PROJECT 3

Minneapolis Drinking Water

SYSTEM AND SOLUTIONS

ANNA STARK / SD-6510-20-F22 / SYSTEMS THINKING / 15.3 / FINAL

Source: parkconnection.org

The Problem

According to the Minnesota Department of Natural Resources, the average Minnesota resident uses about 52 gallons per person per day, and Americans use nearly 9 billion gallons of water on their lawns and landscaping daily. Though, in Minnesota, all cities in the seven-county metropolitan area (including Minneapolis, the location of interest) must have a water supply plan with specific water conservation measures; there is more progress to make.

I did not begin this project with these facts known. I started this systems journey to simply better understand where my drinking water comes from. Not knowing where shared resources like drinking water comes from, how drinking water is treated, and its greater lifecycle, is core to the problem.

I speak generally when I say Americans lack awareness in shared common resource origins, processes and lifecycles. The problem and archetype here is Tragedy of the Commons. Water is a commonly shared resource. Every user of water in Minneapolis benefits from its use, but also shares the cost of its abuse with the community. To maintain the system's health the community must first respect it.

The following pages include Minneapolis drinking water systems views and sustainable solutions through the lens of biomimicry, archetypes and eco-effectiveness. Each solution ultimately centers around the system function of maintaining community. Core to this function is the cultivation of respect for the shared resource of water, each other, and the greater hydrosphere and biosphere.

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System Description

Drinking water for the city of Minneapolis begins with pulling water from the local freshwater sources, which include rivers, groundwater, stormwater and recycled wastewater. The largest source of drinking water is the Mississippi River. Mississippi River water flows into the municipal water treatment facilities located in Fridley and Columbia Heights, just upstream from Minneapolis. Water is softened, filtered, disinfected and finished using various chemicals and elements (lime, aluminum sulfate, sand, granulated carbon, gravity, chlorine, ammonia, polyphosphate and fluoride). After this step, the water is deemed safe to drink and is sent to storage in reservoirs before being sent through a series of pipes to residential homes in Minneapolis. Water testing creates a feedback loop in the process to ensure drinking water conditions remain safe. Drinkable water flows through residential homes of Minneapolis and is consumed and/or wasted by home occupants. Minneapolis residents may also send feedback to the initial treatment facility. Wastewater, via toilets and drains, is sent through a series of pipes to a wastewater treatment facility where the water is filtered, purified in two stages and disinfected before being sent back to the Mississippi River (downstream), where water mixes with the elements of the river's ecosystem and continues to move down stream, yet also enters the larger water lifecycle system that is a source for the initial upstream Mississippi River, beginning the cycle again.

SYSTEM BOUNDARY
At a high level, the boundary of this system is the availability of freshwater to treat for drinking. Per the system overview (page 5), the boundary of this system includes the flow of freshwater from its source, through treatment, consumption and wastewater treatment.

INPUTS
Inputs include the flow of source water into treatment facilities, the flow of treated water into residential homes of Minneapolis and the flow of wastewater into wastewater treatment facilities. Other inputs include labor, electricity, gas/fossil fuel, money, time, chemicals, filtering items (e.g. sand), gravity and pressure.

OUTPUTS
Outputs include water being sent back to the greater water lifecycle, solid waste sent to landfill during the wastewater treatment process, dental health and life for humanity, chemicals from treatment processes sent into the ecosystem.

ENVIRONMENT
The drinking water system interacts with adjacent systems that provide feedback to the initial system. These include, but are not limited to water use and treatment legislation, infrastructure funding, Minnesota Pollution Control Agency processes, corporation pollution and waste management, history of related systemic items (chemicals, lead pipes, waterborne illnesses, etc.), and surrounding and national water systems. Climate is certainly part of the system's environment.

SYSTEM FUNCTION
The purpose if this system is to maintain community. All parties involved must cooperate within an ecosystem. This means we must cultivate respect for each other and the shared resource of water, and in doing so maintain the health of the greater system and ecosystem at large.

PART 1

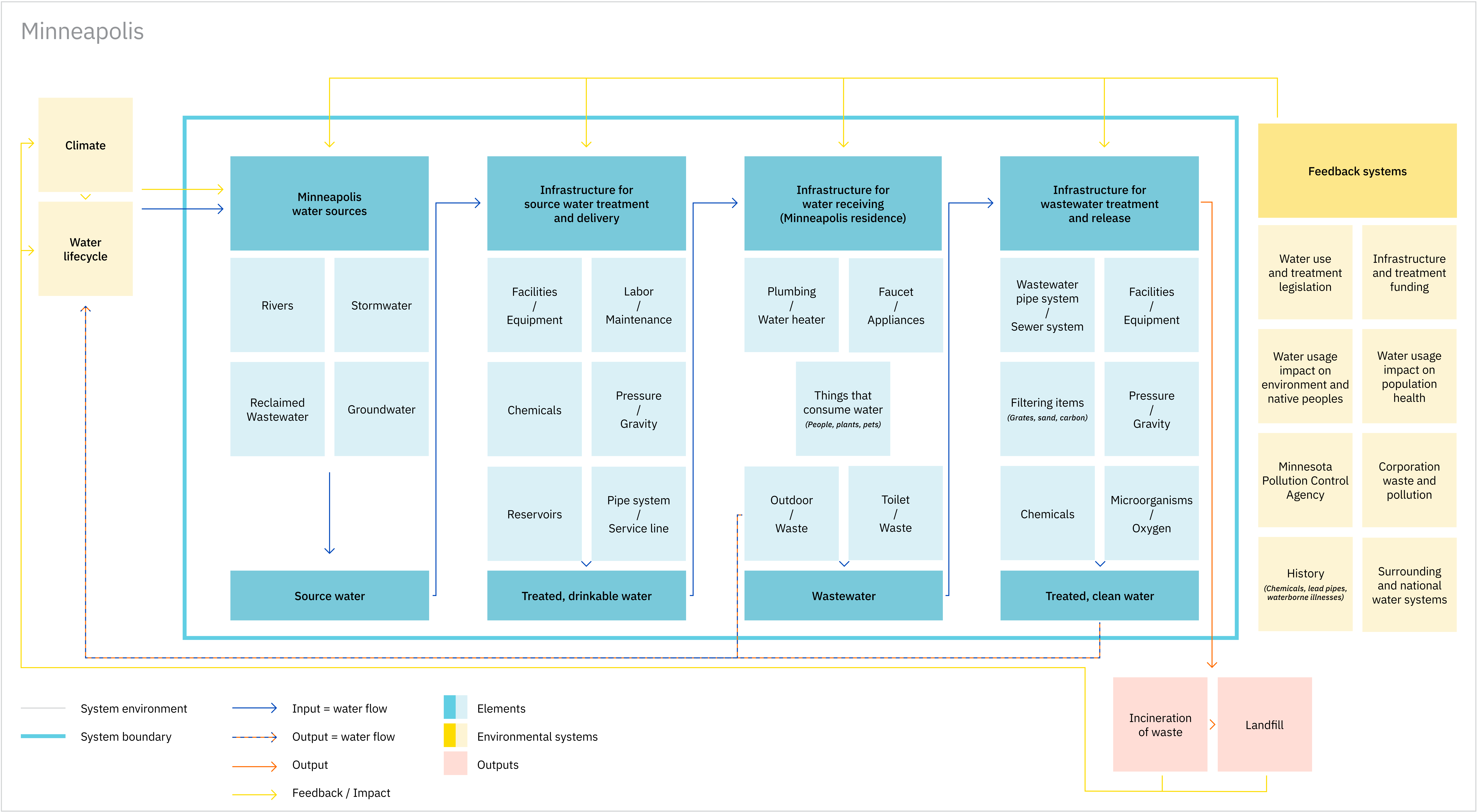
System Views

VIEW 1 / STRUCTURAL

System Overview

SYSTEM VIEW

At right is a structural representation of the drinking water system in Minneapolis. The diagram includes inputs, outputs, elements and impacts, as well as the surrounding relational systems.



VIEW 2 / LIFECYCLE

Minneapolis Drinking Water Lifecycle

SYSTEM VIEW

This view includes the lifecycle of drinking water for the city of Minneapolis. The diagram at right covers the flow of water through the source water treatment process, through a residential home plumbing system (consumption and waste), the wastewater treatment process, and the water lifecycle.
Color indicates the state of water cleanliness (blue = cleanest, red = wastewater). Gray indicates unknown test results may result in varied states of cleanliness.

SYSTEM BOUNDARY

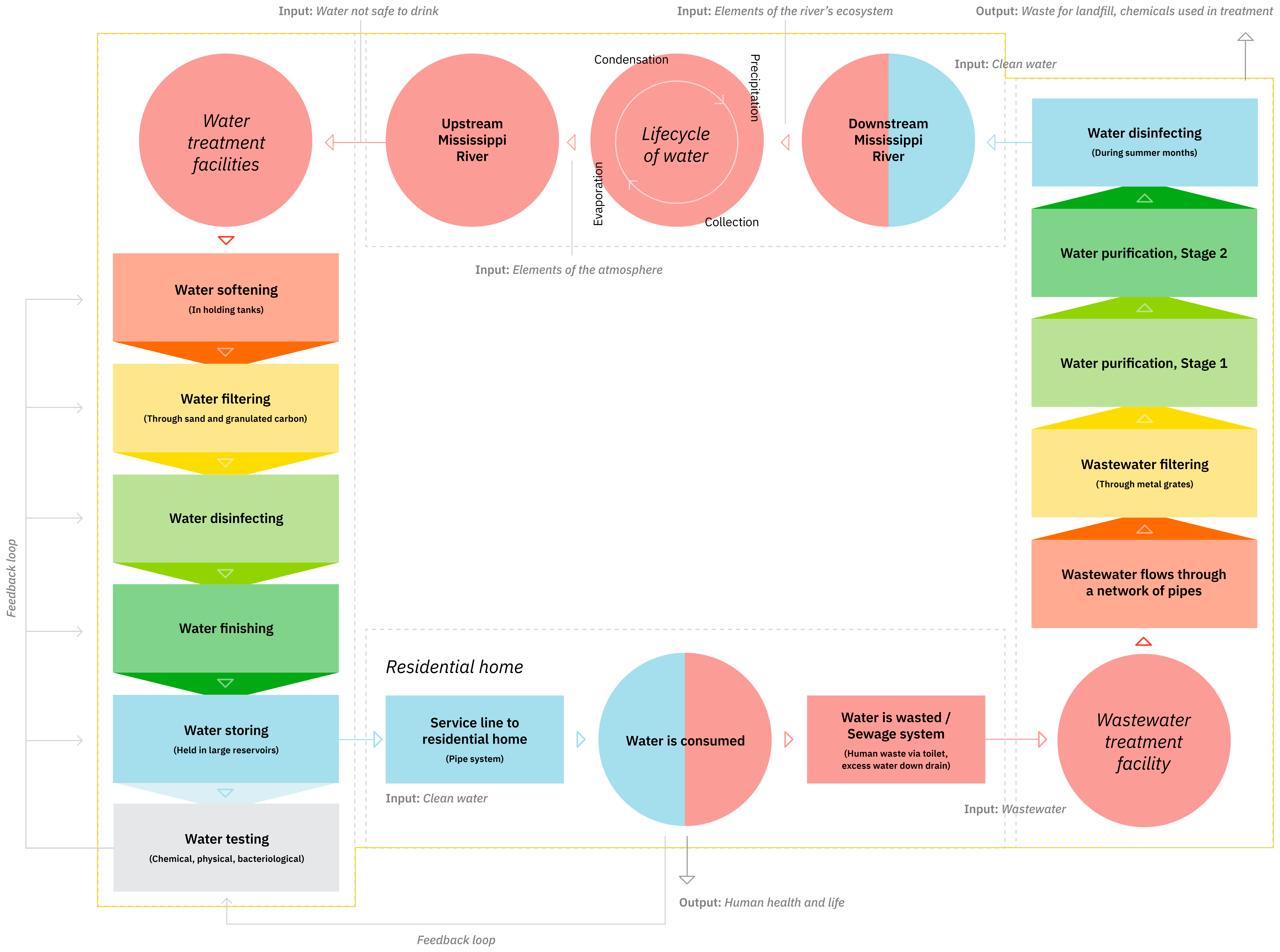
These four sub-systems are defined by the gray dotted boundary lines, the four together represent the overarching system boundary indicated by the solid yellow line.

INPUTS

From this view, the input into each sub-system is the flow of water from one system to the next.

OUTPUTS

From this view, outputs include waste from the wastewater treatment and health and life for humans (assuming treatment chemicals are in check).



VIEW 3A / PROCESS FLOW

Minneapolis Water Treatment & Delivery Process

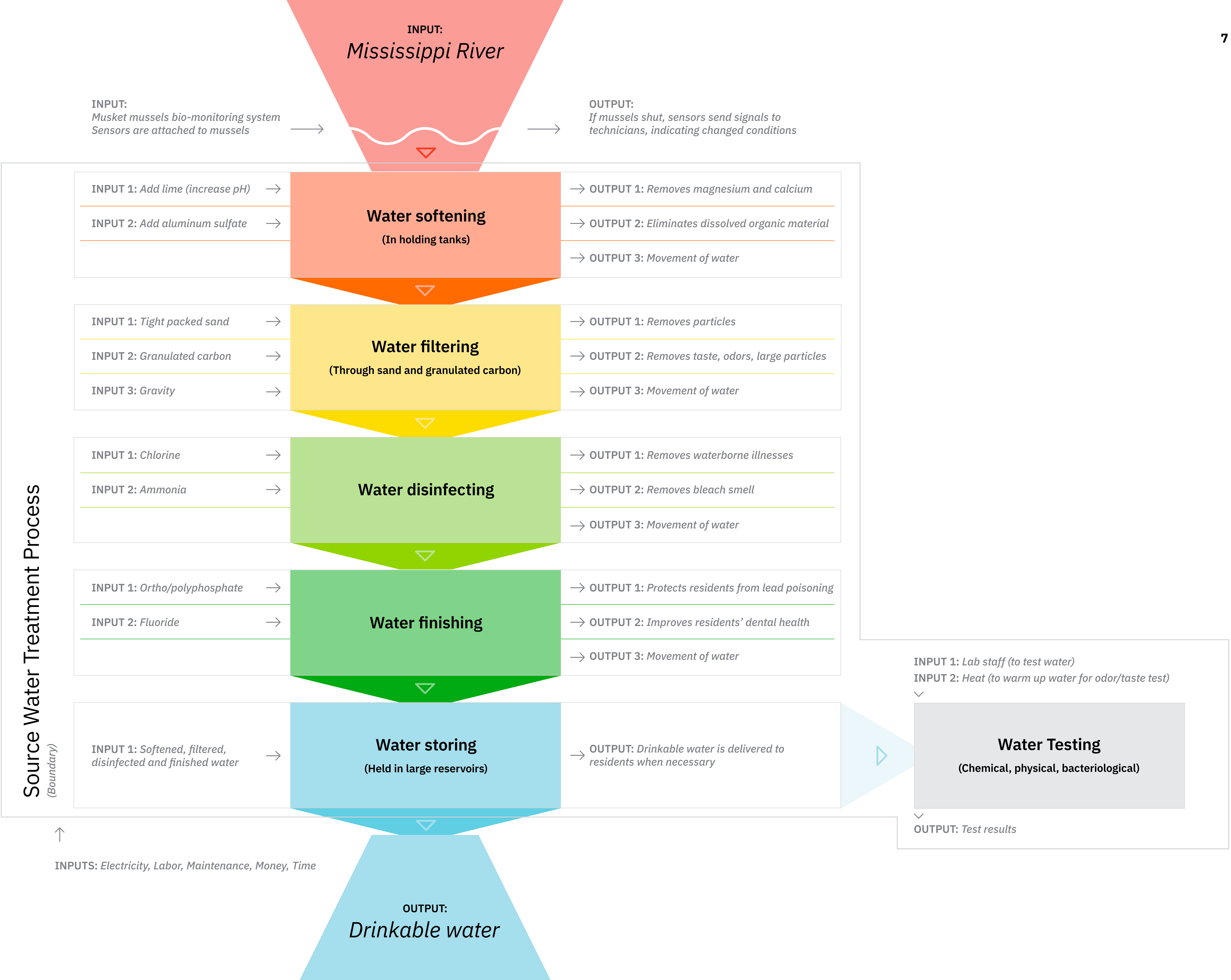
SYSTEM VIEW
This view includes a deeper look at the flow of water through the source water treatment process from the overall drinking water lifecycle.

BOUNDARY
The system boundary of this diagram includes all processes inside the “walls” of the municipal water treatment facility.

INPUTS
Inputs include the water that flows from the Mississippi River, addition of chemicals, pressure, and gravity throughout the water treatment process. Inputs also include electricity, labor/maintenance, money, time and gas to ensure the system operates.

OUTPUTS
Outputs include clean water that is safe to drink, and resident dental and overall health. Outputs also include chemicals released into the biosphere and ecosystem at large.

ELEMENTS
System elements include the water being treated, chemicals being added and people facilitating the water treatment process.



VIEW 3B / PROCESS FLOW

Wastewater Management for Hennepin County

SYSTEM VIEW/BOUNDARY/ELEMENTS

This view includes a deeper look at the flow of wastewater through the wastewater treatment process from the overall drinking water lifecycle. The system boundary of this diagram includes all processes inside the “walls” of the wastewater treatment facility. System elements include the water being treated, chemicals being added and people facilitating the water treatment process.

INPUTS/OUTPUTS

Inputs include the wastewater that flows from Minneapolis homes, addition of chemicals, pressure, gravity, microorganisms and oxygen. Inputs also include electricity, labor/maintenance, money, time and gas to ensure the system operates. Outputs include the clean (safe to swim in) water that may flow back into the Mississippi River. Outputs also include the solid material that is sent to landfill.

PART 2

System Solutions

SYSTEM SOLUTION 1

Biomimicry

Source: Shutterstock

System Function: Maintain Community

COOPERATE WITHIN AN ECOSYSTEM

The two keystones to the overall system are the availability of water and the consumption of water. This system is specifically built for the consumption of water. The amount of water consumed is an amount taken from the source. If consumption outpaces the (re)supply, the system will eventually hit its limit and break (this is a boundary). This affects not only humans consuming water, but all life dependent on the life source of water. Of course the loss of source of water may be affected by additional variables.

Keeping the function of cooperation in mind, the following pages consider potential ways to reduce water consumption within Minneapolis residential homes through the lens of biomimicry.

Selected Biological Strategies

Alerts Provide an Early Warning System: Black-Capped Chickadee

EARLY WARNING SYSTEM

According to AskNature, black-capped chickadees use specific calls to communicate with other birds in the forest if there is a predator nearby and what that predator is doing. They use high pitched calls, that are hard for predatory birds to hear, to tell other chickadees to hide.

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Ecosystems Recover from Disturbances: Riparian Habitat

REPAIR BY BEHAVIOR CHANGE

According to AskNature, resilient species will partition resources between each other and coexist in order for their ecosystem to recover from disturbances.

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SYSTEM APPLICATION:
EARLY WARNING LEADS TO BEHAVIOR CHANGE

Faster indication for the need to reduce water can lead to behaviors that inherently will partition water, and therefore maintain community by virtue of cooperation.

Biological Strategies Applied

EARLY WARNING LEADS TO BEHAVIOR CHANGE

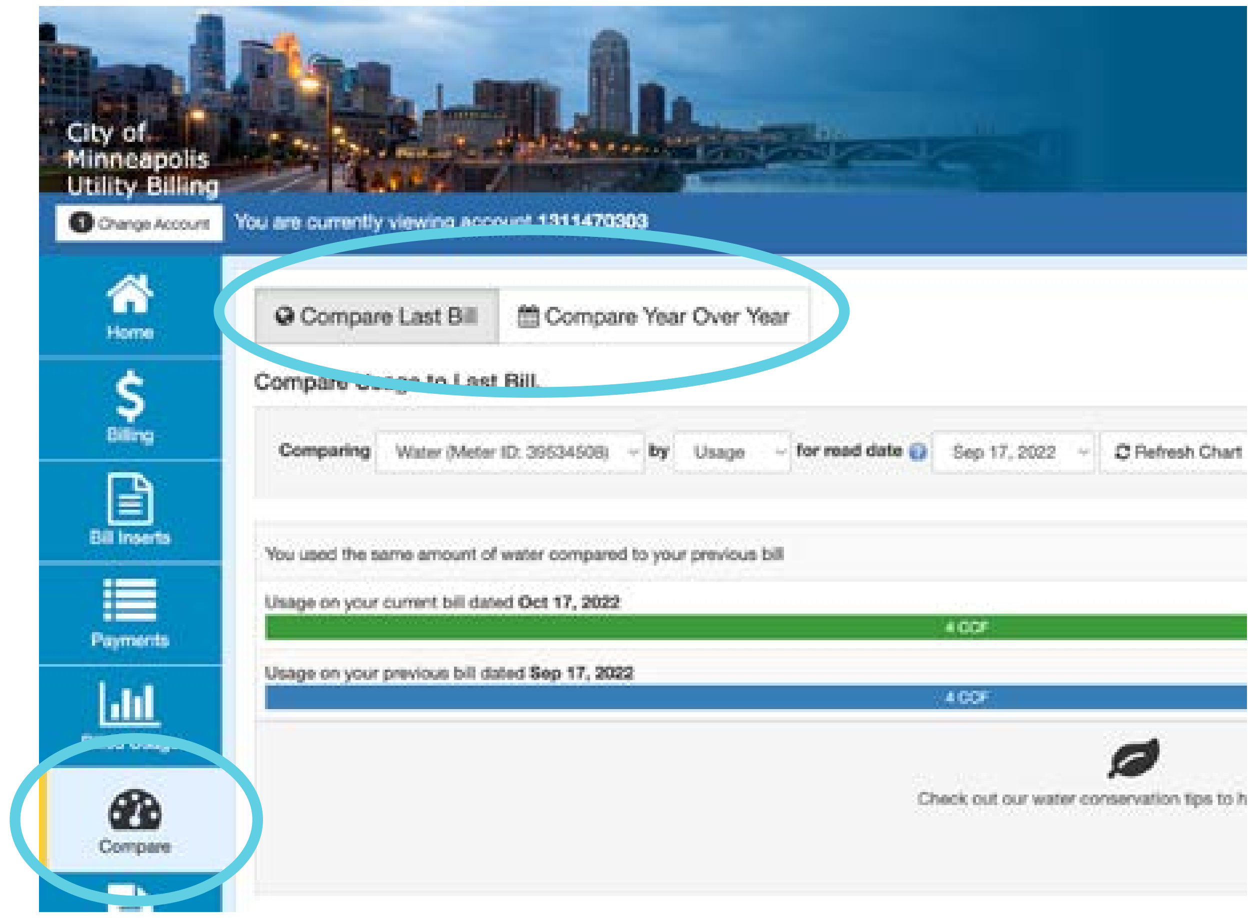


Image source: freshwatersystems.com

EARLY WARNING 1

Add a neighborhood usage map to the utility billing site to compare personal usage and identify problem areas

Minneapolis residential water usage is recorded by meters attached to the main water line of homes. This information is also remotely recorded by the city and can be viewed on the city utility billing site.
There is an opportunity to display the average water usage per neighborhood in the form of a virtual map. As water use is recorded and displayed, the square footage of homes should also be considered for true usage comparison. The neighborhood map should use color coding to indicate water consumption problem areas (outlier usage). By being better informed, neighbors may feel more connected to the system and choose to maintain community by reducing consumption.

EARLY WARNING 2

Prominent weather forecast placements to include a water consumption icon system

The daily weather forecast is always included in prominent spaces such as the front page of newspapers and home screens of mobile phones. Alerts for events such as severe weather, poor air quality and amber alerts, are blasted to mass audiences via push notifications on mobile phones. Water consumption considerations or signs should be included in easy to spot localized placements to influence positive water consumption behaviors. As seen above, a simple water consumption icon system could be added next to any daily weather icon placement.

EARLY WARNING 3

Implement water pressure regulators to indicate the need for reduced water use, based on regional climate data and water availability

I personally do not measure the exact amount of water I consume per day, nor do I follow strict water consumption trends or warnings on a daily basis. By adding a water pressure regulator at the regional water reservoir, water service line and home plumbing systems of residential homes in Minneapolis, water pressure could be adjusted based on the current regional climate and state of water availability, and by forecasting the need to conserve water. Homes could still receive water, but residents would have a physical and visible sense of the state of water availability by virtue of reduced pressure, and therefore would likely take on reduced water consuming behaviors. Additionally, any pressure adjustments would be documented and available to review digitally and by daily newspaper and water utility bill for residents' awareness.

Biological Strategies Prototyping/Process

1 CREATE A NEIGHBORHOOD USAGE MAP
Using data from residential water usage and sewer bills, create a map system for residents to compare their personal water usage to average water usage per street, neighborhood or city wide. The map will be color coded to identify which areas are using the most water by square footage.

2 ASSEMBLE A TEAM AND DETERMINE A MONTHLY GOAL
How much water is too much water? A diverse team of persons from various water conservation and water conscious backgrounds (Minneapolis water agency, federal agency, meteorologists, Clean Water Act, Native peoples, county mayor, other governing officials, etc.) will be assembled to help determine a goal amount of water usage per month per household, by month. Residents may choose to join the team or listen in on meetings. In doing so, residents may better understand the situation and be motivated to meet that month's city water conservation goal. This info may be reported by local news stations, radio stations, the Star Tribune and other motivated local businesses.

3 LAUNCH THE INITIATIVE WITH THE STAR TRIBUNE
With a monthly goal in mind, other systems can be put in place. The team from step 2 will work with the Star Tribune, a respected local news source, to craft a front page article (print and digital), as well as an social posts and stories, initiating the city water conservation goal. In addition, the Star Tribune will launch a water conservation icon system located next to the daily weather forecast on the front page. The icon system will indicate both the city's goal for that month and the city's progress in attaining it's monthly water conservation goal. This will be determined by daily recordings of residential water meters. The initiative will later expand to include the full state. See the layout at right for a mock icon system and explanation.

4 WATER PRESSURE REGULATOR STUDY
Now that the plan has been revealed, the city or independent water conservation agencies may ask residents of Minneapolis to participate in a water conservation study. Willing residents will have water pressure regulators attached to their main water pipe. The water pressure of the home will be adjusted based on the data from the home's water meter and the goal amount. If the home's water use exceeds a determined amount (divided into 3 hour increments), the water pressure will be reduced to physically signal an alert to the residents. Residents who meet their monthly goal will receive a cash award, and will inherently be rewarded with a lower utility bill for that month. The study will occur for one calendar year. The residents will also record any new habits or implementation of water conserving techniques. Recordings must be submitted each month end and done so by simple questionnaire or written by resident.

5 LAUNCH COMMUNITY REWARD SYSTEM
With the city usage map in place and the Star Tribune icon system launched, a community reward system will be included to further motivate residents. If a neighborhood (Armatage, Kinney, Lynnhurst, etc.) attains the determined monthly usage goal, the residents of that neighborhood will receive a percentage off of their water utility bill that month. This localized approach will cultivate community as neighbors reach out to support each other. The system will be reviewed to ensure it doesn't instead become overly competitive and negative progress in the pursuit of maintaining community.

6 IMPLEMENT WATER PRESSURE REGULATORS UPSTREAM
After one year of the water pressure regulator study, the city may choose to implement water pressure regulators in each Minneapolis home. This will be based off of a city wide vote.

7 EXPAND THE INITIATIVE TO THE STATE OF MINNESOTA
If the initiative is successful (monthly goals continue to be met), it may be extended to other counties throughout the state of Minnesota. Other counties will be intrigued with the original launch in step three.


VANISHING NORTH: STATE A LAST REFUGE FOR SONGBIRD SCIENCE

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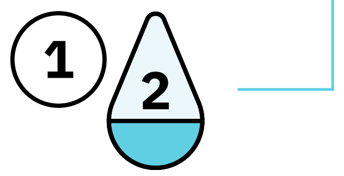
WATER CONSERVATION • A SPECIAL REPORT

MINNEAPOLIS LAUNCHES CITY-WIDE WATER GOAL

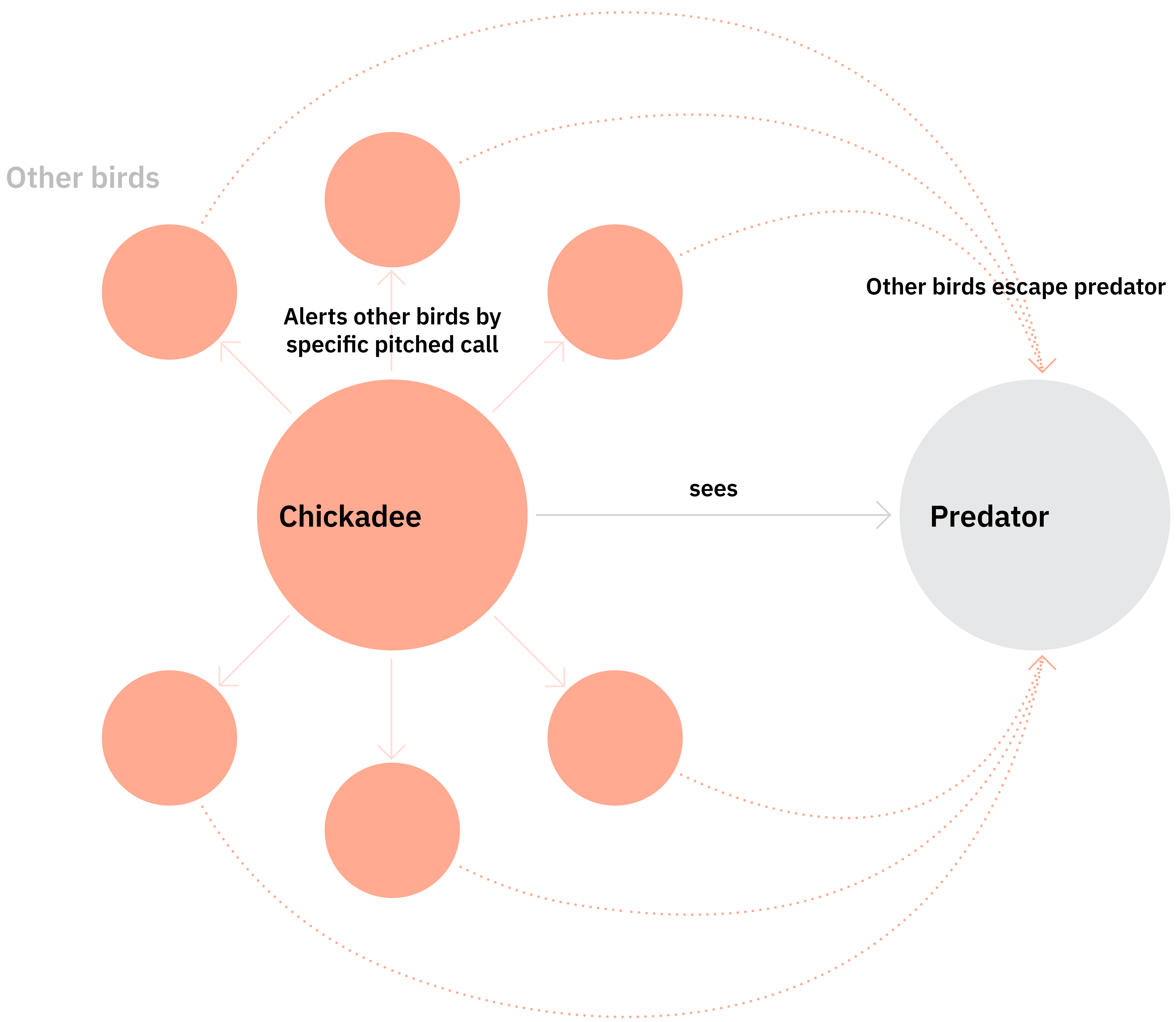
A decade of vitriol put target on Pelosi

House speaker has long been vilified in caustic right-wing attacks.



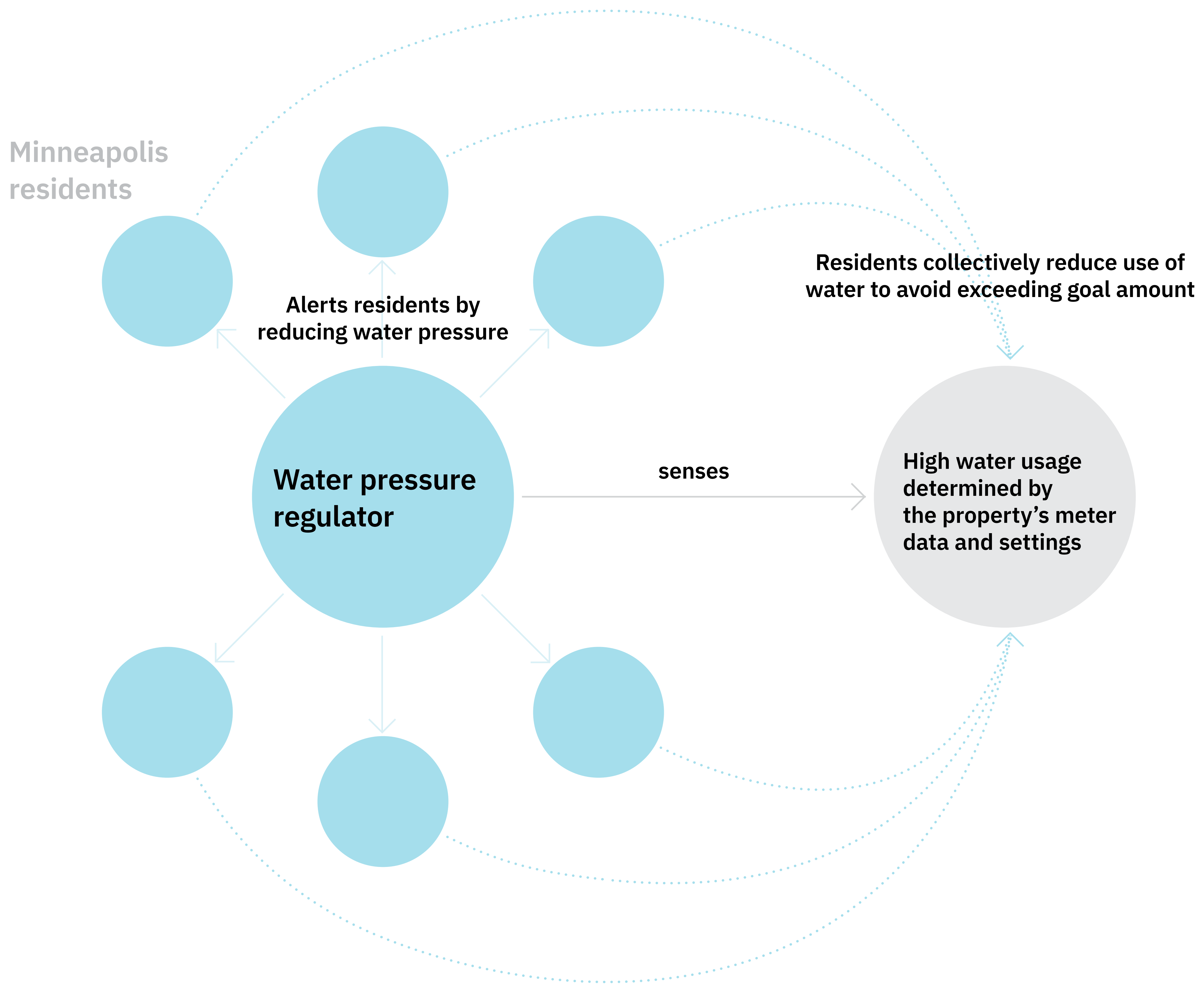
The left circle represents the goal CCF per resident per billing cycle, or month. CCF is the charge for unit of water measured in hundred cubic feet. A hundred cubic feed is approximately 748 gallons of water. The droplet at right indicates an average use of 2 CCF per person per billing cycle. The half filled droplet indicates the need to reduce average daily water usage.

Biological Strategy Diagram



STRATEGY DIAGRAM
A chickadee will alert other birds of a nearby predator with a call of a specific pitch. The other birds will hear the alert and escape the predator by hiding or flying away.

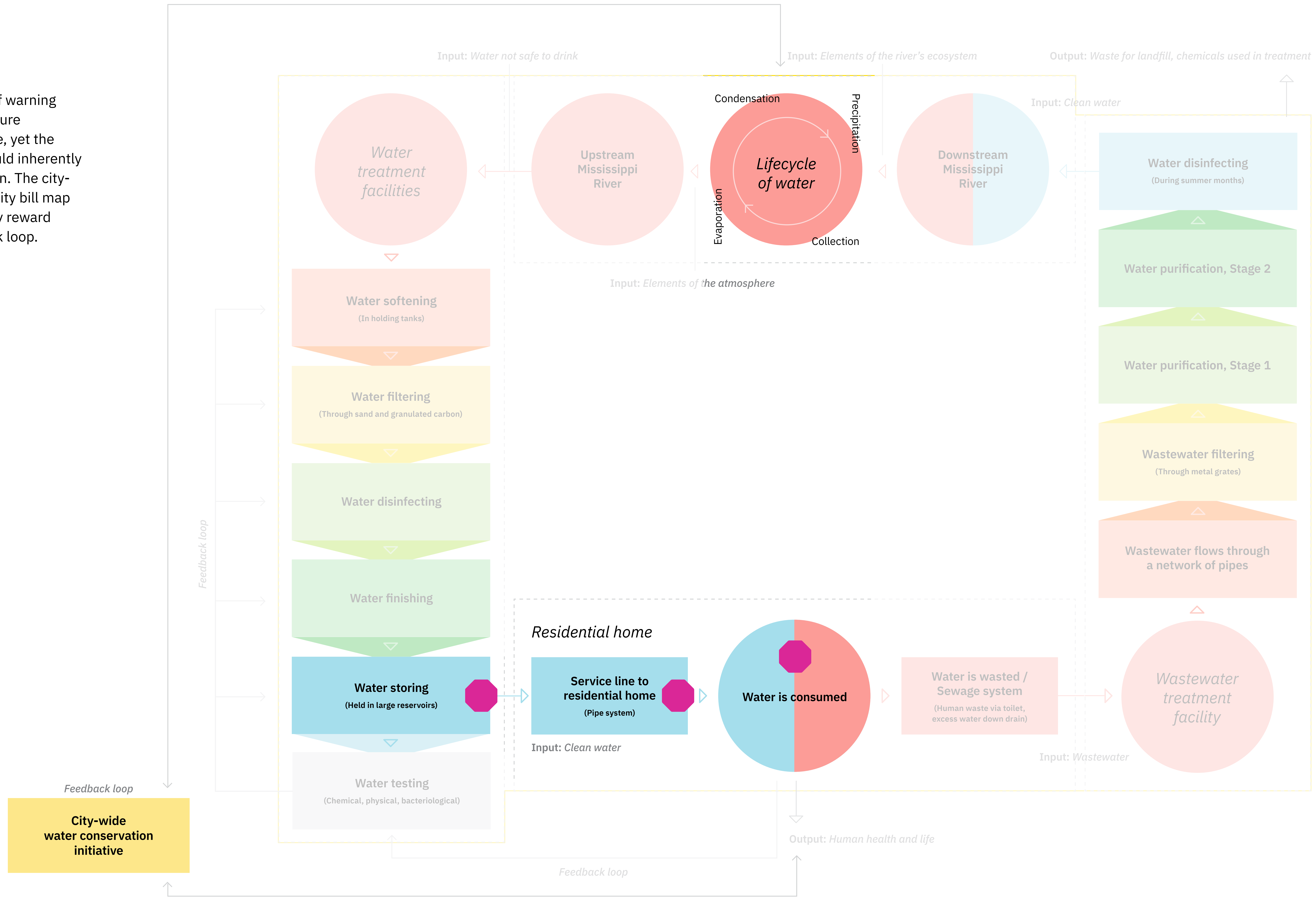
Applied to the System



STRATEGY DIAGRAM
A water pressure regulator will alert residents of high water use by reducing the home's water pressure. Regulation will be based on data by the property's water meter compared to goal usage amount (per three hour increments). The residents will be physically alerted by loss in water pressure and may decide to use less water to maintain their goal usage amount.

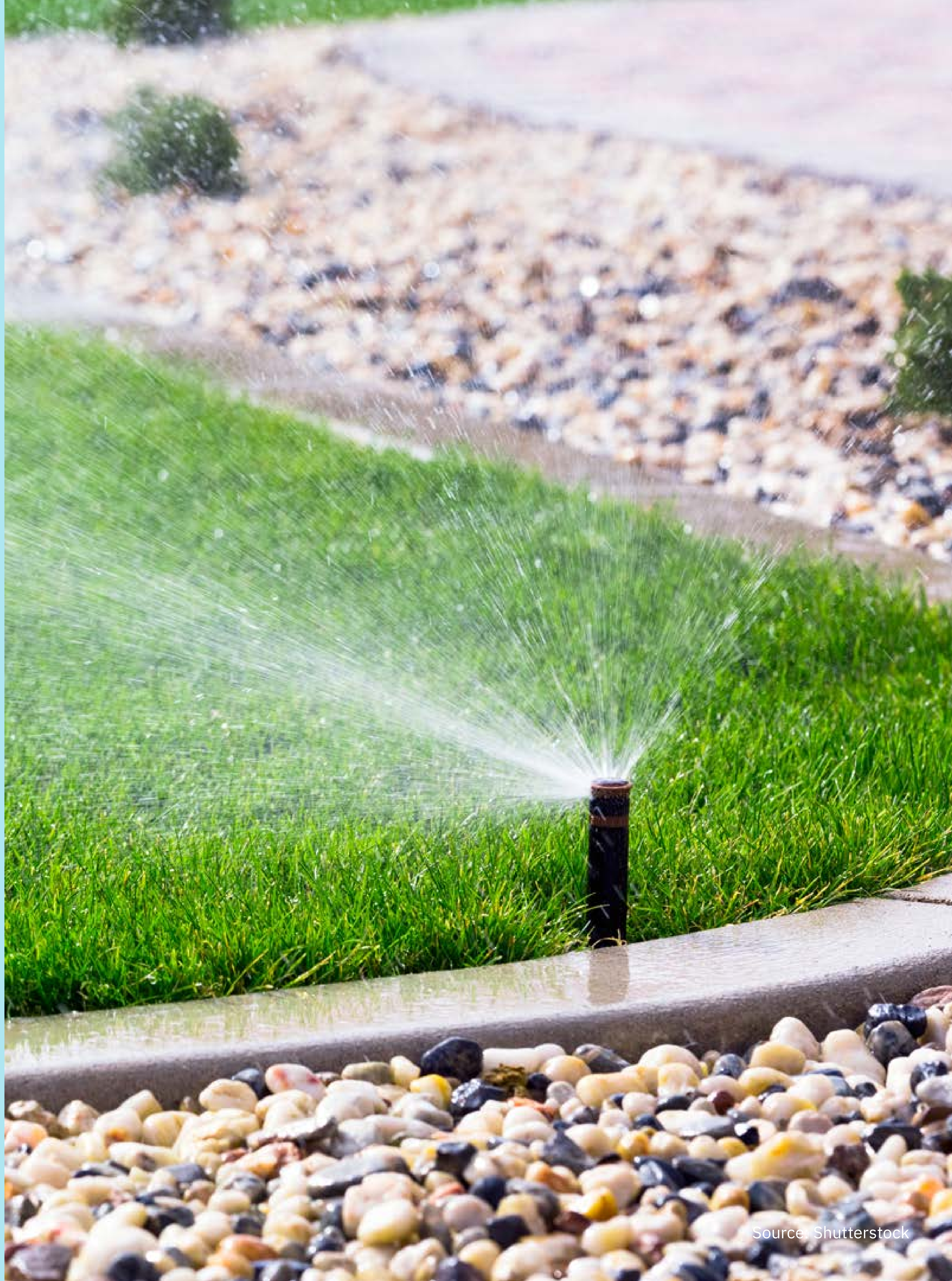
Biological Strategies Applied

At right is the original system with the addition of warning systems indicated by pink octagons (water pressure regulators). The overall system would not change, yet the amount of water flowing through the system would inherently reduce due to overall reduced water consumption. The city-wide water conservation initiative (additional utility bill map system, Star Tribune icon system and community reward program) lives in the super-system as a feedback loop.



SYSTEM SOLUTION 2

Archetypes



Source: Shutterstock

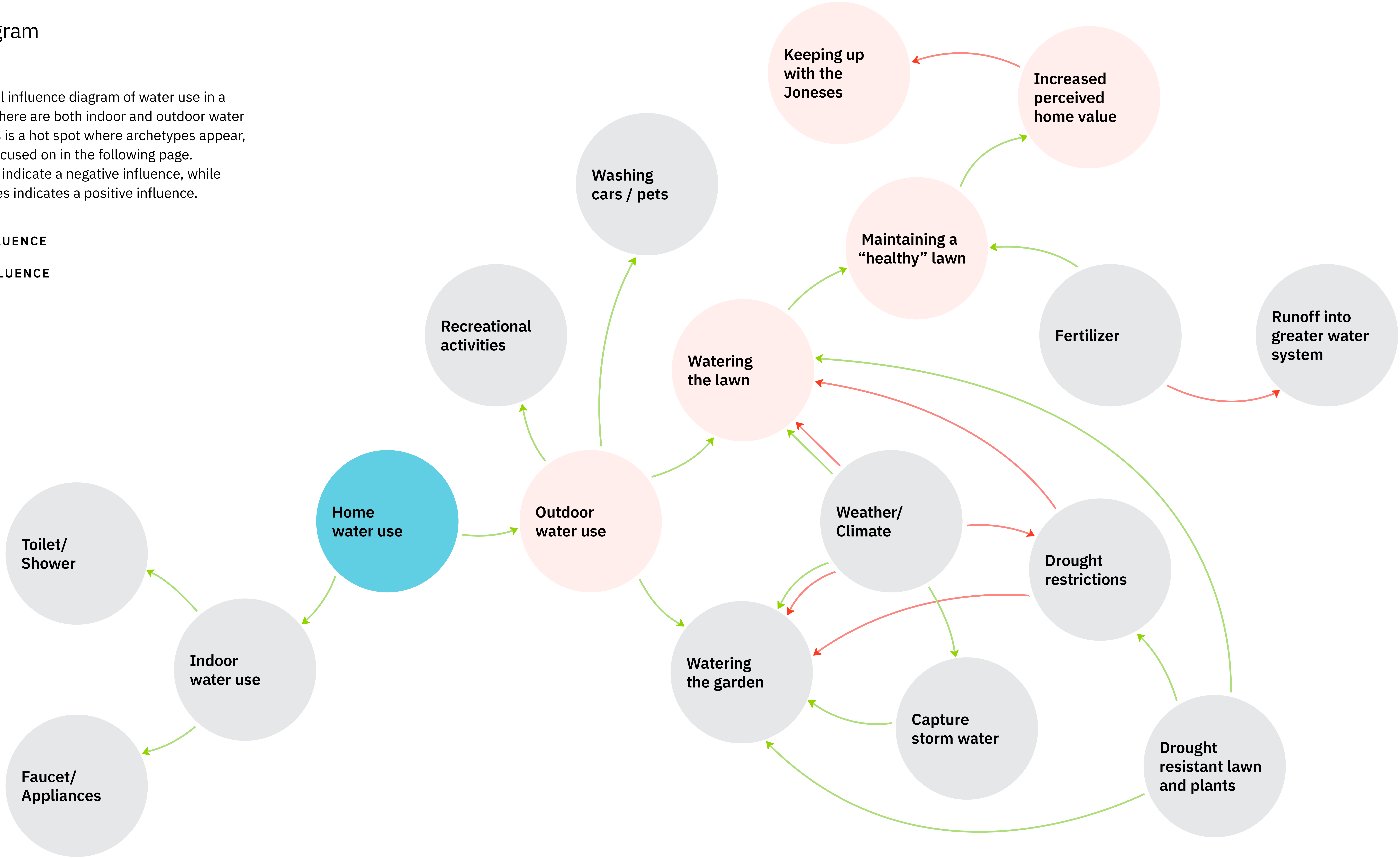
Influence Diagram

SYSTEM CONTEXT

At right is a high-level influence diagram of water use in a Minneapolis home. There are both indoor and outdoor water uses. Watering lawns is a hot spot where archetypes appear, and is what will be focused on in the following page.
Red connecting lines indicate a negative influence, while green connecting lines indicates a positive influence.

POSITIVE INFLUENCE

NEGATIVE INFLUENCE



Tragedy of the Commons

ARCHETYPE IN WATERING LAWNS

Water is a commonly shared resource. Every user of water in Minneapolis benefits from its use, but also shares the cost of its abuse with the community. Overuse of water may result in eroding it until it runs out. Residents may receive communication from their municipal or public water suppliers for details on water use reduction actions and restrictions, but there seems to be no real consequences if rules are bent or broken in the drought restriction phase, e.g. watering lawns regardless of restrictions. Antidotes to Tragedy of the Commons archetype include educating community members of water use consequences (what happens when there is truly little to no water available, e.g. the American SW), privatizing (increasing water utility prices in restriction periods) and regulating water use further (initiate drought task forces as part of neighborhood watch). Though, community members should be given agency and be involved in the ideation of handling the situation to avoid further archetypes like policy resistance.

SOLUTION 1: EDUCATE

To reduce water use in Minneapolis, the Minnesota DNR may choose to hire or incentivize a neighborhood water use task force to help educate neighbors and self regulate water use at a community level. The task force may educate neighbors on current state of water consumption, water use reduction techniques, future state if water use is not reduced, case studies from other areas experiencing the consequences, etc.

HOW TO START

To begin the process, the stakeholders must be notified and by in. The issue and idea should be presented at the both neighborhood and city level and town hall and board meetings.

PROS

For those seeking purpose in water conservation and potentially a position in government, this is a great opportunity to cultivate relationships with neighbors.

CONS

It will take a task force to create a task force. Much effort and time will be involved if the task force is set up as a voluntary position.

SOLUTION 2: PRIVATIZE

Water is a utility that is already privatized, however the neighborhood task force mentioned above may receive agency and choose a specific neighborhood monthly water use goal, and work with the DNR and municipal water suppliers to assist in the process. The community may choose to implement a new, and possibly more strict, utility rate system based on number of occupants in a home, rate increase during water use surges, etc. A credit system may also be launched to reward residents who implement water consumption reduction techniques or use the least water per person per household.

HOW TO START

If a task force is already in place, the group may initiate a study with the DNR to observe water use behavior and send out a water use survey to neighbors to gather neighborhood values.

PROS

Neighborhood autonomy will increase a sense of responsibility for the environment and each other, like an extension of Neighborhood Watch. The new utility rate system may be a draw to the neighborhood and increase its value.

CONS

It may feel that the burden is placed on the community. Some may not agree with how the rate system is established. Some neighbors may choose to move to avoid the extra hassle.

SOLUTION 2: REGULATE

If a neighborhood task force feels to be too much of a burden on the community, the DNR may work with the Minneapolis municipal water supplier to adjust utility pricing per gallon in times of drought or high use (e.g. base rate on rate of water flow through a reservoir). By taking the problem upstream, the archetype of shifting the burden to the intervenor also becomes involved. A task force directly from the DNR (and not necessarily neighbors) may be sent to patrol water use.

HOW TO START

As mentioned in the overall problem statement of this project; in Minnesota, all cities in the seven-county metropolitan area must have a water supply plan with specific water conservation measures. However, the patrolling of water use is light. The DNR may assemble a water use patrol to observe which areas are using the most water, especially at surge times and determine appropriate warnings or consequences in addition to increasing utility fees. Water restrictions should be enforced on industrial and agricultural levels as well.

PROS

Enforcing strict water use patrol will reduce water use in Minneapolis.

CONS

Enforcing strict water use patrol may receive push back by residents.

SYSTEM SOLUTION 3

Eco-effectiveness


Source: Shutterstock

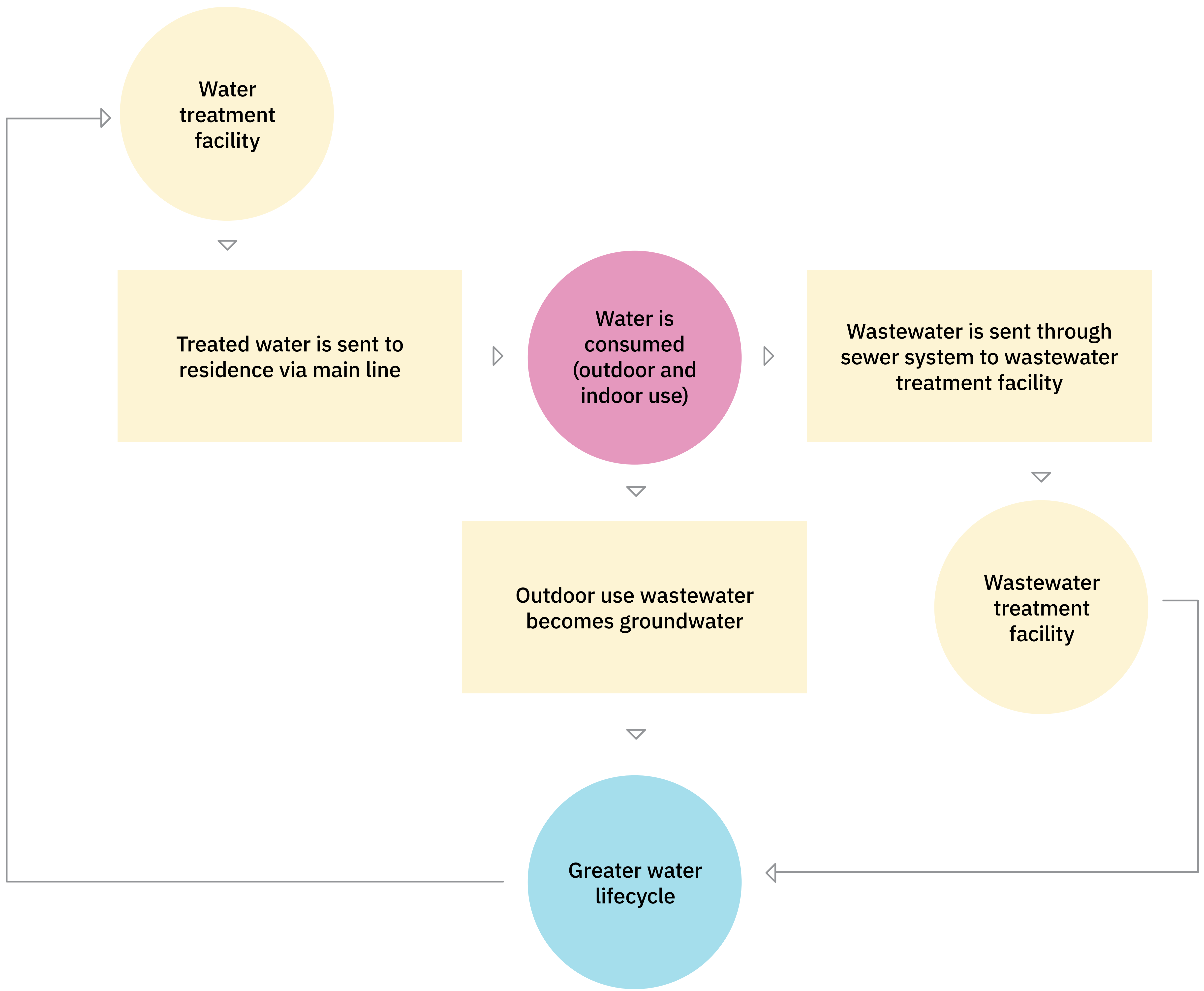
Area of Interest

WATER CONSUMPTION RECAP

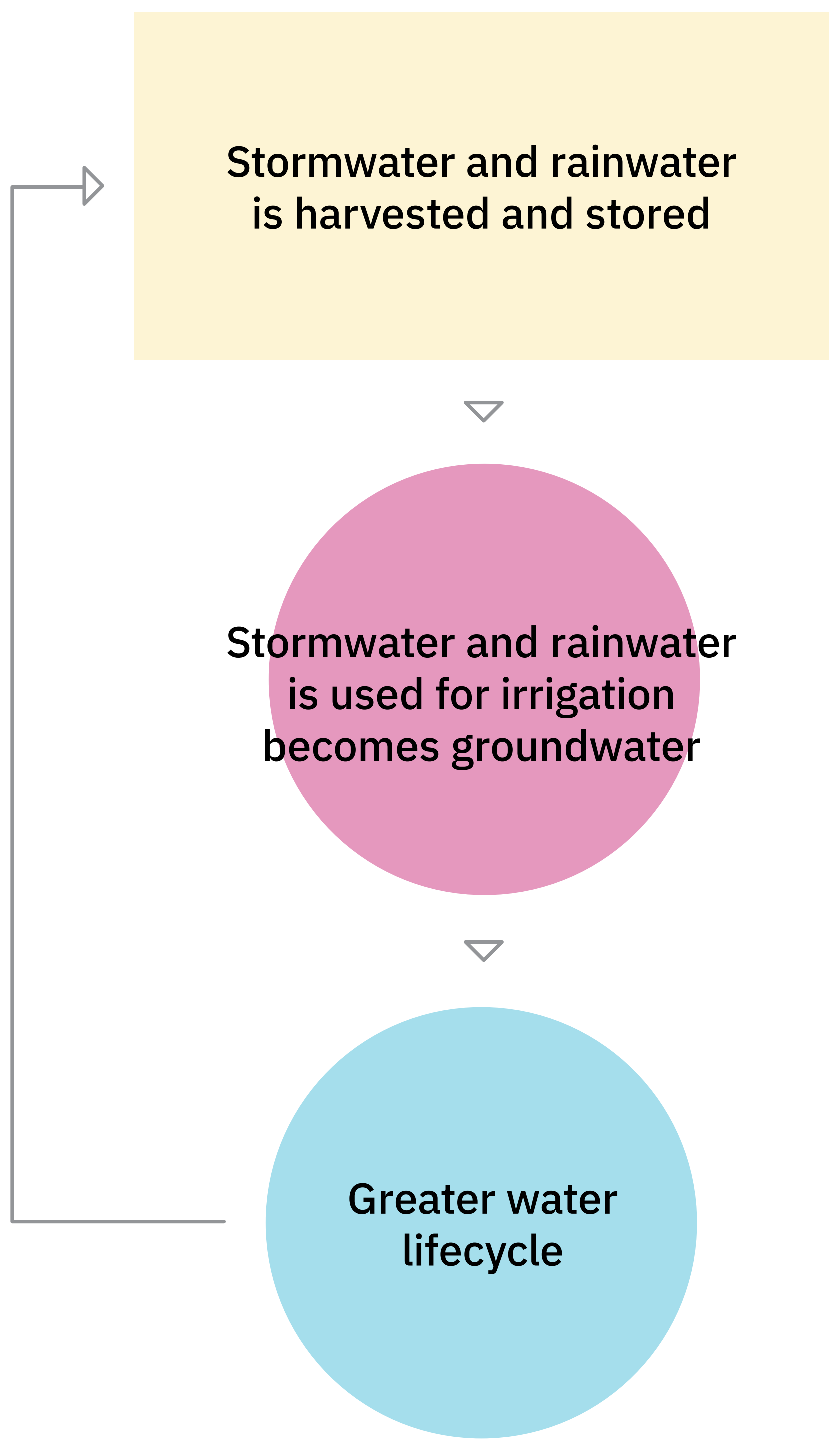
The two keystones to the overall system are the availability of water and the consumption of water. This system is specifically built for the consumption of water. The amount of water consumed is an amount taken from the source. If consumption outpaces the (re)supply, the system will eventually hit its limit and break (this is a boundary). This affects not only humans consuming water, but all life dependent on the life source of water. Of course the loss of source of water may be affected by additional variables.

The following page considers a way to reduce water consumption within Minneapolis residential homes through the lens of eco-effectiveness.

Current System



Stormwater Reuse System



Eco-effective Systems

STORMWATER AND RAINWATER REUSE SYSTEM

The water treatment system may be considered a regenerative system, yet there is room for improvement in diversification and decentralization of water use and reuse. Residents often use water from main lines for outdoor use (e.g. washing a car, watering the lawn). By capturing (and naturally filtering if necessary by means of sand, etc.) stormwater and rainwater may be reused to irrigate lawns and gardens in place of mainline water. At a larger scale, reused water can be used to irrigate larger areas such as golf courses. Stormwater and rainwater may be stored for use during times of drought, though storage may need to be adjusted depending on average rainfall amount expected per area of Minneapolis.

The super-system is the wellbeing of the greater water lifecycle, and therefore the greater wellbeing of the biosphere. Water is a biological nutrient that can be reused without traveling through a water treatment facility and using energy in the process.

COLLECTION SYSTEM EXAMPLE

At right is a diagram of an example collection system. Stormwater is collected via rooftops, green areas and surfaces. These are considered "catchments." Water travels to pre-storage treatment where trash, solids and particles from the harvested stormwater are removed. Harvested stormwater then is stored in a reservoir, which can be an enclosed cistern or detention pond. Filtration and disinfection occurs by biological treatment in the post-storage treatment tanks. Finally, water is distributed by pipes and pumps to indoor uses such as toilet water, and outdoor uses such as lawn irrigation.

NOTE

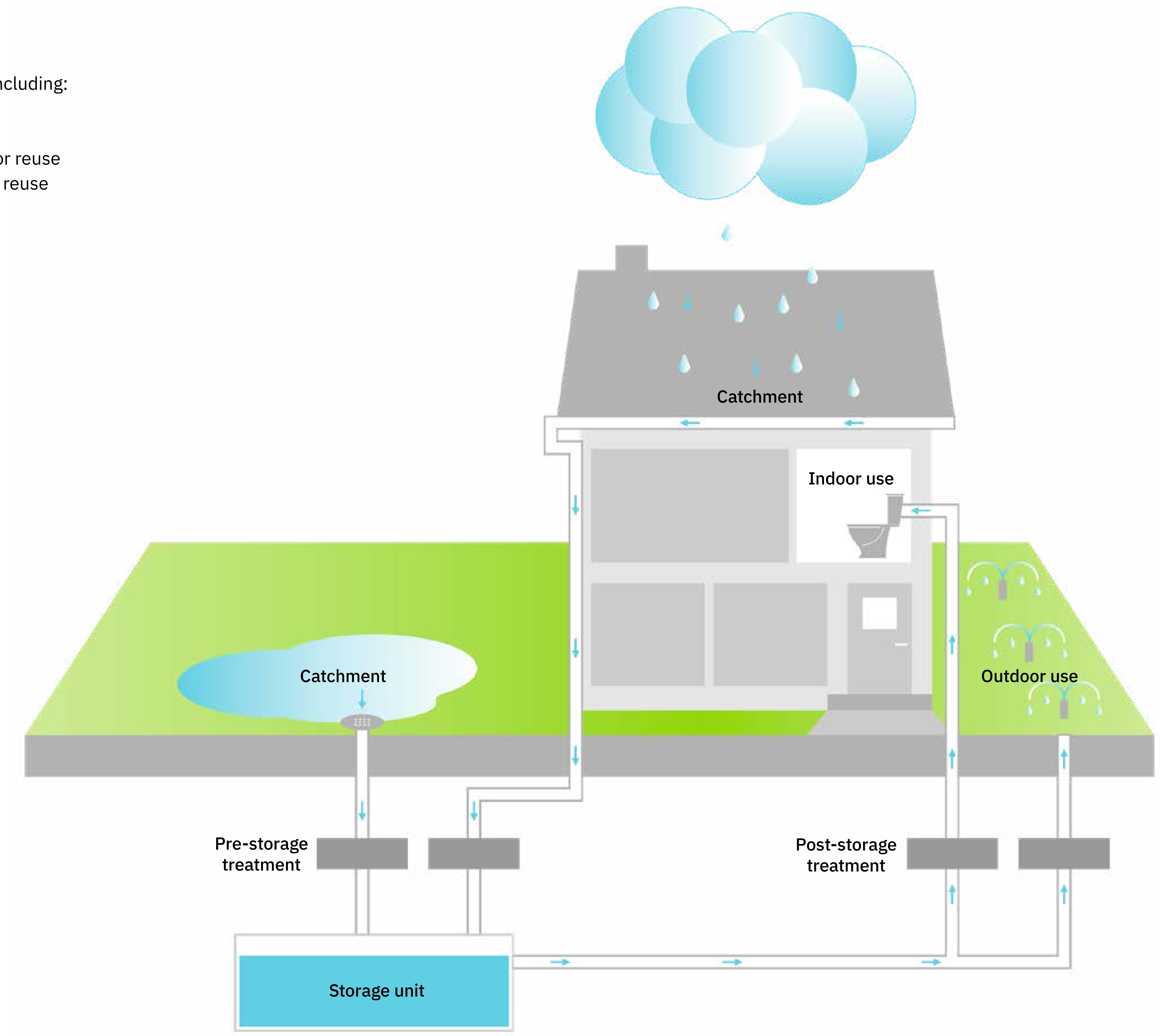
Credit for this general schematic goes to the 2018 Report of the Interagency Workgroup on Water Reuse. The diagram above was redesigned based on a pre-existing schematic.

Minnesota Department of Health. (2018). Advancing Safe and Sustainable Water Reuse in Minnesota. Minnesota Department of Health. Retrieved December 14, 2022, from https://www.health.state.mn.us/communities/environment/water/docs/cwf/2018report.pdf

OTHER WATER REUSE TYPES

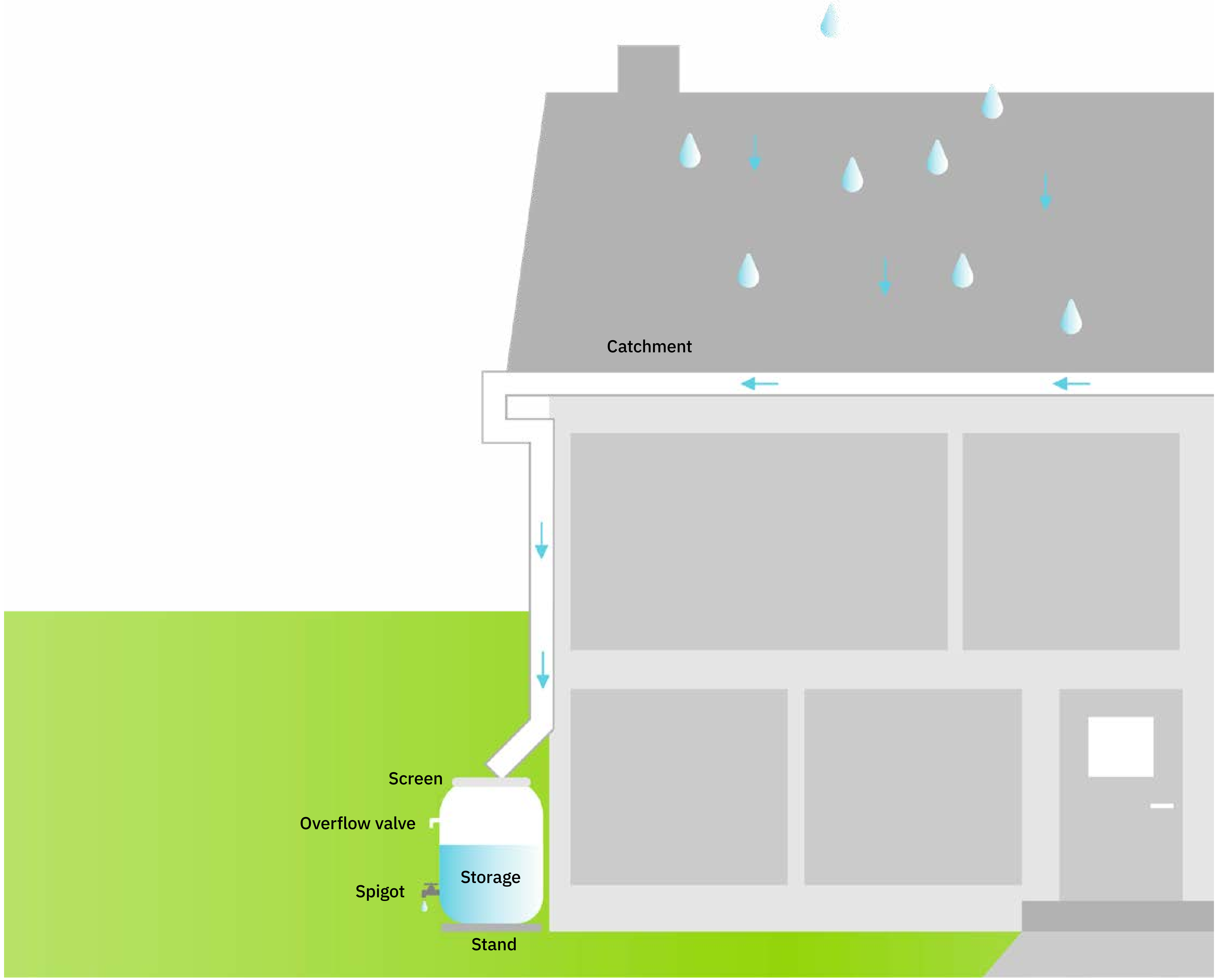
There are other water reuse types including:

- Non potable wastewater reuse
- Potable wastewater reuse
- Stormwater and rainwater outdoor reuse
- Stormwater and rainwater indoor reuse
- Graywater reuse
- Industrial process water reuse
- Food processing water reuse
- Subsurface water reuse



Smaller Scale Eco-effectiveness

RESIDENTIAL RAIN BARREL PROGRAM
Rain barrels are another catchment system that are smaller in scale with less barrier to entry. In the spirit of community engagement, the DNR may partner with the task force (mentioned on page 19) to distribute free barrels (made from technical or bio nutrients to ensure true eco-efficiency) and educate community members on stormwater harvesting, as well as additional methods for water conservation.



Reflection

Initially, I simply wanted to know where my tap water was coming from. My system diagrams led me deeper into how Minneapolis drinking water is treated, its lifecycle, and its associated super-systems (e.g. water lifecycle) and sub-systems (e.g. the treatment process). By viewing the system through the lens of biomimicry, archetypes and eco-effectiveness; I was able to uncover areas of opportunity for implementing more sustainable methods.

One area that was not explored deeply in this process was the limiting and elimination of pollution from sources in the environment that end up in the greater water cycle to initiate the need for water treatment facilities and processes. That will have to be considered for the next system deep dive.

During the process, I started to ask questions like: Is my water truly safe to drink? Is treated water safe for the environment? What is the past, current and future state of fresh water availability? What does the future of drinking water sources, treatment and delivery look like? What does rigid water conservation look like? The list of questions goes on and leads to infinite systems to be considered and system diagrams to be drawn up.

It will take a village of peers to question, diagram and discuss potential solutions for any system, and it's going to take a monumental effort to test and execute those solutions. Yet, with excitement, passion and hope, may we keep the momentum going to build a more sustainable future for all the children of all species for all time.

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