Chloride Trends in the Credit River Watershed and their Potential Impact on Contaminant Transportation to Lake Ontario

To Road Salt Working Group

May 30, 2017

By Lorna Murison and Amanjot Singh

Outline

- A Tour of the Credit River Watershed
  - Chloride concentrations and patterns
    - Rural areas
    - Urban areas
    - Long-Term Monitoring Data
    - Real-Time Monitoring Data
- Lake Ontario Modeling

CREDIT VALLEY CONSERVATION

This presentation will come in the form of a virtual tour of the Credit River watershed and of the trends and patterns we see in chloride concentrations as we move from rural to urban areas of the watershed.

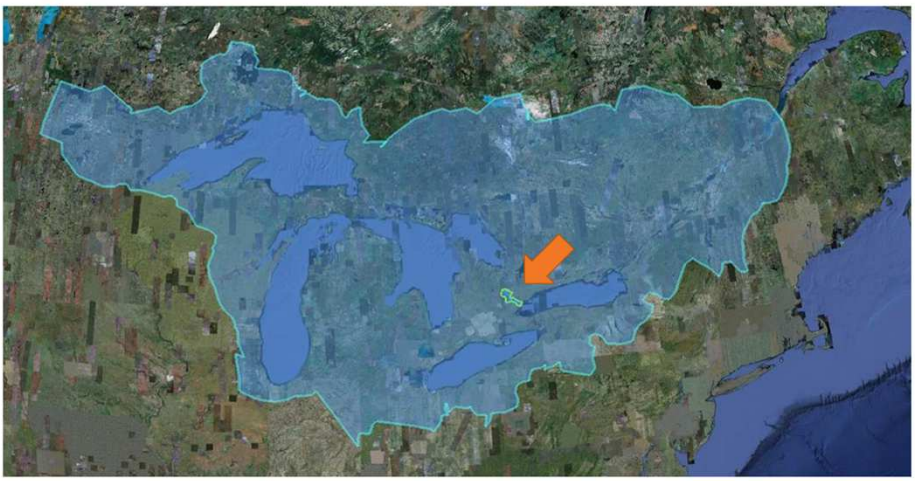
We will be looking at both long term monitoring data and real-time water quality data.

We will finish off by looking at the impact that high instream chloride concentrations can have on Lake Ontario.

Credit River Watershed

Context and Features

CREDIT VALLEY CONSERVATION

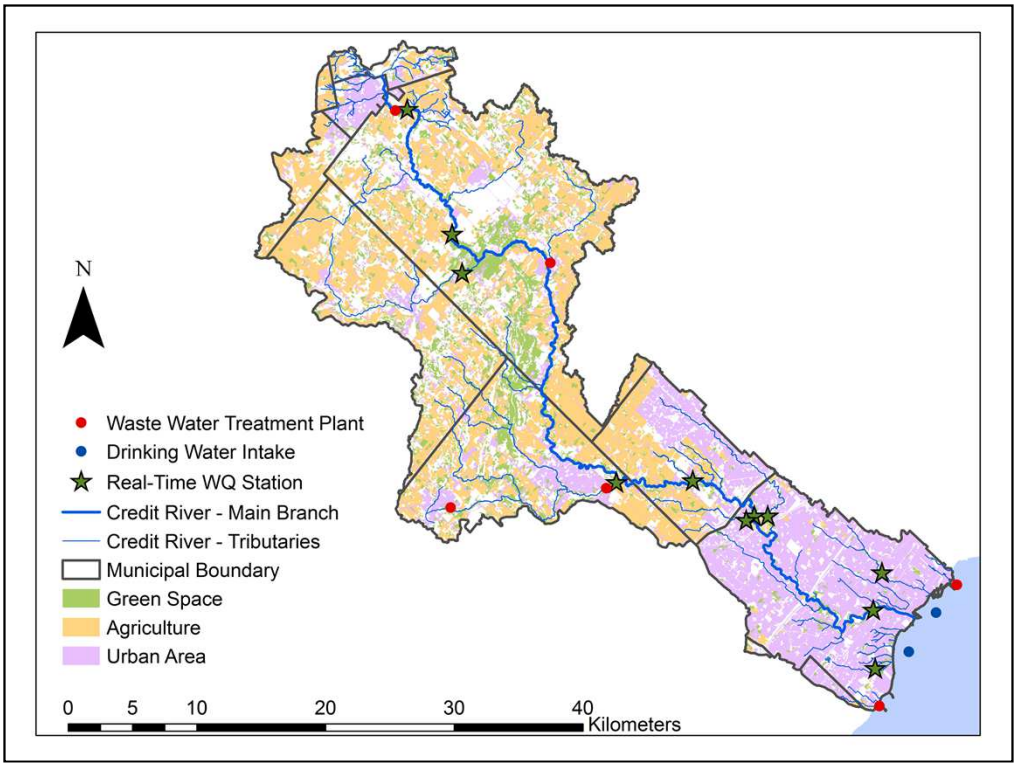


Credit River Watershed

CVC | CREDIT VALLEY CONSERVATION

Our watershed is located on the shore of Lake Ontario, just west of the City of Toronto.

The whole watershed is about 1,000 km^2.



The primary land-uses of the watershed are green space, agriculture, and urban areas shown on this map in green, yellow, and purple.

The watershed has six waste water treatment plants, 2 of them discharge into Lake Ontario.

We also have two drinking water treatment plants with intakes in Lake Ontario

Finally, the 11 real-time water quality stations that we have across the watershed are on this map.

We have a number of grab sample stations not pictured.

Real-Time and Long Term Monitoring Results

A tour of the Credit River watershed

CVC | CREDIT VALLEY CONSERVATION

We are going to have a tour of the watershed, looking at the chloride concentrations measured by our two main water quality monitoring programs at a few key locations.

But first, some background information on these programs.

Integrated Watershed Monitoring Program

- Integration with Provincial Water Quality Monitoring Network (PWQMN)
- Monthly surface water quality grab samples
- Some data since 1960's
- Some data since early 2000's
- Long term trends in water quality
- Identifying parameters of concern

CREDIT VALLEY CONSERVATION

The integrated watershed monitoring program (or IWMP) is, in part, an expansion of the PWQMN.

Every month, on a regularly scheduled day a grab sample is collected at each of our 47 stations. Some of these are PWQMN stations; others have been added as part of IWMP.

The samples are analyzed for around 50 parameters, including chloride.

Depending on the location, we have data going back to the 1960's, 1970's, or early 2000's.

These data help to identify long-term trends in water quality, and emerging parameters of concern.

Real-Time Water Quality Monitoring

- First station installed in 2010
- Currently have 11 stations
- "Samples" nine parameters once every 15 minutes.
- Data automatically uploaded
- Level of detail not possible with grab samples

CREDIT VALLEY CONSERVATION

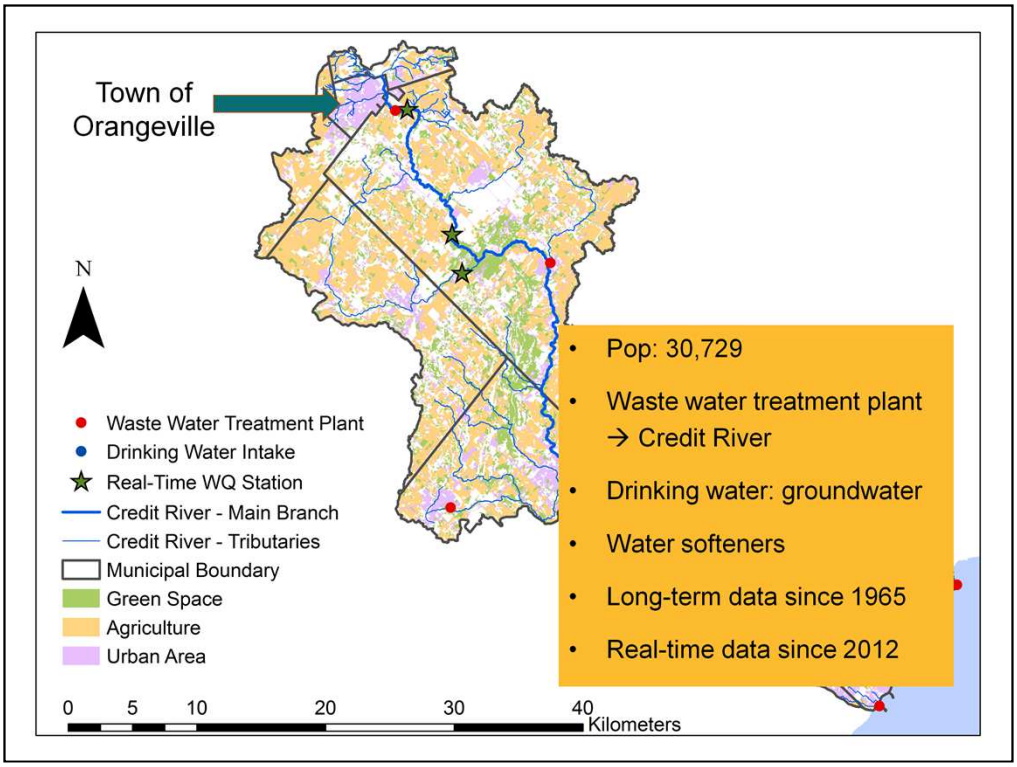
Real-time monitoring began in 2010, and has since expanded to the 11 stations we currently have.

These stations take measurements once every 15 minutes using Hydrolabs.

Each station monitors nine different parameters, including chloride.

CREDIT VALLEY CONSERVATION

We'll begin our tour at the headwaters of the Credit River in the town of Orangeville.

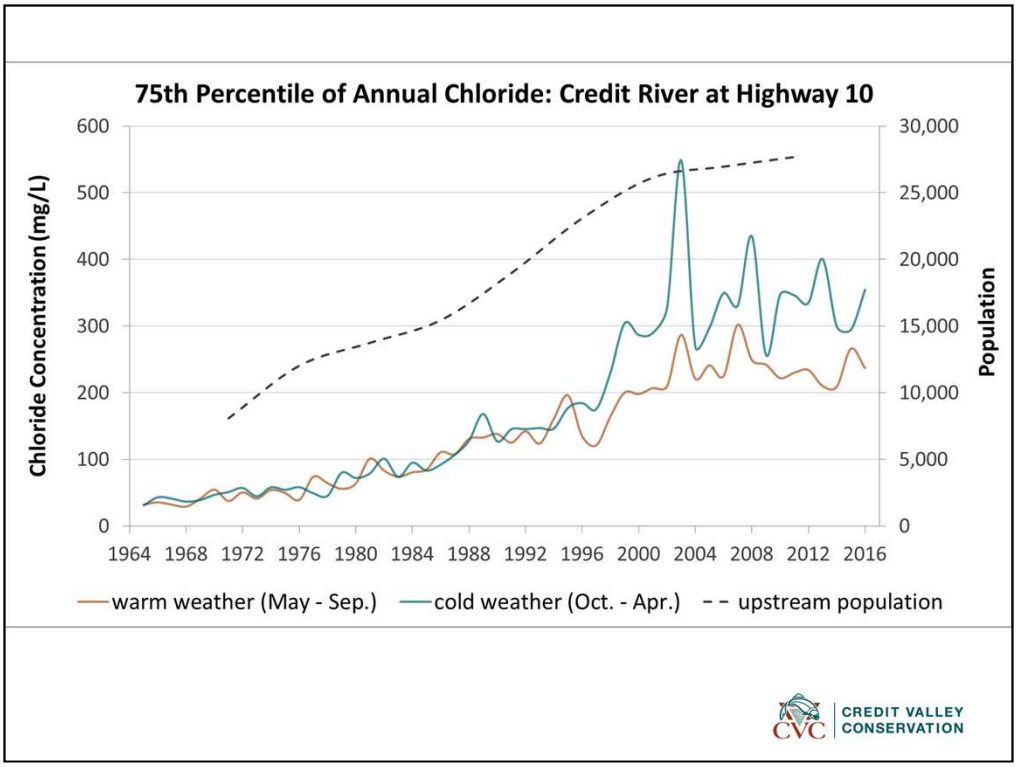


Orangeville is a smallish town with a population of around 30,000.

It has a waste water treatment plant which discharges into the Credit River

Its drinking water comes from groundwater, which means that the use of water softeners is quite common.

We have a monitoring station downstream of the town on the Credit River at highway 10 where we have been collecting grab samples since 1965 and real-time data since 2012.



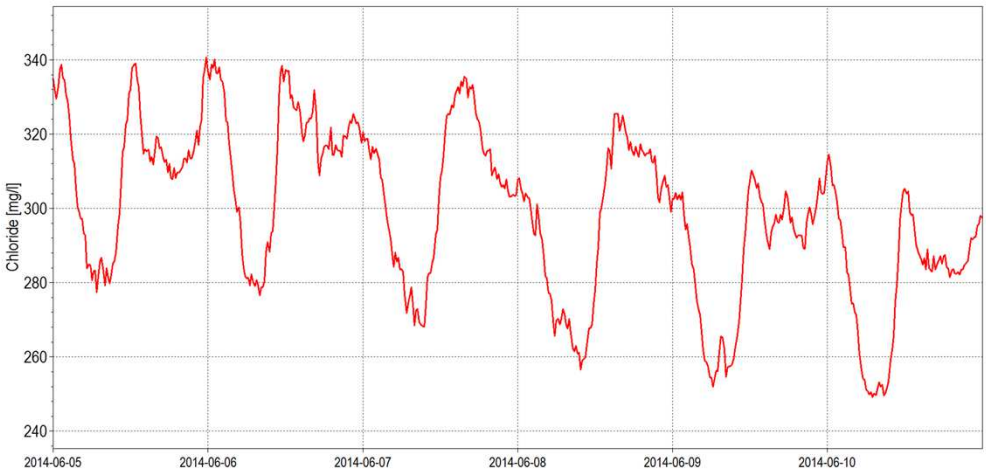
This graph shows the annual 75th percentile of chloride in the grab samples taken since 1965. Samples taken in the warm months and cold months have been separated.

Graph also shows how the population upstream of the sample site has changed.

Both chloride and population have increased.

Starting around 1996 you begin to see cold weather concentrations separate from warm weather ones.

Could there have been a development that caused more road salt to be put down after this time?



Chloride in the Summer

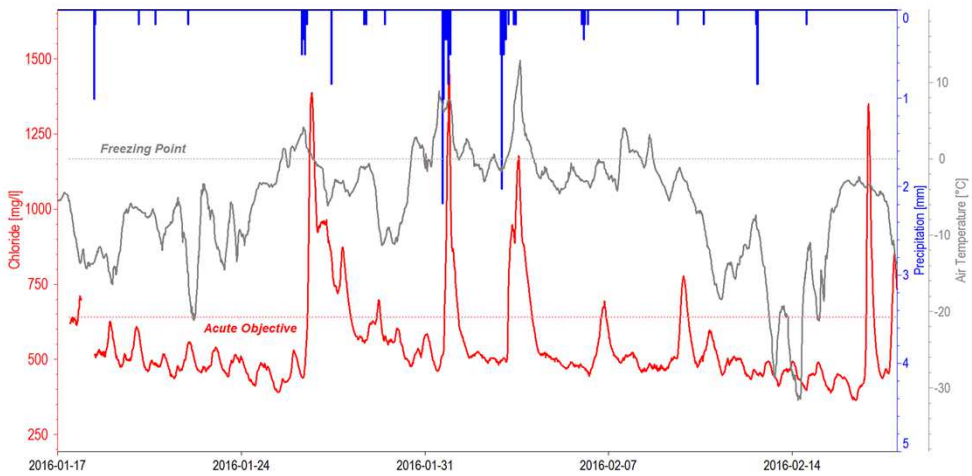
CREDIT VALLEY CONSERVATION

This is what a typical week of real-time chloride measurements look like at this location.

You can see a significant diurnal variation due to the use of water softeners.

Most softeners are timed where they automatically go through a backwash cycle in the middle of the night. There is a bit of a delay, but a few hours later you see concentrations increase, once this salty water has been through the waste water treatment plant.

You'll also notice that here, concentrations are around 240 to 340 mg/L, consistently above the chronic water quality objective for chloride.



Chloride in the Winter

CREDIT VALLEY CONSERVATION

In the winter you can see the same diurnal variation, but with some added spikes that coincide with road salting.

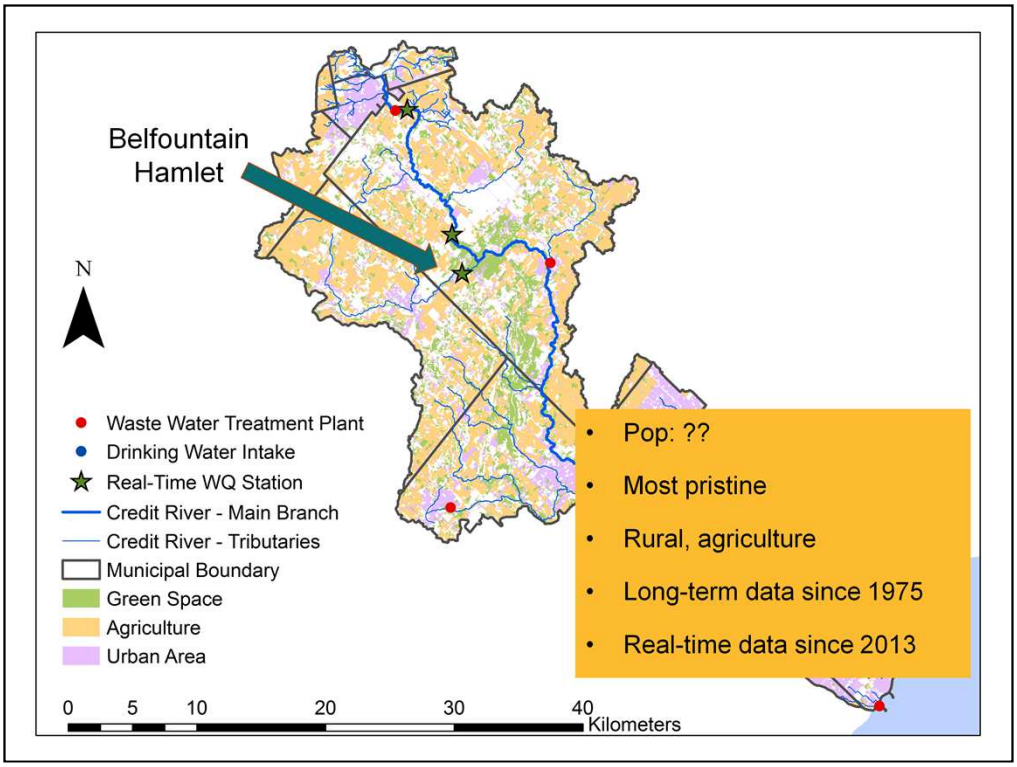
The first 3 spikes in this graph coincide with melting snow. You can see that each time, air temperature (in grey) rises above the freezing point, causing snow to melt and wash into the river.

In some cases this is helped along by rainfall.

The last spike occurred while temperature was still below freezing, so must be the result of direct application of salt to the roads.

CREDIT VALLEY CONSERVATION

We'll continue our tour though the small hamlet of Belfountain



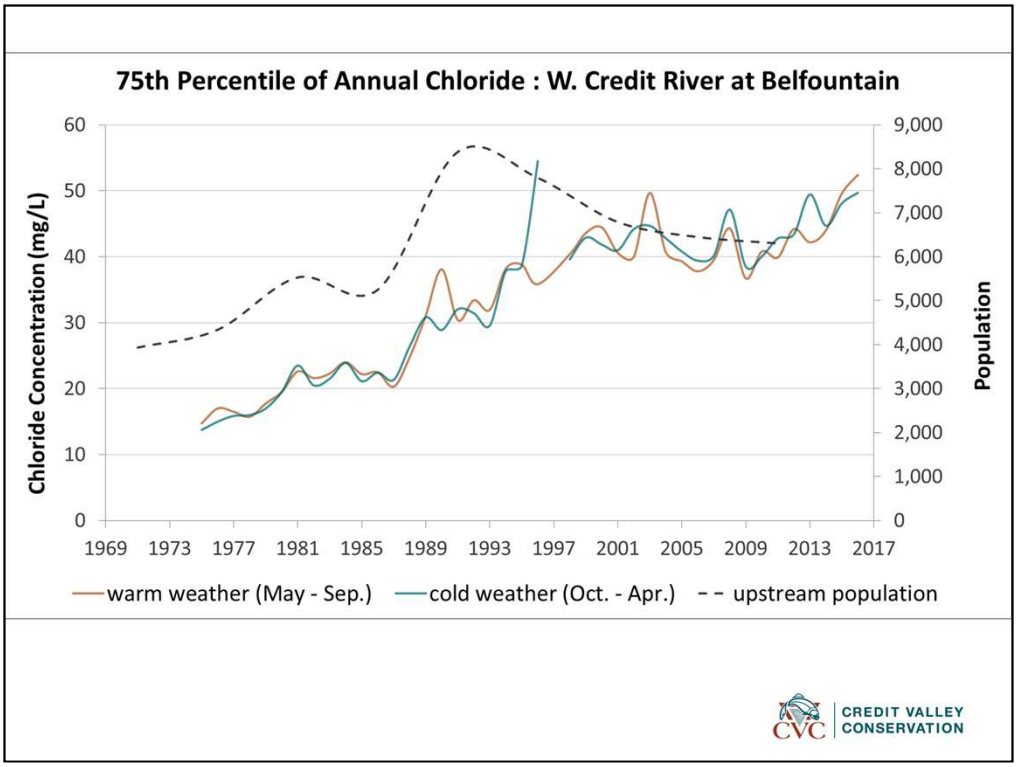
Belfountain is a very small hamlet located in Caledon.

It's so small that I can't find anywhere that tells me what the population is, I'm guessing less than 1,000.

It is in the most pristine area of our watershed.

The drainage area is mostly rural, with agricultural land-use.

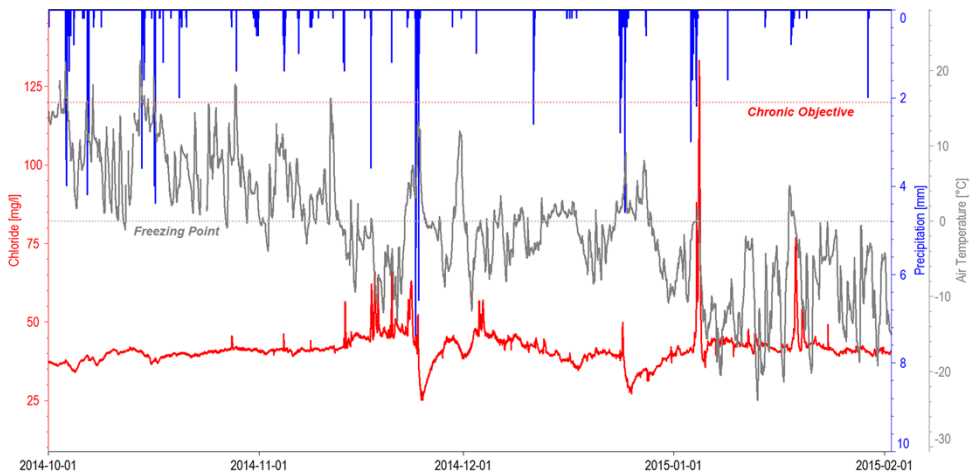
We have long term data since 1975 and real-time data since 2013



This is the same graph as we saw for the previous location.

In this case, however, because such a small portion of the catchment is developed, we don't see a huge difference between winter and summer concentrations in terms of the 75th percentile.

You'll notice a fluctuation in population as well. I suspect this may be due to the way our census data were summarized to the catchment from one year to the next, with evolving dissemination area boundaries.



Chloride in the Winter

CREDIT VALLEY CONSERVATION

This is what a typical winter of real-time data looks like at this location.

This graph covers 4 months of data and there is one small event where chloride exceeds the chronic objective.

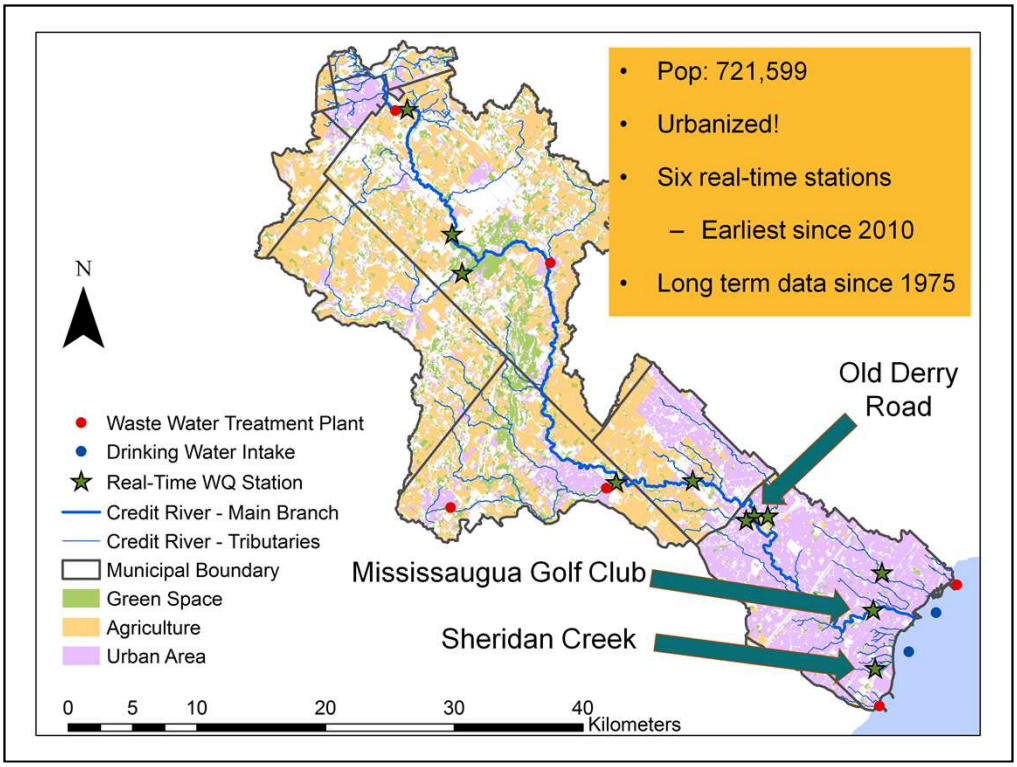
There was some precipitation around that time with temperature really close to the freezing point so maybe there was freezing rain or something of that nature that caused salt to be put down and washed into the river causing this temporary spike.

You can also see a couple of instances where chloride concentrations are diluted by rainfall.

Overall at this location, chloride is not a concern, but it is increasing, as we saw in the previous graph.

CREDIT VALLEY CONSERVATION

Now our tour moves into the lower watershed dominated by the city of Mississauga



Almost the entire lower third of our watershed falls within the city of Mississauga

We have six real-time stations in Mississauga, and many grab sample locations as well.

For this presentation I'm going to highlight three of them.

The Credit River at the upstream end of Mississauga which gives us water quality as it enters the city, but is still representative of the largely rural upstream area.

The Credit River at the MGCC is downstream of all the major tributaries that flow through the city and represents water quality of the River as it enters Lake Ontario.

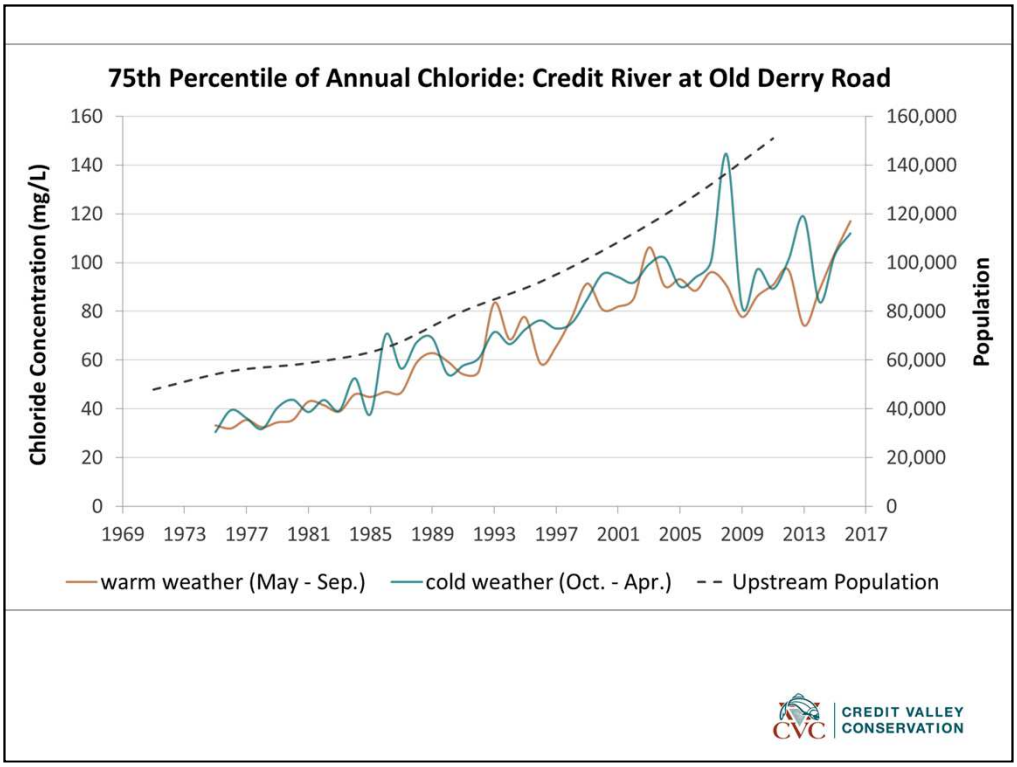
Finally, Sheridan Creek is a small creek draining directly into Lake Ontario

Credit River at Old Derry Road

Credit River entering Mississauga

CVC | CREDIT VALLEY CONSERVATION

We'll begin at the Old Derry Road station which is on the Credit as it enters Mississauga



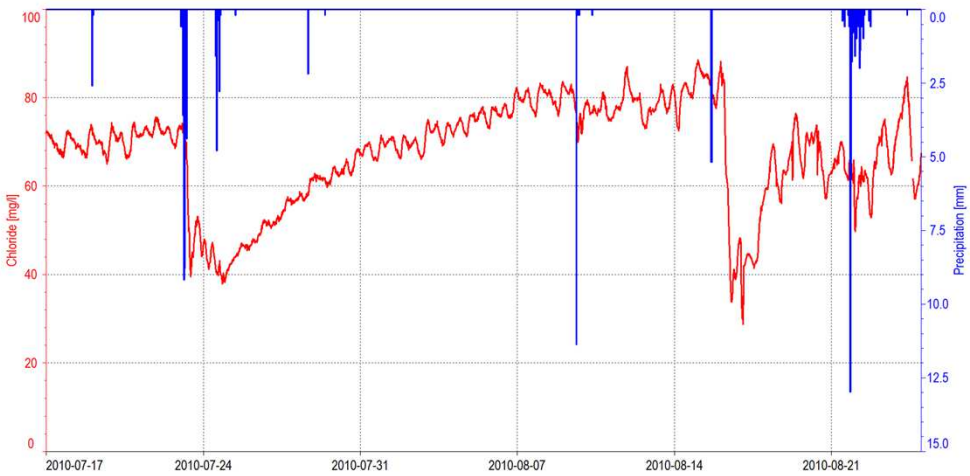
Here is our familiar graph showing long-term trends

Once again, you can't see a huge difference between winter and summer levels.

This is likely because of the mostly rural upstream area.

It will be interesting to compare what we see here, to what we see at the station that is downstream of Mississauga.

We can see a clear increasing trend, though, and a similar increase in population.



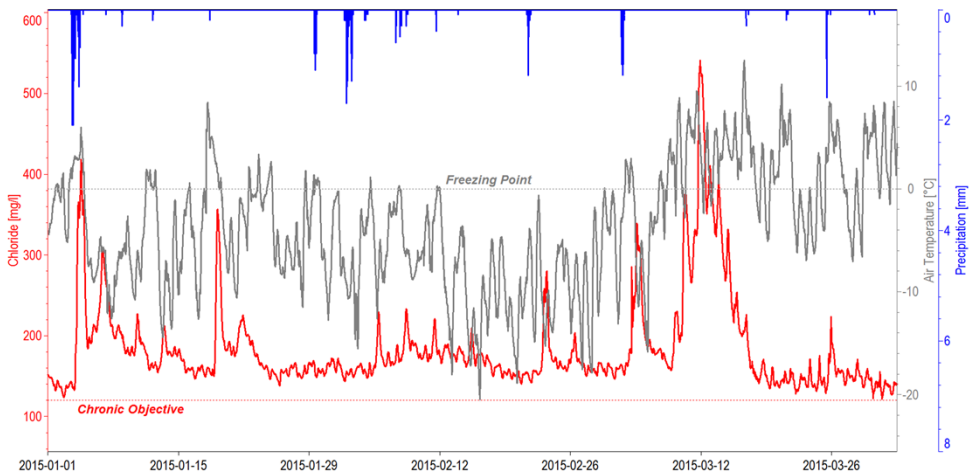
Chloride in the Summer

CREDIT VALLEY CONSERVATION

In the summer at this location, we tend to see a cycle like what is shown on this graph.

A rainfall event dilutes the concentration of chloride, and as flows gradually drop, the concentration increases until it either reaches its ambient concentration, or until another rain event occurs and the concentration is diluted again.

This is the pattern we see across most of the watershed in the summer.



Chloride in the Winter

CREDIT VALLEY CONSERVATION

In the winter the concentrations are a bit higher and you can see spikes in chloride that last for a few days rather than the short pulses we saw up in Belfountain.

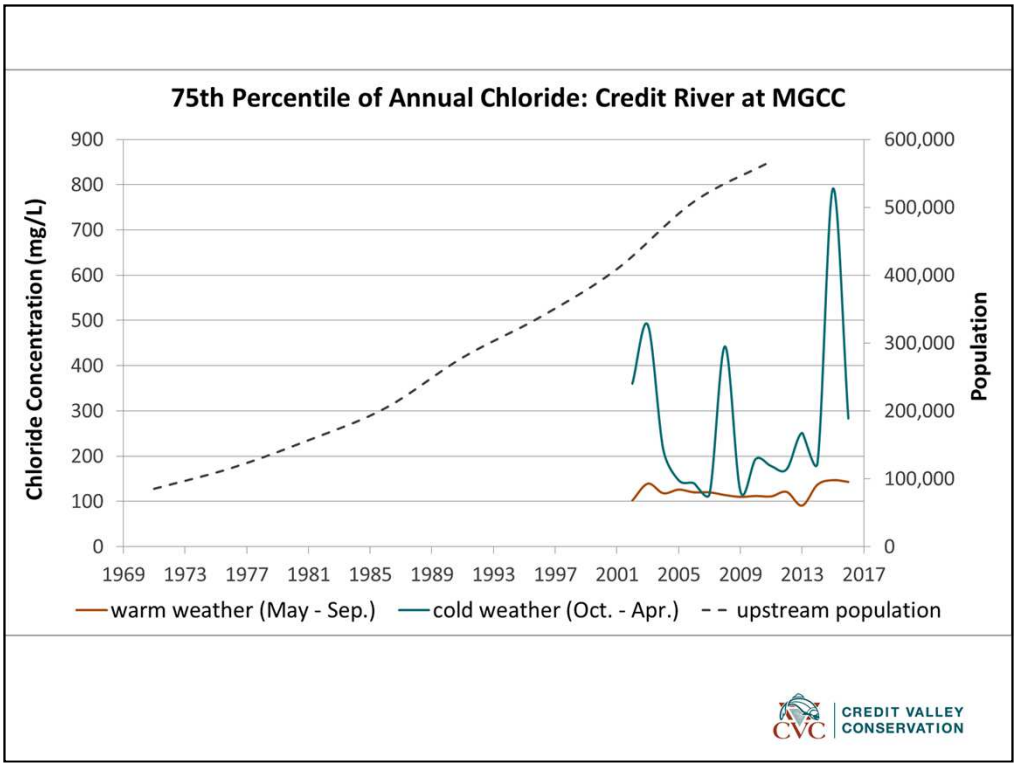
In this graph, you can see a big spike occurring towards the end as a result of melting.

Credit River at Mississaugua Golf and Country Club

Outlet of the Credit River into Lake Ontario

CVC | CREDIT VALLEY CONSERVATION

Let's move on to our station at the mouth of the Credit River at the Mississaugua Golf and Country Club.



Unfortunately, this is one of the stations that we only began monitoring in 2002 so we can't see that long term trend in chloride.

What we can see is a huge increasing trend in population.

We can also see big differences between winter concentrations and summer concentrations.

This is significantly different from what we saw at Old Derry where concentrations in the winter and summer were similar. This change is because of the contribution of road salt from urban areas in Mississauga.

Sheridan Creek

Tributary of Lake Ontario
Small catchment
High density development

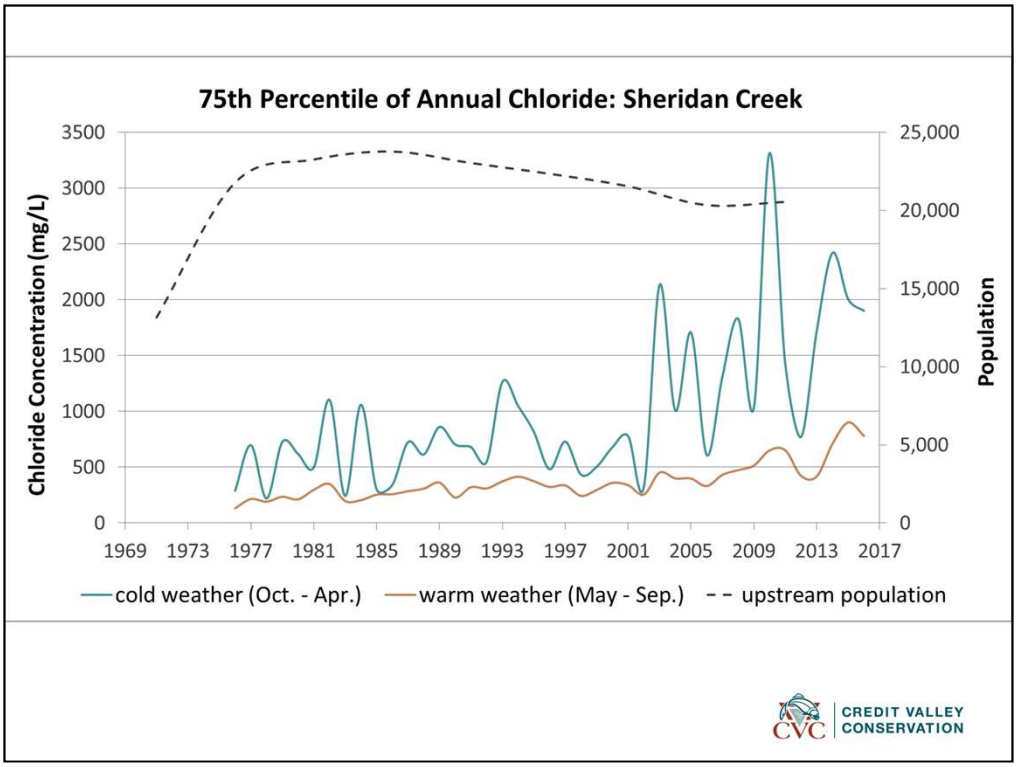
CVC | CREDIT VALLEY CONSERVATION

The final station we are looking at today is Sheridan Creek.

This is a small tributary of Lake Ontario

It has a very small catchment with high density development and was fully developed many decades ago.

It contains very few stormwater management facilities



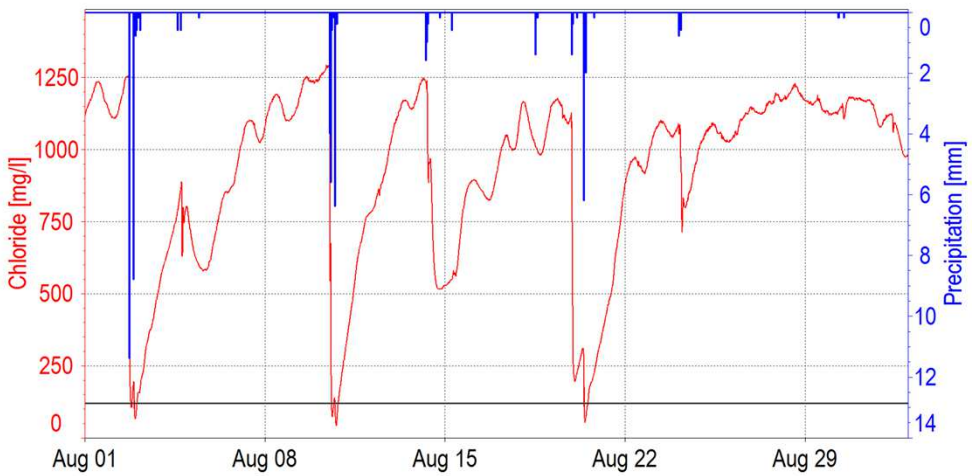
Long term data show that since monitoring began in 1975 there is a huge difference between winter and summer concentrations indicating the huge influence of surface runoff in the winter.

Both winter and summer concentrations are very high

Since monitoring began in 1975 the 75th percentile has been over the chronic guideline, and since 2014, it's been above the acute guideline.

Concentrations are increasing both in the summer and the winter even though population has stabilized since the late 70's.

This indicates that chloride has built-up in the groundwater, and is still accumulating, even if the total volume applied each year remains the same, or even goes down.



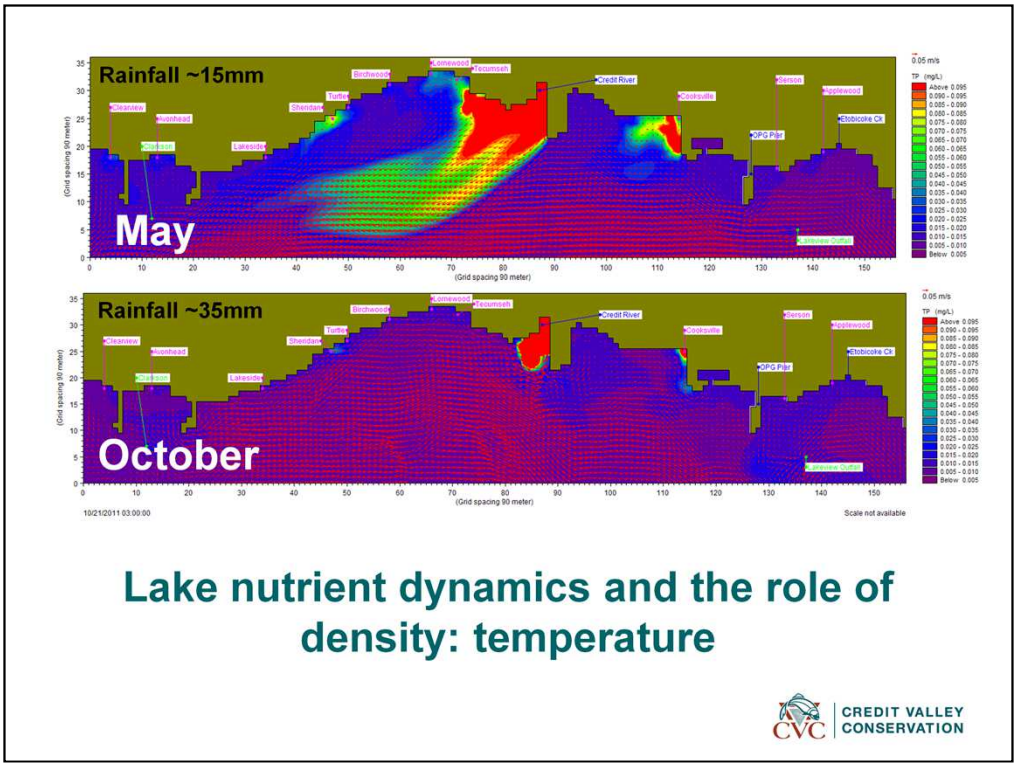
Chloride in the Summer

CVC CREDIT VALLEY CONSERVATION

In the summer at Sheridan Creek we see the familiar pattern of dilution with rain events, and a rise back up to ambient conditions as flows recede.

In this case, though, that ambient condition is over 1000 mg/L. Concentrations that high are all coming from the groundwater.

The only time that concentrations drop below the chronic guideline is for a couple of hours following an intense rainfall.

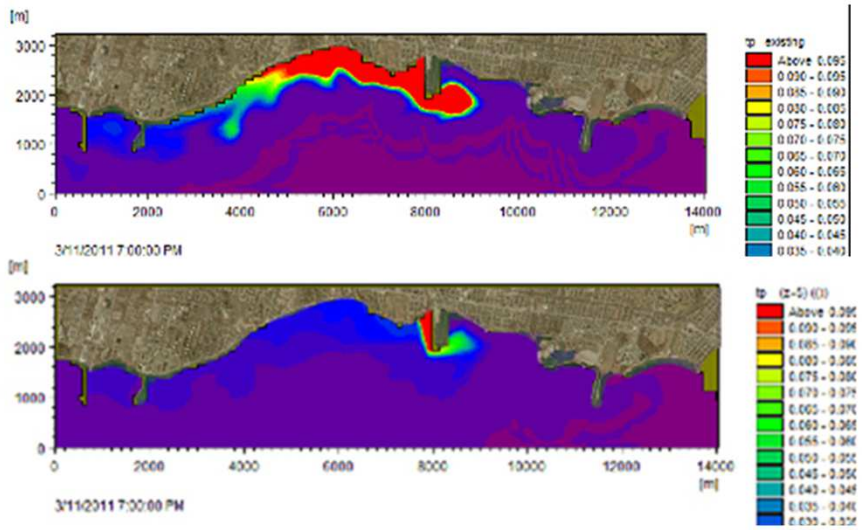


We generated a model of Lake Ontario and ran it for an event in May and an event in October.

To our surprise, the smaller event in May appeared to produce the larger TP plume. Upon closer inspection, this appears to be the impact of water temperature on density at work.

In May, when water in the Credit River is warmer than water in the lake, the plume will tend to float along the surface of the lake causing nutrients to disperse further away from the shore (depending on wind patterns).

In October, when water in the Credit River is colder than water in the lake, the plume will tend to sink to the lake bottom, resulting in what appears to be a visibly smaller plume.

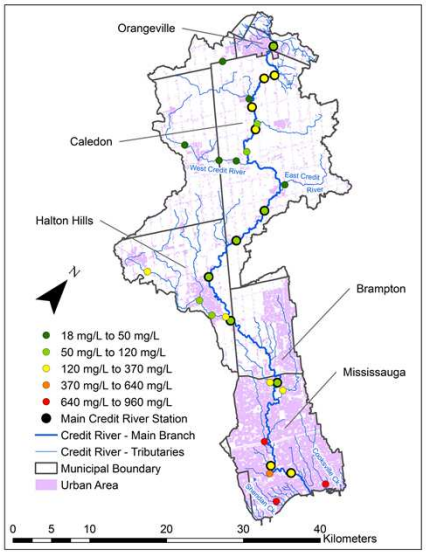


Lake nutrient dynamics and the role of density: temperature and chloride

CREDIT VALLEY CONSERVATION

This caused us to think about the implications of high chloride concentrations and their impact on water density and nutrient dispersal.

In Conclusion



- Map shows 75th percentile of grab samples taken in 2015 from May to September
- Chloride concentrations increase downstream of urban areas
- Long-term and real-time data work together to give us the full picture
- Impacts of instream concentrations extent into the lake
- One Water approach

CVC | CREDIT VALLEY CONSERVATION

The map on this slide shows the 75th percentile of chloride concentrations from May to September 2015 at all of the grab sample locations in our watershed

It clearly shows that concentrations increase downstream of urban areas. The lowest concentrations are found on our largest, most rural tributaries like the East and West Credit River.

We've shown during this presentation, however, that grab samples alone cannot give us the full picture. Real-time data allows us to fully understand the actual peaks in chloride concentration that can be reached, and how a waterbody reacts to salting and rain and snowfall events.

We've also shown that the impact of high chloride concentrations instream can impact the way nutrients are dispersed along the Lake Ontario shoreline.

Any solution to reducing chloride concentrations will have to look at all sources of chloride and all uses of chloride-contaminated water. We have to look at surface water, and groundwater and stormwater as one water, and not manage these features separately because they are all so deeply connected.

Questions

CREDIT VALLEY CONSERVATION

CREDIT VALLEY CONSERVATION

Together, it's our nature to conserve and our future to shape.