Appalachian
STATE UNIVERSITY

Department of Economics Working Paper

Number 17-05| August 2017

The Influence of Scientific Information on the Willingness to Pay for Stormwater Runoff Abatement

Peter A. Groothuis
Appalachian State University

Tanga M. Mohr
Appalachian State University

John C. Whitehead
Appalachian State University

Kristan Cockerill
Appalachian State University

William P. Anderson, Jr.
Appalachian State University

Chuanhui Gu
Appalachian State University

Department of Economics
Appalachian State University
Boone, NC 28608
Phone: (828) 262-2148
Fax: (828) 262-6105
www.business.appstate.edu/economics

The Influence of Scientific Information on the Willingness to Pay for Stormwater Runoff Abatement

Peter A. Groothuis
(Corresponding Author)
Department of Economics
Appalachian State University
groothuispa@appstate.edu

Tanga M. Mohr
Department of Economics
Appalachian State University
mohrtm1@appstate.edu

John C. Whitehead
Department of Economics
Appalachian State University
whiteheadjc@appstate.edu

Kristan Cockerill
Interdisciplinary Studies
Appalachian State University
cockerillkm@appstate.edu

William P. Anderson, Jr.
Department of Geological and Environmental Sciences
Appalachian State University
andersonwp@appstate.edu

and

Chuanhui Gu
Department of Geological and Environmental Sciences
Appalachian State University
guc@appstate.edu

Key Points:

We use scientific information to develop a realistic hypothetical scenario for stormwater management on water quality improvements.

Detailed scientific information reduces the willingness to pay for runoff abatement programs.

Our research offers insights into using science-derived information to improve efforts to assess public attitudes about managing stormwater.

Key Words:
stormwater management, stream water quality, scientific communication, stated preferences, willingness to pay

Abstract: We integrated physical science data with a social science survey to better understand people's preferences for stormwater runoff abatement measures. Data from a long-term monitoring project on Boone Creek in North Carolina revealed that two key concerns from stormwater runoff are thermal pollution and high salinity. We used this data to develop text and images to include in a survey to assess public attitudes about and willingness to pay for stormwater runoff abatement measures in the Appalachian region. The survey provided information about various methods to reduce stormwater runoff including containment systems and permeable pavement. To assess the impact of scientific information on individual preference for stormwater runoff abatement, we randomly assigned different levels of scientific information to survey respondents. Our results show that having more detailed scientific information has two effects. The direct effect is to reduce willingness to pay for runoff abatement programs. Indirectly, the detailed information increases self-reported claims of understanding the information provided and those who claim to understand the information are more likely to be willing to pay for abatement measures.

Stormwater runoff is a growing water quality concern (USEPA 2016). Like all water-related concerns, managing stormwater runoff is complex and requires understanding not only the physical phenomena but social phenomena as well. Therefore, research efforts focused on better understanding the links between the physical and social aspects of stormwater management are warranted. Our work offers some insight into using science-derived information to improve efforts to assess public attitudes about managing stormwater, and more specifically to better assess attitudes toward paying for such management.

In previous research, Whitehead and Groothuis (1992) found that respondents in North Carolina were willing to pay for management to reduce stormwater runoff from agricultural lands. More recently, Londono Cadavid and Ando (2013) found that respondents value reduced basement flooding more than reductions in yard or street flooding. In addition, they found that citizens value improved water quality as well as improved hydrologic function and aquatic habitat from reducing runoff. Bin and Polasky (2004) analyzed how hurricane stormwaters influence property values and found that homes located within a floodplain were of lower market value than those located outside the floodplain. Brent et al. (forthcoming) found that Australian respondents were willing to pay for reduced flash flooding, improved local stream health and decreased peak urban temperatures.

Van Houtven et al. (2007) in a meta-analysis of 18 willingness to pay studies for water quality improvements concluded the following:

> Greater detail and consistency in the type of information reported in published water quality valuation studies would enhance the social utility of the empirical literature. In particular, more detailed characterizations of the studied water resources and affected populations would be beneficial. Ideally, these descriptions would include pre-change and post-change water quality, and information on the spatial and temporal variation in water quality, physical characteristics and typical uses (including designated uses) of the water resources.

As Lund (2015) reported, successfully managing water resources has always required integrating physical and social aspects. Further, he wrote that adapting as water-related problems change requires that we "more explicitly integrate research across disciplines." Toward this end, we integrated physical and social science perspectives to better understand attitudes about paying for stormwater abatement measures. We utilized data from a long-term monitoring project on an urbanized stream in Boone, North Carolina, showing that key stream quality concerns are thermal pollution and salinity from salts used to melt ice on roads and sidewalks. In short, stormwater runoff drives hot, salty water into the creek with concomitant negative consequences (Cockerill and Anderson 2014; Cockerill et al. 2017).

We used these data to generate text and graphics to be applied in a public opinion survey measuring attitudes about stormwater runoff management in the Appalachian region. More specifically, we used the contingent valuation method (CVM) to measure willingness to pay for stormwater runoff abatement practices. We employed the information generated from the Boone Creek monitoring data to develop a realistic hypothetical scenario revealing the negative consequences of runoff on stream water quality and how stormwater management measures can improve stream water quality. To assess the potential influence of science-derived information about the physical system on willingness to pay for runoff abatement, we randomly assigned a subsample of respondents to review fairly detailed scientific information about runoff causes and consequences, while all respondents viewed a simplified version of this information. In addition, all survey respondents saw photographs of various runoff abatement methods (such as permeable pavement and rain barrels) so they knew the amenity being valued.

In the following sections, we summarize the monitoring study that provides the background to the CVM scenario, describe the survey deployed, and provide the empirical results. We conclude with a discussion of the role scientific information may play in social science research and how both social and physical science provide insights to managing stormwater.

Scientific Background on Stormwater Influence on an Urbanized Creek.

Researchers have monitored stream temperatures and salinity levels along Boone Creek for more than a decade (Anderson et al. 2011, Cockerill et al. 2017). The monitoring network now includes five stream gauges, seven electrical conductivity sensors to measure salinity and more than 30 stream temperature sensors along the length of the 1.8 km study reach and adjacent small tributaries.

The data show two primary hydrologic problems in Boone Creek: (1) elevated stream temperatures with many storm-induced temperature surges each year of >1 °C within 15 minutes, and (2) salinity values that are not typical of freshwater high-gradient mountain streams. Stormwater runoff is the primary culprit for both of these phenomena, with temperature surges occurring on warm days due to runoff from heated pavement and buildings and salinity spikes occurring on cold snowy days when road salt has been applied to area infrastructure.

Anderson et al. (2011) first described temperature surges in Boone Creek showing that over four summers of monitoring, the 72 temperature surge events displayed a mean rise of 2.63° C and durations of 30.4 minutes. Cockerill et al. (2017) further noted an increase in the number of surge events through the ten-year monitoring period. In 2015, for example, 111 temperature surge events occurred with 60% rising above 20 °C, which is a critical temperature for cold-water habitat fauna (Wang and Kanehl 2003; Wang et al. 2003).

Saline contamination of Boone Creek is a more complex problem because, unlike heat, salt does not leave the groundwater/stream system. Instead, runoff from storm events, even during summer months, acts to keep the salinity derived from snowmelt runoff in the riparian aquifers lining the stream. Cockerill et al. (2017) demonstrated with numerical experiments that the dynamics of urban mountain streams like Boone Creek, which show frequent flashy conditions, can increase the residence time of salt in the hydrologic system. They also demonstrated that employing stormwater management to reduce stream stage fluctuations by 50% can be nearly as effective at reducing salinity levels as cutting road salt usage in half.

Social Science Survey Methods

We drafted a survey instrument to assess public attitudes about stormwater management and asked several non-expert colleagues to take the draft survey and provide feedback. We used the SurveyMonkey platform to field the final survey online with SurveyMonkey and Survey Sampling International online respondent panels. Our target population included residents of the Appalachian region from North Carolina in the south to New York in the north. This region features mountainous terrain and receives snow. These physical traits allow us to generalize the Boone Creek data for the broader region.

We received 1472 total surveys completed between May 27 and June 6 2016. About 4% of respondents answered the survey in less than five minutes. We eliminated these respondents from our data set because just reading our survey takes at least five minutes. This left a total of 1308 responses with 37% from Pennsylvania, 14% from Tennessee, 11% from West Virginia, 9% from North Carolina, another 9% from Ohio, 8% from Kentucky, and about 4% each from New York, Virginia and Maryland.

To assess how detailed, science-based information influenced responses we conducted an experiment. Early in the survey question sequence, we provided half of our respondents with the following text based on data from the Boone Creek monitoring program:

> University researchers have been monitoring water quality in the Appalachian Region and find that many streams suffer from “thermal pollution.” This means that water temperatures are frequently higher than normal.
>
> Additionally, salt content often exceeds recommended levels for a healthy stream system. The salt is from de-icing streets and sidewalks in the winter. Researchers have concluded that the source of the warm and/or salty water is runoff from roads and buildings when it rains or snows. This is called stormwater runoff.
>
> This research suggests that there is a connection between stormwater runoff, long term salt levels in rivers and streams and “compromised aquatic health." Compromised aquatic health means that fish and the insects they eat or the plants they need for shelter struggle to live in that water.
>
> Because there are complex relationships between stream flow and groundwater, salt remains in the stream’s system all year. When it rains, water pushes the salt from the stream into the groundwater system. Following storm events, groundwater returns to the stream (this is called baseflow) carrying the salt with it. Over time this is increasing the total amount of salt in the system and this contributes to compromised aquatic health.

Additionally, we used the Boone Creek data to populate a model showing rising salinity levels over time. This modeling output was used to create a non-site specific diagram that accompanied the text above (Figure 1). The diagram showed increasing salinity levels and highlighted that these levels do compromise aquatic health. The diagram also showed both summer and winter salinity peaks from stormwater runoff.

The survey provided all respondents with a realistic contingent valuation scenario explaining how stormwater can be managed:

> Slowing down the water flow is important to reduce water temperatures and salt from stormwater runoff so that by the time the water reaches a stream the temperature is lower. There are numerous stormwater management practices that can slow water flow. These include installing permeable pavement in parking lots and sidewalks, installing rain gardens, cisterns, and other water collection systems.

Three photographs of stormwater management practices showing how rain gardens, rain barrels, and permeable pavement can be used in a local landscape accompanied the text (Figure X).

Following the Van Houtven et al. (2007) recommendation that CV descriptions "include pre-change and post-change water quality, and information on the spatial and temporal variation in water quality" we provided a realistic scenario based upon the scientific information. To provide a status quo baseline to our study, at the midpoint of the survey, all respondents viewed Figure 2 (a simplified version of Figure 1) and the following text:

> The graph illustrates the scientific evidence suggesting that if nothing is done to address stormwater runoff and long-term salt levels, rivers and streams in {respondent's County} will suffer from compromised aquatic health within the next few years. Compromised aquatic health means that fish and the insects they eat or the plants they need for shelter struggle to live in that water.

Figure 2 illustrated that the baseline of stream quality is just below the threshold of compromised aquatic quality and that this line will be crossed in the near future if no stormwater management is implemented. The horizontal axis showed the time horizon and how salt levels have risen over time.

The survey then stated:

> Completely eliminating salt use is usually not a realistic option in {respondent's County}. Another option is to install permeable pavement and water collection systems. These can slow down stormwater so that it enters a stream more gradually. This allows the salt level to become more dilute before it enters the stream.

In our CV scenario, we chose different levels of stormwater management implementation to test the importance of the level of change from the status quo. We employed a split sample with respondents receiving one of two scenarios, one noting a ten percent increase in management practices and the other noting a fifty percent increase in management practices. In the survey, we stated:

> Suppose that a stormwater management plan has been designed that would increase the use of stormwater management practices by 10% (50%) in {respondent's County}.

> A 10% (50%) increase means that the number of practices would increase by 10 (50) for every 100 units of current practices. For example, if there were 100 acres of permeable parking lots this number would increase to 110 (150). If the number of rain barrels were 1000 these would increase to 1100 (1500). Scientists believe that a 10% (50%) increase in stormwater management practices could decrease long-term salt levels by (25% 50% 75%).

To test for scope, the survey included a modified version of Figure 2 to illustrate how stormwater management practices can reduce salinity levels by twenty five percent, fifty percent, or seventy five percent over time (Figure X). For illustrative purposes, Figure x shows the fifty percent reduction graph that one third of respondents saw. For all three levels of reduction the salinity trend line was below the dashed line representing compromised aquatic health. Larger values of reduction should increase the willingness to pay for the management program (Whitehead 2016).

The survey included a CV question using a tax payment vehicle. We randomly assigned either an annual payment mechanism or onetime payment mechanism with various levels of the tax payment. This gives us the ability to measure time preferences of our respondents. Leading up to the actual CV voting question, the survey stated:

> The stormwater management plan would require additional funding. Counties in the Appalachian Region raise revenue from different combinations of sales, income and property taxes. Additional revenue from these sources could be used to subsidize the increase in stormwater management practices in {respondent's County}.
>
> One estimate is that it would require a one-time (annual) increase of about $A per household in county sales, income or property taxes to fund the stormwater management plan. So, for example, if your combined county sales, income or property tax bill was $1000 last year it would be $1000 + A this year (and back to $1000 each year after that) (and $1000 + A each year after that). (where $A=28, 78, 128, 178, 228, 278, 328).
>
> Imagine that you have the opportunity to vote on the proposed stormwater management plan in a countywide referendum. If more than one-half (50%) of the voters in {respondent's County} vote for the plan then it would be put into practice and your county tax bill would increase.
>
> Now we would like to know how you would vote in a {respondent's County} referendum.

We then asked: “If you could vote today in a {respondent’s County} referendum, would you vote for or against the stormwater management plan?” Respondents could select from the following options:

“I would vote for the stormwater management plan”

“I would vote against the stormwater management plan”

“I am undecided”

“I would not vote.”

In our analysis, we coded all undecided voters as no votes as suggested by Groothuis and Whitehead (2002) and Caudill and Groothuis (2005). We excluded individuals who stated they would not vote (n = 59).

In table 1, we report the means to the variables used in our study. An average respondent was 46 years old, with 14 years of education and an income of $51,335. Forty-nine percent live in urban areas, twenty-one percent in suburban areas, and thirty percent in rural areas. Thus seventy percent of our respondents live in urban/suburban places where runoff issues are likely similar to those on Boone Creek, making that data applicable. Forty-eight percent were randomly assigned the more detailed scientific information, (labeled **Science** in Table 1). When asked toward the end of the survey, sixty-four percent of the respondents either agreed or strongly agreed with the statement: “I understand all the information presented to me on the proposed stormwater management plan” (labeled **Understand)**. Seventy percent of respondents believe that the stormwater management program could achieve the salinity reduction level they saw in the survey (labeled **Achieve**). Because this result suggests that these respondents are accepting the CV scenario presented as realistic, we used this variable to identify a subset of respondents to compare to the full set of respondents.

In tables 2A and 2B, we report responses by tax level for both the annual and the one-time tax. Consistent with economic theory, the proportion of yes votes falls as the tax rate increases; however, the trend is relatively flat. Also, at the lowest tax level of \$28 only slightly more than fifty percent are in favor of the proposal with a onetime payment and slightly less than fifty percent are in favor with an annual payment suggesting that many people may have a zero willingness to pay for stormwater runoff abatement management. Yet, at the highest tax level of \$328 we find that more than a third of respondents who were asked if they would pay that amount would vote yes on the proposal suggesting that for some stormwater abatement management programs are highly valued.

To theoretically model this decision, consider a resident's utility function who receives utility from both a consumption good, z, and an improvement in water quality, q, where q represents benefits from implementing stormwater runoff abatement measures. Then a resident maximizes her utility, $u(q, z)$, subject to a budget constraint $y = pz$ where the price of z is normalized to one. Solving for the indirect utility function yields $v(q, y)$. The willingness-to-pay, *WTP*, for stormwater abatement is implicitly defined as the payment that equates indirect utility with different water security conditions, $v(q^{o}, y) = v(q', y - WTP)$, where q^{o} is the status quo level of stream salinity and q' is the improved level of water quality. In our case, the willingness to pay question for stormwater runoff abatement measures follows a dichotomous choice framework. The variable *Vote* is a qualitative variable equal to one if the respondents answered: "I would vote for the stormwater management plan." In the next section, we empirically model the vote decision coupled with perceived understanding of information using a bivariate probit.

Influence of Understanding Information and Voting for the Proposal

To explore the influence of the more detailed scientific information on whether respondents claim to understand the proposed management plan and how understanding influences the likelihood to vote for a stormwater runoff abatement proposal, we estimate two bivariate probit equations. The bivariate probit provides the ability to test if voting in favor of the proposal is correlated with understanding the information provided. The seemingly unrelated bivariate probit model allows the independent variables explaining the likelihood of voting in favor to differ from those explaining respondents' perceived understanding. Consider the following model:

$$V = X'\beta + \varepsilon 1,\ U = Z'\phi + \varepsilon 2,\ where\ \varepsilon 1, \varepsilon 2 \sim N(0,0,\sigma 1, \sigma 2, \rho)$$

where *V* is the latent variable equal to one if the respondent is *'For'* the proposal and zero if against, and *U* is the latent variable equal to one if the respondent reported understanding the all the information in the survey. In the bivariate probit model the error terms, $\varepsilon 1$ and $\varepsilon 2$, are assumed to be normally distributed with a constant standard deviation $\sigma 1$ and $\sigma 2$ and a correlation of ρ. A positive correlation between the two probit equations suggests that there is some unobservable characteristic that increases the likelihood of voting yes and also understanding information. A negative correlation suggests the opposite.

For U, the probit model estimating perceived understanding, Z is a vector of explanatory variables that includes the demographic variables education, age, age squared, and a dummy variable indicating if the respondent resided either in an urban or suburban area. We used age and age squared to capture the concave relationship between age and perceived understanding. The variable "science" tests for the influence of the detailed scientific information. We include the dummy variable, runoff, which equals 1 if the respondent correctly defined stormwater runoff, to capture whether current knowledge of stormwater influences perceived understanding. Lastly, we included a dummy variable equal to one if the survey was implemented using SurveyMonkey as opposed to Survey Sampling International.

For the vote probit, *V,* the X vector of explanatory variables includes the tax amount, the scope variable (the level of salinity reduction) and its square, the level of stormwater management (ten or fifty percent), a dummy variable equal to one if the tax payment was annual, a dummy variable equal to one if the respondent received a budget constraint reminder asking them to consider their personal income and noting if they supported the proposal they would have less money for other things, and a dummy variable equal to one if the survey was implemented using SurveyMonkey. We also included demographic variables of age and income, a dummy variable indicating if the respondent resided either in an urban or suburban area. To test for the influence of the detailed scientific information, we included the "science" variable in the vote probit model.

In table 3, we report the results of the full sample. Our results are consistent with economic theory in the vote probit where increases in the tax amount lowers the likelihood of voting for the proposal. We also find that individuals who voted on the annual payment scenario are less likely to vote yes than those with the one time payment scenario. In addition, an increase in scope (as measured by *reduction* and *reduction squared*) increases the likelihood of voting for the proposal at a decreasing rate. In terms of demographics the likelihood of voting for the stormwater management proposal decreases with age but increases if the respondent was from a suburban area. Income has a positive sign as expected, but is insignificant. In terms of scientific information, we find that individuals who received the more detailed science information are less likely to vote for the proposal while individuals who correctly identified the definition of runoff are more likely to vote for the proposal.

In the “understanding” probit we find that individuals with higher education are more likely to state they fully understand the information presented about the management plan, while age has a concave relation peaking at 45 years. This suggest that both young respondents and older respondents are less likely to report that they fully understand the information compared to middle aged respondents. When it comes to science we find that individuals who correctly identified the definition of stormwater runoff are more likely to report they understand the information while the randomly assigned more detailed information had no influence on the likelihood of reporting they understand the information. Lastly, we find that the correlation between probits is 0.47, and significant, suggesting that individuals who report they understand the information are also more likely to vote for the proposal.

To further explore the influence of science on both perceived understanding information and the likelihood of being in favor of the stormwater management proposal we focus on the seventy percent of respondents who believe that the stormwater management program could achieve the salinity reduction level they saw in the survey. We use this subsample because these respondents accept the CV scenario presented as realistic. In table 4, we report the determinants of the variable achieve to discover who is in the subset of respondents who find the survey credible. Our results suggest that respondents with higher education and who identified the definition of stormwater runoff correctly are more likely to believe that the stormwater management program can achieve its goal. Older respondents, however, are less likely to believe the proposal will achieve its goals.

In table 5, we use this subset of respondents who thought the stormwater management program could achieve the reported level of salinity reduction in their county for the bivariate probit. In the vote probit we find that increases in the tax amount lower the likelihood of voting for the proposal. We also find that individuals who voted on the annual payment scenario are less likely to vote yes than those with the onetime payment scenario. In addition, an increase in scope increases the likelihood of voting for the proposal at a decreasing rate. In terms of demographics the likelihood of voting for the stormwater management proposal decreases with age but increases if the respondent was from a suburban area. Once again, income was found to be insignificant.

In terms of scientific information, we find that individuals in the subsample who received the more detailed science information are less likely to vote for the proposal while the coefficient on the dummy variable for individuals who correctly identified the definition of runoff was insignificant. Comparing the full sample to the subsample, we find the results are essentially the same with the only major difference being the change in significance of the runoff dummy.

In the understanding probit using the subsample we find that individuals with higher education are more likely to state they fully understand the information presented about the management plan, while age has a concave relation peaking at 44 years. As in the full sample, both young respondents and older respondents are less likely to report that they fully understand the information than middle aged respondents. When it comes to science we find that both individuals who correctly identified the definition of stormwater runoff and individuals who were randomly assigned the more detailed information were more likely to report they understand the information about the management plan. Lastly, we find that the correlation between probits is .36, and significant, suggesting that individuals who report they understand the information are also more likely to vote for the proposal. In the subsample, we therefore find that the detailed science-based information has two effects on the likelihood of voting for the stormwater management proposal: A direct effect of lowering the likelihood of voting yes and an indirect effect of increasing the likelihood of perceived understanding, which in turn increases the likelihood of voting yes through the correlation between the probits.

Discussion

The results from the willingness to pay scenario align with economic theory, as higher tax amounts lower the willingness to pay and respondents are more willing to pay a onetime over than annual payments. Our results, however, show that only a weak majority support using public funds to manage stormwater. This does not bode well for decision-makers faced with funding stormwater management programs.

Our more specific focus to assess the influence of detailed, science-derived information revealed interesting results with several possible explanations. The lower willingness to pay among respondents who saw the more detailed information may indicate that although the data used in developing the text and graphic was very specific, without naming a local waterway, respondents did not accept that it was relevant to their community. If they perceived that the information was not relevant to them, there was no incentive to address the reported consequences.

Among respondents who feel the proposed management efforts can be achieved, the positive relationship between seeing the more detailed science-based information and reporting that they understand the information provided about the management plan may reflect a "blinded with science" phenomena whereby even a superficial appearance of scientific credibility can sometimes increase a message's persuasive power (Tal and Wansink 2016). The subsequent alignment between accepting the proposed reductions as feasible and voting for the tax referendum is logical; for those who do not believe the proposal is feasible, there is no incentive to pay for something they believe will not work.

Seeing more detailed science information increased the likelihood that respondents claimed to understand the information provided in the survey and this indirectly increased their willingness to pay for stormwater management. This may reflect a reinforcement phenomenon, as those who saw the more detailed text and the graphic in Figure 1 also received the more simplified representation of the science-derived information in Figures 2 and 3. Seeing the information in two different forms at different places in the survey may have helped increase comprehension or at least perceived comprehension. If comprehension actually did increase, this would explain a willingness to pay to avoid the negative consequences of not implementing stormwater management, as portrayed in all of the science-derived text and figures. The influence on a willingness to pay for abatement may have less to do with the overall detail or quality of the information, and more to do with the repetition of the information. This conforms with basic communication principles indicating that low to moderate levels of repetition can enhance retention and increase a message's persuasive power (Petty and Cacioppo 1986).

Overall, our analysis demonstrates that communicating physical science in a social science survey is difficult. The physical science data is site specific and it is a challenge to provide that same level of specificity across a large spatial scale relevant to gathering survey data. Our results do indicate, however, that providing the more detailed information does influence some responses. Therefore, further assessing what information respondents deem relevant, and how much information to provide and in what format are promising topics for further research on assessing public attitudes about stormwater management. Based on our experience with this project, we do believe that incorporating the best scientific information available into a contingent valuation scenario can help ensure more realistic answers to hypothetical questions.

Figure 1.

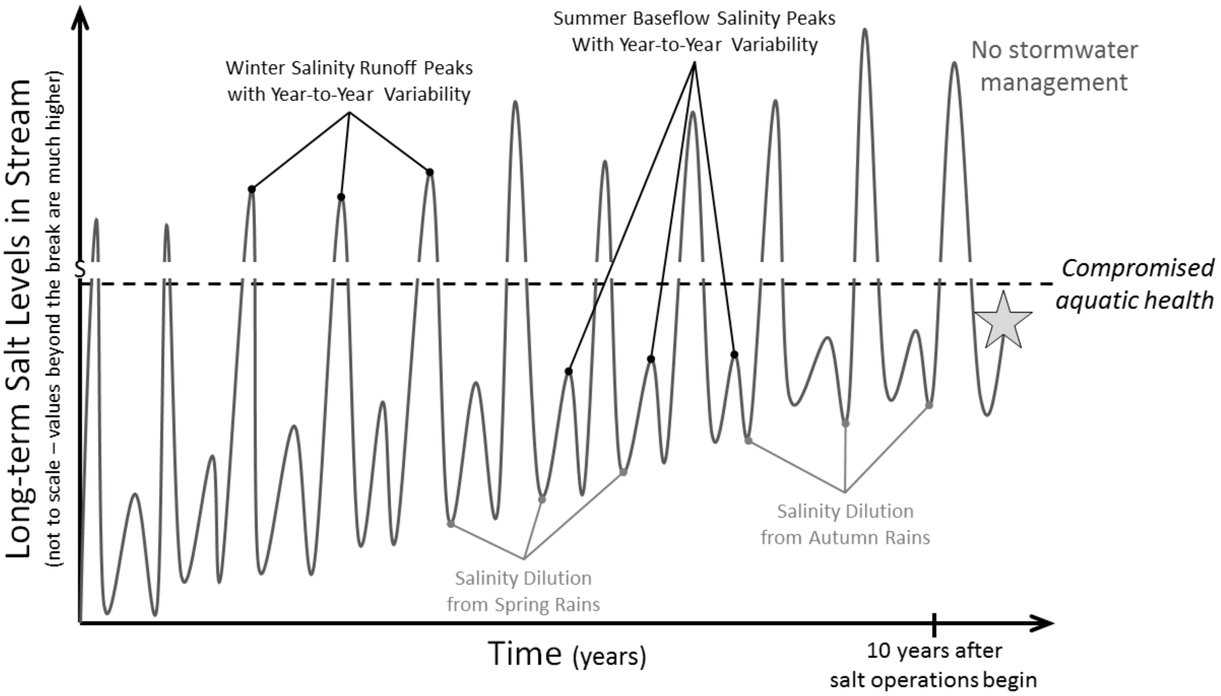


Figure 2

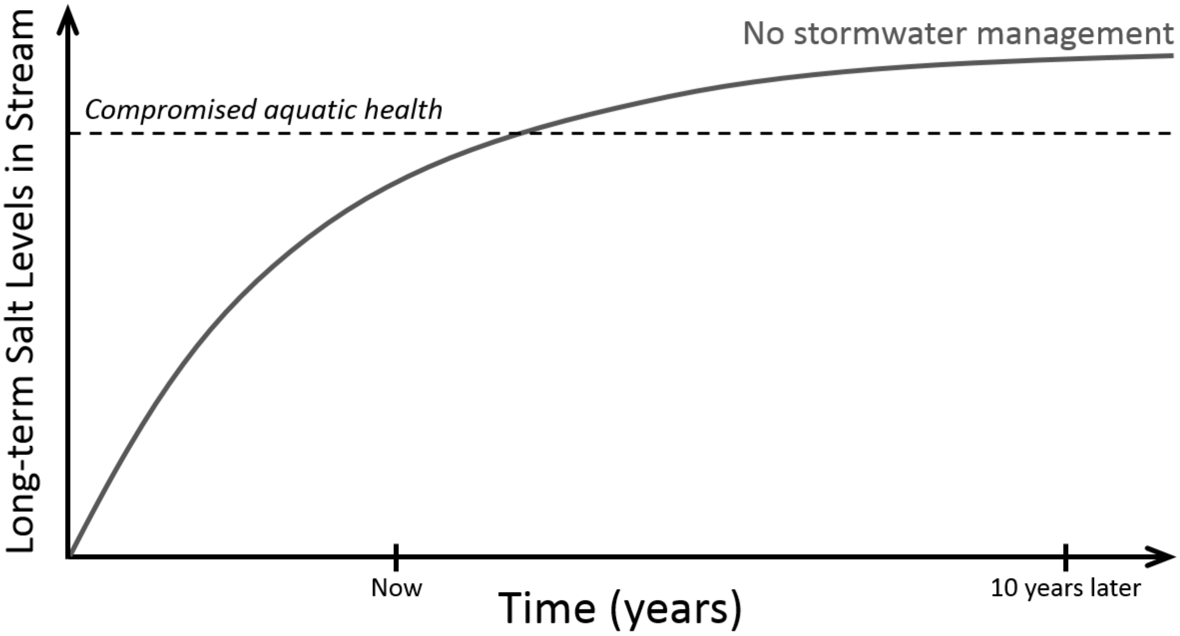
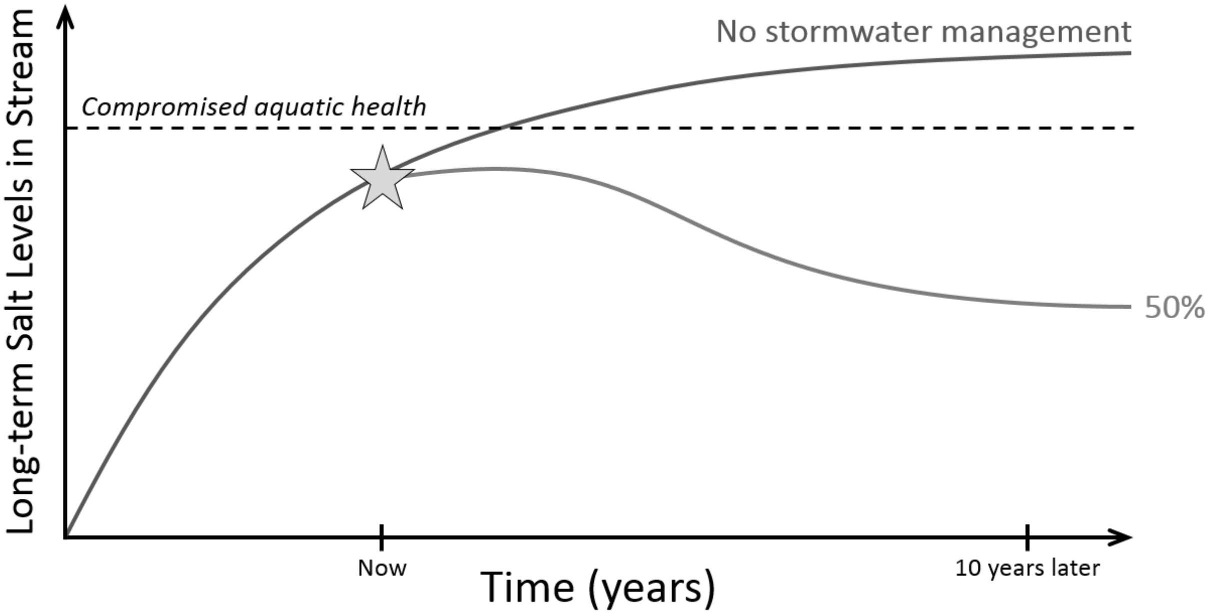
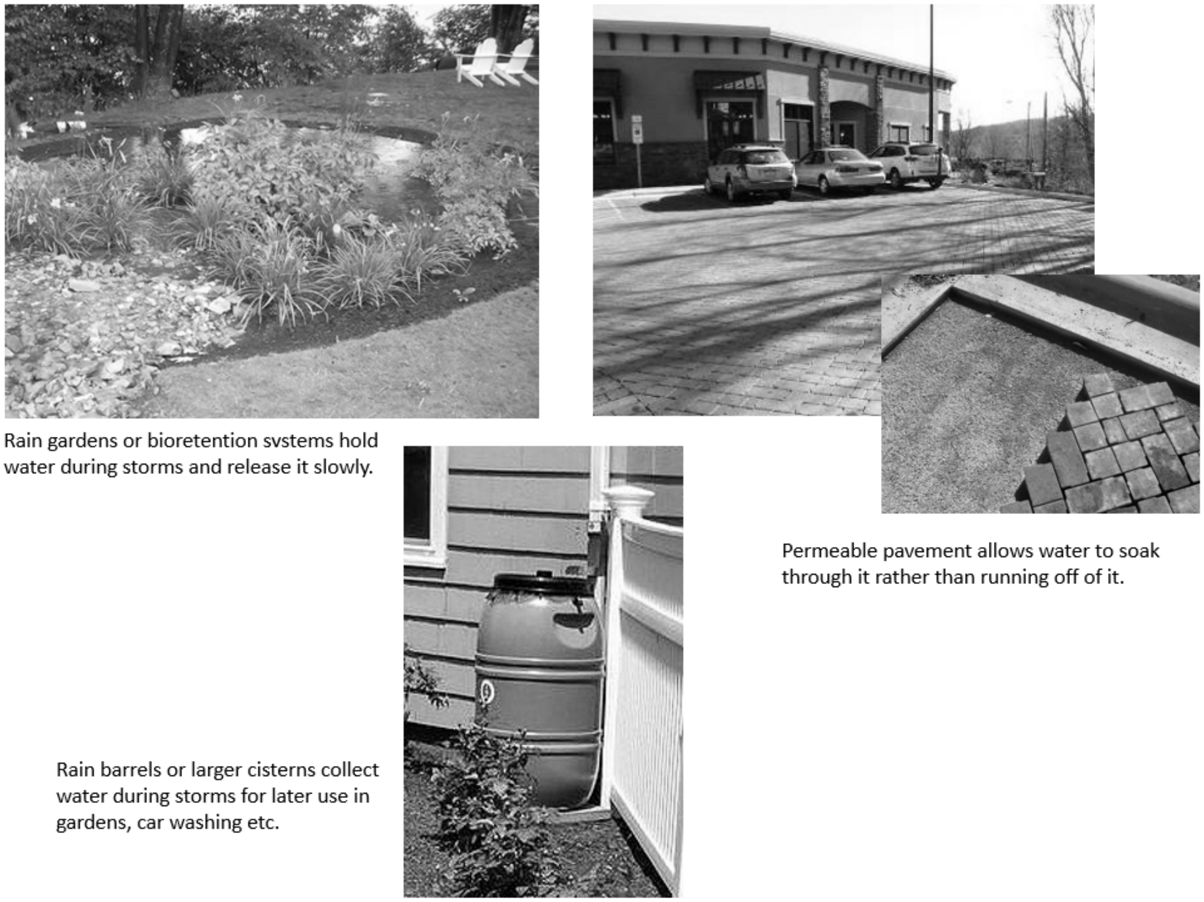


Figure 3



No stormwater management
Compromised aquatic health
Long-term Salt Levels in Stream
50%
Now
10 years later
Time (years)

Figure 4



Rain gardens or bioretention svstems hold water during storms and release it slowly.

Permeable pavement allows water to soak through it rather than running off of it.

Rain barrels or larger cisterns collect water during storms for later use in gardens, car washing etc.

Table 1: Means

Variable	Mean (Standard Deviation)
Science	.48
Informed	.64
Achieve	.70
Runoff	.59
Age	46 (15)
Education	14 (2.2)
Income	$51,335 ($39,113)
Suburban resident	.21
Urban resident	.49
Rural resident	.30
SurveyMonkey Panel Respondent	.69

Sample Size 1308

Table 2A: One Time Payments

Vote	$28	$78	$128	$178	$228	$278	$328	Total
No	44 (47%)	48 (49%)	57 (55%)	50 (52%)	50 (50%)	45 (52%)	52 (63%)	346 (52%)
Yes	50 (53%)	49 (50%)	47 (45%)	47 (48%)	51 (50%)	41 (48%)	31 (37%)	316 (48%)
Total	94	97	104	97	101	86	83	662

Table 2B: Annual Payments

Vote	$28	$78	$128	$178	$228	$278	$328	Total
No	47 (51%)	50 (56%)	52 (63%)	48 (49%)	55 (65%)	59 (55%)	60 (65%)	371 (57%)
Yes	45 (49%)	40 (44%)	31 (37%)	49 (51%)	29 (35%)	48 (45%)	33 (35%)	275 (43%)
Total	92	90	83	97	84	107	93	646

Table 3: Bivariate Probit (Full Sample)

	Vote (standard error)	Understand (standard error)
Tax amount	-.00096** (.00034)	--
Annual Pay	-.1312* (.0677)	--
Reduction	.0255** (.0116)	--
Reduction squared	-.0003** (.0001)	--
Management level	-.0005 (.0016)	--
Reminder	-.0513 (.0679)	--
Runoff	.1191* (.0729)	.2428** (.0730)
Science	-.1136* (.0712)	.0788 (.0722)
Age	-.0103** (.0024)	.0268** (.0137)
Age squared	--	-.0003** (.0001)
Income	.0001 (.0001)	--
Education	--	.0451** (.0161)
Suburban resident	.2287** (.0999)	-.0204 (.1022)
Urban resident	-.1164 (.0814)	-.0211 (.0838)
SurveyMonkey Respondent	.0993 (.0762)	.1528** (.0775)
Constant	-.0280 (.3083)	-1.0303** (.3818)
Rho	.4667** (.0498)	--
Log Likelihood	-1643.64**	--

n=1308 **significance at 5% level. *significance at 10% level.

Table 4: Probit: Determinants of Achieve

	Achieve (standard error)
Runoff	.2032** (.0742)
Science	-.0498 (.0728)
Age	-.0064** (.0025)
Education	.0442** (.0174)
Suburban resident	.1085 (.1051)
Urban resident	-.0910 (.0839)
SurveyMonkey Respondent	.0832 (.0772)
Constant	.0981 (.2789)
Log likelihood	-809.88**

n=1308 **significance at 5% level. *significance at 10% level.

Table 5: Bivariate Probit Achieve Subsample

Vote	Vote (standard error)	Understand (standard error)
Tax amount	-.00102** (.00041)	--
Annual Pay	-.1642** (.0819)	--
Reduction	.0320** (.0141)	--
Reduction squared	-.0003** (.0001)	--
Management level	.0008 (.0020)	--
Reminder	-.0666 (.0821)	--
Runoff	.0483 (.0865)	.0563 (.0923)
Science	-.1743** (.0840)	.2416** (.0900)
Age	-.0085** (.0028)	.0614** (.0174)
Age squared	--	-.0007** (.0001)
Income	.0001 (.0001)	--
Education	--	.0484** (.0209)
Suburban resident	.2196** (.1165)	-.1193 (.1236)
Urban resident	-.0818 (.0957)	-.0611 (.1043)
SurveyMonkey Respondent	.0773 (.0901)	.1697* (.0958)
Constant	.0533 (.3688)	-1.448** (.4786)
Rho	.3624** (.0592)	--
Log Likelihood	-1136.8594**	--

n=945 **significance at 5% level. *significance at 10% level.

References

Anderson, William P. Jr., Storniolo, Rachel. E., and Rice, Joshua S. 2011. Bank thermal storage as a sink of temperature surges in urbanized streams. Journal of Hydrology 409 (1-2): 525-537.

Bin, Okmyung and Stephen Polasky, “Effects of Flood Hazards on Property Values: Evidence Before and After Hurricane Floyd” Land Economics, November 1, 2004 vol. 80 no. 4 490-500.

Brent, D. A., Gangadharan, L., Lassiter, A., Leroux, A. and Raschky, P. A. (), Valuing environmental services provided by local stormwater management. Water Resour. Res.. Accepted Author Manuscript. doi:10.1002/2016WR019776

Caudill, Steven B. and Peter A. Groothuis, “Modeling Hidden Alternatives in Random Utility Models: An Application to Don’t Know Responses in Contingent Valuation,” Land Economics, August 2005.

Cockerill, Kristan and William P. Anderson Jr. 2014. Creating false images: Stream restoration in an urban setting. Journal of the American Water Resources Association 50 (2): 468-482.

Cockerill, Kristan, William P Anderson Jr, F. Claire Harris, Kelli Straka. 2017. A confluence of issues in managing stormwater runoff for urban streams, Journal of the American Water Resources Association (JAWRA) DOI: 10.1111/1752-1688.12528.

Forest Shepherd, 2016, Stream Salt Concentration Dynamics in a Southern Appalachian Urban Watershed, Appalachian State University Honors Thesis.

Groothuis, Peter A. and John C. Whitehead, “Does Don’t Know Mean No? Analysis of ‘Don’t Know’ Responses in Contingent Valuation Questions,” Applied Economics, Vol. 34, October 2002.

Londoño Cadavid, C., and A. W. Ando (2013), Valuing preferences over stormwater-management outcomes including improved hydrologic function, Water Resour. Res., 49, 4114–4125, doi:10.1002/wrcr.20317.

Lund, J. R. (2015), Integrating social and physical sciences in water management, Water Resour. Res., 51, 5905–5918, doi:10.1002/2015WR017125.

Petty, Richard E. and John T. Cacioppo. 1986. Communication and Persuasion: Central and Peripheral Routes to Attitude Change. NY: Springer-Verlag.

Tal, Aner and Brian Wansink. 2016. Blinded with science: Trivial graphs and formulas increase and persuasiveness and belief in product efficacy. Public Understanding of Science 25 (1): 117-125.

US Environmental Protection Agency (USEPA). 2016.Community Solutions for Stormwater Management: A Guide for Voluntary Long-Term Planning. Office of Water (October) www.epa.gov/npdes/stormwater-planning

Van Houtven, G, J. Powers, S.K. Pattanayak, “Valuing water quality improvements in the United States using meta-analysis: is the glass half-full or half-empty for national policy analysis?” Resource and Energy Economics, 29 (3) (2007), pp. 206-228

Wang, L. and P. Kanehl, 2003. Influences of Watershed Urbanization and Instream Habitat on Macroinvertebrates in Cold Water Streams. Journal of the American Water Resources Association 39(5):1181-1196, DOI: 10.1111/j.1752-1688.2003.tb03701.x.

Wang, L., J. Lyons, and P. Kanehl, 2003. Impacts of Urban Land Cover on Trout Streams in Wisconsin and Minnesota. Transactions of the American Fisheries Society 132(5):825-839, DOI: 10.1577/T02-099.

Whitehead, John C. “Plausible responsiveness to scope in contingent valuation” Ecological Economics 128 August 2016, Pages 17-22

Whitehead, John C. and Peter A. Groothuis “Economic Benefits of Improved Water Quality: A Case Study of North Carolina’s Tar-Pamlico River,” Rivers, Vol. 3, No. 3, July 1992

Acknowledgements: We would like to thank Appalachian State University for funding the Water Cluster: Integrating Geology, Economics and Policy Analysis through the CONducting ComplEx Research Together (CONCERT) Grants