

TEXAS DEPARTMENT
OF TRANSPORTATION

**GUIDELINES FOR USING
ULTRA HIGH PRESSURE
WATER CUTTING TO REMOVE
EXCESS ASPHALT**

**RESEARCH PRODUCT 5-5230-P1
RESEARCH STUDY NO. 5-5230-01**



SEPTEMBER 2012

**GUIDELINES FOR USING UHP WATER CUTTING TO REMOVE EXCESS
SURFACE ASPHALT**

Cover image: "Ultra high pressure water cutting for the Bryan Demonstration Project, Grimes County, TX, March 2010" *Image courtesy TTI Visual Media*

TEXAS DEPARTMENT OF TRANSPORTATION

document title

**Guidelines for Using Ultra High Pressure Water Cutting to Remove Excess Asphalt
Research Product 5-5230-P1**

study title

**Implementing the Ultra High Pressure Water Cutter for
Treatment of Flushed Pavements
Research Study No. 5-5230-01**

sponsored by

Texas Department of Transportation

in cooperation with

**U.S. Department of Transportation
Federal Highway Administration**

project director

Darlene C. Goehl, P.E.

project advisory committee

Byron Hicks, P.E.

Edward Morgan

Neal Munn

Michael Taylor, P.E.

publication date

DRAFT: September 12, 2012

authors

William D. Lawson, P.E., Ph.D.

Sanjaya P. Senadheera, Ph.D.

published by

TECHMRT: Multidisciplinary Research in Transportation

TEXAS TECH UNIVERSITY

Box 40123

Lubbock, TX 79409-1023

**GUIDELINES FOR USING UHP WATER CUTTING TO REMOVE EXCESS
SURFACE ASPHALT**

DISCLAIMER

The contents of this report reflect the views of the authors who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Texas Department of Transportation or the Federal Highway Administration. This report does not constitute a standard, specification, or regulation, nor is it intended for construction, bidding, or permit purposes.

PREFACE

This document presents guidelines for implementing the ultra high pressure (UHP) 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 guidance on ultra high pressure water cutting presented herein is intended to 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.

TABLE OF CONTENTS

PREFACE.....	5
1. INTRODUCTION	8
Purpose	8
Background.....	8
Bryan Demonstration Project.....	9
UHP Water Cutter Implementation Project.....	12
About this Guidance Document	14
2. DESCRIPTION	16
Overview.....	16
Equipment.....	18
The Cutting Head	19
UHP Pump and Vacuum System.....	21
Water for UHP Water Cutting.....	22
Debris and Waste Disposal.....	23
Safety Considerations	26
Pre-Treatment Trial Area	27
Evaluation of the Pre-Treatment Trial Area	29
Production UHP Water Cutter Treatment	31
3. APPLICATIONS.....	32
Treatment of Flushed Pavements.....	32
Treatment in Advance of Seal Coating	33
Cleaning Concrete Pavements.....	34
Other Applications	35
4. EVALUATION	36
Research Test Sites.....	36
Treatment Effectiveness	36
Survivability.....	38
Life Expectancy	40
Production Rate.....	41
Cost of UHP Treatment.....	43
Evaluation Summary.....	44

TABLE OF CONTENTS, CONT'D.

5. SELECTION OF CANDIDATE PROJECTS..... 46
Maintenance Treatment Strategy46
Summary of Maintenance Solutions.....46
Can (Should) UHP Water Cutting Be Used for this Road?.....48
How to Think about Whether to use UHP Water Cutting.....48
Factors that Influence UHP Water Cutting Production49
Factors that Influence UHP Water Cutting Treatment Effectiveness.....52
Factors that Influence Durability of the UHP Water Cutter Treatment54
UHP Water Cutter Treatment Problems55
Other Observations59
Candidate Project Selection60

APPENDIX A: SPECIFICATION 62
Equipment for Treatment of Flushed Asphalt Pavement.....63

APPENDIX B: SPECIFICATION 70
Treatment of Flushed Asphalt Pavement Using Ultra High Pressure
Water Cutting71

INTRODUCTION

PURPOSE

This document presents guidelines for the application and use of ultra high pressure (UHP) water cutting as a roadway maintenance tool for removal of excess surface asphalt from Texas roadways. The purpose of this document is to provide Texas Department of Transportation (TxDOT) roadway maintenance professionals with the information they need to know in order to implement UHP water cutting and achieve satisfactory results.

BACKGROUND

In 2006, TxDOT research project 0-5230 identified UHP water cutting as an emerging technology, widely used in Australia and New Zealand, and highly effective in restoring texture to flushed pavement surfaces. This finding initiated a series of attempts to invite New Zealand and Australian companies to mobilize their equipment to Texas and introduce the technology here, but logistics and distance considerations rendered this approach cost-prohibitive. Attempts to have the New Zealand and Australian companies license their technology to a United States company were also unsuccessful.

In 2009, TxDOT learned that certain specialty contractors in the United States possess the UHP water cutting technology. The reason these contractors were not previously identified is that these companies do not typically work on asphalt pavements. Their UHP water cutting services are traditionally applied to concrete pavements, to repair and restoration of bridge decks, and to the removal of tire rubber from the landing areas of concrete airport pavements. However, one contractor, Rampart Hydro Services, Inc., based in Coraopolis, Pennsylvania, a suburb of Pittsburgh, had completed a few small yet high-profile *asphalt* surface retexturing projects.

SECTION 1

BRYAN DEMONSTRATION PROJECT

In March 2010, 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. Rampart Hydro Services, Inc. was selected as the UHP water cutter contractor for the field demonstration project.

As can be seen in Figure 1, the section of FM 2562 selected for treatment was very heavily flushed. The contractor made five passes with the UHP water cutter, precisely varying the rate of advance to accomplish different degrees of asphalt removal.



FIG 1. Flushed pavement, UHP demonstration project, Grimes County, TX (Bryan District).

**GUIDELINES FOR USING UHP WATER CUTTING TO REMOVE EXCESS
SURFACE ASPHALT**

INTRODUCTION

Ultimately the contractor treated the entire lane width (Figure 2). The UHP water cutter process achieved improved macrotexture for the pavement surface by removal of excess asphalt, exposing the seal coat aggregate. The process also achieved improved microtexture, or friction, by scoring the surface of the embedded aggregate.



FIG 2. UHP water cutting, multiple passes for continuous treatment of the lane, Bryan demonstration project, March 2010.

SECTION 1

Observations from the FM 2562 pavement section indicated that the UHP water cutter process has the 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 display minor to severe flushing (Figure 3).

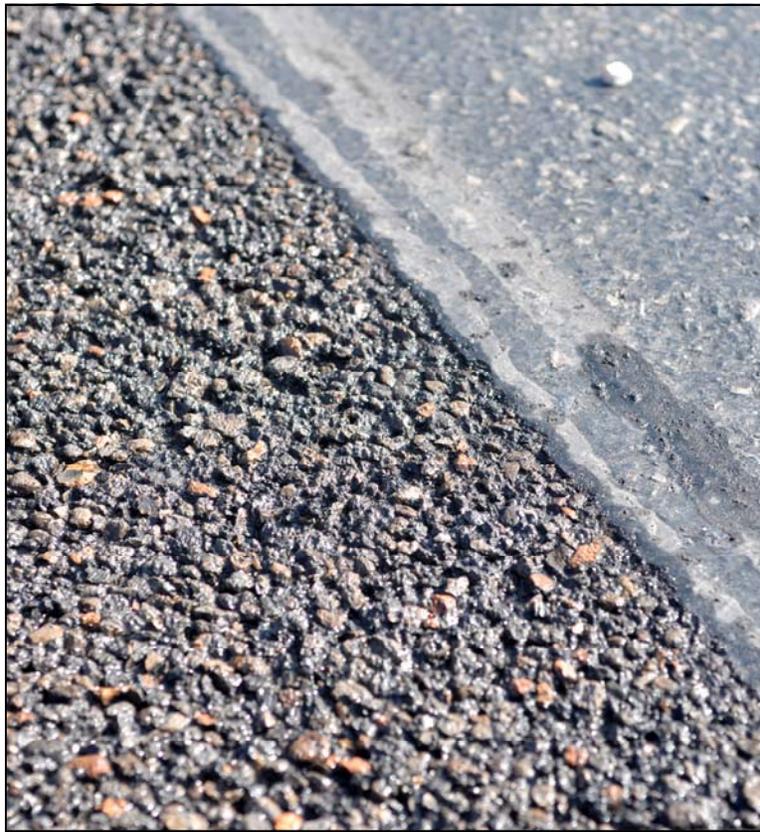


FIG 3. UHP water cutting achieves improved macrotexture and improved friction. *Image courtesy TTI Visual Media.*

INTRODUCTION

UHP WATER CUTTER IMPLEMENTATION PROJECT

Based on the success of the Bryan demonstration project, on November 29, 2010, TxDOT sponsored Implementation Research Project 5-5230-01, "Implementing the Ultra-High Pressure Water Cutter for Roadway Maintenance Applications."

The implementation research project was designed to more systematically evaluate the UHP water cutter as a low-cost, pavement preservation tool for treatment of flushed roads surfaced with a seal coat. Data were collected from January 31 through March 2, 2011, from 14 test sites located in four climatic regions in Texas (Figure 4).

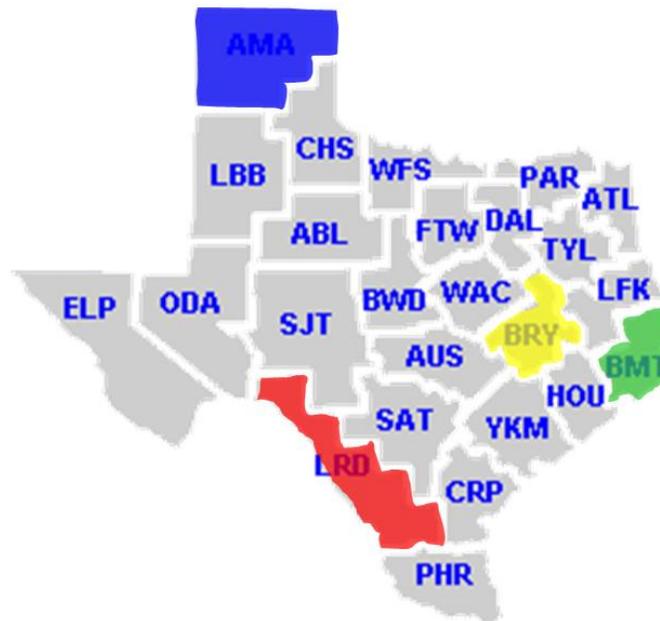


FIG 4. TxDOT Districts selected based on climatic region as test sites for the UHP water cutter implementation project, January-March 2011.

SECTION 1

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.

The research report for 5-5230-01 presents the research design, test plan, and a detailed analysis of the effectiveness and durability of the initial treatment (Figure 5).

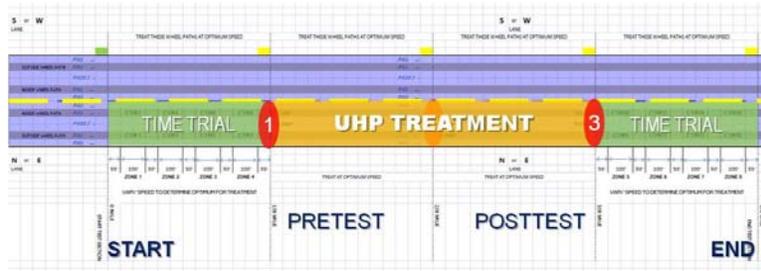


FIG 5. Typical 1/2-mile test strip layout for UHP water cutter implementation research.

In brief, two types of tests, the circular track meter (CTM) and the sand patch test, were used to determine the average pavement surface macrotexture before and after the treatment. In addition, the wet-weather skid resistance was measured using both the TxDOT skid truck and the Dynamic Friction Tester (DFT).

Analyses of these key variables form the basis for the treatment effectiveness, durability, and production recommendations summarized in this document.

INTRODUCTION

ABOUT THIS GUIDANCE DOCUMENT

This guidance document is to provide TxDOT roadway maintenance professionals with the information they need to know in order to implement UHP water cutting and achieve satisfactory results.

TxDOT's history and experience with the UHP water cutting process, presented in the Introduction (Section 1), provide context relative to the development and maturity of UHP water cutting as a roadway maintenance strategy in Texas (Figure 6).



FIG 6. This heavily-flushed FM road in Webb County, TX was treated using the UHP water cutting process.

SECTION 1

Section 2 of this document presents a detailed description of the UHP water cutting process. We have included information about the equipment, materials, and the UHP water cutting procedure.

What roadway maintenance applications are appropriate for UHP water cutting? Section 3 addresses this question.

In Section 4, we summarize TxDOT's technical evaluation of the UHP water cutting process. We comment on treatment effectiveness, durability, production considerations, and cost.

Ultimately, TxDOT maintenance professionals need to be able to identify and select candidate projects which are suitable for UHP water cutting. Section 5 discusses observations, findings, and recommendations developed from the implementation research project in this regard.

The Appendices present two specifications to facilitate contracting for UHP water cutting work. These specifications are currently being peer-evaluated by TxDOT. One is an equipment specification in which TxDOT maintenance professionals would contract for the UHP water cutter equipment and qualified operator, by the hour. The second specification is for turn-key work where TxDOT would contract with the UHP water cutter company to provide all materials, equipment, labor and supervision necessary to treat flushed pavements, with payment made on the basis of area treated.

DESCRIPTION

OVERVIEW

The UHP water cutter combines a UHP pump, water supply, and vacuum recovery system on a truck-mounted unit (Figure 7).



FIG 7. The UHP water cutter system.

This treatment system consists of ultra high pressure pumps, truck mounted and self contained, which supply water to a cutting head, sometimes referred to as a “deck blaster.” The truck includes tanks both for the supply of fresh water and storage of collected waste water and debris.

SECTION 2

A rotating spray bar uses specialized nozzles to direct very fine jets of ultra-high pressure water, ranging from 32,000 to 36,000 psi, at ultrasonic velocity (mach 1.5) on to the road surface (Figure 8).



FIG 8. The rotating spray bar and nozzle configuration.

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.

A source of clean water is required for the UHP water cutting process. Water jet pressure and the travel speed of the truck need to be controlled to prevent damage to the pavement surface. The hardness of the binder will influence the pressure required and time taken to achieve a satisfactory result.

GUIDELINES FOR USING UHP WATER CUTTING TO REMOVE EXCESS SURFACE ASPHALT

DESCRIPTION

The treatment area for UHP water cutting requires traffic control to ensure safety of the traveling public during water cutting operations (Figure 9).



FIG 9. Traffic control for UHP water cutting. *Image courtesy TTI Visual Media.*

EQUIPMENT

The effectiveness, production rate, and cost of UHP water cutting directly depends on the equipment used for the treatment process. The UHP water cutter device used for TxDOT's implementation research study and described herein is a self-contained, truck-mounted unit which has been designed, fabricated, and operated by Rampart Hydro Services, Inc. (Figure 10).

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.

SECTION 2

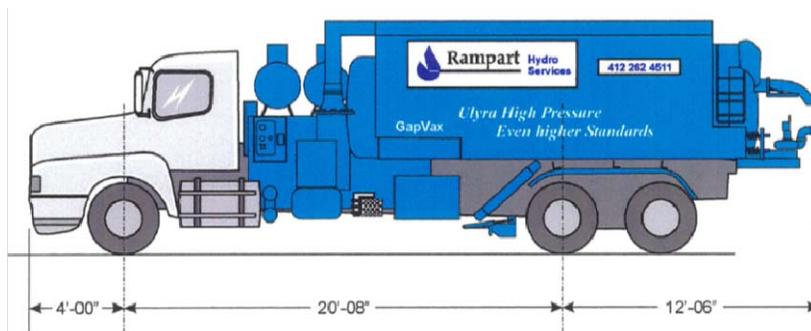


FIG 10. Rampart BlasterVac Truck. *Image courtesy Rampart Hydro Services, Inc.*

With a gross weight of 51,240 pounds, the BlasterVac Truck has historically been used for applications such as airfield rubber removal or hydroscarification. To comply with vehicle weight limits, the truck is 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 11). 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.

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. The spray bar rotation speed can be varied from 0 rpm to 1500 rpm.

**GUIDELINES FOR USING UHP WATER CUTTING TO REMOVE EXCESS
SURFACE ASPHALT**

DESCRIPTION



FIG 11. The BlasterVac cutting head. *Image courtesy TTI Visual Media.*

The pressure in the water leaving the nozzles is in the range of 32,000 to 36,000 psi. 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.

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 550 square yards per hour.

SECTION 2

UHP PUMP AND VACUUM SYSTEM

Ultra high pressure pumps are capable of delivering a water jet traveling at twice the speed of sound at pressures in excess of 27,000 psi. The Blaster-Vac truck chassis incorporates a 4,000 gallon water supply tank, which normally is 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 12).



FIG 12. Debris tank and dump, Rampart BlasterVac truck.

GUIDELINES FOR USING UHP WATER CUTTING TO REMOVE EXCESS SURFACE ASPHALT

DESCRIPTION

WATER FOR UHP WATER CUTTING

Materials associated with the UHP process 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.

Water used for the ultra high pressure water cutting operation must be potable water obtained from a fire hydrant, municipal source or well. Lake or river water, or the use of additives such as chemicals, abrasive materials, or detergents, are not allowed.

Provision of an adequate supply of water is a key logistical consideration for UHP water cutting. One approach, shown in Figure 13, is to deliver water to the worksite using a support water truck.



FIG 13. Filling the Rampart BlasterVac truck on the roadside using a support water truck.

SECTION 2

DEBRIS AND WASTE DISPOSAL

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.

The debris vacuumed from the road surface during UHP water cutter treatment includes asphalt, water, sand, and aggregate, plus other materials and compounds. 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 (Figure 14).



FIG 14. The UHP water cutting operation removes both solids and water from the road surface.

**GUIDELINES FOR USING UHP WATER CUTTING TO REMOVE EXCESS
SURFACE ASPHALT**

DESCRIPTION

The effluent water vacuumed from the road surface during UHP water cutter treatment may be a skin irritant by virtue of emulsifying some of the oils in the binder during cutting. Standard safety protocols and personal protective equipment including skin protection and eye protection are required.

Waste 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.

Advance arrangements for disposal of solid waste are required. Where allowed by Maintenance Division policy, TxDOT maintenance forces may choose to temporarily dump the waste material along the roadside for later pickup. These dump locations are typically located next to the treated area, within the right of way (Figure 15).



FIG 15. Temporary dumping of UHP water cutter waste debris along the roadside for later pickup and removal.

SECTION 2

Maintenance forces may also dispose of the material by creating a bermed disposal site at, say, an existing reclaimed asphalt pavement stockpile area. This is the approach identified in Figure 16.



FIG 16. Waste and solid debris disposal area, at a Reclaimed Asphalt Pavement stockpile, TxDOT Bryan District.

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 also exist, and the choice of the solid waste treatment and/or disposal method will affect production.

GUIDELINES FOR USING UHP WATER CUTTING TO REMOVE EXCESS SURFACE ASPHALT

DESCRIPTION

SAFETY CONSIDERATIONS

The UHP water cutting equipment and treatment processes involve both typical and unique worker safety issues. Equipment operation, for example, engages the UHP cutting head and the vacuum system, both of which incorporate numerous safety considerations (Figure 17). The daily safety meeting should specifically identify and explain the UHP equipment and operational safety issues, including emergency shutoff procedures.



FIG 17. UHP water cutter equipment safety warnings.

As has been noted, UHP water cutting for treatment of flushed pavements is done under traffic control. Depending on the application, traffic control may be a fixed or moving operation, but either way, the traffic control plan must be established in advance.

GUIDELINES FOR USING UHP WATER CUTTING TO REMOVE EXCESS SURFACE ASPHALT

DESCRIPTION

Figure 18 depicts the recommended configuration for a trial area suitable for a two-lane road that is flushed in the wheel paths. Here the pre-treatment area has been established for one lane of the road over a distance of 1/8 mile (660 feet). The treatment area includes four 100-foot treatment zones, typically identified by temporary paint markings on the road surface (see close-up, Figure 19). The treatment zones are designated to vary the truck forward ground speed and other settings on the UHP equipment. The space between the zones is to allow for speed transition.

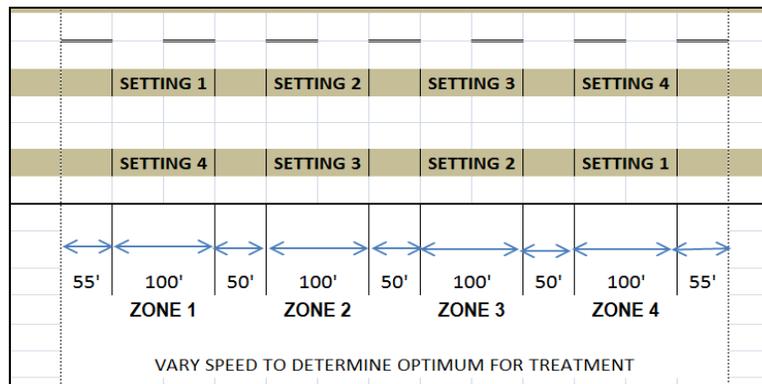


FIG 19. Treatment zones for the recommended trial area.

When pre-treating the trial area, the operator should vary the truck forward ground speed from high to low. For research trials, the maximum treatment speed did not exceed 3.5 mph. This pre-treatment approach recognizes that low treatment speeds will deliver more UHP water cutting energy onto the pavement surface and are more prone to cause damage.

The trial area shown in Figure 19 includes both wheel paths, typically treated in the direction of traffic (inside wheel path) and against traffic (outside wheel path). This allows duplication of the trial treatment strategy for extra assurance. Of course, if this trial layout is not sufficient, additional treatment zones can be defined. Or in cases where much is known in advance about UHP treatment for a particular road; for example, the Engineer is familiar with the equipment and has worked at the site before, a more simple trial area consisting of only one treatment zone can be used.

SECTION 2

EVALUATION OF THE PRE-TREATMENT TRIAL AREA

Evaluation of the pre-treatment trial area is done visually. After pre-treatment, the Engineer and the UHP equipment operator jointly observe the effectiveness of treatment for the different zones (Figure 20).



FIG 20. Evaluating pre-treatment effectiveness. *Image courtesy TTI Visual Media.*

Upon review of the zones, the Engineer and UHP equipment operator mutually select the zone that represents the most effective treatment, and from this selection, they establish the UHP equipment settings for production work.

**GUIDELINES FOR USING UHP WATER CUTTING TO REMOVE EXCESS
SURFACE ASPHALT**

DESCRIPTION

As a supplement to visual evaluation of the treatment area, the Engineer may elect to perform texture tests before and after treatment.

Texture tests may include the Sand Patch test (TEX-436-A) and/or the Circular Track Meter (CTM) test (ASTM E-2157). Both methods determine the “mean profile depth” of the pavement surface and are intended to provide a more quantitative evaluation of treatment effectiveness. Figure 21 shows the sand patch test. Figure 22 shows the CTM test.



FIG 21. Sand patch test (TEX-436-A) to measure pavement texture.

SECTION 2



FIG 22. Circular Track Meter (CTM) test (ASTM E-2157) to measure pavement texture.

PRODUCTION-UHP WATER CUTTER TREATMENT

The pre-treatment trial area, whether evaluated visually or in association with pavement texture tests, is done for the purpose of establishing equipment settings for production treatment.

With the production settings established, the Contractor will proceed with UHP water cutter treatment of the roadway surface. Upon completion of treatment for a project site, the Engineer evaluates the treated area for purposes of measurement and payment. Post-treatment evaluation is done using the same methods as for the trial area.

APPLICATIONS

TREATMENT OF FLUSHED PAVEMENT SURFACES

UHP water cutting can be used to restore texture to flushed pavements which are surfaced with a seal coat or surface treatment (Figure 23). Treatment of flushing is considered a primary application for UHP water cutting technology and has been the focus of TxDOT's research to date in this area.



FIG 23. Restoration of texture to flushed pavements with a seal coat or surface treatment is the primary maintenance application for UHP water cutting.

Applications for which UHP water cutting is considered effective include pavements with flushing in the wheel paths and pavements where the entire lane is flushed. UHP water cutting has been successfully applied to a wide range of binders and aggregates, in different areas of the state. The degree of flushing successfully treated using UHP water cutting has ranged from very light to very heavy. Section 4 of this report summarizes information about treatment effectiveness, treatment durability, production and cost associated with using the UHP water cutter for treatment of flushed pavements.

SECTION 3

TREATMENT IN ADVANCE OF SEAL COATING

UHP water cutter treatment of flushed pavements as a preventive maintenance application may achieve a successful solution for the roadway, providing restored texture and serviceability for multiple years. Similarly, UHP water cutting can be used to prepare the road surface in advance of placing a new seal coat. One of the conditions where this application is appropriate is roads that exhibit severe flushing and which cannot accept a new seal without perpetuating the flushing problem (Figure 24). Similarly, roads with variable patterns of flushing that would require continuous adjustment to the seal-coat operation are candidates for advance treatment. The process is essentially the same as for treating flushed roadways and expands the scope for seal coating as a pavement preservation tool.



FIG 24. UHP water cutting can be used to treat heavily flushed roads in advance of a scheduled seal coat. *Image courtesy TTI Visual Media.*

APPLICATIONS

CLEANING CONCRETE PAVEMENTS

This document emphasizes using UHP water cutting to restore texture to asphalt pavement surfaces. But UHP water cutting can, of course, be used to clean, retexture or otherwise clean concrete pavement surfaces. Figure 25 shows an application that involved removing heavily-tracked asphalt from a concrete pavement surface in the Bryan District.



FIG 25. UHP water cutting can be used to remove tracked asphalt from concrete pavement.

SECTION 3

OTHER APPLICATIONS

In addition to the applications already identified, the UHP water cutting technique is reported as being useful for other pavement maintenance applications. Although not specifically evaluated as part of TxDOT's research, these other applications include removal of pavement markings, thermoplastic striping removal, clean up of residue from spills, and cleaning porous friction course asphalt pavements.

EVALUATION

RESEARCH TEST SITES

This section briefly summarizes the key findings from TxDOT implementation study 5-5230-01. The information presented here provides a broad framework for understanding and interpreting both the strengths and limitations of UHP water cutting as a roadway maintenance tool.

As has been noted, the UHP water cutter treatment for this study was performed from January 31 through March 2, 2011. Table 1 identifies the thirteen roads (test sites) included in the study, all of which were surfaced with a seal coat.

TABLE 1. TxDOT Roadways Selected for UHP Water Cutter Treatment in 2011.

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

Information in Table 1 includes the District location, FHWA climate rating, average daily traffic, an estimate of truck volume, the year the road was last surfaced, and the binder and aggregate types.

SECTION 4

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

- Does it work? (TREATMENT EFFECTIVENESS)
- Does it last? (DURABILITY: SURVIVABILITY/LIFE EXPECTANCY)
- What is the cost? (PRODUCTION/COST EFFECTIVENESS)

The following sections summarize the answers to these questions. Details appear in the research report.

TREATMENT EFFECTIVENESS

The first question that had to be answered for this study 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.

Figure 26 presents the texture data from the study as measured by the sand patch test and the CTM test. This chart shows improvement in texture from pre-treatment to post-treatment at all thirteen test sites. The actual degree of improvement varies by site, ranging from 36 percent improvement to 401 percent improvement. The overall average texture values resulting from the UHP treatment process increased by roughly 200 percent.

Pavement friction as measured by the skid number and Dynamic Friction Test (DFT) friction number also improved as a result of the UHP water cutter treatment. The actual degree of improvement varied by site. Two sites did not show friction improvement, but pavement friction at the remaining sites did improve, with values ranging from 15 percent improvement to 351 percent improvement. The overall average friction values resulting from the UHP treatment process increased by roughly 135 percent.

EVALUATION

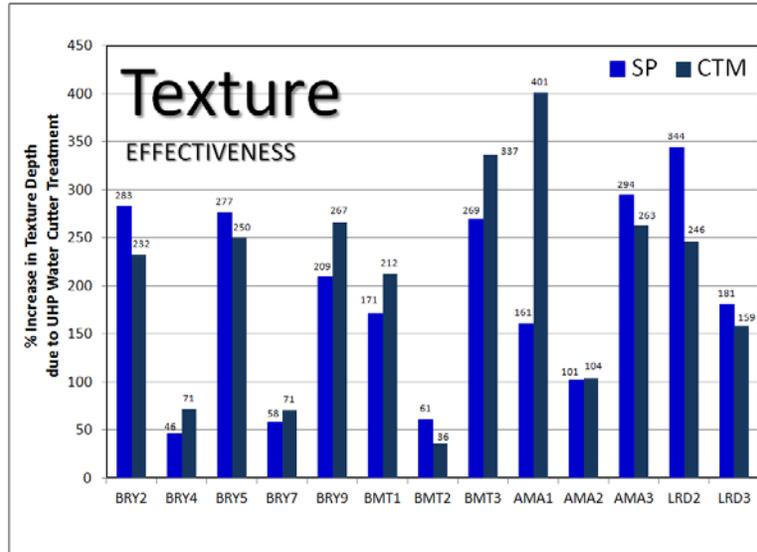


FIG 26. Treatment effectiveness as measured by percent increase in pavement texture resulting from the UHP water cutting process.

In summary, the UHP water cutter process achieved improvement in both pavement texture and friction values at the test sites evaluated for this study. On this basis, it can be said that the UHP water cutter treatment process does work.

SURVIVABILITY

The second question that this study attempted to answer relative to UHP water cutting is, "Does it last?" The implementation study addressed this question through follow-on monitoring of the treatment sites, with 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.

SECTION 4

Survivability refers to whether the treated roadway surface maintained texture or friction values 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 and for required maintenance for both texture and friction. Actual performance was then compared against these thresholds. Figure 27 is the survivability chart associated with the CTM data.

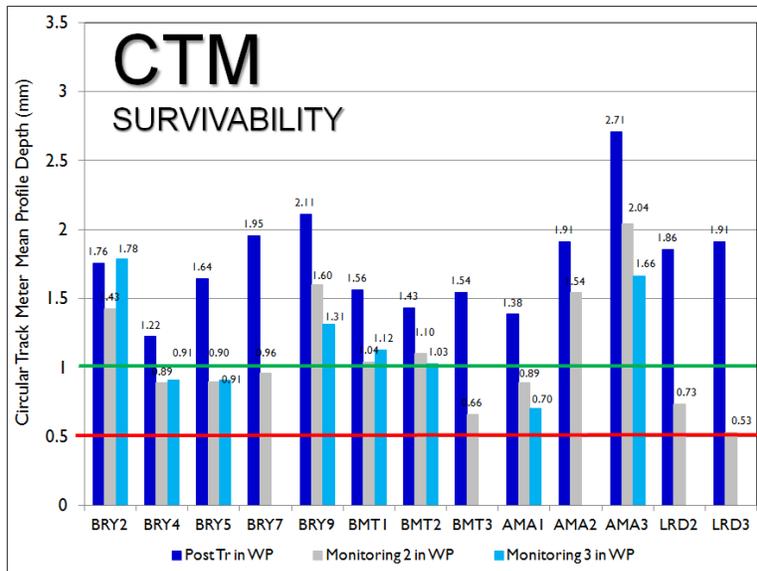


FIG 27. Treatment survivability as measured by whether pavement texture (CTM mean profile depth) survived 12 months (Monitoring 2) or 18 months (Monitoring 3) at or above specified performance threshold values.

Figure 27 shows that pavement texture at completion of monitoring, as measured by the CTM, for six of the thirteen 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).

EVALUATION

Overall, the survivability analysis showed that 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 thirteen sites. Pavement texture and friction values were at or above the *maintenance* threshold for ten of thirteen sites.

LIFE EXPECTANCY

The second way this study evaluated the durability of the pavement texture and friction achieved from the UHP water cutter treatment was in terms of life expectancy. Estimating life expectancy required the generation of decay curves to predict 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, the models are not validated. 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 28 is the life expectancy chart associated with the CTM data.

Review of Figure 28 shows that data for one site are not available (BRY2). For the twelve sites with life expectancy data, Figure 28 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.

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

- ≥ One year: 8 to 11, average 10 of 12 sites
- ≥ Two years: 6 to 10, average 8 of 12 sites
- ≥ Three years: 4 to 8, average 6 of 12 sites
- ≥ Four years: 2 to 6, average 4 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 one-third of the test sites, the treatment may last four or more years.

SECTION 4

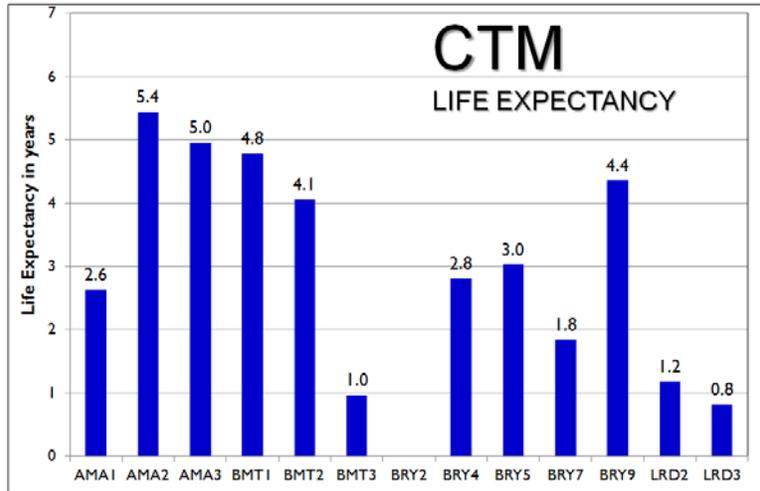


FIG 28. Treatment life expectancy, in years, predicted based on pavement texture (CTM mean profile depth) data.

PRODUCTION RATE

A third question associated with evaluation of the UHP water cutter treatment process has to do with production and cost considerations. During the water cutting process, establishing the forward ground speed is tantamount to setting the production rate, and this is the key variable for defining water cutting production for a particular site.

As noted in the Section 3 of this document, the ground speed must be established in the field using a pre-treatment trial area. This is to account for project site conditions including the roadway surface condition, environmental factors, and desired treatment effectiveness as per the cutting head variables. Table 2 summarizes the speed trial, treatment speed, and production rate data for the thirteen field treatment sites tested in the research study.

EVALUATION

TABLE 2. UHP Water Cutter Speed Trial Data, Treatment Speeds and Production Rates.

Site	Treatment Speed (mph)			Production Rate (SY/hour)	Surface Condition
	Min	Max	Avg		
BRY1			0.5	587	tracked asphalt on concrete
BRY2			0.7	821	moderately flushed seal
BRY4			1.0	1173	lightly flushed seal
BRY5	0.5	0.7	0.6	739	heavily flushed seal
BRY7	0.8	1	0.9	1067	moderately flushed seal
BRY9	0.7	0.8	0.7	845	heavily flushed seal
LRD 2	0.7	0.7	0.7	856	heavily flushed seal
LRD 3	0.5	0.7	0.6	716	heavily flushed seal
BMT 1			1.0	1173	moderately flushed seal
BMT 2	1.1	2.4	1.6	1865	lightly flushed seal
BMT 3	1.0	1.1	1.0	1161	heavily flushed seal
AMA 1			0.8	938	moderately flushed seal
AMA 2	0.8	1.3	1.1	1255	lightly flushed seal
AMA 3	0.4	0.7	0.5	622	very heavily flushed seal

The treatment speed for these sites was established through conducting a series of 8 to 16 trial speed zones per site where the forward ground speed was 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. Upon completion of the time trials, the researchers and TxDOT maintenance professionals visually observed the speed zones and jointly selected the production treatment speed which they felt achieved the most effective outcome; that is, the best treatment.

This effort, summarized in Table 2, reveals that the typical forward ground speed for production treatment varied from 0.5 to 1.6 mph, average 0.8 mph. The treatment area consisted 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, average 990 square yards per hour, for the test sites.

SECTION 4

COST OF UHP TREATMENT

Current approaches available to treat flushed seals are to add a new textured surface over the flushed pavement or to mechanically retexture the existing pavement surface. Of these, the most common approach is to place a strip or spot seal coat (TxDOT Maintenance Function 232). The turn-key cost for this maintenance function varies from \$2.19/SY to \$3.14/SY, average \$2.58/SY (2010 statewide data).

It is common practice for UHP water cutter companies to serve as specialty subcontractors who offer their services to general contractors for a specific project. Here, the specialty contractor would be responsible to provide the UHP water cutter truck and crew (typically consisting of one operator), and the general contractor would be responsible for all other services necessary to complete the project including a water source, waste disposal, 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 will typically range from \$0.90/SY to \$1.15/SY (2011 data). The lower unit cost reflects conditions associated with high production rates. 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.

If the UHP water cutter contractor company serves as general contractor, the unit cost for turn-key UHP water cutter services at production rates typical of the research study will typically range from \$1.40/SY to \$1.65/SY (2011 data). These unit costs are suitable for an apples-to-apples comparison with costs for traditional maintenance functions associated with repair of flushed pavements.

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, UHP water cutting is 25 percent to 77 percent less expensive. All unit cost figures are subject to project-specific variables. Also, the unit cost figures presented refer to actual treatment cost and not the overall life-cycle cost of a particular treatment strategy.

EVALUATION

EVALUATION SUMMARY

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, with details provided in the research report.

- **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 thirteen sites. Pavement texture and friction values were at or above the *maintenance* threshold for ten of thirteen 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 20 percent of the test sites. However, at 80 percent of the test sites, the treatment is predicted to last one or more years. For one-third 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.

SECTION 4

Overall, implementation research study 5-5230-01 offers a reasonably positive view about UHP water cutting as a roadway maintenance tool for Texas roads (Figure 29). Treatment performance at individual sites will vary depending on project-specific details, discussed in the next section.



FIG 29. UHP water cutting is a promising maintenance tool for treatment of flushed pavements. *Image courtesy TTI Visual Media.*

SELECTION OF CANDIDATE PROJECTS

MAINTENANCE TREATMENT STRATEGY

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.

The selection of the treatment approach must also consider the severity of the flushing problem as well as many other factors including environmental conditions (temperature and humidity), type of roadway, traffic levels and types, specific locations on a roadway (curves, intersections, urban or rural environments) and the like.

The objective of treatment is to increase the pavement macrotexture and improve skid resistance. In instances where flushing is seen in the wheel paths, maintenance crews should also try to improve surface water drainage off of the roadway, especially away from (or out of) the wheel paths.

In contrast to treatment of bleeding pavement surfaces, the timing for the retexturing options is during cooler weather when the asphalt binder is least active.

SUMMARY OF MAINTENANCE SOLUTIONS

Table 3 summarizes maintenance solutions available for treatment of flushed pavement surfaces, including UHP water cutting. In relative terms, the overall effectiveness of these solutions can be described as short term (a few days) to long term (one or more years). The cost, also in relative terms, ranges from low (cents per square yard) to high (dollars per square yard). Assertions about the effectiveness and cost for each solution collectively reflect the experiences and perceptions of TxDOT maintenance personnel.

SECTION 5

TABLE 3. Maintenance solutions for flushed asphalt pavements.

Maintenance Solutions for Flushed Asphalt Pavements	Solution Type		Effectiveness			Cost		
	Add New Textured Surface	Retexture Existing Pavement	Short Term	Mid Term	Long Term	Low	Medium	High
Cold milling to remove flushed asphalt		■		■		■	■	
Apply new seal coat	■				■		■	
Microsurfacing	■				■			■
Thin asphaltic concrete overlay	■			■	■		■	■
Ultra high pressure water cutting		■		■	■		■	■
Other solutions	■	■		■	■	■	■	■

This summary of maintenance solutions for flushed pavements is provided to emphasize that selection of the treatment strategy should fit the particular application. For example, retexturing strategies will not correct rutting or improper surface drainage, so approaches that add material to the road surface will be necessary in such cases.

That having been said, UHP water cutting is a viable, sustainable pavement preservation strategy for retexturing flushed pavements. Treatment effectiveness, durability, production and cost-effectiveness are reasonably positive overall, with treatment performance at individual sites dependent on project-specific details. This section is to provide guidance to TxDOT maintenance personnel about factors to consider when choosing UHP water cutting as the treatment strategy of choice.

SELECTION OF CANDIDATE PROJECTS

CAN (SHOULD) UHP WATER CUTTING BE USED FOR THIS ROAD?

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 strip seal, 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 strip seal. This two-step treatment strategy may help prevent rapid recurrence of flushing through the new seal.

HOW TO THINK ABOUT WHETHER TO USE UHP WATER CUTTING

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, the 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, we will identify the factors that influence performance of the UHP water cutting treatment for good or ill, but leave the ultimate decision about whether to use UHP water cutting for a particular application to the judgment of the roadway maintenance professional.

SECTION 5

FACTORS THAT INFLUENCE UHP WATER CUTTING PRODUCTION

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 will directly affect production. In the case of the Rampart Blaster-Vac truck, the cutting head is fixed 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 30). Ultimately, the traffic lane configuration and work area dictate whether traffic control can be a moving operation or if a lane closure is required.



FIG 30. UHP Water Cutting in the Outside Wheel Path on Two-Lane Roads Requires A Full Lane Closure. *Image courtesy TTI Visual Media.*

SELECTION OF CANDIDATE PROJECTS

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 unmodified 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 UHP water cutter 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. In the case of the BlasterVac truck, the water tank is capable of holding 4000 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 TxDOT maintenance yards do not have sufficient overhead clearance to do this and alternative measures such as using a water trailer with a pump (Figure 31) must be used in such situations.

Identifying and providing an approved dump site will significantly impact the rate of production. When the dump gate is opened, water and solid materials will be discharged from the waste tank. The waste disposal operation requires that the disposal area is firm enough to carry the laden UHP water cutter truck that is at least partially filled with water.

Climatic 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.

SECTION 5

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 UHP water cutting unit ineffective.



FIG 31. Use of a water trailer when insufficient overhead clearance exists for the UHP water cutter truck.

SELECTION OF CANDIDATE PROJECTS

FACTORS THAT INFLUENCE UHP WATER CUTTING TREATMENT EFFECTIVENESS

The effectiveness of the UHP water cutting treatment process is most strongly impacted by the capability of the UHP water cutting equipment. In other words, it is possible to achieve effective treatment – that is, significant improvement in pavement texture and friction – for just about any road if the UHP water cutting equipment is fully functional and the treatment settings are optimized.

It has been noted that the focal point of the UHP water cutting system is the cutting head. 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, selection of the optimum travel speed, was discussed under evaluation of production rates.

Through experience and monitored field trials, Rampart Hydro Services has established optimum nozzle configurations for different UHP water cutter applications associated with their BlasterVac equipment including airport rubber removal (28 nozzles), paint removal (20 nozzles), and hydro-scarification (8 nozzles) with fewer nozzles generally corresponding to more aggressive treatment. The 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 (Figure 32). 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 have increased potential to damage the seal coat 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 (Figure 33).

Other cutting head variables for the Rampart equipment 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, and the UHP pump flow rate and pressure.

SECTION 5



FIG 32. The nozzle configuration influences effectiveness of the UHP water cutter process.



FIG 33. Rotational speed for the spray bar influences UHP water cutter effectiveness. *Image courtesy TTI Visual Media.*

SELECTION OF CANDIDATE PROJECTS

FACTORS THAT INFLUENCE DURABILITY OF THE UHP WATER CUTTER TREATMENT

Analysis of variance associated with treatment durability, expressed in terms of survivability and life expectancy, suggest that these parameters are most strongly influenced by average daily traffic volume and by the percentage of trucks (Figure 34). General trends are as follows:

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

Other factors, such as the type of binder, type of aggregate, aggregate hardness, and climate, show 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.

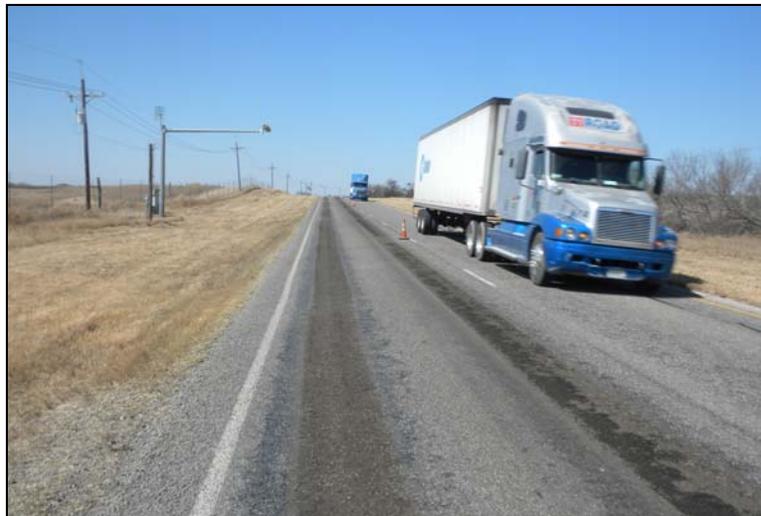


FIG 34. Higher daily traffic and more trucks reduce the survivability and life expectancy of the UHP water cutter treatment.

SECTION 5

UHP WATER CUTTER TREATMENT PROBLEMS

The UHP water cutter removes a significant amount of excess asphalt material from the pavement surface, the actual quantity removed depending on the extent of flushing and other characteristics. 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 35.



FIG 35. Waste debris and water remaining on the pavement surface when the vacuum system is not functioning properly.

In some cases, the vacuum system is fully functional but not adequate for the challenge. Figure 36 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 would clog the vacuum system.

SELECTION OF CANDIDATE PROJECTS

In this case, a maintenance worker had to hand-scrape asphalt lumps from the pavement surface which were 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 showed excessive flushing, and the asphalt 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 are also important considerations when planning water cutter treatment activities. Note also that a power broom must follow the water cutter to ensure that all material is removed from the roadway before traffic is allowed back.



FIG 36. Hand-scraping of excess asphalt lumps, cut but not vacuumed from the pavement surface.

SECTION 5

Another unexpected set of problems occurs when the cutting head nozzles are not properly configured, or when the UHP water cutter treatment speed is too low or too high.



Figure 37 shows damage to the pavement surface associated with an overly aggressive nozzle configuration.

FIG 37. Pavement damage due to an aggressive nozzle configuration.

Figure 38 shows how even the correct nozzle configuration on the spray-bar, left rotating too long in one place, can damage the pavement surface.



FIG 38. Pavement damage due to stationary spray-bar rotation.

SELECTION OF CANDIDATE PROJECTS

Inadequate treatment can result when the pavement surface is rutted. In this case, the vertical distance between the spray bar (nozzle orifice) and the pavement surface is wider at the center of the wheel path than at the edges, and this height variation can be sufficient to diffuse water cutting energy in the middle of the wheel path. The outcome is variable, inadequate treatment. Figure 39 shows the effect of inadequate treatment in the middle of the wheel path. Here, the depth of wheel path rutting is less than 3/8 inch.



FIG 39. Inadequate treatment in the middle of the wheel paths, resulting from a non-uniform pavement surface (rutting).

It should be noted that a variable treatment pattern, similar to that shown in Figure 39 but across the full width of the spray bar, occurs when the UHP water cutter treatment rate; i.e., the forward speed of the truck, is too high.

SECTION 5

OTHER OBSERVATIONS

UHP water cutter treatment should be done during the cooler time of the year when pavement temperatures are lower and the asphalt material is stiffer (more brittle). This allows excess asphalt to be cut more efficiently and effectively, achieving better production rates.

Treatment of flushed asphalt pavements should not be done during the hotter times of the year when the pavement temperatures are higher and the asphalt is more ductile (softer). UHP water cutting during these conditions will significantly reduce production rates and treatment effectiveness, and has a tendency to “gum up” the machinery requiring continual cleaning and maintenance of the equipment.

The UHP process can be operated in cold, damp or wintry conditions where other resurfacing options are not feasible. Because the process involves adding water to the pavement surface, no *functional* reason exists to prevent UHP water cutting from being accomplished during wet weather. However, from a roadway maintenance perspective, traffic control and worker safety considerations associated with UHP water cutting, especially for narrower two-lane roads, are such that performing this type of maintenance during inclement weather is not recommended.

Retexturing should not be used on thin seals where rapid failure may occur as a result of insufficient remaining binder to adequately hold the seal in place.

Care must also be applied when treating very weak and previously patched pavements. Contingency plans may be needed for restoration of patches damaged by the retexturing operations.

SELECTION OF CANDIDATE PROJECTS

CANDIDATE PROJECT SELECTION

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.

TxDOT's 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, TxDOT's data 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.

The specifications presented in the following pages are intended to facilitate contracting for UHP water cutter work so TxDOT maintenance professionals can try this 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.

SECTION 5

APPENDIX A

Equipment for Treatment of Flushed Asphalt Pavement

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 be of sufficient capacity to collect all pavement treatment debris and waste water from the roadway surface.

APPENDIX A

- 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.

SPECIFICATIONS

Equipment for Treatment of Flushed Asphalt Pavement

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

APPENDIX A

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.

SPECIFICATIONS

Equipment for Treatment of Flushed Asphalt Pavement

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.

APPENDIX A

###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.

TEXAS DEPARTMENT OF TRANSPORTATION

SPECIFICATIONS

Equipment for Treatment of Flushed Asphalt Pavement

APPENDIX B

Treatment of Flushed Asphalt Pavement Using Ultra High Pressure Water Cutting

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.

A. **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.

A. **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).

APPENDIX B

###.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 be of sufficient capacity to collect all pavement treatment debris and waste water from the roadway surface.
- 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.

SPECIFICATIONS

Treatment of Flushed Asphalt Pavement Using Ultra High Pressure Water Cutting

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

APPENDIX B

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.

SPECIFICATIONS

Treatment of Flushed Asphalt Pavement Using Ultra High Pressure Water Cutting

- 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 35° F to 85° 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.

APPENDIX B

###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 macrotexture 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.

SPECIFICATIONS

Treatment of Flushed Asphalt Pavement Using Ultra High Pressure Water Cutting

- 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

APPENDIX B

- 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

SPECIFICATIONS

Treatment of Flushed Asphalt Pavement Using Ultra High Pressure Water Cutting

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.

**GUIDELINES FOR USING UHP WATER CUTTING TO REMOVE EXCESS
SURFACE ASPHALT**

APPENDIX B

###.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.

SPECIFICATIONS

Treatment of Flushed Asphalt Pavement Using Ultra High Pressure Water Cutting

**GUIDELINES FOR USING UHP WATER CUTTING TO REMOVE EXCESS
SURFACE ASPHALT**

**GUIDELINES FOR USING UHP WATER CUTTING TO REMOVE EXCESS
SURFACE ASPHALT**

**GUIDELINES FOR USING UHP WATER CUTTING TO REMOVE EXCESS
SURFACE ASPHALT**

sponsored by the
Texas Department of Transportation

in cooperation with
**U.S. Department of Transportation
Federal Highway Administration**

September 2012



TEXAS TECH UNIVERSITY

TECHMRT

MULTIDISCIPLINARY RESEARCH IN TRANSPORTATION

TEXAS TECH UNIVERSITY

Box 41023

Lubbock, TX 79409-1023

Phone: 806.742.3505

Fax: 806.742.4168

Web: <http://www.techmrt.ttu.edu/>