# Predicting Local and State-Level Water Risk Perceptions in Minnesota

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## Abstract

Risk perception research in the field of natural resources science and management has come a long way since the publication of “Perception of Risk” by Paul Slovic in 1987, and some scientists have started attempting to predict risk perceptions. At the time of this writing, 40 percent of assessed waters in Minnesota are reported as impaired. However, resident water risk perceptions are not aligned with technical risk assessments conducted by water experts. To better understand the mechanisms that drive heightened or lowered water risk perceptions, a mail survey was distributed to Minnesota residents across the state. The questionnaire asked residents about their values, perceived community capacity to manage water problems, and perceived awareness of water quality issues in their local area to develop a model predicting perceptions of water risk at two levels: local and statewide. In the survey, an adaptation of the values constructs created by Steg et al. (2014) was employed, and several new value constructs were created for this survey. The multivariate regression model developed was moderately effective, explaining about a third of the variance in water risk perceptions for both local and statewide levels. Consistent with previous research in Minnesota, this study has found gaps between technical assessments of risks to water in Minnesota and public perceptions of this risk. The exploratory nature of this risk perception research suggests that future investigation into the predictors of water risk perceptions should examine

the reliability of the measures used in this study.

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# CHAPTER ONE: PROJECT OVERVIEW

The Minnesota Pollution Control Agency reports that 40 percent of assessed waters in Minnesota are impaired (Minnesota Pollution Control Agency, 2018a). Waters impaired by conventional pollutants (e.g., phosphorus, nitrogen, chloride) and contaminants of emerging concern (e.g., pharmaceuticals, personal care products) pose threats to the beneficial uses of water for human and ecosystem health (Minnesota Pollution Control Agency, 2018b, 2018c, 2018d).

Despite, or perhaps because of these threats, Minnesotans continue to place a high value on water and have demonstrated this by voting to protect water. In 2008, Minnesota voters approved the Clean Water, Land and Legacy Act (Legacy Act) which included a three-eighths of one percent sales tax increase through 2034. The Legacy Act sets aside more than $200 million annually to fund clean water projects. The Clean Water Council, made up of resource managers, tribal government officials, attorneys, farmers, conservation directors, nonprofit leaders, hydrologists, senators, representatives, college professors, economists, geologists, and others, oversees the use of the funds and their allocation to seven partner agencies. According to the legislature, Clean Water Funds are to be used “to protect, enhance, and restore water quality in Minnesota lakes, rivers, streams, and groundwater” (The Minnesota State

Legislature, 2017).

In addition to holding the title of “Land of 10,000 Lakes,” Minnesota is also home to the headwaters of the Mississippi River, Lake Superior, and many other highly revered lakes, rivers, and streams. Many of the downstream and out-of-state water problems found elsewhere in the continent can arise from problems originating in Minnesota because of its position in the landscape and the major drainage basins located in the state (Minnesota Pollution Control Agency, 2014).

Water management will become an increasingly challenging issue as climate change accelerates and global water resources are threatened, affecting water quality and quantity, with disproportionate impacts across the world (Bates, Kundzewicz, Wu, and Palutikof, 2008; Kundzewicz et al., 2008; Crane, Whitehouse, Comber, Ellis, and Wilby, 2005; Vörösmarty, Green, Salisbury, and Lammers, 2000; Arnell, 1999). In the face of reduced quality and quantity of clean water, whether because of growing demand (e.g., population increases, agricultural or industrial intensification), pollution, drought, or otherwise, the onus is on water resource managers and practitioners, as well as users, to manage water in a responsible and democratic manner. Clean water availability is an issue that affects everyone, especially vulnerable groups (Franco-Paredes, Jones, Rodriguez-Morales, and Santos-Preciado, 2007; Farmer, 2003). It is the responsibility of scientists, managers, and practitioners to

engage the public and monitor whether past clean water investments have translated to a real value for residents. The question of whether Clean Water Funds are making a difference in Minnesota's waters persists.

Managers, policymakers, and water users across the state must continue to consider the impacts of different water management regimes on water and the cultural services water supplies. Technical understanding of water risk must be understood in the context of social perceptions of water risk so that smart investments are made that translate to desirable outcomes for residents. Beyond Minnesota's affirmation of the importance of clean water at the voting booth, the Clean Water Council has little public guidance on how to spend Clean Water Funds, or what water initiatives to prioritize. Social science research on public values and beliefs about water will contribute to more informed water management decisions and stakeholder engagement in water funding allocations.

Future allocations of Clean Water Funds and prioritization of clean water initiatives should be informed by Minnesotans themselves. Social science research on water can aid this effort through resident surveys, a form of civic engagement, and the scope of inquiry on water in Minnesota is growing. For example, a recent statewide survey of Minnesota residents from three watersheds in the Minneapolis-Saint Paul Metropolitan Area revealed that 97 percent of respondents believe that clean streams, rivers,

and lakes are important to their community (Pradhananga and Davenport, 2017). In recent years, the Minnesota Clean Water Council has varied in its allocations of Clean Water Fund dollars (Minnesota Clean Water Council, 2014, 2016, 2018). While categorical funding amounts may differ slightly from year to year based on unpredictable and variable annual need, the Minnesota Clean Water Council only recently allocated specific funding to comprehensive local watershed management plans (Table 1). The Minnesota Clean Water Council also recently formally acknowledged in the most recent Clean Water Fund and Policy Recommendations Report that in addition to the chemical, biological, and physical science, social science is a key component of protecting water (Minnesota Clean Water Council, 2018). This project explores how Minnesotans value water and their perceptions of risk to water at local and statewide levels.

This thesis describes findings from a statewide Minnesota Water Values survey (Davenport and Keeler, 2018) that explores residents' water values, awareness of water issues, perceptions of community capacity to protect water, and perceptions of water risk (Appendix B). Biophysical and geochemical water scientists and managers have reached consensus that Minnesota waters are impaired and at risk, but how Minnesota residents perceive water risk across the state is unknown.

In particular, this study asks, what drives residents' water risk perceptions? The process of formulating risk perceptions was described

by Slovic (1987) as “a set of mental strategies, or heuristics, that people employ in order to make sense out of an uncertain world.” Risk perceptions are psychological manifestations of the hazards people deem a threat, or not a threat, to the things that matter to them. Additionally, levels of perceived risk are variable, meaning that psychometric assessments of risk perceptions must provide for more than a simple “threat” or “not a threat” level of detail for risk perception research.

Risk perception research has received increasing attention in natural resources social sciences as a driver of environmental behavior (Lacroix and Gifford, 2018; Masud, Akhtar, and Kari, 2015). However, few studies, like that of Ballew et al. (2019), have investigated the determinants of risk perceptions or examined risk perceptions across geographic scales (e.g., local and state-level). Wilson, Zwickle, and Walpole (2019) attempted to develop a broadly applicable measure of risk perception for use in social surveys through an extensive literature review of previous measures but did not include geographic scales as a risk perception item. However, in their literature review, the researchers found that probability and consequences were commonly used risk perception items in previous studies. Geographic scale, in the context of risk perception research and problem distancing, may be analogous to probability and consequence items, but this connection cannot be established without purposively examining the relationships of these items

to each other in predicting risk perception. Recognizing the differences in risk perceptions between experts and the public may provide insight for managers and practitioners in communicating the importance and severity of certain threats to the public (Krewski, Turner, Lemyre, and Lee, 2012; Slovic, 1987). Predicting the drivers of public risk perceptions will help the Clean Water Council and water managers understand Minnesotans' priorities for Clean Water Funds. It will also enable better water communication, education, engagement programming, and anticipation of citizen-driven expectations for Clean Water Fund outcomes.

There will always be conflicts in management of water resources in Minnesota and elsewhere because of the many different values that people hold around water, but working with the public and using social science to inform water policy will help better account for the wide variety of value orientations, levels of awareness, community capacity, and risk perceptions extant in Minnesota's resident populations.

This thesis details the development and application of a multivariate multiple regression model to predict local and state-level risk perceptions. Building on the work of Slovic (1987), Davenport and Anderson (2005), Davenport and Seekamp (2013), Brinkman, Seekamp, Davenport, and Brehm (2012), and Steg, Perlaviciute, van der Werff, and Lurvink (2014), I have developed a number of hypotheses. First, I believe that perceived risk to water resources at community-level and statewide levels will be amplified among

residents with higher values across a diverse set of value orientations detailed in this study. Additionally, I believe that residents who have greater perceived familiarity with local water problems (i.e., awareness of water problems) will have greater perceived risk to local and statewide water resources. Last, I believe that greater perceived community capacity is negatively related to water risk perceptions.

The first chapter of this thesis provides an introduction to the project study and the state of water in Minnesota, a brief primer on risk perception research and its importance in this work, and a vignette of the role of the Minnesota Clean Water Council in protecting water in the state. The second chapter is presented as a stand-alone article for submission to a refereed journal, and the third chapter details big picture conclusions and benefits of this research.

**Table 1.**

*Minnesota Clean Water Council: Clean Water Fund Recommendations*

| Funding Category | FY 16-17 | FY 18-19 | FY 20-21 |
|---|---|---|---|
| Monitoring and Assessment Programs | 11% | 18% | 14.4% |
| Nonpoint and Point Source Implementation Programs | 61% | 48% | 60% |
| Watershed Restoration and Protection Strategies (WRAPS) Programs | 11% | 30% | 10.2% |
| Drinking Water and Groundwater Protection Programs | 14% | - | 8.9% |
| Applied Research and Tool Development Programs | 3.5% | 4% | 4.5% |

| | | | |
|---|---|---|---|
| Comprehensive Local Watershed Management Plans (One Watershed, One Plan) Development | - | - | 1.7% |

Source: Minnesota Clean Water Council (2014, 2016, 2018)

# CHAPTER TWO: PREDICTING LOCAL AND STATE LEVEL WATER RISK PERCEPTIONS IN MINNESOTA WITH VALUES, COMMUNITY CAPACITY, AND PERCEIVED AWARENESS

## Introduction

Water drives human life and natural ecosystem functions. Despite the importance of this critical resource, human-caused pollution and scarcity pose an increasing threat to this resource. Water resource scientists and managers agree that water resources in Minnesota, U.S. are at risk, threatened by multiple anthropogenic stressors. Public perceptions of threats to water, or water risk perceptions, are important are important to water resource management (Slovic, 1987). Justifying social and financial investments in water protection and restoration requires a basic public understanding of water resource issues and some level of scientific, public, and policymaker agreement that water needs protection and restoration (Slovic, 1987). While water managers and other professionals may rely directly on scientific evidence linking human activities to water stress, civic engagement is needed to increase social acceptability of investing public resources into water protection and restoration programs (Bohnet, 2015). Moreover, watershed-scale management demands that civic engagement includes public and private landowners and diverse resource users to implement solutions. Thus,

public participation processes must be institutionalized by tribal, federal, state, and local governments (Bohnet, 2015). A growing part of incorporating civic engagement and public participation into ecological management decisions is risk perception research (Slimak and Dietz, 2006; Leiserowitz, 2005). Several studies have revealed that understanding public perceptions of risk is vital to understanding the social acceptability of environmental programs or projects and achieving effective civic engagement (Withanachchi et al., 2018; Carlton and Jacobson, 2013).

The primary goal of this study is to investigate the determinants of water risk perception and develop a psychometric model to predict local and state-level risk perceptions in Minnesota. This study is part of a broader project funded by two Minnesota water policy advisory committees to guide decisionmaking and state water protection fund allocation. This paper also introduces a multi-dimensional water values scale that builds upon existing environmental values literature (Steg et al., 2014).

The work by Steg and others (2014) provides a framework for examining the multiple orientations of water values including hedonic, egoistic, altruistic, and biospheric values. This study adapts and applies this framework to predict perceptions of water risk among Minnesota residents. Broadly, the goal of this water values project was to inform

future allocations of water funds and management through a statewide social science-driven survey of residents. This paper examines the influence of six water value orientations including health, recreation, economics, altruism, culture, and biospherism, as well as measures of awareness of local water issues and beliefs about community capacity to protect water, on local and state-levelrisk perception using a multivariate multiple regression model.

## Literature Review

Efficient, effective, and equitable water resource management with finite resources is a primary challenge among water managers and resource professionals. For some, adding public opinion and human behavior to the water management arena only further complicates decision making. However, failing to include the public in decision-making processes can be far more costly, leading to public dissent, non-compliance with “best practices” and further water resource degradation. When public values, beliefs, and norms of behavior around water are collected and understood using systematic social science methods, public opinion can inform and guide science communication, collaborative water resource management, and public policy development. This review examines a growing body of literature on the social determinants of environmental risk perception. Specifically, this researchexplores the

concepts of risk perception, water values, water awareness, and community capacity to protect water (Figure 1).

**Risk Perception**

Slovic's text titled "Perception of Risk" (1987) details the importance of better understanding risk perception so that policymakers and managers can achieve better communication, targeted education of the public, and predict what management actions will be popular or unpopular with the beneficiaries of these actions. Since the publication of that paper, scholarship on risk perception has expanded upon this concept and risk perception has been recognized as a significant part of the policymaking process (Carlton and Jacobson, 2013; Leiserowitz, 2006; Sjöberg, 2000; Slovic, 1999). In researching previous measures of risk perception, Wilson, Zwickle, and Walpole (2019) reviewed 81 studies and found that the use of general measures was most common. The term *general* measures, in this case, referred to the use of questions employing language such as *how risky something is* without addressing specific underlying conditions such as probability, consequences, or risk versus benefit.

Public risk perceptions are often not aligned with technical risk assessments conducted by technical experts (Liverani, 2009; Lieserowitz, 2005). In fact, technical risk assessments are often excluded from risk perception research (Sjöberg, 2000). Slovic (1987) identified a dread

factor as a critical component of public perception of risk; while certain, less acutely catastrophic hazards (i.e. cancer caused by cigarette smoking) may realistically carry a higher probability of occurring than less probabilistic events with more catastrophic or uncontrollable consequences (i.e. nuclear weapons), Slovic found that “perceived lack of control, dread, catastrophic potential, fatal consequences, and the inequitable distribution of risks and benefits” were driving factors behind public risk perception. This is evident in climate change risk and vulnerability assessment research (Lacroix and Gifford, 2018; Carlton and Jacobson, 2013; Lieserowitz, 2005). While the scientific community reached a general consensus decades ago that climate change is not only human-caused, but also poses an existential threat to the survival of humanity, a great subset of the general population and policymakers are still uncertain or in denial about the human causes of climate change. According to national survey data collected in 2019 by the Yale Program on Climate Change Communication and the George Mason Center for Climate Change Communication, 71 percent of Americans believe that global warming is happening, 56 percent believe global warming is caused mostly by human activities, 53 percent believe most scientists think global warming is happening, and 40 percent reported that they are not worried about global warming (Ballew et al., 2019). Public climate change perceptions are not aligned with scientific evidence or scientific

consensus. Contrary to public perceptions, investigations have shown that 97 percent of actively publishing climate scientists agree that climate change is happening, and that it is extremely likely to be a result of human activities (National Aeronautics and Space Administration, 2019). While it is important to note that the risks of climate change will be defined differently across stakeholders, the actual occurrence of the phenomenon alone is still highly debated by the lay public (Leiserowitz, 2005).

Risk perception has been treated as a dependent variable in many studies (Lechowska, 2018; Leiserowitz, 2006; Slimak and Dietz, 2006, Sjöberg, 2000). Experts argue about what causes risk perception, and different data sources suggest different antecedents to risk perception. Climate change, flooding, and many other risk perception phenomena have been studied extensively, and studies have shown mixed results on the conditions or mechanisms driving risk perceptions. Predictor variables such as sociodemographic characteristics, prior experience, media consumption, trust, values, and others have been used to predict risk perceptions (Chauvin, Hermand, and Mullet, 2007; Slovic, Finucane, Peters, and MacGregor, 2004; Siegrist and Cvetkovich, 2000). Other studies have studied the potential influence of risk perceptions on attitudes and behavior (Trumbo, 2018; Masud et al., 2015).

Minnesota and its vast water resources pose an excellent context for studying risk perception because, similar to the scientific consensus on

global climate change, scientists and water managers agree that Minnesota water is at risk throughout the state. Many waters are impaired or at risk for impairment by multiple pollutants or issues such as nitrate, chloride, phosphorus, groundwater depletion, invasive species, and sediment (Minnesota Pollution Control Agency, 2018b, 2018c, 2018d). The exact causes and consequences of water problems are complex but can be attributed to both direct and dispersed human activities. Still, water scientists and managers are challenged to develop effective science communication and public engagement programs that inspire water action among residents, landowners, and resource users (Nelson, Davenport, and Kuphal, 2017).

Recent research suggests a divide between the state of Minnesota waters and public perceptions of risk to local water. In a study conducted in the community in the Seven Mile Creek Watershed of Minnesota, over 80 percent of respondents from the two groups that were sampled reported that they were at least “moderately concerned” about the water quality in Seven Mile Creek; Over 90 percent reported being at least “moderately concerned” about the water quality of lakes and streams in southern Minnesota in general (Fellows, Green, and Davenport, 2017). In one study by the Minnesota Department of Health, water risk perception was measured for private well users (Minnesota Department of Health, 2017). The study found that more than one million Minnesotans (21

percent) get their drinking water from private wells. After the initial water test result, the Minnesota Department of Health provided contaminant information and recommended the well user take action to protect their health. Despite this recommendation, the Minnesota Department of Health reported that 34 percent of well users did not take any action, 36 percent installed a treatment system, and 25 percent chose to instead drink bottled water. The top reported reason (at 50 percent) for not taking action was a lack of concern about the arsenic level. Regardless of the results of the 2017 study by the Minnesota Department of Health, unlike the survey presented in this paper, the findings are exclusive to only a subset of the state's population that uses private wells, necessitating a need for research on all Minnesota residents on clean water priorities.

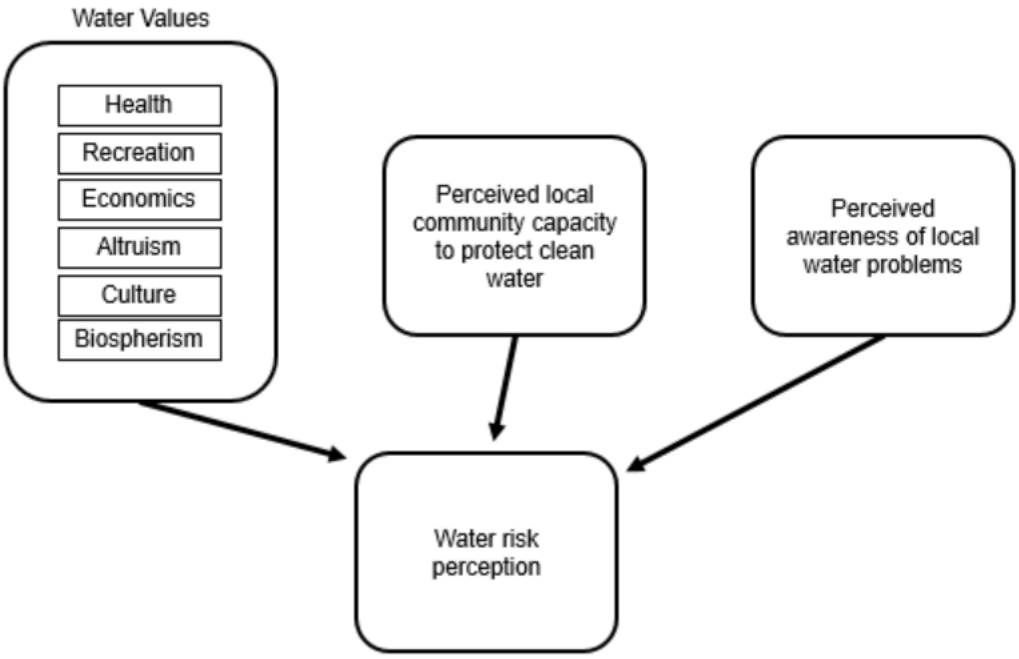
The risk perception measures in this study were developed using the foundation presented by Pradhananga, Fellows, and Davenport (2018). In their measurement of risk perception, respondents were asked to rate their level of agreement or disagreement with statements such as, "water resources in my community are adequately protected" and "water resources in Minnesota need better protection" (Pradhananga et al., 2018). The question items regarding risk perception in this study were structured and worded according to this previous work. Local and statewide water risk perception levels were chosen for this study because of previous research that has found an influence of larger area size on

increased environmental hazard risk perception, although this theory has not been studied extensively (Fleury-Bahi, 2008).

In the risk perception model presented in this paper, water values, community capacity, and awareness are utilized to predict local water risk perception and state-level water risk perception (Figure 1). The justification for this method is that the level of personal importance that individuals hold for different values and uses of water (values), in combination with their perception of their community's ability to protect water resources (community capacity), and their individual awareness of water issues in their local area (awareness) influence their perception of risk around water (risk perception).

**Figure 1.**

*Risk perception model*




**Water Values**

The environmental values framework offered by Steg et al. (2014) provides an opportunity to explore the relationship between water values and water risk perceptions. Values, as defined by Schwartz (1992), are "desirable transsituational goals varying in importance, which serve as a guiding principle in the life of a person or other social entity." This definition was also used by Steg et al. (2014) in capturing the significance of values. Steg and others (2014) investigated the potential of hedonic values as an addition to the previously researched value orientations of egoism, altruism, and biospherism. The researchers found that hedonic values were indeed a necessary addition, with a significant, negative relationship to many environmentally relevant attitudes, preferences, and

actions (Steg et al., 2014). However, rather than focusing soley on the Steg et al. (2014) value orientations of hedonic, egoistic, altruistic, and biospheric values, project personnel postulated that additional meanings and cultural value orientations are central to the relationship people have with water (Davenport and Anderson, 2005).

**Water Awareness and Community Capacity to Protect Water**

Two other determinants of risk perception are of focus in this study: awareness of water issues and community capacity to protect water. In a study in the Cannon River Watershed in Minnesota, Davenport, Pradhananga, and Olson (2014) conducted a landowner survey regarding water resources and conservation action. In the study, researchers found that 62 percent of respondents reported that they were “not at all” to “only slightly familiar with water resource issues.” Another noteworthy takeaway that arose from the Cannon River Watershed study was that while some landowners were more aware of the consequences of environmental problems, their perceived ability to solve problems through conservation practices may be a barrier to the development of personal norms around conservation action (Davenport et al., 2014).

The community capacity measure employed in this study was developed based on the work of Brinkman et al. (2012). In the study by Brinkman and others (2012), the researchers provided a brief account of the state of community capacity research at the time of writing, detailing

the many benefits of strong community, scholarship on motivations behind civic engagement, and key components of strong community capacity frameworks. In the study by Brinkman et al. (2012), the researchers discovered that community empowerment was strongly predictive of community capacity. This is important as it is indicative of a key mechanism behind community capacity building. In this study, the methods used by Brinkman et al. (2012) were replicated to address the concept of community capacity.

The overarching research question of this study is, “What drives water risk perception among Minnesota residents?” I will examine three hypotheses:

$H_1$: Residents who place higher values on water will perceive greater water risk, locally and statewide.

$H_2$: Residents who perceive greater personal familiarity with local water problems will perceive greater water risk, locally and statewide.

$H_3$: Residents who perceive greater community capacity to protect water resources will perceive lesser water risk, locally and statewide.

## Methods

A self-administered mail survey was administered to a sample of

residents across the state of Minnesota in 2018 to examine residents' water values, beliefs about community capacity to deal with water issues, awareness of water problems, and water risk perceptions.

Mailed survey packets included a cover letter explaining the purpose of the study, the eight-page questionnaire instrument, and a postage-paid business reply envelope to mail the questionnaire back to the researchers upon completion of the survey. An adaptation of the tailored design method from Dillman, Smyth, and Christian (2014) was used for this study to increase response rates. Individuals who did not return a completed questionnaire or failed to decline to participate were mailed a second and third reminder to complete the survey, four and six weeks after prior mailings, respectively.

**Sample Selection**

A sample of Minnesota residents was purchased from a survey sampling firm. The sample was geographically stratified by eight regions (Minnesota Association of Soil & Water Conservation Districts, 2019) and a random sample of 750 individuals in each region was selected, for a total of 6,000 across the state (Appendix A). This regional stratification was intended to ensure geographic representation across watersheds, land uses, and management regimes.

**Measures**

The survey questionnaire developed for this study asked residents

about a number of different subjects regarding water, including the ways in which they value water, levels of agreement with the state of water in their community and state, what qualities they value in a community, and others. Question items featured fixed-choice and scale structures. Additional questions were included such as who should be responsible for protecting water and engagement in protecting water. Sociodemographic question items were included at the end of the survey. Question items were structured in a way that guaranteed they were not double-barreled, and an emphasis on clarity and conciseness in question wording was prioritized so as to make questions easy to answer. A great deal of effort was taken in the development of the survey to ensure that each question item contained technically accurate information. A pilot draft of the survey questionnaire was sent to Minnesota Clean Water Council stakeholders for comments and review prior to the mailing of the statewide survey.

**Water Values**

An adaptation of the Steg et al. (2014) framework was used to construct six measures of water values for orientations of altruistic, biospheric, cultural, recreation, economic, and health values (Table 3). Given the prompt, “How important is it to protect and restore Minnesota waters (lakes, streams, rivers, and groundwater) for the following values and uses,” respondents were asked to rate items on a scale ranging from

1 = *not at all important* to 4 = *extremely important*.

In a 2008 study, Schwartz notes that culture "influences the distribution of individual beliefs, actions, goals, and styles of thinking through the press and expectations to which people are exposed" (Schwartz, 2008). Culture is formed when people in a society are inevitably required to define the relations and boundaries between individuals and a group, guarantee the responsible behavior of individuals to preserve the social fabric, and govern the relationship between humans and nature (Schwartz, 2008). As evidenced by Schwartz (2008), culture plays an important role in the different ways people value resources like water, and in many respects, deserves to be analyzed independently for its importance and nuance in water protection behaviors. In this study, the hedonic and egoistic value orientations positied by Steg and others (2014) were further contextualized and operationalized as health, recreation, economics, and cultural value orientations. Value orientations associated with altruism and biospherism were retained.

Haluza-DeLay, Kowalsky, and Parkins (2009) discuss the importance of recognizing the health benefits of the natural environment for humans, providing both mental and physical wellbeing benefits. For the purposes of this study on water values, the health value was an important addition. Many studies have pointed to the benefits of exposure to greenspace for their health benefits, and many scientists are confident

that there is a definitive link (University of East Anglia, 2018). However, there is a lack of research on health as a value itself, necessitating the need for values research around health in a social science context and its incorporation into the water values construct set in this study.

Economic value has historically been researched exclusively within the field of economics. In this study, the economic value was included because of its potential importance in pro-environmental behaviors. Gatersleben, Murtagh, and Abrahamse (2014) cited the possible relevance of incorporating *materialism*, as a value concept, into studies on pro-environmental consumer behaviors. Materialism, in the context of this research, refers to the value people ascribe to certain material goods that serve a beneficial use for the peson who possesses them. In this study on water values, the survey question item wording was adapted from the values framework of Steg et al. (2014), and the materialism value concept was termed economic value.

In the field of landscape and recreation research on values and meanings, many scientists have been moving further into the field of emotional relationships with places, beyond traditional economic valuation, focusing on place attachment and place identity as important facets of human well-being in recreation values research (Junot, Paquet, and Fenouillet, 2018; Davenport and Anderson, 2005; Manzo, 2003; Williams and Vaske, 2003). Research on values has shown that recreation

values can play an important role in conservation decisions (Winter and Lockwood, 2005). In particular, according to Winter and Lockwood (2005, pg. 277), “intrinsic, non-use and use values, and the particular combinations of these values held by individuals, are important influences on the direction and intensity of conservation preferences.” This finding indicates a potential need for incorporating recreation as a value with the other water value constructs included in this study.

The specific question language used for the values items in this study was based directly off of the work from Steg and others (2014).

**Community Capacity to Protect Water Resources**

Building on the work of Brinkman et al. (2012), the questionnaire in this survey asked participants about their perceptions of their community’s capacity to protect water resources. To measure community capacity, Brinkman et al. (2012) prompted respondents with the statement, “please circle the number that best describes how effective your community is at addressing change or solving problems related to the following items.” In this study, similar question wording was used to address perceptions of respondents’ community capacity to address issues to water. The question wording and content from the Cannon River Watershed study by Davenport and others (2014) was used for the survey questionnaire in this study. Community capacity was measured using two statements, where respondents were asked to rate their level of agreement or disagreement

with the statements, “my community has the leadership it needs to protect water resources,” and “residents in my community have the ability to work together to protect water resources (Table 4). Participants rated these statements on a scale ranging from 1 = *strongly disagree* to 5 = *strongly agree*. This question included a neutral option, 3 = *neither disagree nor agree*, which was excluded for the analysis (Baka, Figgou, and Triga, 2012). Scale items were then recoded so that 1 = *strongly disagree*, 2 = *somewhat disagree*, 3 = *somewhat agree*, and 4 = *strongly agree*.

**Awareness: Familiarity with Water Issues in Local Area**

To measure perceived awareness, participants were asked about their familiarity with water issues in their local area using similar question language and content from previous studies on water in Minnesota (Davenport et al., 2014). Respondents were asked to answer the question, “How familiar are you with water issues in your local area?” Responses could vary from 1 = *not at all familiar*, 2 = *slightly familiar*, 3 = *moderately familiar*, and 4 = *very familiar* (Table 5).

**Water Risk Perceptions**

The measure for perceived risk to water was grouped into two levels: local and state-level. Local risk perception represents perceived risk to water on a community level, and state-level risk perception represents perceived risk to water across Minnesota. Clusters of question items were used to create the latent variables for local and state-level risk

perception measures (Table 6). To measure local risk perception, respondents were asked to rate their level of agreement or disagreement with the statements, “water resources in my community are adequately protected” and “protecting water quality in my neighborhood is a lost cause,” on a 5-point scale where 1 = *strongly disagree* and 5 = *strongly agree*. Agreement with both statements, as they are worded in the questionnaire, would result in conflicting levels of local water risk perception without modification. To remedy this issue for the creation of the local water risk perception measure, the statement “water resources in my community are adequately protected” was transformed to “water resources in my community are inadequately protected,” and the item was recoded where 1 = *5*, 2 = *4*, 3 = *3*, and 4 = *2*, and 5 = *1* to match this change in question item language direction. Therefore, with this change, strong agreement (5) with both question items would indicate a high level of perceived local water risk. Similar to the community capacity measure, this question set included a neutral option, 3 = *neither disagree nor agree*, which was excluded for the analysis. Scale items were recoded so that 1 = *strongly disagree*, 2 = *somewhat disagree*, 3 = *somewhat agree*, and 4 = *strongly agree*.

**Statistical Analysis**

Data were analyzed using IBM SPSS Statistics 25 (IBM Corp, 2017). Each scale item was tested for internal consistency through a

calculation of either Cronbach's Alpha or Pearson's correlation coefficient (a decision contingent on the number of scale items), with the exception of the independent variable awareness, which was not derived from multiple scale items. Neutral/"neither disagree nor agree" responses were excluded from analysis due to concerns with inherent issues with neutral response options in Likert scale questions identified by Baka and others (2012). In the article by Baka et al. (2012), the researchers discuss problems with Likert scale questions containing a neutral/"neither disagree nor agree" response option. The researchers argue that inherent and unavoidable issues in measure confidence are introduced when this option is provided. For example, Baka and others (2012) discuss concerns with generalizability of analysis that can be attributed to a number of different factors including social desirability bias, true neutrality on a subject (i.e., a real, measurable midpoint between "agree" and "disagree" scale options for people that are informed on the subject matter), lack of knowledge on an issue (e.g., "don't know"), ambivalence, poor question wording, survey fatigue, and others. When analyzing a Likert scale question with a neutral midpoint option, researchers cannot escape the inherent challenge in understanding the driver of this neutral response choice (Baka et al., 2012).

Grand means were calculated for the values orientations and community capacity independent variables. The dependent variables,

local risk perception and state-level risk perception, were also measured through the calculation of grand means of two items each (Table 6). While some studies have found demographic variables to be informative in predicting risk perception, the model presented in this study does not include antecedent level variables to predict risk perception (e.g., basic demographic or regional variables).

The full sample (n=1,480) was used for this model, with missing items excluded listwise given the large size of the sample collected. A test for multicollinearity between the predictors was conducted using variance inflation factors (VIF); no multicollinearity was found.

## Results

Twenty-eight percent (1,480) of the 5,274 questionnaires that were successfully mailed out were completed and returned. The median age of respondents was 62 (Table 2). The median income category was $50,000-$74,999. The mean reported level of formal educational attainment was associate degree or vocational degree. Using a one-way ANOVA, a wave analysis of respondents was conducted across the three survey waves to test for non-response bias effects (Yusuf, Musa, Dauda, El-Berishy, and Cang, 2014). No other nonresponse bias tests were conducted. Among respondents from the first, second, and third waves, there were significant differences between these groups in mean age and mean reported levels of education ($p$ = .006 and $p$ = .012, respectively). The mean age of

respondents from wave one was 61.3. The mean age of respondents from wave two was similar to wave one, at 61.7. The mean age of wave three respondents was 57.9. The wave one respondents' formal education mean fell into the category of associate degree or vocational degree. For wave two, the mean formal education category was associate degree or vocational degree. The mean formal education category of wave three respondents was "some college but no degree." There were no significant differences in gender between waves in a Pearson's chi square analysis ($p$ = .294).

Almost 80 percent of respondents reported low risk perceptions (low = grand mean of 2 or less, minimum 1) on the local water risk perception measure. The local water risk perception mean was 1.85 on a scale ranging from 1 to 4 (Table 6). The largest mean of the two items comprising the local risk perception measure, "water resources in my community are inadequately protected," was 2.03. More than 85 percent of respondents reported high risk perceptions in the state-level water risk perception measure (high = grand mean of 3 or more, maximum 4). The state-level water risk perception mean was 3.30 (Table 6). The largest mean of the state-level risk perception measure, "water resources in Minnesota need better protection," was 3.39. Using a one-sample t-test, the difference in means between local water risk perception and state-level water risk perception was statistically significant ($\alpha < .001$).

**Table 2.**

*Profile of survey respondents*

| Item | n=1,480 | Valid Percent (within category) |
|---|---|---|
| **Gender** | | |
| Female | 479 | 33.7 |
| Male | 941 | 66.2 |
| Transgender | 1 | <.1 |
| Non-binary/gender non-conforming | 1 | <.1 |
| Prefer not to respond | 45 | - |
| Missing (blank) | 13 | - |
| **Median age** | 62 | - |
| **Education** | | |
| Did not finish high school | 42 | 2.9 |
| Completed high school | 268 | 18.7 |
| Some college but no degree | 227 | 15.8 |
| Associate degree or vocational degree | 292 | 20.4 |
| College bachelor's degree | 313 | 21.8 |
| Some college graduate work | 85 | 5.9 |
| Completed graduate degree (Master's or PhD) | 206 | 14.4 |
| Prefer not to respond | 38 | - |
| Missing (blank) | 9 | - |
| **Race/Ethnicity*** | | |
| White | 1385 | 96.4 |
| Hispanic, Latino, or Spanish heritage | 9 | <.1 |
| Black or African American | 6 | <.1 |
| Asian | 7 | <.1 |
| American Indian or Alaska Native | 21 | 1.5 |
| Middle Eastern or North African | 1 | <.1 |
| Native Hawaiian or other Pacific Islander | 0 | 0 |
| Some other race, ethnicity, or heritage | 8 | <.1 |
| Prefer not to respond | 52 | - |
| Missing (blank) | 13 | - |
| **Household income** | | |
| Under $20,000 | 108 | 8.8 |
| $20,000 – $49,999 | 285 | 23.1 |
| $50,000 – $74,999 | 286 | 23.2 |
| $75,000 – $99,999 | 239 | 19.4 |
| $100,000 – $149,999 | 197 | 16.0 |
| $150,000 – $199,999 | 67 | 5.4 |
| $200,000 – $249,999 | 19 | 1.5 |

| | | |
|---|---|---|
| $250,000 – $299,999 | 11 | 0.9 |
| $300,000 or more | 22 | 1.8 |
| Prefer not to respond | 216 | - |
| Missing (blank) | 30 | - |

*Participants were asked to check all categories that best describe them. 1,445 respondents selected one category, and 22 respondents selected two categories.

**Table 3.**

*Water values construct items and scale reliability*

"How important is it to protect and restore Minnesota waters (lakes, streams, rivers, and groundwater) for the following values and uses?"

| Item* | Mean | SD | α/corr.** |
|---|---|---|---|
| Health | **3.70** | | **.335** |
| 1. Drinking water that is safe and clean | 3.92 | .311 | |
| 2. Healthful and natural foods for people | 3.47 | .712 | |
| Recreation | **3.31** | | |
| 3. Beaches and lakes that are safe for swimming and playing | 3.63 | .571 | **.707** |
| 4. Anglers to be able to fish for preferred species | 3.08 | .867 | |
| 5. High quality recreation opportunities for my or my family's use | 3.21 | .762 | |
| Economics | **3.04** | | **.753** |
| 6. Consistent water supply to water-dependent industries like energy production and agriculture | 3.38 | .711 | |
| 7. Recreation and tourism businesses across Minnesota to continue to thrive | 3.31 | .694 | |
| 8. Lakeshore landowners to maintain their property values | 2.94 | .959 | |
| 9. Consistent water supply for watering lawns and landscaping around my neighborhood | 2.44 | .948 | |
| 10. Towns and cities to avoid costly water treatment expenses | 3.10 | .838 | |
| Altruism | **3.59** | | **.655** |
| 11. Equitable access to public waters for all Minnesotans | 3.41 | .711 | |
| 12. Future generations | 3.78 | .480 | |
| 13. Minnesota not to send water pollution downstream to other states or nations | 3.58 | .677 | |
| Culture | **3.12** | | **.548** |
| 14. Ricers to be able to harvest in historically abundant wild rice waters | 3.00 | .873 | |
| 15. The heritage and identity of Minnesota | 3.25 | .793 | |
| Biospherism | **3.57** | | **.475** |
| 16. Habitat for native fish and wildlife to | 3.68 | .542 | |

| | | |
|---|---|---|
| survive | | |
| 17. Natural systems and processes to be sustained | 3.45 | .681 |

*Item scale: 1 = Not at all important; 2 = Slightly important; 3 = Moderately important; 4 = Extremely important
**Cronbach's Alpha provided for construct items with three or more items in the scale; Correlations provided for scale items with two items in the scale

**Table 4.**

*Community capacity construct items and scale reliability*

"To what extent do you agree or disagree with the following statements?"

| **Item*** | **Mean** | **SD** | **α/corr.** |
|---|---|---|---|
| Community Capacity | **2.89** | | **.542** |
| 1. My community has the leadership it needs to protect water resources | 2.75 | .836 | |
| 2. Residents in my community have the ability to work together to protect water resources | 2.97 | .713 | |

*Item scale: 1 = Strongly disagree; 4 = Strongly agree

**Table 5.**

*Awareness construct items*

| **Item*** | **Mean** | **SD** | **α/corr.** |
|---|---|---|---|
| Awareness | **2.48** | | **-** |
| 1. How familiar are you with water issues in your local area? | 2.48 | .878 | |

*Item scale: 1 = Not at all familiar; 2 = Slightly familiar; 3 = Moderately familiar; 4 = Very familiar

**Table 6.**

*Local and state-level risk perception construct items and scale reliability*

*"To what extent do you agree or disagree with the following statements?"*

| Item* | Mean | SD | α/corr. |
|---|---|---|---|
| Local Risk Perception | **1.85** | | **.243** |
| 1. Water resources in my community are inadequately protected** | 2.03 | .755 | |
| 2. Protecting water quality in my neighborhood is a lost cause | 1.70 | .810 | |
| State-Level Risk Perception | **3.30** | | **.618** |
| 3. Water resources in Minnesota need better protection | 3.39 | .699 | |
| 4. Water resources in Minnesota are at risk | 3.09 | .798 | |

*Item scale: 1 = Strongly disagree; 4 = Strongly agree

**Question scale was inversely recoded from original question wording, "Water resources in my community are adequately protected," to match local and state-level risk perception wording direction when creating the latent variable for Local Risk Perception. Recoded as: 1 = Strongly agree; 4 = Strongly disagree

## Multivariate Multiple Regression Model Findings

A multivariate multiple regression was performed to analyze the contributions of the values, community capacity, and awareness items to the variability observed in the local and state-level risk perception measures (Table 7, Table 8). The model presented in this study was statistically significant at the 0.01 level ($p$ = .000) when predicting both local and state-level risk perception measures. Thirty percent of the variability (adjusted $R^2$) in the local risk perception measure was explained by this model, as well as 32 percent of the variability in the state-level risk perception measure. The adjusted $R^2$ is a statistic that factors in all of the predictors included in the model, and will only increase if additional predictors are added that significantly improve the model.

In the local water risk perception application of the model, community capacity and the economics value orientation measures were

the only significant predictors. Both measures were negative predictors of perceptions of local water risk, although community capacity was the stronger predictor of the two. High economic value orientations and high perceptions of community capacity result in lower perceived risk to local water.

**Table 7.**

*Local water risk perception model application*

| | Unstandardized Coefficients | | Standardized Coefficients | | |
|---|---|---|---|---|---|
| **Construct** | ***B*** | ***SE B*** | **β** | ***t*** | ***p*** |
| Value Orientations | | | | | |
| 1. Health | .059 | .084 | .037 | .710 | **.478** |
| 2. Recreation | -.032 | .066 | -.027 | -.485 | **.628** |
| 3. Economics | -.172** | .059 | -.147** | -2.944 | **.003** |
| 4. Altruism | .041 | .090 | .026 | .451 | **.652** |
| 5. Culture | .058 | .048 | .057 | 1.199 | **.231** |
| 6. Biospherism | .073 | .077 | .051 | .946 | **.345** |
| Community Capacity | -.480** | .038 | -.497** | -12.758 | **<.001** |
| Awareness | -.044 | .034 | -.050 | -1.295 | **.196** |

**$p \leq 0.01$, *$p \leq 0.05$

**Table 8.**

*State-level water risk perception model application*

| | Unstandardized Coefficients | | Standardized Coefficients | | |
|---|---|---|---|---|---|
| **Construct** | ***B*** | ***SE B*** | **β** | ***t*** | ***p*** |
| Value Orientations | | | | | |
| 1. Health | .382** | .082 | .229** | 4.639 | **<.001** |
| 2. Recreation | -.084 | .064 | -.069 | -1.315 | **.189** |
| 3. Economics | -.103 | .057 | -.087 | -1.804 | **.072** |
| 4. Altruism | .258** | .083 | .167** | 3.126 | **.002** |
| 5. Culture | .131** | .047 | .129** | 2.762 | **.006** |
| 6. Biospherism | .290** | .078 | .196** | 3.736 | **<.001** |
| Community Capacity | -.199** | .037 | -.216** | -5.455 | **<.001** |
| Awareness | -.077* | .032 | -.091* | 2.377 | **.018** |

**$p \leq 0.01$, *$p \leq 0.05$

In the state-level risk perception model, health value orientations are the strongest predictors of risk perception. Higher health value orientation coefficients are predicted to lessen perceived risk to water in the state. Community capacity was another strong predictor of risk perception, though its effect was negative. Greater perceptions of community capacity resulted in lesser perceived risk to water in the state of Minnesota. Other positive predictors in the state-level risk perception model include altruism, cultural, and biospheric value orientations, as well as awareness of local water issues. Economic and recreation values orientations are not significant predictors of state-level water risk perception.

## Discussion

The multivariate regression model developed for predicting local and state-level water risk perceptions was moderately effective and explained about a third of the variance in risk perception. More importantly, specific relationships between the independent and dependent variables reveal some significant and actionable insight for science communication, collaborative water resource management, and public water policy development.

My first hypothesis, that increases in water values amplify

perceptions of water risk, has mixed support. For the local risk perception model application, the only significant predictor was the economic value construct, which had a negative impact on perceptions of local water risk. This is a uniquely interesting result, as it was not only the sole significant predictor of local water risk perception, but also only one of two *insignificant* predictors of the state-level risk perception measure. For the state-level risk perception model application, health, altruistic, cultural, and biospheric values were statistically significant predictors. The more that each of these constructs were valued, the greater perceived risk to water in the state. Recreation and economic values were not significant predictors of state-level risk perception.

My second hypothesis, that greater familiarity with local water problems would be positively related to perceptions of local water risk, also had mixed support. While awareness was not a significant predictor of local risk perceptions, in the state-level risk perception model application awareness was a significant predictor. That is, in this study, greater perceived familiarity with local water problems resulted in greater perceived risk to water resources in the state of Minnesota. According to these findings, water managers and decisionmakers in the Minnesota would achieve better communication of the risks to water in the state among the general public if perceived awareness with local water problems could be increased. The failure to find a relationship between

familiarity with local water problems and perceptions of local water risk is also noteworthy for managers; this findings of this study suggest that managers may have difficulties communicating the results of technical risk assessments for local water resources to individuals who may believe their familiarity with the water body is high.

My third hypothesis, that residents who perceive greater community capacity to protect water resources will perceive less water risk, is supported by the results of this study. In both applications of the model, predicting local and state-level water risk perception, the community capacity measure was a significant predictor. The findings from this study show that a greater perceived community ability to protect clean water results in lower perceived water risk, at both local and state levels. For water managers and decisionmakers, this finding suggests that community capacity assessments play a significant role in the way people view risks to water; water authorities should make an effort to assess their community's realistic ability to manage a number of potential issues to water and address gaps in public perceptions of community capacity and true capacity.

## Conclusion

The findings from this study suggest that further research should be conducted on the differences between local and state-level risk perceptions Additionally, the adapted values construct items from Steg et

al. (2014) and Davenport and Anderson (2005) should be investigated further to assess their reliability under repeated measures. In this study, the local and state-level risk perception measures were predicted by different explanatory variables. In the case of the local water risk perception application of the model, lower local water risk perception was predicted only by greater economic values and community capacity. There is a possibility that the prospect of personal economic gain outweighed the risk of impairing local water for some individuals in this study. The assertion that the benefits of a hazard may usurp the level of risk perception is a potential justification for this relationship (Slovic, Fischhoff, and Lichtenstein, 1982). The state-level water risk perception application of the model in this study had many more significant explanatory variables than the local water risk perception application. Moreover, the local water risk perception measure mean was significantly different than the state-level water risk perception mean, indicating support for the theory that larger areas garner greater perceived risk to environmental hazards than smaller, more local areas (Fleury-Bahi, 2008). Future research should examine this relationship further and investigate other potential explanatory factors such as an unrealistic optimism bias for oneself relative to a larger area. Some studies have found that an optimistic bias can be introduced when people extrapolate from their past experience to estimate their future vulnerability (Fleury-Bahi, 2008). For managers and

practitioners, this may be critical, as past experience with hazards could play a role in the way risks are perceived by the public. If there is a lack of prior experience with hazards around water, this may have dramatic implications for public perceptions of water risk, and is an important factor to consider when involving the general public in the water management sphere.

This study found that for many of the water values construct items, the more they were valued, the greater the perceived water risk, at both a local and statewide level. Furthermore, in both of the local and state-level risk perception applications of the model presented, community capacity was a significant predictor of water risk perception. In this study, increased perceived capacity of one's community to manage issues to water resulted in decreased water risk perceptions.

The risk perception model presented in this paper has the potential to be used in future examinations of the relationship between community capacity and water risk perception. The results of this inquiry have a number of practical contributions to future research and management of water. Policymakers and water managers can use this information to address concerns about gaps between public understanding and professional knowledge, such as the capacity of a community to manage issues to water. Water managers may use the results of this study to improve communication with the public to bridge these gaps, or at least

increase perceptions of awareness of local water issues. Policymakers can use this information to improve public policy development by examining differences between local and state risk perceptions and their impact on reactions to policy change. Future funding might be spent on further investigations into the inconsistencies between perceptions of water risk on different geographic scales. In this studyand others, there have been relationships found between area size and perceived risk. This might support policy to communicate water problems through a statewide narrative rather than speaking about them as isolated issues.

While the model presented in this study, although primarily exploratory, provided a reasonable method for predicting local and statewide perceptions of water risk, the mechanisms driving water risk perception are still not fully understood. Questions remain regarding political affiliation, trust, prior experience, and other potential predictors of risk perception, and further investigation is necessary to better understand what affects public water risk perceptions. Additionally, this survey did not fully capture responses from historically underrepresented populations of the public. This limitation has implications for the generalizability of this research for management decisions.

# CHAPTER THREE: BIG PICTURE CONCLUSIONS

## Implications for Managers and Policymakers

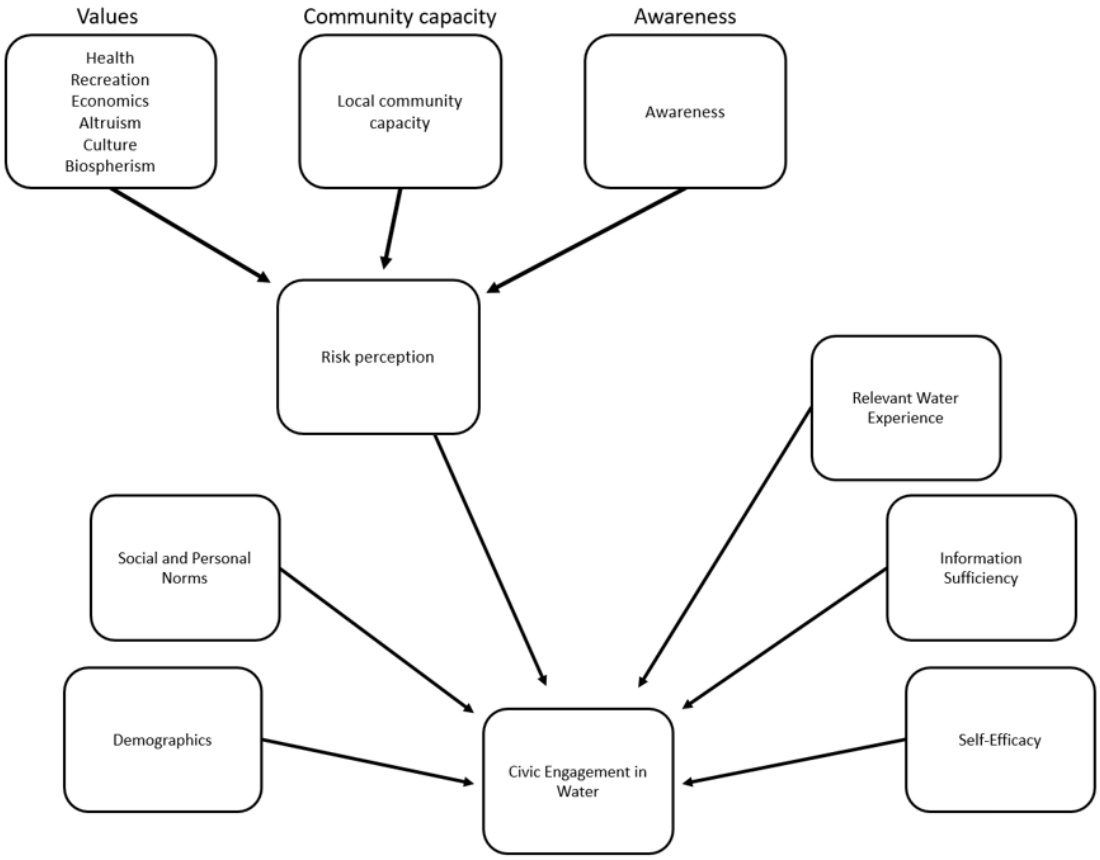
Future management of water must include participation from the public in the decisionmaking process. An important element of public participation is understanding water values, awareness of water issues, perceptions of community capacity to protect water, and perceptions of risks to water. This paper presents a model for using values, community capacity, and awareness to predict measures of local and state-level water risk perceptions.

While technical risk estimates are useful in understanding the degree of concern that individuals should have for potential hazards, risk perception research is fundamental in anticipating public reception to different policy and management decisions. Predicting risk perceptions can be beneficial in not only providing key insight into where to target education of the public, but also possibly explain behavior such as civic engagement in water protection. A parallel study by Kreiter (2019) in the broader project examined the influence of water risk perceptions, along with a suite of other explanatory variables, on civic engagement in water (Figure 2). In addition to finding that water risk perceptions were a significant predictor of community engagement, Kreiter found a negative relationship between concern about the consequences of water problems for local economies and civic engagement (Kreiter, 2019). Continuing to

investigate the drivers of water risk perceptions at local and statewide levels could be a boon to water managers in their efforts to understand what causes people to engage civically in water protection.

In Minnesota, gaining a thorough understanding of water risk perceptions, both what drives risk perceptions and how risk perceptions influence behavior, can aid water protection, restoration, and civic engagement investments by two policy advisory committees, the Minnesota Clean Water Council and the Legislative-Citizen Commission on Minnesota Resources. The findings from this study can also help water management agencies such as the Minnesota Department of Health, the Minnesota Pollution Control Agency, the Minnesota Department of Natural Resources, and the Minnesota Board of Water and Soil Resources focus their efforts in engaging residents in water solutions based on residents' values, awareness of local issues, perceptions of community capacity, and perceptions of local and state-level water risk.

**Figure 2.** Expanded conceptual framework visualization.



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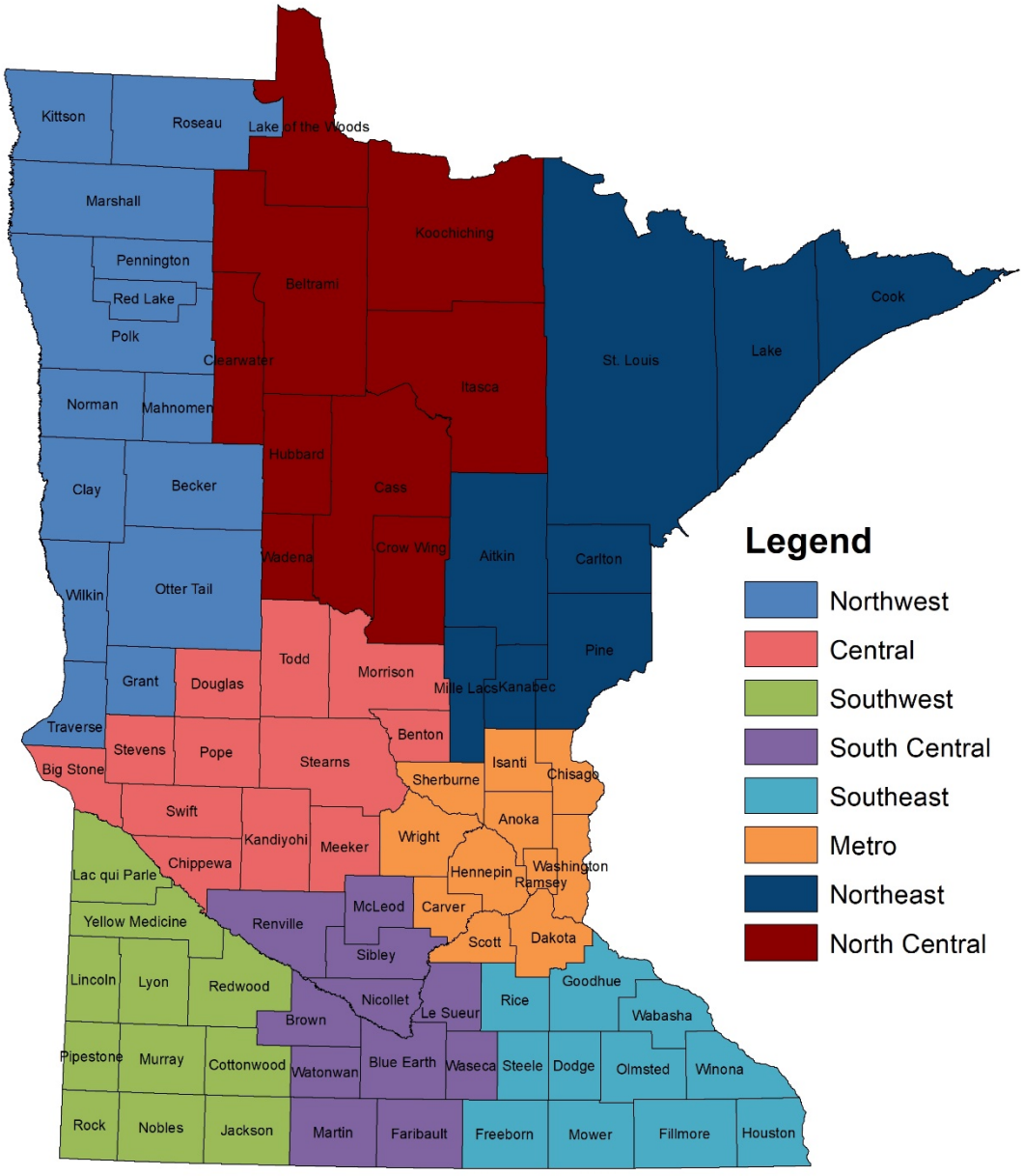
# Appendices

## Appendix A: Study Area

County names and sample regions in Minnesota, USA.



## Appendix B: Survey Questionnaire Instrument

ID#: _____

# The Value of Minnesota Water: A Resident Survey

Center for Changing Landscapes
University of Minnesota
Driven to Discover℠

Institute on the Environment
University of Minnesota
Driven to Discover℠

Environment and Natural Resources Trust Fund

Clean Water Land & Legacy Amendment

**Before you begin:**
We are conducting this survey to better understand Minnesota residents' opinions about the value of water and actions that protect water. This survey is voluntary and confidential. It should take about 15 minutes to complete this questionnaire. Please answer the questions as completely as possible.

**Once you've completed the survey:**
Please fold it in thirds and mail it back in the enclosed self-addressed stamped envelope.

***Thank you for your help!***

## I. Your Community

First, we have a few questions about your community and the value of water resources.

**1. When you think of your community, what comes to mind first?** (*Choose one*)

- [ ] My neighborhood
- [ ] My county
- [ ] My ethnic group
- [ ] My city
- [ ] My watershed
- [ ] My close friends and family
- [ ] My workplace
- [ ] Organizations/groups
- [ ] My school system
- [ ] Other (please specify) _____

2. How important are the following qualities of a community to you? *(Please check one box in each row)*

| | Not at all important | Slightly important | Moderately important | Extremely important |
|---|---|---|---|---|
| a. Good relationships among neighbors | ☐ | ☐ | ☐ | ☐ |
| b. Clean streams, rivers, and lakes | ☐ | ☐ | ☐ | ☐ |
| c. Strong family ties | ☐ | ☐ | ☐ | ☐ |
| d. Access to aesthetically pleasing landscapes/views | ☐ | ☐ | ☐ | ☐ |
| e. Opportunities to express my culture and traditions | ☐ | ☐ | ☐ | ☐ |
| f. Clean and safe drinking water | ☐ | ☐ | ☐ | ☐ |
| g. Opportunities to be involved in community projects | ☐ | ☐ | ☐ | ☐ |
| h. Opportunities for and access to outdoor recreation | ☐ | ☐ | ☐ | ☐ |
| i. A place with a climate that fits my lifestyle | ☐ | ☐ | ☐ | ☐ |

3. To what extent do you agree or disagree with the following statements? *(Please check one box in each row)*

| | Strongly disagree | Somewhat disagree | Neither disagree nor agree | Somewhat agree | Strongly agree |
|---|---|---|---|---|---|
| a. Water resources in my community are adequately protected | ☐ | ☐ | ☐ | ☐ | ☐ |
| b. Water resources in Minnesota need better protection | ☐ | ☐ | ☐ | ☐ | ☐ |
| c. Protecting water in my neighborhood is a lost cause | ☐ | ☐ | ☐ | ☐ | ☐ |
| d. Water resources in Minnesota are at risk | ☐ | ☐ | ☐ | ☐ | ☐ |
| e. Conservation practices contribute to quality of life in my community | ☐ | ☐ | ☐ | ☐ | ☐ |
| f. My community has the leadership it needs to protect water resources | ☐ | ☐ | ☐ | ☐ | ☐ |
| g. Residents in my community have the ability to work together to protect water resources | ☐ | ☐ | ☐ | ☐ | ☐ |

4. How familiar are you with water issues in your local area?

[ ] Not at all familiar [ ] Slightly familiar [ ] Moderately familiar [ ] Very familiar

5. How would you characterize the quality of water in the lake, stream, or river closest to you?

[ ] Very poor [ ] Poor [ ] Fair [ ] Good [ ] Very good [ ] Don't know

6. How would you characterize the quality of water in Minnesota water bodies overall?

[ ] Very poor [ ] Poor [ ] Fair [ ] Good [ ] Very good [ ] Don't know

**7. How important is it to protect and restore Minnesota waters (lakes, streams, rivers, and groundwater) for the following values and uses?** *(Please check one box in each row)*

| | Not at all important | Slightly important | Moderately important | Extremely important |
|---|---|---|---|---|
| a. Drinking water that is safe and clean | ☐ | ☐ | ☐ | ☐ |
| b. Beaches and lakes that are safe for swimming and playing | ☐ | ☐ | ☐ | ☐ |
| c. Consistent water supply to water-dependent industries like energy production and agriculture | ☐ | ☐ | ☐ | ☐ |
| d. Equitable access to public waters for all Minnesotans | ☐ | ☐ | ☐ | ☐ |
| e. Anglers to be able to fish for preferred species | ☐ | ☐ | ☐ | ☐ |
| f. Future generations | ☐ | ☐ | ☐ | ☐ |
| g. High quality recreation opportunities for my or my family's use | ☐ | ☐ | ☐ | ☐ |
| h. Habitat for native fish and wildlife to survive | ☐ | ☐ | ☐ | ☐ |
| i. Recreation and tourism businesses across Minnesota to continue to thrive | ☐ | ☐ | ☐ | ☐ |
| j. Ricers to be able to harvest in historically abundant wild rice waters | ☐ | ☐ | ☐ | ☐ |
| k. The heritage and identity of Minnesota | ☐ | ☐ | ☐ | ☐ |
| l. Lakeshore landowners to maintain their property values | ☐ | ☐ | ☐ | ☐ |
| m. Healthful and natural foods for people | ☐ | ☐ | ☐ | ☐ |
| n. Consistent water supply for watering lawns and landscaping around my neighborhood | ☐ | ☐ | ☐ | ☐ |
| o. Towns and cities to avoid costly water treatment expenses | ☐ | ☐ | ☐ | ☐ |
| p. Natural systems and processes to be sustained | ☐ | ☐ | ☐ | ☐ |
| q. Minnesota <u>not</u> to send water pollution downstream to other states or nations | ☐ | ☐ | ☐ | ☐ |

**r. From the previous list (Question 7, a-q), what three water values or uses are <u>most important to you</u>?** *(Please list in order of first, second, and third most important)*

1. _____ 2. _____ 3. _____

**8. In the last twelve months, about <u>how many times</u> did you visit a lake, river, or stream in Minnesota in which visiting the water body <u>was one of the primary purposes of your trip</u>?**

[ ] 0 (I did not visit a water body) [ ] 1-3 [ ] 4-12 [ ] 13-24 [ ] 25 or more

9. What lake, river, or stream do you visit most often in Minnesota? What city is it in or closest to?

Body of water _____ Closest city _____

a. When you visit this water body, what activities do you engage in? *(Please check all that apply)*

- [ ] Swimming
- [ ] Hiking or walking near water
- [ ] Observing water or wildlife
- [ ] Picnicking near water
- [ ] Wading or playing in the water
- [ ] Motorized boating
- [ ] Non-motorized boating (canoeing, kayaking, paddle-boarding, etc.)
- [ ] Spiritual or cultural practices
- [ ] Fishing (open water)
- [ ] Ice fishing
- [ ] Biking near water
- [ ] Gathering plants (e.g., wild rice)
- [ ] Getting together with others (e.g., friends, family)
- [ ] Hunting waterfowl
- [ ] Other (please specify) _____

b. Do you have a home or vacation property near this water body?

[ ] Yes [ ] No

c. To reach this body of water, about how long do you have to travel from your home?

- [ ] 0-5 minutes (I don't have to travel)
- [ ] 6-20 minutes (It's in my community)
- [ ] 21-60 minutes (It's in a nearby community)
- [ ] More than 1 hour to less than 4 hours
- [ ] 4 or more hours

## II. Concerns about Water

Next, we would like to know if you have concerns about water.

10. To what extent do you agree or disagree with the following statements? *(Please check one box in each row)*

| I am concerned about the consequences of water problems or pollution for.... | Strongly disagree | Somewhat disagree | Neither disagree nor agree | Somewhat agree | Strongly agree |
|---|---|---|---|---|---|
| a. Cultural heritage in Minnesota | ☐ | ☐ | ☐ | ☐ | ☐ |
| b. Recreation opportunities | ☐ | ☐ | ☐ | ☐ | ☐ |
| c. Human health | ☐ | ☐ | ☐ | ☐ | ☐ |
| d. Future generations | ☐ | ☐ | ☐ | ☐ | ☐ |
| e. Aquatic life | ☐ | ☐ | ☐ | ☐ | ☐ |
| f. Local economies | ☐ | ☐ | ☐ | ☐ | ☐ |
| g. People in my community | ☐ | ☐ | ☐ | ☐ | ☐ |
| h. Downstream communities outside of Minnesota | ☐ | ☐ | ☐ | ☐ | ☐ |

**11. In your opinion, how much of a problem are the following water pollutants or issues to water in your local area?** *(Please check one box in each row)*

| | Not a problem | Slight problem | Moderate problem | Severe problem | Don't know |
|---|---|---|---|---|---|
| a. Industrial discharge to streams, rivers, and lakes | ☐ | ☐ | ☐ | ☐ | ☐ |
| b. Agricultural drainage (e.g., drain tiles) | ☐ | ☐ | ☐ | ☐ | ☐ |
| c. Agricultural runoff (e.g., nutrients, fertilizers, pesticides) | ☐ | ☐ | ☐ | ☐ | ☐ |
| d. Sediment in water bodies | ☐ | ☐ | ☐ | ☐ | ☐ |
| e. Urban runoff (e.g., oil, grease, toxic chemicals) | ☐ | ☐ | ☐ | ☐ | ☐ |
| f. Contaminants of emerging concern (e.g., pharmaceuticals, personal care products) | ☐ | ☐ | ☐ | ☐ | ☐ |
| g. Increased frequency or intensity of floods | ☐ | ☐ | ☐ | ☐ | ☐ |
| h. Declining lake water levels | ☐ | ☐ | ☐ | ☐ | ☐ |
| i. Unsealed private wells | ☐ | ☐ | ☐ | ☐ | ☐ |
| j. Road salt runoff (chloride) | ☐ | ☐ | ☐ | ☐ | ☐ |
| k. Bacterial contamination | ☐ | ☐ | ☐ | ☐ | ☐ |
| l. Water scarcity | ☐ | ☐ | ☐ | ☐ | ☐ |
| m. Faulty septic and sewage systems | ☐ | ☐ | ☐ | ☐ | ☐ |
| n. Aquatic invasive species | ☐ | ☐ | ☐ | ☐ | ☐ |

## III. Protecting Water

Now, we would like to understand your perspectives on actions to protect water.

**12. To what extent do you agree or disagree with the following statements?** *(Please check one box in each row)*

| | Strongly disagree | Somewhat disagree | Neither disagree nor agree | Somewhat agree | Strongly agree |
|---|---|---|---|---|---|
| a. It is my personal responsibility to help protect water. | ☐ | ☐ | ☐ | ☐ | ☐ |
| b. Local government should be responsible for protecting water. | ☐ | ☐ | ☐ | ☐ | ☐ |
| c. The state government should be responsible for protecting water. | ☐ | ☐ | ☐ | ☐ | ☐ |
| d. Residents in my area should be responsible for protecting water. | ☐ | ☐ | ☐ | ☐ | ☐ |
| e. The agricultural community in my area should be responsible for protecting water. | ☐ | ☐ | ☐ | ☐ | ☐ |
| f. The urban community in my area should be responsible for protecting water. | ☐ | ☐ | ☐ | ☐ | ☐ |
| g. People in my community expect me to help protect water. | ☐ | ☐ | ☐ | ☐ | ☐ |

**13. To what extent do you support or oppose the following water actions?** *(Please check one box in each row)*

| | Strongly oppose | Somewhat oppose | Neither oppose nor support | Somewhat support | Strongly support |
|---|---|---|---|---|---|
| a. Using conservation practices in my home or on my property | ☐ | ☐ | ☐ | ☐ | ☐ |
| b. Promoting voluntary conservation practices through increased education and outreach programs | ☐ | ☐ | ☐ | ☐ | ☐ |
| c. Expanding programs that offer financial incentives to residents/property owners for conservation practices | ☐ | ☐ | ☐ | ☐ | ☐ |
| d. Engaging more residents in local land use and water resource decision-making | ☐ | ☐ | ☐ | ☐ | ☐ |
| e. Coordinating land use and water planning and management across communities at a regional scale | ☐ | ☐ | ☐ | ☐ | ☐ |
| f. Conducting more water research | ☐ | ☐ | ☐ | ☐ | ☐ |
| g. Monitoring the status and trends of our water bodies | ☐ | ☐ | ☐ | ☐ | ☐ |
| h. Enforcing existing land use laws and regulations | ☐ | ☐ | ☐ | ☐ | ☐ |
| i. Expanding public and private partnerships in conservation | ☐ | ☐ | ☐ | ☐ | ☐ |
| j. Increasing land use laws and regulations | ☐ | ☐ | ☐ | ☐ | ☐ |

**14. Where do you get information on water-related issues?** *(Please check all that apply)*

[ ] Family and friends
[ ] Federal agencies/government
[ ] Tribal agencies/government
[ ] State agencies/government
[ ] County agencies/government
[ ] City or township government
[ ] My neighbors
[ ] Community nonprofit organizations
[ ] Environmental organizations
[ ] University researchers/academic community
[ ] Local business owners/industry experts
[ ] Faith/religious leaders
[ ] Agricultural groups/producers
[ ] Elders in my community
[ ] News media
[ ] Other (please specify): _____

**15. Below are three potential funding scenarios (A-C) for distributing water program funds in Minnesota across four different water program areas (e.g., safe drinking water).**

| Water Program Areas | Scenario A | Scenario B | Scenario C |
|---|---|---|---|
| Safe drinking water | 40% | 40% | 10% |
| High quality swimming and boating | 40% | 10% | 10% |
| Healthy fish and wildlife populations | 10% | 40% | 40% |
| Reduce MN's contribution to water problems outside state lines (e.g., Gulf of Mexico, Lake Winnipeg) | 10% | 10% | 40% |
| **Total** | **=100%** | **=100%** | **=100%** |

**Of the three funding scenarios, which would you support the most?** *(check one box below)*

[ ] Scenario A [ ] Scenario B [ ] Scenario C

16. Now, we would like you to freely assign the proportion of funding that you think should go to each of the four water program areas. *(Please write a percentage for each funding area. Your total should equal 100%.)*

| | Safe drinking water | High quality swimming and boating | Healthy fish and wildlife populations | Reduce MN's contribution to water problems outside state lines (e.g., Gulf of Mexico, Lake Winnipeg) | |
|---|---|---|---|---|---|
| My own funding scenario | _____ | _____ | _____ | _____ | =100% |

17. Have you engaged in the following actions or initiatives in the past 12 months? If yes, how often did you engage in the action or initiative?

| | First, have you engaged in the following actions or initiatives in the past 12 months? | | Second, if you marked "yes", how often did you engage in the action or initiative in the past 12 months? | | | |
|---|---|---|---|---|---|---|
| | Yes | No | Every few months | Once a month | Every two weeks | Weekly or more |
| a. Volunteered for a community organization or an event | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| b. Helped organize a community program | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| c. Heard about a water resource protection initiative | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| d. Talked to others about conservation practices | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| e. Attended a meeting or public hearing about water | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| f. Worked with other community members to protect water | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| g. Taken a leadership role around water resource conservation in the community | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

18. To what extent have you engaged in the following conservation actions in the past 12 months?

| | Never | I have in some areas/occasionally | I have wherever and whenever possible |
|---|---|---|---|
| a. Maintained a vegetative buffer along streams, ditches or lakes on my property | ☐ | ☐ | ☐ |
| b. Used conservation agricultural practices (e.g., no till, cover crops) | ☐ | ☐ | ☐ |
| c. Donated money to a conservation organization | ☐ | ☐ | ☐ |
| d. Reduced or changed my personal household water consumption (e.g., turning off faucet while brushing teeth, etc.) | ☐ | ☐ | ☐ |
| e. Protected or restored wetlands on my land/property | ☐ | ☐ | ☐ |
| f. Used a rain barrel or cistern to store water | ☐ | ☐ | ☐ |
| g. Planted or maintained native plants or shrubs in my yard | ☐ | ☐ | ☐ |
| h. Minimized use of fertilizers/pesticides on lawns and gardens | ☐ | ☐ | ☐ |
| i. Other (please specify): _____ | ☐ | ☐ | ☐ |

## IV. About you

Finally, we have a few questions about you. As a reminder, your responses to the survey are completely confidential and will only be used in aggregate—or in group form. No individual responses will be published.

**19. In what year were you born?** _____ [ ] Prefer not to respond

**20. How do you describe yourself?** [ ] Female [ ] Male [ ] Transgender [ ] Non-binary/gender non-conforming

[ ] Prefer not to respond

**21. What is the highest level of formal education you have completed?** (Please check one box)

[ ] Did not finish high school
[ ] Completed high school
[ ] Some college but no degree
[ ] Associate degree or vocational degree
[ ] College bachelor's degree
[ ] Some college graduate work
[ ] Completed graduate degree (Master's or PhD)
[ ] Prefer not to respond

**22. What category best describes you?** (Please check all that apply)

[ ] **White**
For example, German, Irish, English, Italian, Polish, French, Swedish, Norwegian, etc.

[ ] **Hispanic, Latino, or Spanish heritage**
For example, Mexican or Mexican American, Puerto Rican, Cuban, Salvadoran, Dominican, Colombian, etc.

[ ] **Black or African American**
For example, African American, Jamaican, Haitian, Nigerian, Ethiopian, Somalian, etc.

[ ] **Asian**
For example, Chinese, Filipino, Asian Indian, Vietnamese, Hmong, Korean, Japanese, etc.

[ ] **American Indian or Alaska Native**
For example, Anishinaabe, Dakota (Sioux), Navajo Nation, Mayan, Aztec, Nome Eskimo Community, etc.

[ ] **Middle Eastern or North African**
For example, Lebanese, Iranian, Egyptian, Syrian, Moroccan, Algerian etc.

[ ] **Native Hawaiian or other Pacific Islander**
For example, Native Hawaiian, Samoan, Chamorro, Tongan, Fijian, Marshallese, etc.

[ ] **Some other race, ethnicity or heritage (Please specify):**
_____

[ ] Prefer not to respond

**23. Which of the following best describes your total household income from all sources in 2017 before taxes?** *(Please check one box)*

[ ] Under $20,000
[ ] $20,000 - $49,999
[ ] $50,000 - $74,999
[ ] $75,000 - $99,999
[ ] $100,000 - $149,999
[ ] $150,000 - $199,999
[ ] $200,000 - $249,999
[ ] $250,000 - $299,999
[ ] $300,000 or more
[ ] Prefer not to respond

**24. Approximately what percentage of your total household income is dependent on the following areas?**

Agricultural production ____% Forest production ____% Nature-based tourism or recreation-related industry ____%

**25. Do you have any other comments about water in Minnesota, or comments about this survey?**

*Thank you for your help!*

Please complete the survey, fold it in thirds, and mail it back in the enclosed self-addressed stamped envelope.

## Appendix C: Cover Letter for Mail Survey Packet

UNIVERSITY OF MINNESOTA

*Twin Cities Campus*

*Center for Changing Landscapes*
*College of Food, Agricultural and Natural Resource Sciences*

*115 Green Hall*
*1530 Cleveland Avenue North*
*St. Paul, MN 55108-6112*
*Office: 612-624-9321*
*www.changinglandscapes.umn.edu*

ID#: _____

[First Name] [Last Name]
[Street Address]
[City] [State] [Zip code]

**Minnesota Water Values Survey Information**

May 7, 2018

Dear [First Name] [Last Name],

I am writing to ask for your help in a study about water values in Minnesota. The study is being conducted by Mae Davenport, Center for Changing Landscapes, and Bonnie Keeler, Humphrey School of Public Affairs, at the University of Minnesota and is supported by the Clean Water Council; Clean Water, Land and Legacy Amendment funds; Environment and Natural Resources Trust Fund; and the McKnight Foundation. **The goal of the study is to better understand how Minnesotans value and use water, and how they think water should be protected.** Findings from this study will help decision makers prioritize water programs and will support public engagement in water resource management across the state.

We understand that this may be a busy time of the year for you, so we really appreciate you taking the time to help us with this study. If you are willing, please complete the enclosed questionnaire. **It should take you only about 15 minutes.** We are only contacting a random sample of residents in Minnesota, so it is important that we hear from you! The survey is voluntary and completely confidential. The risks of participating in this study are minimal. You are free to withdraw at any time. Completion of this questionnaire indicates your voluntary consent to participate. Your decision to participate will not affect your current or future relationship with the University of Minnesota. The ID # on the front page of your survey is used to help us track mailings, ensuring that your name is never affiliated with your responses. Please answer the questions as completely as possible. Once you have completed the questionnaire, fold it in thirds and mail it back in the enclosed self-addressed, postage-paid envelope.

**If you would prefer to complete an online version of the questionnaire, please send us a note with your email address to ccl@umn.edu.**

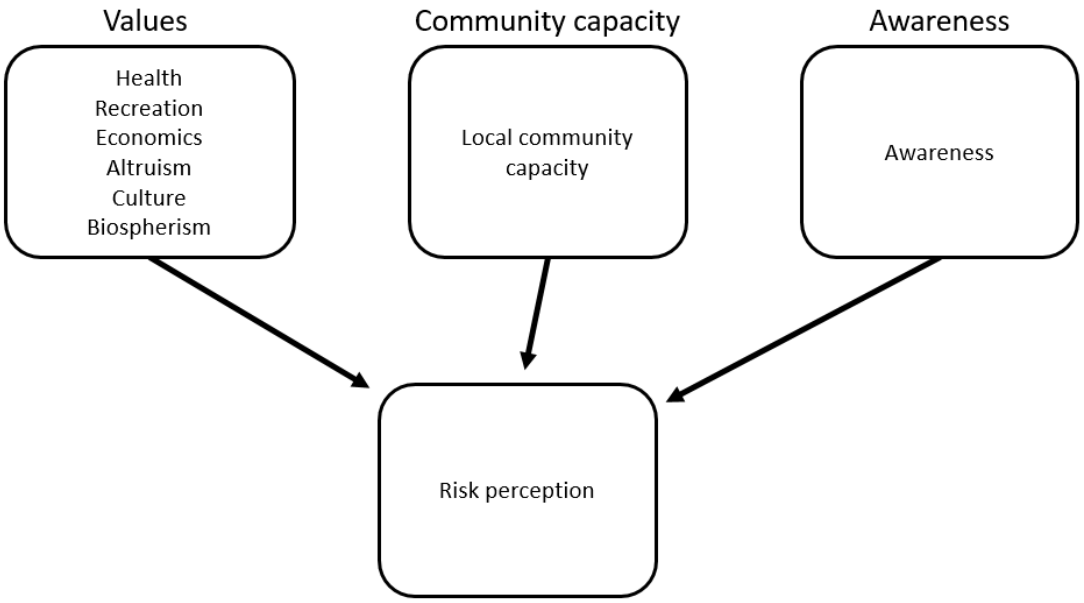
We would be happy to answer any questions or listen to any comments you may have about this study.
Please feel free to contact me by phone at 612-624-9321, or by email at mdaven@umn.edu. If you have any questions or concerns regarding the study and would like to talk to someone other than the researcher(s), you are encouraged to contact the Research Subjects' Advocate Line, D-528 Mayo, 420 Delaware Street S.E., Minneapolis, Minnesota, 55455; telephone 612-625-1650.

I hope you enjoy completing the questionnaire and I look forward to receiving your response.

Sincerely,

Mae Davenport, Ph.D.
Director, Center for Changing Landscapes

## Appendix D: Local and Global Risk Perceptions Conceptual Framework Visualization



## Appendix E: Expanded Conceptual Framework Visualization