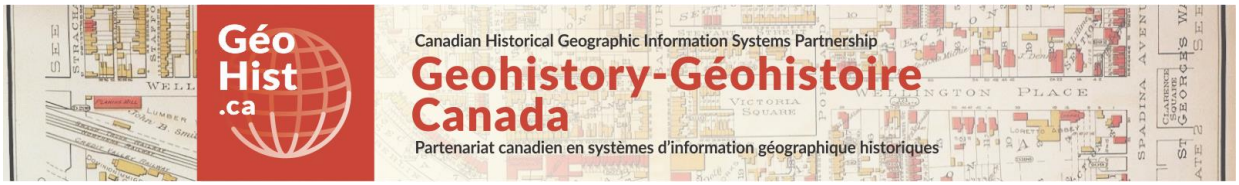


Development document for:
Lost Rivers of Toronto "Disappearing Rivers" web-map
Using: ArcGIS Online (AGOL) and hosted data, published to Canadian HGIS Portal
Link to webmap:
http://hgisportal.esri.ca/portal/apps/MapAndAppGallery/index.html?appid=3272511933fa41498201836717b41a27

REQUIREMENTS: A map of the city of Toronto showing the original hydrographic network of Toronto plotted from historical maps as early as 1802, and how those streams disappeared over time as they were buried for purposes of development, to arrive at the interrupted surface drainage pattern of today. Rivers should be symbolized by year last recorded on a map and a time slider UI tool used to show them disappearing over time. Historical map image showing surface geology for context should be incorporated with adjustable transparency.

Credits: Lost Rivers of Toronto Project, University of Toronto Map and Data Library, Canadian Historical GIS Partnership Development project, GIS and Cartography Office Dept. of Geography University of Toronto, Esri Canada.

Note: The ArcGIS Online documentation is extensive and comprehensive. Therefore many details will only be referenced to that documentation rather than explained in full here.

Approach: Decision made to use ArcGIS Online Web App Builder (WAB), with Time Slider Widget for the Disappearing Rivers functionality, and Layer list widget for image transparency. Two versions created, one with standard WAB Time Slider, and one with customized WAB Time Slider (hosted on independent server.)

Functionality
Mapping functionality: ArcGIS Online Web Map, with Time-Aware layer
Interface functionality: ArcGIS Online Web App Builder - Standard
ArcGIS Online Web App Builder - Custom (Developers Edition)
Historical background map image: ArcGIS Online tile layer (hosted) from ArcGIS Server image service

Map Data:
Overlay Mapping data: Disappearing Rivers: ArcGIS Online Feature layer (hosted)
Background Mapping data: Current rivers, Watersheds, Shoreline 1882:
Base map: Esri World Topo
Historical background map: Georeferenced map image as ArcGIS Server Map Service using tiles cached on server

Note re: Disappearing Rivers data compilation
The Feature layer appearing here as Disappearing Rivers is the result of a long process of research and compilation which should be credited primarily to Helen Mills of the Lost Rivers of Toronto Project, built upon the original efforts of Peter Hare, founder of Lost Rivers, and other volunteers. The first attempt at comprehensively mapping these streams resulted in a poster map: "Lost Rivers of the Downsview Lands and surrounding Toronto Area" produced by Helen Mills and Daniel Spring. The graphics files from this project were georeferenced and converted to ArcGIS shapefiles. The Map and Data Library (MDL) of the

University of Toronto edited and augmented these files with information about the dates individual sections of streams were last seen on historical maps of Toronto, from various map collections, including those of Nathan Ng and the MDL itself. With the help of Mills and Wilson, further compilation and editing took place in the GIS and Cartography Office of University of Toronto. The result is the current "Best Interpreted" version of the original hydrographic network of Toronto. There are many places remaining where this network could be enhanced and improved. It is hoped that the usefulness of the current version will spur and support ongoing efforts to expand and refine these data.

PRODUCTION NOTES
OVERLAY MAPPING DATA

ArcGIS desktop

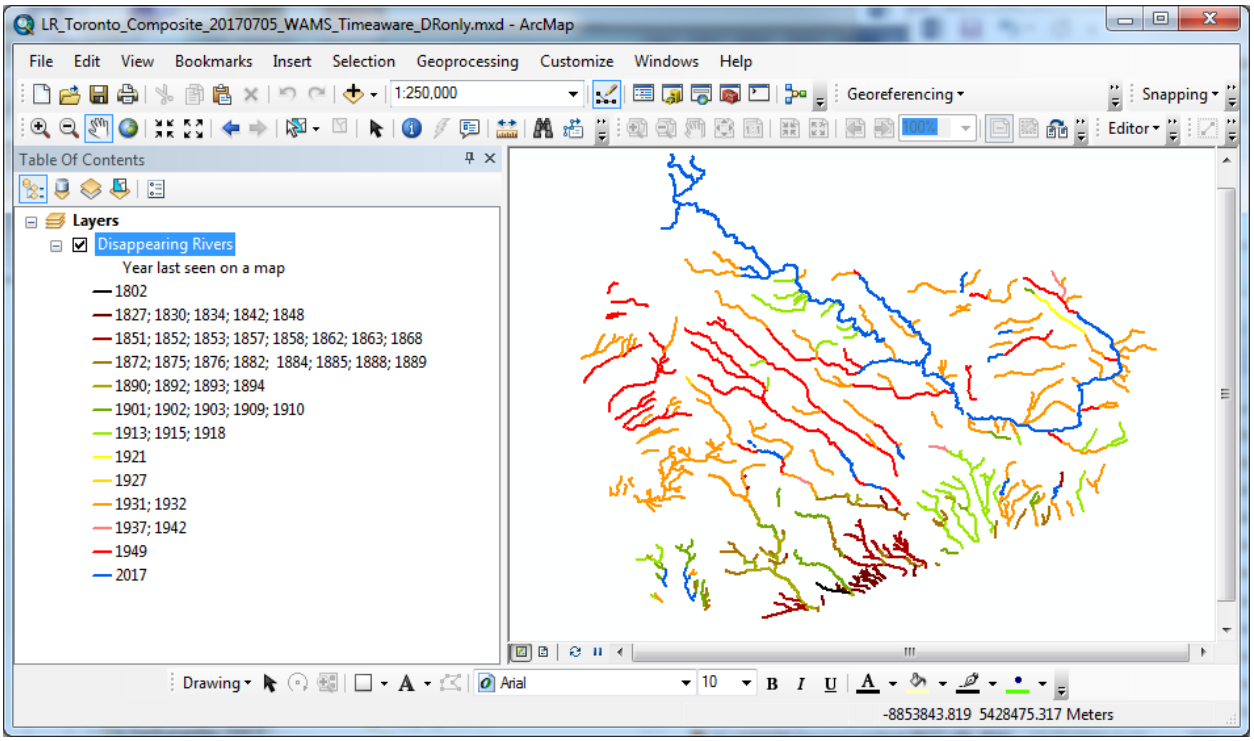
ArcMap was used to create and edit the lines for the Disappearing Rivers.

LINE FEATURES AND SYMBOLIZATION

Line Overlay Layers

Disappearing Rivers
Color: Colour-coded by year last seen on map
Web service: Feature layer: LR_Toronto_Composite_20170705_Time_DRonly
http://hgisportal.esri.ca/portal/home/item.html?id=c837fe78de4e4e91b78930771f1e3831

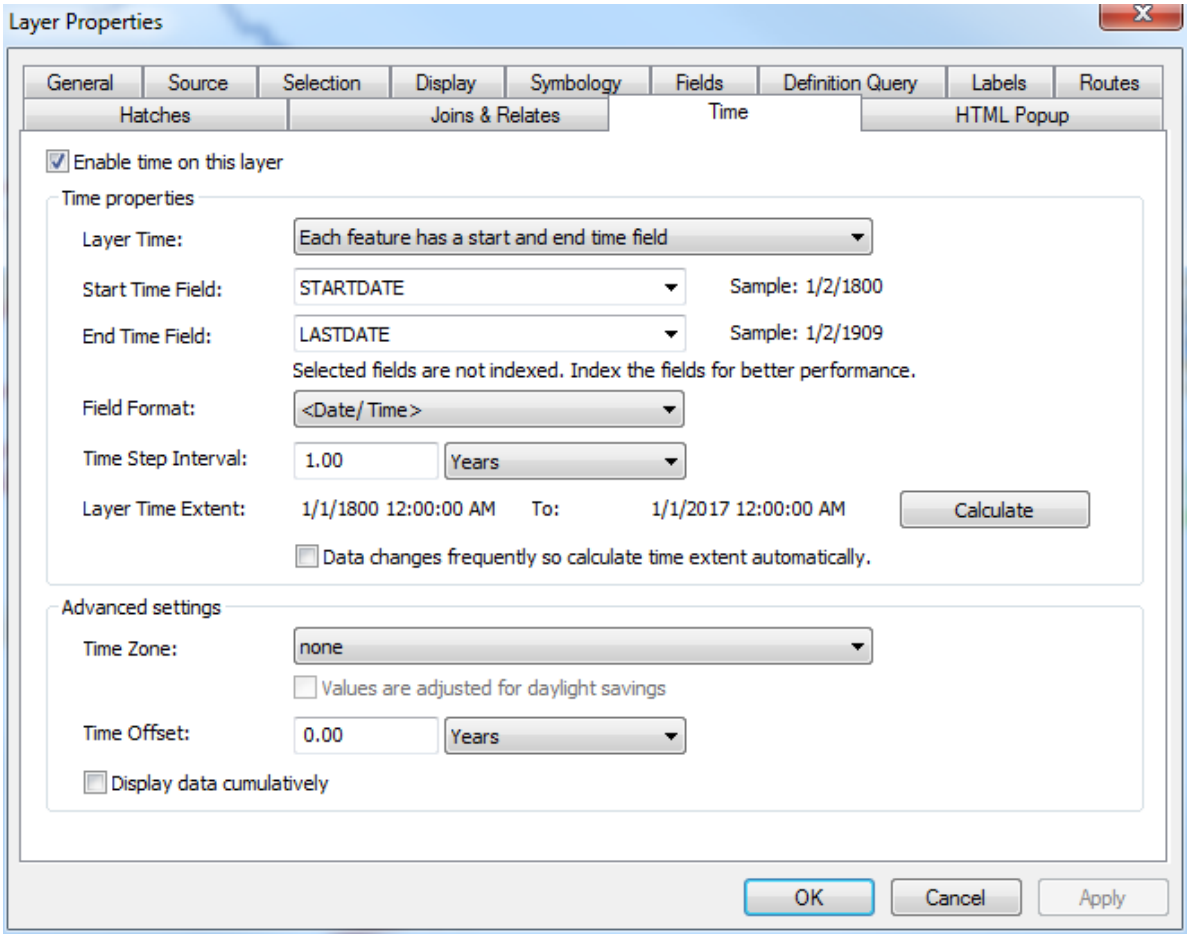
An ArcMap document was prepared to enable publishing web service with only the Disappearing Rivers layer in it. Colour coding is based on attribute values based on the value for field "lastNTS", grouped by time periods. See legend below. Colours were designed for contrast with base map and historical imagery and grouping was designed to show rivers by significant periods of development.



Attributes for line features (Disappearing Rivers)
Eight attribute fields are populated in this file but the only one used for symbolization is lastNTS:

lastNTS - Year last seen on map (Note: Integer, year - usually a NTS National Topographic System map)

The attribute fields used for the Time Aware properties on the layer are formatted as "Date" field.:
STARTDATE - Set for all at 1/1/1800 – later changed to 1/2/1800 (see **ISSUES** note below)
LASTDATE - Set for each line segment at 1/1/yyyy – later 1/2/yyyy (Note: yyyy same as lastNTS)



The layer in the document ArcMap document created to publish the Disappearing Rivers web service must be made Time Aware to work with the Time Slider. Time settings on Layer Properties are shown above. These are carried over to the pubished Feature Service.

ISSUES with Time-Aware Date Offset: To make a layer time aware, the relevant fields must be defined as type: DATE. When a field containing an integer YEAR value is converted to type DATE, it is formatted as MM/DD/YYYY. When a DATE field in published as a service to ArcGIS portal, it adjusts the date to account for the user's computer's time zone - therefore in North America it re-sets the date to the day previous, i.e. January 1, 1800 or 1/1/1800 becomes 12/1/1799. There are work-arounds, but to avoid this issue we recalculated the STARTDATE and LASTDATE fields to January 2 for each year or 1/2/1800 in the example above, by adding one day, using the VBSCRIPT syntax:

STARTDATE = DateAdd ("d", 1, [STARTDATE]).

Background Mapping data: Current rivers, Watersheds, Shoreline 1882
Published Map service: Map Image Layer (grouped feature layers drawn dynamically from the data)
LR_Toronto_Composite_20170814_NoTime_Dynamic
http://hgisportal.esri.ca/portal/home/item.html?id=4f5b2fc2455c4661bab1a36ec4b4baf5

Sources:
Current rivers persisting to 2017: City of Toronto / Open Data / Data catalogue/ Toronto Centreline (TCL)
https://www1.toronto.ca/wps/portal/contentonly?vgnextoid=9acb5f9cd70bb210VgnVCM1000003dd60f89RCRD&vgnextchannel=1a66e03bb8d1e310VgnVCM10000071d60f89RCRD
Watersheds: Toronto Region Conservation Authority, Map and Data Library University of Toronto
https://mdl.library.utoronto.ca/collections/geospatial-data/toronto-region-conservation-authority-data
Shoreline 1882 (McMurrich): GIS and Cartography Office, Dept of Geography, University of Toronto.
Traced from http://oldtorontomaps.blogspot.ca/2013/02/1882-city-engineers-office-plan-of-city.html

BASE MAPS

Reference Base Map: Esri World Topo map

Selected Esri World Topo Map as the most useful option to provide topographic reference for drainage pattern and changes over time, as elevation contours are extremely helpful in interpreting the lay of the land, necessary for the context of the Disappearing Rivers. It also shows where things have changed since the 1931 historical topographic map image.

Historical background map georeferenced raster overlay

Lost Rivers project were eager to include the 1932 geological map of the area around Toronto which was based on the 1931 National Topographic map at 1:63360 (A.P. Coleman. "The Pleistocene of the Toronto region: Including the Toronto interglacial formation" created by the Province of Ontario Department of Mines in 1932. Map No. 41G. Source Map and Data Library, University of Toronto.
http://maps.library.utoronto.ca/cgi-bin/datainventory.pl?idnum=851&display=full

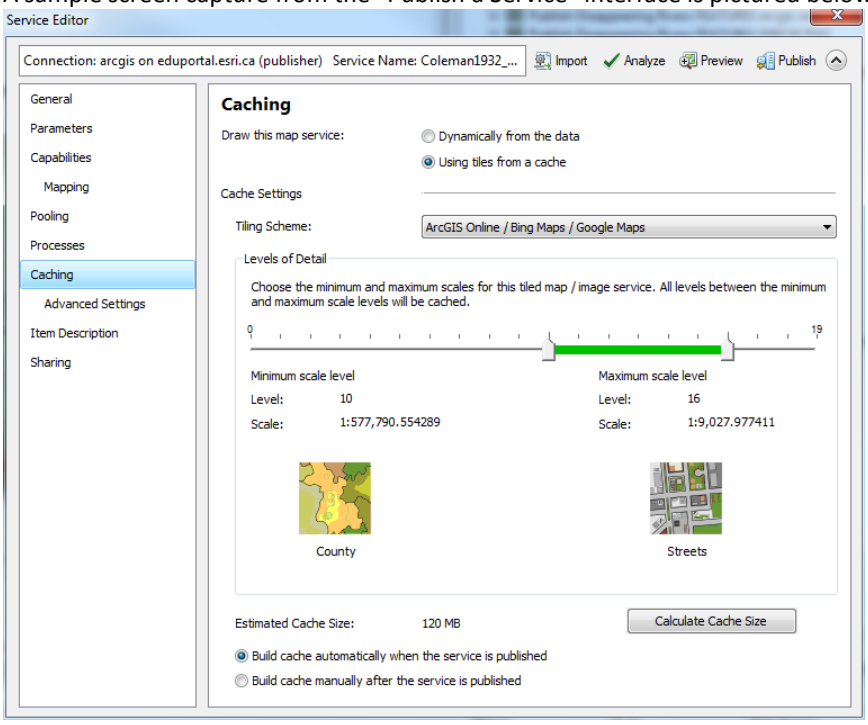
Map was georeferenced in ArcMap, creating a georeferenced TIFF file of about 240 MB. Attempts were made to publish it directly from ArcMap to the Canadian HGIS Portal as a hosted Tile Layer. However this was not possible, due to a shortage of memory on the Portal itself, and the high overhead involved with tiling the image on the Portal. The advice from Esri Canada was to publish an image service from a ArcGIS Mosaic dataset on the ArcGIS Server installed as the back end of the Portal. For reference see:
http://server.arcgis.com/en/server/latest/publish-services/windows/publishing-image-services.htm

This required creating the mosaic dataset, in a ArcGIS geodatabase. Then different parameters on the "Publish a Service" dialog were experimented with, i.e. different settings for publishing the image service from ArcMap to the server. For reference see:
http://server.arcgis.com/en/server/latest/publish-services/windows/key-concepts-for-image-services.htm

The best performance was achieved publishing the map service from an ArcMap document with nothing else in it, using tiles cached on the server. The critical parameters set for this (other than default) were:

General:	Type of Server: ArcGIS Server	Type of Service: Map Service
Capabilities:	Mapping	Operations allowed: Map
Caching:	Using tiles from a cache	Scale levels: Minimum 10; Maximum 16
Caching Advanced:	Area of interest: Full extent of map	Tile format: MIXED Compression: 75
	Create tiles on demand: NO	

A sample screen capture from the "Publish a Service" interface is pictured below:



The resultant map service is available to view at:
http://hgisportal.esri.ca/portal/home/item.html?id=ae95fdc6e19648b5bfc2c7c31a5cbf94

Note: This method requires use of ArcGIS geodatabase, and access to ArcGIS Server.

INTERFACE FUNCTIONALITY

Time slider for Disappearing Rivers

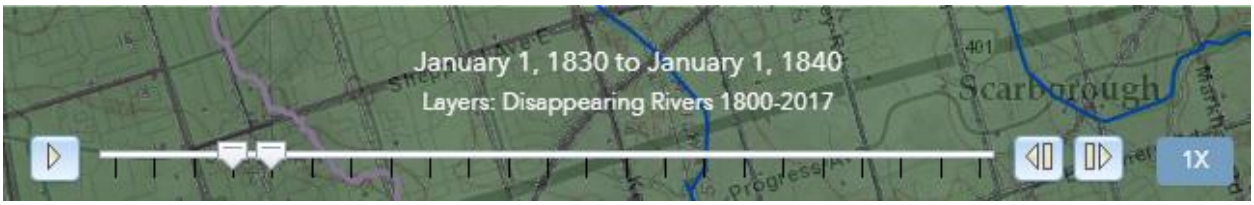
Time slider requirements were: to show rivers symbolized by year last seen on map disappearing over time using an easy-to-understand slider, and to display the date of any point on the slider by YYYY year only. Since the “year last seen on map” is a very approximate level of data precision, it would be spurious to show the date including DD/MM/YYYY. Since the requirement is to show the rivers disappearing over time, having a one-handled slider showing a specific date, i.e. a snapshot in time, rather than a two-handled slider showing an adjustable date range, makes the tool much easier to understand.

Several ArcGIS Online app template options were considered for implementing The Time slider. The first was the Time-Aware App, second was the Web App Builder standard edition, and last was the Web App Builder Developers edition. The Time-Aware app is typical of many of the out-of-the-box AGOL templates: easy to implement but not easily modifiable, apart from the configuration options supplied. It was capable of creating the standard-two handled slider, but not much else.

The decision was made to use the Web App Builder for the map, and to implement it in two forms: the Standard WAB, and the WAB Developers Edition. Details about these implementations and the advantage offered by using the Developers Edition to create a custom time-slider are outlined in the blog post for this project on the Geohistory-Géohistoire website. The relevant section of that document is duplicated below, to ensure completeness of this document.

From Geohistory-Géohistoire blog post on Lost Rivers of Toronto web mapping project:

The **ArcGIS Online versions can be found on the Geohistory-Géohistoire Canada Development Portal** hosted online by our partners at Esri Canada, at: Lost Rivers of Toronto Apps Gallery. To view other Portal content go to: http://hgisportal.esri.ca/portal . The "Gallery" contains 3 apps. This is because there are two versions mounted of the **Disappearing Rivers of Toronto** app. One is hosted on the portal itself, using a "standard" timeline slider to turn the rivers off as they "disappear" over time. That timeline slider looks like this:



This version of the app was built using ArcGIS Online Web AppBuilder, which is a very user-friendly tool which allows authors of web maps to drag and drop user interface components like this standard "Time Slider" widget into their web app. The widget can even be configured specifically for one's map and data, in limited ways, such as the icon that is used for the tool, and whether the time-specific layers are indicated above it.

For more info on the Web App Builder see: http://doc.arcgis.com/en/web-appbuilder/

However, more sophisticated customizations which may be desired, or even necessary, are not possible. For example, the slider has two "handles", set at 1830 and 1840 in the picture above. Each one can slide forward or backward along the timeline independently, to select a "range" of data. This design is very appropriate for some applications - however when the goal is to illustrate a "snapshot" of the environment at a single point in time - like our "Disappearing Rivers" map - it can be confusing, and the resulting map may be unclear. A slider design offering only one handle to the user, identifying a single point in time, like the picture below, simplifies and clarifies the interface.

This customization was accomplished by hosting the app on an independent server (i.e. not on ArcGIS online itself, or the Geohistory Portal) and using the Developer Edition of the Web AppBuiilder for ArcGIS (https://developers.arcgis.com/web-appbuilder/). This is a rather complicated process requiring the installation of the development app on a local computer, registration of the app on the Geohistory Portal so that portal-based web maps may be incorporated, development and testing of the app and customizations on the local computer, deploying the app on the independent server, and then registering the final app on the Geohistory Portal so that it is visible from there.

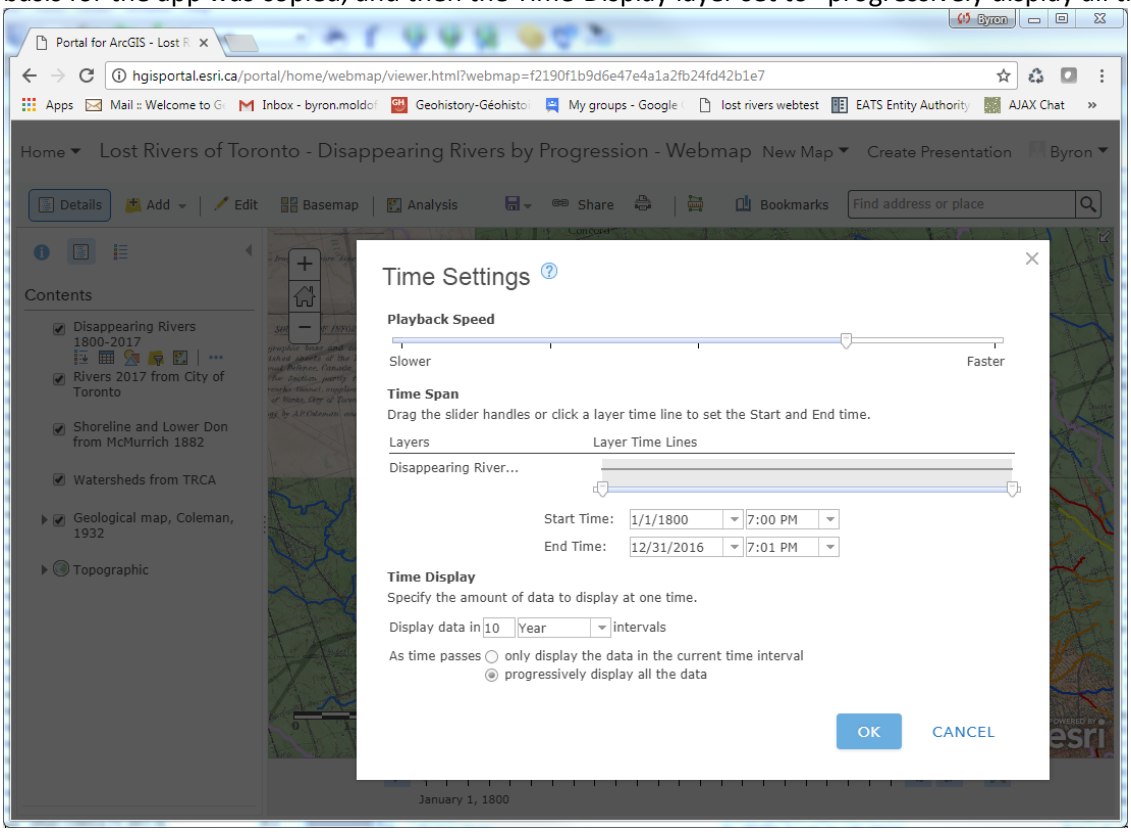
Development doc resumes on next page

Customization of the app using Web AppBuilder Developers Edition

Esri hosts a number of Community discussion boards for users, on their https://community.esri.com site (formerly GeoNet.) These include groups for the Web AppBuilder, and a specific group for Web AppBuilder Custom Widgets. After trying to customize the Time-slider widget code myself for a day or two, I searched the site for suggestions about creating a single-handle version of the widget there. A few posts seemed promising, but I was not able to implement them - probably because the information was several years old, so no longer applicable. So I posted a question myself, about customizing the widget. You can view the thread here: https://community.esri.com/thread/200998-time-slider-widget-customization-single-handle

As can be seen from the back and forth in the discussion board, I tried the suggested changes to the widget code but again could not get it to work. Eventually I was directed to an alternative approach by an Esri Canada staff member, which was successful. The method is counter intuitive in that it only works when the Time-aware layer on the web map is configured as cumulative or "progressive", even though the goal is to make it appear as a single point in time. It uses the function: timeSlider.singleThumbAsTimeInstant(). This is documented here: https://developers.arcgis.com/javascript/3/jsapi/timeslider-amd.html#singlethumbastimeinstant

As stated, setting up and using the Developers Edition is somewhat complex, but the actual customization involved was simple, once we figured out what to do. The original web map used as the basis for the app was copied, and then the Time-Display layer set to "progressively display all the data."



This changes the Time Slider to a single handle, since it is designed to show cumulative data over time.

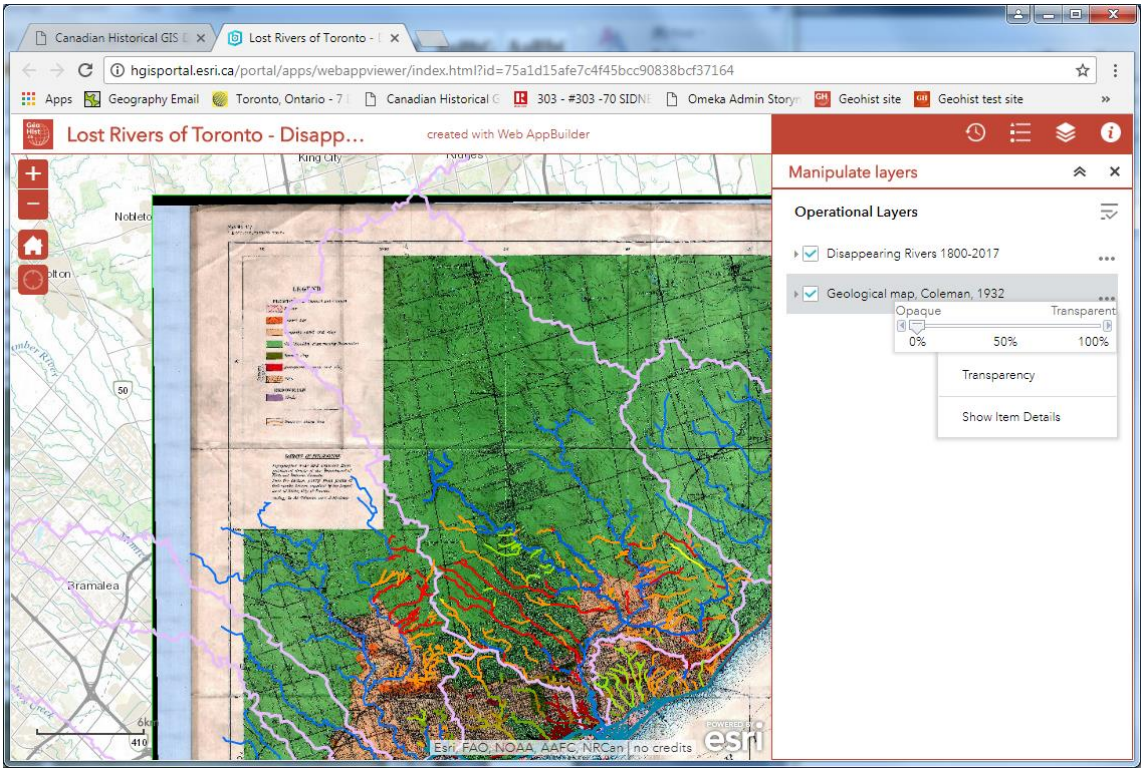
To achieve our goal of a snapshot Time-Slider, a custom widget had to be made, and the single line added to the code:

this.timeSlider.singleThumbAsTimeInstant(true);

A few other minor changes were made as well, and documented as comments in the file. The revised widget directory we created is available for download here:
http://geohist.ca/wp-content/uploads/2017/10/TimeSliderOnehandle.zip

Transparency for Historical background map image

The Layer List widget was used to enable users to adjust the transparency of the historical background map image. By default this allows users to open up a list of the active layers in the web map, toggle them off or on, and for map image layers, to use a transparency slider to adjust opacity. See image below.



ISSUES WITH ARCGIS ONLINE WEB APP BUILDER

Constraint on location of specific widgets

Overall the WAB provides a flexible and user-friendly environment for building web map apps. Its Drag and Drop interface for installing UI widgets on the mapping page is about as simple as it gets. My only issue would be the constraint on where widgets can be positioned: certain widgets are limited to the Header Control panel above or beside the map ("in-panel"widgets); other widgets are limited to the on-the-map positions (off-panel).
See http://doc.arcgis.com/en/web-appbuilder/create-apps/widgets-tab.htm
This may have been designed to avoid inappropriate positions for specific widgets that apply to the whole project - like the Info widget for example – but it seems like an unnecessary barrier to the design flexibility offered to the user, which is the whole reason for the WAB approach.