GOAL 1: INFILTRATION AND STORAGE WILL INCREASE PROPORTIONATE TO LAND USE AND CLIMATE CHANGE.

Measurable outcome: Reduce or keep at current discharge compared to precipitation.

Measure: Double mass curve of annual precipitation and runoff.

Frequency of measure: Annual

Potential measures of level of effort/activity to address goal:

- e-Link or similar BMP database for acre feet of infiltration and storage.
- # regulated stormwater projects.
- # land use planners requiring infiltration per PCA construction stormwater permit.

Targeting implementation activities:

- Model current and past watershed runoff to estimate future infiltration need.
- New development: Integrate infiltration and storage goals.

DATA SOURCES

- USGS discharge data at Saint Francis, with annual total discharge data from 1934 to 2017. There are a few other gages, but they are all further up in the watershed and do not have records as long as Saint Francis. The USGS data is straightforward and has a mean annual quantity value for each year.
- Precipitation data for (N to S) Isle, Onamia, Milaca, Cambridge, and Saint Francis (all from cli-MATE). Precipitation analysis was much more complicated than the discharge data.

METHODS TO DETERMINE PRECIPITATION

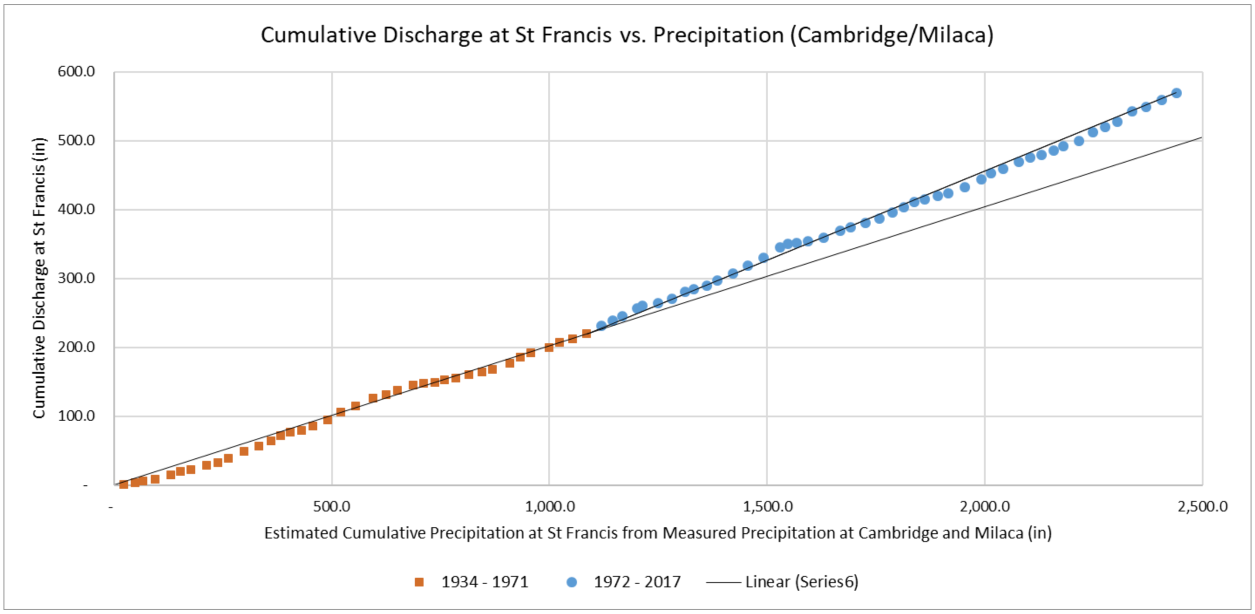
Cambridge and Milaca had the most complete precipitation records. Onamia and St. Francis had almost no data before 1990. Isle has many years of missing data. The St. Francis data is suspect because it appears to be too high (average of 13" greater than Onamia for the period 1991-2004, for example). Both Milaca and Cambridge have complete data from 1934 through 1976, but some missing years after 1976; only one year (2005) had a missing value for both locations. To fill in the missing years, the average rainfall was determined for both Milaca and Cambridge based only on the years where there were annual precipitation totals for both locations. The averages were 29.4" (Milaca) and 28.2" (Cambridge). Using the 4% difference in Milaca, the ratio of 1.04 was used to fill in missing values at either station based on the other location's precipitation for that year. For 2005 (both missing), the Isle value of 35.97" was used for both Milaca and Cambridge. The cumulative quantity was calculated for St. Francis and cumulative precipitation was calculated for both Milaca and Cambridge. The plots based on Milaca and Cambridge are similar and because of this, a new precipitation time series was created that was the average of the Cambridge and Milaca time series.

Summary of annual precipitation data locations and availability.

PRECIPITATION STATION	STATION ID	FIRST YEAR	LAST YEAR	COUNT (1934-2017)
ISLE	USC00214103	1936	2019	50
ONAMIA	USC00216166	1935	2019	23
MILACA	USC00215392	1897	2019	77
CAMBRIDGE	USC00211227	1892	2019	75
ST. FRANCIS	USC00217309	1990	2015	21

RESULTS

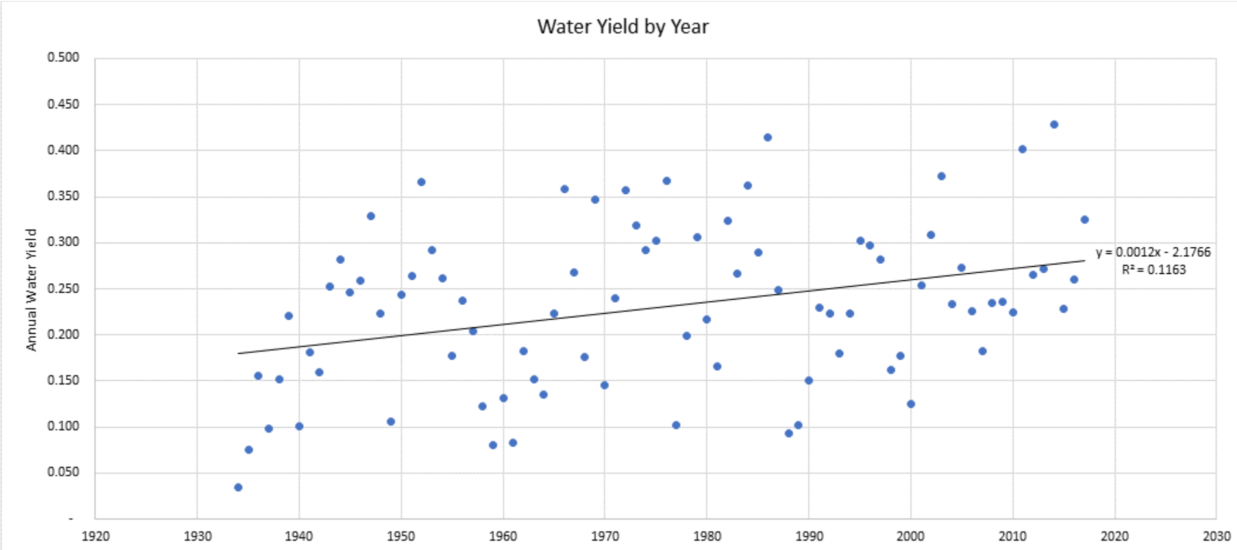
Below is the double mass curve based on the combined dataset of Milaca and Cambridge precipitation plotted against the cumulative discharge at St. Francis. The year 1971 was determined as the breakpoint for representing results based on both an analysis of tabular precipitation/discharge data and visual inspection of the figure below. Trendlines shown in the figure below show an increase in runoff (or water yield, the ratio of runoff to precipitation) beginning in the early 1970s. The difference in the two trendlines by 2017 (the rightmost value in the figure) suggest an suggests an increase in total discharge of approximately 80 in by 2017 beyond what would have been predicted by the water yield line for the period 1934-1971.



Below is a tabular summary of the data for the two time periods. While there was a slight increase in precipitation in the period 1972-2017 (0.8 in/yr), the increase in mean annual runoff (1.8 in/yr) was even larger. The water yield increased from 20.2% from 1934-1971 to 25.9% from 1972-2017.

	1934-1971	1972-2017	DIFFERENCE
MEAN ANNUAL PRECIPITATION (IN)	28.6	29.4	+ 0.8
MEAN ANNUAL RUNOFF (IN)	5.8	7.6	+ 1.8
TOTAL RUNOFF/TOTAL PRECIPITATION	20.2%	25.9%	+ 5.7% (28% increase)

One final graph shows the water yield by year. The slope (0.0012, equivalent to 0.12 or 12% per century) suggests that water yield increased at a rate of 12% per century over the period of record.


Water Yield by Year
Annual Water Yield
0.500
0.450
0.400
0.350
0.300
0.250
0.200
0.150
0.100
0.050
-
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
2030
y = 0.0012x - 2.1766
R² = 0.1163

GOAL 2: PROTECT NON-CONTRIBUTING (HYDROLOGICALLY LANDLOCKED) AREAS SO THEY CONTINUE TO NOT DISCHARGE.

Measurable Outcome: Protect non-contributing (hydrologically landlocked) areas so they continue to not discharge.

Measure: GIS of non-contributing areas (one time).

Frequency of Measure:

Potential Measures of Level of Effort/Activity to address goal:

- # LGUs with ordinance

Targeting implementation activities:

- Model
- Development-specific permitting

GOAL 3: NO INCREASE IN RATE AND VOLUME FROM NEW DEVELOPMENT.

Measurable Outcome: No increase in rate and volume from new development.

Measure:

Frequency of Measure:

Potential Measures of Level of Effort/Activity to address goal:

- # of LGUs that adopt this policy

Targeting implementation activities:

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