

Morton's Evaporation Calculation Tool Instructions

Alberta Environment and Protected Areas originally developed an Excel VBA Morton's monthly evaporation tool converted from FORTRAN based on Morton's evaporation method. The Morton's Excel VBA tool was later modified to compute weekly shallow lake evaporation. This version of the tool builds upon the original Morton's VBA tool to provide updated daily, weekly and monthly Morton's evaporation rates for townships across Alberta, using the ACIS gridded township gap-filled QaQc climate data.

This guide has two parts:

- 1) Tutorial Walk-thru showing how to use the tool to generate and export monthly, weekly and daily Morton's shallow-lake evaporation rates for a township that has the necessary ACIS climate data. If a reservoir has been added to the "ReservoirTable" worksheet, daily, weekly and monthly Morton's deep lake evaporation rates may also be generated.
- 2) Deep lake evaporation methodology.

Part 1: Walk-Thru with Example

The tool opens with a splash screen (Fig 1) which displays the current version. Select "START" to proceed.

Figure 1.



Following the splash screen, a disclaimer notice will pop-up. The purpose of this notice is to alert users to the fact that much of the data resources used for and derived from Morton's Tool are subject to seasonal variability and should be treated as informed estimates. In the case of certain parameters, such as Total Dissolved Solids for example, numbers are derived from seasonal averages, or the most recent data. The recency and availability of this data is informed by site specific monitoring efforts, and this may vary based on capability and priority. Users should keep in mind that data derived from Morton's Tool should be treated with caution, as these calculations are meant to be an informed estimate, not an absolute guarantee. Additionally, this tool and the use of Morton's Method is one of many existing methods to calculate evaporation, the intent of this tool is not to say that Morton's Method is the best formula, the most accurate, or the only option to calculate evaporation in Alberta. To continue using this tool and accept these terms, click the "ACCEPT" button as seen below in figure 1.1.

Figure 3.
Data Import

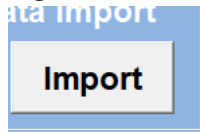


Figure 3.1.

Import ACIS Daily Climate data

1. Download 2. Extract 3. Import

Township: Range: Meridian:

Reservoir:

From: To:

Append (Optional) Cancel

Figure 4.

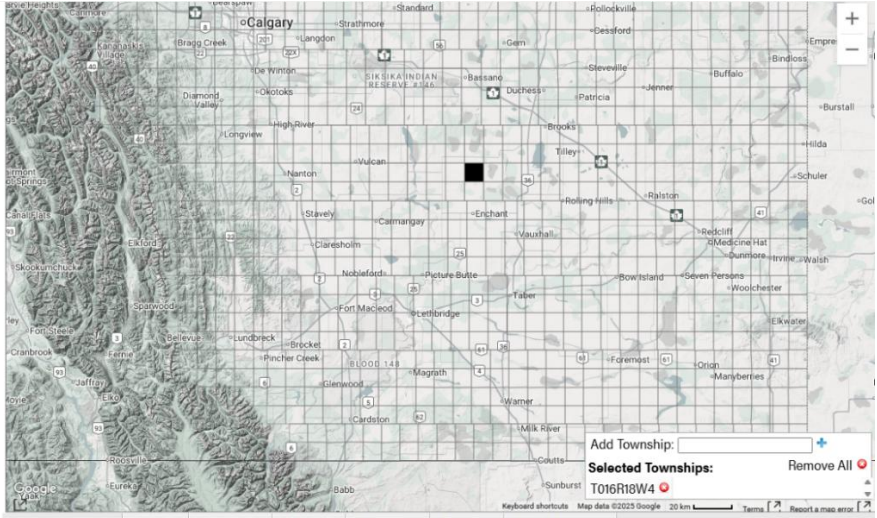


Figure 5.

Selected Townships: T016R18W4 Remove All

Zoom to Region: Peace Northern Central Southern Alberta Your Location

Ready to graph or display data.

Data Interval: Period Start: Period End:

Legend:

- township with data but without a period and/or element choice made
- selected township without a period and/or element choice made
- township with available interpolated data
- township with one or more records unavailable in a given year
- township with missing interpolated data
- selected township with available interpolated data
- selected township with township with one or more records unavailable in a given year
- selected township with missing interpolated data

Element(s):

- Air Temp. Avg. (°C)
- Air Temp. Min. (°C)
- Air Temp. Max. (°C)
- Relative Humidity Avg. (%)
- Precip. (mm)
- Precip. Accumulated (mm)
- Modelled Snow Water Equiv. (mm)
- Incoming Solar Rad. Total (MJ/m2)
- Modelled Incoming Rad. Total (MJ/m2)
- Wind Speed 10 m Avg. (km/h)
- Include Interpolation Flags (Table/CSV)

Interactive Graph Graph Data Table Download CSV

Ensure the data aggregation interval is “Daily” (Fig 5.). Adjust the Daily Period Start Date to your preferred date; in this example it is set to begin at 2015-01-01. Modify the end data if required. Select the required ACIS climate parameters for Morton’s evaporation calculation (Fig 5.).

To conduct Morton’s calculation, the key elements are:

- Air Temp Min.
- Air Temp Max.
- Relative Humidity
- Precip. (mm)
- Solar Radiation

There are two options for Incoming Solar Radiation parameters:

1. Incoming Solar Rad. Total (MJ/m2)
2. Modelled Incoming Rad. Total (MJ/m2).

Option 1 is the solar radiation interpolated from nearby climate stations with recorded solar radiation data.

Option 2 is the estimated solar radiation derived from [maximum and minimum temperatures](#). Recommend using Option 1) if interpolated solar radiation data is available for the township location and period of record of interest otherwise use Option 2). Either option may be imported into the Morton’s Evaporation tool for processing.

However, be sure to only select **ONE** of these options, **NOT BOTH**.

Once you have selected your elements of interest, users have the option to ensure all selected elements are “available” for the given township and time-period. To check the availability of this data prior to downloading, click the **Interactive Graph** button which can be seen in the **bottom left corner of figure 5**. Once selected, you will see a graph representing the selected elements. Figure 5.1 displays a selected township with all elements available for the selected timeframe.

Figure 5.2 displays the same township but with a longer timeframe, and with a missing element, Incoming Solar Radiation in this case. If the timeframe of interest results in missing elements it is necessary to adjust accordingly. In this case, it is possible to **select Modelled Incoming Rad.**, and **un-select Incoming Solar Rad.** to result in a complete data series. However, if an element such as **Relative Humidity (RH)** is missing, this will require adjusting the timeframe or area of interest accordingly, as **RH is necessary** to run the calculation. If a user imports a dataset missing RH data, once the Morton’s Calculation stage is reached in the tool, an error notice will occur prompting the user to analyze their dataset for completeness.

Figure 5.1

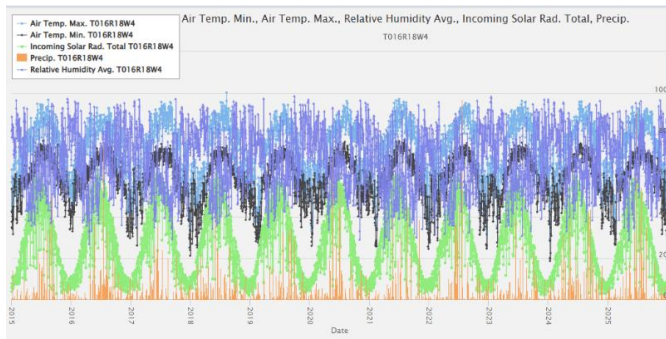
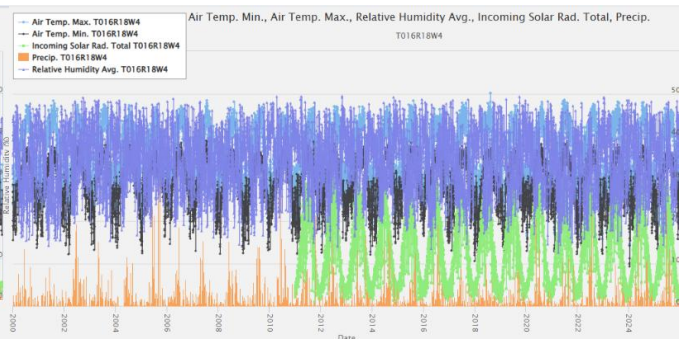


Figure 5.2

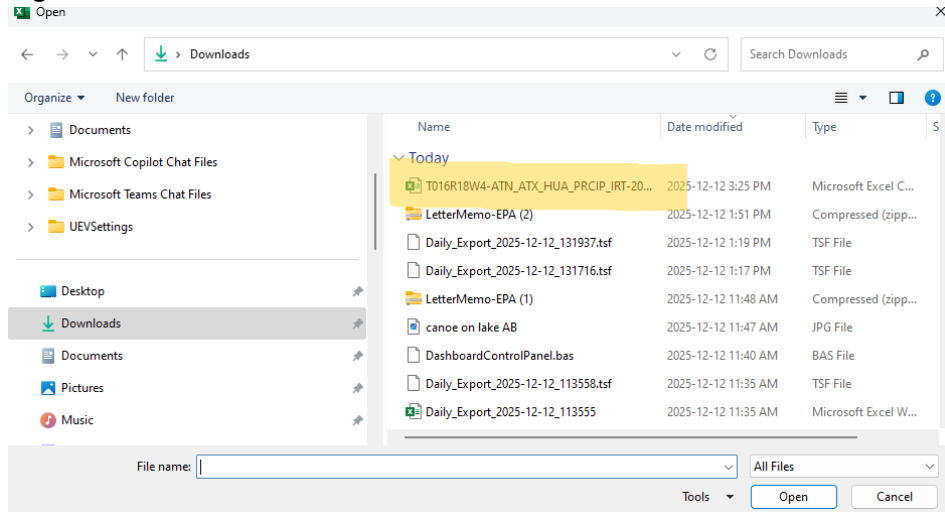


After these elements have been enabled, you may select download as CSV in the bottom right corner (Fig. 5.). Your data has now been added to your downloads folder.

Note: If the wrong “Elements” checkboxes have been selected this will generate an error when importing the data into the Morton’s evaporation tool.

Next, in Morton’s Evaporation Tool, extract the data from your system by selecting “Extract” in the Import Form. This will automatically direct you to your local downloads folder. Select the file, which will be displayed similarly to the highlighted file below in figure 6., select “Open” and then click “Import” in the Import Form.

Figure 6.

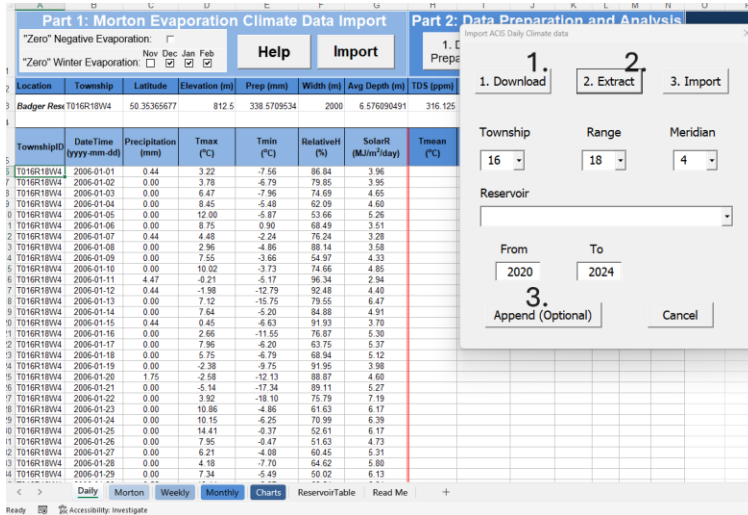


Selecting “Import” will populate Part 1 of the daily sheet. Click “OK” on the notice.

Appending Data – Optional

If you are working with a particular date range for any given township, and want to include more data from this site, prior to your analysis, there is an option to “Append” data to the data set. Simply follow the above steps on the “Import” form, select your new date range from your township, either pre or post your current data set, download as CSV, extract and then select “Append”. Note, that the data set must be continuous with your current set, not replicating, or missing dates. For example, if you have an original data set from 2006-01-01 – **2020-05-20**, and you want to add data up until 2024, the new data extracted from the ACIS website must be entered as: **2020-05-21** – 2024-XX-XX. Once you have the appropriate date range extracted from downloads, you will select the “Append” Button, as opposed to “Import” Steps are visually outlined and can be seen below in figure 6.1.

Figure 6.1.



Step 2: Data Preparation and Analysis

Depending on the Township selected, there may be the option to conduct a Deep Lake Evaporation Calculation. Below, in figure 7., is an example of a township that is not in the Reservoir Table. After importing your data, you may notice there are sections that say, “Not Found”, this is because the ACIS website does not store reservoir information. This information is **NOT** necessary for conducting *Shallow Lake Evaporation*, and is only necessary if you are going to conduct a *Deep Lake Evaporation calculation*. Information for the existing list of reservoirs in Morton’s Tool can be found in the “ReservoirTable” sheet. If you are selecting a Township site that is not in the Reservoir table, your **Location, Width, Avg Depth and TDS** parameters will look like figure 7. below. If there is no available reservoir information for this section, you will skip the Deep Lake Evaporation Calculation step.

However, if you have chosen a Township that **IS** in the ReservoirTable sheet, this information will be recognized in the “Daily” sheet, and these sections will be automatically populated with the specific parameters, as seen below in figure 7.1. Additionally, there is a drop-down option under cell B3 – “Township” which will allow you to toggle between different townships, automatically populating these cells.

Figure 7.

Location	Township	Latitude	Elevation (m)	Prep (mm)	Width (m)	Avg Depth (m)	TDS (ppm)	Remarks
Not Found	T016R04W4	50.35347366	768.9719849	337.5712891	Not Found	Not Found	Not Found	

Figure 7.1

Location	Township	Latitude	Elevation (m)	Prep (mm)	Width (m)	Avg Depth (m)	TDS (ppm)	Remarks
Badger Rese	T016R18W4	50.35365677	812.5	338.5709534	2000	6.576090491	316.125	

Notes Regarding Deep Lake Evaporation Calculations

Note 1: If you are only conducting shallow lake evaporation, you do not need Deep Lake parameters, and you will skip this step. If you attempt to run Deep Lake Evaporation without these parameters, you will receive a “Missing Parameters” notification and will be prompted to continue with the Shallow Lake Evaporation process.

Note 2: There is data for additional reservoirs in Alberta, beyond the sites that are included in the reservoir table in this tool. If you are using Morton’s Tool and want to add reservoir data, this data can be added in the “ReservoirTable” in empty rows below the existing data, and by following the same format of the previously listed sites. Data for additional reservoirs may be found at the Government of Alberta [Water Quality Data Portal](#). To search for specific reservoirs, select parameters necessary to calculate TDS, and download reservoir data, follow the steps laid out in the [Water Quality Data Portal Guide](#). Clicking on this link will open these instructions in a separate document.

Step 2: Preparation and Analysis Process Continued

After the daily climate data has been loaded it may be aggregated into a **monthly time-series** required for Morton’s computations. First select the appropriate checkboxes indicating how to process winter ET rates. The current default is to “zero” out (disable) all winter ET from November to February inclusive (Fig 8.).

Morton’s equations require monthly climate data. To aggregate the ACIS daily climate data to monthly values select the [Data Preparation](#) button on the “Daily” worksheet (Fig 9.). There is no message while processing however the cursor will turn into a spinning wheel. Be patient, depending upon the number of years being processed, this step could take awhile to complete.

Figure 8.

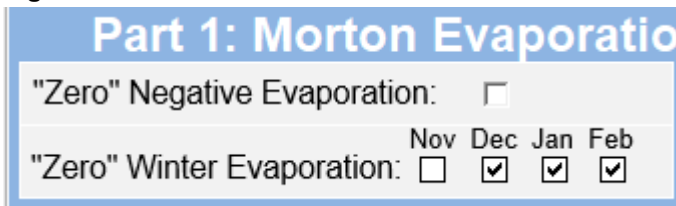


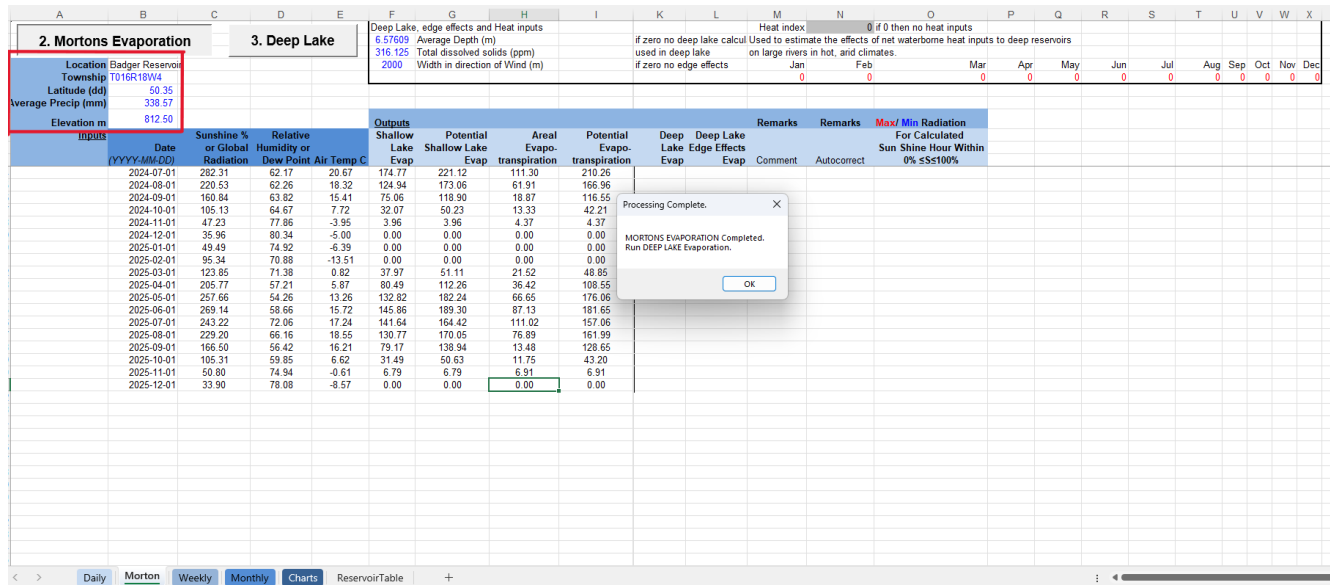
Figure 9.

Location	Township	Latitude	Elevation (m)	Prep (mm)	Width (m)	Avg Depth (m)	TDS (ppm)	Remarks
Badger Res	T016R18W4	50.35365677	812.5	338.5709534	2000	6.576090491	316.125	

Once the daily climate data has been processed a message is displayed and the Morton's evaporation panel will automatically be opened. Once the "OK" button is selected (Fig 10.). Now, the climate data is ready for processing Monthly Morton's evaporation rates. Select the Morton's Evaporation Button.

Morton's computation requires project location latitude, average annual precipitation and elevation for the township centroid. This information is populated automatically for the township location (Fig 10). If the land location is a pre-existing reservoir setup in the *ReservoirTable*, the Morton deep lake evaporation parameters will also be extracted from the "Daily Sheet".

Figure 10.



A message is displayed when Morton's evaporation processing is completed (Fig 10). If there are no Deep Lake evaporation parameters for this location a pop-up window directs back to the "Daily" worksheet to compute daily and weekly evaporation rates based on a linear interpolation of the mid-monthly evaporation rates. However, if Deep Lake evaporation parameters are found, the message indicates that Deep Lake processing may proceed.

When Morton's monthly evaporation computations are complete the "Daily" worksheet is displayed. The final step is to aggregate the Morton's evaporation data into Daily, Weekly and Monthly time-series. From the "Daily" worksheet, click the "Daily Evaporation" button (Fig 11) followed by the "Weekly Evaporation" button. Once "Weekly Evaporation" has been completed, "Monthly Evaporation" will have automatically been calculated as well. The Morton's evaporation rates for "Daily", "Weekly" and "Monthly" time-series may be found on the respective worksheet tabs.

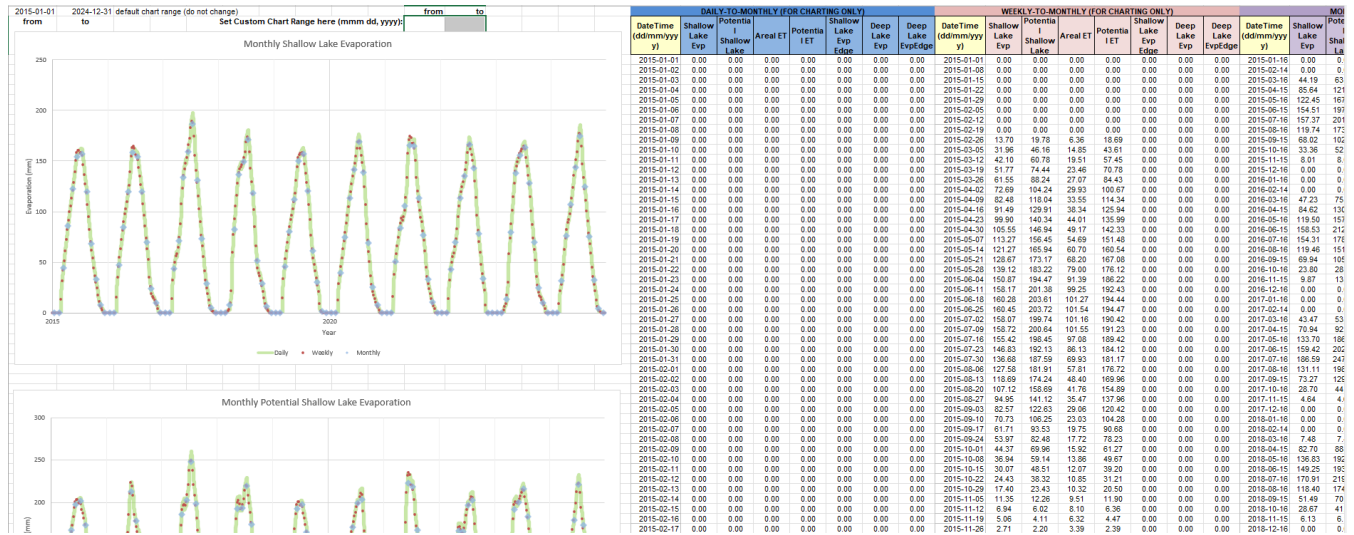
The "Charts" worksheet plots each of the Morton's evaporation parameters as a monthly rate. The daily and weekly rates are converted to an equivalent monthly value for charting/comparison purposes.

Figure 11.



Once all sheets have been processed, you may analyze or export the charted data in the “Charts” sheet (Fig. 12.).

Figure 12.



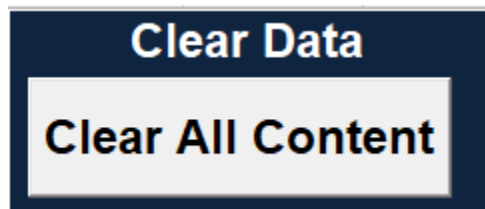
Finally, data can be exported to Excel or TSF format from the “Daily”, “Weekly”, and “Monthly” Sheet (Fig 13.). By clicking the “Export” button on the top right of each worksheet, the dataset will be automatically exported to your local downloads folder.

Figure 13.



NOTE: Once you have completed your analysis, or if you want to research a new date range or township, select “Clear Contents” on the Daily sheet (Fig 14.). “Clearing All Content” is a **NECESSARY** step that will set the user up to work on future evaporation calculations and will prevent cross-contamination of data.

Figure 14.



This concludes the data preparation and analysis component of this tutorial.

Part 2: Deep Lake Evaporation Methodology

The following strategy recommends how to incorporate shallow lake evaporation processed, to estimate deep lake evaporation using the Morton's Evaporation VBA Tool.

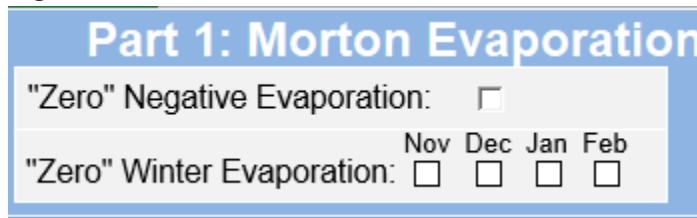
Regardless of if estimating shallow or deep lake evaporation, a wet surface is required for non-zero ET processes to occur. Due to Alberta's continental climate, with winter sub-zero temperatures, water transforms from a liquid (wet) into a solid (ice) typically through the month of November. Typically, by December 1, most of Alberta's lakes are completely froze-over, this may also include deep lakes. Therefore, it follows when Alberta lakes freeze-over, $ET=0$ regardless of the type of Morton's evaporation being estimated including deep lake evaporation.

Although it is recommended to 'zero' Morton's ET for November, this does not apply to Morton's deep lake evaporation. Alberta deep waterbodies do not typically freeze in November due to the latent heat-energy accumulated through the warm summer months and therefore would have a non-zero deep lake evaporation for November. The following steps explain how to use the Morton's daily evaporation tool to estimate deep lake evaporation.

Estimating Morton's deep lake evaporation requires first computing the shallow lake evaporation.

Load the waterbody climate data and deep lake evaporation parameters using the Morton's daily evaporation tool. Ensure all "Zero" check boxes are "unchecked" (Fig 15).

Figure 15.



The screenshot shows a software interface titled "Part 1: Morton Evaporation". It contains two rows of options, each with a label and a checkbox. The first row is labeled "'Zero' Negative Evaporation:" and has a single checkbox that is unchecked. The second row is labeled "'Zero' Winter Evaporation:" and has four checkboxes corresponding to the months "Nov", "Dec", "Jan", and "Feb", all of which are unchecked.

Option	Nov	Dec	Jan	Feb
"Zero" Negative Evaporation:	<input type="checkbox"/>			
"Zero" Winter Evaporation:	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Proceed with estimating Morton's shallow lake. Note the non-zeroed and negative winter evaporation rates (Fig 16). This is OK.

Figure 16.

2. Mortons Evaporation		3. Deep Lake		Deep Lake, edge effects and Heat inputs		Heat index				
Location	Badger Reservoir			6.57609	Average Depth (m)	if zero no deep lake calcul	Used to estimate the effects of net waterborne heat inputs			
Township	T016R18W4			316.125	Total dissolved solids (ppm)	used in deep lake	on large rivers in hot, arid climates.			
Latitude (dd)	50.35			2000	Width in direction of Wind (m)	if zero no edge effects	Jan Feb Mar			
Average Precip (mm)	338.57						0 0 0			
Elevation m	812.50									
Inputs				Outputs				Remarks	Remarks	Max/Min Radiation
Date	Sunshine % or Global Radiation	Relative Humidity or Dew Point	Air Temp C	Shallow Lake Evap	Potential Shallow Lake Evap	Areal Evapo-transpiration	Potential Evapo-transpiration	Deep Lake Evap	Deep Lake Edge Effects Evap	For Calculated Sun Shine Hour Within 0% ≤S≤100%
2016-01-01	51.27	80.41	-6.72	-1.87	-1.87	-1.43	-1.43	6.00	6.00	
2016-02-01	84.14	70.95	0.54	17.53	19.04	15.33	16.83	5.00	5.00	
2016-03-01	143.34	61.25	3.64	47.23	75.78	16.97	66.15	20.00	22.00	
2016-04-01	202.74	52.41	8.73	84.62	130.22	25.20	127.76	55.00	57.00	
2016-05-01	241.70	58.79	11.38	119.50	157.75	66.91	151.68	92.00	94.00	
2016-06-01	286.44	53.83	16.92	168.53	212.95	86.42	205.27	124.00	127.00	
2016-07-01	261.76	70.92	17.91	154.31	178.67	121.11	170.23	149.00	150.00	
2016-08-01	214.53	69.09	17.29	119.46	151.75	77.99	146.61	147.00	147.00	
2016-09-01	163.86	65.07	12.26	69.94	105.82	22.56	102.97	112.00	112.00	
2016-10-01	85.25	78.33	4.35	23.80	28.07	20.00	23.63	63.00	62.00	
2016-11-01	55.69	70.46	4.13	9.87	13.37	3.87	13.89	22.00	22.00	
2016-12-01	44.40	72.54	-11.55	-0.18	-0.18	0.38	0.38	5.00	5.00	
2017-01-01	50.70	76.90	-8.68	-0.44	-0.44	0.05	0.05	4.00	4.00	
2017-02-01	83.37	78.54	-6.27	4.53	4.53	4.53	4.53	4.00	4.00	
2017-03-01	152.75	69.18	-1.35	43.47	53.10	28.20	50.83	17.00	18.00	
2017-04-01	181.86	66.52	5.96	70.94	92.17	40.23	88.35	52.00	53.00	
2017-05-01	258.33	52.93	13.49	133.70	186.20	64.06	180.32	93.00	96.00	
2017-06-01	289.77	58.40	16.36	159.42	202.79	99.38	193.53	124.00	127.00	
2017-07-01	305.82	54.66	20.35	186.59	247.85	104.50	237.35	149.00	152.00	
2017-08-01	234.57	52.91	18.24	131.11	198.86	45.15	194.46	147.00	149.00	
2017-09-01	167.56	54.65	13.17	73.27	129.30	12.86	118.14	112.00	113.00	
2017-10-01	97.73	61.29	5.77	28.70	44.55	12.45	38.14	63.00	62.00	
2017-11-01	60.53	77.15	-4.68	4.64	4.64	4.54	4.54	22.00	21.00	
2017-12-01	41.63	70.03	-8.22	2.50	2.50	2.97	2.97	5.00	5.00	
2018-01-01	58.48	77.31	-8.32	-0.66	-0.66	-0.26	-0.26	4.00	4.00	
2018-02-01	103.48	76.07	-15.37	0.67	0.67	1.12	1.12	4.00	4.00	
2018-03-01	170.24	85.12	-7.52	7.48	7.48	7.46	7.46	17.00	17.00	
2018-04-01	229.72	70.46	1.46	82.70	88.88	68.46	83.38	52.00	53.00	
2018-05-01	256.48	53.08	14.84	136.83	192.72	63.60	186.95	93.00	96.00	
2018-06-01	271.09	58.77	16.44	149.25	193.83	89.18	185.95	124.00	126.00	
2018-07-01	288.54	59.21	18.73	170.91	219.55	104.31	209.35	149.00	151.00	
2018-08-01	211.74	58.64	17.79	118.40	174.10	47.57	169.87	147.00	148.00	

Before running the Deep Lake evaporation computation check the “Zero” Winter Evaporation check boxes for Dec, Jan and Feb (Fig 17). Leave November unchecked, as explained above, non-zero November ET is valid for deep lake evaporation estimates however from December through to February all Alberta lakes, are generally frozen and would have ET=0.

Note: only check “Zero” Negative Evaporation box, if the data is to be used for modelling purposes.

Figure 17.

Part 1: Morton Evaporation Climate Data Import

"Zero" Negative Evaporation:

"Zero" Winter Evaporation: Nov Dec Jan Feb

Help

Import

Run the Deep Lake evaporation computation. Note the results show no negative deep lake evaporation, there is a non-zero November evaporation, and December through to February deep lake evaporation is zero (Fig 18). This strategy should provide the required deep lake evaporation estimates.

Figure 18.

2. Mortons Evaporation		3. Deep Lake			Deep Lake, edge effects and Heat inputs						
Location	Badger Reservoir				6.57609	Average Depth (m)					if zero no deep lake calcu
Township	T016R18W4				316.125	Total dissolved solids (ppm)					used in deep lake
Latitude (dd)	50.35				2000	Width in direction of Wind (m)					if zero no edge effects
Average Precip (mm)	338.57										
Elevation m	812.50										
Inputs					Outputs						
Date (YYYY-MM-DD)	Sunshine % or Global Radiation	Relative Humidity or Dew Point	Air Temp C	Shallow Lake Evap	Potential Shallow Lake Evap	Areal Evapo- transpiration	Potential Evapo- transpiration	Deep Lake Evap	Deep Lake Edge Effects Evap		
2016-01-01	51.27	80.41	-6.72	0.00	0.00	0.00	0.00	0.00	0.00		
2016-02-01	84.14	70.95	0.54	0.00	0.00	0.00	0.00	0.00	0.00		
2016-03-01	143.34	61.25	3.64	47.23	75.78	16.97	66.15	8.00	10.00		
2016-04-01	202.74	52.41	8.73	84.62	130.22	25.20	127.76	42.00	45.00		
2016-05-01	241.70	58.79	11.38	119.50	157.75	66.91	151.68	84.00	86.00		
2016-06-01	286.44	53.83	16.92	158.53	212.95	86.42	205.27	113.00	116.00		
2016-07-01	261.76	70.92	17.91	154.31	178.67	121.11	170.23	139.00	140.00		
2016-08-01	214.53	69.09	17.29	119.46	151.75	77.99	146.61	144.00	144.00		
2016-09-01	163.86	65.07	12.26	69.94	105.82	22.56	102.97	121.00	121.00		
2016-10-01	85.25	78.33	4.35	23.80	28.07	20.00	23.63	81.00	79.00		
2016-11-01	55.69	70.46	4.13	9.87	13.37	3.87	13.89	34.00	33.00		
2016-12-01	44.40	72.54	-11.55	0.00	0.00	0.00	0.00	0.00	0.00		
2017-01-01	50.70	76.90	-8.68	0.00	0.00	0.00	0.00	0.00	0.00		
2017-02-01	83.37	78.54	-6.27	0.00	0.00	0.00	0.00	0.00	0.00		
2017-03-01	152.75	69.18	-1.35	43.47	53.10	28.20	50.83	8.00	9.00		
2017-04-01	181.86	66.52	5.96	70.94	92.17	40.23	88.35	38.00	40.00		
2017-05-01	258.33	52.93	13.49	133.70	186.20	64.06	180.32	80.00	83.00		
2017-06-01	289.77	58.40	16.36	159.42	202.79	99.38	193.53	115.00	118.00		
2017-07-01	305.82	54.66	20.35	186.59	247.85	104.50	237.35	149.00	152.00		
2017-08-01	234.57	52.91	18.24	131.11	198.86	45.15	194.46	161.00	162.00		
2017-09-01	167.56	54.65	13.17	73.27	129.30	12.86	118.14	136.00	136.00		
2017-10-01	97.73	61.29	5.77	28.70	44.55	12.45	38.14	90.00	89.00		
2017-11-01	60.53	77.15	-4.68	4.64	4.64	4.54	4.54	38.00	37.00		
2017-12-01	41.63	70.03	-8.22	0.00	0.00	0.00	0.00	0.00	0.00		
2018-01-01	58.48	77.31	-8.32	0.00	0.00	0.00	0.00	0.00	0.00		
2018-02-01	103.48	76.07	-15.37	0.00	0.00	0.00	0.00	0.00	0.00		
2018-03-01	170.24	85.12	-7.52	7.48	7.48	7.46	7.46	4.00	4.00		
2018-04-01	229.72	70.46	1.46	82.70	88.88	68.46	83.38	24.00	26.00		
2018-05-01	256.48	53.08	14.84	136.83	192.72	63.60	186.95	72.00	76.00		
2018-06-01	271.09	58.77	16.44	149.25	193.83	89.18	185.95	115.00	118.00		
2018-07-01	288.54	59.21	18.73	170.91	219.55	104.31	209.35	143.00	146.00		
2018-08-01	211.74	58.64	17.79	118.40	174.10	47.57	169.87	149.00	150.00		

This concludes the Deep Lake Evaporation methodology component of this tutorial.