Low | Low | Slow | Fast | Slow | Low | 0.000 | High | Macro | Low | Low | Slow | Slow | Very fast | High | 0.000 |
| Low | Micro | High | Low | Slow | Fast | Slow | Low | 0.333 | Low | Micro | High | Low | Slow | Slow | Very fast | High | 0.000 |
| High | Micro | High | Low | Slow | Fast | Slow | Low | 0.667 | High | Micro | High | Low | Slow | Slow | Very fast | High | 0.333 |
| Low | Macro | High | Low | Slow | Fast | Slow | Low | 0.000 | Low | Macro | High | Low | Slow | Slow | Very fast | High | 0.000 |
| High | Macro | High | Low | Slow | Fast | Slow | Low | 0.333 | High | Macro | High | Low | Slow | Slow | Very fast | High | 0.333 |
| Low | Micro | Low | High | Slow | Fast | Slow | Low | 0.000 | Low | Micro | Low | High | Slow | Slow | Very fast | High | 0.000 |
| High | Micro | Low | High | Slow | Fast | Slow | Low | 0.333 | High | Micro | Low | High | Slow | Slow | Very fast | High | 0.000 |
| Low | Macro | Low | High | Slow | Fast | Slow | Low | 0.000 | Low | Macro | Low | High | Slow | Slow | Very fast | High | 0.000 |
| High | Macro | Low | High | Slow | Fast | Slow | Low | 0.000 | High | Macro | Low | High | Slow | Slow | Very fast | High | 0.000 |
| Low | Micro | High | High | Slow | Fast | Slow | Low | 0.000 | Low | Micro | High | High | Slow | Slow | Very fast | High | 0.000 |
| High | Micro | High | High | Slow | Fast | Slow | Low | 0.333 | High | Micro | High | High | Slow | Slow | Very fast | High | 0.000 |
| Low | Macro | High | High | Slow | Fast | Slow | Low | 0.000 | Low | Macro | High | High | Slow | Slow | Very fast | High | 0.000 |
| High | Macro | High | High | Slow | Fast | Slow | Low | 0.000 | High | Macro | High | High | Slow | Slow | Very fast | High | 0.000 |
| Low | Micro | Low | Low | Fast | Slow | Slow | Low | 0.500 | Low | Micro | Low | Low | Fast | Fast | Fast | High | 0.667 |
| High | Micro | Low | Low | Fast | Slow | Slow | Low | 0.667 | High | Micro | Low | Low | Fast | Fast | Fast | High | 0.500 |
| Low | Macro | Low | Low | Fast | Slow | Slow | Low | 0.000 | Low | Macro | Low | Low | Fast | Fast | Fast | High | 0.333 |
| High | Macro | Low | Low | Fast | Slow | Slow | Low | 0.333 | High | Macro | Low | Low | Fast | Fast | Fast | High | 0.667 |
| Low | Micro | High | Low | Fast | Slow | Slow | Low | 0.500 | Low | Micro | High | Low | Fast | Fast | Fast | High | 0.667 |
| High | Micro | High | Low | Fast | Slow | Slow | Low | 0.667 | High | Micro | High | Low | Fast | Fast | Fast | High | 0.667 |
| Low | Macro | High | Low | Fast | Slow | Slow | Low | 0.000 | Low | Macro | High | Low | Fast | Fast | Fast | High | 0.000 |
| High | Macro | High | Low | Fast | Slow | Slow | Low | 0.333 | High | Macro | High | Low | Fast | Fast | Fast | High | 0.500 |
| Low | Micro | Low | High | Fast | Slow | Slow | Low | 0.000 | Low | Micro | Low | High | Fast | Fast | Fast | High | 0.000 |
| High | Micro | Low | High | Fast | Slow | Slow | Low | 0.000 | High | Micro | Low | High | Fast | Fast | Fast | High | 0.000 |
| Low | Macro | Low | High | Fast | Slow | Slow | Low | 0.000 | Low | Macro | Low | High | Fast | Fast | Fast | High | 0.000 |
| High | Macro | Low | High | Fast | Slow | Slow | Low | 0.000 | High | Macro | Low | High | Fast | Fast | Fast | High | 0.000 |
| Low | Micro | High | High | Fast | Slow | Slow | Low | 0.000 | Low | Micro | High | High | Fast | Fast | Fast | High | 0.000 |
| High | Micro | High | High | Fast | Slow | Slow | Low | 0.000 | High | Micro | High | High | Fast | Fast | Fast | High | 0.333 |

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**Table 13** (*continued*)

| Water flux | Crack aperture | Diffusion coefficient | Distribution coefficient | Chemical degradation | Barrier degradation | Monolith degradation | Hydraulic conductivity | Prior conditionalviolation probability | Water flux | Crack aperture | Diffusion coefficient | Distribution coefficient | Chemical degradation | Barrier degradation | Monolith degradation | Hydraulic conductivity | Prior conditionalviolation probability |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Low | Macro | High | High | Fast | Slow | Slow | Low | 0.000 | Low | Macro | High | High | Fast | Fast | Fast | High | 0.000 |
| High | Macro | High | High | Fast | Slow | Slow | Low | 0.000 | High | Macro | High | High | Fast | Fast | Fast | High | 0.000 |
| Low | Micro | Low | Low | Slow | Slow | Slow | Low | 0.500 | Low | Micro | Low | Low | Slow | Fast | Fast | High | 0.500 |
| High | Micro | Low | Low | Slow | Slow | Slow | Low | 0.750 | High | Micro | Low | Low | Slow | Fast | Fast | High | 0.667 |
| Low | Macro | Low | Low | Slow | Slow | Slow | Low | 0.000 | Low | Macro | Low | Low | Slow | Fast | Fast | High | 0.333 |
| High | Macro | Low | Low | Slow | Slow | Slow | Low | 0.000 | High | Macro | Low | Low | Slow | Fast | Fast | High | 0.500 |
| Low | Micro | High | Low | Slow | Slow | Slow | Low | 0.000 | Low | Micro | High | Low | Slow | Fast | Fast | High | 0.333 |
| High | Micro | High | Low | Slow | Slow | Slow | Low | 0.667 | High | Micro | High | Low | Slow | Fast | Fast | High | 0.667 |
| Low | Macro | High | Low | Slow | Slow | Slow | Low | 0.000 | Low | Macro | High | Low | Slow | Fast | Fast | High | 0.000 |
| High | Macro | High | Low | Slow | Slow | Slow | Low | 0.500 | High | Macro | High | Low | Slow | Fast | Fast | High | 0.333 |
| Low | Micro | Low | High | Slow | Slow | Slow | Low | 0.000 | Low | Micro | Low | High | Slow | Fast | Fast | High | 0.000 |
| High | Micro | Low | High | Slow | Slow | Slow | Low | 0.000 | High | Micro | Low | High | Slow | Fast | Fast | High | 0.000 |
| Low | Macro | Low | High | Slow | Slow | Slow | Low | 0.000 | Low | Macro | Low | High | Slow | Fast | Fast | High | 0.000 |
| High | Macro | Low | High | Slow | Slow | Slow | Low | 0.000 | High | Macro | Low | High | Slow | Fast | Fast | High | 0.000 |
| Low | Micro | High | High | Slow | Slow | Slow | Low | 0.333 | Low | Micro | High | High | Slow | Fast | Fast | High | 0.000 |
| High | Micro | High | High | Slow | Slow | Slow | Low | 0.667 | High | Micro | High | High | Slow | Fast | Fast | High | 0.333 |
| Low | Macro | High | High | Slow | Slow | Slow | Low | 0.000 | Low | Macro | High | High | Slow | Fast | Fast | High | 0.000 |
| High | Macro | High | High | Slow | Slow | Slow | Low | 0.000 | High | Macro | High | High | Slow | Fast | Fast | High | 0.000 |
| Low | Micro | Low | Low | Fast | Fast | Very fast | Medium | 0.333 | Low | Micro | Low | Low | Fast | Slow | Fast | High | 0.000 |
| High | Micro | Low | Low | Fast | Fast | Very fast | Medium | 0.667 | High | Micro | Low | Low | Fast | Slow | Fast | High | 0.667 |
| Low | Macro | Low | Low | Fast | Fast | Very fast | Medium | 0.000 | Low | Macro | Low | Low | Fast | Slow | Fast | High | 0.000 |
| High | Macro | Low | Low | Fast | Fast | Very fast | Medium | 0.667 | High | Macro | Low | Low | Fast | Slow | Fast | High | 0.333 |
| Low | Micro | High | Low | Fast | Fast | Very fast | Medium | 0.000 | Low | Micro | High | Low | Fast | Slow | Fast | High | 0.500 |
| High | Micro | High | Low | Fast | Fast | Very fast | Medium | 0.667 | High | Micro | High | Low | Fast | Slow | Fast | High | 0.667 |

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**Table 13** (*continued*)

| Water flux | Crack aperture | Diffusion coefficient | Distribution coefficient | Chemical degradation | Barrier degradation | Monolith degradation | Hydraulic conductivity | Prior conditionalviolation probability | Water flux | Crack aperture | Diffusion coefficient | Distribution coefficient | Chemical degradation | Barrier degradation | Monolith degradation | Hydraulic conductivity | Prior conditionalviolation probability |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Low | Macro | High | Low | Fast | Fast | Very fast | Medium | 0.000 | Low | Macro | High | Low | Fast | Slow | Fast | High | 0.000 |
| High | Macro | High | Low | Fast | Fast | Very fast | Medium | 0.500 | High | Macro | High | Low | Fast | Slow | Fast | High | 0.333 |
| Low | Micro | Low | High | Fast | Fast | Very fast | Medium | 0.000 | Low | Micro | Low | High | Fast | Slow | Fast | High | 0.000 |
| High | Micro | Low | High | Fast | Fast | Very fast | Medium | 0.000 | High | Micro | Low | High | Fast | Slow | Fast | High | 0.000 |
| Low | Macro | Low | High | Fast | Fast | Very fast | Medium | 0.000 | Low | Macro | Low | High | Fast | Slow | Fast | High | 0.250 |
| High | Macro | Low | High | Fast | Fast | Very fast | Medium | 0.000 | High | Macro | Low | High | Fast | Slow | Fast | High | 0.000 |
| Low | Micro | High | High | Fast | Fast | Very fast | Medium | 0.000 | Low | Micro | High | High | Fast | Slow | Fast | High | 0.000 |
| High | Micro | High | High | Fast | Fast | Very fast | Medium | 0.500 | High | Micro | High | High | Fast | Slow | Fast | High | 0.000 |
| Low | Macro | High | High | Fast | Fast | Very fast | Medium | 0.000 | Low | Macro | High | High | Fast | Slow | Fast | High | 0.000 |
| High | Macro | High | High | Fast | Fast | Very fast | Medium | 0.000 | High | Macro | High | High | Fast | Slow | Fast | High | 0.000 |
| Low | Micro | Low | Low | Slow | Fast | Very fast | Medium | 0.000 | Low | Micro | Low | Low | Slow | Slow | Fast | High | 0.333 |
| High | Micro | Low | Low | Slow | Fast | Very fast | Medium | 0.667 | High | Micro | Low | Low | Slow | Slow | Fast | High | 0.333 |
| Low | Macro | Low | Low | Slow | Fast | Very fast | Medium | 0.333 | Low | Macro | Low | Low | Slow | Slow | Fast | High | 0.000 |
| High | Macro | Low | Low | Slow | Fast | Very fast | Medium | 0.500 | High | Macro | Low | Low | Slow | Slow | Fast | High | 0.333 |
| Low | Micro | High | Low | Slow | Fast | Very fast | Medium | 0.000 | Low | Micro | High | Low | Slow | Slow | Fast | High | 0.500 |
| High | Micro | High | Low | Slow | Fast | Very fast | Medium | 0.500 | High | Micro | High | Low | Slow | Slow | Fast | High | 0.250 |

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**Table 13** (*continued*)

| Water flux | Crack aperture | Diffusion coefficient | Distribution coefficient | Chemical degradation | Barrier degradation | Monolith degradation | Hydraulic conductivity | Prior conditionalviolation probability | Water flux | Crack aperture | Diffusion coefficient | Distribution coefficient | Chemical degradation | Barrier degradation | Monolith degradation | Hydraulic conductivity | Prior conditionalviolation probability |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Low | Macro | High | Low | Slow | Fast | Very fast | Medium | 0.000 | Low | Macro | High | Low | Slow | Slow | Fast | High | 0.000 |
| High | Macro | High | Low | Slow | Fast | Very fast | Medium | 0.000 | High | Macro | High | Low | Slow | Slow | Fast | High | 0.000 |
| Low | Micro | Low | High | Slow | Fast | Very fast | Medium | 0.000 | Low | Micro | Low | High | Slow | Slow | Fast | High | 0.000 |
| High | Micro | Low | High | Slow | Fast | Very fast | Medium | 0.000 | High | Micro | Low | High | Slow | Slow | Fast | High | 0.000 |
| Low | Macro | Low | High | Slow | Fast | Very fast | Medium | 0.000 | Low | Macro | Low | High | Slow | Slow | Fast | High | 0.000 |
| High | Macro | Low | High | Slow | Fast | Very fast | Medium | 0.500 | High | Macro | Low | High | Slow | Slow | Fast | High | 0.000 |
| Low | Micro | High | High | Slow | Fast | Very fast | Medium | 0.000 | Low | Micro | High | High | Slow | Slow | Fast | High | 0.000 |
| High | Micro | High | High | Slow | Fast | Very fast | Medium | 0.000 | High | Micro | High | High | Slow | Slow | Fast | High | 0.000 |
| Low | Macro | High | High | Slow | Fast | Very fast | Medium | 0.000 | Low | Macro | High | High | Slow | Slow | Fast | High | 0.000 |
| High | Macro | High | High | Slow | Fast | Very fast | Medium | 0.000 | High | Macro | High | High | Slow | Slow | Fast | High | 0.333 |
| Low | Micro | Low | Low | Fast | Slow | Very fast | Medium | 0.000 | Low | Micro | Low | Low | Fast | Fast | Slow | High | 0.500 |
| High | Micro | Low | Low | Fast | Slow | Very fast | Medium | 0.750 | High | Micro | Low | Low | Fast | Fast | Slow | High | 0.750 |
| Low | Macro | Low | Low | Fast | Slow | Very fast | Medium | 0.000 | Low | Macro | Low | Low | Fast | Fast | Slow | High | 0.000 |
| High | Macro | Low | Low | Fast | Slow | Very fast | Medium | 0.000 | High | Macro | Low | Low | Fast | Fast | Slow | High | 0.333 |
| Low | Micro | High | Low | Fast | Slow | Very fast | Medium | 0.000 | Low | Micro | High | Low | Fast | Fast | Slow | High | 0.500 |
| High | Micro | High | Low | Fast | Slow | Very fast | Medium | 0.000 | High | Micro | High | Low | Fast | Fast | Slow | High | 0.667 |

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**Table 13** (*continued*)

| Water flux | Crack aperture | Diffusion coefficient | Distribution coefficient | Chemical degradation | Barrier degradation | Monolith degradation | Hydraulic conductivity | Prior conditionalviolation probability | Water flux | Crack aperture | Diffusion coefficient | Distribution coefficient | Chemical degradation | Barrier degradation | Monolith degradation | Hydraulic conductivity | Prior conditionalviolation probability |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Low | Macro | High | Low | Fast | Slow | Very fast | Medium | 0.333 | Low | Macro | High | Low | Fast | Fast | Slow | High | 0.000 |
| High | Macro | High | Low | Fast | Slow | Very fast | Medium | 0.000 | High | Macro | High | Low | Fast | Fast | Slow | High | 0.500 |
| Low | Micro | Low | High | Fast | Slow | Very fast | Medium | 0.000 | Low | Micro | Low | High | Fast | Fast | Slow | High | 0.000 |
| High | Micro | Low | High | Fast | Slow | Very fast | Medium | 0.000 | High | Micro | Low | High | Fast | Fast | Slow | High | 0.667 |
| Low | Macro | Low | High | Fast | Slow | Very fast | Medium | 0.000 | Low | Macro | Low | High | Fast | Fast | Slow | High | 0.000 |
| High | Macro | Low | High | Fast | Slow | Very fast | Medium | 0.000 | High | Macro | Low | High | Fast | Fast | Slow | High | 0.000 |
| Low | Micro | High | High | Fast | Slow | Very fast | Medium | 0.000 | Low | Micro | High | High | Fast | Fast | Slow | High | 0.333 |
| High | Micro | High | High | Fast | Slow | Very fast | Medium | 0.000 | High | Micro | High | High | Fast | Fast | Slow | High | 0.000 |
| Low | Macro | High | High | Fast | Slow | Very fast | Medium | 0.000 | Low | Macro | High | High | Fast | Fast | Slow | High | 0.000 |
| High | Macro | High | High | Fast | Slow | Very fast | Medium | 0.000 | High | Macro | High | High | Fast | Fast | Slow | High | 0.000 |
| Low | Micro | Low | Low | Slow | Slow | Very fast | Medium | 0.000 | Low | Micro | Low | Low | Slow | Fast | Slow | High | 0.667 |
| High | Micro | Low | Low | Slow | Slow | Very fast | Medium | 0.333 | High | Micro | Low | Low | Slow | Fast | Slow | High | 0.667 |
| Low | Macro | Low | Low | Slow | Slow | Very fast | Medium | 0.000 | Low | Macro | Low | Low | Slow | Fast | Slow | High | 0.000 |
| High | Macro | Low | Low | Slow | Slow | Very fast | Medium | 0.000 | High | Macro | Low | Low | Slow | Fast | Slow | High | 0.667 |
| Low | Micro | High | Low | Slow | Slow | Very fast | Medium | 0.333 | Low | Micro | High | Low | Slow | Fast | Slow | High | 0.500 |

(*continued on next page*)

**Table 13** (*continued*)

| Water flux | Crack aperture | Diffusion coefficient | Distribution coefficient | Chemical degradation | Barrier degradation | Monolith degradation | Hydraulic conductivity | Prior conditionalviolation probability | Water flux | Crack aperture | Diffusion coefficient | Distribution coefficient | Chemical degradation | Barrier degradation | Monolith degradation | Hydraulic conductivity | Prior conditionalviolation probability |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| High | Micro | High | Low | Slow | Slow | Very fast | Medium | 0.000 | High | Micro | High | Low | Slow | Fast | Slow | High | 0.750 |
| Low | Macro | High | Low | Slow | Slow | Very fast | Medium | 0.000 | Low | Macro | High | Low | Slow | Fast | Slow | High | 0.000 |
| High | Macro | High | Low | Slow | Slow | Very fast | Medium | 0.333 | High | Macro | High | Low | Slow | Fast | Slow | High | 0.333 |
| Low | Micro | Low | High | Slow | Slow | Very fast | Medium | 0.000 | Low | Micro | Low | High | Slow | Fast | Slow | High | 0.000 |
| High | Micro | Low | High | Slow | Slow | Very fast | Medium | 0.000 | High | Micro | Low | High | Slow | Fast | Slow | High | 0.000 |
| Low | Macro | Low | High | Slow | Slow | Very fast | Medium | 0.000 | Low | Macro | Low | High | Slow | Fast | Slow | High | 0.000 |
| High | Macro | Low | High | Slow | Slow | Very fast | Medium | 0.000 | High | Macro | Low | High | Slow | Fast | Slow | High | 0.000 |
| Low | Micro | High | High | Slow | Slow | Very fast | Medium | 0.000 | Low | Micro | High | High | Slow | Fast | Slow | High | 0.500 |
| High | Micro | High | High | Slow | Slow | Very fast | Medium | 0.000 | High | Micro | High | High | Slow | Fast | Slow | High | 0.000 |
| Low | Macro | High | High | Slow | Slow | Very fast | Medium | 0.000 | Low | Macro | High | High | Slow | Fast | Slow | High | 0.000 |
| High | Macro | High | High | Slow | Slow | Very fast | Medium | 0.333 | High | Macro | High | High | Slow | Fast | Slow | High | 0.000 |
| Low | Micro | Low | Low | Fast | Fast | Fast | Medium | 0.333 | Low | Micro | Low | Low | Fast | Slow | Slow | High | 0.667 |
| High | Micro | Low | Low | Fast | Fast | Fast | Medium | 0.667 | High | Micro | Low | Low | Fast | Slow | Slow | High | 0.333 |
| Low | Macro | Low | Low | Fast | Fast | Fast | Medium | 0.000 | Low | Macro | Low | Low | Fast | Slow | Slow | High | 0.000 |
| High | Macro | Low | Low | Fast | Fast | Fast | Medium | 0.667 | High | Macro | Low | Low | Fast | Slow | Slow | High | 0.000 |
| Low | Micro | High | Low | Fast | Fast | Fast | Medium | 0.000 | Low | Micro | High | Low | Fast | Slow | Slow | High | 0.000 |
| High | Micro | High | Low | Fast | Fast | Fast | Medium | 0.667 | High | Micro | High | Low | Fast | Slow | Slow | High | 0.667 |
| Low | Macro | High | Low | Fast | Fast | Fast | Medium | 0.000 | Low | Macro | High | Low | Fast | Slow | Slow | High | 0.000 |

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**Table 13** (*continued*)

| Water flux | Crack aperture | Diffusion coefficient | Distribution coefficient | Chemical degradation | Barrier degradation | Monolith degradation | Hydraulic conductivity | Prior conditionalviolation probability | Water flux | Crack aperture | Diffusion coefficient | Distribution coefficient | Chemical degradation | Barrier degradation | Monolith degradation | Hydraulic conductivity | Prior conditionalviolation probability |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| High | Macro | High | Low | Fast | Fast | Fast | Medium | 0.667 | High | Macro | High | Low | Fast | Slow | Slow | High | 0.333 |
| Low | Micro | Low | High | Fast | Fast | Fast | Medium | 0.000 | Low | Micro | Low | High | Fast | Slow | Slow | High | 0.000 |
| High | Micro | Low | High | Fast | Fast | Fast | Medium | 0.000 | High | Micro | Low | High | Fast | Slow | Slow | High | 0.333 |
| Low | Macro | Low | High | Fast | Fast | Fast | Medium | 0.000 | Low | Macro | Low | High | Fast | Slow | Slow | High | 0.000 |
| High | Macro | Low | High | Fast | Fast | Fast | Medium | 0.667 | High | Macro | Low | High | Fast | Slow | Slow | High | 0.000 |
| Low | Micro | High | High | Fast | Fast | Fast | Medium | 0.333 | Low | Micro | High | High | Fast | Slow | Slow | High | 0.000 |
| High | Micro | High | High | Fast | Fast | Fast | Medium | 0.500 | High | Micro | High | High | Fast | Slow | Slow | High | 0.000 |
| Low | Macro | High | High | Fast | Fast | Fast | Medium | 0.000 | Low | Macro | High | High | Fast | Slow | Slow | High | 0.000 |
| High | Macro | High | High | Fast | Fast | Fast | Medium | 0.000 | High | Macro | High | High | Fast | Slow | Slow | High | 0.000 |
| Low | Micro | Low | Low | Slow | Fast | Fast | Medium | 0.000 | Low | Micro | Low | Low | Slow | Slow | Slow | High | 0.500 |
| High | Micro | Low | Low | Slow | Fast | Fast | Medium | 0.500 | High | Micro | Low | Low | Slow | Slow | Slow | High | 0.750 |
| Low | Macro | Low | Low | Slow | Fast | Fast | Medium | 0.000 | Low | Macro | Low | Low | Slow | Slow | Slow | High | 0.000 |
| High | Macro | Low | Low | Slow | Fast | Fast | Medium | 0.000 | High | Macro | Low | Low | Slow | Slow | Slow | High | 0.000 |
| Low | Micro | High | Low | Slow | Fast | Fast | Medium | 0.667 | Low | Micro | High | Low | Slow | Slow | Slow | High | 0.667 |
| High | Micro | High | Low | Slow | Fast | Fast | Medium | 0.667 | High | Micro | High | Low | Slow | Slow | Slow | High | 0.667 |
| Low | Macro | High | Low | Slow | Fast | Fast | Medium | 0.000 | Low | Macro | High | Low | Slow | Slow | Slow | High | 0.000 |
| High | Macro | High | Low | Slow | Fast | Fast | Medium | 0.750 | High | Macro | High | Low | Slow | Slow | Slow | High | 0.333 |
| Low | Micro | Low | High | Slow | Fast | Fast | Medium | 0.000 | Low | Micro | Low | High | Slow | Slow | Slow | High | 0.000 |
| High | Micro | Low | High | Slow | Fast | Fast | Medium | 0.333 | High | Micro | Low | High | Slow | Slow | Slow | High | 0.000 |
| Low | Macro | Low | High | Slow | Fast | Fast | Medium | 0.000 | Low | Macro | Low | High | Slow | Slow | Slow | High | 0.000 |
| High | Macro | Low | High | Slow | Fast | Fast | Medium | 0.000 | High | Macro | Low | High | Slow | Slow | Slow | High | 0.000 |
| Low | Micro | High | High | Slow | Fast | Fast | Medium | 0.000 | Low | Micro | High | High | Slow | Slow | Slow | High | 0.000 |
| High | Micro | High | High | Slow | Fast | Fast | Medium | 0.000 | High | Micro | High | High | Slow | Slow | Slow | High | 0.333 |
| Low | Macro | High | High | Slow | Fast | Fast | Medium | 0.000 | Low | Macro | High | High | Slow | Slow | Slow | High | 0.000 |
| High | Macro | High | High | Slow | Fast | Fast | Medium | 0.500 | High | Macro | High | High | Slow | Slow | Slow | High | 0.000 |

**Table 14**
Underlying assumptions of different beliefs (fifth to seventh columns) about the probabilities (Table 4 to Table 12) of FEP states (first and second columns) in different subscenarios (i.e., states of their respective parent FEPs, third to fourth columns).

| FEP | FEP state | Parent | Subscenario | Assumption 1 | Assumption 2 | Assumption 3 |
|---|---|---|---|---|---|---|
| Earthquake | BDBE | - | - | Complement to 1 | | - |
| | Major | - | - | Poisson process with return time of 100,000 years | Poisson process with return time of 50,000 years | - |
| Water flux | Low | - | - | Log uniform | Log triangular | - |
| | High | - | - | | | - |
| Crack aperture | Micro | - | - | Log uniform | Complement to 1 | - |
| | Macro | - | - | | -30% compared to Belief 1 | - |
| Diffusion coefficient | Low | - | - | Log uniform | Log triangular | - |
| | High | - | - | | | - |
| Distribution coefficient | Low | - | - | Log uniform | Log triangular | - |
| | High | - | - | | | - |
| Chemical degradation | Fast | - | - | Log uniform | Log triangular | Triangular |
| | Slow | - | - | | | |
| Barrier degradation | Fast | Earthquake | BDBE | Log triangular | Triangular | - |
| | Slow | | | | | - |
| | Fast | | Major | Log Uniform | LogLog Triangular | - |
| | Slow | | | | | - |
| Monolith degradation | Very fast | Earthquake | BDBE | Log Triangular | Triangular | - |
| | Fast | | | | | - |
| | Slow | | | | | - |
| | Very fast | | Major | Same as in the BDBE subscenario | | - |
| | Fast | | | Average between the probs. of Very fast and Fast in the BDBE subscenario (with 1/3 and 2/3 weights, respectively) | | - |
| | Slow | | | Complement to 1 | | - |
| Hydraulic conductivity | Low | Crack aperture | Micro | Beta(0.1,1.8) distribution over a Log Triangular CFD | Beta(0.1,1.5) distribution over a Log Triangular CFD | - |
| | Medium | | | | | - |
| | High | | | | | - |
| | Low | | Macro | Swap of the probabilities of Low and Medium | | - |
| | Medium | | | | | - |
| | High | | | Same as in the Micro subscenario | | - |

abilities would need to be obtained by formal expert-judgment elicitation [5]. The assumptions underlying the FEP probabilities are summarized in Table 14.

For instance, the probability that a *major earthquake* occurs between 350 and 816 years from the present time (i.e., during the so-called isolation phase of the nuclear waste repository taken as the case study [4]) is

$$p_{major} = exp\left(-\frac{350y}{t_{ret}}\right) - exp\left(-\frac{816y}{t_{ret}}\right),$$

where $t_{ret}$ is the return period of the underlying Poisson process. In Table 4, the probabilities of a *major earthquake* are obtained by assuming the return period to be 100,000 (Assumption 1) and 50,000 years (Assumption 2).

Table 5 - Table 12 refer instead to FEPs that overarch sets of consistent parameters in Table 3, such as the FEP *Water flux* and the parameter *Degraded water flux*. In these cases, alternative assumptions were made about the distribution over the ranges of parameter values in Table 3. Continuing with the example of *Degraded water flux* (Table 5), Assumption 1 consists in taking a log-uniform distribution over the range .$[3.17 \cdot 10^{-9} \frac{m}{s}, 3.00 \cdot 10^{-8} \frac{m}{s}]$ Differently, Assumption 2 is a log-triangular probability density function, which has the maximum at $\ln(3.17 \cdot 10^{-9}\ m \cdot s^{-1})$ and linearly decreases until reaching 0 at $\ln(3.00 \cdot 10^{-8}\ m \cdot s^{-1})$. The rationale for using a log-uniform distribution is to spread the probability mass evenly over the orders of magnitude

rather than over the values of a range. A log-triangular distribution serves to a similar purpose, except that more probability mass is assigned to either end of the range.

Then, the probabilities of the different states (e.g., *low* and *high*) are determined by how much probability mass gathers over the corresponding discretized ranges in Table 3 (note that the ranges of all parameters consistent with a given FEP are discretized so that the same distribution results in the same probabilities for the corresponding states).

Finally, the prior probabilities of Table 13 represent the frequencies with which the violation state of the safety target was observed as the result of multiple COMSOL Multiphysics simulations for each subscenario. For example, in the second subscenario of Table 13 *Water flux* is high, *Crack aperture* is micro, *Diffusion coefficient* is low, *Distribution coefficient* is low, *Chemical degradation* is fast, *Barrier degradation* is fast, *Monolith degradation* is very fast and *Hydraulic conductivity* is low. In order to simulate realizations of this subscenario, the parameter values were randomly and uniformly sampled from the corresponding intervals in Table 3 (in keeping with [1], Section 2.3.1). Here, as one of the two simulations leads to the violation state of the safety target, the retained prior probability is assigned a value of 0.5.

## Declaration of Competing Interest

The authors declare no competing interest.

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## Appendix. Range and discretization for the initial water flux

The initial effective hydraulic conductivity of the column made by the monoliths and the module basis can be calculated as

$$K_{eff}^{stack} = \left( \frac{h^{mon}}{h^{stack}} \cdot \frac{1}{K_{eff}^{mon}} + \frac{h^{base}}{h^{stack}} \cdot \frac{1}{x^{K^{mod}}} \right)^{-1},$$

where $h^{mon}$= 7.99 m is the height of the monolith column, $h^{base}$= 2.19 m is the height of the module basis, and $h^{stack} = h^{mon} + h^{base}$. These heights define the proportions between the conductivity of the module basis (the value $x^{K^{mod}}$ of the parameter *Initial hydraulic conductivity of module*) and the effective conductivity of the monoliths. Seeing the transversal section of the column as a monolith flanked by two void channels (assumed to have the same characteristics as the cracks in the module basis) separating it from the other columns, the latter is

$$K_{eff}^{mon} = \frac{2 \cdot x^{crack} \cdot K^{crack} + l^{mon} \cdot x^{K^{mon}}}{2 \cdot x^{crack} + l^{mon}},$$

where the indicative channel width $x^{crack}$ is equal to the parameter *Degraded crack aperture,* $l^{mon}$ = 1.94 m is the width of a monolith, $x^{K^{mon}}$ is the parameter *Initial hydraulic conductivity of monolith*, and the hydraulic conductivity of the channels is

$$K^{crack} = \frac{\rho_W \cdot g \cdot \left(x^{crack}\right)^2}{24 \cdot \mu_W},$$

where $\rho_W$= 1,000 kg m$^{-3}$ is water density, $g$= 9.81 m s$^{-2}$ is gravitational acceleration and $\mu_W$= 1.00E-03 kg m$^{-1}$ s$^{-1}$ is water dynamic viscosity (also remember to turn $x^{crack}$ into meters).

The lower bound of the range for the *Initial water flux* could be set to the value 3.41E-12 m $s^{-1}$ of the *Base* scenario, but because $K_{eff}^{stack}$ could be lower than this, the lower bound is set to

$$a^{IWF} = \min\left(3.41E - 12\ m\ s^{-1}, K_{eff}^{stack}\right).$$

Finally, in consistence with the discretization for the *Degraded water flux* in Table 3, the range $[a^{IWF}, K_{eff}^{stack}]$ is cut at $m^{IWF}$, that is, approximately 60% of this range on a logarithmic scale.

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