# The University of Texas at Arlington

## Project Summary Report 7-1996-S

### Project 7-1996: Mobile Stormwater Sampling System to Collect Stormwater Samples at Highway Speeds Directly from the Road Surface

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PROJECT SUMMARY REPORT

## Purpose and Need

The objective of this research is to develop a highway stormwater sampling device to facilitate compliance with TMDL (Total Maximum Daily Load) and NPDES (National Pollutant Discharge Elimination System) requirements. This project developed and evaluated a mobile stormwater sampling system to collect and sample stormwater from the road surface during storm events. This device can provide a basis for separating direct highway stormwater runoff quality contributions from the total drainage runoff with its highway ancillary drainage contribution. This sampler is unique in that it samples stormwater during real time directly from the roadway surface at traffic speeds. The design is predicated on capturing water picked up by tires and thrown up into the air. A special device is designed to capture the stormwater while an automatic sampler collects and stores the samples for later laboratory analysis.

Additionally, the sampler is coupled with a Global Positioning Satellite (GPS) system, thus allowing sample location to be quickly and accurately determined and recorded. The highway stormwater runoff sample analysis is then transferred to a Geographic Information System (GIS) for spatial reference of data as well as easy data retrieval and useful data recording for study and analyses of highway stormwater quality contributions.

The major project tasks included: 1) literature review; 2) selection of proper vehicle and tires; 3) design, construction, and testing of collection device; 4) selection of Global Positioning Satellite receiver and data collection system; and 5) assembling components into a system and testing the system for functioning and representative sampling.

## What We Did

**Literature Review.** A limited literature review was conducted to determine environmental issues, TxDOT-specific TMDL and NPDES screening requirements, and existing types of runoff samplers.

Extensive literature exists about stormwater pollutant loads and discussions of how to simulate loads for various conditions. Most city governments such as Los Angeles County, California and Austin, Texas are addressing NPDES and TMDL requirements by extensive stormwater monitoring studies. Several attempts are being performed to develop new or adapt old stormwater sampling devices such as: 1) splitter flumes calibrated as a passive hydraulic sampling devices, 2) a sampling kit to screen and assess potential water pollution problems equipped with global positioning and geographic information system technology, 3) development of a low-cost culvert composite sampler to obtain storm-water sampling, and 4) development of a sheet flow sampler to collect highway runoff. The above summary shows some of the work that is occurring in this field. No references were observed indicating work on a mobile roadway surface sampler.

**Vehicle and Tire Selection.** The basic sampler premise came from observing water being thrown up from the roadway surface by vehicle tires during rainstorms. If this water could be collected in sufficient quantity and quality, a sampler might be developed to collect runoff directly from the roadway. A test chamber, created to study water volumes produced from different speeds, is illustrated in Figure 1. An axle was submerged and driven by an electric motor to produce tire rotation at various speeds. A series of pumps maintained a thin film of water at the axle-tire

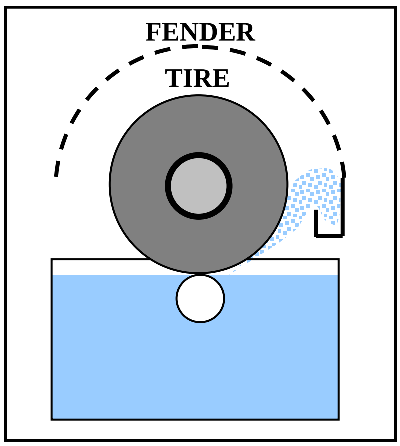


**Figure 1. Tire Simulator**

interface. A clear semicircular plastic fender with a catchment's bucket is used to observe water flow pattern and collect water volumes thrown off.

Three different tires were selected for testing, a general radial all weather tire, a racing slick, and a specially designed rain tire. Test results of the three tire types are shown in Figure 2. The "ET Drag "Slick" was ultimately used for road testing. The slick tire was selected first because of its continuous increase (smoother) discharge with speed. Second, in talking to tire manufacturers, researchers learned that slicks have a reputation of picking up and transporting debris better, i.e., small rock and suspended material.

A standard single axle flat bed 5-foot by 10-foot commercial trailer was selected as a sampler platform. The trailer consisted of a steel frame with a wooden deck, shown in Figure 3.

**Sampler Design.** The collector tire is a third wheel mounted on a steel framework attached to the trailer axle. The frame rotates about the trailer axle and allows the sampling tire to be raised and lowered.

A third tire configuration is used for three basic reasons. First, it allows the sampler (third wheel) to be transported without contact with the road surface to the place of sampling. Second, it facilitates decontamination of the wheel and fender housing assembly between sampling events. Finally, this configuration when locked in the down position forms a three-point contact with the road surface with the sampling wheel being slightly lower than the two main trailer wheels. This insures that the sampling wheel will be one of the two wheels always in contact with the roadway. The three-wheel arrangement is shown in Figures 3 and 4.

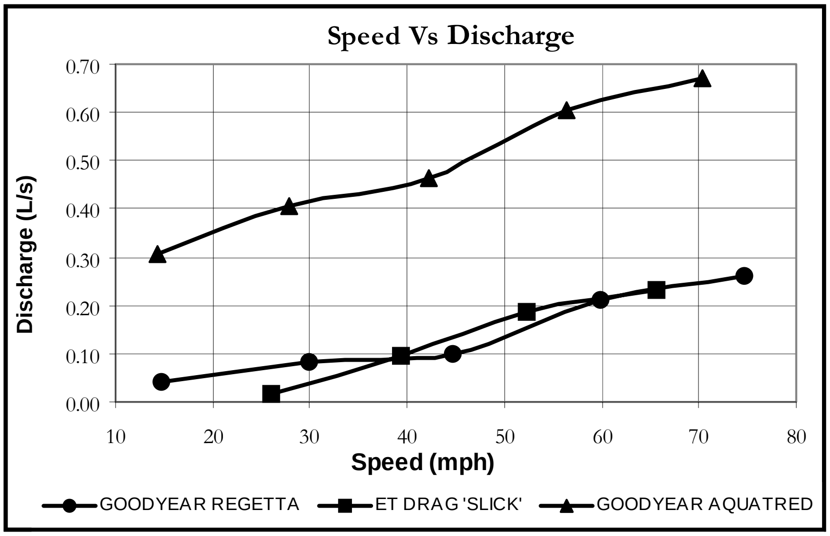


**Figure 2. Tire Testing Results**

An ISCO 3700 Compact portable automated peristaltic pump sampler was used to collect and hold samples. It is fully programmable and has a sample capacity of either one 2.5-gallon bottle or twelve 300-ml bottles. It is battery-operated and is turned off and on from the cab of the towing vehicle.
Flexible tubing connects the ISCO pump to the collection intake on the third wheel fender housing. This tubing is attached to the third wheel steel frame with quick release clamps to allow quick change-out of hoses between sampling and assists decontamination. The hose and the collection intake can be seen in Figure 3.

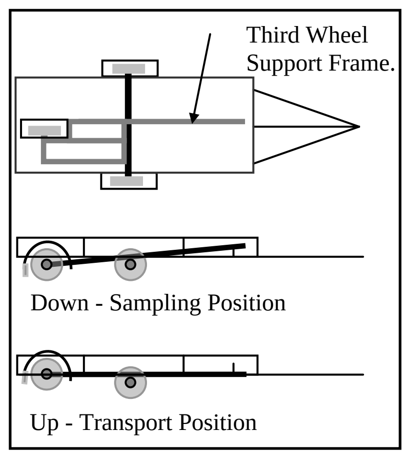


**Figure 4. Third Wheel Suspension**

**Figure 3. Third Wheel in Down Position for Sampling**

The water intake is a plastic rectangular box equipped with a stainless steel mesh to prevent debris from entering the tubing. A close-up of the collection intake is shown in Figure 5. The collection intake is fixed to the third wheel fender with a stiff rubber material to allow some flexibility for impact but resist air drag. The collector bottom is angled to one side to encourage drainage to a hose connector. The design allows small particulate mater to be carried to the sample.

**Figure 5. Collector Intake**

The third wheel fender is hinged to allow raising it away from the sampling wheel, thus simplifying decontamination. Additionally, the side of the fender adjacent to the floor access panel is clear plastic for observation purposes.

**GPS and GIS System.** A Trim-ble GeoExplorer 3 equipped with an external roof mounted antenna was used.

Prior to collection of data in the field, a data dictionary is loaded into the receiver using GPS Pathfinder Office software. This dictionary provides the structure for data gathered by the receiver. It will contain the sampling location data, the road name, the sample date and time, and the laboratory sample ID.

Once the sampling run is started, the locations are automatically recorded along with the time. Afterward the data is downloaded into a GIS system to display sampling locations.

## What We Found

After initial component testing of the sampler, four samplings of roadways were made during rainstorm events. The roadways sampled consisted of two sections of Interstate Highway 30 and a local concrete thoroughfare. The samples were sent to a commercial testing facility for analysis. Only those constituents presently required by regulation for the local TxDOT area were investigated. The sampling results were then compared to runoff observed in local creeks as recorded by local area authorities. These results are listed in Table 1 below.

The results are from roadways during the initial stage of the rainfall. No attempt was made to record the entire storm event. The results obtained from analysis do not appear to be significantly different from the local creek observations. However, no conclusion should be drawn from this data as to relative contributions from the roadway surfaces versus that observed from the creek, i.e., commingled runoff from several different sources.

The tabulated results indicate that the pH, BOD, COD, TSS, and zinc may be higher than those in the local creek data. The remaining constituents appear to be lower than those in the local creek data. Only TSS was consistently greater than the creek reported observations. The roadway surfaces were all concrete at the time of sampling with the exception of Map Site 4, which was surface-treated a few weeks before sampling.

## The Researchers Recommend

This research developed a first-generation sampler capable of sampling directly from the roadway surface during storm events at typical driving speeds. As with all first-generation samplers, enhancements and improvements can improve usability.

**Table 1. Sampling Results**

| Map Site | Davis Road 1 | IH 30 West 3 | IH 30 East 4 | IH 30 East 2 | Local Creek Statistics Avg | Min | Max |
|---|---|---|---|---|---|---|---|
| PH | 8.53 | 8.02 | 8.23 | 8.32 | 7.70 | 7.20 | 8.40 |
| | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L |
| BOD | 26 | 43 | 40 | 10 | 7 | 3 | 16 |
| COD | 40 | 110 | 72 | 82 | 53 | 5 | 140 |
| TSS | 1512 | 1832 | 4600 | 1786 | 132 | 13 | 496 |
| TDS | 80 | 228 | 104 | 66 | 255 | 73 | 932 |
| TH | 28 | 42 | 19 | 43 | 122 | 8 | 491 |
| TN | 1.9 | 10.1 | 4.4 | < 0.05 | 6.66 | 0.62 | 206 |
| TKN | < 1 | < 1 | < 1 | < 1 | 2.27 | 0.15 | 21.0 |
| NO3-N, NO2-N | 1.16 | 2.24 | 1.14 | 0.12 | 0.79 | 0.16 | 1.98 |
| TP | < 0.05 | < 0.06 | < 0.06 | 0.25 | 0.36 | 0.04 | 1.69 |
| Ortho P | < 0.05 | < 0.05 | < 0.05 | < 0.05 | 0.12 | 0.01 | 0.53 |
| Cadmium | <0.005 | <0.005 | <0.005 | <0.005 | 0.68 | 0.05 | 5.00 |
| Chromium | <0.05 | 0.08 | <0.05 | <0.05 | 6.57 | 1.00 | 50.0 |
| Copper | 0.02 | 0.16 | 0.04 | 0.06 | 15.2 | 0.30 | 115 |
| Lead | < 0.05 | 0.19 | 0.05 | <0.05 | 33.7 | 3.00 | 450 |
| Nickel | 0.02 | 0.05 | 0.03 | 0.02 | 10.8 | 0.01 | 28.0 |
| Zinc | 0.195 | 1.322 | 0.276 | 0.165 | 0.12 | 0.02 | 0.84 |
| Phenol | < 0.05 | < 0.05 | < 0.05 | < 5 | 20.6 | 2.00 | 45.0 |
| Oil & Grease | < 5 | < 5 | < 5 | 8 | | | |
| TPH C0-C10 | < 5 | < 5 | < 5 | < 5 | | | |
| TPH < C10-C28 | < 5 | < 5 | < 5 | < 5 | | | |
| TPH Total | < 5 | < 5 | < 5 | < 5 | | | |

Additional sampling under controlled conditions should be performed to assure that no statistical difference exits between this sampling method and present sampling techniques.

The sampling process can be further automated. The raising and lowering of the sampler could be automated with a simple hydraulic system as one example. Another example would be to have a bank of peristaltic pumps, so several testing runs could be sampled before physically removing sampling bottles.

Commercial off-the-shelf pumps are programmed by pump timing instead of by flow measuring. As a result, simple pumps with large sample containers may provide a significant cost reduction by allowing several inexpensive simple pumps to be mounted as a bank of pumps each run independently. To meet NPDES sampling protocol, additional testing is necessary to establish protocols providing equivalent results.

At present rainfall gauges are stationary during sampling. However, the close proximity of traffic on such stations is not clearly known. The integration of rainfall measurement with the moving sampler would be useful. Using local Doppler radar to determine rainfall rate amounts could also be tried.

**For More Details**

The research is documented in Report 7-1996-2: *Mobile Stormwater Sampler System. - s/b 7-1996-2*

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**TxDOT Implementation Status**

This research resulted in the development of a first-generation highway stormwater sampling device to facilitate compliance with new water quality regulations. The device is a towed trailer that collects roadway water samples at traffic operation speeds. The device has the potential to help TxDOT address pending federal and state water quality regulations**.**

For more information, contact – TBD – Research and Technology Implementation Office, at (512) 465-7403, or email rtimain@dot.state.tx.us.



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