QUARTERLY PROGRESS REPORT

January, 1 2011 to March, 31 2011

In this reporting period the new TFHRC Hydraulics Laboratory Support Services contract was awarded and following task order proposal request was submitted to the contractor to conduct the work on the In-situ scour testing device.

Contract No: DTFH61-11-D-00010 “Hydraulics Laboratory Support Services Contract”.
Title: In-situ Scour Testing Device.

The FHWA has a requirement for a new task order under DTFH61-11-D-00010 Contract in support of the statement of work provided below. The proposal submittals by the contractor shall be to the Contracting Officer (CO) and the Contracting Officer’s Technical Representative (COTR) at:

Karen.Marshall@dot.gov, CO
Eric.Munley@dot.gov, COTR

All questions should be forwarded to the CO and the COTR.

RESEARCH OBJECTIVES

The contractor shall work with federal personnel from the Hazard Mitigation team at the Turner Fairbank Highway Research Center (TFHRC) to demonstrate the feasibility of using an in-situ scour testing device to for use as a foundation design aid by the highway and bridge engineering community. The research will be based on a combination of data obtained from the historical scour research literature, laboratory experiments, and data collection.

STATEMENT OF WORK (SOW)

Current methodologies for predicting scour depths around bridge piers typically employ empirical equations derived from physical model studies using non-cohesive, uniformly graded sands. This approach represents a worst-case condition since non-cohesive sands are one of the most erodible soils found in nature. In practice, these equations are commonly applied to all soils that cannot be strictly classified as non-erodible. Since very little, easy-to-apply information is available to evaluate potential scour in erosion resistant soils, a great deal of engineering experience is necessary for one to feel confident about quantifying any reduction of the scour estimated from these equations. Consequently, because of the risks involved, predictions of scour in erosion resistant soils are frequently conservative, resulting in overly deep and expensive pier foundations.

The unlimited range of soil types and combinations of soil types found in nature creates a full continuum of erodibility from the easily erodible, very fine silts to the non-erodible, competent rock. If even possible to fully describe this erodibility continuum, it will take significant time, effort, and money to develop reliable, practical methodologies and models for doing so. More immediate assistance is needed in this regard. An effective in-situ scour testing device could provide this assistance now on a project-by-project basis. Such a field device could more accurately define the scour potential for a given set of hydraulic design conditions and pier type, regardless of the foundation soil type or types present.

In conceptual terms, the prototype field device would consist of a confined column of continuously flowing water directed downward then horizontally across the soils that are to support the bridge pier foundations. The rate, hence, shear characteristics of the flow would be reduced with the depth of advancing scour to reflect the natural decay of the horseshoe vortex. The device would be calibrated through physical model testing at laboratory scales to produce the scour depth predicted for a sand-bed channel with the design hydraulic conditions and proposed pier geometry. The field test would be run until equilibrium conditions are reached in the resulting scour hole, or until some maximum period of time has elapsed (such as the expected cumulative time the foundation will be exposed to the design discharge over the life of the bridge). The in-situ soils would thereby be exposed to the energy necessary to develop the scour depth, as predicted by currently used equations. Any equilibrium or maximum scour depth resulting from a field test that is less than the predicted depth for a sand-bed channel would be attributable to the erosion-resistant characteristics of the in-situ soils.

The device would be used for foundation analysis and design in a manner similar to present-day soil borings in that several tests would be conducted across the channel and floodplain area to be occupied by a proposed new or replacement bridge. The scour depth information resulting from the field test(s) would be used, in conjunction with the subsurface soil boring information, to adjust the design scour depth predicted by the equations for sand-bed channels for the actual soil conditions at the bridge site.

The basis for this approach is the perceived similarity between the scouring horseshoe vortex at the base of a bridge pier and the horizontal shear produced by the device at its interface with the ground. However, because forces other than pure viscous shear contribute to the scour mechanism (turbulence, pressure fluctuations, etc.), this premise needs to be researched and tested.

RESEARCH TASKS

Considering the above, the work shall be performed in accordance to the following tasks:

Task 1: Fabricate Laboratory Device. Identify a practical combination of prototype device components (size of confining column, piping, etc.) and variable speed pumps (or throttles) that can be appropriately scaled down for laboratory testing. Acquire and/or manufacture the scaled-down device for laboratory use. Consider using CFD modeling to supplement developing the laboratory device.

Task 2: Calibrate and Test Laboratory Device. Correlate the discharge rate through the device with the viscous shear that is generated at the head of the device. Create a laboratory setting that will accommodate the sediment and flowing water necessary to conduct the tests both in the dry and submerged by varying depths of water.

Task 3: *Run Experiments with the Laboratory Device.* Identify the critical shear of the easily erodible, fine sand to be used in the tests and the appropriate shear decay function needed to define the reduction in flow rate with scour depth. Run a series of tests using the device in the easily erodible sand with initial shear stresses at the head of the device being multiples of the critical shear. Measure the resultant equilibrium scour depth. Run tests with successively higher initial shear stresses until an equilibrium scour depth on the order of 60-100 ft is attained for the prototype scale. The resulting data point pairs will define the relationship between initial shear and resulting scour depth for a given shear decay function.

Task 4: *Run Experiments with the Laboratory Device for Different Sand Sizes*. Repeat Task 3 using a different sand size to determine the potential impact of gradation.

Task 5: *Final Report*. A detailed final report shall be submitted documenting all the work conducted in tasks 1 to 4.

DELIVERABLES

The project timeline and expected deliverables are outlined in Table I below.

Table I - Project Time frame and expected deliverables

Main Research Tasks	Time period (beginning month to ending month) (All times are based from the effective date of the contract)				
	1 → 12	12 → 14	14 → 15	15 → 17	17 → 18
TASK 1	Fabricate Laboratory Device				
TASK 2		Calibrate and Test Laboratory Device			
TASK 3			Run Experiments with the Laboratory Device		
TASK 4				Run Experiments with the Laboratory Device for Different Sand Sizes	
TASK 5					Final report

PERIOD OF PERFORMANCE

All work on this task order shall be completed 18 months from the effective date of the contract. Approximate start date: 5/01/2011.