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Implementing the Ultra-High Pressure Water Cutter for Roadway Maintenance Applications: Final Report

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16. Abstract
The implementation research project described herein was designed to conduct a systematic evaluation of the ultra high pressure (UHP) water cutter as a pavement preservation tool for treatment of flushed, seal-coat surfaced pavements in Texas. Relative to treatment effectiveness, comparison of pre- and post-treatment data from multiple sets of friction and texture tests collected from 14 sites located in four climatic regions in Texas indicates that the UHP water cutting treatment achieved an average increase in pavement texture of about 200 percent, and an average increase in friction of about 135 percent. Treatment durability was evaluated in terms of the survivability and life expectancy of pavement texture and friction values achieved at treatment. Relative to survivability, pavement texture and friction values were at or above the *desirable* threshold for seven of 13 sites upon completion of monitoring, and values were at or above the *maintenance* threshold for 12 of 13 sites. Relative to life expectancy, predictive models indicate that the improvement in pavement texture and friction achieved by UHP water cutting will last one or more years at 90 percent of the test sites, and for 40 percent of the test sites, the treatment may last four or more years. Relative to production considerations associated with the UHP water cutter treatment process, a direct comparison of unit cost data for UPH water cutting versus the unit costs of other maintenance functions currently used to treat flushed pavements in Texas indicates that UHP water cutting can provide cost savings of 25 percent to 77 percent, typically 41 percent. Overall, the findings from this implementation study offer a reasonably positive view about UHP water cutting as a roadway maintenance tool for Texas roads.

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CHAPTER 1. INTRODUCTION

1.1. Overview

This report presents findings of research implementation project 5-5230-01, which was conducted to implement the Ultra High Pressure (UHP) water cutter to rectify flushed asphalt-surfaced roadways in Texas. This project follows observations made from a Grimes County demonstration project in March 2010, which indicated that UHP water cutting has the potential to be an efficient, sustainable and cost-effective maintenance process. This research implementation project was aimed at conducting a systematic evaluation of the UHP water cutter as a TxDOT maintenance tool.

During the course of this two-year project, data were collected from 14 test projects located throughout the State of Texas where the UHP water cutter process was used to restore texture to flushed pavement surfaces and to correct other pavement problems. Follow-up monitoring at six-month intervals was conducted with the goal being to evaluate the longer term effectiveness of the treatment. Based on this work, guidelines and specifications for the use of UHP water cutter to rectify flushed asphalt pavements have been developed for use by TxDOT maintenance personnel.

1.2. The Maintenance Problem: Correction of Flushed Pavement Surfaces

Research project 0-5230 identified maintenance solutions for bleeding and flushed pavements surfaced with either a seal coat or surface treatment. A technique identified by that study as being highly effective in restoring texture to flushed pavement surfaces was the ultra-high pressure (UHP) water cutter. This technique was found to be useful for other pavement maintenance applications as well, such as treatment in advance of seal coating operations, removal of pavement markings, thermoplastic striping removal, clean up of residue from spills, and cleaning of porous friction course asphalt pavements.

Flushing and bleeding of pavement surfaces with a seal coat as a wearing course create numerous challenges for those who maintain such roads. Both flushing and bleeding involve the presence of excess asphalt on the roadway surface. Flushing and bleeding can be the result of aggregates pressed into soft asphalt cement by vehicle tires, or due to loss of aggregate (a.k.a. raveling or shelling) from a sealed surface. A survey of definitions for flushing and bleeding used by different highway agencies shows significant variation [Lawson et al. 2007]. However, there is agreement that flushing and bleeding result in loss of friction, which is a pavement distress requiring preventive, and sometimes corrective, maintenance.

In addition to the safety concerns resulting from the reduction of skid resistance on flushed wheel paths, highway agencies face the challenge of maintaining roads with uneven surface texture, rendering subsequent full-width seal coating work difficult. If the uneven surface texture across the lane width is not taken into consideration during full-width seal coat application, flushing will reappear soon after the seal is applied. Many treatment options commonly used to address flushed pavement surfaces have proven to be ineffective and temporary in nature [Lawson and Senadheera 2009].

1.3. The UHP Water Cutter: Background and General Description

A relatively novel approach to rectify flushing has been the use of ultra-high pressure (UHP) water jets to "cut" (hence the phrase *UHP water cutting*) excess asphalt, thus rejuvenating pavement texture. This emerging technology has been used in North America for many years to remove tire rubber from landing areas of airport runways. It has also been used to retexture flushed asphalt pavement surfaces in Australia and New Zealand, reportedly with significant success [Waters 2005; Waters and Pidwerbesky 2006]. High pressure water can also be used to remove pavement markings, striping and spills. This treatment can be used in advance of seal coating operations to treat asphalt-rich patches, areas with minor bleeding problems, flushed areas, and to create a uniform surface texture before a subsequent (new) seal coat is applied.

The UHP water cutter combines a truck-mounted UHP pump, water supply, and a vacuum recovery system with an independently operated water blaster that travels on the pavement by the side of the truck (Figure 1.1). This equipment consists of very high pressure pumps, usually truck mounted and self contained, and applicators, which may vary from the hydro-mower (umbilical) type for treating smaller areas, to large tractor or truck-mounted units. Both machine types include tanks for the supply of fresh water and storage of collected water and debris.

FIGURE 1.1 UHP Water Cutter With Fixed Cutting Head Attachment

A rotating spray bar uses specialized nozzles to direct very fine jets of ultra-high pressure water (32-36 ksi) at ultrasonic velocity (mach 1.5) on to the road surface. Precise control of pressure, water volume and speed allows effective removal of excess asphalt binder and surface contamination with minimal disturbance to the bond between the aggregate and the underlying asphalt. Powerful suction heads are used to collect wastewater and debris from the surface for later disposal. The following general requirements and procedures are typical for the UHP water cutting process:

1. A source of clean water is required.
2. Water jet pressure and/or the travel speed of the truck needs to be controlled to prevent damage to the surfacing. The hardness of the binder will influence the pressure required and time taken to achieve a satisfactory result.
3. Traffic control is needed to ensure safety of the traveling public during water cutting operations.

The UHP process is most effective on sprayed seals and asphalt showing loss of texture due to flushed binder. A UHP water cutter combines both water cutting and road cleaning technologies in a single process to simultaneously remove excess binder and contaminants from pavement surfaces, and rejuvenate texture on the asphalt pavement surfaces improving road surface macrotexture and aggregate microtexture (Figure 1.2).

Life expectancy of the water cutting treatment will be influenced by, among other things, the cause of asphalt flushing and the likelihood of further aggregate embedment into underlying asphalt binder. Promotional literature on this treatment option claims that when the UHP water cutter is used to retexture a flushed pavement, further remedial action may not be needed for several years [Gransberg and Pidwerbesky 2007]. The cost of UHP water cutting treatment will depend on the size of the project, with larger machines treating more surface area in a single shift.

FIGURE 1.2 Pavement Surface Before Treatment (Left), and After Treatment (Right) Using the UHP Water Cutter

1.4. Texas Demonstration Project: FM 2562, Grimes County (Bryan District)

TxDOT sponsored a limited field demonstration of UHP water cutting technology to retexture a half-mile portion of FM 2562 in Grimes County (Bryan District) that had experienced severe flushing. The field treatment was accomplished on March 3, 2010, under the direction of Darlene Goehl, P.E. Ms. Goehl, along with engineering staff from the Bryan District, TechMRT researchers, and other TxDOT maintenance personnel observed the demonstration. Figure 1.3 shows images of various stages in the UHP water cutter treatment process for the FM 2562 demonstration project.

The UHP water cutter contractor for the field demonstration project was Rampart Hydro Services, Inc. (Rampart), based in Coraopolis, Pennsylvania (a suburb of Pittsburgh). Identification of Rampart as a United States based contractor that could perform UHP water cutting services on asphalt-surfaced roads represented the culmination of five years of searching for such an entity. As already noted, research project 0-5230 indicated that UHP water cutting was being successfully used in Australia and New Zealand prior to 2005. Numerous attempts were made over the years to invite the New Zealander and Australian companies to mobilize their equipment to Texas and introduce the technology here, but the distance rendered this approach cost-prohibitive. Further attempts were made to have the New Zealand and Australian companies license their technology to a United States company, but this also was not successful. Ultimately, Rampart was identified as a United States company that possessed the same UHP water cutting technology, stateside.

The reason neither Rampart nor any other UHP water cutter contractor had previously been identified is that these companies do not typically work on asphalt pavements. Their UHP water cutting services are traditionally applied to concrete pavements, for repair and restoration of bridge decks, and for removal of tire rubber from the landing areas of concrete airport pavements. However, serendipitously, prior to TechMRT researchers contacting them, Rampart had completed a few small yet high-profile *asphalt* surface retexturing projects on the East Coast, one being aesthetic texturing of a section of pavement in front of the White House, 1600 Pennsylvania Avenue, Washington, DC. When Rampart was contacted, they expressed willingness to participate in the field demonstration project for Texas seal-coat surfaced roads, and also to participate in this implementation project. Treatment of asphalt-surfaced roads to restore texture is, potentially, a new business line for Rampart. Their industry simply has not done UHP water cutting on asphalt roads in any significant degree.

As can be seen in Figure 1.3, the section of FM 2562 selected for treatment was very heavily flushed. The contractor made five passes with the UHP water cutter, varying the rate of advance to accomplish different degrees of asphalt removal. One finding of the demonstration was that Rampart’s technology was actually superior, or more advanced, than the New Zealand/Australia technology previously identified by the research team. Rampart’s UHP water cutter truck uses a *fixed* deck blaster rather than an umbilical-mounted deck blaster, eliminating the need to have a person walk behind the truck and operate the unit. Further, Rampart’s truck relies on a hydrodynamic transmission to better control the rate of advance of the water cutter unit. The result is improved control of the asphalt surface treatment, and a safer maintenance process.

(a) FM 2562, Grimes County

(b) Heavily flushed seal coat, pre-treatment

(c) Initial pass, UHP water cutter

(d) Truck mounted UHP water cutting unit

(e) UHP spray bar with nozzles

(f) Results from first treatment pass

(g) Comparison of pre- vs. post-treatment

(h) Close-up of treated road surface

FIGURE 1.3. UHP Water Cutter Demonstration, FM 2562, Grimes County, March 3, 2010

Ultimately the entire lane width was treated. The UHP water cutter process clearly achieved improved macrotexture for the pavement surface (removal of excess asphalt exposing the seal coat aggregate) as well as improved microtexture (scoring of the surface of the embedded aggregate). Observation of the FM 2562 pavement section indicated that the UHP water cutter process had potential to be an efficient, cost-effective technology for use as a maintenance tool to treat, or retexture, roads surfaced with a seal-coat or surface treatment that displayed minor to severe flushing.

1.5. Authorization of Implementation Project 5-5230-01

TxDOT authorized implementation Project 5-5230-01 on November 29, 2010, in order to develop guidelines and specifications for the use and application of the UHP water cutter as a TxDOT roadway maintenance tool. The project was accomplished in five tasks.

Task 1, "Project Preliminaries and Management," included the project kick-off meeting, development of a subcontract for UHP water cutting services, and procurement of special equipment items that were used to measure pavement texture and friction along with a laptop computer for field data acquisition. These two special pieces of equipment are the Dynamic Friction Tester (DFT) and the Circular Track Meter (CTM).

In Task 2, "Planning and Scheduling Field Work," the research team worked with the Project Monitoring Committee, the four TxDOT districts identified from each climatic region, and the UHP water cutting contractor to finalize the detailed work plan for field work which was undertaken at all 14 field sites. This plan included a data collection protocol.

Task 3, "UHP Water Cutting Projects: Treatment and Data Collection," included all the work performed on the day of the treatment at each test project site. That work consisted of the UHP water cutting treatment, testing for surface texture and friction, and the collection of other field data including data on productivity and process costs.

Task 4, "UHP Water Cutting Projects: Follow-up Monitoring," consisted of monitoring the field test sections at six-month intervals for a total of three monitoring events during the course of this project. The dates for follow-up monitoring were July 2011, January 2012 and July 2012.

Task 5, "Analysis and Reporting," included publishing two research reports: an interim report which summarized data about the effectiveness, production, and cost considerations associated with the UHP water cutter treatment process, and this final research report which presents all test data collected for the study from all 14 field test sections along with information on observations made, data analysis, conclusions and recommendations. Other work under this task included development of two DRAFT specifications for UHP water cutting, and publishing product P1 titled "Guidelines for Using UHP Water Cutting to Remove Excess Surface Asphalt."

1.6. Organization of This Report

This final research report is organized into seven chapters. Chapter 1, the introduction, presents the research problem (flushed pavements) and the proposed solution (UHP water cutting) along with background information in support of the decision to authorize this implementation project.

Chapter 2 presents the research method. This includes the overall research design, a discussion of the UHP water cutter technology and treatment process selected for this study, the UHP treatment test plan and daily activities, and field data collection.

Chapter 3 presents project results relative to evaluation of treatment effectiveness of the UHP water cutter process. These results answer the question, “Does the UHP water cutter work on Texas roads?”

Chapter 4 presents project results relative to evaluation of treatment durability of the UHP water cutter process. These results answer the question, “Does the UHP water cutting treatment last?”

Chapter 5 discusses UHP water cutter production rates, factors that affect production, unit cost data for alternative treatment methods, and unit cost data for UHP water cutting.

Chapter 6, summary and conclusions, briefly summarizes the findings of the study and states the conclusions that are supported by the research.

Chapter 7, recommendations, provides a summary of recommendations for implementation of the UHP water cutter.

In addition to the narrative, this report includes 14 appendices, one for each field test site evaluated as part of this study. Each appendix presents detailed information about the test site including a summary site description, site maps and related identification data, sand patch test data, circular track meter data, skid data, dynamic friction test data, weather data (day of treatment), and selected site photographs.

The report also includes an additional appendix, Appendix O, which presents the two DRAFT specifications developed for this study.

CHAPTER 2. METHOD

2.1 Research Design

The implementation research project was designed to conduct a systematic evaluation of the UHP water cutter as a low-cost, pavement preservation tool. The UHP water cutter was used on 14 pavement sections located in four TxDOT regional districts. The water cutting was done to restore texture of flushed pavement surfaces and to correct other pavement problems. This included thirteen rural flexible pavement sections with seal coat surfaces and one suburban rigid pavement section with tracked asphalt that required cleaning.

Although not entirely based on statistical principles, the field projects were selected by considering factors such as climatic region, heavy vehicle volume, and the materials used for the existing flushed wearing course. The climate regions were selected based on the FHWA climate region map shown in Figure 2.1.

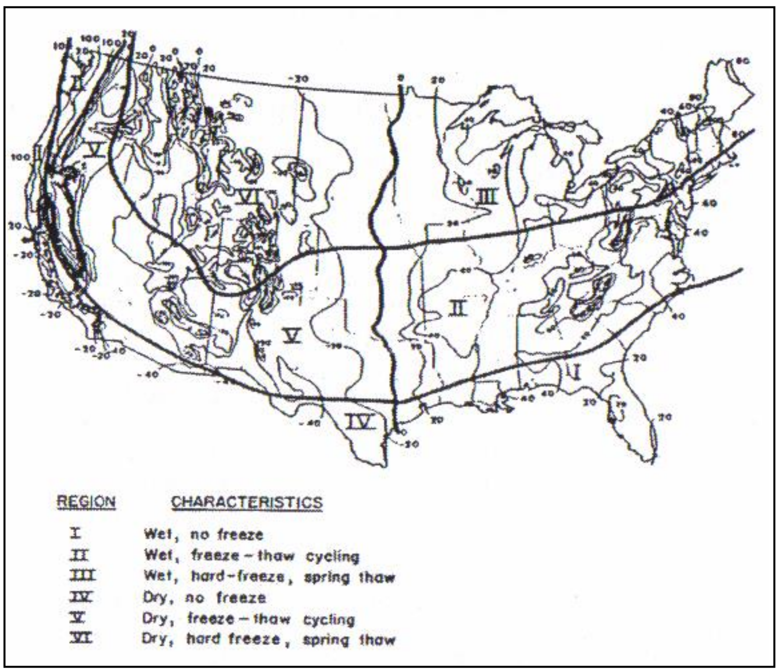


FIGURE 2.1. FHWA Climate Zones *Source*: AASHTO 1993

This selection yielded project sites in Zone I (Beaumont), Zone II (Bryan), Zone IV (Laredo), and Zone V (Amarillo). Once the districts were identified based on climatic zones, the Director of Maintenance in each district identified candidate flushed pavement sections for treatment based on guidelines provided by the researchers. One common factor for all flexible pavement sections was that they displayed some level of flushing, which varied from “light” to “very heavy.” Table 2.1 shows the information on each test section including asphalt binder and aggregate specifications used in the chip seal wearing course. Eleven of the thirteen flexible pavement sections used AC binders on the wearing course and two used CRS-2P. Of the sections with AC binders, seven had AC 20-5TR, two had AC 12-5TR (a cool-weather asphalt cement) and two had unmodified AC 10. Except for the two sections that used CRS-2P, all other sections used pre-coated aggregates. Nine of the sections used grade 4 aggregate and four used grade 3. Time since the last seal surfacing ranged from six years to six months. Three of the sections (BRY7, LRD2 and LRD3) had two lanes in the travel direction in the test section and the others were all two-lane rural highways with one lane in each direction. The two sections in the Laredo district both had very high truck volumes, with LRD 2 being close to a warehouse area. LRD 3 was on Interstate Highway 35 just north of Laredo.

TABLE 2.1. Selected Data on UHP Treatment and Construction for Each Test Site

Test Site	FHWA Climate Region	Heavy Vehicle Volume	Year of Last Surfacing	No. of Lanes in Test Section[1]	Asphalt Binder on Surface	Aggregate on Surface[2]
BRY1	II	Very Low		3	Tined PCC pavement[3]	
BRY2	II	Low-Medium	2005	1	AC 20-5TR	PB GR 3S
BRY4	II	Low	2005	1	AC 20-5TR	PL GR 4
BRY5	II	High	2010	1	AC 12-5TR	PL GR 4
BRY7	II	Medium-High	2010	2	AC 20-5TR	PL GR 4
BRY9	II	Very Low	2009	1	AC 12-5TR	PL GR 4
BMT1	I	Medium-High	2008	1	AC 20-5TR	PB-GR 4
BMT2	I	Low	2009	1	CRS-2P	L-GR 3
BMT3	I	Very Low	2008	1	CRS-2P	L-GR 3
AMA1	V	Low-Medium	2008	1	AC 20-5TR	PB-GR 4
AMA2	V	Medium	2009	1	AC 10	PB GR 4
AMA3	V	Very Low	2009	1	AC 10	PB GR 4
LRD2	IV	Very High	2006	2	AC 20-5TR	PE-GR 3S
LRD3	IV	Very High	2009	2	AC 20-5TR	PE-GR 4S

Notes:
[1] Test section was laid out only in one direction and all tests were conducted in that direction.
[2] Standard TxDOT aggregate types and gradations for seal coats;
[3] Selected to evaluate effectiveness of UHP water cutter technology to remove tracked asphalt from PCC pavement

As noted previously, Table 2.1 identifies a total of 14 test sites. One site (BRY1) was on tined PCC pavement and this site did not receive the texture and friction testing typical of the other 13 sites on flexible pavement. Further, Table 2.1 shows some "missing" sites such as BRY3, BRY6, LRD1, etc. These sites were initially identified for inclusion in the study but were ultimately removed from the study due to schedule and other considerations. Thus, the study is based on data from the 14 test sites identified on Table 2.1, and most of the study effort has focused on correction of flushing at the 13 flexible pavement sites.

2.2 Technology and the Treatment Process

The effectiveness, production rate, and cost of UHP water cutting directly depends on the equipment used for the treatment process. Whereas the results of UHP water cutting – improved texture or friction of the pavement surface – may be measured in different ways and expressed in general terms, the instrument used to achieve those results – the UHP water cutter device – is a complex yet unique entity. Given the infancy of UHP water cutting for treatment of flushed pavements in the United States, it is not possible at this time to compare results for different types of water cutters. Only one system has been tested, and this should be thought of as a type of pilot adaptation of existing technology (typically used to treat concrete pavements) to a new application (treatment of flexible pavement surfaces). The findings from this study will be generalized where possible, but it must be kept in mind that the research results are based on treatment using *one* UHP water cutter device deployed in the winter of 2011 to treat a variety of Texas road conditions.

A Truck-Mounted, Self-Contained Unit

The UHP water cutter device used for this study is a self-contained, truck-mounted unit which has been designed, fabricated, and operated by Rampart Hydro Services, Inc (Figure 2.2). Known as the BlasterVac Truck, this unit includes the truck chassis, the cutting head, ultra high pressure water pump and supply tank, vacuum system, and effluent/debris tank.

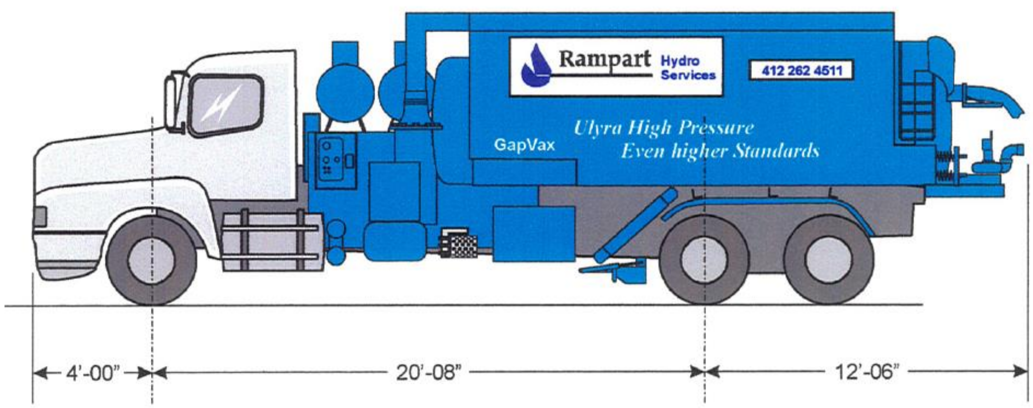


FIGURE 2.2. Rampart BlasterVac Truck (Rampart Hydro Services 2003). *Used by permission*

With a gross weight of 51,240 pounds, the BlasterVac Truck has historically been used for applications such as airfield rubber removal or hydro scarification. To comply with vehicle weight limits, the truck is typically deployed empty and is filled with water on site.

The Cutting Head

The focal point of the UHP water cutting system is the cutting head. For Rampart's BlasterVac truck, the cutting head is mounted on a sliding collar attached to a fixed support bar in front of the truck (Figure 2.3). Unlike the walk-behind umbilical deckblasters employed on water cutting units operating in Australia and New Zealand, the Rampart cutting head is positively attached to the truck and is controlled by the truck operator. Although the support bar allows for a wide range of cutting head movement, the typical cutting position is outside and forward of the left front tire.

FIGURE 2.3. Cutting Head, Rampart BlasterVac Truck

The cutting head consists of a rotating multi-jet spray bar and protective vacuum shield with associated water supply and vacuum hose attachments. The spray bar provides a fixed cutting width of 24 inches and can incorporate up to 28 spray nozzles, which can be configured by number and type for different applications such as hydro scarification, rubber removal, and paint removal. Typical nozzle diameters range from 0.009 to 0.014 inch (Figure 2.4). The spray bar rotation speed can be varied from 0 rpm to 1500 rpm.

(a) cutting head with spray bar (b) water jet nozzles in the spray bar (c) 8-nozzle configuration

FIGURE 2.4. Cutting Head for UHP Water Cutter

The pressure of the water leaving the nozzles is in the range of 32 to 36 kips per square inch. The extent of the water cutting treatment can be controlled by changing the number and size of nozzles, the rotating speed of the spray bar and the travel speed of the vehicle. For an application such as removing excess flushed asphalt from a highway pavement surface, the skill of the operator is very important to make timely adjustments based on roadway conditions. Additional information on the technology used by Rampart Hydro Services is presented elsewhere [Rampart 2012].

While water cutting is in process, the BlasterVac truck is propelled by a hydrostatic drive, independent of the truck transmission, which is capable of regulating forward movement at ground speeds ranging from 0 to 7.0 mph. The actual speed selected for treatment is typically determined based on field trials. Equipment is rated for treating a minimum area of 560 square yards per hour.

Ultra High Pressure Water Pump and Vacuum System

Ultra high pressure pumps are capable of delivering water jets traveling at twice the speed of sound at pressures in excess of 27,000 psi. The Rampart BlasterVac pump is rated at 16 gpm while operating at 36,000 psi, and typically operates at about 16 gpm at pressures of 32,000 to 35,000 psi. The pump requires potable water and the truck chassis incorporates a 4,000 gallon supply tank, which is normally sufficient for four hours of continuous operation. Forcing water through the nozzles at these rates and pressures creates friction which heats the effluent water to about 140° F during cutting.

Rampart's BlasterVac truck incorporates a vacuum pump which captures about 95 percent of the water used in either hydro scarification or surface cleaning. Spent water and associated debris are vacuumed only inches away from where the water is sprayed, keeping the road surface dry everywhere but the immediate work area. The debris tank, which captures the vacuumed water and pavement debris, is 1,000 gallon capacity and located behind the water supply tank at the rear of the BlasterVac truck. Upon filling, this tank must be "dumped" (Figure 2.5).

FIGURE 2.5. Debris Tank and Dump, Rampart BlasterVac Truck

2.3 UHP Treatment Daily Activities

The work performed on the day of the treatment at each test project site included preparation of the test site, UHP water cutting treatment, testing for surface texture and friction, and the collection of other field data including information on productivity and process costs. The researchers also closely followed the UHP water cutting contractor's crew to observe and document data on the 14 projects treated. Treatment and testing of each test section took one full work day. Prior to the treatment activities, pre-treatment skid tests were conducted by TxDOT personnel, and arrangements were made for traffic control on the day of the treatment.

At the beginning of each treatment day, typically 7 am, the TechMRT research team met with district personnel, traffic control crew, and the Rampart Hydro water cutting team at the designated TxDOT maintenance office. This meeting discussed the following activities:

- Communication protocols
- Safety of the UHP water cutter equipment and process
- Traffic control plan
- Water supply for the 4000-gallon UHP water cutter tank
- Meeting time and place at the highway section
- Daily work schedule
- Speed section of treatment
- Production section of treatment
- Waste disposal arrangements

Figure 2.6 illustrates key stages of the UHP water cutter treatment activities discussed at this meeting.

Work at the treatment section began with the setting up of traffic control by the TxDOT district crew or their designated party. While traffic control was being set up, the contractor prepared the UHP water cutter equipment by filling the 4000-gallon water tank and installing and checking the spray bar and nozzles. As soon as traffic control was set up, the researchers set up the mobile weather station.

2.4 The Typical UHP Water Cutter Test Site Layout

Each test site is 0.5 miles long and was divided into four 1/8-mile sub-sections for testing purposes. The first and fourth 1/8-mile sections, referred to as *speed sections* in this report, were used to evaluate the relationship between water cutter travel speed and macrotexture improvement caused by the treatment. A layout of testing locations for a typical speed-trial section is shown in Figure 2.7. Within each speed trial section, four 100-ft long segments were treated at four different travel speeds beginning with the faster speed. That way, if the treatment showed signs of causing raveling, it could be stopped and adjustments could be made. Section 4.2 of this report provides additional detail about this aspect of the research.

The middle ¼-mile treatment section, which is also referred to as the *production section*, consisted of the second and third 1/8-mile sections within the ½-mile test area. Three test points

– TP1, TP2 and TP3 – which were approximately 1/8-mile apart as shown in Figure 2.8, were located within this production section. These three test points were identified as the locations where the research team conducted pavement surface texture and friction measurements before and after treatment. The three additional follow-up monitoring test cycles were conducted by obtaining the same kinds of pavement surface performance data at these same three test points for each site.

FIGURE 2.6. Daily Operations for Ultra High Pressure (UHP) Water Cutter Treatment (a) safety meeting at TxDOT maintenance yard; (b) hazard warnings in the water cutter truck; (c) pumping water into the water cutter truck; (d) getting water to the 4000-gallon water cutter truck - using water trailer when there is insufficient overhead clearance for the truck; (e) adjustment of

water cutter spray bar and nozzles prior to treatment; (f) traffic control for the treatment operation by closing the treatment lane.

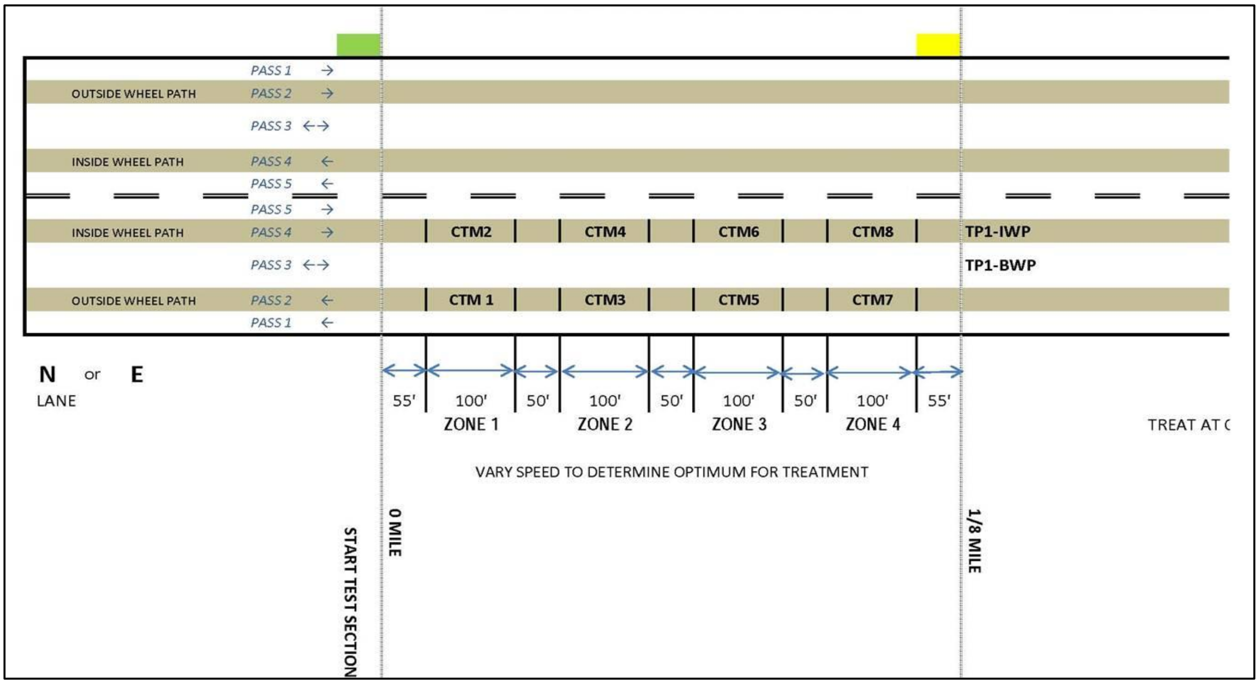


FIGURE 2.7. Test Site Layout for Speed Sections

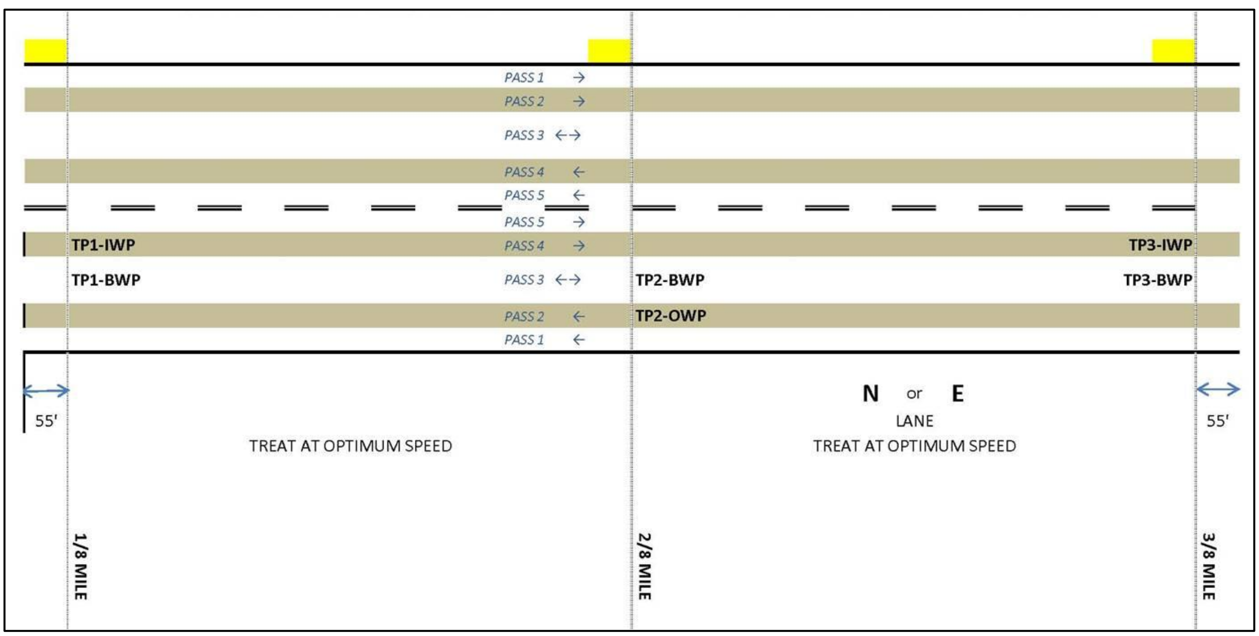


FIGURE 2.8. Test Site Layout for Production Sections

A target "production" travel speed for the middle ¼-mile of the treatment section (second and third 1/8-mile sections as per Figure 2.8) was selected based on observation of the level of texture enhancement deemed to be appropriate for the roadway surface as determined in the speed sections. Selection of the appropriate texture of the treated surface was decided by the researchers in consultation with local TxDOT maintenance personnel with expertise on the subject. This decision was made based on visual evaluation of treatment effectiveness, with one factor being the embedment depth needed to hold the aggregate particles in place without raveling.

As has been noted, the research plan incorporated three follow-up monitoring events for each test section, occurring at six month intervals. The first follow-up monitoring event was conducted in July 2011. The second monitoring event was performed in January 2012 and the final event occurred in July 2012. Texture and friction tests at each test site, including the pre-treatment data, post-treatment data, and the three follow-up monitoring events were conducted at the three test point locations labeled TP1, TP2, and TP3 in the test section layout shown in Figure 2.8.

2.5 Field Test Data for Pavement Texture and Friction

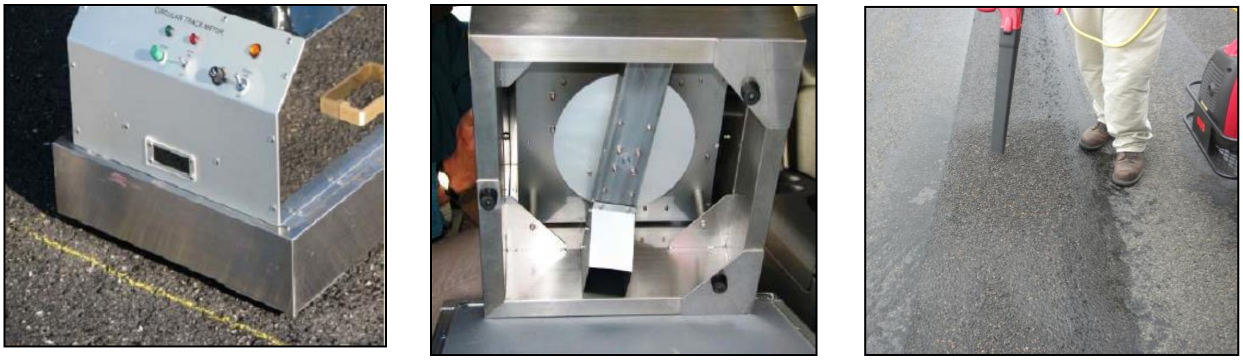
UHP water cutting treatment was performed and associated pavement texture and friction data were collected from January 31 through March 2, 2011, from 14 test sites located in four climatic regions in Texas. The testing protocol for each test site is presented in Table 2.2.

TABLE 2.2. Test Matrix for Each Test Site

	Test Point TP1		Test Point TP2		Test Point TP3	
	Inside Wheelpath	Between Wheelpaths	Outside Wheelpath	Between Wheelpaths	Inside Wheelpath	Between Wheelpaths
Before Treatment	SN, DFT, SP, CTM	SN, DFT, SP, CTM	SN, DFT, SP, CTM	SN, DFT, SP, CTM	SN, DFT, SP, CTM	SN, DFT, SP, CTM
Soon after Treatment	SN, DFT, SP, CTM	SN, DFT, SP, CTM	SN, DFT, SP, CTM	SN, DFT, SP, CTM	SN, DFT, SP, CTM	SN, DFT, SP, CTM
6-mo. after Treatment	SN, DFT, SP, CTM	SN, DFT, SP, CTM	SN, DFT, SP, CTM	SN, DFT, SP, CTM	SN, DFT, SP, CTM	SN, DFT, SP, CTM
12-mo. after Treatment	SN, DFT, SP, CTM	SN, DFT, SP, CTM	SN, DFT, SP, CTM	SN, DFT, SP, CTM	SN, DFT, SP, CTM	SN, DFT, SP, CTM
18-mo. after Treatment	SN, DFT, SP, CTM	SN, DFT, SP, CTM	SN, DFT, SP, CTM	SN, DFT, SP, CTM	SN, DFT, SP, CTM	SN, DFT, SP, CTM

SN-Skid Number using skid truck; DFT-Dynamic Friction Tester;
SP-Sand Patch Mean Texture Depth; CTM-Circular Texture Meter Mean Profile Depth

In brief, two categories of tests, one to measure the texture of the pavement surface, and the other to measure pavement friction, were conducted. Each of these testing categories included two different test protocols. The ASTM E 2157 laser-based circular track meter or CTM test (Figure 2.9) and the ASTM E 965 sand patch test (Figure 2.10) were conducted to determine the average pavement surface texture before and after the treatment. In addition, pavement friction characteristics were determined by ASTM E 274 wet-weather skid resistance using the TxDOT skid truck (Figure 2.11) and ASTM E 1911 dynamic friction test or DFT (Figure 2.12).



(a) view from top (b) view from bottom (c) drying of treated surface prior to CTM testing

FIGURE 2.9. ASTM E-2157 Circular Texture Meter to Measure Pavement Macrotexture

(a) wind screen set-up for sand patch (b) prior to test (c) measuring the sand patch

FIGURE 2.10. Sand Patch Test Method to Measure Pavement Surface Texture Depth

FIGURE 2.11. Skid Truck Used to Measure Skid Number (SN) of Pavement Surfaces. *Image courtesy TxDOT*

(a) view from top **(b) view from bottom** **(c) water supply to testing machine**

Figure 2.12. ASTM E-1911 Dynamic Friction Tester to Measure Skid Resistance

The skid number (SN) test was conducted by TxDOT personnel using TxDOT skid trucks, and the other three tests were conducted by the research team. The skid truck was used to measure the skid number in the inside wheel path (on a scale from 0 to 100) at a speed of 50 miles per hour at each test point (i.e. TP1, TP2 and TP3).

The DFT provides a friction number on a scale from 0 to 1, and data are collected to plot the variation of friction number with speed. One replicate test result was obtained at each test location identified in Table 2.2. This friction value (i.e. skid resistance metric) is a function of several factors including characteristics of the aggregate type used on the pavement surface, the asphalt type and the travel speed of the rubber pads used to measure friction in the DFT.

Pavement surface macrotexture was measured using the sand patch method and the Circular Track Meter (CTM). The CTM uses a laser-based technique to measure pavement surface macrotexture in eight regions A through H in a circular area approximately 12 inches in diameter. Two replicate measurements were taken at each test location using the CTM.

2.6 Research Data Summary

The overall evaluation of UHP water cutting as a pavement preservation strategy for Texas roads focused on answering three questions, namely:

- Does it work? (Treatment Effectiveness)
- Does it last? (Durability: Survivability/Life Expectancy)
- What is the cost? (Production/Cost Effectiveness)

The research plan for this implementation study yielded a significant body of data to answer these questions. In particular, for the thirteen test sites with asphalt (seal coat) surfaced roads, data are as follows:

CHAPTER 3. EVALUATION OF TREATMENT EFFECTIVENESS

3.1 Overview

The first question about UHP water cutting that must be answered by this study is, “Does it work?” The way the research study answered this question was to measure the texture and friction properties of the road surfaces at the 13 flexible pavement test sites prior to treatment and immediately after the UHP water cutter treatment. Comparison of pre- and post-treatment data indicate that the effectiveness of UHP water cutting treatment varies, but overall, UHP water cutting achieved significant improvement in pavement texture and friction.

Pavement surface texture and friction data were collected from each field site on the treatment date, both before and after the treatment, to document the initial effectiveness of the UHP water cutter treatment. Treatment was conducted during the period January 31 to March 2, 2011.

As has been noted, of the 14 test sites for this study, one site (BRY1) was a concrete pavement section in which the UHP water cutter was used to remove some tracked asphalt. This test site was only included to assess the feasibility of UHP water cutter technology to clean concrete pavement surfaces, and as a result, no quantitative test data were obtained for this site. However, this test site was visited and detailed observations were made and recorded including pictures and videos.

The remaining thirteen sites were all flexible pavement sections with sprayed seal wearing courses, and pavement surface texture and friction data were collected for each site using the four test methods discussed in Chapter 2. In addition, data were collected on the UHP water cutter production rates, and key observations made at each site were also recorded. Detailed information collected at each site including field test data, researcher field reports, and selected photos are included in Appendices A through N in the form of test site portfolios.

This chapter provides an analysis of the field test data by consolidating information associated with treatment effectiveness from all thirteen of the flexible pavement test sites. In the discussions that follow, data collected at each test point location (TP1, TP2 and TP3) were averaged to obtain one parameter value for each test method to represent each test site. This allowed a more concise presentation of the results. It must be noted that there were a few test sections in which the extent of flushing was not uniform, and the average value presented in the charts for those sections may not depict the true condition at each test point.

3.2 Pavement Texture Data

Texture data include the Sand Patch test and the CTM test. Figure 3.1 shows the Sand Patch mean texture depth for all 13 test sites both before and immediately after the water cutter treatment. These results show that water cutter treatment resulted in remarkable improvement in the sand patch mean texture depth. Research suggests average texture depths of approximately 0.8mm to 1mm are desirable for satisfactory wet weather skid resistance. The literature does not clearly indicate specific acceptable values for average texture depth, but this range was established by this research team based on the guidance established for seal coats by Transit New Zealand (2002) and the NITRR South Africa as reported by Estakhri and Gonzales (1988). The sand patch mean texture depth prior to the treatment showed three of the 13 sites with macrotexture values equal to or greater than 1mm, with the range of values being 0.4 to 1.2mm. After the treatment, the mean texture depths ranged from 1.3 to 3.2mm.

Similar observations can also be made from Figure 3.2, which shows the pavement texture represented by the CTM mean profile depth. The range of CTM mean profile depth values before treatment was 0.3mm to 1.3mm, which increased to 1.2mm to 2.7mm after treatment.

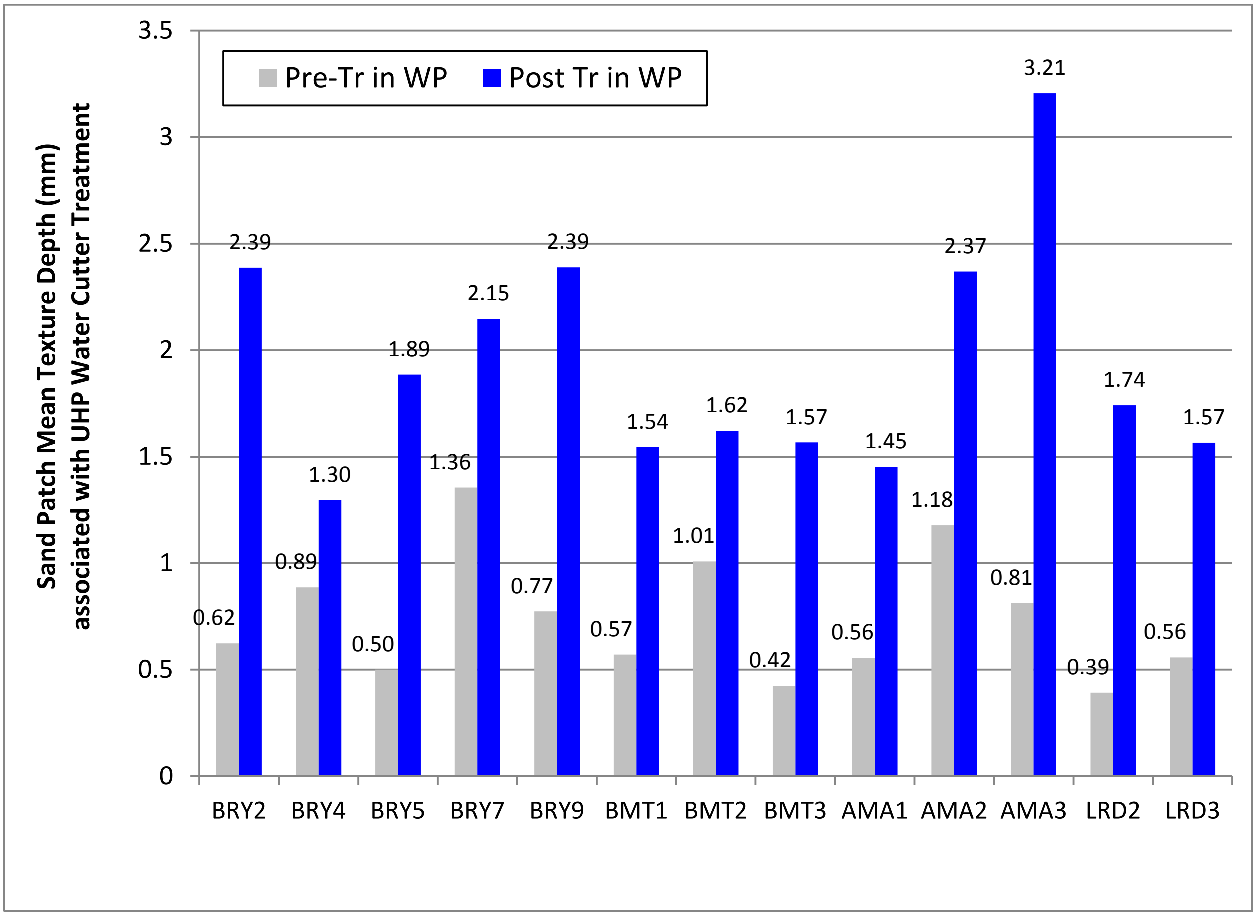


FIGURE 3.1. Sand Patch Mean Texture Depth for All Test Sites Before and Immediately After UHP Treatment

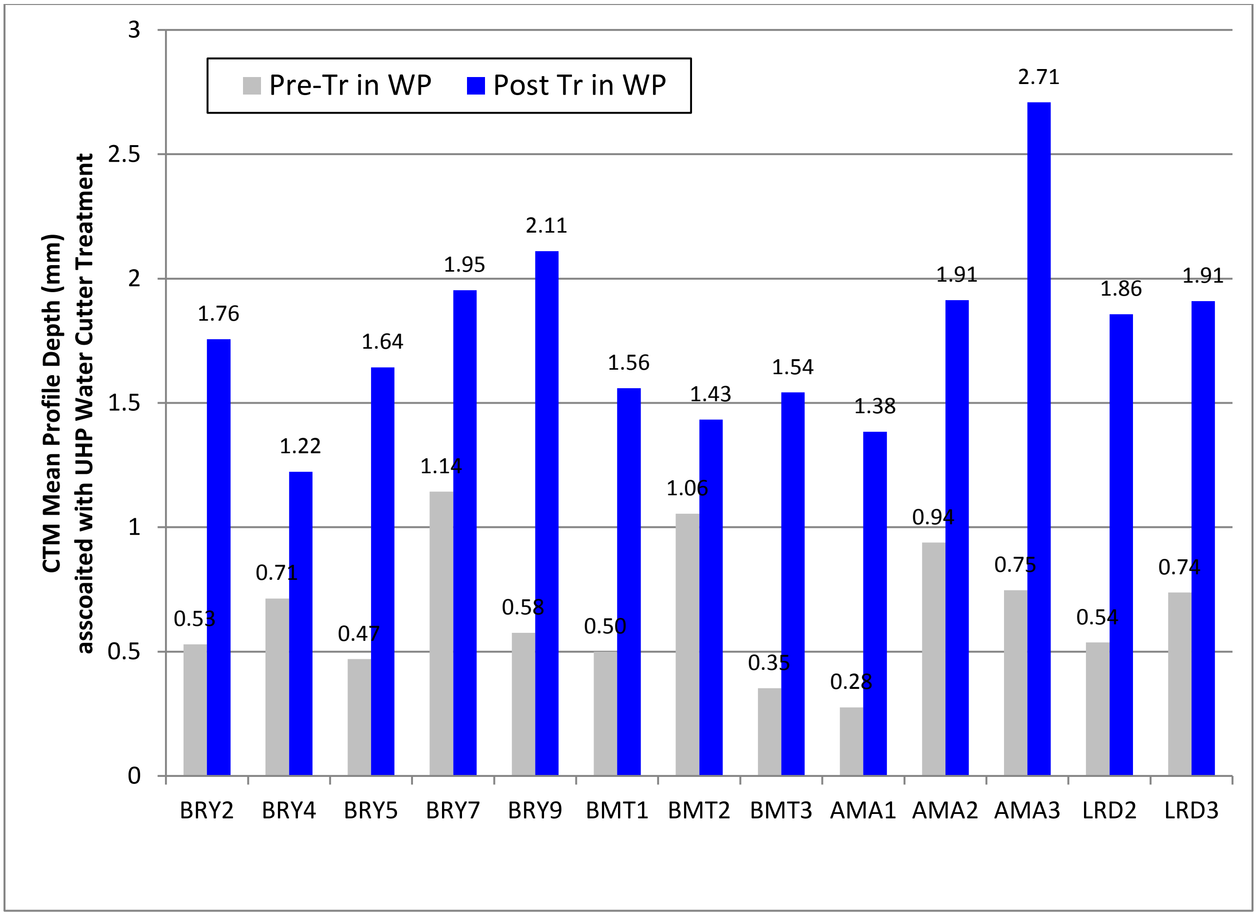


FIGURE 3.2. CTM Mean Profile Depth for All Test Sites Before and Immediately After UHP Treatment

Figure 3.3 shows the percent improvement in sand patch mean texture depth and CTM mean profile depth as a result of water cutter treatment. The results show remarkable improvement in patch mean texture depths, with increases from 46 percent to 344 percent, averaging 189 percent across all sites. Ten of the 13 projects showed improvements of 100 percent or more. The three sites with around 50 percent increase in macrotexture were all sites with non-uniform flushing levels along the section.

Similar results exist for CTM mean profile depths, with increases from 36 percent to 401 percent, average 204 percent across all sites. Again, ten of the 13 projects showed improvements of 100 percent or more.

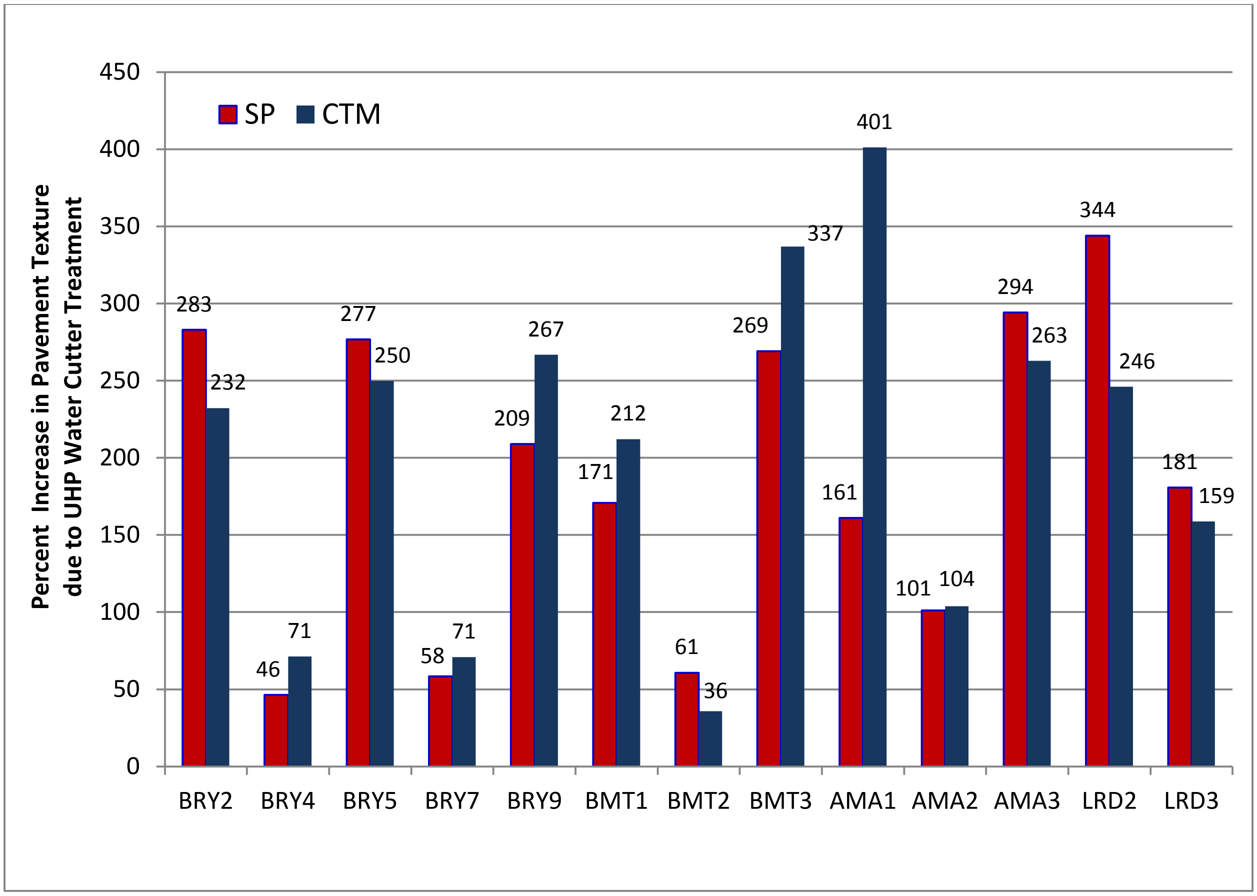


FIGURE 3.3. Percent Increase in Sand Patch Mean Texture Depth and CTM Mean Profile Depth for All Test Sites from Pre-Treatment to Post-Treatment

It is important to note that improvement in texture could perhaps lead to raveling as an unintended consequence. In the roadway sections that were treated with the UHP water cutter, some raveling was observed during treatment. However, this was the result of experimenting with different nozzle configurations and travel speeds, and once a suitable nozzle configuration and a travel speed was decided upon, the treatment appeared to be very effective.

3.3 Pavement Surface Friction Data

Figures 3.4 and 3.5 illustrate the effectiveness of the UHP water cutter treatment in terms of improved friction. Pavement friction parameters were measured using the skid truck and the DFT before and immediately after the treatment. Here again, the improvements are very significant and even dramatic for many of the sites.

Results presented in Figure 3.4 show very high increases in the skid number, indicating the success of this treatment method to improve pavement skid resistance. Prior to the treatment, four of the 13 sections had a skid number greater than 35, five between 20 and 35, three below 20, and one site was not tested. According to the TxDOT project director for this research, a skid number of 20 is generally considered to be the threshold to initiate further investigation of pavement conditions for any type of pavement for a test speed of 50 miles per hour using the smooth tire [Goehl, 2012]. After the treatment, eleven of the 13 sections had skid numbers over 40, which is well above the generally-considered threshold minimum of 35 for high-traffic pavements. The remaining section showed a skid number of 32.

Three of the thirteen test sites showed skid number increase in excess of 40, one showed an increase between 30 and 39, seven showed increases between 20 and 29, and one site had an increase less than 20. The site with the lowest change in the skid number after the treatment exhibited non-uniform and sporadic flushing, so the skid truck likely was not able to test the same location before and after the treatment. Two of the sections with the lower increases in the skid number used low microtexture, low-friction siliceous gravel aggregate. The lowest post-treatment skid numbers may be due to the type of limestone used in these two sites and other factors. The skid number and the DFT friction number are both functions of the macrotexture as well as microtexture. Therefore, the aggregate used in the surface has a significant influence in the final value of the friction parameter value.

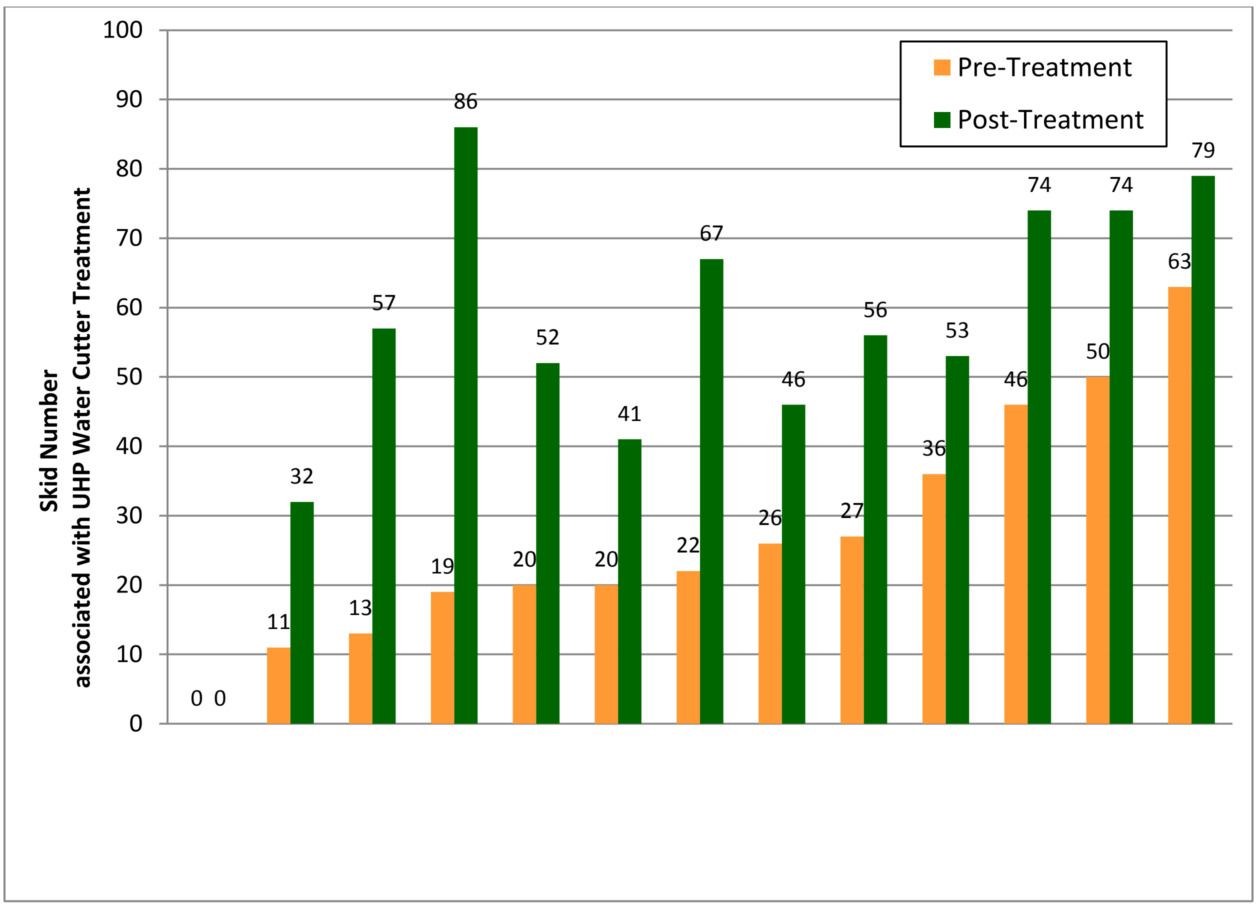


FIGURE 3.4. Skid Number Values in Wheel Path for All Test Sites Before and Immediately After UHP Treatment

The DFT friction numbers showed trends similar to those of the skid number (Figure 3.5). Prior to treatment, seven of the 13 section had DFT friction numbers over 0.35 and six were below.

After the treatment, all thirteen sections had DFT friction numbers above 0.35. In Figure 3.5, the results from the DFT show mostly similar trends in friction values compared to the skid numbers. All sections showed remarkably high increases in the DFT friction value with the lowest increases in the siliceous gravel sections. It is interesting to note that the two sections LRD2 and LRD3, which used the weak limestone, had high post-treatment friction values and also three-fold increases. There appears to be a general correlation between the skid truck and DFT results.

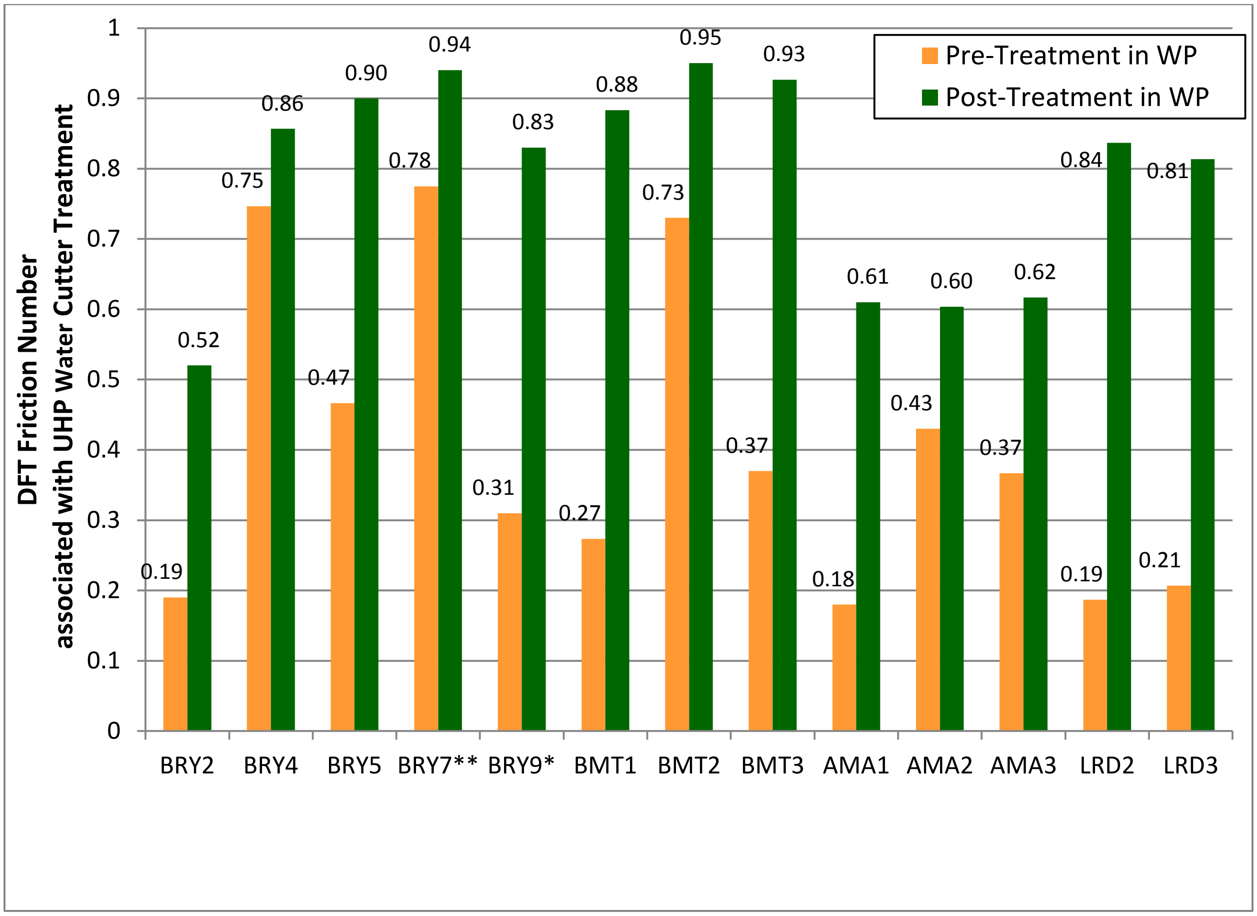


FIGURE 3.5. DFT Friction Number Values for All Test Sites Before and Immediately After UHP Treatment

Figure3.6 shows the percent increase in friction due to the water cutter treatment measured using the skid truck and the DFT. The overall results for skid number values show increases from 0 percent to 351 percent, averaging 129 percent across all sites. Seven of the thirteen sites showed at least a 100 percent increase in the skid number.

Similar results exist for the DFT friction number, with increased from 15 percent to 348 percent, averaging 143 percent across all sites. Seven sites showed at least a 100 percent increase in the DFT friction number.

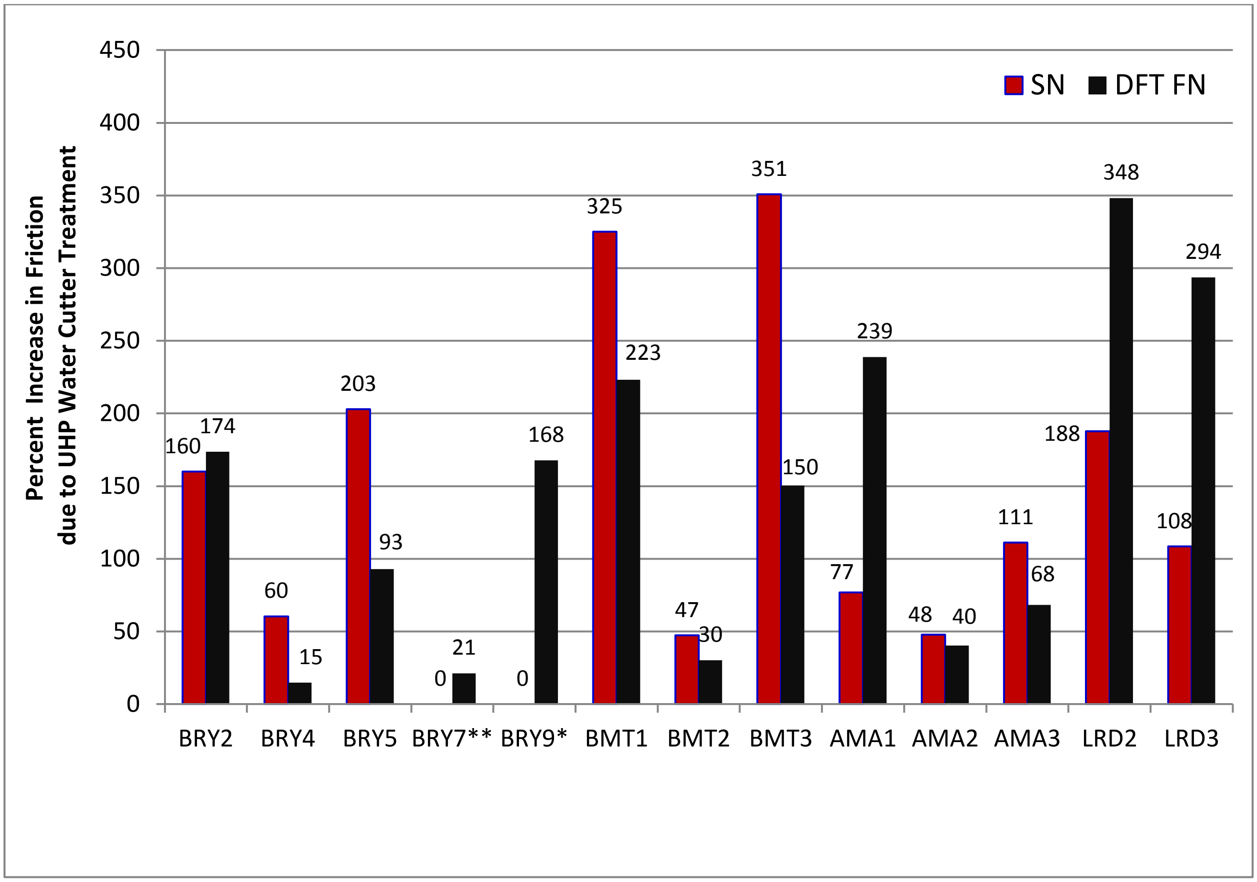


FIGURE 3.6. Percent Increase in Skid Number in Inside Wheel Path for All Test Sites From Pre-Treatment To Post-Treatment

A few sites showed unexpectedly low increases. This may be attributable to factors not related to the general effectiveness of the treatment. The sites that showed low increases either used low friction siliceous gravel aggregate (AMA1, AMA2 and AMA3) or had uneven flushing along the length of the highway section (in BRY4 and BRY7). The trends were similar for both the skid number and DFT friction number values.

3.4 Treatment Effectiveness Summary

The first question that had to be answered for this implementation study about the UHP water cutter was, “Does it work?” The way the research study answered this question was to measure the texture and friction properties of the road surfaces at the thirteen test sites prior to treatment and immediately after the UHP water cutter treatment. Comparison of pre- and post-treatment data indicate that the effectiveness of UHP water cutting treatment varies, but overall, UHP water cutting achieved significant improvement in pavement texture and friction, with average percent increases ranging from 129 percent to 204 percent. On this basis, it can be said that the UHP water cutter treatment process does work.

CHAPTER 4. EVALUATION OF TREATMENT DURABILITY

4.1 Overview

An important question that must be answered relative to implementation of the UHP water cutter treatment is, “Does it last?” The implementation study addressed this question through follow-on monitoring of the treatment sites, with pavement surface texture and friction tests performed at six-month intervals for an 18-month period. The two parameters used to evaluate treatment durability were survivability and life expectancy.

4.2 Data Filtering

Before the durability analyses could be accomplished, the researchers reviewed all monitoring data from the 13 flexible pavement test sites. Irregularities were noted including any data which were affected by inconsistent or variable flushing, instrument error, or missing data. Sites for which maintenance unrelated to the project was performed, precluding further monitoring, were also noted. In addition to these irregularities, friction data at some sites were impacted by the seasonal effect [Henry and Saito 1983], wherein pavement SN and DFT FN values were influenced by temperature variation. Based on this review, the researchers removed unreliable data associated with particular test points and/or tests. This yielded the final, filtered data set for the durability analyses.

4.3 Survivability

Survivability is a measure of the durability of the UHP water cutter treatment and refers to whether the treated roadway surface maintained its texture or friction properties at or above specified performance thresholds for the 12-month to 18-month period following treatment. The way this study evaluated survivability was to identify performance thresholds for both desirable performance (*i.e.*, the desired level of service) and for required maintenance (*i.e.*, the level of service at which maintenance is required) for both the texture and friction parameters, as presented in Table 4.1. Actual performance was then compared against these thresholds.

TABLE 4.1. Survivability Performance Threshold Values for Texture and Friction

Parameter	Test Method	Desirable Performane Threshold	Maintenance Threshold
Texture	Circular Track Meter (CTM)	MPD = 1.0 mm	MPD = 0.5 mm
	Sand Patch (SP)	MPD = 1.0 mm	MPD = 0.5 mm
Friction	Skid Number (SN)	Not available	SN = 20
	DFT Friction Number (DFT FN)	Not available	DFT FN = 0.27

Figures 4.1 and 4.2 present the survivability results associated with the pavement texture data. Figure 4.1 shows that pavement texture, as measured by the CTM at completion of monitoring, for six of the 13 sites was at or above the desired threshold (mean profile depth of 1.0 mm).

Pavement texture at completion of monitoring for all thirteen sites was at or above the maintenance threshold (Mean Profile Depth of 0.5mm). Mean profile depths at last monitoring, as measured by the CTM, varied from 0.53mm to 1.78mm, averaging 1.07mm.

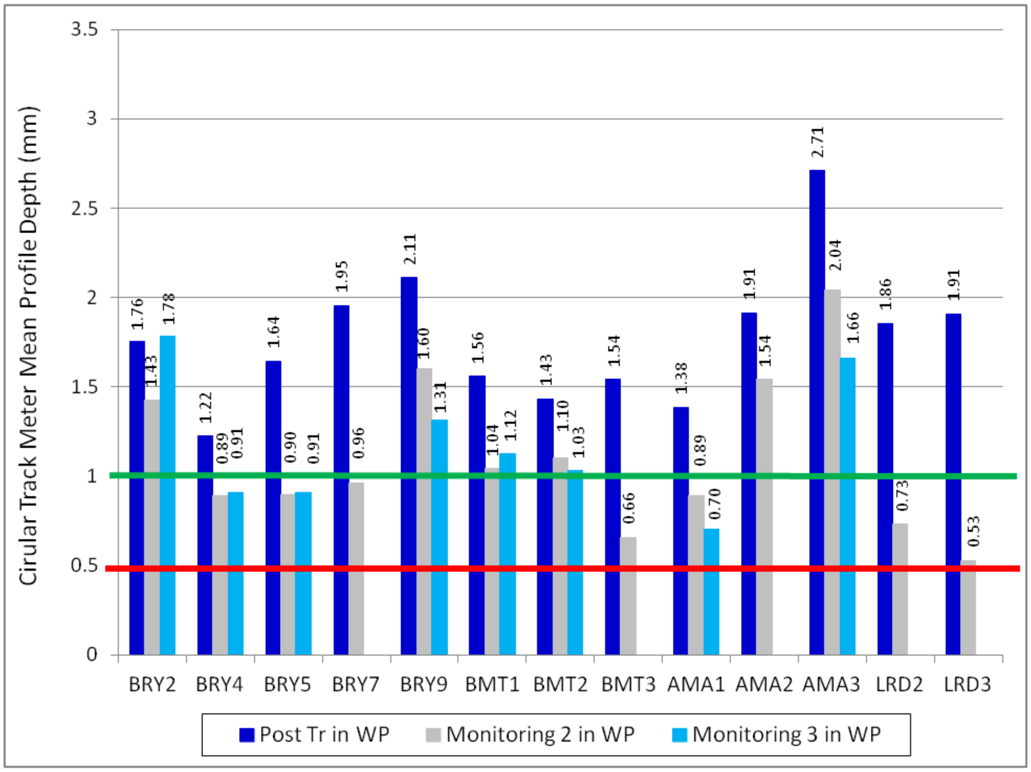


FIGURE 4.1. Treatment Survivability as Measured by Whether Pavement Texture (CTM Mean Profile Depth) Survived to Completion of Monitoring At or Above Specified Performance Threshold Values

Figure 4.2 shows that pavement texture, as measured by the SP test at completion of monitoring, for eight of the 13 sites was at or above the desired threshold (mean texture depth of 1.0 mm). Pavement texture at completion of monitoring for 12 of 13 sites was at or above the maintenance threshold (Mean Texture Depth of 0.5mm). Mean texture depths at last monitoring, as measured by the SP test, varied from 0.49mm to 2.08mm, averaging 1.15mm.

Figures 4.3 and 4.4 present the survivability data associated with the pavement friction data. Figure 4.3 shows that pavement friction, as measured by the SN at completion of monitoring, for ten of the 13 sites was at or above the maintenance threshold (SN = 20). Skid numbers at last monitoring varied from 11 to 64, averaging 40.

Figure 4.4 shows that pavement friction, as measured by the DFT FN at completion of monitoring, for 12 of the 13 sites was at or above the maintenance threshold (DFT FN = 0.27). DFT FN values at last monitoring varied from 0.21 to 0.82, averaging 0.57.

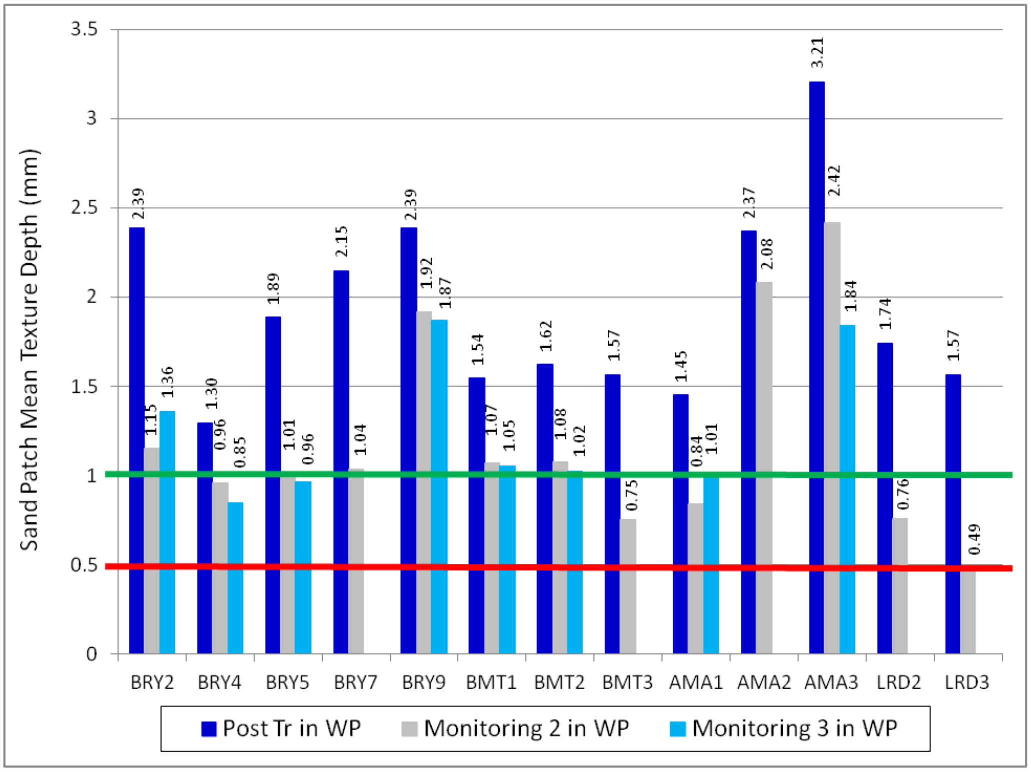


FIGURE 4.2. Treatment Survivability as Measured by Whether Pavement Texture (SP Mean Texture Depth) Survived to Completion of Monitoring At or Above Specified Performance Threshold Values

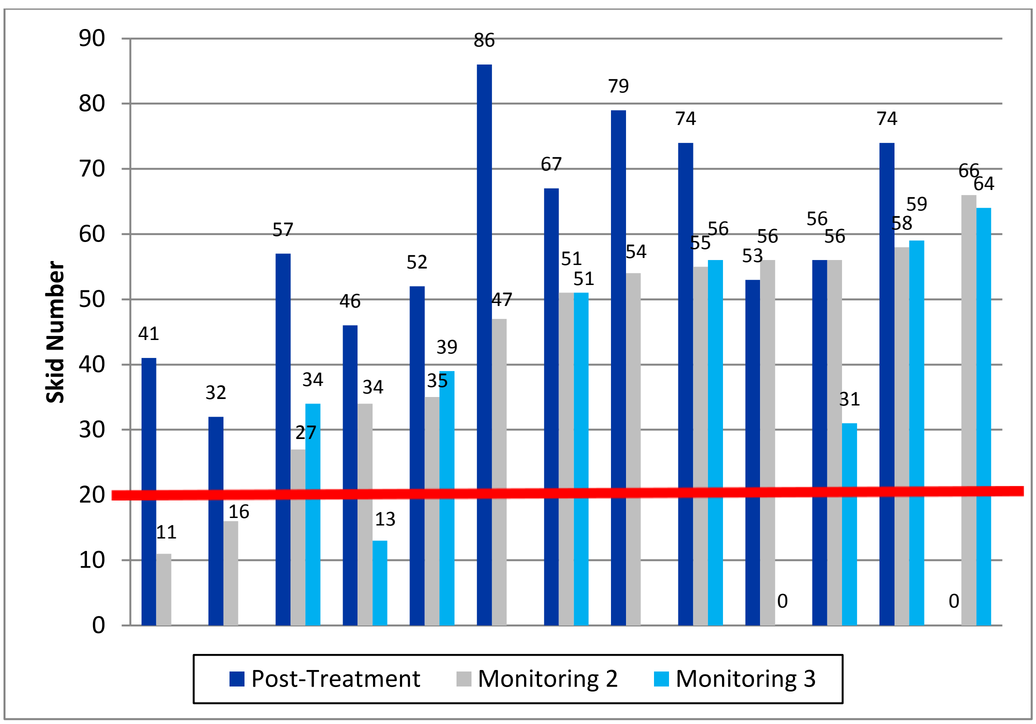


FIGURE 4.3. Treatment Survivability as Measured by Whether Pavement Friction (SN) Survived to Completion of Monitoring At or Above Specified Performance Threshold Value.

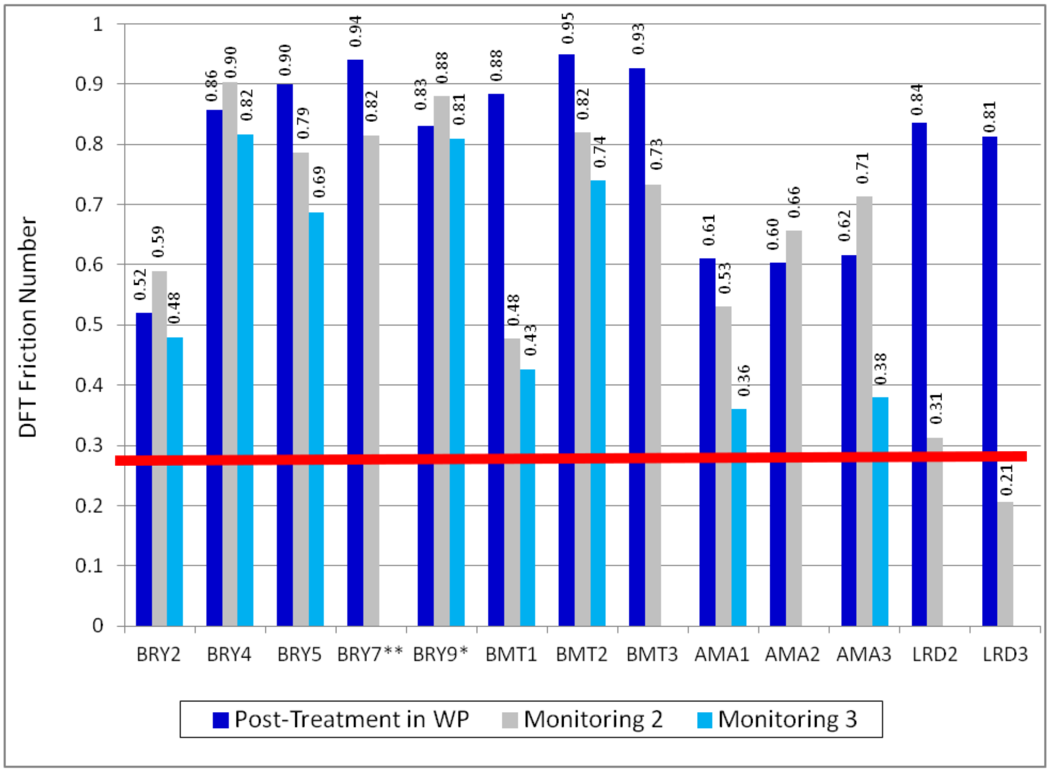


FIGURE 4.4. Treatment Survivability as Measured by Whether Pavement Friction (DFT FN) Survived to Completion of Monitoring At or Above Specified Performance Threshold Value

Overall, the survivability analysis showed that pavement texture values upon completion of monitoring (12 months to 18 months following UHP treatment) survived at or above the *desirable* threshold for seven of 13 sites. Pavement texture and friction values survived at or above the *maintenance* threshold for 12 of 13 sites.

4.4 Life expectancy

The second method by which this study evaluated the durability of the UHP water cutter treatment was in terms of life expectancy. As used in this report, life expectancy refers to the actual or predicted number of years that the treated roadway surface maintains its texture or friction properties at or above the maintenance performance threshold. Estimating life expectancy required the generation of exponential decay curves (Figure 4.5) to estimate how pavement texture and friction would decrease over time. The predictive models for each site are based on data obtained during the 18-month monitoring period, and owing to limited data, all models are not fully validated. Notwithstanding this limitation, using the decay curves, we estimated the life expectancy of the treatment, in years, up to the maintenance threshold for each measure of texture and friction.

Figure 4.6 presents the life expectancy charts associated with the CTM data. Review of Figure 4.6 shows that CTM mean profile depth data for one site are not available (BRY2). For the twelve sites with CTM life expectancy data, Figure 4.6 indicates that the pavement texture, as measured by the CTM, at 11 of these sites is predicted to last one or more years. Similarly, the texture at eight sites is predicted to last two or more years, the texture at six sites is predicted to last three or more years, and the texture at five sites is predicted to last four or more years. Again, these life expectancy predictions are based on CTM decay models.

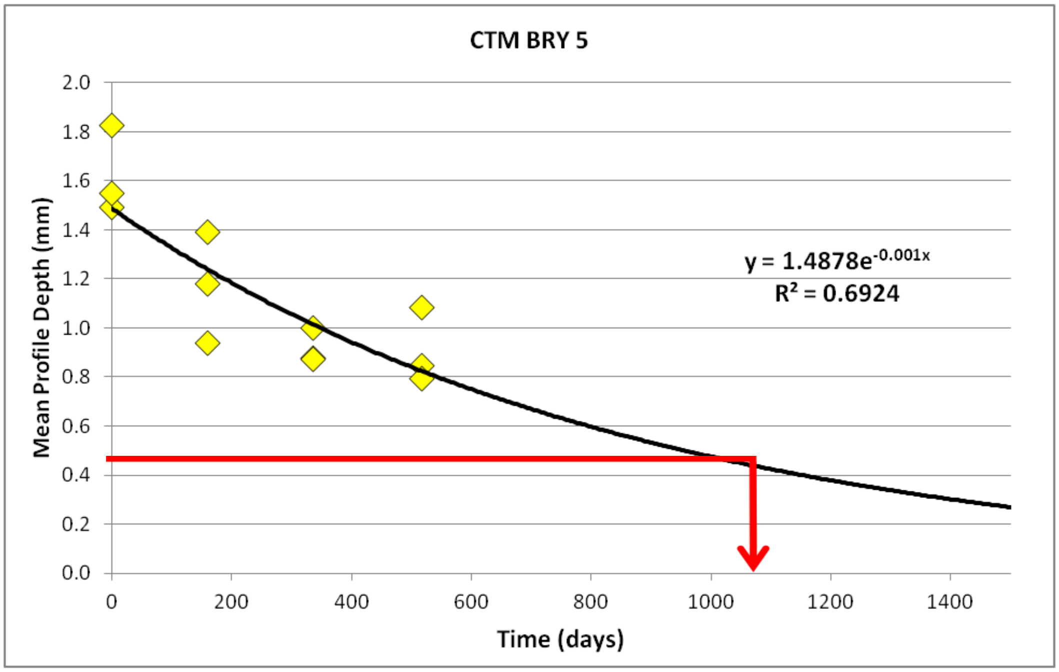


FIGURE 4.5. Typical Exponential Decay Model for Life Expectancy Prediction; CTM Data For BRY5; Life Expectancy Is 1090 Days

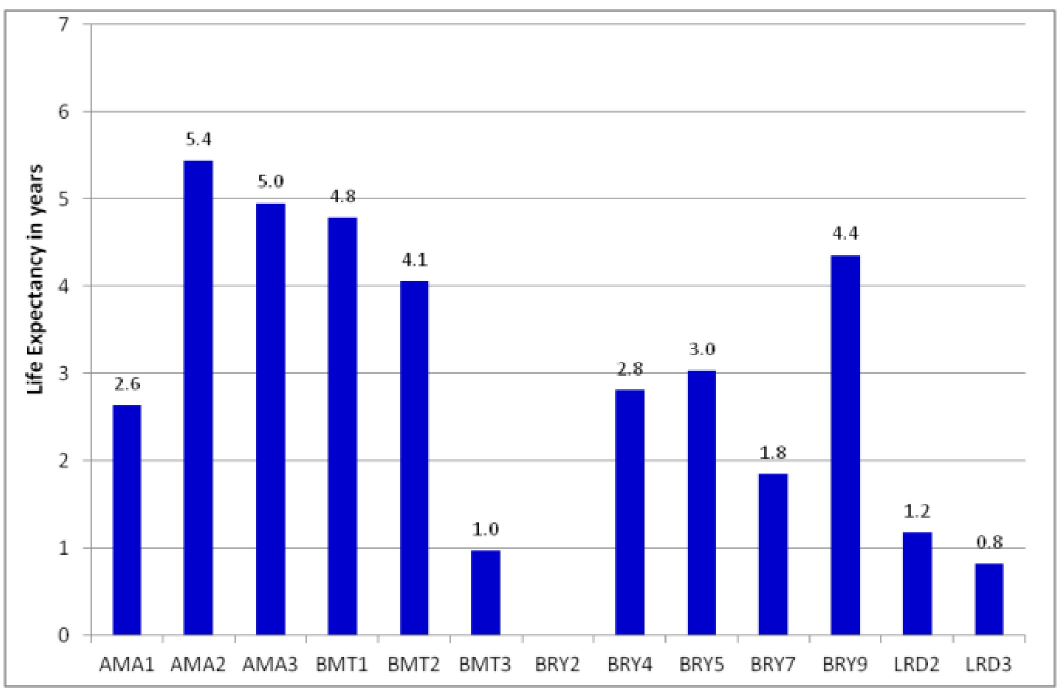


FIGURE 4.6. Treatment Life Expectancy, In Years, Predicted Based On Pavement Texture Estimated From CTM Mean Profile Depth Data

Figures 4.7 through 4.9 provide life expectancy charts associated with the SP data, SN data, and DFT FN data.

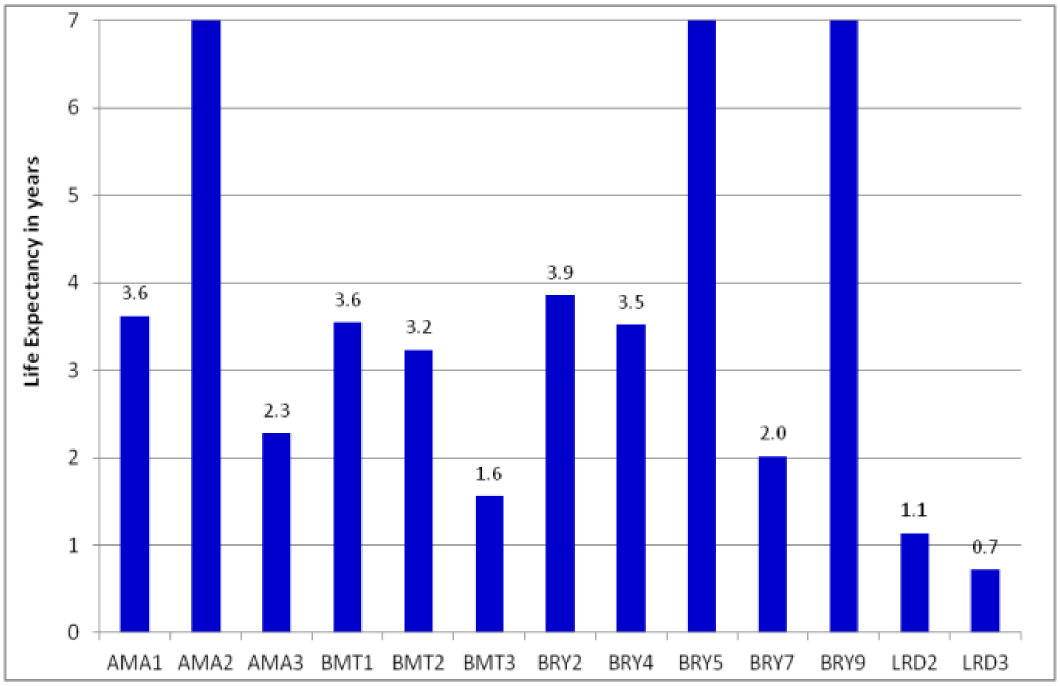


FIGURE 4.7. Treatment Life Expectancy, In Years, Predicted Based On Pavement Texture Estimated From SP Mean Texture Depth Data

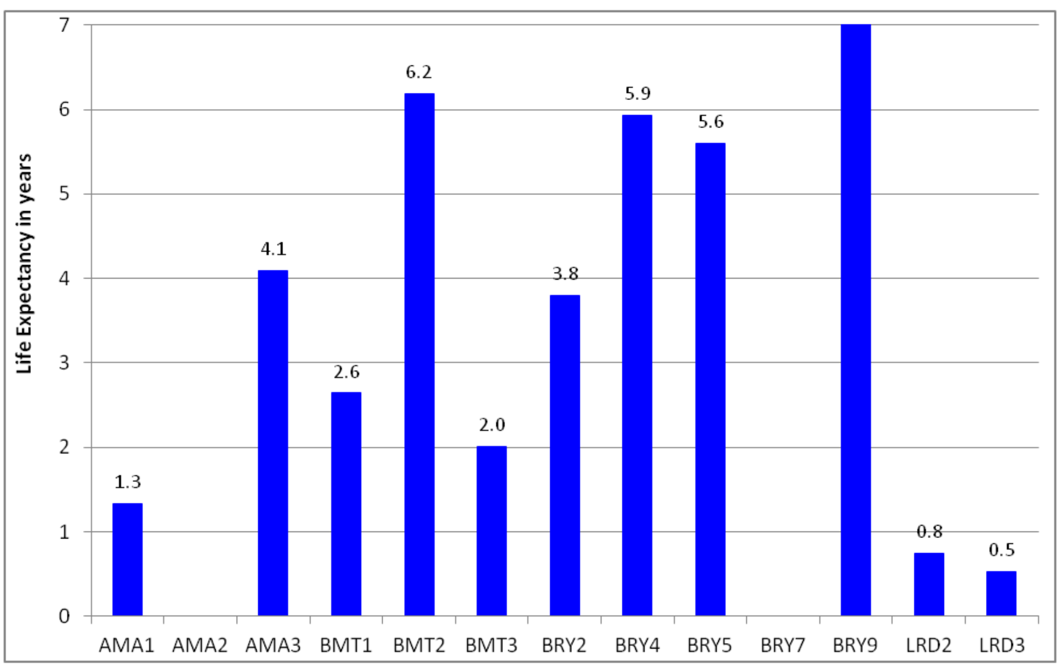


FIGURE 4.8. Treatment Life Expectancy, in Years, Predicted Based on Pavement Friction Estimated From SN Data

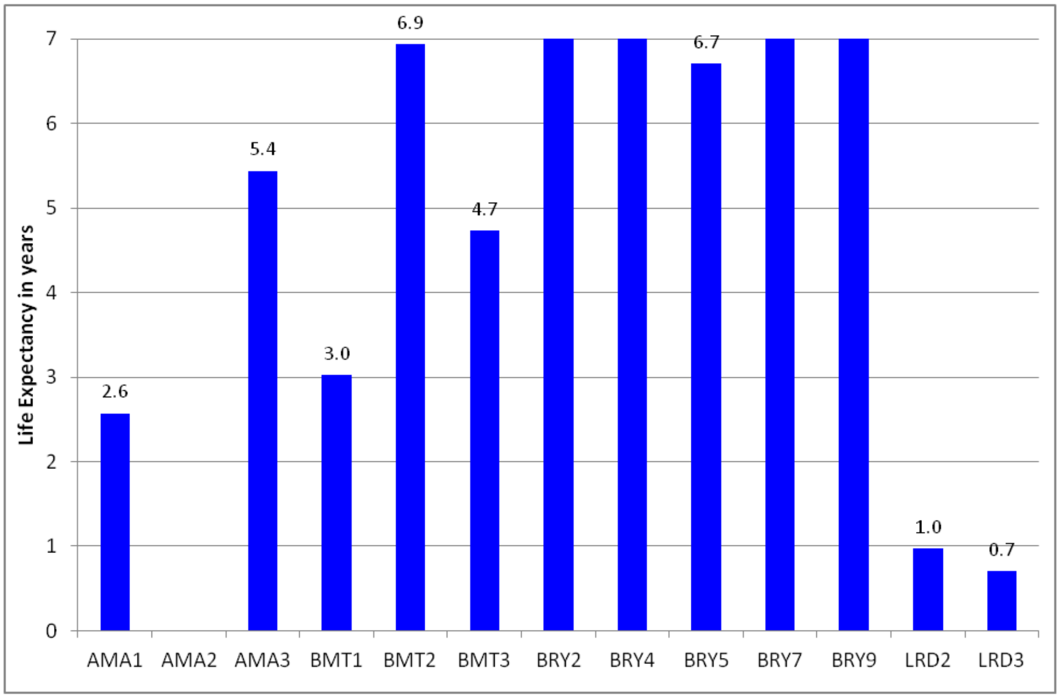


FIGURE 4.9. Treatment Life Expectancy, in Years, Predicted Based on Pavement Friction Estimated from DFT FN Data

Overall, the life expectancy analysis shows that the texture and friction improvements achieved through UHP water cutting treatment will last:

$\geq$ One year: 9 to 12, average 11 of 12 sites

$\geq$ Two years: 8 to 10, average 9 of 12 sites

$\geq$ Three years: 6 to 9, average 7 of 12 sites

$\geq$ Four years: 3 to 8, average 5 of 12 sites

This summary shows that the improvement in pavement texture and friction achieved by UHP water cutting will, at some sites, not last a full year. However, at 40 percent of the test sites, the treatment may last four or more years.

4.5 Factors that Affect Survivability and Life Expectancy

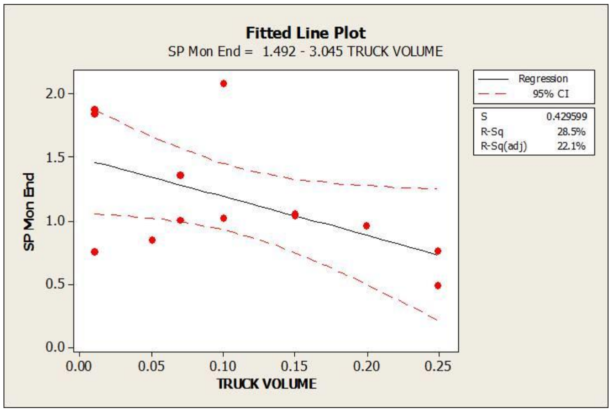
As part of this research, we performed analysis of variance (ANOVA) tests associated with treatment durability, expressed in terms of survivability and life expectancy and based on independent variables presented in Table 4.2.

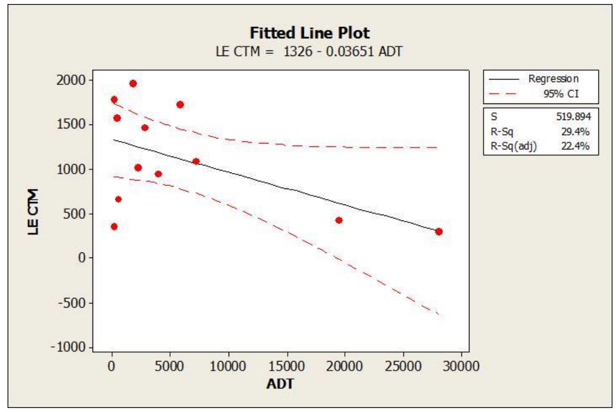
TABLE 4.2. Project Variables Associated with UHP Treatment Durability

Test Site	FHWA Climate Region	ADT	Truck Volume	Year of Last Surfacing	Asphalt Binder on Surface	Aggregate on Surface
BRY2	II	1400	Low-Med	2005	AC 20-5TR	PB GR 3S
BRY4	II	2200	Low	2005	AC 20-5TR	PL GR 4
BRY5	II	7200	High	2010	AC 12-5TR	PL GR 4
BRY7	II	510	Med-High	2010	AC 20-5TR	PL GR 4
BRY9	II	390	Very Low	2009	AC 12-5TR	PL GR 4
BMT1	I	5800	Med-High	2008	AC 20-5TR	PB-GR 4
BMT2	I	2800	Low	2009	CRS-2P	L-GR 3
BMT3	I	100	Very Low	2008	CRS-2P	L-GR 3
AMA1	V	3900	Low-Med	2008	AC 20-5TR	PB-GR 4
AMA2	V	1800	Medium	2009	AC 10	PB GR 4
AMA3	V	120	Very Low	2009	AC 10	PB GR 4
LRD2	IV	19500	Very High	2006	AC 20-5TR	PE-GR 3S
LRD3	IV	28000	Very High	2009	AC 20-5TR	PE-GR 4S

The results from these analyses suggest that durability parameters are most strongly influenced by average daily traffic volume and by the percentage of trucks (Figure 4.10) as would be expected:

- Traffic volume (ADT): higher traffic volume reduces treatment survivability and life expectancy.
- Truck volume: more truck traffic reduces treatment survivability and life expectancy.





a) Influence of truck volume on treatment survivability, as measured by SP mean texture depth

b) Influence of average daily traffic on treatment life expectancy, as measured by CTM mean profile depth

FIGURE 4.10. Factors That Influence UHP Treatment Durability as Determined by Statistical Analyses of the Survivability and Life Expectancy Data

Other factors, such as the type of binder, type of aggregate, aggregate hardness, and climate, showed weaker and/or mixed correlations. This is not to say that these factors do not influence the durability of the UHP water cutter treatment, but that the implementation research design lacked adequate sample size to definitively evaluate their effects. In all cases the data set was small and the independent variables were highly correlated.

4.6 International Friction Index

As part of our evaluation of the UHP water cutter treatment, the research team determined the International Friction Index (IFI) for each test site. IFI is determined as per ASTM E1960, Standard Practice for Calculating International Friction Index of a Pavement Surface [ASTM 2011]. This practice uses measured data of the pavement surface on: (*1) macrotexture,* and *(2) measured friction (FRS)* on wet pavement. The practice accommodates these data measured with different equipment at any measuring speed. Figure 4.11 presents the IFI calibrated friction number, F60 and the speed constant (Sp), both at post treatment and at the end of monitoring.

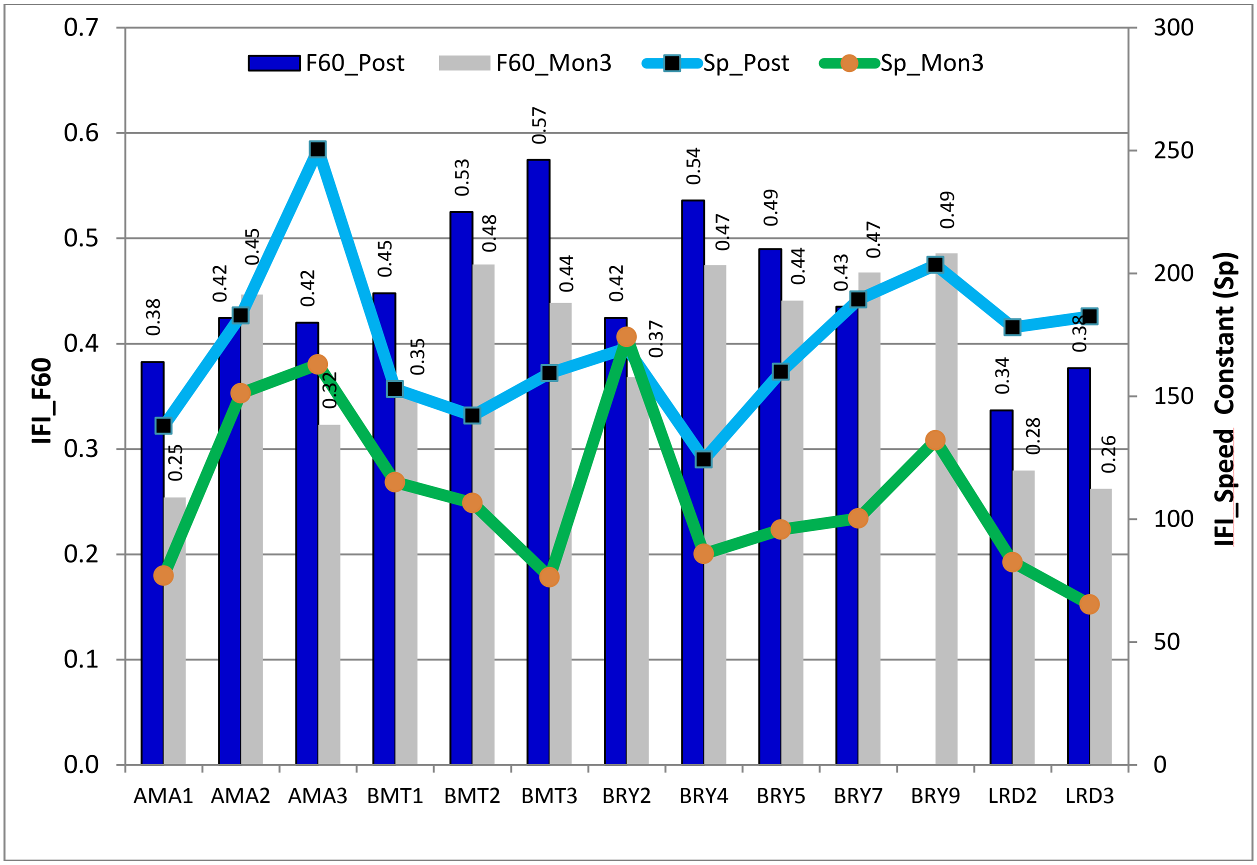


FIGURE 4.11. International Friction Index (IFI) Calibrated Friction Number, F60, and Speed Constant (Sp) for Test Sites

Review of the IFI data indicates that both the F60 and the Sp values decreased over time. F60 values decreased for ten of 12 sites, with variations ranging from +9 percent to -34 percent, averaging -15 percent. Sp values decreased for 12 of 13 sites, with variations ranging from +3 percent to -64 percent, averaging -36 percent.

4.7 Durability Summary

The durability of the UHP water cutter treatment process was evaluated in terms of the survivability and life expectancy of pavement surface texture and friction values achieved through treatment. Relative to survivability, pavement texture values upon completion of monitoring (12 months to 18 months following UHP treatment) were at or above the *desirable* threshold for seven of 13 sites. Pavement texture and friction values were at or above the *maintenance* threshold for 12 of 13 sites. Relative to life expectancy, predictive decay models indicate that the improvement in pavement texture and friction achieved by UHP water cutting will not last a full year at roughly 10 percent of the test sites. However, at 90 percent of the test sites, the treatment is predicted to last one or more years. For 40 percent of the test sites, the treatment may last four or more years.

CHAPTER 5. PRODUCTION AND COST EFFECTIVENESS

5.1 Overview

This chapter discusses production and cost considerations associated with ultra-high pressure water cutting as a maintenance solution for treatment of flushed pavement surfaces. Production topics include information about production rates, factors that influence production, waste disposal, climate considerations, environmental factors, and optimizing the production process. Detailed observations at the district level are also presented. Cost considerations include unit cost data for alternative treatment methods and for UHP water cutting.

5.2 UHP Water Cutter Production Information

5.2.1 Production Rates

During the water cutting process, the BlasterVac truck is propelled by a hydrostatic drive, independent of the truck transmission, with potential forward movement at ground speeds ranging from 0 to 7.0 mph. This means that establishing the forward ground speed is tantamount to setting the production rate, and this is the key variable for defining the water cutting process at a particular site. The ground speed must be established in the field relative to the project site conditions including the roadway surface condition, environmental factors, and desired treatment effectiveness as per the cutting head variables.

To this end, the researchers conducted preliminary speed trials prior to field testing where we varied the forward ground speed from 1.3 mph to 6.7 mph. This preliminary evaluation revealed that forward ground speeds above 3 mph lightly scored but did not treat the flushed pavement surface, so the maximum forward speed for future site-specific time trials was limited to 3 mph.

The research plan called for a series of 8 to 16 trial speed zones per site (refer to Figure 5.1) where the forward ground speed could be varied and evaluated in order to achieve an ideal, target production rate. The typical process was to mark out the speed zones and conduct time trials, intentionally varying the forward ground speed throughout the trials. Four speed levels were selected for speed section treatment, starting with the fastest rate and incrementally slowing treatment throughout the trial. With traffic control in place, the UHP water cutter would begin speed trials in the outside wheel path at the end of the test area (as per Figure 5.1) and travel in the direction opposite to traffic flow. The process would continue, right to left, until reaching the start of the test section, at which point the treatment would shift to the inside wheel path and proceed from left to right, in the direction of traffic.

The texture of the 16 speed section test locations was measured both before and after the treatment using the Circular Track Meter (CTM). At the end of the speed trials, the researchers and TxDOT maintenance professionals would visually observe the speed zones and jointly select the production treatment speed which they felt would achieve the most effective outcome – that is, the best treatment.

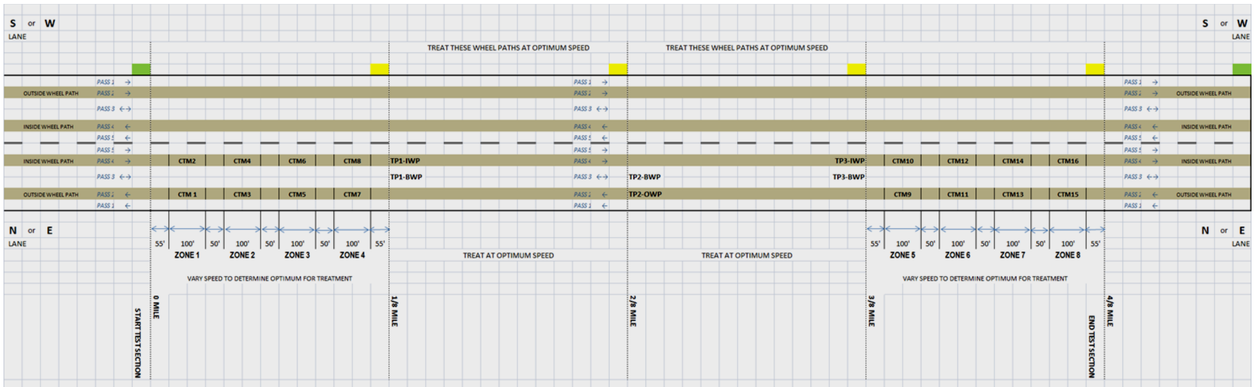


FIGURE 5.1. Schematic of Typical Test Site Indicating Two Outer 1/8-Mile Speed Sections and Middle ¼-Mile Production Section

Table 5.1 summarizes the speed trial, treatment speed, and production rate data for the field treatment sites. These data reveal that the typical forward ground speed for treatment varied from 0.5 to 1.6 mph, with an average of 0.8 mph. The treatment area consists of one wheel path (24-inch cutting width) and on this basis, the treatment speed corresponds to a field-measured production rate of 590 to 1870 square yards per hour, with an average of 990 square yards per hour.

TABLE 5.1. UHP Water Cutter Speed Trial Data, Treatment Speeds and Production Rates

Site	Road	County	Nozzles	Speed Trials (mph)			Treatment Speed (mph)			Production Rate	Surface Condition
				Min	Max	Avg	Min	Max	Avg	(SY/hour)	
BRY1	FM 2347	Brazos	8						0.5	587	tracked asphalt on concrete
BRY2	SH50	Burleson	28	0.5	2.6	1.1			0.7	821	moderately flushed chip seal
BRY4	FM455	Robertson	20	0.6	1.6	1.0			1.0	1173	lightly flushed chip seal
BRY5	US190	Milam	20	0.9	1.8	1.3	0.5	0.7	0.6	739	heavily flushed chip seal
BRY7	SH90	Grimes	28	0.7	1.8	1.1	0.8	1	0.9	1067	moderately flushed chip seal
BRY9	FM2562	Grimes	28				0.7	0.8	0.7	845	heavily flushed chip seal
LRD 2	FM1472	Webb	28	0.7	1.8	1.3	0.7	0.7	0.7	856	heavily flushed chip seal
LRD 3	IH35	Webb	28	0.5	1.6	0.9	0.5	0.7	0.6	716	heavily flushed chip seal
BMT 1	SH321	Liberty	28	0.5	1.3	0.8			1.0	1173	moderately flushed chip seal
BMT 2	SH63	Jasper	28	0.7	1.8	1.2	1.1	2.4	1.6	1865	lightly flushed chip seal
BMT 3	FM82	Jasper	28	0.5	1.3	0.9	1.0	1.1	1.0	1161	heavily flushed chip seal
AMA 1	FM2950	Randall	28						0.8	938	moderately flushed chip seal
AMA 2	RM1061	Oldham	28	0.6	1.7	1.1	0.8	1.3	1.1	1255	lightly flushed chip seal
AMA 3	RM294	Armstrong	28	0.4	0.9	0.6	0.4	0.7	0.5	622	very heavily flushed chip seal

5.2.2 General Observations from the Production Process

<u>Project Factors that Affect Production</u>

The Rampart BlasterVac truck is designed to provide a minimum of 560 square yards of surface treatment per hour and can provide light-duty surface cleaning at rates up to 3,300 square yards per hour. For this pavement implementation project, the BlasterVac achieved an average production rate of 1000 square yards per hour, and a maximum treatment rate of 1,900 square yards per hour. Actual production depends on project factors and on environmental factors.

Project-related factors that affect UHP water cutter production include, but are not limited to, the size of the project, traffic considerations, continuity of treatment areas, the pavement surface condition, the availability of potable water, and availability of approved dump sites. Generally speaking, larger sites which support uninterrupted production will yield higher production rates; whereas, smaller sites which require intermediate mobilization and setup are less efficient. The site layout, traffic lanes, and work area directly affect production because the Rampart BlasterVac truck has a fixed cutting head off the front left side of the vehicle. This means that the truck can proceed in the direction of traffic when treating the inside wheel path, but for two-lane roads without shoulders, the truck must travel against traffic to treat the outside wheel path (Figure 5.2). Ultimately, the traffic lane configuration and work area dictates whether traffic control can be a moving operation or if a lane closure is required.

FIGURE 5.2. UHP Water Cutting in Outside Wheel Path on Two-Lane Roads Requires Full Lane Closure. *Image courtesy Chris Sasser, TTI Visual Media.*

In a manner similar to the size of the project, continuous treatment areas facilitate more efficient production than intermittently-flushed pavement sections. Pavement surface condition strongly influences production, in that more heavily flushed surfaces dictate a slower treatment rate, more debris removed from the road surface, and therefore more frequent dumping of debris, all of which slow production. Severely flushed pavements, characterized by very heavily-flushed pavements and modified binders, can cause additional problems. Such conditions may restrict or clog the vacuum system, or lessen vacuum effectiveness such that the process leaves clumps of binder-aggregate debris on the pavement surface in the wake of the cutting head. In such cases, additional effort is necessary to manually remove and/or sweep debris from the treatment area behind the BlasterVac truck. In contrast, lightly flushed pavements can typically be treated at faster rates with less-frequent dumping.

Because the UHP water cutting process requires potable water, ready access to an acceptable water source directly influences production. The water cutter truck is capable of holding 4,000 gallons of water, and the logistics of filling the truck with water need to be considered. The truck can be filled from its manhole cover at the top, but the filling site must have sufficient clearance to do this. Most project sites did not have sufficient clearance for overhead filling and alternative measures such as using a water trailer with a pump [Figures 2.8 (c) and (d)] were used in such situations.

Waste Disposal

Because the debris tank has only 1,000 gallon capacity and the water supply tank has 4,000 gallon capacity, the location of an approved dump site will significantly impact the rate of production. Figure 5.3 illustrates the key steps involved in the waste disposal process. The back gate of the truck has a gage that indicates the material level in the waste tank [see the circled area in Figure 5.3(f)]. The truck is able to directly back into the disposal area and open the rear gate as shown. This operation requires that the disposal area is firm enough to carry the laden truck that is at least partially filled with water. Once the gate is opened, water spills out of the truck, but the solid material must be pushed out using a hydraulic ram inside the waste tank.

The maintenance supervisor must ensure that the waste material is disposed according to guidelines stipulated by the TxDOT Environmental Division. The waste material consists of ground asphalt, sand, and water. When the temperature of the pavement is relatively high, evidence of some emulsification of the asphalt could be observed. Ideally, the disposal area is to be bermed around to prevent immediate run-off of the material.

Climatic Factors that Affect Production

Climatic site factors affect UHP water cutter production. For example, the stiffness of asphalt binder in flushed chip seals is affected by pavement temperature and this has implications for UHP water cutting. The UHP water cutting process is most efficient at lower pavement temperatures when the binder is stiff, and water cutting is not effective when pavement surface temperatures exceed 110° F and the binder gets soft and sticky. The suitable higher limit of pavement temperature would be lower for unmodified asphalt cements. This places a practical upper limit on pavement surface temperature for UHP water cutting, which nominally is 100°F. At the other end of the spectrum, because UHP water cutting is a water-based process, the practical lower limit on ambient temperature for UHP water cutting is 32°F. Here the issue is not pavement temperature (the colder the better). Rather, freezing temperatures will cause water in the UHP pump and piping systems to freeze, rendering the BlasterVac unit ineffective.

Literature on UHP water cutting sometimes notes that because the process involves adding water to the pavement surface, there is no functional reason why UHP water cutting could not be accomplished during wet weather (Lawson, et al. 2007). This observation is valid relative to operation of the UHP water cutter equipment. However, from a roadway maintenance perspective, traffic control and worker safety considerations associated with UHP water cutting are such that performing this type of maintenance during inclement weather is not recommended.

(a) (b) (c) (d) (e) (f)

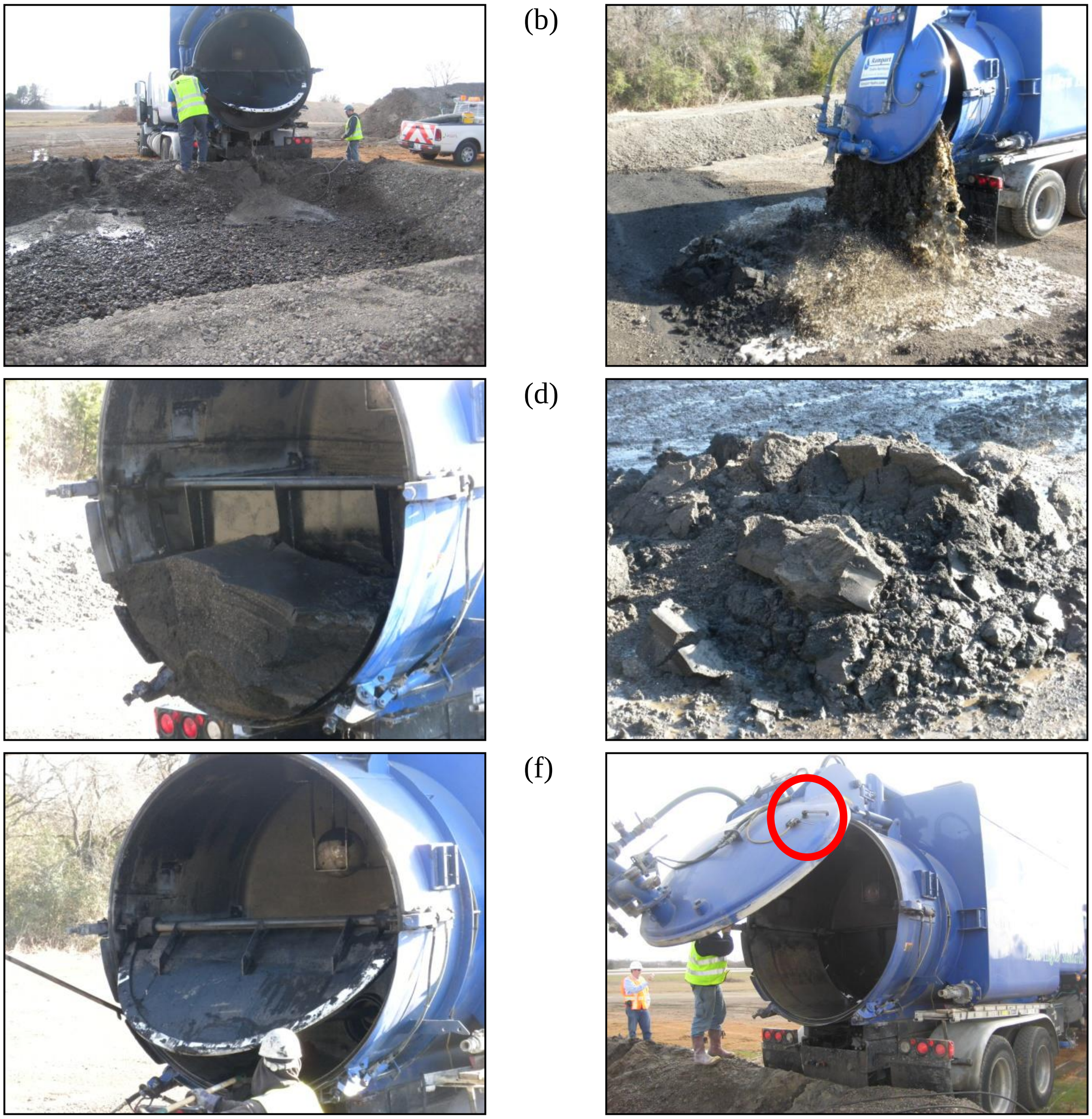


FIGURE 5.3. Disposal of excess flushed asphalt removed by the treatment; (a) A bermed area chosen by the TxDOT maintenance yard used to dispose the material without run-off; (b) Opening of rear gate spills out the water among the waste; (c) lump of asphalt and sand waste pushed out using hydraulic system; (d) lump of asphalt and sand waste on the ground; (e) cleaning of waste tank using high-pressure water jet; (f) cleaning of waste tank solid material – the circle highlights the gage on the rear gate that indicates the material level in the waste tank.

<u>Environmental Factors</u>

UHP water cutting is considered an environmentally-friendly, or sustainable, pavement maintenance strategy because the UHP water cutting process requires low water use, it does not require the addition of more of the same types of materials that created the flushing problem, and the debris vacuumed from the road surface can be recycled.

Rampart's BlasterVac truck is designed to capture about 95 percent of the water used for surface treatment. The debris and water vacuumed from the road surface during UHP water cutter treatment includes asphalt, water, sand, and aggregate, plus other materials/compounds from the road surface. The effluent water may be a skin irritant by virtue of emulsifying some of the oils in the binder during cutting. Observations suggest that for 1,000 gallons of water and debris vacuumed from the road surface, roughly 200 to 500 gallons of water are recovered with the remainder being particulate solids.

Disposal practices vary and must comply with environmental regulations. One option is to capture and treat the effluent and recycle the asphaltic solids into various pavement materials, for example, asphalt-stabilized base or subbase. Where allowed, maintenance forces may also dispose of the material by creating a bermed disposal site at, for example, an existing reclaimed asphalt pavement stockpile area. When effluent water and solids are dumped into these disposal areas, the water evaporates or percolates into the soil, and the solids are blended in with other recycled pavement solids. Other methods of disposal exist, and the choice of waste treatment and/or disposal method will affect production.

Fine-Tuning the UHP Water Cutting Process to Achieve Effective Treatment

It has been noted that the focal point of the UHP water cutting system on the Rampart BlasterVac truck is the cutting head (Figure 5.4). Three variables associated with the cutting head can be manipulated to fine-tune treatment effectiveness and increase production rates, and these are the number of nozzles, the nozzle opening size and configuration, and the spray bar rotation speed. A fourth variable, the water cutter travel speed, was discussed under production rates where data is presented on speed trial sections and the selection of the optimum travel speed.

FIGURE 5.4. *Cutting Head, Rampart BlasterVac*
Image courtesy Chris Sasser, TTI Visual Media

Through experience and monitored field trials, Rampart has established optimum nozzle configurations for different UHP water cutter applications associated with their BlasterVac equipment, including airport rubber removal (28 nozzles, 0.009 in. to 0.014 in.), paint removal (20 nozzles, 0.009 in. to 0.011 in.), and hydro-scarification (8 nozzles, 0.016 in. to 0.022 in.). This implementation research study evaluated Rampart's established nozzle configurations for treatment of flushed pavement surfaces and determined that in most cases, the 28-nozzle configuration was most effective. More aggressive nozzle configurations, expressed in terms of fewer nozzles with larger diameters and increased flow rate, could be used. However, the more aggressive configurations showed potential to damage the chip seal surface.

The rotational speed for the spray bar was typically maintained at what is considered "fast," or approximately 800 rpm. Field tests at lower rotational speeds – *e.g.*, 300 rpm – produced less-effective water cutting treatment. Field tests at severely-flushed sites with polymer-modified binders required the highest rotational speeds, in excess of 1,000 rpm, to keep the spray nozzles clean and functional.

Other cutting head variables are either fixed or viewed as not amenable to manipulation including the width of the spray bar (fixed at 24 inches), the distance from the nozzles to the pavement surface (fixed at 0.66 inches), and the UHP water flow rate (16 gpm) and pressure (32,000 psi to 34,000 psi).

Other Observations

Figures 5.5 through 5.9 illustrate some situations we observed during the treatment process. The UHP water cutter removes a significant amount of excess asphalt material from the pavement surface. The actual quantity removed will depend on the travel speed, rotational speed of the spray bar, the nozzle configuration in the bar, extent of flushing on the road and the asphalt and aggregate material characteristics. Figure 5.5 shows the removed asphalt left on the road when the vacuum system is not operating. Under conditions that can be labeled as "typical," the vacuum system in the machine is capable of sucking up all the material. Typical conditions would mean desirably cool temperatures and modified binders. However, there can be situations where the vacuum system is unable to remove all the cut asphalt as shown in Figure 5.6. Figure 5.7 shows a power broom following the water cutter to ensure that all material is removed from the roadway before traffic is allowed back.

The proper positioning of the treatment head with respect to the driver side wheel path is an important consideration. The Rampart water cutter truck does have some capability to move the treatment head across the lane. It is very important to keep the treatment head outside of the driver side wheel path to prevent removed material not picked up by the vacuum system from being pressed back into the treated area. Figure 5.8 shows a location where this happened. It should be noted that the extent to which the treatment head can be moved away from the truck is restricted because if the head is moved too far out, the water cutter truck will occupy a part of the lane that is not being treated. This can create problems with traffic control, particularly in two-lane roadways where no significant shoulder width is available.

Figure 5.8 also illustrates a phenomenon where the treatment process may leave a sharp shallow drop along the edge of the treated strip. This drop is not deep enough to cause traffic to lose control if caught on the edge. This issue can be alleviated by changing the nozzle configuration to gradually taper-off the treatment depth towards the outside of the treated strip. Another outcome that is influenced by the nozzle configuration is not having sufficient nozzle coverage in a certain part of the treatment trip.

FIGURE 5.5. Flushed Asphalt Removed From Treatment Operation Left on Road When Vacuum Suction Pump Was Turned Off

Figure 5.9 shows a narrow strip along the center of the treated strip where all excess asphalt was not removed. This results in a lightly-scored pattern on the surface, and is associated with pavement rutting. Here, the vertical distance from the spray bar to the pavement surface is wider at the center of the wheel path than at the edges, and this variation can be sufficient to diffuse water cutting energy in the middle of the wheel path. The outcome is variable, inadequate treatment. Figure 5.9 shows the effect of inadequate treatment in the middle of the wheel path associated with wheel path rutting of less than 3/8 inch.

FIGURE 5.6. Traces of Removed Asphalt Left on Treatment Path

FIGURE 5.7. Power Broom Used to Sweep Remaining Asphalt Left After Treatment Head Vacuum System

FIGURE 5.8. Treated Wheel Patch Showing Small Amounts of Asphalt Not Vacuumed and Then Pressed Back Into Lane By Tires of Water Cutter Truck. Picture Also Shows Sharp Edge Sometimes Left by Treatment at Edge Of Strip

FIGURE 5.9. "Holiday" Areas Not Subjected to Treatment Due to Ineffective Nozzle Coverage, in This Case Due To Rutting Along Center of Treatment Path

Figure 5.10 shows treatment of a pavement surface that was heavily flushed. When this section was being treated, the removed asphalt was found to be very sticky and was forming into balls of asphalt that were clogging the vacuum system. This picture shows a maintenance worker pulling out the asphalt lumps not picked up by the vacuum system to make sure they do not get pressed back on to the treated area of the roadway. This section of road had excessive flushing, and the asphalt used was unmodified AC-10. In this case, the stickiness of the asphalt arose in part because the binder was too soft at the working temperature. The binder type and grade is also an important consideration when planning water cutter treatment activities.

FIGURE 5.10. Maintenance Worker Using Shovel to Remove Excess Lumps of Asphalt

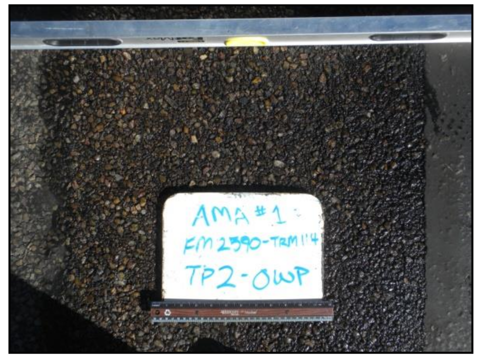
5.2.3 Observations from the Production Process at the District Level

<u>Amarillo District</u>

Snapshots of Amarillo test sections before and after treatment are shown in Figure 5.11. The first section (AMA1) was located near the city of Canyon and had a high ADT. AC20-5TR and siliceous aggregate was used in this section, and was part of a highway that has experienced significant flushing since its surfacing in 2008. Many maintenance treatments have been tried to correct its flushing with little long-term success. The second and third Amarillo District test sections were in rural settings and used unmodified AC 10 binder. AMA2 has significant truck traffic from aggregate pits in the area and AMA3 has very little traffic of any kind. The degree of flushing in AMA3 was extensive. Treatment of AMA1 was very successful. An alternate nozzle configuration was tried in AMA2, with the two larger (0.013”) nozzles placed in the interior of the spray bar and the smaller 0.009” nozzles moved to the outside. This caused raveling in the middle of the treatment strip as shown in Figure 5.11(d). AMA3 treatment was difficult due to soft binder clogging the vacuum system. An additional maintenance worker had to pull the balled asphalt away from underneath the machine to prevent the removed asphalt from being pressed back into the roadway by the tires.

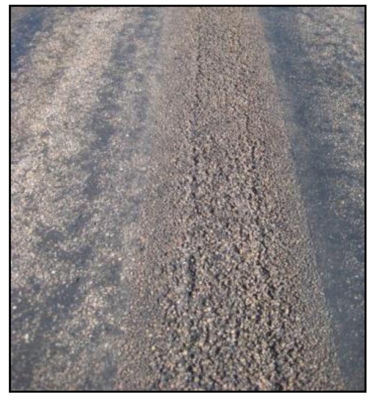
(a)

(b)



(c)

(d)



(e)

(f)

FIGURE 5.11. Test Pavement Pictures from Amarillo District (A) AMA1 Before Treatment; (B) AMA1 Soon After Treatment; (C) AMA2 Before Treatment; (D) AMA2 Soon After Treatment; (E) AMA3 Before Treatment; (F) AMA3 Soon After Treatment

Beaumont District

Snapshots of Beaumont test sections before and after treatment are shown in Figure 5.12. The first of the three Beaumont sections (BMT1) was located near the city of Cleveland and had high traffic including a significant level of trucks. The last surfacing on this section in 2008 used AC20-5TR and limestone aggregate. BMT2 was a rural section in a wooded area and carried some logging truck traffic. BMT3 was near the city of Kirbyville and had a low ADT. BMT2 and BMT3 used CRS-2P emulsion binder with lightweight aggregate. Treatment of these three sections was successful. There was some difficulty in getting the BMT2 section dry after the treatment to conduct the post-treatment CTM test.

(a) (b) (c) (d) (e) (f)

FIGURE 5.12. Test Pavement Pictures from Beaumont District (A) BMT1 Before Treatment; (B) BMT1 Soon After Treatment; (C) BMT2 Before Treatment; (D) BMT2 Soon After Treatment; (E) BMT3 Before Treatment; (F) BMT3 Soon After Treatment

Bryan District

Snapshots of three of the five Bryan District asphalt test sections before and after treatment are shown in Figure 5.13. The first section (BRY2) was located next to cotton fields and had some truck traffic. This section used AC 20-5TR binder and limestone asphalt rock (LRA) aggregate. The treatment process included a 20-nozzle spray bar and the treatment appeared to work reasonably well. It was observed that a dark gray powder was left on the treated area. It was the opinion of the TxDOT personnel that the powder might have come from the LRA aggregate.

The second section in Bryan District (BRY4) also used a 20-nozzle spray bar and the treatment appeared to be working reasonably well.

The third section (BRY5) was done in two stages because of mechanical problems associated with the water cutter truck. On the first day of treatment in this section, a 20-nozzle configuration was used. The machine broke down before the treatment work reached the halfway point and work had to be stopped. The research team fixed the problem and moved to the Laredo District to treat the two test sections there according to the planned work schedule. The team then returned to the Bryan District and completed the remainder of BRY5 and moved to BRY9, which was a section added later.

Prior to the second installment of treatment in BRY5, a decision was made to change the spray bar configuration to include 28 nozzles to produce a more uniform treatment.

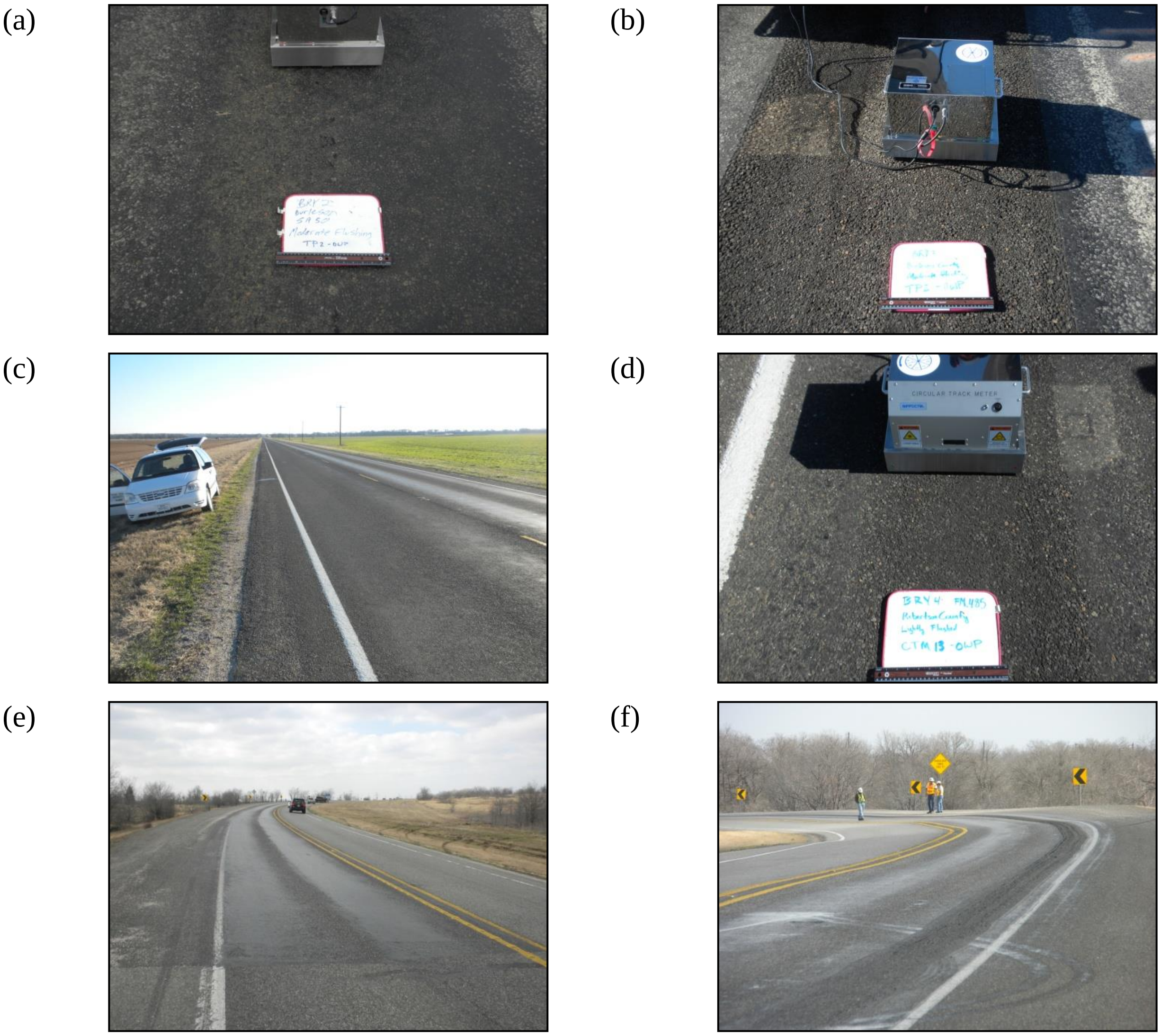


FIGURE 5.13. Test Pavement Pictures from Bryan District (A) BRY2 Before Treatment; (B) BRY2 Soon After Treatment; (C) BRY4 Before Treatment; (D) BRY4 Soon After Treatment; (E) BRY5 Before Treatment; (F) BRY5 Soon After Treatment

Laredo District

The two test projects in the Laredo District both had two lanes in each travel direction. Figure 5.14 illustrates the test project and its “before and after” treatment images. The section LRD2 was near a warehouse area and the outside lane of this roadway, as shown in Figure 5.14(a), was heavily flushed. The treatment in this section was not very successful, perhaps because the aggregate used in this section was a weak and dusty limestone, and it left residue on the roadway that stained the treated area [see Figure 5.14(c)]. On the other hand, the water cutter spray bar was operating at a lower rotational speed in the two Laredo sections, and that contributed to the zig-zag effect along the middle of the treated area. The second test section in Laredo (LRD3) was on IH-30 and had a very high level of truck traffic as well. The materials used on this surface were similar to LRD 2, and the observations were similar in nature.

(a)


(b)


(c)


(d)


(e)


(f)


FIGURE 5.14. Test Pavement Pictures from Laredo District (A) LRD2 Before Treatment; (B) LRD2 Soon After Treatment; (C) LRD2 Close-Up View Soon After Treatment; (D) LRD3 Before Treatment; (E) LRD3 Soon After Treatment; (F) LRD3 Close-Up View Soon After Treatment

Bryan District Rigid Pavement Section

A jointed rigid pavement section was included in the Bryan District treatment program. The objective was to assess the feasibility of the UHP water cutter to remove up to 7mm of tracked asphalt from the tined concrete surface, and Figure 5.15 illustrates the work done at this section. Figure 5.15(a) and (b) show the extent of tracking on the wheelpaths. An 8-nozzle spray bar configuration, shown in Figure 5.15(c), was used for this purpose. Figures 5.15(d) and (e) illustrate that more than one pass of the treatment head was needed to remove the tracked asphalt, and in the thickest areas, it took up to four or five passes to remove all the asphalt. The removal process was particularly difficult because of the transverse tines in the concrete pavement. In the end, the section was successfully cleaned. Once the water cutter operators had more understanding of the extent of tracking and of the concrete surface, adjustments were made to the travel speed of the truck and the rotational speed of the spray bar to remove the asphalt in two passes. The treatment using multiple passes did create some minor spalling at the joints of the concrete pavement and also removed some of the joint sealant material in the treatment area.

(a)

(b)

(c)

(d)

(e)

(f)

FIGURE 5.15. Test pavement pictures from Bryan District concrete pavement section where tracked asphalt was removed using UHP water cutter (a) tracked asphalt on inside wheel path; (b) removal of tracked asphalt using UHP water cutter; (c) 8-nozzle configuration used in spray

bar; (d) inside wheel path after several passes of UHP water cutter; (e) close-up view of treated area; (f) some joint damage (slight spalling) due to water cutter treatment

5.3 Cost Information

5.3.1 Unit Cost Data for Alternative Treatment Methods

Other than UHP water cutting, the basic approaches available to treat flushed chip seals are to add a new textured surface over the flushed pavement, or to mechanically retexture the existing pavement surface. Table 5.2 identifies the TxDOT maintenance functions associated with these techniques and provides 2010 unit cost data for each. The first three maintenance functions identified in Table 5.2 represent typical ways that maintenance forces add a new textured surface on top of a flushed chip seal. The next two maintenance functions describe methods for mechanically retexturing a flushed pavement surface.

TABLE 5.2. Maintenance Functions Used To Treat Flushed Pavements, With 2010 Unit Cost Data (TxDOT Maintenance Forces)

Function Code	Function Code Description	Turn-key Maintenance Cost		
		District Minimum $/SY	District Maximum $/SY	Statewide Average $/SY
212	Leveling or Overlay with Maintainer... The application of asphaltic tack coat and placing layers of asphaltic concrete material	$ 3.91	$ 6.61	$ 4.51
214	Leveling or Overlay with Drag Box... The application of asphaltic tack coat and placing layers of asphaltic concrete material	$ 1.71	$ 6.23	$ 2.60
232	Strip or Spot Seal Coat (Chip Seal)... Application of a single layer of asphaltic material followed by the application of a single layer of aggregate over areas that are not full width of the travel lane or shoulder (6' or less in width), or the full width of the lane or shoulder but less than 1000 feet in length.	$ 2.19	$ 3.14	$ 2.58
252	Milling or Planing... The removal of the pavement surface by planing or milling	$ 1.37	$ 11.46	$ 2.05
253	Spot Milling... The removal of pavement surface by milling using a small milling machine (drum width is 4 feet or less)	$ 3.19	$ 19.81	$ 6.65

The unit-cost data in Table 5.2 derive from TxDOT's Maintenance Management Information System and represent turn-key costs for TxDOT maintenance forces to accomplish the stated maintenance functions including equipment, materials, labor, and traffic control. The "District Minimum" and "District Maximum" values refer to the minimum and maximum costs, respectively, associated with each maintenance function in the four districts where the research test sites are located. The statewide average is based on cost data from all 25 TxDOT districts, not only those with the treatment sites. The maintenance function most commonly used to address flushed pavements is 'strip or spot sealing'.

5.3.2 Unit Cost Data for Ultra High Pressure Water Cutting

It is common practice for UHP water cutter companies, including Rampart, to serve as specialty subcontractors who offer UHP water cutting services to general contractors for a specific project.

Here, Rampart was responsible to provide the BlasterVac truck and crew (typically consisting of one operator), and the general contractor was responsible for all other services necessary to complete the project including a water source, a waste disposal site, traffic control, a mechanical road sweeper if necessary, and any other support services.

Under the preferred subcontractual arrangement, the unit cost for UHP water cutter-only services at production rates representative of this research study typically range from $0.90/SY to $1.15/SY (personal communication with J. Parks-Rampart, unpublished data). The lower unit cost reflects conditions associated with high production rates as discussed in the previous section. The higher unit cost reflects project conditions that reduce efficiency. All unit cost figures are subject to prevailing wage rates, fluctuating fuel costs, mobilization costs, and other project-specific variables.

Should it be necessary for the UHP water contractor company to serve as general contractor, the unit cost for turn-key UHP water cutter services at production rates typical of this research study typically ranges from $1.40/SY to $1.65/SY (personal communication with J. Parks-Rampart, unpublished data). These unit costs are suitable for an apples-to-apples comparison with the maintenance costs presented in Table 5.2. Under average production conditions, UHP water cutting is $1.05/SY less expensive than the statewide average for strip or spot sealing – a cost savings of 41 percent. Relative to the other maintenance functions in Table 5.2, the potential cost savings for UHP water cutting varies from 25 percent to 77 percent. Again, all unit cost figures are subject to project-specific variables.

5.4 Observations about Production and Cost Effectiveness

The data presented herein provide a detailed discussion of the variables and related factors that influence UHP water cutter production rates. Within this context, a direct comparison of unit cost data for UHP water cutting versus the unit costs of other maintenance functions currently used to treat flushed pavements indicates that UHP water cutting can provide cost savings of 25 percent to 77 percent, typically 41 percent.

The results of this implementation study are promising relative to the application of UHP water cutting for seal coat maintenance in Texas. Beyond this basic evaluation, two potential business observations deserve mention. One is that treatment of flushed pavement surfaces by means of UHP water cutting represents a new, untapped market for existing hydrodemolition contractors. A second observation is that the adaptation of UHP water cutter equipment from heavy-duty concrete pavement structures to much lighter-duty seal coat roadway applications presents many opportunities for process optimization, technology transfer, and innovation.

5.5 UHP Water Cutter DRAFT Specifications

Consistent with this discussion of the variables and related factors that influence UHP water cutter production and costs, the research team developed two DRAFT specifications to facilitate implementation of UHP water cutting as a maintenance solution for Texas roads. Appendix O contains the two specifications.

The first specification, “Equipment for Treatment of Flushed Asphalt Pavement,” is intended for TxDOT Districts that wish to retain the UHP service provider as a specialty subcontractor responsible for UHP water cutter surface treatment only. As has been noted, this is the typical way that hydrodemolition contractors provide their services. Under this approach, TxDOT would serve as the general contractor and provide everything needed for the project except the UHP equipment and a qualified operator. TxDOT's responsibilities would include but would not be limited to providing water, waste dump sites, traffic control, and any ancillary manpower or equipment associated with the UHP process, such as a rotary broom and labor to remove excess asphalt. As per the equipment specification, the UHP contractor would be responsible to provide equipment and an operator satisfactory to TxDOT.

The second specification, "Treatment of Flushed Asphalt Pavement Using Ultra High Pressure Water Cutting," is intended for TxDOT Districts that wish to retain the UHP water cutting service on a turn-key project basis. Under this approach, the UHP contractor would be responsible for all materials, equipment, labor, and supervision necessary to restore texture to flushed pavement surfaces. The turn-key specification includes all elements of the equipment specification, plus additional requirements associated with complete execution of the project.

These are DRAFT specifications, subject to evaluation and modification by TxDOT in accordance with their specification review protocol.

CHAPTER 6. SUMMARY, CONCLUSIONS, AND IMPLEMENTATION CONSIDERATIONS

6.1 Summary

TxDOT implementation research project 5-5230-01 was designed to systematically evaluate the UHP water cutter as a low-cost, pavement preservation tool for treatment of flushed roads surfaced with a seal coat. UHP water cutter treatment data were collected from January 31 through March 2, 2011, from 14 test sites located in four climatic regions in Texas.

The UHP water cutter process was used at these sites to restore texture to flushed pavement surfaces and to correct other pavement problems. The study included follow-on monitoring of the treatment sites at six-month intervals for an 18-month period after treatment in order to evaluate the longevity, or durability, of the initial UHP water cutter treatment results. This study represents the first large-scale application of UHP water cutting for treatment of flushed seal coats in the United States.

Two types of tests, the circular track meter and the sand patch test, were used to determine the average pavement surface texture before and after the treatment. In addition, the wet-weather skid resistance was measured using both the TxDOT skid truck and the dynamic friction test. Analyses of these key variables form the basis for the conclusions about UHP water cutter treatment effectiveness, durability, and production considerations summarized in this document.

6.2 Conclusions

TxDOT's evaluation of UHP water cutting as a pavement preservation strategy for Texas roads focused on answering three questions. These questions and their answers are as follows.

- **Does it work?** This question was evaluated in terms of treatment effectiveness, expressed as the percentage increase in pavement texture and friction values achieved as a result of UHP water cutting. While effectiveness varied depending on the site, the average increase in pavement texture was about 200 percent, and the average increase in friction was about 135 percent. On this basis, the UHP water cutter treatment does improve pavement texture and friction.
- **Does it last?** This question was evaluated in terms of the survivability and life expectancy of pavement surface texture and friction values achieved at treatment. Relative to survivability, pavement texture and friction values upon completion of monitoring (12 months to 18 months following UHP treatment) were at or above the *desirable* threshold for seven of 13 sites. Pavement texture and friction values were at or above the *maintenance* threshold for 12 of 13 sites. Relative to life expectancy, predictive decay models indicate that the improvement in pavement texture and friction achieved by UHP water cutting are predicted to last one or more years at 90 percent of the test sites. For 40 percent of the test sites, the treatment may last four or more years.
- **What is the cost?** This question was evaluated based on measured production rates and comparison of the cost of UHP water cutting versus the cost of TxDOT maintenance functions traditionally used to treat flushed pavements, mainly placement

of a strip or spot seal. Under average production conditions, UHP water cutting is $1.05/SY less expensive than the Texas statewide average for strip or spot sealing – a cost savings of 41 percent. Compared to other TxDOT maintenance functions traditionally used to treat flushing, the cost savings for UHP water cutting ranges from 25 to 77 percent.

Overall, implementation research study 5-5230-01 offers a positive view about UHP water cutting as a roadway maintenance tool for Texas roads. Treatment performance at individual sites will vary depending on project-specific details.

Beyond this basic evaluation, two potential business observations deserve mention. One is that treatment of flushed pavement surfaces by means of UHP water cutting represents a new, untapped market for existing hydrodemolition contractors. A second observation is that the adaptation of UHP water cutter equipment from heavy-duty concrete pavement structures to much lighter-duty seal-coat roadway applications presents many opportunities for process optimization, technology transfer, and innovation.

6.3 Implementation Considerations

As established in TxDOT project 0-5230, flushed asphalt pavement, in contrast to bleeding pavement, is typically not a maintenance problem that must be addressed immediately. Maintenance forces have employed a variety of methods to treat flushed asphalt pavements. The basic approaches are to retexture the existing flushed pavement surface, or to add a new textured surface over the flushed pavement. The method chosen often depends upon economics as well as the availability of materials, manpower and equipment at the time of treatment.

UHP water cutting for treatment of flushed pavement surfaces falls within the category of retexturing pavement preservation strategies. Therefore, UHP water cutting can be considered for treatment of flushed roads at any project site where retexturing makes sense. This is the most basic consideration when deciding about UHP water cutting.

UHP water cutting will not correct rutting in the wheel paths. Approaches that add material to the roadway surface, such as placing a blade level-up, will be necessary in such cases. However, in cases where wheel paths are both flushed and exhibit rutting, UHP water cutting might be useful as part of a combined treatment strategy. Here, UHP water cutting can be used to remove excess surface asphalt from the wheel paths, and this can be followed by placement of the blade level-up. This two-step treatment strategy may help prevent rapid recurrence of flushing through the new seal.

Many factors influence the effectiveness, survivability, life expectancy, production rate, and cost of UHP water cutting treatment. Therefore it is difficult to give a simple “yes” or “no” answer to the question of whether to use UHP water cutting for a particular road. The fact is, this TxDOT implementation research study effectively applied UHP water cutting to many kinds of roads under many different types of traffic and environmental conditions.

In some cases the treatment effectiveness was better, or the treatment lasted longer, or was less expensive. But in other cases, for example, retexturing a very heavily flushed pavement surface, UHP water cutting was the only viable treatment strategy short of rebuilding the road. In such cases, the risk reduction and logistical benefits of achieving immediate improvement in texture and friction through UHP water cutting, even for a few months and at greater than average unit cost, might be viewed as a highly beneficial outcome. For this reason, notwithstanding the factors that influence performance of the UHP water cutting treatment for good or ill, it is appropriate to leave the ultimate decision about whether to use UHP water cutting for a particular application to the judgment of the roadway maintenance professional.

CHAPTER 7. RECOMMENDATIONS AND RESOURCES

7.1 Recommendations

Based on the findings of this research project, the researchers recommend that UHP water cutting be implemented as a pavement preservation tool for treatment of flushed seal-coat surfaced roads in Texas.

No hard and fast rules exist to define which roadway projects should be selected for UHP water cutter treatment. As has been noted, the primary consideration is whether the road surface can be improved through retexturing. If so, the road is probably a candidate for UHP water cutting. After that, questions about project selection focus on the challenges associated with achieving effective treatment, followed by the level of production (which directly relates to cost), followed by the durability of the treatment.

Evaluation of the UHP water cutting process indicates that with proper adjustment to the cutting head, most any road surface can be retextured, ranging from those with very light flushing only in the wheel paths, to those which are heavily flushed across the entire lane. The details associated with treatment effectiveness will typically be established through using the pre-treatment trial area.

Relative to production, we have noted that, as with any roadway construction project, the size and scope of the project will influence the production rate. In the case of UHP water cutting, other variables also come into play. These include the type of binder, level of flushing, pavement temperature, availability of water, waste removal and disposal, and more.

Relative to durability, the data presented herein suggest that the retexturing associated with UHP treatment will usually, but not always, last at least one year. In some cases the retexturing will last much longer. Traffic volume and the percentage of trucks are two key variables that influence the durability of the treatment.

7.2 Resources

The specifications presented in the appendix of this report are intended to facilitate contracting for UHP water cutter work so TxDOT maintenance professionals can try out the UHP process, and thus gain their own experience and insight. Especially in the early attempts, it will be beneficial to retain good records for each project so that all lessons learned, including knowledge about how to better utilize the UHP water cutter process, can be shared statewide.

The TxDOT publication, “Guidelines for Using Ultra High Pressure Water Cutting to Remove Excess Asphalt” (Lawson and Senadheera 2012) presents guidelines for implementing the ultra high pressure water cutter as a roadway maintenance tool relative to removal of excess surface asphalt such as exists for flushed asphalt pavements. The following topics are covered:

- An introduction to the ultra high pressure water cutter
- A description of the ultra high pressure water cutting process

- Maintenance applications for ultra high pressure water cutting
- TxDOT’s evaluation of ultra high pressure water cutting in terms of effectiveness, durability, production and cost
- Guidance on selection of candidate projects for ultra high pressure water cutting treatment
- Specifications for ultra high pressure water cutting

Expressed within the broader context of roadway maintenance solutions, the information about ultra high pressure water cutting presented in the guidance document will help TxDOT maintenance professionals address the problem of flushed pavements on Texas roadways in order to better provide safe and reliable transportation solutions for Texas.

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APPENDIX A

SITE BRY 1

Brazos COUNTY

Bryan DISTRICT

Site Description

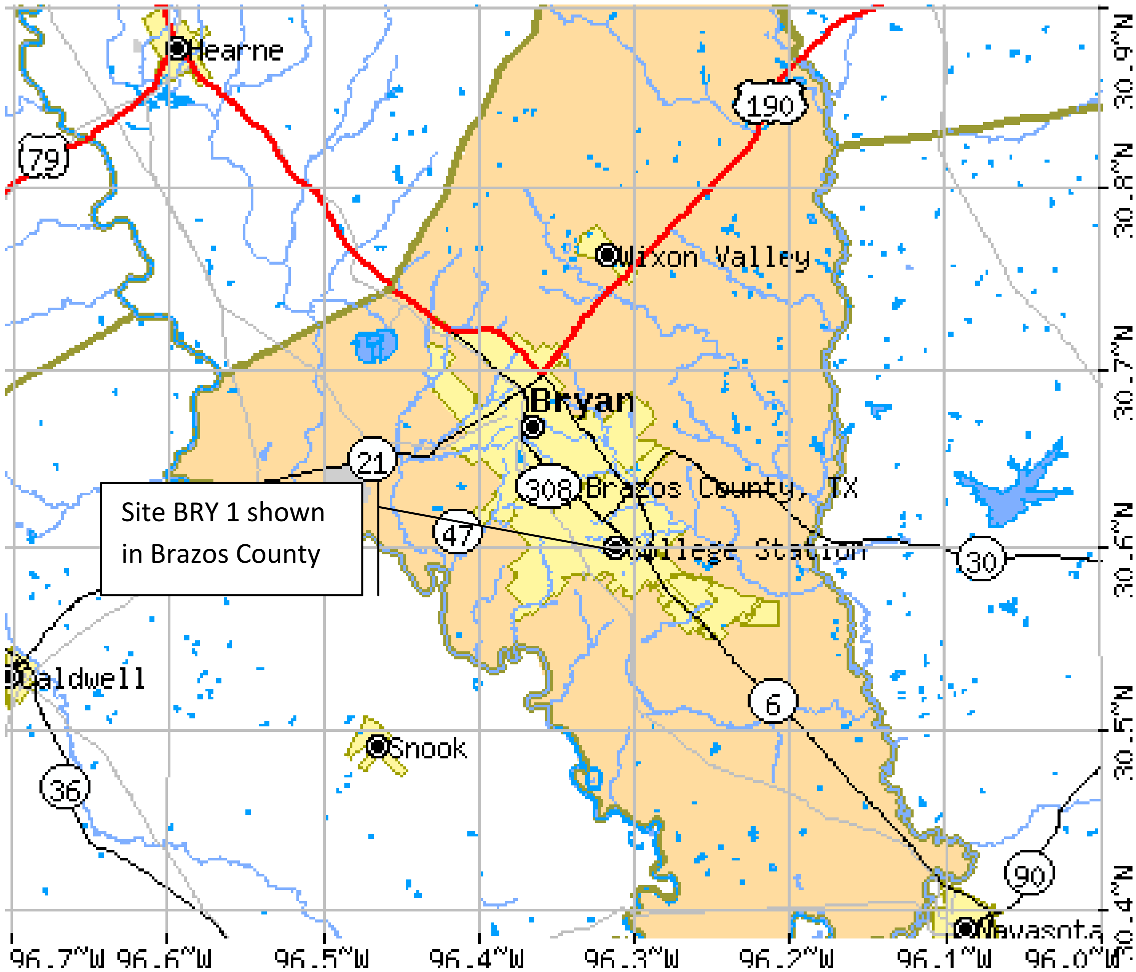
Project Information			
District: Bryan	Test Site: BRY 1	County: Brazos	Road: FM 2347 WB (George Bush Dr)
ADT:	Truck Traffic:	Year Built:	Last Maintained: 2005
Roadway Description Binder: AC 20-5TR Aggregate: PB GR 3S			

Research Test Summary		
Test Location: Wellborn Rd to Olson Blvd	Closest Texas Reference Marker:	
Test Point GPS Coordinates	N	W
TP1	30°35.099'	096°29.894'
TP2	30°35.180'	096°29.986'
TP3	30°35.269'	096°30.098'

Ultra High Pressure Water Cutter Treatment Summary		
Date Treated 1/31/11	Start Time 7:00	End Time 5: 15
Summary Description of Treatment Activity BRY Site 1 was a demonstration or test site that removed asphalt spillage from concrete roadway therefore the typical asphalt flushing was not present This appendix contains a report that ineptly summarizes the events at BRY Site 1.		
Comments		

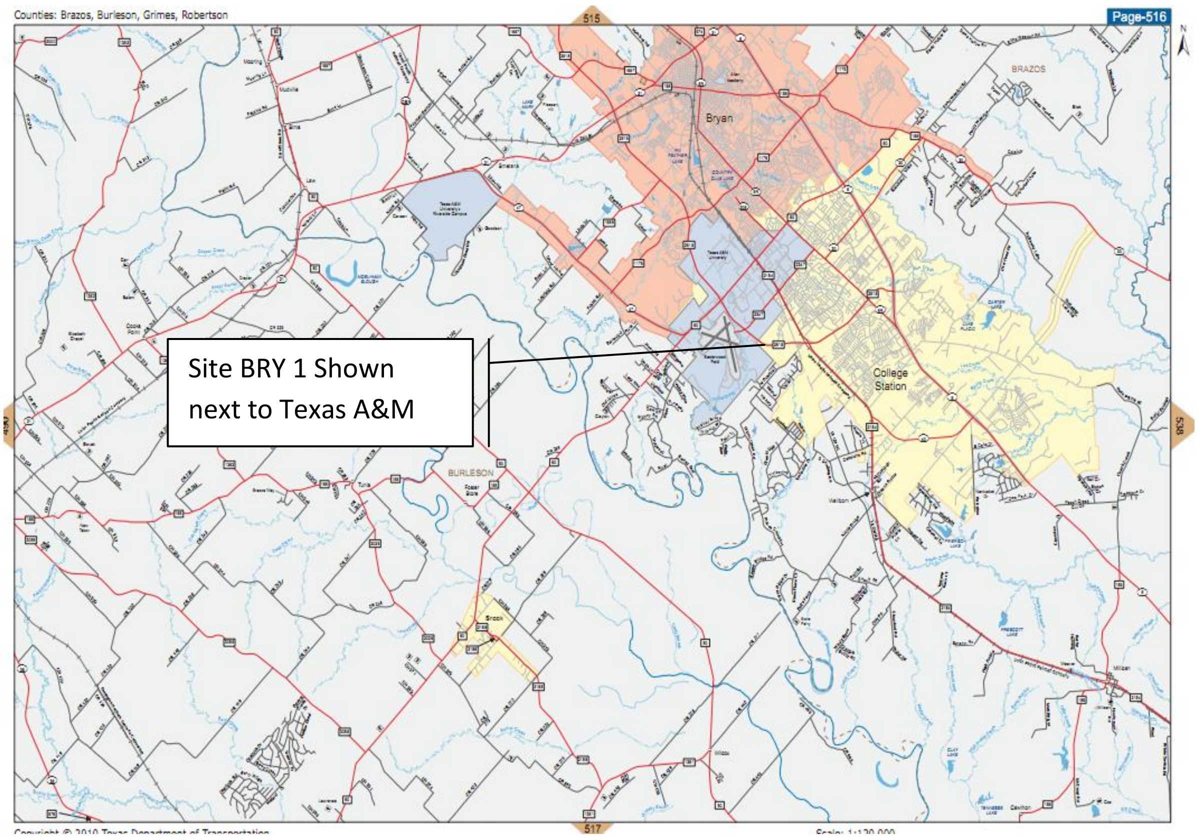
Follow-On Testing Summary	
Date: 7/18/11	Comments: No follow-up monitoring was performed however concrete section was observed.
Date: 1/10/12	Comments: No follow-up monitoring was performed however concrete section was observed.
Date 7/9/12	Comments: No follow-up monitoring was performed however concrete section was observed.

Site Vicinity Map



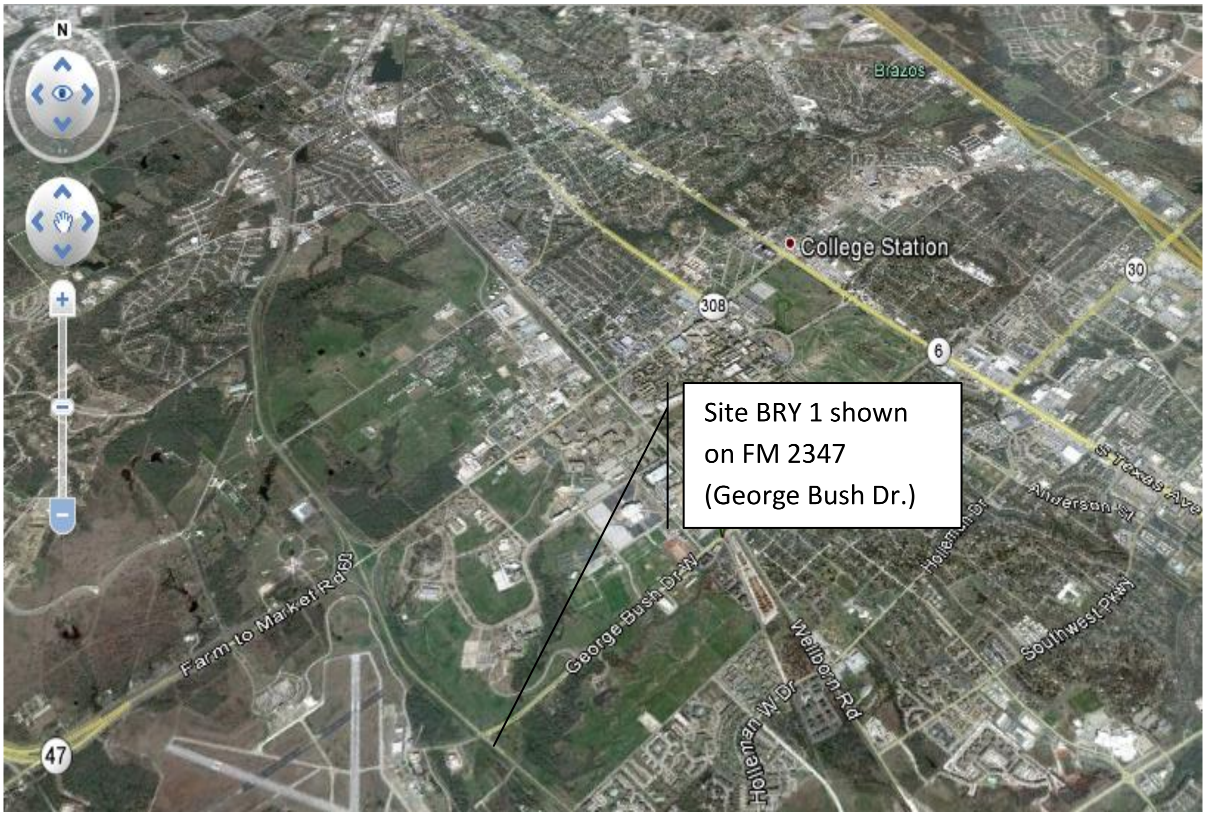
Click here to enter text.

Site Location Map



http://www.txdot.gov/travel/county_grid_search.htm

Aerial Photograph



Google Inc. (2011). Google Earth (Version 6.1.0.5001)

Test Point Plan

Google Inc. (2011). Google Earth (Version 6.1.0.5001)

Weather Data

No weather station data collected due to site being a demonstration site

UHP Watercutter - Research Implementation Project
Bryan District Daily Field Report
Site 1 - Brazos County
FM 2347 (George Bush Drive) at FM 2818
January 31, 2011

Introduction

This report presents a summary of our first site visit in the Bryan (BRY) district on Monday, January 31, 2011. Site 1 is a concrete section which is located on FM 2347 (George Bush Drive) near the intersection of FM 2818 in College Station, Texas. The purpose of our visit was to evaluate the capabilities of the UHP watercutter for removal of tracked asphalt and pavement markings from a concrete pavement section.

Pre-Treatment Pavement Conditions

The subject pavement is constructed of jointed reinforced concrete with transverse tining and jointed pavement slab lengths of 16 feet. The treated area consists of a 13-foot wide by 184-foot long section of concrete pavement which is located in the outside lane of westbound traffic on George Bush Drive. The western end of the treated area terminates into the intersection with FM 2818. FM 2818 appears to be constructed of hot mix asphalt concrete (HMAC) with one or more seal coats. Flushing was moderate to severe near the interface with the subject concrete section.

Asphalt tracking primarily existed the wheel paths in the treatment area. The heaviest deposits of asphalt occurred near the intersection of FM 2818 where the pavement transition from asphalt to concrete occurs. The asphalt tracking was severe near the intersection, tapering off to nothing at the eastern end of the treatment area. The tracking in the inside wheel path appeared to be slightly heavier than in the outside wheel path. The heaviest deposits of asphalt were found to be approximately 7 mm thick.

Ms. Darlene Goehl, PE, Project Director, stated that the asphalt tracking occurred when construction material trucks were allowed to haul flexible base material and hot mix to a nearby construction site on the Texas A&M campus. The truck drivers were apparently allowed to utilize the outside westbound lane of George Bush Drive to transport their materials to the project site in an easterly direction (contrary to normal traffic flow). Thus, the loaded trucks turned off of FM 2818 onto the concrete section heading eastward toward the construction site.

Given the severity of tracking and thickness of asphalt deposits in the vicinity of the intersection, it is likely that the trucks were performing turning movements on an actively bleeding asphalt pavement during a period of hot weather. The combination of hot weather, bleeding asphalt, heavy truck loads and turning movements provided optimum conditions for tracking of asphalt onto the subject concrete section.

Project Personnel

The following personnel participated in the planning, treatment and testing of the first field test section (Site 1) in the Bryan District. Personnel from the Texas Transportation Institute (TTI) documented the field activities on video as part of a separate contract with TxDOT.

Texas Tech (TechMRT)

- Bill Lawson - Research Supervisor
- Sanjaya Senadheera - Associate Professor
- Michael Leaverton - Lead Research Associate
- Timothy Wood - Lead Research Associate
- Andrew Tubb - Research Assistant

Rampart Hydro Services

- Bob Beadling - Lead Technician
- Jim Windich - Assistant Technician

TxDOT - Bryan District (BRY)

- Darlene Goehl - Project Director and District Pavement/Materials Engineer
- Terry Paholek - Director of Operations (present for the watercutter speed trials at the district yard)

TxDOT - Maintenance Division (MNT)

- Neal Munn - Project Advisor
- Byron Hicks - Project Advisor

TxDOT - Brazos County Maintenance Section

- Norman Maurer - Event Manager
- Support personnel
- Contract traffic control crew

Texas Transportation Institute (TTI)

- David Dennis - Contract videographer for TxDOT \

Summary of Events

Morning Activities - The TechMRT team met in the motel lobby at 6:30am and loaded the testing equipment into the TechMRT van. A backup Dynamic Friction Tester (DFT) from Penn State University was loaded into the Research Supervisor's pickup.

The TechMRT team arrived at the Brazos County Maintenance Section at about 6:45am. We waited in the visitors parking area until the others arrived (the maintenance section office appeared to be uninhabited when we arrived).

Bob Beadling and Jim Windich of Rampart Hydro Services arrived at about 7:00am in their UHP Watercutter truck. Ms. Darlene Goehl, TxDOT Project Director arrived at about 7:15am along with the contract traffic control crew.

Ms. Goehl directed us to head back to the maintenance section yard so we could meet with the project team to discuss safety issues, become familiar with the watercutter and discuss the plans and procedures associated with our first test section.

Dr. Bill Lawson, Research Supervisor from Texas Tech (TechMRT) led the meeting for the project team. He started the meeting with introductions followed by an overview of the research implementation project, and more specifically, the plans for the first site in Brazos County.

Ms. Goehl introduced the team to Mr. Norman Maurer who served as the Event Manager for the Brazos County Maintenance Section. Mr. Maurer was in charge of coordinating the entire maintenance function (watercutting operation) in the field which included supervision and direction of the contract traffic control team and the support staff from the maintenance section.

The meeting continued with a safety briefing of the UHP watercutter by Mr. Bob Beadling (Lead Technician for Rampart). Mr. Beadling gave the team a general overview of components and functions of the watercutter truck with special emphasis on the safety aspects of the equipment and their operation.

Mr. Beadling suggested that all members of the project team stay as far away from the watercutter head as possible while in operation, and in particular, the vacuum hose/port that removes the post-treatment water (effluent) and solid particles from the pavement surface and transfers them to the effluent storage tank.

Mr. Beadling noted that articles of clothing have been "sucked up" into the vacuum hose/port in the past from those who have stood too closely to the vacuum port. He pointed out the location of the vacuum system cutoff lever (red in color) on the passenger side of the watercutter vehicle and stressed the need for ear protection and safety glasses for those who planned to be in the vicinity of the watercutter while in operation.

Ms. Goehl indicated that the following personal protection (safety) equipment is required for all members of the team who will be working on the roadway:

- Hardhat
- Safety vest
- Safety glasses
- Steel-toed boots
- Ear protection

Ms. Goehl also indicated that the UHP water cutter team could proceed to a previously unannounced asphalt test section on State Highway 21 (SH 21) in Brazos County in the afternoon if time allows. This site would give the team an opportunity to test out the UHP watercutter on a flushed asphalt section and allow the TechMRT team to run various tests on the pavement surface in advance of our first official asphalt test section.

Dr. Lawson concluded the meeting by outlining the planned sequence of events that would be unfolding throughout the day at the test site. Questions were answered and the meeting was closed by Dr. Lawson at about 8:15am.

Mr. Norman Maurer asked the contract traffic control crew to proceed to the site at that time to begin setting up the traffic control in the appropriate lane and locations. It was agreed that the traffic control crew would setup a full lane closure with a crash attenuator. The lane associated with the treatment area was closed until after 8:30am to minimize disruption to the morning commuters.

The maintenance section crew and the Rampart crew began the process of filling the water storage tank on the water cutter rig in the maintenance yard. The maintenance crew pumped water from a 1000-gallon trailer-mounted water storage tank into Rampart's 4000-gallon water storage tank on the watercutter truck. TxDOT's trailer-mounted tank was being filled from a gravity water line (source) as Rampart's truck was being filled.

The TechMRT team and the Rampart crew departed for the test site at about 9:30am after filling the water storage tank on the Rampart truck.

When the UHP water cutter team arrived at the test site at about 9:55am the contract traffic control crew had substantially completed the lane closure in preparation for our arrival. The maintenance crew recommended the most appropriate positions for the research team vehicle (TechMRT van) and the Rampart truck within the lane closure and directed all other vehicles to park off-road at a nearby staging area on the south side of George Bush Drive.

TechMRT personnel marked out the location of the treatment area and performed some pre-treatment testing over the inside wheel path (on the tracked asphalt) and in-between the wheel paths where no tracked asphalt was present. Testing was limited to the Circular Texture Meter (CTM) which measures the pavement texture on the transversely-tined concrete section.

The Rampart crew spent a significant block of time preparing the UHP watercutter for the initial treatment on the concrete pavement. Preparations included warming up the pump, reconfiguring the nozzles on the spray bar and testing the pump with the spray bar head/housing positioned transverse (perpendicular) to the plane of the pavement surface.

Treatment of the test section began at about 11:00am. The watercutter truck was positioned on the subject concrete test section so that the morning treatment would occur from east to west toward the intersection with FM 2818. The initial treatment sequence followed the normal (westbound) flow of traffic in the outside lane of George Bush Drive.

Given the position of the watercutter treatment head on the left front (driver's side) of the treatment vehicle, the initial pass occurred along the southern edge of the outside lane. Subsequent passes were made by backing the truck to the starting position of the treatment area (at the east end), shifting to the north, and proceeding from east to west.

The watercutter was able to remove most of the tracked asphalt in the inside wheel path after two to five passes. The heavier (thicker) deposits of asphalt required three to four passes during the morning treatment. Lighter deposits required one to two passes.

TechMRT personnel measured the thickness of the heaviest asphalt deposits to be approximately 7 mm. The speed of the watercutter passes during the morning treatment averaged approximately 0.5 mph based on time-distance measurements.

Bob Beadling with Rampart indicated that the ultra high pressure (UHP) pump was not operating at its peak performance during the initial portion of the treatment process. Initial treatment pressures during the morning ranged from 27 to 33 kips per square inch (ksi). Nozzle adjustments were implemented to improve pump performance, and achievedtreatment pressures on the order of 32 to 34 ksi, which is typical.

Mr. Beadling with Rampart indicated that he was surprised at how strongly the asphalt had adhered to the concrete pavement.

Significant water leaks were observed below the rear axle of the watercutter truck as the final passes were made during the morning treatment. The Rampart crew determined that the effluent tank was full and was causing the leakage.

As the watercutter continued to make subsequent treatment passes across the lane (proceeding in a northerly direction across the lane), the last pass in the lane was made when the wheels on the rider's side of the truck reach the curb and gutter on the northern side of the lane.

The Rampart crew finished treating the first half of the lane at about 12:45pm. They left the site at that time with Mr. Norman Maurer (Event Manager for Brazos County MS) to dispose of the effluent (waste water) and the solid asphalt particles into a bermed containment area along SH 47.

Afternoon Activities - The Rampart crew returned to the site at about 1:40pm after disposing of the waste products into a bermed containment area.

The watercutter had to be repositioned in the lane (turned around) and the traffic control adjusted to facilitate completion of the treatment on the concrete test section. The final passes were made from west to east (contrary to normal traffic flow) until the full lane was treated.

The pavement surface exhibited asphalt tracking in the outside wheel path and a variety of white pavement markings in the center and northern portion of the outside lane during the afternoon treatment.

The watercutter generally performed more effectively during the afternoon treatment. Water pump performance was more consistent, maintaining typical pressures in the range of 32 to 34 ksi. Watercutter speed ranged from 0.25 to 0.50 mph during the afternoon event based on time-distance measurements. The watercutter was typically able to remove all of a white pavement marking in one or two passes. The thicker deposits of asphalt in the outside wheel path were completely removed in two or three passes.

The UHP watercutter treated the northern portion of the outside lane in about 40 minutes. The Rampart crew departed the test site at about 2:20pm and disposed of their effluent (waste water) and solid asphalt particles into a bermed containment area along SH 47. The watercutter crew subsequently proceeded to the Bryan District headquarters to perform speed trials on a section of asphaltic concrete pavement.

Some problems were observed on the concrete pavement section during and after the watercutter treatment. Problems included joint seal erosion and some minor spalling. The UHP treatment process fully eroded/dislodged most of the rubber joint sealant from crack control joints. The UHP treatment process also eroded epoxy filler used used seal pavement cuts for vehicle sensors, but to a lesser degree.

When the UHP treatment process encountered a weak pavement area, it tended to exacerbate the problem. That is, the treatment process broke up and spalled concrete in what were formerly cracked areas near pavement joints. Loose stone or concrete pieces would be dislodged.

TechMRT personnel performed post-treatment testing on the inside wheel path and in-between the wheel paths of the westbound lane. Testing was limited to the CTM.

TechMRT researchers took several digital photographs and videos throughout the day to document the field activities associated with the first test section. Weather data for the day was obtained from Easterwood Airport which is located across the street (FM 2818) from the test site in College Station, Texas (Brazos County).

Ms. Darlene Goehl (Project Director) indicated that it was too late in the day to proceed to the "unofficial" asphalt test section on State Highway 21 (SH 21) in Brazos County. TechMRT personnel left the field test site at about 3:00pm.

Watercutter Speed Trials - TechMRT researchers arrived at the TxDOT Bryan District office at about 3:25pm to perform some watercutter speed trials on a section of hot mix asphalt concrete pavement in the equipment yard of the district facility.

The purpose of this impromptu study was to get a better feel for the range of speeds that might be most effective for treating a flushed asphalt pavement. The "test section" to be used for our study consisted of a highly oxidized, brittle, asphaltic concrete pavement with extensive alligator cracking throughout most of the test section.

The properties of the subject asphalt test section were clearly quite different from the properties that one would normally encounter on a flushed asphalt pavement. However, the area was appropriate for speed studies in order to gain some useful information that would be helpful on future asphalt test sections.

TechMRT researchers marked out treatment zones of known distances on the subject asphalt test section. One of our researchers rode in the passenger seat of the Rampart watercutter truck and timed how long it took to treat a section of pavement between a set of marks (a known distance) at an established velocity. Rampart treated the pavement at a variety of speeds and recorded the density of the coverage of the water jets on a given section (area) of pavement.

The results of the testing are presented in the following table:

Watercutter Treatment Speed (mph)	Water Jet Coverage (Rating)
1.3 mph	Good
1.5 mph	Good
2.2 mph	Good
2.3 mph	Good
2.5 mph	Good
3.3 mph	Fair to Good
4.5 mph	Poor (too fast)
6.7 mph	Poor (too fast)

Based on the results of this study, it appears that a good range of speed for the UHP watercutter would be 2 to 4 mph. Treatment at rates higher than 4mph would not be effective. Treatment at slower rates will tend to remove more asphalt.

Mr. Bob Beadling with Rampart indicated that the results that one may obtain with a watercutting treatment is a complex interaction between the following:

- Number of nozzles
- Nozzle types
- Truck speed
- Other hydraulics

Bob indicated that they elected to use 4 nozzles on each side of the spray bar (8 total) to remove the tracked asphalt and pavement markings on the concrete test section earlier today (the same configuration was used on the asphalt pavement time trials).

He also indicated that they could increase the number of nozzles on each side of the spray bar to obtain better water jet coverage per unit area of pavement. This might allow for more rapid treatment of the pavement surface (possibly even faster than 4mph) and thus a more cost-effective treatment process for the owner. The TechMRT team agreed that this would be good idea and asked Rampart to make the change before we treat our first official asphalt test section.

Bob indicated that it would take about 15 minutes to reconfigure the nozzles on the spray bar. He provided a copy his watercutter nozzle configuration plan which shows the number and types of nozzles on the spray bar for various watercutter applications.

Ms. Darlene Goehl (Project Director) and Mr. Terry Paholek (Bryan District Director of Operations) joined us in the equipment yard of the district facility as the research team completed our discussions about the watercutter time trials and the nozzle configurations. Dr. Lawson (Research Supervisor) recapped the results of the day for Ms. Goehl and Mr. Paholek (Project Director for the original BAP research project).

Closing Remarks - Ms. Goehl indicated that we will not be working on the roadway tomorrow (Tuesday, February 1, 2011) given the forecasted very high chance of rain in the area. We will resume operations on Wednesday morning (February 2nd) at 7:00am in the Burleson County Maintenance Section. Upon completion of the meeting, the project team will proceed to the second site (an asphalt test section) in the Bryan District on FM 50 (from SH 21 East to FM 60 East).

She also indicated that we would *probably* not be working on Friday, February 4th given the fact that snow and very cold temperatures are expected in the area. The TechMRT research team left the Bryan District headquarters at about 5:15pm.

The TechMRT team met in Dr. Bill Lawson's motel room at 6:00pm to discuss the events of the day and to go over each component of the report (in detail) for the first site in the Bryan District. Dr. Lawson delegated responsibilities for the report to each of the team members and closed the meeting at 7:00pm.

Site Photographs

(a)

Figure XX. BRY1 Pictures (a) highway and location; (b) roadway surface before treatment; (c) close-up spilt asphalt; (d) roadway surface after treatment; (e) close-up of flushed surface immediately after treatment; (f) close-up of surface at third follow-up ; (g) roadway surface at third follow-up

(b)

(c)

(d)

(e)

(f)

(g)

APPENDIX B

SITE BRY 2

Burleson COUNTY

Bryan DISTRICT

Site Description

Project Information			
District: Bryan	Test Site: BRY2	County: Burleson	Road: FM 50 NB
ADT: 1400	Truck Traffic: Low-Medium	Year Built:	Last Maintained: 2005

Roadway Description:
Aggregate Grade: Ty PB GR 3S
Aggregate Type: Limestone w/ Asphalt
Pit: Vulcan Uvalde
AQMP#:
CSJ: 0648-03-054
CCSJ: 0049-08-056
Binder: AC 20-5TR

Pavement abnormalities:
The pavement was moderately flushed along both wheel paths. The pavement slightly before TP2 and running into Zone 6 in the speed testing area showed evidence of strip seal repairs. This area was also moderately flushed.

Research Test Summary		
Test Location: FM 60 to SH 21	Closest Texas Reference Marker: 420	
Test Point GPS Coordinates	N	W
TP1	30°51.911'	096°42.154'
TP2	30°51.952'	096°42.269'
TP3	30°52.008'	096°42.374'

Ultra High Pressure Water Cutter Treatment Summary		
Date Treated 2/7/2011	Start Time 7:45 AM	End Time 4:20 PM

Summary Description of Treatment Activity

Personnel on site:
TechMRT: Andrew Tubb and Timothy Wood
Rampart: Bob Beadling and Jim Windich
TxDOT: James Robins, Neal Munn and Joe (Burleson Maintenance Office) Traffic Control

Rampart configuration: Rampart used a 28 jet nozzle configuration that they typically use for rubber removal from runways: from the outside they ran 3 0.014in. jets, 4 0.011in. jets and 7 0.009in. jets. They ran the hydraulic pressure consistently from 33000psi to 34000psi.

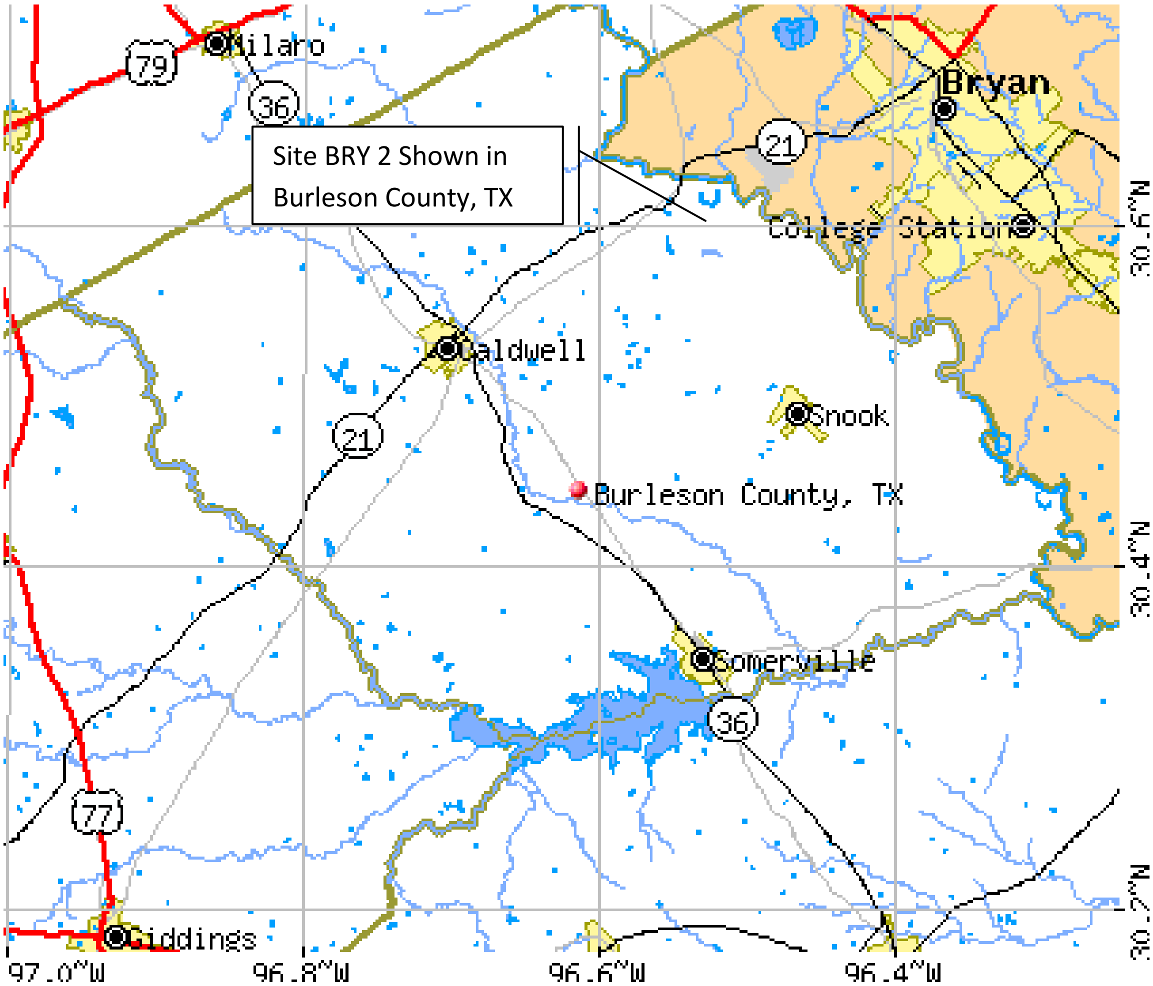
Work Activities:
TechMRT and Rampart participated in the morning meeting with TxDOT. TechMRT and the traffic control arrived at the site at 7:30AM. TechMRT set up the weather station near the start of the site at 7:45. DFT and SP testing at the TP took place from 8:00AM till 9:00AM. Rampart arrived at 8:50AM.

TechMRT and Rampart worked time trials from 9:30AM to 11:30AM. Efforts were made to find a reasonable way to control the rate. The Rampart speedometer system only provided data at single mile an hour increments and the calibration was suspect. The 16 speed test sections were essentially at differing rates rather than 4 rates. It was decided that any rate between 0.5mph and 1.5mph would

be appropriate. The truck rate was approximated by the Rampart driver (Jim), measured in 50ft test strip to be 0.7mph. The Rampart driver then set a block that limited the Rampart speed to 0.7mph. The production testing began at 12:00PM. The production testing was run at 0.7mph. After running the first pass (Pass 5) the Rampart truck had to empty their waste water. They left at approximately 12:20PM and returned at 1:20PM. Passes 4, 2 and 1 were completed from 1:20PM till 15:00PM at which point Rampart left the site to empty the truck and winterize it for the night. The TechMRT team ran the speed trial CTM from 12:20PM till 12:50PM. After completing the CTMs, TechMRT took a short lunch break. Along some of the sections there appeared to be a powdery black residue left on the road way. A conversation between TechMRT, Rampart and TxDOT's Neil Munn and James Robins failed to identify a probably cause. A pressure washer was used to remove the materials. The black powder was easily washed away. TxDOT has a broom truck on the site. They used the truck to attempt to remove some of the powder. Though it did remove a significant portion of the powder, it did not completely clean the surface. During CTM and latter DFT and SP testing, the wire brush and blower to remove more of the powder before testing. At 3:15PM TechMRT began the post treatment CTM, DFT and SP tests at TP1,2 and 3. These tests were only run in the wheel path. Testing was completed at 4:00PM. The vehicle was packed, including the weather station by 4:30. The TechMRT team returned to the hotel by way of the TxDOT Area office where the DFT water jugs were refilled. A teleconference was held from 8:00PM till 9:05PM between all members of the TechMRT team. The conversation discussed the day's work and importance of carefully collecting and recording all meaningful data.
Comments

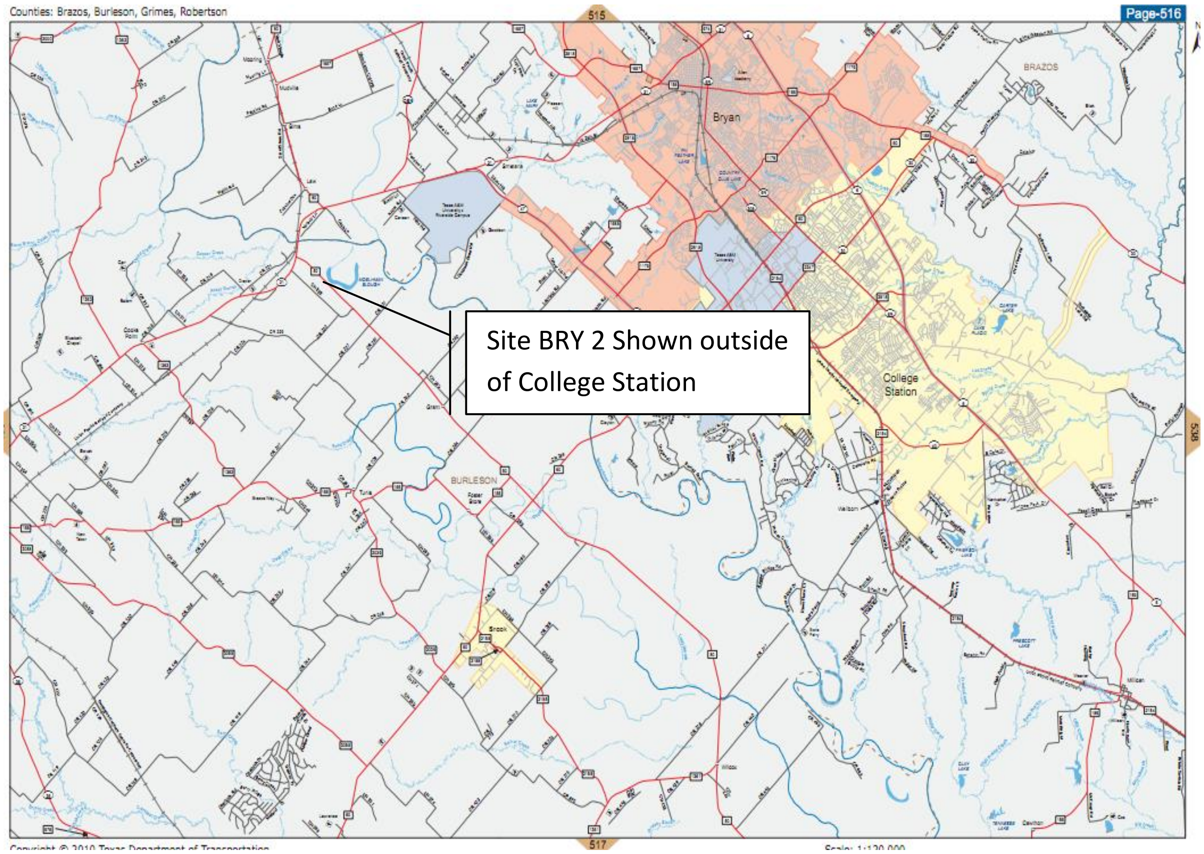
Follow-On Testing Summary	
Date: 7/18/11	Comments: Preformed follow –up monitoring successfully.
Date: 1/10/12	Comments: Preformed follow –up monitoring successfully.
Date 7/9/12	Comments: Preformed follow –up monitoring successfully.

Site Vicinity Map



http://www.city-data.com/

Site Location Map



http://www.txdot.gov/travel/county_grid_search.htm

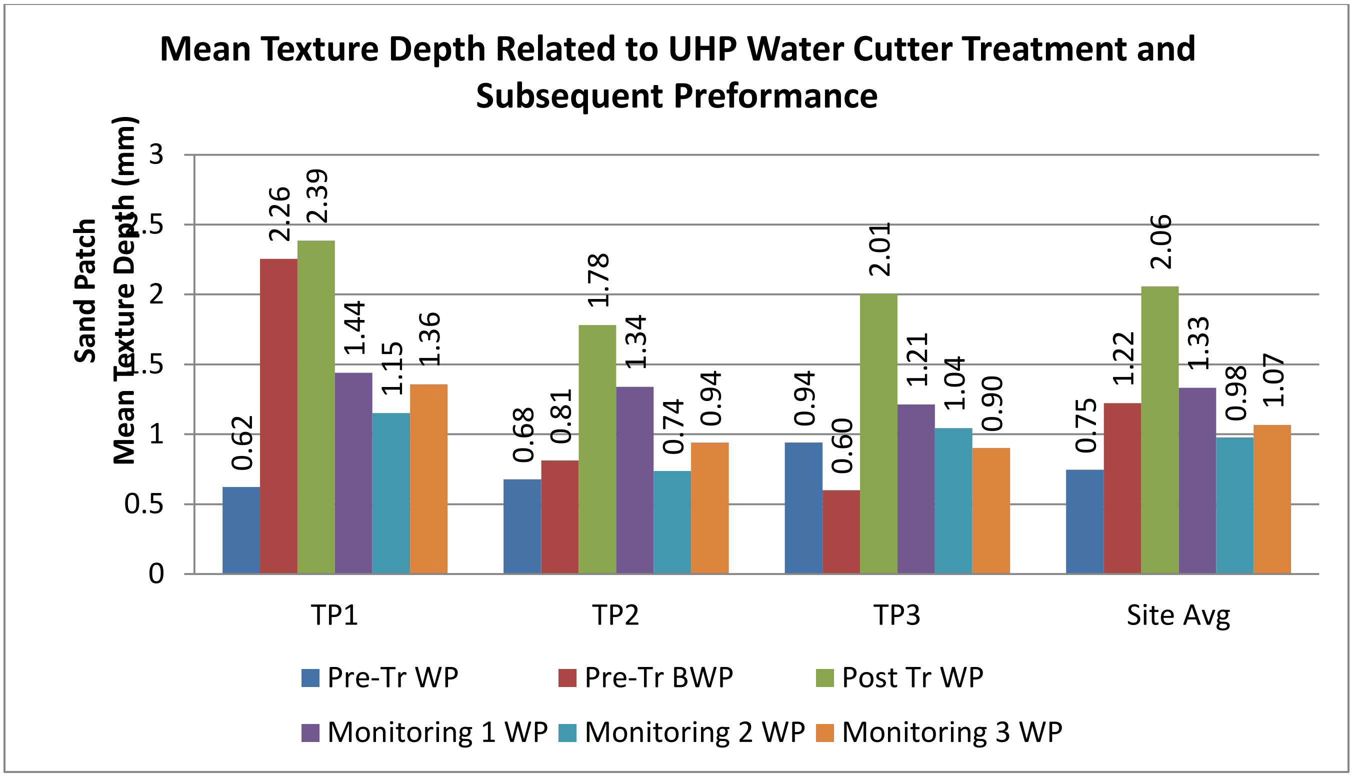
Aerial Photograph

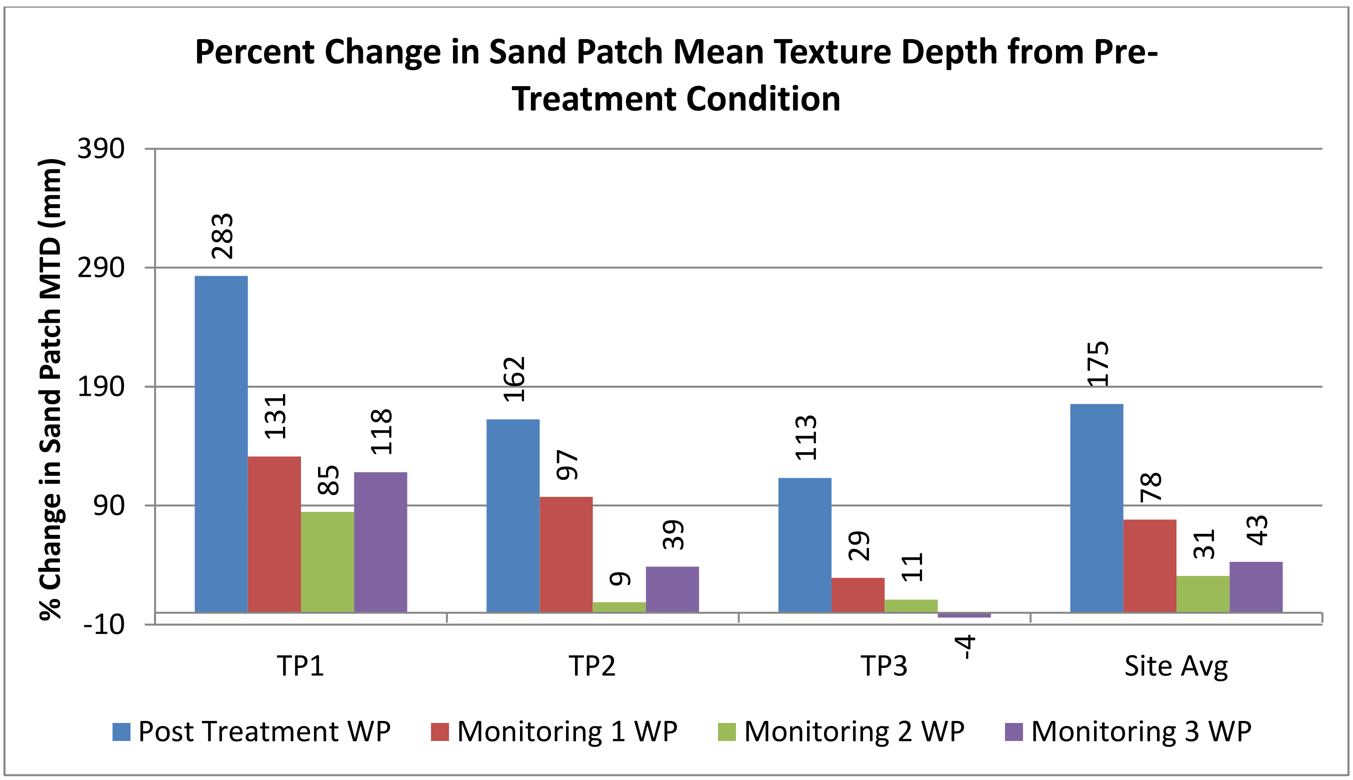
Google Inc. (2011). Google Earth (Version 6.1.0.5001)

Test Point Plan

Google Inc. (2011). Google Earth (Version 6.1.0.5001)

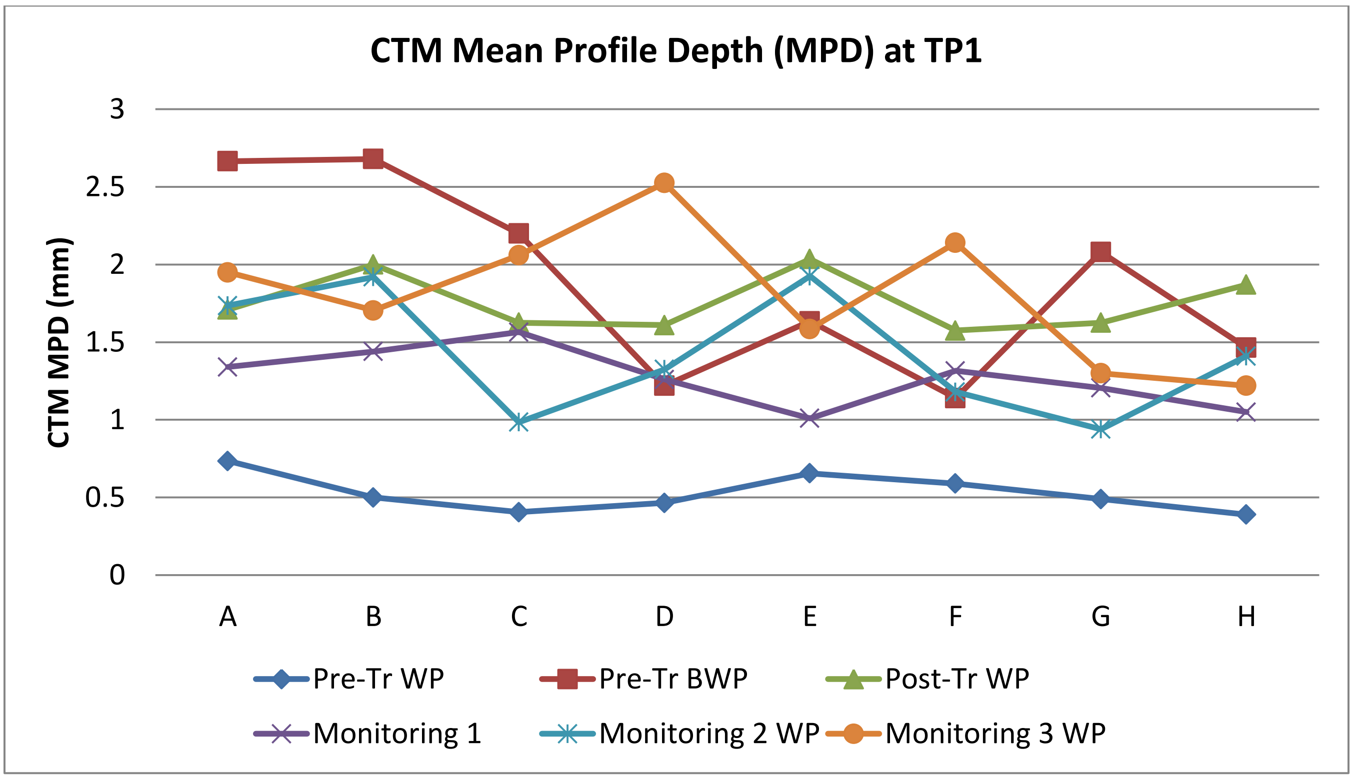
Sand Patch Data





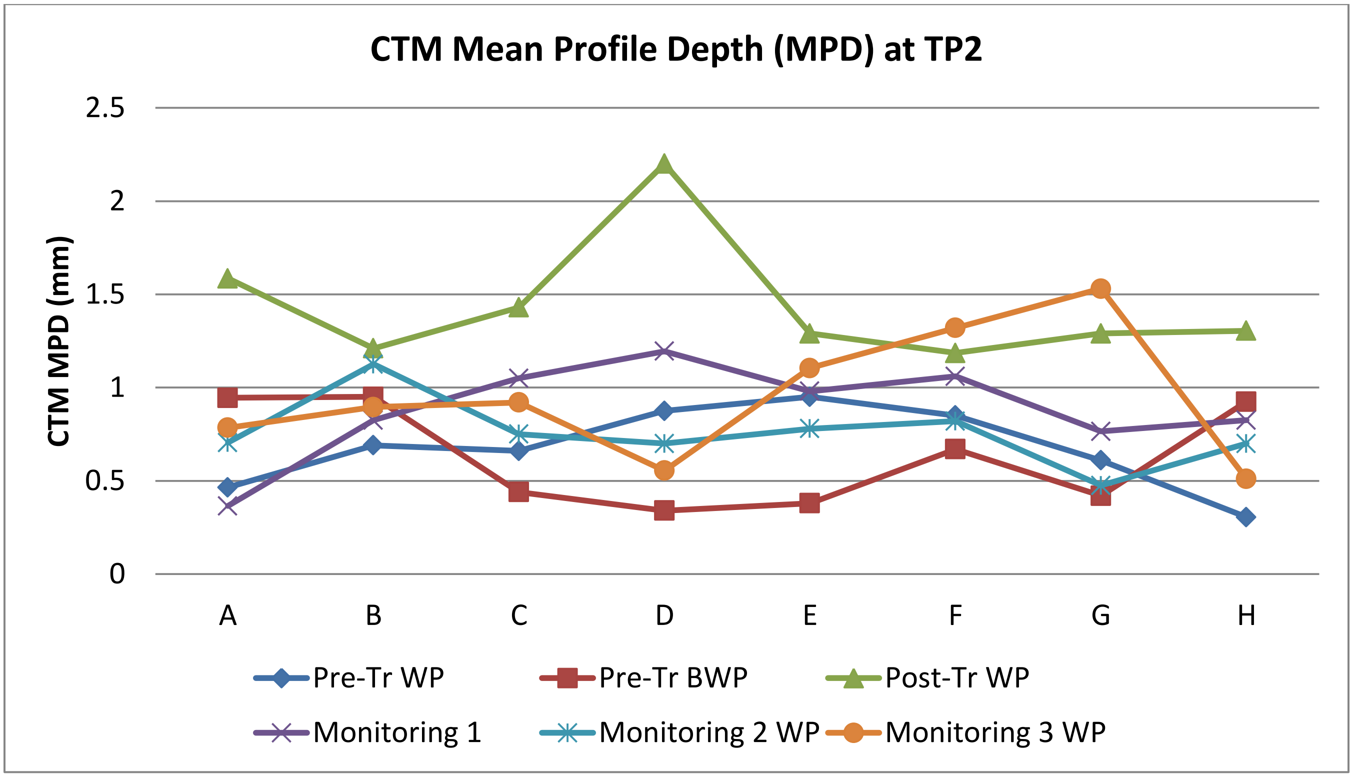
Circular Track Meter (CTM) Mean Profile Depth (in mm) at TP 1

	A	B	C	D	E	F	G	H
Pre-Tr WP	0.735	0.5	0.405	0.465	0.655	0.59	0.49	0.39
Pre-Tr BWP	2.665	2.68	2.2	1.22	1.635	1.14	2.08	1.465
Post-Tr	1.71	2	1.625	1.61	2.035	1.575	1.625	1.87
Monitoring 1	1.34	1.44	1.565	1.26	1.01	1.315	1.205	1.05
Monitoring 2	1.735	1.92	0.985	1.325	1.925	1.18	0.94	1.41
Monitoring 3	1.95	1.705	2.06	2.525	1.585	2.14	1.3	1.22



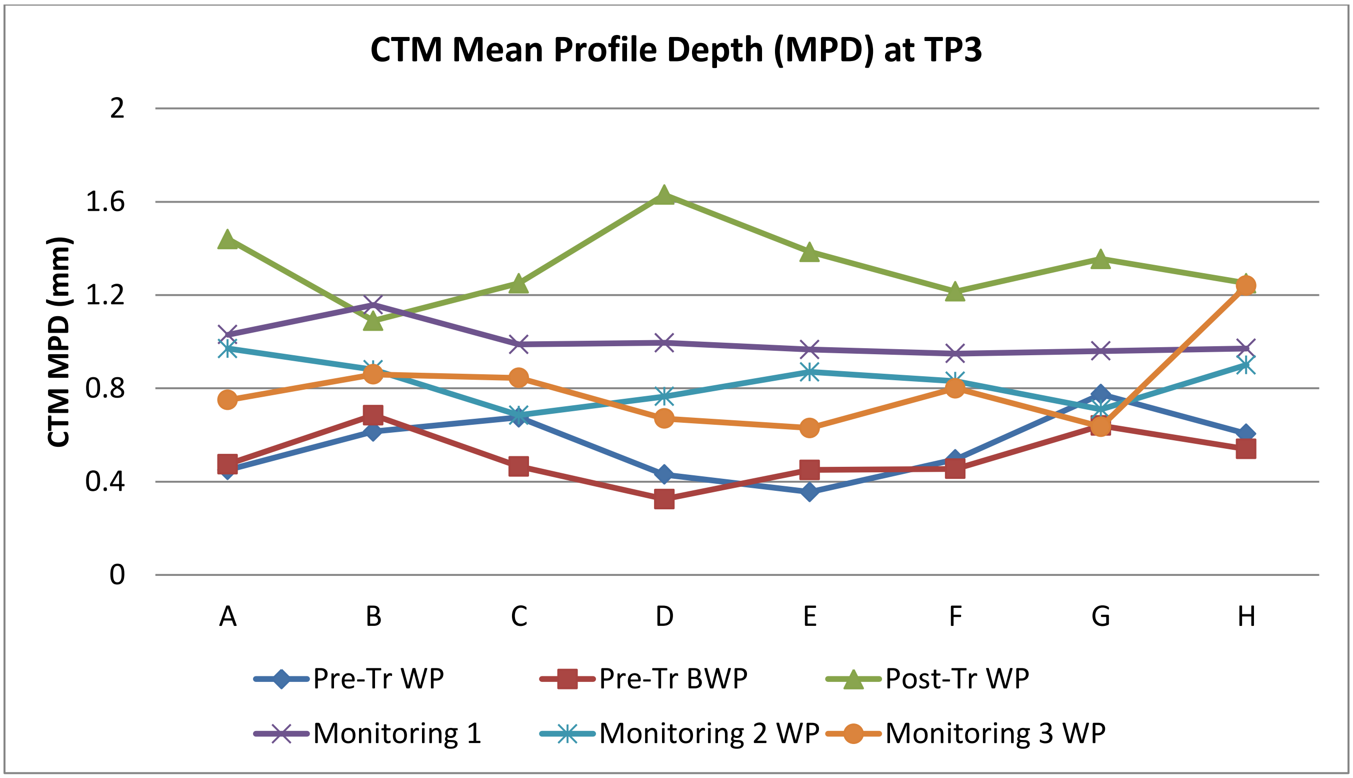
Circular Track Meter (CTM) Mean Profile Depth (in mm) at TP 2

	A	B	C	D	E	F	G	H
Pre-Tr WP	0.465	0.69	0.66	0.875	0.95	0.85	0.61	0.305
Pre-Tr BWP	0.945	0.95	0.44	0.34	0.38	0.67	0.42	0.925
Post-Tr	1.585	1.21	1.43	2.2	1.29	1.185	1.29	1.305
Monitoring 1	0.365	0.825	1.05	1.195	0.98	1.06	0.765	0.825
Monitoring 2	0.705	1.125	0.75	0.7	0.78	0.82	0.475	0.7
Monitoring 3	0.785	0.895	0.92	0.555	1.105	1.32	1.53	0.51

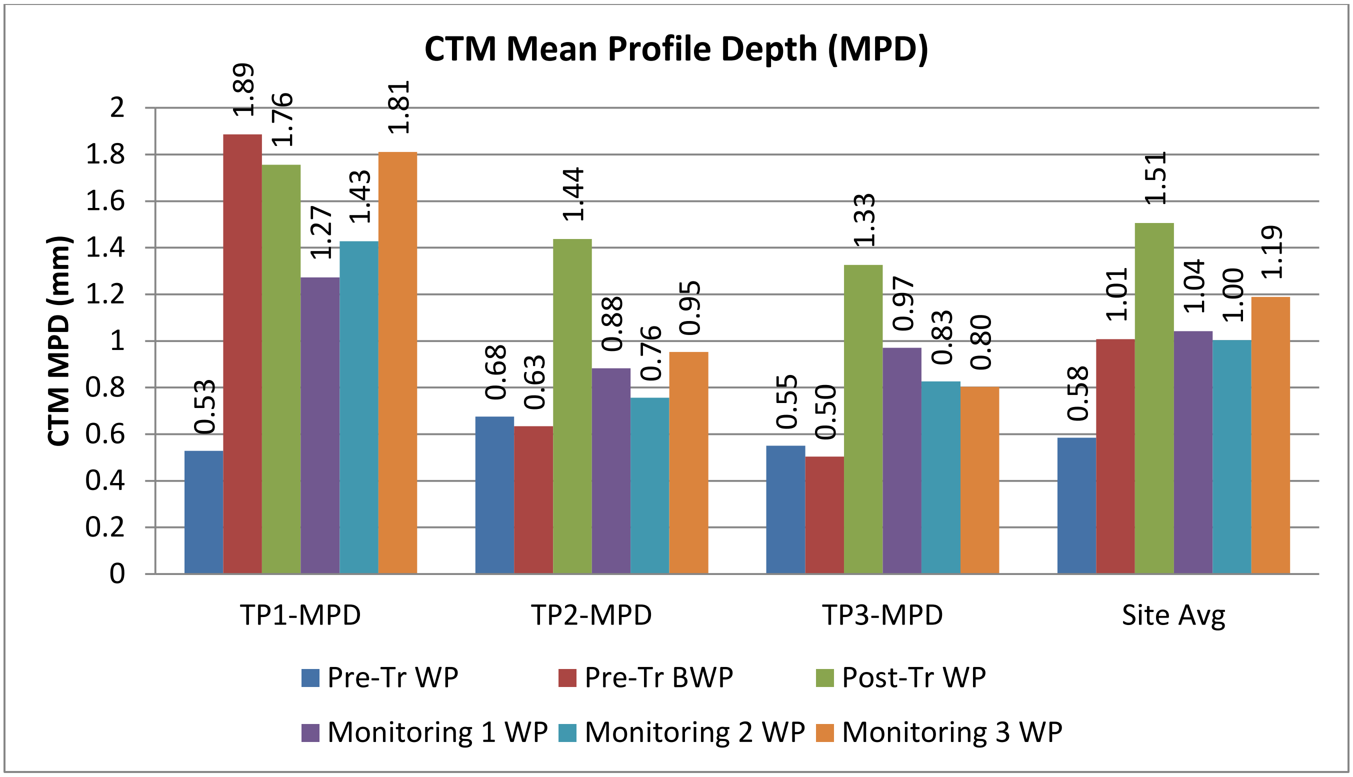


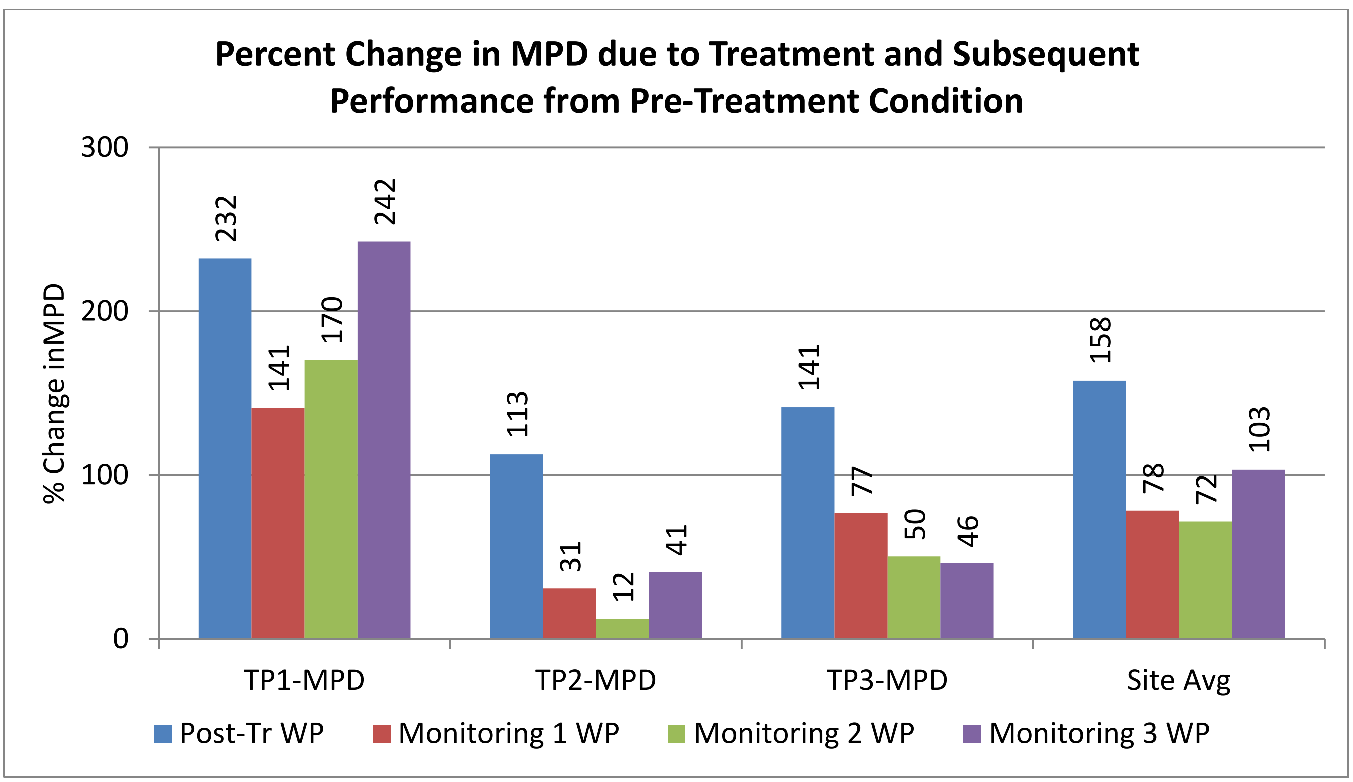
Circular Track Meter (CTM) Mean Profile Depth (in mm) at TP 3

	A	B	C	D	E	F	G	H
Pre-Tr WP	0.45	0.615	0.675	0.43	0.355	0.495	0.775	0.605
Pre-Tr BWP	0.475	0.685	0.465	0.325	0.45	0.455	0.64	0.54
Post-Tr	1.44	1.09	1.25	1.63	1.385	1.215	1.355	1.25
Monitoring 1	1.03	1.1575	0.988333	0.995	0.966	0.949167	0.96	0.97125
Monitoring 2	0.97	0.88	0.685	0.765	0.87	0.83	0.71	0.9
Monitoring 3	0.75	0.86	0.845	0.67	0.63	0.8	0.635	1.24

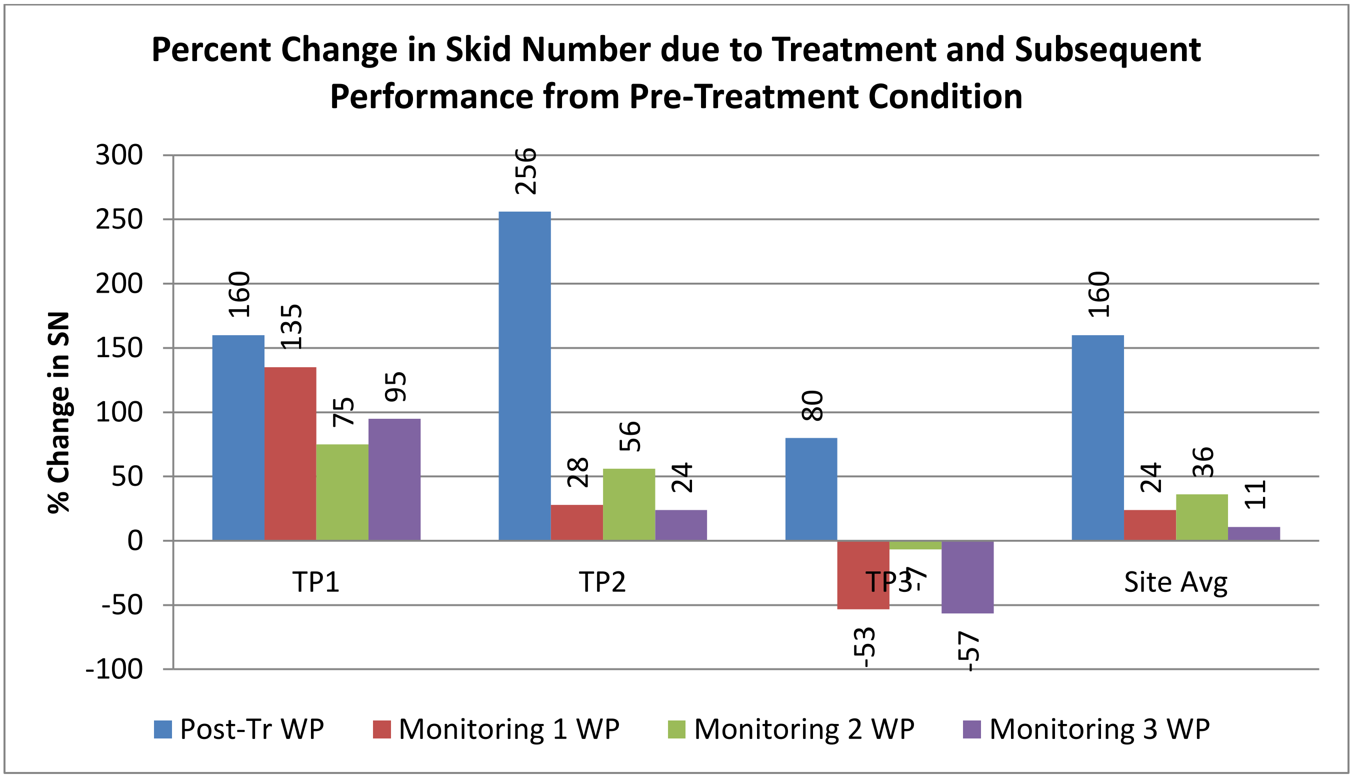


Circular Track Meter (CTM) MPD (mm)



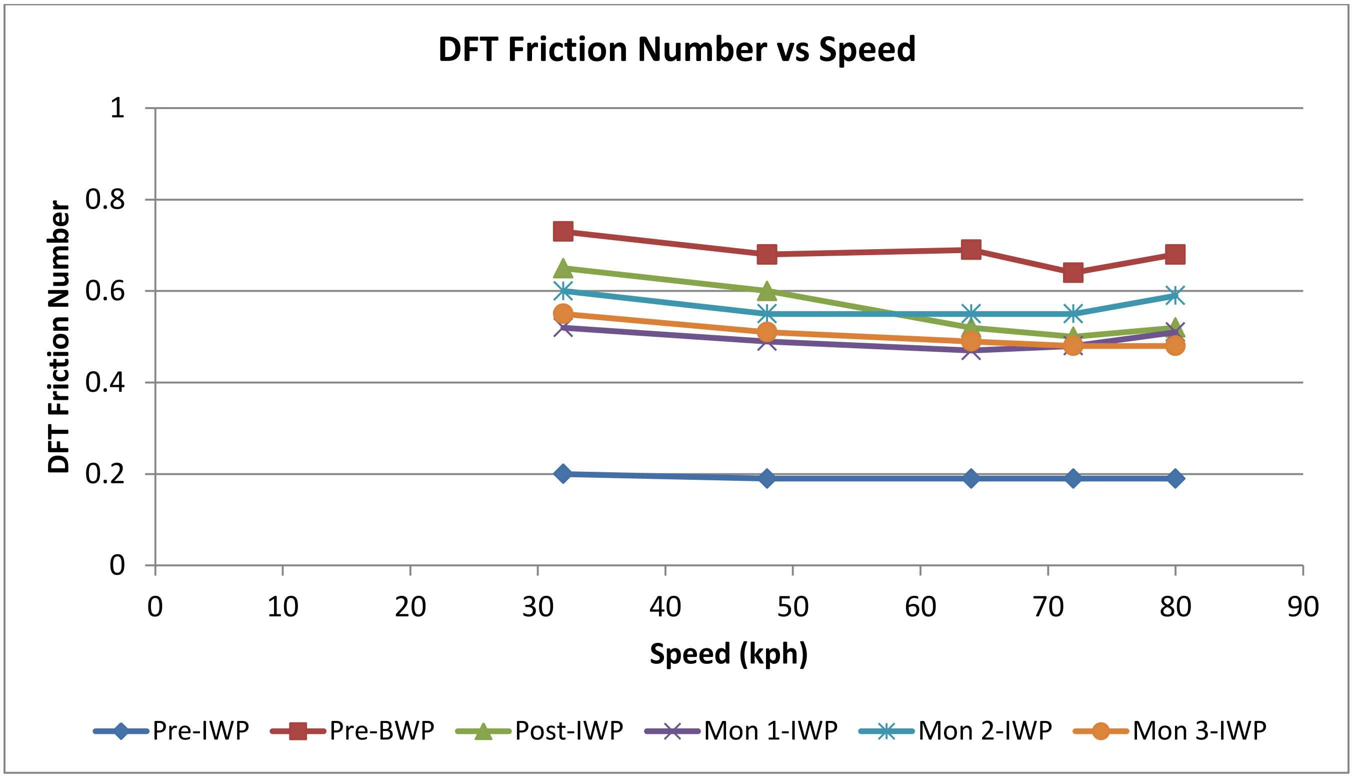


Skid Truck Data



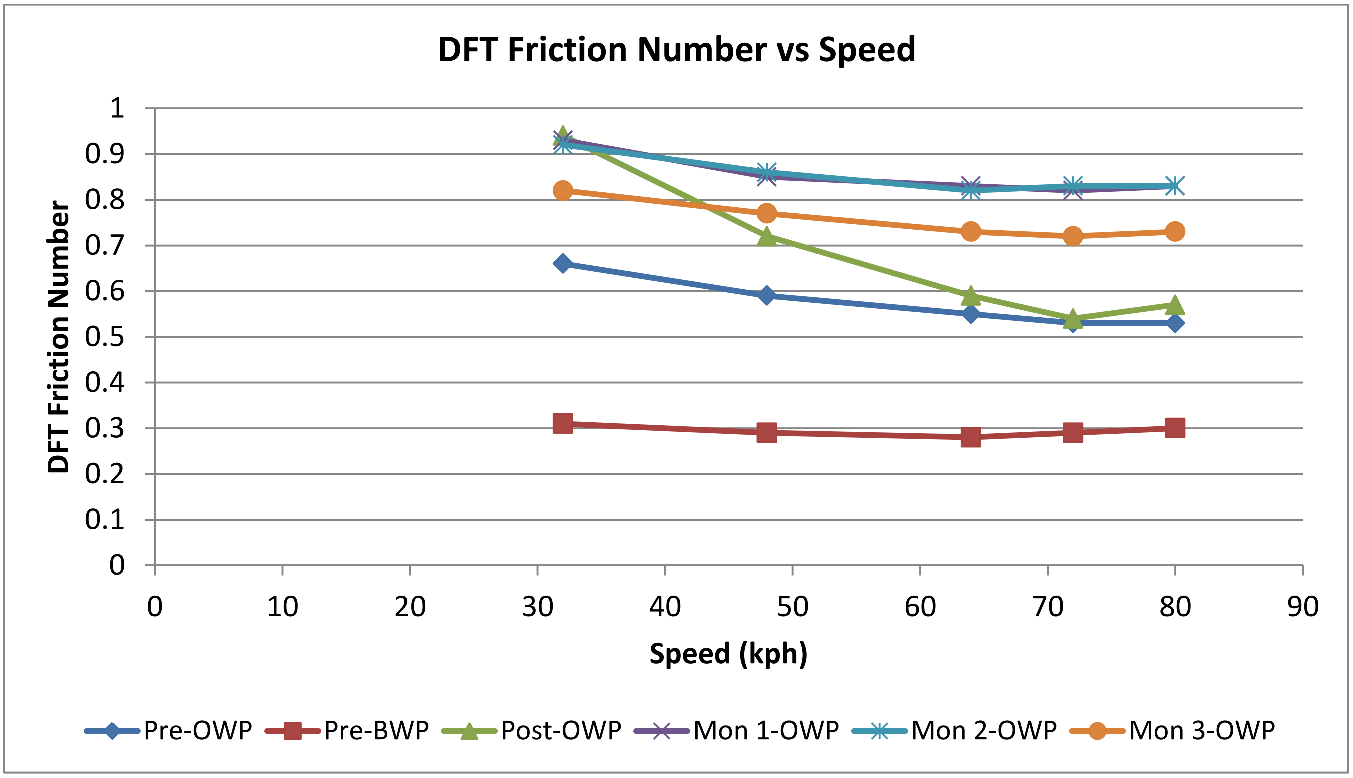
Dynamic Friction Test (DFT) Friction Number Data for TP 1

Speed (kph)	Pre-IWP	Pre-BWP	Post-IWP	Mon 1-IWP	Mon 2-IWP	Mon 3-IWP
32	0.2	0.73	0.65	0.52	0.6	0.55
48	0.19	0.68	0.6	0.49	0.55	0.51
64	0.19	0.69	0.52	0.47	0.55	0.49
72	0.19	0.64	0.5	0.48	0.55	0.48
80	0.19	0.68	0.52	0.51	0.59	0.48



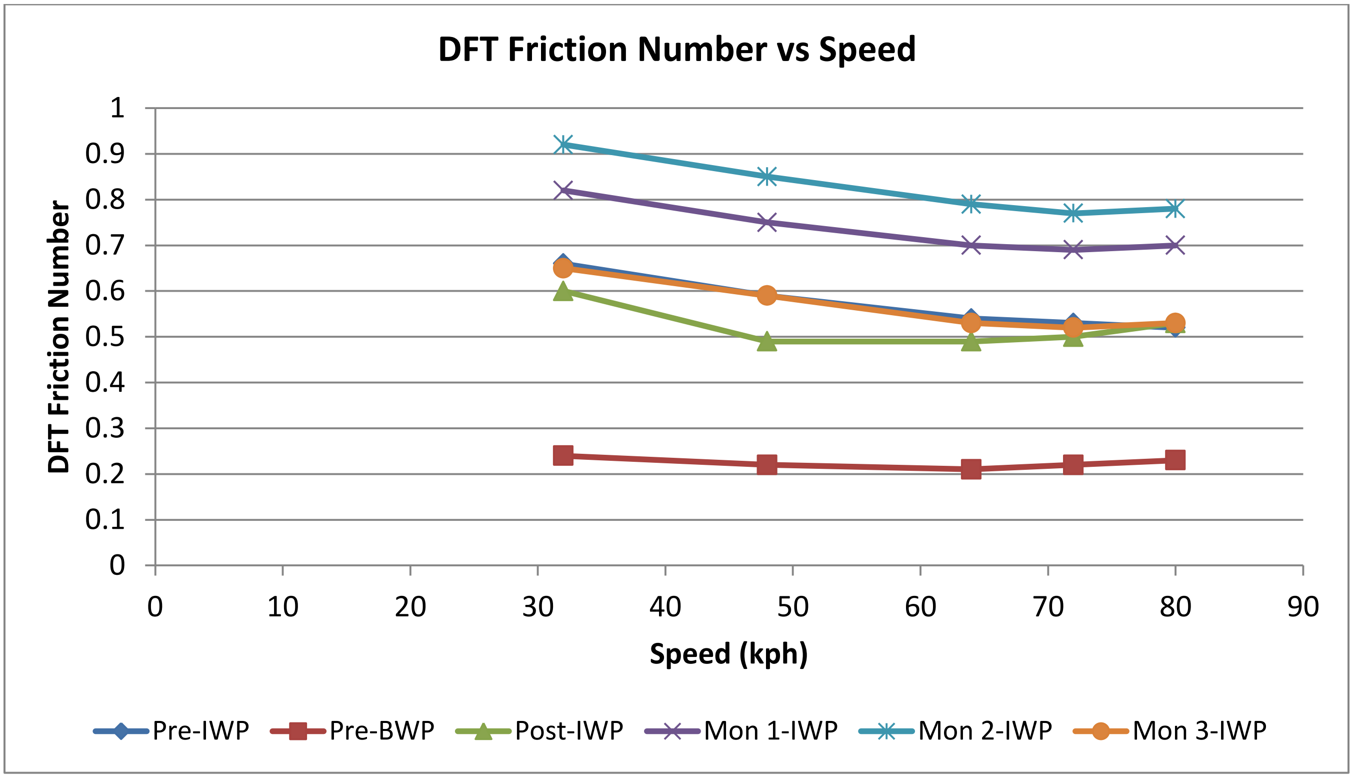
Dynamic Friction Test (DFT) Friction Number Data for TP 2

Speed (kph)	Pre-OWP	Pre-BWP	Post-OWP	Mon 1-OWP	Mon 2-OWP	Mon 3-OWP
32	0.66	0.31	0.94	0.93	0.92	0.82
48	0.59	0.29	0.72	0.85	0.86	0.77
64	0.55	0.28	0.59	0.83	0.82	0.73
72	0.53	0.29	0.54	0.82	0.83	0.72
80	0.53	0.3	0.57	0.83	0.83	0.73



Dynamic Friction Test (DFT) Friction Number Data for TP 3

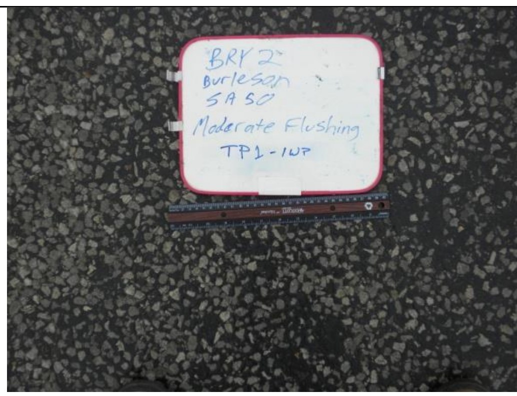
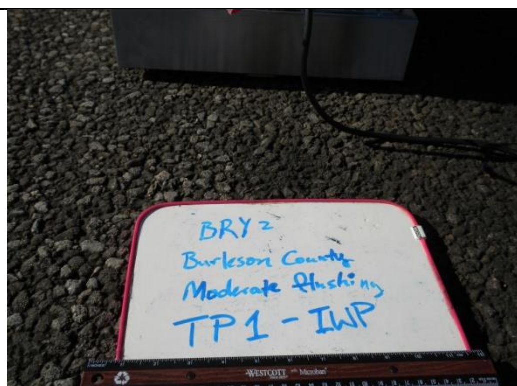
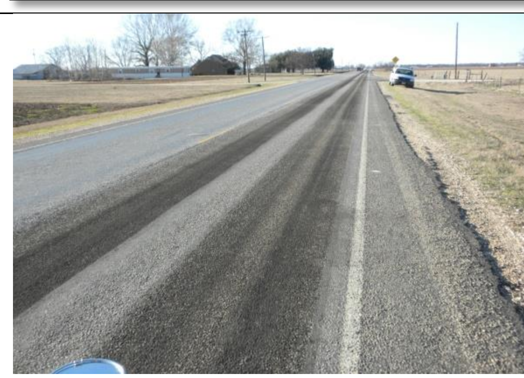
Speed (kph)	Pre-IWP	Pre-BWP	Post-IWP	Mon 1-IWP	Mon 2-IWP	Mon 3-IWP
32	0.66	0.24	0.6	0.82	0.92	0.65
48	0.59	0.22	0.49	0.75	0.85	0.59
64	0.54	0.21	0.49	0.7	0.79	0.53
72	0.53	0.22	0.5	0.69	0.77	0.52
80	0.52	0.23	0.53	0.7	0.78	0.53



Appendix B
Weather Data during UHP Water Cutter Treatment

Date	Time	Temp Out	Hi Temp	Low Temp	Out Hum	Dew Pt.	Wind Speed	Wind Dir	Wind Run	Hi Speed	Hi Dir	Wind Chill	Heat Index	THW Index	THSW Index
2/2/2011	8:50 AM	28.4	35.2	28.4	45	9.7	11	NE	0.92	19	NE	18.7	27.6	17.9	---
2/2/2011	8:55 AM	22.9	28.2	22.9	55	9.1	13	N	1.08	18	NNW	10.8	22.3	10.2	---
2/2/2011	9:00 AM	20.7	22.8	20.7	60	9	14	N	1.17	19	N	7.6	20.2	7.1	---
2/2/2011	9:05 AM	19.9	20.6	19.9	63	9.3	14	N	1.17	20	NNW	6.6	19.5	6.2	---
2/2/2011	9:10 AM	19.8	19.9	19.7	66	10.3	12	N	1	18	N	7.4	19.4	7	---
2/2/2011	9:15 AM	19.7	19.8	19.7	64	9.5	14	N	1.17	22	N	6.3	19.3	5.9	---
2/2/2011	9:20 AM	19.6	19.7	19.6	65	9.7	13	N	1.08	19	NNW	6.7	19.2	6.3	---
2/2/2011	9:25 AM	19.8	19.8	19.6	65	9.9	12	N	1	18	NNW	7.4	19.4	7	---
2/2/2011	9:30 AM	19.8	19.8	19.7	65	9.9	12	N	1	17	NW	7.4	19.4	7	---
2/2/2011	9:35 AM	19.8	19.8	19.8	66	10.3	14	N	1.17	20	N	6.4	19.4	6	---
2/2/2011	9:40 AM	19.8	19.8	19.8	65	9.9	14	N	1.17	20	N	6.4	19.4	6	---
2/2/2011	9:45 AM	19.8	19.8	19.8	66	10.3	14	N	1.17	20	N	6.4	19.4	6	---
2/2/2011	9:50 AM	19.9	19.9	19.8	66	10.4	12	N	1	19	N	7.6	19.5	7.2	---
2/2/2011	9:55 AM	20.2	20.2	20	65	10.3	13	N	1.08	19	N	7.4	19.8	7	---
2/2/2011	10:00 AM	20.3	20.3	20.1	65	10.4	12	N	1	18	NNW	8.1	19.9	7.7	---
2/2/2011	10:05 AM	20.5	20.5	20.3	64	10.2	13	N	1.08	18	N	7.8	20.1	7.4	---
2/2/2011	10:10 AM	20.7	20.7	20.5	66	11.1	11	N	0.92	18	N	9.1	20.3	8.7	---
2/2/2011	10:15 AM	21.2	21.2	20.8	66	11.6	11	N	0.92	16	N	9.7	20.8	9.3	---
2/2/2011	10:20 AM	21.6	21.6	21.3	64	11.3	12	N	1	19	N	9.7	21.2	9.3	---
2/2/2011	10:25 AM	22	22	21.6	64	11.7	12	N	1	18	NNW	10.2	21.6	9.8	---
2/2/2011	10:30 AM	22	22	22	62	11	12	N	1	18	NNW	10.2	21.5	9.7	---
2/2/2011	10:35 AM	22.4	22.4	22	64	12.1	10	N	0.83	18	N	11.8	22	11.4	---
2/2/2011	10:40 AM	22.7	22.7	22.4	61	11.3	12	N	1	19	NNW	11.1	22.2	10.6	---
2/2/2011	10:45 AM	22.7	22.7	22.6	62	11.6	13	NNE	1.08	19	NNE	10.6	22.2	10.1	---
2/2/2011	10:50 AM	23	23	22.6	62	11.9	11	N	0.92	16	N	12	22.5	11.5	---
2/2/2011	10:55 AM	23.3	23.3	23	63	12.6	11	N	0.92	17	N	12.4	22.8	11.9	---
2/2/2011	11:00 AM	24.6	24.6	23.4	62	13.4	8	N	0.67	23	N	15.8	24.1	15.3	---

Site Photographs

(a)			Figure XX. BMT3 Pictures (a) highway and location; (b) close-up of flushed surface before treatment; (c) roadway surface before treatment; (d) close-up of flushed surface immediately after treatment; (e) roadway surface after treatment; (f) close-up of surface at first follow-up ; (g) roadway surface at first follow-up , (h) roadway surface at second follow-up ; (i) close-up of surface at second follow-up , (j) close-up of surface at third follow-up ; (k) roadway surface at third follow-up
(b)		(c)	
(d)		(e)	
(f)		(g)	

(h)		(i)	
(j)		(k)	

APPENDIX C

SITE BRY 4

Robertson COUNTY

Bryan DISTRICT

Site Description

Project Information			
District: Bryan	Test Site: BRY 4	County: Robertson	Road: FM 485 WB
ADT: 2200	Truck Traffic: Low	Year Built:	Last Maintained: 2005

Roadway Description
Aggregate Grade: Ty PL GR 4
Aggregate Type: Expanded Shale Lightweight
Pit: Texas Industries -Streetman
AQMP#: 1817502
CSJ: 0262-03-029
CCSJ: 0049-08-056
Binder: AC 20-5TR

Pavement abnormalities: The pavement was lightly flushed along both wheel paths. The major aggregate appeared to be Grade 4 rock. Additional smaller, potentially Grade 5, rock had been placed to address active bleeding. This resulted in a road way that in many ways didn't look that bad. The result was that treatment was less drastic. The smaller aggregate size limited the effective cutting depth.

Research Test Summary		
Test Location: SH 6 (Hearne) to Milam CL	Closest Texas Reference Marker: 608	
Test Point GPS Coordinates	N	W
TP1	30°53.956'	097°10.253'
TP2	30°53.878'	097°10.150'
TP3	30°53.806'	097°10.057'

Ultra High Pressure Water Cutter Treatment Summary		
Date Treated 2/8/2011	Start Time 8:00 AM	End Time 4:00 PM

Summary Description of Treatment Activity
Personnel on site:
TechMRT: Andrew Tubb and Timothy Wood
Rampart: Bob Beadling and Jim Windich
TxDOT: James Robins, Darlene Goehl (Bryan District), Allen Warden, Connie Flickenger (Area Engineers) James H McCoslin (Robertson County Maintenance Office Event Coordinator), John D. Kempenski and others from the Robertson County Maintenance Office Traffic Control

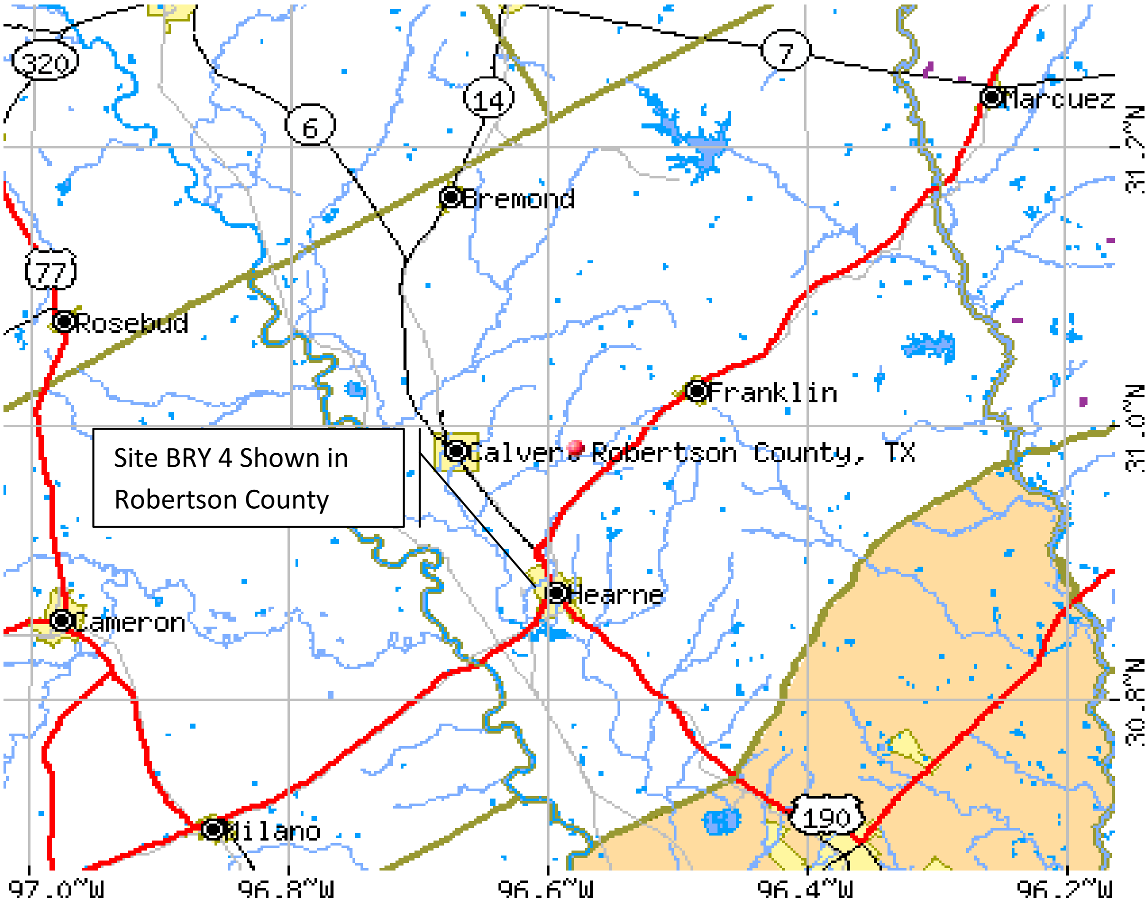
Rampart configuration: Rampart used a 20 jet nozzle configuration: From the outside to center they ran 3 0.014in. jets, 7 0.011in. jets and 4 plugs. They ran the hydraulic pressure consistently from 33000psi to 34000psi.

Work Activities: TechMRT and Rampart participated in the morning meeting with TxDOT. TechMRT and the traffic control arrived at the site at 7:45AM. TechMRT set up the weather station near the start of the site at 8:00AM. DFT and SP testing at the TP took place from 8:30AM till 10:00AM. Rampart arrived at approximately 9:15AM.
TechMRT and Rampart worked time trials from 10:15AM to 11:15AM. Darlene with general

agreement from all participants set rate should at 1.0mph. Rampart was able set the limiting block at slightly greater than 1.0mph. The production testing began at 11:20AM. Rampart was able to treat the wheel paths in one pass each. After completing Pass 2 and 4, Rampart left to empty the waste water at 12:15PM. The test lane was broomed at 1:00PM, though very little dust was noticed. Rampart treated the 0.5mile untested lane from 1:30PM till 3:15PM. Toward the end of Pass 2 a spike in pressure occurred indicating a clogged nozzle. Rampart replaced the clogged nozzle before completing Pass 4 on the 0.5mile treatment section. Rampart left the site to empty the truck at 3:20PM. The TechMRT team ran the speed trial CTMs from 11:30AM till 11:50AM while Rampart was treating the production 0.25mile run in the same lane. TechMRT ran the TP1, 2 and 3 CTM, DFT and SP post treatment test from 12:10PM till 12:50PM while Rampart emptied their truck for the first time. During this SP testing a very light black powder was noticed as the area was swept with the wire brush. It was almost inconsequential compared to that observed at BRY2. Never the less it was still present. Timothy Wood then took video of a walking tour of the whole 0.5mile section from 1:10PM to 1:25PM. TechMRT packed the van including the weather station at 3:00PM. They then went with Rampart to empty the truck. They collected video and still pictures of the emptying process. The solid waste was at capacity along with the water. This indicated that even if the water had been pumped off, more treatment might have overloaded the solid waste capacity of the tank. The solid waste had a decidedly tire rubber smell to it. TechMRT left the dump site and returned to the hotel at 4:00PM. Darlene decided that due to rain and potential sleet and freezing rain Wednesday will be a day off.
Comments

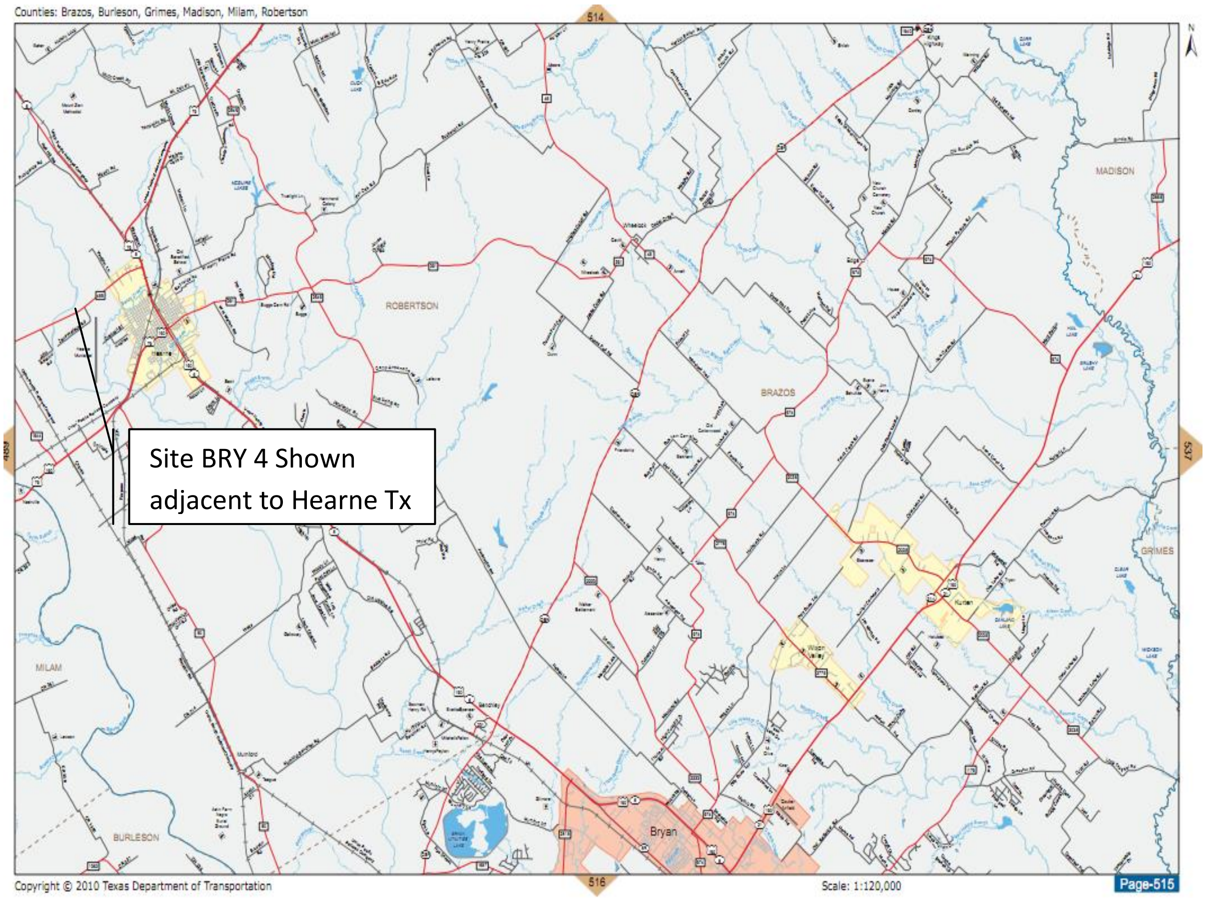
Follow-On Testing Summary	
Date: 7/19/11	Comments: Preformed follow –up monitoring successfully.
Date: 1/11/12	Comments: Preformed follow –up monitoring successfully.
Date 7/10/12	Comments: Preformed follow –up monitoring successfully.

Site Vicinity Map



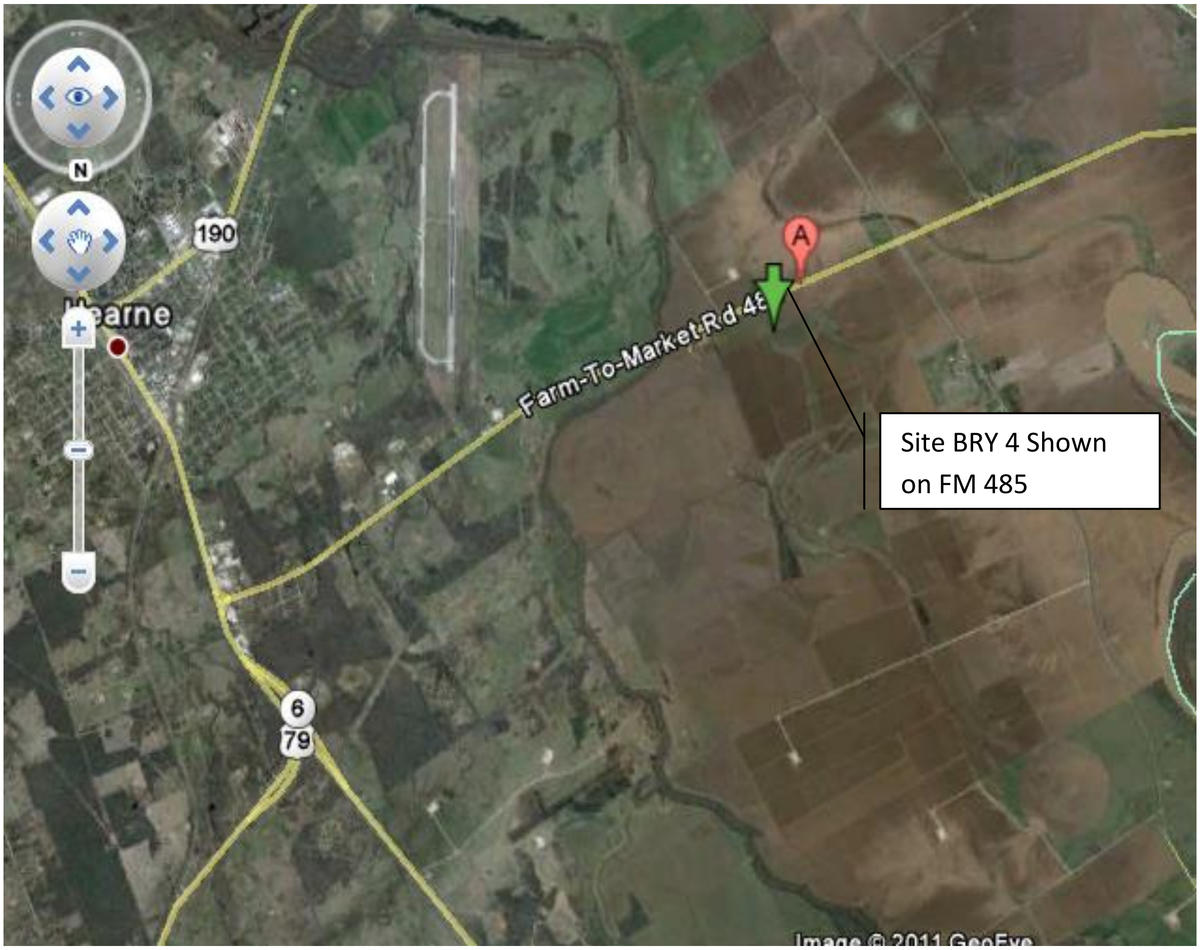
http://www.city-data.com/

Site Location Map



http://www.txdot.gov/travel/county_grid_search.htm

Aerial Photograph

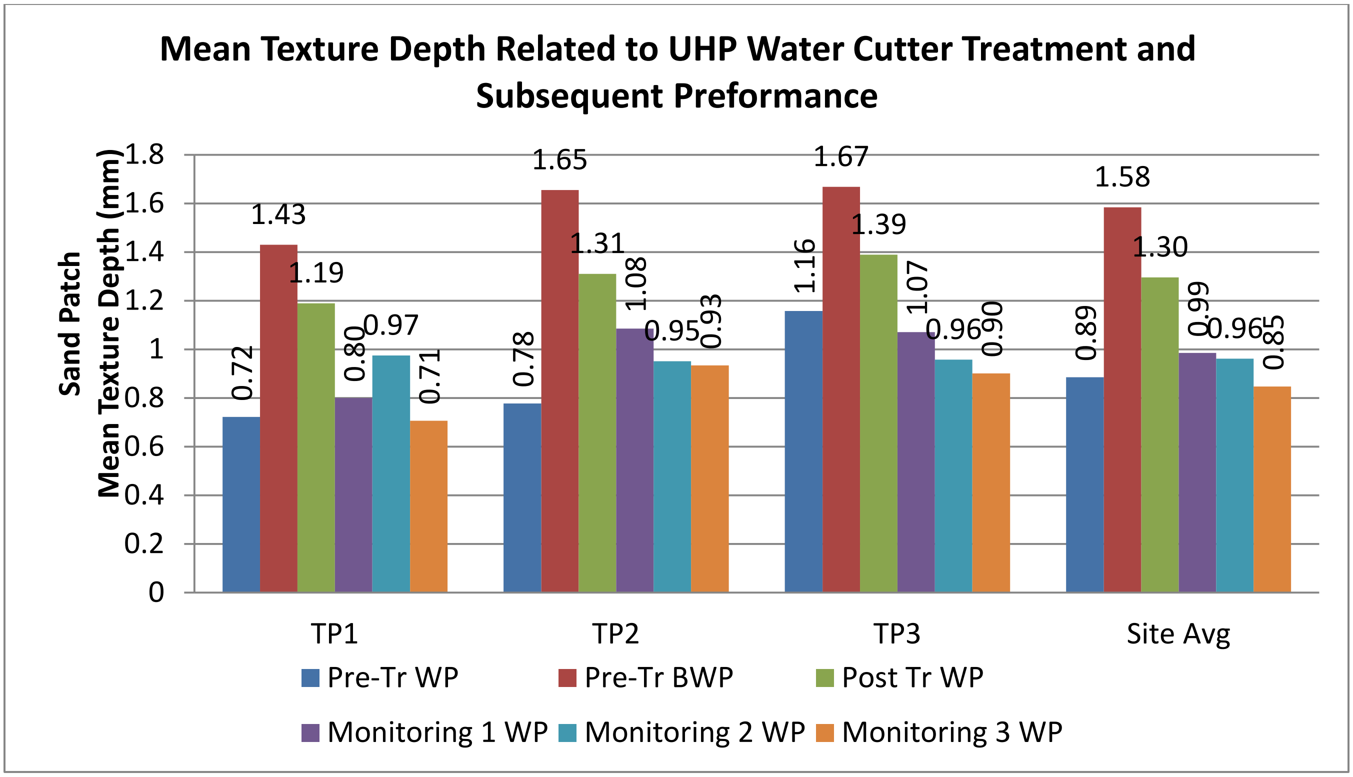


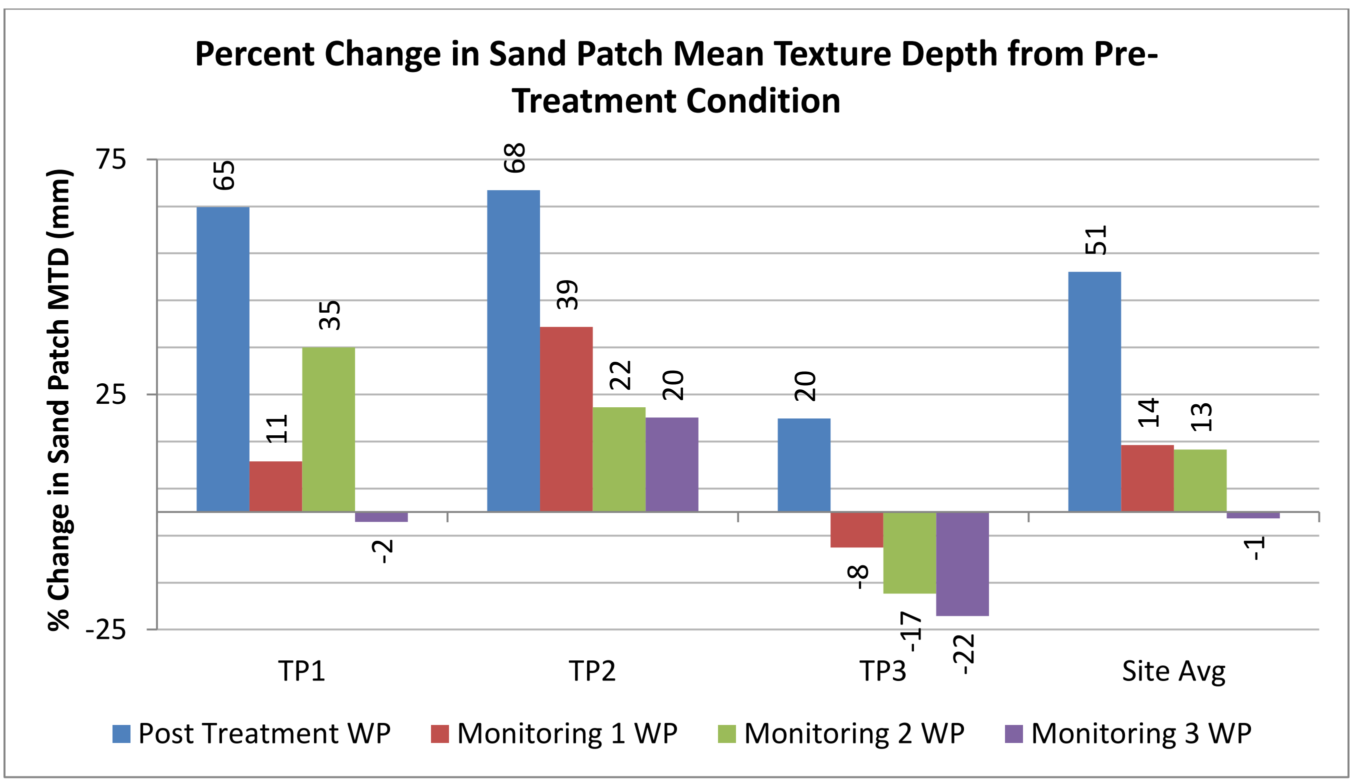
Google Inc. (2011). Google Earth (Version 6.1.0.5001)

Test Point Plan

Google Inc. (2011). Google Earth (Version 6.1.0.5001)

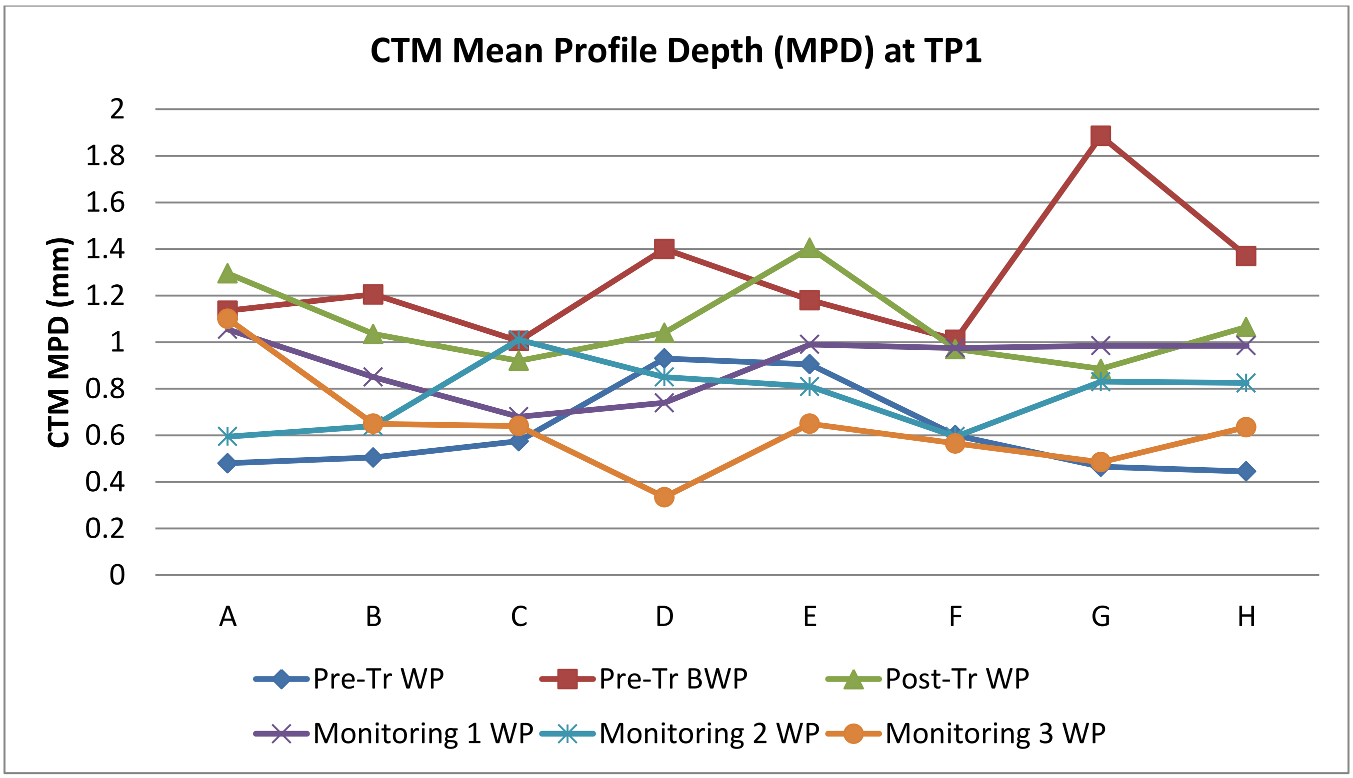
Sand Patch Data





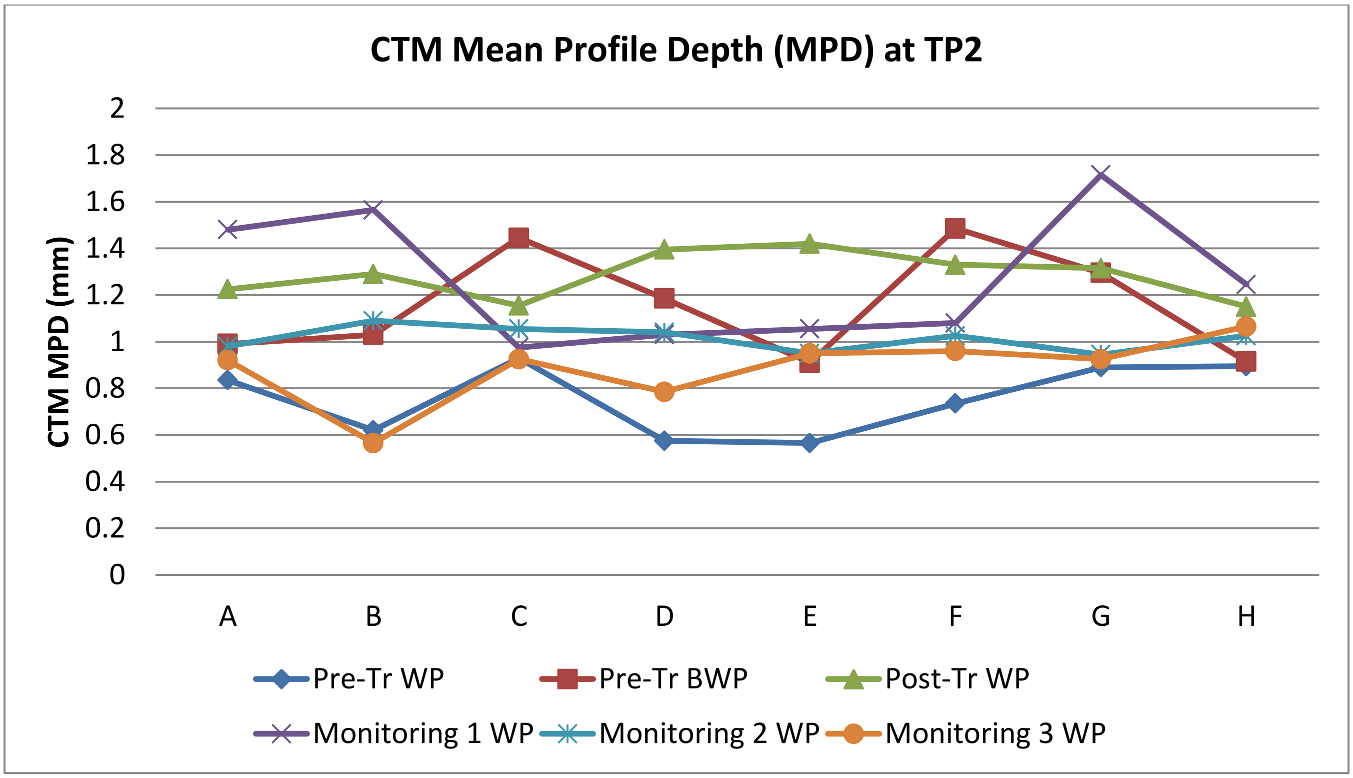
Circular Track Meter (CTM) Mean Profile Depth (in mm) at TP 1

	A	B	C	D	E	F	G	H
Pre-Tr WP	0.48	0.505	0.575	0.93	0.905	0.6	0.465	0.445
Pre-Tr BWP	1.135	1.205	1.005	1.4	1.18	1.01	1.885	1.37
Post-Tr	1.295	1.035	0.92	1.04	1.405	0.97	0.885	1.065
Monitoring 1	1.055	0.85	0.68	0.74	0.99	0.975	0.985	0.985
Monitoring 2	0.595	0.64	1.01	0.85	0.81	0.595	0.83	0.825
Monitoring 3	1.1	0.65	0.64	0.335	0.65	0.565	0.485	0.635



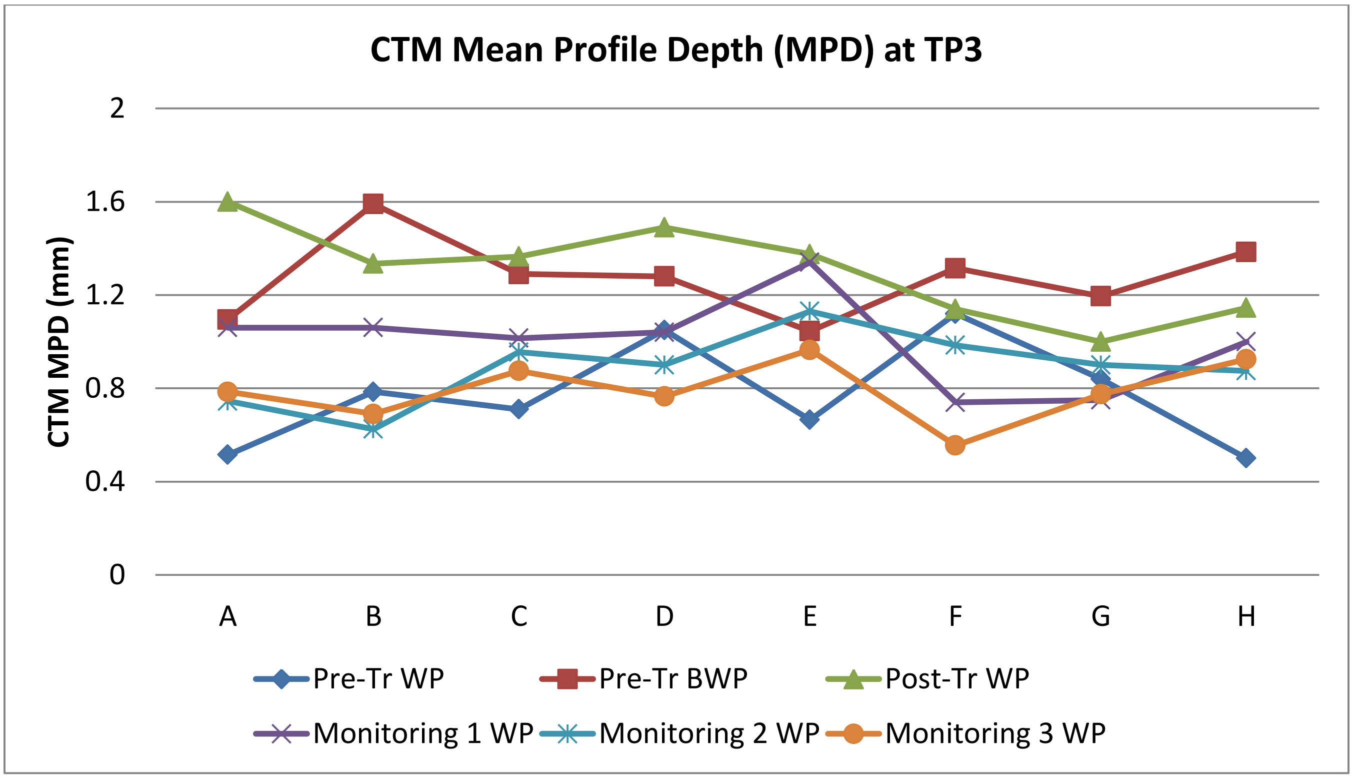
Circular Track Meter (CTM) Mean Profile Depth (in mm) at TP 2

	A	B	C	D	E	F	G	H
Pre-Tr WP	0.835	0.62	0.93	0.575	0.565	0.735	0.89	0.895
Pre-Tr BWP	0.99	1.03	1.445	1.185	0.91	1.485	1.295	0.915
Post-Tr	1.225	1.29	1.155	1.395	1.42	1.33	1.315	1.15
Monitoring 1	1.48	1.565	0.975	1.03	1.055	1.08	1.715	1.245
Monitoring 2	0.98	1.09	1.055	1.04	0.95	1.025	0.945	1.025
Monitoring 3	0.92	0.565	0.925	0.785	0.95	0.96	0.925	1.065

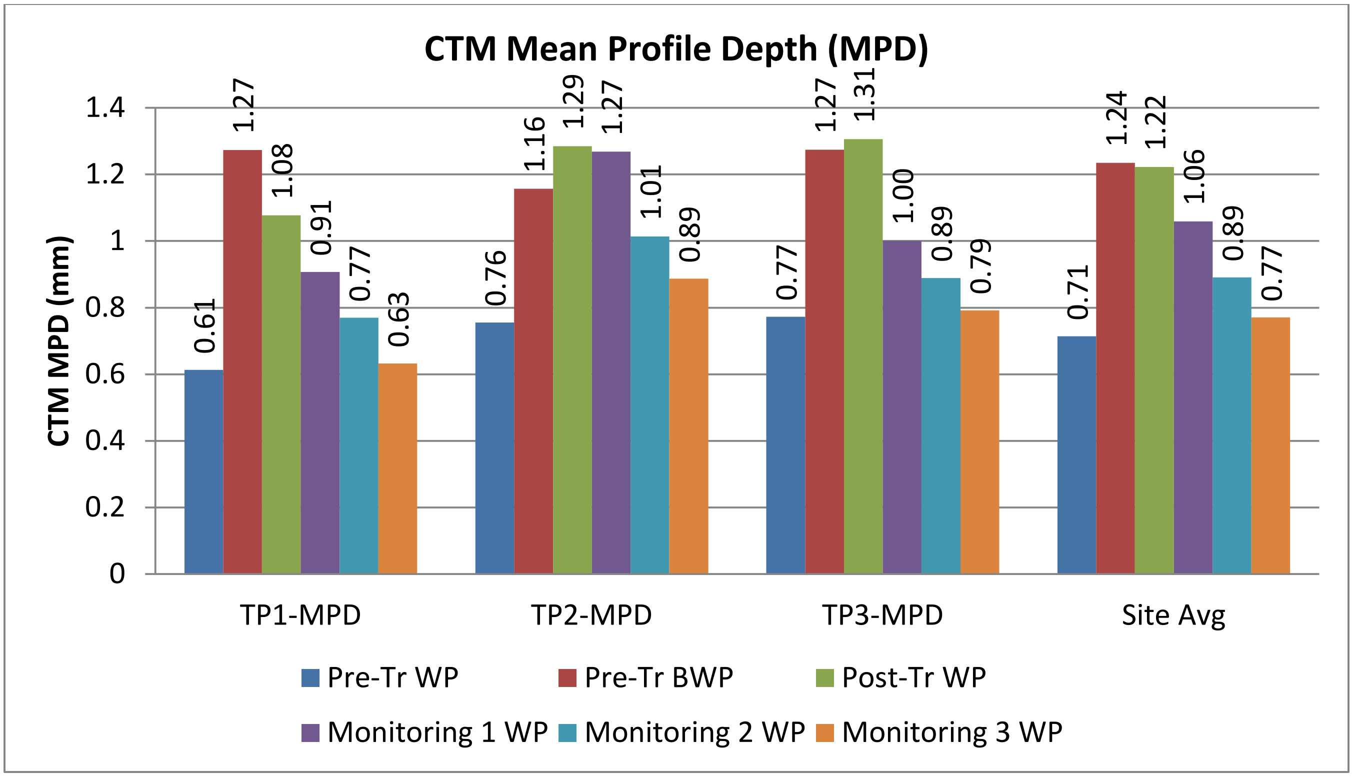


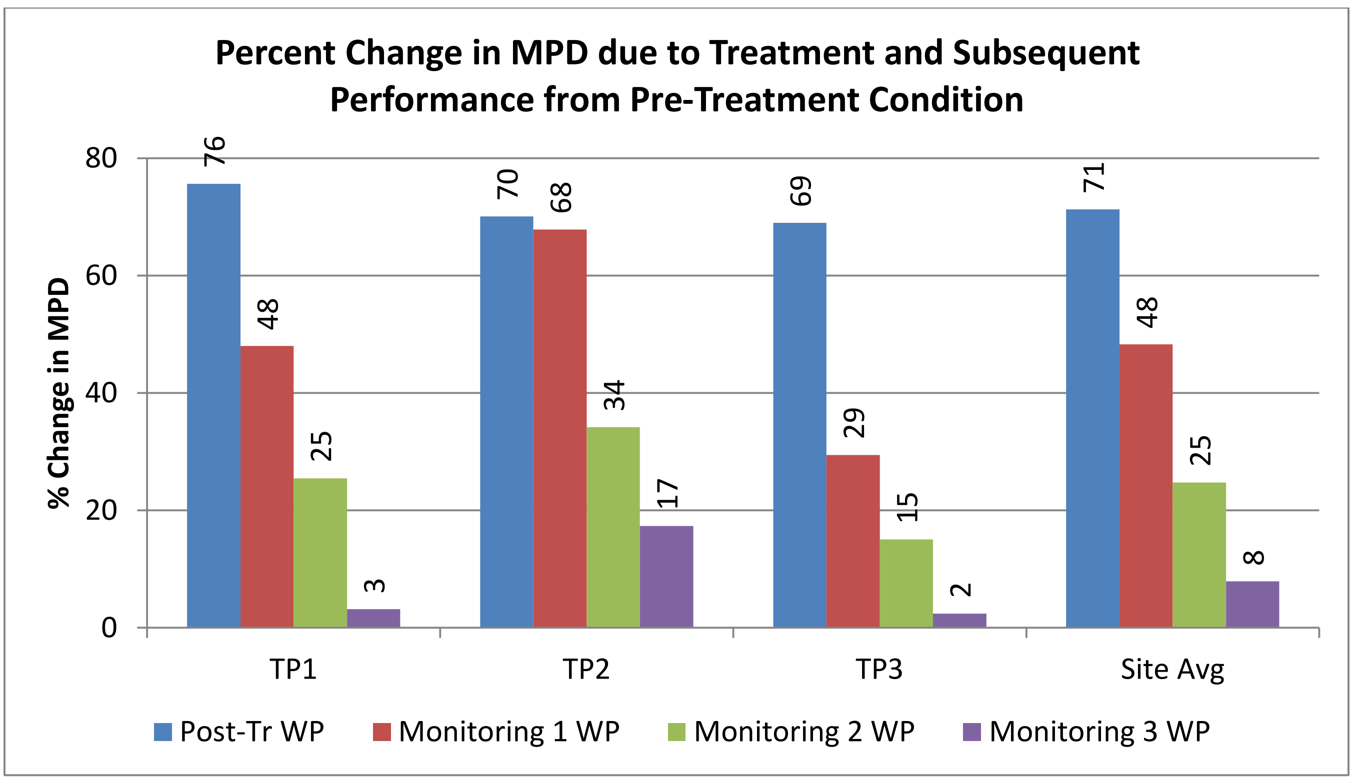
Circular Track Meter (CTM) Mean Profile Depth (in mm) at TP 3

	A	B	C	D	E	F	G	H
Pre-Tr WP	0.515	0.785	0.71	1.05	0.665	1.12	0.84	0.5
Pre-Tr BWP	1.095	1.59	1.29	1.28	1.045	1.315	1.195	1.385
Post-Tr	1.6	1.335	1.365	1.49	1.375	1.14	1	1.145
Monitoring 1	1.06	1.06	1.015	1.04	1.34	0.74	0.75	1
Monitoring 2	0.745	0.625	0.955	0.9	1.13	0.985	0.9	0.875
Monitoring 3	0.785	0.69	0.875	0.765	0.965	0.555	0.775	0.925

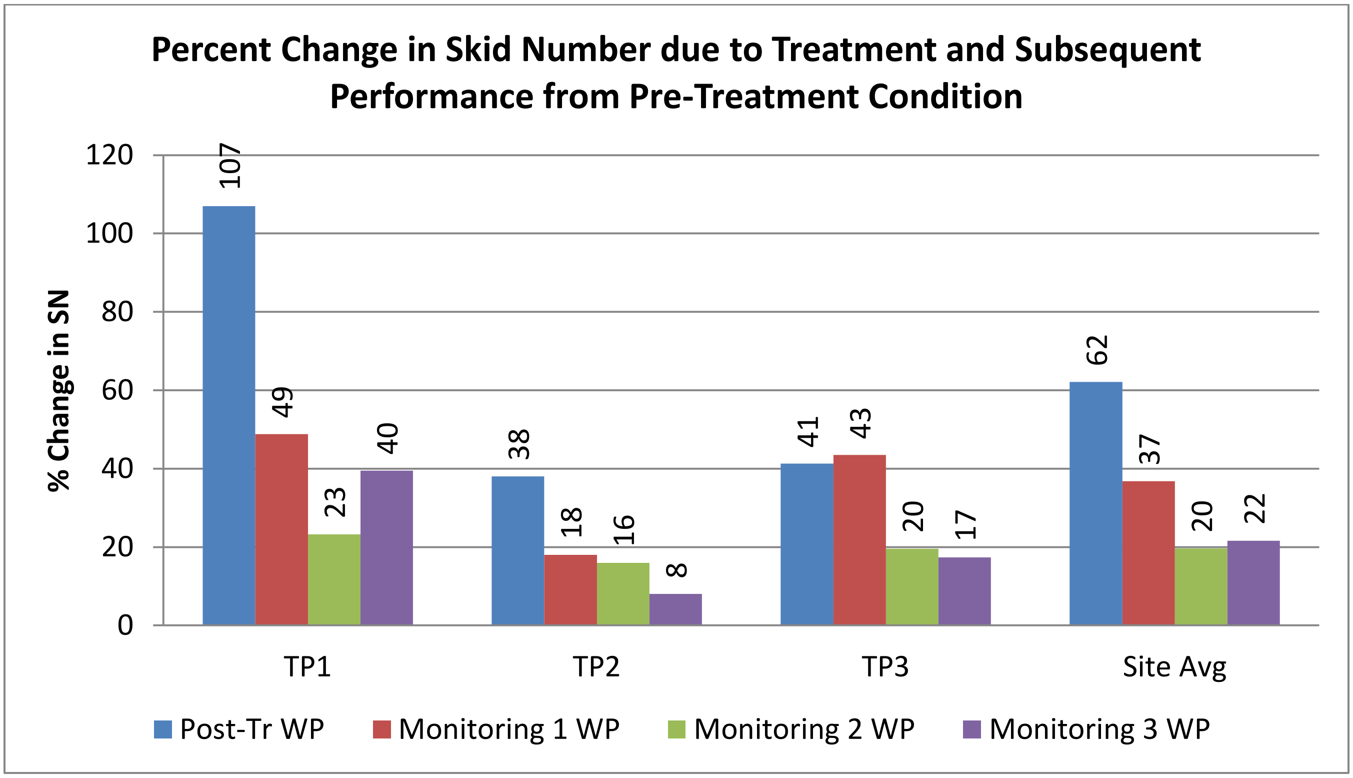


Circular Track Meter (CTM) MPD (mm)



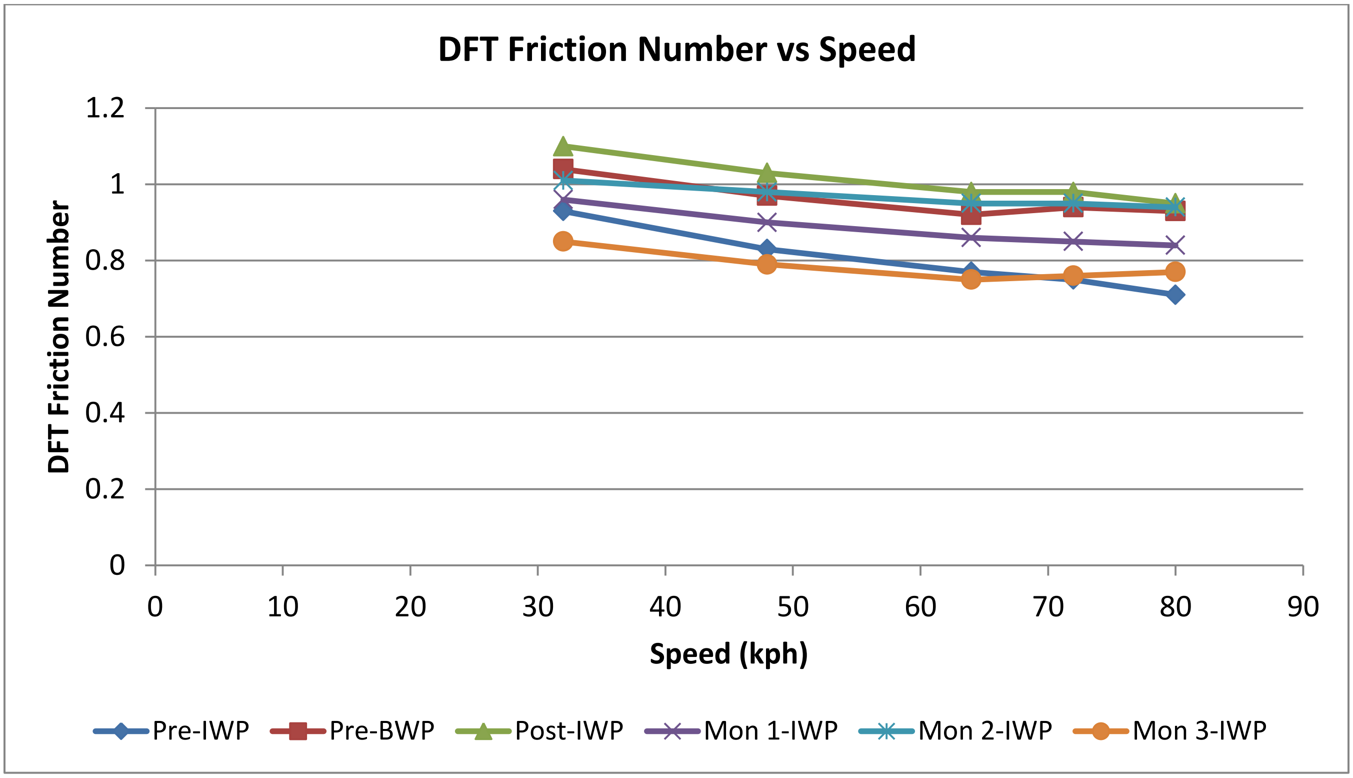


Skid Truck Data



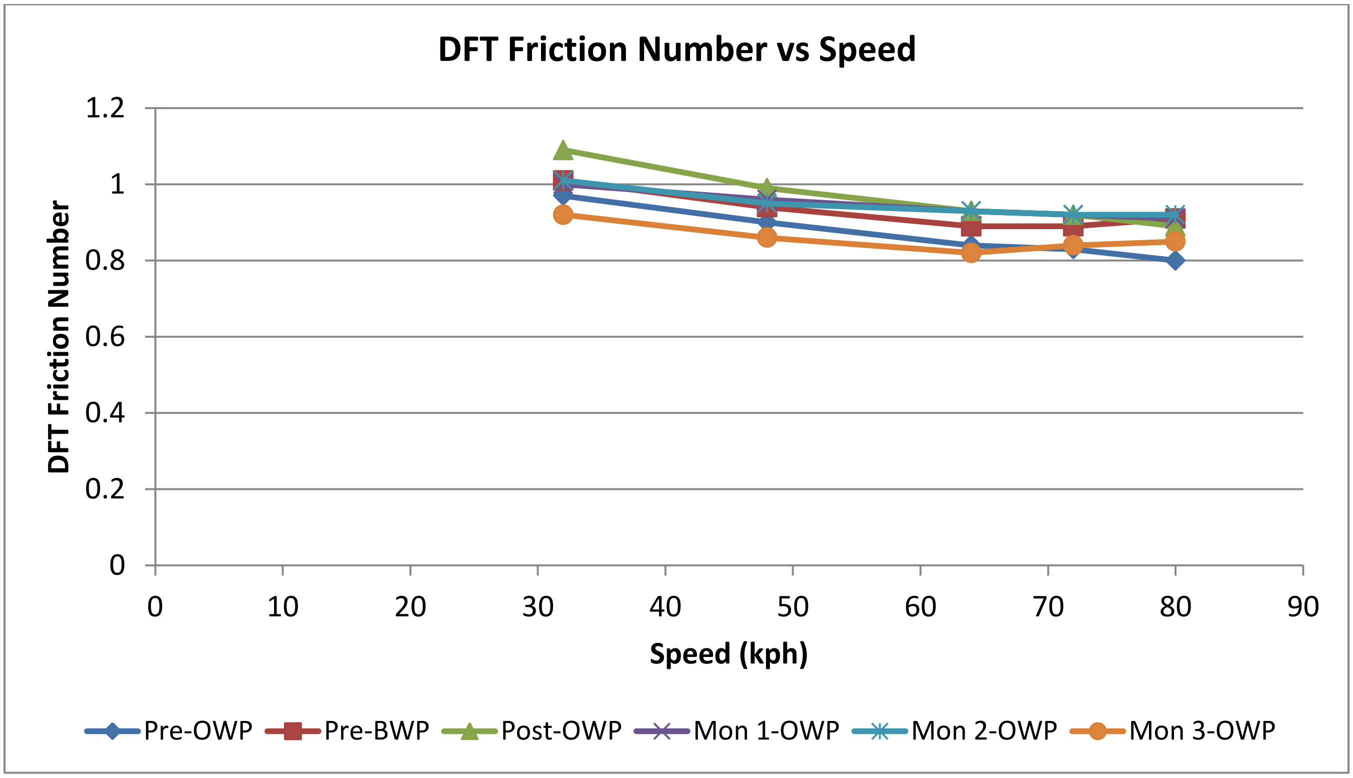
Dynamic Friction Test (DFT) Friction Number Data for TP 1

Speed (kph)	Pre-IWP	Pre-BWP	Post-IWP	Mon 1-IWP	Mon 2-IWP	Mon 3-IWP
32	0.93	1.04	1.1	0.96	1.01	0.85
48	0.83	0.97	1.03	0.9	0.98	0.79
64	0.77	0.92	0.98	0.86	0.95	0.75
72	0.75	0.94	0.98	0.85	0.95	0.76
80	0.71	0.93	0.95	0.84	0.94	0.77



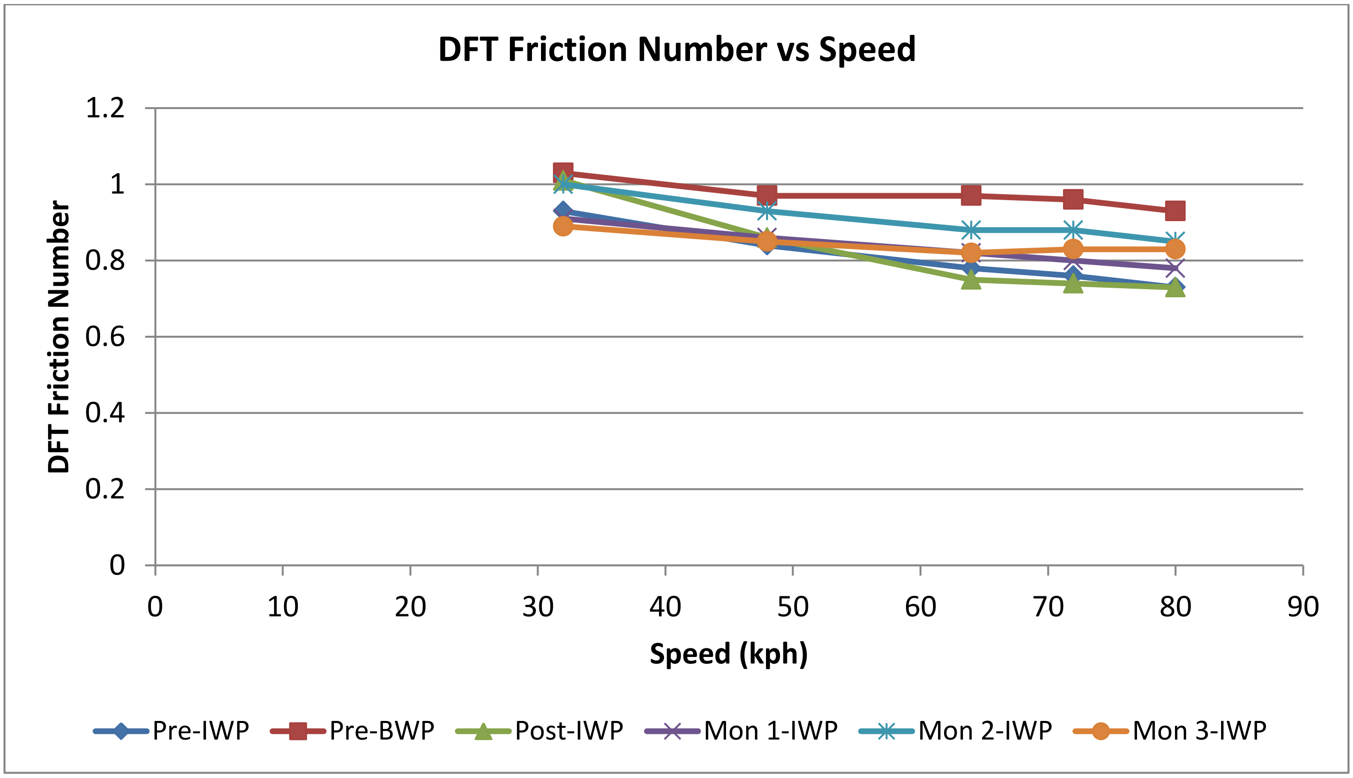
Dynamic Friction Test (DFT) Friction Number Data for TP 2

Speed (kph)	Pre-OWP	Pre-BWP	Post-OWP	Mon 1-OWP	Mon 2-OWP	Mon 3-OWP
32	0.97	1.01	1.09	1	1.01	0.92
48	0.9	0.94	0.99	0.96	0.95	0.86
64	0.84	0.89	0.93	0.93	0.93	0.82
72	0.83	0.89	0.92	0.92	0.92	0.84
80	0.8	0.91	0.89	0.91	0.92	0.85



Dynamic Friction Test (DFT) Friction Number Data for TP 3

Speed (kph)	Pre-IWP	Pre-BWP	Post-IWP	Mon 1-IWP	Mon 2-IWP	Mon 3-IWP
32	0.93	1.03	1.01	0.91	1	0.89
48	0.84	0.97	0.86	0.86	0.93	0.85
64	0.78	0.97	0.75	0.82	0.88	0.82
72	0.76	0.96	0.74	0.8	0.88	0.83
80	0.73	0.93	0.73	0.78	0.85	0.83



Weather Data during UHP Water Cutter Treatment

Date	Time	Temp Out	Hi Temp	Low Temp	Out Hum	Dew Pt.	Wind Speed	Wind Dir	Wind Run	Hi Speed	Hi Dir	Wind Chill	Heat Index	THW Index	THSW Index
2/8/2011	8:00 AM	44.2	48.5	44.2	50	26.7	1	SW	0.17	9	WNW	44.2	43.1	43.1	---
2/8/2011	8:10 AM	36.9	43.9	36.9	68	27.3	6	ESE	1	12	SE	32.1	36.3	31.5	---
2/8/2011	8:20 AM	37.6	37.6	36.9	69	28.3	8	SE	1.33	13	ESE	31.7	37	31.1	---
2/8/2011	8:30 AM	38.3	38.3	37.6	67	28.3	11	SE	1.83	19	ESE	31.1	37.6	30.4	---
2/8/2011	8:40 AM	39.3	39.3	38.3	66	28.9	12	SE	2	18	SE	32	38.6	31.3	---
2/8/2011	8:50 AM	40.3	40.3	39.3	66	29.8	12	SE	2	18	SE	33.2	39.6	32.5	---
2/8/2011	9:00 AM	41.4	41.4	40.3	65	30.5	12	SE	2	17	SE	34.4	40.7	33.7	---
2/8/2011	9:10 AM	42.3	42.3	41.4	63	30.6	13	SE	2.17	19	SE	35.1	41.6	34.4	---
2/8/2011	9:20 AM	43.3	43.3	42.3	63	31.5	13	SE	2.17	20	SE	36.2	42.6	35.5	---
2/8/2011	9:30 AM	45	45	43.4	60	31.9	12	SE	2	16	SE	38.6	44.2	37.8	---
2/8/2011	9:40 AM	46.1	46.1	45	58	32.1	13	SE	2.17	21	SSE	39.4	45.2	38.5	---
2/8/2011	9:50 AM	46.9	46.9	46.1	57	32.4	15	SE	2.5	21	SE	39.7	46	38.8	---
2/8/2011	10:00 AM	47.8	47.8	46.9	57	33.3	15	SE	2.5	21	SE	40.7	46.9	39.8	---
2/8/2011	10:10 AM	47.8	47.8	47.6	57	33.3	16	SSE	2.67	22	SE	40.4	46.9	39.5	---
2/8/2011	10:20 AM	48.9	48.9	47.8	58	34.8	16	SE	2.67	24	SE	41.6	48	40.7	---
2/8/2011	10:30 AM	49.2	49.2	48.9	55	33.7	18	SE	3	26	SSE	41.4	48.2	40.4	---
2/8/2011	10:40 AM	50.1	50.1	49.2	56	35	17	SE	2.83	24	SE	42.7	49.1	41.7	---
2/8/2011	10:50 AM	51.4	51.4	50.1	54	35.3	16	SE	2.67	24	ESE	44.5	50.2	43.3	---
2/8/2011	11:00 AM	52.1	52.1	51.4	52	35	16	SSE	2.67	23	SE	45.3	50.7	43.9	---
2/8/2011	11:10 AM	52.4	52.6	52.1	51	34.8	17	SE	2.83	26	SE	45.3	50.9	43.8	---
2/8/2011	11:20 AM	53.3	53.3	52.4	51	35.6	17	SE	2.83	25	SE	46.3	51.7	44.7	---
2/8/2011	11:30 AM	54	54	53.3	52	36.8	18	SE	3	25	SSE	46.9	52.4	45.3	---
2/8/2011	11:40 AM	54.5	54.5	54	50	36.2	18	SE	3	26	SSE	47.5	52.8	45.8	---
2/8/2011	11:50 AM	55	55	54.5	49	36.2	18	SE	3	26	SE	48	53.1	46.1	---
2/8/2011	12:00 PM	55.5	55.6	55	48	36.1	16	SSE	2.67	23	SE	49.2	53.5	47.2	---

2/8/2011	12:10 PM	56.6	56.6	55.5	47	36.6	16	SSE	2.67	25	SE	50.4	54.5	48.3	---
2/8/2011	12:20 PM	57.3	57.3	56.7	47	37.2	15	SE	2.5	22	SSE	51.5	55.2	49.4	---
2/8/2011	12:30 PM	57.1	57.3	57.1	49	38.1	16	SSE	2.67	24	SE	50.9	55.1	48.9	---
2/8/2011	12:40 PM	57.8	57.8	57.1	48	38.2	17	SSE	2.83	26	SE	51.5	55.7	49.4	---
2/8/2011	12:50 PM	58.4	58.4	57.7	48	38.8	16	SE	2.67	26	SE	52.4	56.3	50.3	---
2/8/2011	1:00 PM	59	59	58.4	47	38.8	16	SE	2.67	25	SE	53.1	56.8	50.9	---
2/8/2011	1:10 PM	58.9	59	58.7	47	38.7	16	SE	2.67	26	SE	53	56.7	50.8	---
2/8/2011	1:20 PM	59.3	59.3	58.7	46	38.5	14	SSE	2.33	22	S	54.1	57.1	51.9	---
2/8/2011	1:30 PM	59.3	59.5	59.1	48	39.6	16	SSE	2.67	26	SSE	53.4	57.2	51.3	---
2/8/2011	1:40 PM	59.7	59.7	59.3	47	39.4	16	SE	2.67	23	SE	53.9	57.5	51.7	---
2/8/2011	1:50 PM	60.1	60.3	59.7	44	38.1	17	SE	2.83	24	SE	54	57.7	51.6	---
2/8/2011	2:00 PM	61	61	60.1	44	38.9	16	SE	2.67	24	SSE	55.4	58.6	53	---
2/8/2011	2:10 PM	61.1	61.4	61	45	39.6	15	SSE	2.5	23	SE	55.8	58.8	53.5	---
2/8/2011	2:20 PM	60.7	61.2	60.7	43	38.1	19	SE	3.17	27	SE	54.2	58.2	51.7	---
2/8/2011	2:30 PM	61	61	60.7	42	37.7	17	SE	2.83	25	SE	55.1	58.5	52.6	---
2/8/2011	2:40 PM	60.8	60.9	60.6	42	37.5	20	SE	3.33	28	ESE	54.1	58.3	51.6	---
2/8/2011	2:50 PM	60.6	60.8	60.6	43	38	20	SE	3.33	27	SE	53.9	58.1	51.4	---
2/8/2011	3:00 PM	63.4	63.4	60.6	42	39.9	5	SSE	0.83	25	E	63.4	60.9	60.9	---
2/8/2011	3:10 PM	65.8	65.8	63.4	39	40.1	0	---	0	0	---	65.8	63.1	63.1	---
2/8/2011	3:20 PM	67	67	65.9	37	39.9	0	---	0	0	---	67	64.1	64.1	---
2/8/2011	3:30 PM	67.4	67.4	67	37	40.2	0	---	0	0	---	67.4	64.6	64.6	---
2/8/2011	3:40 PM	67.2	67.5	67.2	37	40	0	---	0	0	---	67.2	64.4	64.4	---
2/8/2011	3:50 PM	67.1	67.2	67.1	37	39.9	0	---	0	0	---	67.1	64.3	64.3	---

Site Photographs

(a)

Figure XX. BMT3 Pictures (a) highway and location; (b) close-up of flushed surface before treatment; (c) roadway surface before treatment; (d) close-up of flushed surface immediately after treatment; (e) roadway surface after treatment; (f) close-up of surface at first follow-up ; (g) roadway surface at first follow-up , (h) roadway surface at second follow-up ; (i) close-up of surface at second follow-up , (j) close-up of surface at third follow-up ; (k) roadway surface at third follow-up

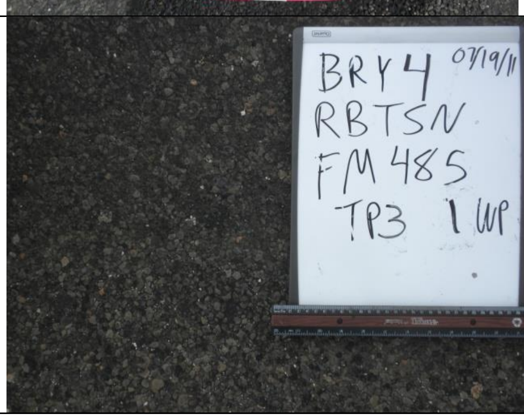
(b)

(c)

(d)

(e)

(f)



(g)

(h)	 BRY4 FM 485 CTM 16 IWP SPEED 6	(i)	 TP2
(j)	 UHP Water Cutter Monitoring 3: BRY4 - FM 485 ROBERTSON Co. 7-10-2012 TP1 - BWP	(k)	

APPENDIX D

SITE BRY 5

Milam COUNTY

Bryan DISTRICT

Site Description

Project Information			
District: Bryan	Test Site: BRY 5	County: Milam	Road: SH 36/US 190 EB
ADT: 7200	Truck Traffic: High	Year Built:	Last Maintained: 2010

Roadway Description
Aggregate Grade: Ty PL GR 5
Aggregate Type: Expanded Shale Lightweight
Pit: Texas Industries -Streetman
AQMP#: 1817502
CSJ: In House
CCSJ: Maintenance
Binder: AC 12-5TR
Pavement abnormalities: The pavement was heavily flushed along both wheel paths. The major aggregate appeared to be Grade 4 rock in a full width patch or seal coat.

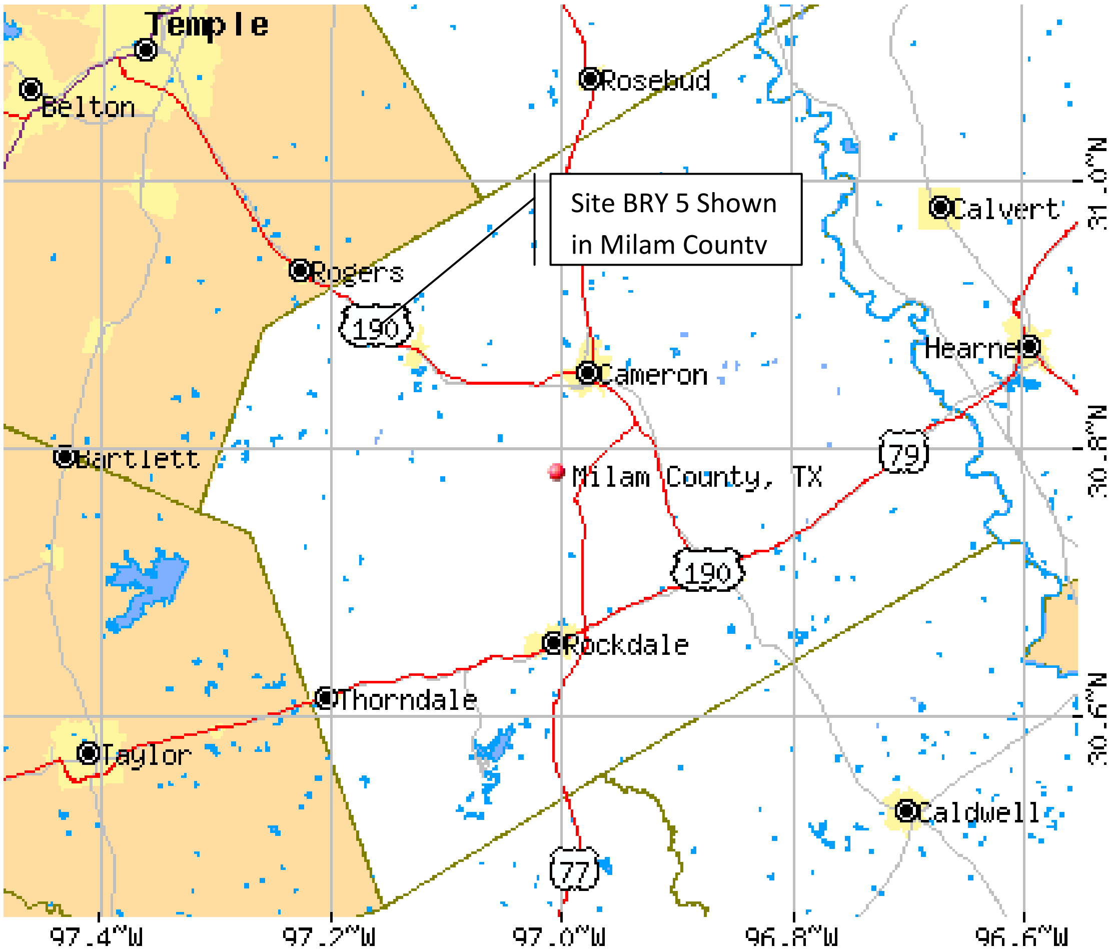
Research Test Summary		
Test Location: Rogers to Cameron	Closest Texas Reference Marker: 610	
Test Point GPS Coordinates	N	W
TP1	30°35.688'	095°55.304'
TP2	30°35.767'	095°55.225'
TP3	30°35.838'	095°55.149'

Ultra High Pressure Water Cutter Treatment Summary		
Date Treated 2/10/2011	Start Time 7:00 AM	End Time 3:30 PM

Summary Description of Treatment Activity
Personnel on site:
TechMRT: Andrew Tubb and Timothy Wood
Rampart: Bob Beadling and Jim Windich
TxDOT: Darlene Goehl (Bryan District), German Claros, David Rinn, Blain Laywell, Richard Vonzo (Malin County Maintenance Office Event Coordinator) and others from the Malin County Maintenance Office Traffic Control
Rampart configuration: Rampart used a 20 jet nozzle configuration: From the outside to center they ran 3 0.014in. jets, 7 0.011in. jets and 4 plugs. They ran the hydraulic pressure consistently from 33000psi to 34000psi.
Work Activities: TechMRT and Rampart participated in the morning meeting at the maintenance office at 7:00AM. Traffic control was not scheduled to be at the maintenance office until 8:00AM. TechMRT went straight to the Bryan Site 5 on US190/SH36.
TechMRT arrived on site at 7:40AM. The weather station was set up near TP3 at 7:45AM. From 7:50AM till 8:45AM TechMRT identified the test points and marked the speed test points. Traffic control for some reason did not arrive until 9:30AM. Traffic control was in place by 9:50AM. TechMRT performed all pretest from 9:55AM till 11:05AM.
TechMRT contacted Rampart at 10:05AM and instructed them to fill the truck based on rising pavement temperatures. Because of low water pressure at the maintenance office, Rampart was not

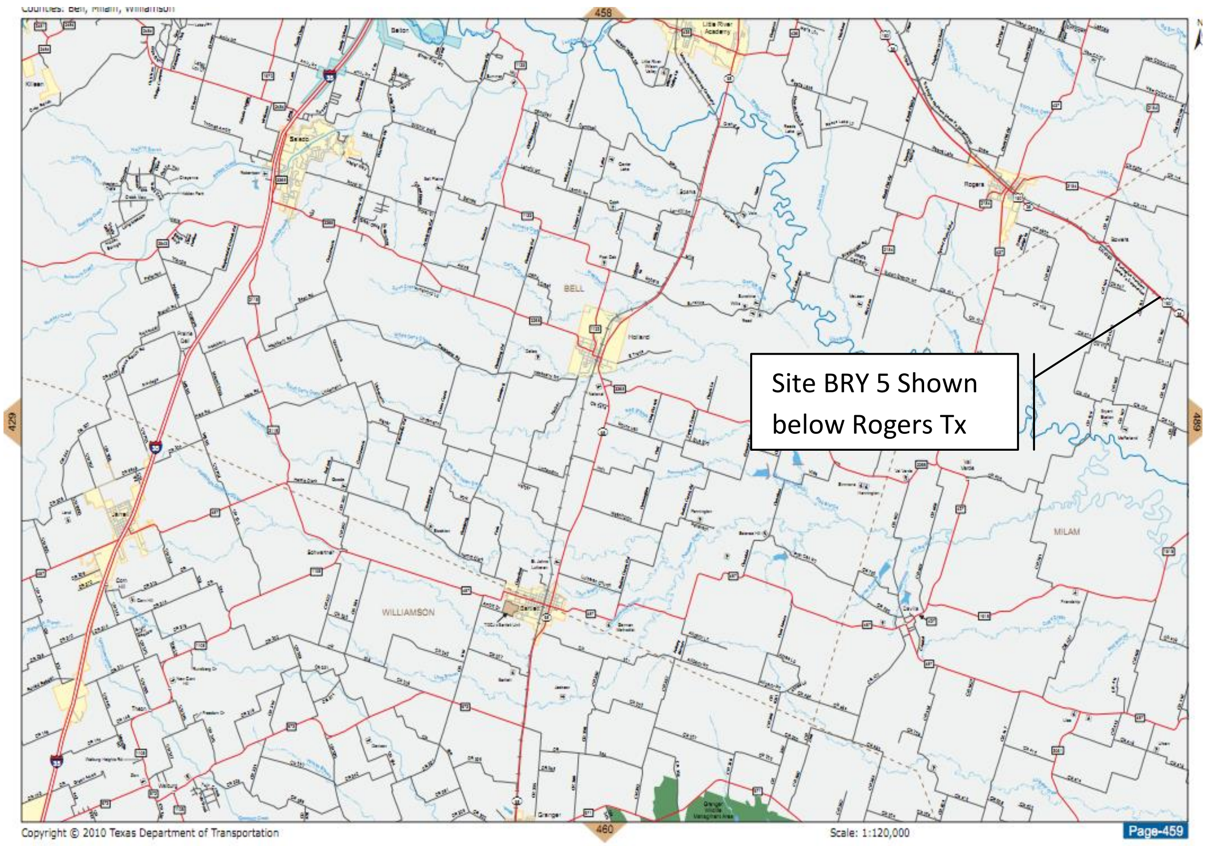
finished filling the truck till nearly 12:00PM. Rampart arrived at the 12:20PM. They de-winterized the truck and warmed up the hydraulic pumps. Work on the speed sections began at 12:50PM. Rampart was able complete the first 1/8mile speed pass. Half way through the second pass, the sprayer bar stopped spinning. Therefore Rampart stopped treating the roadway at 1:15PM. Rampart then worked to find and repair an electrical short which led them to identify a failed hydraulic actuator. They worked from 1:15PM till 3:30PM on the road. They then moved to the local maintenance yard to continue the work. They were able to repair the truck by 6:00PM. TechMRT did the post CTM testing on the treated speed sections, namely the outside wheel path in speed section 3 through 8. This took place from 3:00PM to 3:30PM. At 3:30PM TechMRT loaded the weather station and followed Rampart to the maintenance yard. After a short conference, TechMRT returned to the hotel. Once Rampart confirmed that the truck was operational, Darlene was informed that TechMRT would be ready for work on Friday morning.	
Comments	
Follow-On Testing Summary	
Date: 7/19/11	Comments: Preformed follow –up monitoring successfully.
Date: 1/11/12	Comments: Preformed follow –up monitoring successfully.
Date: 7/10/12	Comments: Preformed follow –up monitoring successfully.

Site Vicinity Map



http://www.city-data.com/

Site Location Map



http://www.txdot.gov/travel/county_grid_search.htm

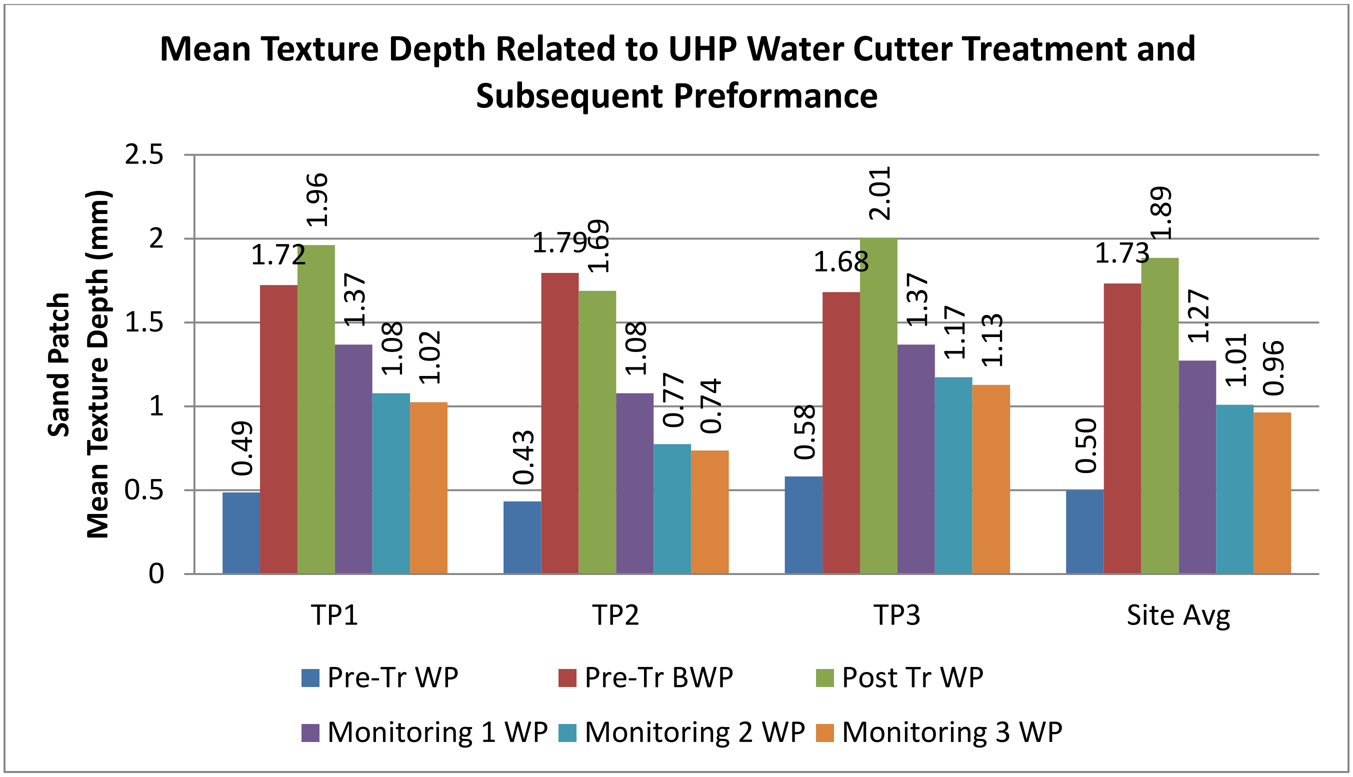
Aerial Photograph

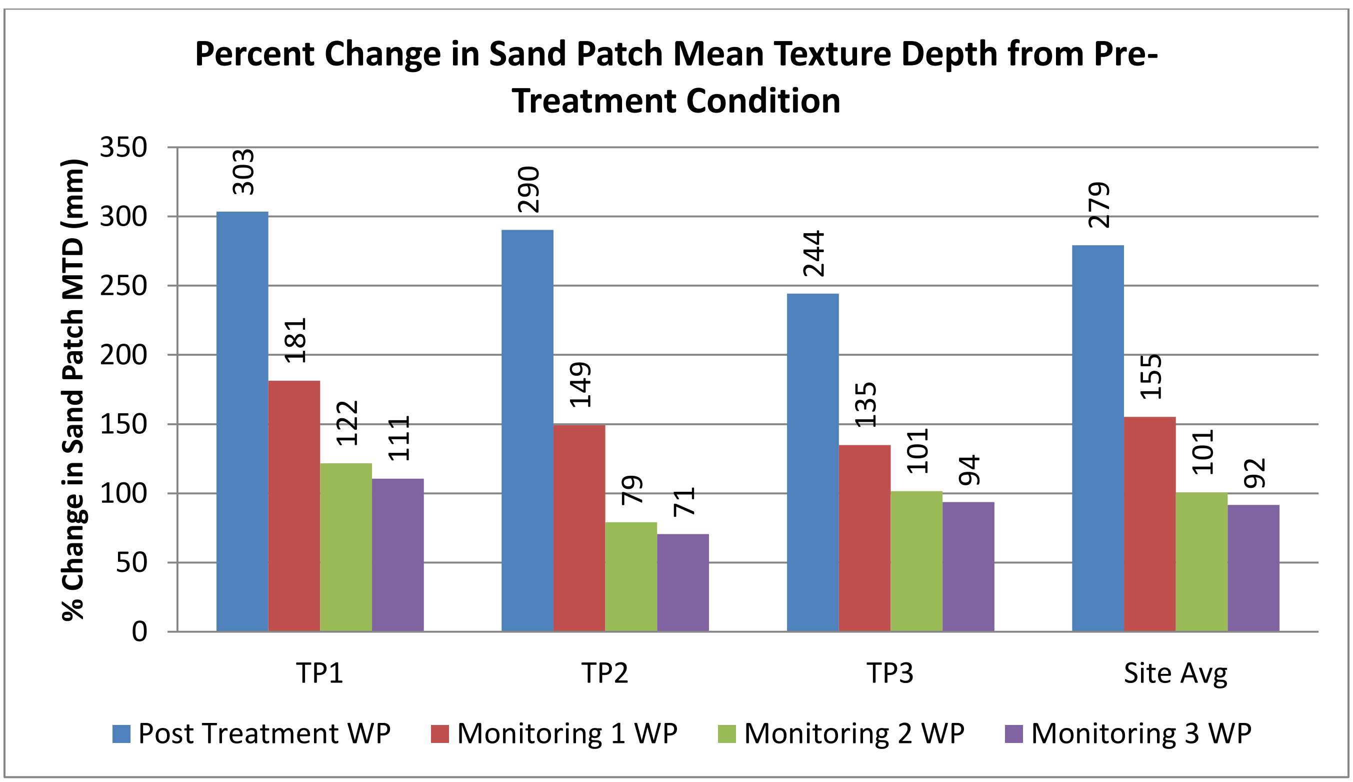
Google Inc. (2011). Google Earth (Version 6.1.0.5001)

Test Point Plan

Google Inc. (2011). Google Earth (Version 6.1.0.5001)

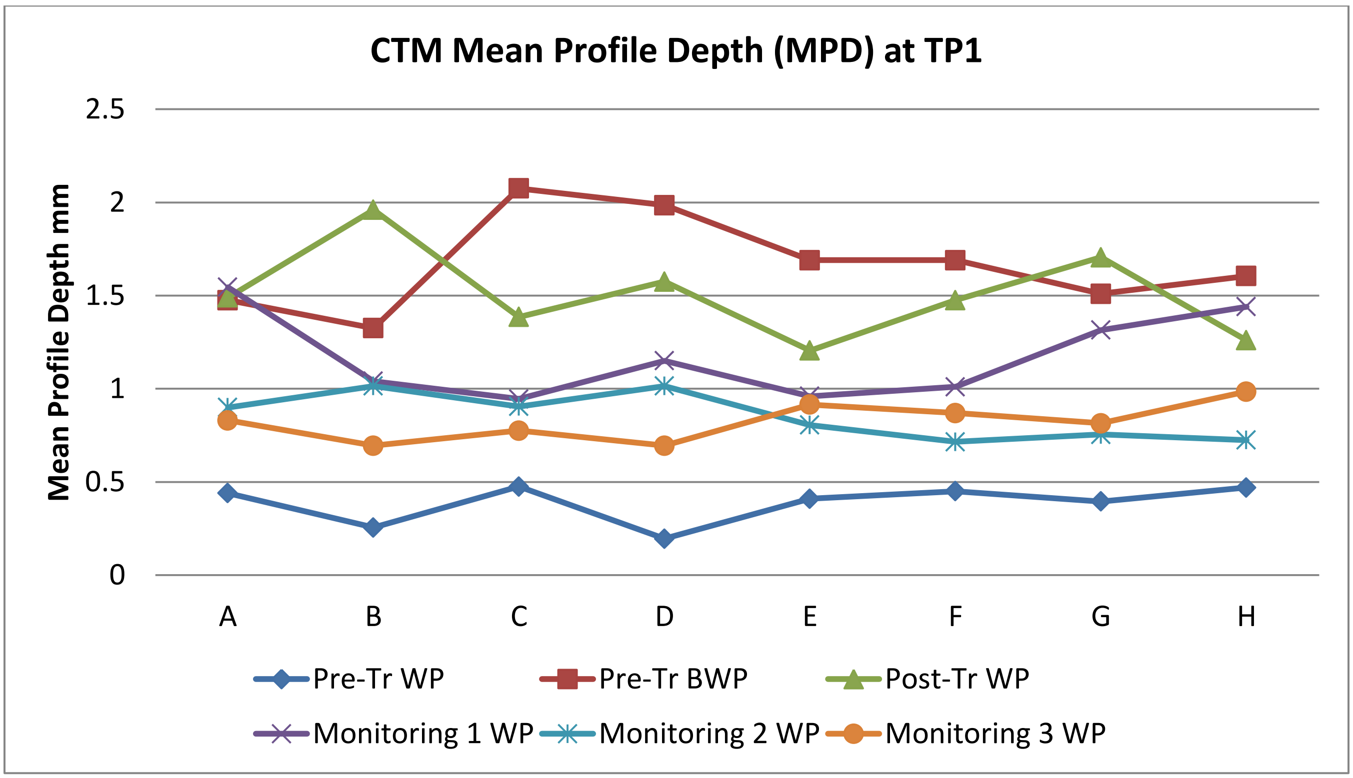
Sand Patch Data





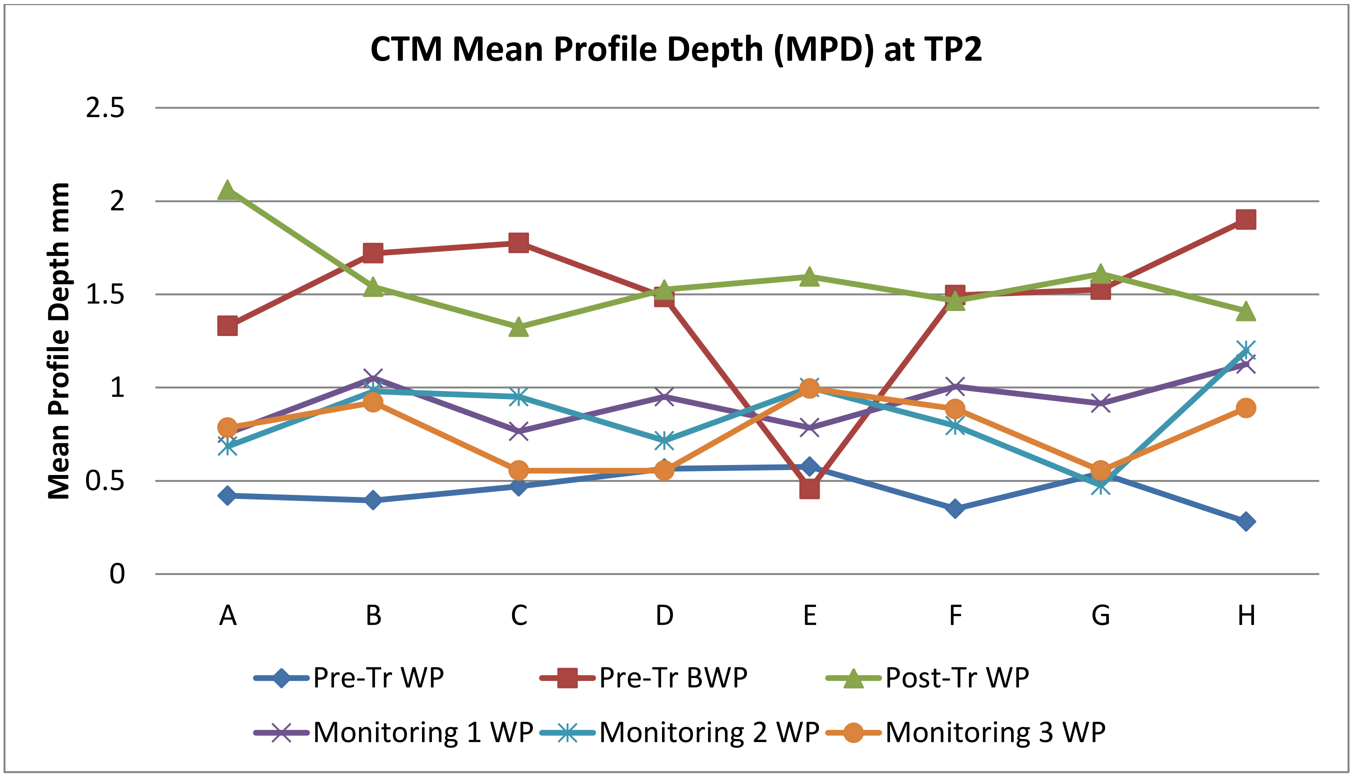
Circular Track Meter (CTM) Mean Profile Depth (in mm) at TP 1

	A	B	C	D	E	F	G	H
Pre-Tr WP	0.44	0.255	0.475	0.195	0.41	0.45	0.395	0.47
Pre-Tr BWP	1.475	1.325	2.075	1.985	1.69	1.69	1.51	1.605
Post-Tr	1.49	1.96	1.385	1.575	1.205	1.475	1.705	1.26
Monitoring 1	1.545	1.04	0.945	1.15	0.96	1.01	1.315	1.44
Monitoring 2	0.9	1.015	0.905	1.015	0.805	0.715	0.755	0.725
Monitoring 3	0.83	0.695	0.775	0.695	0.915	0.87	0.815	0.985



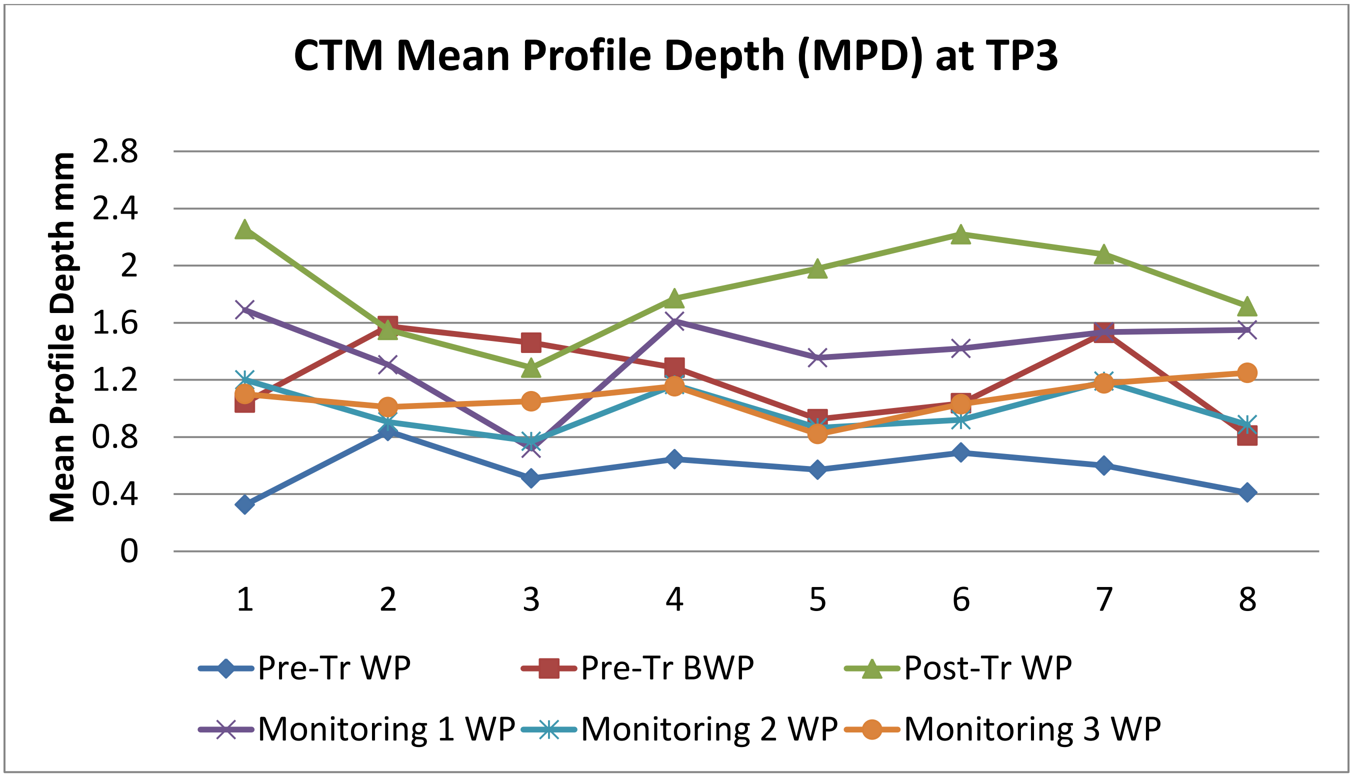
Circular Track Meter (CTM) Mean Profile Depth (in mm) at TP 2

	A	B	C	D	E	F	G	H
Pre-Tr WP	0.42	0.395	0.47	0.565	0.575	0.35	0.54	0.28
Pre-Tr BWP	1.33	1.72	1.775	1.485	0.455	1.495	1.525	1.9
Post-Tr	2.06	1.54	1.325	1.525	1.595	1.465	1.61	1.41
Monitoring 1	0.755	1.05	0.765	0.95	0.785	1.005	0.915	1.125
Monitoring 2	0.685	0.98	0.95	0.715	1	0.795	0.475	1.2
Monitoring 3	0.785	0.92	0.555	0.555	0.995	0.885	0.555	0.89

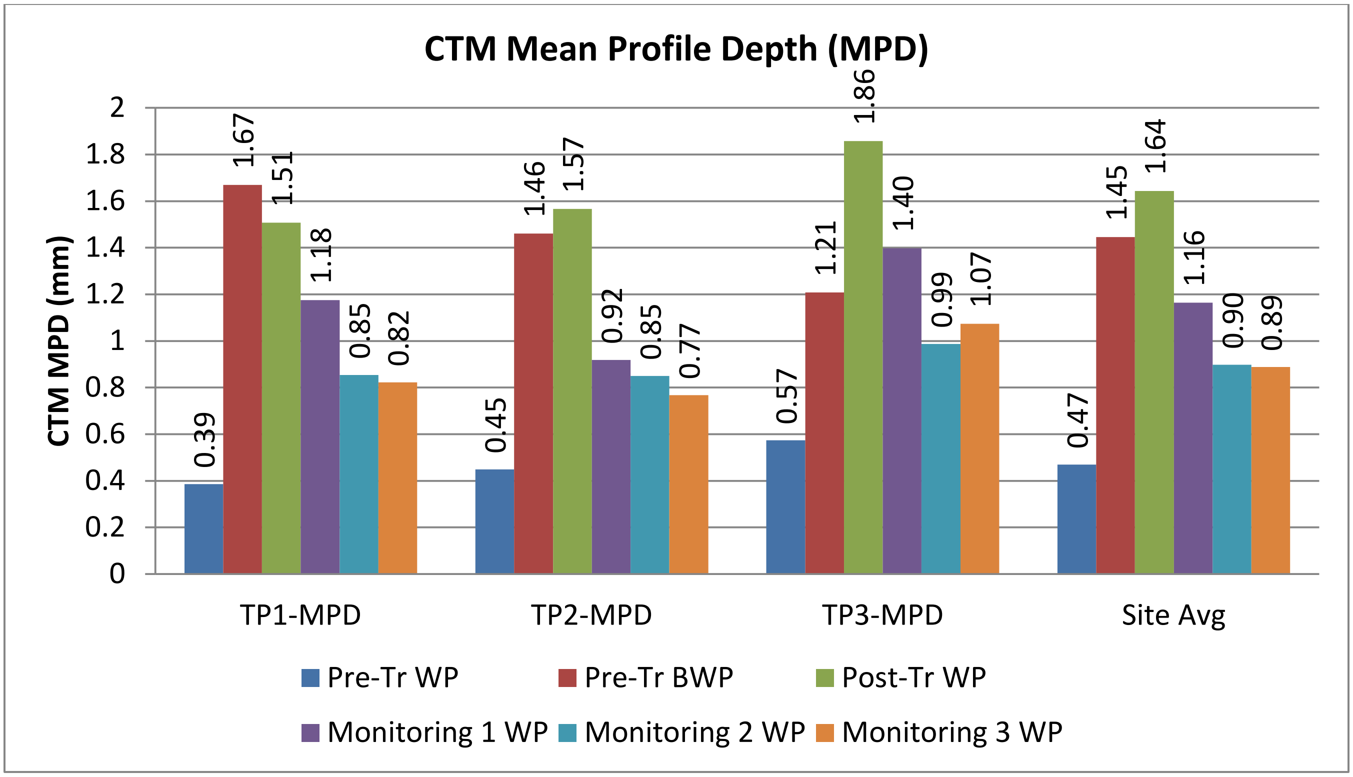


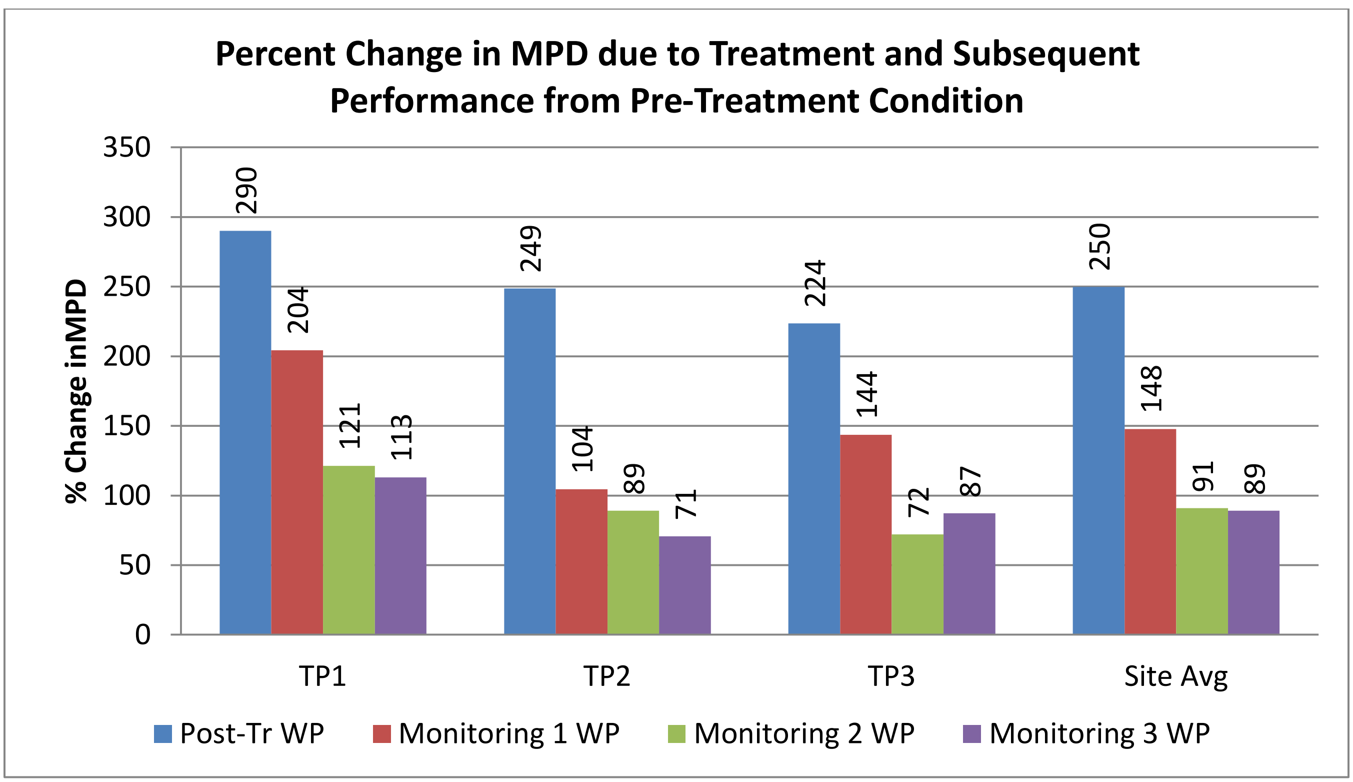
Circular Track Meter (CTM) Mean Profile Depth (in mm) at TP 3

	A	B	C	D	E	F	G	H
Pre-Tr WP	0.325	0.84	0.51	0.645	0.57	0.69	0.6	0.41
Pre-Tr BWP	1.04	1.575	1.46	1.285	0.925	1.035	1.53	0.81
Post-Tr	2.255	1.55	1.285	1.77	1.98	2.22	2.08	1.715
Monitoring 1	1.69	1.305	0.72	1.61	1.355	1.42	1.535	1.55
Monitoring 2	1.2	0.905	0.77	1.165	0.865	0.92	1.19	0.885
Monitoring 3	1.1	1.01	1.05	1.155	0.82	1.03	1.175	1.25

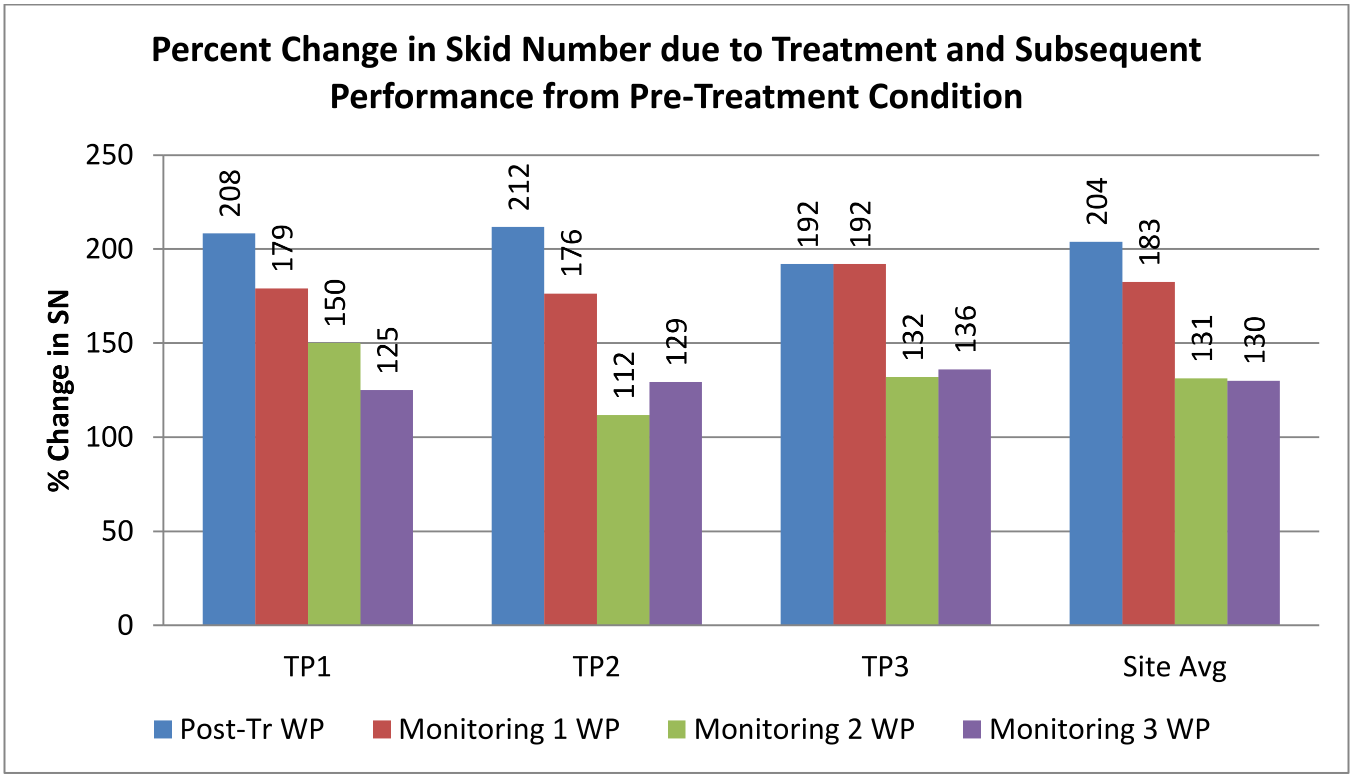


Circular Track Meter (CTM) MPD (mm)



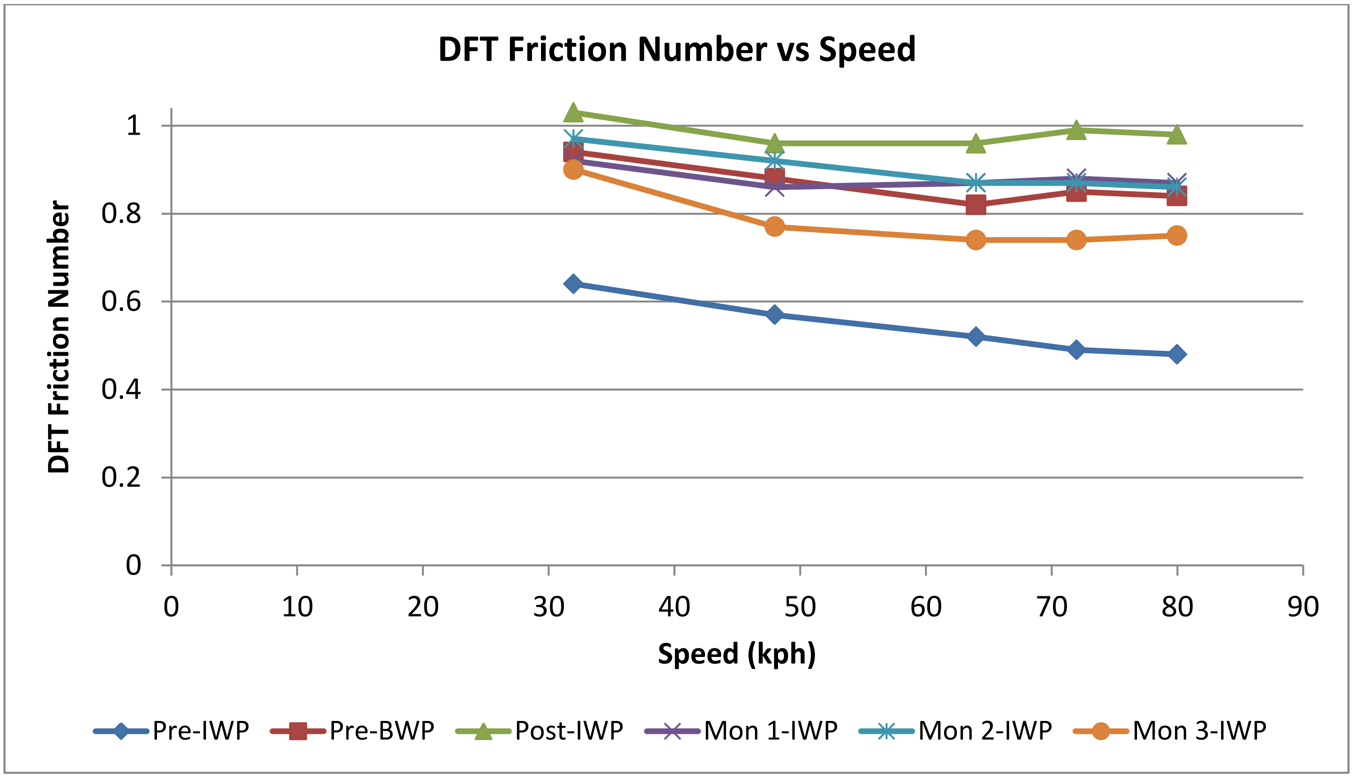


Skid Truck Data



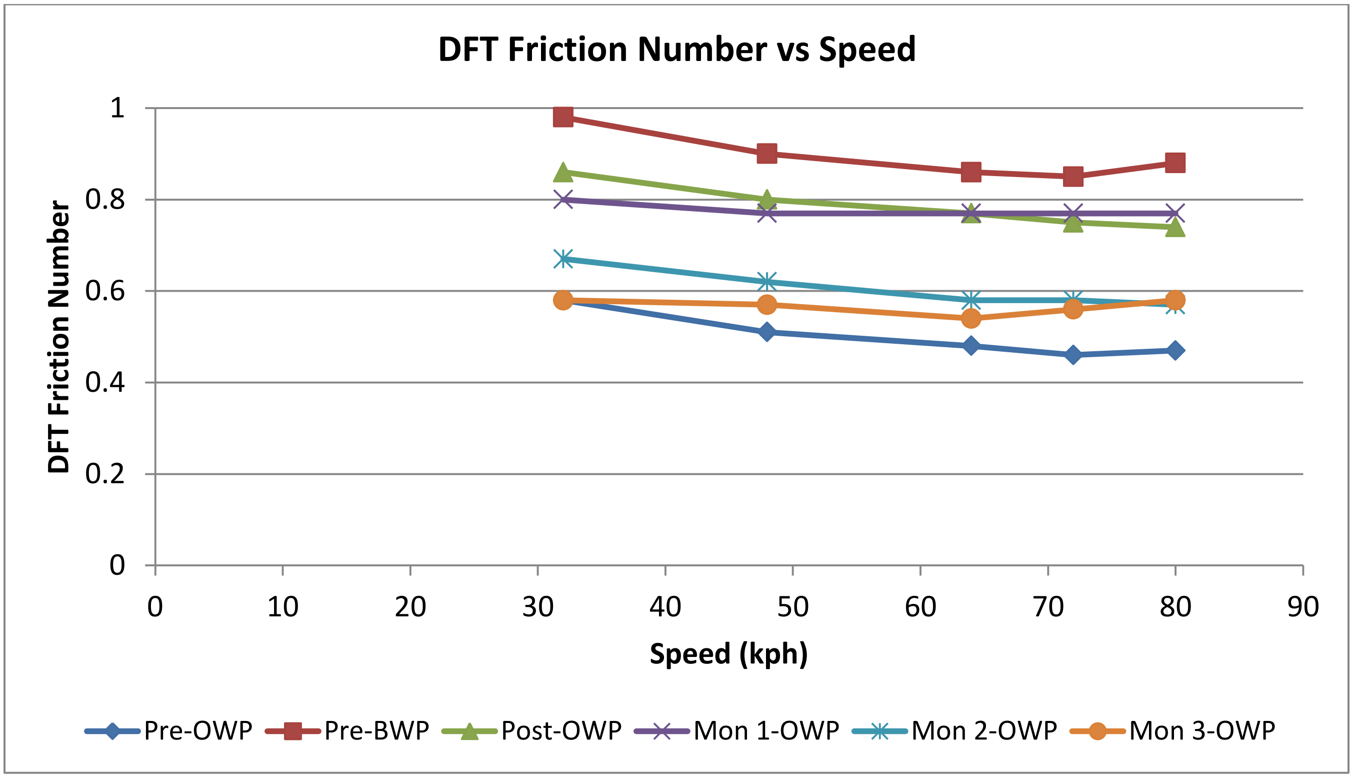
Dynamic Friction Test (DFT) Friction Number Data for TP 1

Speed (kph)	Pre-IWP	Pre-BWP	Post-IWP	Mon 1-IWP	Mon 2-IWP	Mon 3-IWP
32	0.64	0.94	1.03	0.92	0.97	0.9
48	0.57	0.88	0.96	0.86	0.92	0.77
64	0.52	0.82	0.96	0.87	0.87	0.74
72	0.49	0.85	0.99	0.88	0.87	0.74
80	0.48	0.84	0.98	0.87	0.86	0.75



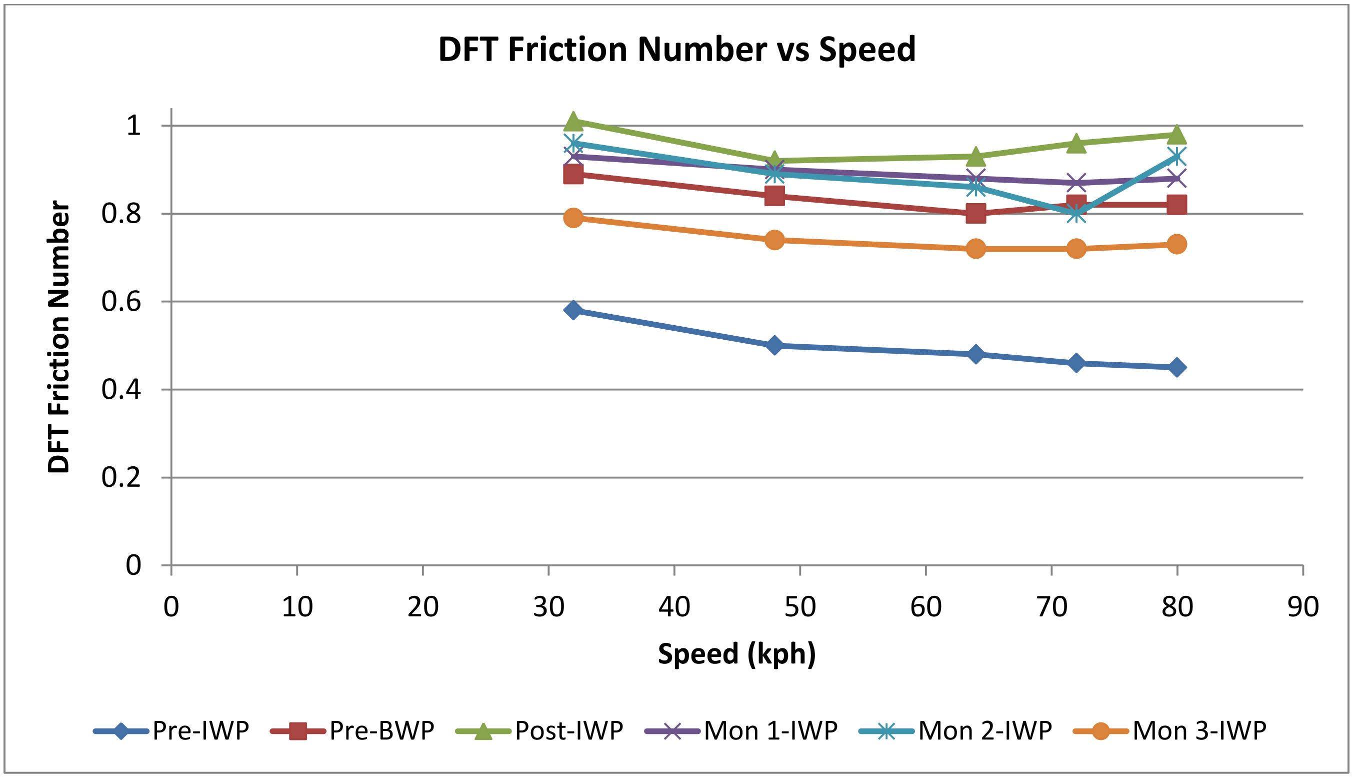
Dynamic Friction Test (DFT) Friction Number Data for TP 2

Speed (kph)	Pre-OWP	Pre-BWP	Post-OWP	Mon 1-OWP	Mon 2-OWP	Mon 3-OWP
32	0.58	0.98	0.86	0.8	0.67	0.58
48	0.51	0.9	0.8	0.77	0.62	0.57
64	0.48	0.86	0.77	0.77	0.58	0.54
72	0.46	0.85	0.75	0.77	0.58	0.56
80	0.47	0.88	0.74	0.77	0.57	0.58



Dynamic Friction Test (DFT) Friction Number Data for TP 3

Speed (kph)	Pre-IWP	Pre-BWP	Post-IWP	Mon 1-IWP	Mon 2-IWP	Mon 3-IWP
32	0.58	0.89	1.01	0.93	0.96	0.79
48	0.5	0.84	0.92	0.9	0.89	0.74
64	0.48	0.8	0.93	0.88	0.86	0.72
72	0.46	0.82	0.96	0.87	0.8	0.72
80	0.45	0.82	0.98	0.88	0.93	0.73



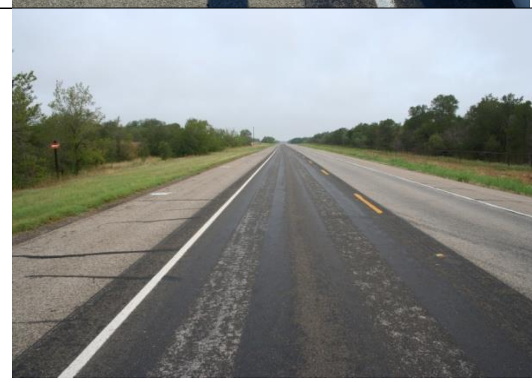
Weather Data during UHP Water Cutter Treatment

Date	Time	Temp Out	Hi Temp	Low Temp	Out Hum	Dew Pt.	Wind Speed	Wind Dir	Wind Run	Hi Speed	Hi Dir	Wind Chill	Heat Index	THW Index	THSW Index
2/10/2011	7:50 AM	29.7	40.7	29.7	39	7.7	0	NE	0	4	ENE	29.7	28.7	28.7	---
2/10/2011	8:00 AM	19.7	29.2	19.7	59	7.7	5	NW	0.83	10	NNW	12.6	19.3	12.2	---
2/10/2011	8:10 AM	19.6	19.7	19.4	62	8.7	6	NW	1	9	NW	11.5	19.2	11.1	---
2/10/2011	8:20 AM	20	20	19.6	62	9.1	6	NNW	1	12	NW	11.9	19.6	11.5	---
2/10/2011	8:30 AM	20.4	20.5	20	61	9.1	7	NW	1.17	13	NNW	11.5	20	11.1	---
2/10/2011	8:40 AM	21	21	20.5	61	9.6	6	NW	1	13	NNW	13.1	20.5	12.6	---
2/10/2011	8:50 AM	21.7	21.7	21.1	60	9.9	6	NNW	1	11	NW	14	21.2	13.5	---
2/10/2011	9:00 AM	22.1	22.1	21.7	59	9.9	7	NW	1.17	12	NNW	13.6	21.6	13.1	---
2/10/2011	9:10 AM	22.4	22.5	22.1	59	10.2	7	NNW	1.17	14	NW	13.9	21.9	13.4	---
2/10/2011	9:20 AM	22.9	23.1	22.4	59	10.7	6	NW	1	11	NNW	15.4	22.4	14.9	---
2/10/2011	9:30 AM	23.6	23.6	22.9	58	11	6	N	1	11	NNW	16.2	23.1	15.7	---
2/10/2011	9:40 AM	24.1	24.1	23.5	59	11.8	6	NNW	1	13	NNW	16.8	23.6	16.3	---
2/10/2011	9:50 AM	24.9	24.9	24.2	59	12.6	6	NW	1	12	NW	17.8	24.4	17.3	---
2/10/2011	10:00 AM	25.4	25.4	24.8	57	12.3	6	NNW	1	11	NW	18.4	24.8	17.8	---
2/10/2011	10:10 AM	25.3	25.6	25.3	58	12.6	6	N	1	11	NW	18.3	24.7	17.7	---
2/10/2011	10:20 AM	26.2	26.2	25.3	58	13.4	7	NNW	1.17	13	NW	18.5	25.6	17.9	---
2/10/2011	10:30 AM	27.1	27.1	26.2	60	15	5	NNW	0.83	11	WNW	21.3	26.5	20.7	---
2/10/2011	10:40 AM	27.2	27.2	27	58	14.4	6	NNW	1	11	NNW	20.5	26.6	19.9	---
2/10/2011	10:50 AM	27.8	27.8	27.2	59	15.3	6	NNW	1	12	NW	21.2	27.2	20.6	---
2/10/2011	11:00 AM	28.2	28.3	27.8	58	15.3	5	NNE	0.83	10	NNW	22.6	27.6	22	---
2/10/2011	11:10 AM	28.8	29	28.2	57	15.5	5	NNW	0.83	11	NW	23.3	28.1	22.6	---
2/10/2011	11:20 AM	29.3	29.4	28.7	56	15.5	6	NNW	1	11	NW	23	28.6	22.3	---
2/10/2011	11:30 AM	30.2	30.2	29.3	56	16.4	6	NW	1	12	NW	24.1	29.5	23.4	---
2/10/2011	11:40 AM	30.3	30.4	29.9	54	15.6	6	N	1	11	NW	24.2	29.5	23.4	---
2/10/2011	11:50 AM	31	31	30.1	55	16.7	5	NNW	0.83	11	ENE	25.9	30.2	25.1	---
2/10/2011	12:00 PM	32.5	32.5	31	53	17.2	6	NW	1	12	NNW	26.8	31.7	26	---

2/10/2011	12:10 PM	31.5	32.5	31.5	55	17.2	6	NNW	1	13	NW	25.6	30.7	24.8	---
2/10/2011	12:20 PM	32.2	32.2	31.4	54	17.4	5	NNW	0.83	10	N	27.3	31.4	26.5	---
2/10/2011	12:30 PM	32.2	32.5	32.2	53	17	6	NNW	1	11	NNW	26.5	31.4	25.7	---
2/10/2011	12:40 PM	33.4	33.4	32.2	53	18.1	5	N	0.83	16	WNW	28.7	32.6	27.9	---
2/10/2011	12:50 PM	34.4	34.5	33.3	52	18.6	5	NNW	0.83	11	NW	29.9	33.5	29	---
2/10/2011	1:00 PM	34.5	34.5	33.9	54	19.5	5	N	0.83	10	N	30	33.7	29.2	---
2/10/2011	1:10 PM	34.5	35.1	34.5	51	18.2	4	N	0.67	9	NNE	31	33.6	30.1	---
2/10/2011	1:20 PM	34.7	34.8	34.3	51	18.4	5	NW	0.83	10	N	30.2	33.8	29.3	---
2/10/2011	1:30 PM	35.4	35.5	34.6	50	18.6	6	NNW	1	11	NNW	30.3	34.5	29.4	---
2/10/2011	1:40 PM	35.3	35.5	34.9	49	18	6	NW	1	13	NW	30.2	34.3	29.2	---
2/10/2011	1:50 PM	36.3	36.3	35.3	50	19.4	5	NNW	0.83	11	NNW	32.1	35.3	31.1	---
2/10/2011	2:00 PM	36.8	36.9	36.1	48	18.9	5	NNW	0.83	12	NNW	32.7	35.8	31.7	---
2/10/2011	2:10 PM	36.6	37	36.4	49	19.2	5	NNW	0.83	10	NNE	32.5	35.6	31.5	---
2/10/2011	2:20 PM	37.3	37.6	36.6	49	19.9	4	NW	0.67	11	NE	34.2	36.3	33.2	---
2/10/2011	2:30 PM	37.1	37.7	37.1	48	19.2	5	NNW	0.83	10	NNW	33.1	36.1	32.1	---
2/10/2011	2:40 PM	37.7	37.7	36.8	48	19.8	5	NW	0.83	11	NW	33.8	36.7	32.8	---
2/10/2011	2:50 PM	38	38	37.7	48	20	5	N	0.83	11	NNW	34.1	37	33.1	---
2/10/2011	3:00 PM	38.2	38.7	37.8	45	18.7	5	NNW	0.83	9	NNW	34.4	37.1	33.3	---
2/10/2011	3:10 PM	38.4	38.4	37.8	48	20.4	5	NW	0.83	9	NNW	34.6	37.3	33.5	---
2/10/2011	3:20 PM	38.2	38.4	38	47	19.7	5	NNW	0.83	10	NW	34.4	37.1	33.3	---
2/10/2011	3:30 PM	39.1	39.3	38.2	46	20	4	NNW	0.67	10	NNW	36.3	37.9	35.1	---
2/10/2011	3:40 PM	38.7	39.1	38.4	46	19.7	4	NNW	0.67	7	NNW	35.8	37.6	34.7	---
2/10/2011	3:50 PM	44.1	44.1	38.7	48	25.6	1	NNW	0.17	9	NW	44.1	42.9	42.9	---

Site Photographs

<table>
<tr><td>(a)</td><td>
</td><td></td><td>Figure XX. BMT3 Pictures (a) highway and location; (b) close-up of flushed surface before treatment; (c) roadway surface before treatment; (d) close-up of flushed surface immediately after treatment; (e) roadway surface after treatment; (f) close-up of surface at first follow-up ; (g) roadway surface at first follow-up , (h) roadway surface at second follow-up ; (i) close-up of surface at second follow-up , (j) close-up of surface at third follow-up ; (k) roadway surface at third follow-up</td></tr>
<tr><td>(b)</td><td>
</td><td>(c)</td><td></td></tr>
<tr><td>(d)</td><td>
</td><td>(e)</td><td></td></tr>
<tr><td>(f)</td><td>
</td><td>(g)</td><td></td></tr>
</table>

(h)		(i)	
(j)		(k)	

APPENDIX E

SITE BRY 7

Grimes COUNTY

Bryan DISTRICT

Site Description

Project Information			
District: Bryan	Test Site: BRY 7	County: Grimes	Road: SH 90 SB
ADT: 510	Truck Traffic: Medium-High	Year Built:	Last Maintained: 2010

Roadway Description
Aggregate Grade: Ty PL GR 6
Aggregate Type: Expanded Shale Lightweight
Pit: Texas Industries -Streetman
AQMP#: 1817502
CSJ: 0315-03-051
CCSJ: 0049-14-009
Binder: AC 20-5TR

Pavement abnormalities:
The pavement was light to moderately flushed in both wheel paths. Flushing was variable along the length of the section. The major aggregate appeared to be Grade 3 rock in a full width seal coat. The seal coat included tire rubber and had been placed in the summer of 2010. The section is centered at the top of hill with moderate grades on either side. When treated with the UPH water cutter, sticky, stringy, gummy clumps of road materials were left behind. The majority of the clumps were swept off the road with a broom truck as soon as the treatment was completed. Even though a great deal of material was left on the road, the Rampart truck still collected a great deal of solid waste. The sticker texture of the trimmings is believed to be related to the very young age of the strip seal.

Research Test Summary		
Test Location: FM 149 to SH 6 (Navasota)	Closest Texas Reference Marker: 430	
Test Point GPS Coordinates	N	W
TP1	31°00.000'	096°33.664'
TP2	31°00.042'	096°33.550'
TP3	31°00.082'	096°33.448'

Ultra High Pressure Water Cutter Treatment Summary		
Date Treated 2/11/2011	Start Time 7:55 AM	End Time 3:40 PM

Summary Description of Treatment Activity

Personnel on site:
TechMRT: Andrew Tubb and Timothy Wood
Rampart: Bob Beadling and Jim Windich
TxDOT: Darlene Goehl (Bryan District), Carl Shaoder (Grimes County Maintenance Office Event Coordinator) and others from the Grimes County Maintenance Office Traffic Control

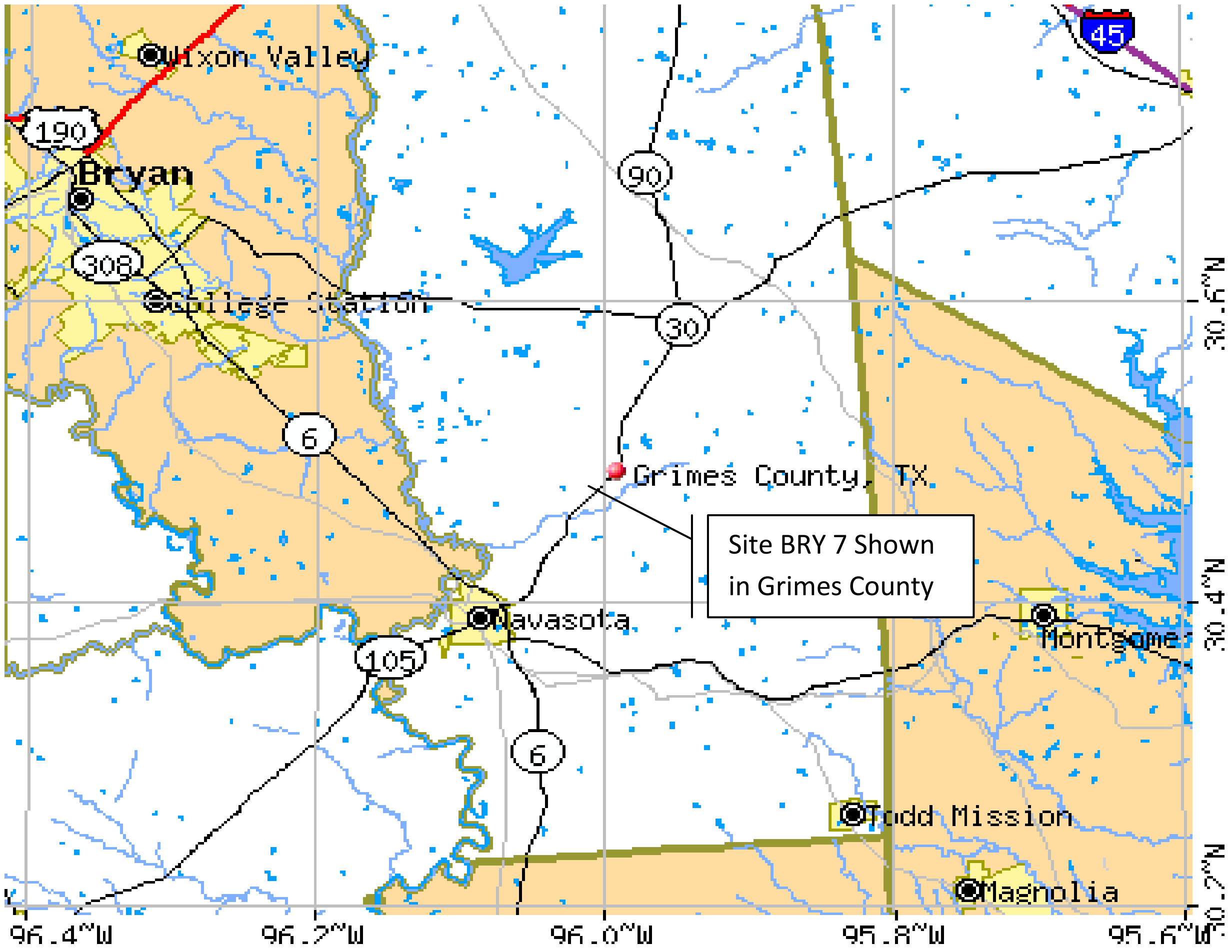
Rampart configuration: Rampart used a 20 jet nozzle configuration: From the outside to center they ran 2 0.014in. jets, 6 0.011in. jets and 6 0.009in. jets. They ran the hydraulic pressure at 32,000psi when running uphill and 34,000psi running downhill.

Work Activities: TechMRT and Rampart were at the maintenance office before 7:00AM. TechMRT and Rampart participated in the morning meeting and a short discussion with Darlene and Carl at the maintenance office at 7:30AM. TechMRT went straight to the Bryan Site 7 on SH90.
TechMRT arrived on site at 7:55AM. However Darlene had indicated some interest in treating the

eastbound rather than the westbound lane. At 8:10AM, traffic control arrived with Carl who confirmed the decision to treat the east bound lane. From 8:15AM till 8:45AM TechMRT setup the weather station at TP1 and remarked all test points and the speed sections for the eastbound lane. Because the test lane had been changed the test points and speed sections were labeled counter to the traffic direction. TechMRT performed all pretest from 8:45AM till 9:45AM. From 9:50AM till 10:05AM, a walking video tour was taken of the site before treatment to catalogue the variation in flushing along the site. Rampart was present at the site beginning at 9:00AM. They treated the whole section from 10:15AM till 12:10PM. As mentioned in the discussion of the pavement, the treatment left behind sticky balls of asphalt which were immediately swept from the pavement with a broom truck. They left to empty the truck from 12:25PM till 1:10PM. TechMRT performed all post testing from 12:25PM till 1:10PM. This took longer because the low wind conditions left the road wet after treatment. Therefore TechMRT had to dry each section before performing the CTM and sand patch. The weather station was packed at 1:20PM. At this point it was decided to relocate the traffic control to the first curve on SH90 outside of the Navasota city limits. Rampart then treated both lanes for a little over 1000ft from 2:05PM till 3:40PM. At 3:50PM Rampart and TechMRT returned to Bryan. Darlene also suggested that TechMRT should consider getting at 3ft level and taking pictures which show that the treatment merely removes excess asphalt but does not cause rutting or ponding.
Comments

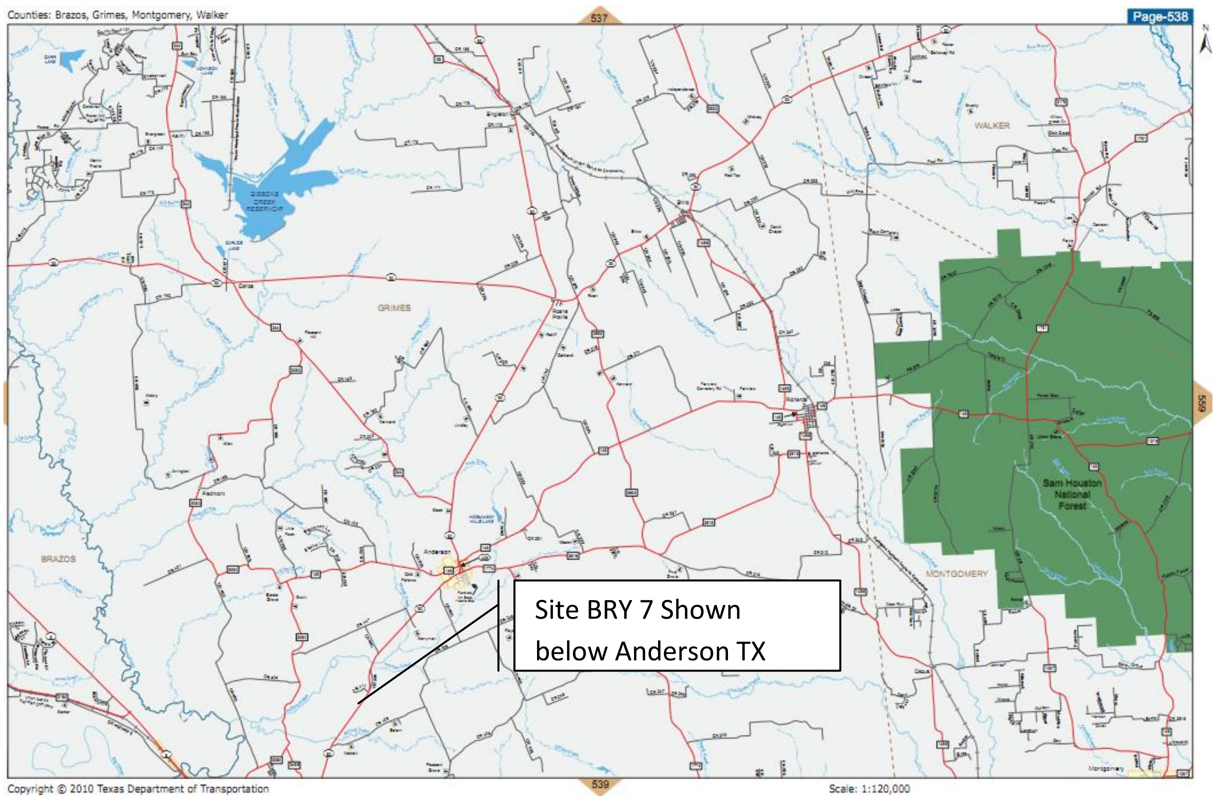
Follow-On Testing Summary	
Date: 7/20/11	Comments: Preformed follow –up monitoring successfully.
Date: 1/12/12	Comments: Preformed follow –up monitoring successfully.
Date	Comments: No follow-up monitoring was performed due to reoccurrence of flushing therefore seal coat treatment was necessary.

Site Vicinity Map



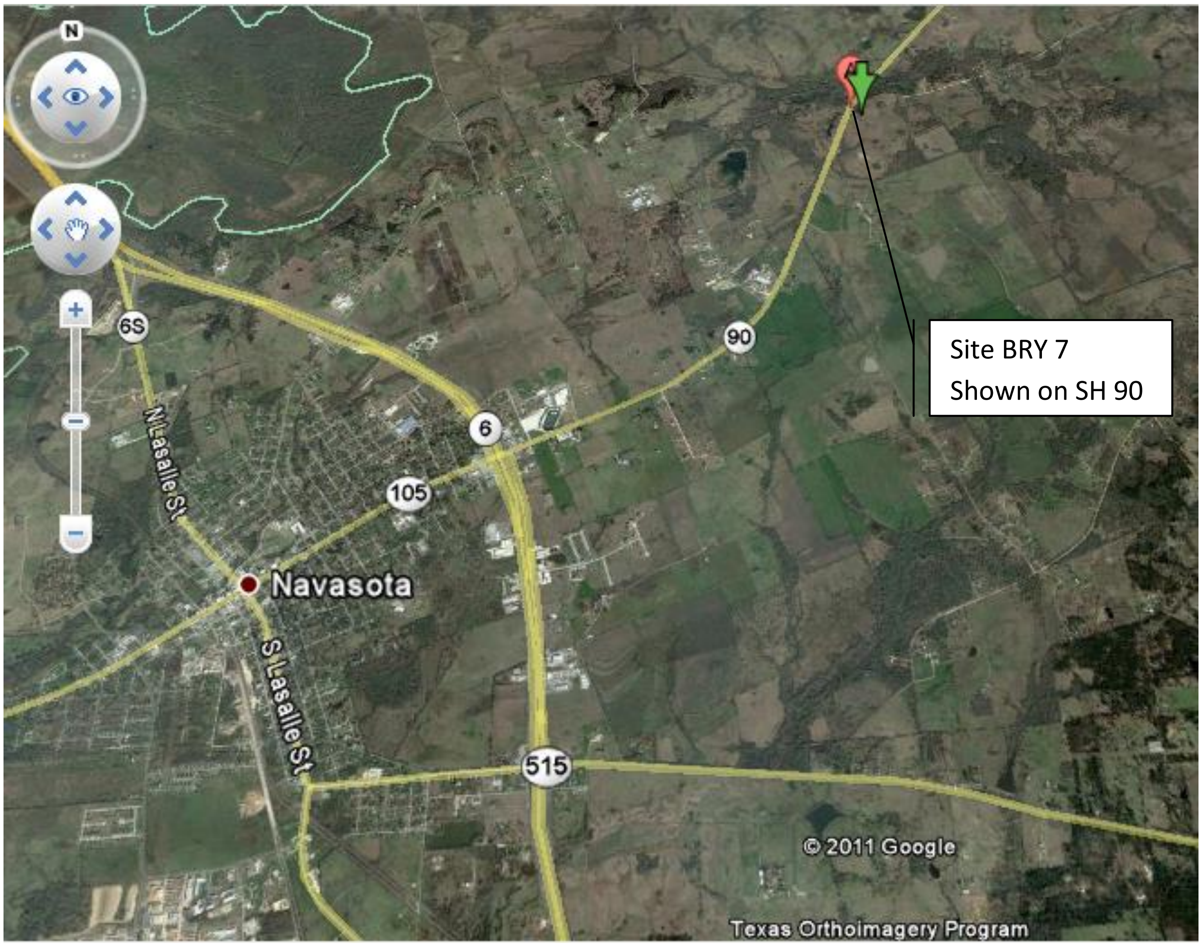
http://www.city-data.com/

Site Location Map



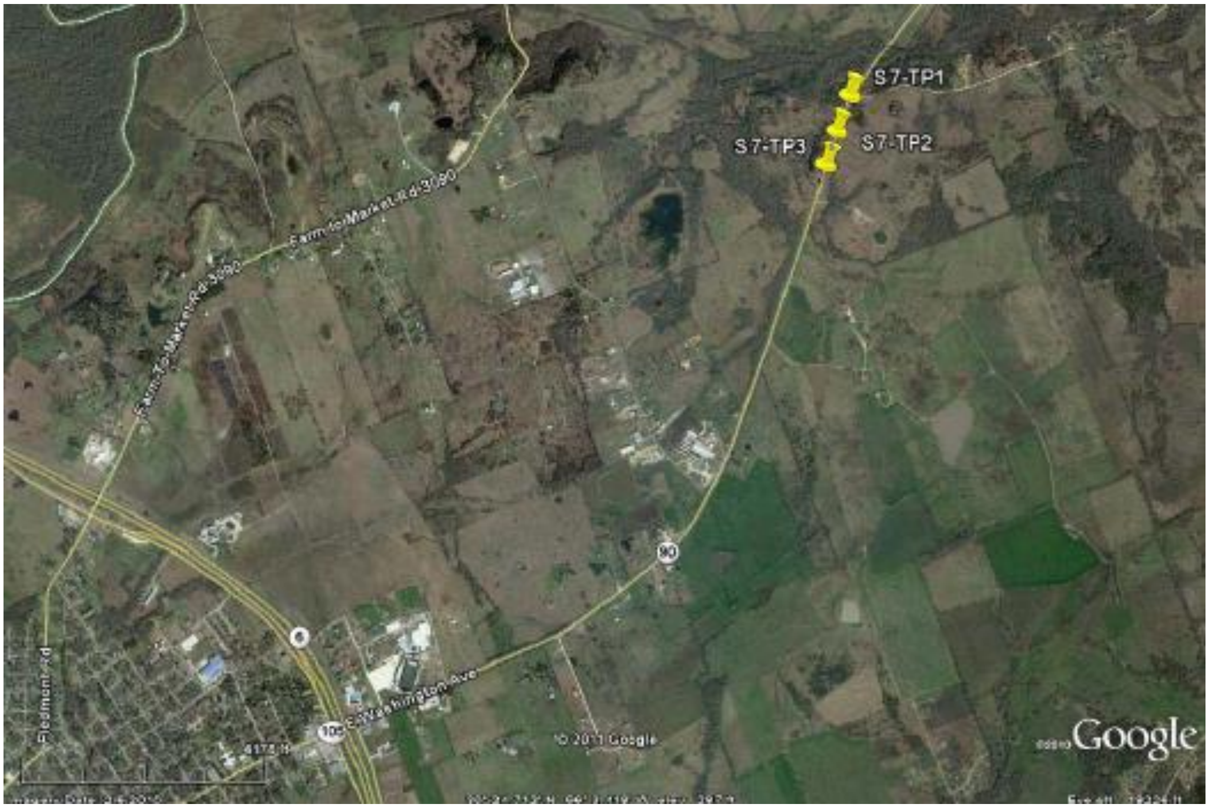
http://www.txdot.gov/travel/county_grid_search.htm

Aerial Photograph



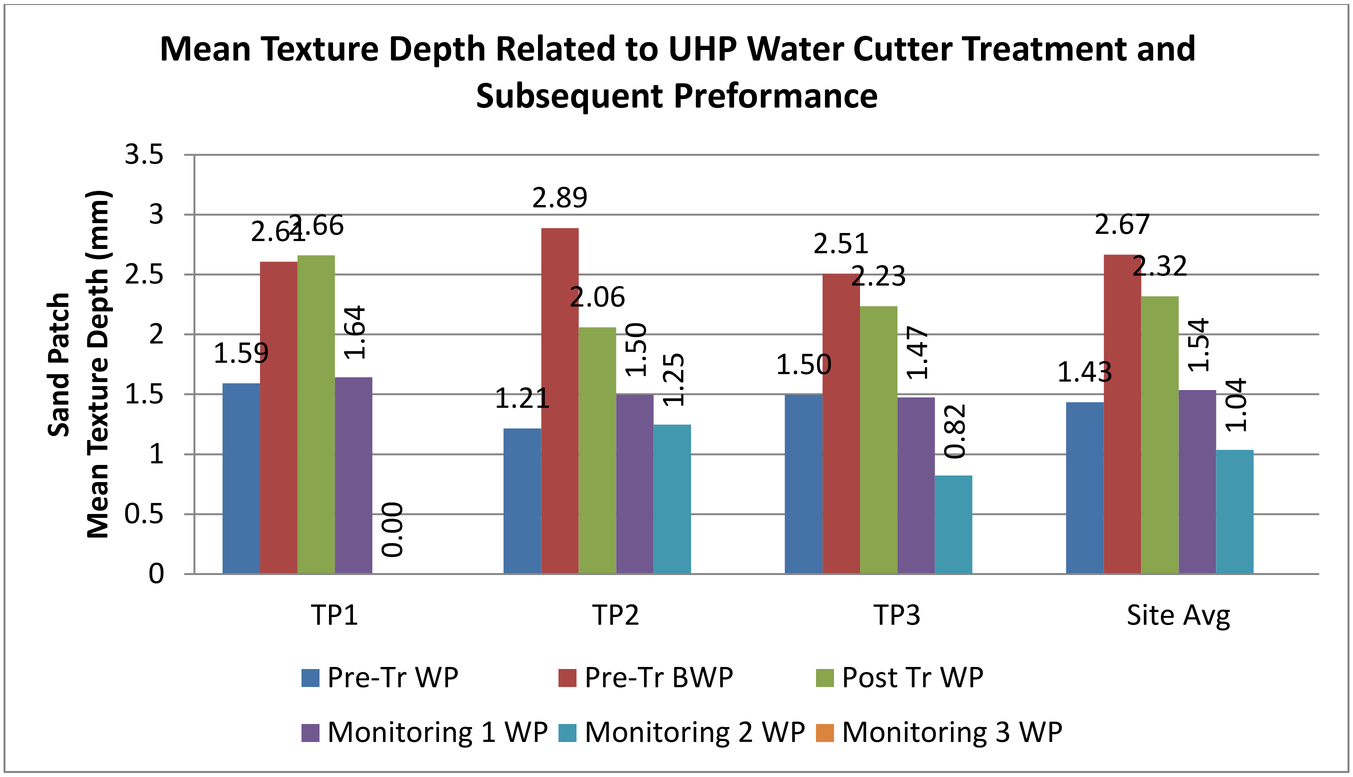
Google Inc. (2011). Google Earth (Version 6.1.0.5001)

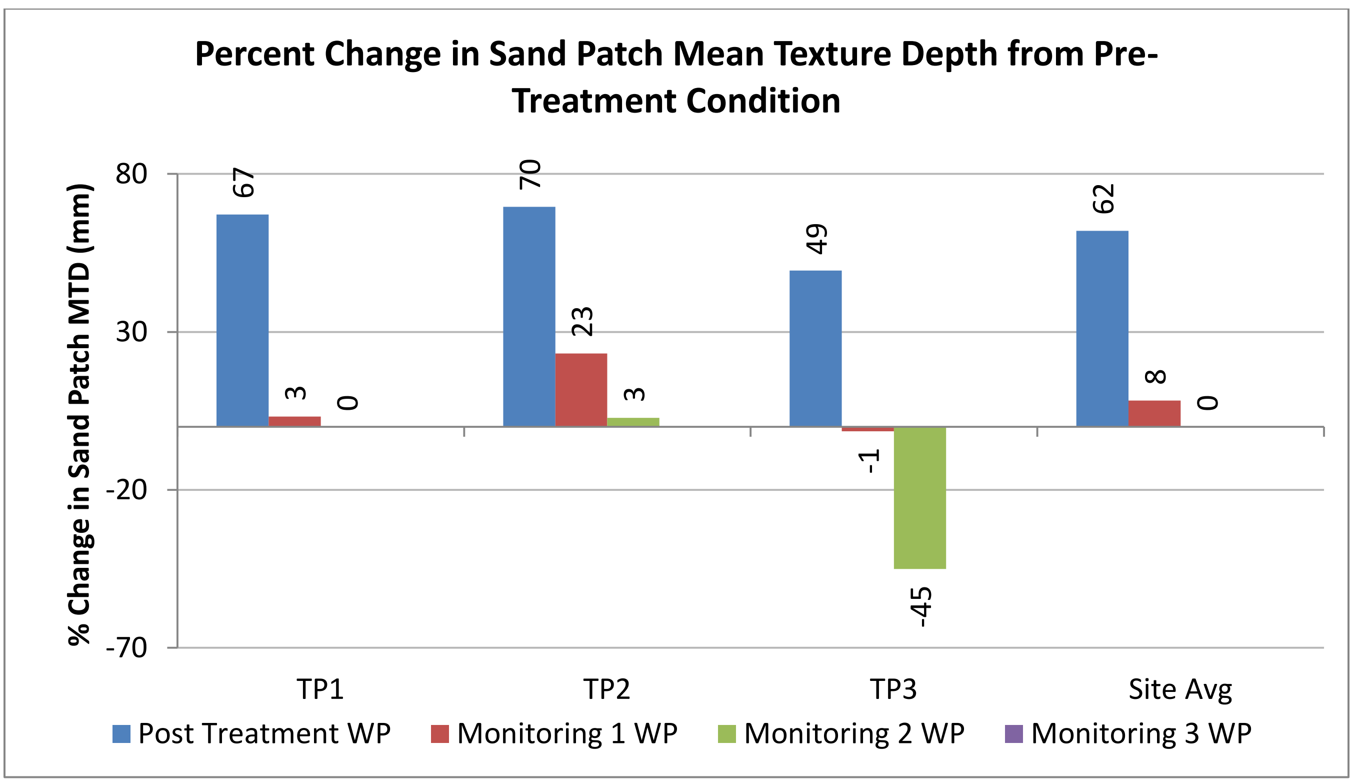
Test Point Plan



Google Inc. (2011). Google Earth (Version 6.1.0.5001)

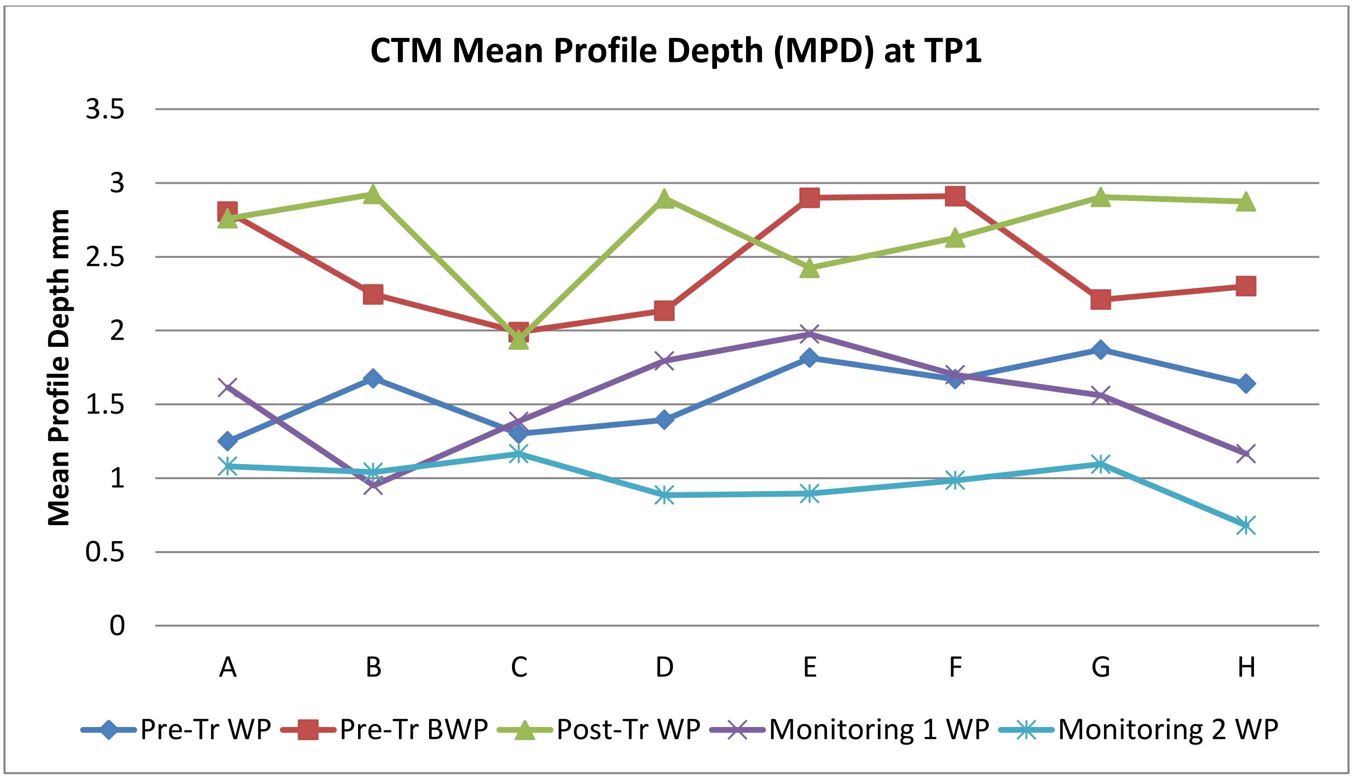
Sand Patch Data





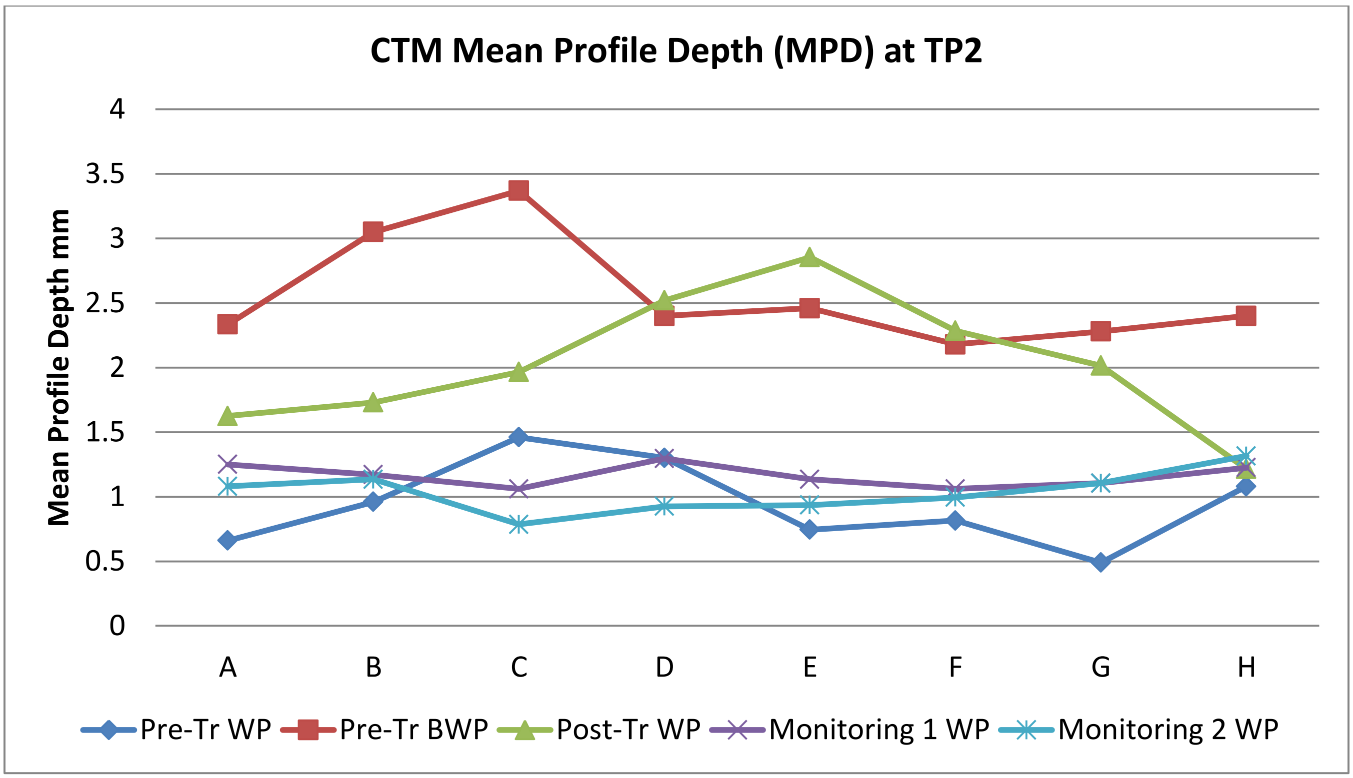
Circular Track Meter (CTM) Mean Profile Depth (in mm) at TP 1

	A	B	C	D	E	F	G	H
Pre-Tr WP	1.25	1.675	1.3	1.395	1.815	1.67	1.87	1.64
Pre-Tr BWP	2.805	2.245	1.99	2.135	2.9	2.91	2.21	2.3
Post-Tr	2.76	2.925	1.94	2.895	2.425	2.63	2.905	2.875
Monitoring 1	1.615	0.95	1.385	1.795	1.975	1.7	1.56	1.165
Monitoring 2	1.08	1.04	1.165	0.885	0.895	0.985	1.095	0.68
Monitoring 3	Not conducted due to maintenance/rehabilitation work on the section							



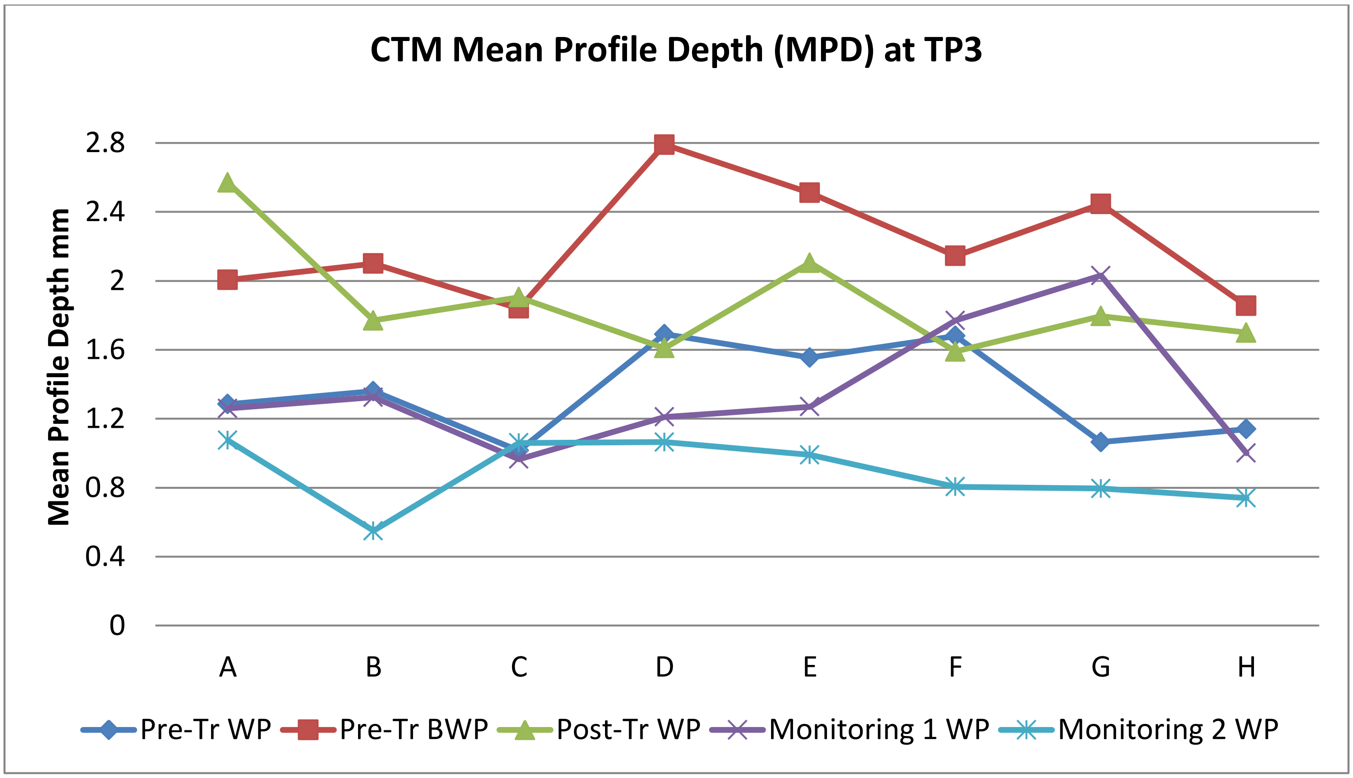
Circular Track Meter (CTM) Mean Profile Depth (in mm) at TP 2

	A	B	C	D	E	F	G	H
Pre-Tr WP	0.66	0.96	1.46	1.3	0.745	0.815	0.49	1.08
Pre-Tr BWP	2.335	3.05	3.37	2.4	2.46	2.18	2.28	2.4
Post-Tr	1.625	1.73	1.965	2.52	2.855	2.285	2.015	1.215
Monitoring 1	1.25	1.17	1.06	1.295	1.135	1.06	1.105	1.225
Monitoring 2	1.08	1.135	0.785	0.925	0.935	0.995	1.105	1.315
Monitoring 3	Not conducted due to maintenance/rehabilitation work on the section							

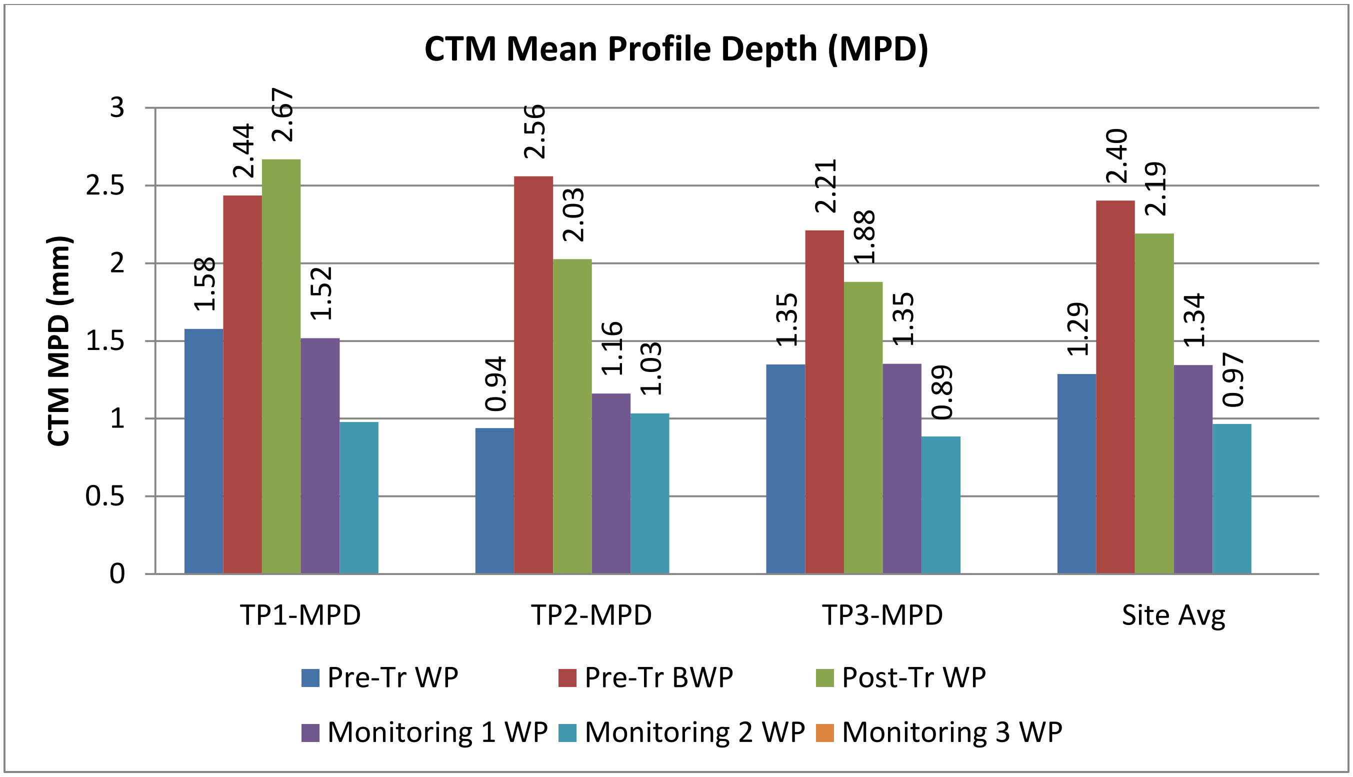


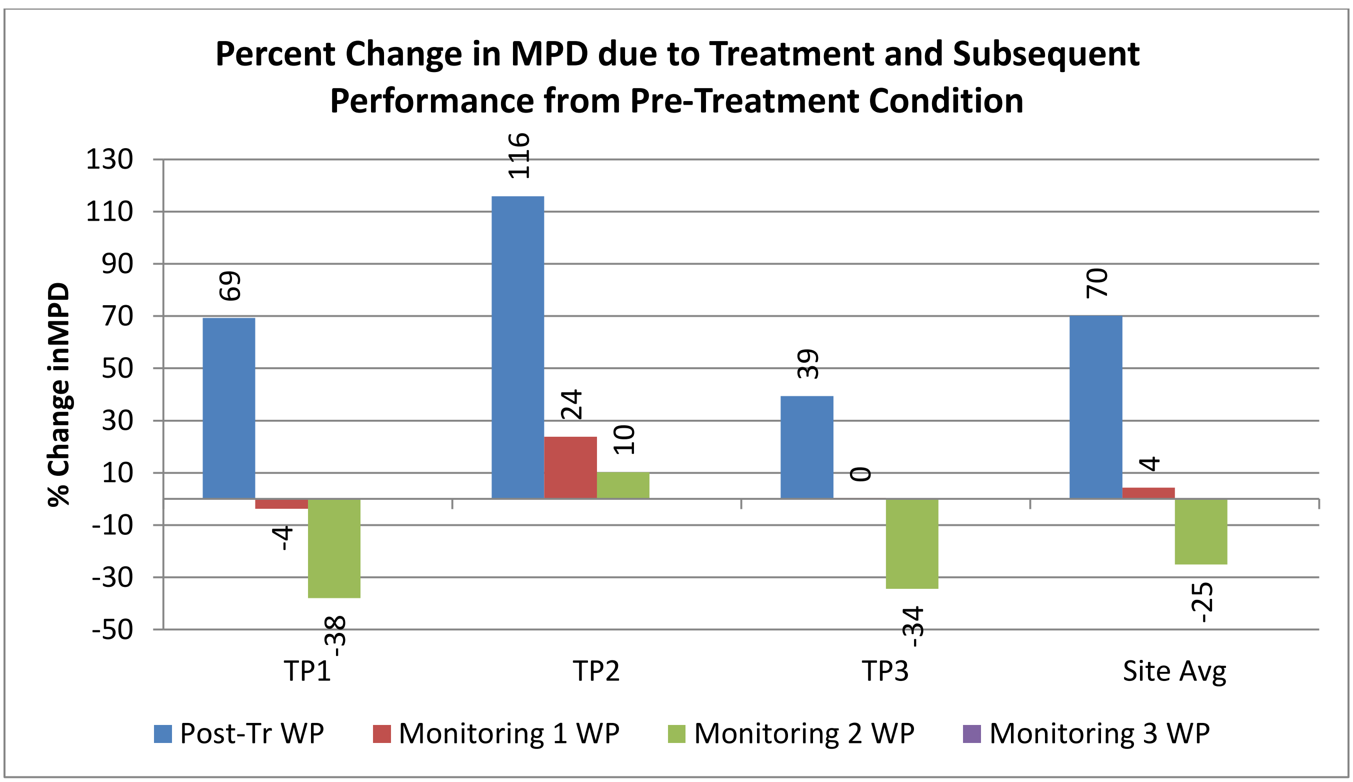
Circular Track Meter (CTM) Mean Profile Depth (in mm) at TP 3

	A	B	C	D	E	F	G	H
Pre-Tr WP	1.285	1.36	1.015	1.69	1.555	1.68	1.065	1.14
Pre-Tr BWP	2.005	2.1	1.84	2.79	2.51	2.145	2.445	1.855
Post-Tr	2.57	1.77	1.905	1.61	2.105	1.59	1.795	1.7
Monitoring 1	1.26	1.325	0.965	1.21	1.27	1.77	2.03	1
Monitoring 2	1.075	0.55	1.06	1.065	0.99	0.805	0.795	0.74
Monitoring 3	Not conducted due to maintenance/rehabilitation work on the section							

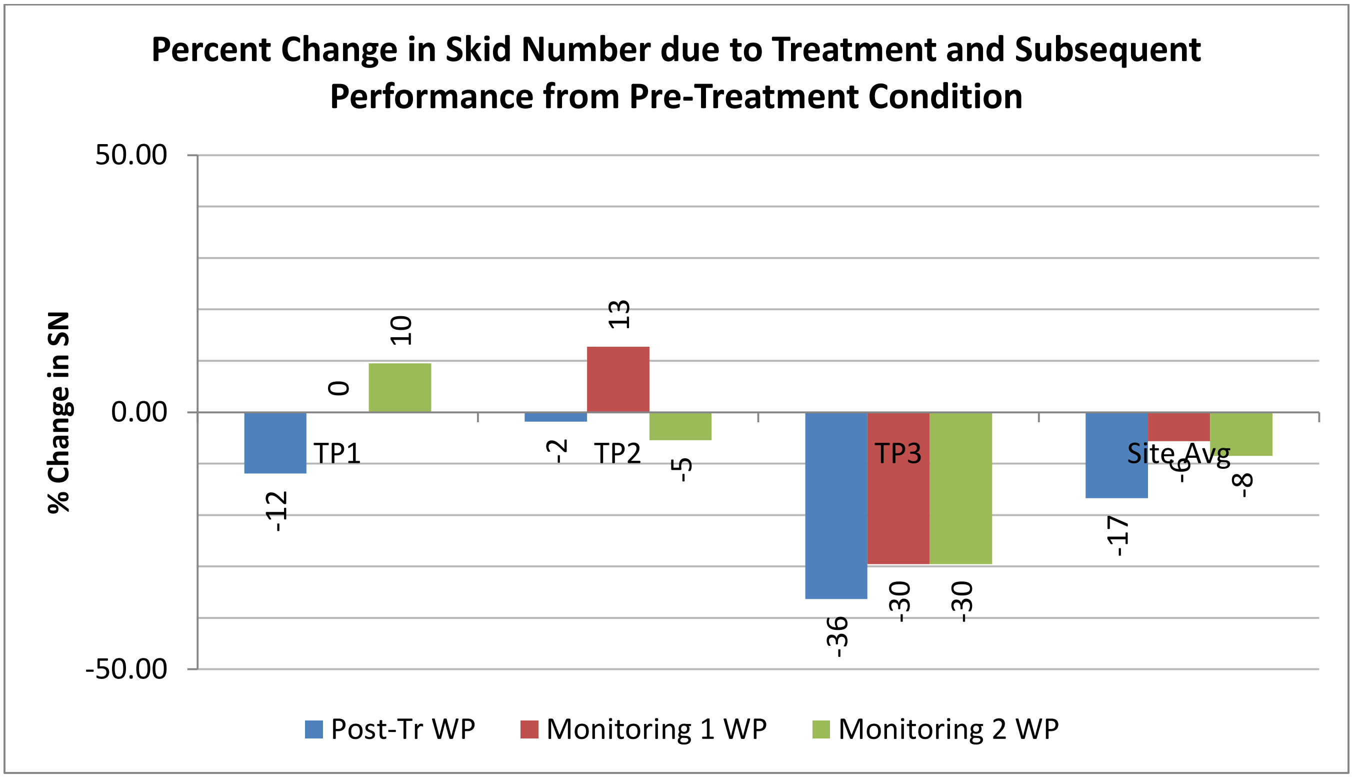


Circular Track Meter (CTM) MPD (mm)



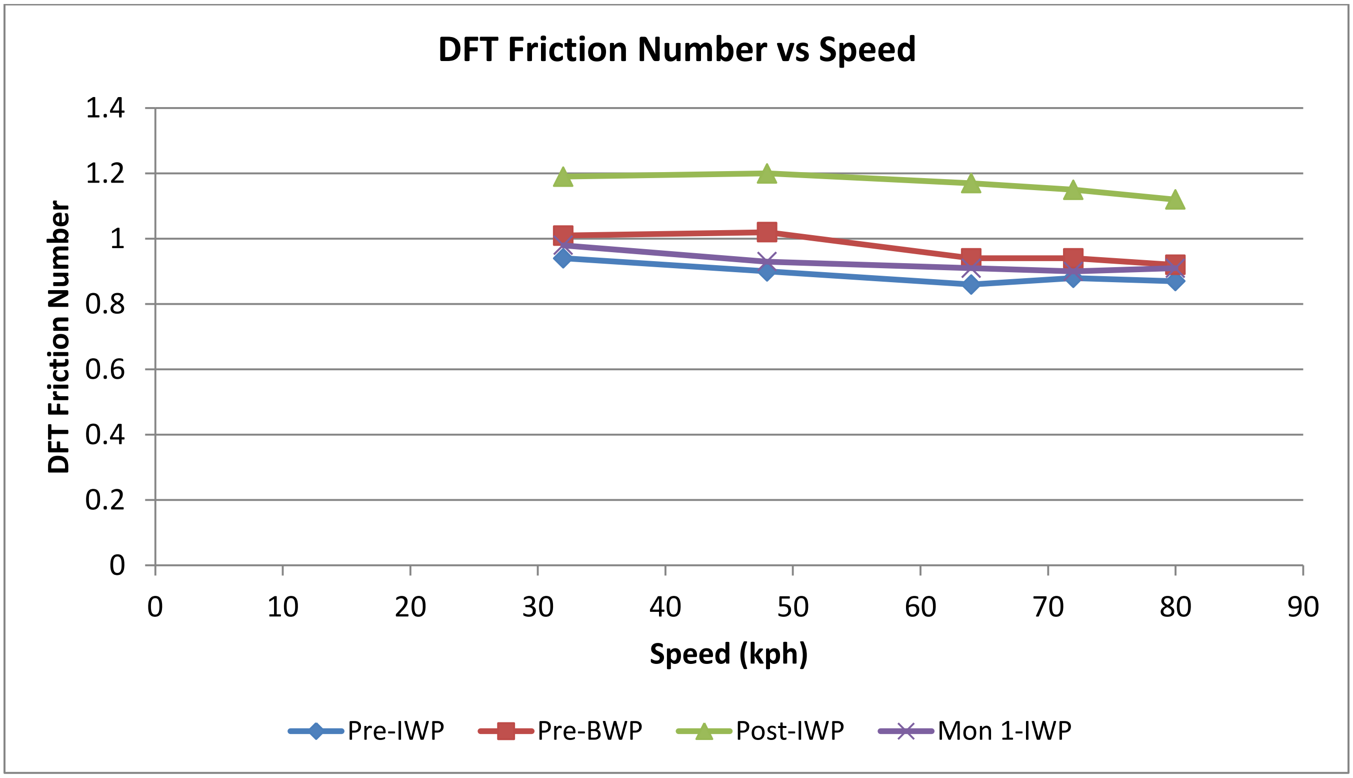


Skid Truck Data



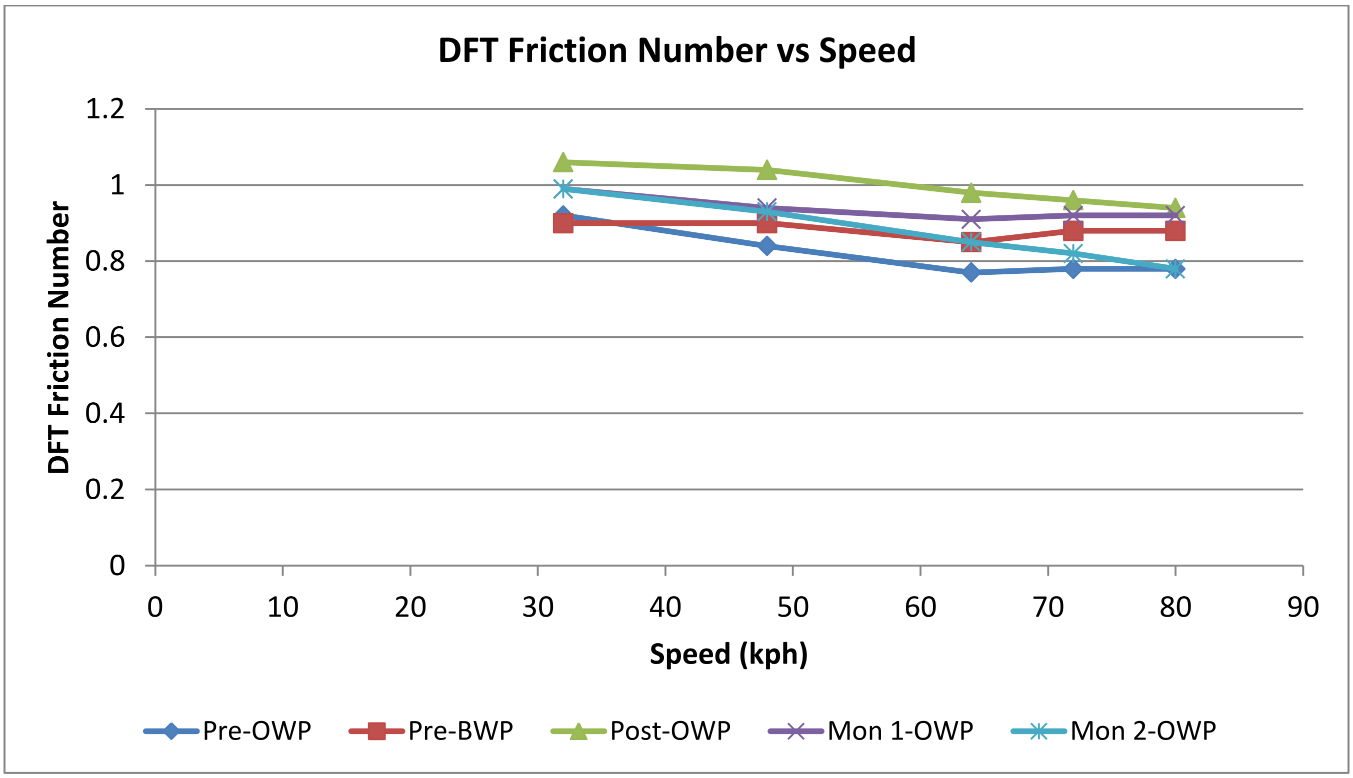
Dynamic Friction Test (DFT) Friction Number Data for TP 1

Speed (kph)	Pre-IWP	Pre-BWP	Post-IWP	Mon 1-IWP	Mon 2-IWP	Mon 3-IWP
32	0.94	1.01	1.19	0.98	Not conducted due to maintenance/rehabilitation work on the section	Not conducted due to maintenance/rehabilitation work on the section
48	0.9	1.02	1.2	0.93		
64	0.86	0.94	1.17	0.91		
72	0.88	0.94	1.15	0.9		
80	0.87	0.92	1.12	0.91		



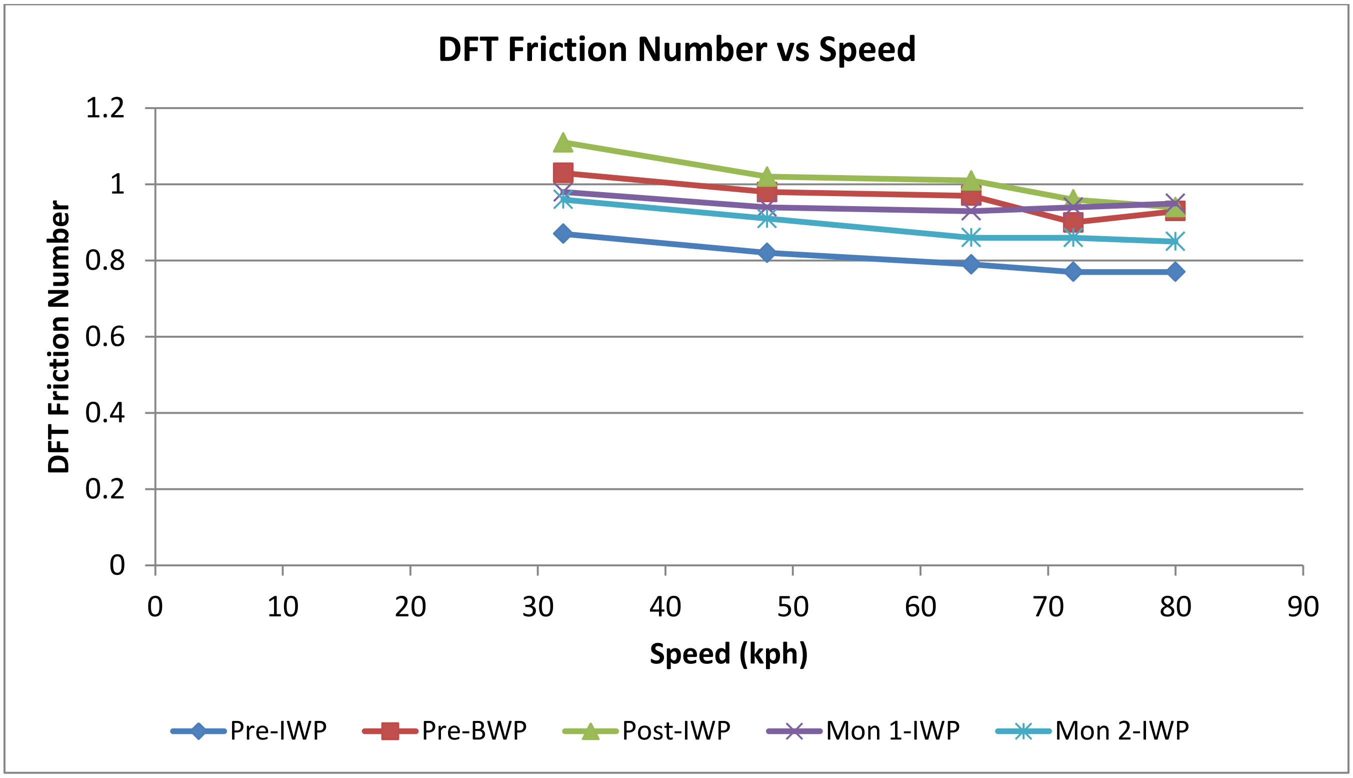
Dynamic Friction Test (DFT) Friction Number Data for TP 2

Speed (kph)	Pre-OWP	Pre-BWP	Post-OWP	Mon 1-OWP	Mon 2-OWP	Mon 3-OWP
32	0.92	0.9	1.06	0.99	0.99	Not conducted due to maintenance/rehabilitation work on the section
48	0.84	0.9	1.04	0.94	0.93	
64	0.77	0.85	0.98	0.91	0.85	
72	0.78	0.88	0.96	0.92	0.82	
80	0.78	0.88	0.94	0.92	0.78	



Dynamic Friction Test (DFT) Friction Number Data for TP 3

Speed (kph)	Pre-IWP	Pre-BWP	Post-IWP	Mon 1-IWP	Mon 2-IWP	Mon 3-IWP
32	0.87	1.03	1.11	0.98	0.96	Not conducted due to maintenance/rehabilitation work on the section
48	0.82	0.98	1.02	0.94	0.91	
64	0.79	0.97	1.01	0.93	0.86	
72	0.77	0.9	0.96	0.94	0.86	
80	0.77	0.93	0.94	0.95	0.85	



Weather Data during UHP Water Cutter Treatment

Date	Time	Temp Out	Hi Temp	Low Temp	Out Hum	Dew Pt.	Wind Speed	Wind Dir	Wind Run	Hi Speed	Hi Dir	Wind Chill	Heat Index	THW Index	THSW Index
2/11/2011	8:20 AM	26.9	48.2	26.9	68	17.7	0	WSW	0	1	NNE	26.9	26.5	26.5	---
2/11/2011	8:30 AM	25.4	26.7	25.1	82	20.7	0	---	0	0	---	25.4	25.1	25.1	---
2/11/2011	8:40 AM	27.4	27.4	25.4	85	23.5	0	WSW	0	2	WSW	27.4	27.2	27.2	---
2/11/2011	8:50 AM	29.1	29.1	27.4	83	24.6	1	WSW	0.17	2	WSW	29.1	28.9	28.9	---
2/11/2011	9:00 AM	30.6	30.6	29.1	81	25.5	1	WSW	0.17	3	WSW	30.6	30.3	30.3	---
2/11/2011	9:10 AM	31.6	31.6	30.6	77	25.2	2	W	0.33	5	W	30.5	31.2	30.1	---
2/11/2011	9:20 AM	32.8	32.8	31.6	76	26.1	1	W	0.17	3	W	32.8	32.4	32.4	---
2/11/2011	9:30 AM	33.4	33.4	32.8	76	26.6	1	W	0.17	3	W	33.4	33	33	---
2/11/2011	9:40 AM	34.9	34.9	33.5	72	26.8	1	W	0.17	4	W	34.9	34.4	34.4	---
2/11/2011	9:50 AM	35.8	35.8	34.9	66	25.5	1	WNW	0.17	5	W	35.8	35.1	35.1	---
2/11/2011	10:00 AM	36.3	36.3	35.7	67	26.4	1	W	0.17	5	WNW	36.3	35.6	35.6	---
2/11/2011	10:10 AM	37.3	37.5	36.3	63	25.8	1	NW	0.17	4	WNW	37.3	36.6	36.6	---
2/11/2011	10:20 AM	38.7	38.7	37.3	61	26.4	1	WNW	0.17	4	NW	38.7	37.9	37.9	---
2/11/2011	10:30 AM	39.5	39.6	38.5	58	25.9	1	NE	0.17	5	ENE	39.5	38.6	38.6	---
2/11/2011	10:40 AM	40	40.2	39.4	58	26.4	2	NNE	0.33	5	E	39.8	39.1	38.9	---
2/11/2011	10:50 AM	40.6	40.6	39.9	54	25.2	2	E	0.33	5	E	40.5	39.6	39.5	---
2/11/2011	11:00 AM	41.1	41.6	40.7	51	24.3	2	ENE	0.33	5	NNE	41	40	39.9	---
2/11/2011	11:10 AM	42.7	42.7	41.2	49	24.8	1	NE	0.17	5	N	42.7	41.6	41.6	---
2/11/2011	11:20 AM	42.5	42.8	42.4	49	24.7	2	ENE	0.33	7	E	42.5	41.4	41.4	---
2/11/2011	11:30 AM	42.9	43.2	42.2	45	23	2	ENE	0.33	5	E	42.9	41.6	41.6	---
2/11/2011	11:40 AM	43.8	43.9	42.9	44	23.3	3	E	0.5	7	NE	42.7	42.5	41.4	---
2/11/2011	11:50 AM	45.1	45.1	43	46	25.5	2	E	0.33	8	N	45.1	43.8	43.8	---
2/11/2011	12:00 PM	45.7	46.4	45.2	42	23.9	3	ENE	0.5	7	NE	44.8	44.3	43.4	---
2/11/2011	12:10 PM	46.7	46.7	45.6	38	22.4	4	ENE	0.67	9	E	45	45.1	43.4	---
2/11/2011	12:20 PM	47.2	47.2	46.5	41	24.7	3	ENE	0.5	7	NNE	46.5	45.7	45	---

2/11/2011	12:30 PM	47	47.5	46.8	39	23.3	3	ENE	0.5	9	E	46.3	45.5	44.8	---
2/11/2011	12:40 PM	48.3	48.3	47	36	22.5	3	ENE	0.5	8	E	47.7	46.6	46	---
2/11/2011	12:50 PM	48.3	49.1	48.3	36	22.5	4	E	0.67	12	E	46.9	46.6	45.2	---
2/11/2011	1:00 PM	49.2	49.6	48.3	36	23.4	3	E	0.5	9	N	48.7	47.5	47	---
2/11/2011	1:10 PM	49.9	50.1	49.2	32	21.2	4	E	0.67	10	E	48.8	48.1	47	---
2/11/2011	1:20 PM	55.1	55.1	49.6	33	26.5	2	E	0.33	8	E	55.1	52.4	52.4	---

Site Photographs

<table>
<tr><td>(a)</td><td>
</td><td>(b)</td><td>Figure XX. BMT3 Pictures (a) highway and location; (b) close-up of flushed surface before treatment; (c) roadway surface before treatment; (d) close-up of flushed surface immediately after treatment; (e) roadway surface after treatment; (f) close-up of surface at first follow-up ; (g) roadway surface at first follow-up , (h) roadway surface at second follow-up ; (i) close-up of surface at second follow-up .</td></tr>
<tr><td>(b)</td><td>
</td><td>(c)</td><td>
</td></tr>
<tr><td>(d)</td><td>
</td><td>(e)</td><td>
</td></tr>
<tr><td>(f)</td><td>
</td><td>(g)</td><td></td></tr>
</table>

(h)		(i)	

APPENDIX F

SITE BRY 9

Grimes COUNTY

Bryan DISTRICT

Site Description

Project Information			
District: Bryan	Test Site: BRY	County: Grimes	Road: FM 2562 NB
ADT: 390	Truck Traffic: Low	Year Built:	Last Maintained: 2009
Roadway Description Aggregate Grade: Ty PL GR 6 Aggregate Type: Expanded Shale Lightweight Pit: Texas Industries -Streetman AQMP#: 1817502 CSJ: 3302-01-013 CCSJ: Binder: AC 12-5TR			

Research Test Summary		
Test Location: FM 149 to SH 30	Closest Texas Reference Marker:	
Test Point GPS Coordinates	N	W
TP1	30°25.538'	096°02.650'
TP2	30°25.437'	096°02.693'
TP3	30°25.344'	096°02.729'

Ultra High Pressure Water Cutter Treatment Summary		
Date Treated 2/18/2011	Start Time 7: 30	End Time 4:42

Summary Description of Treatment Activity

Personnel on site:

TechMRT: Sanja Senadheera, Andrew Tubb
Rampart: Bob Beadling and Jim Windich
TxDOT: others from the Grimes County

Rampart configuration: Rampart used their typical 28 jet nozzle configuration running at 32ksi.

Work Activities: TechMRT and Rampart were at the maintenance office before 7:00AM. TechMRT participated in the morning meeting and then headed to the site at 7:30AM while rampart filled the truck.

TechMRT arrived on site at 7:45AM. TechMRT setup weather station at TP 1 at 8:00. At 8:20 traffic control arrived and marked all test points and the speed sections. TechMRT performed all pretest from 9:15AM till 1045AM.

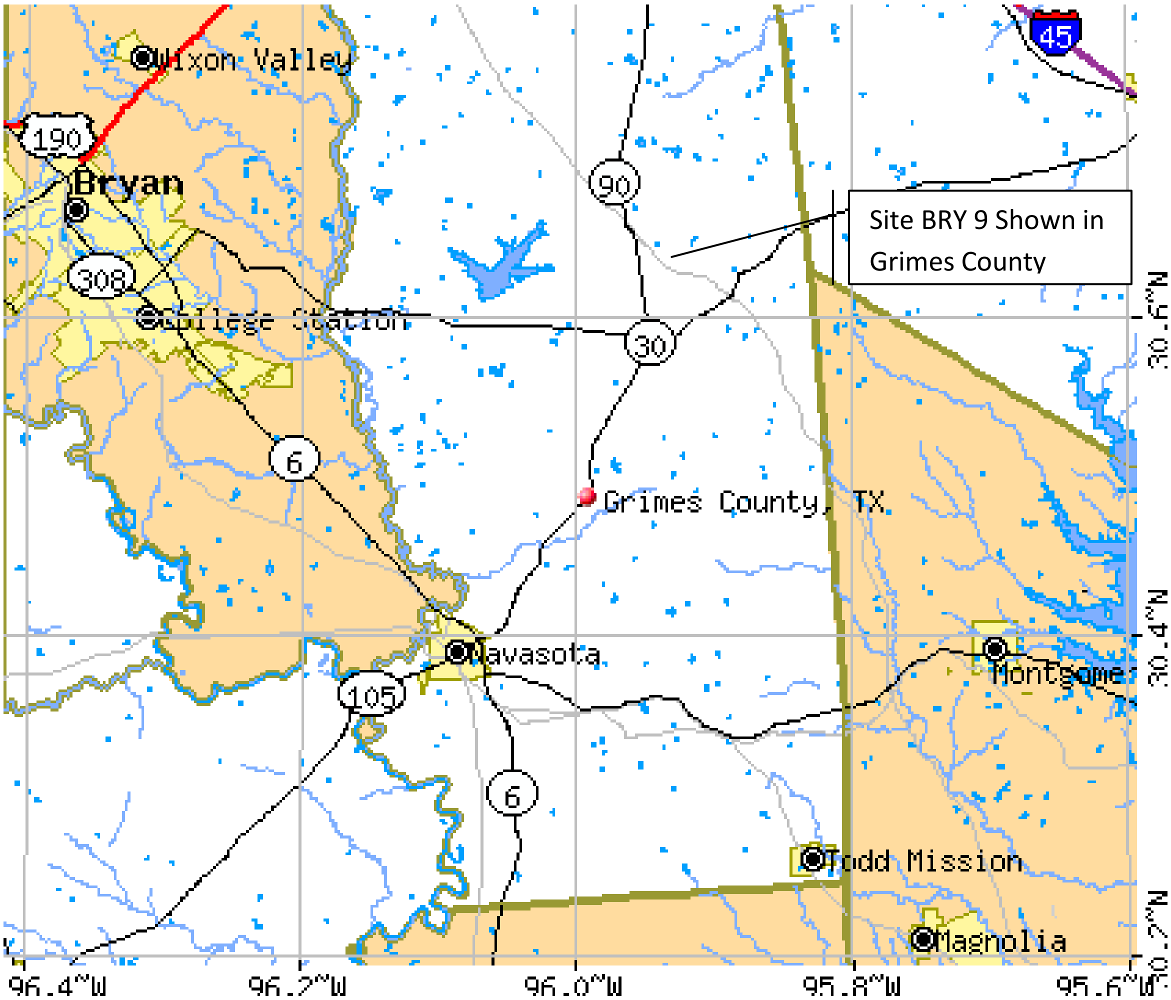
Rampart treated the center of the wheel paths with a single pass for the two wheel paths in the speed zones .They then treated passes 1 and 5 on the inside quarter mile. Rampart then treated passes 2 and 4 on in the inside quarter mile. TxDOT broomed each section after treated.

Comments

Follow-On Testing Summary	
Date: 7/20/11	Comments: Preformed follow –up monitoring successfully.

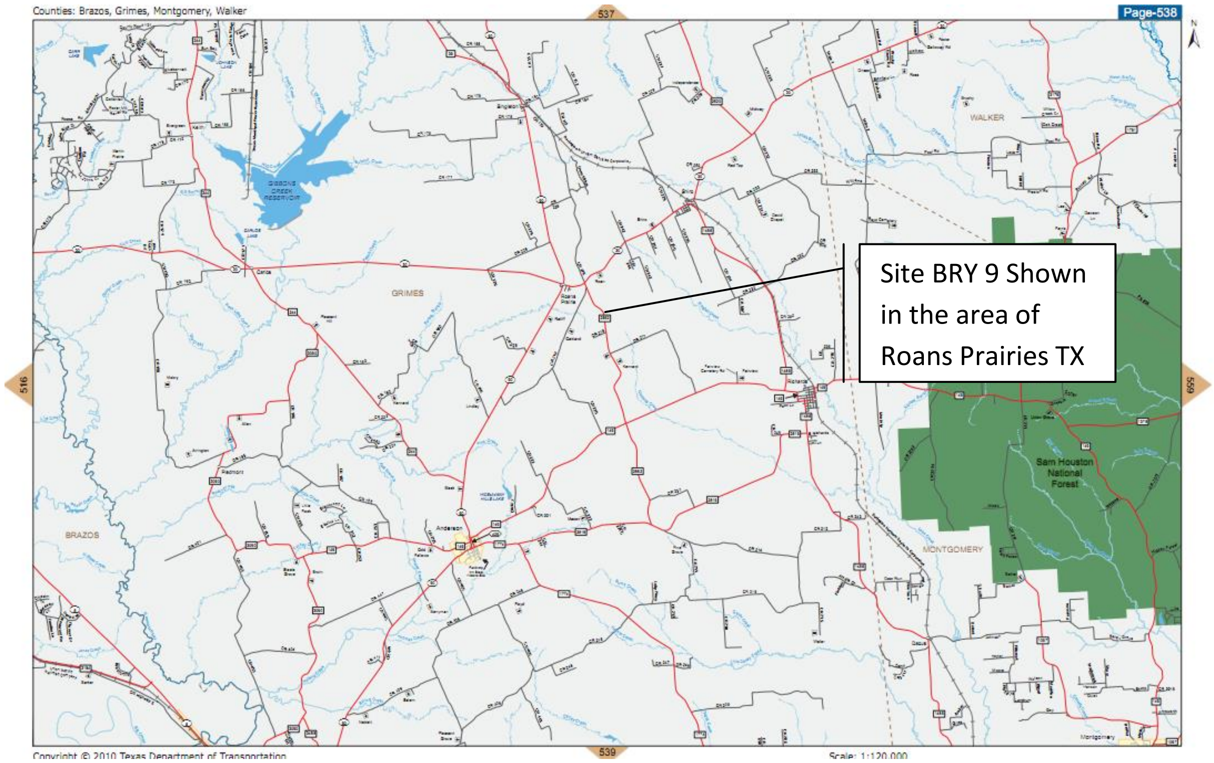
Date: 1/12/12	Comments: Preformed follow –up monitoring successfully.
Date: 7/9/12	Comments: Preformed follow –up monitoring successfully.

Site Vicinity Map



http://www.city-data.com/

Site Location Map



http://www.txdot.gov/travel/county_grid_search.htm

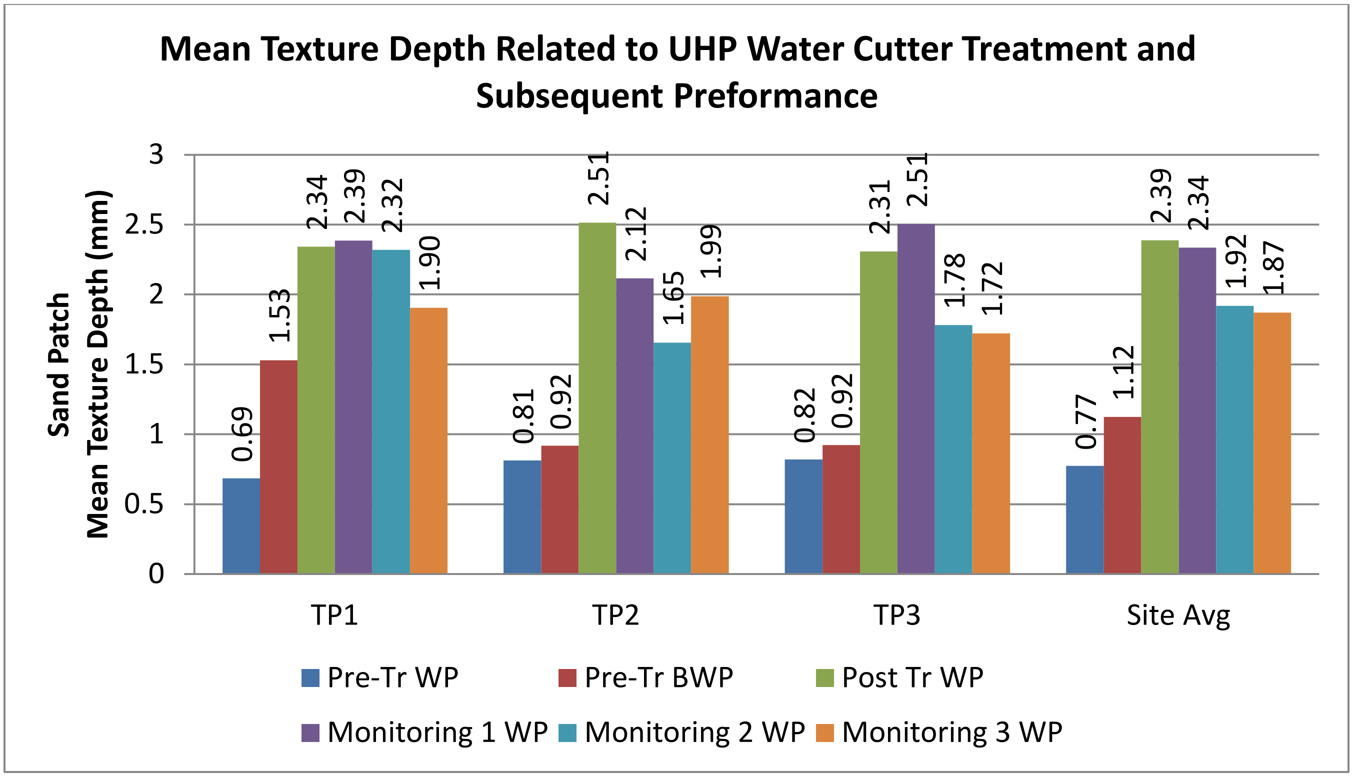
Aerial Photograph

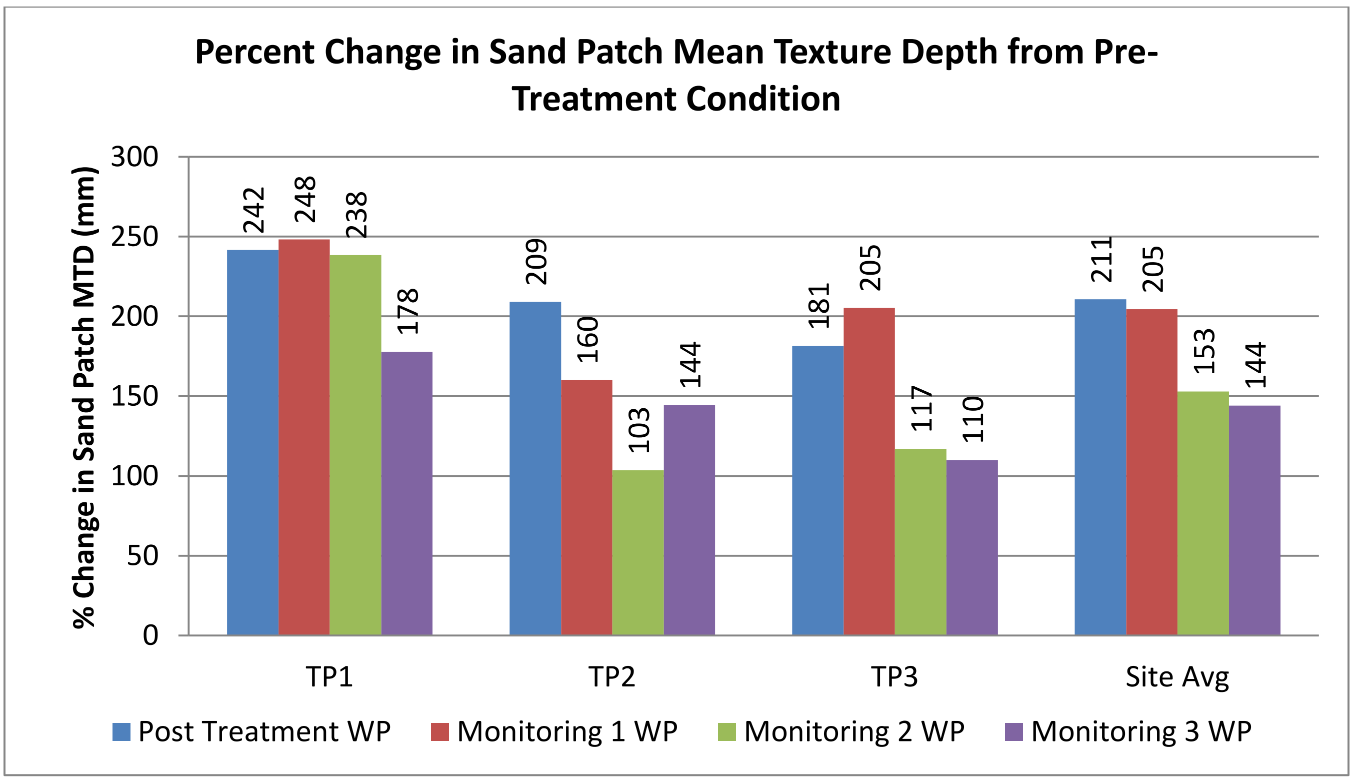
Google Inc. (2011). Google Earth (Version 6.1.0.5001)

Test Point Plan

Google Inc. (2011). Google Earth (Version 6.1.0.5001)

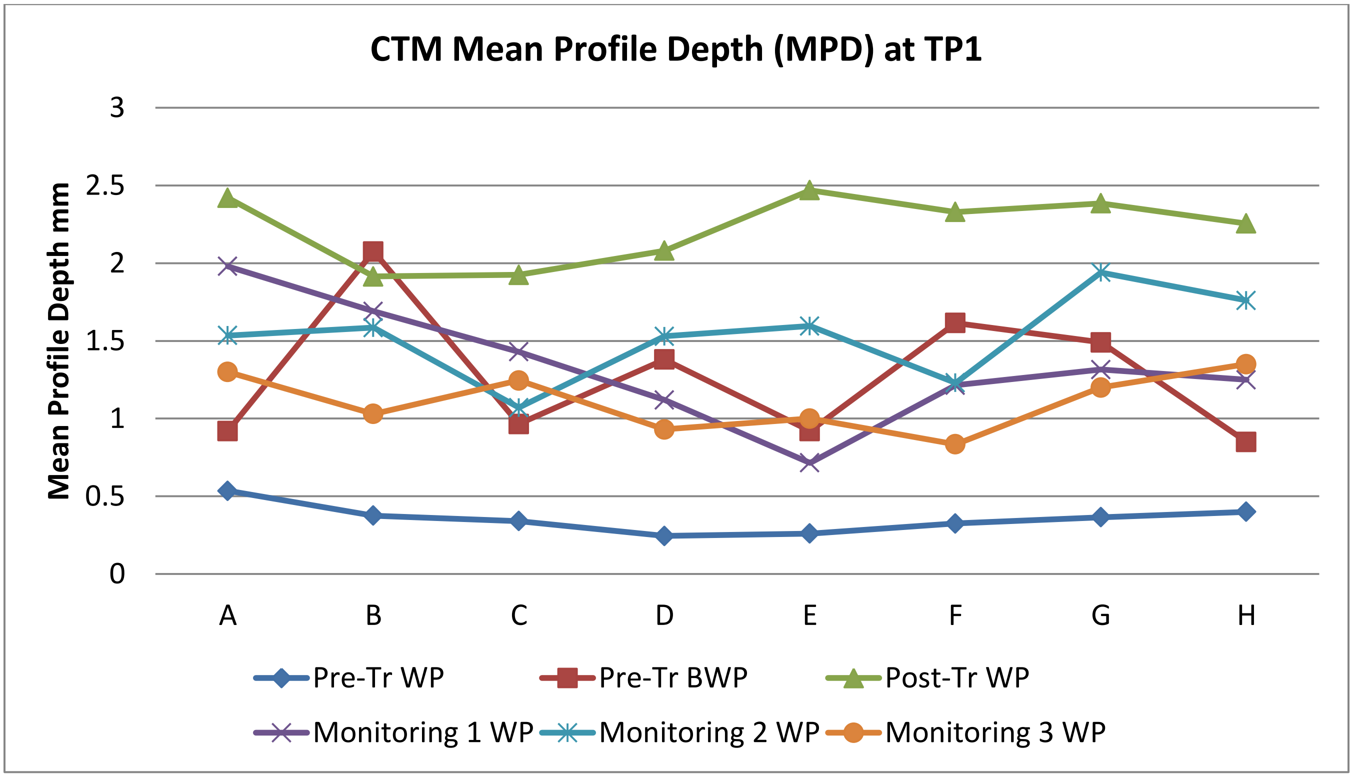
Sand Patch Data





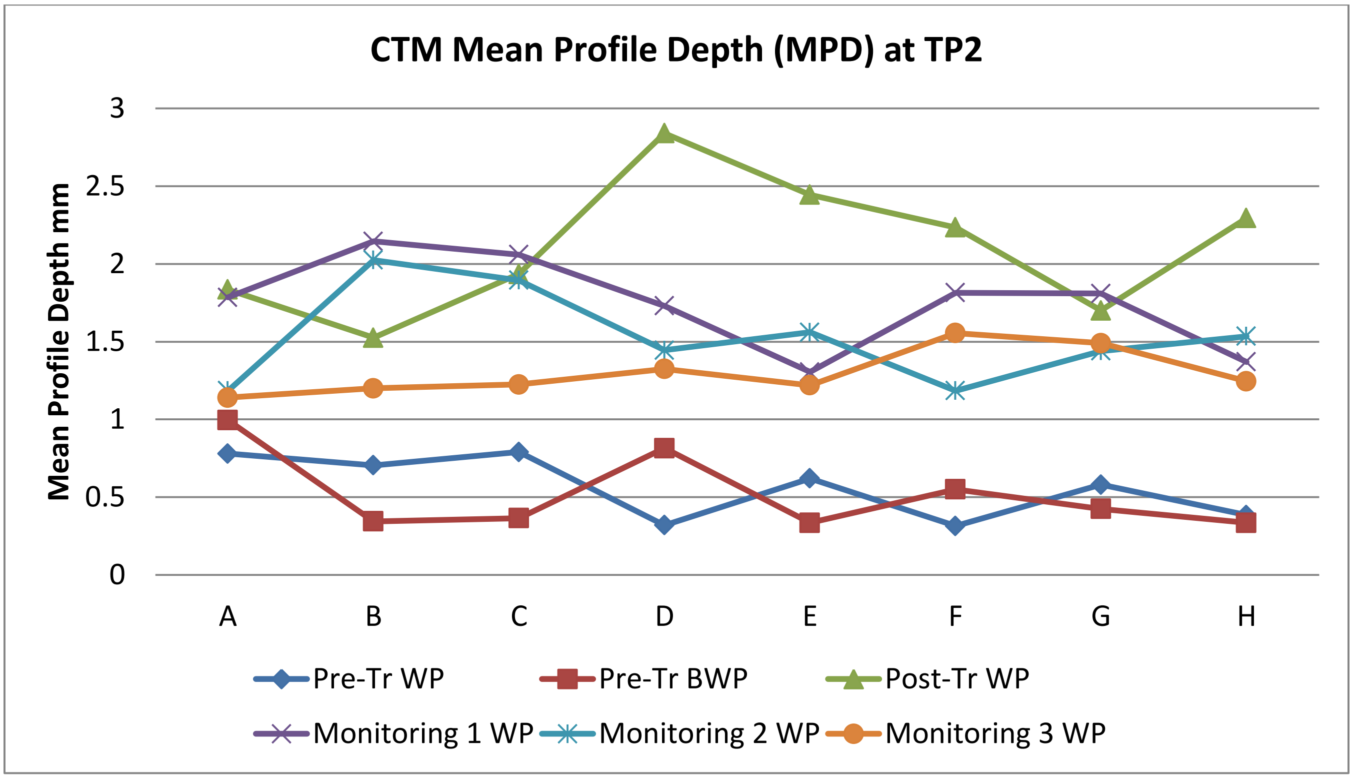
Circular Track Meter (CTM) Mean Profile Depth (in mm) at TP 1

	A	B	C	D	E	F	G	H
Pre-Tr WP	0.535	0.375	0.34	0.245	0.26	0.325	0.365	0.4
Pre-Tr BWP	0.92	2.075	0.965	1.38	0.92	1.615	1.49	0.85
Post-Tr	2.42	1.915	1.925	2.08	2.47	2.33	2.385	2.255
Monitoring 1	1.98	1.69	1.43	1.12	0.715	1.215	1.315	1.25
Monitoring 2	1.535	1.585	1.07	1.53	1.595	1.23	1.94	1.76
Monitoring 3	1.3	1.03	1.245	0.93	1	0.835	1.2	1.35



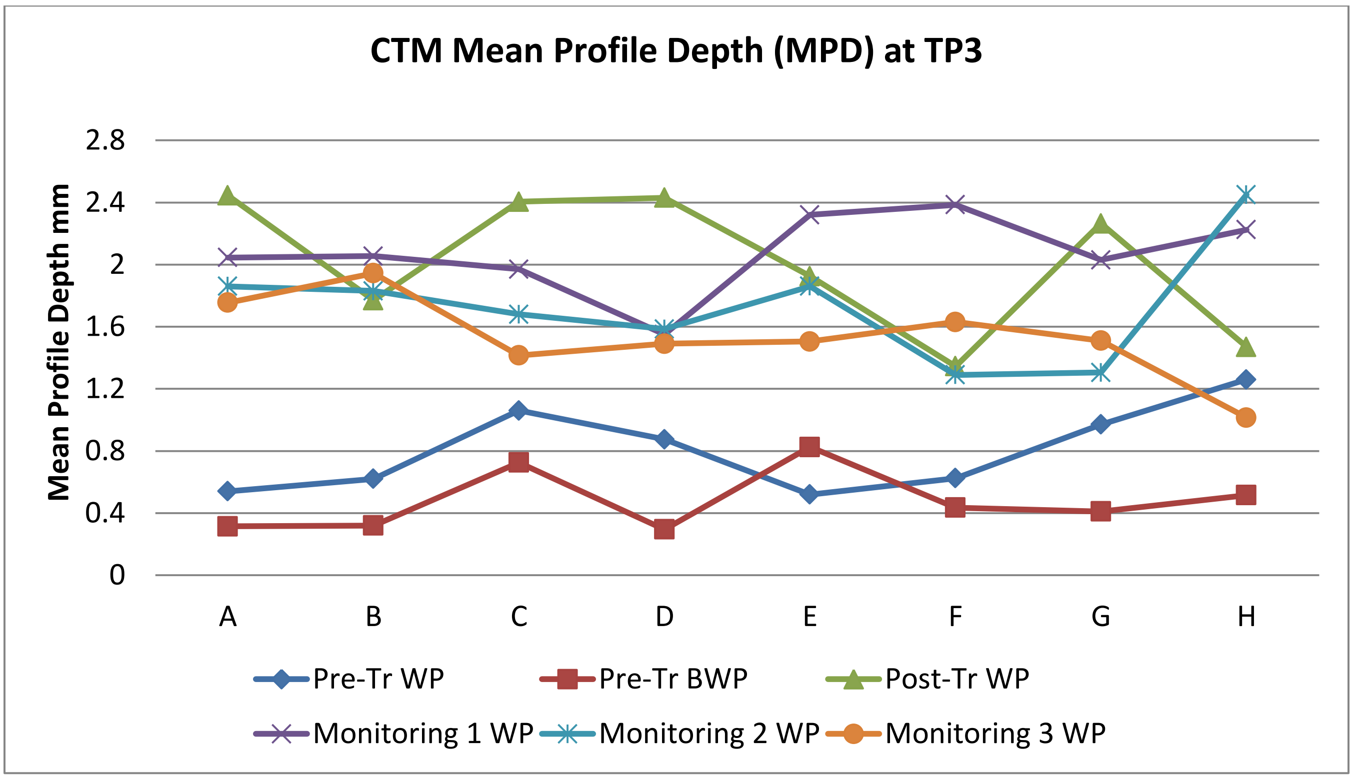
Circular Track Meter (CTM) Mean Profile Depth (in mm) at TP 2

	A	B	C	D	E	F	G	H
Pre-Tr WP	0.78	0.705	0.79	0.32	0.62	0.315	0.58	0.385
Pre-Tr BWP	0.995	0.345	0.365	0.815	0.335	0.55	0.425	0.335
Post-Tr	1.835	1.525	1.935	2.84	2.445	2.235	1.7	2.295
Monitoring 1	1.785	2.145	2.06	1.73	1.305	1.815	1.81	1.37
Monitoring 2	1.185	2.025	1.895	1.445	1.56	1.185	1.44	1.535
Monitoring 3	1.14	1.2	1.225	1.325	1.22	1.555	1.49	1.245

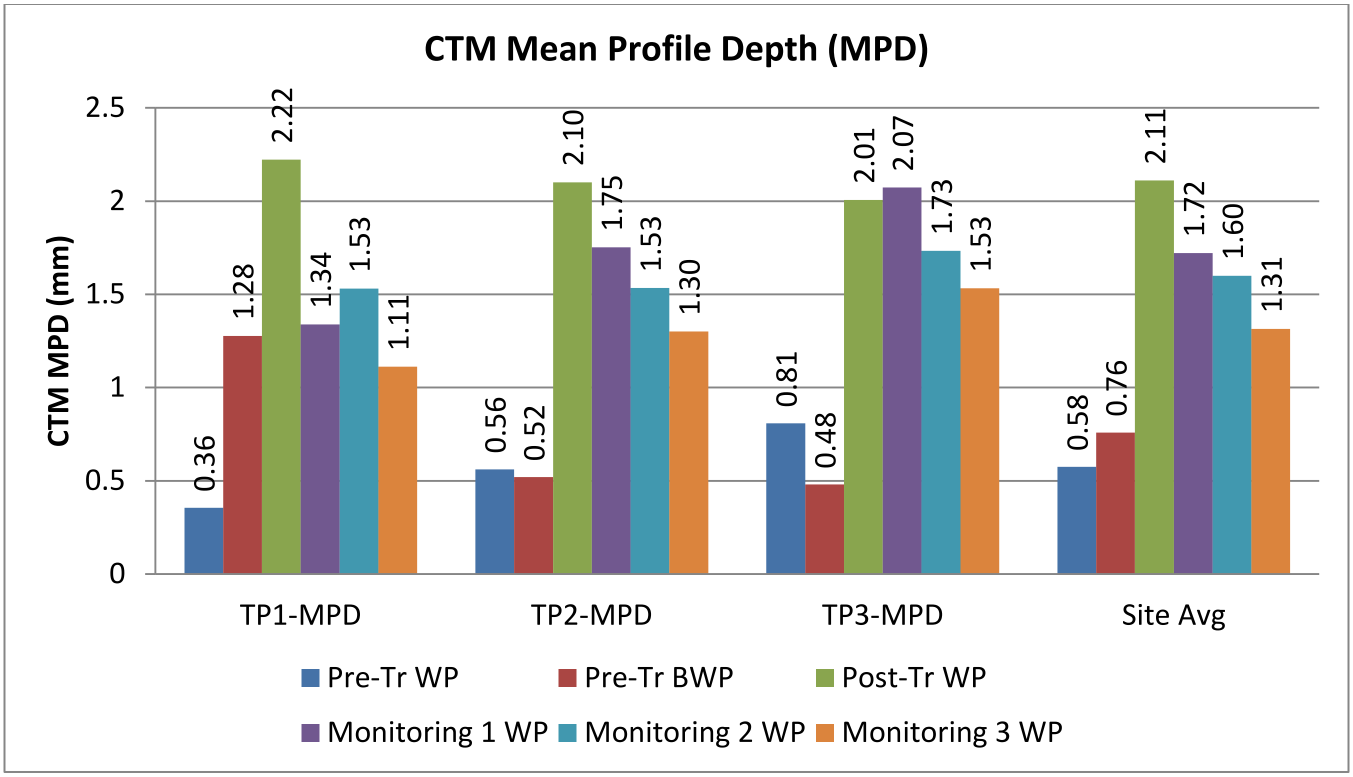


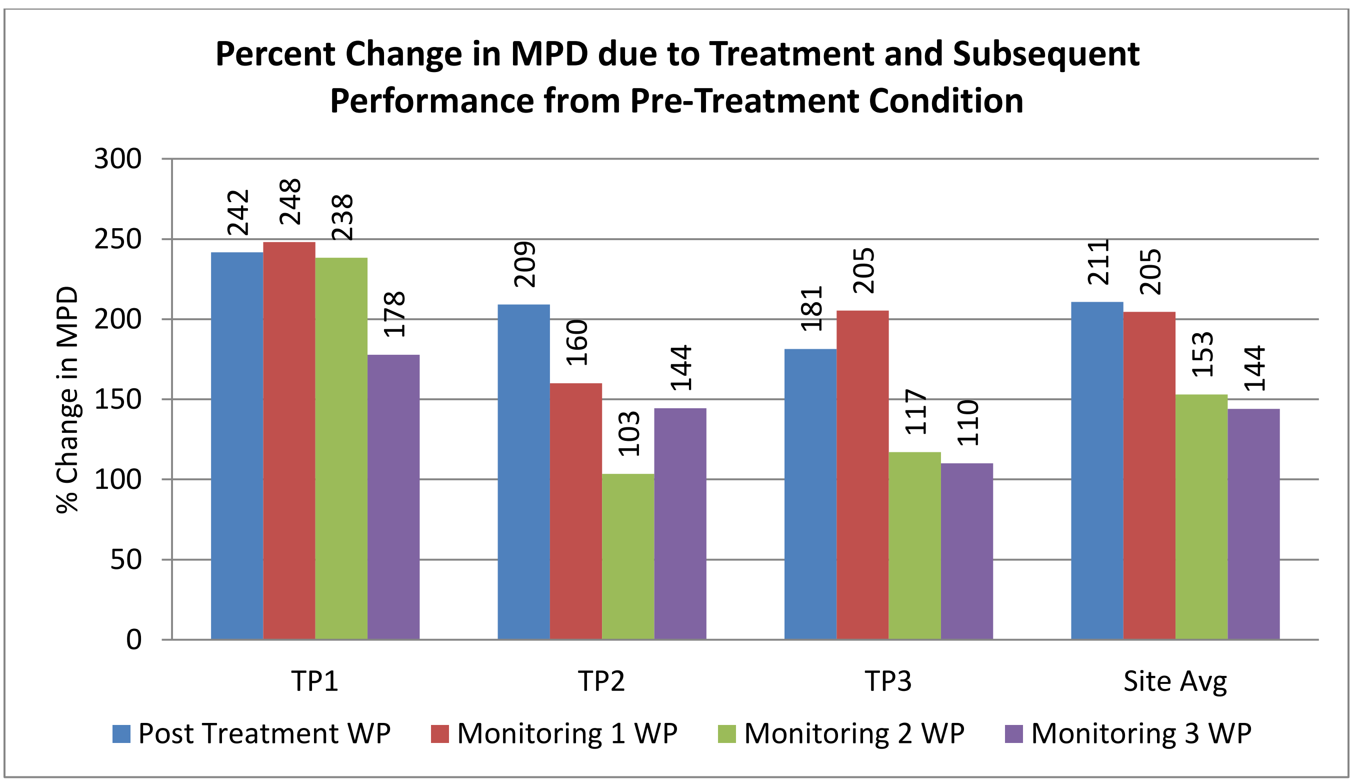
Circular Track Meter (CTM) Mean Profile Depth (in mm) at TP 3

	A	B	C	D	E	F	G	H
Pre-Tr WP	0.54	0.62	1.06	0.875	0.52	0.625	0.97	1.26
Pre-Tr BWP	0.315	0.32	0.725	0.295	0.825	0.435	0.41	0.515
Post-Tr	2.445	1.77	2.405	2.43	1.925	1.345	2.265	1.47
Monitoring 1	2.045	2.055	1.97	1.55	2.32	2.385	2.03	2.225
Monitoring 2	1.86	1.83	1.68	1.585	1.86	1.29	1.305	2.45
Monitoring 3	1.755	1.945	1.415	1.49	1.505	1.63	1.51	1.015



Circular Track Meter (CTM) MPD (mm)



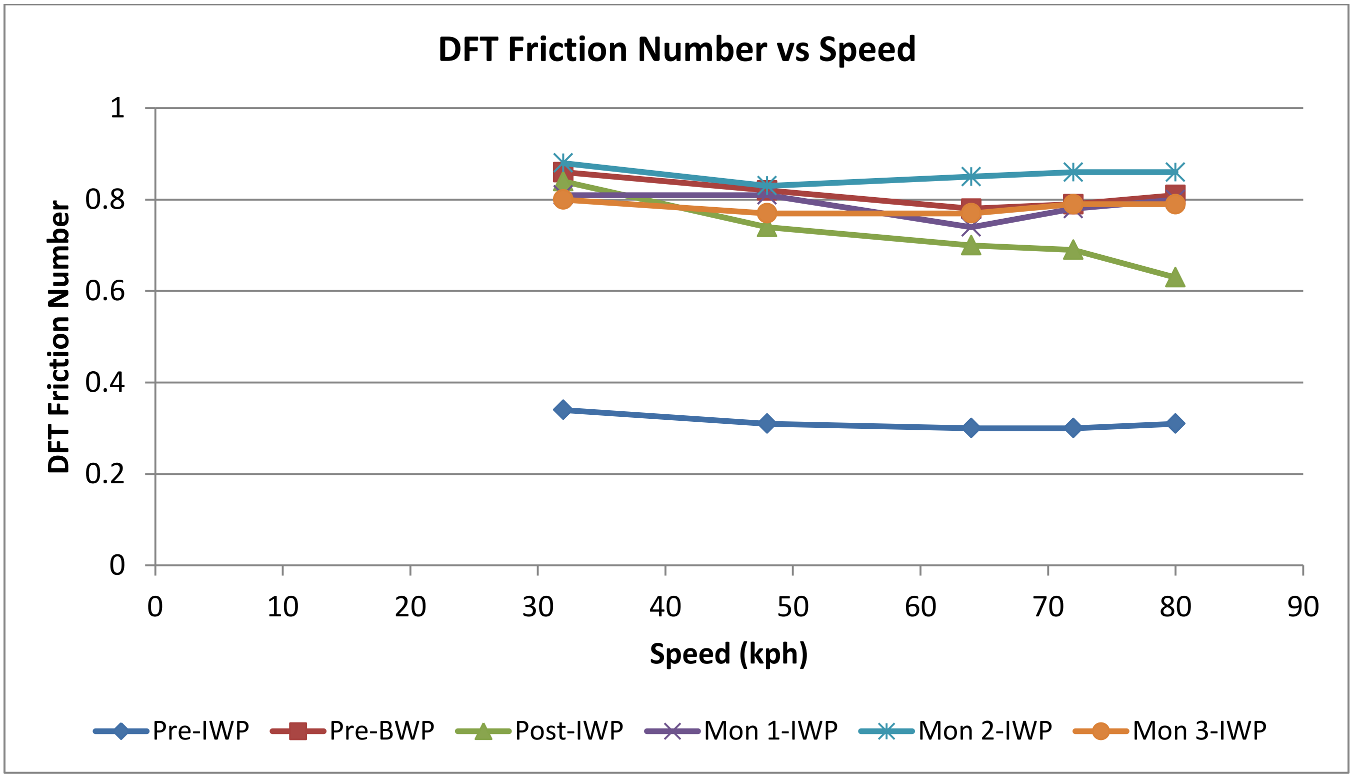


Skid Truck Data

No Pre and Post Skid Truck Data was collect at test site

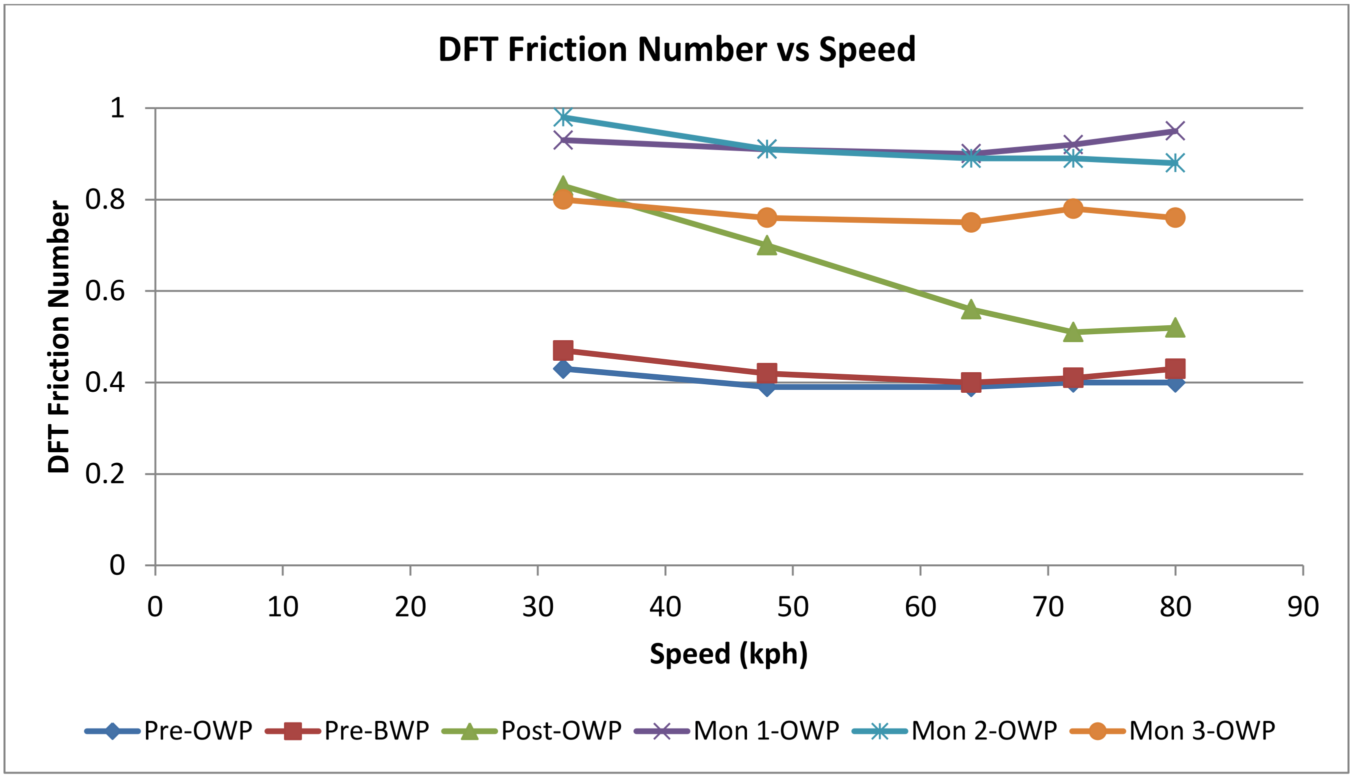
Dynamic Friction Test (DFT) Friction Number Data for TP 1

Speed (kph)	Pre-IWP	Pre-BWP	Post-IWP	Mon 1-IWP	Mon 2-IWP	Mon 3-IWP
32	0.34	0.86	0.84	0.81	0.88	0.8
48	0.31	0.82	0.74	0.81	0.83	0.77
64	0.3	0.78	0.7	0.74	0.85	0.77
72	0.3	0.79	0.69	0.78	0.86	0.79
80	0.31	0.81	0.63	0.8	0.86	0.79



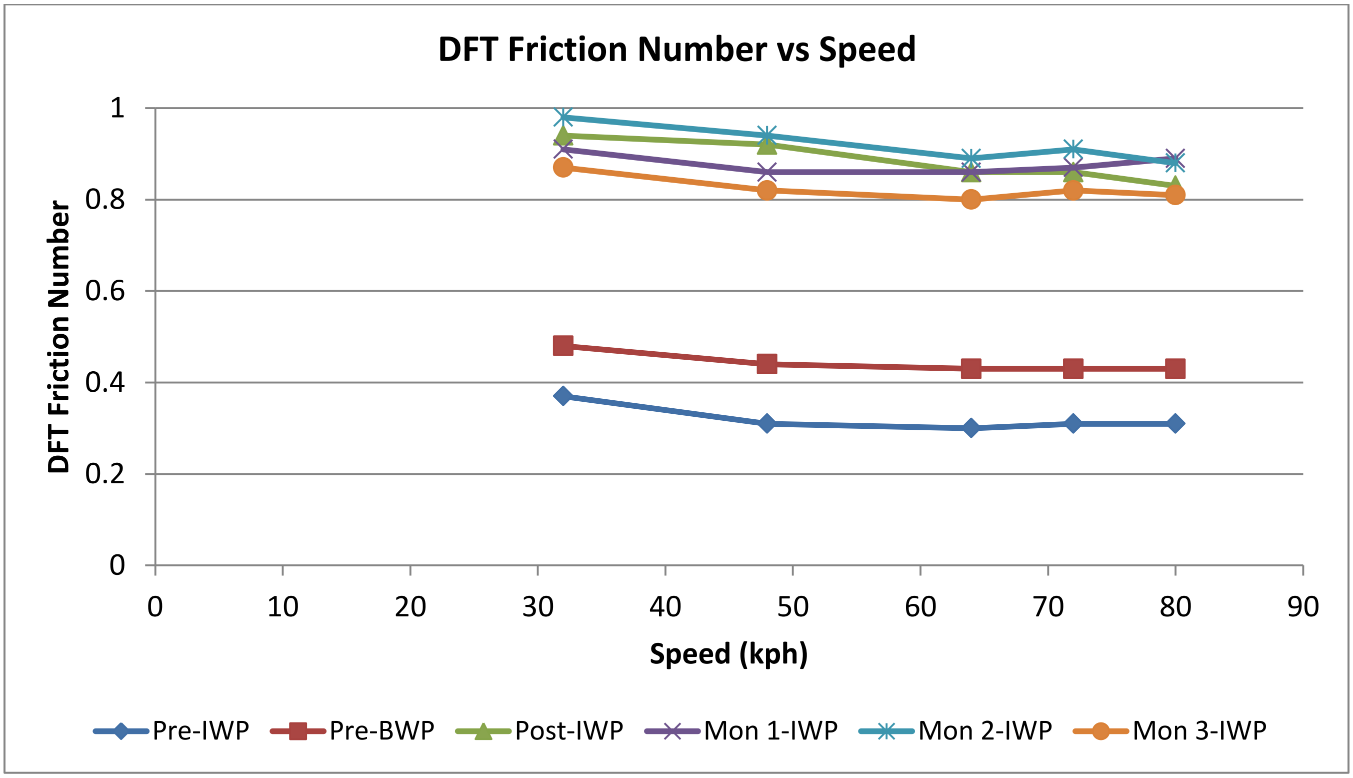
Dynamic Friction Test (DFT) Friction Number Data for TP 2

Speed (kph)	Pre-OWP	Pre-BWP	Post-OWP	Mon 1-OWP	Mon 2-OWP	Mon 3-OWP
32	0.43	0.47	0.83	0.93	0.98	0.8
48	0.39	0.42	0.7	0.91	0.91	0.76
64	0.39	0.4	0.56	0.9	0.89	0.75
72	0.4	0.41	0.51	0.92	0.89	0.78
80	0.4	0.43	0.52	0.95	0.88	0.76



Dynamic Friction Test (DFT) Friction Number Data for TP 3

Speed (kph)	Pre-IWP	Pre-BWP	Post-IWP	Mon 1-IWP	Mon 2-IWP	Mon 3-IWP
32	0.37	0.48	0.94	0.91	0.98	0.87
48	0.31	0.44	0.92	0.86	0.94	0.82
64	0.3	0.43	0.86	0.86	0.89	0.8
72	0.31	0.43	0.86	0.87	0.91	0.82
80	0.31	0.43	0.83	0.89	0.88	0.81



Weather Data during UHP Water Cutter Treatment

Date	Time	Temp Out	Hi Temp	Low Temp	Out Hum	Dew Pt.	Wind Speed	Wind Dir	Wind Run	Hi Speed	Hi Dir	Wind Chill	Heat Index	THW Index	THSW Index
2/18/2011	9:00 AM	69.6	69.6	69.3	77	62.1	0	E	0	4	E	69.6	70.6	70.6	---
2/18/2011	9:10 AM	67.9	69.6	67.9	81	61.9	4	S	0.67	10	S	67.9	69.2	69.2	---
2/18/2011	9:20 AM	67.6	67.8	67.4	81	61.6	7	SSW	1.17	11	SW	67.6	68.9	68.9	---
2/18/2011	9:30 AM	68.3	68.3	67.6	79	61.5	6	SSW	1	11	SSW	68.3	69.6	69.6	---
2/18/2011	9:40 AM	68.5	68.5	68.3	79	61.7	8	SSW	1.33	12	SSW	67.8	69.8	69.1	---
2/18/2011	9:50 AM	69.5	69.5	68.5	77	62	8	SSW	1.33	13	SSW	68.9	70.5	69.9	---
2/18/2011	10:00 AM	69.6	69.7	69.5	76	61.7	9	SSW	1.5	16	SW	68.2	70.5	69.1	---
2/18/2011	10:10 AM	69.7	69.8	69.6	76	61.8	10	SSW	1.67	15	SSW	67.6	70.5	68.4	---
2/18/2011	10:20 AM	70	70	69.7	76	62.1	9	SSW	1.5	15	SSW	68.6	70.7	69.3	---
2/18/2011	10:30 AM	70	70.1	69.9	75	61.7	9	SSW	1.5	14	SSW	68.6	70.6	69.2	---
2/18/2011	10:40 AM	70.8	70.8	70	74	62.1	9	SSW	1.5	13	SSW	69.4	71.5	70.1	---
2/18/2011	10:50 AM	71.4	71.4	70.8	70	61.1	10	SSW	1.67	16	SSW	69.3	71.9	69.8	---
2/18/2011	11:00 AM	71	71.4	71	70	60.7	10	SSW	1.67	14	SSW	68.9	71.4	69.3	---
2/18/2011	11:10 AM	71.2	71.2	70.8	71	61.3	9	SW	1.5	14	WSW	69.8	71.7	70.3	---
2/18/2011	11:20 AM	71.7	71.7	71.2	70	61.4	8	SSW	1.33	14	SSW	71.2	72.3	71.8	---
2/18/2011	11:30 AM	72.4	72.4	71.7	68	61.2	8	SSW	1.33	14	SSW	71.9	73.1	72.6	---
2/18/2011	11:40 AM	72.3	72.5	72.3	68	61.1	8	SSW	1.33	14	SW	71.8	73	72.5	---
2/18/2011	11:50 AM	72.5	72.6	72.3	67	60.9	7	S	1.17	11	S	72.5	73.2	73.2	---
2/18/2011	12:00 PM	73	73	72.2	67	61.4	8	S	1.33	13	SSW	72.5	73.9	73.4	---
2/18/2011	12:10 PM	74.9	74.9	73	64	61.9	6	S	1	11	S	74.9	76.1	76.1	---
2/18/2011	12:20 PM	75.8	75.8	74.9	62	61.8	6	SW	1	12	S	75.8	76.7	76.7	---
2/18/2011	12:30 PM	76.3	77.3	75.8	60	61.4	9	SSW	1.5	15	SSW	75	77	75.7	---
2/18/2011	12:40 PM	74.4	76.3	74.4	62	60.5	7	S	1.17	10	SSW	74.4	75.4	75.4	---
2/18/2011	12:50 PM	74	74.4	73.8	64	61	5	SSW	0.83	11	SW	74	75.1	75.1	---
2/18/2011	1:00 PM	74.4	74.4	73.9	63	61	6	SSW	1	10	SW	74.4	75.5	75.5	---
2/18/2011	1:10 PM	75.6	75.6	74.3	60	60.7	8	S	1.33	15	SSE	75.1	76.4	75.9	---

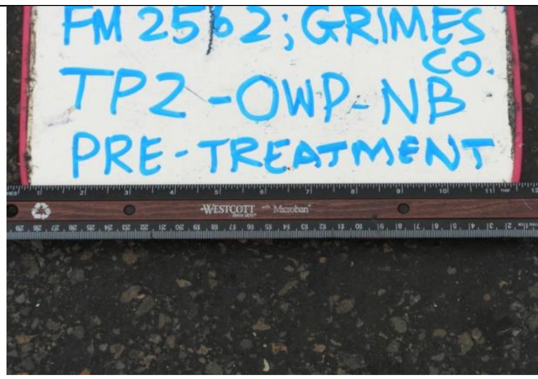
2/18/2011	1:20 PM	75.3	75.8	75	60	60.5	7	SSW	1.17	12	S	75.3	76.1	76.1	---
2/18/2011	1:30 PM	77.8	77.8	75.2	57	61.3	8	S	1.33	16	SSW	77.3	78.4	77.9	---
2/18/2011	1:40 PM	78.5	78.6	77.9	55	61	10	SSW	1.67	17	SW	76.8	79.1	77.4	---
2/18/2011	1:50 PM	78	78.4	76.9	56	61	8	SSE	1.33	14	SSW	77.5	78.6	78.1	---
2/18/2011	2:00 PM	78	78.3	77.3	56	61	8	S	1.33	14	S	77.5	78.6	78.1	---
2/18/2011	2:10 PM	80.2	80.2	78.1	52	61	1	S	0.17	15	SSW	80.2	80.6	80.6	---

Site Photographs

(a)

Figure XX. BMT3 Pictures (a) highway and location; (b) close-up of flushed surface before treatment; (c) roadway surface before treatment; (d) close-up of flushed surface immediately after treatment; (e) roadway surface after treatment; (f) close-up of surface at first follow-up ; (g) roadway surface at first follow-up , (h) roadway surface at second follow-up ; (i) close-up of surface at second follow-up , (j) close-up of surface at third follow-up ; (k) roadway surface at third follow-up

(b)



(c)

(d)

(e)

(f)

(g)

(h)		(i)	
(j)		(k)	

APPENDIX G

SITE BMT 1

Liberty COUNTY

Beaumont DISTRICT

Site Description

Project Information			
District: Beaumont	Test Site: BMT 1	County: Liberty	Road: SH 321 NB
ADT:5800	Truck Traffic: Medium-High	Year Built:	Last Maintained: Summer 2008

Roadway Description
Aggregate Grade: Ty PB GR 4 SAC B
Aggregate Type: Limestone w/ Asphalt
Pit: Martin Marietta - Black Spur
AQMP#: NA
CSJ: 0593-01-109
CCSJ: 0028-06-068
Binder: AC 20-5TR

Pavement abnormalities:
The pavement was moderately flushed in both wheel paths. The major aggregate appeared to be Grade 3 or 4 rock in a full width seal coat. The pavement was broomed off as soon as the treatment was completed to remove the very light coat of asphalt dust from the roadway.

Research Test Summary		
Test Location: FM 1008 to FM 163	Closest Texas Reference Marker: 436	
Test Point GPS Coordinates	N	W
TP1	30°17.852'	094°58.841
TP2	30°17.949'	094°58.898'
TP3	30°18.050'	094°58.956'

Ultra High Pressure Water Cutter Treatment Summary		
Date Treated 2/23/2011	Start Time 7:45 AM	End Time 2:30 PM

Summary Description of Treatment Activity

Personnel on site:
TechMRT: Andrew Tubb and Timothy Wood
Rampart: Bob Beadling and Jim Windich
TxDOT: John Snoddy (Beaumont District), others from the Liberty County Maintenance Office

Rampart configuration: Rampart used their typical 28 jet nozzle configuration running at 32ksi.

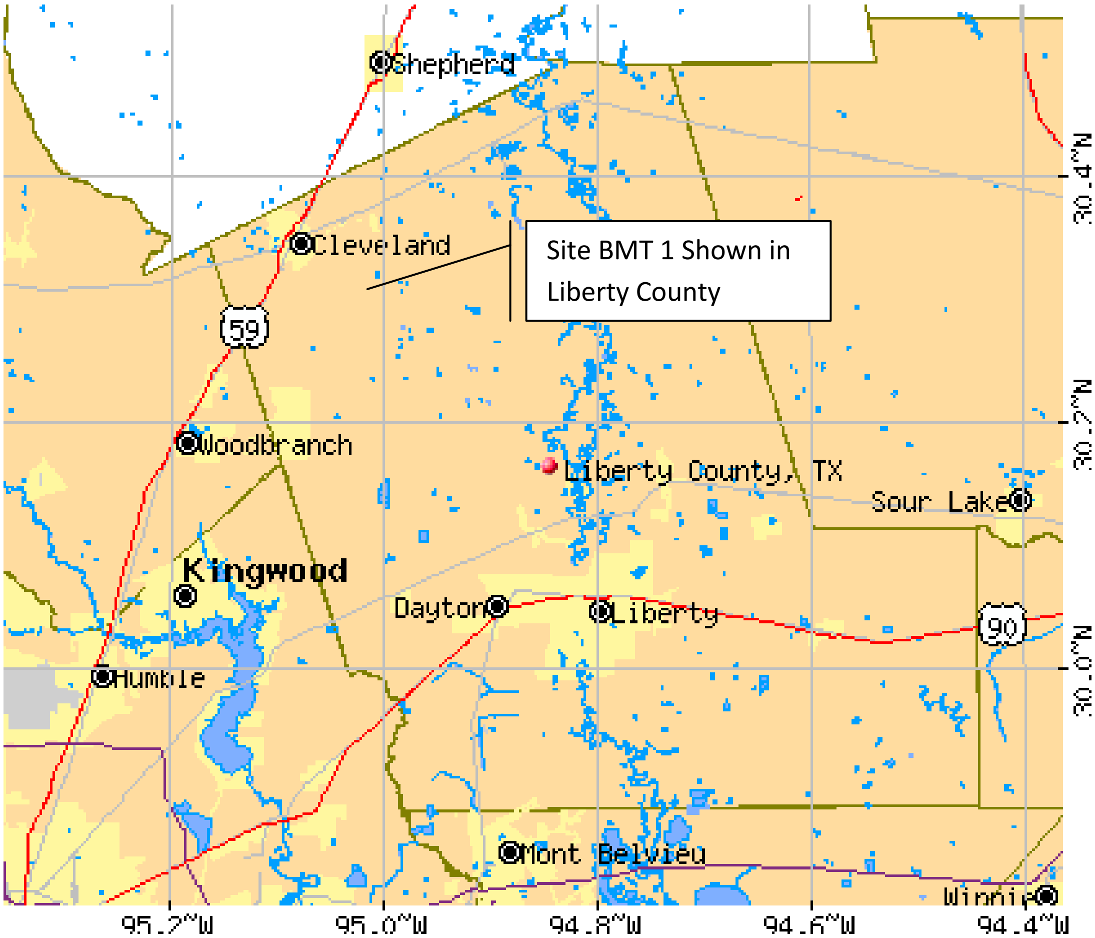
Work Activities: TechMRT and Rampart were at the maintenance office before 7:00AM. TechMRT participated in the morning meeting and then headed to the site at 7:10AM while rampart filled the truck.

TechMRT arrived on site at 7:45AM. From 7:45AM till 9:00AM everyone waited for the very light drizzle to slow down. At 9:00AM the decision was made to dry the roadway with the leaf blower for each test point. TechMRT setup the weather station at TP3 and remarked all test points and the speed sections for the northbound lane from 9:00AM to 9:30AM. TechMRT performed all pretest from 9:30AM till 11:00AM.

Rampart was present at the site beginning at 8:30AM. They treated the center of the wheel paths with

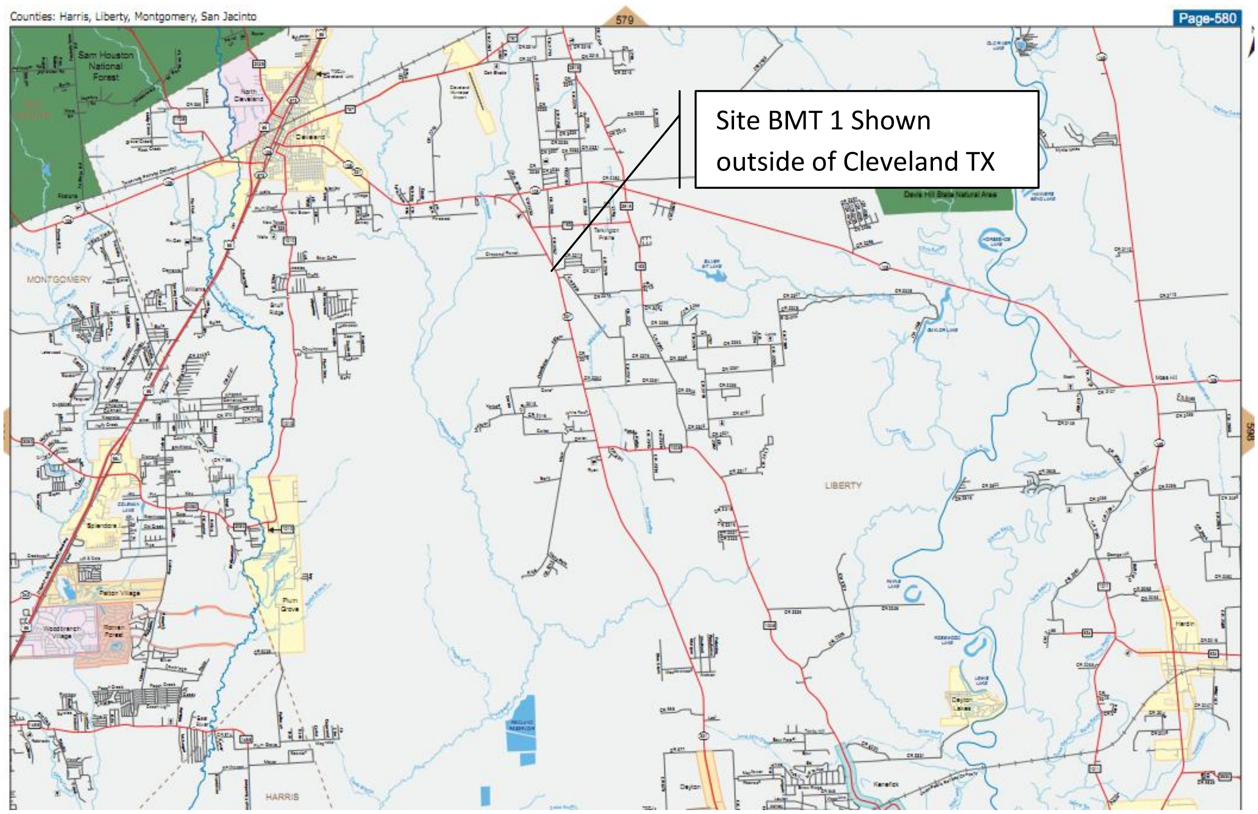
a single pass for the two wheel paths in the speed zones from 11:15AM to 12:15PM. They then treated passes 1 and 5 on the inside quarter mile from 12:20PM to 1:00PM. From 1:00PM to 1:35PM they left to empty the truck. Rampart then treated passes 2 and 4 on in the inside quarter mile from 1:50 till 3:00PM. From 2:30PM till 2:50PM Rampart changed the nozzles and fixed a broken safety check. TechMRT performed all post testing from 1:00PM till 1:50PM. By noon the skies had cleared and the sun was actively drying the pavement. The weather station was retrieved at 2:15PM. Returned to Beaumont at 3:20AM.	
Comments	
Follow-On Testing Summary	
Date: 7/22/11	Comments: Preformed follow –up monitoring successfully.
Date: 1/6/12	Comments: Preformed follow –up monitoring successfully.
Date: 7/20/12	Comments: Preformed follow –up monitoring successfully.

Site Vicinity Map



http://www.city-data.com/

Site Location Map

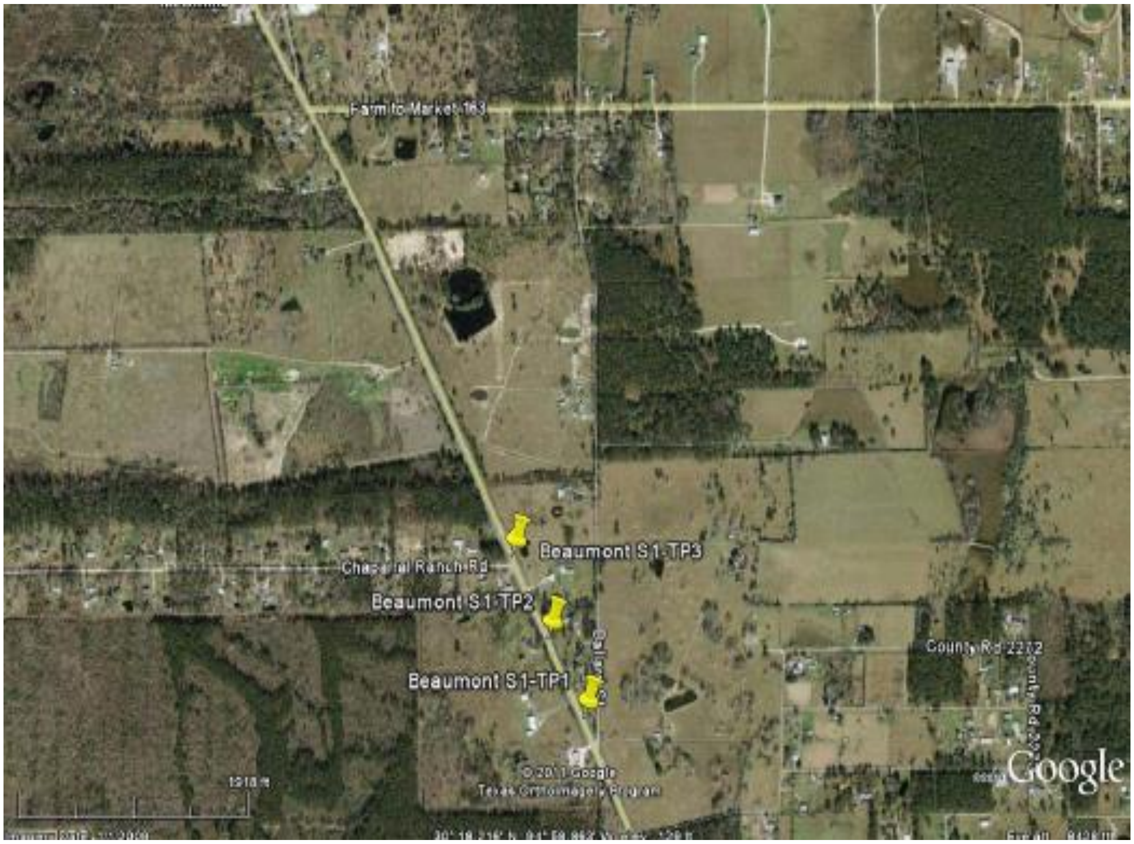


http://www.txdot.gov/travel/county_grid_search.htm

Aerial Photograph

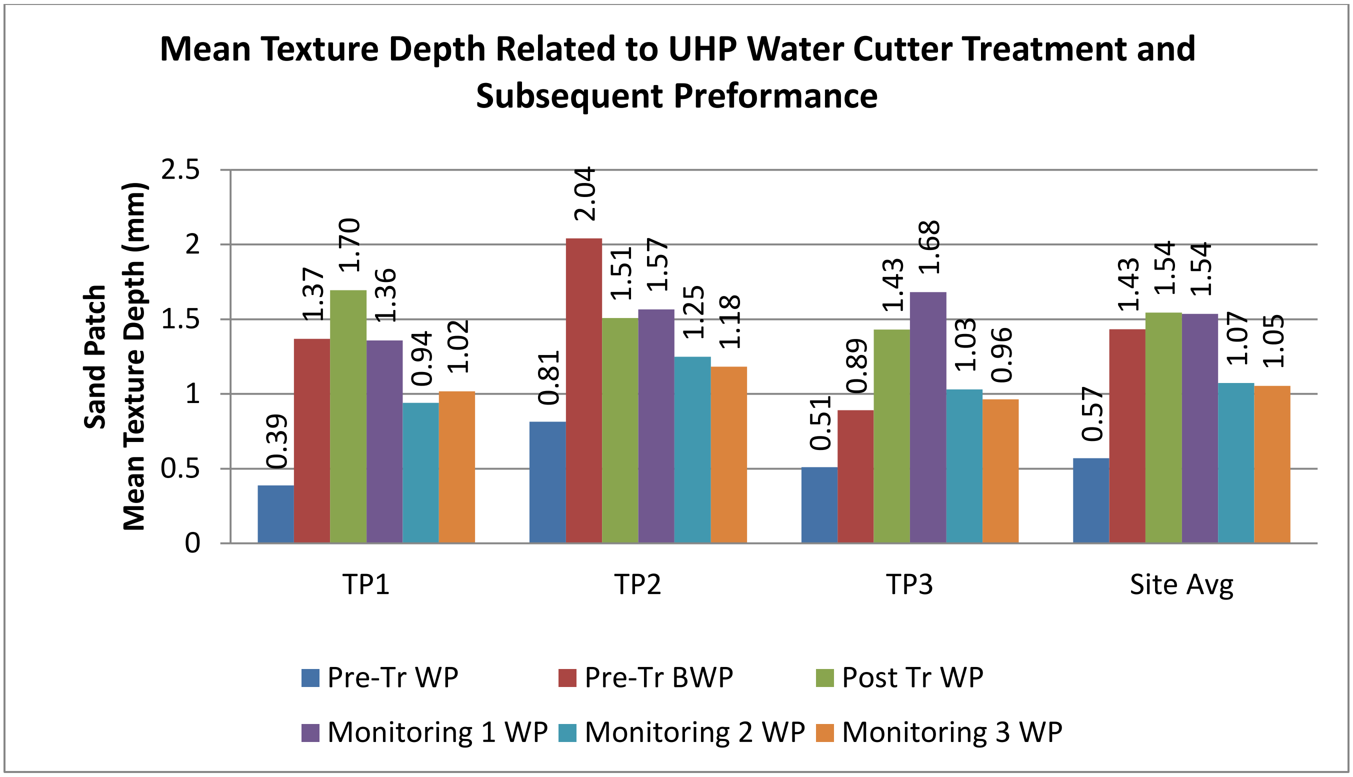
Google Inc. (2011). Google Earth (Version 6.1.0.5001)

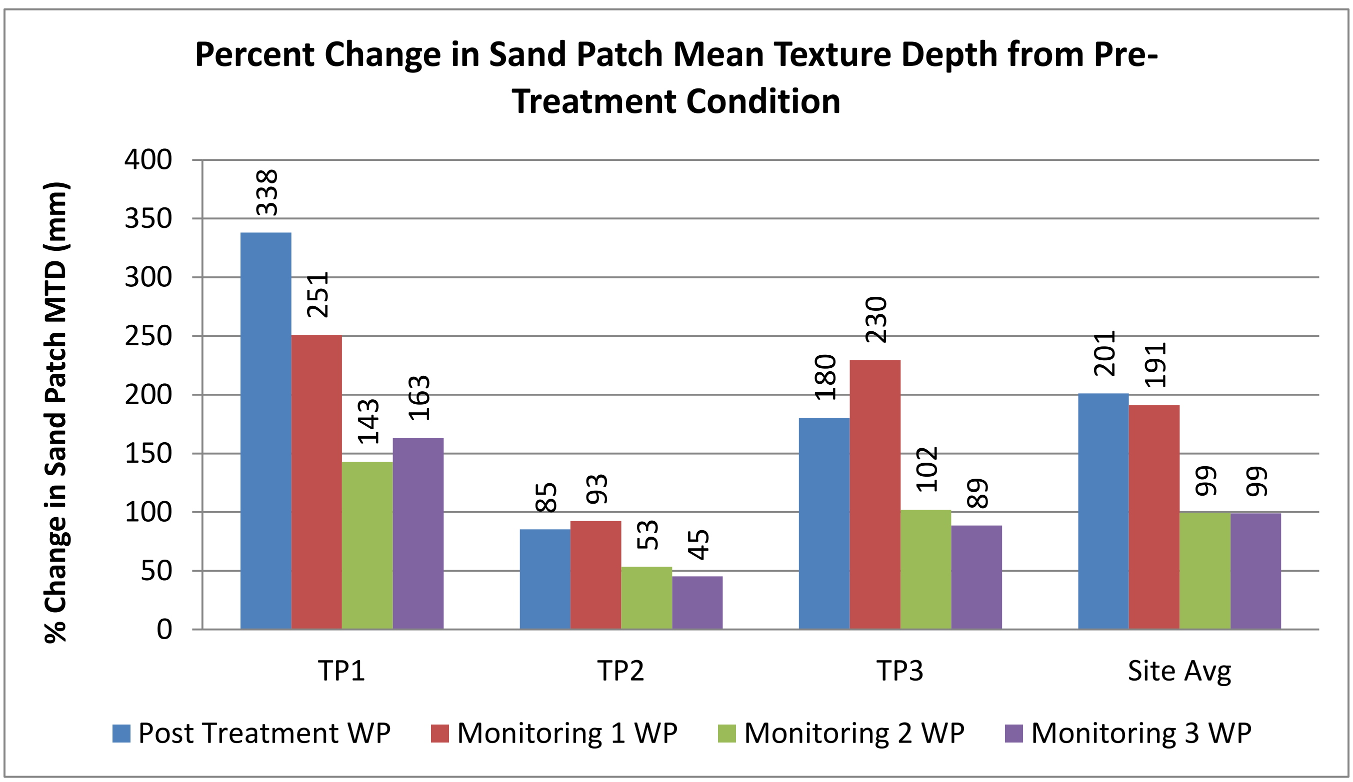
Test Point Plan



Google Inc. (2011). Google Earth (Version 6.1.0.5001)

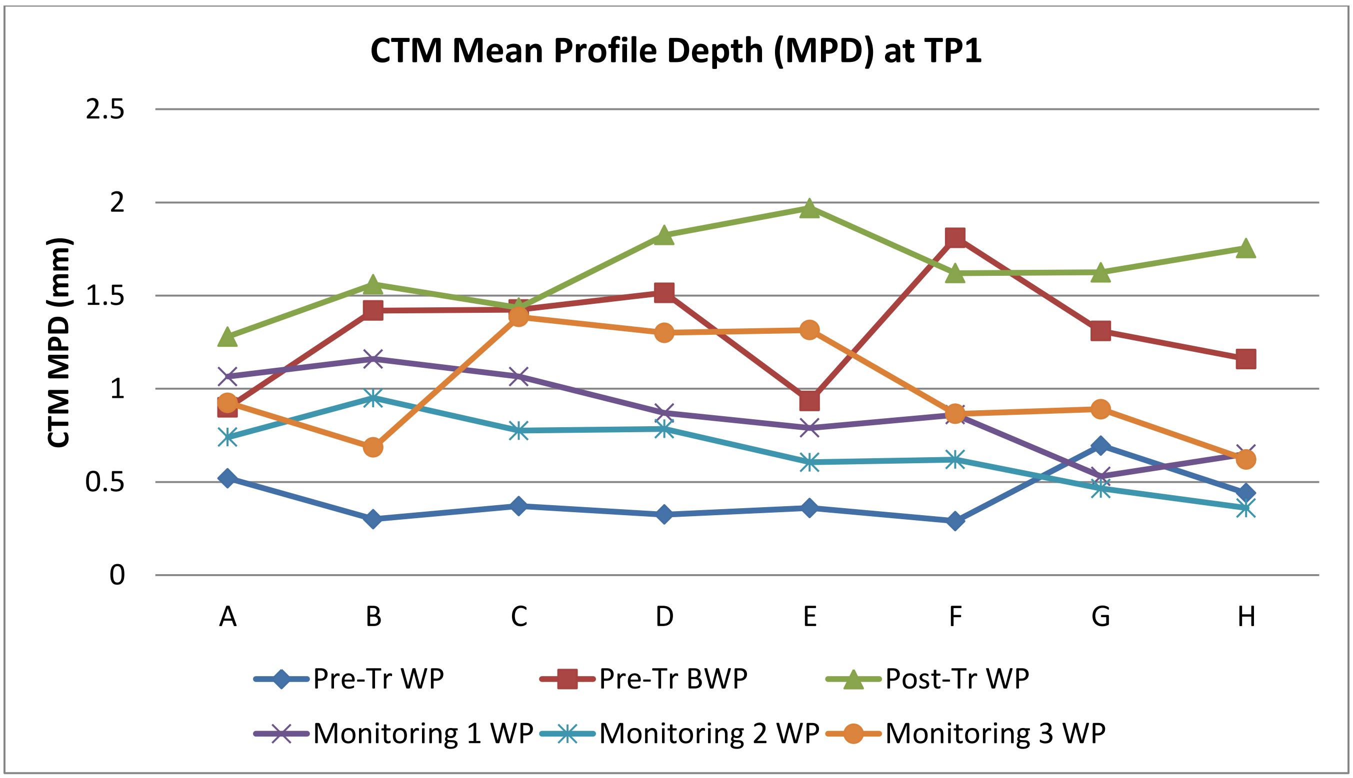
Sand Patch Data





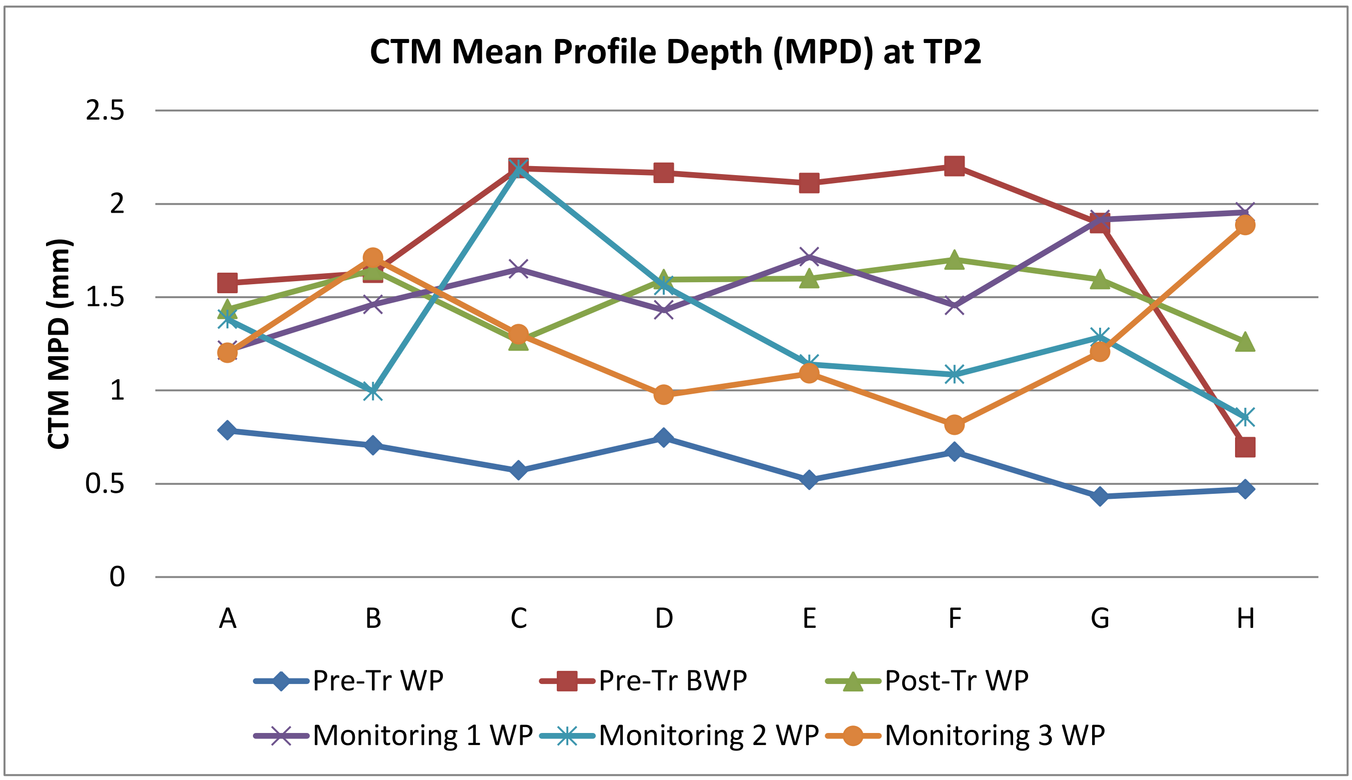
Circular Track Meter (CTM) Mean Profile Depth (in mm) at TP 1

	A	B	C	D	E	F	G	H
Pre-Tr WP	0.52	0.3	0.37	0.325	0.36	0.29	0.695	0.44
Pre-Tr BWP	0.9	1.42	1.425	1.515	0.935	1.81	1.31	1.16
Post-Tr	1.28	1.56	1.435	1.825	1.97	1.62	1.625	1.755
Monitoring 1	1.065	1.16	1.065	0.87	0.79	0.86	0.53	0.65
Monitoring 2	0.74	0.95	0.775	0.785	0.605	0.62	0.465	0.36
Monitoring 3	0.925	0.685	1.385	1.3	1.315	0.865	0.89	0.62



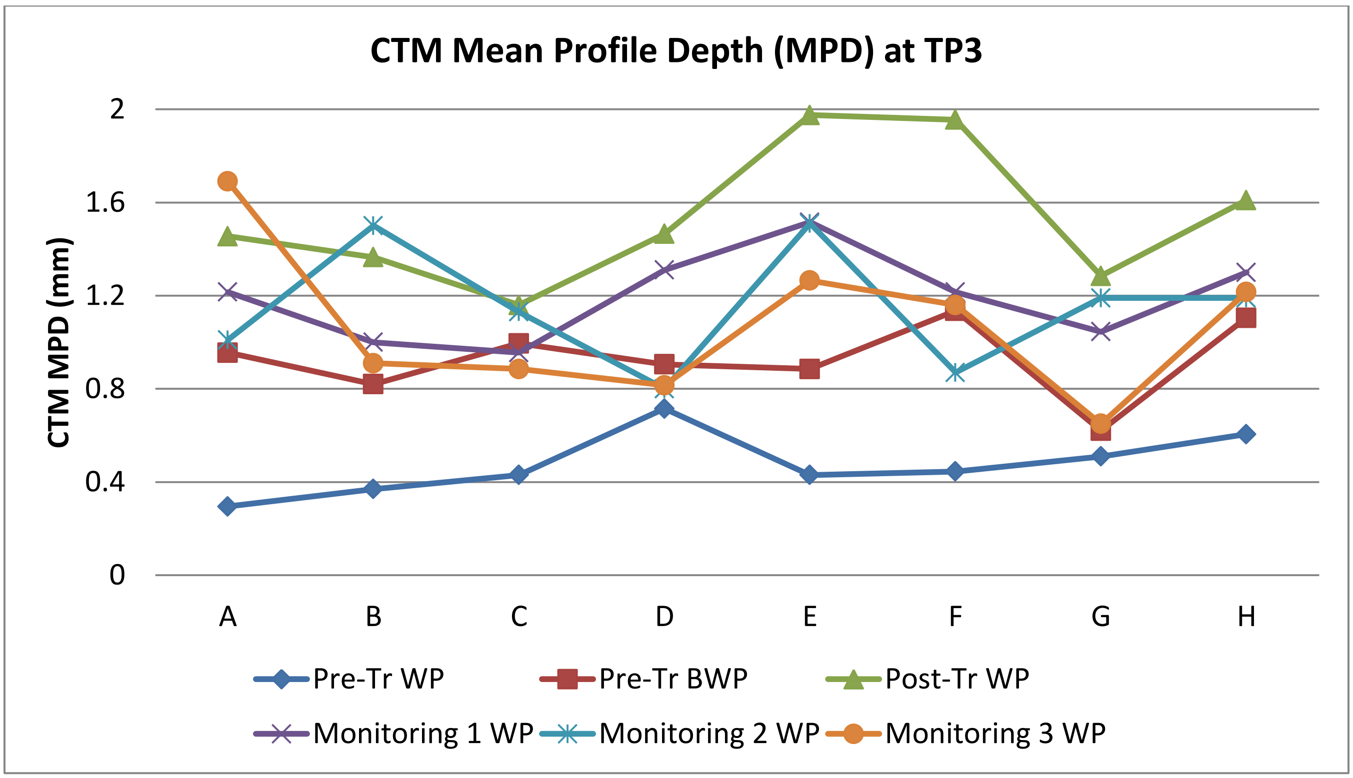
Circular Track Meter (CTM) Mean Profile Depth (in mm) at TP 2

	A	B	C	D	E	F	G	H
Pre-Tr WP	0.785	0.705	0.57	0.745	0.52	0.67	0.43	0.47
Pre-Tr BWP	1.575	1.63	2.19	2.165	2.11	2.2	1.895	0.695
Post-Tr	1.435	1.645	1.265	1.595	1.6	1.7	1.595	1.26
Monitoring 1	1.215	1.46	1.65	1.43	1.715	1.455	1.915	1.955
Monitoring 2	1.38	0.995	2.185	1.56	1.14	1.085	1.285	0.855
Monitoring 3	1.2	1.71	1.3	0.975	1.09	0.815	1.205	1.885

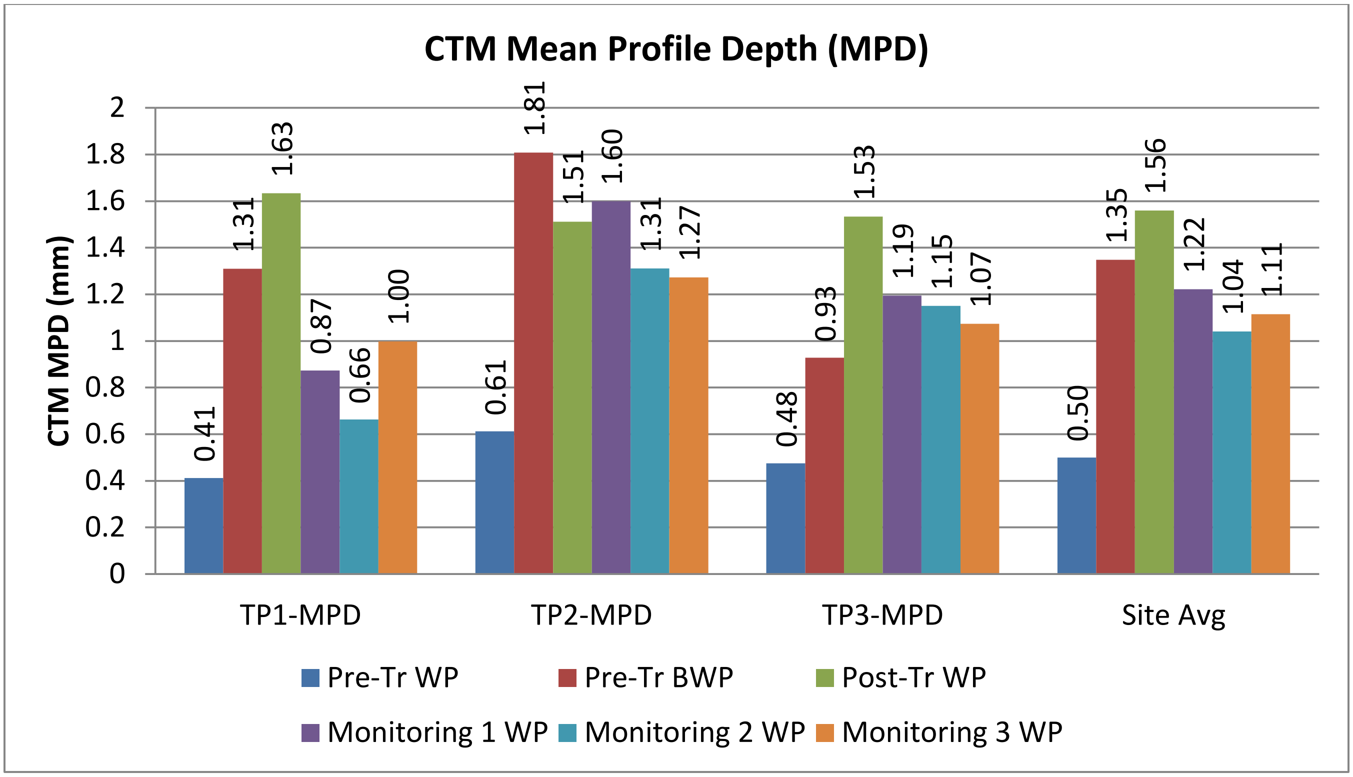


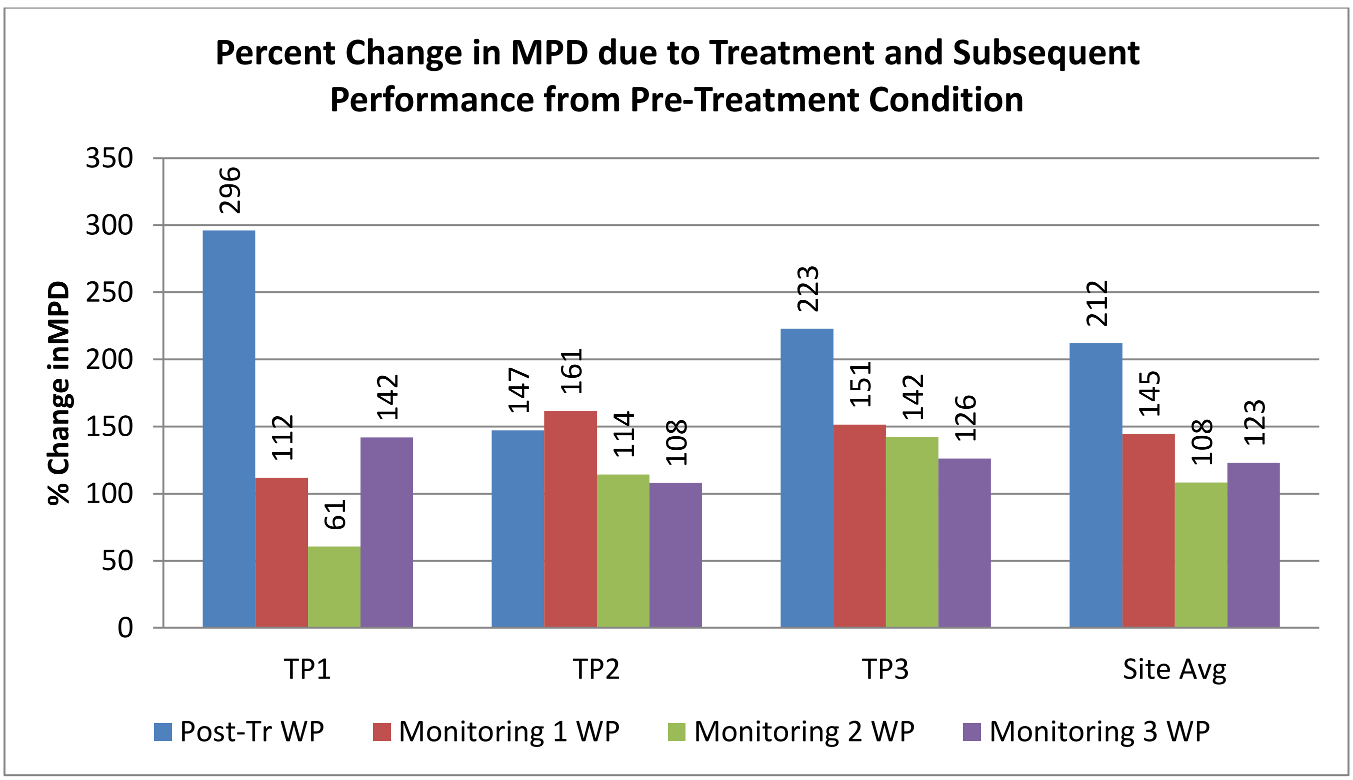
Circular Track Meter (CTM) Mean Profile Depth (in mm) at TP 3

	A	B	C	D	E	F	G	H
Pre-Tr WP	0.295	0.37	0.43	0.715	0.43	0.445	0.51	0.605
Pre-Tr BWP	0.955	0.82	0.995	0.905	0.885	1.135	0.62	1.105
Post-Tr	1.455	1.365	1.16	1.465	1.975	1.955	1.285	1.61
Monitoring 1	1.215	1	0.955	1.31	1.515	1.215	1.045	1.3
Monitoring 2	1.01	1.5	1.13	0.8	1.51	0.87	1.19	1.19
Monitoring 3	1.69	0.91	0.885	0.815	1.265	1.16	0.65	1.215

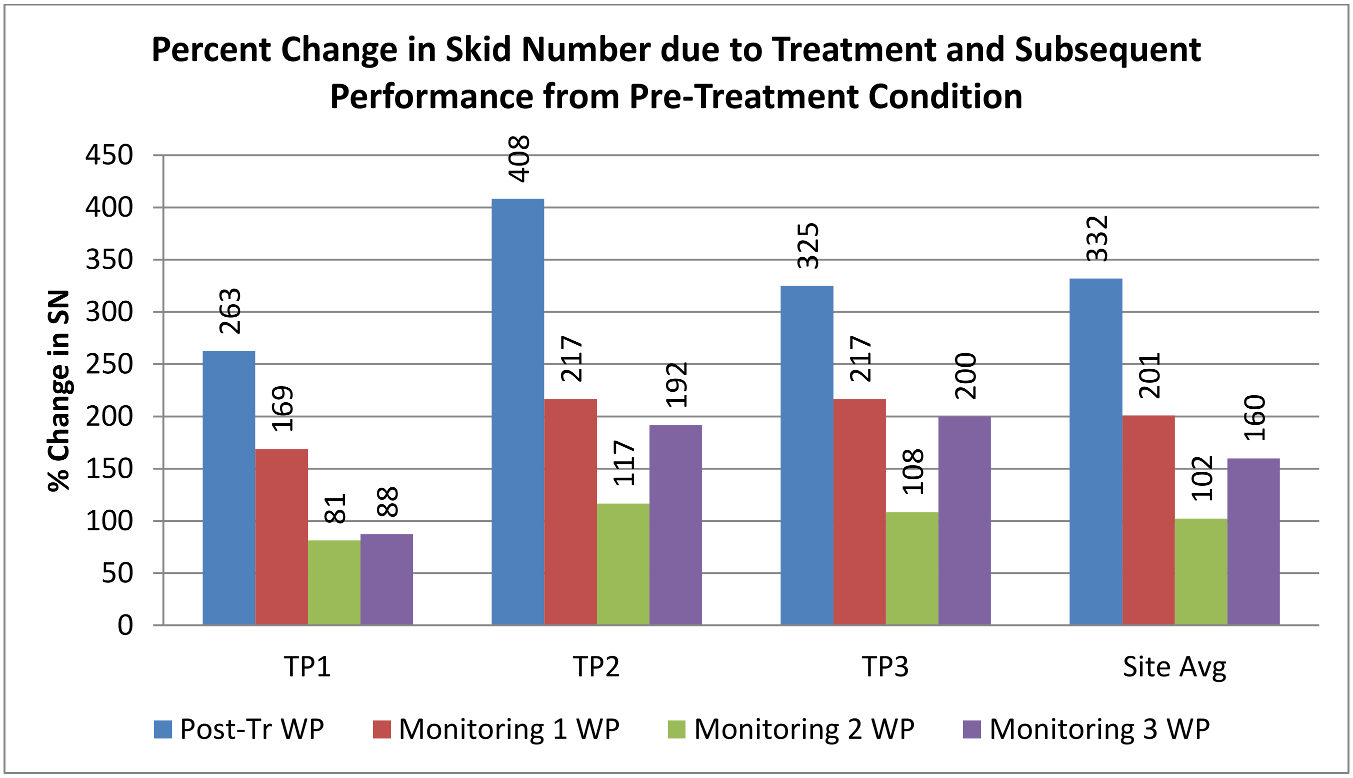


Circular Track Meter (CTM) MPD (mm)



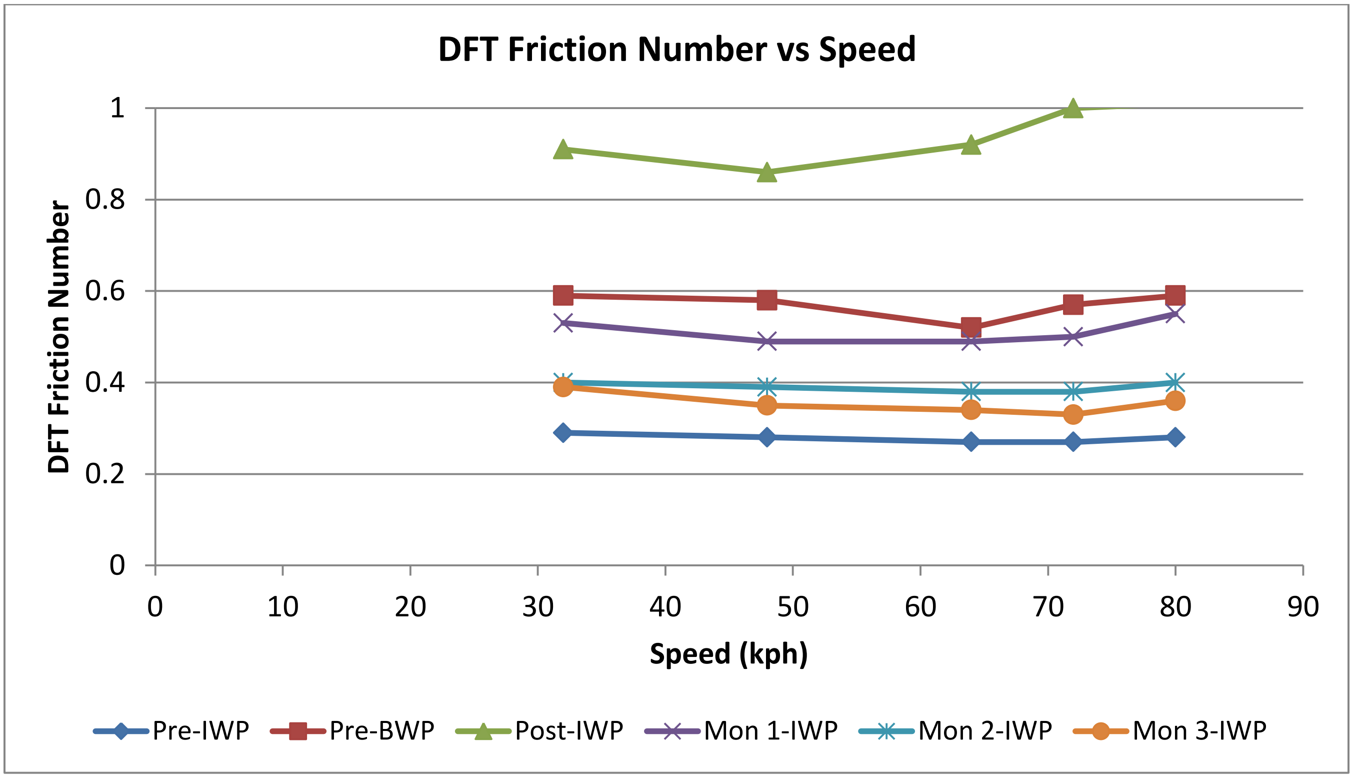


Skid Truck Data



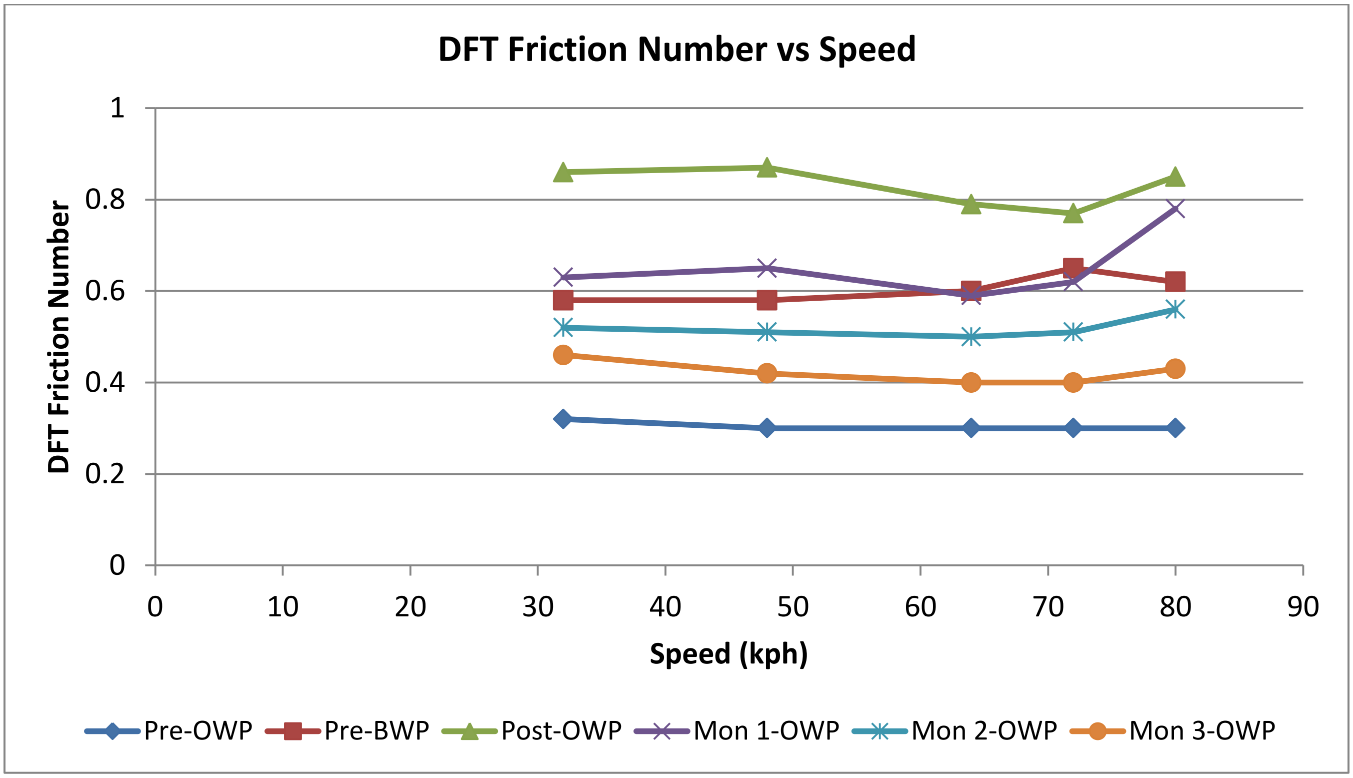
Dynamic Friction Test (DFT) Friction Number Data for TP 1

Speed (kph)	Pre-IWP	Pre-BWP	Post-IWP	Mon 1-IWP	Mon 2-IWP	Mon 3-IWP
32	0.29	0.59	0.91	0.53	0.4	0.39
48	0.28	0.58	0.86	0.49	0.39	0.35
64	0.27	0.52	0.92	0.49	0.38	0.34
72	0.27	0.57	1	0.5	0.38	0.33
80	0.28	0.59	1.01	0.55	0.4	0.36



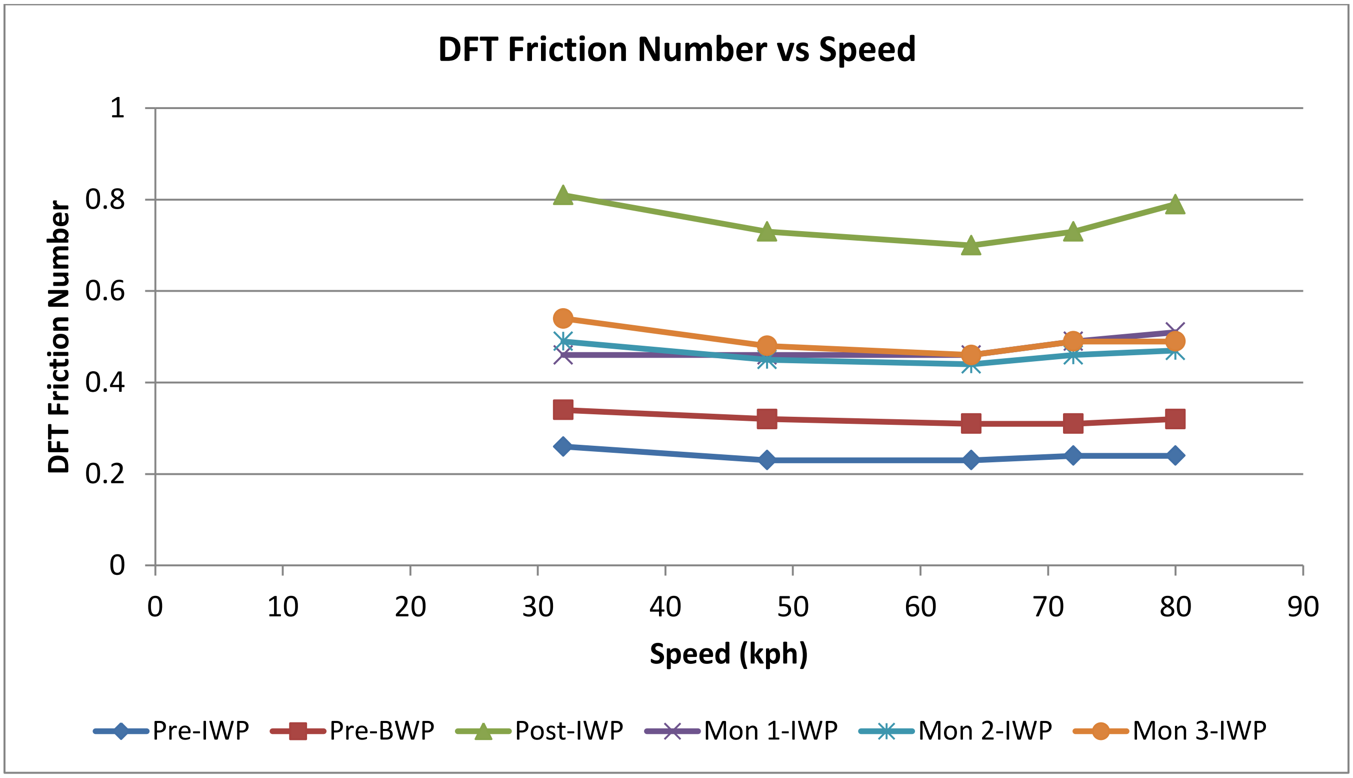
Dynamic Friction Test (DFT) Friction Number Data for TP 2

Speed (kph)	Pre-OWP	Pre-BWP	Post-OWP	Mon 1-OWP	Mon 2-OWP	Mon 3-OWP
32	0.32	0.58	0.86	0.63	0.52	0.46
48	0.3	0.58	0.87	0.65	0.51	0.42
64	0.3	0.6	0.79	0.59	0.5	0.4
72	0.3	0.65	0.77	0.62	0.51	0.4
80	0.3	0.62	0.85	0.78	0.56	0.43



Dynamic Friction Test (DFT) Friction Number Data for TP 3

Speed (kph)	Pre-IWP	Pre-BWP	Post-IWP	Mon 1-IWP	Mon 2-IWP	Mon 3-IWP
32	0.26	0.34	0.81	0.46	0.49	0.54
48	0.23	0.32	0.73	0.46	0.45	0.48
64	0.23	0.31	0.7	0.46	0.44	0.46
72	0.24	0.31	0.73	0.49	0.46	0.49
80	0.24	0.32	0.79	0.51	0.47	0.49

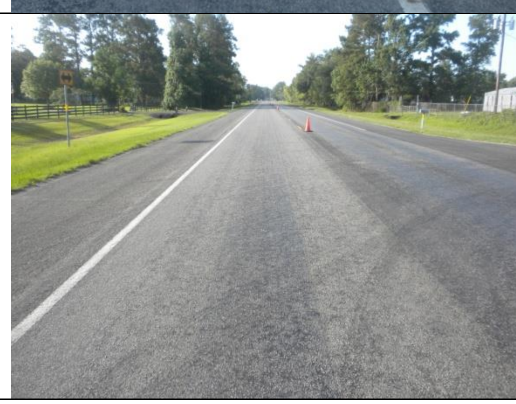


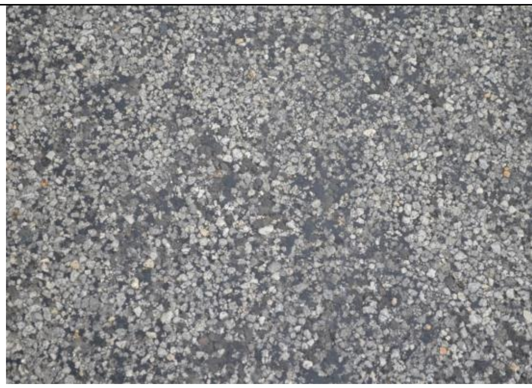
Weather Data during UHP Water Cutter Treatment

Date	Time	Temp Out	Hi Temp	Low Temp	Out Hum	Dew Pt.	Wind Speed	Wind Dir	Wind Run	Hi Speed	Hi Dir	Wind Chill	Heat Index	THW Index	THSW Index
2/23/2011	9:10 AM	68.8	69.5	68.8	85	64.1	0	SSE	0	2	S	68.8	70.5	70.5	---
2/23/2011	9:20 AM	66.8	68.8	66.8	91	64.1	2	S	0.33	5	SE	66.8	68.3	68.3	---
2/23/2011	9:30 AM	66.6	66.8	66.6	93	64.5	1	S	0.17	5	SSE	66.6	68.1	68.1	---
2/23/2011	9:40 AM	66.9	66.9	66.6	93	64.8	2	S	0.33	6	S	66.9	68.4	68.4	---
2/23/2011	9:50 AM	67.2	67.2	66.9	93	65.1	2	S	0.33	6	S	67.2	68.8	68.8	---
2/23/2011	10:00 AM	67.3	67.3	67.2	94	65.5	3	S	0.5	8	S	67.3	69	69	---
2/23/2011	10:10 AM	68.1	68.1	67.3	94	66.3	3	S	0.5	8	S	68.1	70	70	---
2/23/2011	10:20 AM	68.3	68.3	68.1	92	65.9	4	S	0.67	11	S	68.3	70.2	70.2	---
2/23/2011	10:30 AM	68.5	68.5	68.3	92	66.1	5	S	0.83	10	S	68.5	70.4	70.4	---
2/23/2011	10:40 AM	68.7	68.7	68.5	91	66	4	SSE	0.67	8	SSE	68.7	70.7	70.7	---
2/23/2011	10:50 AM	69.2	69.2	68.7	92	66.8	3	S	0.5	6	S	69.2	71.3	71.3	---
2/23/2011	11:00 AM	70.1	70.2	69.2	89	66.7	3	S	0.5	8	SSE	70.1	72	72	---
2/23/2011	11:10 AM	69.8	70.1	69.8	89	66.4	5	S	0.83	11	S	69.8	71.7	71.7	---
2/23/2011	11:20 AM	69.8	69.9	69.7	90	66.7	3	S	0.5	8	S	69.8	71.8	71.8	---
2/23/2011	11:30 AM	69.9	69.9	69.7	89	66.5	3	SSW	0.5	7	S	69.9	71.8	71.8	---
2/23/2011	11:40 AM	69.8	70	69.8	89	66.4	4	SSW	0.67	7	SW	69.8	71.7	71.7	---
2/23/2011	11:50 AM	70.4	70.4	69.8	89	67	4	SSW	0.67	9	SE	70.4	72.4	72.4	---
2/23/2011	12:00 PM	71.9	71.9	70.4	88	68.2	4	S	0.67	9	SSW	71.9	73.9	73.9	---
2/23/2011	12:10 PM	73.5	73.5	71.9	82	67.7	5	SSW	0.83	8	SSW	73.5	75.5	75.5	---
2/23/2011	12:20 PM	73.4	73.7	73.3	82	67.6	5	SSE	0.83	9	SSE	73.4	75.4	75.4	---
2/23/2011	12:30 PM	74	74.1	73.3	79	67.1	5	S	0.83	10	SSE	74	76	76	---
2/23/2011	12:40 PM	75.2	75.2	74	76	67.1	5	S	0.83	10	WSW	75.2	77.4	77.4	---
2/23/2011	12:50 PM	74.9	75.6	74.9	73	65.7	6	S	1	12	S	74.9	76.8	76.8	---
2/23/2011	1:00 PM	75.5	75.5	74.6	73	66.2	5	SSW	0.83	10	SSW	75.5	77.6	77.6	---
2/23/2011	1:10 PM	76.2	76.2	75.5	71	66.1	6	SSW	1	12	SW	76.2	78.1	78.1	---
2/23/2011	1:20 PM	76.8	76.9	76.2	69	65.9	6	SSW	1	12	SW	76.8	78.6	78.6	---

2/23/2011	1:30 PM	77	77.1	76.4	68	65.6	6	S	1	14	S	77	78.7	78.7	---
2/23/2011	1:40 PM	76.4	77	76.4	69	65.5	6	SSW	1	13	WSW	76.4	78.1	78.1	---
2/23/2011	1:50 PM	77.2	77.2	76.3	68	65.8	6	S	1	12	S	77.2	78.9	78.9	---
2/23/2011	2:00 PM	76.8	77.2	76.8	69	65.9	6	S	1	14	SSE	76.8	78.6	78.6	---
2/23/2011	2:10 PM	77.3	77.3	76.6	69	66.3	4	S	0.67	11	SW	77.3	79.1	79.1	---
2/23/2011	2:20 PM	79.2	79.2	77.3	66	66.9	2	SSW	0.33	9	S	79.2	81.1	81.1	---

Site Photographs

(a)			Figure XX. BMT3 Pictures (a) highway and location; (b) close-up of flushed surface before treatment; (c) roadway surface before treatment; (d) close-up of flushed surface immediately after treatment; (e) roadway surface after treatment; (f) close-up of surface at first follow-up ; (g) roadway surface at first follow-up , (h) roadway surface at second follow-up ; (i) close-up of surface at second follow-up , (j) close-up of surface at third follow-up ; (k) roadway surface at third follow-up
(b)		(c)	
(d)		(e)	
(f)		(g)	

(h)		(i)	
(j)		(k)	

APPENDIX H

SITE BMT 2

Jasper COUNTY

Beaumont DISTRICT

Site Description

Project Information			
District: Beaumont	Test Site: BMT 2	County: Jasper	Road: SH 63 NB
ADT: 2800	Truck Medium:	Year Built:	Last Maintained: Summer 2009

Roadway Description
Aggregate Grade: Ty L GR 3LW SAC B
Aggregate Type: Expanded Shale Lightweight
Pit: Texas Industry-Streetman Pit
AQMP#: 1817502
CSJ: 0244-02-091
CCSJ: 0028-06-069
Binder: CRS-2P

Pavement abnormalities:
The pavement was lightly flushed in both wheel paths. The major aggregate appeared to be Grade 3 or 4 rock in a full width seal coat. The pavement was broomed off as soon as the treatment was completed to remove the light coat of asphalt dust from the roadway.

Research Test Summary		
Test Location: RR 255 to 2 mi N of RR 255	Closest Texas Reference Marker: 750	
Test Point GPS Coordinates	N	W
TP1	31°02.521'	094°11.265'
TP2	31°02.595'	094°11.358'
TP3	31°02.669'	094°11.453'

Ultra High Pressure Water Cutter Treatment Summary		
Date Treated 2/22/2011	Start Time 7:25 AM	End Time 2:00 PM

Summary Description of Treatment Activity

Personnel on site:
TechMRT: Andrew Tubb and Timothy Wood
Rampart: Bob Beadling and Jim Windich
TxDOT: John Snoddy (Beaumont District), others from the Jasper County Maintenance Office

Rampart configuration: Rampart used their typical 28 jet nozzle configuration running at 32ksi.

Work Activities: TechMRT and Rampart were at the maintenance office before 7:00AM. TechMRT participated in the morning meeting and then headed to the site at 7:10AM while rampart filled the truck.

TechMRT arrived on site at 7:25AM. From 7:30AM till 8:10AM TechMRT setup the weather station between at TP1 and remarked all test points and the speed sections for the northbound lane. The distance from the start of the test section to TP1 was 768’. TechMRT performed all pretest from 8:45AM till 9:40AM.

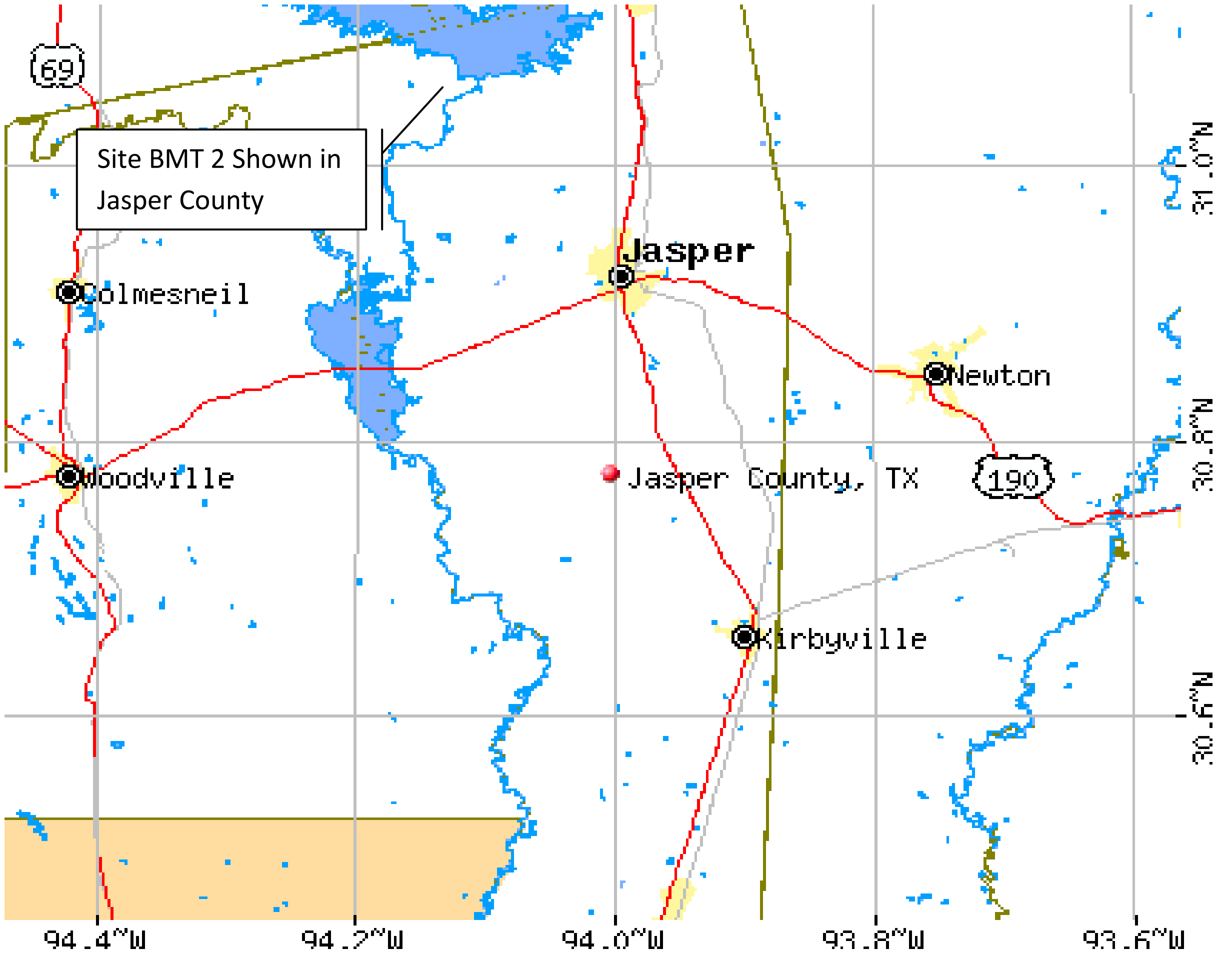
Rampart was present at the site beginning at 8:30AM. They treated the center of the wheel paths with a single pass for a total of two complete passes from 10:00AM to 11:45AM. At 12:00PM Rampart left to empty the truck.

TechMRT performed all post testing from 11:40AM till 1:30PM. Because of the high humidity, cool

temperatures and overcast skies, the pavement did not dry on its own. Rather approximately 10minutes of drying with the blower were required for each test site. The weather station was stored at 2:20PM. Rampart treated the center of both wheel paths (two complete passes) in the southbound lane from 2:00PM till 3:00PM Returned to Beaumont at 3:320M.
Comments

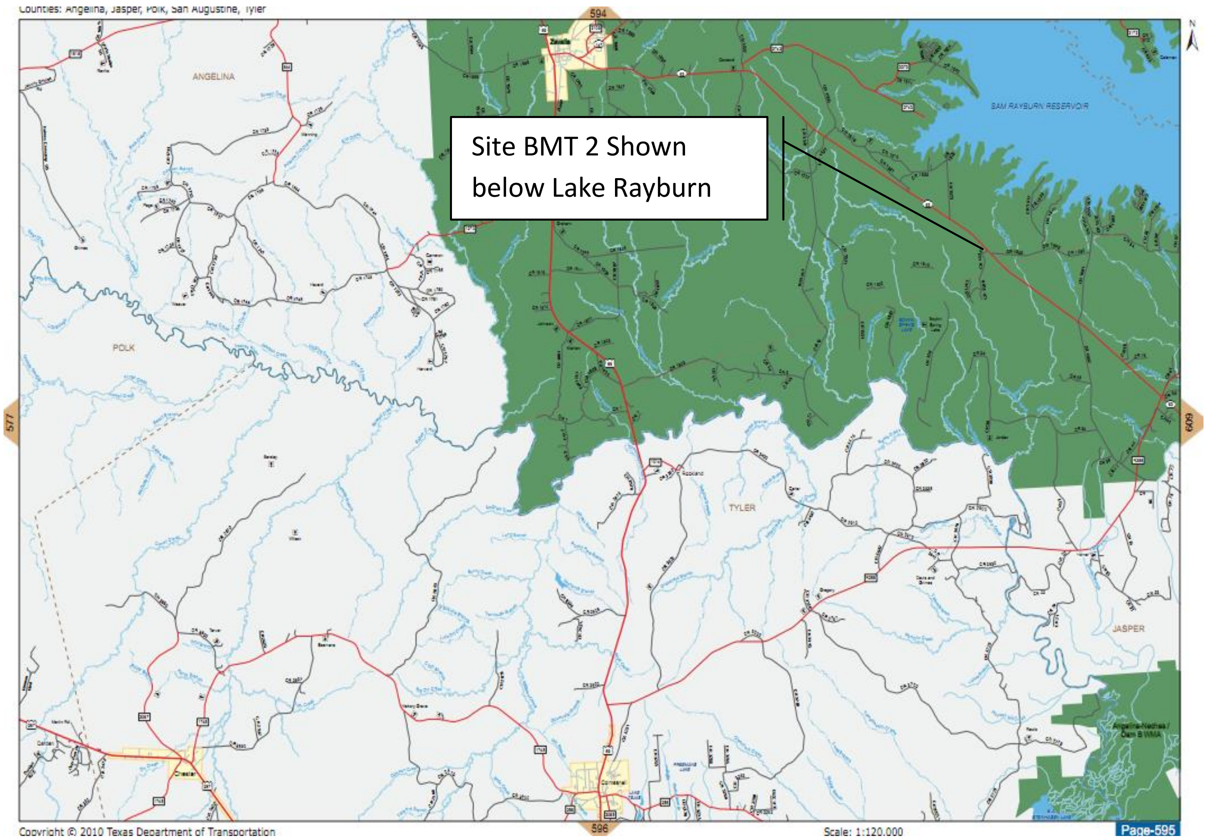
Follow-On Testing Summary	
Date: 7/21/11	Comments: Preformed follow –up monitoring successfully.
Date: 1/13/12	Comments: Preformed follow –up monitoring successfully.
Date: 7/19/12	Comments: Preformed follow –up monitoring successfully.

Site Vicinity Map



http://www.city-data.com/

Site Location Map



http://www.txdot.gov/travel/county_grid_search.htm

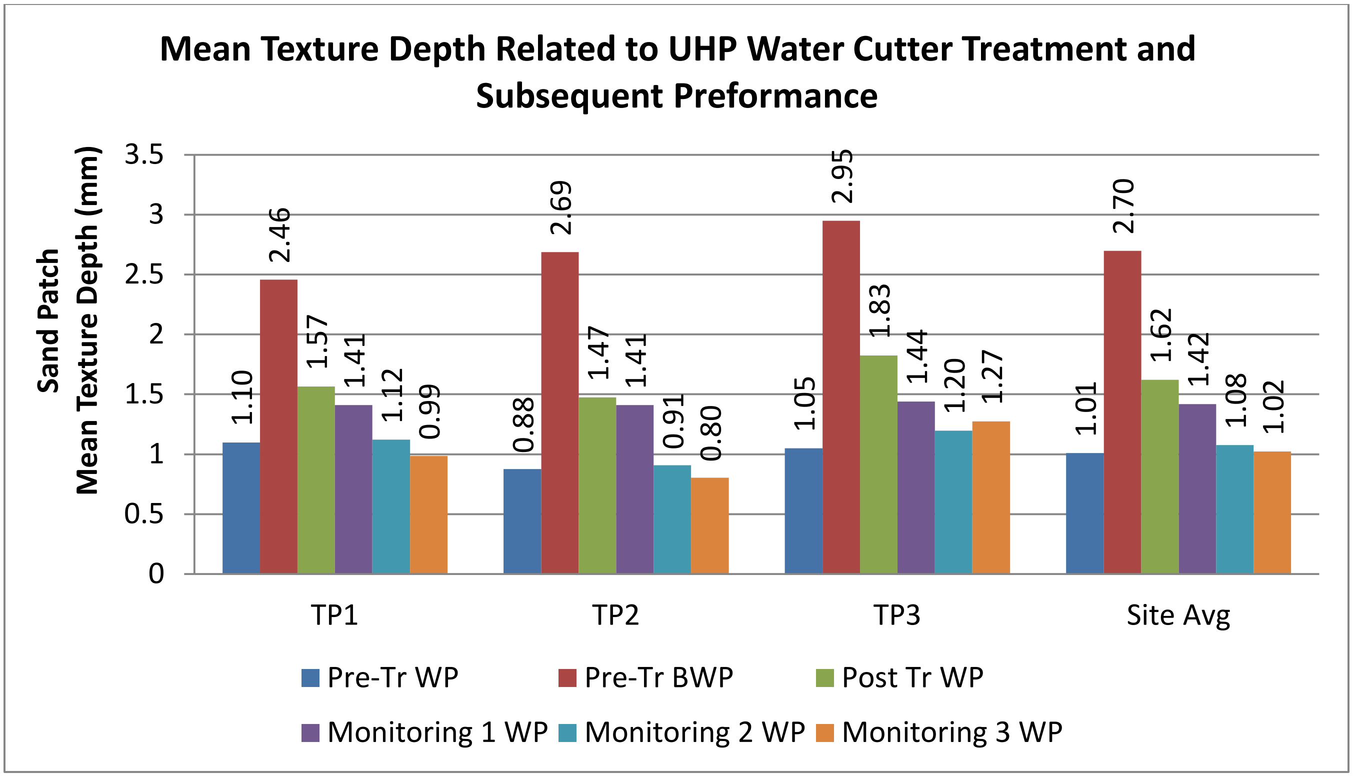
Aerial Photograph

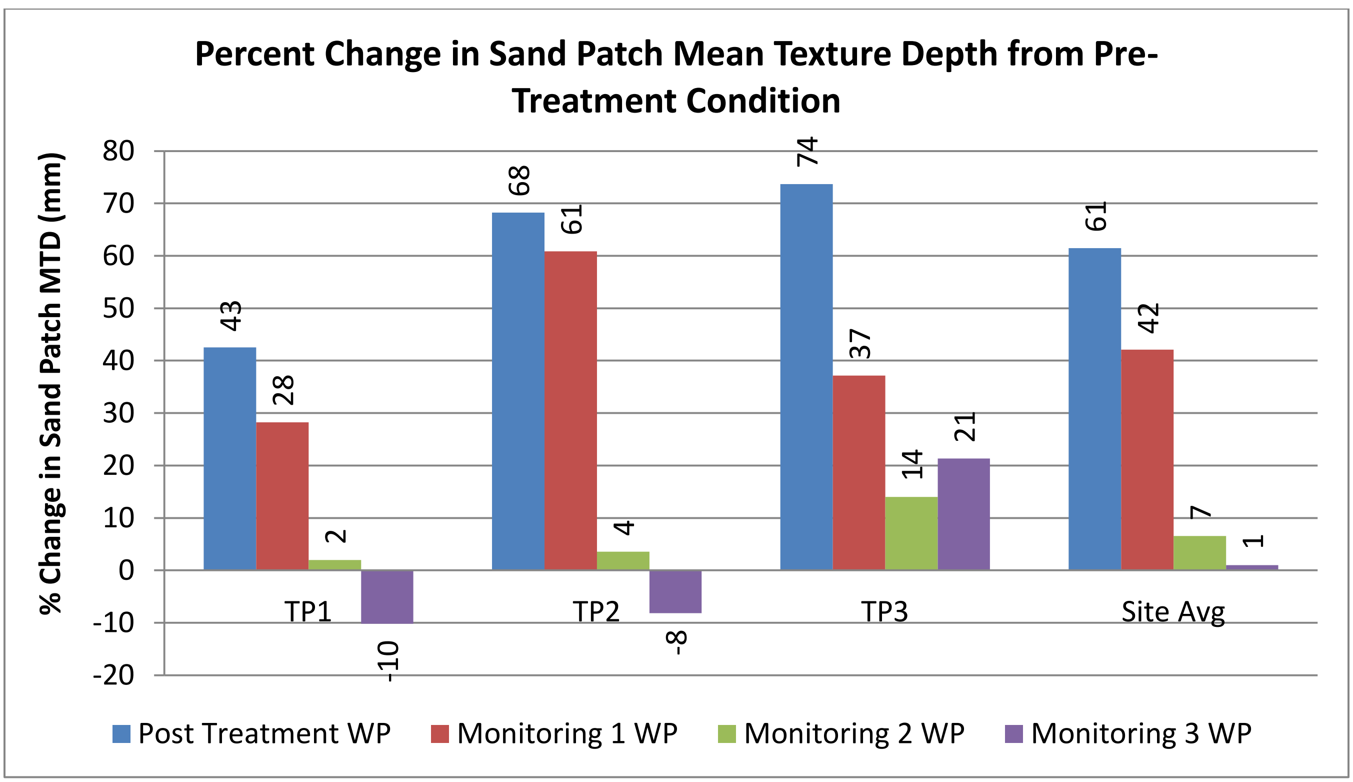
Google Inc. (2011). Google Earth (Version 6.1.0.5001)

Test Point Plan

Google Inc. (2011). Google Earth (Version 6.1.0.5001)

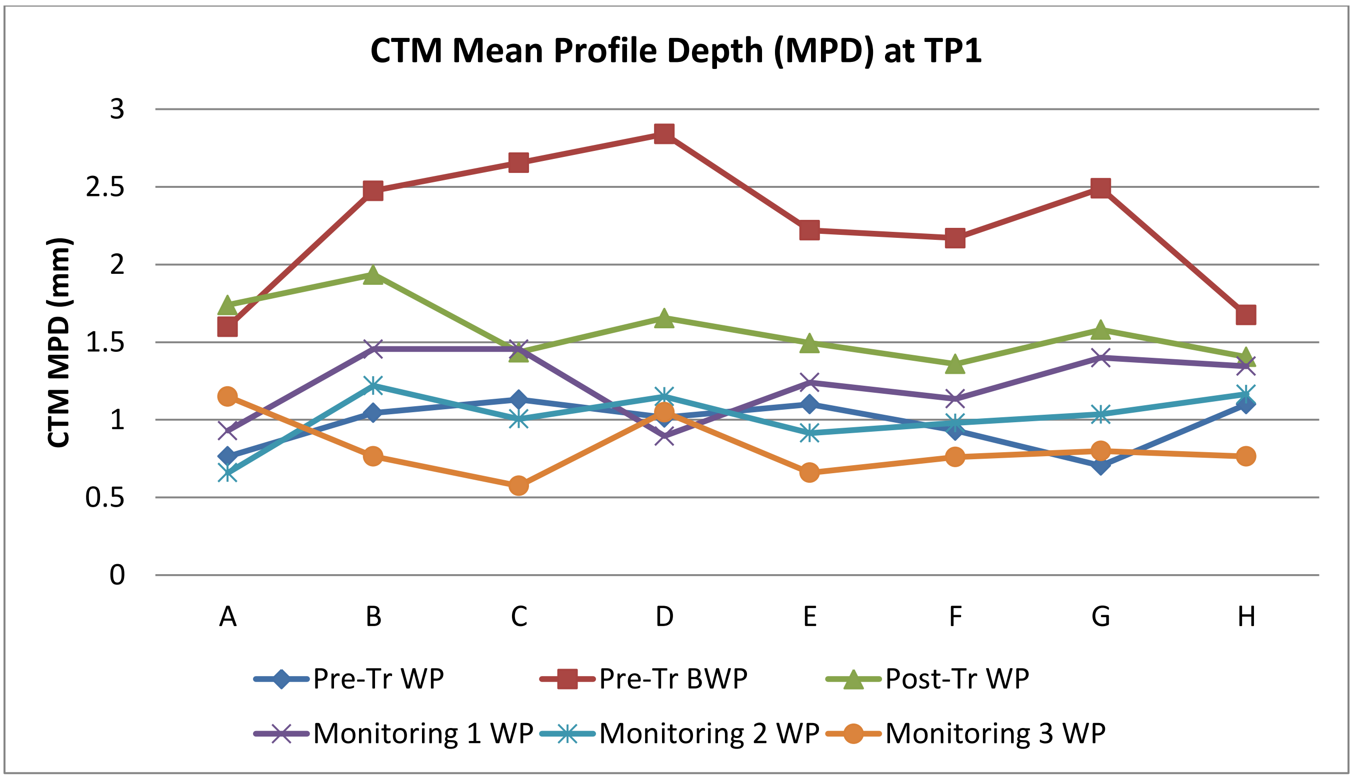
Sand Patch Data





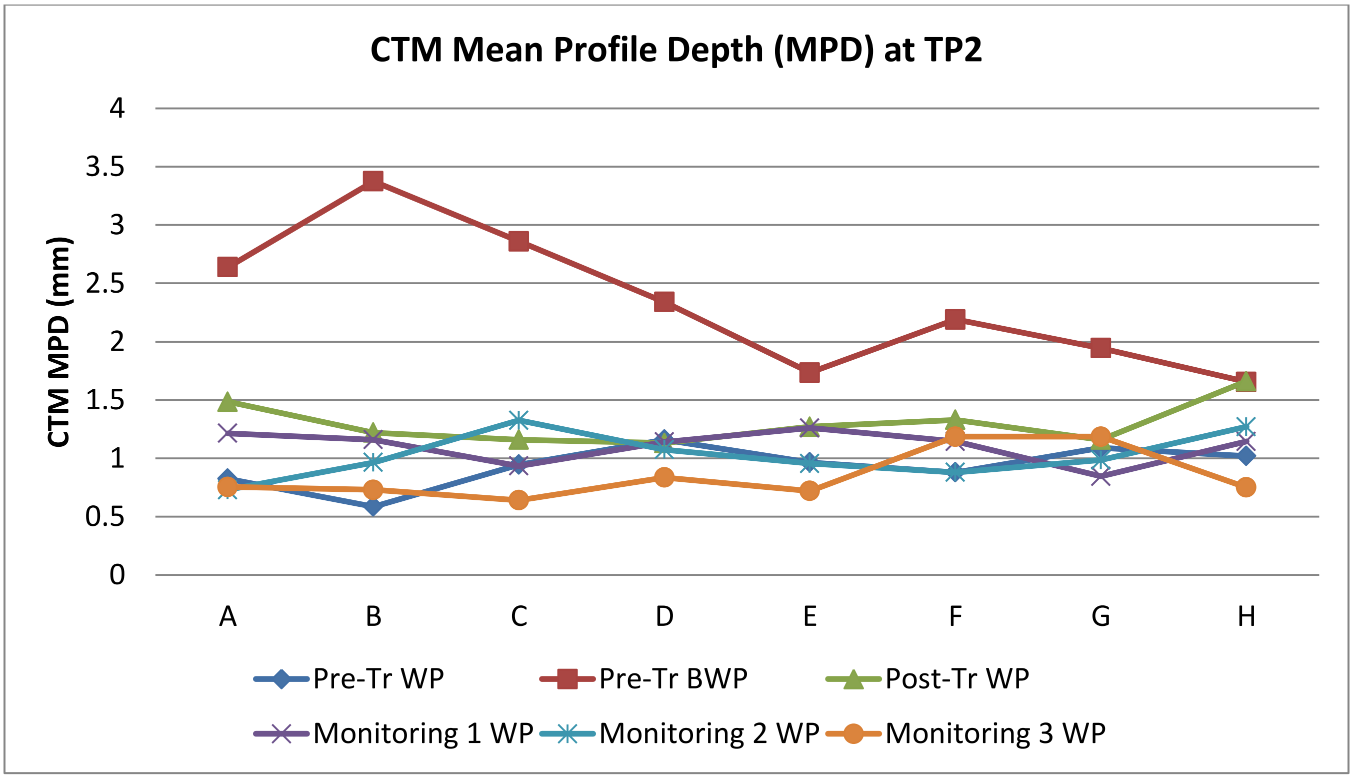
Circular Track Meter (CTM) Mean Profile Depth (in mm) at TP 1

	A	B	C	D	E	F	G	H
Pre-Tr WP	0.765	1.045	1.13	1.015	1.1	0.93	0.705	1.1
Pre-Tr BWP	1.6	2.475	2.655	2.84	2.22	2.17	2.49	1.675
Post-Tr	1.74	1.935	1.435	1.655	1.495	1.36	1.58	1.405
Monitoring 1	0.93	1.455	1.455	0.895	1.24	1.135	1.4	1.345
Monitoring 2	0.66	1.22	1.005	1.15	0.915	0.98	1.035	1.165
Monitoring 3	1.15	0.765	0.575	1.05	0.66	0.76	0.8	0.765



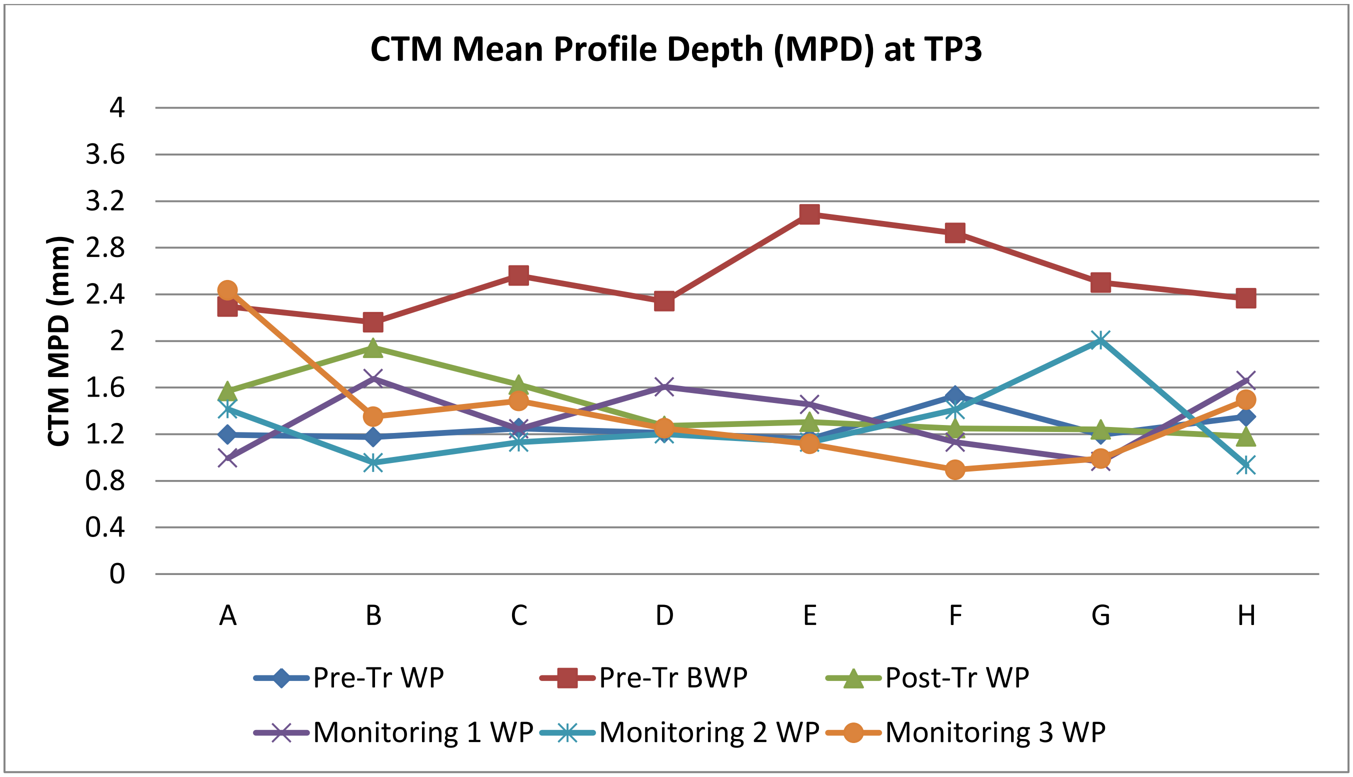
Circular Track Meter (CTM) Mean Profile Depth (in mm) at TP 2

	A	B	C	D	E	F	G	H
Pre-Tr WP	0.825	0.585	0.945	1.16	0.965	0.88	1.09	1.02
Pre-Tr BWP	2.64	3.375	2.86	2.34	1.735	2.19	1.945	1.655
Post-Tr	1.485	1.22	1.16	1.13	1.27	1.33	1.16	1.66
Monitoring 1	1.215	1.16	0.935	1.14	1.26	1.145	0.845	1.145
Monitoring 2	0.73	0.965	1.325	1.075	0.955	0.88	0.985	1.27
Monitoring 3	0.755	0.73	0.64	0.835	0.72	1.185	1.185	0.75

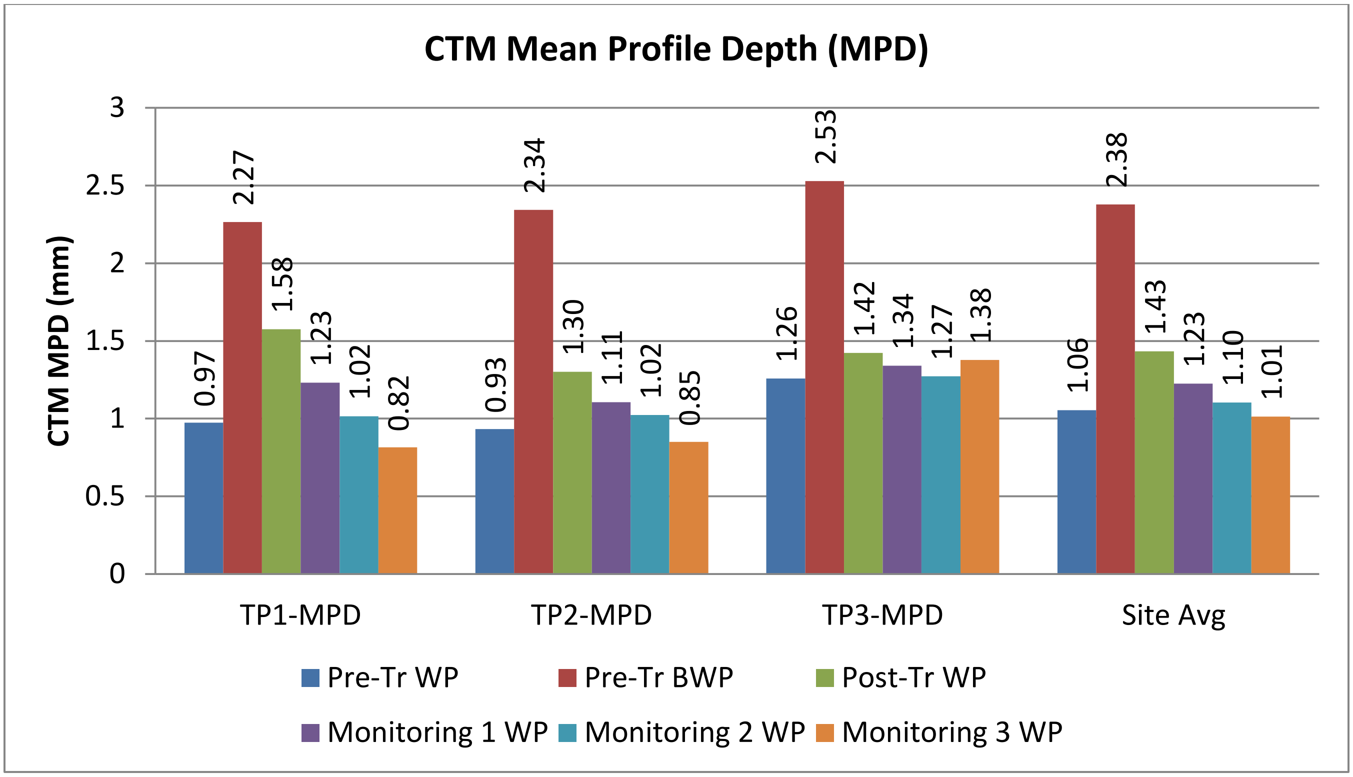


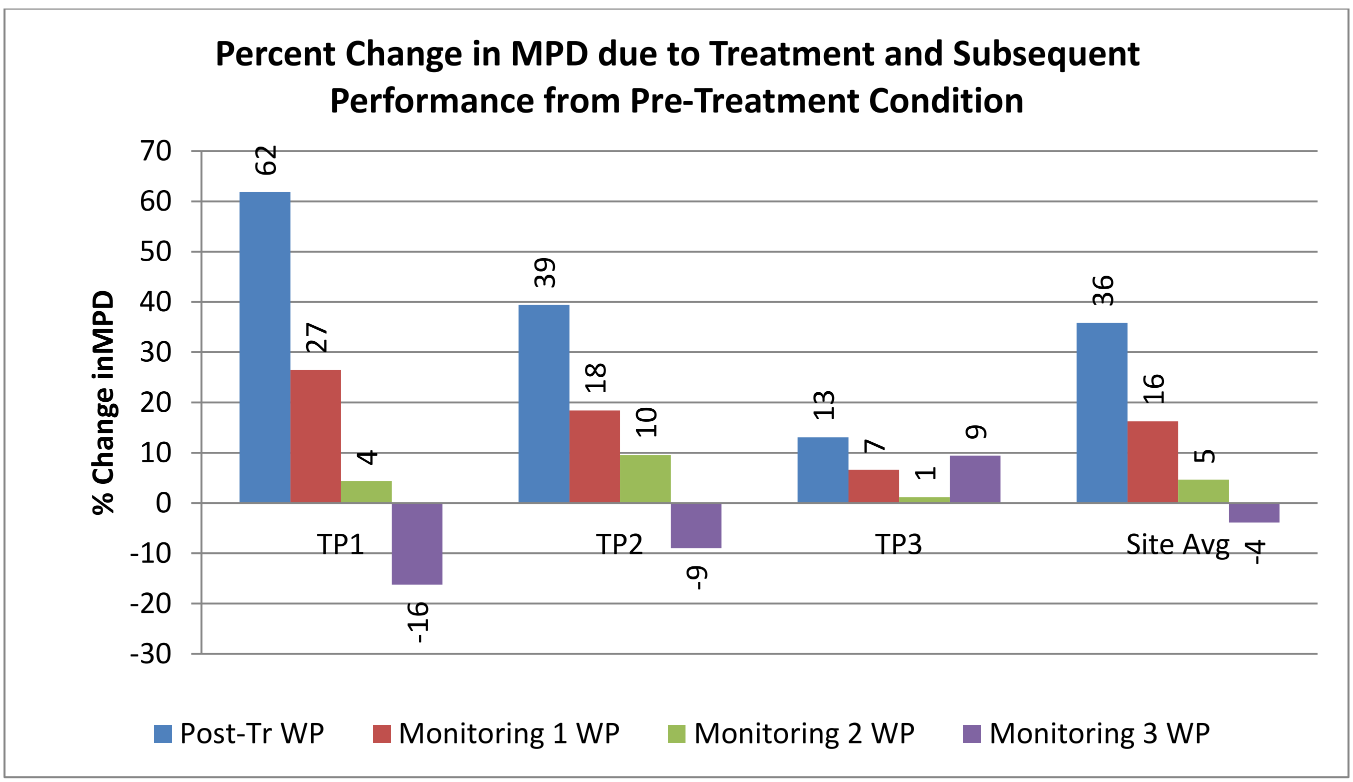
Circular Track Meter (CTM) Mean Profile Depth (in mm) at TP 3

	A	B	C	D	E	F	G	H
Pre-Tr WP	1.195	1.175	1.25	1.21	1.16	1.53	1.195	1.35
Pre-Tr BWP	2.295	2.16	2.56	2.34	3.085	2.925	2.5	2.365
Post-Tr	1.57	1.94	1.625	1.27	1.305	1.25	1.24	1.18
Monitoring 1	0.995	1.675	1.245	1.605	1.455	1.13	0.965	1.66
Monitoring 2	1.415	0.955	1.13	1.2	1.13	1.41	2.005	0.935
Monitoring 3	2.435	1.35	1.485	1.25	1.115	0.895	0.99	1.495

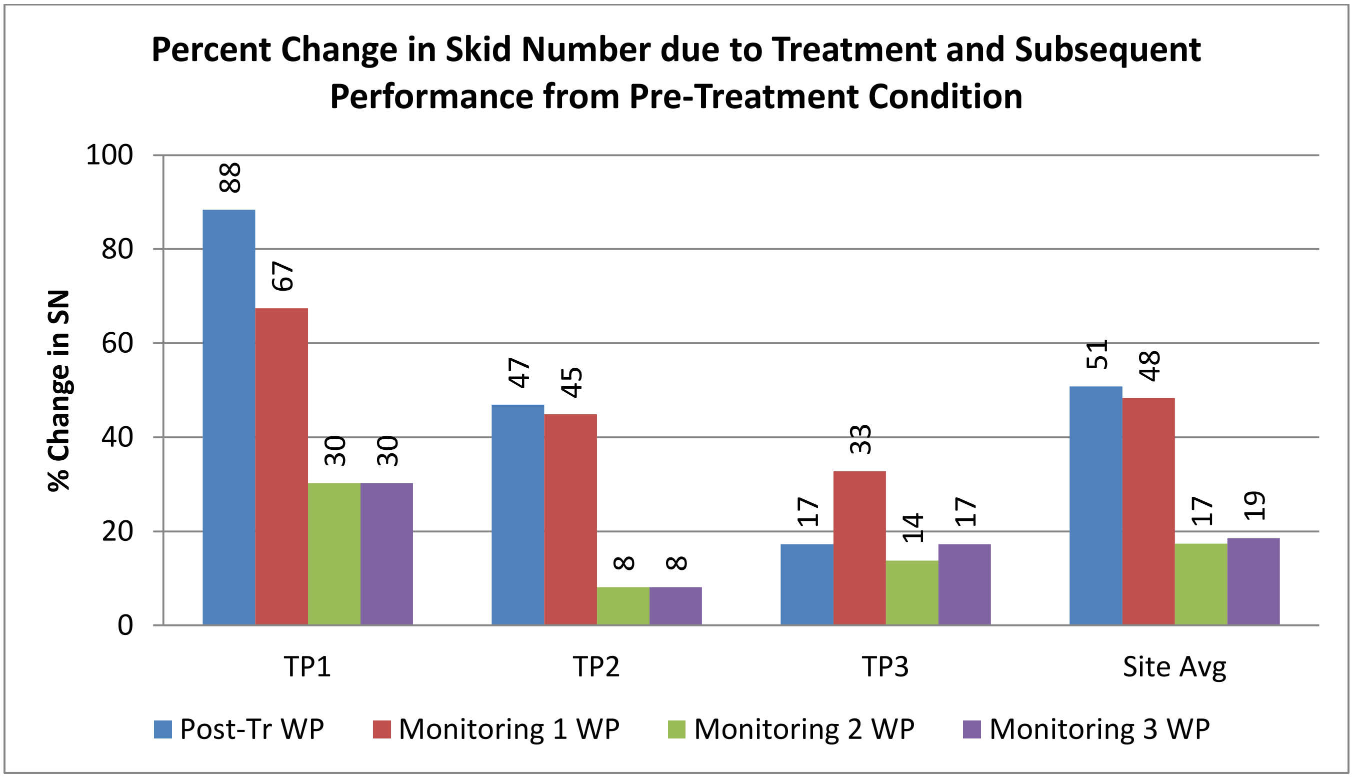


Circular Track Meter (CTM) MPD (mm)



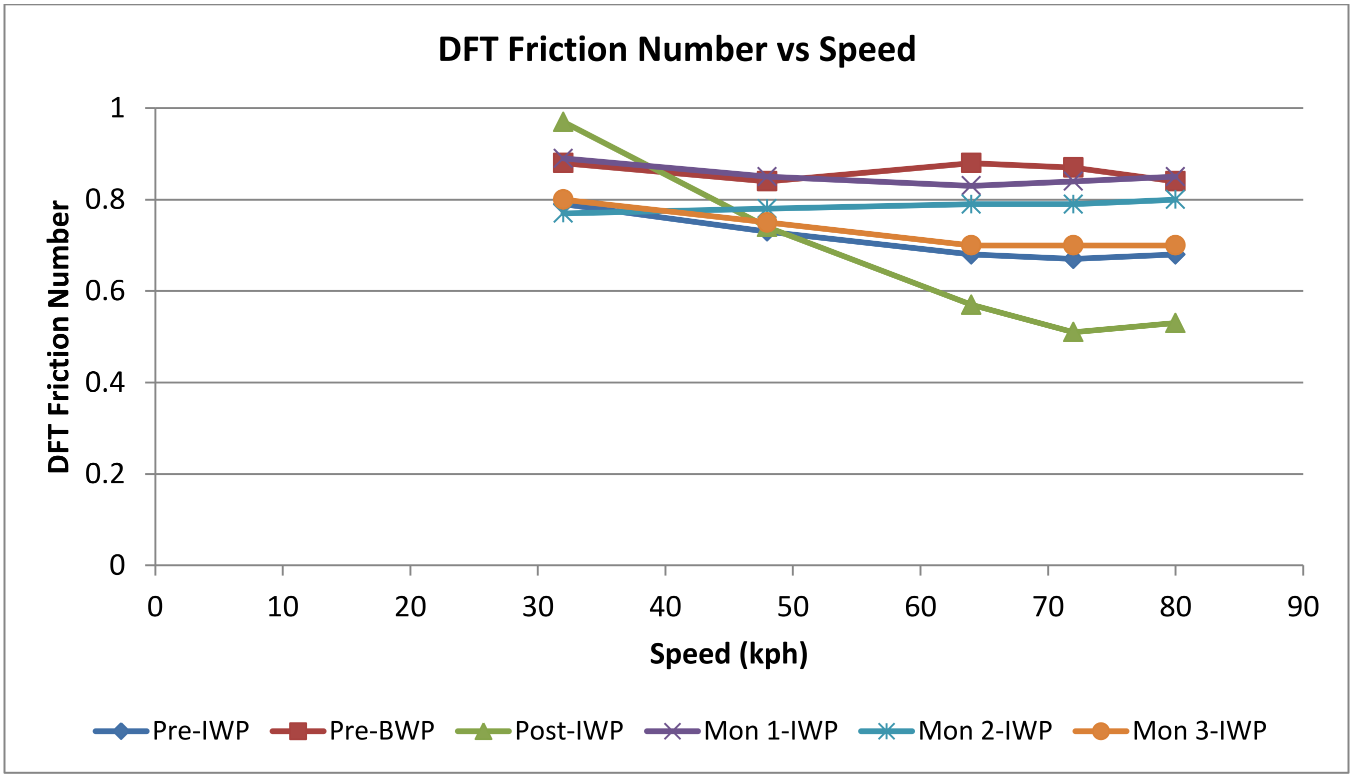


Skid Truck Data



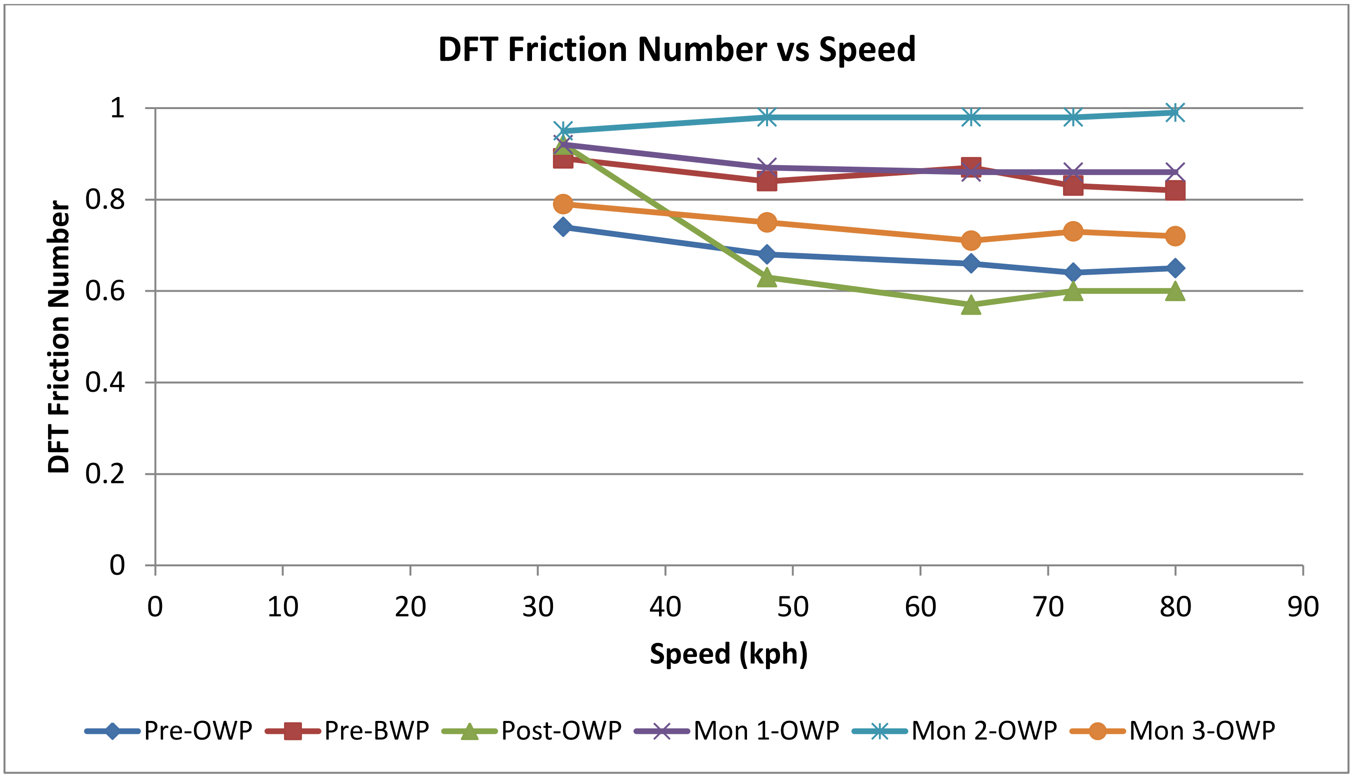
Dynamic Friction Test (DFT) Friction Number Data for TP 1

Speed (kph)	Pre-IWP	Pre-BWP	Post-IWP	Mon 1-IWP	Mon 2-IWP	Mon 3-IWP
32	0.79	0.88	0.97	0.89	0.77	0.8
48	0.73	0.84	0.74	0.85	0.78	0.75
64	0.68	0.88	0.57	0.83	0.79	0.7
72	0.67	0.87	0.51	0.84	0.79	0.7
80	0.68	0.84	0.53	0.85	0.8	0.7



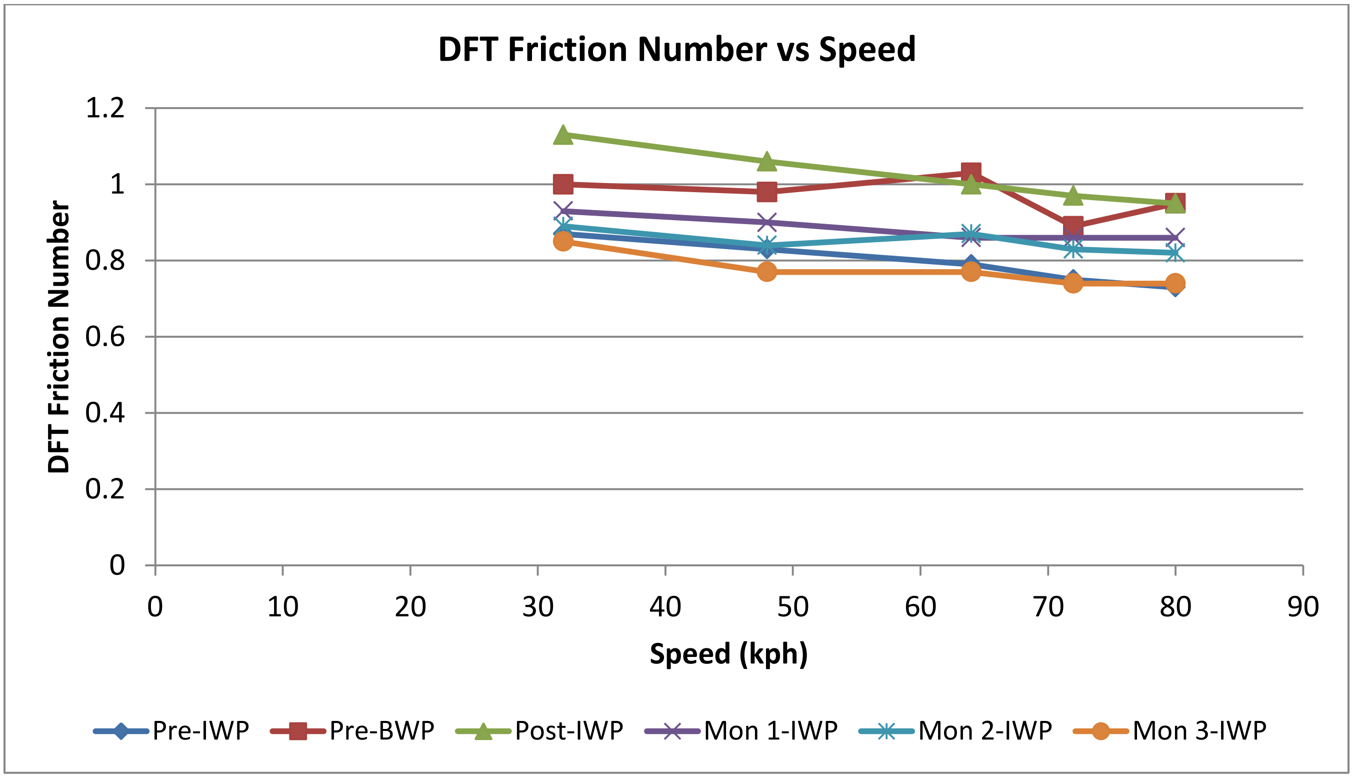
Dynamic Friction Test (DFT) Friction Number Data for TP 2

Speed (kph)	Pre-OWP	Pre-BWP	Post-OWP	Mon 1-OWP	Mon 2-OWP	Mon 3-OWP
32	0.74	0.89	0.92	0.92	0.95	0.79
48	0.68	0.84	0.63	0.87	0.98	0.75
64	0.66	0.87	0.57	0.86	0.98	0.71
72	0.64	0.83	0.6	0.86	0.98	0.73
80	0.65	0.82	0.6	0.86	0.99	0.72



Dynamic Friction Test (DFT) Friction Number Data for TP 3

Speed (kph)	Pre-IWP	Pre-BWP	Post-IWP	Mon 1-IWP	Mon 2-IWP	Mon 3-IWP
32	0.87	1	1.13	0.93	0.89	0.85
48	0.83	0.98	1.06	0.9	0.84	0.77
64	0.79	1.03	1	0.86	0.87	0.77
72	0.75	0.89	0.97	0.86	0.83	0.74
80	0.73	0.95	0.95	0.86	0.82	0.74

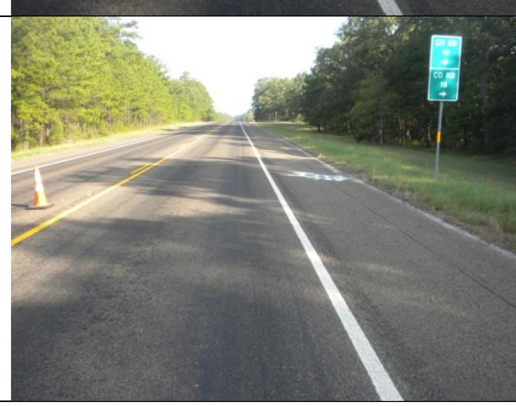


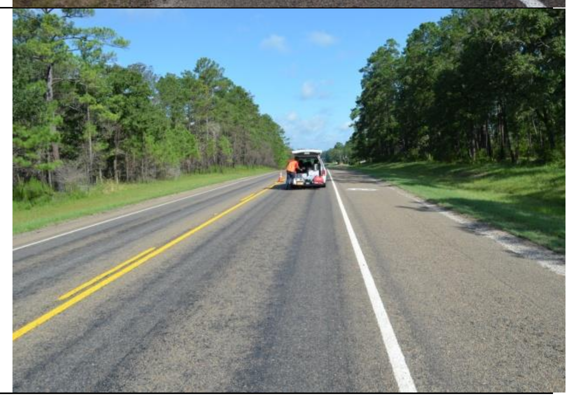
Weather Data during UHP Water Cutter Treatment

Date	Time	Temp Out	Hi Temp	Low Temp	Out Hum	Dew Pt.	Wind Speed	Wind Dir	Wind Run	Hi Speed	Hi Dir	Wind Chill	Heat Index	THW Index	THSW Index
2/22/2011	7:40 AM	60	67.3	60	60	46.1	0	NE	0	1	NE	60	58.7	58.7	---
2/22/2011	7:50 AM	55.3	59.8	55.3	69	45.3	1	NW	0.17	5	WNW	55.3	54.5	54.5	---
2/22/2011	8:00 AM	55.2	55.4	55.2	69	45.2	1	WSW	0.17	4	SE	55.2	54.4	54.4	---
2/22/2011	8:10 AM	55.2	55.3	55.2	69	45.2	1	WNW	0.17	5	NW	55.2	54.4	54.4	---
2/22/2011	8:20 AM	55.5	55.5	55.2	71	46.2	1	NW	0.17	8	W	55.5	54.8	54.8	---
2/22/2011	8:30 AM	55.5	55.6	55.5	69	45.5	1	SW	0.17	5	SE	55.5	54.7	54.7	---
2/22/2011	8:40 AM	56	56	55.5	70	46.4	2	WNW	0.33	7	W	56	55.2	55.2	---
2/22/2011	8:50 AM	56.4	56.4	56	69	46.4	2	ENE	0.33	7	NW	56.4	55.6	55.6	---
2/22/2011	9:00 AM	56.9	56.9	56.4	69	46.8	1	S	0.17	5	SE	56.9	56.1	56.1	---
2/22/2011	9:10 AM	56.9	56.9	56.8	69	46.8	1	WNW	0.17	6	WNW	56.9	56.1	56.1	---
2/22/2011	9:20 AM	56.9	56.9	56.7	69	46.8	1	ESE	0.17	6	ESE	56.9	56.1	56.1	---
2/22/2011	9:30 AM	57.1	57.1	56.9	70	47.4	2	WNW	0.33	7	WNW	57.1	56.3	56.3	---
2/22/2011	9:40 AM	57.2	57.5	57.2	69	47.1	2	SE	0.33	7	WNW	57.2	56.4	56.4	---
2/22/2011	9:50 AM	57.5	57.5	57	70	47.8	1	SW	0.17	6	WNW	57.5	56.7	56.7	---
2/22/2011	10:00 AM	57.4	57.6	57.4	71	48.1	1	NW	0.17	6	WNW	57.4	56.7	56.7	---
2/22/2011	10:10 AM	57.5	57.5	57.4	72	48.5	0	NW	0	4	WNW	57.5	56.8	56.8	---
2/22/2011	10:20 AM	57.3	57.5	57.3	72	48.3	1	SSW	0.17	2	W	57.3	56.6	56.6	---
2/22/2011	10:30 AM	57.8	57.8	57.2	72	48.8	0	S	0	2	S	57.8	57.1	57.1	---
2/22/2011	10:40 AM	58.2	58.4	57.8	72	49.2	1	SE	0.17	4	SSE	58.2	57.5	57.5	---
2/22/2011	10:50 AM	58.7	58.7	58.2	72	49.7	0	SE	0	2	SE	58.7	58.1	58.1	---
2/22/2011	11:00 AM	59.3	59.3	58.7	73	50.6	0	SSE	0	2	S	59.3	58.7	58.7	---
2/22/2011	11:10 AM	60	60	59.3	71	50.6	1	SSE	0.17	4	WNW	60	59.4	59.4	---
2/22/2011	11:20 AM	60.2	60.2	59.9	71	50.8	1	E	0.17	4	ESE	60.2	59.6	59.6	---
2/22/2011	11:30 AM	61.2	61.2	60.2	70	51.3	1	S	0.17	8	WNW	61.2	60.6	60.6	---
2/22/2011	11:40 AM	61.1	61.4	61.1	70	51.2	1	SSW	0.17	4	SE	61.1	60.5	60.5	---

2/22/2011	11:50 AM	61.4	61.4	61	71	51.9	1	NE	0.17	5	WSW	61.4	60.9	60.9	---
2/22/2011	12:00 PM	62.2	62.2	61.5	70	52.3	1	SSE	0.17	6	S	62.2	61.7	61.7	---
2/22/2011	12:10 PM	62.7	62.7	62.2	70	52.8	2	SE	0.33	6	S	62.7	62.3	62.3	---
2/22/2011	12:20 PM	62.6	62.8	62.6	69	52.3	2	SSE	0.33	6	S	62.6	62.2	62.2	---
2/22/2011	12:30 PM	62.6	62.6	62.4	70	52.7	1	SSE	0.17	6	ESE	62.6	62.2	62.2	---
2/22/2011	12:40 PM	62.9	62.9	62.5	69	52.6	1	WSW	0.17	5	SE	62.9	62.5	62.5	---
2/22/2011	12:50 PM	63.6	63.8	62.9	68	52.8	1	SSE	0.17	5	NW	63.6	63.2	63.2	---
2/22/2011	1:00 PM	63.2	63.6	63.1	70	53.3	1	ENE	0.17	4	NNW	63.2	62.9	62.9	---
2/22/2011	1:10 PM	63.1	63.2	63	70	53.2	0	NE	0	2	ESE	63.1	62.8	62.8	---
2/22/2011	1:20 PM	64	64	63.2	69	53.6	1	E	0.17	7	S	64	63.7	63.7	---
2/22/2011	1:30 PM	64.8	64.8	63.9	68	54	2	S	0.33	6	S	64.8	64.6	64.6	---
2/22/2011	1:40 PM	64.2	64.8	64.2	69	53.8	1	ESE	0.17	6	SE	64.2	64	64	---
2/22/2011	1:50 PM	63.6	64.2	63.6	71	54	1	SSE	0.17	5	SSE	63.6	63.4	63.4	---
2/22/2011	2:00 PM	63.8	63.8	63.5	73	55	1	SSE	0.17	4	SSE	63.8	63.7	63.7	---
2/22/2011	2:10 PM	64.1	64.2	63.8	71	54.5	1	S	0.17	6	SSE	64.1	64	64	---

Site Photographs

(a)			Figure XX. BMT3 Pictures (a) highway and location; (b) close-up of flushed surface before treatment; (c) roadway surface before treatment; (d) close-up of flushed surface immediately after treatment; (e) roadway surface after treatment; (f) close-up of surface at first follow-up ; (g) roadway surface at first follow-up , (h) roadway surface at second follow-up ; (i) close-up of surface at second follow-up , (j) close-up of surface at third follow-up ; (k) roadway surface at third follow-up
(b)		(c)	
(d)		(e)	
(f)		(g)	

(h)		(i)	
(j)		(k)	

APPENDIX I

SITE BMT 3

Jasper COUNTY

Beaumont DISTRICT

Site Description

Project Information			
District: Beaumont	Test Site: BMT 3	County: Jasper	Road: FM 82 EB
ADT: 100	Truck Traffic: Very Low	Year Built:	Last Maintained: Summer 2008

Roadway Description
Binder: CRS-2P Aggregate: L-GR 3LW (SAC-B)
Pavement abnormalities:
The pavement was moderately heavy flushing in both wheel paths. The major aggregate appeared to be Grade 3 or 4 rock in a full width seal coat. When treated with the UPH water cutter, sticky, gummy clumps of road materials were left behind, though far less than seen at other sites. The majority of the clumps were swept off the road with a broom truck as soon as the treatment was completed.

Research Test Summary		
Test Location: US 96 (Kirbyville) to 2 mi W of US 96	Closest Texas Reference Marker: 762	
Test Point GPS Coordinates	N	W
TP1	30°38.518'	093°54.472'
TP2	30°38.519'	093°54.329'
TP3	30°38.522'	093°54.149'

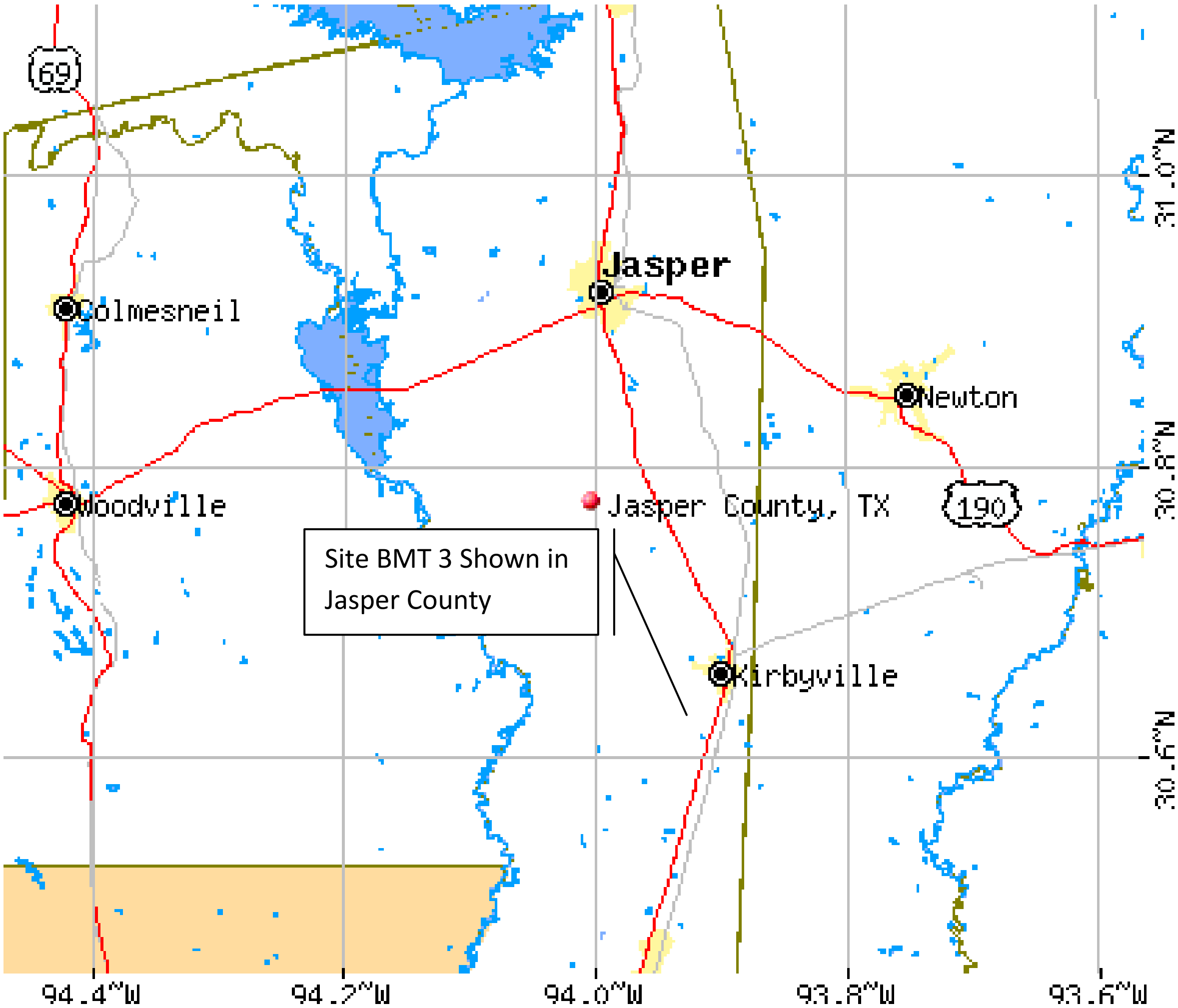
Ultra High Pressure Water Cutter Treatment Summary		
Date Treated 2/21/2011	Start Time 7:40 AM	End Time 4:40 PM

Summary Description of Treatment Activity
Personnel on site:
TechMRT: Andrew Tubb and Timothy Wood
Rampart: Bob Beadling and Jim Windich
TxDOT: John Snoddy (Beaumont District), George "You-heard-that-right" Bush (Jasper County Maintenance Office Event Coordinator) and others from the Jasper County Maintenance Office
Rampart configuration: Rampart used their typical 28 jet nozzle configuration.
Work Activities: TechMRT and Rampart were at the maintenance office before 7:00AM. TechMRT and Rampart meet with John Snoddy and George Bush. TechMRT went straight to the Beaumont Site 3 on FM82 with TxDOT traffic control at 7:40.
TechMRT arrived on site at 8:05AM. From 8:10AM till 8:45AM TechMRT setup the weather station between TP1 and TP2 and remarked all test points and the speed sections for the eastbound lane. The distance between test points was longer than an eighth of mile due to an attempt to align the test points with landmarks. The distance between TP1 and TP2 was 750ft. The distance between TP2 and TP3 was 950ft. The distance from the start of the test section to TP1 was 950'. TechMRT performed all pretest from 9:05AM till 10:10AM.
Rampart was present at the site beginning at 9:00AM. They treated the speed trails from 10:15AM to 11:15AM. Due to the nearness of the section to a transition in the pavement, an intersection and an uncertainty about the ability of drivers to follow the traffic control, the speed zones 5 through 8 were treated as part of the production treatment. The treated zones 1 through 4 were treated in single passes down the center of the wheel path. From 11:15AM to 12:00PM Rampart attempted to

implement and calibrate a new DMI device. This attempt ended in failure. From 12:00PM to 12:50PM Rampart treated the innermost pass. Due to the width of the flushing, the production treatment was done in four passes, two per wheel path. From 1:00PM to 1:35PM Rampart emptied the truck. TechMRT performed all CTM post testing from 1:15PM till 1:40PM. Rampart resumed treatment on the outermost pass followed by the next inside pass from 1:35PM to 2:45PM at 0.75mph. From 2:50PM to 3:40PM they emptied the truck. From 3:40PM to 4:00 PM they completed the treatment. TechMRT completed the post testing from 3:00 to 3:30PM. The weather station was stored at 4:40PM. TechMRT filled the water buckets from Ramparts truck at 4:45PM. Returned to Beaumont at 5:00PM.
Comments

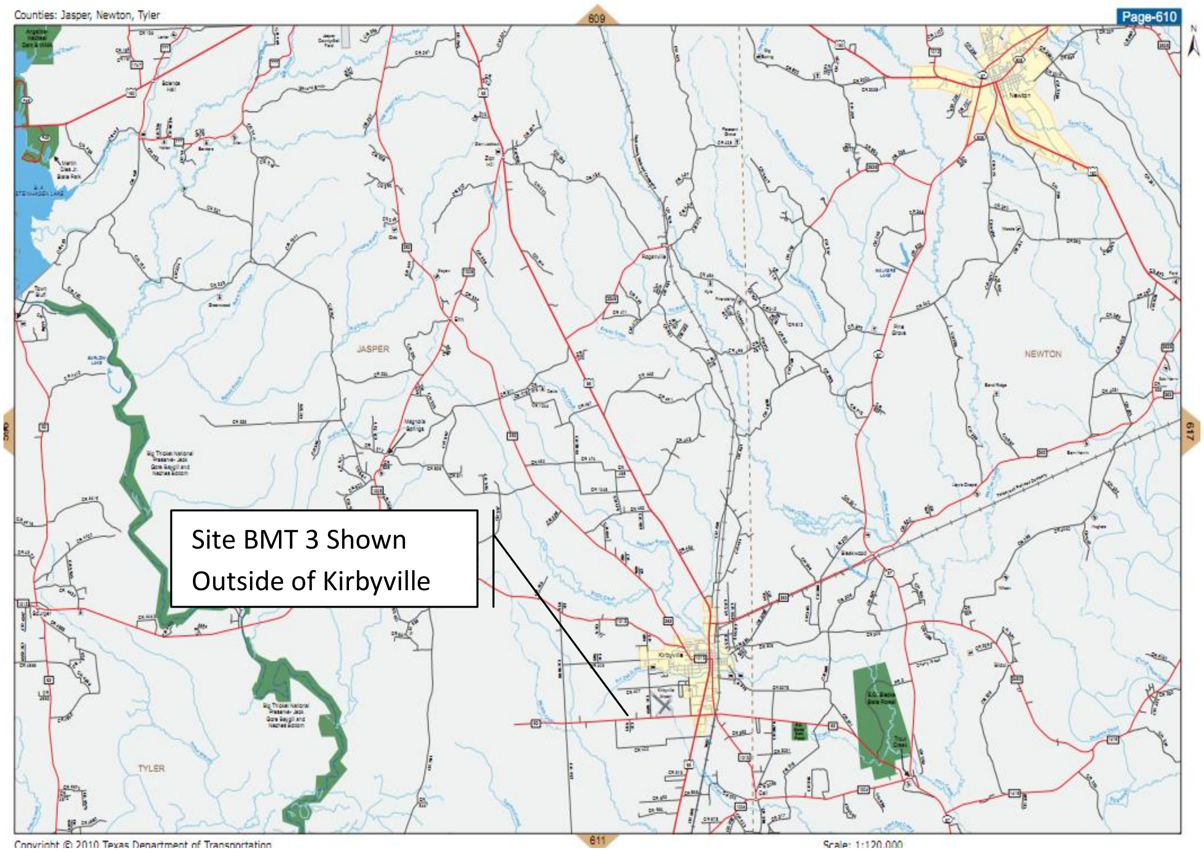
Follow-On Testing Summary	
Date: 7/21/11	Comments: Preformed follow –up monitoring successfully.
Date: 1/13/12	Comments: Preformed follow –up monitoring successfully.
Date	Comments: No follow-up monitoring was performed due to reoccurrence of flushing therefore seal coat treatment was necessary.

Site Vicinity Map



http://www.city-data.com/

Site Location Map



http://www.txdot.gov/travel/county_grid_search.htm

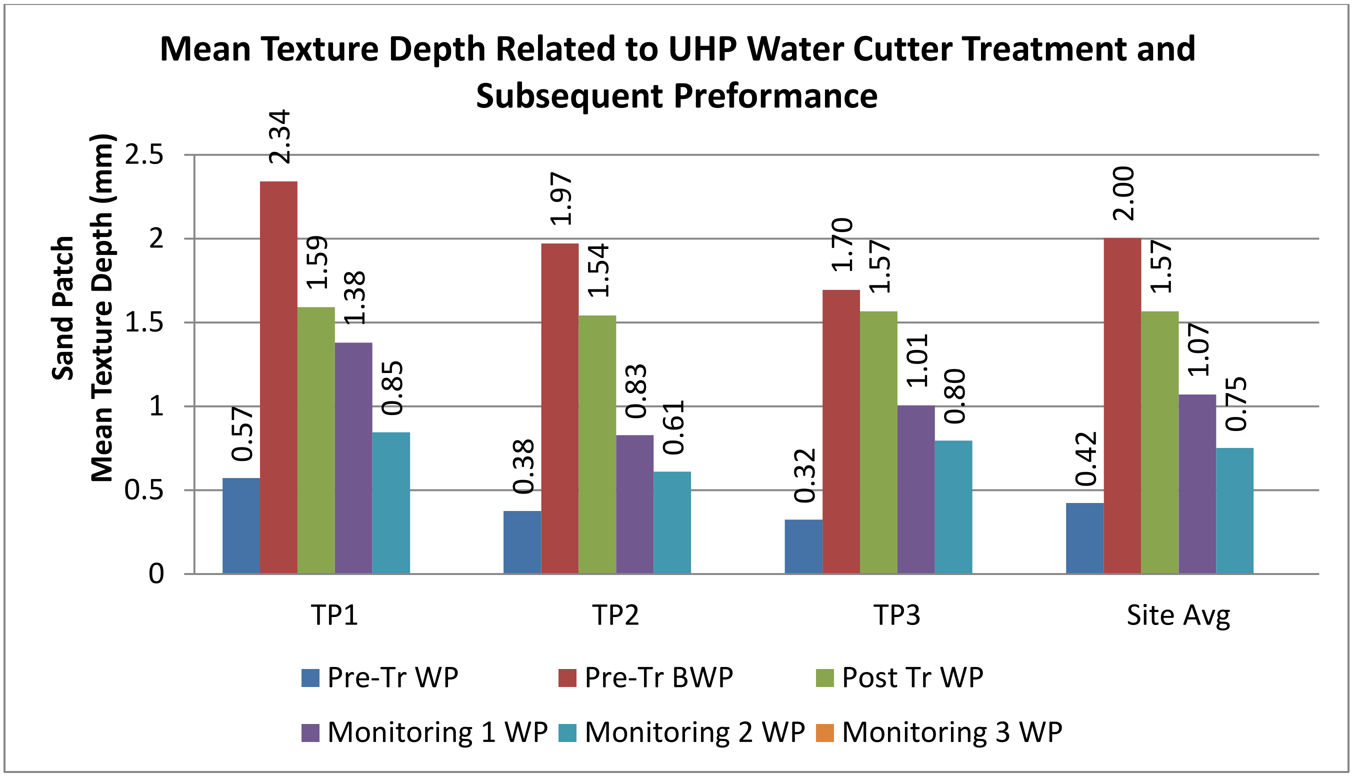
Aerial Photograph

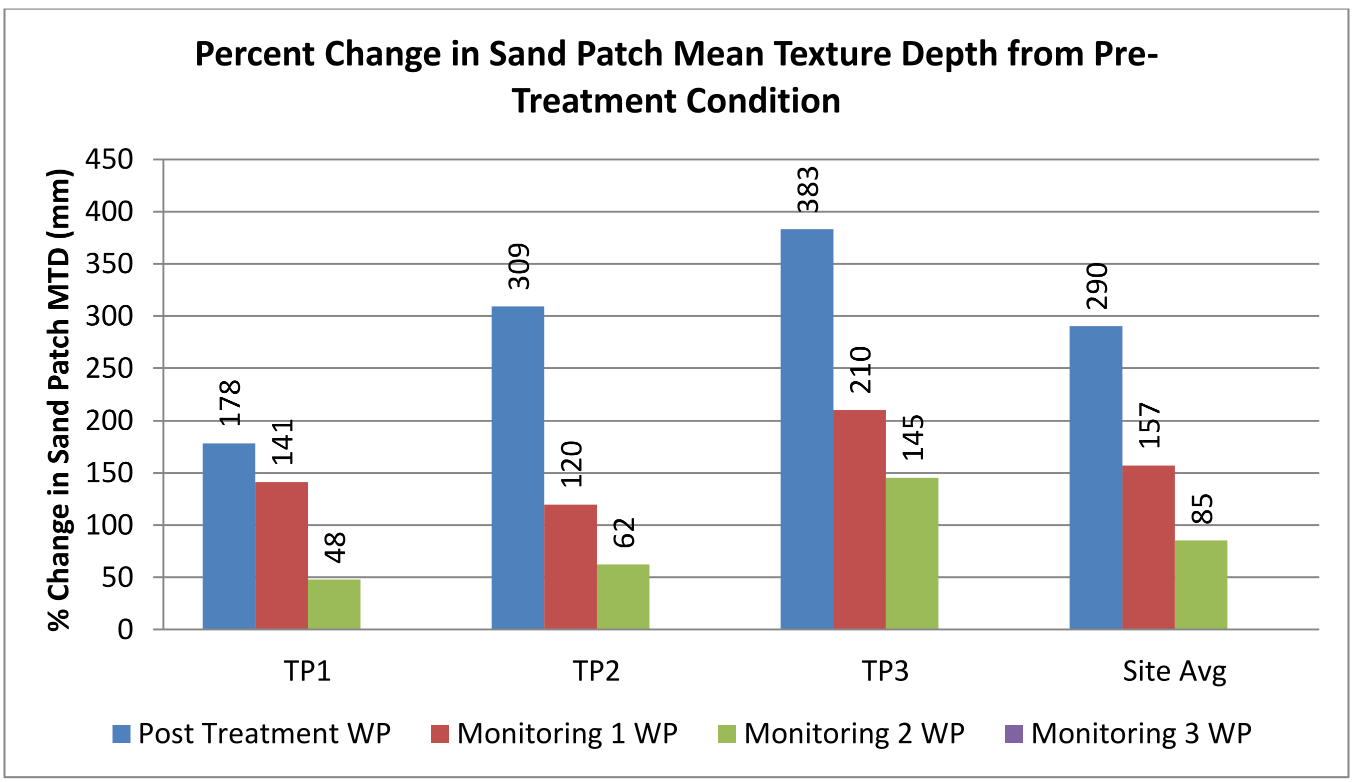
Google Inc. (2011). Google Earth (Version 6.1.0.5001)

Test Point Plan

Google Inc. (2011). Google Earth (Version 6.1.0.5001)

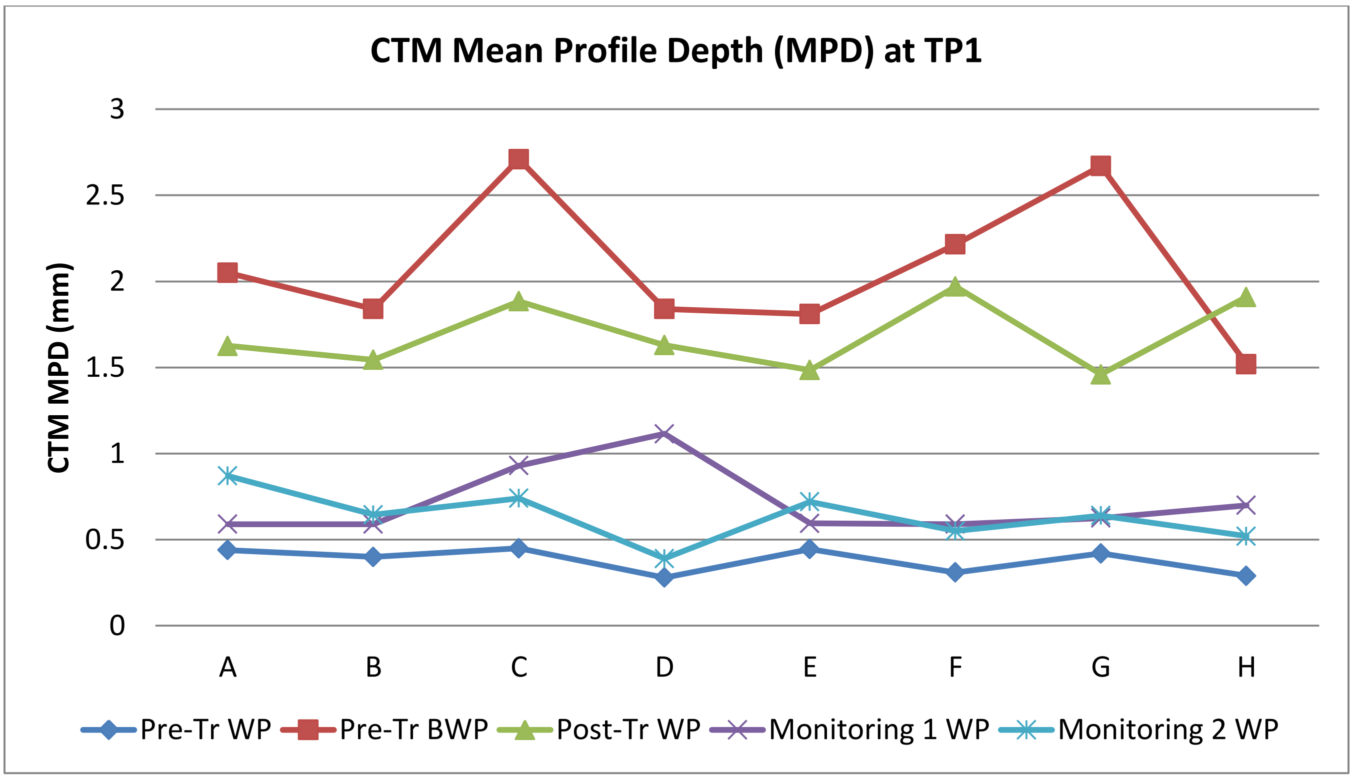
Sand Patch Data





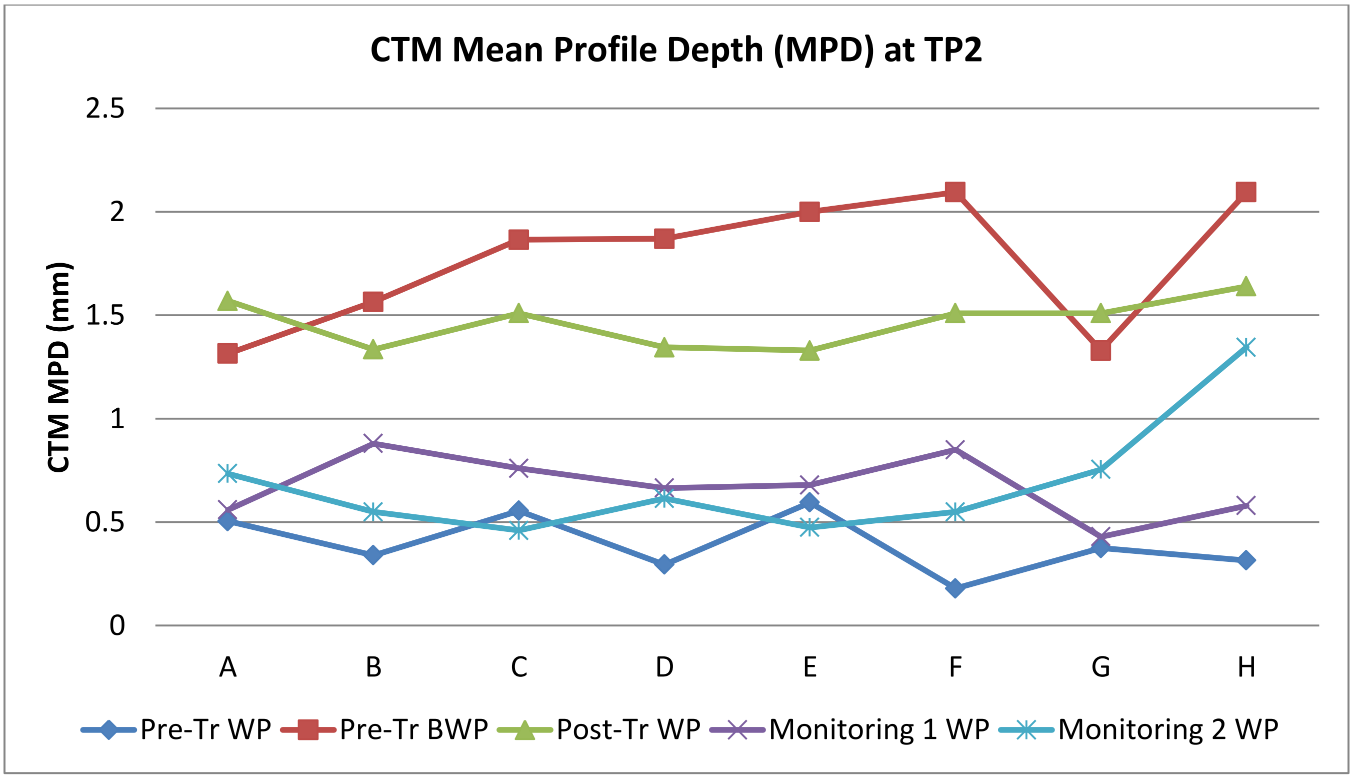
Circular Track Meter (CTM) Mean Profile Depth (in mm) at TP 1

	A	B	C	D	E	F	G	H
Pre-Tr WP	0.44	0.4	0.45	0.28	0.445	0.31	0.42	0.29
Pre-Tr BWP	2.05	1.84	2.71	1.84	1.81	2.215	2.67	1.52
Post-Tr	1.625	1.545	1.885	1.63	1.485	1.97	1.46	1.91
Monitoring 1	0.59	0.59	0.93	1.115	0.595	0.59	0.625	0.7
Monitoring 2	0.87	0.645	0.74	0.39	0.72	0.55	0.64	0.52
Monitoring 3	Not conducted due to maintenance/rehabilitation work on the section							



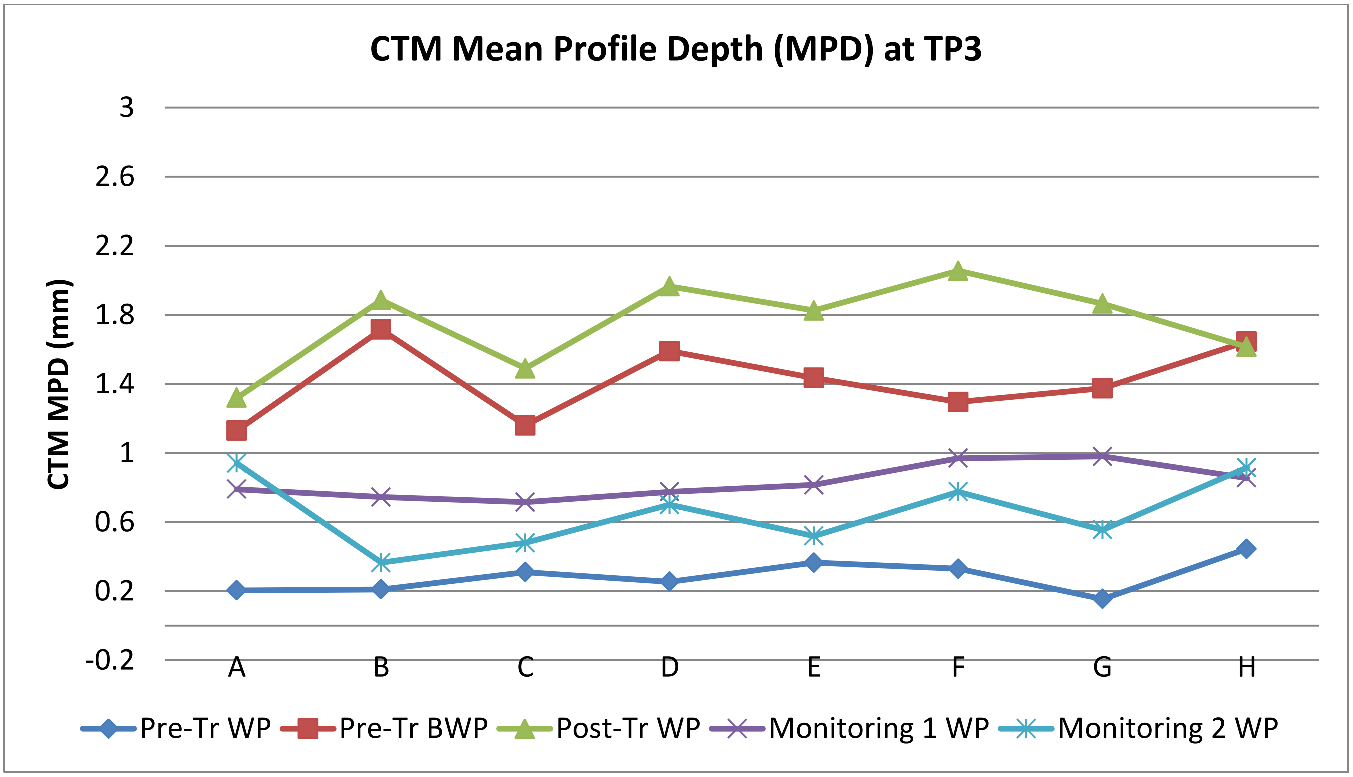
Circular Track Meter (CTM) Mean Profile Depth (in mm) at TP 2

	A	B	C	D	E	F	G	H
Pre-Tr WP	0.505	0.34	0.555	0.295	0.595	0.18	0.375	0.315
Pre-Tr BWP	1.315	1.565	1.865	1.87	2	2.095	1.33	2.095
Post-Tr	1.57	1.335	1.51	1.345	1.33	1.51	1.51	1.64
Monitoring 1	0.56	0.88	0.76	0.665	0.68	0.85	0.43	0.58
Monitoring 2	0.735	0.55	0.46	0.615	0.475	0.55	0.755	1.345
Monitoring 3	Not conducted due to maintenance/rehabilitation work on the section							

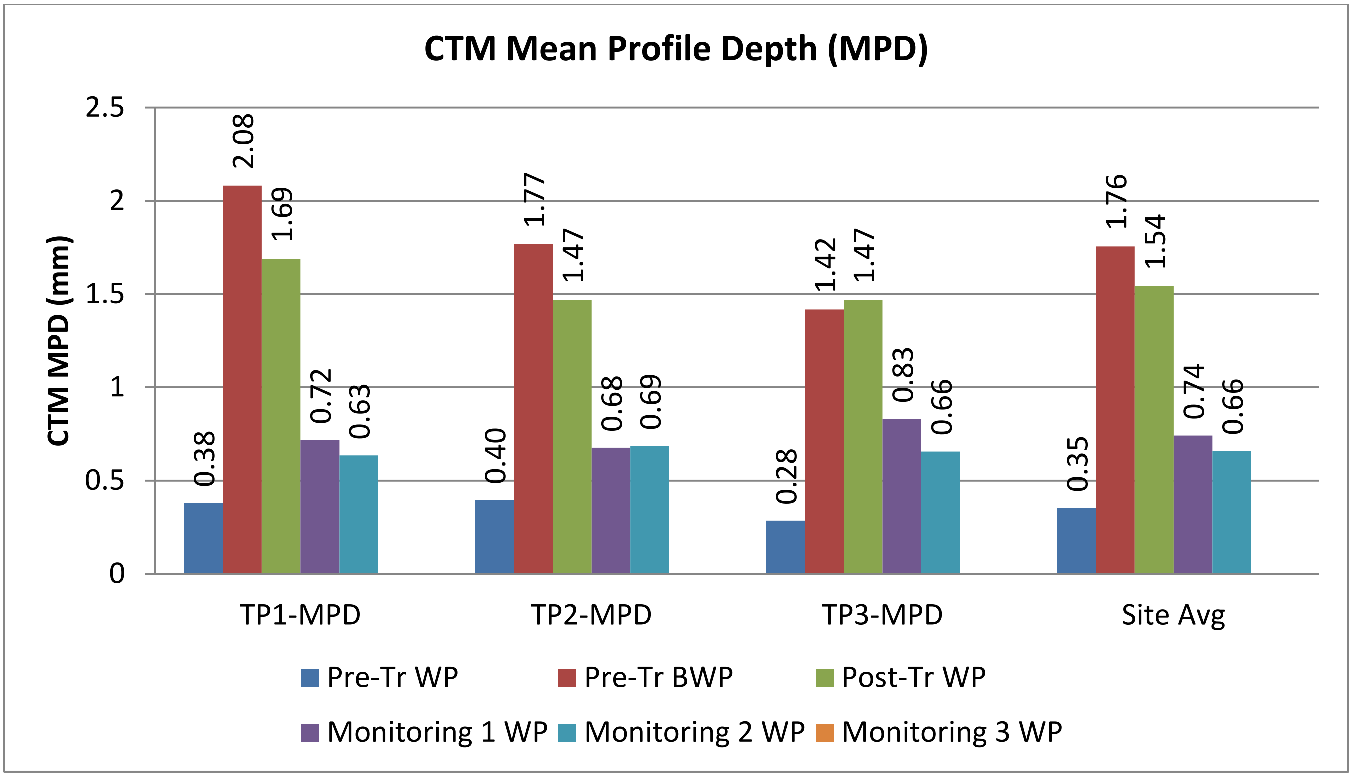


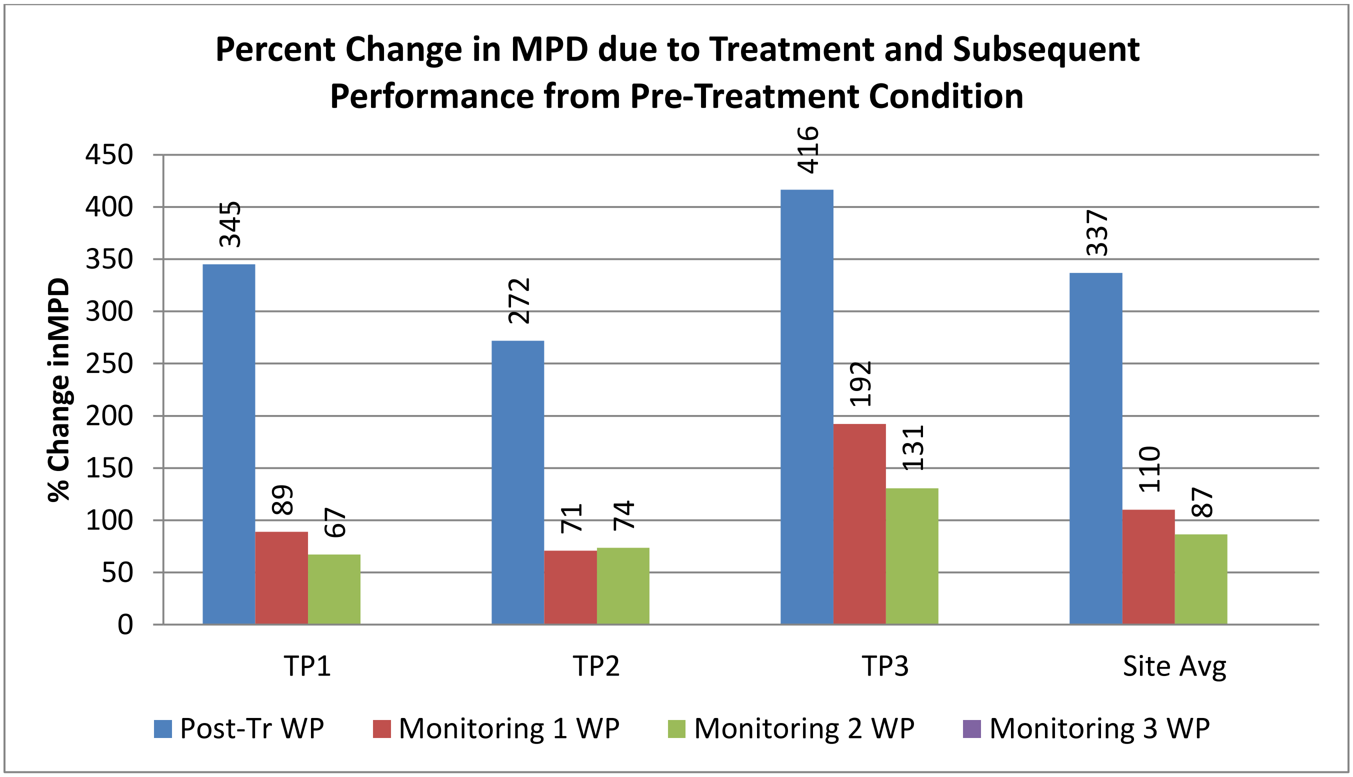
Circular Track Meter (CTM) Mean Profile Depth (in mm) at TP 3

	A	B	C	D	E	F	G	H
Pre-Tr WP	0.205	0.21	0.31	0.255	0.365	0.33	0.155	0.445
Pre-Tr BWP	1.13	1.715	1.16	1.59	1.435	1.295	1.375	1.645
Post-Tr	1.32	1.885	1.49	1.965	1.825	2.055	1.865	1.615
Monitoring 1	0.79	0.745	0.715	0.775	0.815	0.97	0.98	0.855
Monitoring 2	0.94	0.365	0.48	0.7	0.52	0.775	0.555	0.915
Monitoring 3	Not conducted due to maintenance/rehabilitation work on the section							

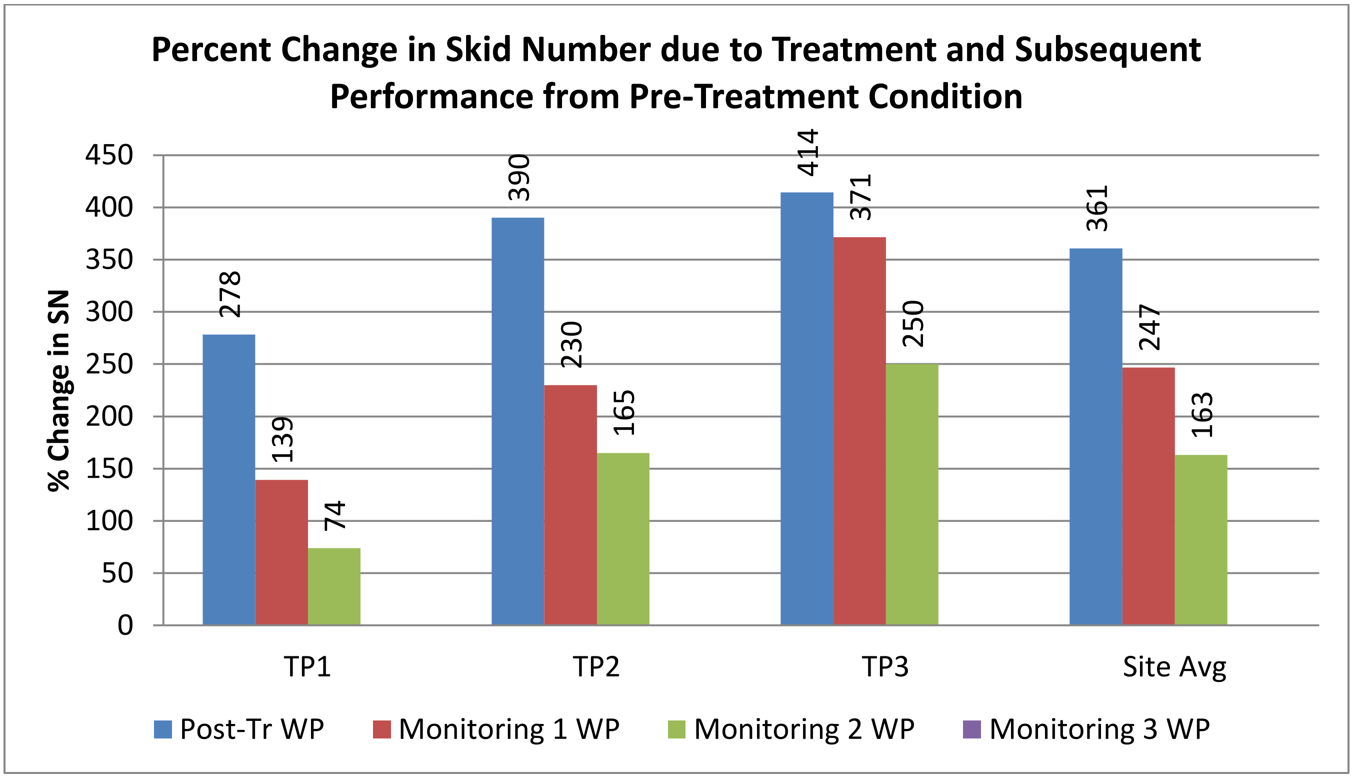


Circular Track Meter (CTM) MPD (mm)



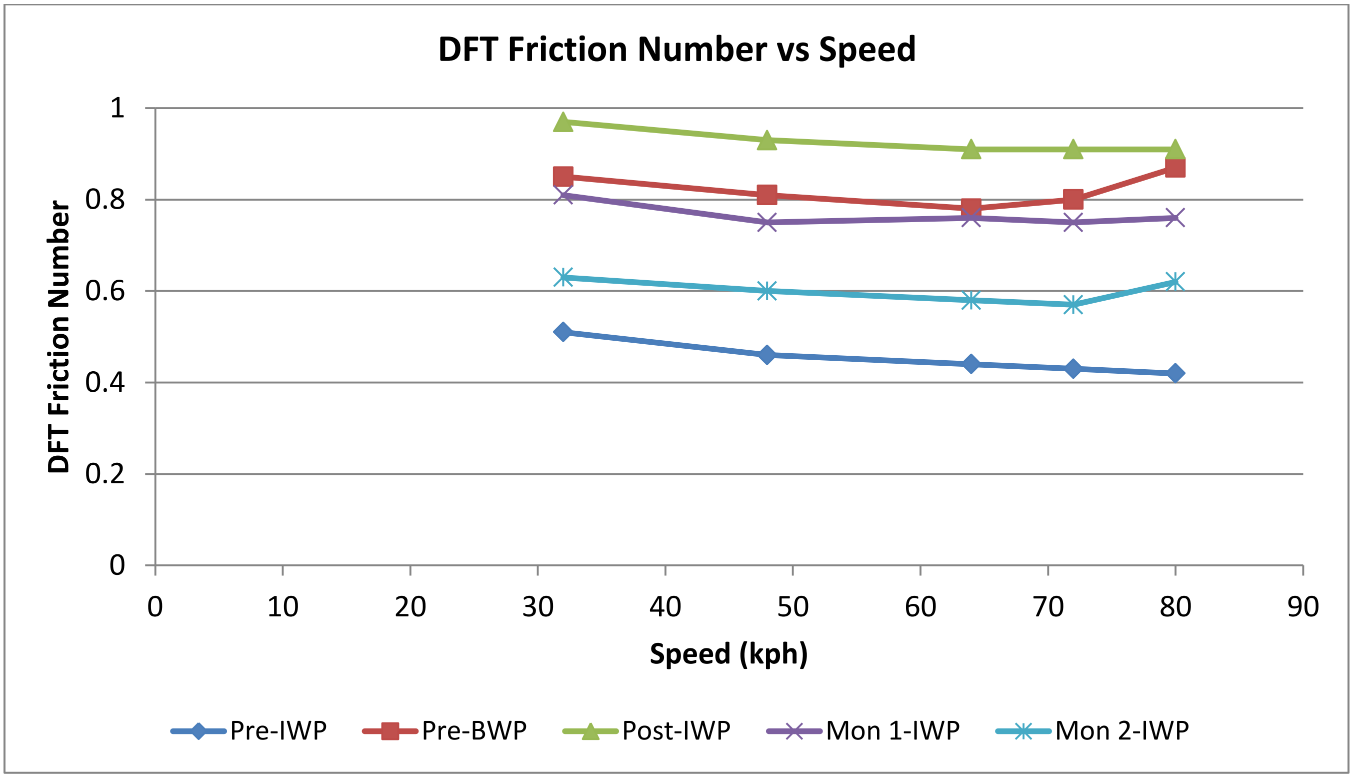


Skid Truck Data



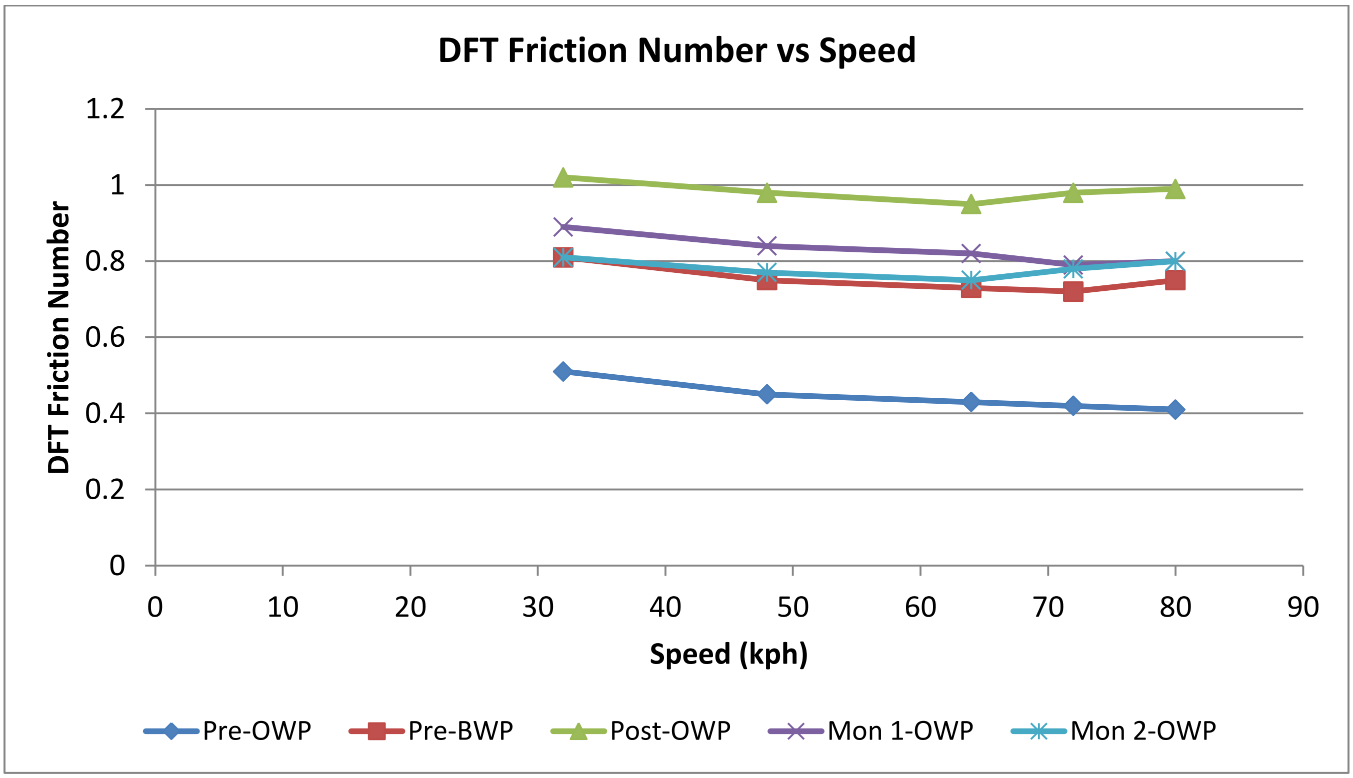
Dynamic Friction Test (DFT) Friction Number Data for TP 1

Speed (kph)	Pre-IWP	Pre-BWP	Post-IWP	Mon 1-IWP	Mon 2-IWP	Mon 3-IWP
32	0.51	0.85	0.97	0.81	0.63	Not conducted due to maintenance/rehabilitation work on the section
48	0.46	0.81	0.93	0.75	0.6	
64	0.44	0.78	0.91	0.76	0.58	
72	0.43	0.8	0.91	0.75	0.57	
80	0.42	0.87	0.91	0.76	0.62	



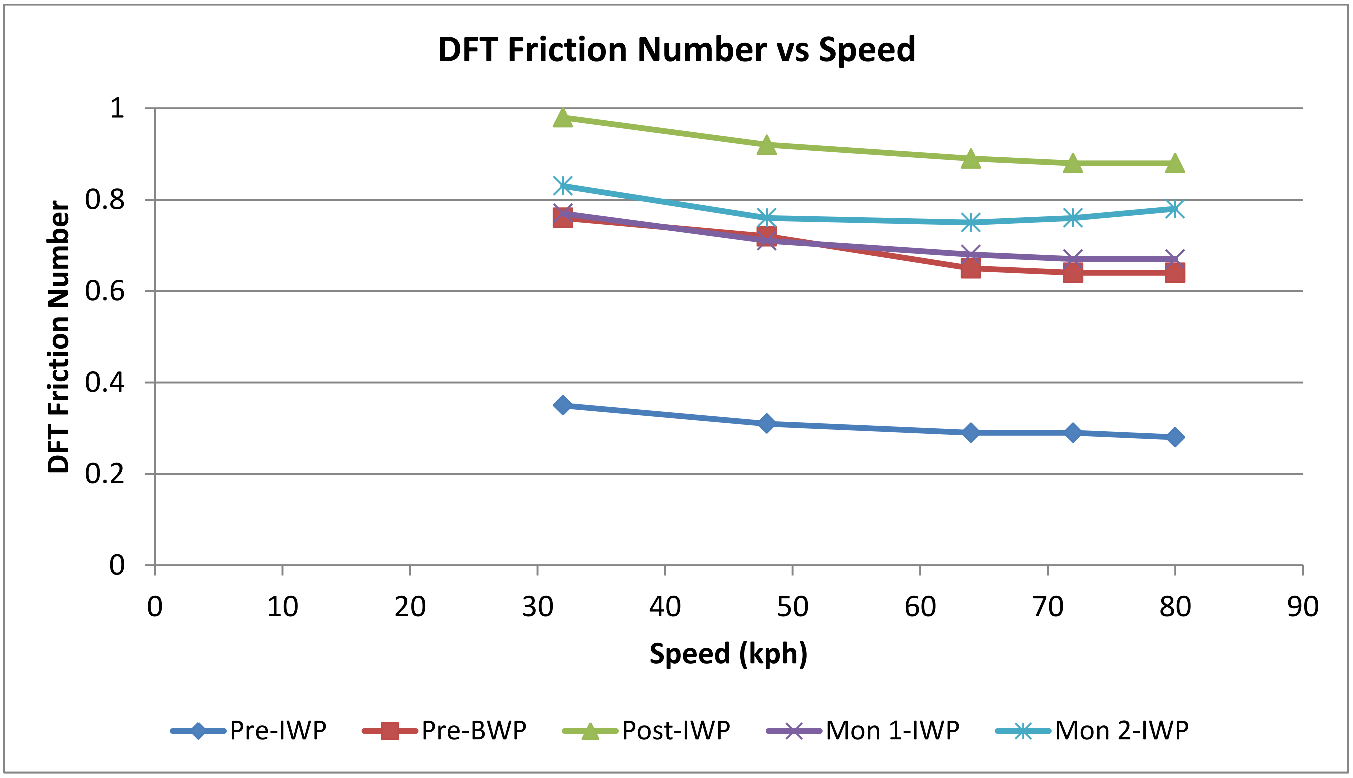
Dynamic Friction Test (DFT) Friction Number Data for TP 2

Speed (kph)	Pre-OWP	Pre-BWP	Post-OWP	Mon 1-OWP	Mon 2-OWP	Mon 3-OWP
32	0.51	0.81	1.02	0.89	0.81	Not conducted due to maintenance/rehabilitation work on the section
48	0.45	0.75	0.98	0.84	0.77	
64	0.43	0.73	0.95	0.82	0.75	
72	0.42	0.72	0.98	0.79	0.78	
80	0.41	0.75	0.99	0.8	0.8	



Dynamic Friction Test (DFT) Friction Number Data for TP 3

Speed (kph)	Pre-IWP	Pre-BWP	Post-IWP	Mon 1-IWP	Mon 2-IWP	Mon 3-IWP
32	0.35	0.76	0.98	0.77	0.83	Not conducted due to maintenance/rehabilitation work on the section
48	0.31	0.72	0.92	0.71	0.76	
64	0.29	0.65	0.89	0.68	0.75	
72	0.29	0.64	0.88	0.67	0.76	
80	0.28	0.64	0.88	0.67	0.78	

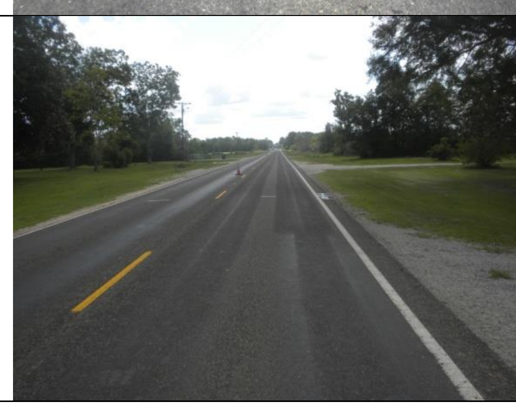


Weather Data during UHP Water Cutter Treatment

Date	Time	Temp Out	Hi Temp	Low Temp	Out Hum	Dew Pt.	Wind Speed	Wind Dir	Wind Run	Hi Speed	Hi Dir	Wind Chill	Heat Index	THW Index	THSW Index
2/21/2011	8:20 AM	67.7	68.3	67.7	82	62	3	SSW	0.5	14	SSW	67.7	69	69	---
2/21/2011	8:30 AM	67.3	67.7	67.2	84	62.3	5	SSW	0.83	14	SW	67.3	68.6	68.6	---
2/21/2011	8:40 AM	67.6	67.6	67.3	84	62.6	7	SSW	1.17	21	S	67.6	69	69	---
2/21/2011	8:50 AM	68.2	68.2	67.6	82	62.5	6	SSW	1	13	SSW	68.2	69.6	69.6	---
2/21/2011	9:00 AM	69	69	68.2	81	62.9	6	SSW	1	13	SSW	69	70.6	70.6	---
2/21/2011	9:10 AM	69.8	69.8	69.1	79	63	7	SSW	1.17	16	SSW	69.8	70.9	70.9	---
2/21/2011	9:20 AM	69.6	70	69.5	78	62.4	7	SSW	1.17	16	SSW	69.6	70.7	70.7	---
2/21/2011	9:30 AM	69.5	69.6	69.4	79	62.7	6	SSW	1	12	WSW	69.5	70.7	70.7	---
2/21/2011	9:40 AM	71	71	69.5	76	63.1	7	SSW	1.17	15	SSW	71	71.9	71.9	---
2/21/2011	9:50 AM	70.7	71	70.5	76	62.8	7	SSW	1.17	16	SSW	70.7	71.5	71.5	---
2/21/2011	10:00 AM	72.2	72.2	70.8	73	63.1	7	SSW	1.17	15	SSW	72.2	73.2	73.2	---
2/21/2011	10:10 AM	72.2	73.4	72.2	72	62.7	5	SSW	0.83	16	SSW	72.2	73.1	73.1	---
2/21/2011	10:20 AM	73.9	74.1	72.3	67	62.2	6	S	1	19	S	73.9	75.2	75.2	---
2/21/2011	10:30 AM	72.3	73.8	72.3	69	61.6	8	SSW	1.33	18	SSW	71.8	73	72.5	---
2/21/2011	10:40 AM	71.9	72.2	71.8	68	60.8	6	SSW	1	13	S	71.9	72.4	72.4	---
2/21/2011	10:50 AM	72.1	72.1	71.8	70	61.8	5	SSW	0.83	14	SSW	72.1	72.8	72.8	---
2/21/2011	11:00 AM	74.6	74.7	72.2	63	61.2	7	SSW	1.17	16	SW	74.6	75.7	75.7	---
2/21/2011	11:10 AM	73.6	74.5	73.6	63	60.2	8	SSW	1.33	18	SSW	73.1	74.4	73.9	---
2/21/2011	11:20 AM	74.7	74.9	73.5	62	60.8	7	SSW	1.17	21	SSW	74.7	75.7	75.7	---
2/21/2011	11:30 AM	77	77	74.6	59	61.6	9	SSW	1.5	20	SW	75.8	77.7	76.5	---
2/21/2011	11:40 AM	77.1	77.3	76.9	57	60.7	8	SSW	1.33	20	SW	76.6	77.6	77.1	---
2/21/2011	11:50 AM	77.8	77.8	77	57	61.3	7	SSW	1.17	17	SW	77.8	78.4	78.4	---
2/21/2011	12:00 PM	77.5	78.2	77.1	55	60.1	6	SSW	1	15	S	77.5	77.9	77.9	---
2/21/2011	12:10 PM	76.8	77.5	76.7	57	60.4	6	SSW	1	17	SSW	76.8	77.3	77.3	---
2/21/2011	12:20 PM	78.6	78.7	76.8	54	60.6	7	SSW	1.17	15	SSW	78.6	79.1	79.1	---

2/21/2011	12:30 PM	79.9	80.2	78.5	51	60.2	9	SSW	1.5	19	SSW	78.8	80.1	79	---
2/21/2011	12:40 PM	79	79.8	78.1	54	60.9	7	SSW	1.17	18	SSW	79	79.5	79.5	---
2/21/2011	12:50 PM	76.5	79	76.5	57	60.1	5	SSW	0.83	15	SSW	76.5	77	77	---
2/21/2011	1:00 PM	76.4	76.5	76.2	58	60.5	2	S	0.33	6	WSW	76.4	77	77	---
2/21/2011	1:10 PM	77.9	77.9	76.4	55	60.4	5	SSW	0.83	14	SW	77.9	78.4	78.4	---
2/21/2011	1:20 PM	76.8	78.4	76.8	54	58.9	5	SSW	0.83	13	SW	76.8	77	77	---
2/21/2011	1:30 PM	76.9	76.9	76.5	56	60	3	SSW	0.5	14	W	76.9	77.3	77.3	---
2/21/2011	1:40 PM	78.3	78.3	76.9	55	60.8	4	SSW	0.67	12	SSW	78.3	78.8	78.8	---
2/21/2011	1:50 PM	77.7	79.3	77.6	54	59.7	4	SSW	0.67	12	SW	77.7	78	78	---
2/21/2011	2:00 PM	78.8	79.7	77.7	52	59.7	6	SSW	1	15	SSW	78.8	79.1	79.1	---
2/21/2011	2:10 PM	80.4	80.4	78.2	50	60.1	4	SSW	0.67	11	SSW	80.4	80.5	80.5	---
2/21/2011	2:20 PM	77.7	80.4	77.6	53	59.2	5	SSW	0.83	13	SW	77.7	77.9	77.9	---
2/21/2011	2:30 PM	79.8	80	77.8	50	59.5	8	SSW	1.33	17	SW	79.4	79.9	79.5	---
2/21/2011	2:40 PM	79.4	79.8	78.8	49	58.6	6	SSW	1	16	SSW	79.4	79.5	79.5	---
2/21/2011	2:50 PM	78.8	79.6	78.8	51	59.1	6	SSW	1	17	SSW	78.8	79	79	---
2/21/2011	3:00 PM	78.4	78.8	78.3	52	59.3	6	SSW	1	12	SSW	78.4	78.7	78.7	---
2/21/2011	3:10 PM	78.3	79	78.3	52	59.2	5	SSW	0.83	13	SSW	78.3	78.5	78.5	---
2/21/2011	3:20 PM	79.5	79.5	78.1	51	59.8	6	SSW	1	14	SSW	79.5	79.8	79.8	---
2/21/2011	3:30 PM	79.4	79.8	79.4	51	59.7	7	SSW	1.17	15	SSW	79.4	79.7	79.7	---
2/21/2011	3:40 PM	78.9	79.6	78.9	51	59.2	5	SSW	0.83	13	SSW	78.9	79.2	79.2	---
2/21/2011	3:50 PM	79.2	79.2	78.6	52	60.1	6	SSW	1	12	SSW	79.2	79.6	79.6	---
2/21/2011	4:00 PM	77.1	79.2	77.1	54	59.2	6	SSW	1	13	S	77.1	77.3	77.3	---
2/21/2011	4:10 PM	78.2	78.2	76.7	54	60.2	6	SSW	1	14	SSW	78.2	78.6	78.6	---
2/21/2011	4:20 PM	78.2	78.5	78.1	54	60.2	5	SSW	0.83	13	SSW	78.2	78.6	78.6	---
2/21/2011	4:30 PM	77.1	78.3	77.1	55	59.7	4	SSW	0.67	13	SSW	77.1	77.4	77.4	---
2/21/2011	4:40 PM	75.6	77	75.6	54	57.8	2	S	0.33	8	SSW	75.6	75.9	75.9	---

Site Photographs

(a)			Figure XX. BMT3 Pictures (a) highway and location; (b) close-up of flushed surface before treatment; (c) roadway surface before treatment; (d) close-up of flushed surface immediately after treatment; (e) roadway surface after treatment; (f) close-up of surface at first follow-up ; (g) roadway surface at first follow-up , (h) roadway surface at second follow-up ; (i) close-up of surface at second follow-up .
(b)		(c)	
(d)		(e)	
(f)		(g)	

(h)		(i)	

APPENDIX J

SITE LRD 2

Webb COUNTY

Laredo DISTRICT

Site Description

Project Information			
District: Laredo	Test Site: LRD 2	County: Webb	Road: FM 1472 (Mines Rd.) EB
ADT: 19500	Truck Traffic: Very High	Year Built:	Last Maintained: 2006
Roadway Description Aggregate Grade: Ty PE GR 3S Aggregate Type: Limestone w/ Asphalt Pit: Vulcan Uvalde AQMP#: CSJ: 0018-03-039 Binder: AC 20-5TR			
Research Test Summary			
Test Location: Toll Rd 255 to RR 3338 (Las Tiendas Rd)		Closest Texas Reference Marker: 424	
Test Point GPS Coordinates		N	W
TP1		27°41.605'	099°42.793'
TP2		27°41.553'	099°42.685'
TP3		27°41.505'	099°42.577'
Ultra High Pressure Water Cutter Treatment Summary			
Date Treated 2/15/2011		Start Time 7:45 AM	End Time 3:10 PM

Summary Description of Treatment Activity

Rampart configuration: Rampart used a 20 jet nozzle configuration: From the outside to center they ran 2 0.014in. jets, 6 0.011in. jets and 6 0.009in. jets. They ran the hydraulic pressure at 32,000psi when running uphill and 34,000psi running downhill.

Work Activities:

TechMRT and Rampart were at the maintenance office before 6:40AM. TechMRT and Rampart participated in the morning meeting and a short discussion with Darlene and Carl at the maintenance office at 7:30AM. TechMRT went straight to the Laredo Site 2.

TechMRT arrived on site at 7:45AM. At 8:10AM, traffic control arrived. From 8:05AM till 8:20AM TechMRT setup the weather station at TP1 and remarked all test points.

TechMRT performed all pretest from 8:05AM till 9:55AM. From 9:50AM till 10:05AM, a walking video tour was taken of the site before treatment to catalogue the variation in flushing along the site.

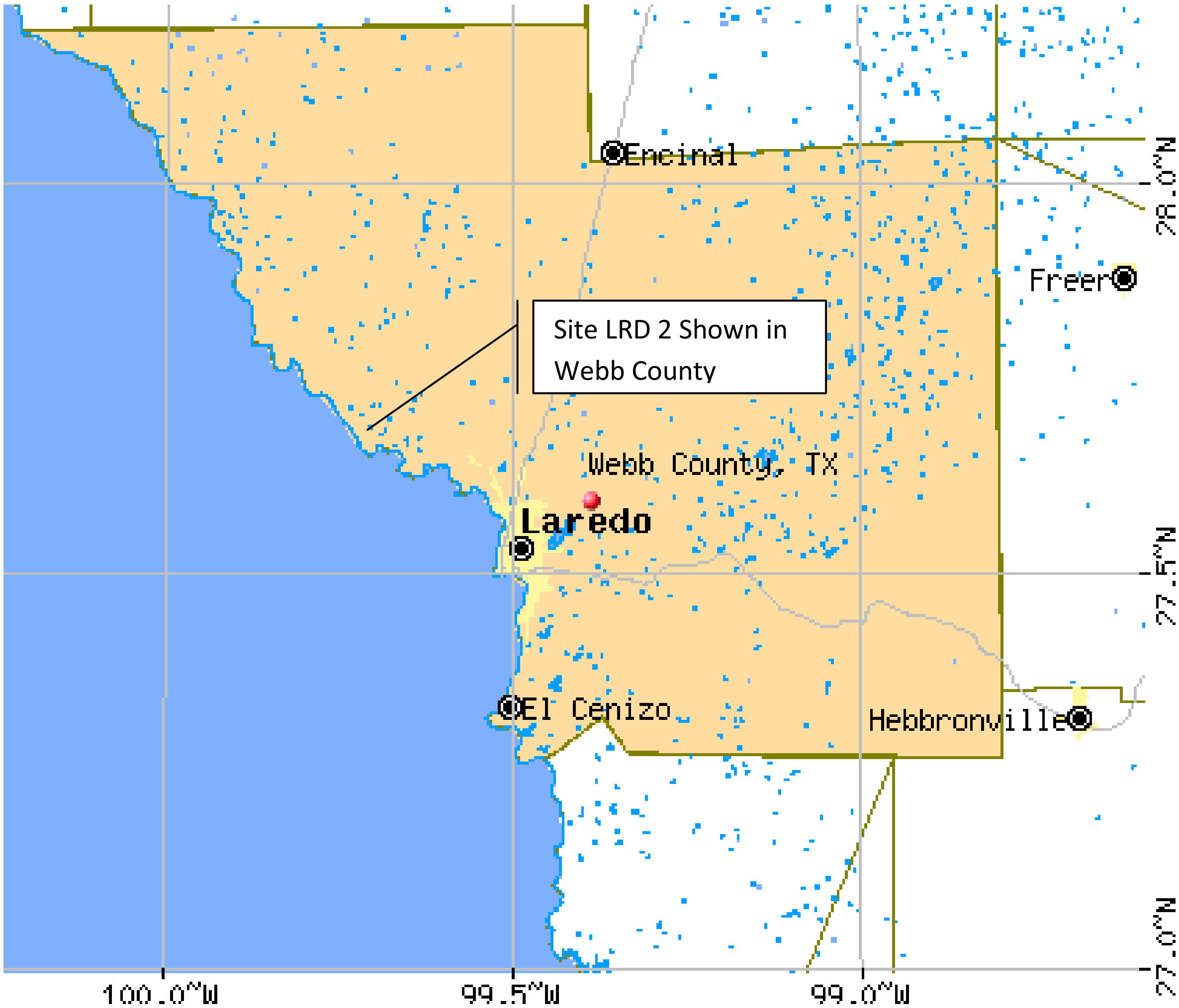
Rampart was present at the site beginning at 9:00AM. They treated the whole section from 10:15AM till 12:10PM. As mentioned in the discussion of the pavement, the treatment left behind sticky balls of asphalt which were immediately swept from the pavement with a broom truck. They left to empty the truck from 12:25PM till 1:10PM.

TechMRT performed all post testing from 12:25PM till 1:35PM. Therefore TechMRT had to dry each section before performing the CTM and sand patch. The weather station was packed at 3:00PM.

Rampart treated 2nd .5 mile 1:15 to 2:45 at .75 mph

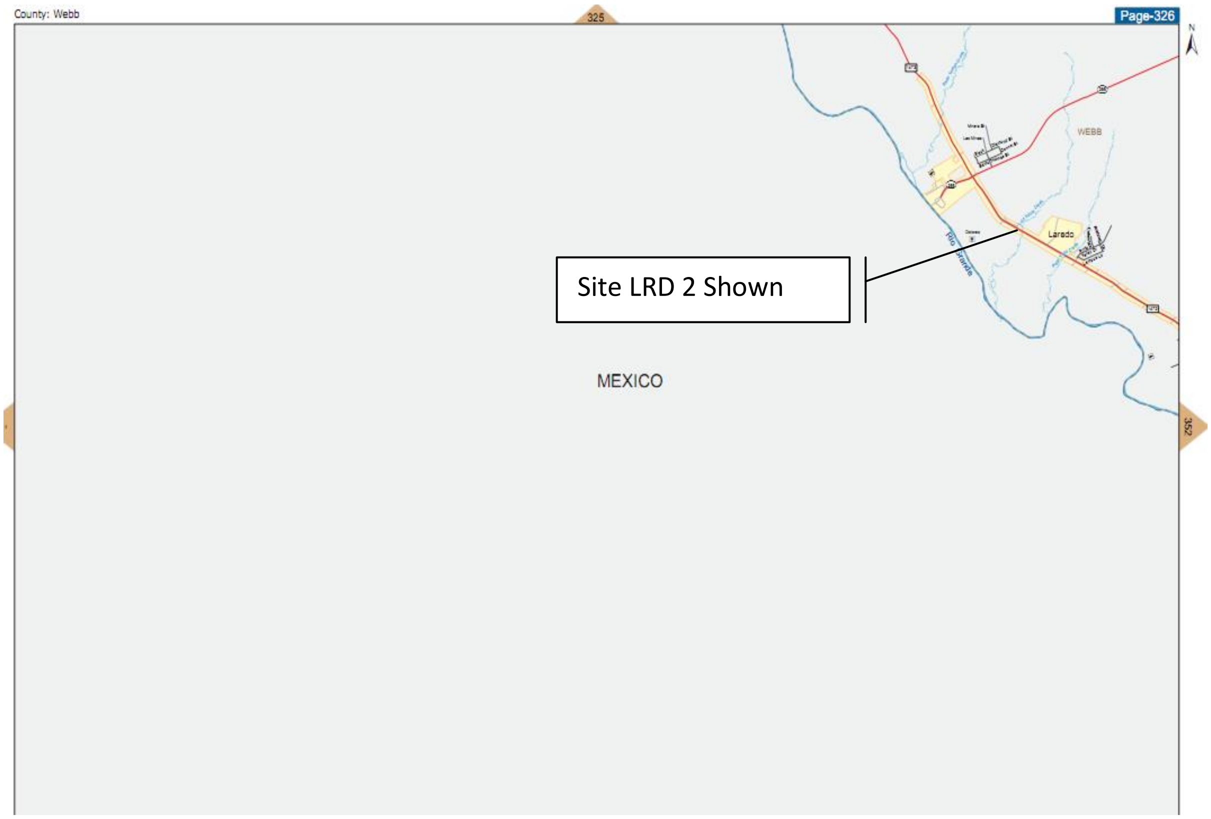
Comments	
Follow-On Testing Summary	
Date: 7/25/11	Comments: Preformed follow –up monitoring successfully.
Date: 1/4/12	Comments: Preformed follow –up monitoring successfully.
Date	Comments: No follow-up monitoring was performed due to flushing reaching or surpassing original state so no further data was necessary.

Site Vicinity Map



http://www.city-data.com/

Site Location Map

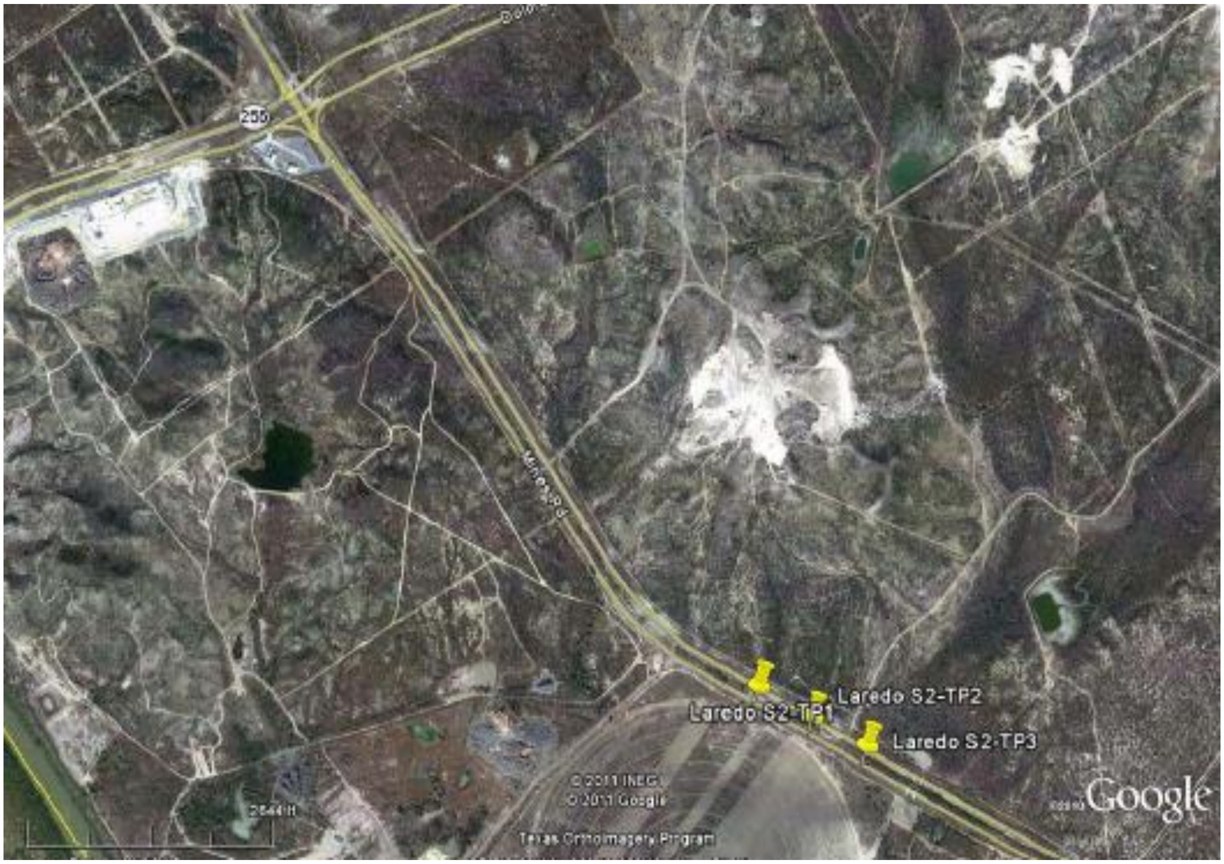


http://www.txdot.gov/travel/county_grid_search.htm

Aerial Photograph

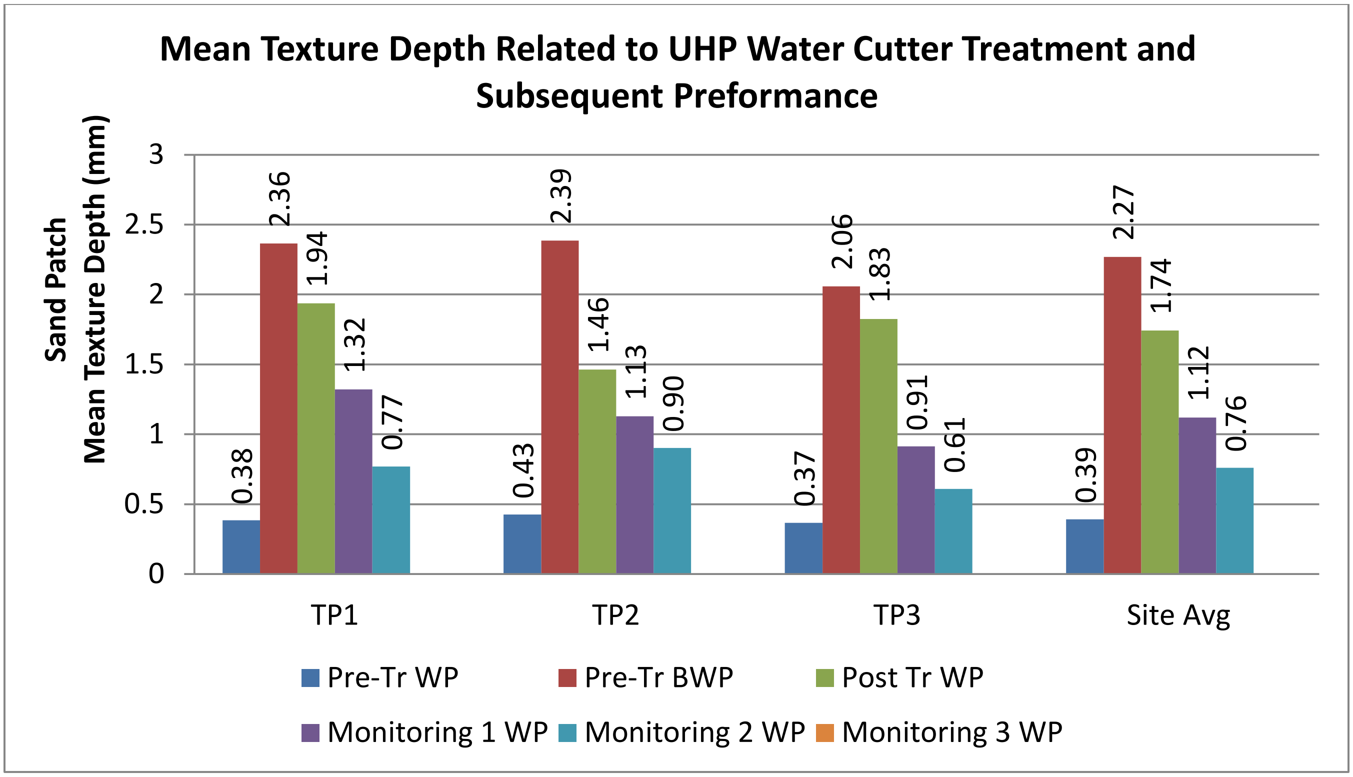
Google Inc. (2011). Google Earth (Version 6.1.0.5001)

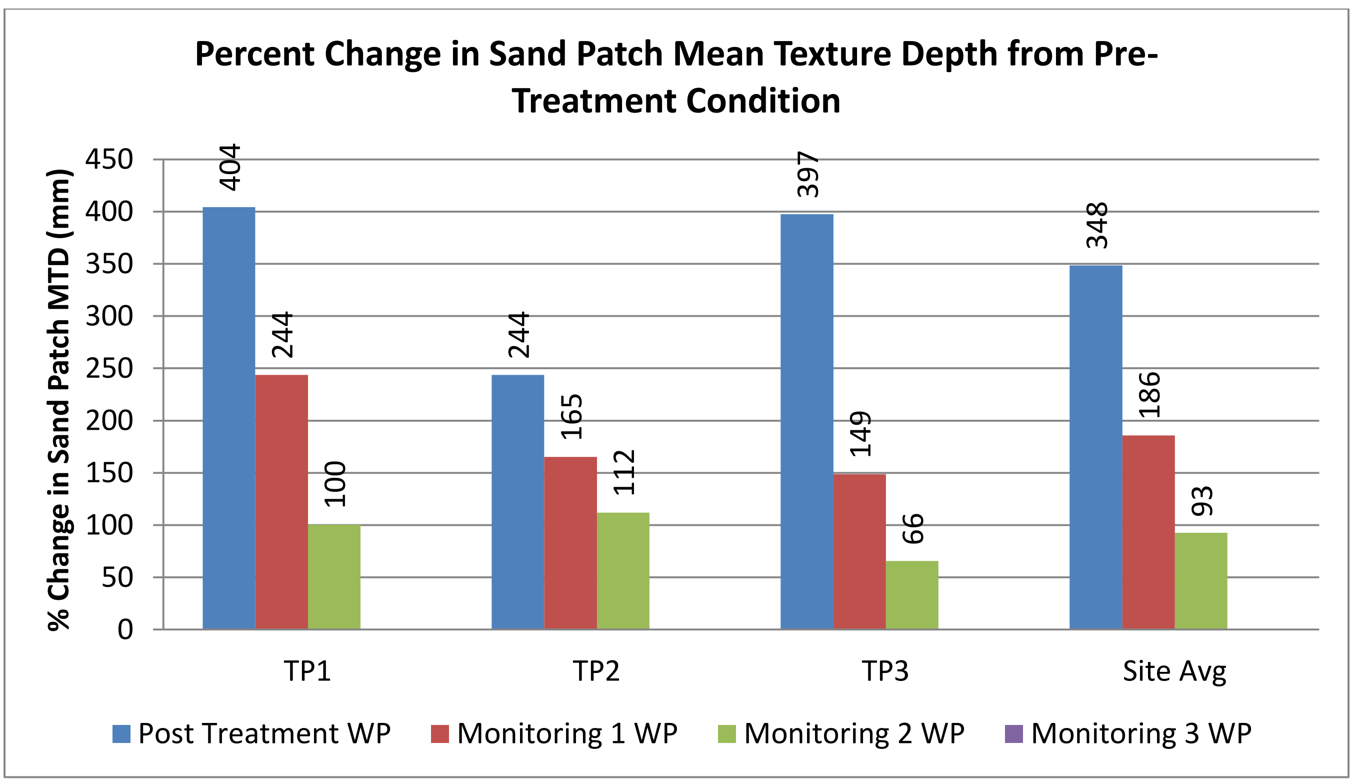
Test Point Plan



Google Inc. (2011). Google Earth (Version 6.1.0.5001)

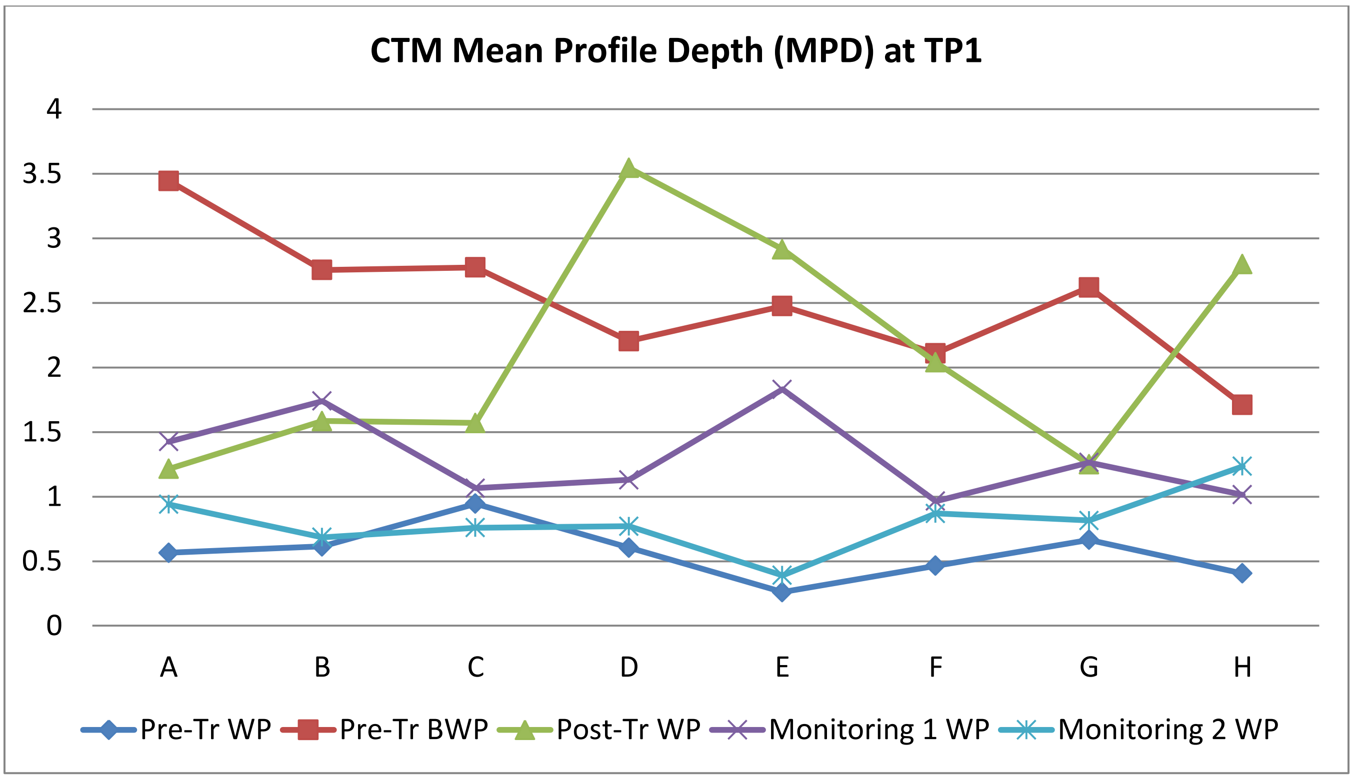
Sand Patch Data





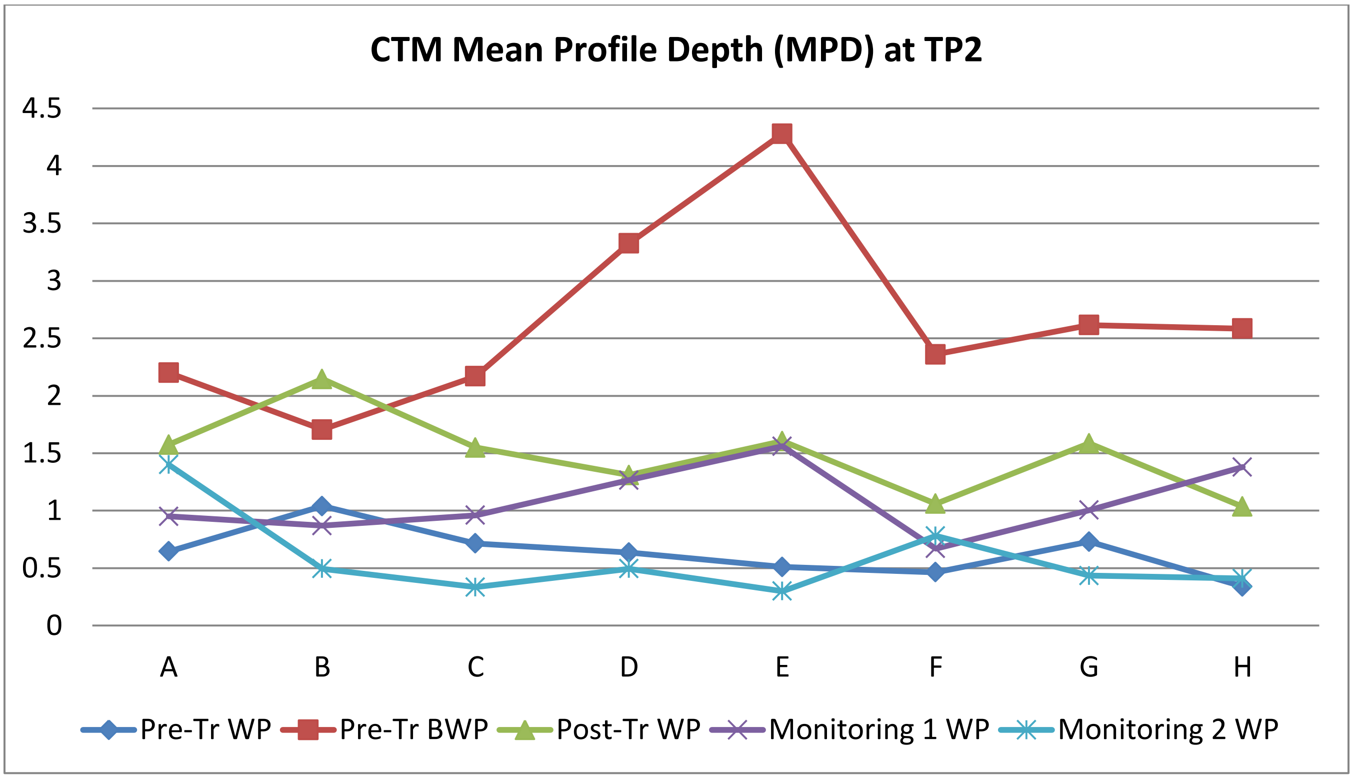
Circular Track Meter (CTM) Mean Profile Depth (in mm) at TP 1

	A	B	C	D	E	F	G	H
Pre-Tr WP	0.565	0.615	0.945	0.605	0.26	0.465	0.665	0.405
Pre-Tr BWP	3.445	2.755	2.775	2.205	2.475	2.11	2.62	1.71
Post-Tr	1.215	1.585	1.57	3.545	2.915	2.04	1.25	2.8
Monitoring 1	1.425	1.74	1.065	1.13	1.83	0.965	1.265	1.015
Monitoring 2	0.94	0.685	0.76	0.77	0.39	0.87	0.815	1.235
Monitoring 3	Not conducted due to maintenance/rehabilitation work on the section							



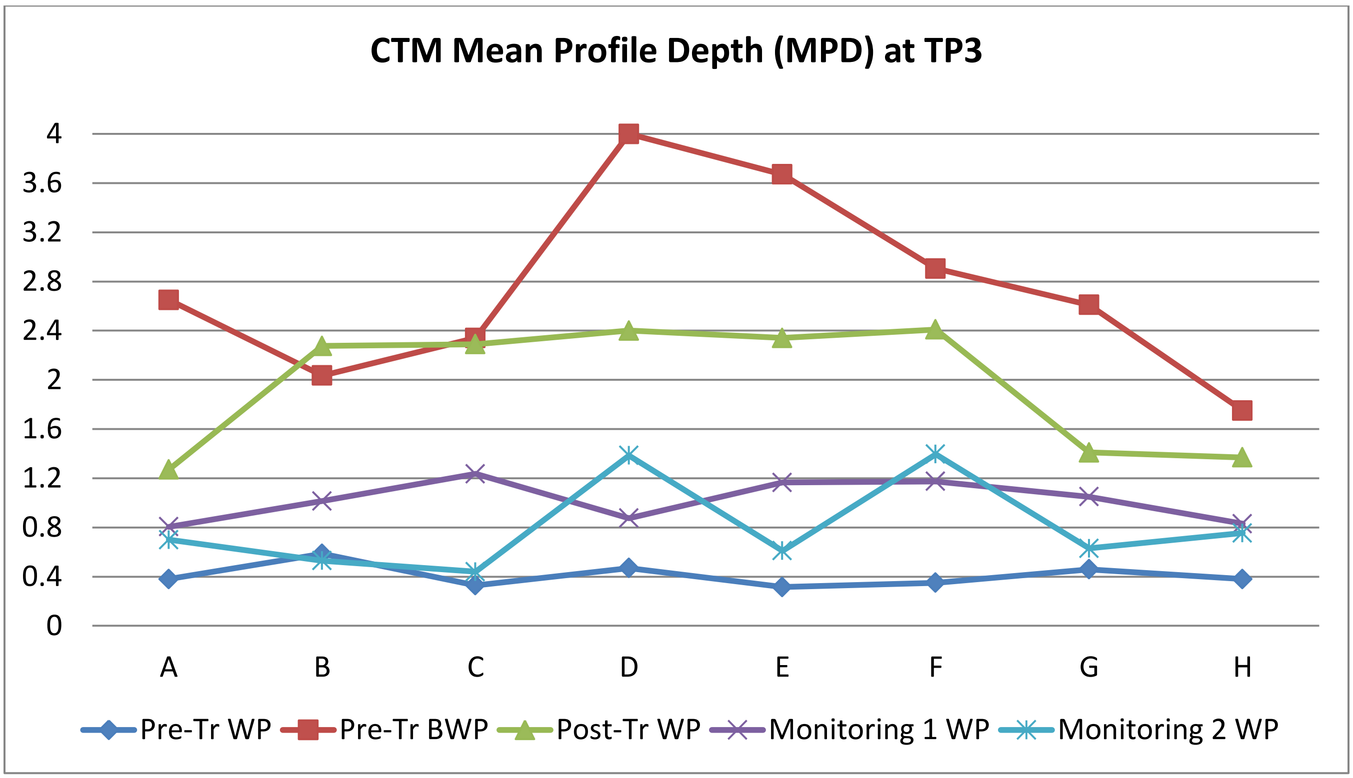
Circular Track Meter (CTM) Mean Profile Depth (in mm) at TP 2

	A	B	C	D	E	F	G	H
Pre-Tr WP	0.645	1.04	0.715	0.635	0.51	0.465	0.73	0.34
Pre-Tr BWP	2.2	1.705	2.17	3.325	4.28	2.36	2.615	2.585
Post-Tr	1.575	2.145	1.55	1.31	1.605	1.06	1.585	1.035
Monitoring 1	0.95	0.87	0.96	1.265	1.56	0.67	1.005	1.38
Monitoring 2	1.4	0.495	0.335	0.495	0.3	0.78	0.435	0.41
Monitoring 3	Not conducted due to maintenance/rehabilitation work on the section							

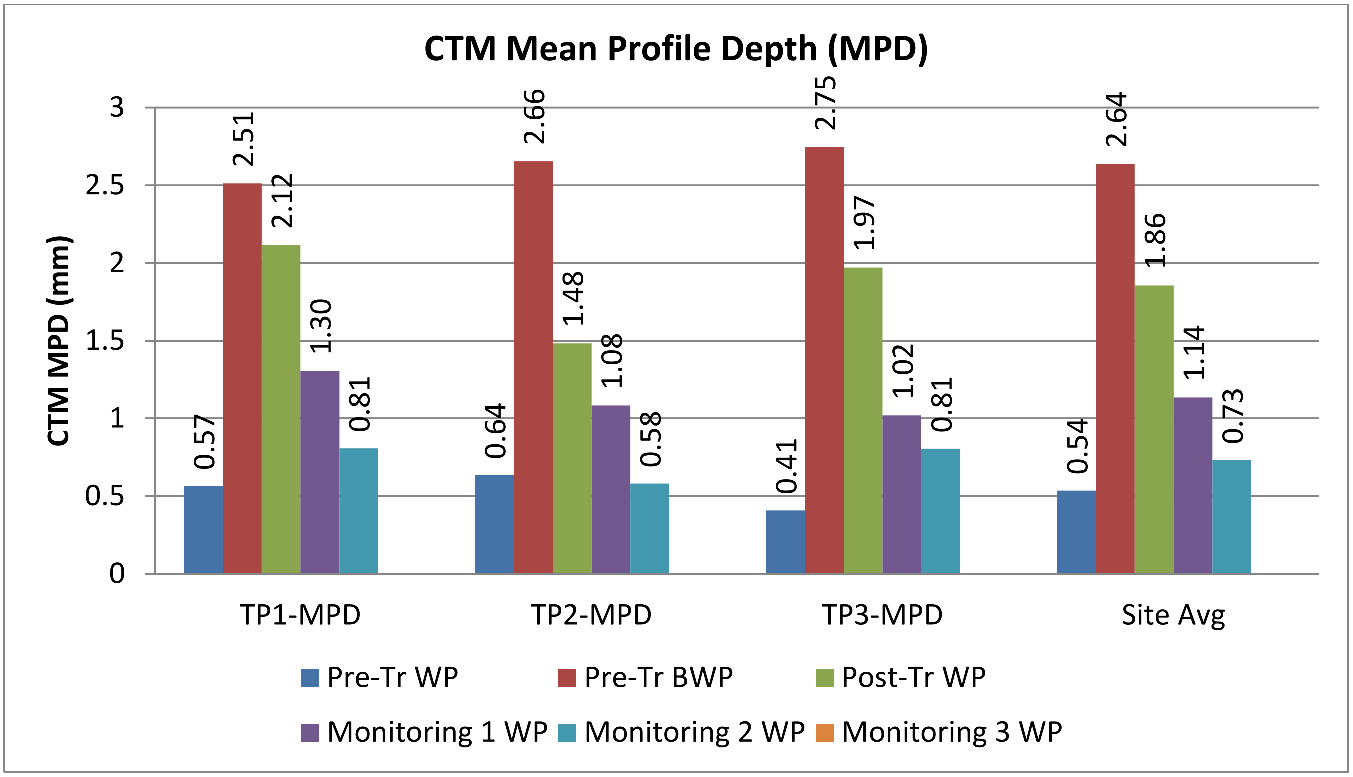


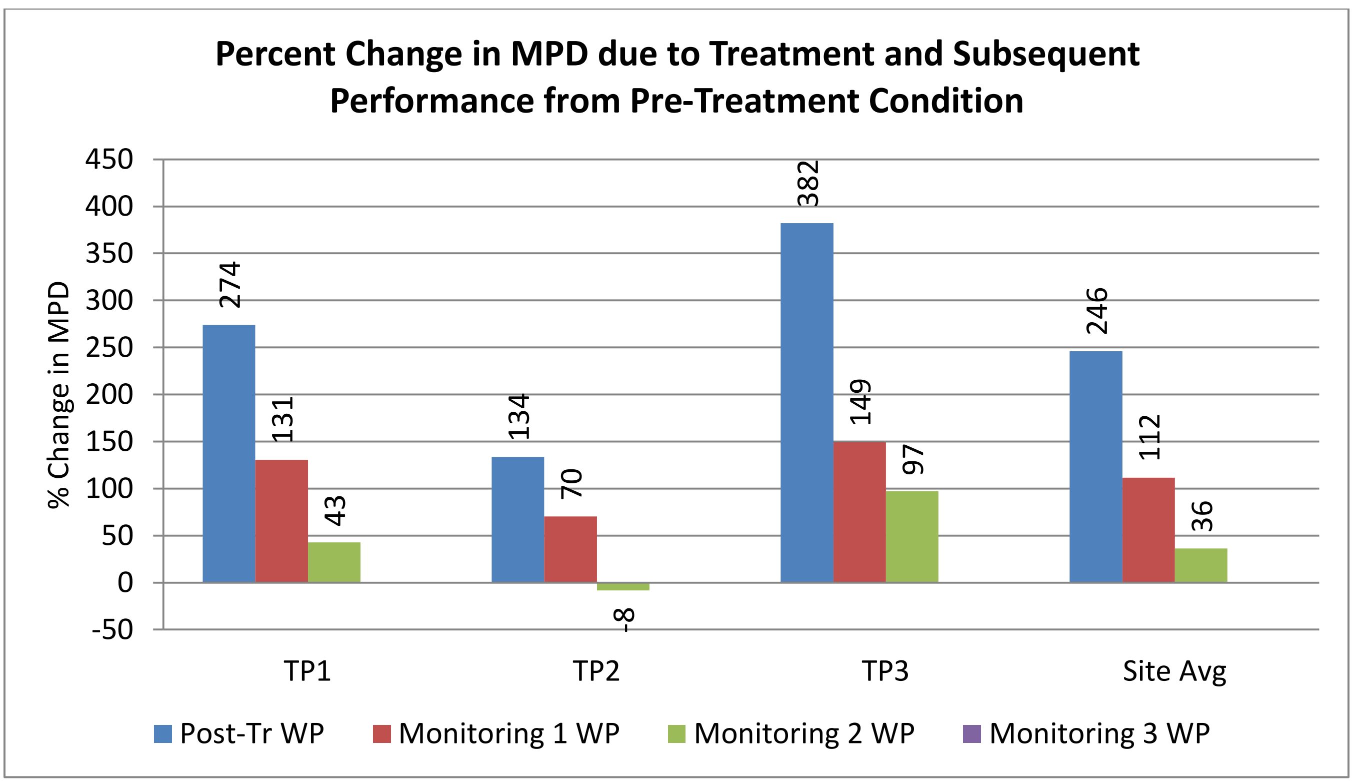
Circular Track Meter (CTM) Mean Profile Depth (in mm) at TP 3

	A	B	C	D	E	F	G	H
Pre-Tr WP	0.38	0.585	0.33	0.47	0.315	0.35	0.46	0.38
Pre-Tr BWP	2.65	2.035	2.34	4	3.67	2.905	2.61	1.75
Post-Tr	1.27	2.275	2.29	2.4	2.34	2.41	1.41	1.37
Monitoring 1	0.805	1.015	1.235	0.875	1.165	1.175	1.05	0.83
Monitoring 2	0.7	0.53	0.44	1.385	0.61	1.395	0.63	0.755
Monitoring 3	Not conducted due to maintenance/rehabilitation work on the section							

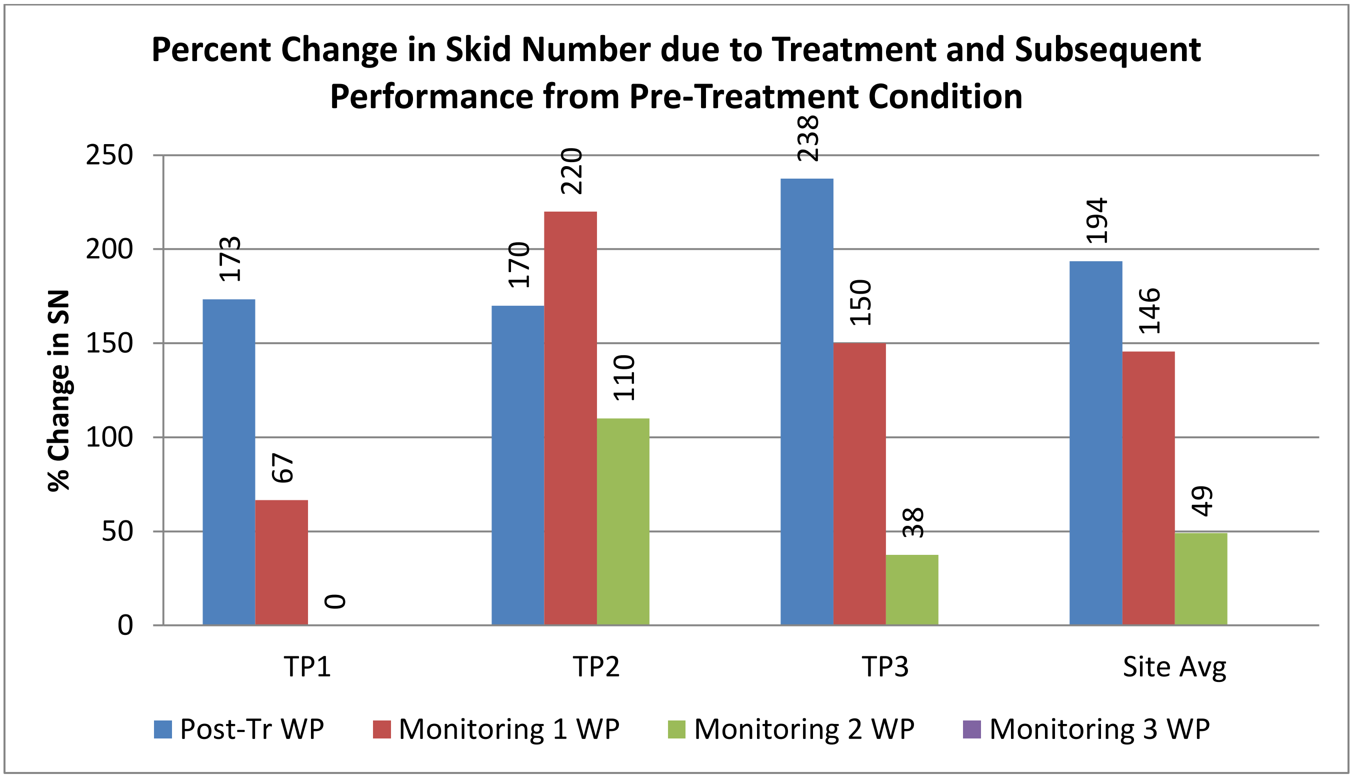


Circular Track Meter (CTM) MPD (mm)



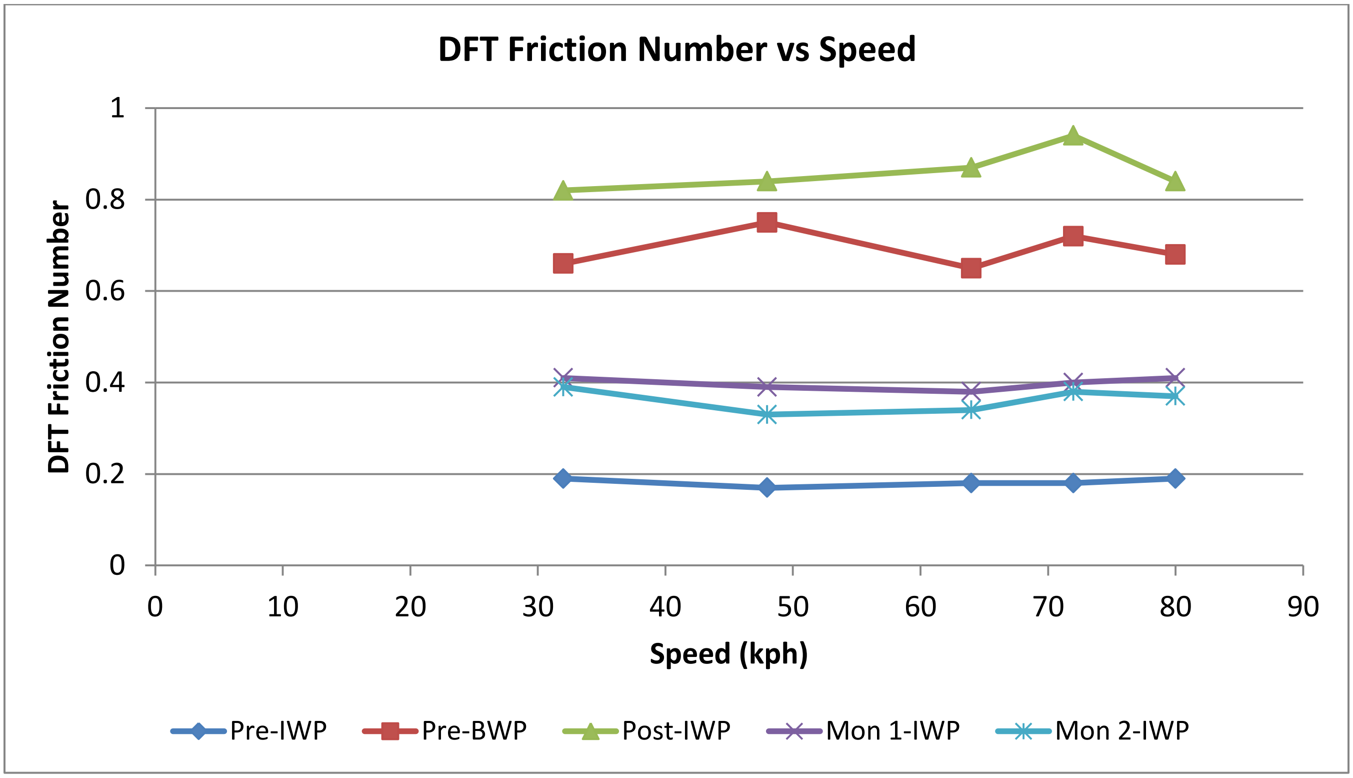


Skid Truck Data



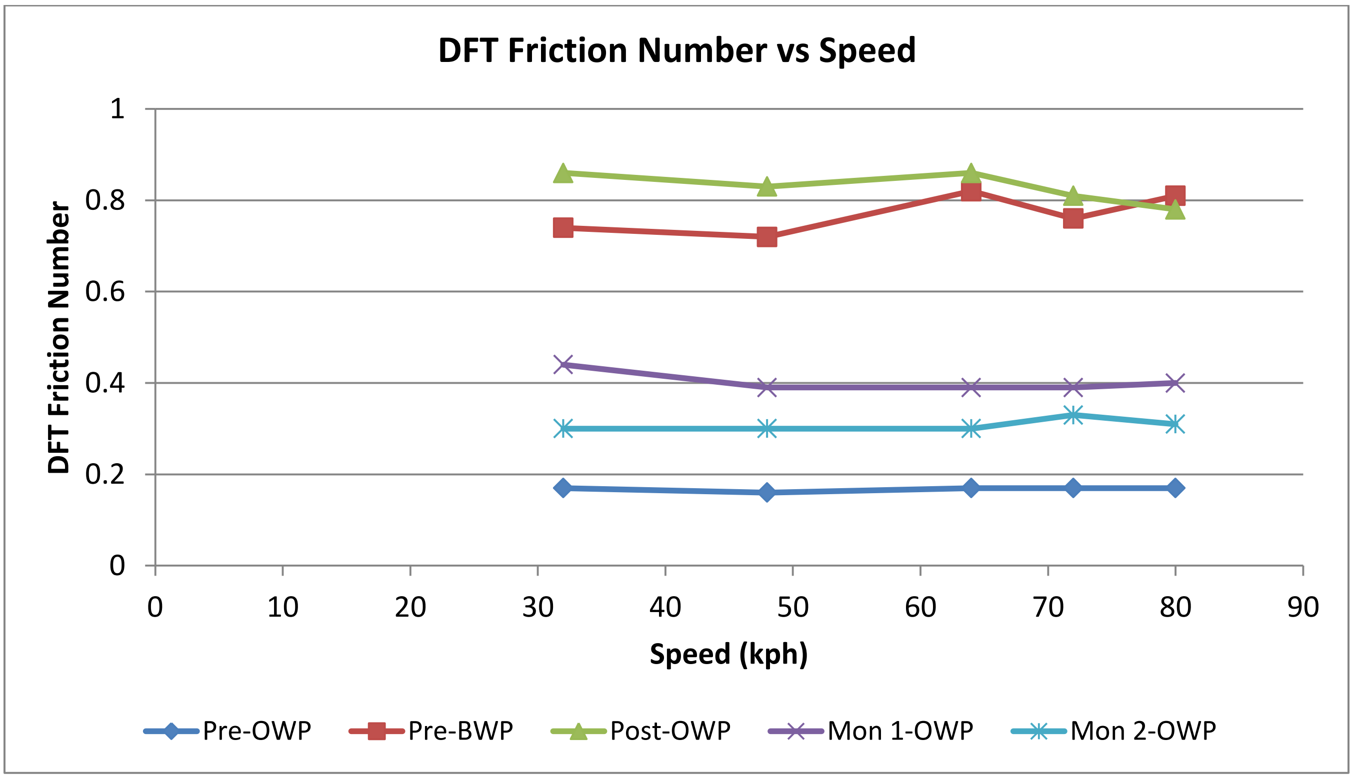
Dynamic Friction Test (DFT) Friction Number Data for TP 1

Speed (kph)	Pre-IWP	Pre-BWP	Post-IWP	Mon 1-IWP	Mon 2-IWP	Mon 3-IWP
32	0.19	0.66	0.82	0.41	0.39	Not conducted due to maintenance/rehabilitation work on the section
48	0.17	0.75	0.84	0.39	0.33	
64	0.18	0.65	0.87	0.38	0.34	
72	0.18	0.72	0.94	0.4	0.38	
80	0.19	0.68	0.84	0.41	0.37	



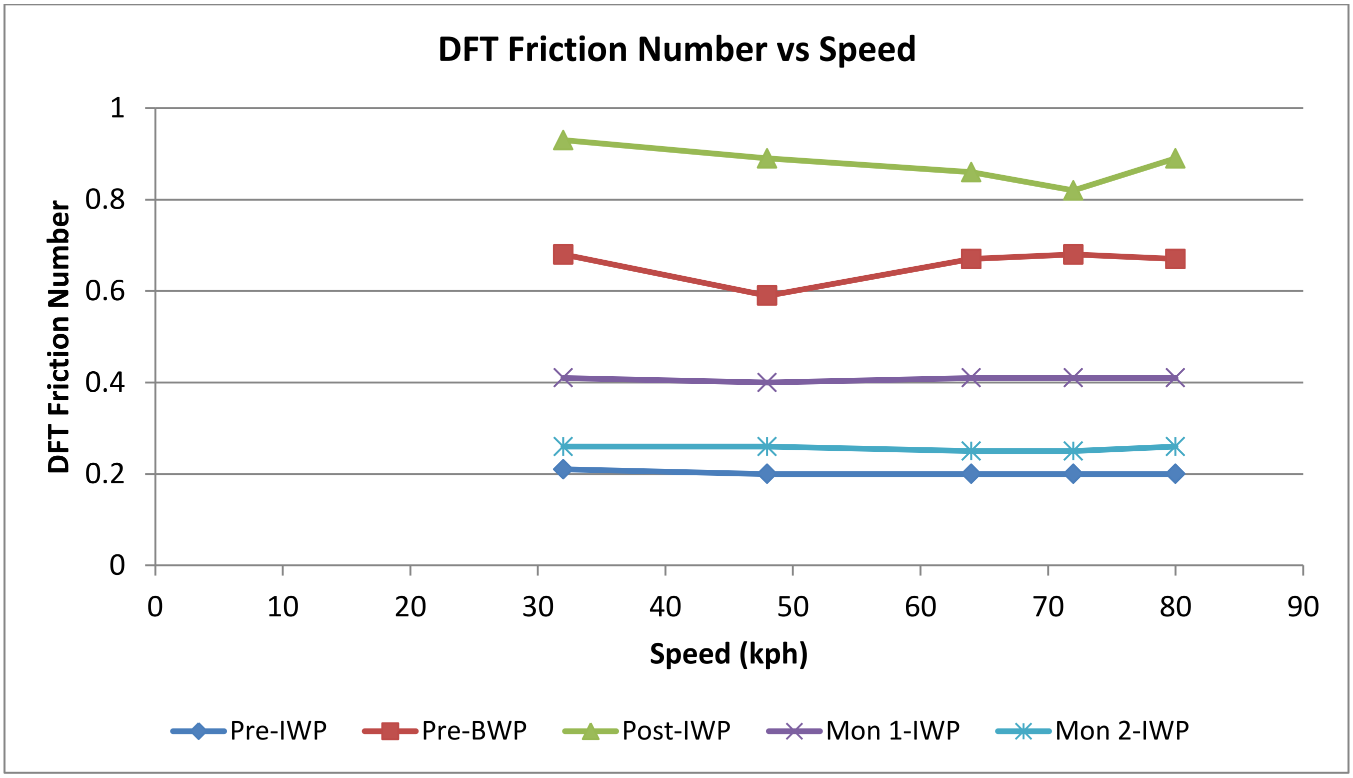
Dynamic Friction Test (DFT) Friction Number Data for TP 2

Speed (kph)	Pre-OWP	Pre-BWP	Post-OWP	Mon 1-OWP	Mon 2-OWP	Mon 3-OWP
32	0.17	0.74	0.86	0.44	0.3	Not conducted due to maintenance/rehabilitation work on the section
48	0.16	0.72	0.83	0.39	0.3	
64	0.17	0.82	0.86	0.39	0.3	
72	0.17	0.76	0.81	0.39	0.33	
80	0.17	0.81	0.78	0.4	0.31	



Dynamic Friction Test (DFT) Friction Number Data for TP 3

Speed (kph)	Pre-IWP	Pre-BWP	Post-IWP	Mon 1-IWP	Mon 2-IWP	Mon 3-IWP
32	0.21	0.68	0.93	0.41	0.26	Not conducted due to maintenance/rehabilitation work on the section
48	0.2	0.59	0.89	0.4	0.26	
64	0.2	0.67	0.86	0.41	0.25	
72	0.2	0.68	0.82	0.41	0.25	
80	0.2	0.67	0.89	0.41	0.26	



Weather Data during UHP Water Cutter Treatment

Date	Time	Temp Out	Hi Temp	Low Temp	Out Hum	Dew Pt.	Wind Speed	Wind Dir	Wind Run	Hi Speed	Hi Dir	Wind Chill	Heat Index	THW Index	THSW Index
2/15/2011	8:00 AM	67.9	68.9	67.9	73	58.9	1	SSW	0.17	6	SSW	67.9	68.7	68.7	---
2/15/2011	8:10 AM	63.6	67.8	63.6	83	58.3	5	S	0.83	8	SSW	63.6	64.1	64.1	---
2/15/2011	8:20 AM	63.3	63.5	63.3	85	58.7	7	S	1.17	12	SSW	63.2	63.8	63.7	---
2/15/2011	8:30 AM	63.6	63.6	63.3	85	59	8	S	1.33	13	S	62.8	64.2	63.4	---
2/15/2011	8:40 AM	63.7	63.8	63.6	84	58.8	9	S	1.5	14	S	62	64.2	62.5	---
2/15/2011	8:50 AM	64	64	63.6	84	59.1	9	S	1.5	14	S	62.4	64.6	63	---
2/15/2011	9:00 AM	64.5	64.5	64	83	59.2	8	S	1.33	13	S	63.8	65.2	64.5	---
2/15/2011	9:10 AM	64.9	64.9	64.5	82	59.3	8	S	1.33	12	SSE	64.3	65.6	65	---
2/15/2011	9:20 AM	65.9	65.9	64.9	81	59.9	7	S	1.17	12	S	65.9	66.8	66.8	---
2/15/2011	9:30 AM	66.9	66.9	65.9	77	59.5	8	S	1.33	14	S	66.3	67.7	67.1	---
2/15/2011	9:40 AM	67.8	67.8	66.9	76	60	8	SSE	1.33	14	S	67.1	68.7	68	---
2/15/2011	9:50 AM	67.8	68.2	67.5	75	59.6	9	S	1.5	13	SSW	66.4	68.7	67.3	---
2/15/2011	10:00 AM	68.9	69	67.9	72	59.5	10	SSW	1.67	16	SSW	66.8	69.5	67.4	---
2/15/2011	10:10 AM	70.2	70.2	69	70	60	10	S	1.67	18	SSW	68.1	70.4	68.3	---
2/15/2011	10:20 AM	71.3	71.3	70.2	68	60.2	9	S	1.5	15	SSW	69.9	71.6	70.2	---
2/15/2011	10:30 AM	72.4	72.4	71.3	66	60.4	8	S	1.33	14	SSW	71.9	72.9	72.4	---
2/15/2011	10:40 AM	73.2	73.2	72.3	64	60.3	7	SSE	1.17	12	SSW	73.2	73.9	73.9	---
2/15/2011	10:50 AM	73.8	73.8	73.3	62	60	10	SSW	1.67	20	SSW	71.8	74.6	72.6	---
2/15/2011	11:00 AM	74.9	75.1	73.8	58	59.1	10	S	1.67	16	S	72.9	75.6	73.6	---
2/15/2011	11:10 AM	75.7	76	75	57	59.4	10	SSW	1.67	17	S	73.8	76.2	74.3	---
2/15/2011	11:20 AM	77.1	77.1	75.5	54	59.2	10	SSW	1.67	18	SSW	75.2	77.3	75.4	---
2/15/2011	11:30 AM	77.9	77.9	77	52	58.9	10	SSW	1.67	16	SSW	76.1	78.1	76.3	---
2/15/2011	11:40 AM	78.3	78.3	77.8	52	59.2	11	SSW	1.83	18	SSW	76.2	78.5	76.4	---
2/15/2011	11:50 AM	78.9	79	78.4	50	58.7	10	S	1.67	17	S	77.2	79.1	77.4	---
2/15/2011	12:00 PM	80.1	80.1	78.8	47	58	10	S	1.67	15	S	78.5	79.9	78.3	---

2/15/2011	12:10 PM	79.8	80.3	79.7	48	58.4	9	S	1.5	16	S	78.7	79.7	78.6	---
2/15/2011	12:20 PM	80.5	80.6	79.8	46	57.8	10	S	1.67	17	SSW	79	80.2	78.7	---
2/15/2011	12:30 PM	81	81	79.9	45	57.7	11	SSW	1.83	18	SSW	79.2	80.6	78.8	---
2/15/2011	12:40 PM	81.2	81.2	80.7	43	56.6	8	S	1.33	16	SSW	80.8	80.6	80.2	---
2/15/2011	12:50 PM	81.5	81.8	81.2	45	58.1	9	S	1.5	15	SSW	80.6	81.3	80.4	---
2/15/2011	1:00 PM	83	83	81.5	43	58.2	8	SW	1.33	17	SSW	82.7	83.2	82.9	---
2/15/2011	1:10 PM	82.3	83.6	82.1	43	57.6	7	SSE	1.17	14	SSW	82.3	82.1	82.1	---
2/15/2011	1:20 PM	82.8	83.1	82.3	42	57.4	7	S	1.17	14	SSW	82.8	82.7	82.7	---
2/15/2011	1:30 PM	82.3	83.1	82.3	42	56.9	7	S	1.17	16	SSE	82.3	82	82	---
2/15/2011	1:40 PM	83.3	83.7	82.2	40	56.5	7	S	1.17	17	S	83.3	83.2	83.2	---
2/15/2011	1:50 PM	84.5	84.7	83.1	38	56.1	6	SSE	1	12	S	84.5	84.3	84.3	---
2/15/2011	2:00 PM	84.9	85	83.7	38	56.5	6	SSE	1	12	S	84.9	84.7	84.7	---
2/15/2011	2:10 PM	85.4	85.4	84.6	37	56.2	8	SSE	1.33	12	SSE	85.2	85	84.8	---
2/15/2011	2:20 PM	85.4	85.5	84.5	36	55.4	8	SSE	1.33	14	SSE	85.2	84.8	84.6	---
2/15/2011	2:30 PM	85.1	85.6	85	36	55.1	7	S	1.17	13	ESE	85.1	84.5	84.5	---
2/15/2011	2:40 PM	85.9	85.9	85.1	34	54.3	7	SSE	1.17	14	SSE	85.9	85	85	---
2/15/2011	2:50 PM	85.6	86	85.4	33	53.2	7	S	1.17	12	S	85.6	84.5	84.5	---
2/15/2011	3:00 PM	85.6	86.4	85.5	36	55.6	4	SSE	0.67	13	S	85.6	85	85	---

Site Photographs

(a)

Figure XX. BMT3 Pictures (a) highway and location; (b) close-up of flushed surface before treatment; (c) roadway surface before treatment; (d) close-up of flushed surface immediately after treatment; (e) roadway surface after treatment; (f) close-up of surface at first follow-up ; (g) roadway surface at first follow-up , (h) roadway surface at second follow-up ; (i) close-up of surface at second follow-up , (j) close-up of surface at third follow-up ; (k) roadway surface at third follow-up

(b)

(c)

(d)

(e)

(f)

(g)

(h)		(i)	

APPENDIX K

SITE LRD 3

Webb COUNTY

Laredo DISTRICT

Site Description

Project Information			
District: Laredo	Test Site: LRD 3	County: Webb	Road: IH 35 Outside Main Lane NB
ADT: 28000	Truck Traffic: Very High	Year Built:	Last Maintained: 2009
Roadway Description: Aggregate Grade: Ty PE GR 4S SAC B Aggregate Type: Limestone w/ Asphalt Pit: Vulcan Uvalde AQMP#: CSJ: 0018-03-043 Binder: AC 20-5TR			

Research Test Summary		
Test Location: MP 32 to MP 33	Closest Texas Reference Marker: MP 32	
Test Point GPS Coordinates	N	W
TP1	27°56.751"	099°23.012'
TP2	27°56.849'	099°22.968'
TP3	27°56.959'	099°22.934'

Ultra High Pressure Water Cutter Treatment Summary		
Date Treated 2/14/2011	Start Time 8:25AM	End Time 4:20 PM

Summary Description of Treatment Activity

Personnel on site:

TechMRT: Sanja Senadheera, Andrew Tubb and Timothy Wood
Rampart: Bob Beadling and Jim Windich
TxDOT: others from the Webb County

Rampart configuration: Rampart used their typical 28 jet nozzle configuration running at 32ksi.

Work Activities: TechMRT and Rampart were at the maintenance office before 6:50AM. TechMRT participated in the morning meeting and then headed to the site at 7:30AM while rampart filled the truck.

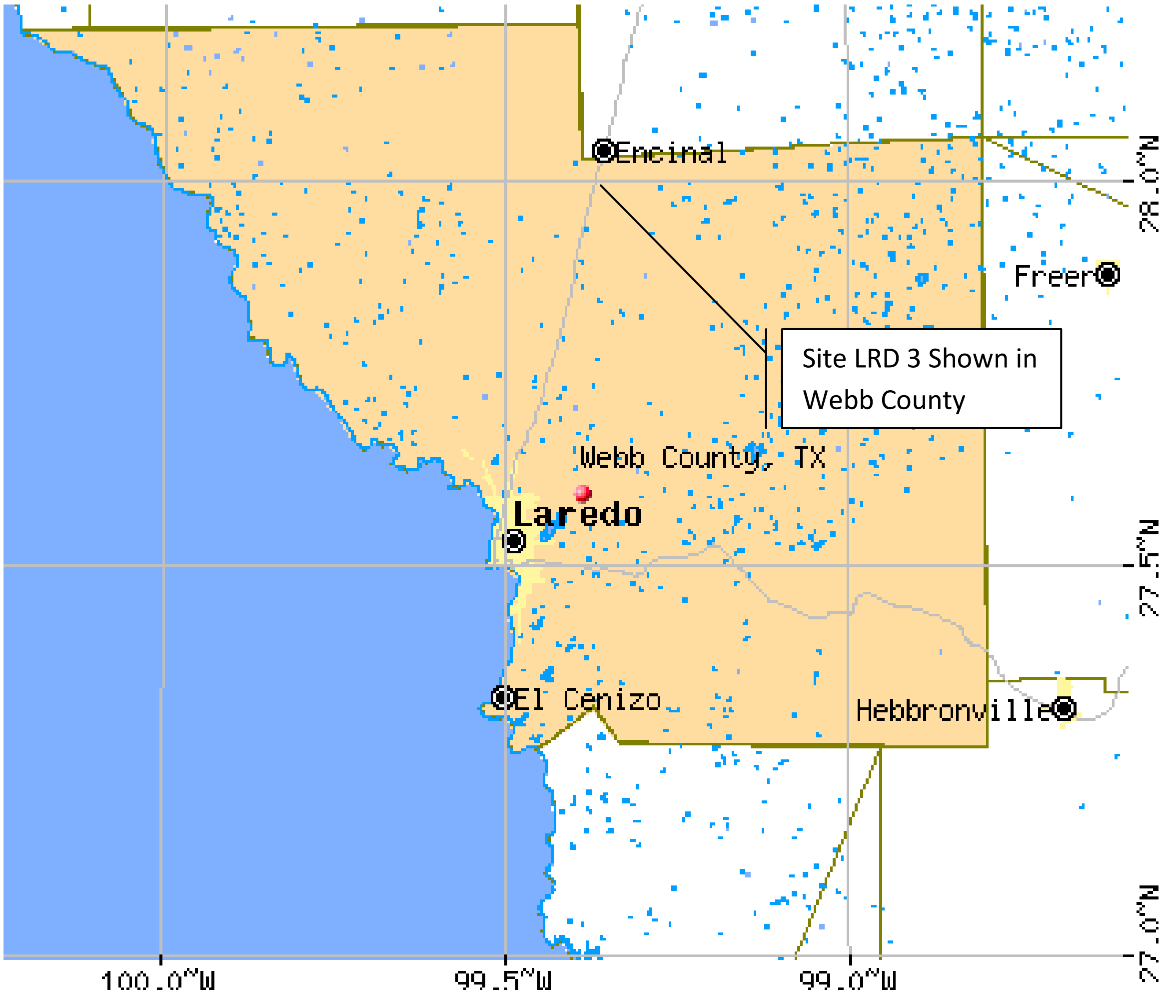
TechMRT arrived on site at 8:25AM. TechMRT setup weather station at TP 1 at 8:35. At 9:20 traffic control arrived and marked all test points and the speed sections. TechMRT performed all pretest from 9:30AM till 11:20AM.

Rampart was present at the site beginning at 8:30AM. They treated the center of the wheel paths with a single pass for the two wheel paths in the speed zones from 11:20AM to 12:15PM. They then treated passes 1 and 5 on the inside quarter mile from 12:20PM to 1:00PM. Rampart then treated passes 2 and 4 on in the inside quarter mile from 2:30 till 3:00PM.

TechMRT performed all post testing from 3:30PM till 4:20PM. The weather station was retrieved at 4:20PM.Depated from site at 4:30.

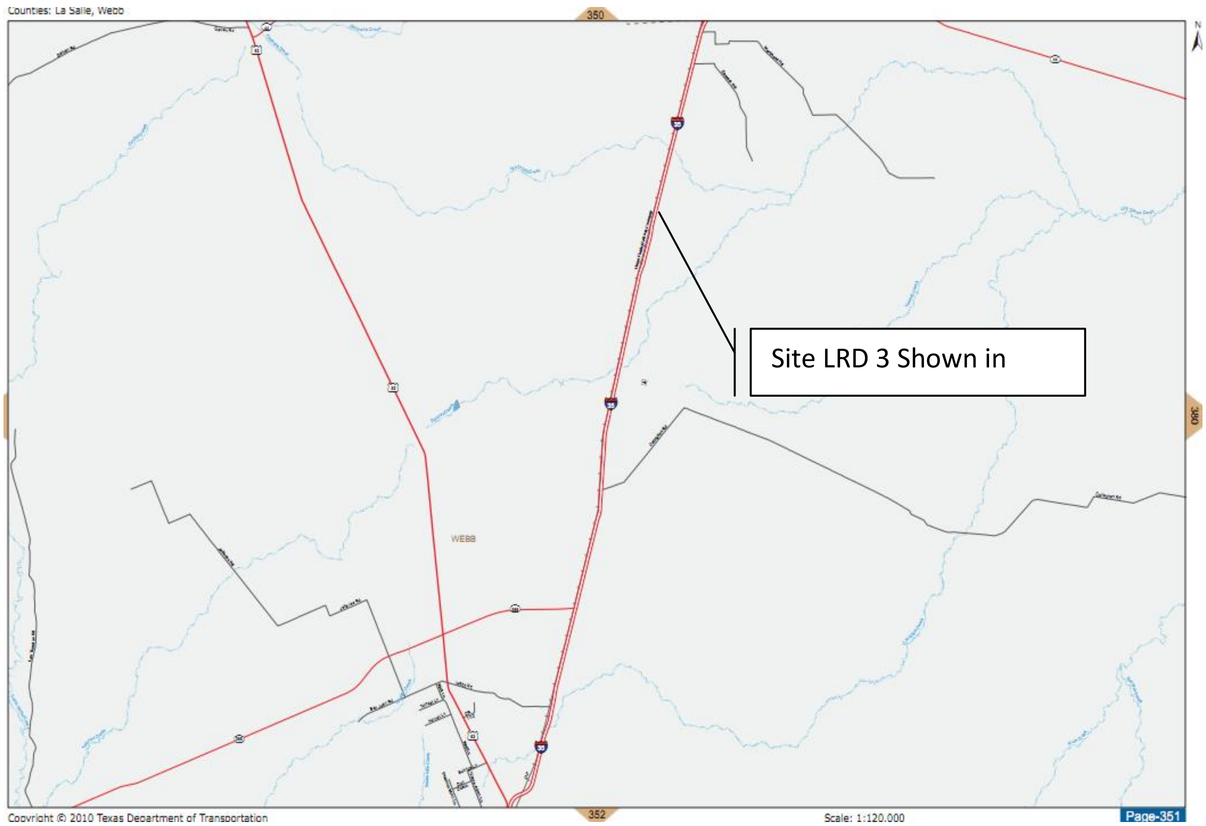
Comments	
Follow-On Testing Summary	
Date: 7/26/11	Comments: Preformed follow –up monitoring successfully.
Date: 1/4/12	Comments: Preformed follow –up monitoring successfully.
Date	Comments: No follow-up monitoring was performed due to flushing reaching or surpassing original state so no further data was necessary.

Site Vicinity Map



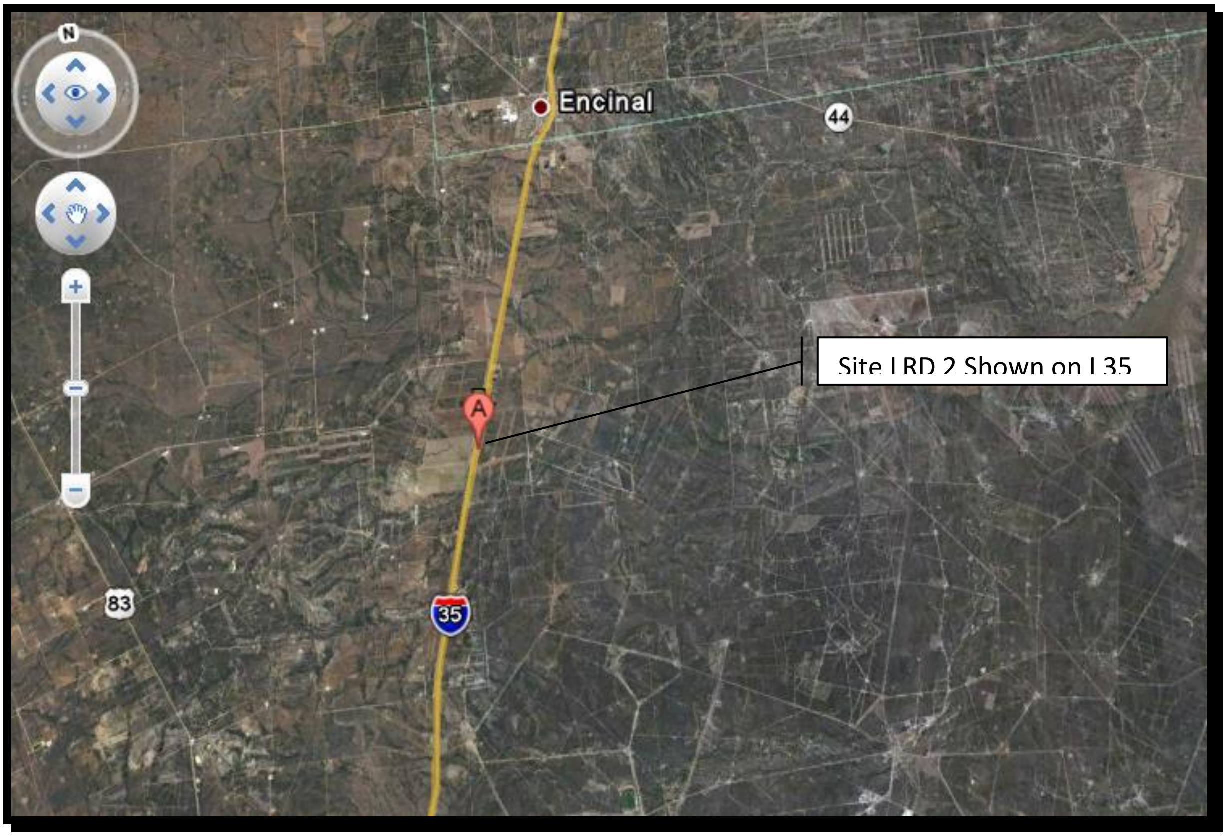
http://www.city-data.com/

Site Location Map



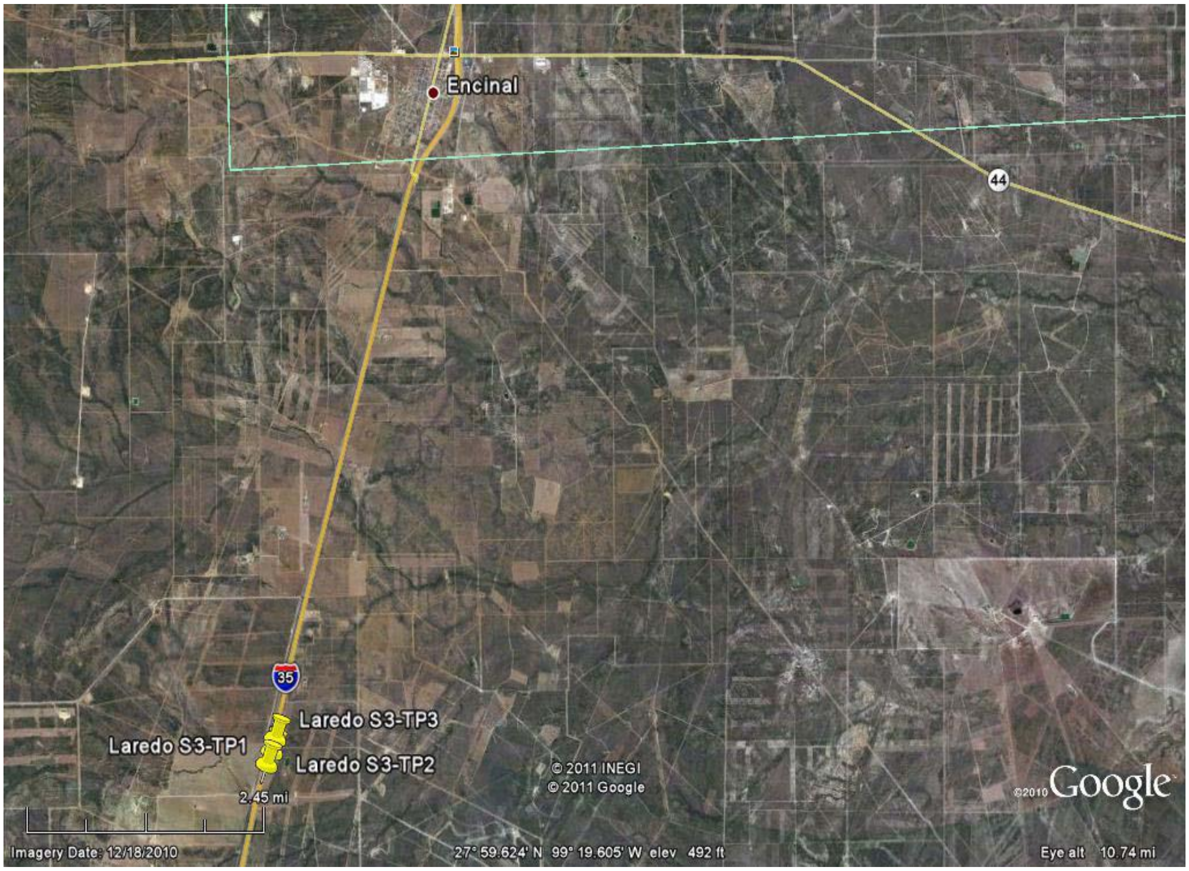
http://www.txdot.gov/travel/county_grid_search.htm

Aerial Photograph



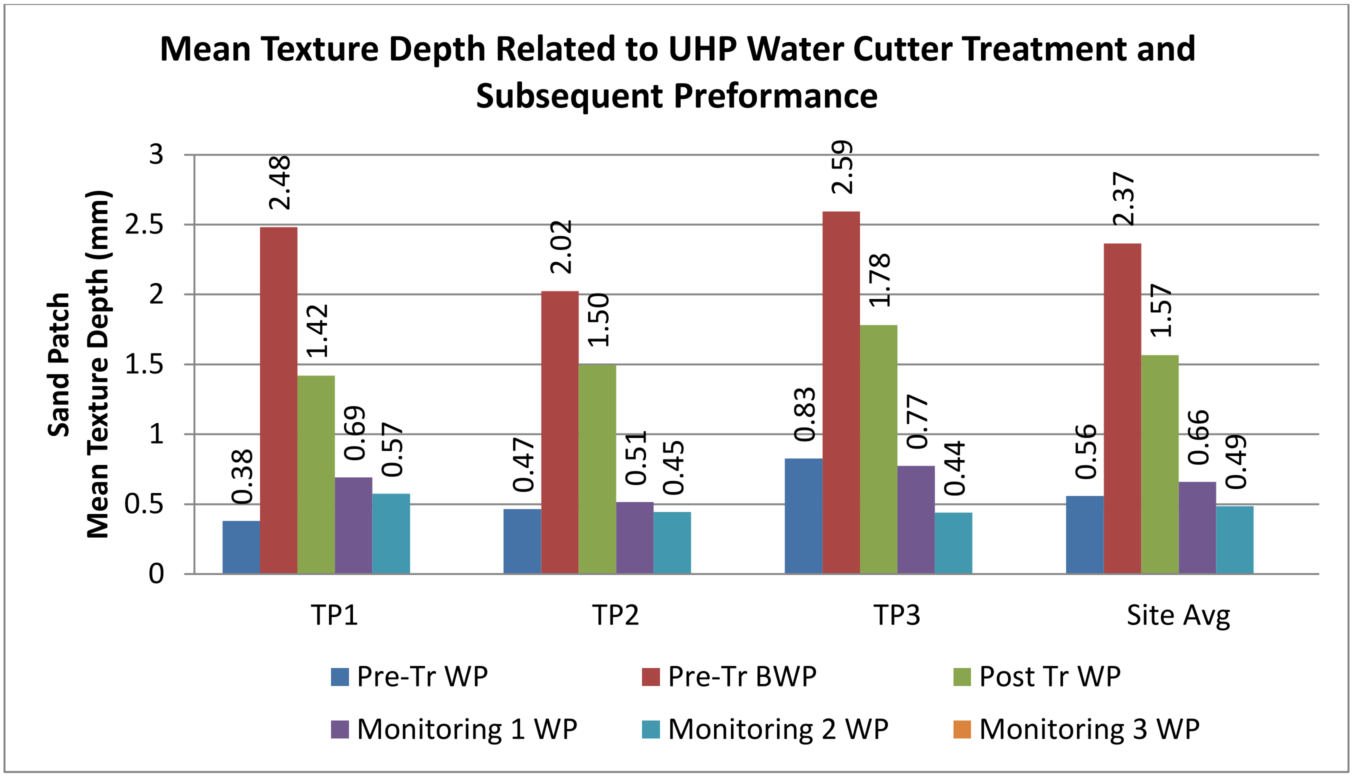
Google Inc. (2011). Google Earth (Version 6.1.0.5001)

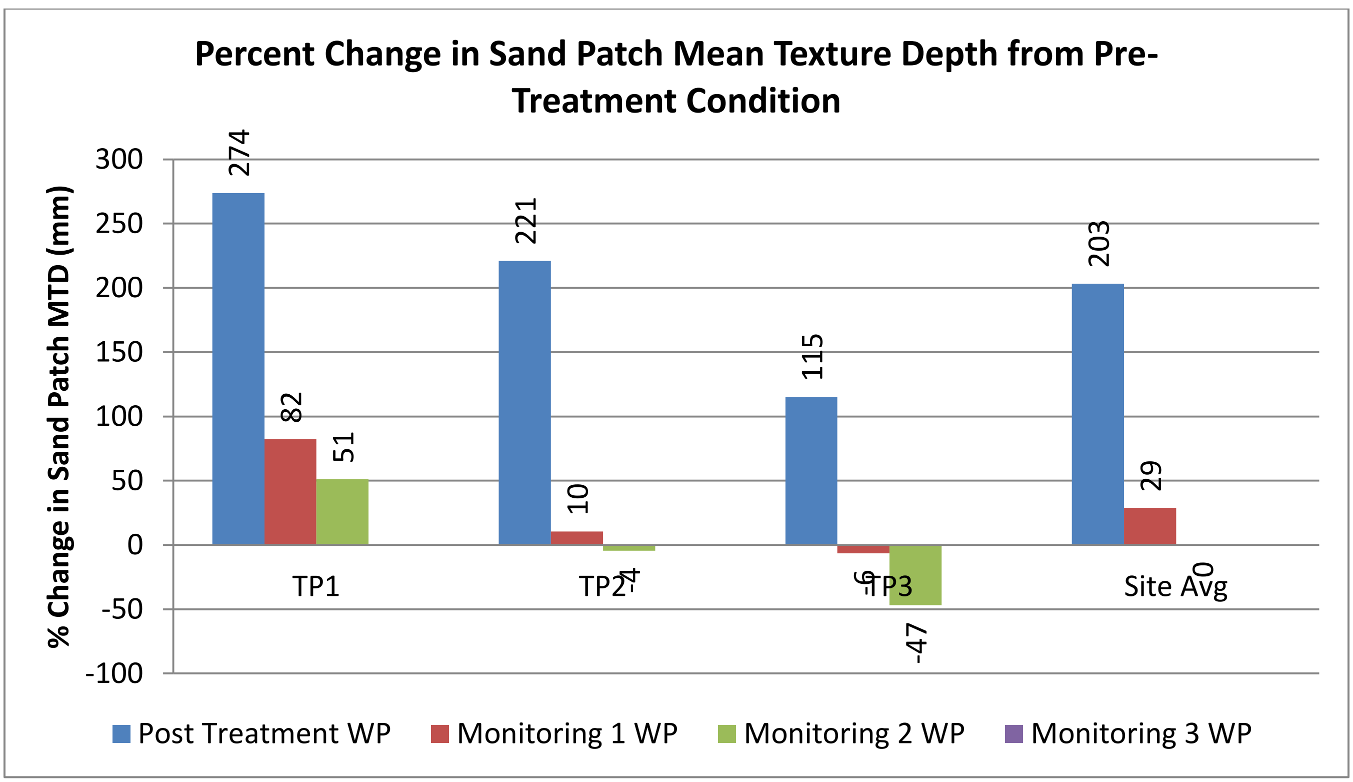
Test Point Plan



Google Inc. (2011). Google Earth (Version 6.1.0.5001)

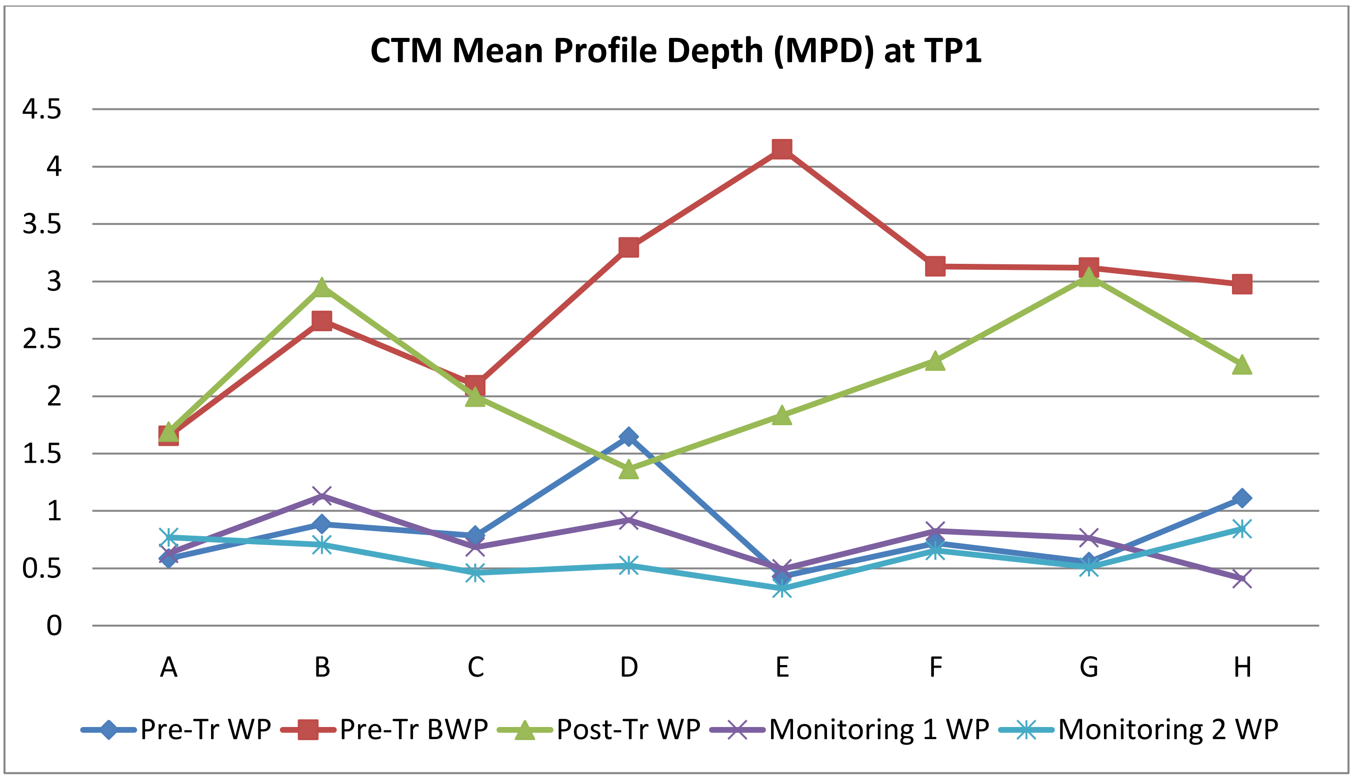
Sand Patch Data





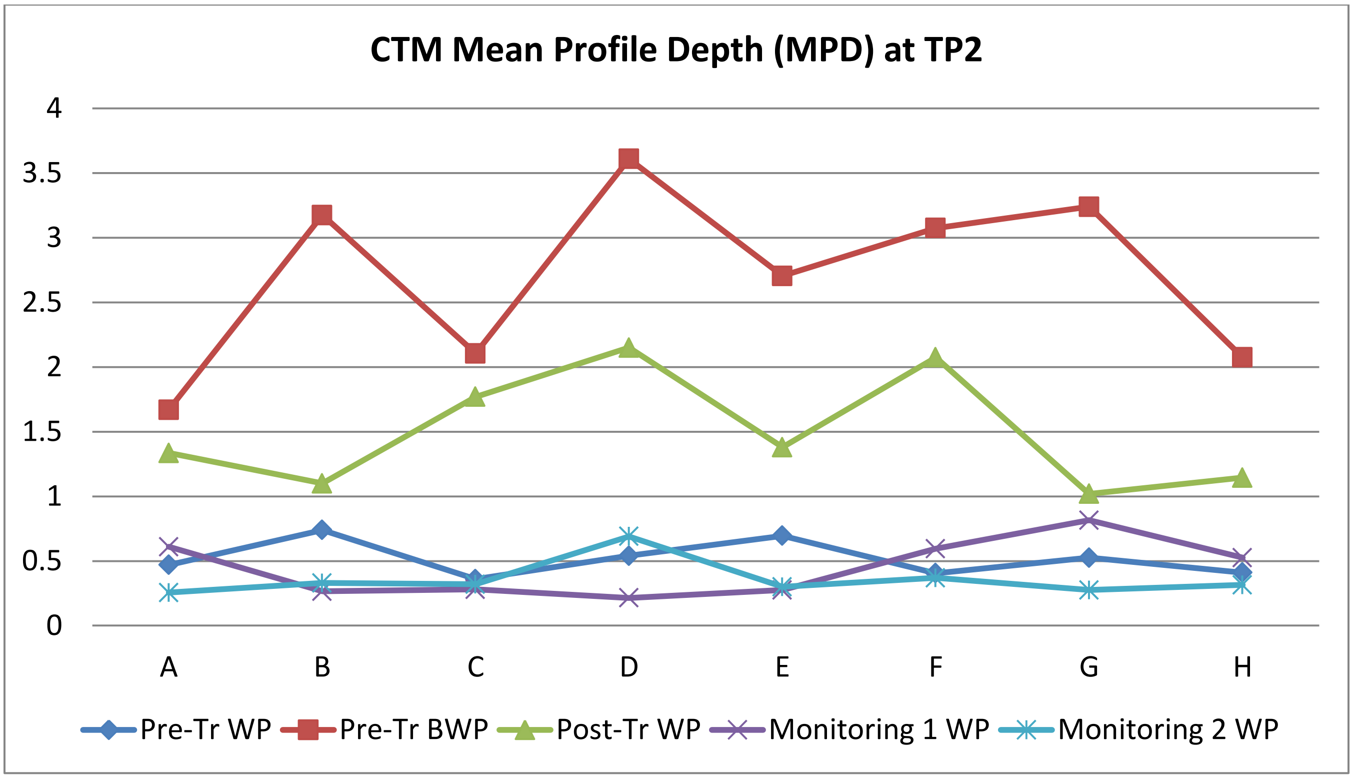
Circular Track Meter (CTM) Mean Profile Depth (in mm) at TP 1

	A	B	C	D	E	F	G	H
Pre-Tr WP	0.585	0.885	0.785	1.645	0.43	0.72	0.555	1.11
Pre-Tr BWP	1.655	2.655	2.095	3.295	4.15	3.13	3.12	2.975
Post-Tr	1.69	2.95	1.995	1.365	1.835	2.31	3.04	2.275
Monitoring 1	0.63	1.13	0.685	0.92	0.495	0.825	0.765	0.41
Monitoring 2	0.77	0.705	0.46	0.525	0.325	0.655	0.51	0.845
Monitoring 3	Not conducted due to maintenance/rehabilitation work on the section							



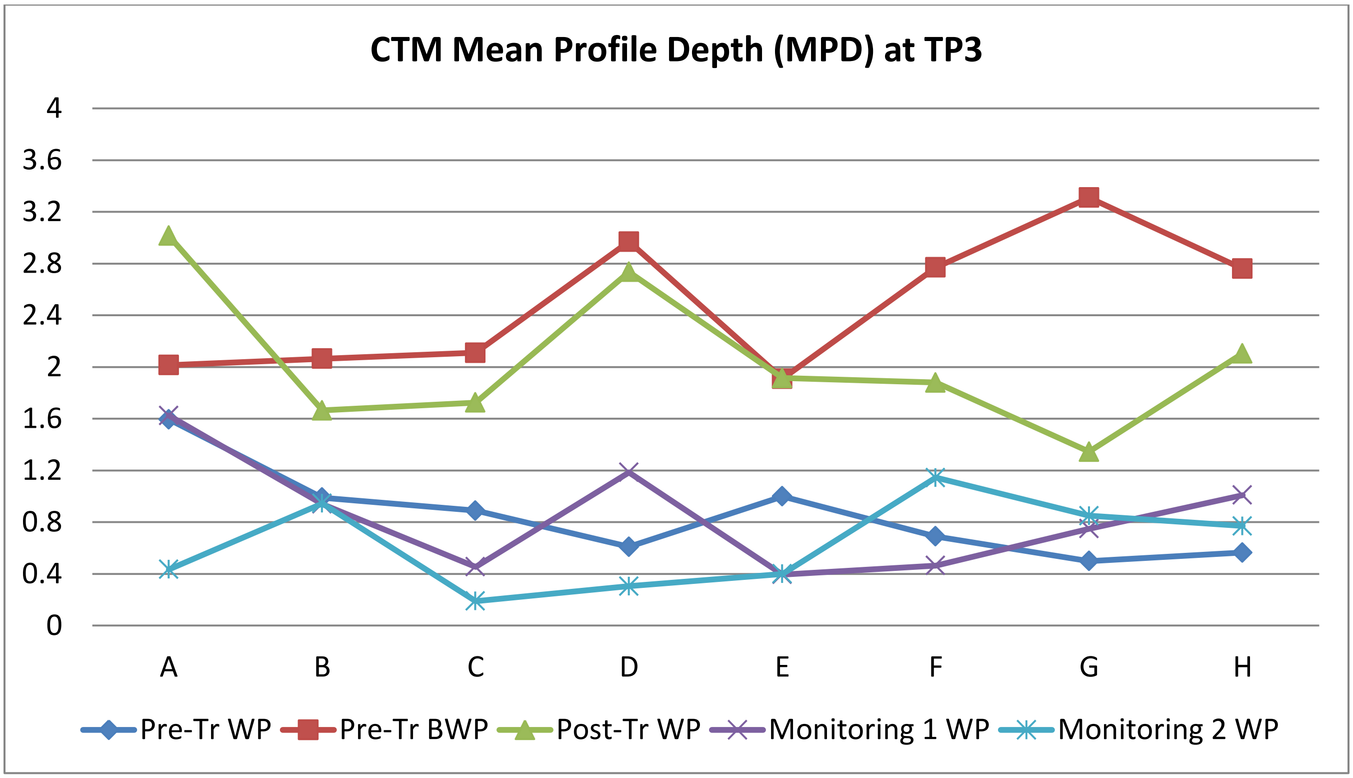
Circular Track Meter (CTM) Mean Profile Depth (in mm) at TP 2

	A	B	C	D	E	F	G	H
Pre-Tr WP	0.47	0.74	0.36	0.54	0.695	0.405	0.525	0.41
Pre-Tr BWP	1.67	3.175	2.105	3.61	2.705	3.075	3.24	2.075
Post-Tr	1.335	1.1	1.77	2.15	1.38	2.075	1.02	1.145
Monitoring 1	0.61	0.265	0.28	0.215	0.275	0.595	0.815	0.525
Monitoring 2	0.255	0.33	0.32	0.69	0.3	0.37	0.275	0.315
Monitoring 3	Not conducted due to maintenance/rehabilitation work on the section							

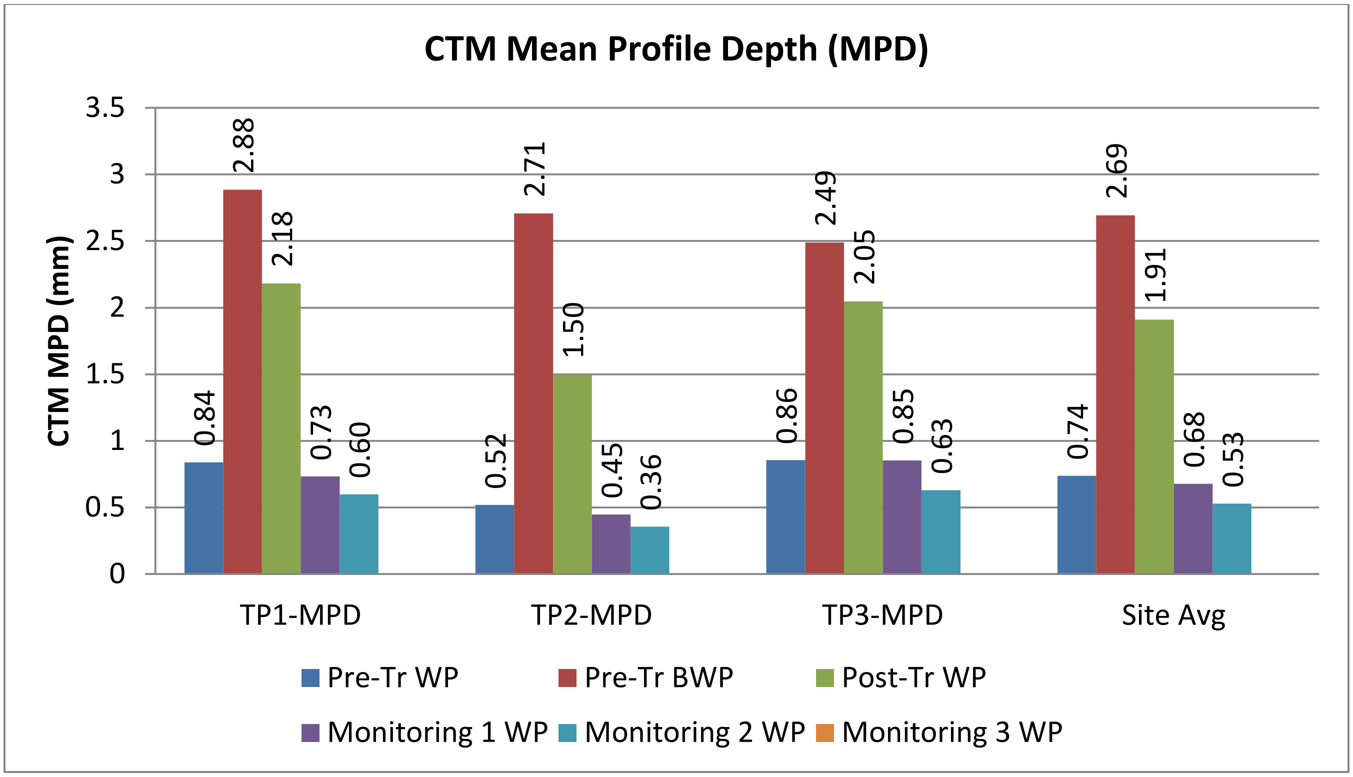


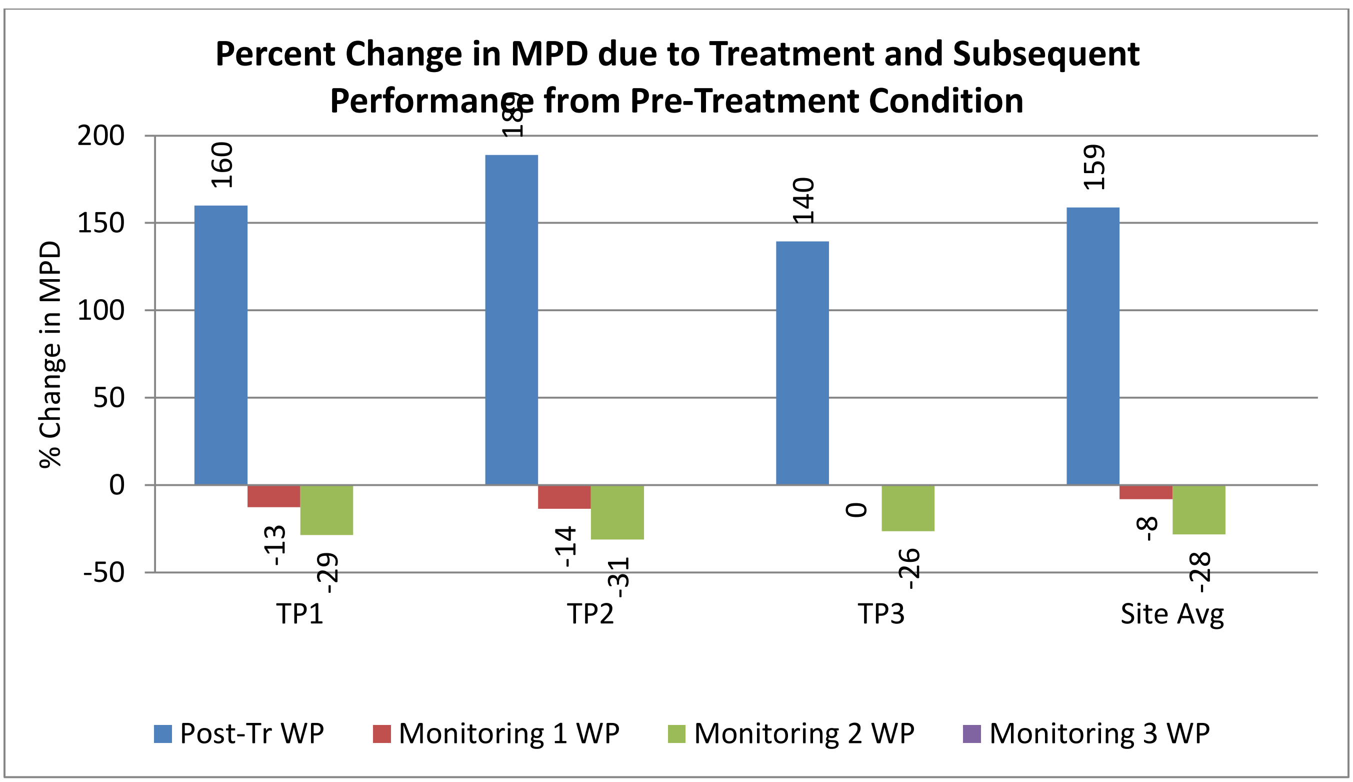
Circular Track Meter (CTM) Mean Profile Depth (in mm) at TP 3

	A	B	C	D	E	F	G	H
Pre-Tr WP	1.595	0.99	0.89	0.61	1	0.69	0.5	0.565
Pre-Tr BWP	2.015	2.065	2.11	2.97	1.91	2.77	3.31	2.76
Post-Tr	3.015	1.665	1.725	2.735	1.915	1.88	1.345	2.105
Monitoring 1	1.625	0.94	0.455	1.185	0.395	0.465	0.75	1.01
Monitoring 2	0.435	0.945	0.19	0.305	0.4	1.145	0.85	0.77
Monitoring 3	Not conducted due to maintenance/rehabilitation work on the section							

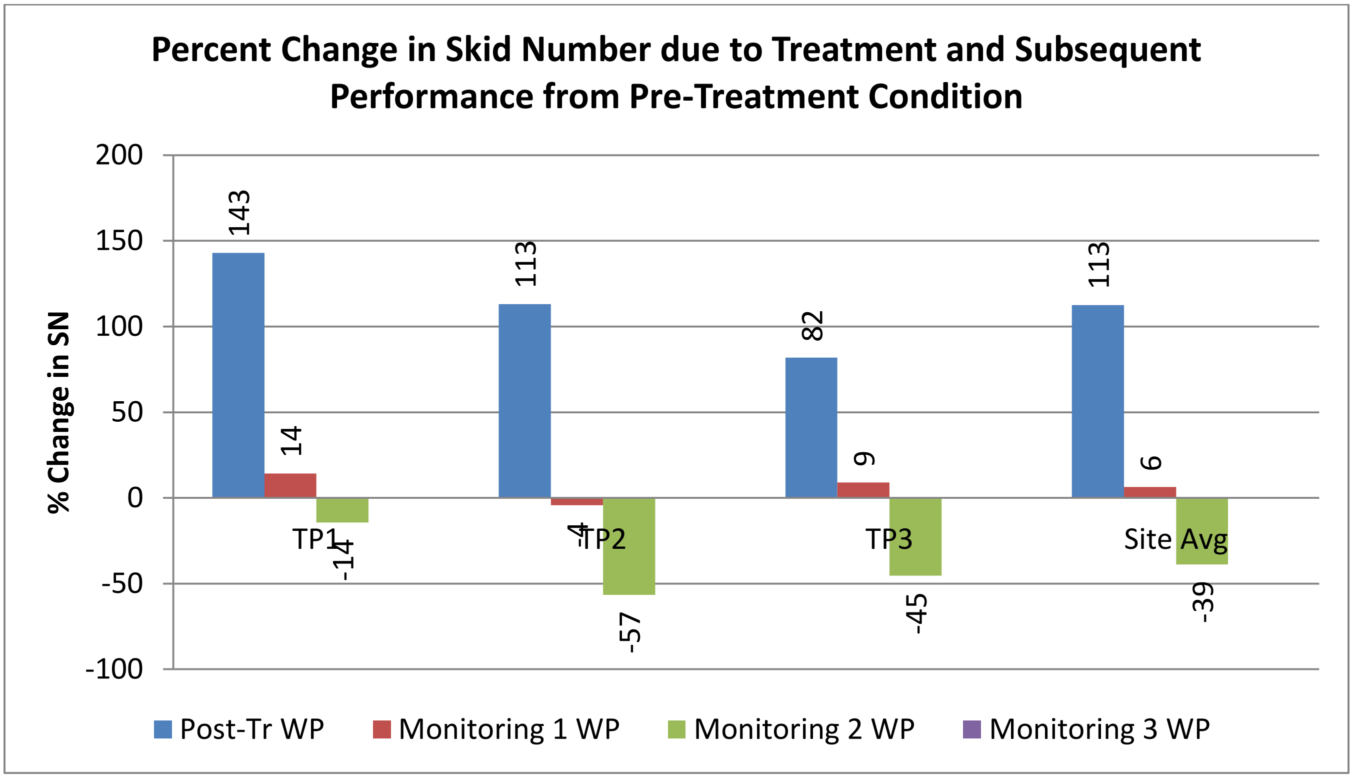


Circular Track Meter (CTM) MPD (mm)



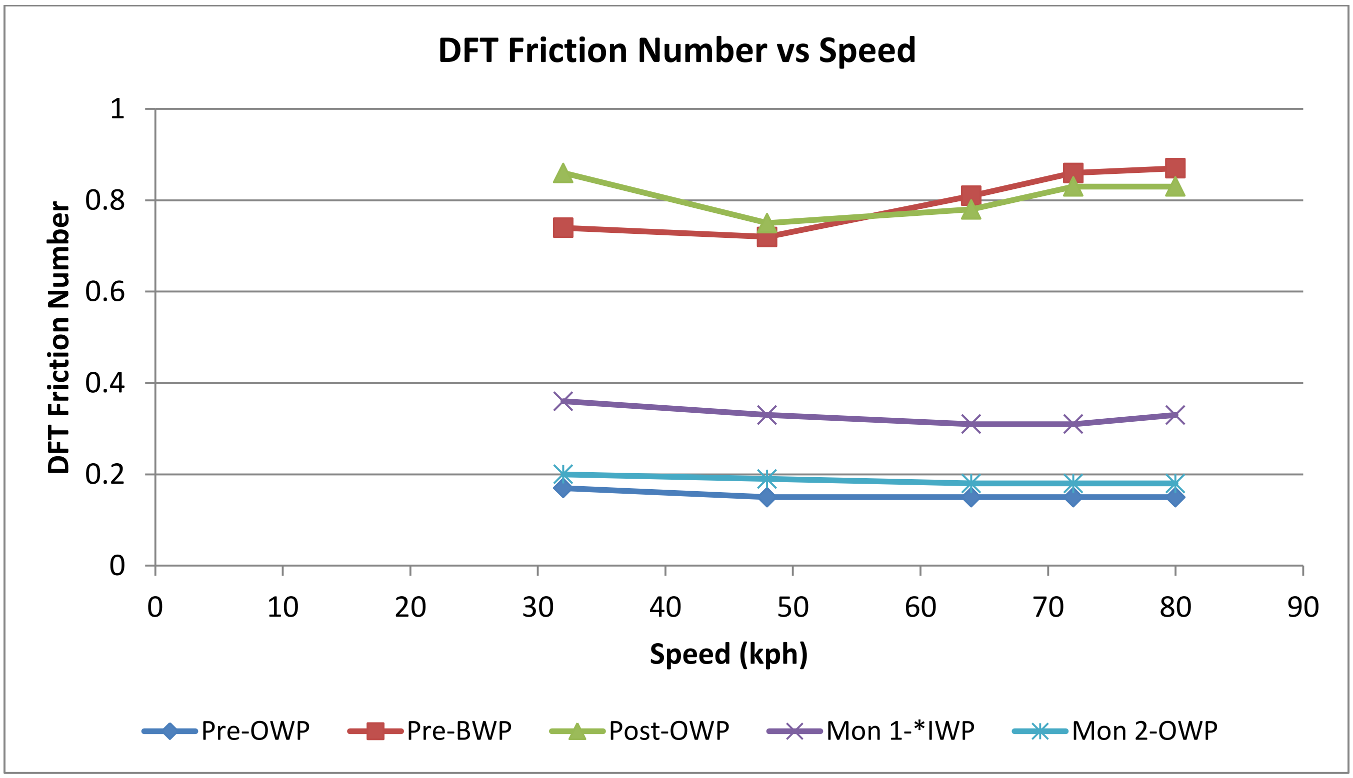


Skid Truck Data



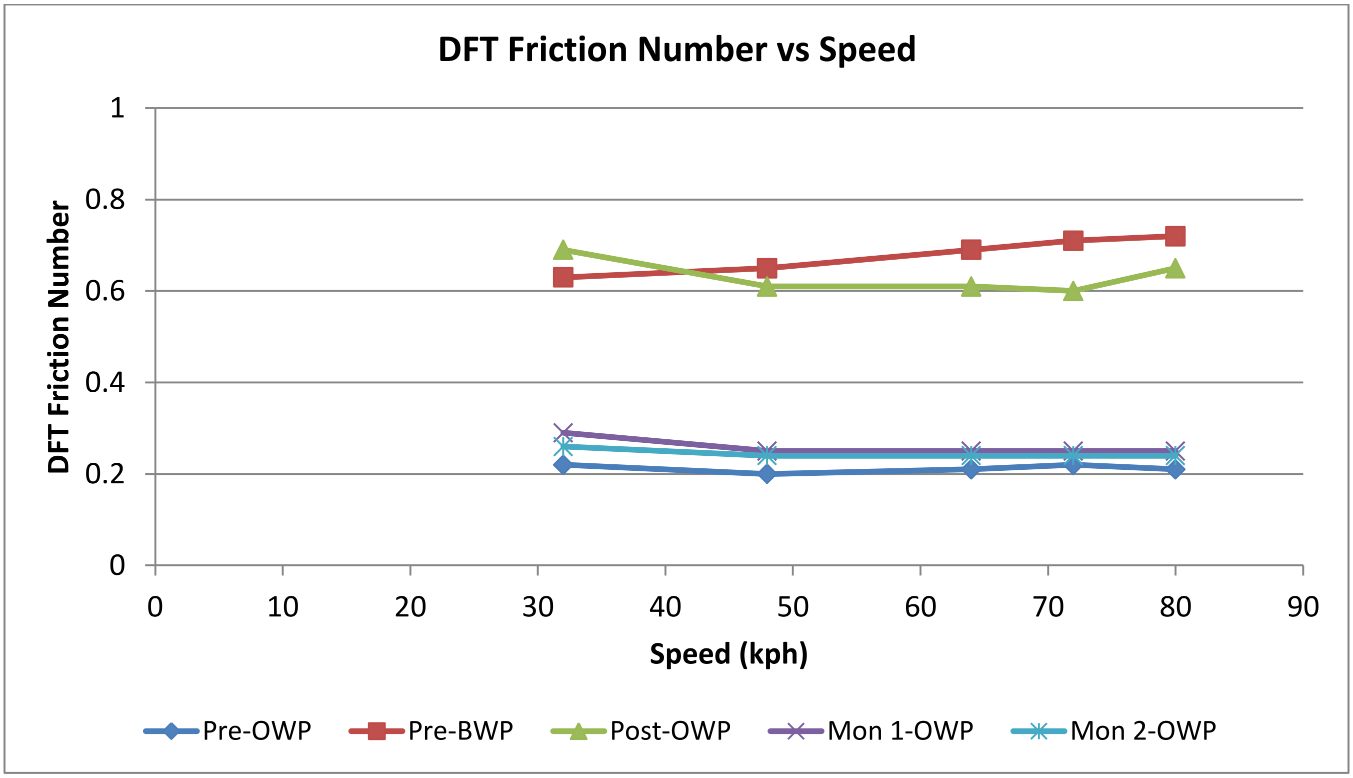
Dynamic Friction Test (DFT) Friction Number Data for TP 1

Speed (kph)	Pre-OWP	Pre-BWP	Post-OWP	Mon 1-*IWP	Mon 2-OWP	Mon 3-OWP
32	0.17	0.74	0.86	0.36	0.2	Not conducted due to maintenance/rehabilitation work on the section
48	0.15	0.72	0.75	0.33	0.19	
64	0.15	0.81	0.78	0.31	0.18	
72	0.15	0.86	0.83	0.31	0.18	
80	0.15	0.87	0.83	0.33	0.18	



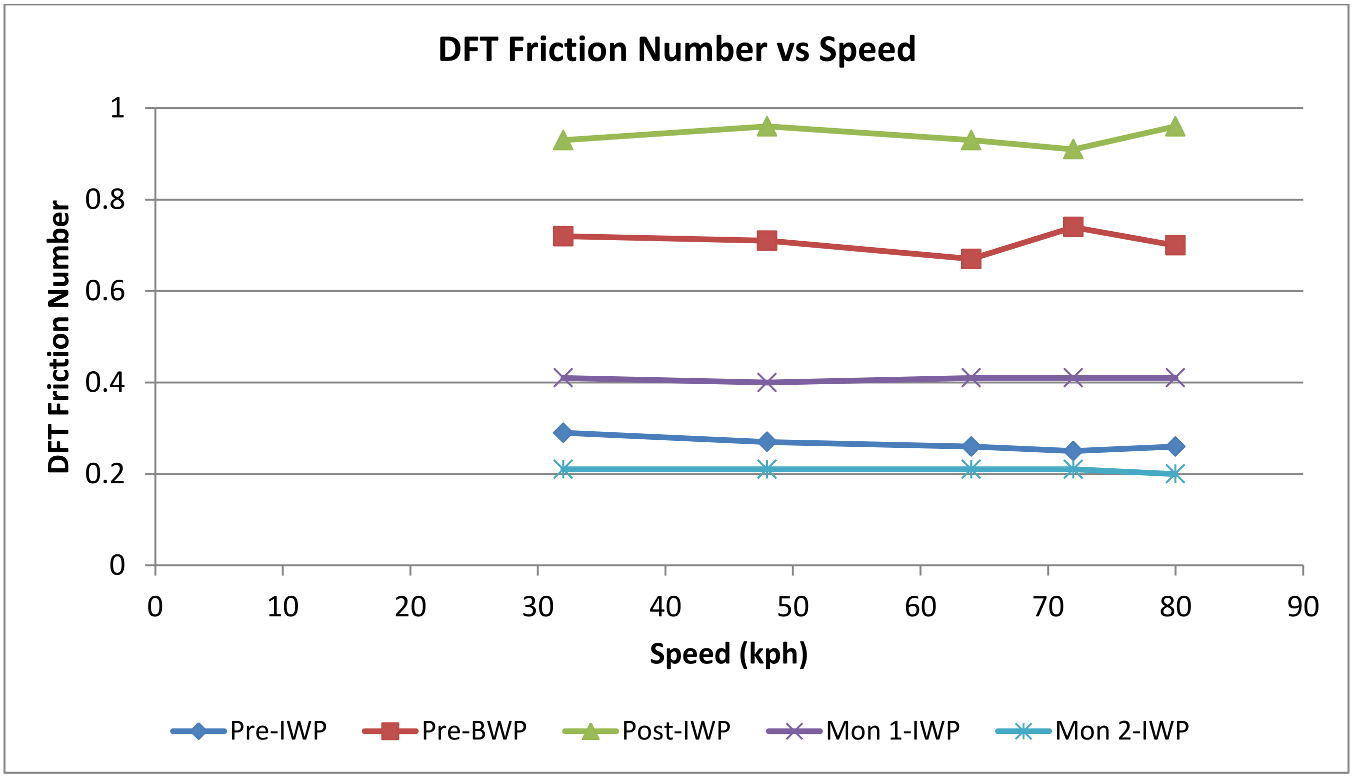
Dynamic Friction Test (DFT) Friction Number Data for TP 2

Speed (kph)	Pre-OWP	Pre-BWP	Post-OWP	Mon 1-OWP	Mon 2-OWP	Mon 3-OWP
32	0.22	0.63	0.69	0.29	0.26	Not conducted due to maintenance/rehabilitation work on the section
48	0.2	0.65	0.61	0.25	0.24	
64	0.21	0.69	0.61	0.25	0.24	
72	0.22	0.71	0.6	0.25	0.24	
80	0.21	0.72	0.65	0.25	0.24	



Dynamic Friction Test (DFT) Friction Number Data for TP 3

Speed (kph)	Pre-IWP	Pre-BWP	Post-IWP	Mon 1-IWP	Mon 2-IWP	Mon 3-IWP
32	0.29	0.72	0.93	0.41	0.21	Not conducted due to maintenance/rehabilitation work on the section
48	0.27	0.71	0.96	0.4	0.21	
64	0.26	0.67	0.93	0.41	0.21	
72	0.25	0.74	0.91	0.41	0.21	
80	0.26	0.7	0.96	0.41	0.2	

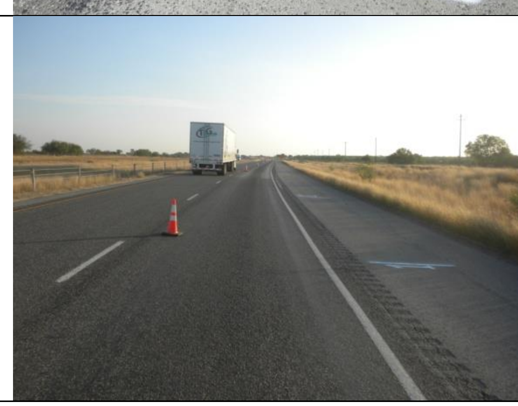


Weather Data during UHP Water Cutter Treatment

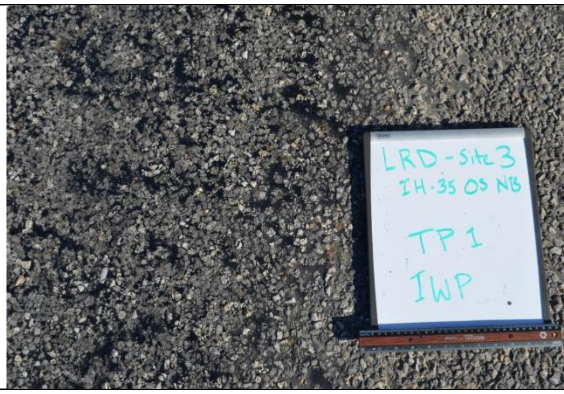
Date	Time	Temp Out	Hi Temp	Low Temp	Out Hum	Dew Pt.	Wind Speed	Wind Dir	Wind Run	Hi Speed	Hi Dir	Wind Chill	Heat Index	THW Index
2/14/2011	8:40 AM	55.7	61.4	55.7	76	48.2	0	E	0	5	E	55.7	55.2	55.2
2/14/2011	8:50 AM	52.7	55.5	52.6	87	48.9	1	N	0.17	4	N	52.7	52.7	52.7
2/14/2011	9:00 AM	54.2	54.2	52.8	87	50.4	0	N	0	2	NNE	54.2	54.2	54.2
2/14/2011	9:10 AM	56.4	56.4	54.2	85	51.9	1	E	0.17	4	SSW	56.4	56.3	56.3
2/14/2011	9:20 AM	58.9	58.9	56.4	81	53.1	4	SSE	0.67	9	SSE	58.9	58.7	58.7
2/14/2011	9:30 AM	59.8	59.8	58.9	78	52.9	5	SE	0.83	9	SSE	59.8	59.6	59.6
2/14/2011	9:40 AM	60.8	60.8	59.8	77	53.5	4	S	0.67	8	SSE	60.8	60.6	60.6
2/14/2011	9:50 AM	62.2	62.2	60.8	75	54.2	4	SSE	0.67	8	SE	62.2	62	62
2/14/2011	10:00 AM	63.6	63.8	62.3	71	54	3	S	0.5	6	SE	63.6	63.4	63.4
2/14/2011	10:10 AM	64.4	64.4	63.5	70	54.4	3	SSE	0.5	8	SSE	64.4	64.3	64.3
2/14/2011	10:20 AM	65.6	65.8	64.4	66	53.9	4	SSE	0.67	9	SSW	65.6	65.4	65.4
2/14/2011	10:30 AM	67.1	67.1	65.5	64	54.5	4	SE	0.67	8	ESE	67.1	67	67
2/14/2011	10:40 AM	67.9	68.1	67.1	62	54.4	3	SSW	0.5	7	SSW	67.9	67.8	67.8
2/14/2011	10:50 AM	69.3	69.3	68	61	55.3	4	S	0.67	8	S	69.3	68.7	68.7
2/14/2011	11:00 AM	70.3	70.3	69.4	58	54.8	4	SSE	0.67	8	SSW	70.3	69.4	69.4
2/14/2011	11:10 AM	71.4	71.4	70.2	56	54.9	5	S	0.83	9	S	71.4	70.7	70.7
2/14/2011	11:20 AM	71.3	71.7	71.3	55	54.3	5	S	0.83	12	S	71.3	70.5	70.5
2/14/2011	11:30 AM	73.6	73.6	71.1	53	55.4	3	SSE	0.5	8	SSW	73.6	73.5	73.5
2/14/2011	11:40 AM	74.2	74.2	73.7	50	54.4	4	S	0.67	8	SSE	74.2	74	74
2/14/2011	11:50 AM	75	75.1	74.1	49	54.5	5	S	0.83	12	SE	75	75	75
2/14/2011	12:00 PM	75.7	75.7	74.9	48	54.6	5	SSE	0.83	9	SE	75.7	75.6	75.6
2/14/2011	12:10 PM	75.3	75.7	75.1	49	54.8	3	SE	0.5	8	SSE	75.3	75.3	75.3
2/14/2011	12:20 PM	76.8	76.8	75.4	46	54.5	4	S	0.67	11	S	76.8	76.4	76.4
2/14/2011	12:30 PM	78.1	78.2	76.9	44	54.4	5	S	0.83	10	SSW	78.1	77.6	77.6
2/14/2011	12:40 PM	77.9	78	77.4	44	54.2	4	SSE	0.67	9	SSW	77.9	77.4	77.4

2/14/2011	12:50 PM	78.2	78.5	77.9	43	53.9	4	SSE	0.67	11	ESE	78.2	77.6	77.6
2/14/2011	1:00 PM	78.7	78.7	78	43	54.3	3	ESE	0.5	9	SE	78.7	78.2	78.2
2/14/2011	1:10 PM	79.7	79.8	78.5	40	53.2	4	SSW	0.67	10	SSW	79.7	78.8	78.8
2/14/2011	1:20 PM	81.1	81.1	79.7	39	53.8	3	SSW	0.5	10	SW	81.1	80	80
2/14/2011	1:30 PM	81.1	81.5	81	38	53.1	5	SSW	0.83	10	SSW	81.1	79.9	79.9
2/14/2011	1:40 PM	81.1	82.2	81	38	53.1	2	SSE	0.33	11	SE	81.1	79.9	79.9
2/14/2011	1:50 PM	82	82	80	37	53.2	4	SSE	0.67	10	SE	82	80.9	80.9
2/14/2011	2:00 PM	81.8	82.4	81.8	36	52.2	2	SSE	0.33	7	SSE	81.8	80.6	80.6
2/14/2011	2:10 PM	81.9	82.7	81.8	34	50.8	5	SSE	0.83	10	SE	81.9	80.5	80.5
2/14/2011	2:20 PM	83.4	83.4	81.6	33	51.3	4	SE	0.67	11	ESE	83.4	82	82
2/14/2011	2:30 PM	83.2	83.6	83	33	51.1	5	SE	0.83	11	E	83.2	81.8	81.8
2/14/2011	2:40 PM	83.6	83.6	82.7	32	50.6	3	NE	0.5	10	NE	83.6	82.1	82.1
2/14/2011	2:50 PM	84.2	84.5	83.4	31	50.3	5	SSE	0.83	10	E	84.2	82.7	82.7
2/14/2011	3:00 PM	84	84.5	84	31	50.1	5	ESE	0.83	11	ESE	84	82.5	82.5
2/14/2011	3:10 PM	84.1	84.2	83.8	30	49.3	5	ESE	0.83	9	ESE	84.1	82.4	82.4
2/14/2011	3:20 PM	84.3	84.3	83.7	30	49.5	4	E	0.67	9	SE	84.3	82.6	82.6
2/14/2011	3:30 PM	84.5	84.5	84.2	28	47.8	5	S	0.83	12	S	84.5	82.4	82.4
2/14/2011	3:40 PM	84.1	84.7	84.1	30	49.3	4	ESE	0.67	11	ESE	84.1	82.4	82.4
2/14/2011	3:50 PM	84.8	84.9	83.7	28	48.1	3	SSE	0.5	9	SSE	84.8	82.7	82.7
2/14/2011	4:00 PM	84.7	85.3	84.7	26	46	4	ESE	0.67	8	SE	84.7	82.3	82.3
2/14/2011	4:10 PM	84.4	84.8	84.4	27	46.8	5	SSE	0.83	10	SE	84.4	82.2	82.2
2/14/2011	4:20 PM	85.4	85.4	84.1	29	49.5	2	S	0.33	8	S	85.4	83.5	83.5

Site Photographs

(a)			Figure XX. BMT3 Pictures (a) highway and location; (b) close-up of flushed surface before treatment; (c) roadway surface before treatment; (d) close-up of flushed surface immediately after treatment; (e) roadway surface after treatment; (f) close-up of surface at first follow-up ; (g) roadway surface at first follow-up , (h) roadway surface at second follow-up ; (i) close-up of surface at second follow-up.
(b)		(c)	
(d)		(e)	
(f)		(g)	

(h)



(i)

SITE AMA 1

Randall COUNTY

Amarillo DISTRICT

Site Description

Project Information			
District: Amarillo	Test Site: AMA 1	County: Randall	Road: FM 2590 SB
ADT: 3900	Truck Traffic: Low-Medium	Year Built:	Last Maintained: 2008
Roadway Description Aggregate Grade: Ty PB GR 4 Aggregate Type: Siliceous River Gravel Pit: J Lee Milligan, Boys Ranch AQMP#: 418008 CSJ: 2614-01-017 Binder: AC 20-5TR			

Research Test Summary		
Test Location: FM 2219 to FM 3331	Closest Texas Reference Marker: 114	
Test Point GPS Coordinates	N	W
TP1	35°02.112'	101°56.194'
TP2	35°02.003'	101°56.195'
TP3	35°01.897'	101°56.196

Ultra High Pressure Water Cutter Treatment Summary		
Date Treated 3/2/2011	Start Time 7:35 AM	End Time 12:40 PM

Summary Description of Treatment Activity

TechMRT: Bill Lawson Sanja Senadheera, Andrew Tubb and Timothy Wood
Rampart: Bob Beadling and Jim Windich
TxDOT: Mike Taylor and Ron Herr (Amarillo District), others from the Olham County Maintenance Office

Rampart configuration: Rampart used their typical 28 jet nozzle configuration running at 32ksi for the last three sections: a little over three eighths of a mile.

Work Activities: TechMRT and Rampart were at the maintenance office before 7:00AM. TechMRT participated in a very informal morning meeting and then headed to the site at 7:10AM while Rampart filled the truck.

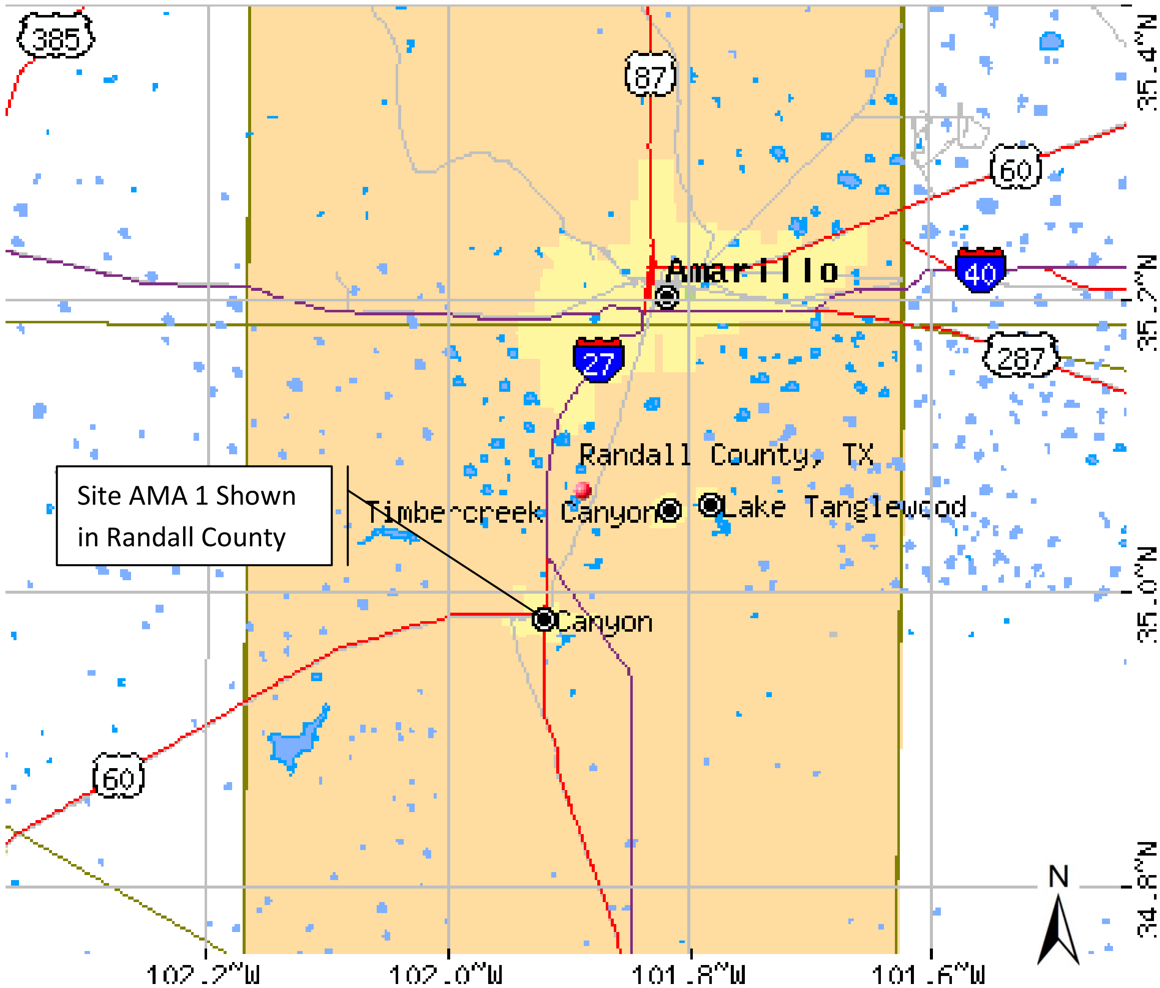
TechMRT arrived on site at 7:30AM. Art 7:40 AM TechMRT setup the weather station at TP1 and remarked all test points and the speed sections for the westbound lane. Traffic control was slow to set up. TechMRT performed all pretest from 8:50AM till 9:40AM.

Rampart was present at the site beginning at 8:30AM. At this point TechMART began to video tape the work activity. Rampart treated the center of the wheel paths with a single pass for the inside wheel path in speed zones 5 through 8 from 10:45AM to 11:00AM. Then TxDOT broomed the asphalt residue. Rampart then treated the inside wheel path on the inside quarter mile at 0.8mph. The outside wheel path in sections 2 through 4 was treated at approximately 1.4mph. This took from 11:00AM till 12:15PM. Rampart left the site at 12:20 PM to empty the truck for the first time that day.

TechMRT did pre-testing in the nozzle configuration speed zones 1 through 4. They then completed the regularly scheduled post testing from 10:10AM to 10:52PM.From 11:00PM to 11:10PM, packed weather station. TechMRT returned to Amarillo at 12:30PM.

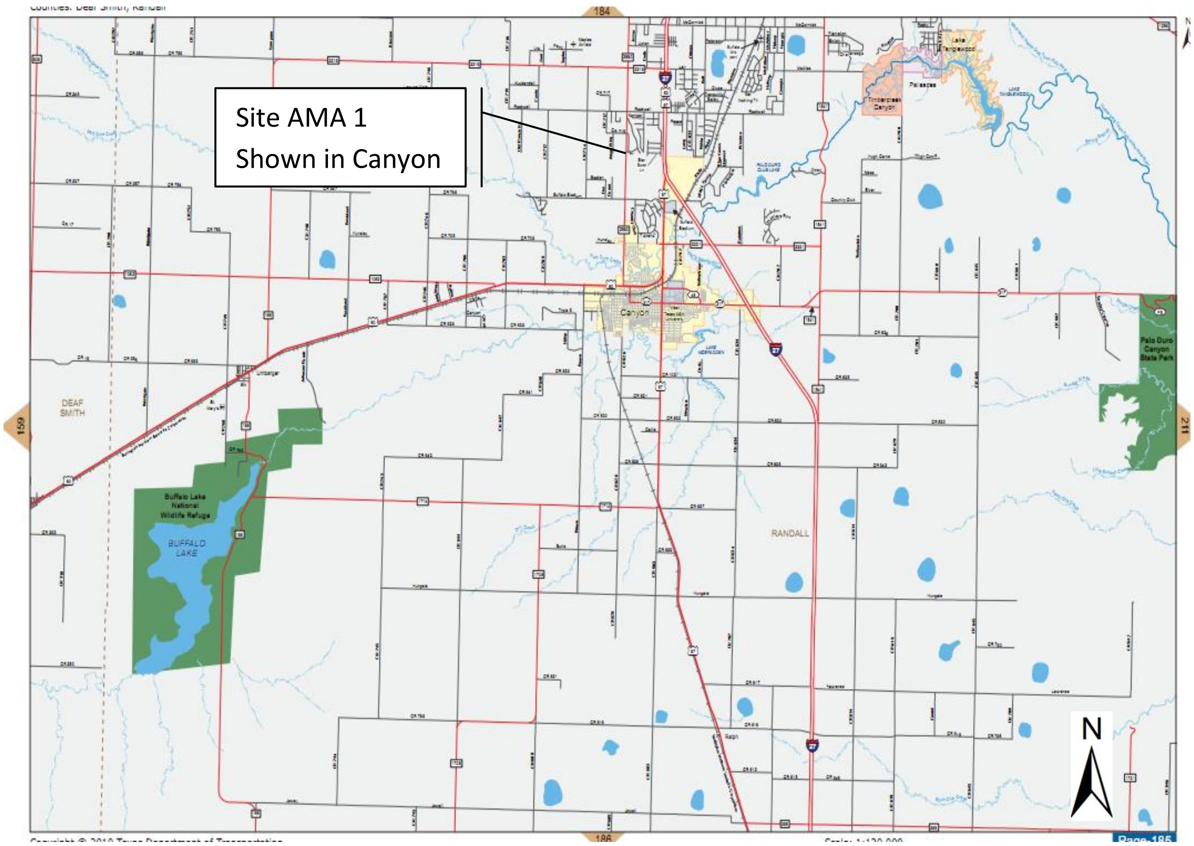
Comments	
Follow-On Testing Summary	
Date: 8/1/11	Comments: Preformed follow –up monitoring successfully.
Date: 1/17/12	Comments: Preformed follow –up monitoring successfully.
Date:7/17/12	Comments: Preformed follow –up monitoring successfully.

Site Vicinity Map



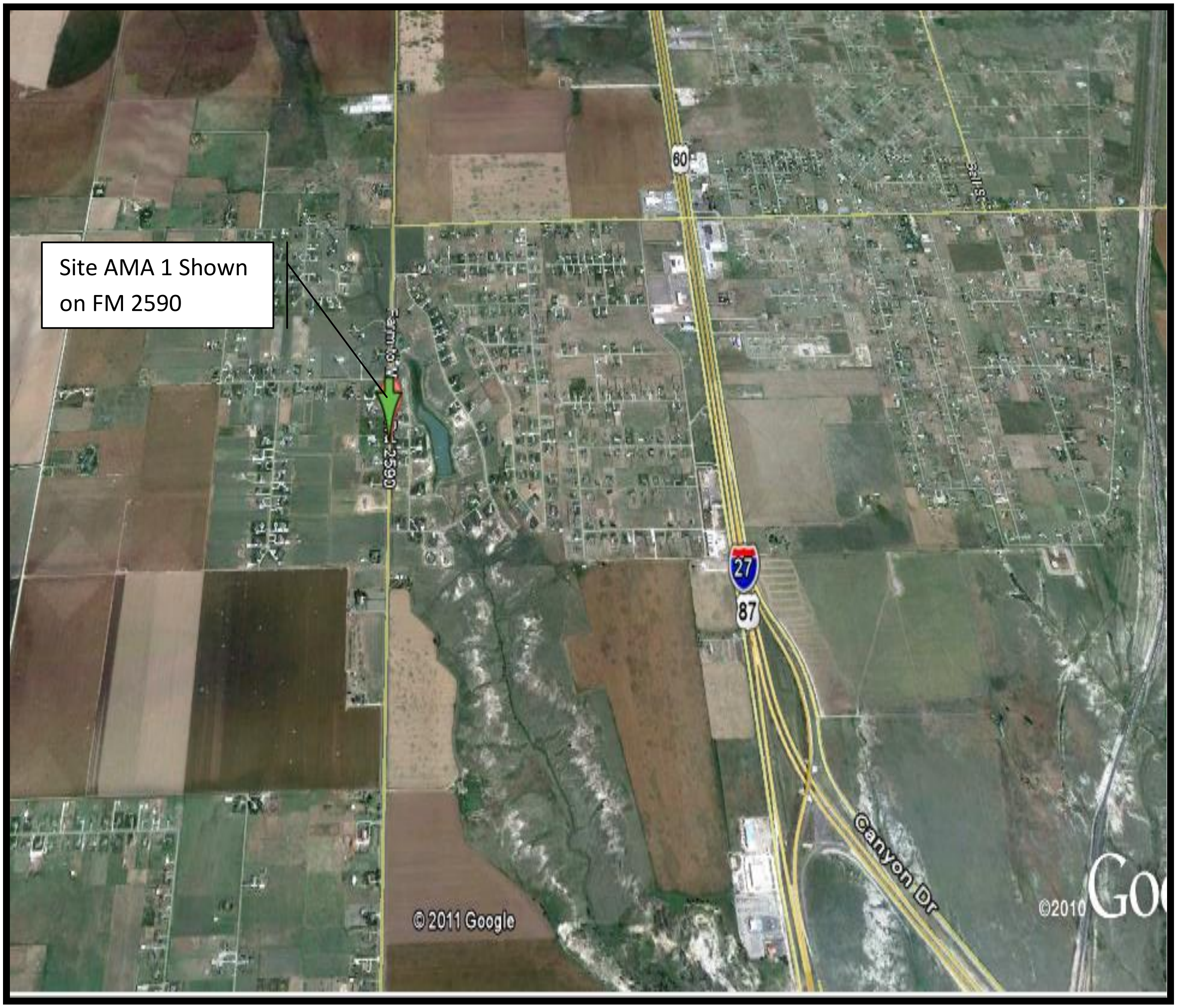
http://www.city-data.com/

Site Location Map



http://www.txdot.gov/travel/county_grid_search.htm

Aerial Photograph

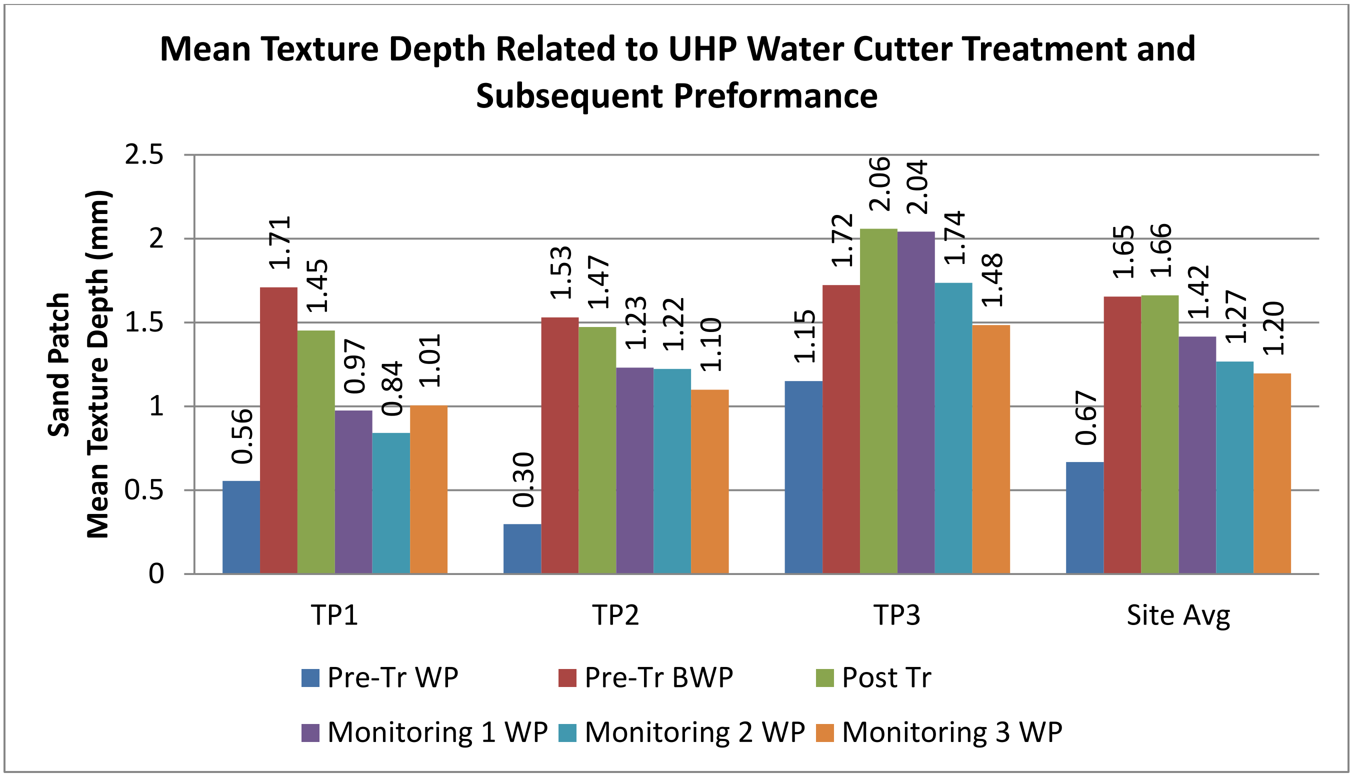


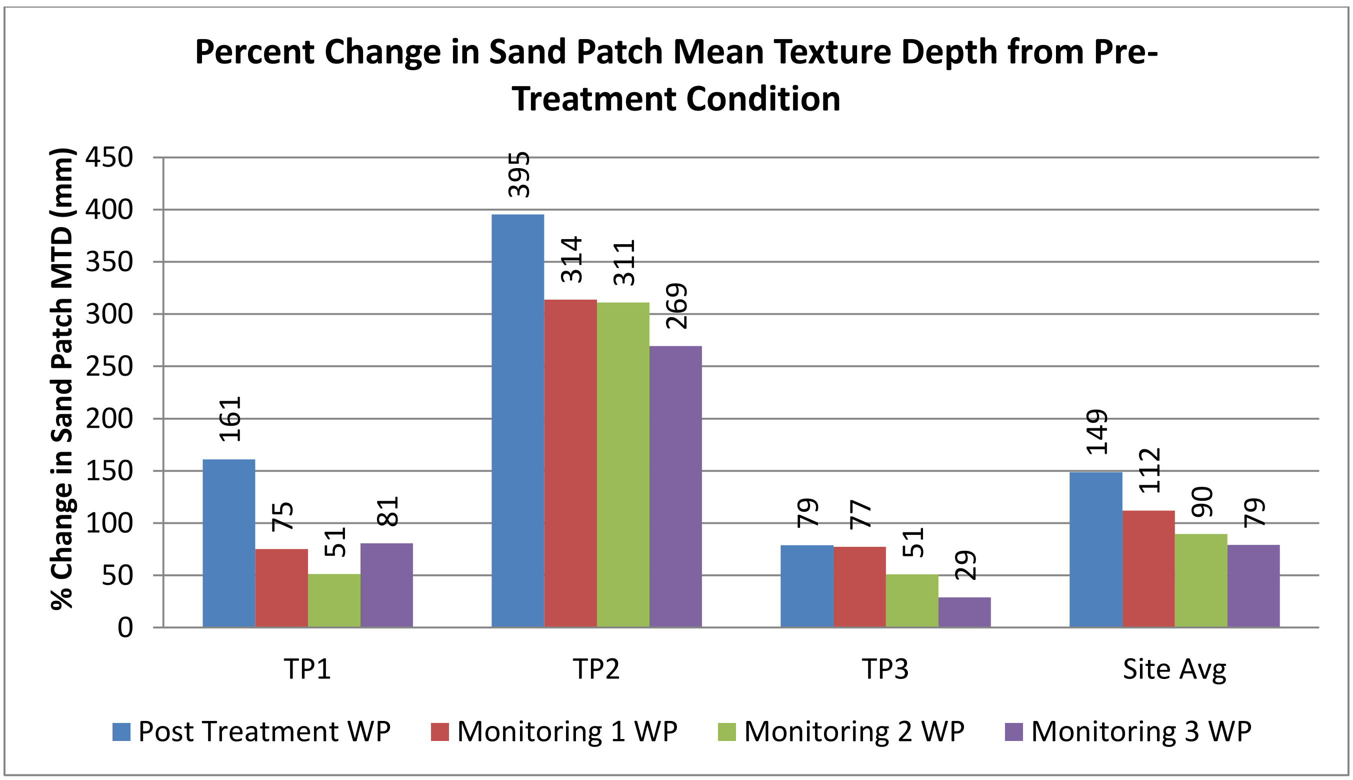
Google Inc. (2011). Google Earth (Version 6.1.0.5001)

Test Point Plan

Google Inc. (2011). Google Earth (Version 6.1.0.5001)

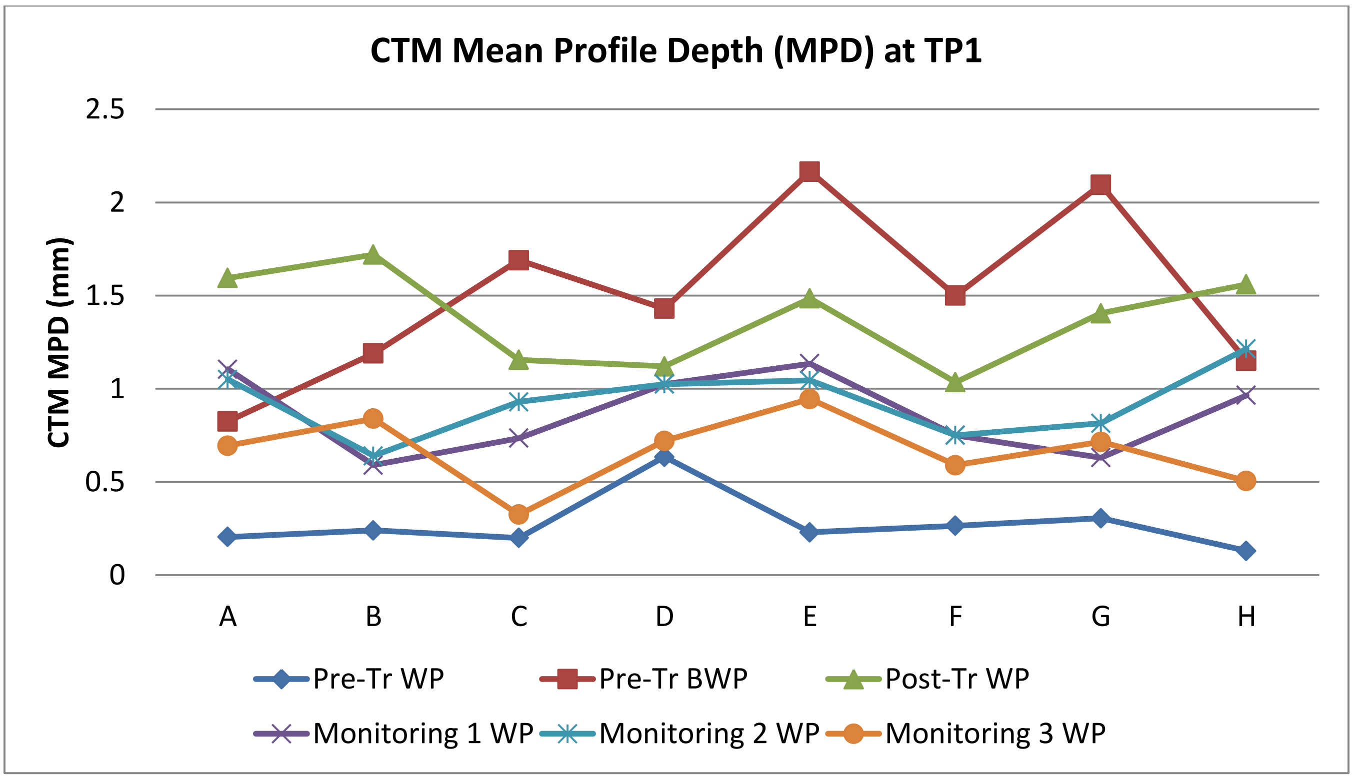
Sand Patch Data





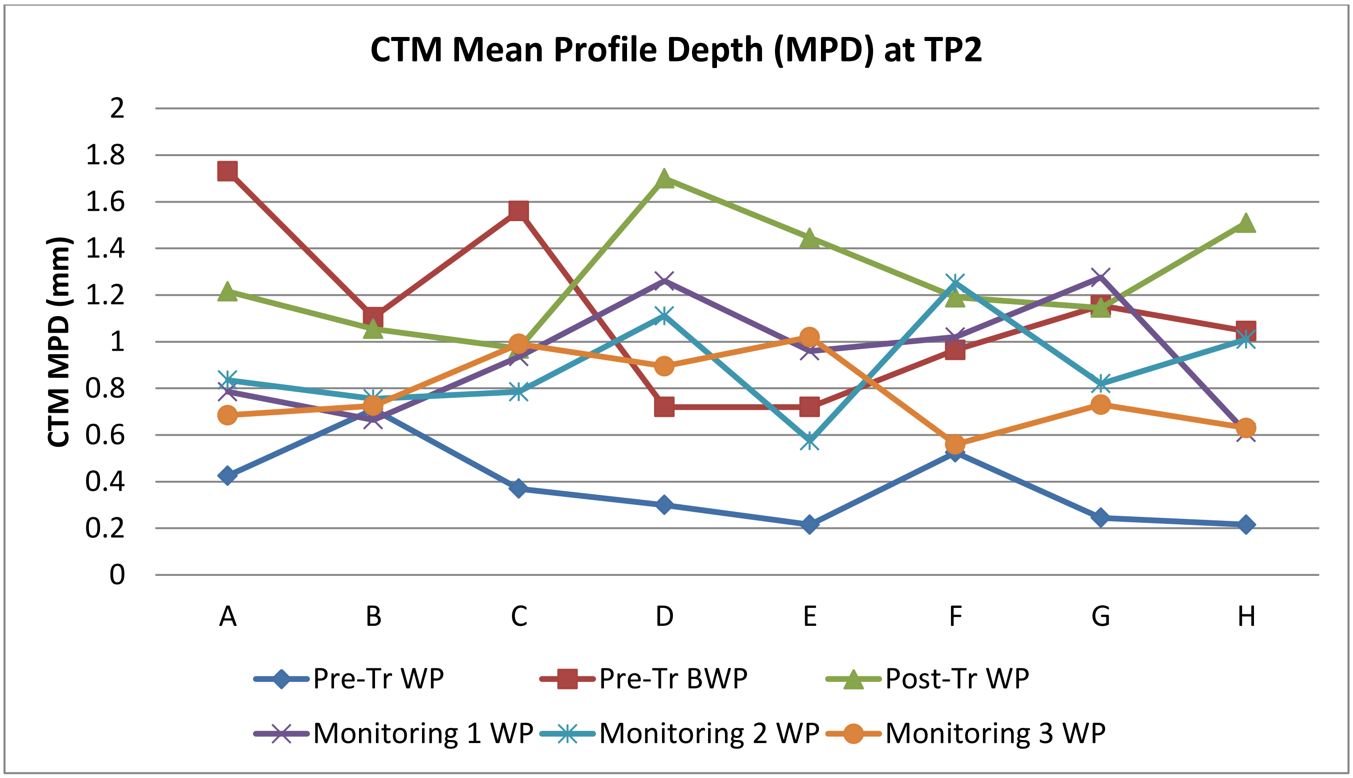
Circular Track Meter (CTM) Mean Profile Depth (in mm) at TP 1

	A	B	C	D	E	F	G	H
Pre-Tr WP	0.205	0.24	0.2	0.635	0.23	0.265	0.305	0.13
Pre-Tr BWP	0.825	1.19	1.69	1.43	2.165	1.5	2.095	1.15
Post-Tr	1.595	1.72	1.155	1.12	1.485	1.035	1.405	1.56
Monitoring 1	1.105	0.59	0.735	1.025	1.135	0.75	0.63	0.965
Monitoring 2	1.05	0.64	0.93	1.025	1.045	0.75	0.815	1.215
Monitoring 3	0.695	0.84	0.325	0.72	0.945	0.59	0.715	0.505



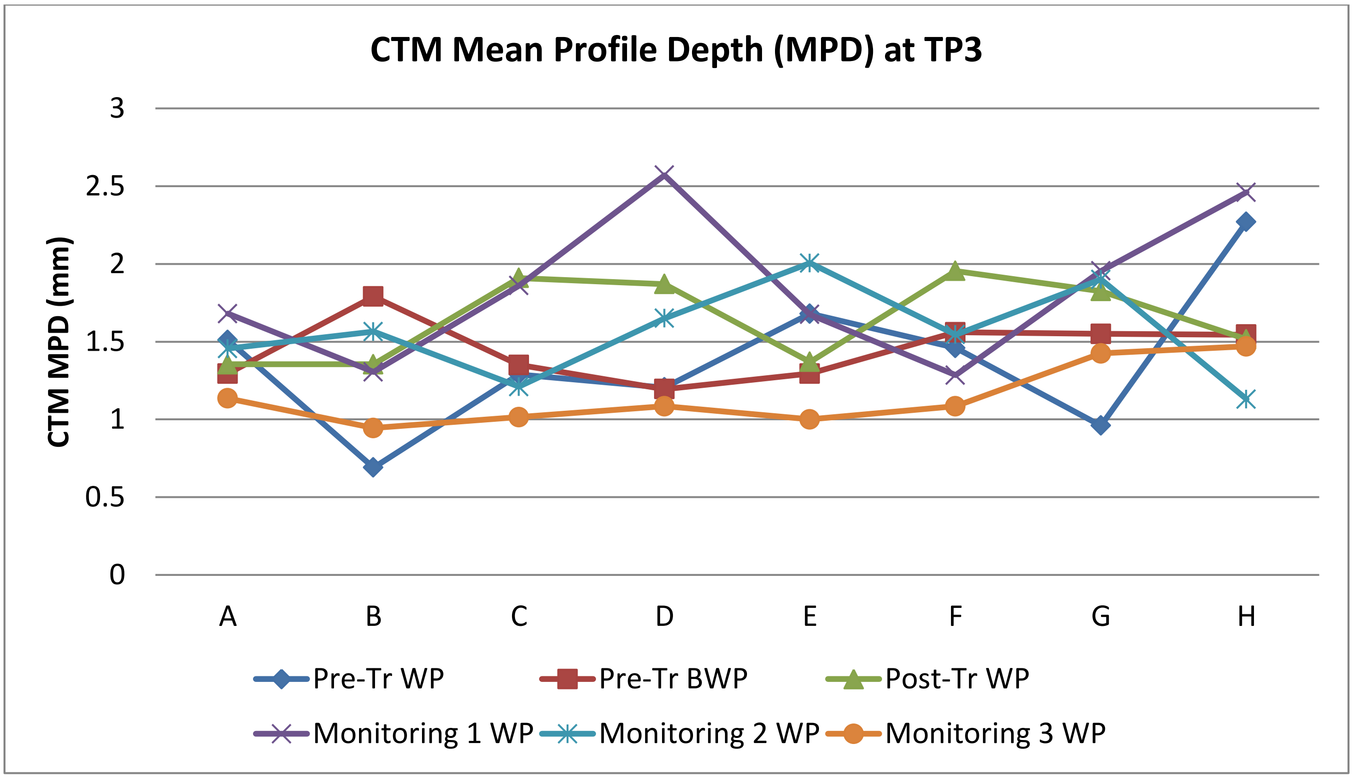
Circular Track Meter (CTM) Mean Profile Depth (in mm) at TP 2

	A	B	C	D	E	F	G	H
Pre-Tr WP	0.425	0.71	0.37	0.3	0.215	0.525	0.245	0.215
Pre-Tr BWP	1.73	1.105	1.56	0.72	0.72	0.965	1.155	1.045
Post-Tr	1.215	1.055	0.97	1.7	1.445	1.19	1.145	1.51
Monitoring 1	0.785	0.665	0.935	1.26	0.96	1.02	1.275	0.61
Monitoring 2	0.835	0.755	0.785	1.11	0.575	1.25	0.82	1.01
Monitoring 3	0.685	0.725	0.99	0.895	1.02	0.56	0.73	0.63

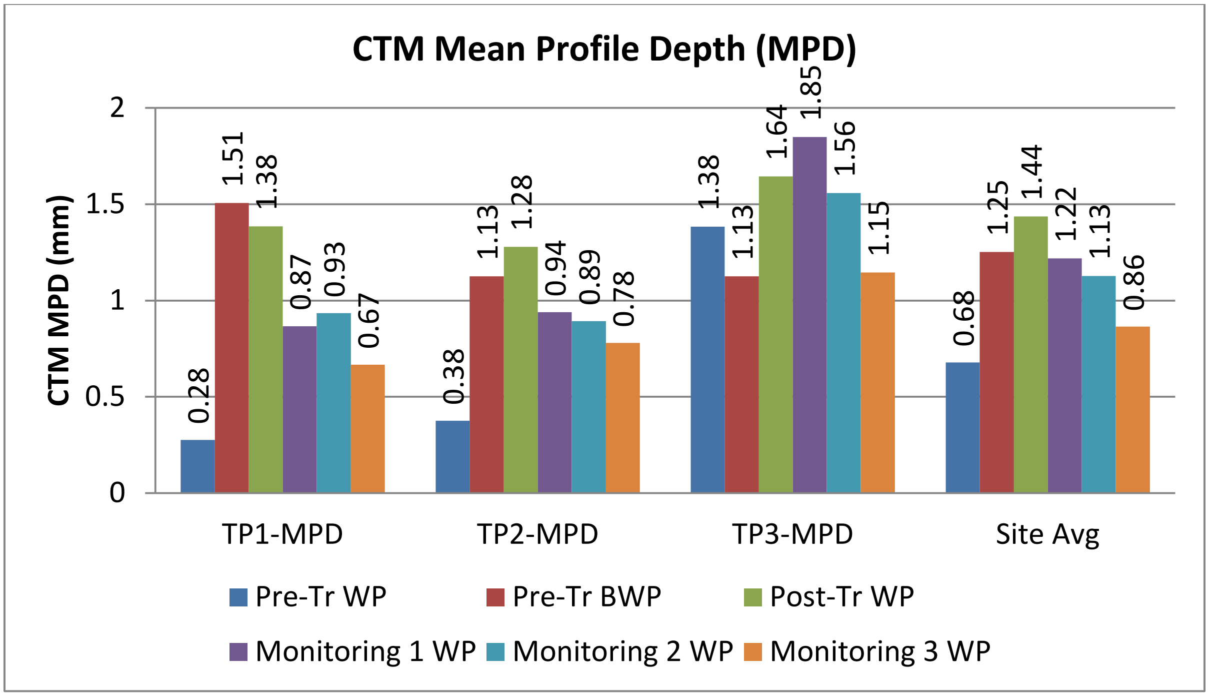


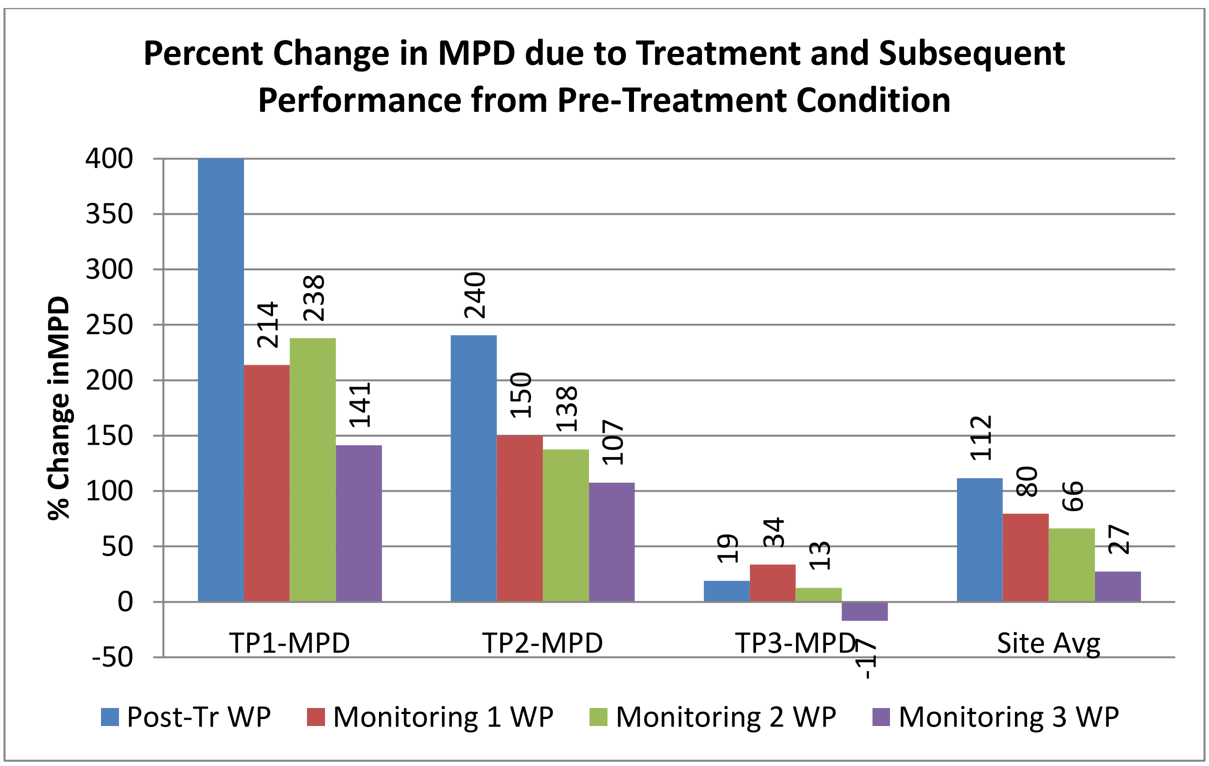
Circular Track Meter (CTM) Mean Profile Depth (in mm) at TP 3

	A	B	C	D	E	F	G	H
Pre-Tr WP	1.51	0.69	1.29	1.205	1.68	1.46	0.96	2.27
Pre-Tr BWP	1.295	1.79	1.35	1.195	1.295	1.56	1.55	1.545
Post-Tr	1.355	1.355	1.91	1.87	1.37	1.955	1.825	1.515
Monitoring 1	1.68	1.305	1.86	2.57	1.675	1.285	1.955	2.46
Monitoring 2	1.455	1.565	1.21	1.65	2.005	1.545	1.9	1.13
Monitoring 3	1.135	0.945	1.015	1.085	1	1.085	1.425	1.47

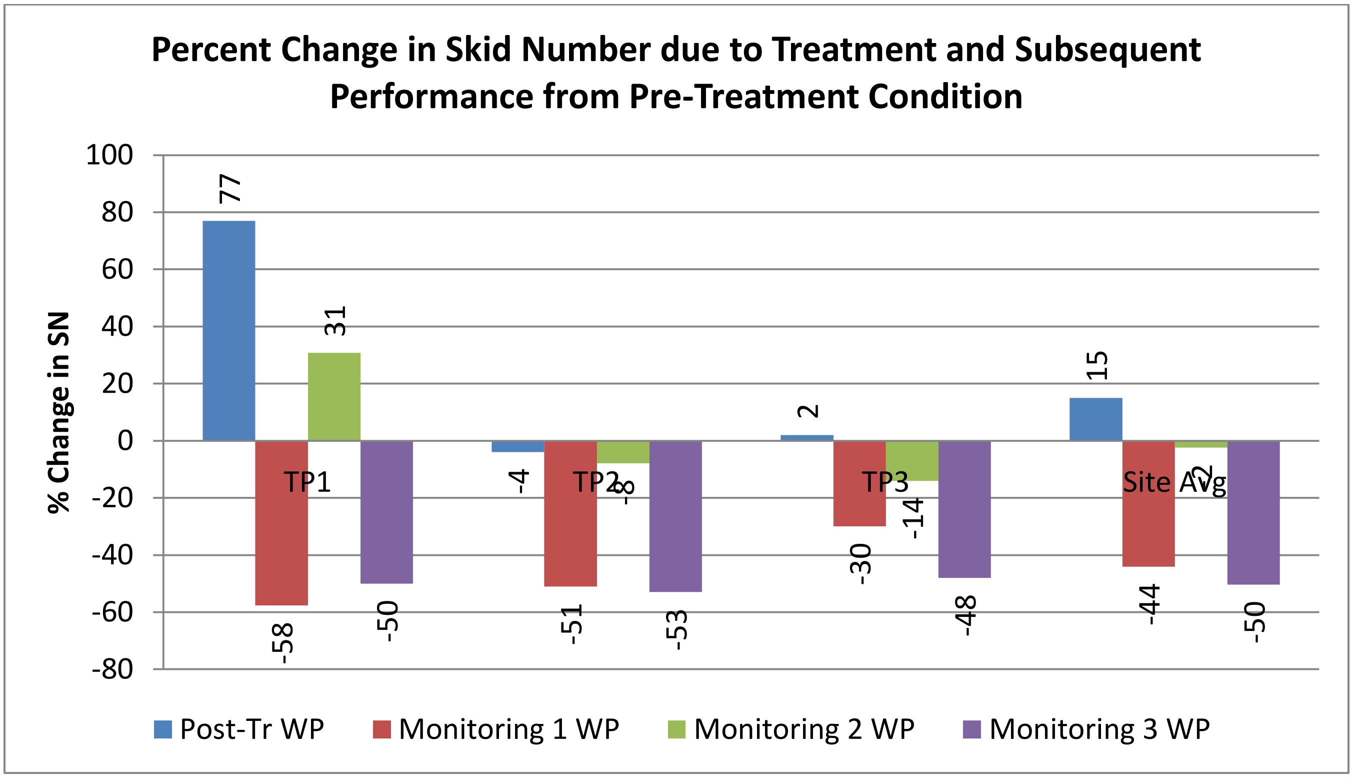


Circular Track Meter (CTM) MPD (mm)



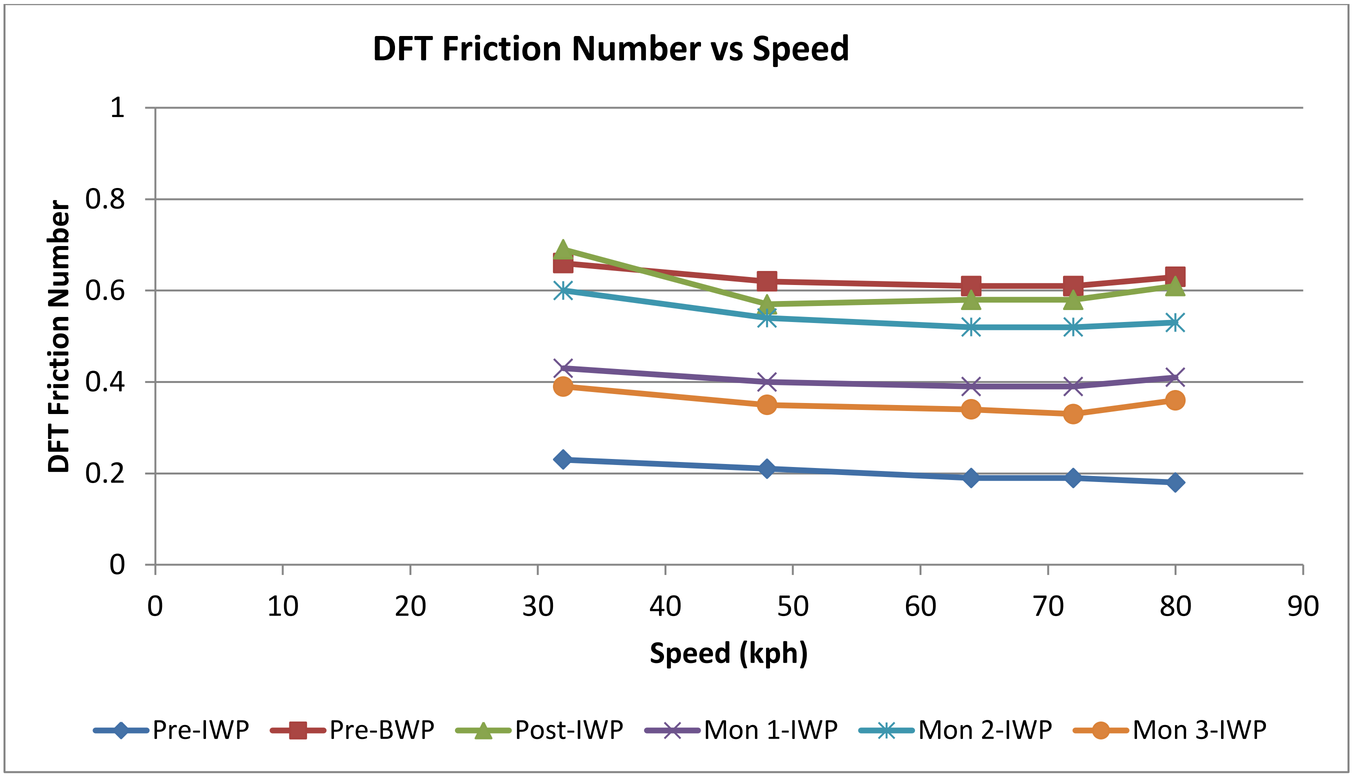


Skid Truck Data



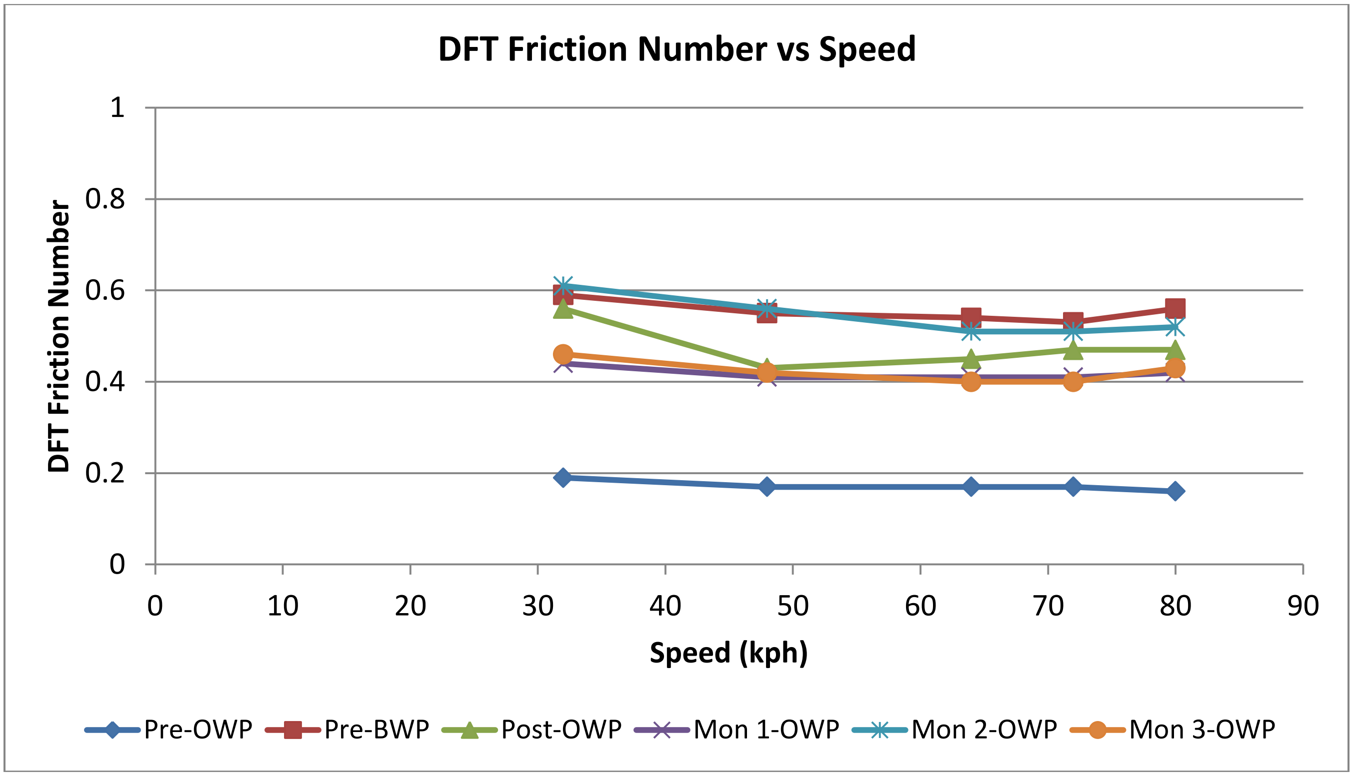
Dynamic Friction Test (DFT) Friction Number Data for TP 1

Speed (kph)	Pre-IWP	Pre-BWP	Post-IWP	Mon 1-IWP	Mon 2-IWP	Mon 3-IWP
32	0.23	0.66	0.69	0.43	0.6	0.39
48	0.21	0.62	0.57	0.4	0.54	0.35
64	0.19	0.61	0.58	0.39	0.52	0.34
72	0.19	0.61	0.58	0.39	0.52	0.33
80	0.18	0.63	0.61	0.41	0.53	0.36



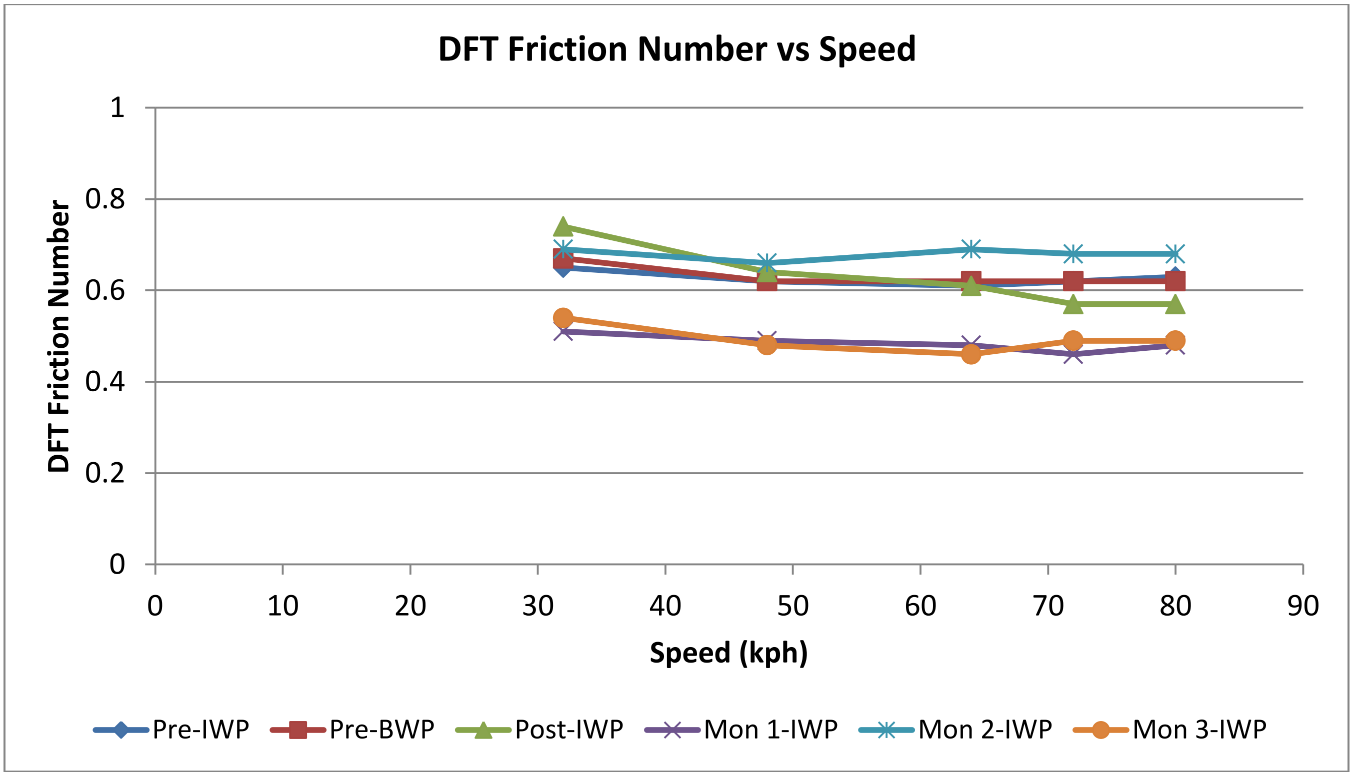
Dynamic Friction Test (DFT) Friction Number Data for TP 2

Speed (kph)	Pre-OWP	Pre-BWP	Post-OWP	Mon 1-OWP	Mon 2-OWP	Mon 3-OWP
32	0.19	0.59	0.56	0.44	0.61	0.46
48	0.17	0.55	0.43	0.41	0.56	0.42
64	0.17	0.54	0.45	0.41	0.51	0.4
72	0.17	0.53	0.47	0.41	0.51	0.4
80	0.16	0.56	0.47	0.42	0.52	0.43



Dynamic Friction Test (DFT) Friction Number Data for TP 3

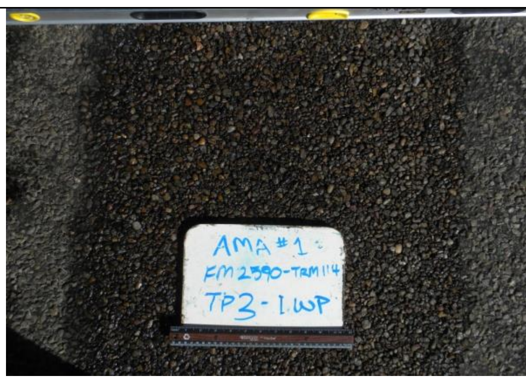
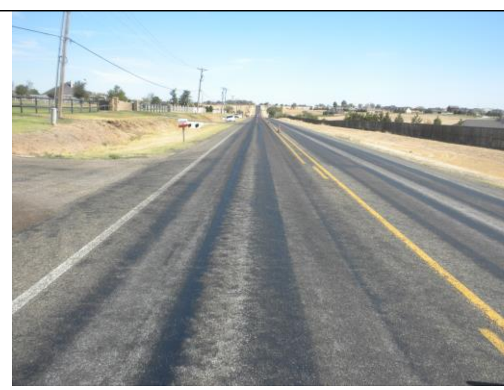
Speed (kph)	Pre-IWP	Pre-BWP	Post-IWP	Mon 1-IWP	Mon 2-IWP	Mon 3-IWP
32	0.65	0.67	0.74	0.51	0.69	0.54
48	0.62	0.62	0.64	0.49	0.66	0.48
64	0.61	0.62	0.61	0.48	0.69	0.46
72	0.62	0.62	0.57	0.46	0.68	0.49
80	0.63	0.62	0.57	0.48	0.68	0.49



Weather Data during UHP Water Cutter Treatment

Date	Time	Temp Out	Hi Temp	Low Temp	Out Hum	Dew Pt.	Wind Speed	Wind Dir	Wind Run	Hi Speed	Hi Dir	Wind Chill	Heat Index	THW Index	THSW Index
3/2/2011	7:50 AM	51.1	62.8	51.1	32	22.2	0	NNW	0	4	NNW	51.1	49.1	49.1	---
3/2/2011	8:00 AM	42.8	50.8	42.8	46	23.4	1	NE	0.17	4	SE	42.8	41.6	41.6	---
3/2/2011	8:10 AM	41.2	42.7	41.1	50	23.9	2	SSE	0.33	4	SSE	41.1	40.1	40	---
3/2/2011	8:20 AM	41.8	42	41.3	48	23.5	2	SSE	0.33	5	SSE	41.8	40.7	40.7	---
3/2/2011	8:30 AM	43.5	43.5	41.9	48	25.1	2	SE	0.33	6	N	43.5	42.3	42.3	---
3/2/2011	8:40 AM	45.3	45.3	43.5	44	24.6	2	SSE	0.33	5	SSE	45.3	44	44	---
3/2/2011	8:50 AM	46	46	45.3	43	24.7	1	SSE	0.17	5	S	46	44.6	44.6	---
3/2/2011	9:00 AM	47.8	47.8	46	40	24.6	1	SSW	0.17	5	S	47.8	46.3	46.3	---
3/2/2011	9:10 AM	48.6	48.6	47.9	40	25.3	1	S	0.17	4	S	48.6	47.1	47.1	---
3/2/2011	9:20 AM	50.4	50.4	48.6	38	25.7	2	SW	0.33	4	SW	50.4	48.7	48.7	---
3/2/2011	9:30 AM	52.1	52.1	50.4	36	25.9	2	WNW	0.33	5	W	52.1	50	50	---
3/2/2011	9:40 AM	53.7	53.7	52.1	32	24.5	4	WNW	0.67	7	WNW	53.1	51.1	50.5	---
3/2/2011	9:50 AM	54.9	54.9	53.7	30	24	4	NW	0.67	7	WNW	54.5	52	51.6	---
3/2/2011	10:00 AM	55.9	56	54.9	27	22.4	5	WNW	0.83	8	W	55.2	52.5	51.8	---
3/2/2011	10:10 AM	55.6	55.9	55.6	26	21.2	6	NW	1	9	WNW	54.3	52.2	50.9	---
3/2/2011	10:20 AM	55.7	56	55.6	27	22.2	6	NW	1	10	NNW	54.4	52.4	51.1	---
3/2/2011	10:30 AM	55.9	55.9	55.3	26	21.5	5	NNW	0.83	10	NNW	55.2	52.4	51.7	---
3/2/2011	10:40 AM	56.1	56.2	55.9	25	20.7	4	NNW	0.67	7	N	55.9	52.5	52.3	---
3/2/2011	10:50 AM	55.7	56.3	55.7	25	20.4	3	N	0.5	8	NNW	55.7	52.2	52.2	---
3/2/2011	11:00 AM	60	60	55.7	28	26.8	1	NNE	0.17	4	NNE	60	56.2	56.2	---

Site Photographs

(a)			Figure XX. BMT3 Pictures (a) highway and location; (b) close-up of flushed surface before treatment; (c) roadway surface before treatment; (d) close-up of flushed surface immediately after treatment; (e) roadway surface after treatment; (f) close-up of surface at first follow-up ; (g) roadway surface at first follow-up , (h) roadway surface at second follow-up ; (i) close-up of surface at second follow-up , (j) close-up of surface at third follow-up ; (k) roadway surface at third follow-up
(b)		(c)	
(d)		(e)	
(f)		(g)	

(h)		(i)	
(j)		(k)	

APPENDIX M

SITE AMA 2

Oldham COUNTY

Amarillo DISTRICT

Site Description

Project Information			
District: Amarillo	Test Site: AMA 2	County: Oldham	Road: FM 1061 NB
ADT: 1800	Truck Traffic: Medium	Year Built:	Last Maintained: 2009

Roadway Description
Aggregate Grade: Ty PB GR 4
Aggregate Type: Siliceous River Gravel
Pit: J Lee Milligan, Boys Ranch
AQMP#: 418008
CSJ: 1245-01-012
Binder: AC 10

Pavement abnormalities:
The pavement was lightly flushed in the inside wheel path and only very lightly flushed in the outside path. There was light rutting throughout the section with a very large rut in speed zone 4. The pavement was bladed and broomed off as soon as the treatment was completed to remove the heavy deposits asphalt from the roadway.

Research Test Summary		
Test Location: FM 2381 to US 385	Closest Texas Reference Marker: 82	
Test Point GPS Coordinates	N	W
TP1	35°29.066'	102°11.548'
TP2	35°29.141'	102°11.649'
TP3	35°29.213'	102°11.747

Ultra High Pressure Water Cutter Treatment Summary		
Date Treated 3/1/2011	Start Time 7:45 AM	End Time:3:00 PM

Summary Description of Treatment Activity

Personnel on site:
TechMRT: Sanja Senadheera, Andrew Tubb and Timothy Wood
Rampart: Bob Beadling and Jim Windich
TxDOT: Mike Taylor and Ron Herr (Amarillo District), others from the Olham County Maintenance Office

Rampart configuration: Rampart used their typical 28 jet nozzle configuration running at 32ksi for the last three sections: a little over three eighths of a mile. The same nozzle configuration was inverted with the 14mil jets on the inside and the 6mil jets on the outside for the first eighth mile section. The alternate configuration ran between 29ksi in the outside wheel path and 31ksi on the inside wheel path.

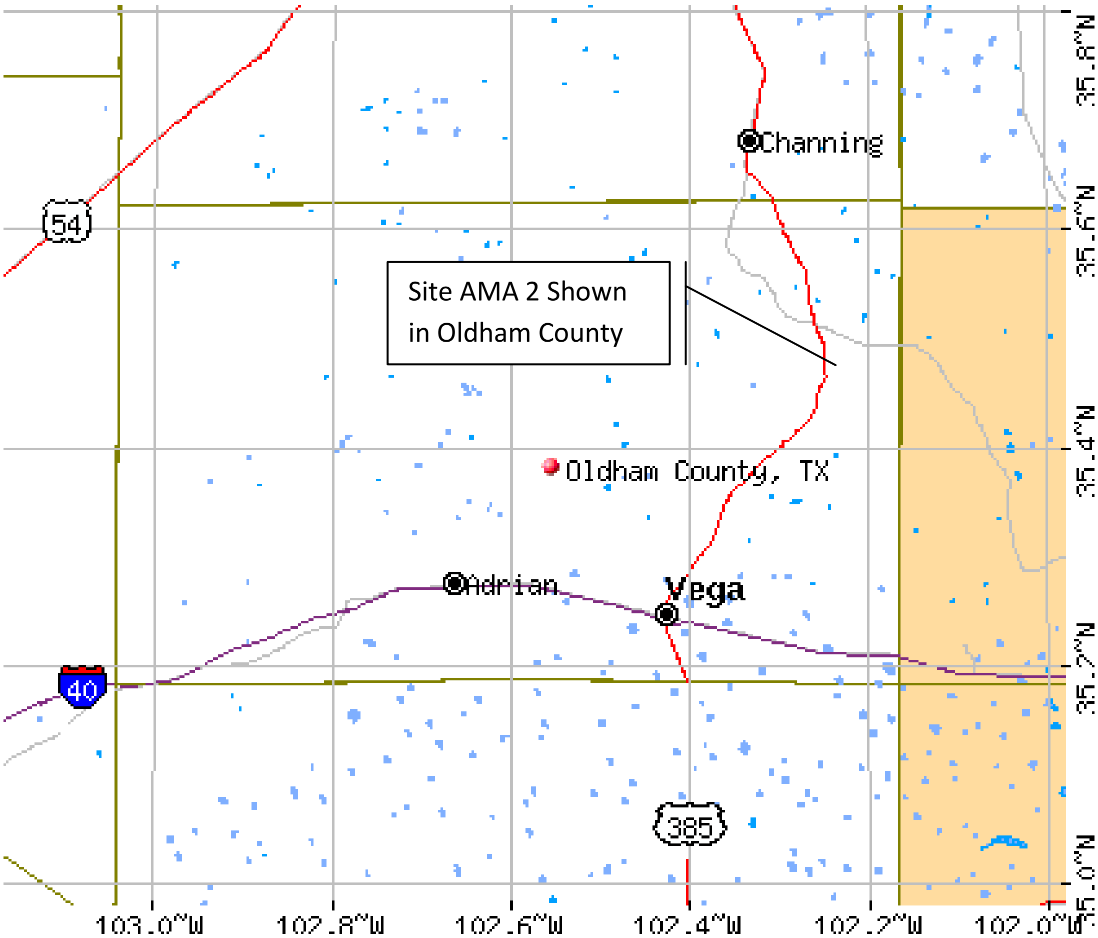
Work Activities: TechMRT and Rampart were at the maintenance office before 7:00AM. TechMRT participated in a very informal morning meeting and then headed to the site at 7:10AM while Rampart filled the truck.

TechMRT arrived on site at 7:45AM. From 7:50AM till 8:30AM TechMRT set up the weather station at TP1 and remarked all test points and the speed sections for the westbound lane. Traffic control was slow to set up. TechMRT performed all pretest from 9:10AM till 10:15AM.

Rampart was present at the site beginning at 8:30AM. They treated the center of the wheel paths with a single pass for the inside wheel path in speed zones 5 through 8 from 10:45AM to 11:00AM. The inside wheel path was actually mostly flushed toward the middle of the lane than the typical location of the wheel path. They then treated the inside wheel path on the inside quarter mile at 0.8mph. The outside wheel path in sections 2 through 4 was treated at approximately 1.4mph. This took from 11:00AM till 12:15PM. TechMRT did pre testing in the nozzle configuration speed zones 1 through 4. They then completed the regularly scheduled post testing from 11:40AM to 12:30PM. Rampart then switched nozzles to the alternate configuration described above. The physical switch was from 12:30PM to 12:45PM. Rampart then worked from 12:45PM till 1:50PM to adjust the hydraulic settings on the truck to compensate for the alternate nozzle configuration. Rampart then treated the remaining section as a speed section from 2:00PM to 2:20PM. The alternate configuration caused a more sever pattern on the pavement. The outside edges, those affected by the 9mil jets, were relatively untreated but the edge was still visible. The middle section affected by the 14mil jets was damaged in varying degrees. At the fastest sections a few rocks were removed. In the slower sections massive aggregate loss occurred. In the center of the wheel path, damage ranged from helix patterns remaining to major aggregate loss. Ron Herr of TxDOT was very upset with the damage and basically ended the day then and there. Rampart left the site at 2:30PM to empty the truck for the first time that day and to empty their truck. TechMRT did the post testing on the alternate nozzle configuration test section from 2:30PM to 2:50PM. From 2:50PM to 3:00PM, the weather station was collected and a short video of the damaged section was taken. TechMRT returned to Amarillo at 3:00PM.
Comments

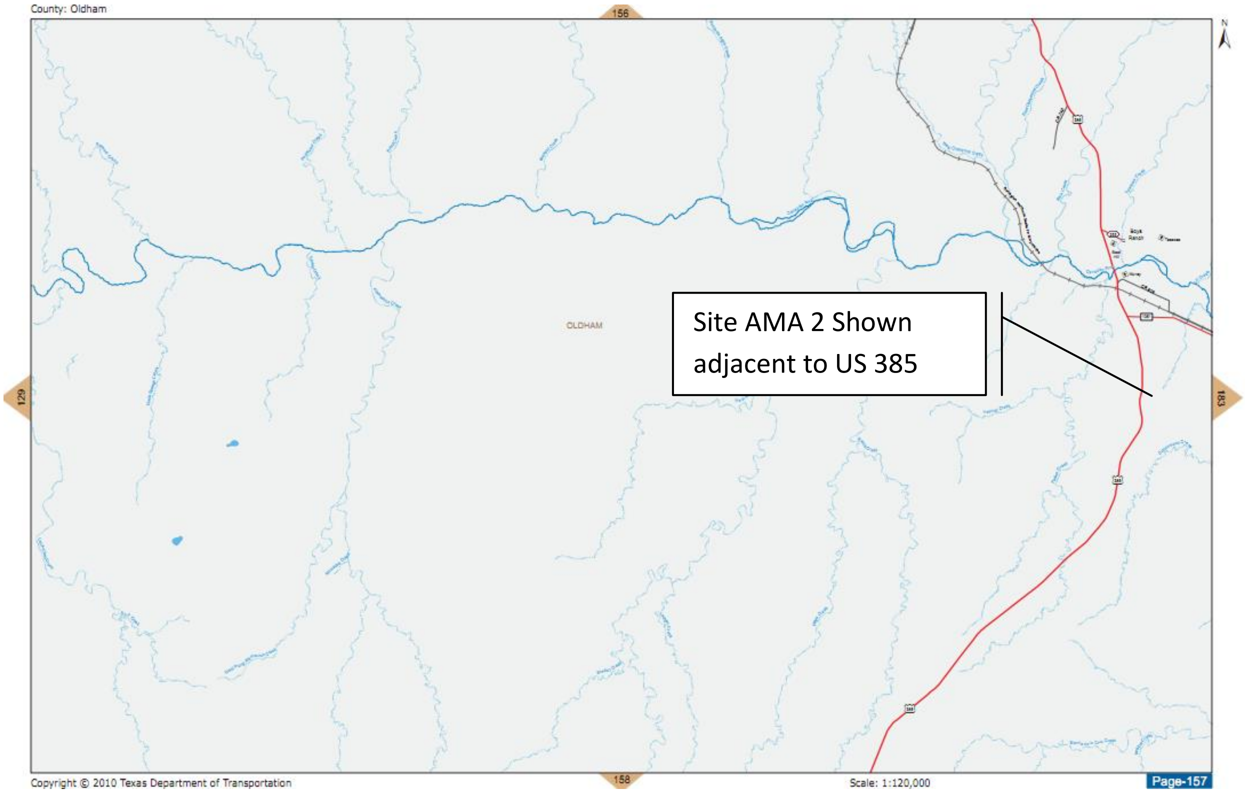
Follow-On Testing Summary	
Date: 8/2/11	Comments: Preformed follow –up monitoring successfully.
Date: 1/17/12	Comments: Preformed follow –up monitoring successfully.
Date: 7/17/12	Comments: No follow-up monitoring was performed due to reoccurrence of flushing therefore seal coat treatment was necessary.

Site Vicinity Map



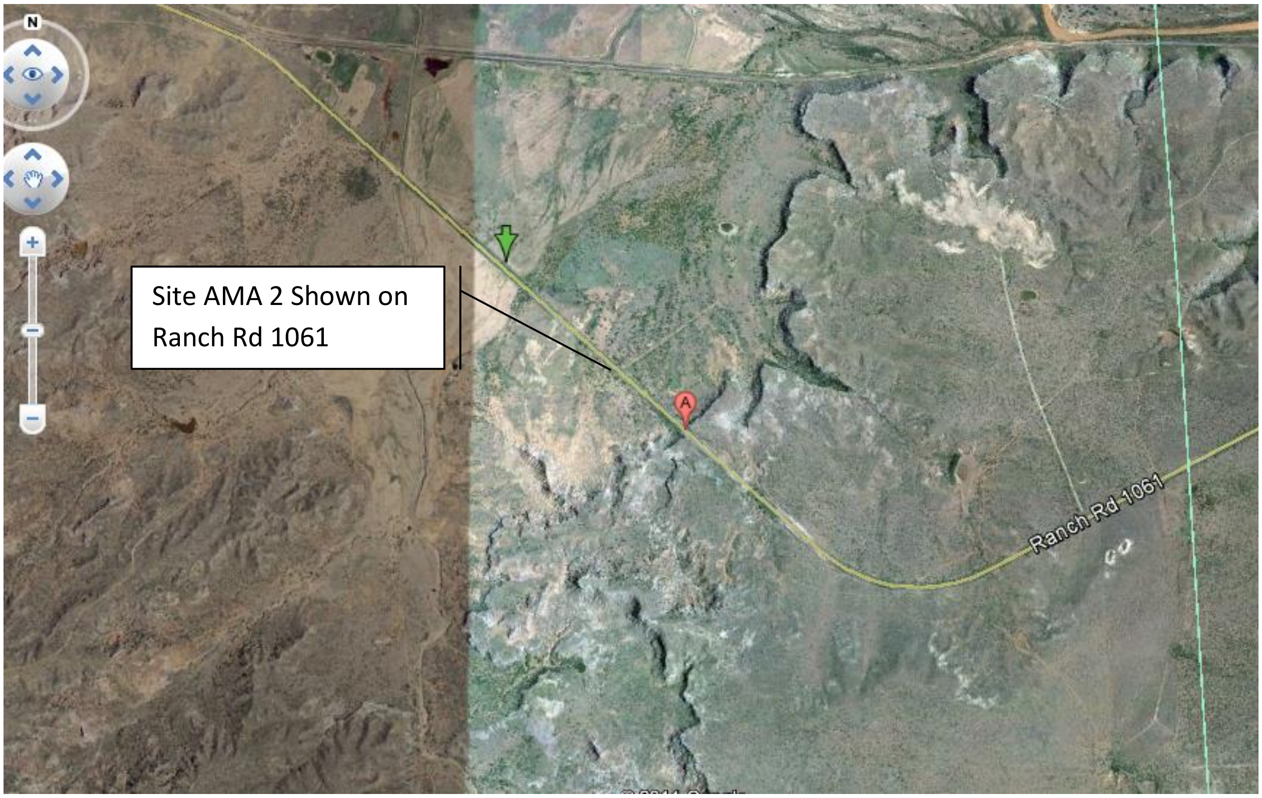
http://www.city-data.com/

Site Location Map



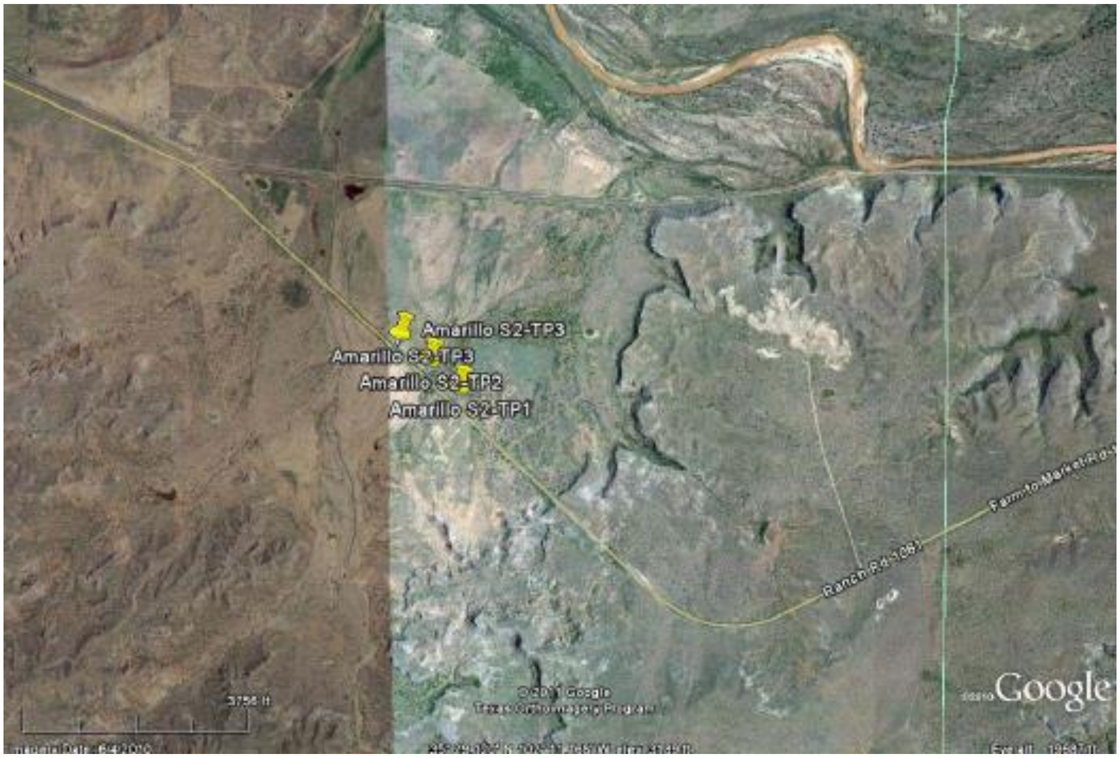
http://www.txdot.gov/travel/county_grid_search.htm

Aerial Photograph



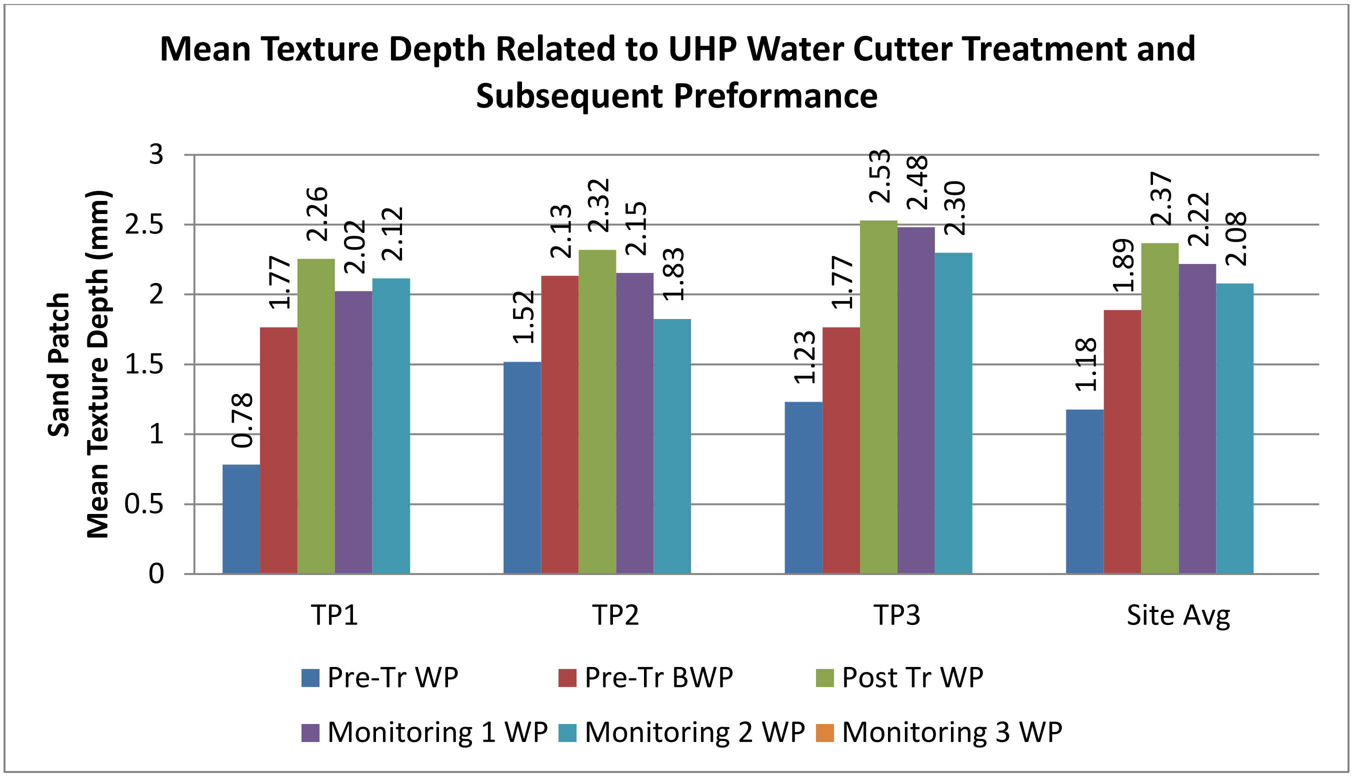
Google Inc. (2011). Google Earth (Version 6.1.0.5001)

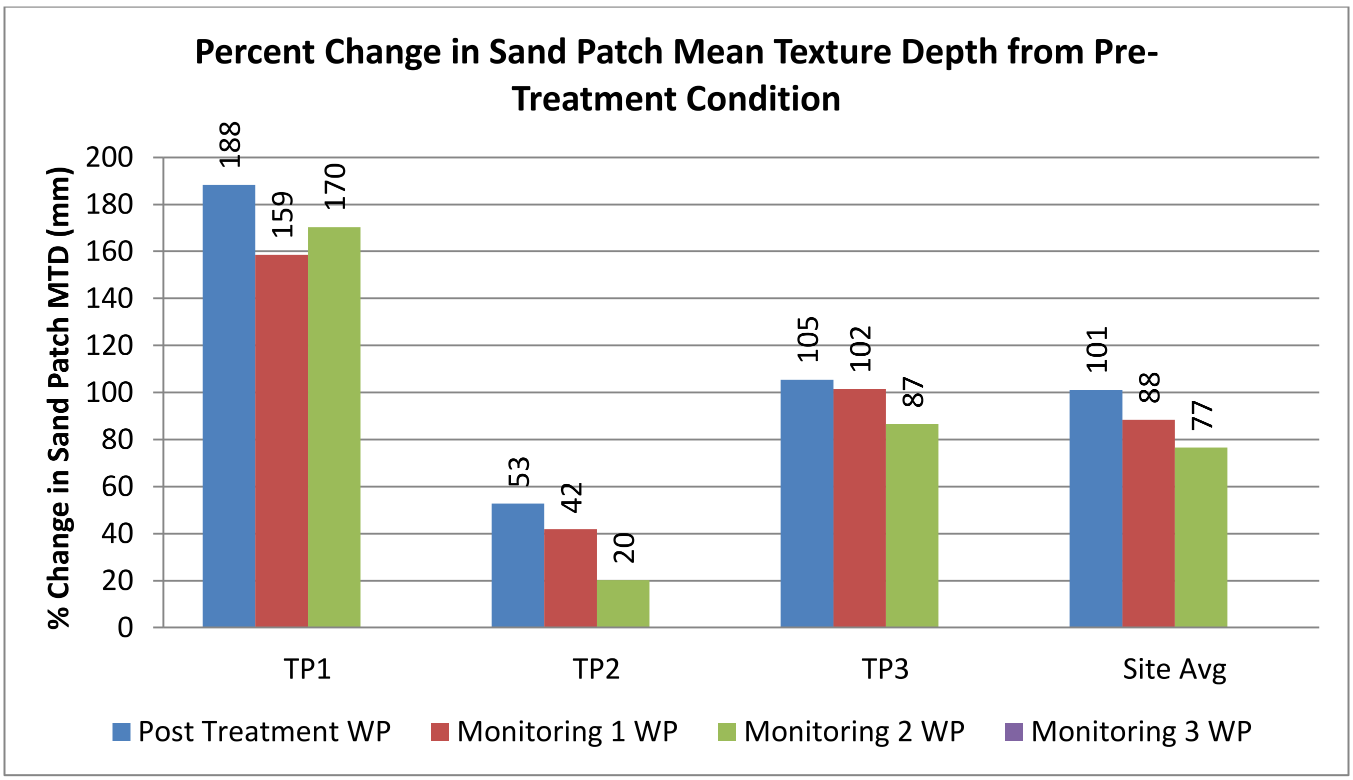
Test Point Plan



Google Inc. (2011). Google Earth (Version 6.1.0.5001)

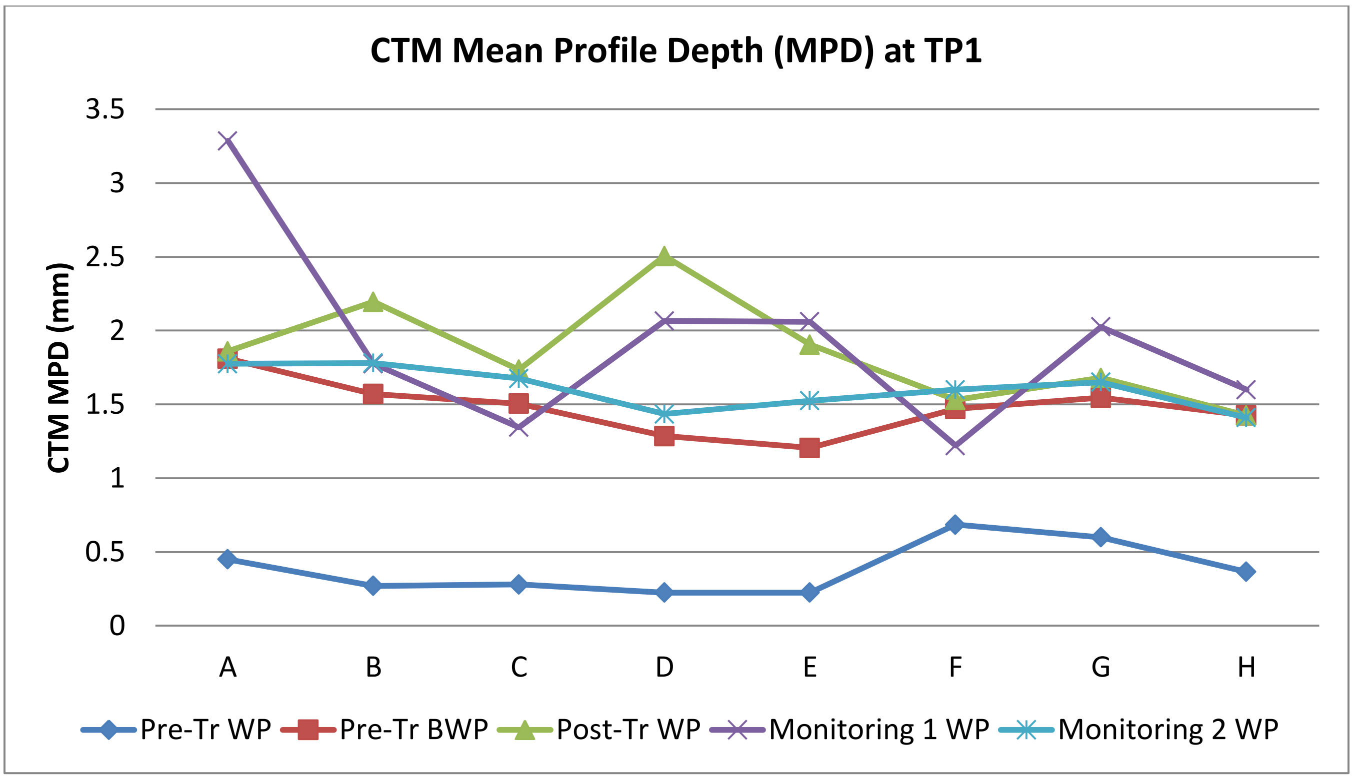
Sand Patch Data





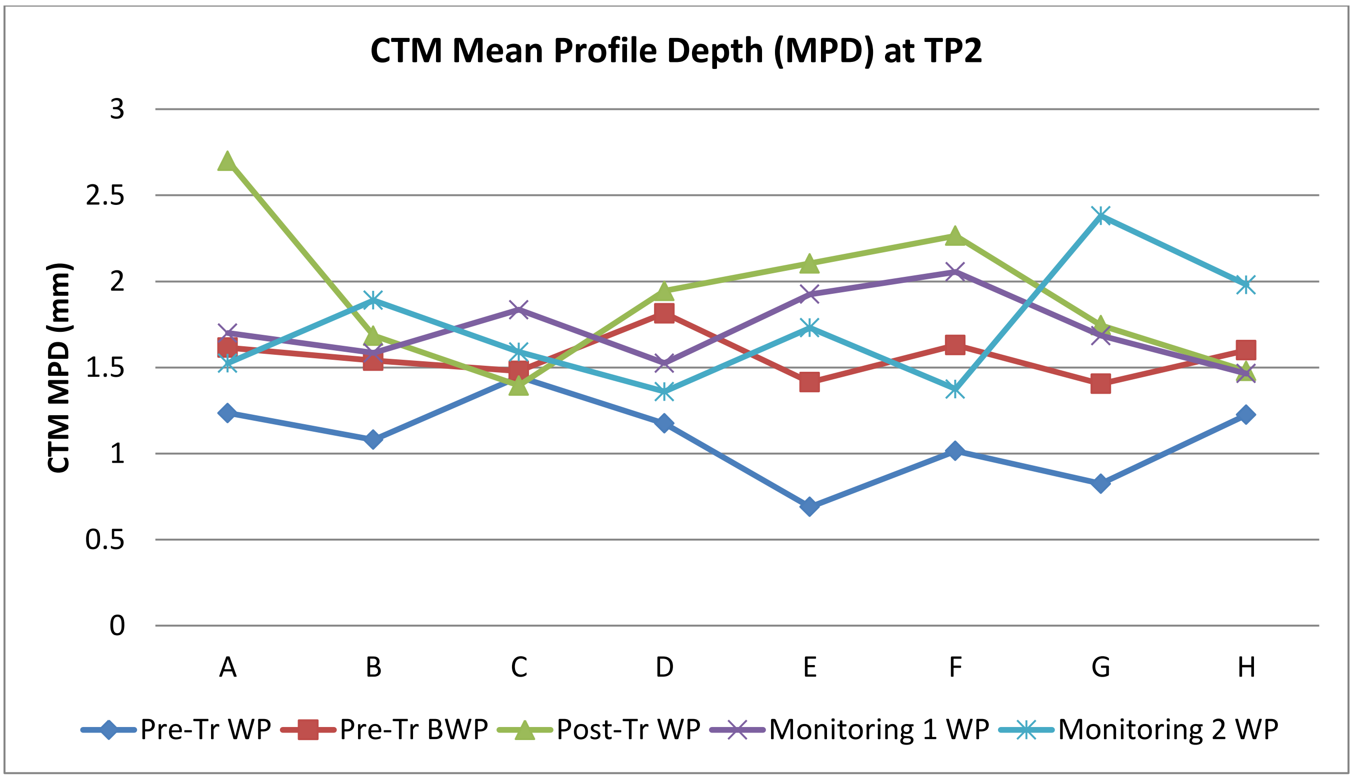
Circular Track Meter (CTM) Mean Profile Depth (in mm) at TP 1

	A	B	C	D	E	F	G	H
Pre-Tr WP	0.45	0.27	0.28	0.225	0.225	0.685	0.6	0.365
Pre-Tr BWP	1.81	1.57	1.505	1.285	1.205	1.47	1.545	1.425
Post-Tr	1.86	2.195	1.735	2.505	1.905	1.53	1.68	1.425
Monitoring 1	3.285	1.775	1.345	2.065	2.06	1.22	2.025	1.6
Monitoring 2	1.775	1.78	1.675	1.435	1.525	1.6	1.65	1.41
Monitoring 3	Not conducted due to maintenance/rehabilitation work on the section							



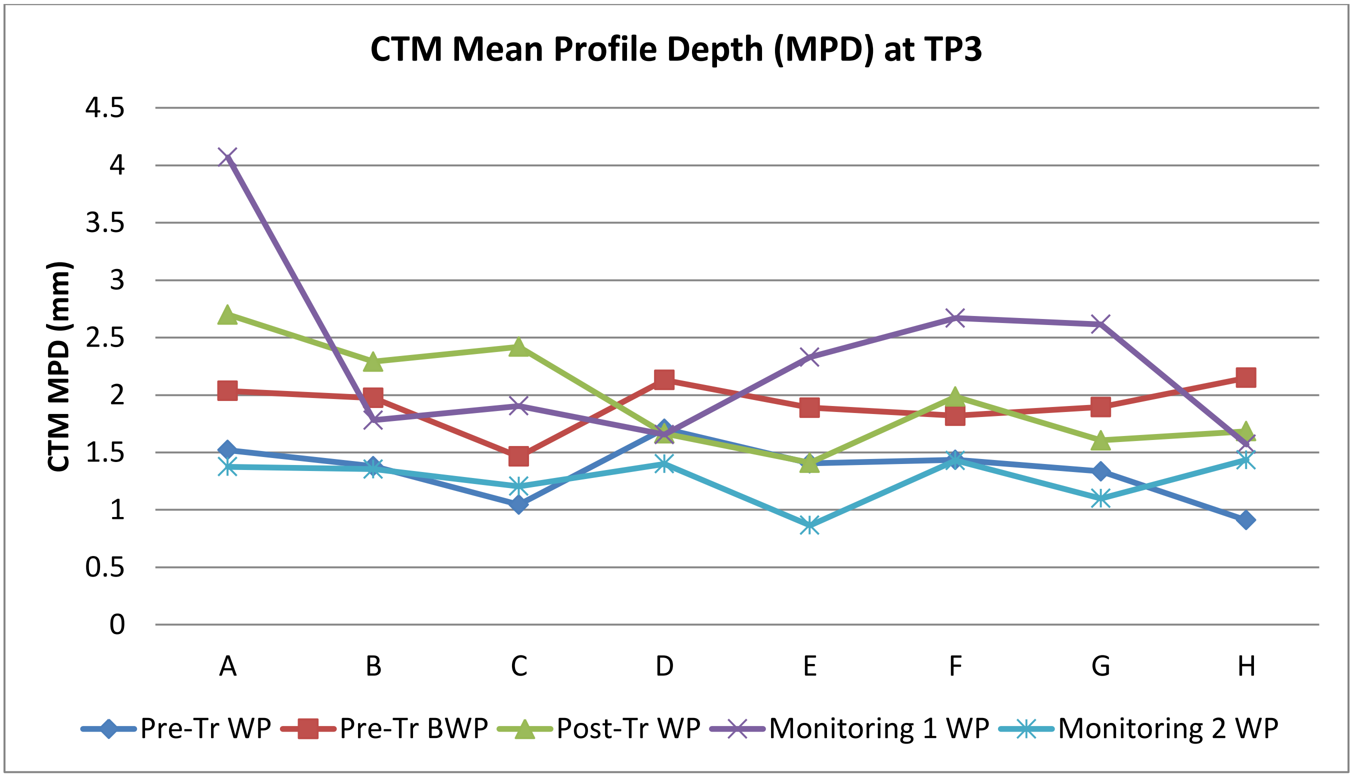
Circular Track Meter (CTM) Mean Profile Depth (in mm) at TP 2

	A	B	C	D	E	F	G	H
Pre-Tr WP	1.235	1.08	1.445	1.175	0.69	1.015	0.825	1.225
Pre-Tr BWP	1.615	1.54	1.48	1.815	1.415	1.63	1.405	1.6
Post-Tr	2.7	1.685	1.395	1.945	2.105	2.265	1.745	1.48
Monitoring 1	1.7	1.585	1.835	1.525	1.925	2.055	1.685	1.465
Monitoring 2	1.525	1.89	1.59	1.36	1.73	1.375	2.38	1.98
Monitoring 3	Not conducted due to maintenance/rehabilitation work on the section							

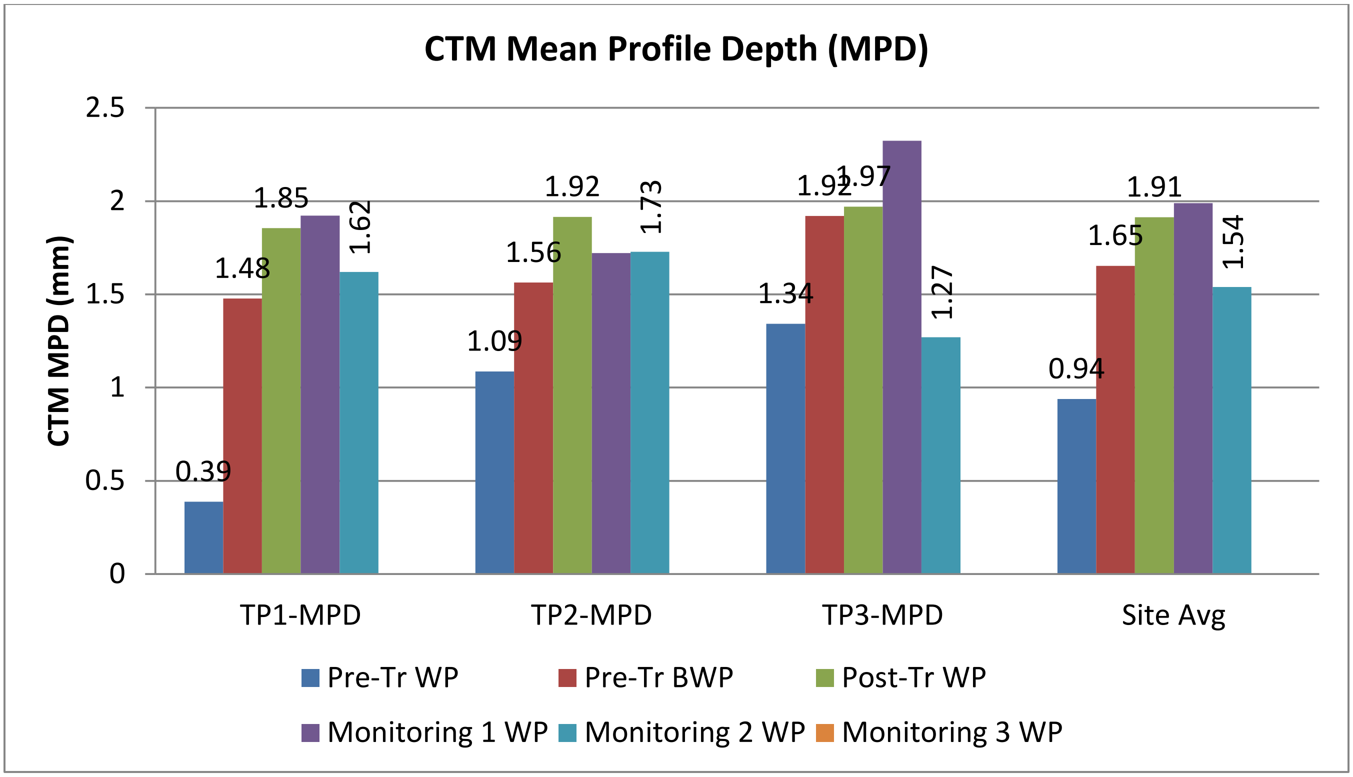


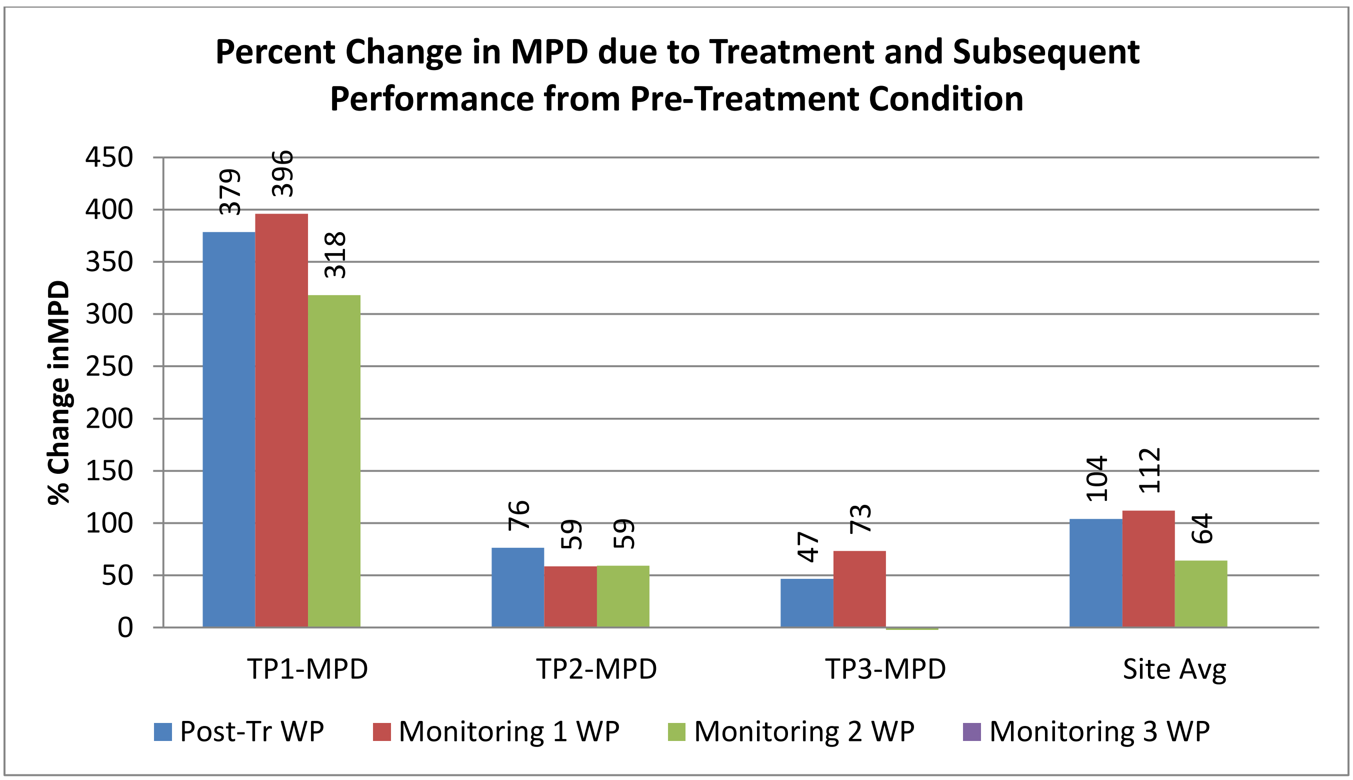
Circular Track Meter (CTM) Mean Profile Depth (in mm) at TP 3

	A	B	C	D	E	F	G	H
Pre-Tr WP	1.52	1.38	1.045	1.705	1.405	1.435	1.335	0.91
Pre-Tr BWP	2.035	1.975	1.465	2.13	1.89	1.82	1.895	2.15
Post-Tr	2.7	2.29	2.42	1.665	1.41	1.985	1.605	1.685
Monitoring 1	4.07	1.78	1.905	1.655	2.33	2.67	2.615	1.57
Monitoring 2	1.375	1.355	1.205	1.4	0.865	1.43	1.1	1.435
Monitoring 3	Not conducted due to maintenance/rehabilitation work on the section							

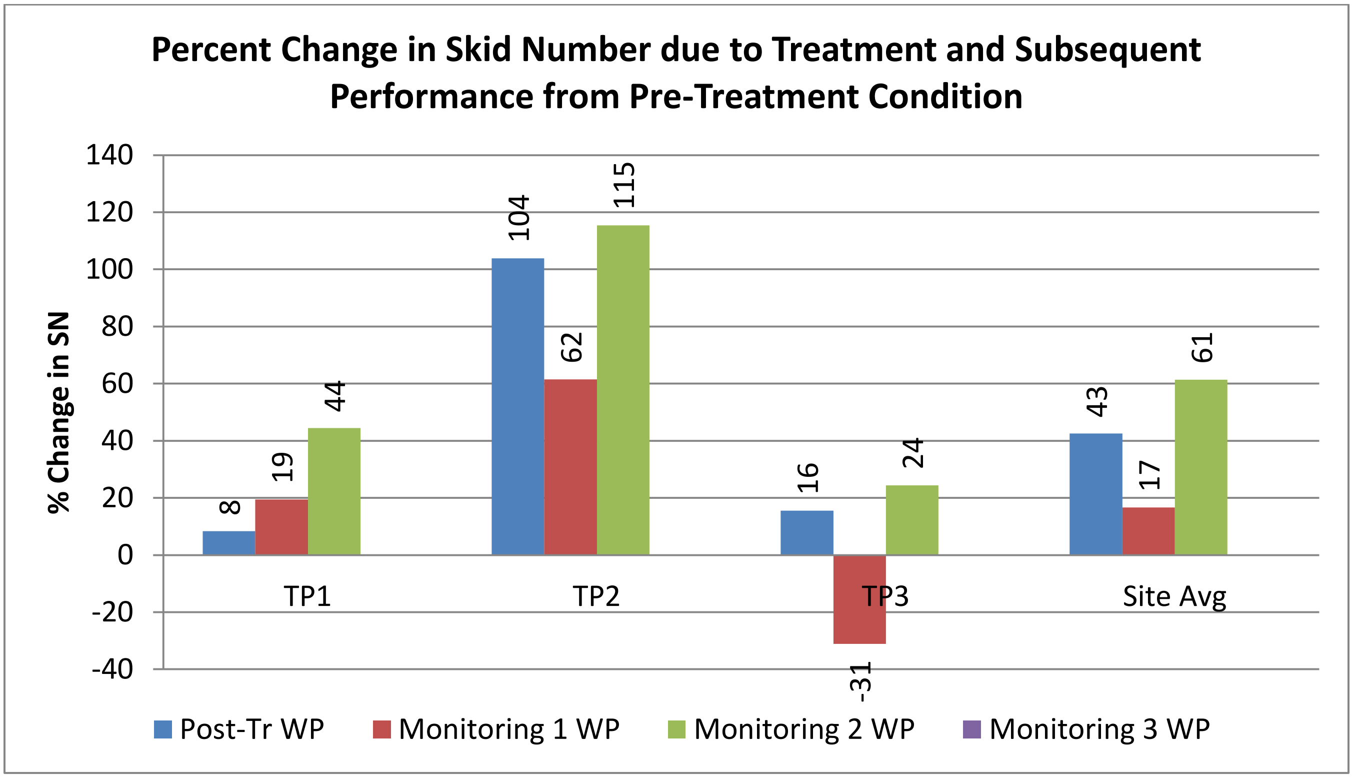


Circular Track Meter (CTM) MPD (mm)



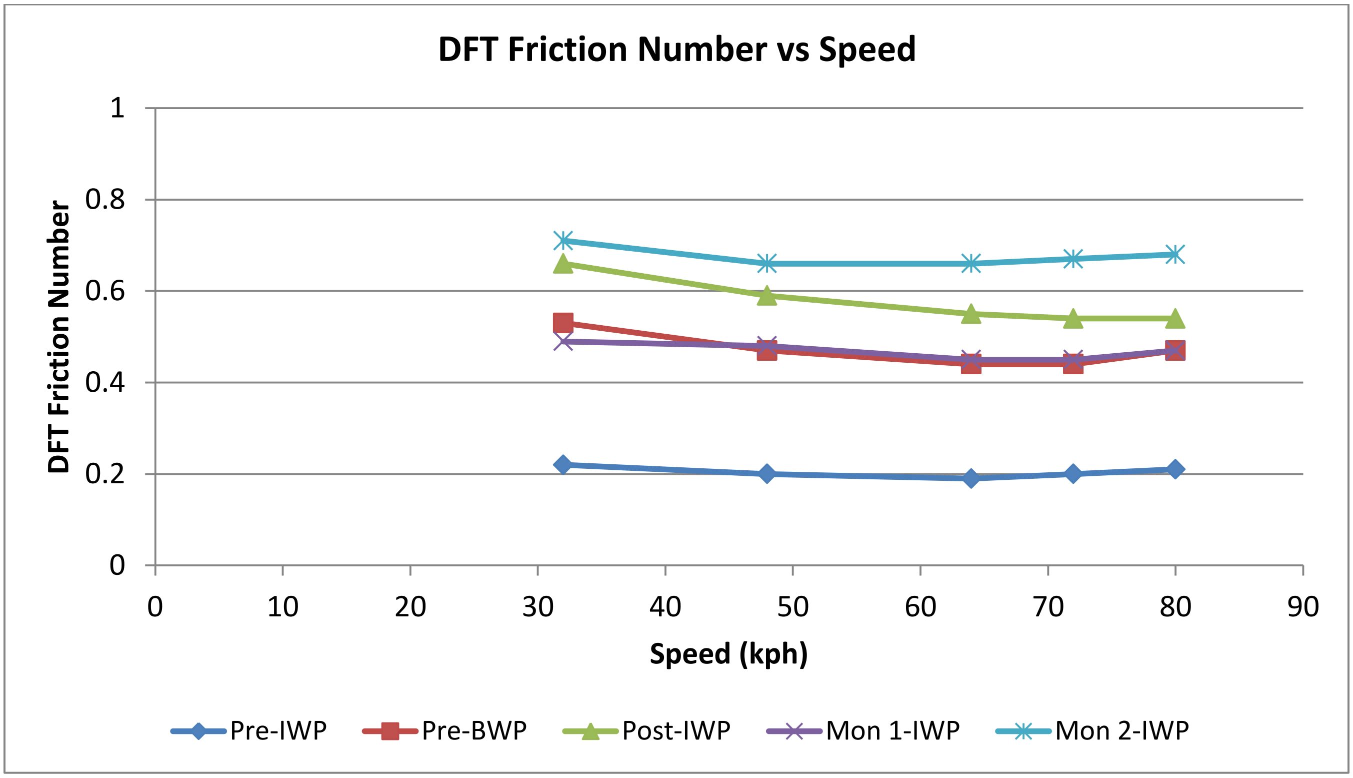


Skid Truck Data



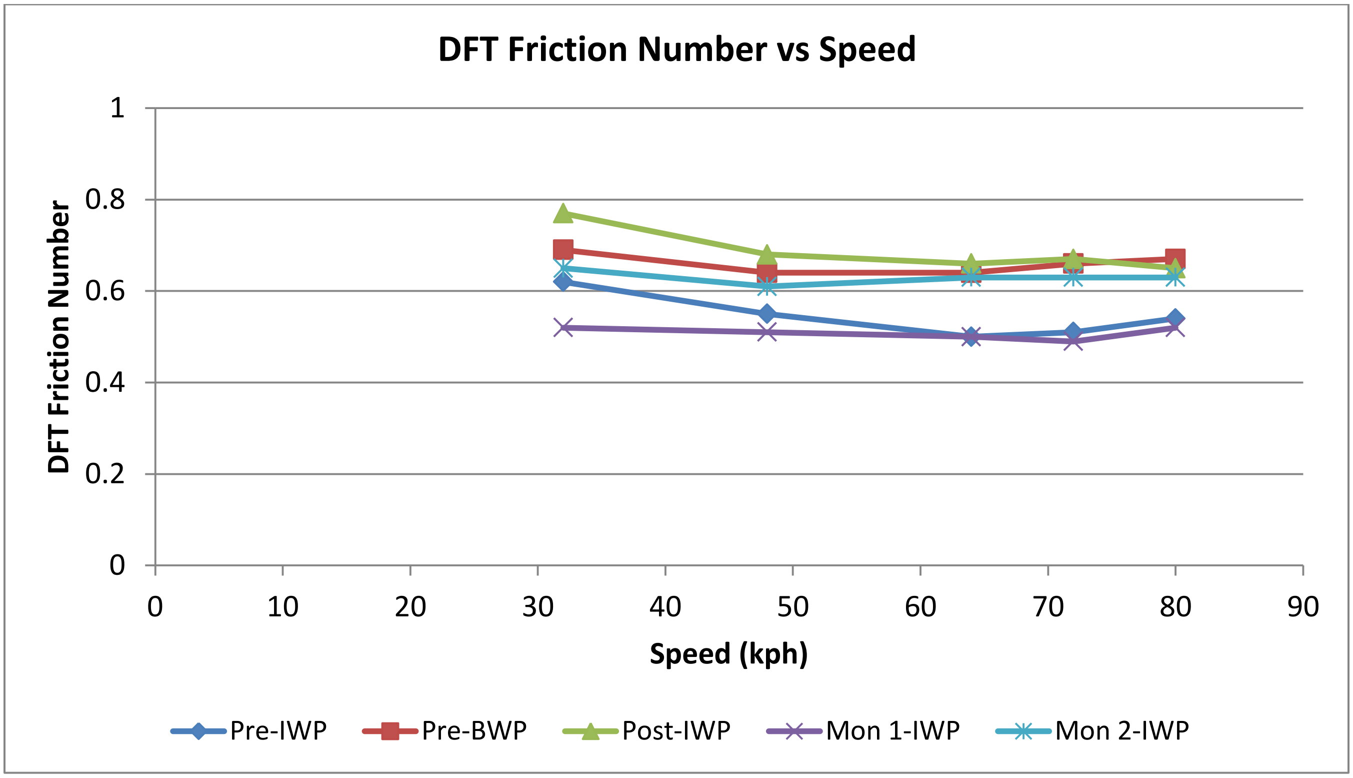
Dynamic Friction Test (DFT) Friction Number Data for TP 1

Speed (kph)	Pre-IWP	Pre-BWP	Post-IWP	Mon 1-IWP	Mon 2-IWP	Mon 3-IWP
32	0.22	0.53	0.66	0.49	0.71	Not conducted due to maintenance/rehabilitati on work on the section
48	0.2	0.47	0.59	0.48	0.66	
64	0.19	0.44	0.55	0.45	0.66	
72	0.2	0.44	0.54	0.45	0.67	
80	0.21	0.47	0.54	0.47	0.68	



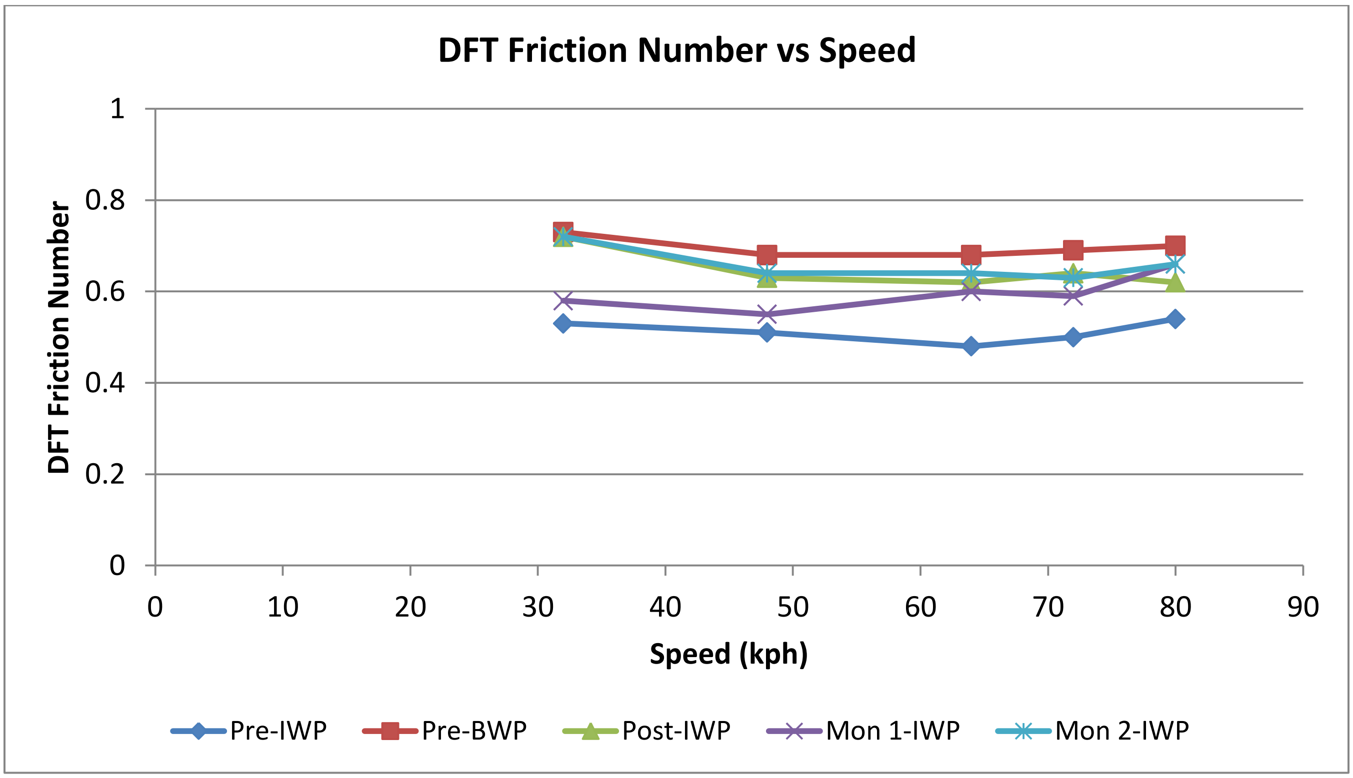
Dynamic Friction Test (DFT) Friction Number Data for TP 2

Speed (kph)	Pre-IWP	Pre-BWP	Post-IWP	Mon 1-IWP	Mon 2-IWP	Mon 3-IWP
32	0.62	0.69	0.77	0.52	0.65	Not conducted due to maintenance/rehabilitation work on the section
48	0.55	0.64	0.68	0.51	0.61	
64	0.5	0.64	0.66	0.5	0.63	
72	0.51	0.66	0.67	0.49	0.63	
80	0.54	0.67	0.65	0.52	0.63	



Dynamic Friction Test (DFT) Friction Number Data for TP 3

Speed (kph)	Pre-IWP	Pre-BWP	Post-IWP	Mon 1-IWP	Mon 2-IWP	Mon 3-IWP
32	0.53	0.73	0.72	0.58	0.72	Not conducted due to maintenance/rehabilitation work on the section
48	0.51	0.68	0.63	0.55	0.64	
64	0.48	0.68	0.62	0.6	0.64	
72	0.5	0.69	0.64	0.59	0.63	
80	0.54	0.7	0.62	0.66	0.66	



Weather Data during UHP Water Cutter Treatment

Date	Time	Temp Out	Hi Temp	Low Temp	Out Hum	Dew Pt.	Wind Speed	Wind Dir	Wind Run	Hi Speed	Hi Dir	Wind Chill	Heat Index	THW Index	THSW Index
3/1/2011	8:00 AM	39.8	78.9	39.8	39	16.8	0	NE	0	3	NE	39.8	38.5	38.5	---
3/1/2011	8:10 AM	37.5	39.5	36.7	46	18.6	0	SSE	0	2	ESE	37.5	36.4	36.4	---
3/1/2011	8:20 AM	37.6	38.2	37.5	47	19.2	1	NNE	0.17	4	N	37.6	36.5	36.5	---
3/1/2011	8:30 AM	38.7	38.7	37.4	48	20.7	2	N	0.33	4	N	38.3	37.6	37.2	---
3/1/2011	8:40 AM	41	41	38.7	42	19.6	1	NNE	0.17	3	NNE	41	39.7	39.7	---
3/1/2011	8:50 AM	42.2	42.2	41	42	20.7	2	NNE	0.33	4	NNE	42.2	40.9	40.9	---
3/1/2011	9:00 AM	43.6	43.6	42.3	40	20.8	1	NNE	0.17	3	NNE	43.6	42.2	42.2	---
3/1/2011	9:10 AM	45.5	45.5	43.6	38	21.3	1	NNE	0.17	3	NNE	45.5	44	44	---
3/1/2011	9:20 AM	47.8	47.8	45.6	36	22.1	3	NE	0.5	6	NNE	47.2	46.1	45.5	---
3/1/2011	9:30 AM	50.4	50.4	47.8	32	21.6	2	NE	0.33	5	NNW	50.4	48.5	48.5	---
3/1/2011	9:40 AM	52.6	52.6	50.4	30	22	3	N	0.5	6	NNW	52.6	50.1	50.1	---
3/1/2011	9:50 AM	54.8	54.8	52.6	27	21.4	3	N	0.5	6	NNW	54.8	51.6	51.6	---
3/1/2011	10:00 AM	56.1	56.1	54.8	24	19.8	4	NNW	0.67	6	NNW	55.9	52.4	52.2	---
3/1/2011	10:10 AM	59.1	59.1	56.1	22	20.2	4	NW	0.67	7	NNW	59.1	54.8	54.8	---
3/1/2011	10:20 AM	63.2	63.2	59.1	17	17.6	8	WSW	1.33	16	SW	62.3	58	57.1	---
3/1/2011	10:30 AM	64.6	64.6	63.3	16	17.3	11	WSW	1.83	19	W	61.6	59.3	56.3	---
3/1/2011	10:40 AM	65	65	64.6	14	14.6	13	WSW	2.17	21	W	61	59.5	55.5	---
3/1/2011	10:50 AM	65.9	65.9	65	13	13.6	12	WSW	2	20	WSW	62.5	60.3	56.9	---
3/1/2011	11:00 AM	66.8	66.8	66	12	12.5	13	WSW	2.17	21	W	63.1	61.1	57.4	---
3/1/2011	11:10 AM	67.6	67.6	66.8	12	13.1	13	W	2.17	20	W	64	61.8	58.2	---
3/1/2011	11:20 AM	68	68	67.7	12	13.4	13	WSW	2.17	22	WSW	64.4	62.2	58.6	---
3/1/2011	11:30 AM	69.3	69.5	68.1	12	14.4	12	WSW	2	20	W	66.2	63.9	60.8	---
3/1/2011	11:40 AM	69.1	69.3	68.8	11	12.3	13	W	2.17	19	W	65.5	63.5	59.9	---
3/1/2011	11:50 AM	69.7	69.9	69.2	10	10.6	13	WSW	2.17	20	WSW	66.2	64.1	60.6	---
3/1/2011	12:00 PM	69.7	70.1	69.6	9	8.3	13	WSW	2.17	21	W	66.2	64.1	60.6	---

3/1/2011	12:10 PM	70.4	70.4	69.7	9	8.8	13	WSW	2.17	22	W	66.9	65	61.5	---
3/1/2011	12:20 PM	70.5	70.6	70.2	9	8.9	13	WSW	2.17	26	W	67	65.1	61.6	---
3/1/2011	12:30 PM	70.7	70.7	70.4	9	9	13	WSW	2.17	20	WSW	67.2	65.4	61.9	---
3/1/2011	12:40 PM	71.5	71.5	70.7	8	7	13	WSW	2.17	20	W	68.1	66.4	63	---
3/1/2011	12:50 PM	72.9	72.9	71.2	8	8.1	10	WSW	1.67	21	WSW	70.8	68.3	66.2	---
3/1/2011	1:00 PM	73.8	74.1	72.9	8	8.7	9	SW	1.5	19	SW	72.5	69.4	68.1	---
3/1/2011	1:10 PM	73.5	73.8	73.3	8	8.5	10	SW	1.67	19	SW	71.5	69	67	---
3/1/2011	1:20 PM	72.8	73.4	72.8	8	8	12	SW	2	22	SW	69.8	68.1	65.1	---
3/1/2011	1:30 PM	73.1	73.4	72.8	9	10.8	12	WSW	2	19	WSW	70.1	68.6	65.6	---
3/1/2011	1:40 PM	73.3	73.3	73.1	8	8.4	12	WSW	2	21	W	70.3	68.8	65.8	---
3/1/2011	1:50 PM	73.4	73.7	73.3	9	11.1	12	SW	2	21	SW	70.4	69	66	---
3/1/2011	2:00 PM	73.5	73.8	73.4	8	8.5	12	SW	2	20	WSW	70.6	69	66.1	---
3/1/2011	2:10 PM	73.8	73.8	73.5	8	8.7	14	SW	2.33	20	SW	70.2	69.4	65.8	---
3/1/2011	2:20 PM	74.5	74.5	73.8	8	9.3	12	SW	2	21	SSW	71.7	70.6	67.8	---
3/1/2011	2:30 PM	74.8	74.8	74.3	7	6.5	11	SW	1.83	19	SW	72.4	71	68.6	---
3/1/2011	2:40 PM	74.8	75.2	74.8	6	3.1	11	SW	1.83	21	WSW	72.4	71	68.6	---
3/1/2011	2:50 PM	74.6	74.8	74.1	7	6.4	11	SW	1.83	20	SW	72.2	70.7	68.3	---
3/1/2011	3:00 PM	75.1	75.1	74.6	7	6.7	7	SW	1.17	17	SSW	75.1	71.5	71.5	---

Site Photographs

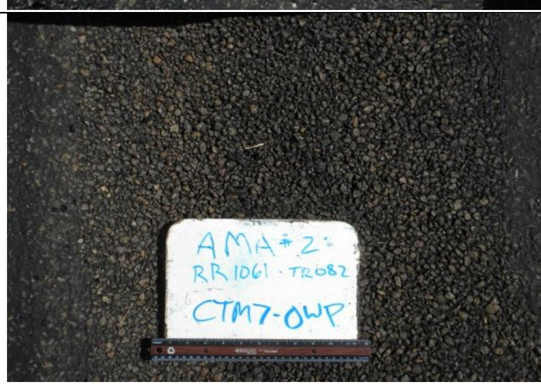
(a)

Figure XX. BMT3 Pictures (a) highway and location; (b) close-up of flushed surface before treatment; (c) roadway surface before treatment; (d) close-up of flushed surface immediately after treatment; (e) roadway surface after treatment; (f) close-up of surface at first follow-up ; (g) roadway surface at first follow-up , (h) roadway surface at second follow-up ; (i) close-up of surface at second follow-up.

(b)

(c)

(d)



(e)

(f)

(g)

(h)		(i)	

APPENDIX N

SITE AMA 3

Armstrong COUNTY

Amarillo DISTRICT

Site Description

Project Information			
District: Amarillo	Test Site: AMA 3	County: Armstrong	Road: FM 294 SB
ADT:120	Truck Traffic: Low-Medium	Year Built:	Last Maintained: 2009

Roadway Description
Aggregate Grade: Ty B GR 4
Aggregate Type: Siliceous River Gravel
Pit: ED Baker, Johnson Pit
AQMP#: 411807
CSJ: 0788-03-020
Binder: AC 10

Pavement abnormalities:
The pavement was heavily flushed in both wheel paths. The pavement was broomed off as soon as the treatment was completed to remove the heavy deposits asphalt from the roadway. Baseball to softball size clods of asphalt were removed manually.

Research Test Summary		
Test Location: IH 40 to FM 1151	Closest Texas Reference Marker: 108	
Test Point GPS Coordinates	N	W
TP1	35°09.543'	101°11.217'
TP2	35°09.431'	101°11.218'
TP3	35°09.322'	101°11.219'

Ultra High Pressure Water Cutter Treatment Summary		
Date Treated 2/28/2011	Start Time 7:00 AM	End Time 3:45 PM

Summary Description of Treatment Activity

Personnel on site:
TechMRT: Sanjaya Senadheera, Andrew Tubb and Timothy Wood
Rampart: Bob Beadling and Jim Windich
TxDOT: Mike Taylor and Ron Herr (Amarillo District), others from the Armstrong County Maintenance Office

Rampart configuration: Rampart used their typical 28 jet nozzle configuration running at 32ksi.

Work Activities: TechMRT and Rampart were at the maintenance office before 7:00AM. TechMRT participated in a very informal morning meeting and then headed to the site at 7:10AM while Rampart filled the truck. Many of the TxDOT workers had been up all night fighting wildfires and were eager to get the work started so they could go home and rest.

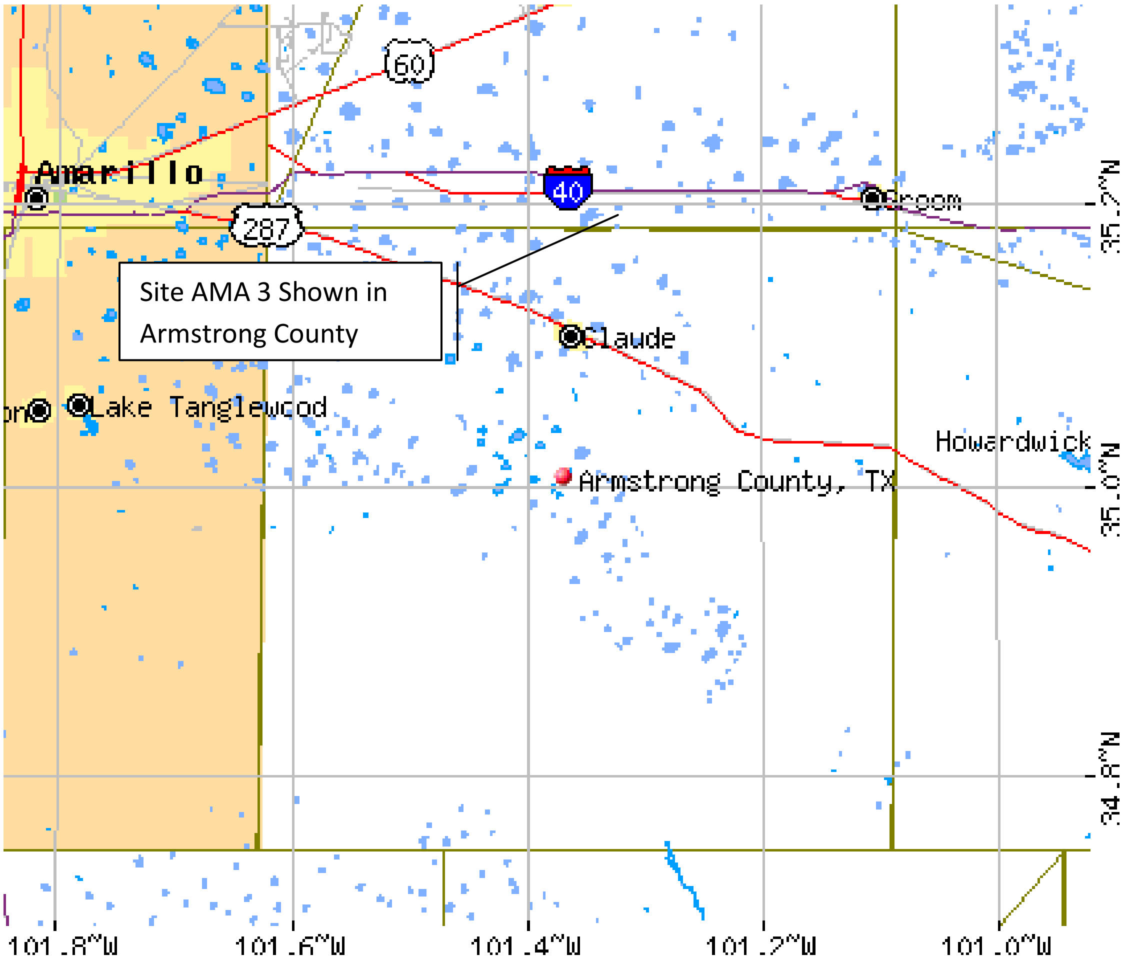
TechMRT arrived on site at 7:50AM. From 8:00AM till 8:30AM TechMRT setup the weather station at TP1 and remarked all test points and the speed sections for the southbound lane. TechMRT performed all pretest from 8:50AM till 10:00AM.

Rampart was present at the site beginning at 8:30AM. They treated the center of the wheel paths with a single pass for the two wheel paths in the speed zones from 10:00AM to 1:20PM. The inside wheel path was only moderately heavily flushed and was treated in the normal amount of time. The outside lane was very heavily flushed. The roadway was covered with as much as 5mm of asphalt. The

degree of flushing caused the vacuum truck to clog. Then because the material was not being removed, the asphalt balled up and stopped the sprayer bar from rotating. This happened with as little as 5 treated feet. The rotation was significantly increased as well as attempts to run the truck very quickly or very slowly. The solution that allowed for marginal progress involved raising the deck, running the sprayer bar at a very rapid rotation, progressing forward very slowly and letting the pavement temperature rise above 70degrees. As the temperature continued to rise, the truck seemed to leave more and more chunks of asphalt behind. The truck was emptied at the side of the road for 1:20PM to 1:40PM. TechMRT did post testing on the speed section from 1:40PM to 2:00PM. Rampart treated the middle of the wheel paths of the inside quarter mile. 1:45PM to 3:20PM. They then emptied the truck and performed final maintenance for the day. TechMRT performed the post testing at the TPs from 2:45PM to 3:30PM. The weather station was packed and TechMRT headed back to hotel. All present members of the TechMRT team then meet briefly at the hotel to plan for the next day's testing. The decision was made to use the last 1/8mile speed section to try an alternate nozzle configuration. The alternate nozzle configuration will be the inverse of the typical configuration. The largest nozzles will be placed in the center of the sprayer bar.
Comments

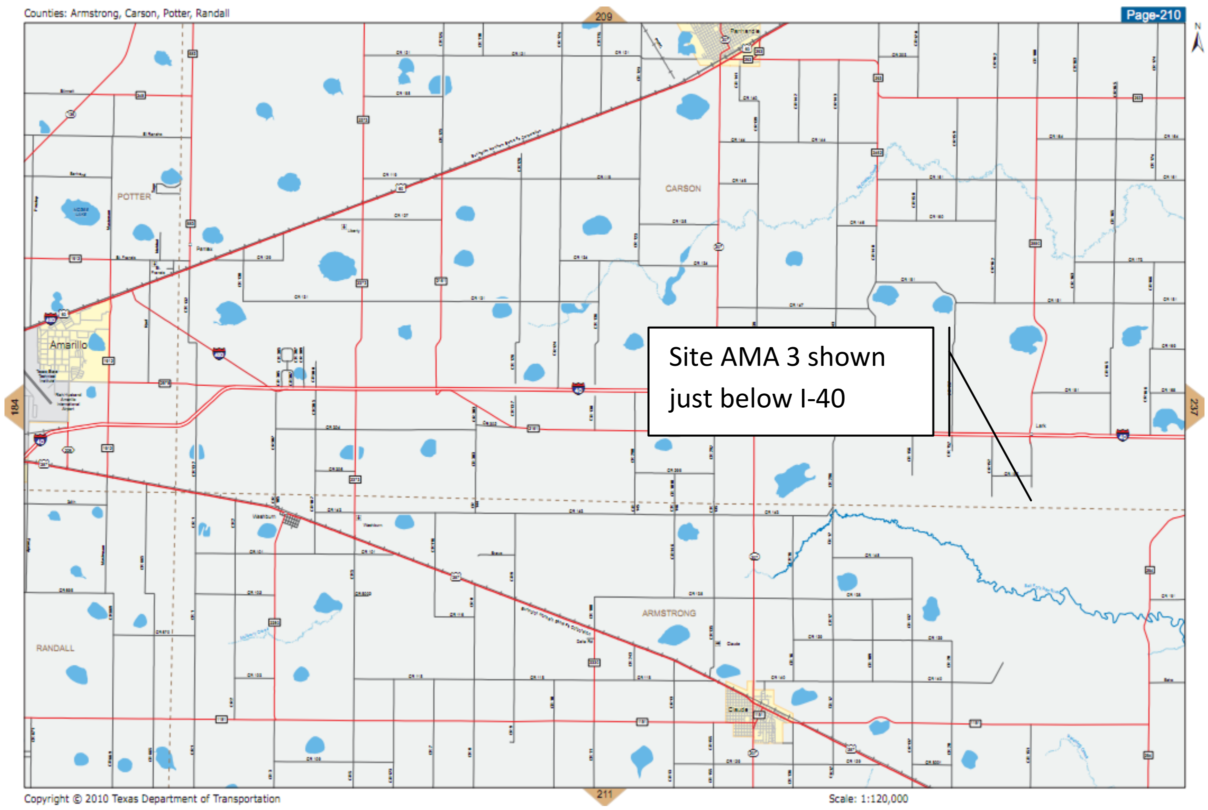
Follow-On Testing Summary	
Date: 8/3/11	Comments: Preformed follow –up monitoring successfully.
Date: 1/18/12	Comments: Preformed follow –up monitoring successfully.
Date	Comments: Preformed follow –up monitoring successfully.

Site Vicinity Map



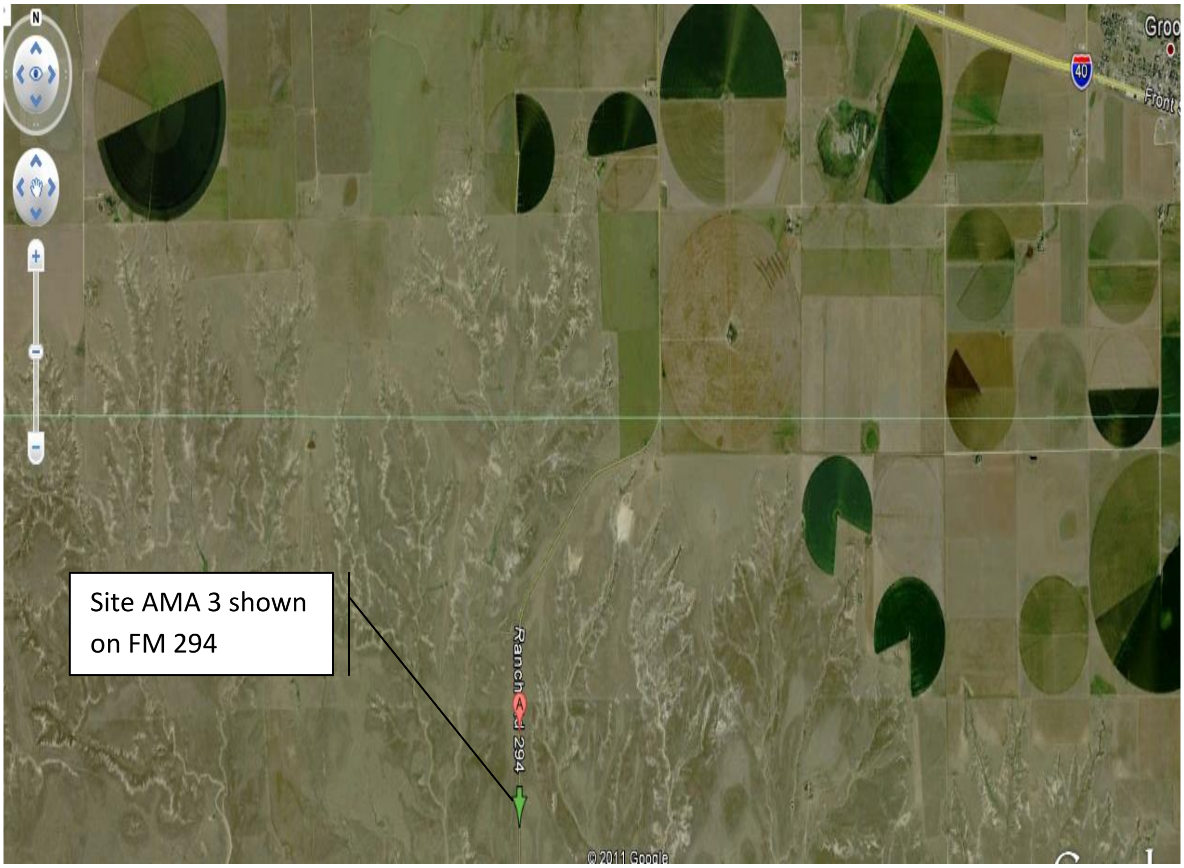
http://www.city-data.com/

Site Location Map



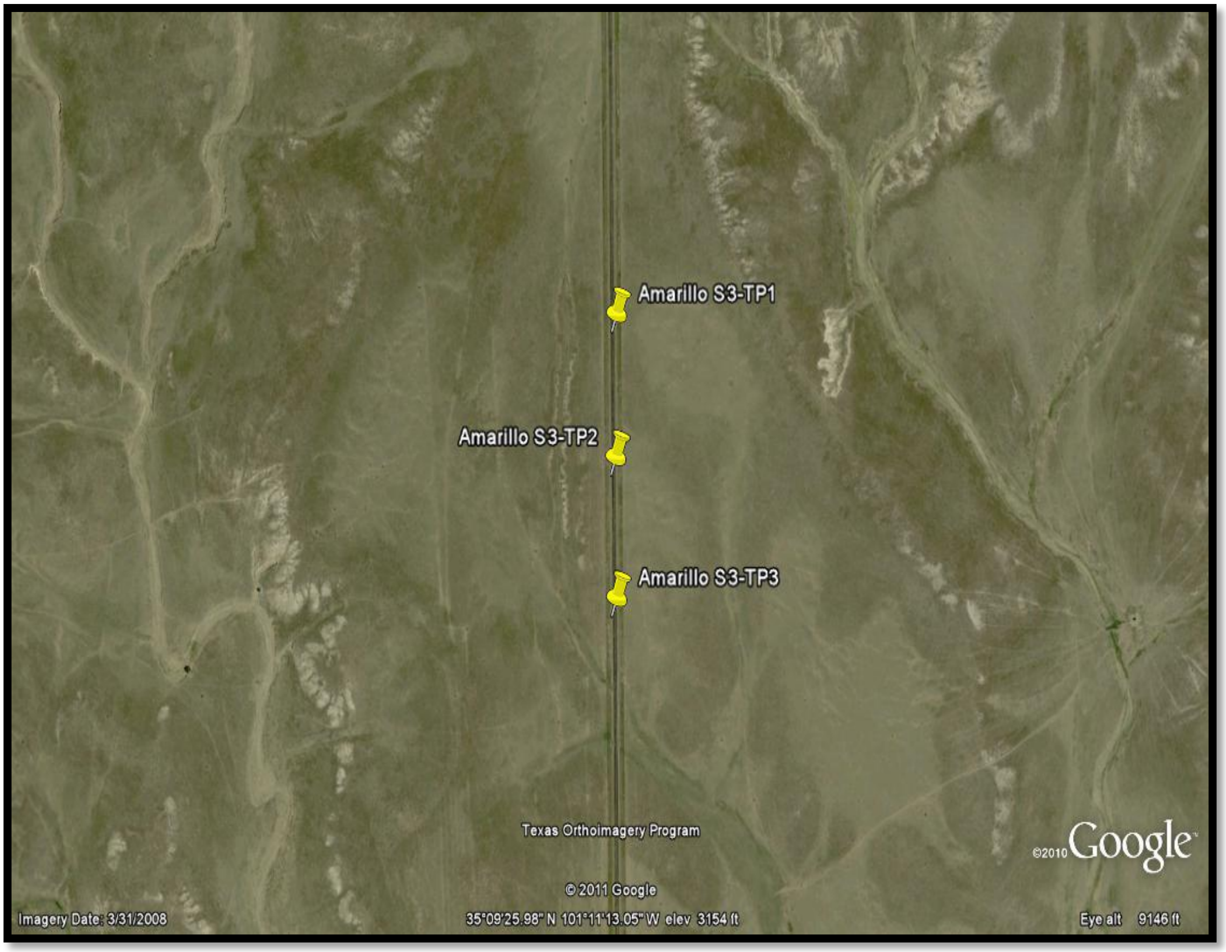
http://www.txdot.gov/travel/county_grid_search.htm

Aerial Photograph



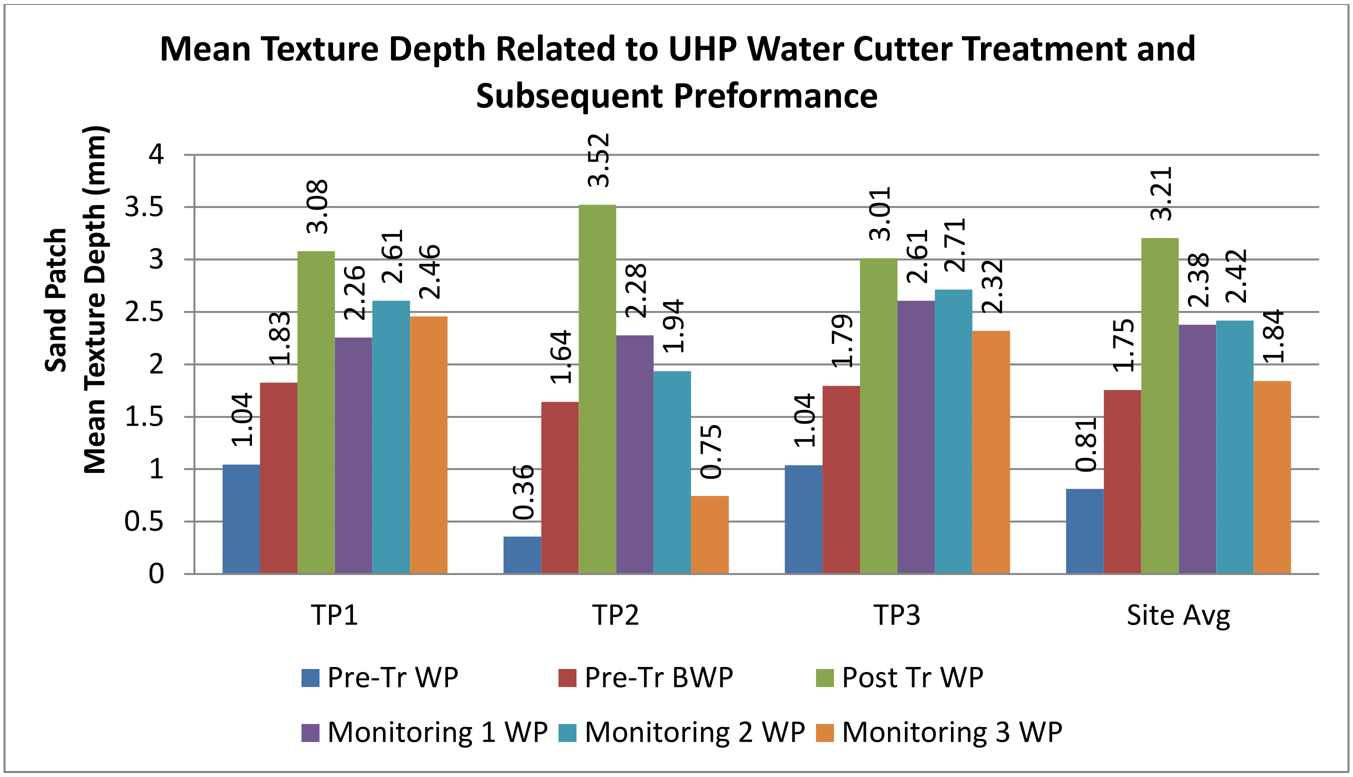
Google Inc. (2011). Google Earth (Version 6.1.0.5001)

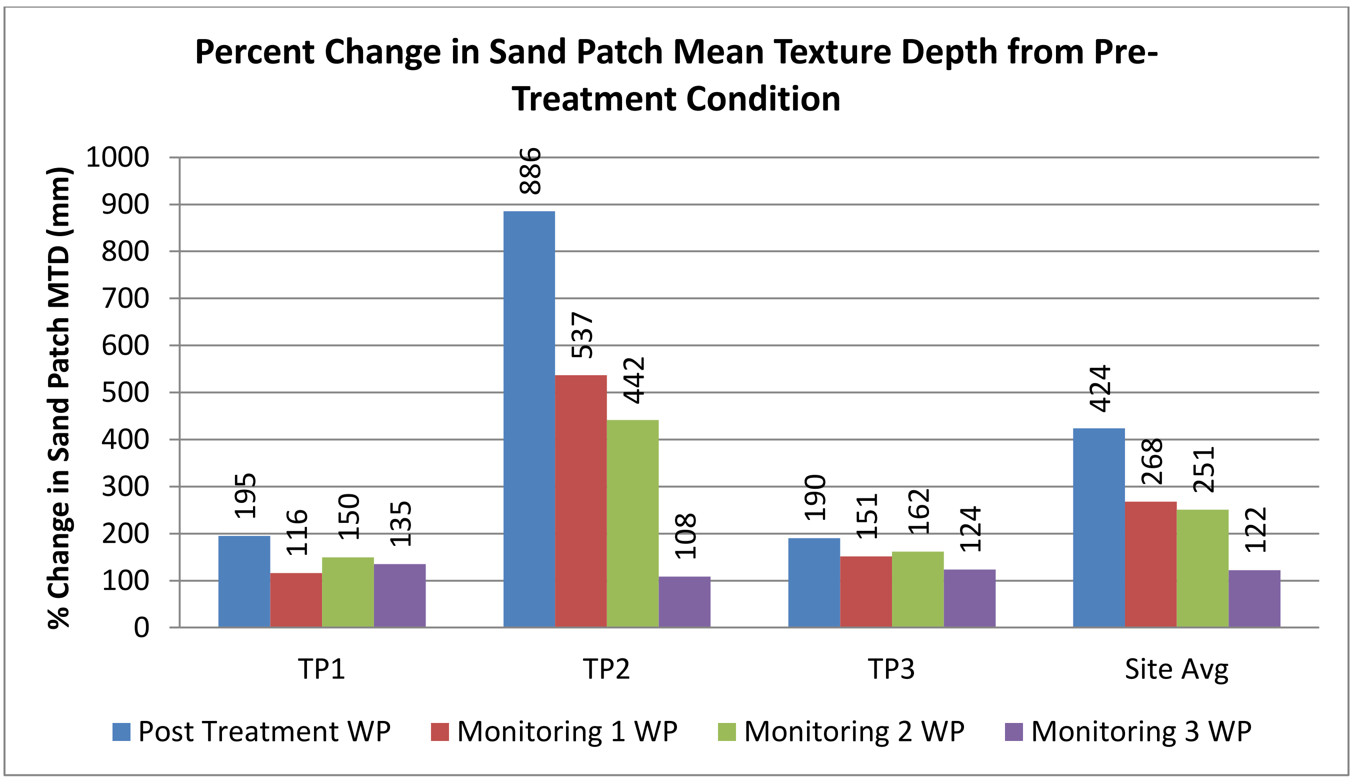
Test Point Plan



Google Inc. (2011). Google Earth (Version 6.1.0.5001)

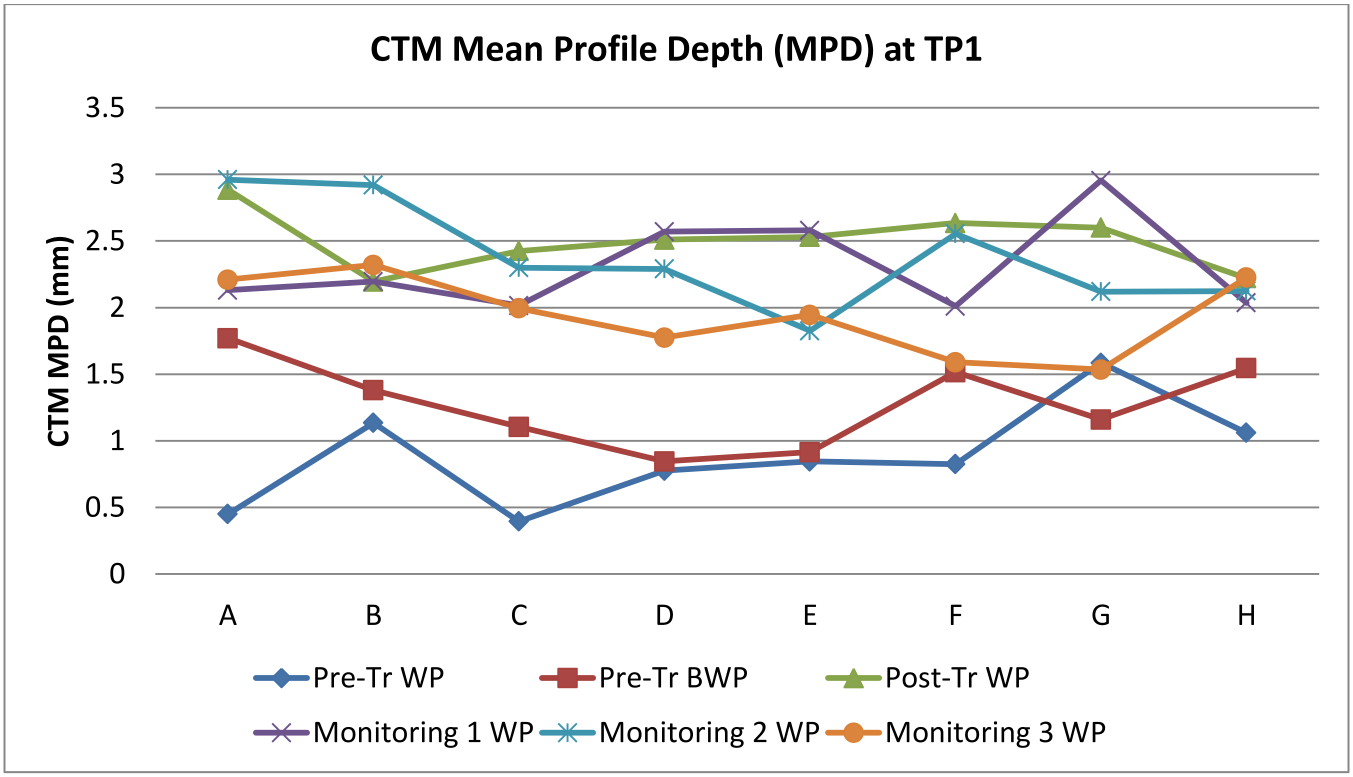
Sand Patch Data





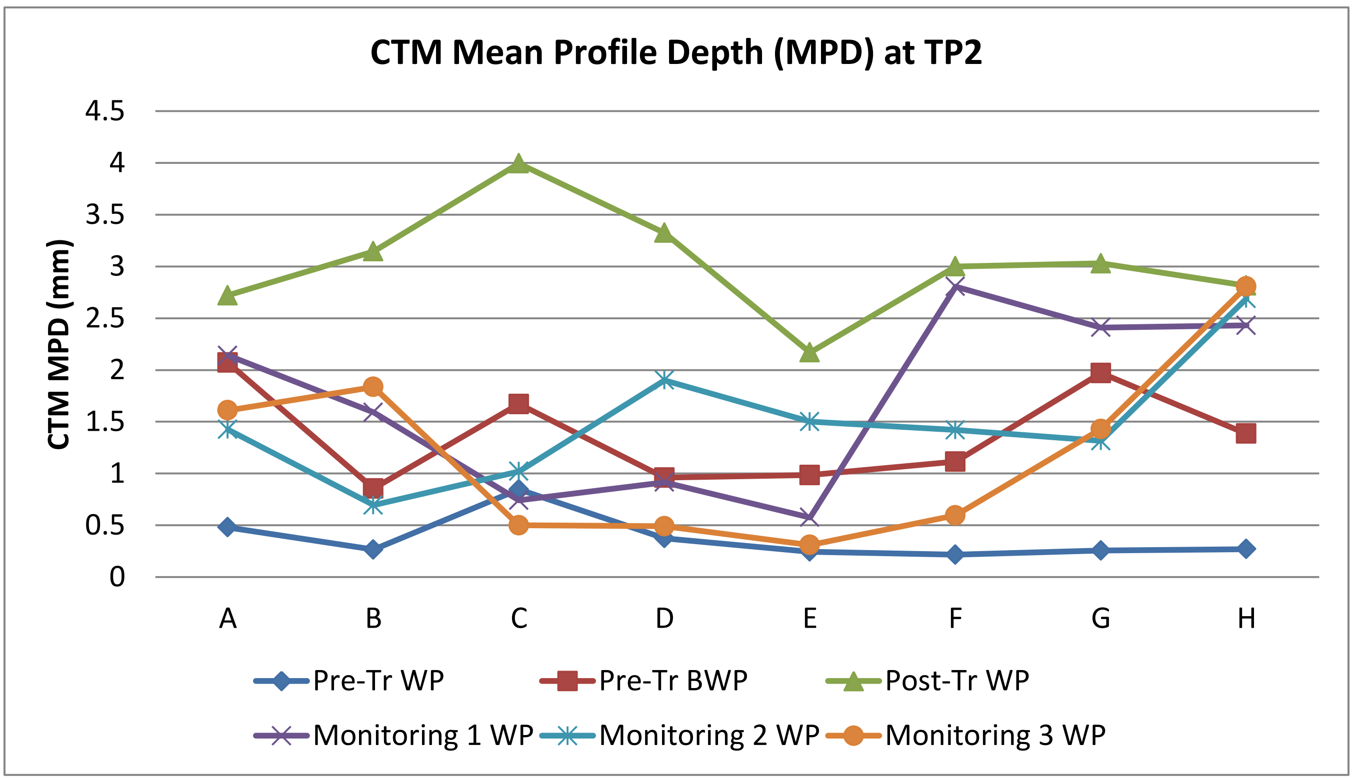
Circular Track Meter (CTM) Mean Profile Depth (in mm) at TP 1

	A	B	C	D	E	F	G	H
Pre-Tr WP	0.45	1.135	0.395	0.775	0.845	0.825	1.585	1.06
Pre-Tr BWP	1.77	1.38	1.105	0.845	0.915	1.515	1.16	1.545
Post-Tr	2.885	2.195	2.425	2.51	2.53	2.635	2.6	2.22
Monitoring 1	2.13	2.195	2.015	2.57	2.58	2.01	2.955	2.035
Monitoring 2	2.96	2.92	2.3	2.29	1.825	2.555	2.12	2.125
Monitoring 3	2.21	2.32	1.995	1.775	1.945	1.59	1.535	2.225



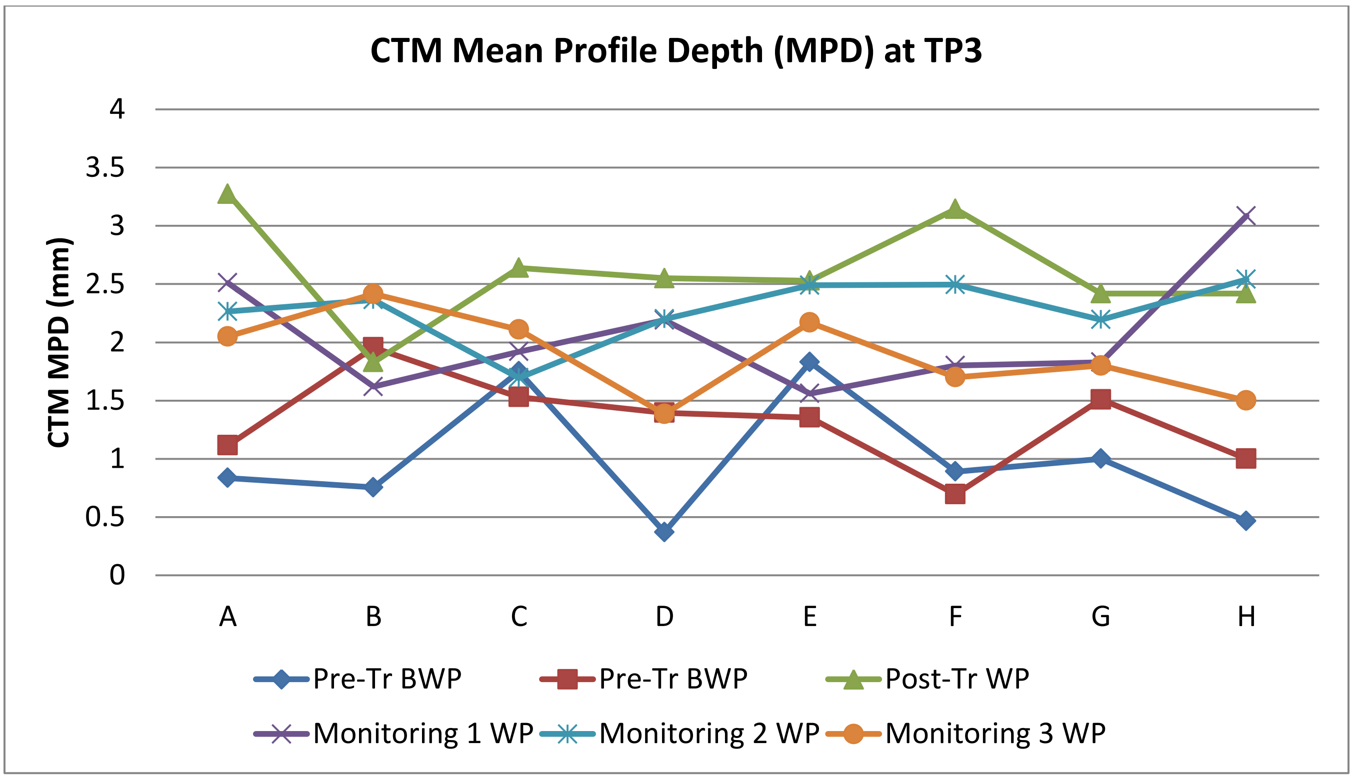
Circular Track Meter (CTM) Mean Profile Depth (in mm) at TP 2

	A	B	C	D	E	F	G	H
Pre-Tr WP	0.48	0.265	0.845	0.375	0.245	0.215	0.255	0.27
Pre-Tr BWP	2.07	0.855	1.67	0.96	0.985	1.115	1.97	1.385
Post-Tr	2.72	3.145	3.995	3.325	2.17	3	3.03	2.815
Monitoring 1	2.14	1.59	0.74	0.915	0.575	2.805	2.41	2.43
Monitoring 2	1.425	0.695	1.02	1.9	1.5	1.42	1.315	2.69
Monitoring 3	1.61	1.835	0.5	0.49	0.31	0.595	1.43	2.805

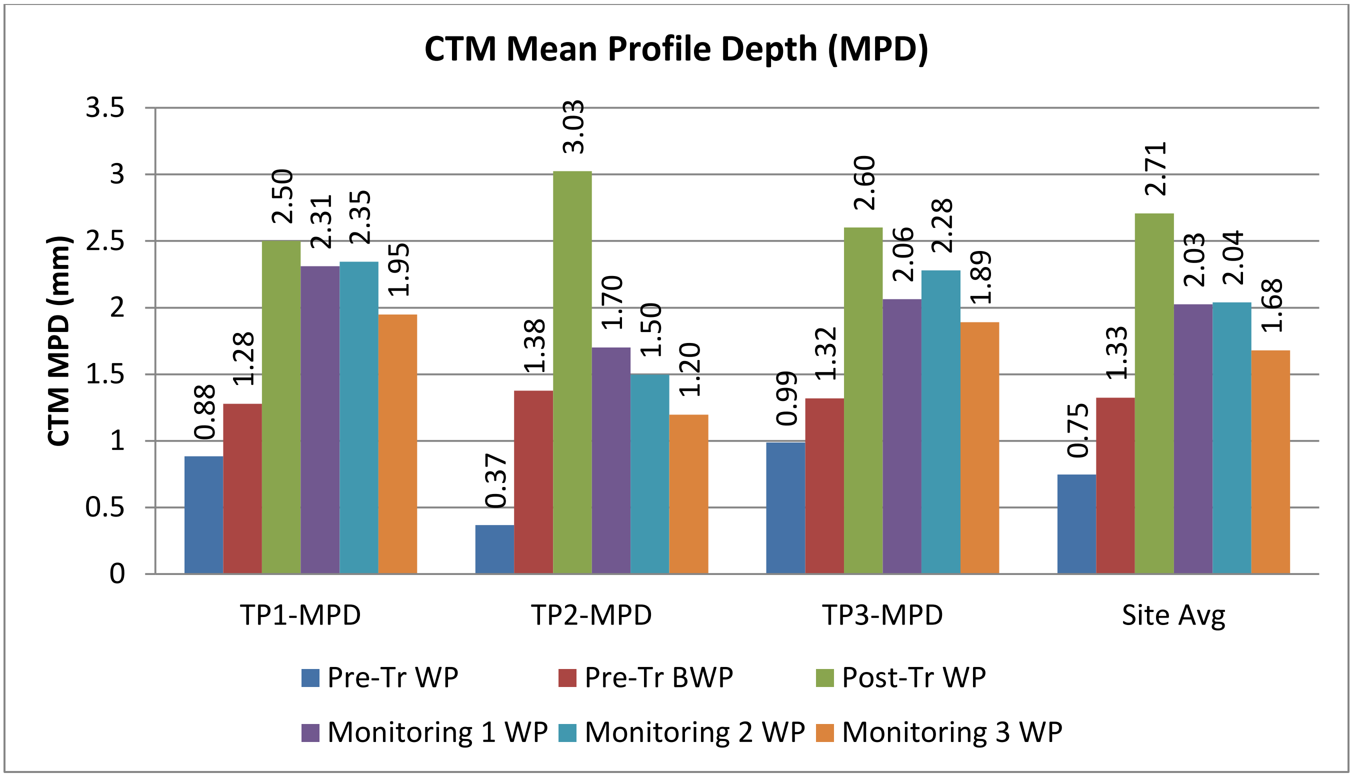


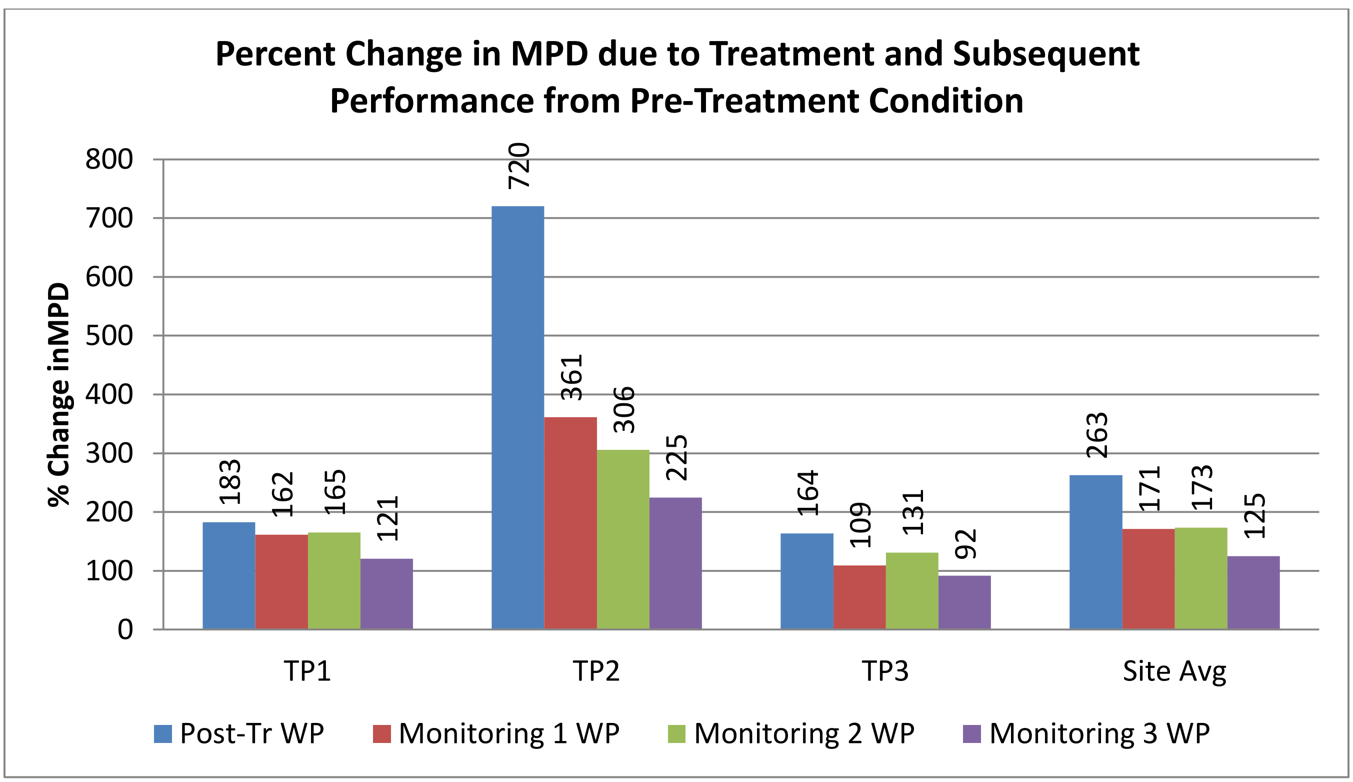
Circular Track Meter (CTM) Mean Profile Depth (in mm) at TP 3

	A	B	C	D	E	F	G	H
Pre-Tr WP	0.835	0.755	1.75	0.37	1.83	0.89	1	0.465
Pre-Tr BWP	1.115	1.955	1.53	1.395	1.355	0.695	1.51	1
Post-Tr	3.275	1.83	2.64	2.55	2.53	3.145	2.42	2.42
Monitoring 1	2.51	1.62	1.92	2.19	1.56	1.8	1.83	3.085
Monitoring 2	2.265	2.365	1.695	2.2	2.49	2.495	2.195	2.54
Monitoring 3	2.05	2.415	2.11	1.385	2.17	1.7	1.8	1.5

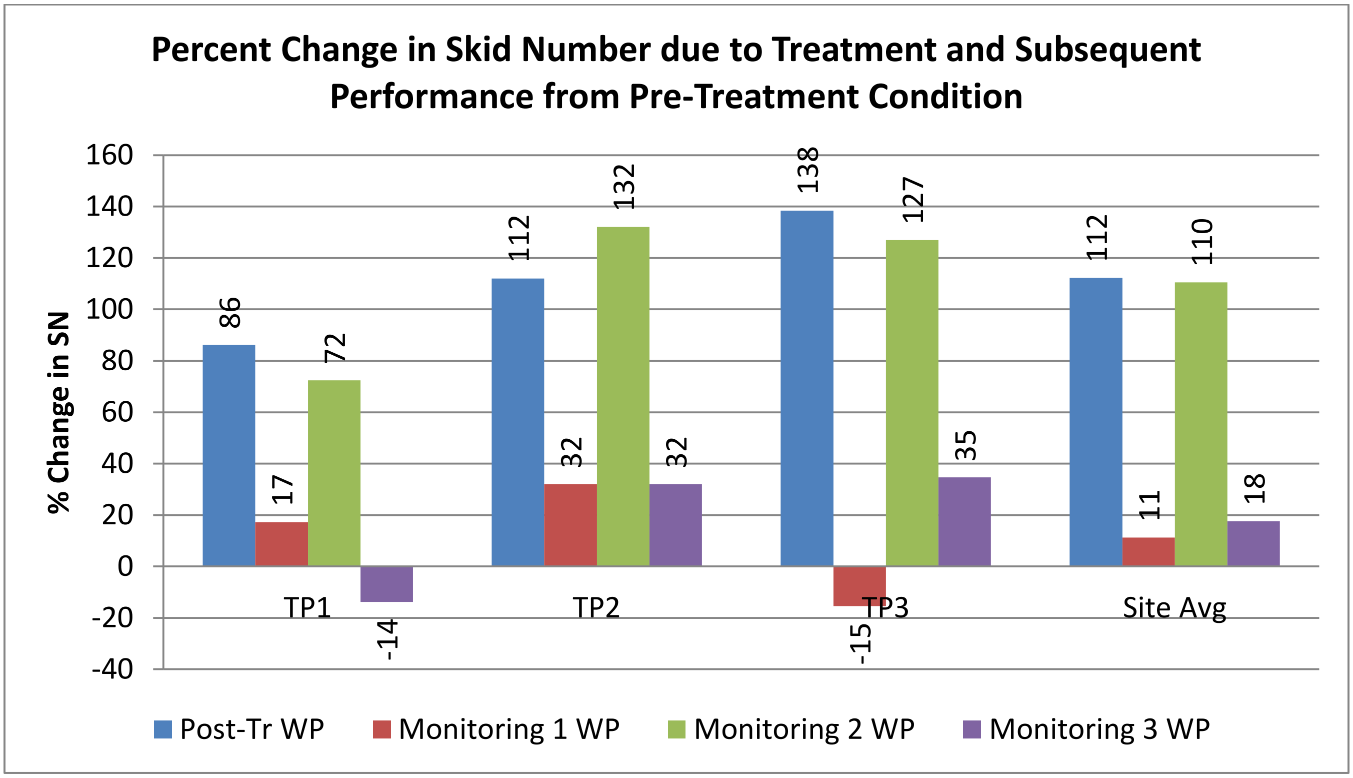


Circular Track Meter (CTM) MPD (mm)



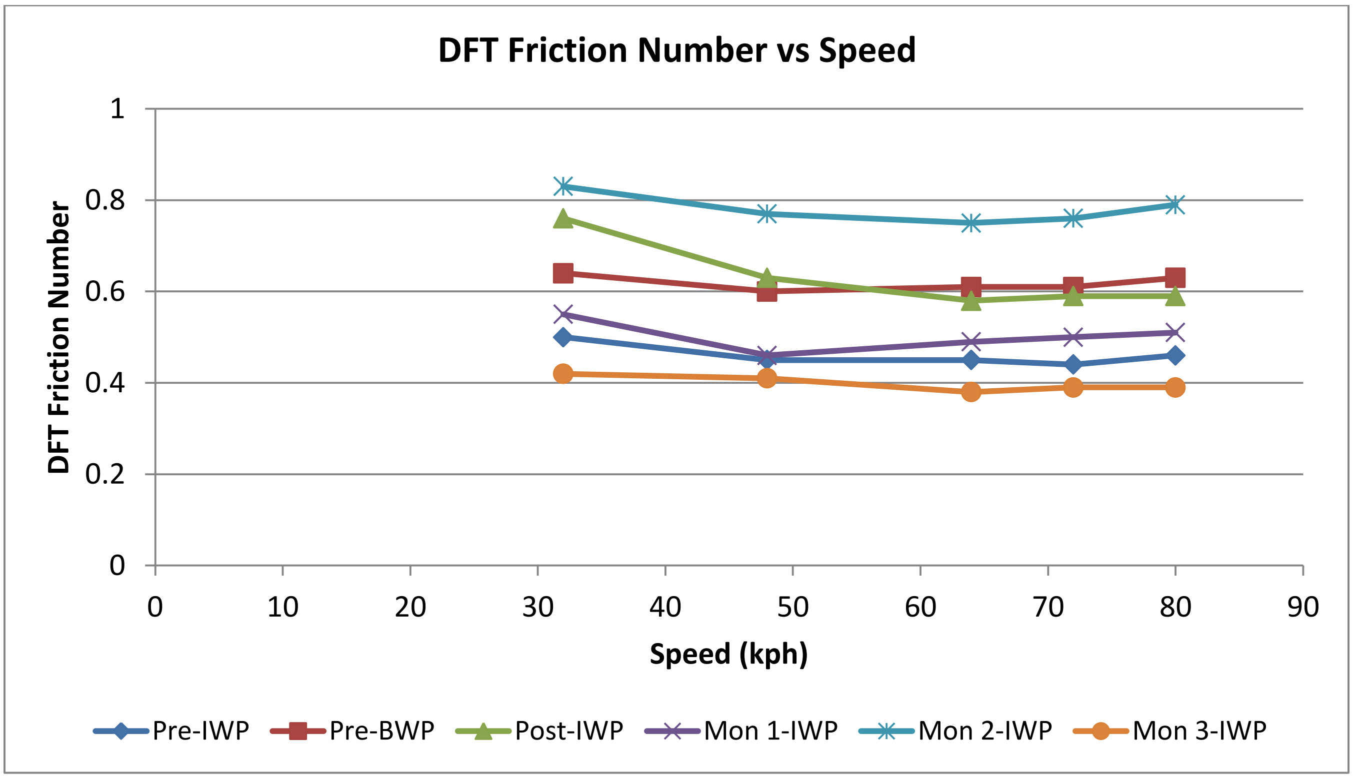


Skid Truck Data



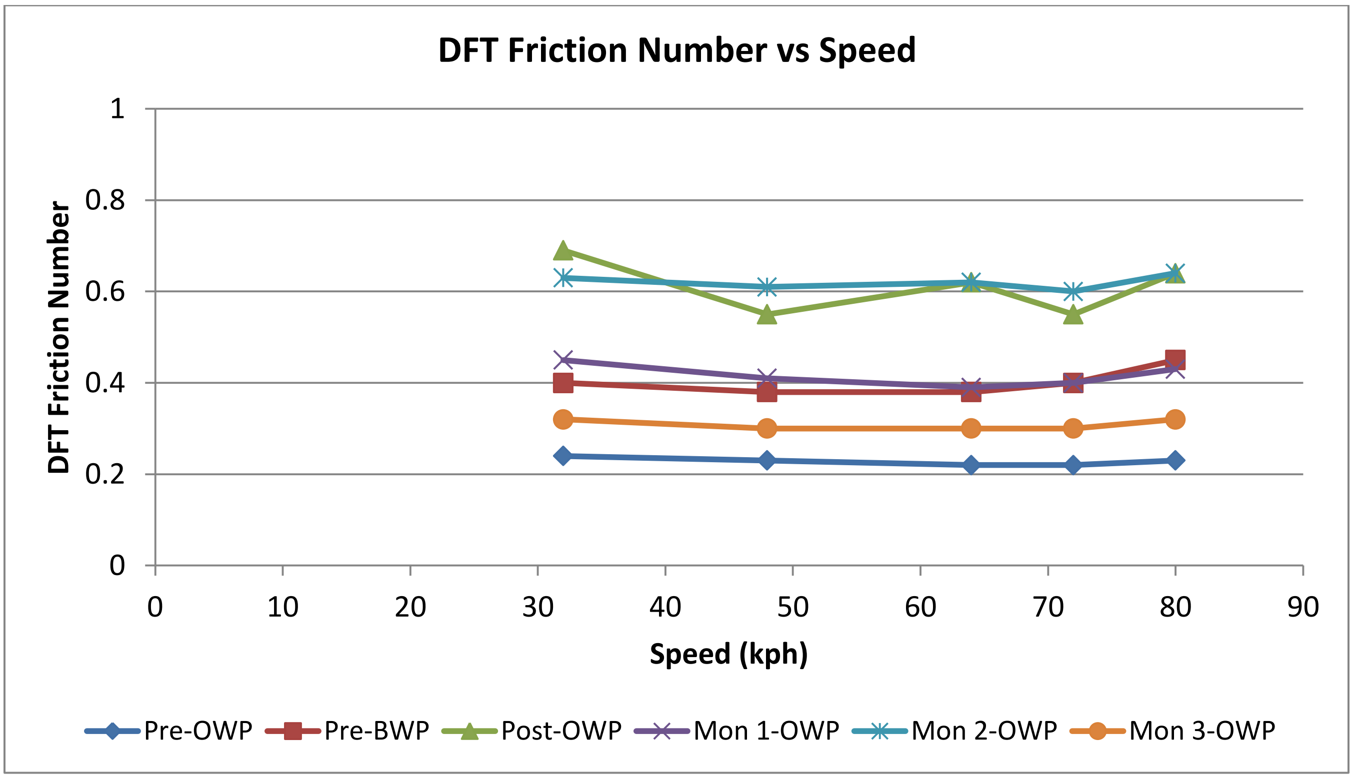
Dynamic Friction Test (DFT) Friction Number Data for TP 1

Speed (kph)	Pre-IWP	Pre-BWP	Post-IWP	Mon 1-IWP	Mon 2-IWP	Mon 3-IWP
32	0.5	0.64	0.76	0.55	0.83	0.42
48	0.45	0.6	0.63	0.46	0.77	0.41
64	0.45	0.61	0.58	0.49	0.75	0.38
72	0.44	0.61	0.59	0.5	0.76	0.39
80	0.46	0.63	0.59	0.51	0.79	0.39



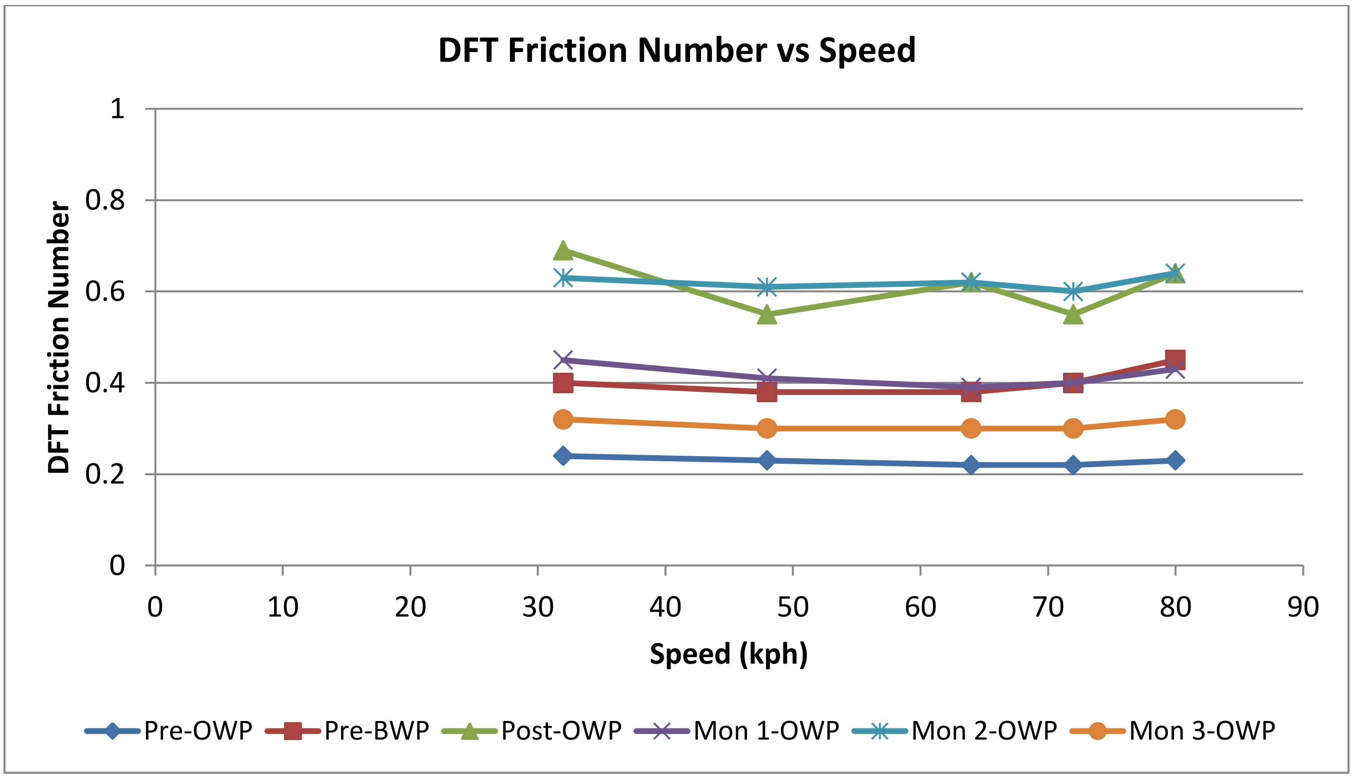
Dynamic Friction Test (DFT) Friction Number Data for TP 2

Speed (kph)	Pre-OWP	Pre-BWP	Post-OWP	Mon 1-OWP	Mon 2-OWP	Mon 3-OWP
32	0.24	0.4	0.69	0.45	0.63	0.32
48	0.23	0.38	0.55	0.41	0.61	0.3
64	0.22	0.38	0.62	0.39	0.62	0.3
72	0.22	0.4	0.55	0.4	0.6	0.3
80	0.23	0.45	0.64	0.43	0.64	0.32



Dynamic Friction Test (DFT) Friction Number Data for TP 3

Speed (kph)	Pre-OWP	Pre-BWP	Post-OWP	Mon 1-OWP	Mon 2-OWP	Mon 3-OWP
32	0.24	0.4	0.69	0.45	0.63	0.32
48	0.23	0.38	0.55	0.41	0.61	0.3
64	0.22	0.38	0.62	0.39	0.62	0.3
72	0.22	0.4	0.55	0.4	0.6	0.3
80	0.23	0.45	0.64	0.43	0.64	0.32



Weather Data during UHP Water Cutter Treatment

Date	Time	Temp Out	Hi Temp	Low Temp	Out Hum	Dew Pt.	Wind Speed	Wind Dir	Wind Run	Hi Speed	Hi Dir	Wind Chill	Heat Index	THW Index	THSW Index
2/28/2011	8:10 AM	32.8	39.4	32.8	51	16.6	7	NNW	1.17	24	NW	26.5	31.9	25.6	---
2/28/2011	8:20 AM	29.2	32.6	29.2	59	16.6	16	NNW	2.67	23	NNW	17.6	28.6	17	---
2/28/2011	8:30 AM	29.6	29.6	29.2	58	16.6	16	NNW	2.67	22	NW	18.1	28.9	17.4	---
2/28/2011	8:40 AM	30.6	30.6	29.6	56	16.7	15	NNW	2.5	23	NNW	19.8	29.9	19.1	---
2/28/2011	8:50 AM	31.8	31.8	30.6	54	17	15	NW	2.5	21	NW	21.3	31	20.5	---
2/28/2011	9:00 AM	33.3	33.3	31.8	51	17.1	11	NW	1.83	17	NNW	24.9	32.4	24	---
2/28/2011	9:10 AM	34.4	34.4	33.3	49	17.2	11	NW	1.83	18	NNW	26.2	33.5	25.3	---
2/28/2011	9:20 AM	35.2	35.2	34.4	47	17	11	NW	1.83	17	NW	27.2	34.2	26.2	---
2/28/2011	9:30 AM	36	36	35.2	46	17.2	9	NW	1.5	15	NW	29.2	34.9	28.1	---
2/28/2011	9:40 AM	36.9	36.9	36.1	45	17.5	10	NNW	1.67	15	NNW	29.8	35.8	28.7	---
2/28/2011	9:50 AM	38	38	36.9	43	17.5	11	NW	1.83	18	NW	30.7	36.9	29.6	---
2/28/2011	10:00 AM	39.7	39.7	38	42	18.5	9	NW	1.5	15	NW	33.7	38.4	32.4	---
2/28/2011	10:10 AM	40.5	40.5	39.6	40	18	8	WNW	1.33	14	WNW	35.2	39.2	33.9	---
2/28/2011	10:20 AM	41.2	41.2	40.4	40	18.7	9	NW	1.5	15	NW	35.5	39.8	34.1	---
2/28/2011	10:30 AM	42	42	41.2	37	17.6	10	NW	1.67	17	NW	36	40.5	34.5	---
2/28/2011	10:40 AM	43	43	42	36	17.8	10	NW	1.67	15	NW	37.1	41.4	35.5	---
2/28/2011	10:50 AM	43.4	43.4	43	33	16.2	9	NW	1.5	14	NW	38.1	41.8	36.5	---
2/28/2011	11:00 AM	45.4	45.4	43.5	31	16.5	9	NW	1.5	14	NW	40.5	43.7	38.8	---
2/28/2011	11:10 AM	46	46	45.4	32	17.7	9	NW	1.5	14	WNW	41.2	44.3	39.5	---
2/28/2011	11:20 AM	46.3	46.5	46	31	17.3	7	NW	1.17	13	NNW	42.8	44.5	41	---
2/28/2011	11:30 AM	47.5	47.5	46.3	30	17.6	7	NNW	1.17	13	N	44.2	45.7	42.4	---
2/28/2011	11:40 AM	48.1	48.3	47.4	30	18.1	6	NNW	1	11	NNW	45.4	46.2	43.5	---
2/28/2011	11:50 AM	49.4	49.4	48.2	29	18.4	6	NW	1	10	N	47	47.5	45.1	---
2/28/2011	12:00 PM	50	50.1	49.1	28	18.1	5	NNW	0.83	10	NNW	48.2	48	46.2	---
2/28/2011	12:10 PM	50.4	50.4	49.9	28	18.5	3	NNW	0.5	10	NNW	50.1	48.3	48	---

2/28/2011	12:20 PM	51.5	51.5	50.4	27	18.6	3	NNW	0.5	6	WNW	51.4	49.1	49	---
2/28/2011	12:30 PM	51.4	51.8	51.4	26	17.6	3	NW	0.5	8	NNW	51.2	48.9	48.7	---
2/28/2011	12:40 PM	51	51.4	50.6	26	17.3	2	NNE	0.33	5	ENE	51	48.7	48.7	---
2/28/2011	12:50 PM	53.3	53.6	51	25	18.3	3	W	0.5	7	WNW	53.3	50.3	50.3	---
2/28/2011	1:00 PM	54.9	54.9	53	24	18.7	2	S	0.33	7	SE	54.9	51.5	51.5	---
2/28/2011	1:10 PM	55.3	55.3	54.3	24	19.1	3	ESE	0.5	8	SSE	55.3	51.8	51.8	---
2/28/2011	1:20 PM	54.6	55.4	54.4	24	18.5	3	SSE	0.5	7	SSW	54.6	51.3	51.3	---
2/28/2011	1:30 PM	54.7	56.2	54.6	24	18.6	3	SSE	0.5	8	ESE	54.7	51.3	51.3	---
2/28/2011	1:40 PM	55.6	56	54.8	23	18.3	3	SE	0.5	8	SE	55.6	52	52	---
2/28/2011	1:50 PM	54.9	56	54.9	23	17.7	3	ESE	0.5	6	SSE	54.9	51.4	51.4	---
2/28/2011	2:00 PM	55.8	56	54.8	23	18.5	2	SE	0.33	6	SE	55.8	52.2	52.2	---
2/28/2011	2:10 PM	57.2	57.2	55.8	22	18.6	3	E	0.5	8	ESE	57.2	53.2	53.2	---
2/28/2011	2:20 PM	58.1	58.6	57.2	21	18.3	3	SW	0.5	7	SSE	58.1	53.9	53.9	---
2/28/2011	2:30 PM	58.6	58.6	57.9	22	19.8	5	SE	0.83	11	SE	58.3	54.4	54.1	---
2/28/2011	2:40 PM	59.6	59.7	58.7	21	19.6	5	S	0.83	9	SE	59.5	55.2	55.1	---
2/28/2011	2:50 PM	59.7	60	59.5	21	19.6	5	S	0.83	9	SSE	59.6	55.3	55.2	---
2/28/2011	3:00 PM	60.3	60.9	59.8	20	19	7	SSW	1.17	12	SSW	59.6	55.7	55	---
2/28/2011	3:10 PM	60.5	60.7	59.7	21	20.3	6	SSW	1	11	WSW	60.2	56	55.7	---
2/28/2011	3:20 PM	61.6	61.7	60.2	20	20.1	5	SSE	0.83	12	S	61.6	56.8	56.8	---
2/28/2011	3:30 PM	61.5	61.6	61.1	20	20	7	SW	1.17	13	SSW	61.1	56.8	56.4	---
2/28/2011	3:40 PM	61	61.9	61	20	19.6	6	SSW	1	12	S	60.8	56.3	56.1	---
2/28/2011	3:50 PM	70.4	70.4	60.6	17	23.5	0	SSW	0	5	SSW	70.4	65.7	65.7	---

Site Photographs

Figure XX. BMT3 Pictures (a) highway and location; (b) close-up of flushed surface before treatment; (c) roadway surface before treatment; (d) close-up of flushed surface immediately after treatment; (e) roadway surface after treatment; (f) close-up of surface at first follow-up ; (g) roadway surface at first follow-up , (h) roadway surface at second follow-up ; (i) close-up of surface at second follow-up , (j) close-up of surface at third follow-up ; (k) roadway surface at third follow-up

(a)

(b)

(c)

(d)

(e)

(f)

(g)

(h)		(i)	
(j)		(k)	

DRAFT Specifications

DRAFT Equipment Specifications

ITEM
EQUIPMENT FOR TREATMENT OF FLUSHED ASPHALT PAVEMENT

###.1 Description. Provide equipment and qualified operator to treat flushed asphalt pavement surfaces using ultra high pressure water jet technology as directed by the Engineer.

###.2 Ultra High Pressure Water Cutting Equipment. Equipment shall be capable of treating pavement surfaces showing various levels of flushing (moderate to severe) without damage to the pavement surface from the ultra high pressure water jets. Equipment shall provide continuous, uniform production as follows:

A. **Self-contained Vehicle.** The equipment used for ultra high pressure treatment of flushed pavement surfaces shall be licensed to travel on the public roadway and capable of traveling at highway speeds. The roadway treatment vehicle shall self-contained for treatment of flushed pavements and shall contain an ultra-high pressure water pump, spray head, vacuum system, water supply tank, and waste storage and disposal system.

B. **Ultra High Pressure Pump.** The ultra high pressure pump shall be capable of delivering a minimum of 16 gpm while operating at 36,000 psi. Alternative pump specifications will be considered, subject to approval by the Engineer.

C. **Multi-jet Spray Head.** The roadway treatment vehicle shall have a multi-jet spray head, which is capable of rotating at 2,000 rpm. The spray head shall be a minimum of 24 inches wide and contain a minimum of 28 nozzles. Alternative spray head specifications will be considered, subject to approval by the Engineer.

D. **Vacuum Equipment.** The vacuum system shall be connected directly to the multi-jet spray head and shall be capable of removing asphalt binder, granular debris and water from the treated pavement surface. Material collected during the vacuuming operation shall be discharged to a waste storage system. Vacuum equipment shall provide a minimum suction pressure of 12 inches of mercury at a flow rate of 1,900 cubic feet per minute and shall be of sufficient capacity to collect all pavement treatment debris and waste water from the roadway surface. Alternative vacuum system specifications will be considered, subject to approval by the Engineer.

E. **Water Reservoir and Waste Storage.** The roadway treatment vehicle shall be capable of carrying sufficient water to operate continuously for a minimum of four hours. The vehicle shall have equivalent storage capacity for waste that is vacuumed from the roadway surface. Alternative water reservoir and waste storage specifications will be considered, subject to approval by the Engineer.

F. **Production Capability.**

   1. **Safety.** All equipment shall be safe and shall meet or exceed applicable OSHA requirements including but not limited to signage, warning lights, and safety shut-offs.

2. **Vehicle Alignment.** The treatment vehicle shall be capable of production within the limits of one traffic lane such that the treatment vehicle does not disrupt movement of traffic in the adjoining lane. The spray head shall be located such that the treated area is not directly in line with and followed by the treatment vehicle tires.
3. **Vehicle Speed.** The roadway treatment vehicle shall have an independent drive, separate from the truck transmission, capable of infinitely varying the forward speed of the truck from 0 to 7 mph during surface treatment. The drive system shall be capable of maintaining forward ground speed within 0.1mph of pre-set target speed, over roadway slopes of +/- 3 percent grade.
4. **On the Go Adjustment.** The ultra high pressure treatment system including vehicle speed, spray bar rotation speed, vacuum system pressure, and waste material removal shall be capable of adjustment on the go as needed to maintain quality of the treatment process.
5. **Treatment Area Visibility**. The treatment area adjacent to and behind the cutting head shall be continuously visible to the operator (line of sight or high-resolution video camera) or observer with sufficient detail to facilitate identification of any treatment anomalies.
6. **Avoid Pavement Damage**. The work shall be performed without causing damage to the pavement surface; for example, raveling of aggregate or localized removal of the asphalt seal that exposes the underlying base or pavement layer. Work shall not damage existing delineation features such as pavement striping or raised pavement markers.
7. **Ultra High Pressure Pump System.** The ultra high pressure pump, spray head, and vacuum system shall be capable of treating a minimum of 550 square yards per hour.

G. **Calibration and Monitoring.** The roadway treatment vehicle shall be equipped with instrumentation to facilitate calibration, monitor treatment effectiveness, and capture treatment production data. Instrument gages shall be visible to the operator at all times. Gage readings shall be benchmarked to time (daily work shift), and capable of continuous measurement and recording as follows:

1. Forward ground speed, certified reliable to 0.1mph over a range of 0.1mph to 7.0mph.
2. Spray bar rotational speed, certified reliable to 10 rpm over a range of 100 rpm to 2,000 rpm.
3. Ultra high pressure pump system pressure, measured as follows:
    i. At the pump, certified reliable to 100 psi over a range of 5,000 psi to 50,000 psi.
    ii. At the spray head, certified reliable to 100 psi over a range of 5,000 psi to 50,000 psi.
4. Pavement temperature, measured in front of the cutting head, certified reliable to 1°F over a range of 0°F to 165°F.
5. Water storage tank level, certified reliable to 100 gallons over the full tank capacity range.

6. Ultra high pressure pump usage, in hours, certified reliable to 0.1 hour.

H. **Routine Equipment Maintenance.** Contractor shall keep equipment in good repair, clean, and free of leaks. Contractor shall maintain, on the roadway treatment vehicle, an inventory of common wear parts and replacement accessories for equipment adequate to ensure that routine maintenance tasks can be performed without delay to the project schedule.

I. **Non-conforming Work.** If in the sole opinion of the Engineer the ultra high pressure cleaning equipment does not produce satisfactory results or if the equipment cannot maintain the specified pressure and flow rates or production rates during the trial, then the Engineer will require that the equipment be removed from the project and replaced with equipment that can meet the requirements of the specifications. No additional time will be allowed for failure to bring the proper equipment to the project. Any substitute equipment must first be tested as described herein prior to acceptance for the project.

###.3 Operator for Ultra High Pressure Water Cutter Equipment. The ultra high pressure water cutting equipment shall only be operated by personnel who are qualified by sufficient training and experience. Desired qualifications are identified below, with minimum qualifications established by the Engineer.

A. **Operator Training.** The operator shall be trained in the proper use and safety of the equipment and shall be certified as such by the equipment manufacturer.

B. **Operator Experience.** The operator shall have a minimum of two years ultra high pressure water cutting equipment operation experience on jobs of similar type and size.

C. **Company Experience.** The company for whom the operator is employed shall have successfully completed at least four similar projects within the past two years.

###.4 Contractor Responsibility. The Contractor shall submit the following:

A. **Post-Award Submittals.** To be awarded this contract, the following submittals are required:

1. Submit manufacturer's specification for ultra high pressure equipment including operating procedures and parameters. Include the operating pressures, water flow rate and production capabilities when used for similar applications.
2. Submit the manufacturer's specification for the vacuum system.
3. Submit contractor's equipment safety features and safety program.
4. Submit documentation that the operator of the ultra high pressure equipment has been trained and certified in the safe and proper use of the equipment by the manufacturer and that he/she has at least two years experience operating the equipment.

5. Submit verification that the company responsible for performing the work described in this specification has performed similar work. Submit documentation for at least four similar projects performed within the past two years. Include the name of the project, location, area treated, before and after treatment images, project duration, production rates, owner name, and the name and phone number of the individual responsible for overseeing the work performed.

B. **Daily Submittals.** The operator shall submit a daily production report that addresses the following:
   1. Project name, location, and treatment area.
   2. Total daily equipment use for treatment including travel time between sites (hours).
   3. Square yards of flushed pavement successfully treated.
   4. Target treatment settings:
      a) Forward ground speed
      b) Nozzle configuration
      c) Spray bar rotational speed
      d) Water pressure at the pump
      e) Water pressure at the spray head
   5. Instrument data recording of actual system performance during operation, benchmarked to time (daily work shift):
      a) Forward ground speed
      b) Spray bar rotational speed
      c) Water pressure at the pump
      d) Water pressure at the spray head
      e) Pavement temperature
      f) Water storage tank level
      g) Ultra high pressure system pump usage
   6. Documentation of time used for filling the water tanks and dumping waste.
   7. Documentation of any equipment idle time and downtime.
   8. Documentation of any pavement damage caused by the treatment.

###.5 Measurement and Payment.

A. **Measurement.** Equipment use will be measured by the actual number of hours the equipment is operated for treatment of flushed pavement surfaces Time starts when the UHP water cutting equipment arrives at the first project treatment site for the day and ends when the equipment departs from the last treatment site for the day, less any down-time.

B. **Payment.** The work performed in accordance with this Item and measured as provided under “Measurement” will be paid for at the unit prices bid for “Equipment for Treatment of Flushed Asphalt Pavement" for the number of treatment hours per day worked. A site number or numbers will be specified corresponding to the detail location description in the plans when multiple sites are bid separately. This price is full compensation for furnishing and operating equipment including labor, tools, reporting, and incidentals.

DRAFT Process Specifications

ITEM ###
TREATMENT OF FLUSHED ASPHALT PAVEMENT USING ULTRA HIGH PRESSURE WATER CUTTING

###.1 Description. Provide all materials, equipment, labor, and supervision necessary to restore the macrotexture of flushed pavement surfaces as indicated on the drawings and specifications or as directed by the Engineer. The method of treatment shall consist of ultra high pressure water cutting with work defined as square yard of treatment.

###.2 Materials. Materials shall consist of potable water used to restore macrotexture to the flushed pavement surface, and waste debris and solid debris resulting from the water cutting operation.

A. **Water**
   1. **Source.** Water used for the ultra high pressure water cutting operation shall be furnished by Contractor. The Contractor is responsible for supplying all permits, equipment and tools necessary to tap into the water source.
   2. **Quality.** Water shall be potable water obtained from a fire hydrant, municipal source or well. Lake or river water will not be allowed. The use of chemicals, abrasive materials, grinders, detergents or salt water will not be allowed.

B. **Waste Debris**
   1. **Source.** Waste vacuumed from the pavement surface shall consist of water, asphalt binder, and aggregate obtained from the ultra high pressure water cutting operation.
   2. **Disposal.** The Contractor shall provide or designate approved dump site(s) where the Contractor shall dispose of waste debris.

C. **Solid Debris**
   1. **Source.** Solid material remaining on the pavement surface after the ultra high pressure water cutting treatment, such as clumps of asphalt binder and aggregate, shall be removed and collected for disposal.
   2. **Disposal.** The Contractor shall dispose of solid waste at approved dump site(s).

###.3 Ultra High Pressure Water Cutting Equipment. Equipment shall be capable of treating pavement surfaces showing various levels of flushing (moderate to severe) without damage to the pavement surface from the ultra high pressure water jets. Equipment shall provide continuous, uniform production as follows:

A. **Self-contained Vehicle.** The equipment used for ultra high pressure treatment of flushed pavement surfaces shall be licensed to travel on the public roadway and capable of traveling at highway speeds. The roadway treatment vehicle shall self-contained for treatment of flushed pavements and shall contain an ultra-high pressure water pump, spray head, vacuum system, water supply tank, and waste storage and disposal system.

B. **Ultra High Pressure Pump.** The ultra high pressure pump shall be capable of delivering a minimum of 16 gpm while operating at 36,000 psi. Alternative pump specifications will be considered, subject to approval by the Engineer.

C. **Multi-jet Spray Head.** The roadway treatment vehicle shall have a multi-jet spray head, which is capable of rotating at 2,000 rpm. The spray head shall be a minimum of 24 inches wide and contain a minimum of 28 nozzles. Alternative spray head specifications will be considered, subject to approval by the Engineer.

D. **Vacuum Equipment.** The vacuum system shall be connected directly to the multi-jet spray head and shall be capable of removing asphalt binder, granular debris and water from the treated pavement surface. Material collected during the vacuuming operation shall be discharged to a waste storage system. Vacuum equipment shall provide a minimum suction pressure of 12 inches of mercury at a flow rate of 1,900 cubic feet per minute and shall be of sufficient capacity to collect all pavement treatment debris and waste water from the roadway surface. Alternative vacuum system specifications will be considered, subject to approval by the Engineer.

E. **Water Reservoir and Waste Storage.** The roadway treatment vehicle shall be capable of carrying sufficient water to operate continuously for a minimum of four hours. The vehicle shall have equivalent storage capacity for waste that is vacuumed from the roadway surface. Alternative water reservoir and waste storage specifications will be considered, subject to approval by the Engineer.

F. **Production Capability.**

1. **Safety.** All equipment shall be safe and shall meet or exceed applicable OSHA requirements including but not limited to signage, warning lights, and safety shut-offs.
2. **Vehicle Alignment.** The treatment vehicle shall be capable of production within the limits of one traffic lane such that the treatment vehicle does not disrupt movement of traffic in the adjoining lane. The spray head shall be located such that the treated area is not directly in line with and followed by the treatment vehicle tires.
3. **Vehicle Speed.** The roadway treatment vehicle shall have an independent drive, separate from the truck transmission, capable of infinitely varying the forward speed of the truck from 0 to 7 mph during surface treatment. The drive system shall be capable of maintaining forward ground speed within 0.1mph of pre-set target speed, over roadway slopes of +/- 3 percent grade.
4. **On the Go Adjustment.** The ultra high pressure treatment system including vehicle speed, spray bar rotation speed, vacuum system pressure, and waste material removal shall be capable of adjustment on the go as needed to maintain quality of the treatment process.
5. **Treatment Area Visibility**. The treatment area adjacent to and behind the cutting head shall be continuously visible to the operator (line of sight or high-resolution video camera) or observer with sufficient detail to facilitate identification of any treatment anomalies.

6. **Avoid Pavement Damage**. The work shall be performed without causing damage to the pavement surface; for example, raveling of aggregate or localized removal of the asphalt seal that exposes the underlying base or pavement layer. Work shall not damage existing delineation features such as pavement striping or raised pavement markers.
7. **Ultra High Pressure Pump System.** The ultra high pressure pump, spray head, and vacuum system shall be capable of treating a minimum of 550 square yards per hour.

G. **Calibration and Monitoring.** The roadway treatment vehicle shall be equipped with instrumentation to facilitate calibration, monitor treatment effectiveness, and capture treatment production data. Instrument gages shall be visible to the operator at all times. Gage readings shall be benchmarked to time (daily work shift), and capable of continuous measurement and recording as follows:

1. Forward ground speed, certified reliable to 0.1mph over a range of 0.1mph to 7.0mph.
2. Spray bar rotational speed, certified reliable to 10 rpm over a range of 100 rpm to 2,000 rpm.
3. Ultra high pressure pump system pressure, measured as follows:
    i. At the pump, certified reliable to 100 psi over a range of 5,000 psi to 50,000 psi.
    ii. At the spray head, certified reliable to 100 psi over a range of 5,000 psi to 50,000 psi.
4. Pavement temperature, measured in front of the cutting head, certified reliable to 1°F over a range of 0°F to 165°F.
5. Water storage tank level, certified reliable to 100 gallons over the full tank capacity range.
6. Ultra high pressure pump usage, in hours, certified reliable to 0.1 hour.

H. **Routine Equipment Maintenance.** Contractor shall keep equipment in good repair, clean, and free of leaks. Contractor shall maintain, on the roadway treatment vehicle, an inventory of common wear parts and replacement accessories for equipment adequate to ensure that routine maintenance tasks can be performed without delay to the project schedule.

###.4 Operator for Ultra High Pressure Water Cutter Equipment. The ultra high pressure water cutting equipment shall only be operated by personnel who are qualified by sufficient training and experience. Desired qualifications are identified below, with minimum qualifications established by the Engineer.

A. **Operator Training.** The operator shall be trained in the proper use and safety of the equipment and shall be certified as such by the equipment manufacturer.

B. **Operator Experience.** The operator shall have a minimum of two years ultra high pressure water cutting equipment operation experience on jobs of similar type and size.

C. **Company Experience.** Work shall be performed by organizations that have successfully completed at least five verifiable projects of similar type and size within the past three years.

###.5 Execution. The ultra high pressure water cutting operation shall be executed as follows:

A. **Designated Location.** The work shall be performed at the locations designated on the plans or as directed by the Engineer.

B. **Allowable Temperature.** Work shall be performed at ambient temperatures that facilitate effective water cutting, typically within an ambient temperature range of 35º F to 85º F, or as directed by the Engineer.

C. **Traffic Control.** The Contractor shall provide traffic control associated with the ultra high pressure water cutting operation as required by the plans and specifications.

D. **Inclement Weather.** Work on active roadways shall not be performed during inclement weather.

E. **Acceptance of Treatment.** Pavement sections treated using ultra high pressure water cutting shall be evaluated and accepted as described in Section 6 of this specification.

F. **Additional Cleaning.** The ultra high pressure water cutting operation shall achieve a clean pavement surface free from excessive debris such as; for example, clumps of asphalt binder. In cases where the vacuum system does not adequately remove debris from the pavement surface, the Contractor shall remove such debris using a mechanical sweeper, shovel, hand scraper or other tools and equipment, to the satisfaction of the Engineer.

G. **Restoration of Pavement Damage.** Any damage to the pavement surface or delineation features caused by the Contractor's operation shall be repaired at the Contractor's expense, to the satisfaction of the Engineer.

###.6 Trial Area. A trial area shall be designated by the Engineer to demonstrate that equipment, personnel and methods of operation are capable of producing treatment results satisfactory to the Engineer.

A. **Trial Size.** The trial area shall be at least 100 feet long by 10 feet wide, and adequately delineated to clearly differentiate variable treatment settings, as directed by the Engineer.

B. **Frequency.** Trials shall be required prior to commencing treatment operations at each site, daily, or more frequently as directed by the Engineer.

C. **Initial Settings.** The UHP pump shall be set at its operating pressure and flow rate, and at nozzle configuration, spray bar rotational speed, and vacuum system pressure appropriate for treatment of flushed pavement.

D. **Trial Process.** The equipment shall start cleaning at one end of the test area and travel to the other end (100 linear feet). Variation in travel speed shall proceed from highest speed to lowest speed, with care taken to avoid damage to the pavement surface. All procedures shall be demonstrated. The production settings for each component of the system shall be recorded.

E. **Varying Treatment Settings.** The forward speed of the vehicle, and other parameters as necessary, shall be adjusted to achieve optimal treatment of the flushed pavement surface.

F. **Inspection.** The Engineer shall inspect the trial area visually and/or using macrotecture tests to establish the target settings for the UHP water cutting treatment process and to confirm that no pavement damage has occurred.

G. **Target Production Rate.** The target production rate of the combined operation, as measured in square yards per hour, shall be determined and agreed upon jointly by the Engineer and the Operator after evaluation of the trial area.

H. **Acceptance.** The Engineer shall determine if the treatment results are acceptable and may at his sole discretion terminate the work if damage has occurred.

I. **Non-conforming Work.** If in the sole opinion of the Engineer the ultra high pressure cleaning equipment does not produce satisfactory results or if the equipment cannot maintain the specified pressure and flow rates or production rates during the trial, then the Engineer will require that the equipment be removed from the project and replaced with equipment that can meet the requirements of the specifications. No additional time will be allowed for failure to bring the proper equipment to the project. Any substitute equipment must first be tested as described herein prior to acceptance for the project.

###.7 Quality Control. Visual evaluation and field testing for acceptance of the ultra high pressure water cutting operation shall be executed as follows:

A. Visual Inspection. The Engineer shall visually examine the treated pavement surface after each shift.

1. The visual inspection will be to verify that the treatment has achieved satisfactory restoration of macrotexture consistent with the trial area, that the pavement surface is clean and free of debris, and without damage.
2. Where unsatisfactory treatment has been performed, the Engineer will direct Contractor to perform additional treatment. Engineer will re-inspect after each additional treatment.

3. After inspections are complete and all treatment accepted, the Engineer and Contractor shall measure and document the approved areas for payment.

B. **Macrotexture Measurements.** The Engineer may elect to obtain macrotexture measurements before and after treatment to quantify treatment effectiveness as determined from visual inspection.

1. Approved methods of macrotexture measurement include the Sand Patch test (TEX-436-A) and the Circular Track Meter test (ASTM E-2157). Both methods determine the "mean profile depth" of the pavement surface. The Engineer shall select the test method.
2. Baseline macrotexture measurements for the project site (entire project) shall be obtained for representative sections of the untreated pavement surface at a minimum frequency of one test per each half mile of roadway, with a minimum of three tests for the project site. At least one baseline measurement shall be from the trial area.
3. Post-treatment macrotexture measurements for the project site (entire project) shall be obtained for representative sections of the untreated pavement surface at a minimum frequency of one test per each half mile of roadway, with a minimum of three tests for the project site. At least one post-treatment measurement shall be from the approved section of the trial area.
4. The Engineer shall use macrotexture measurement data, together with visual inspection, to evaluate treatment effectiveness.
5. Where unsatisfactory treatment has been performed, the Engineer will direct Contractor to perform additional treatment. Engineer will re-test after each additional treatment.
6. After inspections are complete and all treatment accepted, the Engineer and Contractor shall measure and document the approved areas for payment.

###.8 Contractor Responsibility. The Contractor shall submit the following:

A. **Post-Award Submittals.** To be awarded this contract, the following submittals are required:

1. Submit manufacturer's specification for ultra high pressure equipment including operating procedures and parameters. Include the operating pressures, water flow rate and production capabilities when used for similar applications.
2. Submit the manufacturer's specification for the vacuum system.
3. Submit contractor's equipment safety features and safety program.
4. Submit documentation that the operator of the ultra high pressure equipment has been trained and certified in the safe and proper use of the equipment by the manufacturer and that he/she has at least two years experience operating the equipment.
5. Submit verification that the company responsible for performing the work described in this specification has performed similar work. Submit documentation for at least five similar projects performed within the past three years. Include the name of the project, location, area treated, before and after treatment images,

project duration, production rates, owner name, and the name and phone number of the individual responsible for overseeing the work performed.

B. **Project Submittals.** To execute this contract, the following project submittals are required:

1. Submit Contractor's water use permit.
2. Submit Contractor's waste disposal plan.
3. Submit Contractor's traffic control plan.

C. **Daily Submittals.** The operator shall submit a daily production report that addresses the following:

1. Project name, location, and treatment area.
2. Total daily equipment use for treatment including travel time between sites (hours).
3. Square yards of flushed pavement successfully treated.
4. Target treatment settings:
   a) Forward ground speed
   b) Nozzle configuration
   c) Spray bar rotational speed
   d) Water pressure at the pump
   e) Water pressure at the spray head
5. Instrument data recording of actual system performance during operation, benchmarked to time (daily work shift):
   a) Forward ground speed
   b) Spray bar rotational speed
   c) Water pressure at the pump
   d) Water pressure at the spray head
   e) Pavement temperature
   f) Water storage tank level
   g) Ultra high pressure system pump usage
6. Documentation of time used for filling the water tanks and dumping waste.
7. Documentation of any equipment idle time and downtime.
8. Documentation of any pavement damage caused by the treatment.

###.9 Measurement and Payment.

A. **Measurement.** The unit of measurement shall be per square yard of pavement surface treated and accepted by the Engineer.

B. **Payment.** The work performed in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit prices bid for "Treatment of Flushed Pavement Surfaces using Ultra High Pressure Water Cutting" for the number of square yards of approved treatment. A site number or numbers will be specified corresponding to the detail location description in the plans when multiple sites are bid separately. This price is full compensation for furnishing all materials, equipment, labor, and supervision including tools, reporting, and incidentals.

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