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From:	Melissa DeSantis
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Subject:	DRAFT Technical Memorandum on the Feasibility of an Expert Panel on MS4 Outreach as an Urban BMP

I. Introduction

Under the terms of their Municipal Separate Storm Sewer System (MS4) permits, many Chesapeake Bay communities are required to develop and implement stormwater education and public involvement programs for the general public to increase awareness of the importance of reducing stormwater pollution. The purpose of the national literature review that Tetra Tech has undertaken was to identify and locate any actual monitoring data that shows that these programs actually result in behavior changes that result in reducing nutrient and/or sediment loads that could lead to verifiable credits. Tetra Tech found 57 reports, studies, presentations, and other documents that describe the results of outreach programs focusing on six behaviors—residential fertilizer use, pet waste disposal, septic tank maintenance, car washing, disposal of grass clippings, and use of marina pumpouts. Sections II–IV provide a summary of how the research was conducted, key overall findings, and recommendations for outreach programs. Section V describes findings for each of the six behaviors typically targeted by MS4 or nonpoint source outreach programs.

II. Explanation of Research Conducted

Tetra Tech completed a targeted keyword search of the primary and gray literature for each of the identified outreach activities. Initial search efforts focused on change (e.g., change in awareness, perception, or attitude; change in the rate of actual target behavior; change in pollutant concentration or loads in urban stormwater) documented in the primary literature through keyword searches of EBSCO (a provider of research databases and e-journals) and Google Scholar. The primary literature contained infrequent descriptions of change attributed to outreach efforts. As a result, the research team adjusted subsequent targeted keyword searches to focus on the available gray literature obtained through Google searches. Prior to, and throughout initial search efforts, the team regularly met to establish and review keyword search terms. Regular meetings were critical for streamlining searches among identified outreach activities, as well as for sharing search terms found to be effective or ineffective for a given outreach activity. Tetra Tech documented search terms used for each outreach activity reviewed.

Tetra Tech summarized available literature in an Excel spreadsheet, recording which sources noted positive or negative change in awareness, perception, or attitude; change in rate of actual target behavior; or change in pollutant concentration or loads in urban stormwater as a result of outreach efforts. Tetra Tech acknowledges that a limitation of EBSCO, Google Scholar, and Google searches is that studies must first be published and searchable on the Web before results can be obtained by online keyword searches. As such, unpublished or small-scale outreach activities might not be fully represented in the search results.

In addition to the targeted keyword searches, Tetra Tech reviewed literature documented in *Recommendations of the Expert Panel to Define Removal Rates for Urban Nutrient Management: CBP Approved Final Report*, EPA's online Nonpoint Source Outreach Toolbox, and user responses to a NPSINFO (email discussion list) request for sources, which were summarized, as appropriate.

III. Overall Findings

In reviewing the 57 literature sources, several key findings surfaced:

- **Lack of water quality monitoring data to support outreach results.** It is clear that outreach programs around the country are making a difference in terms of increasing both awareness of the causes of stormwater pollution and the likelihood that citizens will adopt stormwater-friendly behaviors after outreach campaigns. However, most of the literature reviewed did not discuss actual water quality improvements backed up by monitoring data. Although eight studies did discuss water quality, several only made *estimates* of water quality reductions based on factors like the pounds of pet waste picked up at disposal stations, the number of people claiming to pick up after their pets, and the number of people reporting that they were using less fertilizer after the campaign. The best monitoring data was provided by Dietz et al. (2004), who used a paired watershed design (control and treatment watersheds) in Long Island Sound communities in Connecticut to evaluate the impact of lawn care practices after an educational campaign. Their results showed a 75% reduction in nitrate-N concentrations and a 127% reduction in fecal coliform bacteria concentrations after education efforts. Total nitrogen, total phosphorus, and ammonia-N concentrations did not change significantly (Dietz et al. 2004).

  In addition, very few studies that were reviewed included any specific outreach efforts related to sediment from residential yards/property. Reports by Senecal-Albrect (2009) discussed inclusion of erosion messages in their outreach campaign, but did not provide follow-up data to see if behaviors or water quality changed as a result. Survey results by Pelegrin Research Group (2004b) showed inconsistent results when educating the public about sweeping leaves, dirt, and debris from in front of gutters to keep it out of storm drains. Some results showed that people are less likely to sweep up dirt from gutters after the campaign. Other results showed that some groups self-reported that, after the campaign, they are less likely to hose dirt from their driveway into the street, while other groups reported they do this more often after the campaign.

- **Lack of consistent, statistically significant behavior change results**. Although many of the literature sources found indications of positive trends in terms of both awareness and behavior change, not all showed *statistically* significant changes in post-campaign survey results when compared to pre-campaign surveys or a control group. Forty-four percent of the sources (25 of 57) incorporated some type of statistical analysis in their report to back up claims of significance or insignificance. Those 25 studies used a variety of statistical approaches and software including SPSS (Statistical Package for the Social Sciences) software, chi-square tests, t-tests, 5% rule of thumb, Fisher's exact test of independence, crosstabs, ANOVA (a one-way analysis of variance), rank-sum tests, or other methods.

  Some studies demonstrated statistically significant behavior change results. For example, Brehm and Eisenhauer (2014) noted the following:

  > *…because there are so many possible intervening variables that can influence change over time, it is difficult to connect this change to a SINGLE influence, such as our PFF campaign. However, the consistency in statistically significant changes in the use of BMPs that all indicate an increase in BMP use is the single best indicator of project effects. The increase in the use of all seven BMPs was statistically significant, with the use of phosphorus free fertilizer and properly disposing of pet waste showing the largest increases in adoption over time.*

  However, some of the studies that did have statistically significant changes for the good in some behaviors, also reported some variations or even increases in negative behaviors over time. Those sources that did not demonstrate the use of statistical analysis methods might have made claims of significant changes in a subjective way, but the analysis does not prove the results were significant. Even in some cases where there was statistically significant behavior changes or water quality improvements, many authors were quick to note that they could not definitively link

changes in behavior to water quality improvements that were realized. For those studies that do report significant changes in survey results, it must be remembered that the changes are primarily in self-reported behaviors or intentions of behavior change, and not actual observable, provable changes.

- **Lack of data from the Chesapeake Bay watershed.** Out of 57 sources, only six reported on projects within Chesapeake Bay states (Maryland, Virginia, and baywide). Of those, the one from Arlington, Virginia, did not focus on water quality as much as it did on water conservation. A study by Prince George's County had some promising results that indicated an overwhelming willingness by property owners to adopt more environmentally sensitive activities (Coffmann n.d.), but the survey results did not demonstrate a significant change in targeted activities as a result of the program's outreach efforts. Moreover, it was not clear if the reduction of nitrogen/phosphorus detected with water quality monitoring was directly related to the outreach efforts; the reduction could have been associated with variations in rainfall or runoff patterns and intensities. The other bay-areas studies did not provide water quality monitoring data.

  Data found for states from other climatic regions of the country might not be relevant to the Chesapeake Bay area due to difference in climate, population demographics, land use/land cover, and local regulations and social norms. A breakdown of literature sources by region is provided in Table 1.

Table 1. Literature Sources by Location

State/Region	# of Literature Sources Found
Washington State (Puget Sound region)	13
Southern states (FL, NC, SC, TN, TX)	13
New England states (CT, MA, ME, NH, RI, VT)	9
Western states (CA, CO)	7
Midwest states (IL, MI)	7
Chesapeake Bay states (MD, VA, baywide)	6
Canada	1
National	1

- **Not enough monitoring data for expert panel.** Based on review of the available literature, not enough monitoring data is currently available to warrant the convening of an expert panel to develop pollution reduction credits for stormwater outreach in the Chesapeake Bay. This is not to say that stormwater outreach programs do not work, but rather that currently not enough data has been published to provide a direct correlation between outreach efforts and specific water quality improvements in a watershed. This situation could be due to several factors:
  - Education and outreach programs are generally conducted by local and state staff who are not involved in water quality monitoring.
  - Outreach programs are typically underfunded, which renders them unlikely to be able to afford comprehensive, robust programs that include statistically valid before-and-after research, paired watershed studies, or downstream monitoring for specific treatment watersheds.
  - Outside variables such as rainfall patterns, changes in land use and development patterns, and a growing population in many urban areas make it difficult to pinpoint the exact cause of many water quality improvements or degradation.

IV. Recommendations for MS4 Outreach

Many of the literature sources reviewed indicated that awareness and behavior change is possible despite inherent difficulties in linking behavior changes to long-term water quality improvements. Therefore, Tetra Tech developed the following set of recommendations and best practices that should be considered by MS4s when developing outreach programs targeting nutrient and sediment pollution in the Chesapeake Bay watershed:

- **Link Efforts to Water Quality Monitoring.**
  No matter what the focus of the program, all outreach programs should link their efforts to water quality monitoring in some way. One example of this approach is conducting smaller-scale pilot outreach programs at the subwatershed or neighborhood scale so it is easier to detect water quality changes and definitively link them to the outreach itself. Public outreach specialists at the municipal level should set up regular meetings and work closely with state or local monitoring staff to ensure that this water quality improvement metrics are included at the outset when the outreach campaign is being developed.
- **Use Before-and-After Analysis.**
  Despite whether or not it is feasible to conduct water quality monitoring as part of an outreach program, all programs must include a before-and-after analysis to determine the effectiveness of the outreach messages, materials, and activities. This analysis can be supported using focus groups, phone or email surveys, observations, or other methods. Performing the analysis in a statistically valid manner is key to understanding and acting on the results. Hiring a firm or working with a university that is well-versed in market research and statistical analysis tools is the best way to do this.
- **Fertilizer Use Reduction.** Although this literature review focused on outreach targeted to homeowners, it should be noted that targeting commercial fertilizer applicators (e.g. landscaping/lawn care companies) with training can be one of best ways to reduce residential fertilizer use by those how are not DIY'ers. Other recommendations include the following:
  - Using social norms (i.e., peer pressure) is a powerful method to promote participation/change. Social norms are shared beliefs within a community. In a campaign to reduce fertilizer use in Bangor, Maine, residents were divided into 3 groups (one control, one with a simple environmental message, and one with an environmental message plus social norm). The group who showed the greatest intention to adopt the new lawn care behaviors was the group targeted with messages that included social norms. The message to that group focused on telling individuals that their neighbors are using less fertilizer, and thus, they should use less also.
  - Encouraging homeowners to read/follow labels and use soil tests can be effective ways to teach them how to use the proper amount of fertilizer.
  - When conducting a campaign, use undesirable terms like "lawn chemicals" instead of fertilizers. Also campaign messages should be delivered before people buy fertilizer or hire/contact a lawn service.
  - When building in metrics to evaluate the success of fertilizer outreach, programs could also try to look for ways to track non-farm fertilizer sales trends either using state agricultural statistics or data from industry sources. Limitations and considerations when using this type of data are discussed in detail in Schueler and Lane (2013).
- **Proper Pet Waste Disposal**
  Installing, regular maintenance, and data tracking for pet waste disposal stations seem to be the most effective ways to ensure that more citizens are properly disposing of pet waste. Signage, bag distribution, and behavior modeling/intervention also have positive results, but due to changes in homeownerships, etc., this outreach activity must be in play on a continual basis to be effective.

- **Proper Septic Tank Maintenance**
  - Many programs are finding some success educating septic tank owners through direct classroom workshops and site inspections. Because most septic problems cannot be seen, or even smelled, property owners tend to be reactive only in the worst-case scenarios (e.g., backups, yard flooding). Outreach programs addressing septic maintenance are most effective when coupled with inspection requirements by local jurisdictions and incentives (e.g., discounts or coupons for inspections).
  - Municipalities should provide standardized training programs through which professionals or property owners can be certified in septic inspections to increase the capacity for recognizing and addressing problems early in their development. Many jurisdictions in the Puget Sound region, for example, are using this approach successfully.
  - The most successful outreach programs support homeowners in conducting maintenance (e.g., checking septic tank sludge levels) and include a tracking system to track system locations, types, owners, inspection frequency, pump-outs, and so forth (USEPA 2012).

V. Issue-Specific Findings Noting Changes in Awareness, Behavior, and Water Quality

III.a. Residential Fertilizer Use Reduction

Tetra Tech identified 24 sources that included a discussion of outreach efforts taken to address residential fertilizer reduction. Of the 24 sources, 19 showed increases in awareness and behaviors that reduce fertilizer use. Most importantly, six of the 19 sources (covering four outreach campaigns total) found some improvements (either directly measured or estimated) in water quality associated with the educational campaigns. Of the 24 sources, two were located within the Chesapeake Bay watershed.

Water Quality Change

Six of the 24 literature sources showed improvements in water quality, in addition to increased awareness and positive behavior changes. Dietz et al. (2004) used a paired watershed design (control and treatment watersheds) in Long Island Sound communities in Connecticut. The researchers educated homeowners in the treatment watershed about ways to minimize nonpoint source pollution and gaged homeowners' knowledge by conducting surveys before and after the education component. Eleven percent of survey respondents in the treatment watershed began fertilizing their lawns based on the results of a soil test, compared to none in the initial survey. The results also showed a 75% reduction in nitrate-N concentrations and a 127% reduction in fecal coliform bacteria concentrations after education efforts. Total nitrogen, total phosphorus, and ammonia-N concentrations did not change significantly (Dietz et al. 2004).

Following distribution of a mailing by Clark County, Washington, to raise awareness about natural gardening, the number of Felida, Washington, residents believing their personal lawn care impacted water quality increased by 15% (of those surveyed pre-mailing versus post-mailing). Additionally, 18% of residents that recalled the mailer reported that the mailing prompted a behavior change. Quantified improvements included a self-reported reduction in spot-fertilizing (6% decrease) and fewer residents using combined weed and fertilizer products (9% decrease) (DHM 2013). Water quality and stormwater volume downstream of Felida remained similar before and after the campaign; only 2 of 13 monitored parameters (i.e., dichlobenil herbicide and nitrate-nitrite as N) showed significant reductions in median concentrations. In addition, data showed that the median total phosphorus significantly increased from pre- to post-education periods (Hutton 2014).

The city of Tallahassee, Florida, launched the Think about Personal Pollution (TAPP) multimedia public education campaign in 2003 to generate awareness about personal impacts on water resources. Comparison of pre- and post-campaign surveys indicate that the TAPP program inspired almost 40% of surveyed households to make behavioral changes, including an 11% decrease in households applying fertilizer and increased use of phosphorus-free fertilizer. City officials chose not to use a paired watershed approach or an upstream/downstream comparison approach because they felt they were not able to limit their outreach and media exposure to a specific watershed and were concerned about variability in rain events, which could skew the results. Therefore, they used a public survey to estimate water quality improvements (showing a direct link is not possible) based on what the public reported in the survey. To determine nitrogen reductions from reduced fertilizer use, they assumed a certain rate of application and applied the reported decrease in fertilizer use to that rate. Their data showed a 28% reduction in nitrogen load and a 53% reduction in phosphorus load (Florida Stormwater Association 2011).

After Austin, Texas, implemented the Grow Green stormwater education program in 2000, survey results show that residents reduced chemical and weed-and-feed fertilizer use and increased organic fertilizer use (Shay 2011). Surveys were also implemented at Austin garden centers, where educational brochures were distributed. Survey responses from garden center staff supported those from residents and indicate that the Grow Green program has affected fertilizer sales (e.g., organic sales increased and non-organic sales decreased) and increased sales of plants promoted by the program (USEPA 2014). Grow Green project staff monitored groundwater springs and surface water runoff at several inlets for about a year after the outreach program began. Although measured water quality changes were inconsistent and complicated by a lack of consistent rainfall events, decreased orthophosphorus levels were observed at

two locations. Orthophosphorus concentrations decreased at Backdoor Springs after education and might have decreased after education at Tanglewood, although the statistically significant change at Tanglewood was non-significant (p=0.06). However, monitoring showed increases in nitrate concentrations, which were attributed to increased urbanization in the watershed (Shay 2011). Ammonia decreased at four of five sites in the post-education time period.

Net Positive Behavior or Awareness Change

Thirteen of the 24 literature sources showed improvements in fertilizer reduction behavior. Cunningham Environmental Consulting conducted a paired survey to track behavior changes by Kitsap Peninsula, Washington, residents before and after local and regional outreach programs. The data show a reduction in the use of lawn and garden fertilizer from 2008 (52% for entire lawn coverage and 57% for spot coverage) to 2011 (used by 21% of respondents). Based on the survey, 2011 respondents were more likely than 2008 respondents to think that pesticides and fertilizers from yards significantly contribute to pollution (Cunningham Environmental Consulting 2011). In a summary of several outreach campaigns, Kitsap County residents who recalled water pollution messages—such as those describing the impacts on the ecosystem and humans—reported lower usage of yard chemicals (24%) than those who did not recall the messages (38%) (Elway Research 2009).

One educational campaign also affected residential fertilizer use in the Chesapeake Bay watershed. The Save the Crabs, Then Eat 'Em campaign sought to convince area residents not to fertilize in the spring or to hire a bay-friendly lawn service. Post-campaign data suggest that the campaign might have influenced some people's decisions about whether to fertilize. In the 2004 pre-campaign survey, 23% of respondents reported they were not planning to fertilize that year, while 28% of those in the 2005 post-campaign survey reported that they were not planning to fertilize (Landers et al. 2006). Another survey of residents in the Chesapeake Bay watershed assessed the effectiveness of nutrient education efforts, specifically evaluating current behavior, awareness of outreach efforts, and whether residents had modified their behavior because of the outreach. As a result of receiving lawn care advice, 13% of respondents made significant changes to the way they care for their lawns (Swann 1999).

In the New England area, Eisenhauer et al. (2010a) found that data from post-outreach surveys indicated that some turf care behaviors changed as intended: 56% of respondents exposed to outreach programs used fewer lawn chemicals as a result, but only 25% of respondents had encountered turf care information from the programs in the past 3 years. Additional data shows that residents used less fertilizer between surveys: those applying fertilizer once a year decreased from 29% to 27%, twice a year decreased from 27% to 8%, 3 times a year decreased from 14% to 2%, and 4 or more times a year decreased from 21% to 3% (Eisenhauer et al. 2010a). An education and behavior change campaign was also implemented in Bangor, Maine, as part of the research. Three sets of self-administered questionnaires were randomly distributed in six area neighborhoods and differences in outreach approaches were assessed. Findings indicated that those who received campaign materials stating neighborhood norms gathered from Eisenhauer et al. (2010a)—for example, the norm used was that most neighbors choose not to use fertilizers and pesticides on their lawns—were most likely to have intentions of reducing or eliminating their use of fertilizers or pesticides. Recipients of standard campaign materials were more likely to have intentions to decrease fertilizer and pesticide use than those who received no materials (Eisenhauer et al. 2010a, 2010b).

In Chittenden County, Vermont, entities with stormwater interests collaborated in the Regional Stormwater Education Program (RSEP) to raise awareness of stormwater pollution. Since forming in 2003, RSEP administered surveys in 2007 and 2013 to track progress. Despite no significant difference in fertilizer use from 2003 to 2007 (University of Vermont 2007), 2013 survey results show the number of surveyed residents fertilizing their lawns decreased from 50% (2003) to 29% (2013) and that residents were increasingly testing their soil to determine whether fertilizer was needed (Regional Stormwater Education Program 2013). Improvements were also seen in reduced fertilizing in the winter (89% reduction from 2008 to 2013) and increased use of phosphorus-free fertilizers (69% increase from 2008 to 2013) (Becot 2013).

In New Hampshire, Pennichuck Water Works implemented a social marketing program for the Stump Pond Brook subwatershed. In a follow-up survey, 89% of respondents who fertilize their lawns indicated they used less fertilizer the summer of the survey or planned to use less fertilizer the next year; 11% planned to use the same amount. When asked about fertilizer type, 90% of respondents who fertilize their lawns and do not already use a slow-release, low-phosphorus or organic lawn fertilizer, indicated they have or will change to one. Of survey respondents, 67% completed a soil test as a result of the program or plan to do one next year; 28% did not or do not plan to do a soil test. When asked if additional information was needed to complete a soil test and determine proper fertilizer use, 22% indicated *yes* (Comprehensive Environmental n.d.).

The Southwest Florida Water Management District implemented the "Florida-Friendly Fertilizing" campaign to inform district residents of adverse effects associated with excess and improper fertilization. Survey results quantified the success of the campaign, including an 8% increase in surveyed residents' awareness that they should use slow-release fertilizer, coupled with a 5% increase in residents who used slow-release fertilizer. Additionally, there was a 56% increase in residents' awareness that they should not fertilize before heavy rain, coupled with a 43% decrease in residents who applied fertilizer before heavy rain events (Kerr and Downs Research 2011).

A project in the Nippersink Creek watershed in Illinois sought to evaluate a phosphorus-free campaign by measuring adoption of some BMPs from 2010 to 2013. Adoption of the "Use of Phosphorus-Free Fertilizer" BMP increased from 35% to 58%. Also a statistically significant increase in BMP adoption correlated with recognition of the Nippersink logo. Fertilizer BMP adoption increased from 56% among those who did not see the logo, to 68% among those who did see the logo. One other interesting finding was that use of phosphorus-free fertilizer increased from 41% among those not familiar with the Watershed Management Plan to 53% among those who were familiar with the plan. The authors did note that many factors are in play, and it is difficult to connect the changes seen to a single influence, such as the campaign (Brehm and Eisenhauer 2014).

In Canada, 73% of survey respondents indicated they would change one or more of their lawn care practices as a result of information on Health Canada's Healthy Lawns website. Of those who indicated they would change practices, 32% reported they would reduce lawn care pesticides, 28% reported they would change their aerating practices, and 27% reported they would change their feeding practices. Of the written comments received from respondents, eight reported they already use or always use the types of practices described on the Healthy Lawns website, six reported they will or probably will change their practices, five reported they were uncertain about whether they would change practices, and one reported he/she does not use pesticides (Health Canada n.d.).

No Net Change in Behavior

Of the 24 sources that addressed fertilizer reduction, three sources showed no clear link between the outreach and any positive behaviors or water quality improvements (Coffman n.d.; Diorka 2008; Foushee 2010). One study about general stormwater practices showed changes in behavior related primarily to water conservation instead of water quality protection (Wilbur 2008). Another study in Florida showed that survey respondents were statistically more likely to agree with statements that reflect water-friendly behavioral goals when it comes to fertilizer use (in this case recommendation for fertilizing only twice a year) if they reported seeing an ad about fertilizer (Salter Mitchell n.d.). However, on the flip side, those who stated they had not seen the ad reported that they fertilized *less* than those that did recall the ad no matter if they hire a lawn service or if someone in the household applies the fertilizer.

III.b. Evidence of Proper Pet Waste Disposal

Tetra Tech identified 29 sources that included a discussion of outreach efforts taken to address residential pet waste pickup. Of the 29 sources, 3 sources were located within the Chesapeake Bay watershed, 5 sources noted estimated or actual water quality improvements, and 19 sources showed clear positive trends in either awareness, behavior, water quality change, or a combination of those factors.

Water Quality Change

Four of the 29 sources reported positive behavior change and measurable water quality improvements as a result of outreach efforts. A multimedia public education campaign was conducted in Tallahassee, which included topics on pet waste removal. A post-campaign survey found that, out of respondents with dogs, 30% began picking up pet waste following the outreach campaign. Estimations for water quality improvements after the campaign found that instream total nitrogen and total phosphorus concentrations decreased by and estimated 10% and 12%, respectively, when compared to monitoring before the campaign (Florida Stormwater Association 2011). The estimated load reductions were calculated using literature sources for the amount of nitrogen typically found in dog feces. Monitoring studies conducted by the Grand Valley Metropolitan Council (2008) in Michigan showed that the installation of 23 new pet waste disposal stations in the state translated into an estimated reduction of 7.916×10^{10} fecal coliform colonies/day from entering nearby waterways within the Lower Grand River watershed. Montgomery County, Maryland (2014), reported that installing pet waste collection stations resulted in the collection of 1,826 pounds of pet waste. The county then calculated that the pet waste stations prevented 20 trillion fecal coliform bacteria, 105 pounds of nitrogen, and 14 pounds of phosphorous from entering surrounding waterways. As mentioned in the residential fertilizer use section above, Dietz et al. (2004) reported in a paired watershed study a reduction in nitrite + nitrate - N and fecal coliform bacteria concentrations as a result of an intensive BMP education effort in the form of workshops, one-on-one consultation, and implemented BMP structural changes designed to minimize nonpoint pollution from a variety of sources.

Net Positive Behavior Change

Jason et al. (1979) documented pet owner responses to educational sign prompts and direct one-on-one outreach and education within a one block area of northside Chicago, Illinois, inside a 8x5 block target study area. The researchers reported that 5% of dog owners picked up after their pets during baseline observations. Sign prompts alone resulted in a 1% increase in positive pet waste pickup behavior. However, during the direct outreach and education phase of the study—in which owners were given waste bags and shown how to use them—82% of dog owners picked up after their dogs. Furthermore, 63% continued to do so during a 3-month follow-up phase (Jason et al. 1979). Twenty-five months after the study, Jason and Zolik (1980) reported a 69% reduction in pet waste in the 8x5 block area surrounding the outreach site and an 89% reduction on the block where the outreach occurred.

Jason et al. (1980) conducted a similar study in another Chicago neighborhood documenting responses after direct one-on-one outreach related to educating dog owners about a new ordinance for dog owners to carry a receptacle to clean up after their dogs. Dog owners were offered information and a receptacle if they did not already have one. During the baseline phase, the authors reported that no pet waste was picked up. In response to outreach, positive pet waste pickup behavior increased to 87% during the campaign, before decreasing to 53% after the outreach effort was discontinued. After a second outreach phase was implemented, positive pet waste pickup behavior again increased, this time to 89%, or approximately the same levels as noted following the first outreach effort. The authors noted that, during the second outreach phase, the city posted a metal sign in the study area informing dog owners of the $200 fine they might be subject to if they did not remove their pets' litter. Posting the sign was not part of the planned outreach by Jason et al. (1980) and might have contributed to the noted results. Follow-up data by Jason and Zolik (1980) indicated that in the 4x2 block area surrounding the study area, there was an overall 85% reduction in pet waste and a 94% reduction in the outreach study site.

Several studies have been conducted in Chittenden County, Vermont, by the Regional Stormwater Education Program (RSEP). RSEP has used radio and TV advertising, a tip sheet, a website, videos, a bookmark, a magnet, and other fact sheets in their outreach campaign about pet waste removal. To gauge the effectiveness of the campaign, RSEP collected two data sets from surveys before the campaign and one data set after the 4-year campaign. RSEP reported that outreach efforts steadily increased the percentage of respondents reporting pet waste pickup over the 10-year monitoring period. RSEP monitored two aspects of pet waste pickup: pet waste pickup while on a walk, and pet waste pickup at home. More than 80% of survey respondents reported picking up pet waste while on a walk in 2013 (Becot 2013; Regional Stormwater Education Program 2013) compared to approximately 72% in

2007 (University of Vermont 2007; Senecal-Albrecht 2009) and 62% in 2003 (University of Vermont 2007; Senecal-Albrecht 2009; Regional Stormwater Education Program 2013). In response to pet waste pickup at home, Becot (2013) reported that the percentage of pet owners who picked up their pets' waste and put the pet waste in the trash increased from 54% in 2008 to 66% in 2013.

Other key findings include paired or multiyear survey design studies noting positive behavior changes in response to outreach activities. A multifaceted public outreach campaign was conducted in Alachua County, Florida, that included a slogan, logo, educational posters, pamphlet, mailings, campaign Web page, outreach at association meetings, two commercials, a pledge for dog owners, and promotional items. As a result of the outreach activities, Alachua County Public Works (2009) found that 57% of the post-campaign respondents reported putting their pet waste in the trash, a 9% increase from pre-campaign levels. Brehm and Eisenhauer (2014) surveyed various BMP adoption methods in the Nippersink Creek watershed in Illinois and Wisconsin. They reported that, from 2010 to 2013, proper disposal of pet waste increased from 60% before the outreach campaign to 80% after the outreach campaign. Cunningham Environmental Consulting (2011) found that, as a result of regional stormwater outreach programs in the Kitsap Peninsula, Washington, respondents who left dog waste on the ground most of the time when walking their dog decreased from 11% in 2008 to 5% in 2011. San Bernardino County (2013) in California focused on the issue of pet waste by designing and implementing a behavior change campaign that addressed specific barriers to pet waste removal and motivators to encourage dog owners to pick up after their pets. The county reported an increase in positive behavior among dog owners who picked up 90% or less of the time before the campaign, showed an increase in positive behavior practices more than 5% after outreach activities. In similar findings in two towns in Washington State, Elway Research (2009) reported that in randomly timed surveys, Snohomish pet owners provided with educational material describing proper pet waste disposal were twice as likely to report always picking up dog waste and putting it in the trash versus residents of Pierce who were not provided educational material.

Two studies reported decreases in observed "poop piles", after the installation of pet waste bag stations. In Washington's Central Puget Sound area, a partnership between the KapKa Cooperative Primary School and the Fauntleroy Watershed Council reported a decrease in the maximum number of poop piles observed (from 30 piles in 2004 to 13 piles in 2008, based on monitoring conducted every 4–6 weeks between October and March) and decreases in the average number of poop piles observed (from 14 in 2004 to 11 in 2008) after the installation of bag dispensers at park entrances (Fauntleroy Watershed Council 2008). O'Hara (n.d.) reported that in Linear Park, Florida, within the Tampa Bay Estuary, poop piles decreased by 20% following the installation of pet waste bag stations. Additional findings by O'Hara (n.d.) reported a decrease of poop piles in Rivercrest Park, Florida, by 35% from baseline after 3 months of outreach; an additional 10% decrease after 7 months of outreach; and an additional 3% decrease after 10 months of outreach. Outreach in Rivercrest Park included an information booth, distribution of educational information, community presentations, and blogging.

In a similar study in Washington State, West Sound Stormwater (2012) reported that the installation of 81 new pet waste stations (bringing the total to 294 stations) diverted 89 tons of pet waste from surface waters in 2012 alone. The study monitoring showed steady increasing trends in pet waste diversion each year from 2009 to 2012.

No Net Behavior Change

In contrast to the studies reporting positive behavior change in response to outreach activities, several studies reported no change in positive behavior as a result of outreach (Research Dynamics 2000; Pelegrin Research Group 2004b; Foushee 2010). Other studies show mixed responses to outreach activities (Pelegrin Research Group 2004a); for example, survey results showed that willingness to pick up pet waste before and after campaign efforts increased in 2003 (from 87% to 92% before and after campaign efforts), while there was a decrease in 2004 (from 90% to 87%, before and after campaign efforts). Several studies found that in cases in which adopted behavior rates were already high pre-campaign, campaign efforts resulted in little additional improvement. Additionally, positive behavior changes might have been observed in subpopulation groups, such as the worst offenders, but not at the

overall population level. Another study cited user unwillingness to recognize the contribution of pet waste to water quality problems as well as unwillingness to change behavior regardless of consequences as reasons for no change in behavior. Swann (1999) indicated that 44% of those surveyed would not clean up after their pet even with the possibility of a fine, after complaints, or with convenient collection or disposal methods. Thirty-seven percent of dog walkers surveyed did not agree or expressed no knowledge when asked if pet waste could contribute nutrients to local water bodies (Swann 1999).

Change in Awareness

Three of the 29 studies demonstrated change in awareness regarding pet waste issues. Diorka (2008) evaluated change in awareness in Michigan, in response to the Delhi Charter Township's Stormwater Public Education Program via a survey. Diorka (2008) indicated that 24% of survey respondents noticed pet waste stations and 57% of respondents used the stations. Respondents had high levels of awareness of actual behaviors related to the removal of pet waste from their yards and while on walks. Jones and Bruyere (2004) reported that in a pilot study accurate knowledge of pet waste issues increased from 33% to 90% after the Leave No Trace on Open Space campaign in Colorado. However, the authors note that an increase in visitor awareness does not necessarily equate to behavior change. Young (2012) reported that awareness of the water quality issues related to pet waste increased from 37% to 68% after an outreach and educational effort in South Carolina.

Inadequate Data

Franz and Bailey (2003) report change in awareness and behavior regarding pet waste pickup over time; however, the report did not indicate that the response data was tied to a particular outreach effort. Wilbur (2006) reviewed the Neighborhood Water Stewardship Program, a community partnership program in Virginia, aimed at encouraging the public to adopt actions to protect water quality and/or conserve water. Pet waste was a target behavior in the program; however, specific adoption rates were not provided.

III.c. Evidence of Proper Septic Tank Maintenance

Tetra Tech identified 10 studies that included a discussion of outreach efforts taken to address septic tank maintenance. None of the studies provided water quality monitoring data to correlate any behavior changes to water quality improvement. Seven reported on outreach related to septic tank maintenance in the Puget Sound region of Washington. Several of them are discussed in this section. Two of the 10 sources document results from the same outreach program (Snohomish County, Washington). Only one study was found in the Chesapeake Bay watershed; however, not enough information was provided about the outreach program to determine its effectiveness (Miller n.d.).

Net Positive Awareness or Behavior Change

In the Snohomish County, Washington, septic outreach program (Frenzl and Ball 2011), the county compared the likelihood for behavior change across several outreach tactics—direct mail, homeowner workshops, website information, and septic system "house calls" (also called sanitary surveys) by an inspector. They found that workshop participants are significantly more likely to adopt behaviors indicative of proper septic tank maintenance than those who do not attend a workshop. Additionally, workshop participants were much more likely to request a sanitary survey than those notified of this opportunity through direct mail or door hangars. The lack of a regulatory requirement or a monetary incentive (such as a free inspection by a professional) for the Snohomish program likely contributed to a lack of interest in sanitary surveys. The county also concluded that—although direct mailers and sanitary surveys appear to be somewhat effective at increasing knowledge about how septic systems work and how to care for them—they are ineffective at promoting behavior change.

Documentation for septic outreach evaluation was found from several other Washington counties as well, many of which used grant funding to evaluate different types of septic outreach, including Clallam, Island, King, Skagit, and Thurston counties. It should be noted that 10 of the 12 Puget Sound area counties require septic system maintenance inspections every 1, 3, or 5 years, depending on location and type of system. Inspectors, whether property owners or professionals, must be certified to do the inspections. This requirement is a primary driver of homeowner interest in attending septic workshops. In Clallam

County's survey, they found that respondents who have attended a Septic 101 or 201 training workshop were significantly more likely to have had their septic system inspected (71%) when compared to those who did not attend a training (62%). Those who had read the newsletter or attended a septics training were also more likely to have adopted other septic-friendly water habits, although no comparison data was provided for those who had not read the newsletter or taken a class (Clallam County Health & Human Services 2014).

The Island County Public Health Department (2014) found that outreach efforts, including a website, community meetings, printed materials, and workshops, increased knowledge levels but did not increase homeowner willingness to have systems inspected without the threat of enforcement. In a report by the Puget Sound Action Team (2004), the Seattle/King County Department of Public Health conducted a follow-up outreach survey that showed that their septic workshops, call-in TV shows, and Web-based video clips resulted in 98% of the respondents who attended the workshops changing at least one septic behavior to protect water quality. Thirty-seven percent of the people surveyed said that they had their system inspected, monitored, or pumped. However, there was no data to compare pre-outreach campaign behaviors, so there is no way to know if the outreach itself resulted in adoption of the new behavior.

Lastly, a large-scale outreach program in Walpole, Massachusetts, might have had promising outreach results had the Walpole Health Department kept accurate, up-to-date computer records of pumpouts following the outreach campaign. The database suggests that pumping at least doubled, and in several years nearly tripled, following an education campaign. However, the lead contact for the project stated that an objective evaluation of the outreach was rendered impossible due to significant structural problems with the Walpole Septic Database (Neponset River Watershed Association and Walpole Septic Maintenance Task Force 2006).

III.d. Reduction in Rate of Driveway Car Washing

Tetra Tech identified 12 literature sources that included discussions of outreach efforts undertaken to address residential car washing. Only one of the 12 included outreach conducted within the Chesapeake Bay watershed (i.e., Arlington County, Virginia). The Arlington County outreach project involved building citizen-led neighborhood eco-teams to spur neighbors into adopting environmentally friendly behaviors (Wilbur 2006). Although some of the behaviors included practices that can reduce runoff such as environmentally friendly car washing, as noted earlier, most of the behaviors promoted by the program focused on water conservation rather than on water quality protection.

Net Positive Awareness or Behavior Change

Cunningham Environmental Consulting (2011) found that as a result of outreach efforts in the Kitsap Peninsula in Washington, although more residents are now washing their cars at home, they have adopted the new behavior of washing their cars on grass, gravel, or other permeable surfaces (40% in 2008 to 69% in 2011). Likewise, Elway Research (2009) found that 17% of survey respondents in Tacoma, Washington, who received outreach materials on car care practices reported washing their cars on pavement, which is a decrease from the 23% reported in a previous survey. Additionally, the percentage of those saying that they wash their cars on permeable surfaces increased from 34% to 42% (Elway Research 2009).

Other key findings include two studies that asked survey respondents where their dirty washwater flows when they wash their cars at home. Franz and Bailey (2003) found that in the city of San Diego, California, the percentage of those who let washwater flow into driveways, streets, or gutters decreased slightly from 2001 to 2003 (from 78% to 72%) as a result of the city's Storm Water Pollution Program. The North Carolina Clean Water Education Partnership (CWEP) found that, after a mass media outreach campaign (TV public service announcements), citizens were less likely to let the washwater flow onto the driveway (21%) than those in the baseline survey (40%). Additionally, respondents who recalled having seen the televised public service announcements (PSAs) were more likely to let washwater flow to permeable surfaces (Foushee 2010). Conversely, Diorka (2008) determined that survey results following an educational campaign that included a flyer showing a man washing his car on top of a lake "did not

show sufficient evidence to conclude there was a positive linear correlation between the paired results of awareness scores and number of exposures to educational materials."

Three of the 12 documents discuss outreach conducted by several Chittenden County, Vermont, communities that have worked together for more than 10 years to operate the Regional Stormwater Education Program (RSEP). RSEP used radio and TV advertising, tip sheets, a website, videos, a bookmark, a magnet, and other fact sheets in their outreach campaign. As noted earlier, the group conducted a baseline survey in 2003 and a follow-up survey in 2007. From 2003 to 2007, their outreach resulted in a significant increase in the number of citizens reporting that they never wash their car at home (Senecal-Albrect 2009; University of Vermont 2007). However, in the same survey, when residents were asked how often they wash their cars on paved surfaces at home, there was an increase (although not significant) in the number of people who reported they always wash their cars on paved surfaces and a corresponding decrease in the number of people who reported that they never wash their cars on paved surfaces (University of Vermont 2007). In 2008, RSEP revamped their questionnaire and conducted a new survey to develop a new, more accurate baseline. They found that the majority of people in the region (74%) understand that washing a vehicle at a commercial car wash or on their lawn are the most environmentally friendly options. As a result of the survey, RSEP determined that no additional outreach on the topic was necessary (Senecal-Albrect 2009). In a 2013 follow-up survey, the percentage was similar (56% thought that commercial car washes introduce the least pollution to streams; 24% thought washing a car on their lawn introduced the least pollution) (Becot 2013). Although the needle appears to have moved toward proper car washing behavior as a result of early outreach from 2003 to 2007, there is no way to know whether this change is due to an increased number of people who simply just do not wash their cars because car washes are expensive or because they believe trying to keep their cars clean is a futile effort in New England due to the weather.

III.e. Other Targeted Behaviors

III.e.1. Proper Handling of Lawn Clippings

Tetra Tech identified 12 literature sources that addressed the disposal and handling of yard waste, such as grass and leaves. Of the 12 studies reviewed, seven showed increases in positive behaviors after outreach was conducted. One study showed no clear link between outreach and positive behaviors or water quality improvement (Coffman n.d.), whereas Foushee (2010) did find some improvement in the number of residents that left clippings on the lawn or mulched them. However, differences in Foushee's post-campaign survey population between those who recalled seeing a television spot and those who did not were not substantial. Two studies showed mixed results, with one study showing reductions in a positive activity (throwing clippings into the trash) as well as increases in a negative activity (sweeping clippings into the street or gutter) (Franz and Bailey 2003), and another study showing a small decrease in people leaving clippings on the lawn after outreach (Salter Mitchell n.d.).

Net Positive Behavior Change

In an outreach campaign in Alachua County, Florida, the majority of homeowners reported that they blow clippings back into their yards. After the outreach campaign, more homeowners claimed that they always take this action (Alachua County Environmental Protection Department 2012). The Los Angeles County Department of Public Works implemented a county stormwater pollution education program. Pre- and post-campaign surveys showed that proper yard waste disposal improved, with 29% (2003) and 25% (2004) properly disposing of yard waste, which was an increase from pre-campaign levels: 17% (2003) and 18% (2004) (Pelegrin Research Group 2004a). JD Franz Research (2000) conducted a follow-up survey to evaluate grasscycling campaigns in Contra Costa, Napa, and Solano counties (Bay area); Los Angeles County; and Riverside and San Bernardino counties (Inland Empire) in California. The percentage of homeowners reporting recycling grass clippings increased between the pre- and post-survey from 37% to 40% (Bay area), 36% to 38% (Inland Empire), and 41% to 48% (Los Angeles County), while those reporting throwing clippings in the trash reduced between surveys from 24% to 20% (Bay area), 32% to 26% (Inland Empire), and 35% to 28% (Los Angeles County) (JD Franz Research 2000).

Cunningham Environmental Consulting conducted a paired survey (2008 and 2011) to track changes in behavior by Kitsap Peninsula, Washington, residents. Results show that 2011 respondents were more likely to compost yard waste, as well as burn and dispose of it in the woods (Cunningham Environmental Consulting 2011). As mentioned earlier, in Long Island Sound communities in Connecticut, Dietz et al. (2004) used a paired watershed design (control and treatment watersheds). In the treatment watershed, homeowners were educated about ways to minimize nonpoint source pollution. The survey showed 82% of respondents in the treatment watershed left clippings on the lawn, compared to 62% previously (Dietz et al. 2004). A small change was seen by Research Dynamics (2000) in Memphis, Tennessee, residents' awareness and opinions, with those reporting that they bag leaves and grass clippings for the city to pick up increasing from 67% in 1999 to 70% in 2000.

Additionally, a project in the Nippersink Creek watershed in Illinois sought to evaluate the phosphorus-free campaign by measuring adoption of some BMPs between 2010 and 2013. Adoption of the "Keep Grass Clippings and Leaves Out of Roads, Ditches, Gutters" BMP increased from 66% to 84% of those surveyed. The findings also show a statistically significant increase in BMP adoption correlated with recognition of the Nippersink logo. For grass clippings, adoption increased from 82% for those who had never see the logo to 93% for those who had seen the logo (Brehm and Eisenhauer 2014).

III.e.2. Proper Handling of Marina Waste Disposal Using Pumpout Facilities

Two sources were found that included a discussion of outreach efforts taken to address marina pumpout use by boaters. Both sources showed changes in public awareness. Neither of the two sources was located within the Chesapeake Bay watershed.

Since 2008, the San Francisco Estuary Partnership (SFEP) has conducted a regional pumpout monitoring program that includes an extensive outreach component (e.g., education at boat shows, marinas, and yacht clubs; annual mailings and other printed education materials provided to the public; clean boating videos on the subjects of oil, fuel, and sewage). Further, SFEP has been conducting mobile pumpout events to engage the public in new settings and introduce new sewage-reducing techniques. To date, SFEP estimates that these events have prevented over 8,800 gallons of sewage from entering California's waterways from a total of 278 vessels (SFEP and ABAG 2015).

Banigan and Whitford (2013) conducted a paired written survey to assess how outreach—particularly the distribution of educational materials, direct one-on-one outreach, and the distribution of "Clean Boating Kits"—affected boaters' awareness of sewage discharge. A comparison of the initial and follow-up surveys indicated increased boater recognition of the pumpout symbol (from 32 to 43 respondents) and a slight increase in boater understanding that untreated sewage from boats can harm the environment (from 35 to 38 respondents). There was no reported change in awareness when recreational boaters were asked if it was illegal to dump untreated sewage and whether untreated sewage from boats was biodegradable and generally harmless; correct responses were high in both surveys.

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VII. Appendix: Outreach Literature Spreadsheet