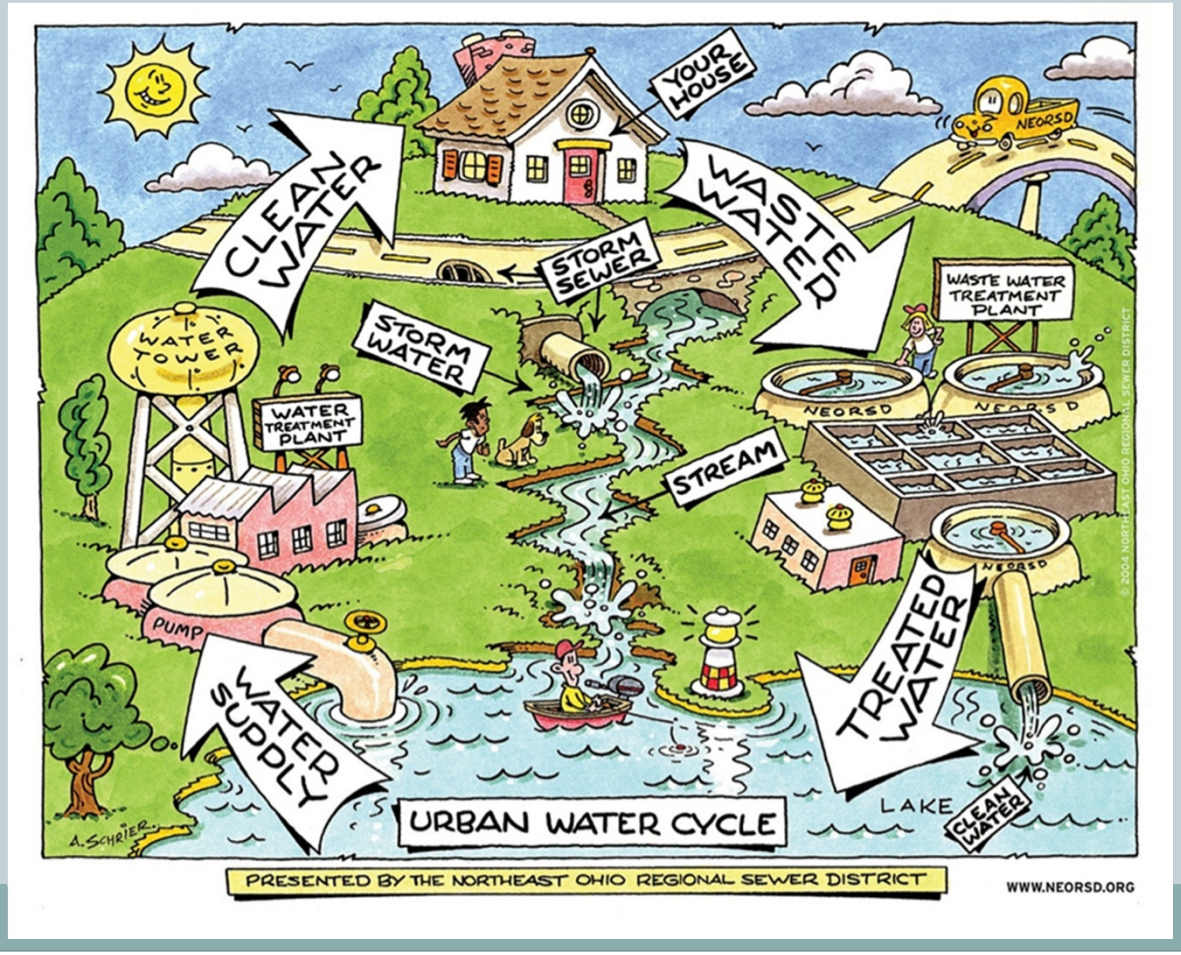
Burlington Flowing

WATER, WASTEWATER AND STORMWATER SYSTEMS IN THE QUEEN CITY

It's all the same water…

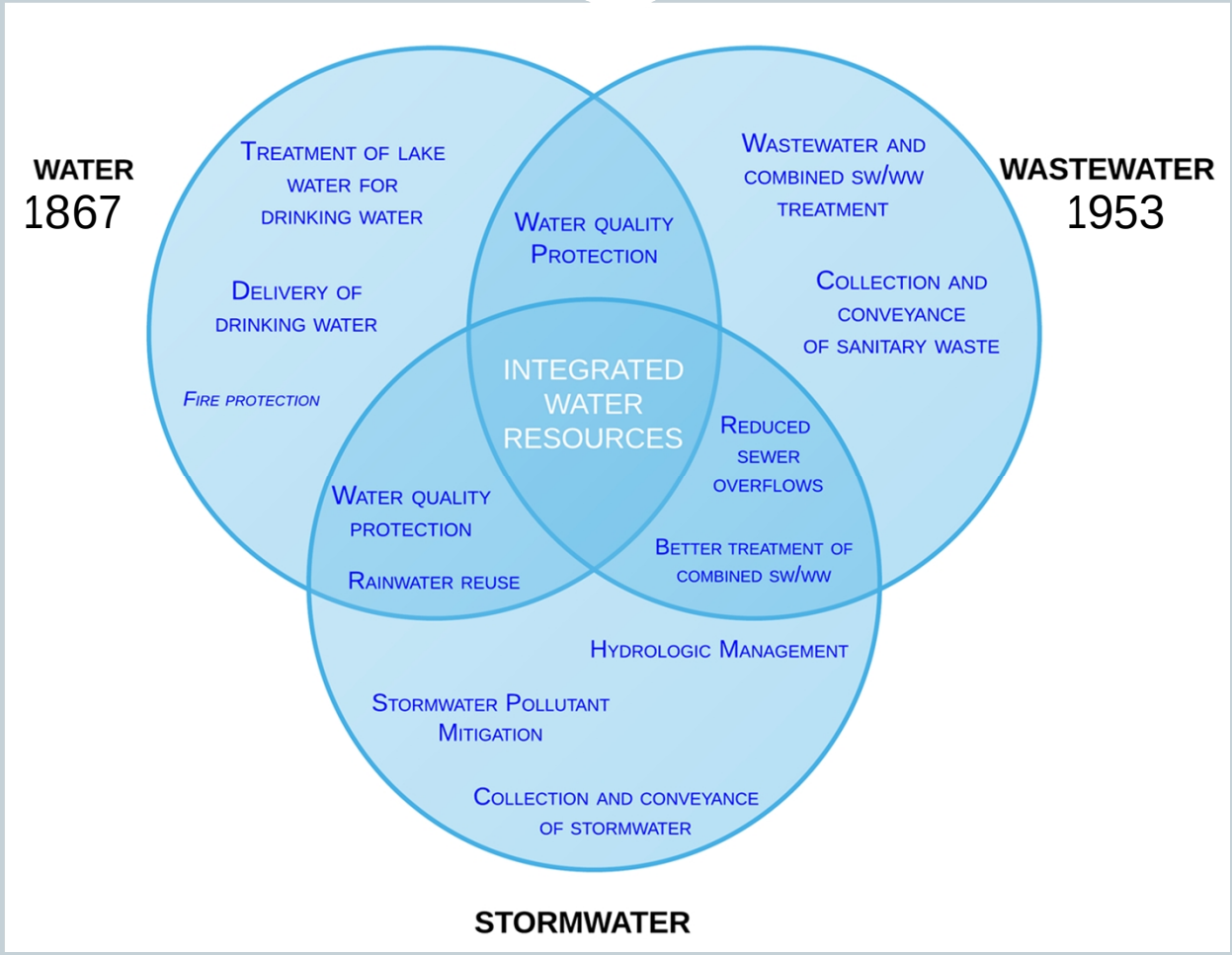
- Every drop of water that we use continues through the water cycle. What we put down the drain ends up in someone or something else's water.



Water Resources

BURLINGTON, VT PUBLIC WORKS

Burlington Water Resources: One Water



Water Resources

BURLINGTON, VT PUBLIC WORKS

Water Resources by the Numbers

- 1 water plant
- 110 miles of water mains
- 3 Wastewater Treatment Plants
- 49 miles of sanitary sewer
- 45 miles of combined sanitary / storm sewer
- 37 miles of storm sewer
- 25 pump stations
- 176 storm water outfalls
- 2,000+ catch basins
- 900 fire hydrants

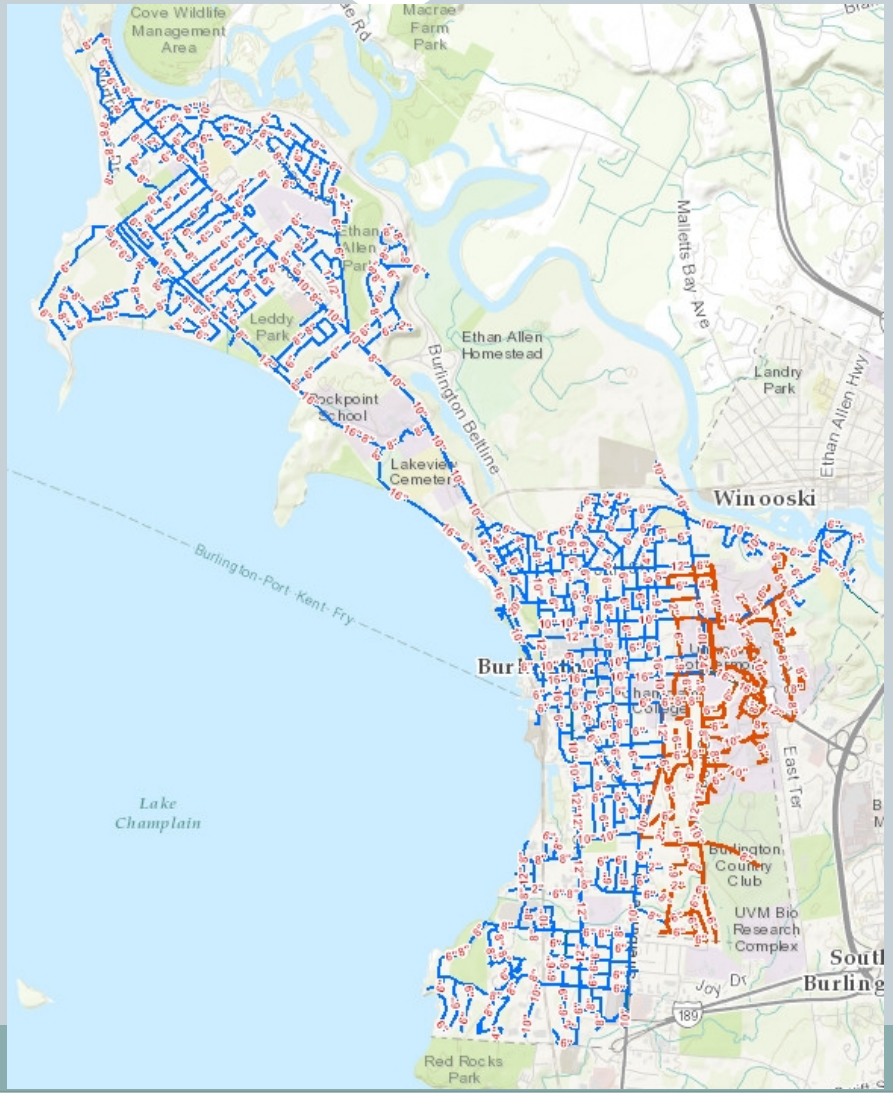
Water Math:
1 cubic foot = 7.48 gallons

Terminology

- Water
  - drinking/potable water (water to drink)
  - sufficient water supply (pressure and flow) to fight fires, aka fire protection
  - *water treatment plant, distribution system, valves, hydrants, water service line, reservoirs/tanks, high service (tanks), low service*
- Wastewater
  - sanitary sewage
    - waste from toilets (black water)
    - waste from sinks, showers/tubs, washing machines (grey water)
  - *wastewater treatment plants (3), collection system, manholes, sanitary laterals, pump stations*
- Stormwater
  - Stormwater runoff = water that falls as rain and runs off impervious surfaces (or in a perfect world we allow to infiltrate)
  - *collection system, storm drains, low impact development/ green stormwater infrastructure (bioretention), water quality and quantity management, outfalls*
- Combined Sewage
  - mixture of wastewater and stormwater
  - *combined sewer overflows, wet-weather management*

Current Distribution (Water Delivery) System

- 110 miles of water mains

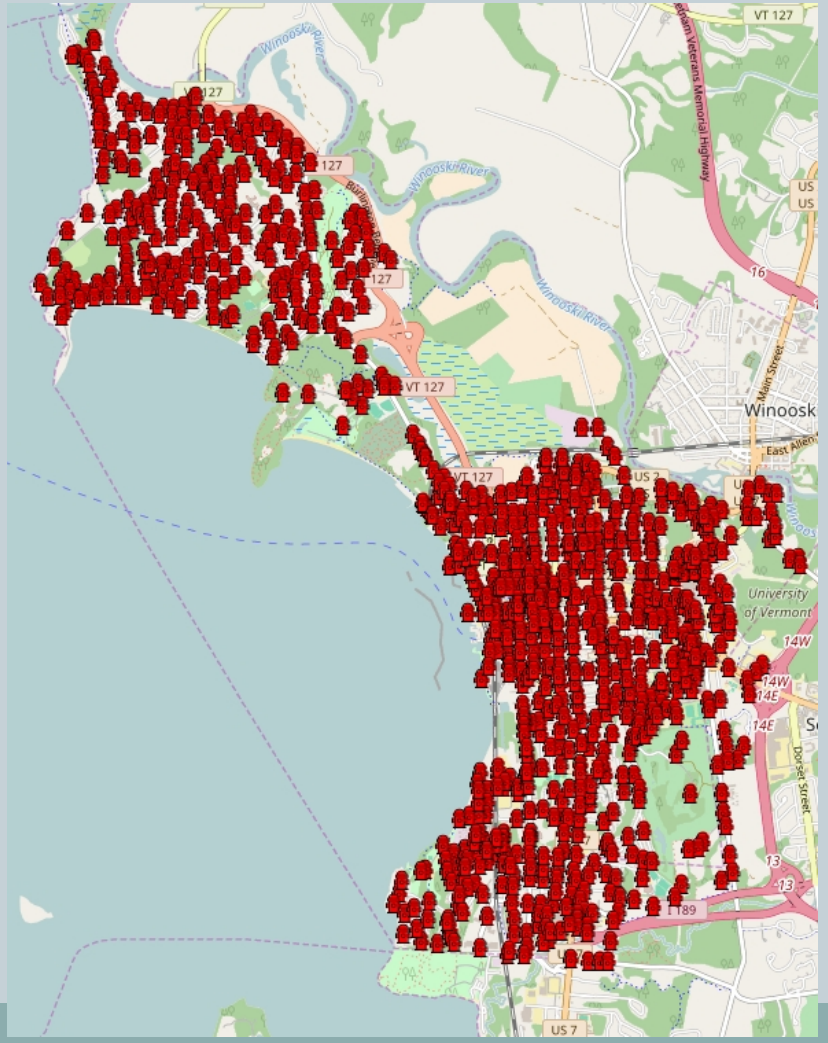


Water Resources

BURLINGTON, VT PUBLIC WORKS

Hydrants (not just for doggies)

- 900+ hydrants
- Critical to fire protection in the City



Water Resources

BURLINGTON, VT PUBLIC WORKS

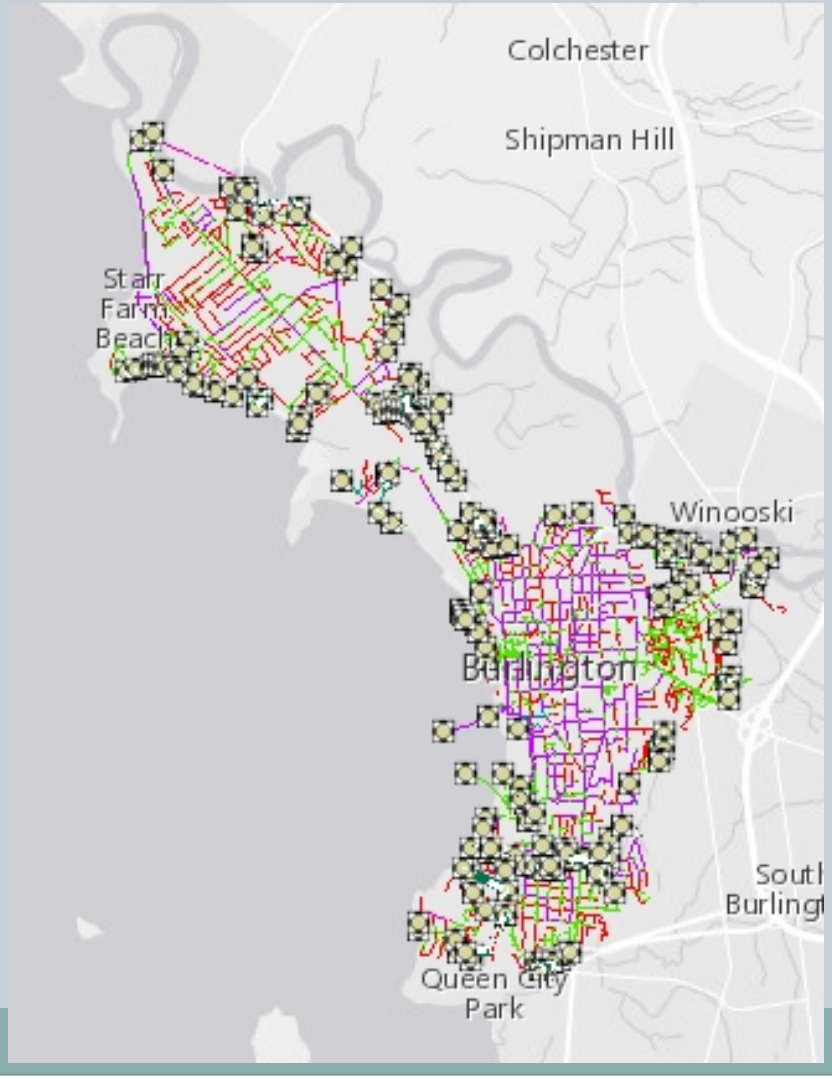
Sanitary, Combined and Storm Sewer Collection Systems

outfall

sanitary

combined sewer

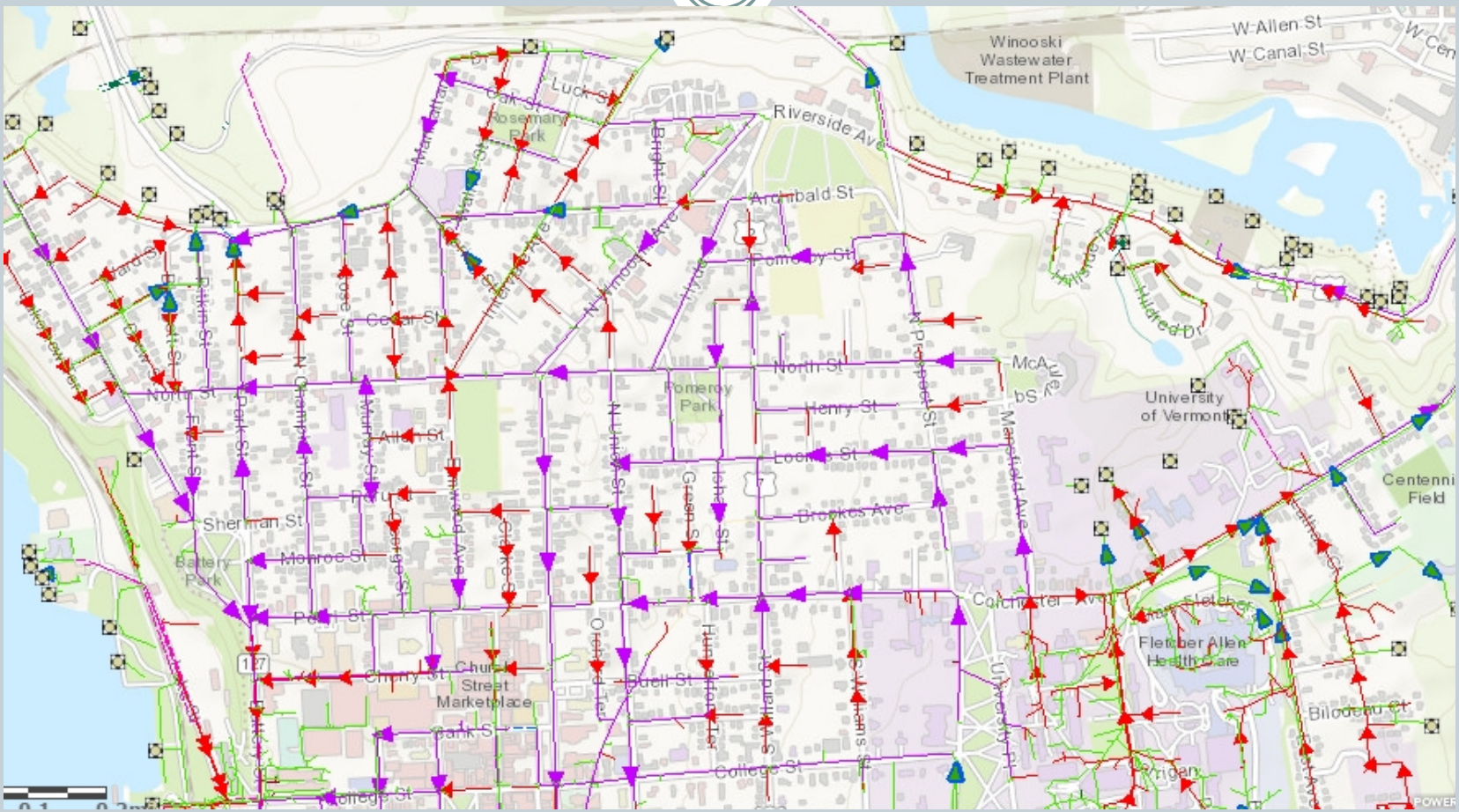
storm



Water Resources

BURLINGTON, VT PUBLIC WORKS

Closer Look at The Collection System

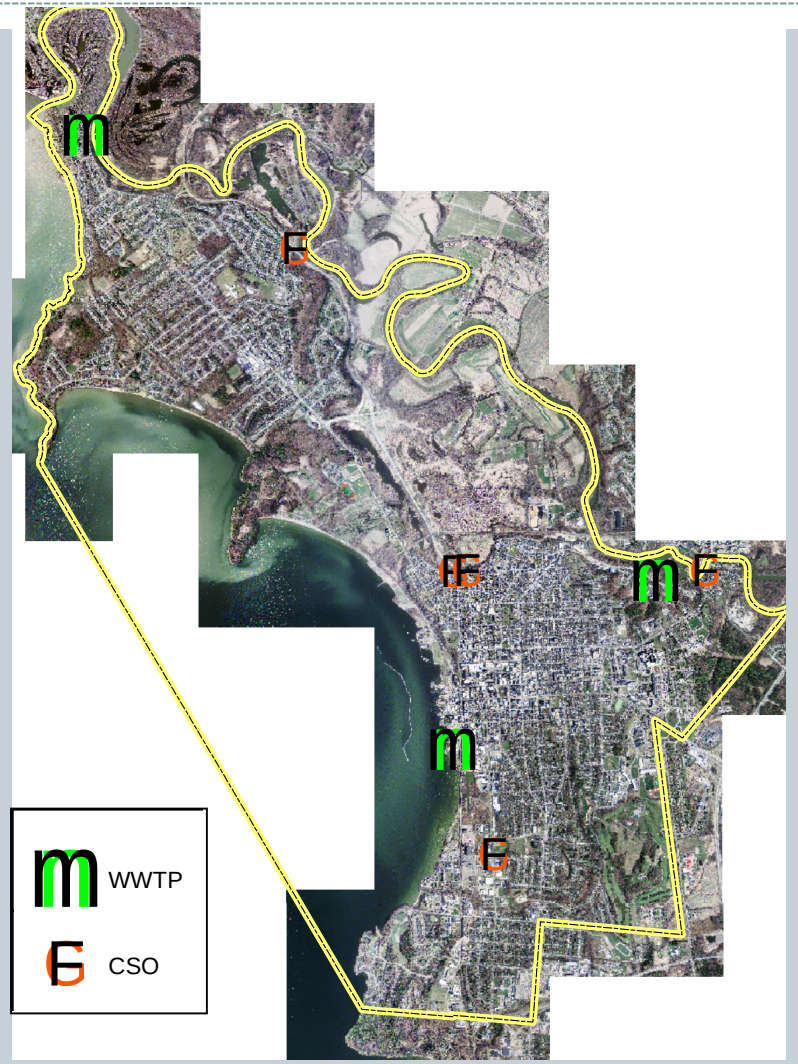


outfall sanitary combined sewer storm

Water Resources

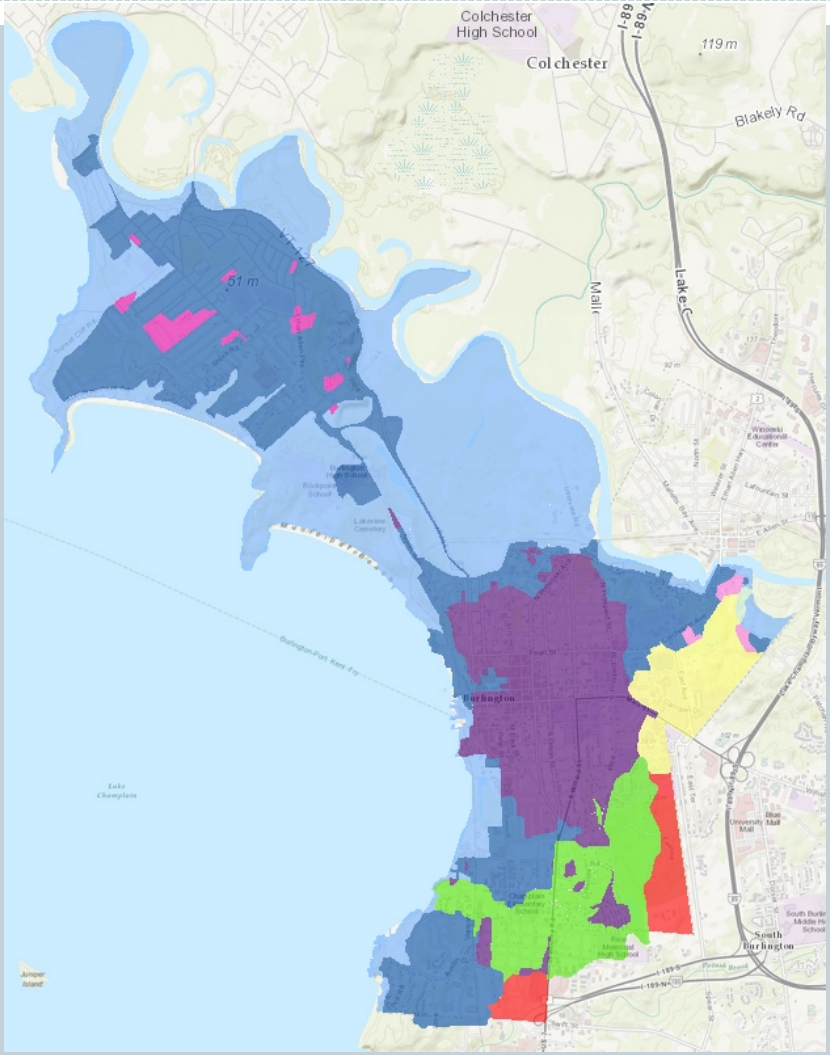
BURLINGTON, VT PUBLIC WORKS

Wastewater Treatment Plants and CSOs



- 3 WWTPs with P removal to 0.8 mg/L or better (avg. <0.3 mg/L at North and Main curr.)
  - Main Plant (5.3 MGD)
  - East ("Riverside") Plant (1.2 MGD)
  - North Plant (2.0 MGD)
- 49 miles of sanitary pipe
- 45 miles of combined sewer pipe
- 25 pump stations
- 5 untreated CSO outfalls
  - Pine Barge CSO is most active

Map of Combined and Separate Sewersheds



Drainage Area

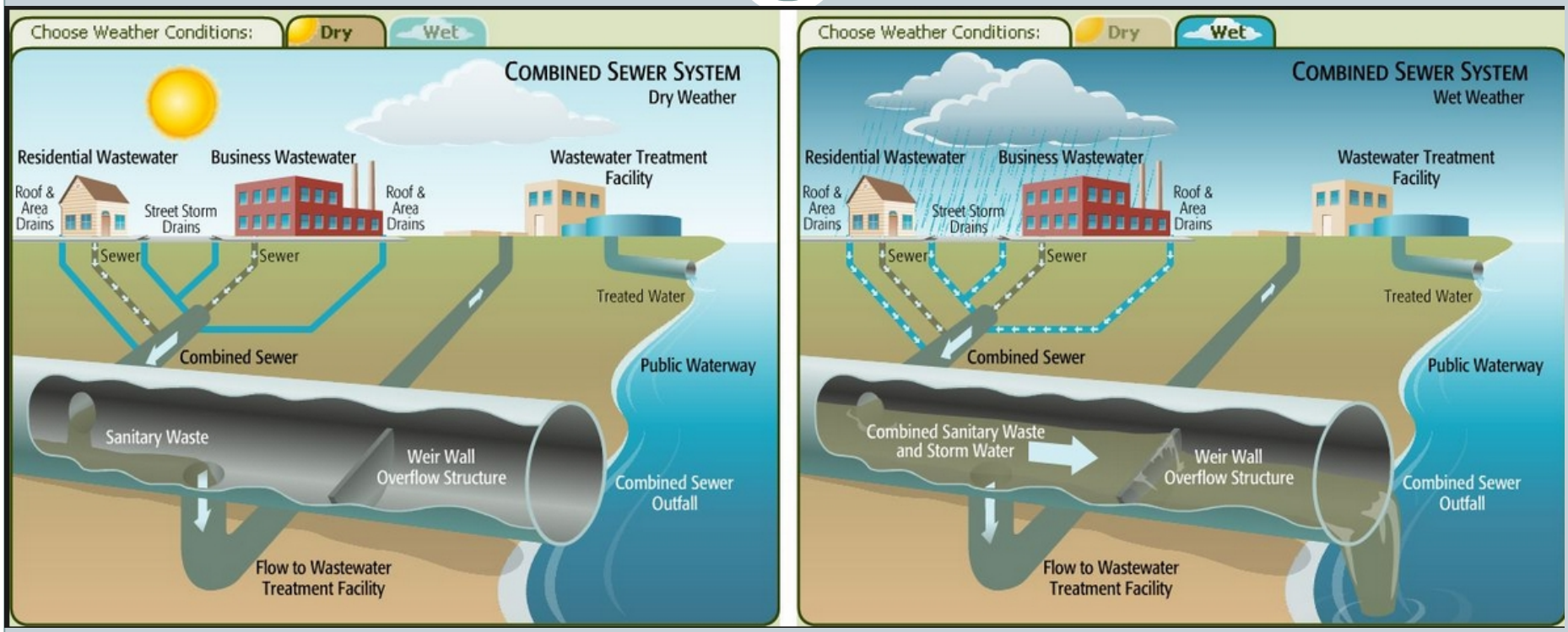
- 1.1 Main Plant
- 1.2 North Plant
- 1.3 East Plant
- 2.1 Englesby Brook
- 2.2 Centennial Brook
- 2.3 Potash Brook
- 3 MS4 (Non Impaired)
- 4 Direct Discharge (Non Impaired)

Everything ends up in Lake Champlain!!

Water Resources

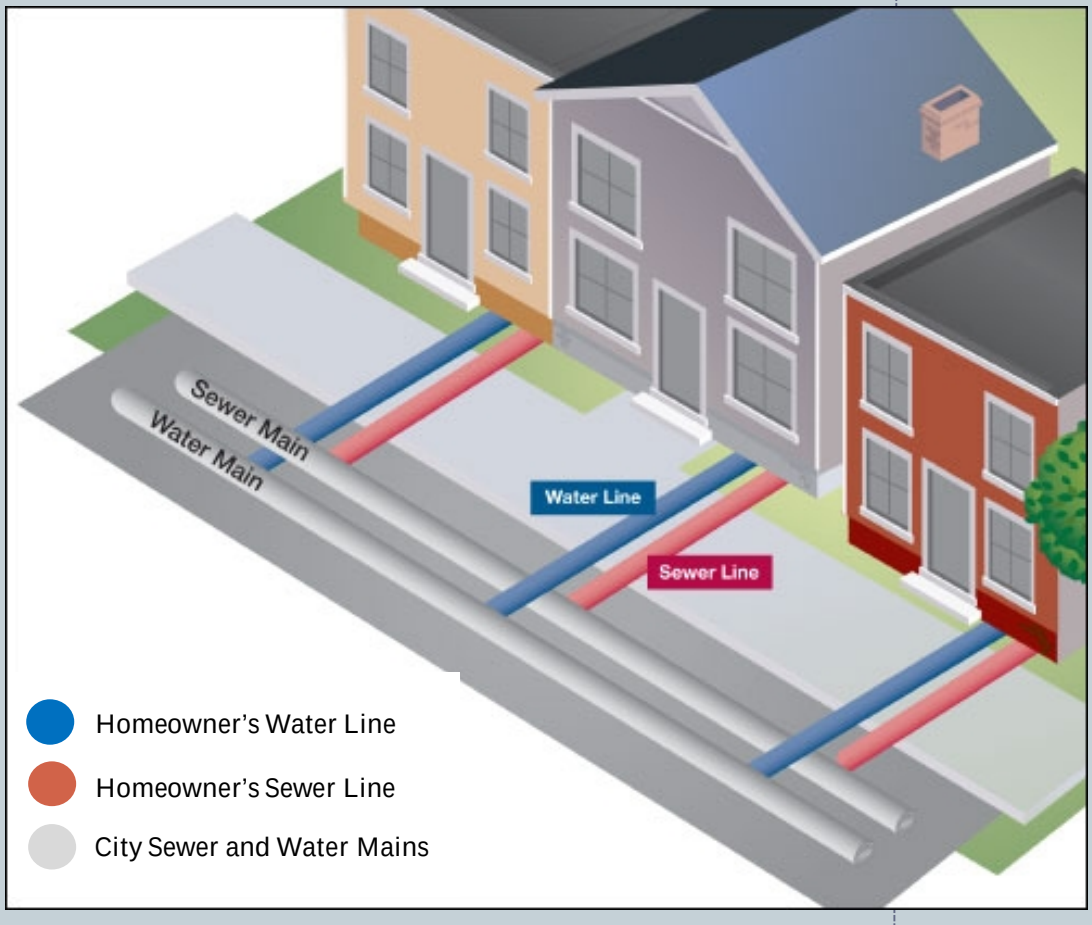
BURLINGTON, VT PUBLIC WORKS

What is a combined sewer?



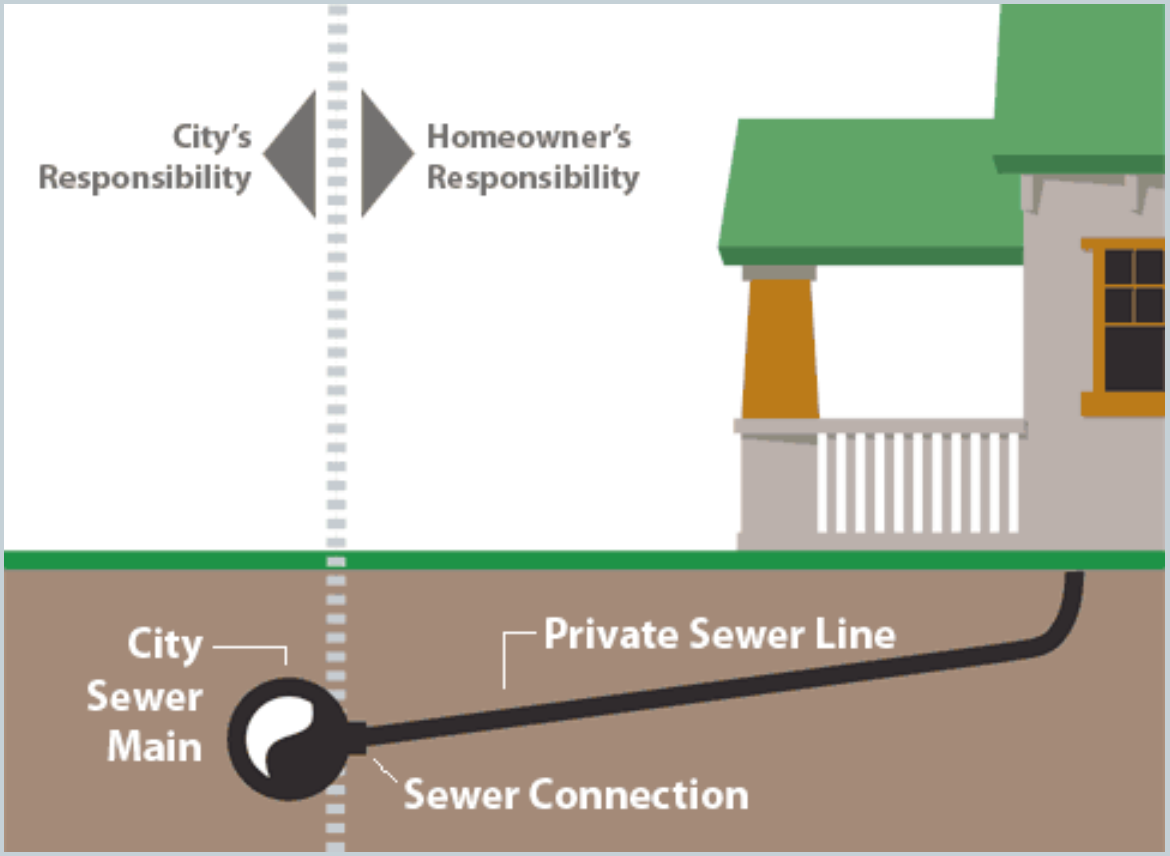
CSO = Combined Sewer Overflow

Water and Sewer Service Lines



- Properties are served by:
  - a water service line that delivers drinking/washing water
  - a sewer lateral that drains sanitary waste (from sinks, toilets, showers)

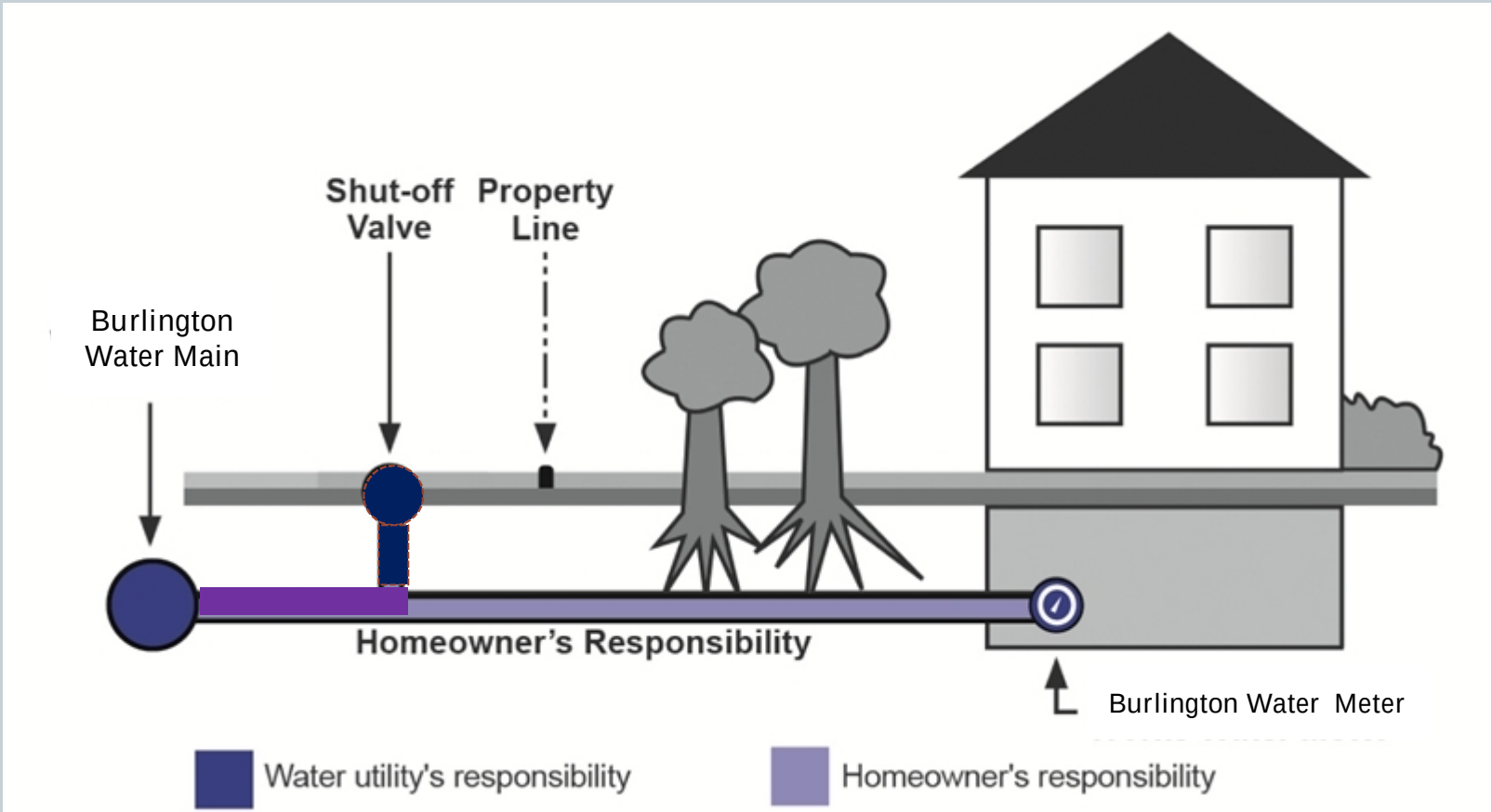
Anatomy of Your Sewer Lateral



Water Resources

BURLINGTON, VT PUBLIC WORKS

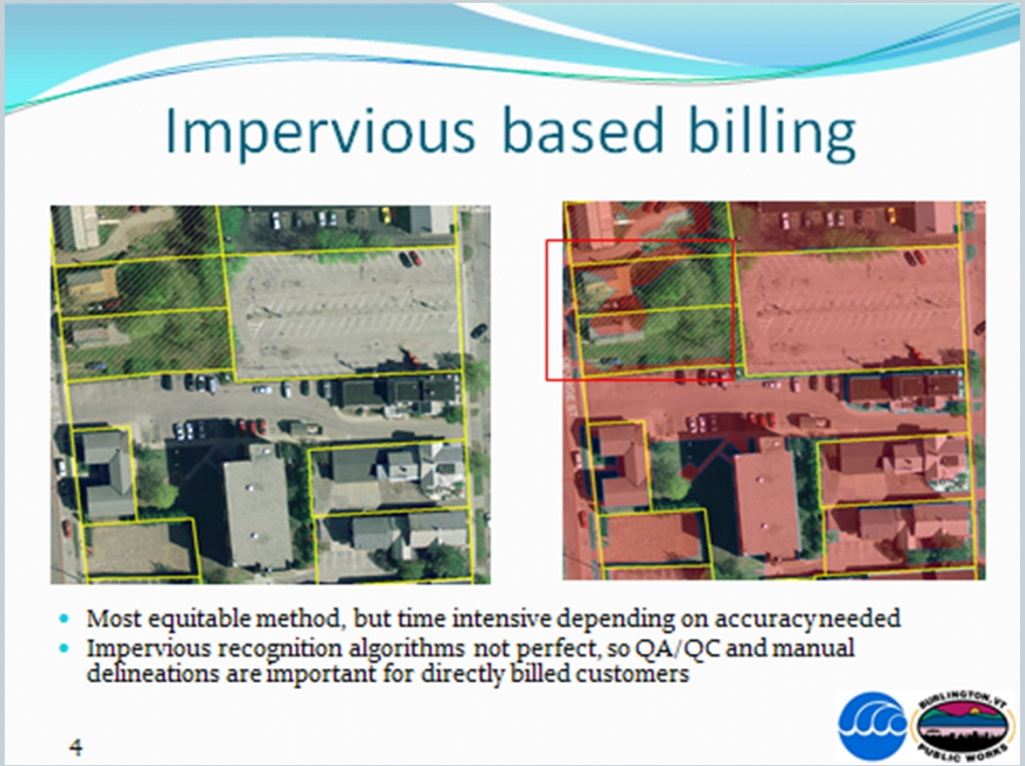
Anatomy of Your Drinking Water Service Line



50% Cost Share on repairs

Water Resources

How does Water Resources calculate customer charges?



- Water and Sewer costs are based on the amount of water used monthly (measured by water meter)
  - Water: $4.05/100 cf
  - Wastewater:$5.55/100 cf
- Stormwater is based on impervious surface measurements
  - Monthly flat fee for single family ($6.60), duplex ($6.56), triplex ($7.56)
  - Directly measured and billed for other properties
    - $2.47/1000 sq. ft. of impervious

Burlington Water Resources History: Before Burlington Waterworks

- 1820 → 1865: Grew from 3000 to 8000 inhabitants
  - Citizens depended on cisterns and wells, with a few obtaining it from Burlington Aqueduct Company or directly from Lake by casks
  - Health officer noted "the cholera is a true epidemic" and called for *abundant supply of fresh running water and good sewerage as indispensable to the security, prosperity and health of the City.*

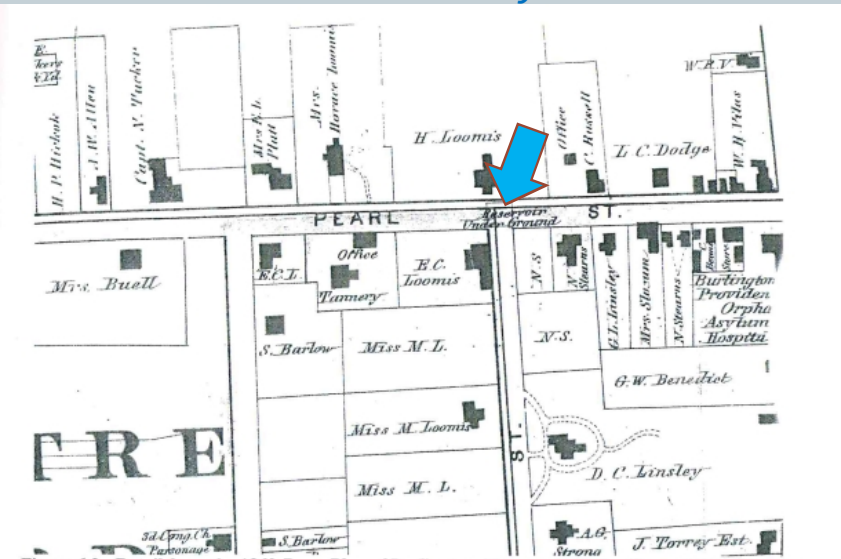


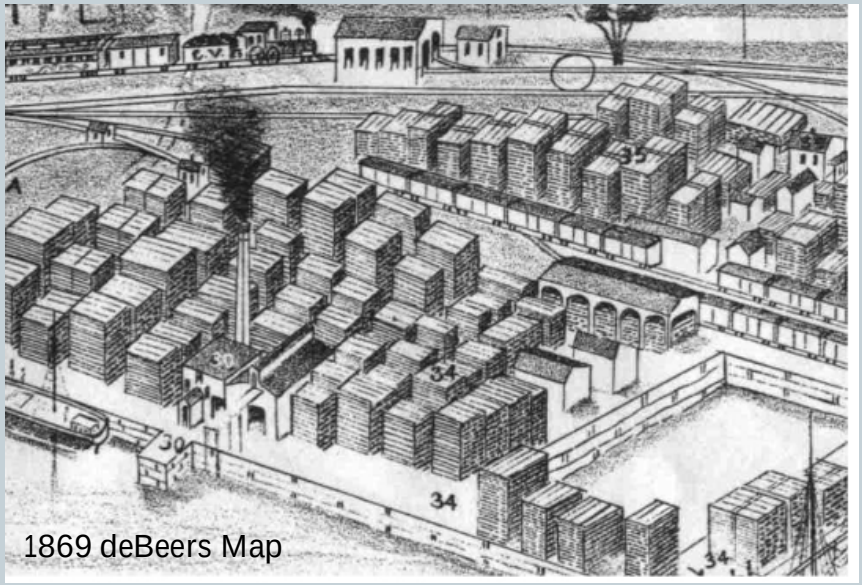
Figure 6.2: Detail from the 1869 *Beers Plan of Burlington*; "Reservoir Under Ground," built by the Aqueduct Company, is shown on Pearl Street, just below the H. Loomis property; George Linsley's property is located three lots to the right, and D. C. Linsley's residence is on the lower right, on Williams Street

Figure 6.3: The site of the Burlington Aqueduct Company's underground reservoir on Pearl Street, directly in front of the Henry Loomis House

~ 4000 gallon cistern, originally fed by 4 springs

Birth of a Municipal Water System

- 1866: City of Burlington purchases Burlington Aqueduct Co.
- 1867: "plan for a construction of waterworks"
  - pumphouse built on waterfront (same location as today)
  - water intake laid 50' off shore
  - North Reservoir built (2.236 M gallons)



1869 deBeers Map

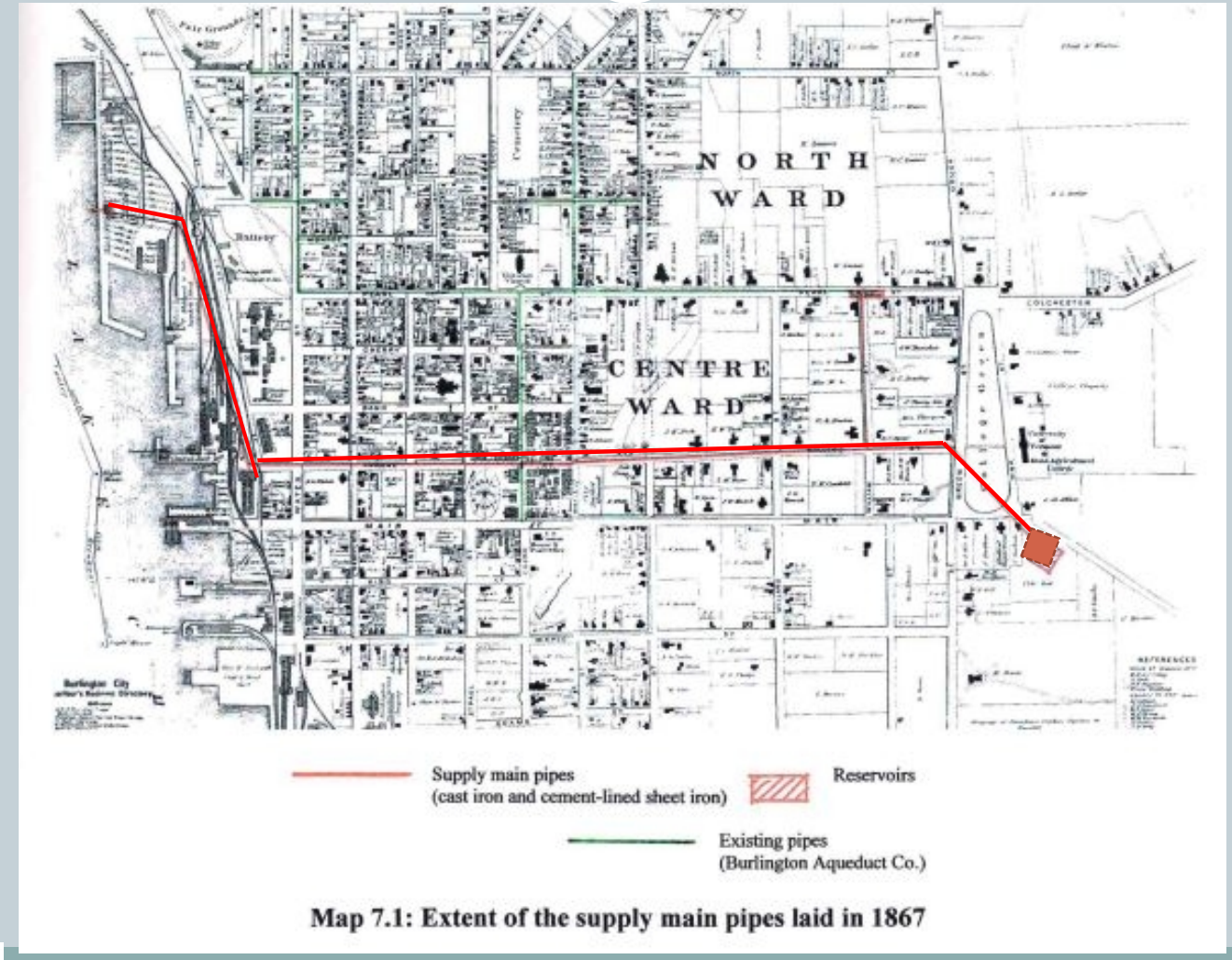

Figure 7.3: Circa 1887 photograph of the lakefront pump house and chimney, with the intake well in the foreground (Courtesy Special Collections, UVM Libraries)

Water Resources

Truly "Lake to Tap" – raw water with no treatment

BURLINGTON, VT PUBLIC WORKS

Birth of a Municipal Water System



Map 7.1: Extent of the supply main pipes laid in 1867

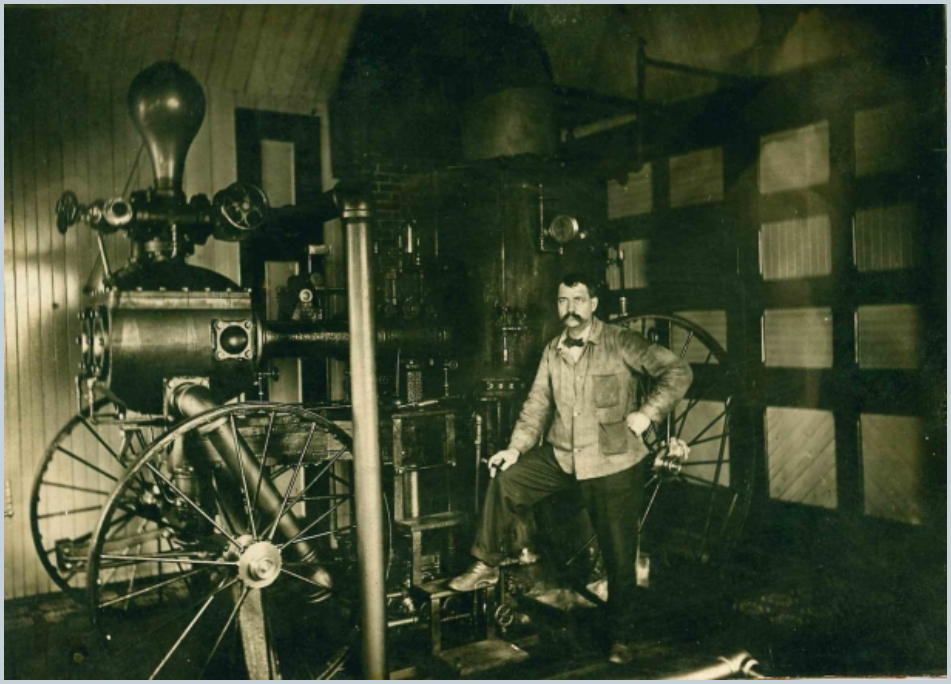
Truly "Lake to Tap" – raw water with no treatment

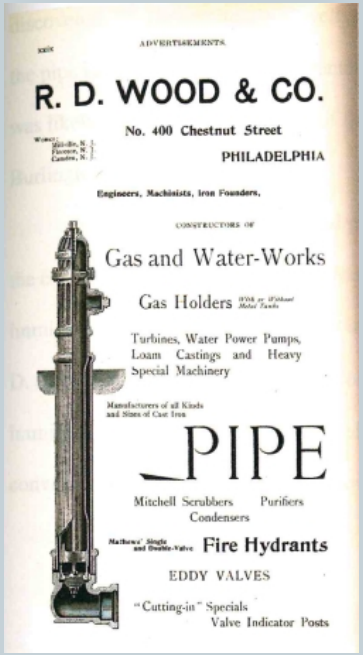
Water Resources

BURLINGTON, VT PUBLIC WORKS

Not just drinking water – fire protection!

- 1869: Fire Department established, begin transitioning from use of portable pumps to hoses which connect to pressurized system of hydrants.

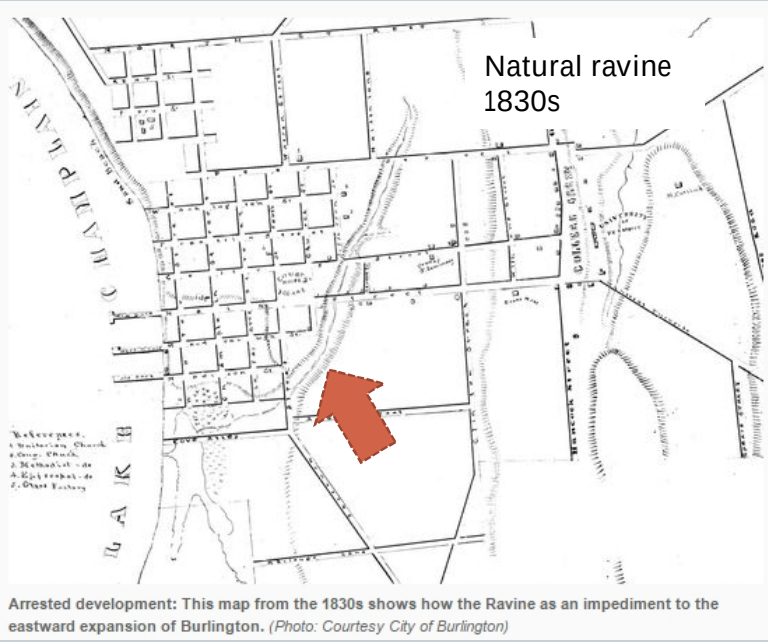




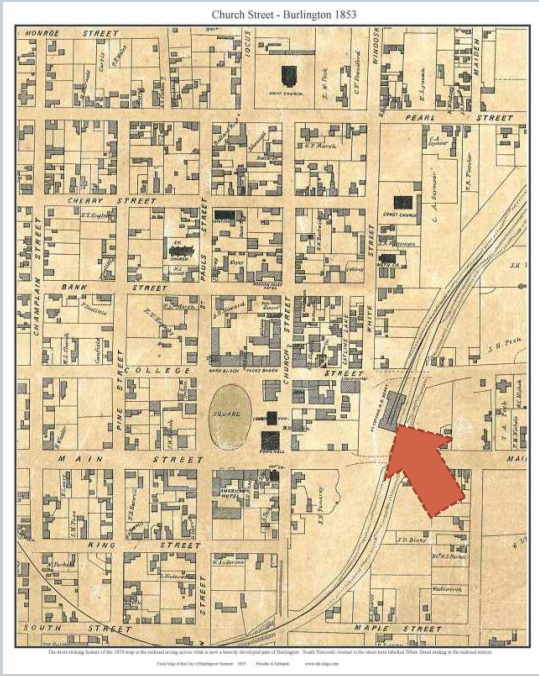
- 1869-1875: Nearly every mayoral address in these years mentions the importance of the new waterworks in aiding the fire department in its work

Meanwhile on the sewer side…

- 1869: construction of sewers in vicinity of College and St.Paul begins, with a sewage outfall at bottom of College Street (4 blocks south of water intake)
- 1873-1880: major construction of sewers; hill section drains to ravine sewer empting at bottom of Maple; west of ravine, everything drains to College Street.
  - First mention of stormwater catchbasins/stormdrains being connected to sewer system



Arrested development: This map from the 1830s shows how the Ravine as an impediment to the eastward expansion of Burlington. *(Photo: Courtesy City of Burlington)*



Ravine occupied by Rail in 1853

- 1872 - 1874: (no coincidence!) City Health Officer noted impurity of Lake water near shore and discussed possibility of an intake out in deep water

Water System Evolution: More storage needed!

- 1878: Identified need for “high service” capacity for nearly completed Mary Fletcher Hospital
  - Redstone storage tank built 1880-1883 (106,000 gallons)
  - Gatehouse @ reservoir → pumphouse
  - Created high service (vs. low service)

And More Storage…

- 1872-1880: City determined needed additional water for low service system (second reservoir), but delayed many years because of worries about quality of City water supply
- 1888-1891: Construction of South Reservoir (~4 MG) and renovation of North Reservoir, bringing total to ~7 MG

Figure 7.18: Main Street reservoir, drained of water and under renovation, circa 1890 (Courtesy Burlington Water Department)

Water Resources

Burlington population ~18,000 residents

PUBLIC WORKS

Continued Water Quality problems…

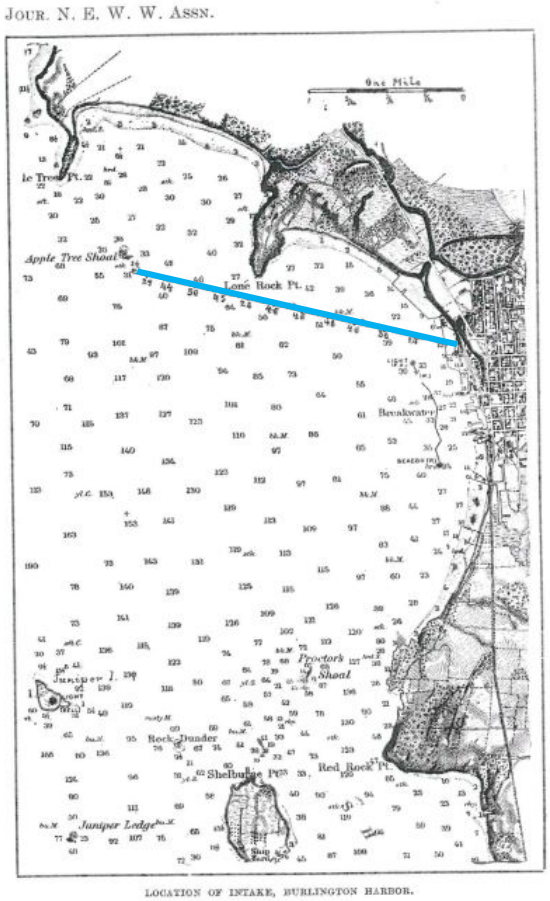


Figure 10.3: Illustration of Burlington Bay, showing water depths and the location of Apple Tree Shoal, where the new intake pipe was to be located, from *Journal of the New England Waterworks Association* (1894)

- Significant waterborne illness epidemics

Table 10.2
Selected health statistics relating to the water supply of Burlington, 1883 -1894
(Compiled from "Reports of the City Health Officer," Burlington *Annual Report*)

YEAR	Total deaths	Deaths from infectious ('zymotic') disease	Percent of total deaths from infectious disease	Deaths from Cholera morbus	Deaths from Cholera Infantum	Deaths from Typhoid fever	Deaths from other diarrheal illness	Percent of total deaths for children under 5 yrs.
1883	242	41	20%	0	8	1	5	46%
1884	322	57	18%	0	12	10	NA	43%
1885	368	59	16%	0	15	2	NA	38%
1886	381	52	20%	0	19	2	20	41%
1887	428	172	26%	4	15	10	NA	29%
1888	375	96	25%	2	32	8	NA	44%
1889	248	70	35%	0	19	8	NA	32%
1890	300	39	13%	2	26	3	NA	36%
1891	272	26	10%	0	16	4	18	35%
1892	280	24	25%	0	37	3	NA	33%
1893	306	40	13%	2	15	8	NA	40%

- 1894: installed new raw water intake 2 miles off shore on Appletree Shoal

1894 Intake Project

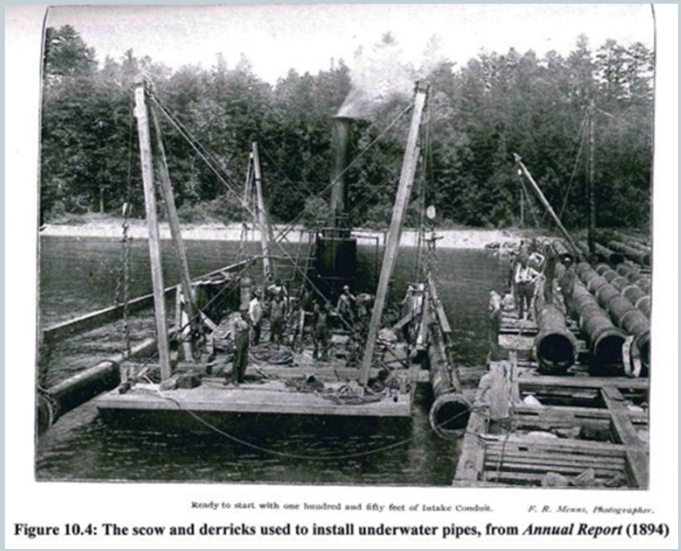

Ready to start with one hundred and fifty feet of Intake Conduit. F. R. Means, Photographer.

Figure 10.4: The scow and derricks used to install underwater pipes, from *Annual Report* (1894)

- 24” diameter
- 2 miles off-shore
- Really heavy diving suits!

Water Resources

BURLINGTON, VT PUBLIC WORKS

Uh Oh – Deep Intake Didn't Work☹

- Continued waterborne illness…

Table 10.4
Selected health statistics relating to the water supply of Burlington, 1895 -1905
(Compiled from "Reports of the City Health Officer," Burlington *Annual Reports)*

YEAR	Total deaths	Deaths from infectious ('zymotic') disease	Percent of total deaths from infectious disease	Deaths from Cholera morbus	Deaths from Cholera Infantum	Deaths from Typhoid fever	Deaths from other diarrheal illness	Percent of total deaths for children under 5 yrs.
1895	311	39	12%	1	14	1	24	36%
1896	360	52	14%	0	28	3	2	46%
1897	333	NA	NA	2	22	3	10	42%
1898	283	NA	NA	0	3	5	13	36%
1899	378	NA	NA	1	21	1	28	44%
1900	329	NA	NA	1	20	7	22	42%
1901	326	NA	NA	1	21	3	13	43%
1902	312	NA	NA	0	17	2	18	39%
1903	379	NA	NA	1	16	7	12	35%
1904	365	NA	NA	1	15	7	19	41%
1905	434	NA	NA	0	17	3	23	43%

- Designers hadn't taken into account that there were southerly flows from the Winooski River

Water treatment is born! (in the form of a filter)

- 1904: Understood that sewage was a likely contributor…debates about whether to "purify" sewage or filter the drinking water. As there was no practical purification for sewage… decided to go with water filtration

- 1908: Construction of filter plant using sand filtration, with alum as coagulant before (still no disinfection)
  - Also recommended covering the reservoirs to prevent contamination of the filtered water (this would not happen until 1984)

Finally…disinfection!

- Typhoid was still an issue after filter plant constructed
- 1910: Followed a few other U.S. cities and began adding hypochlorite of lime (bleach) to coagulation basin
- 1921: Due to continued persistence of typhoid, replaced hypochlorite system with more efficient gas chlorination system

1920's work on distribution system

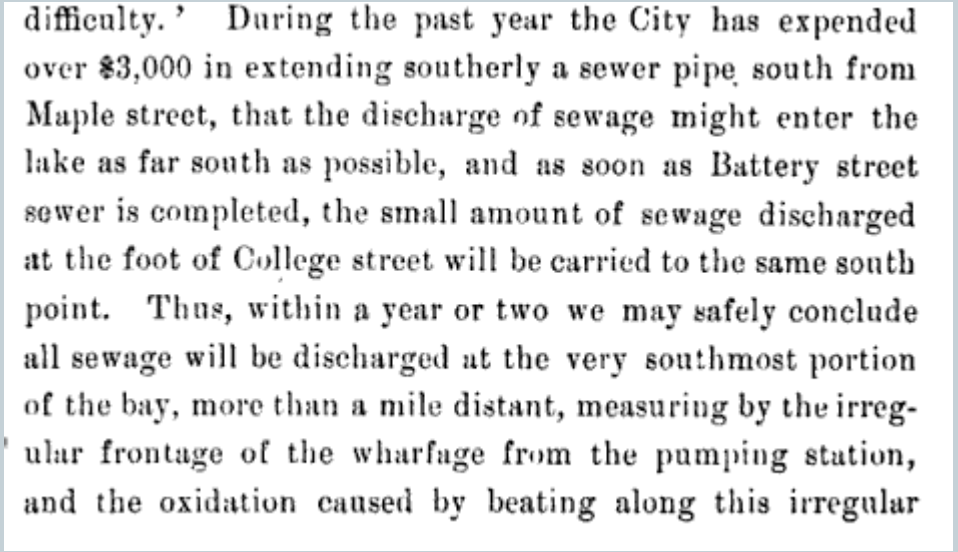
Various expansions of filter capacity followed until 1980s

Water Resources

BURLINGTON, VT PUBLIC WORKS

Early Wastewater Treatment

- 1911-1914: Serious recommendations from the City Engineer and Street Commission for a sewage "sterilization" plant
- 1927: First sewage treatment plant (settling basin and chlorinator) serving families near Fletcher Place (off of Colchester Ave)
- 1932: Construction of Maple Trunk Line Sewer from Maple and Church down to waterfront



difficulty.' During the past year the City has expended over $3,000 in extending southerly a sewer pipe south from Maple street, that the discharge of sewage might enter the lake as far south as possible, and as soon as Battery street sewer is completed, the small amount of sewage discharged at the foot of College street will be carried to the same south point. Thus, within a year or two we may safely conclude all sewage will be discharged at the very southmost portion of the bay, more than a mile distant, measuring by the irregular frontage of the wharfage from the pumping station, and the oxidation caused by beating along this irregular

1930 - 1952

- 1934: new elevated water tank at Redstone (150,000 gallons)
- 1940s: calls for wastewater treatment on waterfront and in the Winooski valley
- 1948: continued growth in water use required expansion of filter beds
- 1951: began chlorination of water storage reservoirs (still open)
- 1950: construction of Main Plant Wastewater Treatment Plant delayed by small group of public officials and citizens (even though voters had provided approval)
- 1952: upon recommendation of local medical and dental societies, began fluoridation of water supply to prevent tooth decay

Wastewater Treatment Arrives!

- 1953: Main WWTP constructed (clarification and chlorination); Sewage Disposal Dept created, later renamed Water Pollution Control Dept.

Water Resources

BURLINGTON, VT PUBLIC WORKS

Wastewater Treatment Arrives!

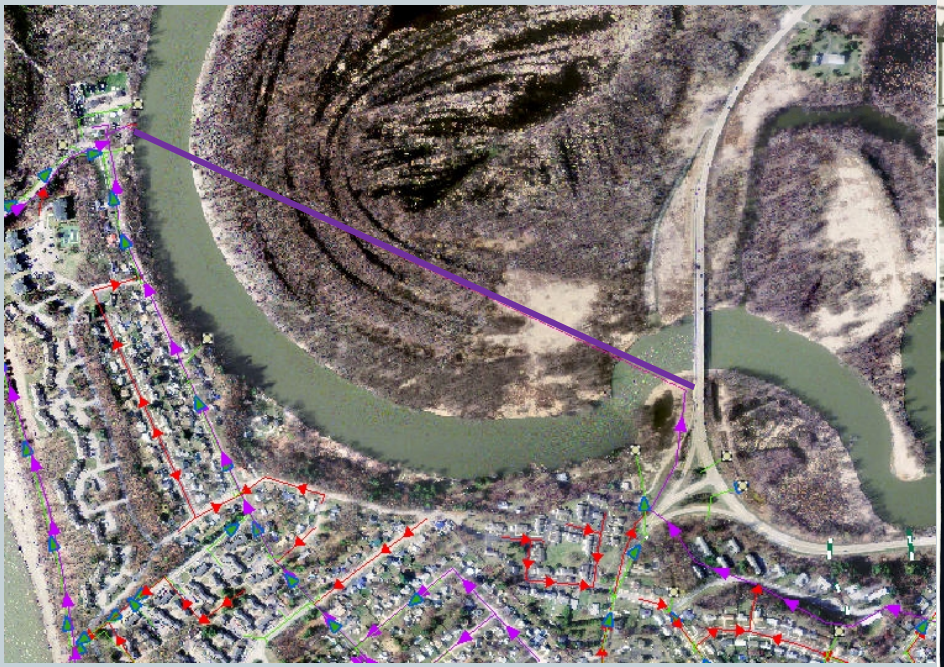
- 1959: North WWTP constructed at end of North Avenue

Water Resources

BURLINGTON, VT PUBLIC WORKS

Wastewater Treatment Arrives!

- Sewer River Crossing (North Plant Collection System)



Water Resources

BURLINGTON, VT PUBLIC WORKS

Wastewater Treatment Arrives!

- 1965: East/Riverside WWTP constructed (Finally!)
- 1968: ordered by State to upgrade to secondary treatment
- 1973: All plants were upgraded again (improved pollutant removal from 35% to 95% with addition of biological treatment); outfall at Main Plant extended to deeper water

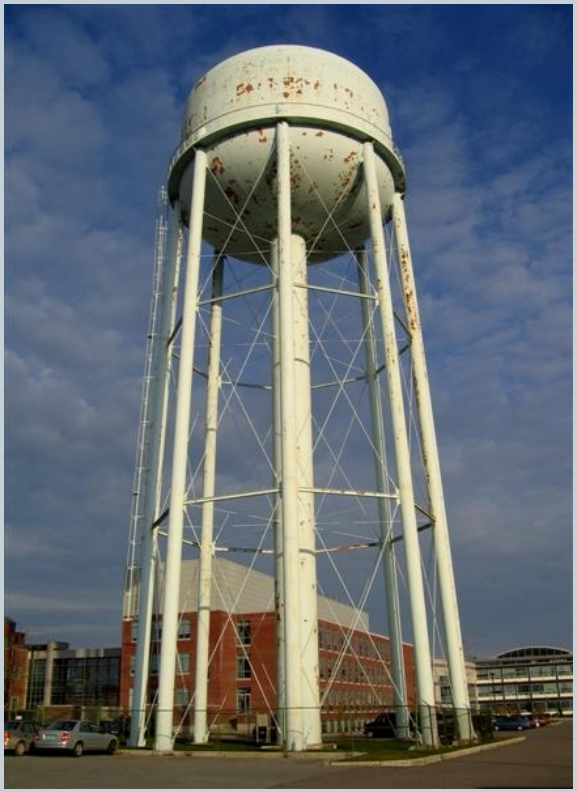
Main Plant 1973

Water Resources

BURLINGTON, VT PUBLIC WORKS

Meanwhile... Burlington continued to increase water usage

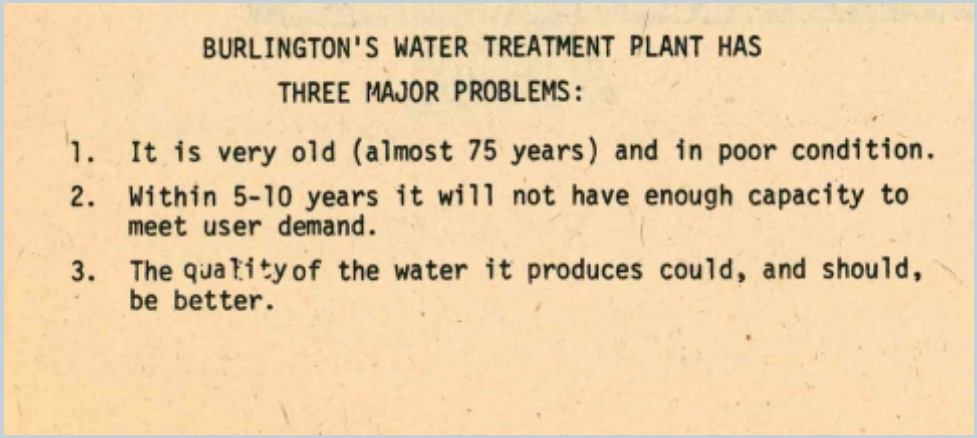
- 1954: Growth in high service area required construction of another storage tank (500,000 gallons)
  - Improved fire protection for main UVM campus, hospital and northern Hill section
- 1956-57: increased water usage throughout City required more raw water
  - 1984 intake cut near rock point and second additional 24” intake laid
- Late 1960-1970s: water supplied to 66,000 users in Burlington, South Burlington, part of Willston, Winooski and Colchester Fire District
  - 1972 – Champlain Water District starts own treatment and supply facilities



1954 UVM Water Tank

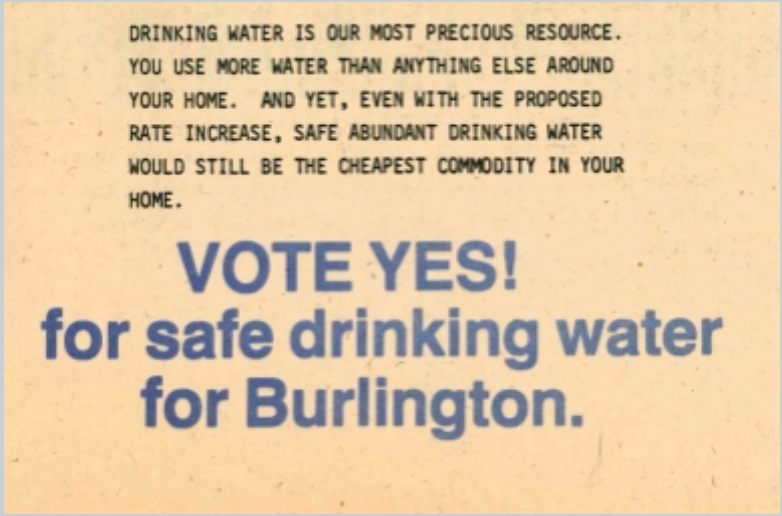
1974 Safe Drinking Water Act brings changes

- 1975: Vermont Dept. of Health cites lack of "complete" treatment and reservoir covers as two most serious problems
  - Additionally, growth rate projects showed Burlington would not be able to meet anticipate water needs (10 MGD by year 2000 – *BTW this didn't happen*)
  - System required a great deal of chlorine addition, increasing chance of disinfection byproducts
  - $12 million complete treatment plant upgrade, lining and covering of reservoirs and new 30" intake



BURLINGTON'S WATER TREATMENT PLANT HAS
THREE MAJOR PROBLEMS:

1. It is very old (almost 75 years) and in poor condition.
2. Within 5-10 years it will not have enough capacity to meet user demand.
3. The quality of the water it produces could, and should, be better.



DRINKING WATER IS OUR MOST PRECIOUS RESOURCE. YOU USE MORE WATER THAN ANYTHING ELSE AROUND YOUR HOME. AND YET, EVEN WITH THE PROPOSED RATE INCREASE, SAFE ABUNDANT DRINKING WATER WOULD STILL BE THE CHEAPEST COMMODITY IN YOUR HOME.

VOTE YES!
for safe drinking water
for Burlington.

Improved reservoirs

- 1982-84: Lined and covered reservoirs reducing contamination and need for chlorination

Improved reservoirs

- 1982-84: Lined and covered reservoirs reducing contamination

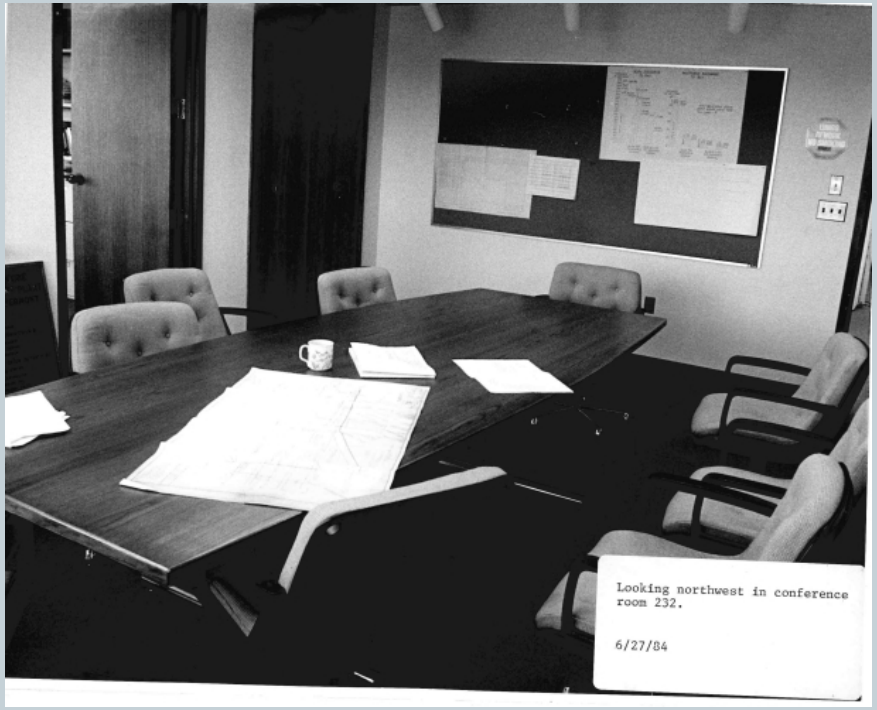
WOODEN FILL/DRAW PIPE AT THE BURLINGTON, VERMONT NORTH RESERVOIR. THE RESERVOIR WAS CONSTRUCTED IN 1867. THE PIPE IS WOOD STAVE CONSTRUCTION AND TAPERS FROM 16 TO 22 INCHES IN DIAMETER. THE PIPE WAS REMOVED FROM SERVICE IN 1982 AFTER 105 YEARS OF SERVICE AND IS BEING RESTORED FOR DISPLAY BY THE BURLINGTON WATER RESOURCES DEPARTMENT

Modernized Plant

- Overhaul of treatment plant

- Because water usage did not grow at predicted rates (daily use averages between 3.6 -4.4 MGD vs. predicted 10 MGD) water operators have optimized the plant to provide two stage filtration – water passes through filters in series vs. in parallel!

Some things never change:

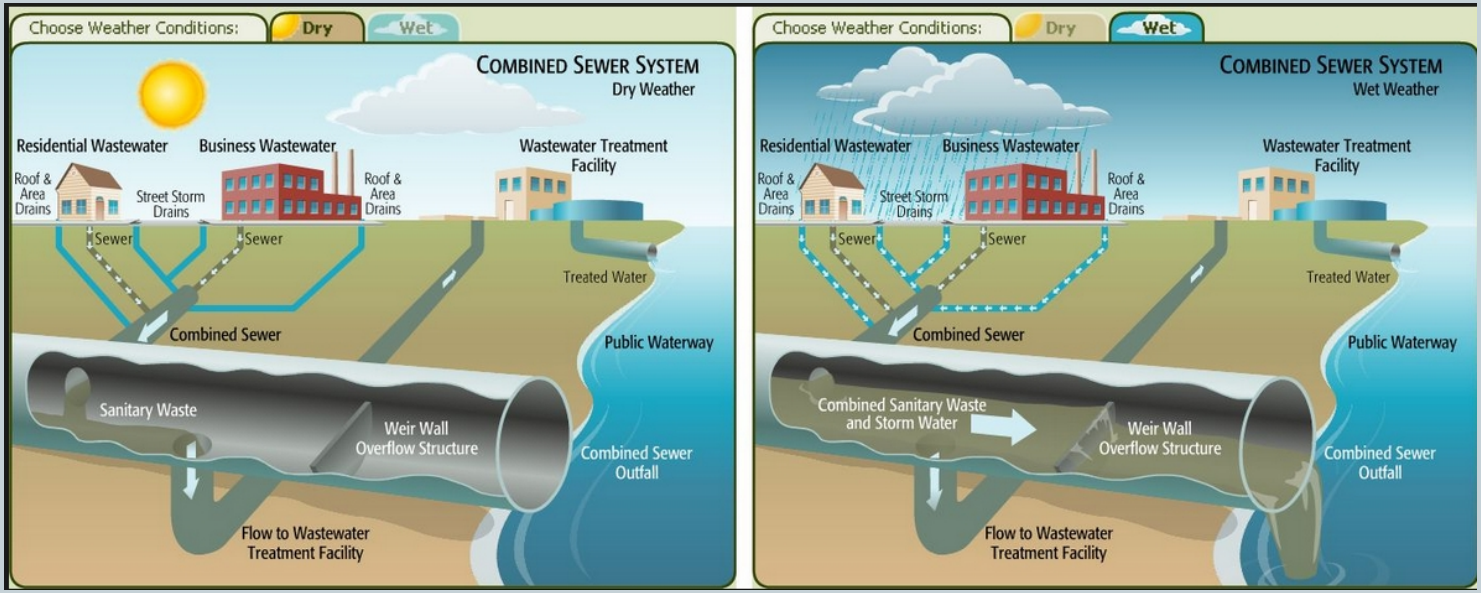


1984 Conference Room

2016 Conference Room

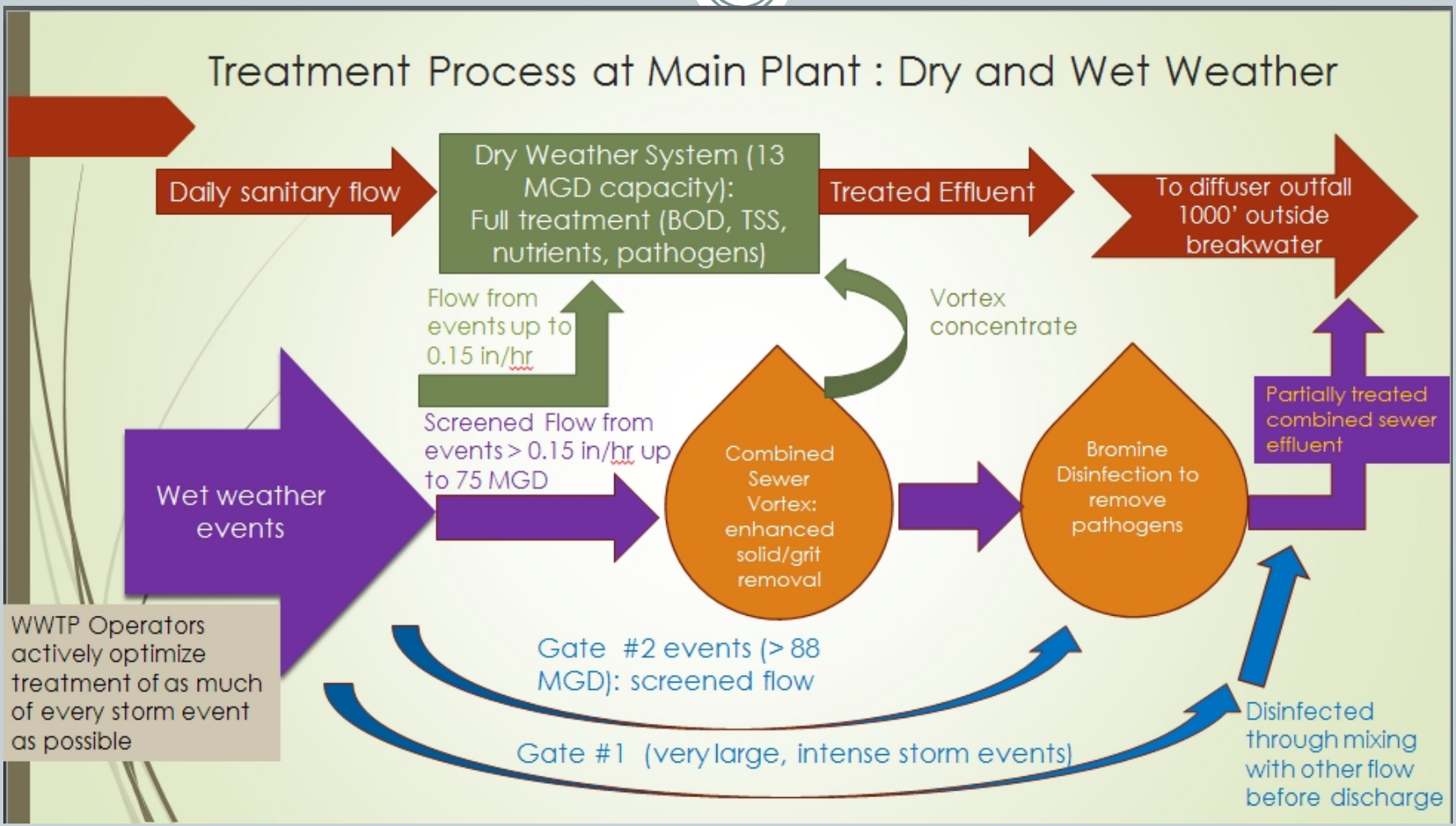
Late 1980s Wastewater and Combined Sewer Improvements

- 1980s: ~11+ Combined Sewer Overflow locations

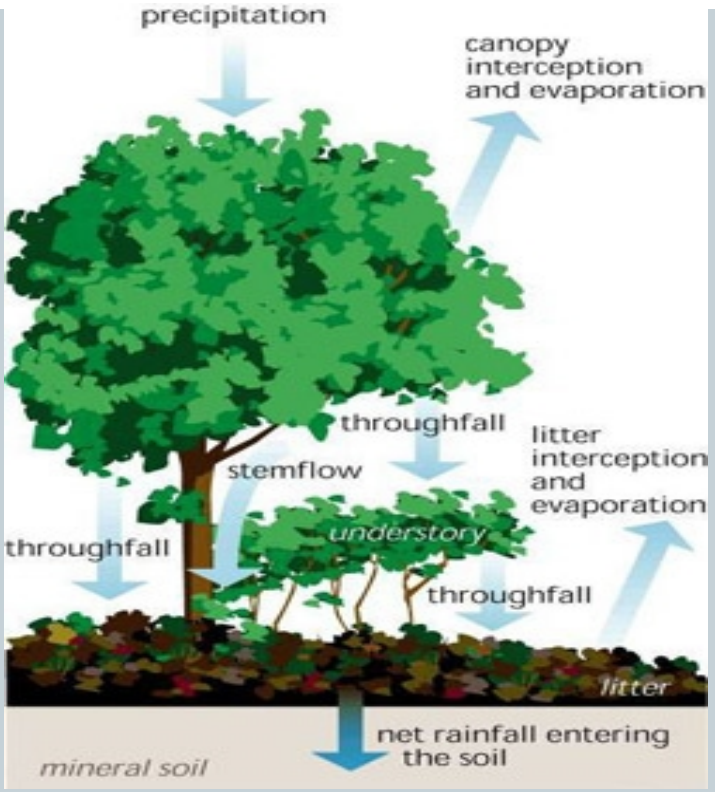


- Late 1980s – 1994: $52 million for significant separation of combined sewer (5 left, all but 2 infrequent), WWTP nutrient removal upgrades at all 3 plants and wet weather treatment system at Main Plant

Upgraded Wet-Weather Treatment Capacity



The Youngster: Stormwater



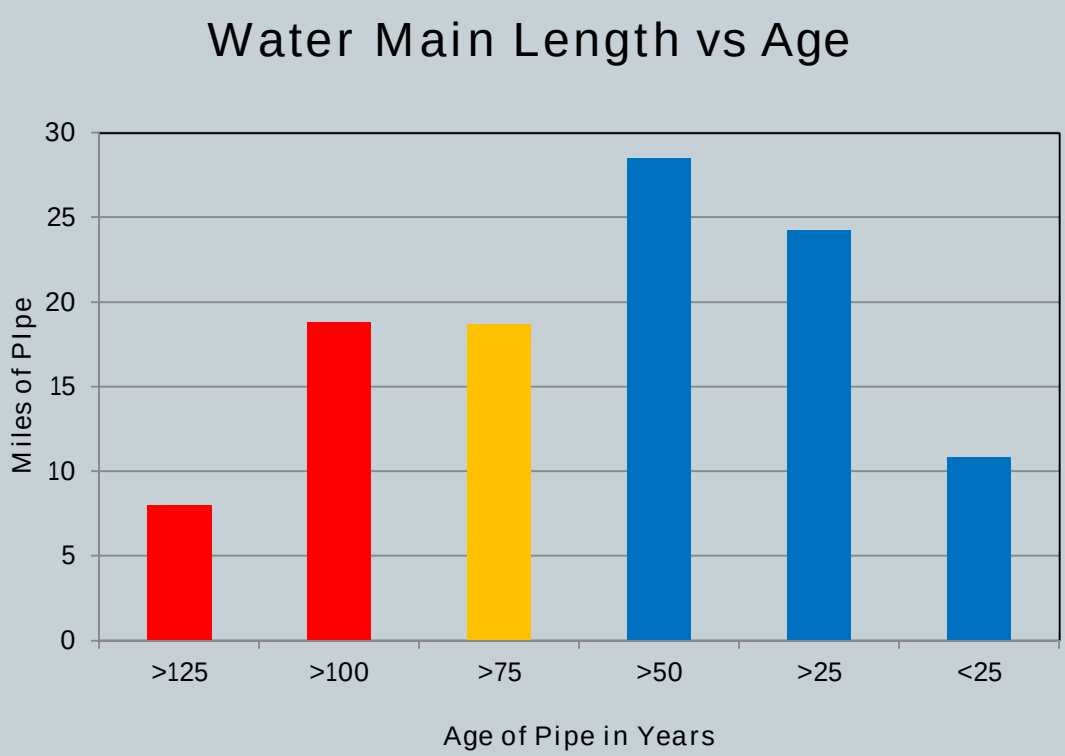
- Increases in impervious surface (paved and unpaved surfaces, rooftops) and removal of vegetation

The Youngster: Stormwater

- Increased *connections* of impervious surface to waterbodies
  - Increases amount of water and speed with which water reaches waterbodies
- Late 1990s/2000s: water resource professionals begin to realize the chronic impacts of stormwater runoff
- 2009: Burlington Stormwater Program formed with dedicated funding

Challenges:
Infrastructure deficit in water distribution system

- Useful life of metal water pipes is typically 75-100 years depending on installation and soil conditions
- In total 42% of our water pipes are older than 75 years, with almost 25% over 100 years old
- To get back on an average 75-100 year replacement schedule (~ 88 years as target), need to spend ~$2.3 M annually in next 25 years



Challenge: Water Quality and Quantity Issues

Normally forming tuberculation (internal corrosion i.e. rust) which forms in all metal water pipes everywhere leads to:

Our hydrant flushing program and our addition of anti-corrosion agents to our water slow this process down but many of our pipes are heavily tuberculated

Reduction in pipe capacity which can cause water pressure issues and ultimately impact fire fighting ability

Discolored water at the tap and in appliances when rust particles break off when there is a pressure change

While this rusty water is not a health risk, no one wants to discolored drink water, clog their aerators and filters or to risk staining their laundry

Water Resources

Burlington citizens expect and deserve clear water at their taps.

BURLINGTON, VT PUBLIC WORKS

What can happen if you don't integrate subsurface infrastructure replacement with other capital programs...

Breaks

Road Patches

Streets with Water Main Breaks <u>after</u> Paving (since 2009)

- Howard
- Pine
- Scarff
- S. Champlain
- Industrial
- S. Prospect
- St. Louis
- St. Paul
- Henry
- Brookes
- Hayward
- College

Patches grow up to be potholes!

Currently proposed $8.4 Million Water Bond will provide funds to renew critical water pipes before paving through open dig and newer relining technology.

Water Resources

BURLINGTON, VT PUBLIC WORKS

The Flint Michigan Question

- Burlington has no lead water mains
- No known lead services
- Older internal plumbing of properties MAY still have lead components
- We add Zinc Orthophosphate, an anti-corrosion agent, which helps to coat any remaining lead on the private side of the meter
  - Flint opted to not add this type of anti-corrosion when it switched water supplies (saving itself ~$140/day)

Clean Water (Wastewater and Stormwater) Challenges

Protecting Ecosystems and Human Health, Meeting the Clean Water Act, Adapting to Climate Change and Maintaining Existing Infrastructure

Water Resources

BURLINGTON, VT PUBLIC WORKS

Storm Outfall Needs

- 150+ outfall pipes
- 10-20% outfall areas are failed, with others in poor condition

→water quality impacts (sediment)

→ in some cases affecting public and private infrastructure

GAZO OUTFALL FAILURE

Water Resources

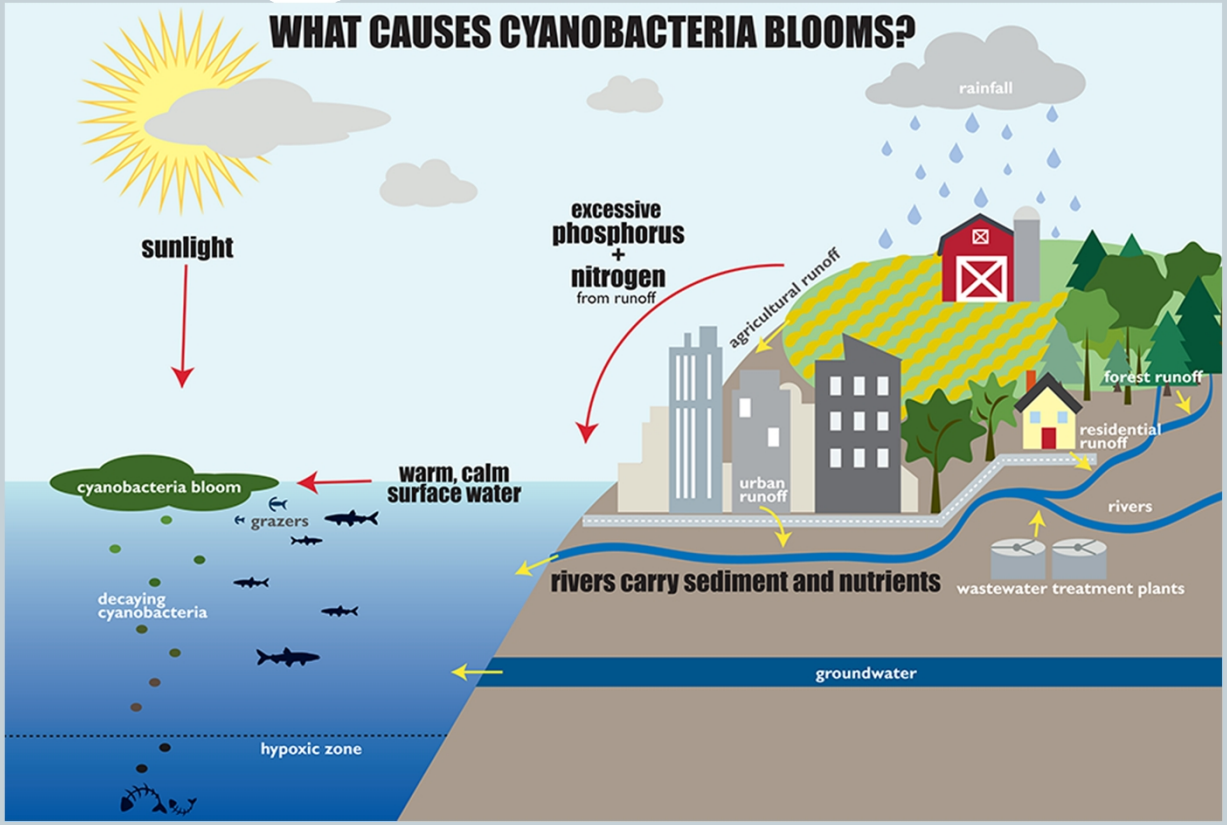
BURLINGTON, VT PUBLIC WORKS

Sanitary and Storm Sewer Needs

~53,000 linear feet of Corrugated Metal Pipe (CMP)

~50% have some sort of structural deficiency;
~10-20% need near term repair

Algae Blooms



BURLINGTON PARKS RECREATION WATERFRONT VERMONT

2016

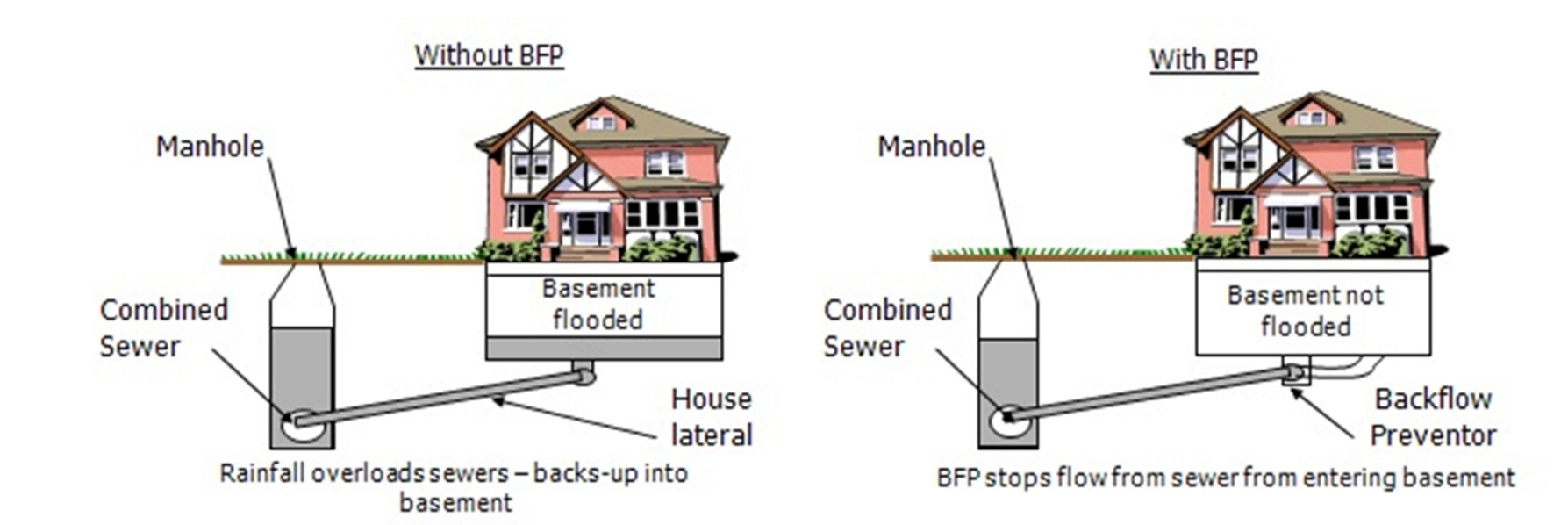
7/11 North Beach and Texaco are closed to swimming due to signs of blue-green algae (cyanobacteria). All beaches have passed e-coli water testing. So Leddy and Oakledge are open to swimming.

7/7 All of North Beach and Texaco Beach is closed due to Blue-Green Algae (cyanobacteria). Please respect posted signs. Do NOT allow dogs or children to swim in the water until it's clear. Leddy Beach is reopened for swimming today. Ecoli test came back with passing number of 54.

Water Resources

BURLINGTON, VT PUBLIC WORKS

Combined Sewer Basement Backups



- Plumbing code requires that property owners install backwater prevention valves on fixtures that are lower than the elevation of the next upstream manhole cover in the street
- Low lying homes in the in the combined sewer system are particularly susceptible

- For more information: http://www.burlingtonvt.gov/DPW/Information-Related-to-Sewage-Backups-During-Storm-Events

“The Fix” is more complex than olden days…

- What do we fix first?
- 80:20 rule
- Last 20% takes 80% of the money and effort

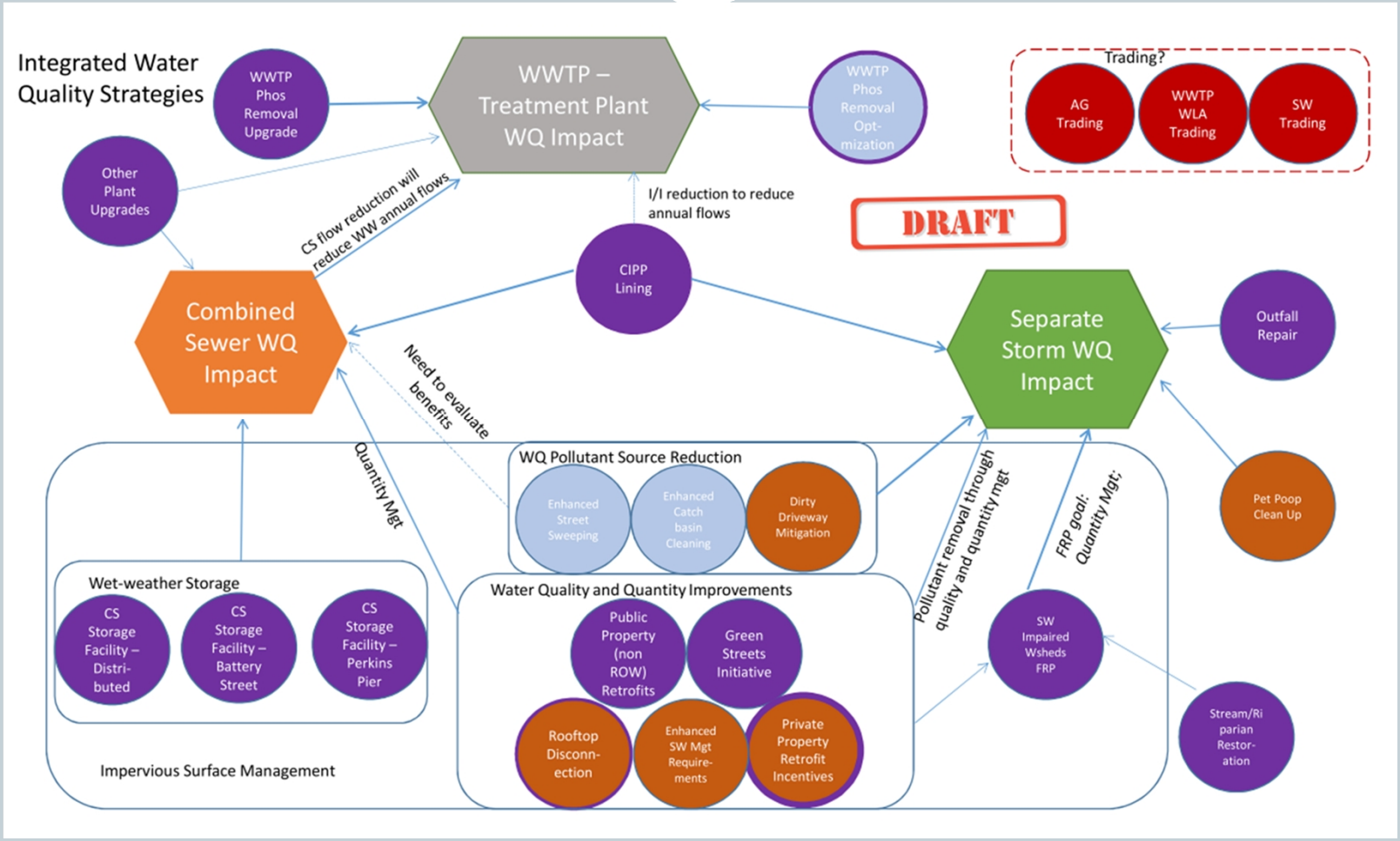
Solutions may not be as simple as “end of pipe” if we want to maximize co-benefits

Stormwater Bumpouts on North Street

Water Resources

BURLINGTON, VT PUBLIC WORKS

Integrated Water Quality Planning



Consider Your Choices When Paying for Drinking Water

- Consider 24 ct 16.9 oz bottles @$8.99

- Paying $2.84/gallon
- 2/3rds of bottle water purchases are single bottles (~$7.50/gallon)
- Paying more than cost of gasoline!

- Consider current water rate ($4.05/100 cf water)
  - $4.05 for 748 gallons of water
  - delivered to your home!

Only Tap Water Delivers℠

- $0.0054/gallon

Thank you to...

- Jean Innamorati, “The Burlington Waterworks 1965-1915” M.S. Historic Preservation, UVM, 2008.
- Jim Howley, 23rd Water Resources Superintendent “A History of the Burlington Water Resources Department”
- Water Operator Dick Benjamin for answering questions about 1980s – now
- Water Resource Engineer Steve Roy for always being willing to answer any “liquid” related question
- Various other Water Resource employees who took time over the years to compile documents, notes, newspaper clippings and photos

Questions?

...abundant supply of fresh running water and good sewerage [and stormwater management]... indispensable to the security, prosperity and health of the City.

City Health Officer, 1860s

with

a 2016 revision by Megan Moir, 25th Water Resources "Superintendent"