Typical Pollutants Leaving a Highway Construction Site in the Houston Area, and the Effectiveness of Selected Temporary Sediment Controls

Joseph P. Muscara[1], Deborah J. Roberts[2], KH Wang[3], and Theodore G. Cleveland[3]

Abstract

A highway construction project in the Houston area was monitored from pre-construction to near completion to determine the type of pollutants that leave the site. The effectiveness of temporary sediment controls (TSCs) for pollutant control was also monitored. Most nutrients and metals appeared to be negligible pollutants as their concentrations in stormwater leaving the site were relatively unchanged when compared to ambient levels in the receiving waters. Suspended solids and turbidity were the most significant measured parameters that were observed to change during rainfall.

The results of the on-going work will be presented. Currently, the data indicate that there is little or no effect of construction on the receiving water for the sample sites analyzed to date.

Introduction

The U.S. Environmental Protection Agency requires Stormwater Pollution Prevention Plans (SW3Ps) to be developed for any construction site of five acres or larger. This requires agencies such as the Texas Department of Transportation (TxDOT) to design and submit a stormwater pollution prevention plan that meets the requirements of the

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[1] Masters Candidate, Department of Civil and Environmental Engineering, University of Houston, Houston, Texas 77204-4791

[2] Assistant Professor, Department of Civil and Environmental Engineering, University of Houston, Houston, Texas 77204-4791

[3] Associate Professor, Department of Civil and Environmental Engineering, University of Houston, Houston, Texas 77204-4791; Associate Member American Society of Civil Engineers

EPA National Pollutant Discharge Elimination System (NPDES) General Permit for any project greater than five acres where soil disturbing activities will occur. This plan includes, among other items, the location of major structural and nonstructural controls identified in the plan, structural practices, a description of the procedures for maintenance and inspection of sediment control measures, the hydraulics of the site, and the affected surface water bodies for each phase of construction.

These requirements carry with them obvious design costs, as well as the costs of installing and maintaining the temporary sediment controls. All TSCs at the site are required to be checked after every 1/2 inch of rain, or every week, whichever comes first. Therefore, there are some concerns from TxDOT and similar organizations nationwide regarding the effectiveness of TSCs, as well as the optimal use of these devices.

The assumption that drives the use of SW3Ps is that non-point sources of pollution are carried to receiving waters during storm events by storm water flowing through the construction site. These non-point contaminates can originate from numerous sources, such as natural materials for forms of nitrogen and phosphorus, to man-made and construction materials for metals. These contaminates are assumed to upset the existing pre-construction balance in the receiving water bodies by either accelerating or preventing growth of particular organisms.

For this phase of the research, two types of temporary sediment controls were investigated, the rock filter dam and the sediment control fence. Both types are used during construction activities to protect receiving waters by preventing sediments from moving offsite, reducing erosive forces of runoff, diverting runoff away from exposed areas, and conveying runoff (TxDOT, 1993).

According to TxDOTs "Storm Water Management Guidelines for Construction Activities," a rock filter dam is a temporary berm constructed of open-graded rock whose purpose is to intercept and slow down sediment laden storm water runoff from disturbed areas, retain the sediment, and release the water in sheet flow. This runoff should outfall directly to undisturbed or stabilized area. They are used where there is sheet flow or concentrated flow in a channel above the rock filter dam (TxDOT, 1993).

The design guidelines for rock filter dams specify that the drainage area be less than 5 acres, the maximum flow through rate be 60 gal/min/ft, and the rock be 3 - 5 inches in diameter. At this site and for this research, all rock filter dams studied are Type 1, specified as 18 inches in height, 2 foot minimum top width, with water velocities less than 8 ft/sec. These rock filter dams are recommended for the toe of slopes, around inlets, in small ditches, and at dike and swale outlets (TxDOT, 1993).

A sediment control fence is a temporary barrier fence made of geotextile filter fabric that is water permeable and traps water borne sediment and is reinforced with a wire backing. Its purpose is to intercept and detain waterborne sediment from stormwater runoff. They are used during the construction period near the perimeter of a disturbed area to intercept sediment while water percolates through, and they should remain until disturbed area is permanently stabilized. They should not be used where there is a concentration of water in a channel or drainageway or where soil conditions prevent a minimum toe-in depth of 6 inches or installation of support post to a depth of 12 inches. Sediment control fences should be replaced with rock filter dams if concentrated flow occurs after installation (TxDOT, 1993).

The design guidelines for sediment control fences specify that the drainage area be less than 2 acres, the maximum flow through rate be 40 gal/min/ft^2 of frontal area, that they have a 24 inch minimum height and a six inch minimum toe-in. Sediment control fences should be placed and constructed in such a manner that runoff will be intercepted, sediment trapped, and surface runoff allowed to percolate through the structure onto an undisturbed or stabilized area (TxDOT, 1993).

Methods

The test site agreed upon by TxDOT and the University of Houston research team was a two mile long construction site on NASA Rd. 1 in Clear Lake. The primary purpose of the construction activities is to widen the road; the work at the site would then include consist of grading, structures, utility relocation, storm sewers, base, concrete pavement, traffic signals, signing and pavement markings.

Five permanent monitoring locations (PM-1 through PM-5) were chosen for ambient sampling. The locations of PM-1 through PM-4 were selected based upon storm sewer outfalls along the construction site, while PM-5 was selected as an upstream baseline in a large body of water so that construction would have no effect. PM-2 was lost early due to construction at that location. An alternate has been selected but is unavailable. Except for PM-5, all permanent monitoring locations had an "upstream" and a "downstream" sampling point.

Five temporary sediment controls (TSC-1 through TSC-5) were selected based upon convenience, safety, storm flows, and type. Three TSCs were rock filter dams with two being simple rock filter dams in a median channel and the third protecting a storm sewer inlet in the median. The other two TSCs were sediment control fences in median channels. All five temporary sediment controls had an "upstream" and a "downstream" sampling point.

The sampling plan consisted of two types of sampling, ambient and storm influenced. The ambient sampling plan consisted of sampling the permanent monitoring locations regularly, which was approximately every two weeks. The purpose of these samples was to create a baseline with which to compare the storm influenced samples, as well as possibly determine if there were any long term effects in the receiving water bodies, as the ambient sampling started before construction groundbreaking began. Since there were no storm flows when the ambient samples were taken, these samples were only taken at the downstream sample points.

During or as soon as possible after a storm event occurred, samples were taken at the permanent monitoring locations and temporary sediment controls, at their respective upstream and downstream points, for storm influenced samples. When samples were taken during a storm, as many locations as possible were sampled upstream and downstream every 15 minutes. Since the location of the test site relative to the University of Houston made timing of "catching" storms difficult, it was decided that it would be advantageous to also sample all ten locations as soon as possible after a storm event. Again, these samples were taken at all upstream and downstream points. Of course, there had to be sufficient rainfall to create flows in storm sewers and upstream and downstream of all TSCs to take samples.

Each sample was analyzed for a total of fifteen parameters that were pH, temperature, conductivity, total dissolved solids, NO_3, NO_2, NH_4 SO_4 PO_4 Cl, turbidity, suspended solids, Zn, Ni, and Fe. The first three were analyzed in the field whenever possible using a Hach One pH meter and a Hach Conductivity meter. The remaining were analyzed on a Hach DR/2000 Spectrophotometer, which uses a colormetric technique where the constituent of interest is converted via a chemical reaction into a substance whose solution or suspension is colored and will absorb radiant energy (Fishman and Friedman, 1989).

Since the constituent measurements are intended only to be used as indicators of water quality problems resulting from runoff at highway construction sites, the laboratory analyses were performed at a survey or screening level. No digestions were performed for metals analyses, only reactive phosphorus (orthophosphate) was measured, and distillation was not performed for ammonia nitrogen. Both the nitrite and sulfate methods are EPA approved, and the reactive phosphorus method is from Standard Methods (Hach Company, 1992). This experimental methodology was agreed upon by the Texas Department of Transportation and the research team at the University of Houston. Several of the methods are also USGS approved (Fishman and Friedman, 1989).

Results

A total of 22 sample sets were taken from the period of April 10, 1996 to October 2, 1996. Of these, 13 were ambient, three were post-storm storm-influenced, and six were time-based storm samples. Since there was only one set of time-based storm event samples, each of these individual samples was analyzed as separate storm influenced samples.

The complete data analysis for this research is currently ongoing. The following results are an investigation of the influences of storm events at PM-1.

The test performed on the PM-1 data was a t-test of a hypothesis on the mean. The specific t-test performed was a two sample test, assuming unequal variances. This test compares two sample sets for equal means. Therefore, for each parameter analyzed, the hypothesis to be tested is $\mu_{Ambient} = \mu_{Storm\ Influenced}$. The critical region corresponds to a 5 percent level of significance ($\alpha = 0.05$).

Table 1 shows the results of the data analysis for each parameter. For each, the mean and variance for ambient versus storm influenced data is shown, as well as the data for the t-test and whether the above hypothesis was accepted or rejected. The hypothesis was tested by calculating the t statistic (t Stat) and comparing it to t critical, which was obtained from a table. If the t statistic was between ±t critical, the hypothesis is accepted; otherwise, it is rejected (Dixon, 1983).

Since the pH, temperature, conductivity, and total dissolved solids of the storm influenced samples were measured in the lab after the samples had begun to chill during transport, comparing these parameters to their ambient counterparts is not valid and results from these measurements are not shown here.

Table 1: t-Test Two Sample Assuming Unequal Variances

Parameter	Ambient Mean	Ambient Variance	Storm Influenced Mean	Storm Influenced Variance	t Stat	t Critical (two tail)	Hypothesis?
Sus. Solids	13	153.83	183.5	12216.57	-4.35	2.36	Reject
Turbidity	13.6	97.26	104	3786	-4.12	2.36	Reject
Iron (Fe)	0.23	0.05	0.28	0.03	-0.56	2.09	Accept
Zinc (Zn)	0.017	0.00085	0.0225	0.00034	-0.49	2.13	Accept
Nickel (Ni)	0.024	0.00108	0.0788	0.00127	-3.25	2.14	Reject
SO_4	90.09	23812.7	6.78	171.9	1.78	2.23	Accept
Cl^-	297.73	334858.	30.875	2321.03	1.52	2.23	Accept
Phosphorus	0.085	0.002	0.058	0.0014	1.53	2.09	Accept
NO_3-N	0.354	0.266	0.333	0.035	0.13	2.12	Accept
NO_2-N	0.0047	$7.7*10^{-6}$	0.016	0.00045	-1.57	2.31	Accept
NH_3-N	0.219	0.0213	0.806	0.0838	-5.27	2.23	Reject

Conclusion and Future Work

Current data at this test site is showing that there is little or no effect of construction on the receiving water at PM-1. The ongoing research will attempt to determine if this is a result of the temporary sediment controls that were in place, or if other factors reduced the quantity of pollutants leaving the test site. Further analysis will also include similar analyses for the remaining permanent monitoring sites, a comparison of upstream versus downstream at all temporary sediment controls, and a comparison of upstream versus downstream at all permanent monitoring sites to study dilution effects.

References

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