EFFECTS OF STAKEHOLDER INVOLVEMENT IN REDUCTION OF SEDIMENTATION IN NORTHERN VIRGINIA STREAMS

by

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Effects of Stakeholder Involvement in Reduction of Sedimentation in Northern Virginia Streams

A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy at George Mason University

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DEDICATION

This dissertation is dedicated to my parents who have always encouraged me to seek knowledge and provided encouraging words of wisdom throughout.

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Abstract

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This thesis investigates the motivational factors and personal characteristics of individuals who are willing to participate in stormwater quality assessments at construction sites. Prior studies have shown that the effectiveness of stakeholder involvement in decisions that require knowledge of complex environmental issues has been limited by a lack of knowledge (Smedley, 2012). This research explores the effectiveness of several training approaches in improving stakeholders' knowledge, as well as on the willingness to volunteer and on the amount of time willing to volunteer. The training approaches consisted of various combinations of three training components: a PowerPoint demonstration, an interactive demonstration, and a statement of endorsement from a public official to use the data collected by volunteers.

A questionnaire was developed and administered to collect data on the willingness of various members of the public to participate in data collection efforts related to sedimentation issues caused by construction sites in Northern Virginia. A total of 212 participants took part in the survey. Participants were from Northern Virginia Community

College (NVCC) – Alexandria campus, George Mason University (GMU) – Fairfax campus, Metropolitan Washington Airports Authority (MWAA) at Ronald Reagan Washington National Airport (DCA) and Dulles International Airport (IAD), Friends of Accotink Creek (FAC), Friends of Accotink Park (FAP), and the Woodstone Homeowner Association (WHOA) in Alexandria, Virginia.

Willingness to participate as a volunteer in construction site data collection efforts positively correlated with an improved understanding of the problem ($r=-0.093$, $p<0.05$). Within this research effort, "willingness" is defined as an intention to volunteer as measured by Likert scale survey responses. The survey responses were also analyzed by age, education, gender, and organization type. The analysis showed that the willingness to participate post treatment improved with an increased education level. As education level increased, so did the likeliness to volunteer. Participants with graduate coursework were the most likely to volunteer and the least likely to be influenced by any of the training methods. Individuals with no education were the least likely to volunteer. Data for the amount of time that an individual is willing to volunteer was also collected and analyzed. The willingness to participate and amount of time willing to volunteer were found to be strongly and positively correlated ($R^2 > 0.7$). Citizens' willingness to participate and time to participate improved significantly ($p<0.05$) with the PowerPoint presentation. This research contributes to academic literature on the topic of public participation by improving the understanding of emerging theoretical development within the field of stakeholder participation. Thus, this research will help practitioners and decision makers develop improved outreach programs that will better engage citizens in environmental data collection programs.

CHAPTER 1 - INTRODUCTION

1.1 Significance of the Study

This research studies several factors that contribute to the willingness of the public to participate in stormwater data collection programs at construction sites. Regulations are in place to protect water bodies from receiving excessive sedimentation from stormwater related to construction activities. Unfortunately, there is a lack of enforcement and regulatory oversight due to an insufficient number of regulatory personnel to keep up with the growing number of construction projects (Alsharif, 2010). Additionally, federal and state budget cuts have not helped with hiring or even maintaining enforcement personnel. Incorporation of local citizens to monitor construction sites would be a prudent solution because of their access to the construction sites and concern for their local water bodies.

Hartwell and Shafer (2011) have found that public volunteers can reduce the costs associated with environmental data collection. This was particularly applicable in cases that required the collection of data across a geographically dispersed area. Technical tasks that require minimal training are perfect for volunteers. “While there are invariably some pitfalls that will arise as a result of increased public participation and transparency, the authors believe that the overall benefits conveyed by maximizing public involvement to the greatest extent practical generally far outweigh any detrimental factors" (Hartwell and Shafer, 2011).

1.2 The Land Development Sedimentation Problem

Clean water is paramount for human existence. Thus, water quality issues are a high priority for a variety of environmental stakeholders. Lack of sedimentation erosion control is a major threat to the cleanliness of all water bodies. Sediment erosion is a naturally occurring process which affects water quality. However, human alterations of the natural environment significantly increase the rate of sediment erosion. During land disturbances, soil erosion can be caused by a host of human activities, such as not having proper sediment erosion controls, clear cutting of trees, creating steep elevations where there are no vegetative buffers to control erosion, or extensive asphalt or concrete areas that allow for stormwater to flow uncontrolled (EPA, 2002; Stephenson, 2003). According to Myers et al. (1985), intensive construction sites have the ability to cause severe degradation of surface water quality due to high pollution loads. Further, excess stormwater runoff is difficult to control because it is too diffused to be readily recognized as a pollutant (Novotny, 1988; Shuster et al., 2005). The housing booms of the early 1990s and mid 2000s further exacerbated the problem. Stenstrom et al. (2007) has identified that stormwater pollution has been increasing due to unremitting development. Contributing factors included environmental degradation of land due to extensive construction, poor land management practices, and lack of attention to improved environmental regulations (Alsharif, 2010). Environmental degradation through land development contributes to water pollution, destruction of wetlands, premature conversion of prime agricultural land, and excessive exposure of people and property to natural hazards (Alsharif, 2010; Burby and Paterson, 1993). Construction activities that ultimately disturb land impact point sources of discharge to waters of the U.S. (40 CFR 122.26(b)(14((x))). Also, sediment runoff from construction sites may cause significant nonpoint pollution into waterways, adversely impacting wetlands, ponds, lakes, streams, and rivers (Davis, 1995). The EPA estimates that sediment runoff rates from construction sites are 10 to 20 times greater than those from agricultural sites and 1,000 to 2,000 times greater than those from forested sites (EPA, 2000). Additionally, the EPA has identified that construction activities over a short period of time can contribute to sediment deposition into streams equivalent to natural geologic sediment depositions that accumulate over several decades (EPA, 2000). According to Novotney and Somlyody (1995), the amount of soil eroded from construction sites during urban development can reach magnitudes of over 100 tons/ha/year. Poorly managed construction sites have the potential to adversely impact water quality through uncontrolled sediment transport in stormwater discharge.

Because of the dire impact of stormwater discharge, many relevant regulations were initiated. The Federal Water Pollution Control Act of 1972 (now known as the Clean Water Act (CWA) established a comprehensive program to restore and maintain the chemical, physical, and biological integrity of the Nation's waters (33 U.S.C. 1251 (a)). The CWA prohibits the discharge of any pollutants to navigable waters of the United States from point sources unless authorized by a National Pollution Discharge

Elimination System (NPDES) permit. The objective of the CWA is to attain "water quality which provides for the protection and propagation of fish, shellfish and wildlife and … recreation in and on the water" (33 U.S.C. 1251 (a)(2)).

Beyond the CWA, there have been many more regulations aimed at controlling water pollution: the passage of the Federal Water Pollution Control Act (FWPCA) of 1948, amendments to the FWPCA made in 1972 that was more commonly known as the CWA, the amendment of the Water Quality Act of 1987, and the establishment of the NPDES program. To improve water quality under the NPDES program, initial efforts were focused on reducing pollutants from wastewater and municipal sewage treatment plant discharges. After many years of operation of the NPDES program, it was observed that non-point source pollution, such as stormwater runoff from construction sites, was also a significant contributor to the decline in water quality (Barrett et al., 1993). The Water Quality Act (WQA) of 1987 enhanced the CWA to include section 402(p), directing the EPA to regulate stormwater discharge under the NPDES program. Also, on November 16, 1990, the EPA enacted the "Phase I rule" of the WQA; this rule establishes the permit application requirements for stormwater discharge associated with various activities: construction sites larger than 5 acres, (55 FR 47990), landfills, hazardous waste treatment, storage and disposal facilities, steam electric power generation facilities, along with a variety of mining, manufacturing, transport and recycling facilities that would be identified using Standard Industrial Classification (SIC) codes (City of Portland, 2000).

On December 8, 1999, the “Phase II rule” of the NPDES permit system became final with an effective date of February 16, 2012. Currently, under Phase II of the NPDES program, there are no numeric limits on turbidity (Schaner and Farris, 2012). The NPDES permitting system provides regulatory guidelines for controlling and minimizing sediment and pollutant runoff from construction sites. No matter how stringent the regulations in principle, several human factors (e.g. lack of monitoring, willful negligence, and/or ignorance related to environmental regulation) can result in ineffective regulation. Indeed, currently existing regulations rely heavily on self-monitoring. All of the regulations noted above failed to curb or minimize sediment discharge from large and small construction projects (Stenstorm et al., 2007).

According to Schaner and Farris (2012), Alsharif (2010) and Burby and Paterson (1993), compliance with state regulatory standards has been low due to limited resource availability. For example, the U.S. EPA recently announced that Toll Brothers Inc., one of the nation’s largest homebuilders, reached a settlement with the EPA and the U.S. Department of Justice to pay $741,000 for penalties related to violations of the Clean Water Act and to implement company-wide stormwater controls to prevent millions of pounds of sediment and pollution from entering U.S. waterways (U.S. EPA, 2012). The case was to settle 600 stormwater violations that were discovered through site inspection. The EPA penalty was a result of the Toll Brothers’ repeated failure to comply with permit requirements and failure to install adequate stormwater pollution controls at construction sites in multiple states, including Maryland and Virginia. Houck (2002) identified that there are two major problems with enforcement of regulations: the delay in action after the violation is committed and the insufficient penalties to recover the damage caused by the violations. Implementation of the Phase II stormwater construction regulatory program has put a significant strain on regulators to focus on inspecting construction sites for deficiencies related to engineering controls in order to curb sediment erosion and other pollutants. Under the Phase I NPDES permitting program, there were insufficient resources to provide adequate oversight on permitted facilities (City of Portland, 2000). With further strengthening of regulations related to pollutant discharge per the Phase II NPDES permitting system, the original problem of a lack of regulatory oversight has been exacerbated, since the number of regulators has not increased to keep up with the new regulations. This has put an added strain on the limited field inspectors who were already in short supply (Alsharif, 2010). Burby and Patterson (1993) have also identified that centralized enforcement does not necessarily enhance compliance with regulation. Lack of compliance is a consequence of an individual's lack of concern for the environment and his/her disregard of social and moral obligations, resulting in general neglect of environmental issues (Bamberg, 2003). Additionally, Houck (2002) states that governments, at all levels, lack the necessary financial and human resources to prosecute every single violator.

Best Management Practices (BMPs) for sediment erosion control at construction sites require a written plan of action be submitted and approved by the local government prior to any land disturbance. BMPs for silt fence installation include all of the following: (1)

trenching prior to installation of silt fences, (2) maintaining specific distances between silt fence posts to ensure sturdiness of the silt fence, (3) re-grading any area that has recently been disturbed that exceeds a gradient of 10% or greater, (4) inspecting the site before, during, and after storm events to identify and correct any damages to the filter fabric, and (5) ensuring that the construction site entrance is underlain with filter fabric covered with wrist sized crushed stone to trap sediment attached to construction vehicles and equipment leaving the construction site (Richmond, 2008). A proper silt fence installation is like a long chain; if one link is broken, the whole system is ineffective. Silt fence installation requires attention to the following six links: placement, quantity, installation, compaction, posting, and attachment (Land and Water Inc., 1998).

There are many potential problems associated with the aforementioned BMPs. Even if the devices are constructed and maintained properly, the filter fabric is not designed to contain 100% of the sediment. Also, failure of silt fences is common since they are not specifically designed to withstand significant rain events. Instead, silt fences are engineered to minimize adverse effects associated with soil excavation and erosion. Figures 1 and 2 illustrate some of the more common failure means. When silt fences fail, polluted stormwater laden with extra sediment gushes into local water bodies. Broz et al. (2003), identified runoff from construction sites as a major source of sedimentation from urban areas due to the volume and rate of runoff and vulnerability of bare soil to erosion.

Figure 1: Silt Fence Overlain with Excessive Sediment

Figure 2: Silt Fence Inundated by Excessive Runoff

William Dennison, Vice President of the University of Maryland Center for Environmental Science, reported that the 2012 conditions in the Chesapeake Bay were the worst ever due to Hurricane Irene and Tropical Storm Lee. Significant amounts of nitrogen, phosphorus, and sediment were washed into Chesapeake Bay's mainstream as a result of the storms. Unfortunately, the NPDES Stormwater Regulations (Phase I and Phase II) do not take into account the intensity of hurricanes and the excessive amounts of stormwater that may be generated within a relatively short time (Kobell, 2012).

Typical sediment loading rates from construction sites vary from 100 to 200 tons per acre per year and can range as high as 1,100 tons per acre per year. Typical problems associated with construction site BMPs that lead to their inefficacy and failures, as noted by Broz et al., (2003) are as follows:

- Fences not adequately installed and supported due to excessive sediment buildup behind silt fence
- Drainage area too large, thus stormwater follows the path of least resistance
- Inadequate inspections of silt fences causing sediment buildup, thus leading to accumulation and failure of barriers
- Upstream slopes are too steep or too long putting undue stress on sediment barriers
- Installation of erosion control devices in areas that are not designed to support such barriers

The Washington, D.C. metropolitan region has seen a significant increase in the number of residential and commercial construction sites since the 1990s. Currently, state officials are not able to meet the demands to inspect construction sites for stormwater protection violations. Public participation in inspecting construction sites may improve compliance with existing regulations.

1.3 Public Participation

Over the past two decades, public participation in environmental decision making has significantly increased (Kollmuss & Agyeman, 2002, p. 240). This participation has shaped ground rules and expectations for federal and state funded actions (Gregory, 2000). Too often, decision makers cast a wide net for hearing citizen views, go behind closed doors to interpret what they have heard, and make decisions based on their interpretation of the citizen comments (Gregory, 2000). Decision makers' tools for understanding the concerns of the community, technical experts, and interest groups have not kept pace with the rhetoric of incorporating the views of the public in the decision making process (Gregory, 2000). Ultimately, the public and state, local, and national rule makers become dissatisfied with the quality and meaningfulness of stakeholder input to environmental decisions. Additionally, concepts of participation tend to be clouded by practitioner's anecdotes, but lack context and social construction (Creighton, 2005). Many times, the information is interpreted incorrectly by the practitioner. Concerns tend to be over-simplified, and in many cases, misstated. A minimal amount of research substantiates the assertions implied by the practitioner's anecdotes (Creighton, 2005). Moreover, the anecdotes are often discussed without the inclusion of the very voices that these developments seek to benefit (Gregory, 2000).

Currently available participatory tools lack in-depth social baseline information and the clear understanding of community experience that tends to impact the public's understanding and willingness to participate in the decision making process (Lynam, et al., 2007). "Willingness" in this research effort is defined as an intention to volunteer.

Meaningful public participation is a necessary element of informed decisions that affect the environment. The National Research Council (NRC) is researching the link between public participation and sound science by focusing on two major questions:

- Are most policy decisions based on scientific principles or do public concerns outweigh scientific fundamentals?
- How do the view points of the public relate to the science-based facts?

The goal of the NRC research is to increase both the quality and the acceptability of environmental policy decisions through better understanding of the link between the stakeholders and the scientist. To date, very little research has focused on how to motivate the public to become involved in environmental policy decisions (McDougle et al., 2011).

Active stakeholder involvement, especially within the environmental decision making process, results in decisions that benefit stakeholder concerns (Finnegan and Sexton, 1999). Collective decision making on environmental issues provides an opportunity for stakeholders to be actively involved to bring about a favorable solution to a potentially divisive issue. Actually, when it comes to public participation, the importance of public participation is not the issue. Instead, many questions remain about the method for achieving desired participation (Turaga et al., 2010, p. 211). This research explores this question as it relates to public participation in sedimentation control policy decisions.

1.4 The Research

In Fairfax County, VA, construction related activities are the primary cause of sedimentation pollution (Fairfax County, 2013). Citizens can play an important role in helping to monitor construction sites to ensure that best practices are used and maintained. The question is: what is the best way to engage potential volunteers? My research investigates alternatives for recruiting and instructing potential volunteers about stormwater sedimentation and control devices. I used groups who would be likely to volunteer to test various instructional methods. College students, homeowner association members, quasi-government employees, and stream protection groups comprised the participants. Using various training methods, I tested the change in their knowledge, the change in their willingness to volunteer, and the change in the length of time that they are willing to volunteer. Specifically, I tested the following instructional methods (treatments):

1. PowerPoint presentation on sedimentation pollution and Best Management Practices for installing silt fences
2. An interactive demonstration of sedimentation and control devices
3. PowerPoint presentation that includes a statement from a public official to describe the importance of public participation and the manner in which the results will be used

My objective was to find a practical approach that would increase public participation and knowledge of the problems associated with sedimentation. I selected training approaches that could be easily and cost effectively adopted by laymen to highlight the problem related to construction site sedimentation.

My research consisted of the hypotheses listed below.

1. Willingness of local citizens and the time they are willing to volunteer in construction site data collection will increase as they are educated using the following means ("treatments"):
    - Powerpoint on sedimentation problem caused by construction activities
    - "Hands on" demonstration of the mechanics of sedimentation runoff
    - Commitment by public officials to incorporate findings into stormwater Best Management Practices (BMPs)
2. As the citizens are exposed to more treatments, their willingness and time to volunteer will increase.
3. As the local citizens' knowledge of stormwater pollution and protection increases, so does their willingness and time to volunteer.

Although the scope and findings of this research are limited to survey results, it should be noted that the research findings from Carlsson and Martinsson (2001) have shown that there is no difference between hypothetical and actual environmental willingness to contribute.

CHAPTER 2 - REVIEW OF LITERATURE

2.1 Public Participation in Environmental Decision Making

A well-run public participation program allows interested and affected individuals to have an opportunity to participate to influence and shape policies. A significant sticking point within stakeholder participation is the lack of agreement on what constitutes and influences effective stakeholder involvement (Levin, 1999, Witte et al., 1999, Arkema et al., 2006, Smedley, 2012).

The academic focus of the research has been on defining and theoretically validating the concept and practice of public participation. The International Finance Corporation (IFC) (2007), which is an arm of the World Bank (WB), has stated that the terms "public participation", "citizen participation" and "stakeholder participation" are all similar in concept, meaning, and application. Stakeholder "engagement", "involvement", "participation" and "contribution" have also been identified to have a similar meaning and are often used interchangeably.

Behavioral decision research (BDR) and decision analysis (DA) forms the basis for the theory and practice of environmental decision making (Bazerman and Moore, 2008). BDR has a descriptive focus and investigates why humans are bad at making complex decisions that involve the application of experimental findings to real life situations.

These shortcomings in decision making abilities are attributed to the fact that individuals systematically employ cognitive shortcuts and tend to have very limited instinctive ability to structure decision tasks, balance dual goals, and achieve satisfactory levels of judgment (Gregory, 2000). DA has been shown to improve the quality of individual and group decision making which would be the basis for participation and consists of the following five tasks, each with its own set of relevant questions (Gregory, 2000).

1. Framing the decision – what are the key contextual elements of the decision situation and what are the reasonable goals of the consultation process?
2. Defining key objectives – how do people think they will be affected by the proposed action and what values matter most to the stakeholder?
3. Establishing alternatives – in light of relevant constraints, what alternative actions might be taken?
4. Identifying consequences – what are the most important impacts that could affect the stated objectives and how certain is their occurrence?
5. Clarifying tradeoffs – what are the important conflicts across desired objectives and how can this knowledge be used to create new and better alternatives?

Stakeholder opinions are critical; their views define what matters to those most affected by the proposed action. Elicitation of the importance of the various objectives is a critical step in the process and involves a qualitative approach. Decisions are not purely quantitative in nature. The process is aided by clear communication channels between stakeholders and decision makers.

According to Habermas (1996), the word stakeholder is a legally constructed term that pertains to citizen participatory agreements and related guidelines (Camilleri, 1990). Similarly, a stakeholder in a business usually stands to benefit financially from a decision (Wheeler et al., 2002, Dryzek, 2002). Stakeholders in environmental decision making provide their views on resource management and conservation and may try to influence the management and conservation of resources (Jones, 1997, Coppola, 1997, and Gregory, 2000). Peelle (1995) defines stakeholders by their level of influence.

- Key stakeholders-stakeholders who have significant power and clout to influence and contribute to a decision
- Primary stakeholders-stakeholders who are ultimately affected by the process
- Secondary stakeholders-stakeholders who refer to other participants who are not directly impacted by the process but share some concern for environmental protection as a whole or other related aspects related to the decision

2.2 Rationale for Public Participation

There are three popular schools of thought that drive the discussion related to public participation and participation for development (Eckersley, 1992). The three schools of thought are termed “development”, “political”, and “capabilities”. Meaningful participation is viewed as a requirement towards the general well-being of society and acceptable socio-economic development of social order.

The development school of thought espouses the idea that involvement within the public arena concerns building relationships and partnerships to help solve problems in a democratic way (Eckersley, 1992). Formulating partnerships and building relationships is considered as a bottom up process. The development school of thought employs inductive reasoning as the individual pieces of a system combine to help make a grand and complete structure. The information that is obtained from the surrounding environment is synthesized. Put another way, the elements of the sub systems are specified in great detail; this information forms the base of the building blocks of the grand system. When the base is solid and sturdy, it strengthens the whole system (Lisk, 1988).

Typically, the least informed, least educated, and least organized citizens have minimal influence when compared with that of more powerful stakeholders, who tend to be better informed, more educated, and more organized. It should be noted that less influential citizens can compound the problem of getting projects accomplished since they are generally larger in number than more influential citizens. Tandon and Cordeiro (1998) identify participation as the process through which the most affected influence and share control of their development initiatives, decisions, and resources. Incorporating and involving all stakeholders is crucial in ensuring stakeholder ownership, which is vital to project success. In summary, the development school of thought on participation is advocating individual and collective development to resolve and achieve participatory success together.

The political school of thought states that participation is a mode for citizens to facilitate political change in favor of the deprived (Robb, 1999; Blackburn and Holland 1998; Norton and Stephens 1995). Thompson (1995) suggested that participation tends to hold a significant amount of influence beyond the borders of a typical project framework and enlightens policy makers who are planning to implement large scale government programs and projects. Therefore, better partnerships between stakeholders and direct community involvement tend to positively influence the decision making process related to the general well-being of the community to help better understand, accept, and support its values related to the decision. In other words, the political school of thought is focused on the administrative aspects of participation to help focus and achieve participatory achievement.

The capabilities school identifies participation as a process of strengthening the knowledge and ability of citizens in order to regulate their own development. Helping citizens gain knowledge and experience through training would result in a more informed public (Nelson and Wright 1995). The capabilities school of thought concentrates on improving social capabilities including leadership, trust, and social belonging within the framework of participation and problem resolution. This school of thought seeks to strengthen the socioeconomic capabilities to improve citizen participation.

Engaging the public in environmental field studies is becoming increasingly important as government budgets for these services decline. In recognizing the significant contribution that the public can make, scientists and policy analysts are studying the role of the concerned citizen in environmental monitoring, data collection, and research (Groffman et al., 2010; Shneider & Snieder 2011; Shafer & Hartwell, 2011, in press). Hartwell and Shafer (2011) have identified the importance of establishing a network of citizens to help monitor projects.

2.3 Defining Public Participation

The definition of participation is fundamental to understanding participatory theory. There are many definitions that describe participation (Korten, 1980; Cvetkovich and Earle, 1994; Naranya, 1995, Nare et al, 2011, Reed, 2008). These definitions range from that of having individuals' voices heard to more complex definitions that involve "forums for exchange that facilitate communication between government, citizens, stakeholders, and interest groups regarding a specific decision making or problem resolution" (Webler, and Ortwin, 1995). Arnstein (1969) was at the forefront of her time when she equated participation with power; the redistribution of power enables the have-not citizens that were excluded from political and economic processes to be deliberately included for the future. All of the definitions related to public participation have common themes that range from sharing opinions, influencing, contributing, sharing power, and disseminating knowledge and resources. For the purpose of this research, public participation is defined as a means to incorporate citizens who have a stake in the decision making process. Further, from here onwards, the definition of public participation will refer to local citizen involvement only.

Public participation is a voluntary process where interested and affected parties come together to share ideas and knowledge in order to influence a decision that might ultimately affect them. Participation involves the identification of interested parties or stakeholders and requires clear communication between all involved entities to reach an agreement or decision. Naryan (1995) succinctly identified public participation as an exercise in one's voice with that of choice.

2.4 Stakeholder Participation

As discussed above, the term stakeholder encompasses a wide variety of definitions. When considering participation, Leach et al. (2002) defines stakeholder as any individual or organization interested in a particular policy issue. There are numerous views of stakeholder theory that are presented throughout literature with a key distinction that can be drawn between the tenets of Stakeholder. The conventional input-output model identifies stakeholder partnerships as converting investor, supplier, and employee inputs into customer outputs (Donaldson and Preston, 1995). In contrast, stakeholder theory argues that every legitimate person or group participating in the activities of a firm does so to obtain benefits. Further, the priorities and the interests of all legitimate stakeholders are not initially self-evident. Stakeholder participation is a collaborative approach. It is a consensus seeking partnership that involves affected stakeholders (Leach et al., 2002). Stakeholder participation can include multiple groups such as local citizens, landowners, business entities, national or local advocacy groups, trade organizations, and multiple government entities (Leach et al., 2002).

There are many degrees of stakeholder participation. This concept was initiated by Arnstein (1969) in her "ladder theory" with the different rungs of the ladder symbolizing the degree of participation. Participation can have a wide range of meanings that include participation without sharing responsibility or ownership, participation where the process is led by others, passive participation, and even manipulation. Typically, stakeholder participatory planning, monitoring, and evaluation entail a higher degree of involvement. As stakeholders, individuals help define their own problems and come up with suitable solutions; this implies a higher degree of ownership, in which individuals are actively involved and empowered.

Figure 3 depicts stakeholder involvement as a process. The characterization of the stakeholder and the degree of involvement are important elements of the process. Luyet et al. (2012) investigated the implementation of various techniques to engage stakeholders at different levels in the environmental decision process. Different approaches from "information only" through workshop participation (hands-on training) are proposed for different levels of public involvement. Results of this study suggest that additional research is needed to correlate the degree of involvement to the approach selected for public engagement.

Environmental Stakeholder Involvement (SI) in infrastructure projects was studied by El-Gohary, Osman, and El-Diraby (2006). In the context of construction projects, the authors point out that "stakeholders may be interested in monitoring and evaluating project impacts related to their particular field to make sure that the impact is not greater than what was considered in the planning phase". To determine the best way of engaging stakeholders, they model involvement as a system as shown in Figure 4. Important components of the system are the products used to engage stakeholders. Different products, such as public meetings, web pages, workshops, and videos, were shown to have varying degrees of effectiveness in involving the public.

Figure: 3 Stakeholder Involvement Process (Luyet, et al. 2012)

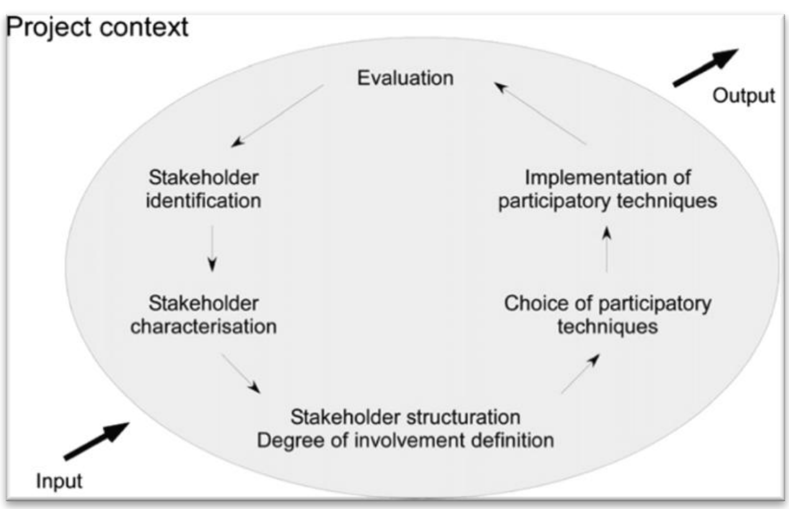
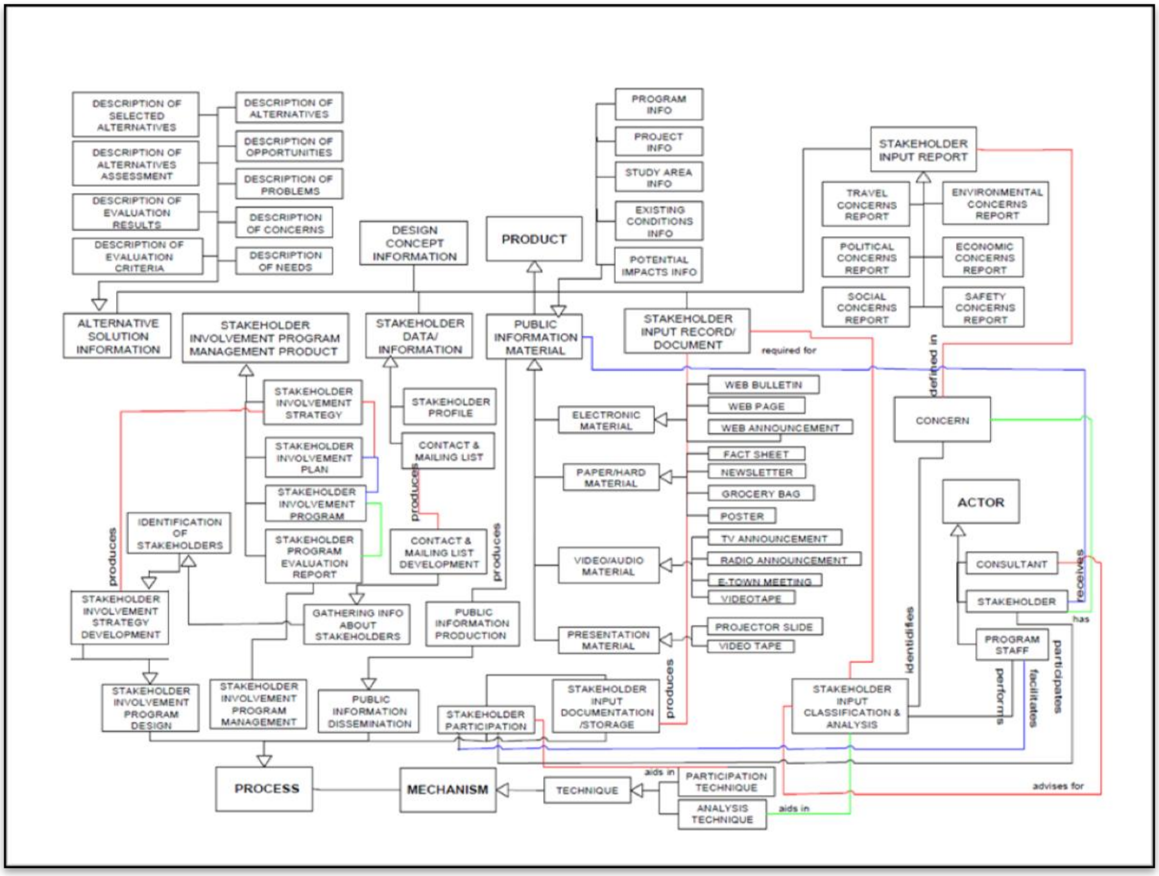


Figure 4: Stakeholder System



2.5 Why Involve Stakeholders?

The research community is well versed in research and modeling regarding environmental regulatory enforcement or monitoring. On the other hand, local communities and stakeholders are knowledgeable about local barriers to implementation. Active engagement and participation by all groups will help facilitate development of new policies through development of a collaborative network of stakeholders throughout the research process (Armsworth et al., 2010). Transparency in the entire process will help build credibility towards the entire process and facilitate tangible solutions

(Korfmacher, 2001). Stakeholders are greater in number than regulators. Also, stakeholders often have more influence than federal, state and local decision makers, since the latter are ultimately voted in or out by the general population. Therefore, stakeholders and the general public are more likely than the scientific community to influence political decisions regarding environmental policy (Voinov and Gaddis, 2008).

Research has shown that stakeholders should be actively involved at the beginning of any decision making process or steering group (Korfmacher, 2001; Voinov and Gaddis, 2008). Stakeholders are local to potential problems. Therefore, they have both opportunity and motivation to minimize any potential environmental impact (Rohrschneider, 1988). Stakeholders bring benefit to researchers by understanding local concerns. In the case of water quality monitoring, they are watch guards of the water bodies. A local and engaged stakeholder group can help save time and money. Ultimately, stakeholders are the ones who will continue to monitor and observe a situation long after the research community or regulators have concluded their work.

2.6 Justification for Public Participation

Public participation brings all affected parties, who have a legitimate interest in the issue at hand, together to identify issues and any potential problems (Sewell and Coppock, 1977). This is a good starting point from which to begin identifying key players and come up with a preliminary plan for resolution. In contrast to the scientific community's wide focus, the public's concerns are local. The public helps to highlight their environmental interests via public participation. Schatzow (1978) showed that public participation is a mechanism for incorporating disadvantaged groups. Local communities tend to be knowledgeable on issues related to their neighborhood and can enlighten regulators and researchers to potential problems on community concerns. Involved citizens can assist in disseminating information related to regulatory issues that would help increase participation and reduce statistical error (Korfmacher et al., 2001). By incorporating the public in environmental management, costs associated with sample collection and monitoring can be reduced (Voinov et al., 2008). Active engagement and participation will facilitate new policies through development of collaborative networks of stakeholders throughout the research process (Armsworth et al., 2010). On the opposite side, public participation should be managed carefully. One-sided participation can enable special interest groups to highjack the decision processes (Brulle, 2000; NRC, 1998). Problems that may result during the policy formulation phase can be minimized by involving the public in the decision process early and often (Kraft, 2004). Also, Sirianni (2009) succinctly identified that government can be the problem. Rather than encouraging citizens to engage in civic activity, government has often put obstacles in their way, inadvertently discouraging citizen participation.

2.7 Stormwater Protection Regulatory Mechanisms: The National Pollution Discharge Elimination System (NPDES)

The goal of NPDES is to control stormwater discharge from three potential sources: (1) municipal separate storm sewer systems, more commonly known as MS4s, (2) construction activities, and (3) industrial activities. This objective is achieved through the implementation of a system that prevents unpermitted stormwater runoff from washing harmful pollutants into local surface waters such as streams, rivers, lakes and coastal waters (Illinois EPA, July 2002). Many stormwater discharges are considered point sources of discharge, especially for municipal systems (MS4s) and industrial activities. The point source designation is due to the fact that these discharges occur from established facilities that release from designated piping systems to a particular body of water or location. On the other hand, construction sites and activities involve temporary systems which accumulate and discharge stormwater. The discharge from construction activities involves non-point, diffused, and dispersed discharges. Point source discharges are relatively easy to identify, especially since the point of discharge is known or can be visually observed. According to the EPA, "stormwater runoff" is identified as any rain water or melted snow that runs off the land and enters lakes, rivers, streams and ponds (Illinois EPA, July 2002). Typically, as this stormwater runoff moves through land, it picks up and carries a host of pollutants such as pesticides, metals, oils, and sediment and carries it into waterways (U.S. EPA, 2012). Stormwater is known for increased sediment erosion, especially from recently disturbed lands where more soil is known to be carried into surface waters and deposited (U.S. EPA, 2012). Stormwater pollutants and sedimentation are known causes of water quality degradation (Illinois EPA, July 2002). In general, the NPDES stormwater program is administered and monitored by states, with the exception of specific states and territories on most tribal lands, where the EPA has governing authority. The NPDES stormwater program is responsible for all of the following:

- large, medium, and regulated small MS4s for stormwater discharge,
- large and small construction activity, and
- industrial activities covered by 40 CFR 122.26(b)(14)(i)-(xi).

Parties involved in any type of land disturbance are required to apply for and obtain a multi-sector general permit (MSGP) to operate. The MSGP specifies three steps a facility is required to follow as listed:

1. submission of a notice of intent (NOI),
2. installation of stormwater controls, measures to control and minimize pollutants from entering via stormwater runoff, and
3. development of the stormwater pollution prevention plan (SWPPP), which includes Best Management Practices (BMPs) used to control and minimize pollution entering waterways.

2.8 Phase II of the NPDES Stormwater Management Program

Phase II of the NPDES permit system began in March 2003 and applies to MS4s and construction sites that disturb at least 1-acre but less than 5 acres (U.S. EPA, 2012). The intent of the regulation is to minimize pollutants entering bodies of water via stormwater. NPDES permits require that owners/operators apply and obtain discharge permits prior to any activity or land disturbance on a property exceeding 1-acre or more. Subsequently, owners/operators must fully implement all stormwater runoff control practices identified within the permit (Illinois EPA, July 2002). The Phase II permit system does not add any new industrial categories to that of the Phase I program that required 11 industrial categories to obtain NPDES permits for stormwater discharge. The 11 industrial categories are as listed below:

- Category One (i): Facilities subject to federal stormwater effluent discharge standards in 40 CFR Parts 405-471
- Category Two (ii): Heavy manufacturing (for example, paper mills, chemical plants, petroleum refineries, and steel mills and foundries)
- Category Three (iii): Coal and mineral mining and oil and gas exploration and processing
- Category Four (iv): Hazardous waste treatment, storage, or disposal facilities
- Category Five (v): Landfills, land application sites, and open dumps with industrial wastes
- Category Six (vi): Metal scrap yards, salvage yards, automobile junkyards, and battery reclaimers
- Category Seven (vii): Steam electric power generating plants
- Category Eight (viii): Transportation facilities that have vehicle maintenance, equipment cleaning, or airport deicing operations
- Category Nine (ix): Treatment works treating domestic sewage with a design flow of 1 million gallons per day or more
- Category Ten (x): construction sites that disturb five acres or more; however, because of the significant difference in the nature of those activities, construction sites are permitted separately

- Category Eleven (xi): Light manufacturing (For example, food processing, printing and publishing, electronic and other electrical equipment manufacturing, and public warehousing and storage)

("Categories of Industrial Activity that Require Permit Coverage", 2009)

As per the phase I permitting criteria, there was a "no exposure" requirement, with an unlimited time permit, limited to light industrial facilities. However, the Phase II permitting requirements expanded on the original "no exposure" exclusion to include all industrial facilities covered under the Phase I permitting criteria, except construction activities, and included a 5-year time period on the permit. The "no exposure" criteria under Phase II was further defined to include all industrial materials and activities that would be properly protected from a storm such as storm resistant shelters to prevent exposure to rain, snowmelt and runoff. Industrial materials include materials or activities such as industrial machinery, raw materials, intermediate products, by-products, final products, and waste products (Illinois EPA, July 2002). Individual states have decision making authority on granting and denying such a request submitted under the permit requirements where decisions would be made on a case by case basis. Therefore, if "no exposure" requirements were denied by the state or failed to achieve by the operator, the facility owner or the operator would be required to immediately apply for a NPDES stormwater permit to be in compliance with the regulations.

The Phase II stormwater program automatically applies to all construction activities that would disturb one to five acres of land. These smaller sites need to apply for and receive an NPDES permit prior to beginning any earth moving activities. Typically, sites between one and five acres tend to be residential developments. In order to comply with the Phase II stormwater program requirements, all owners or operators would be required to follow the following steps:

- Determine who is considered an "operator" and identify their responsibilities under the Phase II requirements. An operator would be the owner or party who would maintain overall operational control of construction plans, specifications, and the ability to change plan specifications.
- Complete and submit a notice of intent (NOI) to the state EPA division of water pollution control prior to any earth disturbing activities.
- Develop a stormwater pollution prevention plan (SWPPP) prior to beginning construction. The SWPPP will need to be available on site and accessible to all parties concerned.
- Implement the SWPPP and comply with Best Management Practices (BMP). Complete required inspection reports and make it accessible to all parties concerned.
- Complete final site stabilization upon the completion of construction.
- Complete and submit a notice of termination (NOT) to state EPA division of water pollution control.

In accordance with the EPA, site stabilization is accomplished when all earth moving activities have been completed and uniform perennial vegetation (with a density of 70%) has been established and covered the unpaved areas of the land, excluding any buildings. For residential construction, stabilization is considered complete upon temporary stabilization, and after the homeowner has been informed that final stabilization is required upon assuming control of the property.

2.8 What is a Stormwater Pollution Prevention Plan (SWPPP)?

Developing and adhering to a SWPPP is a pollution prevention plan requirement for owners and operators of industrial facilities to address stormwater flow through their property. Under the NPDES permit criteria, the SWPPP is also a regulatory requirement. A SWPPP addresses stormwater runoff in the form of rain or snowmelt that does not immediately infiltrate into the ground and flows through natural or man-made storage or conveyance systems (U.S. EPA 2009). Under a general permit criterion for industrial activities and within the NPDES permit, a SWPPP is required to comply with any special eligibility provisions and the submission of a NOI.

A SWPPP is a site specific document that is developed to prevent pollutants from making their way into stormwater runoff. Under the NPDES permit criteria, the SWPPP is a living document and, therefore, needs to be updated when site conditions change.

According to EPA guidelines, a SWPPP must contain the following information:

- Detailed site description
- Potential sources of pollution on site that may affect the quality of stormwater discharge from the property
- Appropriate BMPs that would include erosion and sedimentation control and stormwater management controls that would be utilized to minimize discharge of pollutants from the property
- Detailed description of both
    - the steps taken to prevent and control pollutants in stormwater discharge from the property
    - inspection records of all disturbed areas, undisturbed areas, and maintenance activities to control effective operational success related to pollutant discharge and migration through stormwater

To obtain state coverage under the general permit criteria, a NOI must be submitted with the SWPPP. The submission of the NOI form to the permitting authority indicates that the site/operator has met the eligibility requirements for coverage under the permit. In summary, an extensive amount of regulatory detail is required to apply for and obtain a SWPPP. Unfortunately, the SWPPP fails to guarantee protection to water bodies because of a lack of monitoring. The SWPPP is supposed to be self-monitoring, but most developers do not monitor themselves (Kwan, 2001).

2.9 Factors that Affect Public Attitudes Towards Environmental Volunteerism

Since the 1960s researchers have focused on the motivations of individuals that engage in pro-environmental behavior (Kollmuss & Agyeman, 2002, p. 240). Despite numerous research efforts, scientists have yet to find a common ground from which to develop an integrated understanding of environmental behavior (Turaga et al., 2010, p. 211). Pro-environmental behaviors were once thought to be driven by motivations that transcended self-interest (Schwartz, 1973, 1977). Recent literature suggests that pro-environmental behavior consists of a number of differentiated actions that can be divided into classes (McDougle et al., 2011). Stern (2000) identified the following four behavioral classes: (1) environmental activism involving committed activist behavior, (2) non-activist behaviors in the public sphere involving activities demonstrating an individual's level of civic engagement, (3) private-sphere environmentalism involving daily personal actions undertaken with consideration for the environment, and (4) other environmentally significant behaviors involving actions intended to influence the environmental behavior of businesses and corporations.

The general public is becoming increasingly supportive of environmental issues, as suggested by the immense popularity of Earth Day and sincere concern for the effects of environmental disasters such as the Exxon Valdes and BP oil spills (McKay, 2010). Today, citizens value green facilities and employers who engage in environmentally responsible behavior (Hewlett et al., 2009). There is a strong focus on pro-environment activities such as recycling, waste reduction, ride sharing, and use of public transportation (Vining & Ebreo, 1992; Kaiser et al., 1999).

Many environmental problems may benefit from organized community-oriented participation. It is important to understand the incentives that encourage the willingness and motivations behind such public participation. Conrad et al., (2011) has identified a need to understand how best to motivate citizen scientists to monitor local ecosystems. Few studies have examined why citizens volunteer or the factors that motivate them to participate in environmental programs (McDougle et al., 2011).

Donald (1997) found that several attributes of an organization, including the size, focus, and public perception of the organization, impact on how actively a member participates. Pelletier and Sharp (2008) identified that the framing of a message plays a role in the level of motivation of a targeted population. An appropriately structured message can increase volunteer level.

The relevant literature has further identified multiple factors that influence public participation in environmental action. Emotional factors such as sadness have a negative influence on altruism and willingness to contribute (Underwood et al., 1976). As age increases, support for environmental protection increases (Lowe et al., 1980). Citizens favor stricter local environmental regulations and are more likely to become involved in local environmental problems (Rohrschneider, 1988). Social organizations have been shown to elicit positive behavioral commitment towards environmental protection (Manzo and Weinstein, 1987). Gender also has an influence on environmental volunteerism as related to the subject matter at hand. Women were more willing to volunteer if the activity was related to a local issue (Schahn and Holzer, 1990). Finally, Innes and Booher (2004) have identified that public participation is enhanced through a multi-way interaction in which citizens and policy makers engage in formal and informal dialog.

2.10 Summary of Literature

The literature review suggests that the motivating factors behind the public's willingness to volunteer are not well understood. Construction sedimentation monitoring is ideally suited to public involvement due to the geographically dispersed nature of the sites, the minimal amount of technical training needed, the significant environmental damage caused by a poorly constructed or maintained system, and the lack of adequate government personnel to sufficiently monitor construction sites.

The following findings from the literature review form the basis for my research:

- Stormwater runoff contributes significantly to water quality problems in surface water bodies
- The geographically dispersed nature of construction sites, coupled with limited local government budgets, limits the inspection and monitoring of stormwater BMPs
- Public participation in construction site monitoring has several advantages

- The factors that affect the willingness of the public to participate in stormwater quality monitoring are not well understood
- Research shows that the stated willingness to contribute and the actual willingness to contribute in environmental efforts are not different

CHAPTER 3 - HYPOTHESIS AND METHODOLOGY

3.1 Survey Considerations

The review of literature suggested a need to explore the factors that contribute to the willingness of the public to participate in environmental problem solving. Stormwater management BMPs at construction sites provide an ideal opportunity for researching this sort of public participation because construction sites are geographically near places of residence and work, budget cuts have reduced the state workforces available to monitor sites, and there is little to no information regarding the effectiveness of silt fences for controlling sediment. According to Babbie (1995), a survey is viewed as the most appropriate means by which a complete picture of the willingness to participate can be determined. Fairfax County was selected as the research location due to the county being the most populous and diverse jurisdiction in the Commonwealth of Virginia. Fairfax County comprises 13.5% of Virginia's population. It is also the most populous jurisdiction of the Washington, DC metropolitan area with a 13.1% combined statistical area population.

A questionnaire was developed and personally administered to help understand the willingness of the public to participate in data collection efforts related to sedimentation associated with construction sites. The questionnaire was selected in lieu of an interview. According to Dillman et al. (2009), phone interviews and face-to-face interviews have been shown to adversely impact the quality of the data being collected. This is due to a number of factors. When interviewed face-to-face, the subjects may not feel comfortable with providing honest and complete answers. Attempts to conduct phone interviews can result in poor response rates due to call screening. Also, a significant portion of the population has cell phones as opposed to land lines; cell phone numbers are typically unlisted. A personally-administered questionnaire provides the best instrument for collecting data. The subject can physically see and communicate with the surveyor. This conveys the message that the questionnaire is important due to time dedicated by the surveyor (Dillman et al., 2009).

Dillman et al. (2009) notes that good survey results depend on highly detailed procedures for interaction with the subjects. The survey was designed based on Dillman's (1978) Total Design Method to help maximize response rates and utility. The following considerations were factored into the survey tool:

- Salience of the content of the questionnaire to respondents
- Length of the questionnaire
- Nature of cover and endorsement letter
- Timing of survey
- Procedures for contacting subjects
- Follow-up procedures

3.2 Locality

The research design consists of a survey of representative citizens from Fairfax County, Virginia. Fairfax County has 30 watersheds that ultimately drain into the Potomac River and into the Chesapeake Bay. The watersheds of Fairfax County are shown in Figure 5.

Figure 5: Watersheds of Fairfax County
(County of Fairfax, Virginia, 2013)

Public participation in environmental matters is greatest at the local level where there is a better understanding of local needs and concerns (Rohrschneider, 1988; Barr, 2003; Abel, 1998; Abel et al., 1998). Therefore, individuals who work, live, or attend school in Fairfax County were selected for the survey.

3.3 Research Objective and Hypothesis

The objective of this research is to study the effects of various factors on an individual's willingness to participate in stormwater data collection at construction sites in Northern Virginia. The research investigated the impact of various combinations of the individual training methods described below.

1. This was the control group. No information was provided.
2. A PowerPoint presentation on the adverse effects of sedimentation increased understanding of the sedimentation problem caused by construction related activities.
3. A "hands on" experiment to better understand the siltation process.
4. A commitment by public officials to incorporate participants' findings into stormwater BMPs provides an incentive to participate.

A detailed description of the treatments comprised of these training approaches is provided as Table 1.

Table 1: Training Approaches Used in Each Treatment

Treatment Index number	Training Approach			
	None	PowerPoint	Hands-on	VDEQ commitment
1	X			
2		X		
3		X	X	
4		X	X	X

For treatment 1, the survey was administered only once. For treatments 2, 3, and 4, the survey was administered before and after the treatment. My hypotheses are as follows:

1. Willingness of local citizens and the time they are willing to volunteer in construction site data collection will increase as they are educated using the following means ("treatments")
    a. PowerPoint on sedimentation problems – construction activities
    b. "Hands on" demonstration and interaction
    c. Commitment by public officials to incorporate findings into stormwater best management practices (BMPs)
2. As the citizens are exposed to more treatments, their willingness and time to volunteer will increase
3. As the local citizens' knowledge of stormwater pollution and protection increases, so does their willingness and time to volunteer

The treatment provided is the independent variable which will influence the intermediate variable: knowledge of the issue. The willingness to participate is also compared for different personal factors[1] such as age, sex, level of education, and type of organizational entity. Lastly, I investigate the relationship between willingness to participate and amount of time that a person is willing to participate.

[1] Although these personal factors were noted as part of the survey, they do not represent an independent variable in my formal hypothesis. Calculations were made to determine if correlation exists between these personal factors and the willingness to participate.

As discussed in Chapter 2, research has shown that participatory mechanisms that involve direct and meaningful processes result in effective environmental policies. The results of this research will contribute to the body of knowledge related to stakeholder engagement and may be used to better attract and engage citizens in volunteer efforts to collect environmental protection data.

3.4 Survey Methodology

The data collection methodology was based on the following assumptions that were verified through the literature research:

1. Public participation in environmental data collection has significant advantages over non-participation
2. Stormwater runoff contributes significantly to water quality problems in surface water bodies
3. The factors that affect the willingness of the public to participate in stormwater quality data collection are not well understood
4. A personally administered survey is an effective instrument for measuring the variables of interest

It is imperative that the right research methods are employed to help understand the accuracy and validity of subjects' motivations and willingness to participate (Glesne, 1992; Marshall et al., 2010). Quantitative research tends to focus on the data and make direct conclusions related to the issue. Human understanding, interaction, and experiences within the environment are critical aspects that help explain why decisions are made by different individuals in select ways (Liu and Matthews, 2005). A 5-point Likert scale was selected to measure the dependent variable, namely willingness to participate. A Likert scale offers the advantage over a simple yes/no answer in that it provides information on the degree of opinion. Willingness to participate is not an absolute yes/no variable. It can be measured at various levels depending on the topic and interests of the individual. Thus, the Likert scale provided the opportunity to study the degree of willingness to participate. The willingness to participate was measured according to the following scale:

1 Not willing

2 A little willing

3 Moderately willing

4 Willing

5 Strongly willing

To measure the effect of various communication techniques on the willingness to participate in a stormwater collection effort at a construction site, survey participants were asked to rate their willingness to participate before and after the training technique. Each group of participants was provided similar information; however, the information was presented in a different manner for different groups. In one case, a PowerPoint presentation on stormwater runoff from construction sites was used to instruct the audience. The second technique involved both a PowerPoint presentation and a hands-on demonstration to illustrate how water quality is impacted by different ground covers and siltation fences. Lastly, the PowerPoint presentation was modified to include a statement of commitment from the Virginia Department of Environmental Quality that the collected data would be used to improve the regulation of stormwater quality. Also, the amount of time that an individual was willing to volunteer (hours per month) was measured before and after the treatment technique was applied.

3.5 Independent Variables

To better understand the factors surrounding willingness to participate (the dependent variable), a treatment was selected and applied to the survey group. An intermediate variable was the knowledge gained from the treatment. The individual treatments were described in section 3.3 and listed as Table 1 within Section 3.3. The survey included basic questions regarding stormwater runoff from construction sites, stormwater laws and regulations, and protection devices such as silt fences. The answers to 14 questions on these topics were collected before and after the treatment, graded, and scored on a number correct out of 14. The improvement in knowledge as measured by the improvement in the number correct was an intermediate dependent variable. It is hypothesized that the willingness to participate will increase as a result of exposure to any of the treatments as well as an increase in knowledge (refer to Table 1 for an explanation of each treatment).

3.6 Survey Instrument

The survey instrument consisted of 22 multiple-choice questions divided into four sections. Dillman's Total Design Method (1978) was followed to maximize response rates and utility. The survey began with general questions and became progressively more detailed. For treatment 1, the questionnaire was given once since so training was provided. For the rest of the treatments, the same questionnaire was administered to the subjects twice: prior to any influence by the treatment (the independent variable) and after the introduction of the treatment. This was done to measure the change in the willingness to volunteer (dependent variable) and knowledge (intermediate variable).

The complete questionnaire is provided in the appendix. Section one consisted of a total of seven general questions related to stormwater, silt fences and environmental policy. Section two consisted of four questions related the subjects' willingness to participate. This section questioned survey participants on their past experience with participation, types of previous participation, and the amount of time they would be inclined to spend on data collection and monitoring of stormwater sedimentation control devices.
Section three consisted of seven questions which focused on very specific knowledge and experience related to Virginia silt fence regulations. People who have this knowledge would be able to identify deficiencies with silt fences during citizen inspections.
Section four asked four questions regarding personal characteristics of the survey participant including: the distance of their residence from a water body, gender, age range, and level of education.

3.7 Sampling Frame

The sampling consisted of administering the questionnaire, after presenting a treatment (see Table 1 for the list of treatments), to various organizational groups in Fairfax County. The respondents were comprised of individuals from George Mason University graduate and undergraduate classes, Northern Virginia Community College classes, employees of the Metropolitan Washington Airports Authority at Regan National Airport and Washington Dulles International Airport, the Woodstone Homeowner Association (located in Alexandria Virginia adjacent to Huntly Meadows Park and Barnyard Run), Friends of Accotink Creek, and Friends of Accotink Park. Survey data was collected from the above mentioned groups before and after a randomly selected treatment.

Treatment 1 was the control group. No training was provided and the survey was administered only once. This group of citizens based their responses on personal knowledge of the adverse effects of sedimentation and silt fence violations.

In treatment 2, subjects were first provided the survey. Next, they were provided with a detailed PowerPoint presentation on the detrimental effects on sedimentation, silt fense control devices, and the adverse effects of sedimentation on water quality. Immediately following the presetation, the same survey was adminstered.

Treatment 3 was identical to treatment 2 with one addition:a hands on demonstration showing rates of sediment erosion with different land cover. The hands on demonstration consisted of multiple 2-liter soda bottles that were laid horizontally, cut 1/3 from the top nd filled with different soil cover materials (simulating various insitu construction site conditions). The bottles were then filled with water (approximately 1 cup to each cover materials simulating a rain event) to illustrate the quantity and quality of stormwater for various soil cover conditions. Cups were placed by the mouth of each bottle to collect and show the rates of water infilitration and sediment erosion. Subjects were allowed to visually observe and participate in (if necessary) the hands-on demonstration. Subsequently, the subjects were evaluated via the same quesitonaire. Figure 6 depicts the hands-on demonstration instrument prior to the additon of any liquid. Figure 7 depicts the hands on demonstration instrument after water was poured into the bottles.

Figure 6: Hands on Demonstration Instrument Before Addition of Water

Figure 7: “Hands on” Demonstration Instrument After Addition of Water

Treatment **four** was identical to the third treatment with one additon: a statement from the Virginia Department of Environmental Quality (VDEQ) related to the importance of citizen participation and how data collected by ctizen volunteers could be used to improve the program and minimize sediment erosion violations from construction sites. Afterwards, the subjects were evaluated via the same questionaire administered at the beginning.

CHAPTER 4 – SURVEY RESULTS

4.1 Response Rate

The overall response rate for the survey was 100%. Participation was voluntary and participants were informed ahead of time that there would be no direct benefit for participating or penalty for not participating in the survey. All potential participants opted to participate in the survey.

4.2 Participation

A total of 212 participants took part in the survey. Participants were from Northern Virginia Community College (NVCC) – Alexandria campus, George Mason University (GMU) – Fairfax campus, Metropolitan Washington Airports Authority (MWAA) – Ronald Reagan Washington National Airport (DCA) and Dulles International Airport (IAD), Friends of Accotink Creek (FAC), Friends of Accotink Park (FAP), and the Woodstone Homeowner Association (WHOA) – Alexandria, Virginia. A summary of the survey participant information by organization is provided in Table 2.

The participants from NVCC represented three classes; two of which were introductory biology classes and one was an introductory environmental science class. At GMU, four classes participated in the survey. One 400 level biology, two 400 level environmental science, and one graduate level water engineering class were represented. At MWAA, there were three groups; one was from Dulles Airport and two were from Reagan Airport.

All of the participants from MWAA were employees in the facilities and engineering group. Friends of Accotink Creek and Friends of Accotink Park comprised the friends group.

Table 2: Participant Information

Organizational Group	**Number of Participants**	**Participant Percentage**
Northern Virginia Community College	42	19.8%
George Mason University	64	30.2%
Metropolitan Washington Airports Authority	79	37.3%
Accotink Friends Group	18	8.5%
Woodstone HOA	9	4.2%
Average	**42.4**	**N/A**
Total	**212**	**100%**

Table 3: Treatment Information

Treatment number and description	**Number of Participants**	**Participant Percentage**
(1) Control Group	25	11.8%
(2) PowerPoint presentation only	42	19.8%
(3) PowerPoint presentation and hands-on demonstration	68	32.1%
(4) PowerPoint presentation, hands on demonstration and VDEQ input	77	36.3%
Average	**53**	**N/A**
Total	**212**	**100%**

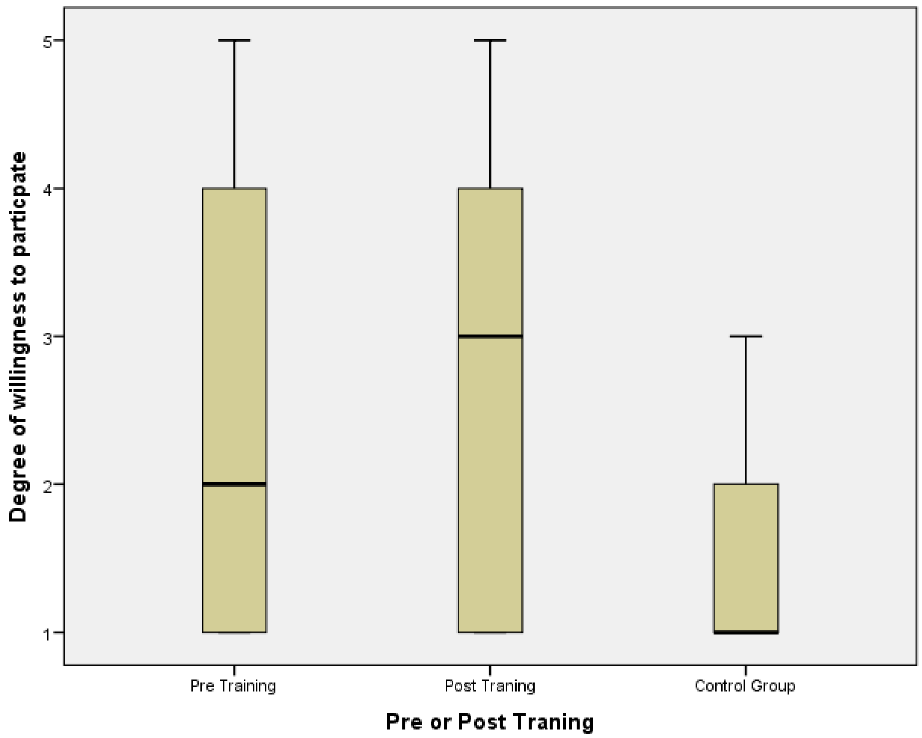
A summary of participants by treatment is provided in Table 3. Treatment 1 was applied to a group from the MWAA. The control group consisted of 25 participants. The makeup of this group was similar to the makeup of the rest of the MWAA participants in their background and other characteristics The PowerPoint presentation (treatment 2) was used at MWAA, GMU (undergraduate), and NVCC. Treatment 3 was applied to MWAA, NVCC, GMU (undergraduates), and the Accotink Friends. Treatment 4 was used at MWAA, GMU (undergraduates), GMU (graduate students), Accotink Friends and the Woodstone HOA. An attempt was made to spread the treatments across the different groups and to equalize the number of participants represented by each treatment; however, these aspects were extremely difficult to control. The number of participants depended on the attendance at each class or meeting. The type of treatment applied to each group was decided upon in advance to minimize any potential bias.

4.3 Willingness to Participate

The primary objective of this research was to investigate the effect of various treatments on the willingness to participate, along with the number of hours the individual was willing to volunteer. The effectiveness of the various treatments was measured in terms of the change in willingness and number of hours. Secondly, the relationship between knowledge (as measured by the number of correct answers pre- and post-treatment) and the willingness to participate and the number of hours willing to volunteer (pre- and post-treatment) was studied. Lastly, the willingness of individuals to participate was analyzed by organizational group, age, education, and gender. Please refer to Chapter 5 for details of the statistical analysis performed for the survey data.

The box-and-whisker plot shown in Figure 8 summarizes the results for all 212 participants regardless of type of treatment. The degree of willingness to participate ranged from 1 (unwilling) to 5 (strongly willing). Following a treatment, the median value for the degree of willingness to participate increased by 1 unit. The 25^{th} and 75^{th} percentiles were 1 and 4 respectively for both the pre- and post-treatment. It is also interesting to note that the willingness of the control group to participate was much lower than any of the other groups. The median value for the control group was 1 (unwilling to participate) and the 25th and 75th percentiles were 1 and 2 respectively.

Figure 8: Willingness to Participate, Pre- and Post- treatment Comparison



4.3.1 Treatment Effects on Willingness to Participate

Table 4 presents the results of the survey for the various treatments. Sixteen survey sessions were held during the spring 2013 semester. One control group took only the survey but did not receive any training. Four groups were provided the PowerPoint presentation only. Five groups received training consisting of the PowerPoint presentation and a hands-on demonstration. Six groups received training consisting of the PowerPoint presentation, a hands-on demonstration, and an endorsement from VDEQ.

The difference between the pre and post rate of willingness to volunteer for all experiment groups had a positive value, with the exception of GMU graduate students. The GMU graduate students had a negative rate for the difference between the pre and post values: - 0.33. The highest difference pre and post experiment was observed for the MWAA group of subjects that were administered only the power point presentation: 0.70. The largest difference between the pre and post experimental group difference was observed for the PowerPoint presentation group that had an average increase of 0.78.

Table 4: Willingness to Volunteer by Treatment

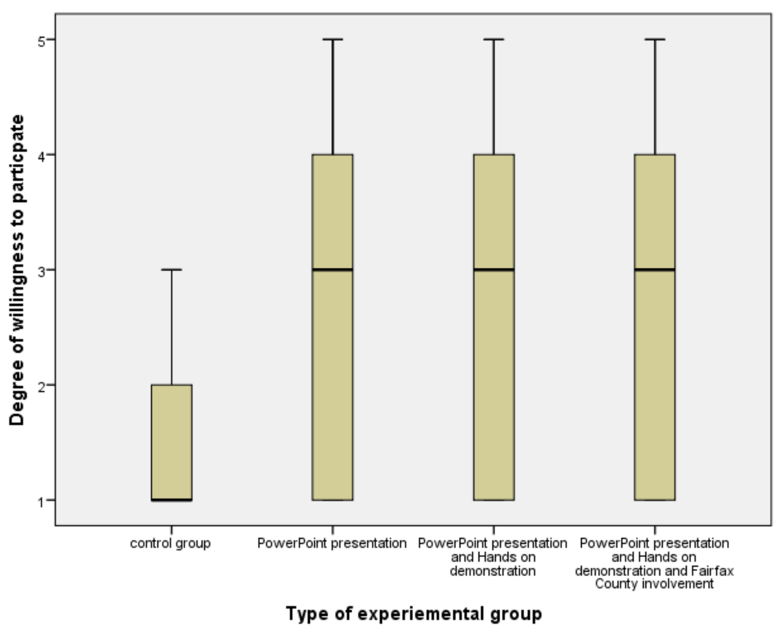
Treatment	Number of participants by organization						Willingness to Volunteer Average Survey Result		
	MWAA	NVCC	GMU Undergrad	GMU Grad	Friends Group	HOA	Pre treatment	Post treatment	Difference
1	25						1.21		
2	10						1.70	2.40	+0.70
2		20					2.90	3.35	+0.45
2			12				2.00	3.42	+1.42
2 (sub-total)	42						2.36	3.14	+0.78
3	22						2.55	2.68	+0.13
3		22					2.95	3.00	+0.05
3			13				1.46	1.77	+0.31
3					11		3.27	3.45	+0.18
3 (sub-total)	68						2.59	2.74	+0.15
4	22						2.68	2.82	+0.14
4			18				2.17	2.33	+0.16
4					7		3.71	3.71	0
4						9	2.33	2.67	+0.34
4				21			2.90	2.57	-0.33
4 (sub-total)	77						2.59	2.75	+0.16

Treatment 1- control group
Treatment 2 - PP: PowerPoint presentation
Treatment 3 - HO: Hands-on demonstration
Treatment 4 - VDEQ: VDEQ endorsement

Figure 9 shows a box and whisker plot for the degree of willingness to participate to identify silt fence and sediment control violations; the willingness to participate for different types of experimental groups had a range from 1 to 5. The control group had a median value of 1. For the rest of the experiment groups (group 2, 3 and 4), the median value was 2.

The 25th to 75th percentile for the control group ranged from 1 to 2, while for the rest of the experiment groups (group 2, 3 and 4), the median value ranged from 1 to 4. Therefore, for all types of experimental groups, 50% of the data for willingness to participate ranged from 1 to 4. On the other hand, the median value for the control group was 1 and 50% of this data ranged from 1 to 2 for the degree of willingness to participate to identify silt fence and sediment control violations.

Figure 9 – Degree of Willingness to Participate by Treatment



4.3.2 Relationship Between Knowledge and Willingness to Participate

The participants increase in knowledge was measured by the answers to fourteen questions on the survey that related to stormwater management. Table 5 summarizes the results of the survey for these questions by organizational group. As shown in Table 6, after the treatment, the average number of correct responses increased for each of the fifteen groups shown. The median number of correct scores increased from 5.41 to 8.56 correct answers (out of 14 questions). Figure 10 illustrates the relationship between knowledge (i.e. the number of correct answers) and willingness to participate. In general, the trend, from pre- to post-treatment, shows an increase in willingness to participate as the average score values increase.

Table 5: Summary Participant Survey Results

Organizational Group	Pre-treatment Number Correct	Percent Correct (%)	Post-treatment Number Correct	Percent Correct (%)	Number Correct Difference	Percent Difference (%)
Northern Virginia Community College	5.10	36.7	8.54	61.0	+3.44	+24.3
George Mason University	4.10	29.3	7.56	54.0	+3.46	+24.7
Metropolitan Washington Airports Authority (DCA and IAD)	5.57	39.8	7.78	55.6	+2.21	+15.8
Friends Group (FAC and FAP)	9.20	65.7	11.50	82.1	+2.30	+16.4
Homeowner Association Group (WHOA)	6.67	47.6	8.56	61.1	+1.89	+13.5
Average	**6.13**	**43.82**	**8.79**	**62.76**	**+2.66**	**+18.94**

Table 6: Average Knowledge Results by Treatment

Treatment	Number of participants by organization						Average Correct Responses (out of 14)	
	MWAA	NVCC	GMU Undergrad	GMU Grad	Friends Group	HOA	Pre treatment	Post treatment
1	10						5.30	6.20
2		20					5.36	8.88
2			12				4.83	5.17
2 (sub-total)	42						5.16	6.75
3	22						6.00	8.95
3		22					4.59	7.86
3			13				2.77	7.77
3					11		12.18	12.18
3 (sub-total)	68						6.38	9.18
4	22						5.41	8.18
4			18				3.17	7.06
4					7		6.29	10.86
4						9	6.67	8.56
4				21			5.62	10.24
4 (sub-total)	77						5.43	8.98

Treatment 1- control group
Treatment 2 - PP: PowerPoint presentation
Treatment 3 - HO: Hands-on demonstration
Treatment 4 – PP, HO and VDEQ endorsement

Table 7 summarizes the improvement in knowledge by treatment. The percent improvement increases with each additional treatment.

Figure 10 - Willingness to Participate as a Function of Knowledge

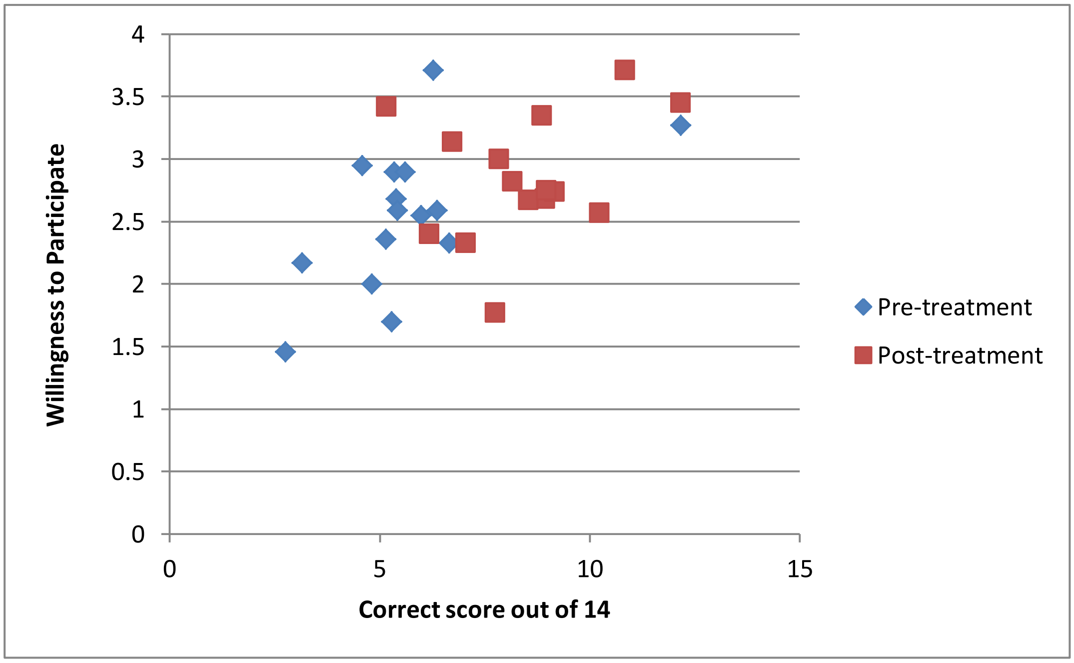


Table 7: Increase in Average Score by Treatment

Treatment	Pre Survey Number Correct	Percent Correct (%)	Post Survey Number Correct	Percent Correct (%)	Number Correct Difference	Percent Difference (%)	p
1 – Control	2.76	19.7	N/A	N/A	N/A	N/A	NA
2 - PowerPoint presentation only	5.21	37.2	7.28	52.0	+2.07	+14.8	0.00
3 - PowerPoint presentation and hands on demonstration	6.38	45.6	9.19	65.6	+2.81	+20.0	0.12
4 -PowerPoint presentation, hands on demonstration and VDEQ input	5.43	38.8	8.98	64.1	+3.55	+25.3	0.34
Average	**4.94**	**35.32**	**8.48**	**60.57**	**+2.81**	**+20.0**	**0.00**

4.3.3 Willingness to Participate by Individual Characteristics

Table 8 summarizes the degree of willingness to volunteer by organizational group. The pre- and post-treatment values increased for all organizational groups, with the exception of the GMU graduate class.

Table 8: Summary Willingness to Volunteer by Organization

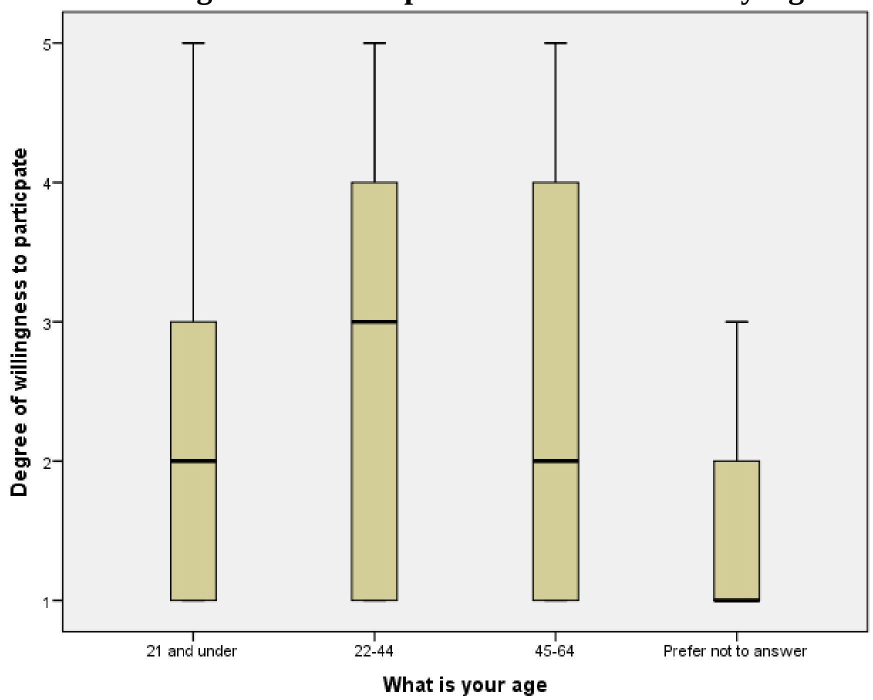
Organization	Willingness to Volunteer			
	N	**Pre**	**Post**	**Difference**
MWAA	54	2.45	2.69	+0.24
NVCC	42	2.93	3.17	+0.24
GMU_U	43	1.91	2.47	+0.56
GMU_G	21	2.90	2.57	-0.33
Friends Group	18	3.44	3.56	+0.12
HOA	9	2.33	2.67	+0.34
Average	**31**	**2.66**	**2.86**	**+0.20**

Table 9 summarizes the degree of willingness to volunteer by age group. The willingness to volunteer increased post-treatment for individuals less than 21 years of age and for individuals between 45 and 64 years in age. The greatest increase was noted for the individuals less than 21 years of age and for individuals between 45 and 64 years of age. The box-and-whisker plot for each age group is shown in Figure 11.

Table 9: Willingness to Volunteer by Age Group

Age	Willingness to Volunteer			
	N	Pre	Post	Difference
<=21	85	2.16	2.62	+0.46
22-44	76	2.92	2.92	0
45-64	34	3.19	3.65	+0.46
None provided	4	1.25	1.25	0
Average	**50**	**2.38**	**2.61**	**+0.23**

Figure 11 – Willingness to Participate Box-and-Whisker by Age Group



As shown in the box-and-whisker plot in Figure 12, and by the information in Table 10, males indicated a slightly lower willingness to volunteer than females. On average, the willingness to volunteer for men increased by 0.24 following all treatments. Similarly, the willingness value increased by 0.21 for female subjects. Females were also more likely to volunteer as compared to their male counterparts.

Figure 12 – Degree of Willingness to Participate (Post-treatment) by Gender

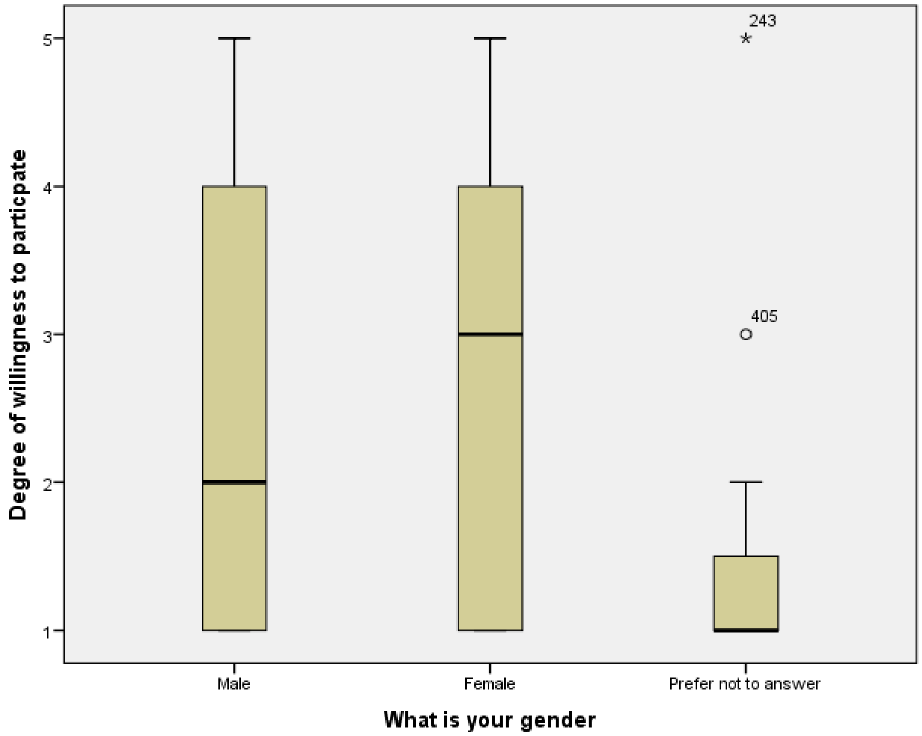


Table 10: Summary Willingness to Volunteer by Gender

Gender	Willingness to Volunteer			
	N	Pre	Post	Difference
M	116	2.57	2.81	+0.24
F	65	2.68	2.89	+0.21
None provided	4	1.50	2.00	+0.50
Average	**62**	**2.25**	**2.57**	**+0.32**

Table 11 summarizes the degree of willingness to volunteer by level of education. The difference between the pre and post rate of willingness to volunteer for all organizational groups surveyed had a positive value, with the exception of individuals with graduate school education. The graduate school subjects had a negative value difference between the pre and post assessment of -0.16 for the willingness to volunteer. The highest difference for the willingness to volunteer, pre and post experiment, was observed for subjects with some high school education: 2.00. It is observed that as the level of education increases, the willingness to volunteer decreases.

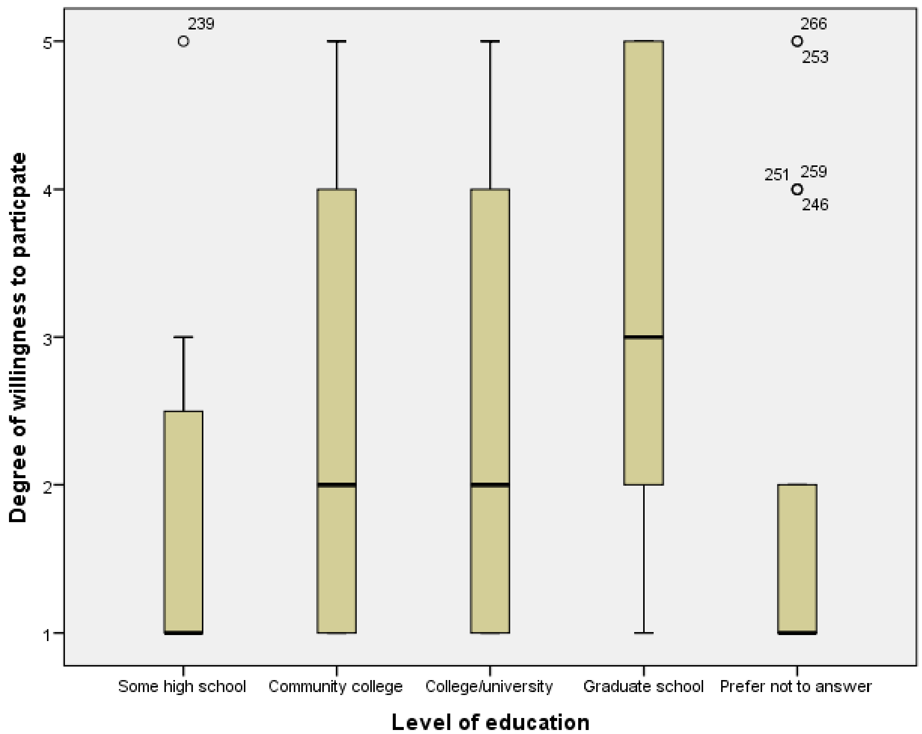
Table 11: Willingness to Volunteer by Education Level

Education	Willingness to Volunteer			
	N	**Pre**	**Post**	**Difference**
Some High School	2	1.00	3.00	+2.00
Community college	65	2.77	2.95	+0.32
College/University	81	2.33	2.70	+0.37
Graduate School	25	3.20	3.04	-0.16
Prefer not to answer	10	2.00	1.70	-0.30
Average	**37**	**2.26**	**2.68**	**+0.45**

The box-and-whisker plot in Figure 13 shows that the degree of willingness to participate to identify silt fence and sediment control violations, grouped by level of education, ranged from 1 to 5. Individuals with some high school education had a median value of 1, community college and college/university education had a median value of 2, and individuals with a graduate school education had a median value of 3.

The 25th to 75th percentile for individuals with some high school education ranged from 1 to 2.5. The 25th to 75th percentile for individuals with high school education and college/university ranged from 1 to 4. The 25th to 75th percentile for individuals with some graduate school education ranged from 2 to 5. Therefore, 50% of the data for willingness to participate ranged from 1 to 5.

Figure 13 - Willingness to Participate (Post-treatment) by Education Level



4.4 Volunteer Time

4.4.1 Relationship between Willingness to Volunteer and Volunteer Time

The box-and-whisker plots shown in Figure 14 for the amount of time willing to volunteer on a monthly basis were identical for the pre and post training, i.e. the 25th to 75th percentiles and the medians were identical. The median value was 2, while the 25th to 75th percentile ranged from 1 to 3. 50% of the data ranged from 1 to 3 for pre and post willingness to volunteer on a monthly basis. Outliers of the data for the control group consisted of sample numbers 187, 196, 206 and 277 and are identified in Figure 10.

Figure 14 – Amount of Time Willing to Volunteer Monthly by Training Group

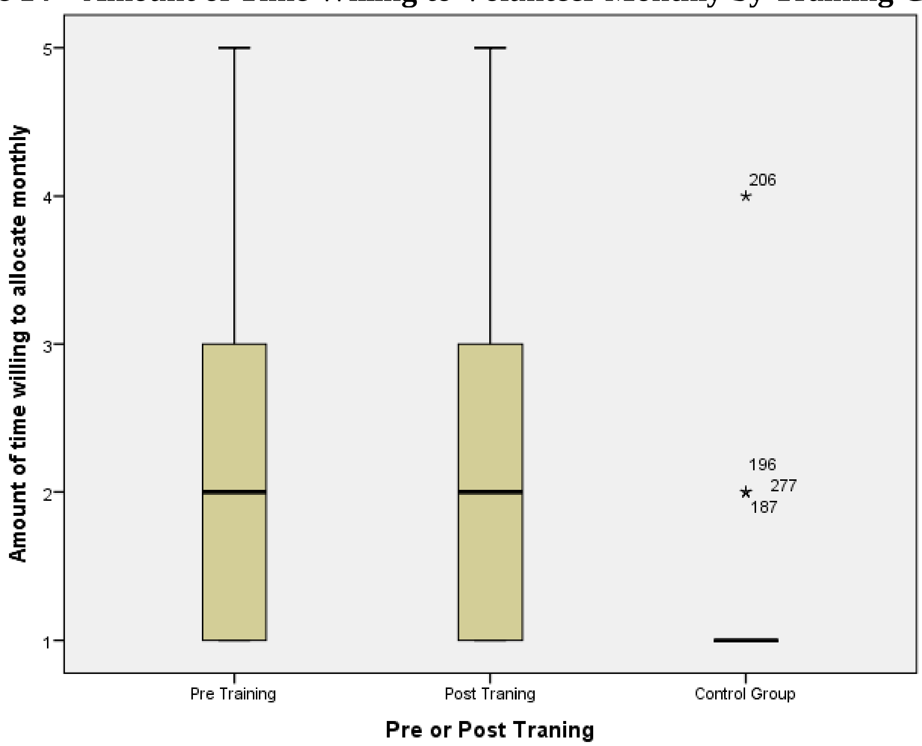


Table 12 is a summary of the total amount of time willing to volunteer on a monthly basis at construction sites. The difference between the pre and post rate of time willing to volunteer for all experiment groups had a positive value, with the exception of GMU graduate students, which showed a difference of - 0.05. The highest difference pre and post experiment was observed for the NVCC group of subjects that were administered only the power point presentation. The difference between the pre and post values for this group and experiment type was +0.75. The largest difference between the pre and post experimental group difference was observed for the PowerPoint presentation group that had an average difference of +0.88.

Table 12: Summary Time Willing to Volunteer by Experiment Type

Treatment	Group (N)						Time to Volunteer (hrs/mo) Average Survey Result		
	MWAA	NVCC	GMU _U	GMU_G	Friends Group	HOA	Pre	Post	Difference
1	25						1.15		
2	10						1.50	1.90	+0.40
2		20					2.10	2.85	+0.75
2			12				1.50	3.00	+1.50
2 (sub-total)	42						1.79	2.67	+0.88
3	22						2.23	2.32	+0.09
3		22					2.45	2.50	+0.05
3			13				1.31	1.54	+0.23
3					11		2.64	2.64	0
3 (sub-total)	68						2.19	2.28	+0.09
4	22						1.91	2.05	+0.14
4			18				1.94	2.06	+0.12
4					7		2.86	3.14	+0.28
4						9	1.89	2.11	+0.22
4				21			2.19	2.14	-0.05
4 (sub-total)	77						2.04	2.20	+0.16

Treatment 1- control group
Treatment 2 - PowerPoint presentation (PP)
Treatment 3 - Hands-on demonstration (HO)
Treatment 4 – PP, HO and VDEQ endorsement

As shown in the box-and-whisker plot in Figure 15, the amount of time participants were willing to volunteer on a monthly basis for the experimental groups ranged from 1 to 5. The control group had a median value of 1; for the rest of the experiment groups, the median value was 2. The 25th to 75th percentile for groups 2, 3 and 4 had a median value range from 1 to 3. The median value for the control group was 1.

Figure 15 – Amount of Time Willing to Volunteer Monthly by Treatment

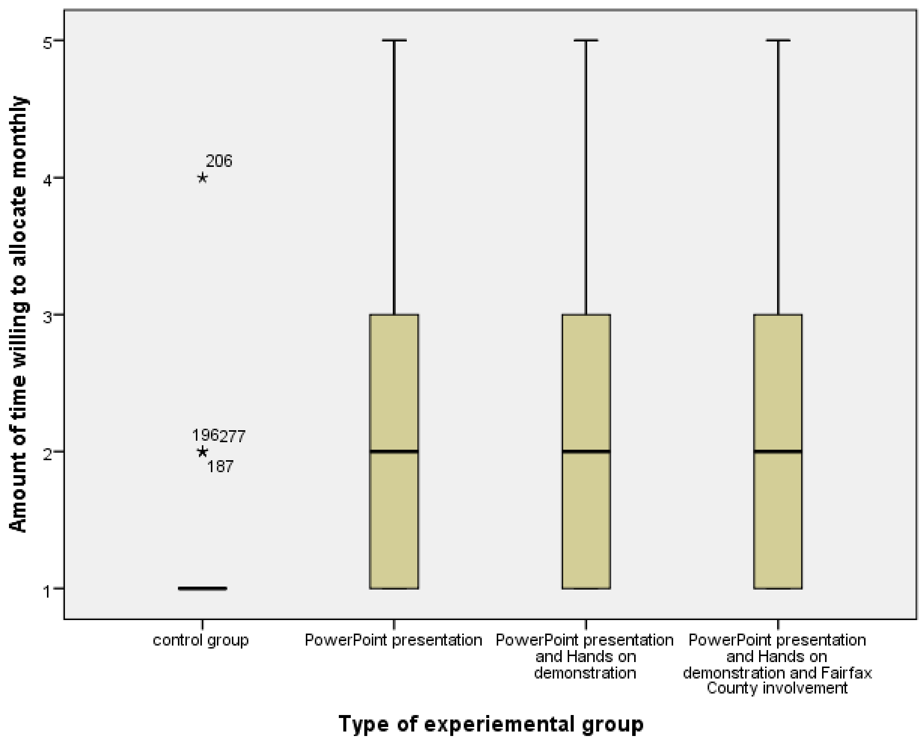


Table 13 summarizes the time willing to volunteer by organizational group. The difference between the pre and post time willing to volunteer for all treatments had a positive value with the exception of the GMU graduate students. The GMU graduate subjects had a negative difference between the pre and post assessment of - 0.05. The highest difference pre and post experiment was observed for the GMU undergraduate subjects with a difference of +0.53 for the willingness to volunteer.

Table 13: Summary Time Willing to Volunteer by Organization

Organization	Time to Volunteer (hrs/mo)			
	N	**Pre**	**Post**	**Difference**
MWAA	54	1.96	2.13	+0.17
NVCC	42	2.28	2.67	+0.38
GMU_U	43	1.63	2.16	+0.53
GMU_G	21	2.19	2.14	-0.05
Friends Group	18	2.72	2.83	+0.11
HOA	9	1.89	2.11	+0.22
Average	**31**	**2.11**	**2.34**	**+0.24**

The box-and-whisker plot in Figure 16 indicates the amount of time willing to volunteer on a monthly basis to inspect silt fences and sediment control devices by age group. The age group of 21 years of age and under had a median value of 1.5. The age groups of 22 to 44 years of age and 45 to 64 years of age had a median value of 2. The 25^{th} to 75^{th} percentiles ranged from 1 to 3 for the age groups 21 and under, 22 to 44 years of age, and 45 to 64 years of age.

Figure 16 – Amount of Time Willing to Volunteer Monthly by Age

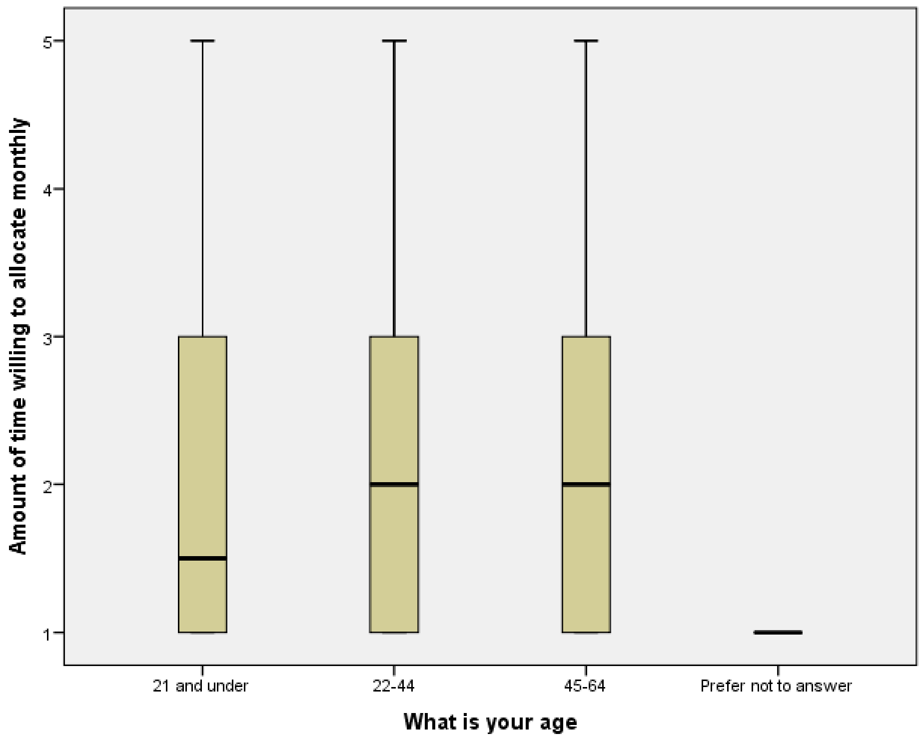


Table 14 summarizes the time willing to volunteer identified by age group. The difference between the pre and post time willing to volunteer for the groups containing individuals less than 21 years of age and individuals between 45 to 64 years in age surveyed had a positive value. The age range of 22 to 44 years had no difference for willingness to volunteer, pre and post training. The highest difference (+0.51) of pre and post experiment was for the age range between 45 and 64 years. It is observed that the age ranges of individuals 21 years and under and individuals 45 to 64 years of age were the most willing to allocate time to volunteer.

Table 14: Summary Time Willing to Volunteer by Age

Age	Time to Volunteer (hrs/mo)			
	N	Pre	Post	Difference
<=21	85	1.82	2.26	+0.44
22-44	76	2.37	2.37	0
45-64	34	2.09	2.60	+0.51
None provided	4	1.00	1.00	0
Average		1.82	2.06	+0.24

Figure 17 shows the box-and-whisker plot for the amount of time willing to volunteer on a monthly basis to inspect silt fence and sediment control devices by gender; the range was from 1 to 5 hours. Males and females had a median value of 2 hours. The 25th to 75th percentile for both sexes ranged from 1 to 3 hours. Samples 243 and 405 were outliers. Table 15 summarizes the time willing to volunteer identified by the gender of the individuals surveyed. The difference between the pre and post rate of time willing to volunteer for males was +0.24. The difference between the pre and post rate of time willing to volunteer for females was +0.32. It is observed that females were more likely to allocate time to volunteer when compared with males surveyed.

Figure 17 – Amount of Time Willing to Volunteer Monthly by Gender

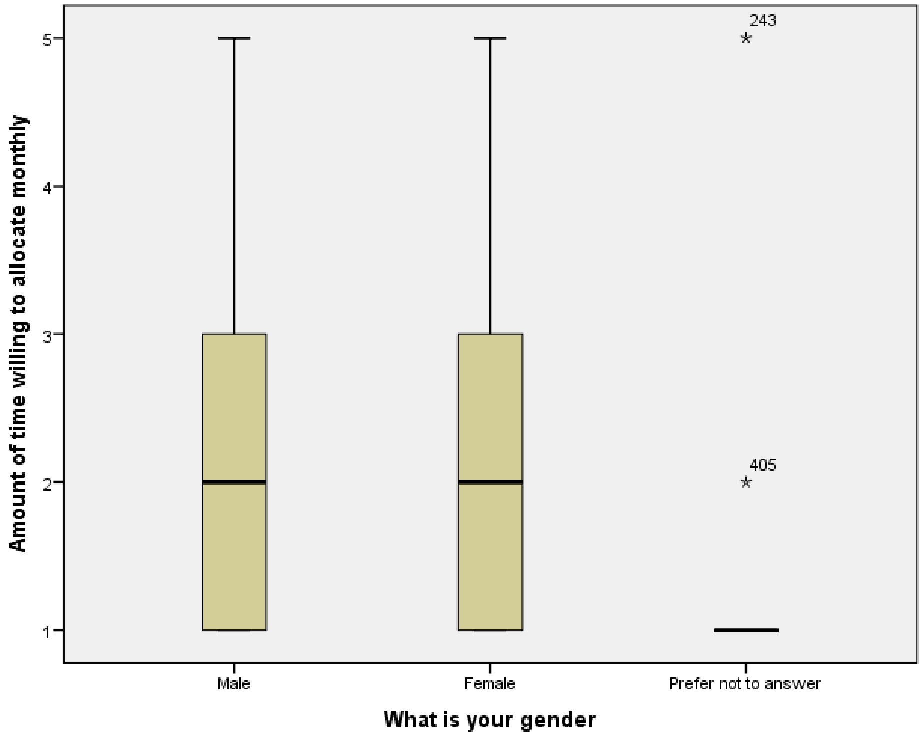


Table 15: Summary Time Willing to Volunteer by Gender

Gender	Time to Volunteer (hrs/mo)			
	N	Pre	Post	Difference
M	116	1.97	2.21	+0.24
F	65	2.26	2.58	+0.32
None provided	4	1.25	2.00	+0.75
Average		**1.83**	**2.26**	**+0.44**

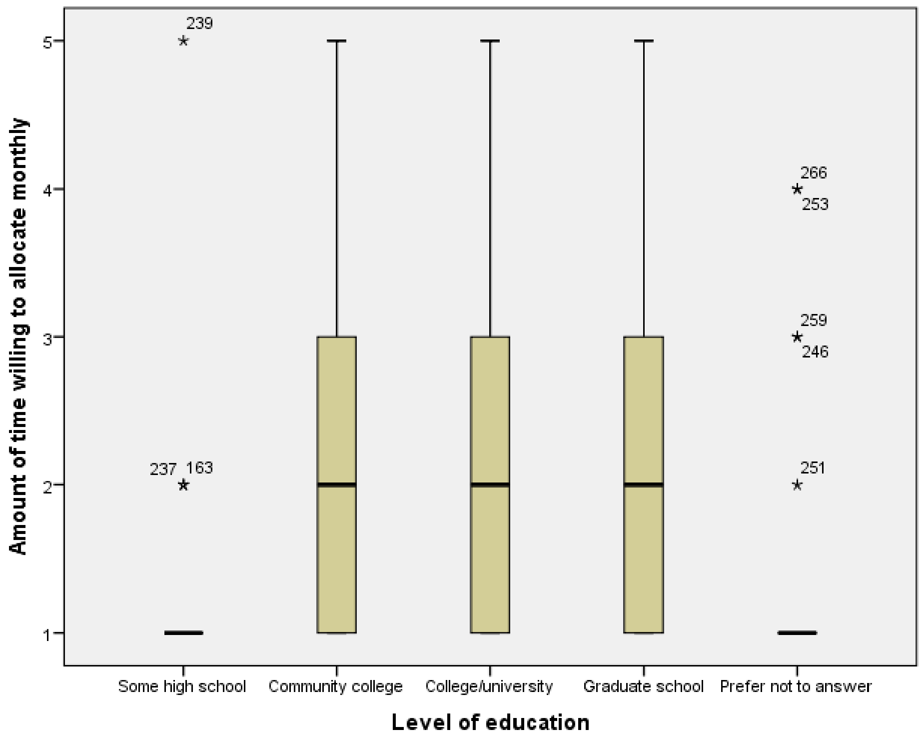
Table 16 summarizes the time willing to volunteer identified by level of education. The difference between the pre and post rate of time willing to volunteer for all organizational groups surveyed had a positive value. The highest difference pre and post experiment was observed for subjects with some high school education and had a difference of +1.00 for the time willing to volunteer. It is observed that as the level of education increases, the time willing to volunteer decreases.

Table 16: Summary Time Willing to Volunteer by Education

Education	Time to Volunteer (hrs/mo)			
	N	Pre	Post	Difference
Some High School	2	1.00	2.00	+1.00
High School	65	2.15	2.38	+0.23
College/University	81	1.93	2.32	+0.39
Graduate School	25	2.40	2.44	+0.04
Prefer not to answer	10	1.60	1.50	-0.10
Average	**37**	**1.82**	**2.13**	**+0.31**

The box-and-whisker plot in Figure 18 shows the amount of time willing to volunteer on a monthly basis by level of education ranges from 1 to 5 hours. Individuals for all educational levels had the identical median value of 2 hours. The 25th to 75th percentile for all educational levels ranged from 1 to 3 hours.

Figure 18 – Amount of Time Willing to Volunteer Monthly by Level of Education



CHAPTER 5 – STATISTICAL ANALYSIS

5.1 Statistical Analysis of Survey Results

IBM's SPSS(Statistical Analytical Software Package) 20.0 was utilized for the statistical analysis of the survey data. The dependent variables for the statistical analysis were willingness to participate and time to participate; knowledge was an intermediate variable. The independent variables were age and gender. The statistical method used to analyze the data was a one-tailed pairwise t-test. The p-value for the data was statistically significant if the value was less than 0.05 which indicated statistical significance. The groups were combined by treatment; other types of groupings would render the sample size too small, which would invalidate the statistical results. A coefficient of determination, R^2, was calculated for the data to identify how well the observed data outcomes are correlated to independent or intermediate variables. The higher the coefficient of determination, the better the fit of the data.

5.2 Analysis by Organization

Table 17 presents the analysis for the comparison of the pre and post treatment means for the dependent variables (willingness to participate, time to participate, and knowledge) by organizational group. The change in willingness to participate was statistically significant for GMU students ($p<0.05$). The change in time willing to allocate to inspect silt fences and stormwater deficiencies at construction sites was statistically significant for GMU students and for Woodstone HOA participants ($p<0.05$). Also. the change in knowledge related to sedimentation at construction sites and silt fences was statistically significant for all organizational participants ($p<0.05$).

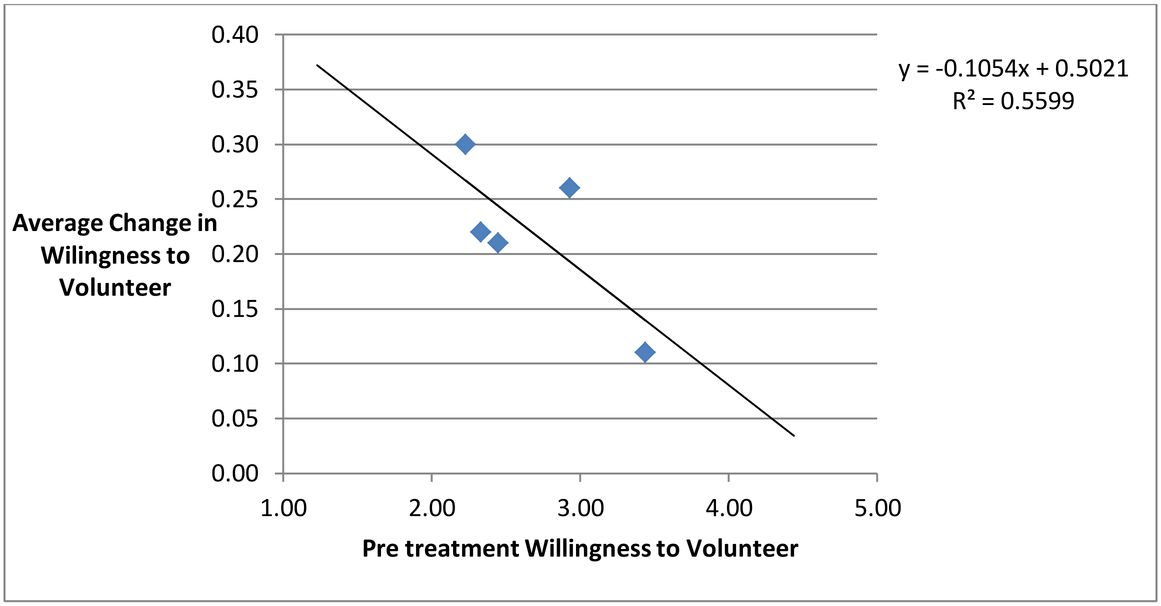
Pre-treatment willingness to volunteer for each organization was plotted against the average change in willingness to volunteer and is represented in Figure 19. The average change in willingness to volunteer was inversely proportional to that of pre-treatment willingness to volunteer. The coefficient of determination was 0.56 which indicated a positive correlation between the pre-treatment willingness to volunteer and the increase in willingness to volunteer. Thus, the ability of a treatment to impact the willingness to volunteer seems to be affected by the original willingness, as exemplified by the friends group. The average willingness to volunteer prior to any treatment value was the highest value among all organizational groups (3.44) for the friends group but the improvement(0.11) for this group was also the smallest .

Table 17: Statistical Summary by Organization

Dependent variable	Organization	N	Mean difference	Confidence		Test statistic (t)	Confidence level (p)	Pre-treatment average
				Lower	Upper			
Willingness to Participate	NVCC	42	0.26	-0.21	0.73	1.12	0.27	2.93
	GMU	64	0.30	0.01	0.58	2.06	0.04*	2.23
	MWAA	54	0.21	0.00	0.41	2.03	0.05*	2.45
	Friends	18	0.11	-0.05	0.27	1.46	0.16	3.44
	HOA	9	0.22	-0.29	0.73	1.00	0.35	2.33
Time to participate	NVCC	42	0.40	-0.07	0.88	1.73	0.09	2.28
	GMU	64	0.39	0.01	0.68	2.72	0.01*	1.81
	MWAA	54	0.13	-0.04	0.30	1.55	0.13	1.96
	Friends	18	0.00	-0.40	0.40	0.00	1.00	2.72
	HOA	9	0.22	0.10	0.34	3.67	0.01*	1.89
Knowledge	NVCC	42	3.38	2.89	3.87	14.04	<0.001*	5.10
	GMU	64	3.69	2.98	4.40	10.40	<0.001*	4.10
	MWAA	54	1.92	0.95	2.90	3.97	<0.001*	5.57
	Friends	18	4.28	3.45	5.11	10.36	<0.001*	9.20
	HOA	9	1.11	0.76	1.46	6.37	<0.001*	6.67

The organizations that showed a statistically significant improvement in the dependent variable are identified by an asterisk.

Figure 19 - Pre-treatment Willingness to Volunteer vs. Average Change in Willingness to Volunteer



5.3 Summary of Statistics Grouped by Characteristics

Table 18 summarizes the statistical significance of the improvements for the willingness to participate, time to participate, and knowledge across all treatments and participants. As shown, the training was statistically significant ($p<0.05$) in improving all of the aforementioned dependent/intermediate variables. The characteristic groups that showed a statistically significant improvement are identified by an asterisk.

Table 18 Survey participation

Dependent variables	**N**	Confidence level **(p)**
Willingness to participate (pre vs. post)	187	0.02*
Time to participate (pre vs. post)	187	<0.001*
Knowledge	187	<0.001*

Tables 19, 20, and 21 show the p-values (from the one-tailed t-test) for improvements in the willingness and time to volunteer by age group, gender, and education level. The groups that showed a statistically significant improvement are identified by an asterisk.

Table 19 Statistics for Willingness and Time to Volunteer by Age Group

Age	**N**	Confidence level **(p)** **(willingness)**	Confidence level **(p)** **(time)**
<=21	85	0.01*	0.01*
45-64	34	0.08	0.08
Total	119	<0.001*	<0.001*

Table 20 Statistics for Willingness and Time to Volunteer by Gender

Sex	**N**	Confidence level **(p)** **(willingness)**	Confidence level **(p)** **(time)**
M	116	0.09	0.04*
F	65	0.16	0.04*
Total	**181**	**0.06**	0.04*

Table 21 Statistics for Willingness and Time to Volunteer by Educational Level

Education	N	Confidence level **(p)** **(willingness)**	Confidence level **(p)** **(time)**
High School	65	0.24	0.01*
College/University	81	0.03*	0.05*
Graduate School	25	0.29	0.08
Total	**186**	**<0.001***	**<0.001***

5.4 Summary of Statistics Grouped by Treatment

Table 22 presents the results of the statistical analysis by treatment. The treatments that showed a statistically significant improvement are identified by an asterisk. The improvement in knowledge was statistically significant for all treatments. The improvements in willingness and time to volunteer were only significant for treatment 2.

Table 22 Statistics by Treatment

				95% Confidence			
Dependent Variable	**Treatment**	**N**	**Mean Difference**	**Lower**	**Upper**	**Test statistic (t)**	**Confidence level (p)**
Willingness to participate	2	42	0.76	0.33	1.20	3.57	<0.001*
Willingness to participate	3	68	0.15	-0.01	0.39	1.20	0.23
Willingness to participate	4	78	0.03	-0.15	0.20	0.29	0.77
Willingness to participate	All	187	0.17	0.03	0.31	2.46	0.02*
Time to participate	2	42	0.86	0.37	1.35	3.56	<0.001*
Time to participate	3	68	0.09	-0.09	0.26	1.00	0.32
Time to participate	4	78	0.10	-0.05	0.25	1.34	0.18
Time to participate	All	187	0.20	0.07	0.33	3.07	<0.001*
Knowledge	2	42	1.95	1.10	2.89	4.20	<0.001*
Knowledge	3	68	2.97	2.32	3.62	9.11	<0.001*
Knowledge	4	78	3.62	3.01	4.23	11.80	<0.001*
Knowledge	All	187	3.01	2.60	3.42	14.55	<0.001*

Treatment 2: PowerPoint presentation
Treatment 3: PowerPoint and Hands-on demonstration
Treatment 4: PowerPoint, Hands-on demonstration and VDEQ endorsement

Willingness to volunteer and volunteer time were plotted, pre administration of the survey instrument and post administration of the survey instrument; the plots are shown in Figure 8 and Figure 9 respectively. Generally, as the willingness to volunteer at construction sites increases, so does the number of hours one is willing to volunteer. As shown in Figures 20 and 21, the coefficient of determination is 0.70 and 0.76,respectively, for pre and post willingness to participate against the number of hours willing to volunteer. Based on the coefficient of determination values, the regression is a good fit of the data and is a good predictor of future outcomes.

The coefficient of determination value, post administration of the survey instrument, was greater than the pre administration value. This indicates that post regression data is a better fit and a better predictor of the outcome, further indicating that the data is closely correlated and that the independent variable is a good predictor of the dependent variable.

Figure 20: Pre Willingness to Participate vs. Hours Willing to Volunteer

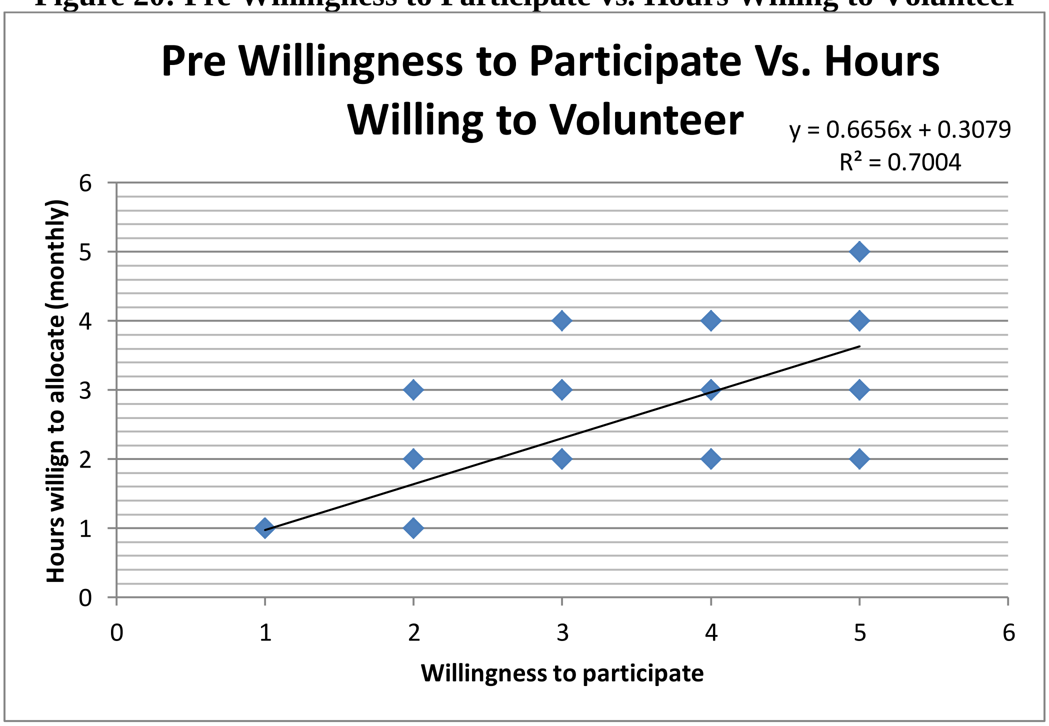
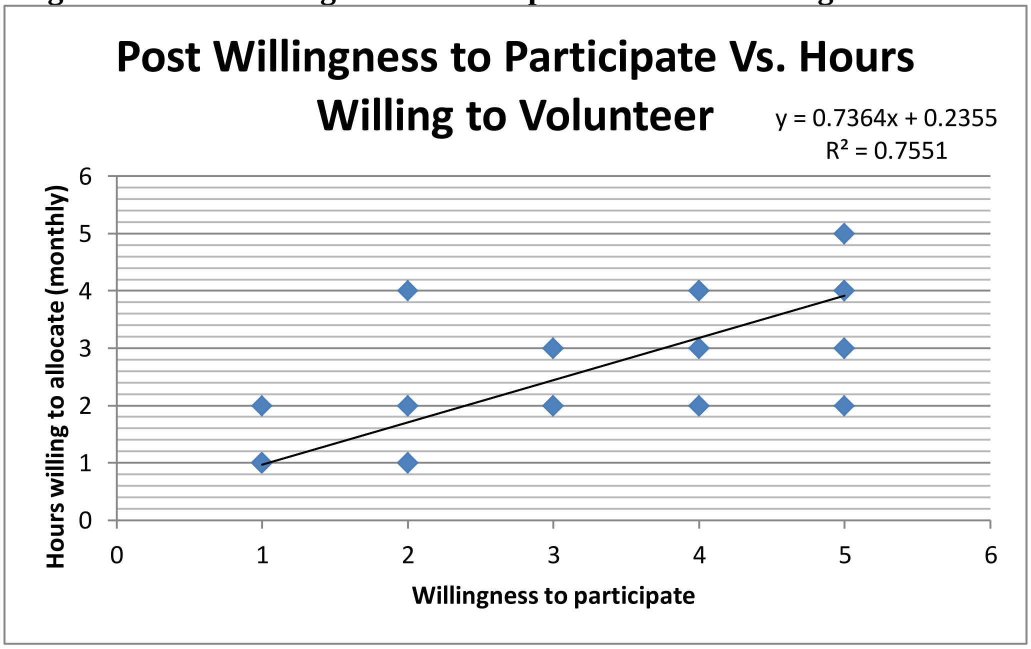


Figure 21: Post Willingness to Participate vs. Hours Willing to Volunteer



CHAPTER 6 – CONCLUSION

6.1 Summary of Findings

I researched the impact of various treatments (See Table 1) on an individual's willingness to participate in stormwater data collection at construction sites in Northern Virginia. The following treatment components were used:

1. A PowerPoint presentation on the adverse effects of sedimentation to increase understanding of the sedimentation problem caused by construction related activities.
2. A "hands on" experiment to better understand the siltation process.
3. A commitment by public officials to incorporate participants' findings into stormwater BMPs.

6.1.1 Improved Knowledge Related to Sedimentation Issues

The research concluded that knowledge of the problems caused by sedimentation improved as the amount of training increased (control group < PowerPoint presentation only < PowerPoint presentation and hands on demonstration < PowerPoint presentation, hands on demonstration, and input from VDEQ). The results indicate the existence of a strong and positive correlation between the participants' understanding of the problem and their willingness to participate in data collection efforts. Based on the research findings, formal education is not always a factor that can be relied upon to influence participation. Instead, the ability of a treatment to impact the willingness to volunteer was affected by the original (pre-treatment) willingness. Therefore, if the pre-treatment willingness to volunteer is high, there is only a small change after the treatment in willingness to volunteer.

6.1.2 PowerPoint

Citizens' willingness to participate and time to participate improved significantly ($p<0.05$) with the PowerPoint presentation. The hands on experience and commitment by VDEQ showed an average improvement that was not statistically significant for either dependent variable. In the future, practitioners would be well served by incorporating a simple demonstration related to the problem/subject matter to elicit better responses and improve both willingness and time for participation.

6.1.3 Regulatory Commitment

Surprisingly, it was difficult to obtain a commitment by Fairfax County and VDEQ regulators to use the sedimentation data from construction sites collected by Fairfax County citizens. Multiple requests to do so were made to many individuals and divisions within Fairfax County (stormwater division, soil division, planning and zoning, and construction code compliance division). This was also the case with VDEQ. Despite the level of effort to obtain a statement from either Fairfax County or VDEQ, no commitment was obtained from Fairfax County, and a very limited statement of endorsement from VDEQ was received. The group that received the training that included an endorsement from VDEQ showed a higher level of knowledge improvement than the other treatments ($p<0.05$). However, considering the amount of time invested to obtain the commitment, practitioners would be well advised to focus on other ways to improve citizen participation. On the other hand, if the county or state endorsement is readily available, it should be incorporated into the training material.

6.2 Recommendations for Future Research

Future research might focus on how the commitment to volunteer wanes with time by conducting another survey on the original participants. It would be interesting to compare how the knowledge stays with people depending on the treatment received. If more time were available, it would be desirable to perform a similar study at the beginning and the end of a semester in order to survey the same individuals.

This study contributes to the body of knowledge surrounding the practice of participation. The intent was to benefit practitioners, the research community, and regulatory decision makers who are seeking improved means to engage the public in environmental decisions. Therefore, my contribution towards academic literature expands on the topic of public participation and the willingness of the public to participate by increasing understanding of emerging theoretical development within the field of stakeholder participation. Thus, this research will help practitioners and decision makers develop improved outreach programs that will better engage citizens in environmental data collection programs.

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APPENDICES

Appendix A – Power Point Presentation

Effects of Sedimentation in Northern Virginia Streams

ASHIQ YUSUF
DOCTORAL CANDIDATE
GEORGE MASON UNIVERSITY

What is Soil Erosion?

Process of detachment and transportation of soil materials by water, wind, ice and gravity

What is Sedimentation?

Process by which the eroded soil particles are transported and deposited

Soil Erosion

- "Geologic" erosion naturally produces about 30 percent of the total sedimentation within the U.S.
- "Accelerated" soil erosion from human use of land accounts for the remaining 70 percent.

Soil Erosion (cont.)

- Adverse effects of soil erosion on waterbodies:
  - Decrease in natural water storage - decreased water depth
  - Water pollution – decreased oxygen
  - More frequent flooding – sheet flow
  - Stream channel damage – fast flow

Types of Erosions

- Raindrop erosion
  - Breaks down soil structure
- Sheet erosion
  - Shallow flow running over land

1

Types of Erosions (cont.)

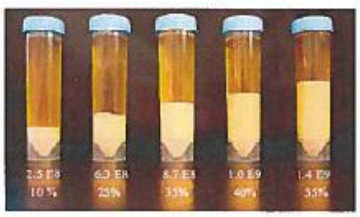
- Rill erosion
  - Velocity and turbidity increase

- Gully erosion
  - Rill coming together in large channel

Aerial view of sediment erosion

Uncontrolled sediment erosion from residential development in Birmingham adversely impacts Bayview Lake of Village Creek of the Black Warrior (Jefferson County).

Sediment Deposition

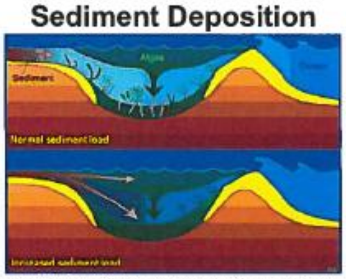


Over time, sediment erosion can accumulate and decrease total volume of water held by a waterbody. Small rain events can cause river banks to overflow and flood.

Fine sediment clouding water

- Fine sediment can stay suspended in water for 24 to 48 hours.
- Suspended silt and clay particles cloud the water, preventing sunlight penetration. SAV need sunlight to photosynthesize.
- Suspended silt and clay deposit in fish gills suffocates and kills fish.
- Sediment deposit on fish eggs suffocates and kills fish eggs.

Sediment Deposition



Sedimentation smothers benthic communities, preventing nutrients from being recycled.

Stream Bank Damage

Stream erosion caused by extreme and uncontrolled flash flooding

2

Stream Bank Damage (cont.)

Stream erosion caused by flash flooding –Swan's Creek

Stream Bank Damage (cont.)

Extreme stream bed erosion

Stream Bank Damage (cont.)

Stream erosion threatening residential property and land value.

Excess Nutrients in Water

Fibrous, hairy, slime layers with visible air bubbles may indicate an algae bloom brought on by excess nutrients within the water.

Sediment Runoff

Muddy brown sediment runoff from unchecked construction sites: Disturbed sediment enters waterways during storm events.

Sediment Runoff (cont.)

Lake Accotink was formed in 1918. Originally, it covered 110 acres and was 23 feet deep. Today, due to sedimentation, the lake is only 55 acres and shallow enough to walk across.

3

Fish Kill

Fish kill caused by sedimentation: Fish get their oxygen from the water, Sediment enters gills and prevents breathing.

Fish Kill (cont.)

Sediment prevents sunlight penetration, decreasing oxygen levels. Low levels of dissolved oxygen attribute to fish kill.

Sediment Tracking

A common problem around poorly managed construction sites is tracking sediment.

BMP Violations

All construction sites should have silt fences to contain silt within construction site and out of waterways

Failed Silt Fence

An incorrectly installed or improperly maintained silt fence allows sediment to run off site during rain events.

Good Construction Entrance

4

Poor Construction Entrance

Good Perimeter Control

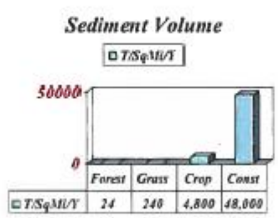
Poor Perimeter Control

Impact of polluted stormwater runoff

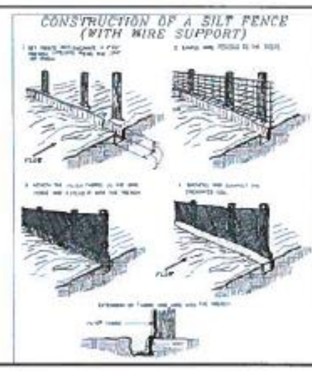
- Leading cause of impairment for nearly 40% of surveyed U.S. water bodies.
- Causes flooding and the degradation of habitat for aquatic life.
- Over 10,000 stream miles degraded by past development
- Major impacts to aquatic life in watersheds with as little as 10% land development.

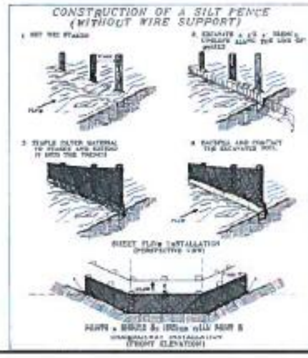
Construction sites produce high volume of sediment

Rate of erosion is greatest per acre on urban construction projects



Note: T/SqMi/Y stands for Tons per Square Miles per Year





Reporting Violations

- Pollution response contact numbers:
  - Department of Environmental Quality (DEQ), Northern regional office: 703-583-3800

http://www.deq.virginia.gov/prep/nrocont.html

Reporting Violations (cont.)

- Pollution response contact numbers:
  - Department of Emergency Management (24 hrs.)

    In-state 1-800-468-8892

    Out-of-state 1-800-674-2400

http://www.deq.virginia.gov/prep/h2rpt.html

Reporting Violations (cont.)

- Pollution response contact number for Arlington, Virginia
  - Arlington Environmental Services 703-558-2222

http://www.arlingtonva.us/departments/EnvironmentalServices/epo/EnvironmentalServicesEpoReportingStreamPollution.aspx

Reporting Violations (cont.)

- Pollution response contact number for Fairfax, Virginia
  - Fairfax County Environment and energy, erosion and sedimentation 703-324-1937

http://www.fairfaxcounty.gov/living/environment/report-environmental-crimes.htm

Reporting Violations (cont.)

- Pollution response contact number for Alexandria, Virginia
  - Alexandria Environmental Industrial Unit

    703-838-4660

http://alexandriava.gov/code/info/DailyUpdate.aspx?id=30584

DEQ and Stormwater Program

- James Beckley of DEQ, Quality Assurance Coordinator indicated:
- DCR now oversees stormwater runoff program – non enforcement
- Near future, DEQ could get stormwater runoff program from DCR
- Possible assessment of monetary penalties for stormwater violations if DEQ gets program

Local Government and Stormwater Program

- Citizen reporting critical, provide maximum monitoring coverage. Storm events cover wide area within short time
- Localities could enlist citizen volunteers to report stormwater issues
- Timely citizen reporting to locality lead to prompt response - correct issues
- Citizens possibly provided legal protection by Locality for reporting

Potential data usage by DEQ

- Enhance current stormwater laws/regulations
- Enhance inspection program
- Increase reporting frequency by citizen monitors – enforceable by DEQ, future
- Dispatch DEQ staff to independently investigate citizen monitor reports
- Fund program through revenue generated by permit fees and fines

QUESTIONS/ COMMENTS?

7

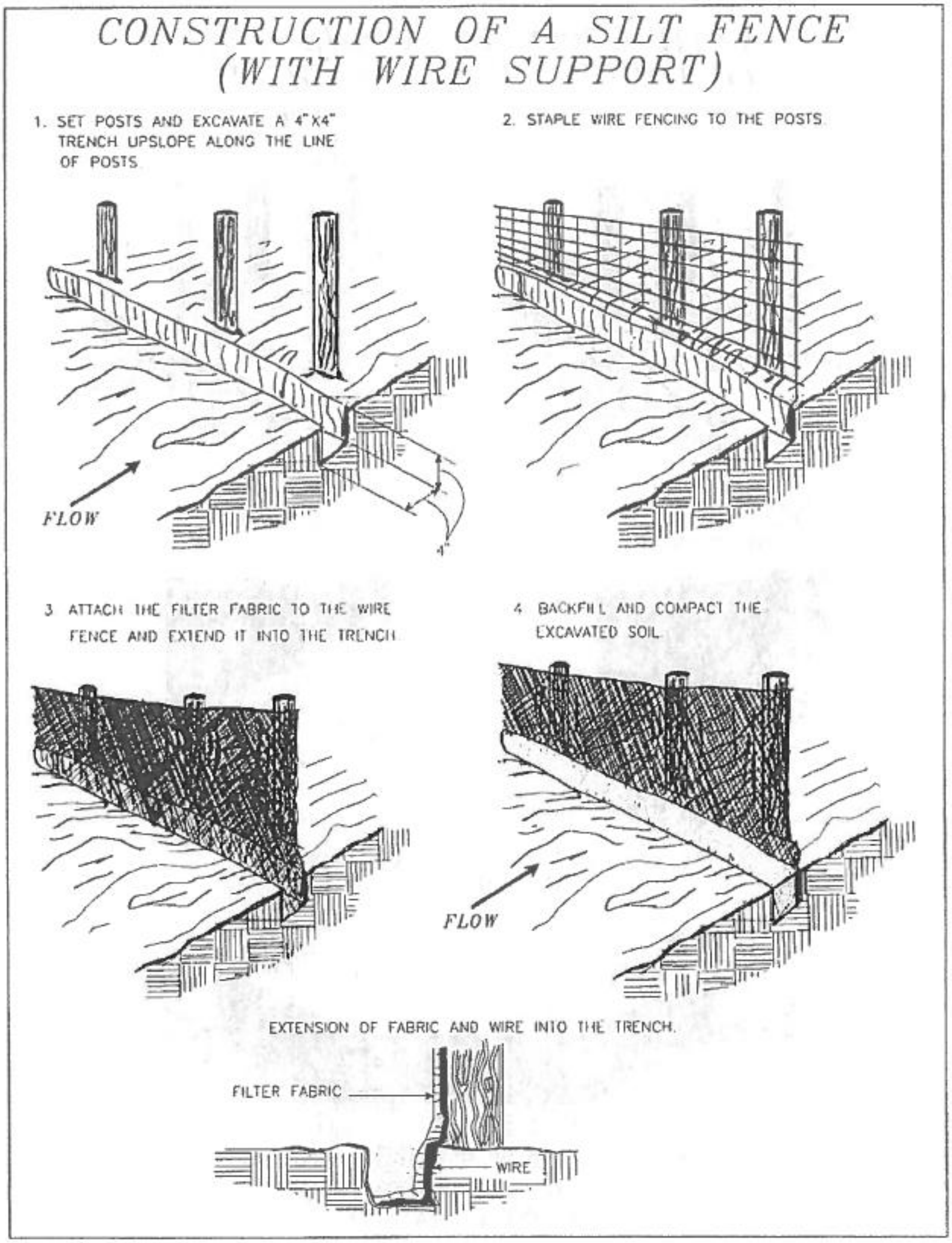
Appendix B – Citizen Field Inspection Checklist

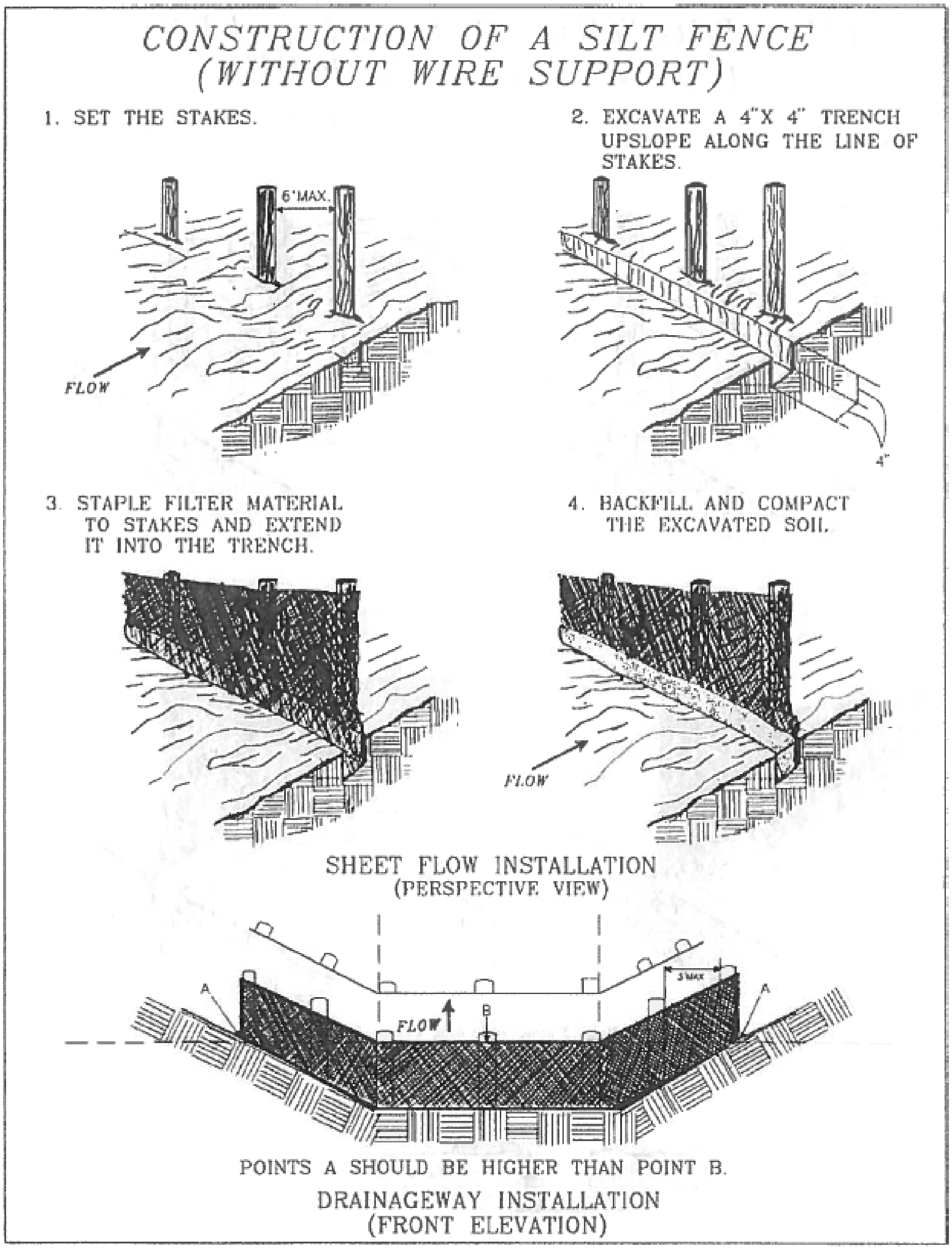
Citizen Field Inspection Checklist
Sediment and Erosion Control at Construction Sites

(Conducting this citizen inspection at construction sites is voluntary. Under no circumstances should one trespass, put oneself in physical danger or get into a confrontation or altercation with property owner or their representatives. Always conduct citizen field inspections with a partner and follow the law.)

Date of inspection	Site address
Time of inspection	Weather condition (ex: clear, cloudy, rain)
Inspector(s) name(s)	Location of pollution
Type of pollution violation ☐ Sediment runoff from construction site ☐ Silt fence violation ☐ Stockpile stabilization violation ☐ Other (specify)	Photo documentation ☐ Yes ☐ No
Vehicles tires tracking sediment offsite ☐ Yes ☐ No	Construction entrance underlain with filter cloth and stone ☐ Yes ☐ No
Dewatering activities entering waterways or wetlands ☐ Yes ☐ No	Silt fence trenched properly ☐ Yes ☐ No
Silt fence backfilled properly ☐ Yes ☐ No	Silt fence maintained in good condition ☐ Yes ☐ No

Appendix C – Construction Silt Fence Specifications




CONSTRUCTION OF A SILT FENCE
(WITHOUT WIRE SUPPORT)
1. SET THE STAKES.
6' MAX.
FLOW
2. EXCAVATE A 4"X 4" TRENCH UPSLOPE ALONG THE LINE OF STAKES.
4"
3. STAPLE FILTER MATERIAL TO STAKES AND EXTEND IT INTO THE TRENCH.
4. BACKFILL AND COMPACT THE EXCAVATED SOIL.
FLOW
SHEET FLOW INSTALLATION
(PERSPECTIVE VIEW)
A
B
FLOW
A
POINTS A SHOULD BE HIGHER THAN POINT B.
DRAINAGEWAY INSTALLATION
(FRONT ELEVATION)

Appendix D – "Hands on" Demonstration Tool

Appendix E – Survey Questionnaire Instrument

Survey Questionnaire

Read each question and fill in completely the most appropriate answer bubble. If you change your response, erase or cross out completely the incorrect answer bubble and fill in completely the most appropriate new answer bubble. Answer all questions.

General knowledge related to stormwater, silt fences and environmental policy

1. Soil erosion is the process of detachment and transportation of soil materials by water, wind, ice and gravity. What is the natural geologic rate of erosion for the United States?

   O None
   O 5%
   O 10%
   O 20%
   O 30%

2. What is the accelerated rate of sediment erosion from humans use of land in the United States?

   O None
   O 90%
   O 70%
   O 50%
   O 30%

3. What are the adverse effects associated with sediment erosion from human activity such as land disturbance for construction activity?

   O Decrease in natural water storage
   O Water pollution
   O More frequent flooding
   O Stream channel damage
   O All of the above

4. As authorized by the Clean Water Act, the National Pollutant Discharge Elimination System (NPDES) permit program controls water pollution by regulating point sources that discharge pollutants into waters of the United States. Which of the statements below is **true** related to an NPDES permit?

   O Regulates the flow of water into streams and rivers from point sources
   O Regulates pollution limits for the discharge of wastewater
   O 1-5 acre sites are exempt and do not require a permit
   O For large construction sites permit requirements are voluntary
   O I and II

5. Federal regulations and State rules require many types of businesses to obtain an industrial storm water permit and to prepare a written Storm Water Pollution Prevention Plan (SWPPP) to address and control stormwater discharge from their facility to the environment. Some of the minimum components addressed in a SWPPP are?

O Identification and establishment of a pollution prevention team
O Risk identification and material inventory
O Good housekeeping, visual inspection and detailed record keeping
O Spill prevention, sediment erosion control and employee training
O All of the above

6. Stormwater polluted with excessive sedimentation adversely impacts streams, rivers and lakes by the following?

O Preventing sunlight from penetrating submerged aquatic vegetation (SAV)
O Reduces the depth of a body of water by reducing its volume
O Threatens aquatic life by limiting oxygen content in the water
O None of the above
O All of the above

7. What constitutes illicit discharge related to stormwater runoff from construction sites and its adverse implications to streams, lakes, rivers and wetlands?

O Stormwater breakthrough and overflow beyond a silt fence
O Stormwater accumulation in a sediment retention pond
O Stormwater that flows from the site that has been disturbed less than 15 days
O As long as there is an NPDES permit for the site there is no illicit discharge of stormwater
O All of the above

/illingness to participate

8. Do you have volunteer experience related to public participation?

O Yes
O No

9. If yes response to the above question (do you have volunteer experience related to public participation), please identify groups you have experience working with?

O Civic groups
O School groups
O Environmental groups
O State or regulatory agency groups
O Other

10. Training will be provided at no cost to you. Are you willing to inspect construction sites for sediment control violations within 5 miles of your residence or work place?

O---------------------O--------------------O---------------------O----------------O
1 2 3 4 5
Not willing to perform inspections — Willing to perform inspections

11. If yes to the above question, what amount of time are you willing to allocate on a monthly basis to inspect for sediment control violations?

O---------------------O--------------------O---------------------O----------------O
0 2 4 6 8
hours — hours or more

Specific knowledge/experience related to silt fences

12. What is the filtering efficiency (%) of a standard silt fence to filter sediment from a storm flow (ASTM 5141)?

O 45%
O 60%
O 75%
O 85%
O 95%

13. What is the minimum and maximum height requirement for installation of a silt fence above the original ground elevation?

O Minimum 10" and a maximum 25"
O Minimum 14" and a maximum 33"
O Minimum 16" and a maximum 34"
O Minimum 21" and a maximum 42"
O There is no minimum or maximum height requirement

14. What is the minimum usable construction life for a silt fence synthetic fabric that shall contain ultraviolet ray inhibition?

O One year
O Six months
O Three months
O One month
O As long as the synthetic fabric is required for usage

15. What is the temperature range that a synthetic fabric silt fence is designed to withstand?

O 0° F to 100° F
O 0° F to 120° F
O 10° F to 150° F
O 50° F to 150° F
O No temperature requirement for synthetic fabric

16. What is the maximum gradient allowed behind a silt fence?

O 100% or 5:1
O 75% or 3:1
O 50% or 2:1
O 25% or 4:1
O 10% or 1:1

17. What is the standard excavation requirement for trench depth on the upslope side of a silt fence?

O 6" wide and 6" deep
O 5" wide and 5" deep
O 4" wide and 4" deep
O 3" wide and 3" deep
O 2" wide and 2" deep

18. If wire support is used with extra-strength filter cloth, what is the maximum distance between silt fence posts?

O 10 feet apart
O 8 feet apart
O 6 feet apart
O 4 feet apart
O 2 feet apart

General information related to participants

19. What is your physical distance from a stream, lake, river, creek or wetland?

O Live on the water
O My community is adjacent to a body of water
O Work close to a body of water
O Live and work less than a mile from a body of water
O Prefer not to answer

20. What is your gender?

O Male
O Female
O Prefer not to answer

21. What is your age?

O 21 and under
O 22-44
O 45-64
O 65 and over
O Prefer not to answer

22. What is your level of education?

O Some high school
O Community college
O College/university
O Graduate school
O Prefer not to answer

Appendix F – Office of Integrity and Assurance Approval

GEORGE MASON UNIVERSITY

Office of Research Integrity and Assurance

Research Hall
4400 University Drive, MS 6D5, Fairfax, Virginia 22030
Phone: 703-993-4121; Fax: 703-993-9590

TO: Dann Skalrew, College of Sciences

FROM: Aurali Dade
Assistant Vice President, Research Compliance

PROTOCOL NO.: 8546 Research Category: Doctoral Dissertation

PROPOSAL NO.: N/A

TITLE: Effects of Stakeholder Involvement in Reduction of Sedimentation in Northern Virginia Streams

DATE: February 12, 2013

Cc: Mohamed Ashiq Yusuf

On 2/12/2013, the George Mason University Institutional Review Board (GMU IRB) reviewed and approved the above-cited protocol following expedited review procedures.

Please note the following:

1. A copy of the final approved consent document is attached. You must use this copy with the IRB stamp of approval for your research. Please keep copies of the signed consent forms used for this research for three years after the completion of the research.
2. **Any modification to your research (including the protocol, consent, advertisements, instruments, funding, etc.) must be submitted to the Office of Research Integrity & Assurance (ORIA) for review and approval prior to implementation.**
3. Any adverse events or unanticipated problems involving risks to subjects including problems involving confidentiality of the data identifying the participants must be reported to the ORIA and reviewed by the IRB.

The anniversary date of this study is 2/11/2014. **You may not collect data beyond that date without GMU IRB approval.** A continuing review form must be completed and submitted to the ORIA 30 days prior to the anniversary date or upon completion of the project. In addition, prior to that date, the ORIA will send you a reminder regarding continuing review procedures.

If you have any questions, please do not hesitate to contact me at 703-993-5381.

Curriculum Vitae

Mohamed Ashiq Yusuf received his Bachelor of Science from Washington College in Chestertown, MD in 1998. He was employed as a research scientist in Columbia, MD for five years and received his Master of Science in Environmental Management from University of Maryland University College in 2002. While completing his Ph.D., he worked as the Government Programs Engineer for Metropolitan Washington Airports Authority at Ronald Reagan Washington National Airport.