PUBLIC HEALTH LAW CENTER
at Mitchell Hamline School of Law

MEMORANDUM

To: **Twin Cities Metro Area Healthy Community Planning Project Team**

From: **Matthew Gabb, Research Assistant and Ross Daniels, Community Planner**
Public Health Law Center

Re: **Intense Rain Events and Flooding for Metropolitan Communities**
Healthy Communities Planning Project

Date: **October 1, 2021**

This project is supported by the Statewide Health Improvement Partnership, Minnesota Department of Health

P: 651.290.7506 F: 651.290.7515
W: www.PublicHealthLawCenter.org

875 Summit Avenue, St. Paul,
Minnesota 55105

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W: www.PublicHealthLawCenter.org
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Minnesota 55105

Indicator: Intense Rain Events and Flooding

The following discussion includes key findings and analysis of the reviewed comprehensive plans regarding the intense rain events and flooding health indicator. The Project Team defined this indicator as planning to increase "resilience of natural and built environment infrastructure for more intense rain events and associated flooding."[1]

Overall Takeaways

In total, 42 of the 49 studied comprehensive plans include a discussion of intense rain events and flooding as part of their comprehensive plan. The discussion of intense rain events and flooding in the comprehensive plans reviewed by the project researchers takes two general forms. The first is a highly technical, detailed discussion of "gray" stormwater infrastructure such as sewers, curbs, gutters, and pavement. The second is a focus on goals and policies related to "green" stormwater infrastructure designed to more closely mimic where rainfall is captured in nature, including wetlands, retention ponds, and bioswales.[2] Additionally, the project researchers noted the relative strength of suburban communities compared to rural and urban ones for this indicator.

Among communities that made equity a focus in their plans, the project researchers identified two themes: climate vulnerability and water supply. Additionally, two overall themes were generally consistent among all the communities that included a discussion of intense rain events and flooding. First, these plans contain discussions of stormwater management infrastructure needed to address rain events, limit flooding, and reduce the impact of floods when they do occur. Second, and relatedly, they discuss flood mitigation strategies.

Equity

Climate Vulnerability

Urban, suburban, and rural plans include discussions about the connection between climate change and increasingly strong rain events and the related disparate impacts of these events on vulnerable communities. In setting up its resilience planning efforts, **Marine on St. Croix** explicitly recognizes "the vulnerability of individuals and local systems to the impacts of changing weather, climate, and environmental, societal and economic challenges" (Marine on St. Croix, 35). **Woodbury**, also planning for resiliency, discusses the potential to "[i]nvestigate the creation of a Resilience Action Plan for Woodbury. This plan may include information on challenges, a vulnerability assessment, details on clean energy, energy efficiency, waste management, natural environment, water resources, resilient and sustainable infrastructure, community resilience and preparedness, considerations of vulnerable populations and collaboration with community groups" (Woodbury, 193). **Burnsville** "recognizes the importance of resiliency and in a water resources context resiliency can be attributed to the ability to adapt to the climate related variability and reduce the vulnerability of the community to extreme events" (Burnsville, 288).

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Water Supply

The issue of equitable water supply was noted in multiple plans. **Woodbury** this in the context of affordability endeavoring to "[o]perate [its] system efficiently so that water is affordable," and "[r]eview and adjust rates to ensure a cost effective and equitable system when making improvements to water supply infrastructure" in pursuit of this goal (Woodbury, 245). **Minneapolis**'s discussion of supply is focused more on environmental stewardship. Its plan contains a policy dedicated to sustainable water system management, which seeks to "[m]anage the city's surface waters, groundwater, stormwater, wastewater and drinking water equitably and sustainably, while minimizing the adverse impacts of climate change" (Minneapolis, 217).

Stormwater Management Infrastructure

Stormwater management is a major component of many plans, with communities outlining goals and policies to create and improve stormwater infrastructure and adopt practices to minimize flood risk. Communities take different approaches to addressing stormwater management in their plans. Different approaches identified include dedicating a specific chapter to stormwater management, weaving stormwater management throughout the plan, or using a combination of these approaches. Rainwater management and flooding goals and policies are predominantly included in these discussions. For instance, in **Landfall**'s water resources chapter, the city identifies impaired waters within its city limits, and commits to "taking steps to reduce potential contamination through its stormwater management practices" (Landfall, 30). **Stillwater** includes stormwater management in chapters not expressly dedicated to the topic as seen in its Downtown Stillwater Framework Plan that indicates that "[n]ew parking should include technology to cleanse and manage stormwater on-site" among its parking objectives (Stillwater, 129). **Lilydale** is among the communities to include stormwater management standards within building permit requirements, indicating that these permits "should not be issued for any development until the developer provides plans that show in detail the flow and dispersal of stormwater" (Lilydale, 67).

Flood Mitigation

As communities build up their stormwater management infrastructure and actions, many also recognize that more intense rain events in the 20-year horizon of the comprehensive plan will lead to more flooding. Many discuss strategies to mitigate the impacts of these floods. **Nowthen**'s stormwater management policy includes a goal to "[r]equire all new development to manage all on-site storm water generation to ensure that no negative impact will occur with regard to downstream flooding or water quality" (Nowthen, 33). In an acknowledgement of changing weather patterns, **Golden Valley** recognizes the potential impact of flooding on public utilities and buildings in its "Resilience and Sustainability" chapter, indicating that "[a]s heavy precipitation events increase, the possibility of flash-flooding also increases. Flash floods can damage property and be unsafe for pedestrians and drivers. The City continues to preserve floodplain areas and install stormwater infrastructure to reduce the potential for flood damage" (Golden Valley, 1480). **Newport** wants to "[p]rotect homes and infrastructure along the Mississippi River by purchasing flood-prone properties in the floodplain" (Newport, 194).

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Interesting and Innovative Approaches

Some of the most interesting approaches taken by communities include addressing the impact of intense rain and flooding on drinking water and water infrastructure on transportation systems; placing maximums on the amount of impervious surfaces in the city; improving city-owned facilities; creating building elevation requirements; and using trees and native plants to improve water infrastructure, amongst other creative approaches.

Consideration of Drinking Water

Several communities across the Metro area include residential drinking water as part of their considerations for flooding and intense rain. **Woodbury** indicates that "[f]or the City to provide an adequate supply of clean drinking water to residents, now and in the future, consideration of climate change and other threats facing infrastructure is necessary. Trend analysis has revealed that the region is experiencing greater frequency and intensity of precipitation events" (Woodbury, 232). To increase the supply of drinking water, **Corcoran** plans to "[c]onsider strategies to reduce the use of potable water for irrigation" (Corcoran, 143).

Water & Transportation Systems

Some communities also examine the intersection of flooding and their transportation systems. **St. Francis** plans to "[a]dopt a 'Living Street' policy that provides for multiple modes of transportation and street design that reduces environmental impacts by reducing impervious surface, managing stormwater, and providing shade" (St. Francis, 88). **Minneapolis** includes a policy in its plan focused on "Environmental Impacts of Transportation" indicating that "[t]his intersection of people and infrastructure also creates a high level of vulnerability to the impacts of climate change, as warming temperatures, extreme weather events, and flooding can all threaten the reliability and security of the energy systems we depend on" (Minneapolis, 138).

Impervious Surface Maximums

Many communities call for reducing the amount of impervious surfaces to limit the amount of runoff that has the potential to cause flooding. Some communities take this one step further by imposing a maximum amount of impervious surfaces that can exist in certain parts of the community. Two of **Belle Plaine**'s zoning classifications have the following maximums, "B-3: Maximum impervious coverage 85%. B-2: Maximum impervious surface coverage 70%" (Belle Plaine, 88). **Cologne** includes a policy to "continue to limit impervious surfaces to 25% for single family lots and 75% for commercial and industrial lots" (Cologne, 99). In **Vadnais Heights**, "[t]he Zoning Ordinance provides a maximum impervious surface coverage for commercial and industrial development" (Vadnais Heights, 25).

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Creative Reuses of Stormwater

To reduce the need to use potable water, some communities are also considering ways to creatively reuse stormwater. **Golden Valley** will "[e] ncourage businesses and residences to retain stormwater runoff onsite and to reuse it whenever feasible" (Golden Valley, 1491). **Bloomington** will "[s]tudy the feasibility to treat and reuse stormwater for non-potable water sources" (Bloomington, 194). **Oakdale** plans to "[e]xplore opportunities for creative re-use of stormwater in the right-of-way to irrigate boulevard trees and other landscaping" (Oakdale, 69).

Improving City Facilities & Practices

To make tangible changes and demonstrate various methods for improving water infrastructure, some communities are planning to make improvements at city-owned facilities and in city practices. **Woodland** is going to "[c]orrect flooding issues on City property as necessary to protect public safety and minimize potential for property damage" (Woodland, 72). In **West St. Paul**, the city's Environmental Committee has been charged to "review City facilities and practices for environmentally sound and sustainable best practices including rain gardens, erosion control and native plantings" (West St. Paul, 160).

Building Elevation Regulations

Rural and suburban communities are beginning to utilize building elevation regulations to protect infrastructure and homes. **Denmark Township** plans to implement "[f]loodplain standards and building elevations […] for future development, especially in areas around landlocked basins" (Denmark Township, 88). **Lake Elmo** will "continue to enforce the VBWD standard that minimum floor elevations of buildings be 2' or more above the 100- year flood plain and will continue to enforce the standard on development that is not reviewed by the Watershed District" (Lake Elmo, 237). **Eden Prairie** has a regulation to "[r]equire that new or redeveloped structures adjacent to landlocked basins with no outlets be constructed with a lowest floor elevation at least 2 feet above the flood elevation of two consecutive (back-to-back) 1-percent chance (100-year) return frequency storm events" (Eden Prairie, 752). For **White Bear Township**, "[m]ethods used by the Township to prevent flooding include enforcement of its floodplain and shoreland ordinances, enforcement of its erosion and sediment control requirements, and certifying that the low floor elevation of new construction in flood-prone areas meets the required elevation" (White Bear Township, 340).

Native Plant Species in Buffer Areas & Landscapes

Some rural communities include an increased focus on utilizing plant species native to Minnesota as part of buffer areas and landscaping. In **Inver Grove Heights**, "[n]ative plants, such as prairie plantings, should be used in parks and open space to reduce landscape maintenance requirements, to provide food and shelter for wildlife, to buffer shorelines, to control runoff and to manage geese populations" (Inver Grove Heights, 184). **Corcoran's** plan states that:

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> "Remnant native plant communities persist, and the City's Parks and Trails Plan identifies search areas for greenway corridors and open spaces that coincide with ecologically significant communities in upland and wetland areas. Such areas provide habitat for many species and help protect water quality by limiting impervious surfaces and maintaining vegetation that infiltrates stormwater runoff" (Corcoran, 128).

Using Trees for Stormwater

Suburban and urban communities leverage their existing trees and canopy to regulate water resources. **Minnetonka Beach** plans to "[m]aintain, protect, and enhance trees and wooded areas which provide numerous public and private benefits to the community. These benefits include […] [s]tabilization of the soil which prevents erosion and sedimentation [and] [r]eduction of storm water runoff" (Minnetonka Beach, 25). In **North St. Paul**,

> "Green infrastructure can also be included in developments and redevelopments within the city such as green roofs, permeable pavement, rainwater harvesting, rain gardens, planter boxes, and urban tree canopy. New developments are encouraged to consider sustainable green building design, conserve valuable energy and environmental resources, and protect air and water quality for future generations" (North St. Paul, 213).

Minneapolis indicates that "[t]rees on public property process 200 million gallons of water annually, resulting in a $5.9M savings in storm water management costs. [...] The City supports maintaining the health of all the city's trees and increasing the city's tree canopy to make Minneapolis a healthier place for all its residents" (Minneapolis, 136).

Leveraging Parking Infrastructure

Suburban communities with a lot of parking lots and other parking infrastructure high in impervious surfaces are rethinking these spaces and how to leverage them in reducing flooding. **Minnetonka Beach** is "[r]educing the amount of impervious surface in parking lots by the use of pervious pavers, porous bituminous or concrete or reducing parking isle and parking stall widths" (Minnetonka Beach, 65). **Stillwater** plans to "[u]tilize previous and other green infrastructure and technologies for stormwater treatment associated with parking lot and street improvements where possible and economically feasible" (Stillwater, 235).

Public Education & Outreach

Some suburban communities hope to engage with residents to be partners in mitigating the effects of extreme weather and flooding. **Shakopee** has a goal to "[e]ducate and inform the public on pertinent water resources management issues and increase public participation in water management activities" (Shakopee, 301). **Eden Prairie** will "[p]rovide information, educational opportunities, and rebate programs for residents to provide guidance and opportunities for installation of infiltration BMPs such as

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rain gardens or shoreline restoration to reduce runoff from existing impervious surface" (Eden Prairie, 753).

Property-Level Policies

Some urban communities are implementing policies at the parcel and property level to encourage residents to adopt better water management practices that benefit the entire community. **Golden Valley** will "[r]eview and update lawn maintenance ordinance to encourage native, low water-use plantings" (Golden Valley, 1491). **New Hope** states that:

> "In the past, the City had undertaken a series of backyard drainage projects to correct drainage issues, and patterns that had become obstructed over time. The City had since moved away from these projects. However, there is need again to improve stormwater drainage consistent with the City's Comprehensive Stormwater Plan. In this regard, the City will consider future backyard drainage maintenance/improvement projects where needed" (New Hope, 130).

Reducing Capital Expenditures

Recovering from flooding and repairing damages is expensive for cities, and some urban communities identify reducing these capital expenditures as a priority when implementing changes and improvements to their water infrastructure. A goal for **New Brighton** is to "[p]reserve, maintain and expand (where possible) the stormwater storage and detention systems to control excessive runoff volumes and rates, prevent flooding, protect public health and safety, and minimize public capital expenditures" (New Brighton, 140). **West St. Paul** indicates that it is important to "[p]revent flooding from surface flows while reducing, to the greatest extent practicable, the public capital expenditures necessary to control excessive volumes and rates of runoff" (West St. Paul, 250). **Crystal** wants to "[m]inimize public capital expenditures needed to correct flooding and water quality problems" (Crystal, 896).

Other Approaches

Other interesting intense rain event and flooding management approaches identified include:

- Coordinated emergency planning & management: Many communities include emergency management planning when thinking through future water crises. **Newport** specifically prioritizes coordinating this planning with other partners, with a goal to "[c]oordinate emergency response plans among local partners including the Refinery, schools, railroads and Washington County" (Newport, 144).
- Impacts of water emergencies on power & transportation: **Woodbury** connects water emergencies to other infrastructure that would be at risk indicating that, "[l]arge rain events may lead to flooding, posing a risk to the power grid and transportation network, which would increase the difficulty to respond to a water emergency" (Woodbury, 230).

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Ranking Analysis

Communities received a score of 1 to 4 on the intense rain events and flooding indicator, which ranks them on how much they incorporated the resilience of the natural and built environment infrastructure in response to intense rain and flooding events in their comprehensive plan. If a community scored a 1, that means there was no mention of increasing resilience of the natural and built environment infrastructure. The intense rain and flooding components of plans scoring between 2 and 4 were scored with the following criteria:

- Level 2 communities broadly mention incorporating resilience of the natural and built environment in the body of the plan but do not include goals and policies to this end.
- Level 3 communities include goals and/or policies for incorporating resilience of the natural and built environment.
- Level 4 communities include goals and policies for incorporating resilience of the natural and built environment, and dedicate resources to implementation.

The number of communities to receive each score was:

Level 1	7 communities
Level 2	20
Level 3	11
Level 4	11

Differences in themes and focus across the ranking levels show what different communities rely on to improve the resiliency of the built and natural environment to better withstand intense rain and flooding events. As discussed earlier, there are, generally, two distinct ways in which communities discuss this topic: a technical discussion of infrastructural capacity and needs ("gray" infrastructure), and an assessment of how the natural environment can play a role ("green" infrastructure). Many communities do both. These distinctions can occur within the same level, and often even the same plan, and are borne out in the discussion below.

Level 2

Communities that received a score of 2 on this indicator mention incorporating resilience of the natural and built environment against intense rain events and flooding in the body of the plan, but do not include goals and policies to this end. The themes identified by these communities generally focus on capital improvements, water quality, and rain gardens and vegetative landscaping.

Focus on Capital Improvements

Level 2 communities often refer to their capital improvements plans, which outline scopes and budgets for specific infrastructure projects. As part of its water resources chapter, **Crystal** discusses its challenges

P: 651.290.7506 F: 651.290.7515
W: www.PublicHealthLawCenter.org
875 Summit Avenue, St. Paul,
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with reducing inflow and infiltration stating that, "[r]eplacement of the sanitary sewer manhole lids with solid covers has resulted in noticeable reduction in inflow during large rain events," and refers to a list of its capital projects (Crystal, 65). **New Hope** alludes to capital projects in its chapter on financing planning projects generally noting that "the current local tax levies include funding of capital improvements for local streets, utilities, and stormwater improvements which eliminate special assessments for taxpaying New Hope property owners" (New Hope, 161). **St. Anthony Village** includes a sanitary sewer chapter where it outlines specific "capital improvements and the significant maintenance and rehabilitation work planned for the City of St. Anthony's sewer system," along with cost estimates (St. Anthony Village, 162).

Water Quality

Level 2 communities also tend to acknowledge the relationship between intense rain and flooding and water quality. Within its environmental protection chapter, **New Brighton** discusses the goals of its surface water management plan to "[p]reserve, maintain and expand (where possible) the stormwater storage and detention systems to control excessive runoff volumes and rates, prevent flooding, [and] protect public health and safety," while also "maintain[ing] water quality by preventing erosion and sedimentation from occurring […]" (New Brighton, 140). **Cologne** bridges the gap further between quality and flooding in its Water Resources Plan stating that, "[l]ocalized stormwater treatment projects can improve water quality by reducing pollutant levels in runoff discharge" (Cologne, 99). **Roseville** includes a goal to "[i]mprove drainage within the City while improving and protecting water quality and reducing the risk of localized flooding" (Roseville, 402).

Rain Gardens and Vegetative Landscaping

In a nod to the impact of green infrastructure on addressing flood control issues, several communities discuss the benefits of rain gardens and vegetative landscaping in capturing stormwater at its point. **Denmark Township** identifies areas of the township that need preservation and environmental management, aiming to "[p]rovide uninterrupted vegetated shorelines by restricting or prohibiting development on shoreland and floodplain areas, wetlands, and other natural features that serve important environmental functions" (Denmark Township, 116). **Woodland** seeks to boost its runoff storage capacity by "collaborat[ing] as necessary with Watershed Districts and willing private landowners to install stormwater treatment measures (i.e. rain gardens, stormwater treatment devices, etc.) throughout the City to provide additional runoff storage capacity, reduce runoff rates and volumes, and/or reduce pollutant loads" (Woodland, 72). **Osseo** similarly seeks to "[i]ncorporate the use of storm water reduction methods, including rain gardens, swales, and permeable pavement where appropriate [and] [e]ncourage landscaping that utilizes native plant selection, high-efficiency irrigation technology, rainwater harvesting, and other systems that reduce water consumption" (Osseo, 131).

Level 3

A ranking of 3 on this indicator means that the plan includes goals and/or policies to address resilience of the natural and built environment against intense rain events and flooding. Themes identified in Level 3

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communities include site plan standards, emergency management planning, runoff and erosion, and the reduction of impervious surfaces or the increase of pervious ones.

Site Planning

Many Level 3 communities outline requirements or incentives for site design to reduce runoff. **Lilydale** specifies that, "[b]uilding permits should not be issued for any development until the developer provides plans that show in detail the flow and dispersal of stormwater" (Lilydale, 67). **Lake Elmo** "supports and will encourage developers and landowners to use storm water practices that promote infiltration/filtration and decrease impervious areas through site design and use of Low Impact Development (LID) techniques and Green Design" (Lake Elmo, 245). As part of **Belle Plaine**'s "safe and prepared community" goal, the city plans to "[a]dminister site design and development standards to decrease and minimize the possibility of flooding and instability of bluffs and steep slopes" (Belle Plaine, 57).

Emergency Management

Level 3 communities often package their discussion of intense rain and flooding events in an emergency management context. **Maplewood** seeks to "[s]trengthen emergency management capacity to respond to weather-related emergencies" (Maplewood, 160). **Mahtomedi**'s water chapter addresses emergency preparedness to deal with water emergencies that can occur due to, among other factors, natural disasters. **Mahtomedi** indicates that, "[t]he purpose of emergency planning is to develop emergency response procedures and to identify actions needed to improve emergency preparedness. In the case of a municipality, these procedures should be in support of, and part of, an all-hazard emergency operations plan" (Mahtomedi, 209).

Runoff and Erosion

Reducing stormwater runoff and erosion is a strong focus of many Level 3 plans. **Mahtomedi** strives to "[p]rotect the capacity of the City's stormwater management system, prevent flooding, and maintain water quality by preventing erosion and sedimentation from occurring, and correct existing erosion and sedimentation problems" (Mahtomedi, 242). As part of **Bloomington**'s strategy to mitigate flood risk, the city plans to "[h]old new development runoff to pre-development runoff rates" (Bloomington, 194). As part of its goal to "[m]inimize the impacts of flood events on the community's development and investments," **St. Francis** will "[e]ncourage runoff management and volume/rate control measures to minimize the immediate bounce in waterways after rain events" (St. Francis, 143).

Impervious and Pervious Surfaces

A number of Level 3 communities discuss the necessity of either decreasing impervious surfaces or increasing the coverage of pervious surfaces to collect stormwater and prevent runoff in their cities. **Lake Elmo** "[s]upports and will encourage developers and landowners to use storm water practices that promote infiltration/filtration and decrease impervious areas through site design and use of Low Impact Development (LID) techniques and Green Design" (Lake Elmo, 245). **Minnetonka Beach** discusses the

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utility of impervious surfaces in its transportation section. **Minnetonka Beach** identifies strategies to create environmentally friendly streets and parking areas by "[r]educing the amount of impervious surface on streets, where appropriate, in the community by using porous bituminous or concrete" and "[r]educing the amount of impervious surface in parking lots by the use of pervious pavers" (Minnetonka Beach, 65). **Falcon Heights** discusses a similar goal in its housing policy, promoting practices that "[p]reserve pervious and indirectly connect impervious surfaces, [to] minimize directly connected impervious surface" (Falcon Heights, 34)

Level 4

To score a 4 for this indicator, communities must include goals and policies for incorporating resilience of the natural and built environment while also dedicating resources to implementation. The project researchers identified three themes across Level 4 communities: adherence to the National Oceanic and Atmospheric Association's Atlas 14 standards, protecting water quality, and an explicit discussion of climate change.

Atlas 14

Atlas 14 is an ongoing study by the National Oceanic and Atmospheric Association (NOAA) to analyze historic precipitation patterns to project future patterns.[3] Level 4 communities often specify Atlas 14 as at least the partial basis of their infrastructure decisions related to intense rain events and flooding. **Vadnais Heights** contains the following discussion of its water resource issues:

> "Potential water resource related issues the City faces are climate change and groundwater sustainability. The City recognizes the importance of resiliency. The City has amended [its] stormwater management standards to recognize the updated Atlas 14 depths and distributions and will endeavor to continue to adapt its policies and standards with the climate change trends" (Vadnais Heights, 124).

In an assessment of its surface water system, **Woodbury**'s plan states that it and its watershed districts will need to develop more resiliency in their surface water systems by, in part "[d]esigning […] future systems for Atlas 14 rainfall" (Woodbury, 60). **Burnsville**, also in the context of water resources resiliency, "amended the stormwater management standards to recognize the updated Atlas 14 depths and distributions and will endeavor to continue to adapt its policies and standards with the climate change trends" (Burnsville, 287-8).

Water Quality

Level 4 communities are concerned with protecting water quality, with many of these policies directed at development and redevelopment. In **North St. Paul,** "[n]ew developments are encouraged to consider sustainable green building design, conserve valuable energy and environmental resources, and protect air and water quality for future generations" (North St. Paul, 213). **West St. Paul** "[s]upports development and redevelopment that has a low impact on the environment. New development and redevelopment is required to meet the Stormwater Management Ordinance to improve water quality and effective

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conservation of the community's water resources" (West St. Paul, 177). One of **Corcoran**'s resilience goals is to "[p]reserve floodplain areas for flood mitigation and water quality," with a partial focus on using overlay districts to limit development in floodplain and shoreland zones (Corcoran, 143).

Climate Change

Climate change is a strong undercurrent of the discussion by many communities regarding intense rain events and flooding. These communities often discuss increasingly erratic precipitation patterns and the need to enhance emergency response. Level 4 communities name climate change as the underlying problem, and contextualize their rain and flooding discussions, goals, and policies in this way. **Vadnais Heights** discusses how "climate change and groundwater sustainability" has caused it to "amend [… its] stormwater management standards" (Vadnais Heights, 124). **Burnsville** attributes its amendment of local stormwater management standards to "the importance of resiliency," recognizing that "in a water resources context resiliency can be attributed to the ability to adapt to the climate related variability and reduce the vulnerability of the community to extreme events" (Burnsville, 288). **Woodbury** maintains that it and its watershed districts "will need to partner on climate adaptation and developing more resiliency in their surface water systems" (Woodbury, 60).

Community Designation Analysis

All 49 plans, representing 51 communities, reviewed in the Project were sorted into three main designations: urban, suburban, or rural. The project researchers analyzed these types of communities separately to see if they approached the task of intense rain and flooding in different ways that were more specific to their community type. These larger categories are combinations of the more narrowly defined categories the Metropolitan Council uses to distinguish communities. The urban category is made up of urban center and urban communities, while the suburban category is made up of towns that Met Council defines as suburban, suburban edge, and emerging suburban edge communities. The rural category is a combination of rural center, diversified rural, rural residential, and agricultural communities.

Urban

Urban communities focus on mitigation and adaptation efforts, including incorporating rainfall into multiple aspects of their plans; using climate-informed rainfall projections; prioritizing stormwater storage and retention; and increasing the amount of rain gardens, vegetative landscaping, and natural stormwater buffers.

Equity — Preparing for Climate Migrants

Minneapolis's plan contains a "Climate Change Resilience" goal. In support of this goal, its water resources guiding principles indicate:

> "To be resilient to the effects of climate change and diminishing natural resources [...] requires stormwater infrastructure that can handle larger storm events, and it requires water resources

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W: www.PublicHealthLawCenter.org
875 Summit Avenue, St. Paul, Minnesota 55105

> sufficient to last through periods of drought. [...] It requires a transportation system that functions throughout extreme weather events, and it requires [the] areas housing and employment [to be] capable of accommodating population shifts due to climate migration" (Minneapolis, 41).

Incorporation of Rainfall into Multiple Aspects of the Comp. Plan

An approach common to urban communities is incorporating rainfall and water infrastructure into multiple aspects of their comprehensive plan (such as the housing and transportation chapters), and not just in environmental or stormwater-specific sections. **Minneapolis'** plan states that:

> "To be resilient to the effects of climate change and diminishing natural resources [...] requires stormwater infrastructure that can handle larger storm events, and it requires water resources sufficient to last through periods of drought. [...] It requires a transportation system that functions throughout extreme weather events, and it requires [the] areas housing and employment [to be] capable of accommodating population shifts due to climate migration" (Minneapolis, 41).

Falcon Heights includes a goal in its housing chapter to "[p]romote the following practices: [...] b. Expanded urban tree canopy. c. Preserve pervious and indirectly connect impervious surfaces, minimize directly connected impervious surface. d. Maintain stormwater infrastructure" (Falcon Heights, 34). A strategy in **St. Louis Park's** parks system section is to "incorporate rain gardens, natural vegetative buffers, and other stormwater management techniques best suited to that park area, where appropriate" during redevelopment of any park areas (St. Louis Park, 74).

Climate-Informed Rainfall Projections

Urban communities are also incorporating rainfall projections specifically tied to climate change into their comprehensive plans. **Bloomington** will "[c]onsider the impacts of future precipitation and climate trends when developing and implementing City water resource management projects and programs"" (Bloomington, 194). In **Maplewood**, "precipitation patterns are anticipated to change, providing an increase in the overall rainfall as well as an increase in the number of days without rain - exacerbating both flooding and drought potential" (Maplewood, 160). **Golden Valley** plans to "[c]onsider emerging climate patterns when designing stormwater infrastructure" (Golden Valley, 1492).

Stormwater Storage & Retention

Urban communities in the Metro also focus on planning for stormwater storage and retention as rainfall and the risk of flooding increase in the coming decades. **Maplewood** will "[p]reserve, maintain and enhance the storm water storage and detention systems to control excessive volumes and rates of runoff, control flooding, [and] protect public health and safety" (Maplewood, 262). **Columbia Heights** plans to "[e]ncourage the addition of more native plants into landscaping to enhance the health and diversity of pollinators and wildlife populations, and help filter and store stormwater" (Columbia Heights, 38). **Roseville** will "strive to incorporate construction, building, and landscape designs and practices that mimic natural systems, and infiltrate, retain, and detain rainfall onsite, or can reduce excess flows into our sewers, streets, and waterways on City infrastructure projects" (Roseville, 335).

P: 651.290.7506 F: 651.290.7515
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Many of these communities are planning to leverage existing natural storage methods and areas as part of stormwater retention. **Bloomington** plans to "[u]tilize existing natural ponding areas for impoundment and treatment of surface water runoff as outlined in the Local Surface Water Management Plan" (Bloomington, 194). A goal for **Crystal** is to "[p]rotect, preserve, and use natural surface and groundwater storage and retention systems" (Crystal, 896). **North St. Paul** has "begun to enhance its natural resources by protecting areas like PCU Environmental Learning Center and the Urban Ecology Center which include wetland restorations and the establishment of native upland buffers. [...] [indicating that] wetlands serve as natural storm water retention areas during runoff periods" (North St. Paul, 210).

Rain Gardens, Vegetative Landscaping & Natural Buffers

A focus for urban communities is increasing the number of rain gardens throughout the community to help maintain and reduce runoff and localized flooding. **Osseo** plans to incorporate "the use of storm water reduction methods, including rain gardens, swales, and permeable pavement where appropriate [and] [e]ncourage landscaping that utilizes native plant selection, high-efficiency irrigation technology, rainwater harvesting, and other systems that reduce water consumption" (Osseo, 132). **Bloomington's** plan states that:

> "Rain gardens are shallow depressions designed to capture runoff from rainwater and snow melt onsite and allow it to infiltrate into the ground rather than entering the storm sewer system. During street reconstruction the City works to identify interested parties to coordinate construction. Since 2009 there have been over 80 rain gardens installed in Bloomington" (Bloominton, 80).

St. Anthony Village will "[c]ontinue to implement effective and innovative stormwater management practices and rain gardens and incentivize private rain gardens and stormwater BMPs" (St. Anthony Village, 198).

In addition to rain gardens, urban communities also utilize natural stormwater buffers such as wetlands, swales, and other vegetative landscaping. A policy of **St. Louis Park** is to "incorporate rain gardens, natural vegetative buffers, and other stormwater management techniques best suited to that park area, where appropriate" as part of redevelopment of any park areas (St. Louis Park, 74). **Falcon Heights** plans to "[i]ncrease resiliency to weather events by the planting of buffer zones in park borders and public building properties or on public right of ways next to streets" (Falcon Heights, 126). **Golden Valley** will "[m]aintain and improve natural infrastructure assets, such as streambanks, wetlands, ponds, and rain gardens. [...] Encourage the preservation or establishment of native and natural vegetation near shorelands. [...] Continue to review development proposals for conformance with ordinances regarding water quality, wetland protection and mitigation, and floodplain and shoreland protection" (Golden Valley, 1490).

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Suburban

Suburban communities focus on improving their infrastructure to reduce risk from increased rainfall and flooding. These communities are generally doing this through using Atlas 14 projections, reducing stormwater runoff, site planning, implementing development restrictions and regulations, reducing erosion/sedimentation, and reducing impervious surfaces.

Equity — Emergency Communications & Underinvested Communities

As suburban communities prepare for increased water emergencies and risks, some are ensuring that the needs of underinvested communities are included in this. In **Woodbury**, "[a]dditional issues when considering water system resilience include [...] emergency response protocol, particularly for vulnerable populations" (Woodbury, 224). A priority for **Newport** is to "[c]ommunicate emergency plans to at-risk populations" (Newport, 144).

Atlas 14

Atlas 14 is an ongoing study by the National Oceanic and Atmospheric Association (NOAA) to analyze historic precipitation patterns to project future patterns. Suburban communities often specify Atlas 14 as at least a partial basis of their infrastructural decisions related to intense rain events and flooding. **Vadnais Heights** "recognizes the importance of resiliency. The City has amended its stormwater management standards to recognize the updated Atlas 14 depths and distributions and will endeavor to continue to adapt its policies and standards with the climate change trends" (Vadnais Heights, 124). **Woodbury** indicates that it "will need to partner on climate adaptation and developing more resiliency in [its] surface water systems. Specifically, Woodbury will assist by: Designing its future systems for Atlas 14 rainfall. Implementing Atlas 14 retrofits to increase quantity resiliency [...]" (Woodbury, 60). **White Bear Township** "will consider adopting MIDS to minimize stormwater runoff and pollution and preserve natural resources" while indicating that "[t]he Township will consider incorporating NOAA Atlas 14 Frequency Estimates" (White Bear Township, 334).

Reducing Stormwater Runoff

A priority for suburban communities is reducing the volume of stormwater runoff in their cities. **Eden Prairie** plans to "[e]ncourage property owners to enhance industrial flex tech areas with foundation landscaping, bioswales, and other forms of green infrastructure to beautify the area and mitigate flooding, pollution, and stormwater runoff" (Eden Prairie, 99). **White Bear Township** "will consider adopting MIDS to minimize stormwater runoff and pollution and preserve natural resources" (White Bear Township, 334). **Shakopee** is considering "adopting and using Minnesota's Minimal Impact Design Standards (MIDS) to address site stormwater runoff and pollution" (Shakopee, 353).

Site Planning

Many suburban communities outline requirements or incentives for site design to reduce runoff. **Eden Prairie** will "[e]ncourage property owners to enhance industrial flex tech areas with foundation

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landscaping, bioswales, and other forms of green infrastructure to beautify the area and mitigate flooding, pollution, and stormwater runoff" (Eden Prairie, 99). **Lilydale** has a policy that:

> "Building permits should not be issued for any development until the developer provides plans that show in detail the flow and dispersal of stormwater [… and requires] that all new development or redevelopment proposals in all Districts be accompanied by a site plan that includes […] standards to ensure that […] stormwater runoff [is] compatible with the character and use of the river" (Lilydale, 67).

Woodland plans to encourage "[c]ompliance of new lot development and redevelopment with stormwater management and erosion control requirements, including wetland and shoreland buffer areas of the Minnehaha Creek Watershed" (Woodland, 34).

Development Restrictions & Regulations

In addition to site planning, suburban communities are implementing a variety of development restrictions and regulations to protect water resources. **Lilydale** will "[p]rohibit development on a parcel of land with an average slope greater than 18 percent when slopes lie below a designated bluff line" (Lilydale, 67). **Newport** will "allow housing densities and subdivision design that encourage conservation development to provide efficient use of land by preserving open space, scenic views, natural drainage systems, and other desirable features of the natural environment" (Newport, 164). One of **Eden Prairie's** policies is to:

> "Require that development and redevelopment projects demonstrate no net increase in the annual runoff water volume from the site compared to pre-development conditions. [...] Require a Green Infrastructure Analysis to provide reduction of impervious surface area and disconnection of impervious surfaces during development review to reduce runoff and pollutant and nutrient loading to water resources" (Eden Prairie, 752).

Reducing Erosion & Sedimentation

Reducing erosion and sedimentation into the water system is a priority for many suburban communities. **Woodland** plans to enforce "[c]ompliance of new lot development and redevelopment with stormwater management and erosion control requirements, including wetland and shoreland buffer areas of the Minnehaha Creek Watershed" (Woodland, 34). **Stillwater** includes a goal to "[p]revent flooding and erosion by implementing flood plain management and erosion control systems" (Stillwater, 668). **Mahtomedi** will "[p]rotect the capacity of the City's stormwater management system, prevent flooding, and maintain water quality by preventing erosion and sedimentation from occurring, and correct existing erosion and sedimentation problems" (Mahtomedi, 242).

Reducing Impervious Surfaces

Suburban communities also focus on reducing the amount of impervious surfaces in order to reduce runoff. **Chanhassen** creates an Overlay District that "defines a Primary Zone, which is intended to be open space, and a Secondary Zone, in which regulated development may occur. Within this Secondary

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Zone, the ordinance requires a more stringent bluff setback [and] limits the amount of impervious surface allowed based on bluff slope" (Chanhassen, 333). **Oakdale** will "[p]romote water infiltration techniques such as raingardens and pervious pavers to replenish groundwater resources" (Oakdale, 69). **Newport** will "manage land use and development within the MRCCA to be consistent with its Land Use plan for 2040 and the requirements of MRCCA rules, including minimizing impervious cover and maintain natural drainage routes" (Newport, 164).

Rural

Many rural communities address increased rainfall and flooding through infrastructural policies, including restrictions and regulations for development and reducing impervious surfaces.

Development Restrictions & Regulations

Rural communities focus on limiting and regulating development near water bodies to protect valuable resources and infrastructure. **Denmark Township** plans to "[p]rovide uninterrupted vegetated shorelines by restricting or prohibiting development on shoreland and floodplain areas, wetlands, and other natural features that serve important environmental functions" (Denmark Township, 116). **Nowthen** identifies policies to:

> "Require all new development to manage all on-site storm water generation to ensure that no negative impact will occur with regard to downstream flooding or water quality. [...] Require grading and drainage plans as part of any new residential, commercial or industrial development illustrating proposed drainage patterns, plans for on-site storm water retention, and erosion control" (Nowthen, 33).

Cologne will "[p]rohibit and/or regulate new development in floodplains, steep slopes, wetlands and other environmentally sensitive areas" (Cologne, 12). **Belle Plaine** will "[a]dminister site design and development standards to decrease and minimize the possibility of flooding and instability of bluffs and steep slopes" (Belle Plaine, 57).

Some rural communities use zoning overlay districts to apply development regulations. **Marine on St. Croix** recognizes the "Lower St. Croix Overlay District Section" as a zoning district to "[regulate] the setback of structures and sanitary waste treatment facilities from shorelines to protect the natural scenic value, floodplain, and water quality" (Marine on St. Croix, 84). **Corcoran** includes a policy to "[c]ontinue to limit development in floodplain and shoreland zones through the adopted Floodplain and Shoreland Overlay Districts" (Corcoran, 143). **Scandia** has a series of overlay districts which include "Shoreland Ordinance [...] Saint Croix River Overlay District [...] Floodplain Overlay District" (Scandia, 137).

Reducing Impervious Surfaces

Rural communities also focus on reducing the amount of impervious surfaces in order to reduce runoff. **Inver Grove Heights** will "[r]educe volumes of stormwater runoff and the amount of impervious surfaces in the developed parts of the City" (Inver Grove Heights, 259). **Lake Elmo** "supports and will

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encourage developers and landowners to use storm water practices that promote infiltration/filtration and decrease impervious areas through site design and use of Low Impact Development (LID) techniques and Green Design" (Lake Elmo, 245). In **Denmark Township,** "[t]he [Shoreland District] ordinance will mandate a maximum impervious surface of 25%" (Denmark Township, 99).

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[1] "Key Definitions," Twin Cities Metro Area Healthy Communities Planning Project Team - MN DEPT OF HEALTH (2020), internal project document available upon request.
[2] "Why You Should Consider Green Stormwater Infrastructure for Your Community," U.S. ENV. PROT. AGY, available at: https://www.epa.gov/G3/why-you-should-consider-green-stormwater-infrastructure-your-community.
[3] See **"**NOAA Atlas 14 - Precipitation Frequency Estimates**",** MN DEPT. OF NAT. RES., available at: https://www.dnr.state.mn.us/climate/noaa_atlas_14.html.

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