

Atoll Freshwater Lens Tool

Users' Guide

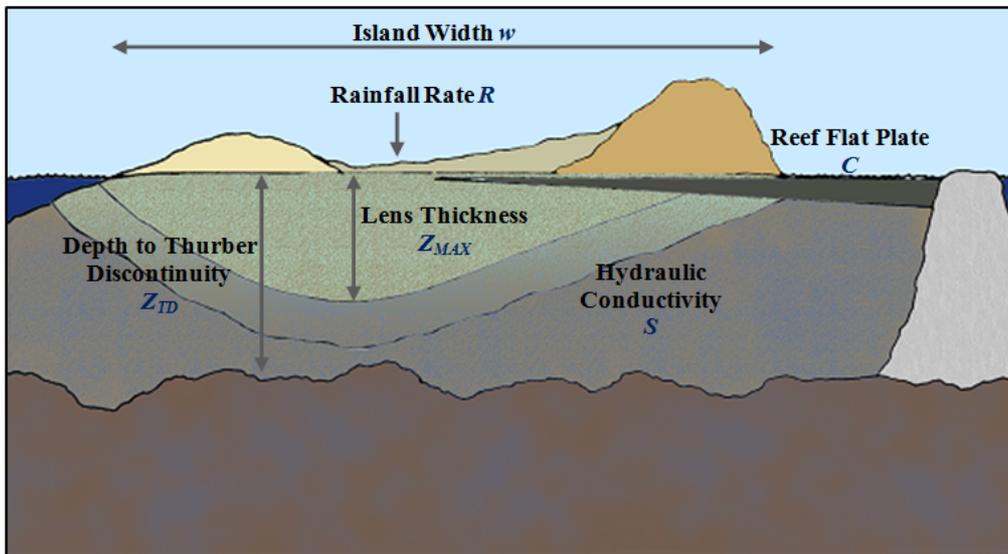
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1. Overview

The *Atoll Freshwater Lens Tool* spreadsheet was designed to automate the atoll freshwater lens algebraic model, which calculates the thickness of the freshwater lens based on island width, upper aquifer hydraulic conductivity, annual rainfall rate, depth to the Thurber Discontinuity, presence of the reef flat plate, and transient recharge conditions. The island features and associated model parameters that will be discussed are presented in the following figure.



Specifically, the spreadsheet tool automates the following equations, given the island characteristics provided by the user:

$$L = y_0 + (Z_{TD} - y_0)(1 - e^{-cw}) \quad (1)$$

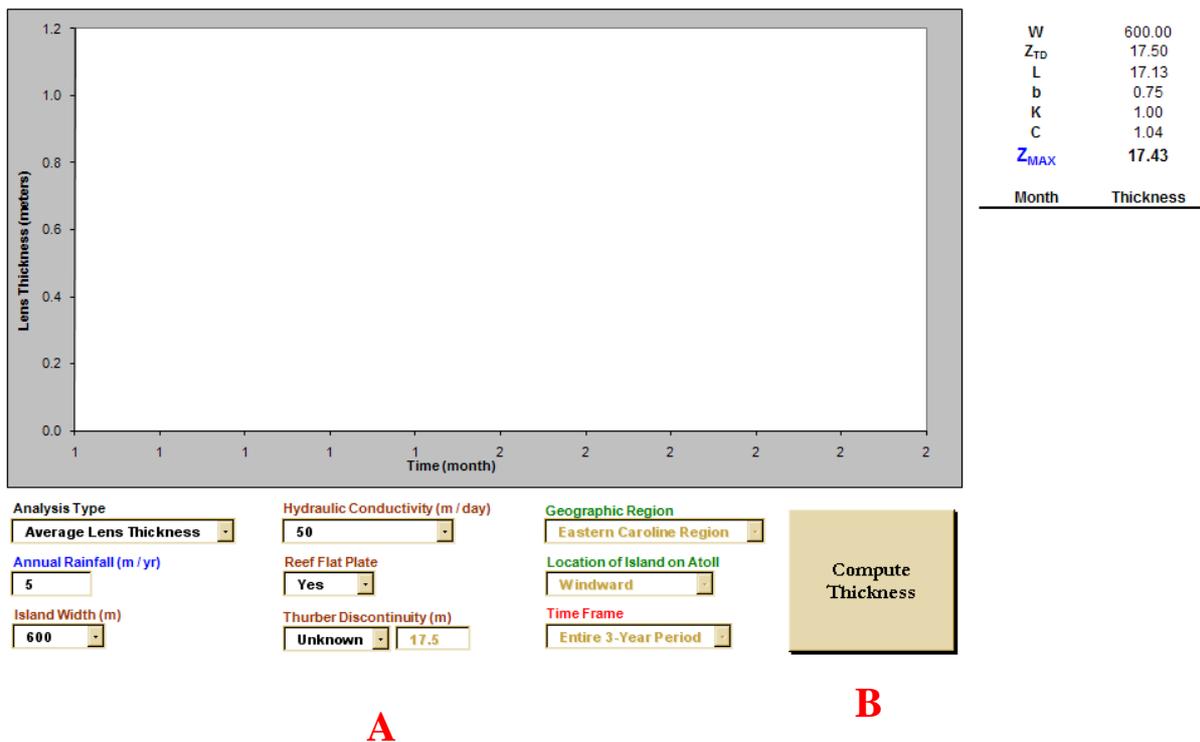
$$Z_{MAX} = L(1 - e^{-bR})SCD \quad (2)$$

The value L is the maximum possible lens thickness given the width of the island, w , and the depth to the Thurber Discontinuity, Z_{TD} . The value Z_{MAX} is the thickness of the lens in the middle of the island, given L , calculated in equation 1; the annual rainfall rate, R ; and scaling parameters S , C and D , associated with upper aquifer hydraulic conductivity, the presence of the reef flat plate, and effects of transient recharge rates, respectively.

2. Spreadsheet User Interface

The spreadsheet consists of 4 sheets:

- Sheet 1: **Enter Data:** enter island and rainfall data, and view results
- Sheet 2: **Parameters:** values for the K , b , and C parameters
- Sheet 3: **Seasonal:** values for the seasonal variation parameter
- Sheet 4: **El Nino:** values for the drought parameter



The user interface, on the Enter Data sheet, is presented in the above figure. There are 5 main parts to the interface:

- A** Controls that allow the user to specify the attributes of the island hydrology, geology, and geography
- B** The *Compute Thickness* button, which calculates the lens thickness using equations 1 and 2.

- C** Output of the parameter values used in the algebraic model, and the resulting steady-state lens thickness.
- D** Output of the lens thickness through the time for either a seasonal period or an El Nino period.
- E** Display of the fluctuation of the lens through time for either a seasonal period or an El Nino period.

3. Steady-State Calculations

For steady-state calculations, the user enters the following data:

- **Analysis Type:** select *Average Lens Thickness*
- **Annual Rainfall:** enter an annual rainfall rate, in $m\ yr^{-1}$.
- **Island Width:** enter the width of the island, in m .
- **Hydraulic Conductivity:** enter the actual hydraulic conductivity of the upper aquifer, in $m\ day^{-1}$. If not known, use $50\ m\ day^{-1}$ if the island is on the leeward side of the atoll and $400\ m\ day^{-1}$ if the island is on the windward side of the atoll.
- **Reef Flat Plate:** is the reef flat plate is present on the island, select *Yes*. Otherwise, select *No*.
- **Thurber Discontinuity:** if known, select *Known*, and then enter the depth to the Thurber Discontinuity in m . Otherwise, select *Unknown*, and the program will use the default value of $17.5\ m$.

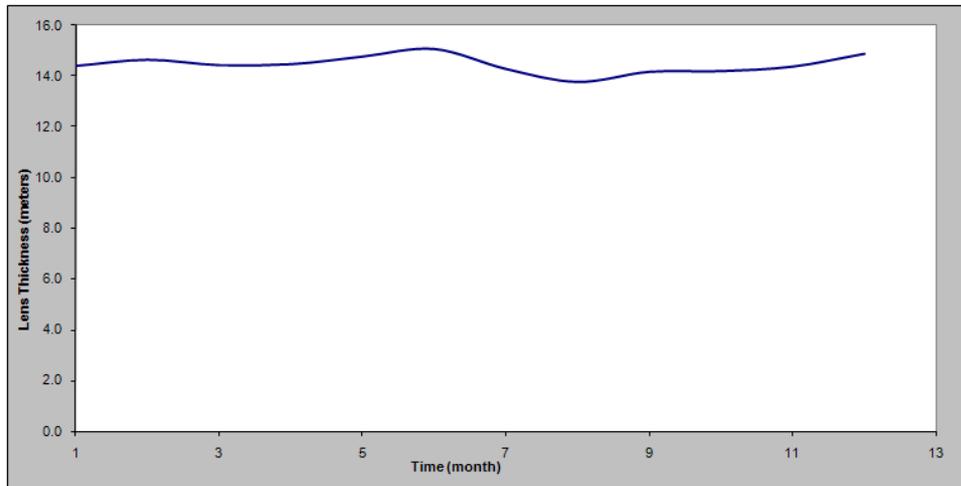
Push the *Compute Thickness* button. The algebraic model parameters will appear in the C part of the user interface, along with the computed lens thickness.

4. Transient Calculations

For lens thickness fluctuation during a typical year, enter the following data:

- **Analysis Type:** select *Seasonal Variation*. Notice that the *Geographic Region* and *Location of Island on Atoll* controls are now active.
- Enter data for rainfall rate, island width, hydraulic conductivity, reef flat plate, and Thurber Discontinuity depth.
- **Geographic Region:** select either *Eastern Caroline Region* or *Western Caroline Region*. The Eastern Caroline Region represents rainfall rates typical of Pohnpei (high rainfall) and the Western Caroline Region represents rainfall rates typical of Yap (moderate rainfall).
- **Location of Island on Atoll:** enter either *Windward* or *Leeward*.

Push the *Compute Thickness* button. In addition to outputting the algebraic model parameters, the lens thickness throughout the 12 months of the year are output in section **D**, and a graph of the follows is shown in section **E** (figure below).



W 600.00
 Z_{TD} 17.50
 L 17.13
 b 0.75
 K 1.00
 C 1.04
Z_{MAX} 15.96

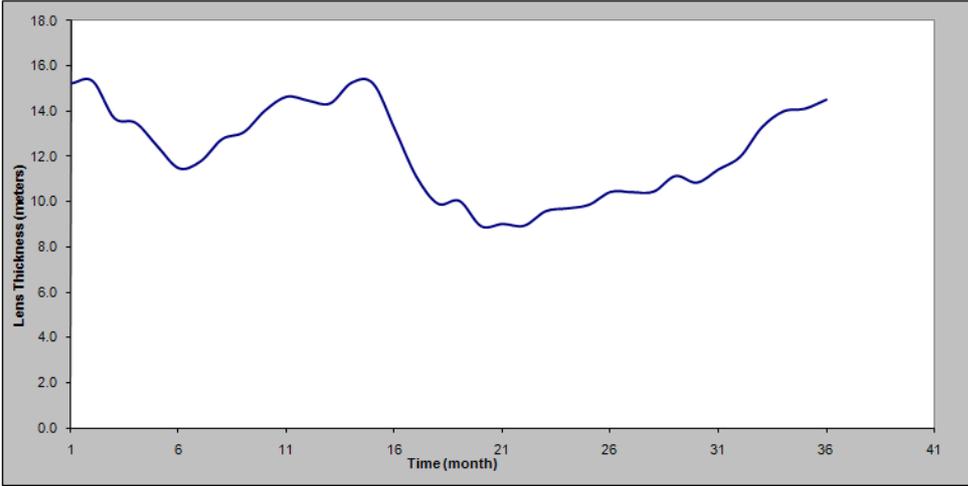
Month	Thickness
Jan	14.398
Feb	14.644
Mar	14.428
Apr	14.467
May	14.775
Jun	15.080
Jul	14.273
Aug	13.753
Sep	14.160
Oct	14.186
Nov	14.371
Dec	14.888

Analysis Type Seasonal Variation	Hydraulic Conductivity (m / day) 50	Geographic Region Western Caroline Region	Compute Thickness
Annual Rainfall (m / yr) 3	Reef Flat Plate Yes	Location of Island on Atoll Leeward	
Island Width (m) 600	Thurber Discontinuity (m) Unknown 17.5	Time Frame Entire 3-Year Period	

For lens thickness fluctuation during an El Nino event, enter the following data:

- **Analysis Type:** select *El Nino Period*. Notice that the *Time Frame* control now becomes active.
- Enter data for rainfall rate, island width, hydraulic conductivity, reef flat plate, and Thurber Discontinuity depth.
- **Geographic Region:** select either *Eastern Caroline Region* or *Western Caroline Region*. The Eastern Caroline Region represents rainfall rates typical of Pohnpei (high rainfall) and the Western Caroline Region represents rainfall rates typical of Yap (moderate rainfall).
- **Location of Island on Atoll:** enter either *Windward* or *Leeward*.
- **Time Frame:** The El Nino period consists of 3 years: the El Nino year, the Post-El Nino year, and the Recovery year. Any or all of these periods can be selected for display.

Push the *Compute Thickness* button. In addition to outputting the algebraic model parameters, the lens thickness throughout the time frame selected are output in section **D**, and a graph of the follows is shown in section **E** (figure below).



W 600.00
Z_{TD} 17.50
L 17.13
b 0.75
K 1.00
C 1.04
Z_{MAX} 15.96

Month	Thickness
Jan	15.233
Feb	15.333
Mar	13.699
Apr	13.482
May	12.452
Jun	11.475
Jul	11.782
Aug	12.765
Sep	13.073
Oct	14.040
Nov	14.645
Dec	14.468
Jan	14.344
Feb	15.263
Mar	15.223
Apr	13.204
May	11.108
Jun	9.908
Jul	10.029
Aug	8.910
Sep	9.012
Oct	8.936
Nov	9.577
Dec	9.700

Analysis Type El Niño Period	Hydraulic Conductivity (m / day) 50	Geographic Region Western Caroline Region	Compute Thickness
Annual Rainfall (m / yr) 3	Reef Flat Plate Yes	Location of Island on Atoll Leeward	
Island Width (m) 600	Thurber Discontinuity (m) Unknown 47.5	Time Frame Entire 3-Year Period	