THE EFFECTS OF CHANGES IN POPULATION DENSITY ON DISCHARGES FOR THE MIDWESTERN UNITED STATES

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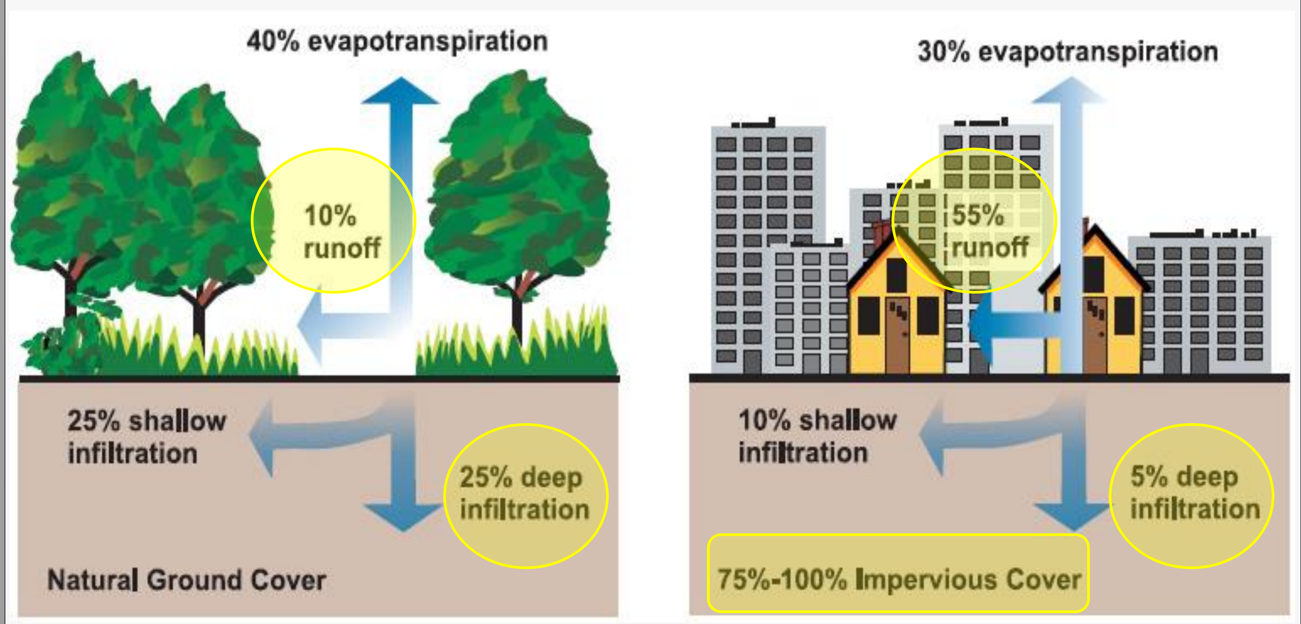
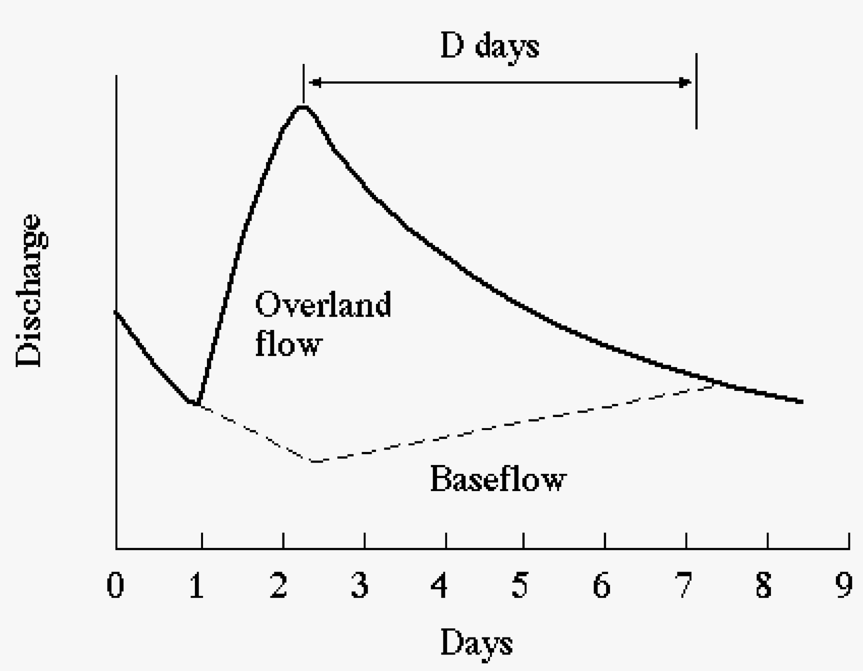
ABSTRACT

River baseflow is the river discharge supported predominantly by groundwater, and can be greatly impacted by changes in land. Intuitively, the baseflow of a river would decrease with increased urbanization, as urbanization increases the amount of impervious surfaces, limiting the ability of precipitation to infiltrate into the ground and recharge the local groundwater. However, evidence suggests that the baseflow of rivers in urbanized areas can increase as a result of leaky subsurface water infrastructures that add water to groundwater and replenish baseflow. Another reason for the baseflow increase in urbanized watersheds is that water supply systems are over-pressurized by design to reduce the chances of contamination, contributing extra water to the local system. Cities that have decreased in population over the last century may experience an even greater addition to baseflow as leaky water infrastructures may not be attentively maintained due to the fact that there are less people in the area to supply water to. Given these conflicting urban influences on baseflow, it is important to investigate this relationship further. The goal of this project is to empirically investigate how decreased population in urban areas has impacted baseflow in the Midwestern region of the U.S. The project uses USGS gage data from streams within the Rust Belt, specifically from the states of MI, NY, PA, and OH. The results determined that there is mainly a positive relationship between depopulation and baseflow in cities that lie within the geophysical province of the Central Lowlands.

BACKGROUND

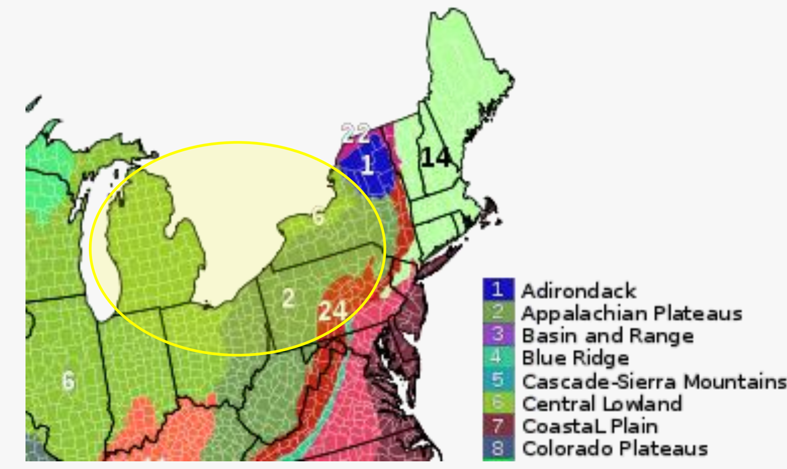


As urban areas develop, the amount of impervious surfaces typically increases, producing a decrease in infiltration rate and an increase in runoff. The increased runoff produces a more "flashy" stream with quickly increasing and decreasing discharges, and intuitively less baseflow.



GAGE CRITERIA AND DISCHARGE METRICS

1) Continuous data, ≥ 40 years
   - -Not immediately downstream of large dams/impoundments
   - -Drainage area of less than 400 miles^2
2) Baseflow per unit drainage area (BF, m^3/yr)
3) Runoff (RO, m^3/yr)
4) Total flow (TF, m^3/yr)
5) A ratio of baseflow to precip over area (BF/P/A, unitless)
6) A ratio of runoff to precip over area (RO/P/A, unitless)
7) A ratio of total flow to precip over area (TF/P/A, unitless)



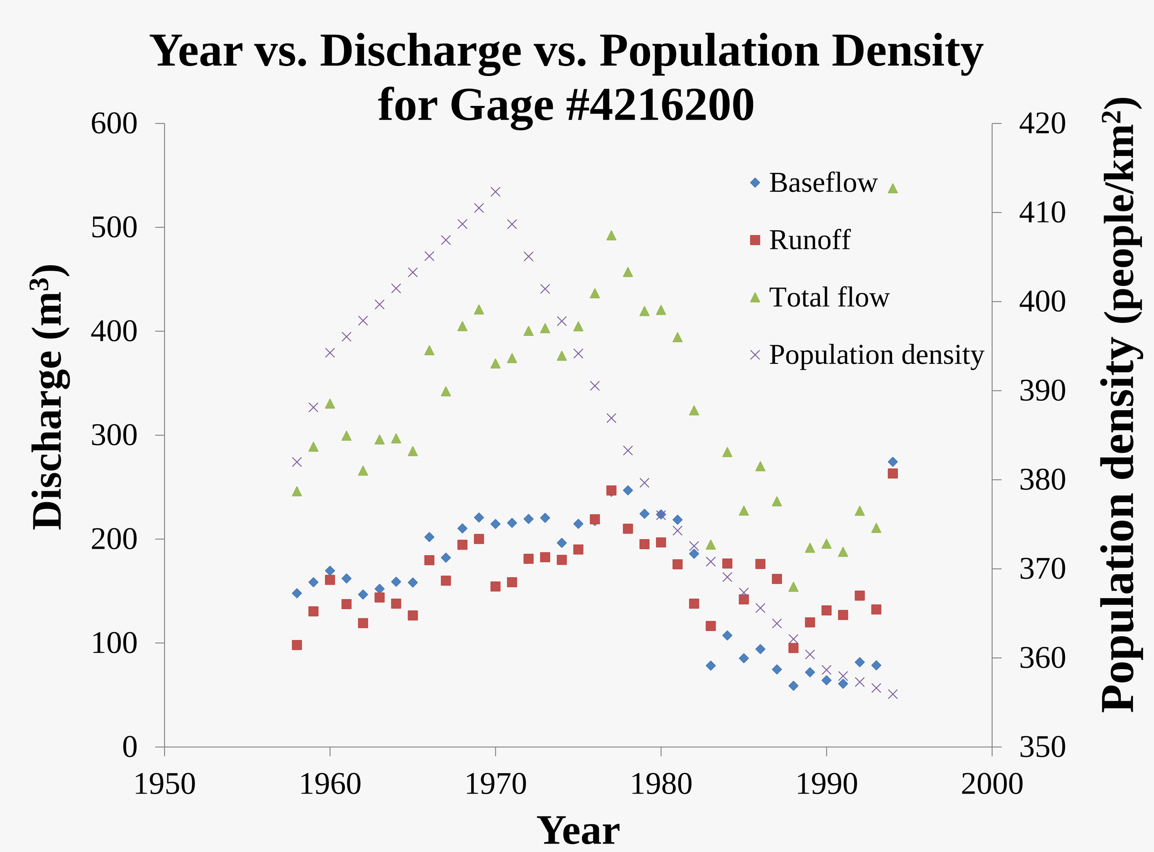
Geophysical Provinces of the Conterminous United States

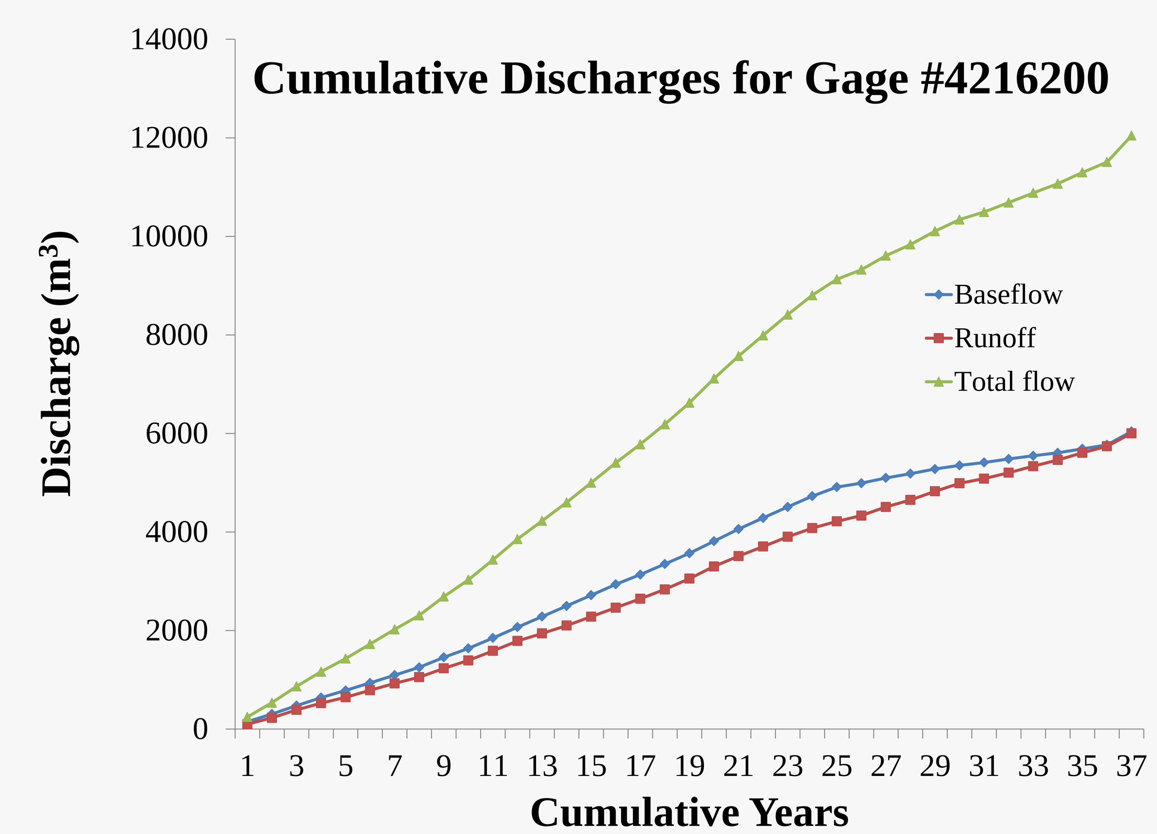
RESULTS

LOG Data

Gage Name	Gage #	BF X-var	p-value	RO X-var	p-value	TF X-var	p-value
Little Pine Creek near Etna, PA	3049800	0.2	0.643257922	0.0	0.927760993	0.1	0.889730881
Abers Creek near Murrysville, PA	3084000	0.6	0.176393986	0.4	0.361263501	0.5	0.222733363
Turtle Creek at Trafford, PA	3084500	-0.9	0.193384719	-1.7	0.063136787	-1.3	0.078252139
Chartiers Creek at Carnegie, PA	3085500	-0.1	0.841827498	-0.5	0.032827621	-0.2	0.441273993
Mill Creek at Youngstown, OH	3098500	-1.5	0.71968476	-1.4	0.6024937	-1.6	0.661382187
Tinkers Creek at Bedford, OH	4207200	-0.9	0.031646894	-0.5	0.271409155	-0.7	0.080919754
Mill Creek at Carthage, OH	3259000	1.8	0.297274063	1.3	0.197906612	1.5	0.279303436
Wolf Creek at Dayton, OH	3271000	4.3	**6.14568E-05**	3.1	**1.9839E-05**	3.9	**4.35295E-05**
Kearsley Creek near Davison, MI	4148140	0.0	0.996544672	0.2	0.82092308	0.1	0.92628168
Paint Creek at Rochester, MI	4161540	0.5	0.037586928	0.4	0.049125091	0.5	0.035363258
Big Beaver Creek near Warren, MI	4162900	-3.1	**0.001820606**	-2.0	**0.013020099**	-2.4	**0.005271217**
Plum Brook at Utica, MI	4163400	2.8	0.036313976	2.3	0.036283081	2.6	0.038591831
N. Branch Clinton River near Mt. Clemens, MI	4164500	0.2	0.117787498	0.1	0.425709706	0.1	0.230124101
River Rouge at Birmingham, MI	4166000	0.7	**2.64695E-05**	0.7	**3.37068E-05**	0.7	**2.0715E-05**
Evans Ditch at Southfield, MI	4166200	0.5	**0.007043811**	0.8	**0.002337173**	0.7	**0.002482704**
Upper River Rouge at Farmington, MI	4166300	1.4	**9.62108E-10**	1.5	**4.8414E-09**	1.4	**7.55781E-10**
Middle River Rouge near Garden City, MI	4167000	-4.0	**0.006258648**	-3.2	**0.003870154**	-3.7	**0.005653588**
Lower River Rouge at Inkster, MI	4168000	-2.9	**8.87879E-13**	-1.2	**0.00051004**	-2.1	**4.46341E-09**
Ottawa River at University of Toledo at Toledo, OH	4177000	-1.9	0.563864643	-0.8	0.681552314	-1.5	0.592615639
Rocky River near Berea, OH	4201500	-1.0	**0.007858974**	-0.6	**0.003509393**	-0.9	**0.002519883**
Cayuga Creek near Lancaster, NY	4215000	4.0	**0.001067166**	1.8	**0.010847902**	3.2	**0.002331941**
Cazenovia Creek at Ebenezer, NY	4215500	0.1	0.557280059	-0.2	0.529096623	0.0	0.913566392
Scajaquada Creek at Buffalo, NY	4216200	7.2	**1.71084E-07**	1.6	**0.013235566**	4.1	**5.03429E-06**
Ellicott Creek below Williamsville, NY	4218518	-2.2	**6.79407E-06**	-0.3	0.644188899	-1.4	**0.008505673**
Allen Creek near Rochester, NY	4232050	-0.1	0.896840739	1.9	**0.00790679**	0.8	0.234080624
Irondequoit Cr. above Blossom Rd. near Rochester, NY	423205010	1.4	0.306640892	2.0	0.28511338	1.6	0.268716731

Appalachian Plateaus	**Positive Trend**	**0.01 significance**
Central Lowland	**Negative Trend**	**0.05 significance**





DISCUSSION

Depopulated cities of the "Rust Belt", situated within the Central Lowlands physiographic province, experience urban karstification more intensely than other urban areas because of the underlying rock. The urban karstification process happens at a faster rate than it would naturally because the over-pressurization of the subsurface water infrastructure erodes the surrounding rock more quickly than naturally flowing waters in a typical karst system. Because of urban karstification, select cities are experiencing an increase in baseflow despite a decrease in population.

Urban Karstification

Leaks, by design, due to over-pressurization to decrease [water] contamination.

Subsurface water infrastructure acting as a conduit for flow, increases secondary porosity and permeability characteristics.

Lifespan of water infrastructures are approaching, resulting in system failure.

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