VIRGINIA DEPARTMENT OF TRANSPORTATION
DRAFT SPECIAL PROVISION FOR
COLD IN-PLACE RECYCLING (CIR)

November 6, 2012

I. DESCRIPTION

Cold In-place Recycling (CIR) is defined as those processes in which a portion of existing asphalt concrete pavement layers are pulverized, stabilized, and repaved in place. This is most commonly performed using foamed asphalt or asphalt emulsion as the primary stabilizing additive to a thickness of 3 to 6 inches. The pavement may be milled, stabilized, and repaved using the same machine or machine train, or paved from a stabilized, windrowed material using traditional practices.

The Contractor shall furnish all labor, materials and equipment required for completing the work. The Contractor shall select the final mix design (job mix formula- JMF) and construction methods to meet the performance requirements specified herein. The Contractor shall also be responsible for developing and implementing a Quality Control Plan to ensure that operational techniques and activities under their control provide a homogeneous and finished material of acceptable quality. Contractor sampling and testing shall be performed to control the processes and ensure material compliance with the requirements of this special provision. The Contractor shall provide their Quality Control Plan (in accordance with the requirements of this special provision) and the Job Mix Formula(s) they intend to accomplish the work to the applicable local Materials Engineer for Department approval no less than thirty (30) calendar days prior to the start of CIR operations.

For each CIR project, a project specific Quality Control Plan is required, and shall include the following (minimum) information:

i) A description of the Contractor's Quality Control organization, including the number of full-time equivalent employees or Sub-Contractors with specific Quality Control responsibilities, including an organizational chart showing lines of authority and reporting responsibilities.

ii) A listing by discipline with the name, qualifications, duties, responsibilities and authorities for all persons proposed to be responsible for Construction Quality Control;

iii) A Quality Control Sampling, Testing and Analysis Plan with methods that include a description of how random locations for testing and sampling are determined;

iv) Identification and description (Accreditation) of the laboratory(s) to be used for each type of testing;

v) Specify documentation for QC activities;

vi) Procedures to meet contract requirements for corrective action when QC criteria are not met.

vii) Procedures to protect stabilized material from receiving excessive moisture from weather events (i.e. rain, fog, etc.) and corrective actions when criteria are not met.

The Contractor is required to have a technical representative at the project site during mixing and placement operations. At a minimum, this person must:

- Have 2 years minimum experience with the CIR process,
- Have personally supervised a minimum of 5 successful CIR projects,
- Have personal experience in developing CIR mix designs,
- Have the experience to perform and supervise field process control testing, and

- Submit a list of references, with current telephone numbers, of persons who are able to verify the experience required herein

The Contractor may use consultants or manufacturers' representatives to satisfy the technical representative requirements of this section provided these individuals meet the requirements listed above and are on-site at all times construction operations are being performed.

II. MATERIALS

a) **Stabilizing Agent (Emulsified or Foamed Asphalt)** – All liquid asphalts used for stabilizing agents shall be emulsions and PG binders (Lists Nos.50 and 50.1) on the VDOT Materials Division's Approved List. Asphalt emulsions shall conform to the requirements of Section 210 of the Specifications; liquid asphalts shall meet the requirements of Section 211.02 of the Specifications.

b) **Water** – Any water used for mixing shall meet the requirements of Section 216 of the Specifications.

c) **CIR** – The CIR material shall have 100% of all particles passing the 1.5 inch (37mm) size sieve and meeting the gradation requirements in **TABLE 3** herein prior to the addition of any stabilizing agents.

d) **Other Additives** – If necessary, additional additives may be used to meet the requirements in **TABLE 4**. In the case where an additional additive is used, the type and dosage must be described in the Job Mix Formula(s) submitted to the Department.

e) **Addition of Crushed Reclaimed Asphalt Pavement (RAP) Material** – Additional RAP material (other than that reclaimed from the project) may be added by the Contractor and, if added, shall meet the requirements of Section 211.02(j) of the Specifications and **TABLE 1** herein.

TABLE 1 – ADDITIONAL CRUSHED RAP

Tests	Method	Limit
Deleterious Materials: Clay Lumps and Friable Particles in Aggregate	AASHT O T 112	0.2% maximum
Maximum Sieve Size, 1.5 inches (37mm)	AASHT O T 27	100% Passing,

f) **Additional aggregate** – Based on the results of the job mixture design(s) or other requirements of this provision, the Contractor shall determine if additional aggregate is required. If the Contractor determines additional aggregate is needed, any additional aggregate shall meet the requirements of Section 203 and **TABLE 2** herein, and it shall be graded to produce a product which meets the specification given in **TABLE 3.**

TABLE 2 – ADDITIONAL AGGREGATE

Tests	Method	Limit
Los Angeles Abrasion Value	AASHT O T 96	45% maximum loss
Sand Equivalent	AASHT O T 176	60% minimum
Maximum size, 100% Passing, Sieve Size	AASHT O T 27	1.5 inches (37mm)

Water absorption	AASHT O T 85	3% maximum

III. Job Mix Formula

Mixture Designs – CIR mix design(s) in the form of a job-mix formula(s) (JMF) shall be submitted to the Engineer for Department approval no less than 30 calendar days prior to the start of CIR operations; more than one JMF may be required. The gradation of each JMF shall fall within the bands shown in **TABLE 3.**

TABLE 3 – GRADATION REQUIREMENTS

Sieve Size	Foamed Asphalt*		Asphalt Emulsion*	
	Lower	Upper	Lower	Upper
1.5"	100	100	100	100
1.0"	78	100	85	100
3/4"	70	93	75	96
3/8"	--	55	--	55

*based on pulverized materials, prior to stabilization, washed, following AASHTO T 27 and T 11

The JMF(s) shall be created using existing materials obtained directly from the project site (prior to the start of construction). Sampling shall be conducted at a maximum of once per 2500 lane-feet. Each JMF shall provide, as a minimum, the following mix design parameters:

1) Target field density,

2) Percent by weight of all stabilizing agent(s) to be added to the recycled mix,

3) Percent by weight of water (at room temperature) required,

4) Expansion ratio and half-life characteristics and temperature of asphalt binder at the time of dosage into foaming chamber (for mixtures using foamed asphalt), minimum curing time/set time for the asphalt emulsion and temperature of asphalt emulsion at the time of dosage into the mixture (for mixtures using asphalt emulsion), and

5) Target gradation (including any aggregate to be added).

If a change in source materials is made during construction, a new JMF(s) shall be established, submitted to the Engineer and approved prior to use on the project. The JMF(s) shall meet the criteria of **TABLE 4** at the approved stabilizing agent(s) content.

TABLE 4 – CIR MIX DESIGN REQUIREMENTS

Item	Test Method	Criteria	Fabrication / Conditioning Procedure

Asphalt Emulsion Stabilized Materials			
1	Moisture Density Relations AASHTO T 180	Determined by Design	
2	Marshall Stability Test ASTM 5581 (6 inch specimens), AASHTO T 245 (4 inch specimens)	2500 lbs minimum (6 inch (150mm) diameter specimen), or 1250 lbs (4 inch (100mm) diameter specimen)	Three (3) specimens shall be produced at 75 blows per side (or 30 gyrations per AASHTO T 312) and cured at 60 °C to constant mass, hold specimens at 40 °C for 2 hours in a forced draft oven immediately prior to testing.
3	Retained Stability ASTM 5581 (6 inch specimens), AASHTO T 245 (4 inch specimens)	70% of results of #2	An additional three (3) specimens shall be produced at cured at 60 °C to constant mass. Specimens shall then be vacuum saturated to 55-65%, 25 °C water bath for 23 hours and 40 °C water bath for an additional hour immediately prior to testing
4	Raveling Stability (ASTM D 7196)	Maximum 2%	Specimens shall be produced using a gyratory at 20 gyrations and cured at 10°C for 4 hours at 50% humidity.
5*	Thermal Cracking (Indirect Tensile Test, AASHTO T 322)	The critical cracking temperature must be less than or equal to the pavement temperature given for the project climate area and pavement depth by LTPPBind.	See Notes 1 through 7 below.
6	Resilient Modulus (ASTM D 7369)	150,000 psi minimum	Same as Item 2.
Foamed Asphalt Stabilized Materials			
8	Moisture Density Relations AASHTO T 180	Determined by Design	
9	Dry Indirect Tensile Strength (ITS), AASHTO T 283 Section 11	45 psi minimum	Three (3) specimens shall be produced using 75 blows per side (or 30 gyrations per AASHTO T 312) compacted at or below OMC and cured as follows: 4 inch (100 mm) diameter specimens, oven dry at 40 °C for 72 hrs and cool to ambient temperature for 24 hrs; 6 inch (150 mm) diameter specimens, air dried for 24 hours, then an additional 48 hours at 40 °C in sealed plastic bag, cool to ambient temperature for 24 hrs.
10	Retained Indirect Tensile Strength, AASHTO T 283 Section 11	Minimum, 70% of the Dry ITS from Item 9	An additional three (3) specimens shall be produced and cured according to Item 9, and then submerged in 25 °C water bath for 24 hours prior to testing.
11	Resilient Modulus ASTM D 7369	150,000 psi minimum	Same as Item 9.

All materials (asphalt emulsion and foamed asphalt) shall be controlled following Item 12.

12	Materials Gradation Test (AASHTO T 27), prior to stabilization	Coarse and fine gradation to control field production.	

* 1. Specification temperature shall be chosen using current FHWA LTPPBind software, using the weather station closest to the project. The required temperature shall be the coldest temperature at the top of the recycled layer, using 98% reliability.
2. Samples shall be compacted to 150 mm diameter and at least 115 mm height, compacted to within 1% of design air voids at the design stabilizing agent content. Compacted samples shall be cured at 60 °C no less than 48 hours. Before testing, sample mass shall be checked every two (2) hours until change in mass between successive checks does not exceed 0.05%. After curing, two (2) specimens shall be sawcut from each compacted sample to 50 mm in height. Perform bulk density testing after sawcutting.
3. Three (3) specimens are required at each of the three (3) testing temperatures.
4. Select two (2) testing temperatures that bracket the specification temperature above. For example, if the specification temperature is -25 °C, then two (2) of the selected testing temperatures shall be -20 °C and -30 °C. A temperature of -10 °C or -40 °C shall be used as the third testing temperature.
5. The tensile strength test shall be performed on each specimen directly after the tensile creep test (at the same temperature as the creep test).
6. The critical cracking temperature is defined as the temperature at the intersection of the thermal stress curve (derived from the creep data) and the tensile strength line (the line connecting the average tensile strengths at the three testing temperatures).
7. To meet this specification, the critical cracking temperature predicted by the Indirect Tensile Test must be less than or equal to the pavement temperature given for the project climate area and pavement depth by LTPPBind.

IV. EQUIPMENT

(a) **CIR** – The CIR work shall be completed with the following required equipment.

A self-propelled machine with a down cutting milling head that is capable of pulverizing and recycling the existing bituminous pavement to a maximum depth of 6 inches (0.12m), uniformly incorporating the stabilizing agent(s) and water, and mixing the materials to produce a homogeneous product. The machine shall be capable of pulverizing and recycling the full lane width in no more than two passes (with the longitudinal joint located between the anticipated wheel paths). The machine shall have the ability to meter dosage rates for stabilizing agent(s) and water relative to the machine's ground speed. Individual valves on the spray bar shall be capable of being turned off as necessary to minimize stabilizing agent(s) and water overlap on subsequent passes. The equipment shall be operated in accordance with the manufacturers' recommendations.

The self-propelled machine may also have a screed attached to the milling and mixing unit. The screed shall have slope control and the ability to convey material out to the side of the screed if there is a surge of material between the mixing chamber and the screed. The mixing unit and screed combination must have electronic grade controls. In lieu of a screed attachment, the material may be placed into an asphalt paver that meets the requirements of Section 315.03(b) by means of a material transfer device.

Any additives such as water, lime slurry, etc. added by the equipment at the milling head or mixing unit shall be controlled through liquid metering devices capable of automatically adjusting for the variation in the weight of the pulverized bituminous material going into the mixing unit.

The metering devices shall be capable of delivering the amount of additive to within +/- 0.2% of the required amount by weight of the pulverized bituminous material, except that a capability of adding up to 5% water by weight of the pulverized bituminous material is mandatory. It is not required, by the Department, to meter the water added at the milling machine to control dust in the screens, belts, or crusher/material sizing unit.

A pozzolonic material distributor truck shall be used if dry stabilizing agent(s) is/are applied directly to the bituminous pavement prior to CIR operations. The pozzolonic material distributor truck shall have the ability to uniformly apply the stabilizing agent(s) at the specified rate.

(b) **Rollers** – All rollers shall be self-propelled. At least one pneumatic tire roller shall have a minimum gross operating weight of not less than 50,000 lbs. (22,600 kg). At least one double steel-wheeled vibratory roller shall have a gross operating weight of not less than 24,000 lbs. (10,800 kg) and a width of 78 inches (2.0 meters). All rollers must have properly working scrapers and water spraying systems.

V. Test Strip

One week before planned start of full production, stabilize a 2,500 foot long test strip, one-lane wide, at the designated thickness and designed optimal stabilizing agent(s) content provided in the approved job mix design. Construct the test strip on the project at an approved location.

Construct the test strip using construction procedures intended for the entire project. Cease production after construction of the test strip until the test strip is evaluated and accepted. Payment will follow the payment tables established in this specification

VI. CONSTRUCTION METHODS

(a) Grass and other vegetation shall be removed from the edge of the existing pavement to prevent contamination of the pulverized bituminous material during the milling operation.

(b) The existing bituminous pavement shall be milled to the required depth and width as indicated on the plans. Recycling shall be performed in a manner that does not disturb the underlying material in the existing roadway. The milling operation shall be conducted so that the amount of fines occurring along the vertical faces of the cut shall not prevent bonding of the CIR materials. If needed, the CIR materials shall be processed by crushing or sizing to the required gradation specified in **TABLE 3**. When a paving fabric is encountered during the CIR operation, the Contractor shall make the necessary adjustments in equipment or operations so that at least ninety percent (90%) of the shredded fabric in the recycled material is no more than the particle size specified in Section II.c herein. These changes may include, but shall not be limited to: adjusting the milling rate, the milling depth, and/or adding or removing screens in order to obtain the specified recycled material. The Contractor will be required to waste material containing over-sized pieces of paving fabric as directed by the Engineer. The Contractor will not receive additional payment for the necessary adjustments to his equipment or CIR operations to accommodate the presence and processing of the paving fabric.

(c) Adjacent CIR passes shall overlap by 4 to 6 inches. The stabilizing agent shall be controlled such that it is not applied at the joint overlap location more than the dosage rate in the approved mix design by the total of the passes.

(d) Compaction of the recycled mix shall be completed using rollers meeting the requirements of Section IV.c herein. The Contractor shall establish rolling patterns to achieve the density target as determined by nuclear density testing. Final rolling to eliminate pneumatic tire marks and to achieve density shall be done by double drum steel roller(s), either operating in a static, oscillating or vibratory mode. Oscillating and vibratory mode should only be used if it is shown to not damage the pavement. Rolling shall be performed until the material reaches a density of 98% the maximum theoretical density as measured via a nuclear density gauge. Rolling shall start no

more than 30 minutes after initiation of paving. Finish rolling shall be completed no more than one hour after paving is completed, unless otherwise approved by the Engineer. When possible, rolling shall not be started or stopped on uncompacted material but performed with rolling patterns established so that they begin or end on previously compacted material or the existing pavement.

(e) After compaction of the recycled material, a fog seal shall be applied to the recycled surface at a uniform application rate of 0.05 gal/sy. The fog seal shall be a CSS-1h, CQS-1h, or Non Tracking Tack Coat conforming to the requirements of Section 210 of the Specifications and the Special Provision For *Non Tracking Tack Coat* included in the Contract. A light grit may be applied to reduce raveling. After fog sealing, no traffic, including the Contractor's equipment, will be permitted on the completed recycled material for at least two (2) hours. After two hours rolling traffic may be permitted on the recycled material. This time may be adjusted by the Engineer to allow establishment of sufficient cure so traffic will not initiate raveling. After opening to traffic, the surface of the recycled pavement shall be maintained in a condition suitable for the safe movement of traffic. All loose particles that may develop on the pavement surface shall be removed by power brooming.

(f) Any damage to the completed CIR material shall be repaired by the Contractor at their expense, to the Engineer's satisfaction, prior to the placement of the asphalt concrete surface course(s), or other applicable surface treatment. Damage unrelated to Contractor's construction procedures or quality of work, such as due to poor base conditions, shall be paid for as described in the VDOT Special Provision for *Surface Preparation and Restoration Prior to Plant-Mix Overlay* included in the Contract.

(g) Before placing the asphalt concrete surface course(s), or other applicable surface treatment, the CIR material shall be allowed to cure until the moisture of the material is a maximum of 50% of the optimum moisture content or until approval of the Engineer is received. Moisture content shall be measured per AASHTO T 329 on samples (immediately placed in a sealed plastic bag) taken from two stratified random locations as determined by the Engineer for each production day. Other methods and sampling rates may be used if supplied in the Contractor's Quality Control Plan and approved by the Engineer. Split samples may be taken at the direction of the Engineer.

VII. ACCEPTANCE TESTING

(a) **Field Compaction** – A nuclear density gauge conforming to the requirements of VTM-10 shall be used for determining mat density by the Direct Transmission method. The Contractor's nuclear density gauge shall have been calibrated within the previous 12 months by an approved calibration service. In addition, the Contractor shall maintain documentation of such calibration service for the 12-month period from the date of the calibration service and furnish the same to the Engineer if requested. The Contractor shall determine a roller pattern and construct a control strip in accordance with the requirements of VTM 10. Density test locations shall be marked and labeled by the Contractor in accordance with the requirements of VTM-76. The control strip will be acceptable if the field proctor (AASHTO T 180) is at least 98% of the target density from the approved job mix design(s). The required density of the compacted CIR course shall not be less than 98.0 percent of the target density from the approved job mix design(s).

Test section (lot) – For the purposes of acceptance, each day's production will be considered a lot unless the paving length is less than 3,000 linear feet or greater than 7,500 linear feet. When paving is less than 3,000 feet, it shall be combined with the previous day's production or added to the next day's production to create a lot as described below.

The standard size of a lot shall be 5,000 linear feet, with 1,000 linear foot sublots, of any pass 6 feet or greater made by the paving train for the thickness of the course. When a partial lot occurs at the end of a day's production or upon completion of the project, the lot shall be 1) added to the

previous lot if the partial lot contains one or two sublots or 2) redefined to be an entire lot if the partial lot contains three or four sublots.

Each lot shall be tested for density by taking a nuclear density reading from two random test sites selected by the Engineer within each sublot used for acceptance. Test sites shall not be located within 18 inches of the edge of any application width for CIR mixes.

The average of the sublot density measurements will be compared to the target nuclear density established by the approved mix design to determine the acceptability of the lot. Once the average density of the lot has been determined, the Contractor will not be permitted to provide additional compaction to raise the average. If two consecutive sublots produce density results less than 98 percent of the target density, the Contractor shall immediately notify the Engineer and institute corrective action. By the end of the day's operations, the Contractor shall furnish the test data developed during the day's recycling to the Engineer. The Contractor shall verify their results for every lot by performing a field proctor (AASHTO T180). The field proctor shall be at least 98% of the target density from the approved mix design.

The tonnage or square yards of each lot will be based on the lot's width and length and the mixture application rate as designated in the Contract or as revised by the Engineer. Payment will be made in accordance with the requirements of **TABLE 5.**

TABLE 5 - PAYMENT SCHEDULE FOR LOT DENSITIES

% of Target Control Strip Density	% of Payment
98.0 or greater	100
97.0 to less than 98.0	95
96.0 to less than 97.0	90
Less than 96.0	75

(b) **Material Composition** – The Contractor shall determine material composition properties by obtaining samples and testing ITS/Stability in the lab. Testing ITS/stability values shall be conducted twice per lot.

The minimum ITS/stability value shall be a minimum of 95% of the approved JMF and maintain a retained ITS/stability value of 60% for field produced, laboratory compacted samples. Six ITS/Stability specimens shall be tested in accordance with **TABLE 4**. Payment for that lot will be based on **TABLE 6**.

TABLE 6 – ITS/STABILITY PAY ADJUSTMENTS

ITS/stability, % of approved JMF	% of Payment
95% or greater	100
90% to 95%	90
80% to 90%	80
Less than 80% and greater than 45 psi/2500 lbs	50
Less than 80% and less than 45 psi/2500 lbs	0

In the event the Contractor disputes the ITS/stability value results, the Contractor, under the supervision of the Engineer, shall obtain 6 cores (randomly stratified) for the lot in question. Payment for that sublot in question will be based on **TABLE 6**.

(c) **Gradation** – For CIR, the Contractor shall verify that the unstabilized gradation conforms to the JMF at the beginning of each production day and wherever there are changes in the pavement structure being recycled. Gradation bands shall be established for the day by operating the machine at two distinct speeds and sampling the associated unstabilized material for field gradation testing.

(d) **Depth Check** – Depth checks shall be performed by the Contractor by coring in accordance with VTM-38 at a rate of twice per 5,000 linear feet after compaction and placement of the first lift of asphalt. Depth checks shall be taken at the Engineer's direction. Depth check cores will be retained by the Department.

Acceptance of CIR course for depth will be based on the mean result of measurements of samples taken from each lot of material placed.

A lot will be considered acceptable for depth if the mean result of the tests is within the tolerance of the plan depth for the number of tests taken as shown in **TABLE 7**.

TABLE 7 – PROCESS TOLERANCE FOR DEPTH CHECKS

Plan Depth, inches	Tolerance, inches			
	1 test	2 tests	3 tests	4 tests
≤ 4	0.6	0.45	0.35	0.30
>4 ≤ 6	0.9	0.65	0.50	0.40

If an individual depth test exceeds the tolerance for one test, that portion of the lot represented by the test will be excluded from the lot. If an individual test result indicates that the depth of material represented by the test is more than the tolerance for one test for the specified depth, the Contractor will not be paid for that material in excess of the tolerance throughout the length and width of that portion of the lot represented by the test. If an individual test result indicates that the depth of the material represented by the test is deficient by more than the tolerance for one test, correction of that portion of the lot of the CIR course represented by the test shall be made as specified hereinafter.

If the mean depth of a lot of material is excessive, the Contractor will not be paid for that material in excess of the tolerance for the plan depth specified throughout the length and width of the lot of material represented by the tests.

If the mean depth of a lot of material is deficient by more than the allowable tolerance for the plan depth specified, correction will not normally be required and the Contractor will be paid for the quantity of material that has been placed in the lot.

For excessive depth CIR courses, the rate of deduction from the tonnage allowed for payment as CIR course will be calculated based on the JMF weight per square yard per inch of depth in excess of the tolerance for the plan depth specified or the Department can require excessive material to be removed at the Contractor's expense.

For sections of CIR course that are deficient in depth by more than the tolerance for one test and less than 1.50 inches, the Contractor shall furnish and place material specified for the subsequent course to bring the deficient CIR course depth within the tolerance of the specified plan depth. This additional material shall be placed at the Contractor's expense.

If the deficiency is more than 1.50 inches, the Contractor shall furnish and place the CIR course material to bring the thickness within the tolerance of the specified plan depth. Corrections for deficient CIR course depth shall be made in a manner to provide a finished pavement that is smooth and uniform. Sections requiring significant grade adjustments that have been previously

identified and documented by the Engineer as being outside of the control of the Contractor will be exempt from deduction or corrective action.

(e) **Stabilizing Agent Dosage Rate** – The Contractor shall verify the stabilizing agent dosage rate by reading a calibrated meter ten times per lot. The dosage rate shall be within 0.20 percentage points of the approved JMF. If the dosage rate is outside 0.20 percentage points, then paving/production shall stop and the Contractor shall take corrective measures to bring the dosage rate within tolerance. The Engineer will calculate the yield at the end of each production day.

(f) **Construction Records** – The Contractor shall prepare separate test reports meeting the requirements of AASHTO R 18 or may use the current appropriate VDOT forms. Records documenting the dosage rate of stabilizing agent(s) and other test results from **TABLE 4** shall be provided to the Engineer, unless specified otherwise.

VIII. WEATHER LIMITATIONS

Recycling operations shall be completed when the atmospheric temperature and material to be processed (measured in the shade and away from artificial heat) is a minimum 50°F (10 °C). The weather forecast shall not call for freezing temperature within 48 hours after placement of CIR on any portion of the project.

IX. MEASUREMENT AND PAYMENT

Cold In-Place Recycling (CIR) will be measured by the square yard (or square meter) of the completed sections for the depth specified in the plans and will be paid for at the Contract unit price per square yard (square meter) of depth. This price shall be full compensation for removal and processing of the existing pavement; for preparing, hauling, and placing of all materials; furnishing stabilizing agents, fog seal, grit and additives, for all freight involved; for all manipulations, including removal of grass and other vegetation, rolling and brooming, for testing and documentation, asphalt supplier services, and for all labor, tools, equipment and incidentals necessary to complete the work.

Liquid Asphalt (Emulsion) will be measured and paid for at the Contract unit price per ton (Metric ton). This price shall be full compensation for furnishing and incorporating the emulsion into the mixture. An emulsion content of 3.0% by weight of the milled bituminous material shall be used for bidding purposes prior to the completed mix design. The actual emulsion content will be adjusted based on the quantity necessary to meet the design requirements in **TABLE 4.**

Liquid Asphalt (Foamed) will be measured and paid for at the Contract unit price per ton (Metric ton). This price shall be full compensation for furnishing and incorporating the foamed asphalt into the mixture. A foamed asphalt content of 2.5% by weight of the milled bituminous material shall be used for bidding purposes prior to the completed mix design. The actual foamed asphalt content will be adjusted based on the quantity necessary to meet the design requirements in **TABLE 4**.

Additional Crushed RAP if required to meet the contract requirements will be measured and paid for at the Contract unit price per ton (Metric ton). This price shall be full compensation for furnishing and incorporating the additional RAP into the mixture. The additional RAP must meet the requirements of Section II (e) herein for payment purposes.

Additional Aggregate, if required, in accordance with the JMF and other contract requirements, will be measured and paid for at the Contract unit price per ton (Metric ton). This price shall be full compensation for furnishing and incorporating the additional aggregate material into the mixture. The additional aggregate material must meet the requirements of Section II (f) herein for payment purposes.

Payment will be made under:

Pay Items	Unit
Cold In-Place Recycling (CIR) (Depth)	Square Yard
Liquid Asphalt (Emulsion)	Ton
Liquid Asphalt (Foamed)	Ton
Additional Crushed RAP	Ton
Additional Aggregate	Ton

VIRGINIA DEPARTMENT OF TRANSPORTATION
DRAFT SPECIAL PROVISION FOR
COLD PLANT RECYCLING (CPR)

November 6, 2012

I. DESCRIPTION

Cold Plant Recycling (CPR) is a process in which a portion of existing asphalt concrete pavement layers from a roadway are milled, stabilized at a plant (with minimal further processing), and then used to repave using conventional equipment. Recycling asphalt pavement in this manner is most commonly performed using foamed asphalt or asphalt emulsion as the primary stabilizing additive to a thickness of 3 to 6 inches. Alternatively, an existing supply of reclaimed asphalt pavement (RAP) may be used as the source material on maintenance and reconstruction projects.

The Contractor shall furnish all labor, materials and equipment required for completing this work. The Contractor shall select the final mix design (job mix formula- JMF) and construction methods to meet the performance requirements specified herein. The Contractor shall be responsible for developing and implementing a Quality Control Plan to ensure that operational techniques and activities under his control provide a homogeneous and finished material of acceptable quality meeting the requirements of this provision. Contractor sampling and testing shall be performed to control the processes and ensure material compliance with the requirements of this special provision. The Contractor shall provide their Quality Control Plan (in accordance with this special provision) and Job Mix Formula(s) to the Department for approval no less than thirty (30) calendar days prior to the start of CPR operations.

For each CPR project, a project specific Quality Control Plan is required, and shall include the following (minimum) information:

i) A description of the Contractor's Quality Control organization, including the number of full-time equivalent employees or Sub-Contractors with specific Quality Control responsibilities, including an organizational chart showing lines of authority and reporting responsibilities.

ii) A listing by discipline with the name, qualifications, duties, responsibilities and authorities for all persons proposed to be responsible for Construction Quality Control;

iii) A Quality Control Sampling, Testing and Analysis Plan with methods that include a description of how random locations for testing and sampling are determined;

iv) Identification and description of the laboratory(s) to be used for each type of testing;

v) Specify documentation for QC activities;

vi) Procedures to meet contract requirements for corrective action when QC criteria are not met.

vii) Procedures to protect stabilized material from receiving excessive moisture from weather events (i.e. rain, fog, etc.) and corrective actions when criteria are not met.

The Contractor is required to have a technical representative at the project site during mixing and placement operations. At a minimum, this person must:

- Have 2 years minimum experience with the CPR process,
- Have personally supervised a minimum of 5 successful CPR projects,

- Have personal experience in developing CPR mix designs,
- Have the experience to perform and supervise field process control testing, and
- Submit a list of references, with current telephone numbers, of persons who are able to verify the experience required herein

The Contractor may use consultants or manufacturers' representatives to satisfy the technical representative requirements of this section provided these individuals meet the requirements listed above and are on-site at all times construction operations involving this material are being performed.

II. MATERIALS

a) **Stabilizing Agent (Emulsified or Foamed Asphalt)** – All liquid asphalts used for stabilizing agents shall be emulsions and PG binders (Lists Nos.50 and 50.1) on the VDOT Materials Division's Approved List. Asphalt emulsions shall conform to the requirements of Section 210 of the Specifications; liquid asphalts shall meet the requirements of Section 211.02 of the Specifications.

b) **Water** – Any water used for mixing shall meet the requirements of Section 216 of the Specifications.

c) **CPR** – The CPR material shall have 100% of all particles passing the 1.5 inch (37mm) size sieve and meeting the gradation requirements in **TABLE 3** herein prior to the addition of any stabilizing agents.

d) **Other Additives** – If necessary, additional additives may be used to meet the requirements in **TABLE 4**. In the case where an additional additive is used, the type and dosage must be described in the Job Mix Formula(s) submitted to the Department.

e) **Addition of Crushed Reclaimed Asphalt Pavement (RAP) Material** – Additional RAP material (other than that reclaimed from the project) may be added by the Contractor and, if added, shall meet the requirements of Section 211.02(j) of the Specifications and **TABLE 1** herein.

TABLE 1 – ADDITIONAL CRUSHED RAP

Tests	Method	Limit
Deleterious Materials: Clay Lumps and Friable Particles in Aggregate	AASHTO T 112	0.2% maximum
Maximum Sieve Size, 1.5 inches (37mm)	AASHTO T 27	100% Passing,

f) **Additional aggregate** – Based on the results of the job mixture design(s) or other requirements of this provision, the Contractor shall determine if additional aggregate is required. If the Contractor determines additional aggregate is needed any additional aggregate shall meet the requirements of Section 203 of the Specifications and **TABLE 2 herein**, and it shall be graded to produce a product which meets the specification requirements given in **TABLE 3.**

TABLE 2 – ADDITIONAL AGGREGATE

Tests	Method	Limit

Los Angeles Abrasion Value	AASHTO T 96	45% maximum loss
Sand Equivalent	AASHTO T 176	60% minimum
Maximum size, 100% Passing, Sieve Size	AASHTO T 27	1.5 inches (37mm)
Water absorption	AASHTO T 85	3% maximum

III. Job Mix Formula

Mixture Designs – C PR mix design(s) in the form of a job-mix formula(s) (JMF) shall be submitted to the Engineer for Department approval no less than 30 calendar days prior to the start of CPR operations; more than one JMF may be required. The gradation of each JMF shall fall within the bands shown in **TABLE 3.**

TABLE 3 – GRADATION REQUIREMENTS

Sieve Size	Foamed Asphalt*		Asphalt Emulsion*	
	Lower	Upper	Lower	Upper
1.5"	100	100	100	100
1.0"	78	100	85	100
3/4"	70	93	75	96
3/8"	--	55	--	55

*based on pulverized materials, prior to stabilization, washed, following AASHTO T 27 and T 11

The JMF(s) shall be created using either existing materials obtained directly from the project site (prior to the start of construction) or from an existing stockpile of Reclaimed Asphalt Pavement (RAP) stored at the plant. Sampling shall be conducted at a maximum of once per 2500 lane-feet. Each JMF shall provide as a minimum the following mix design parameters:

1) Target field density,

2) Percent by weight of all stabilizing agent(s) to be added to the recycled mix,

3) Percent by weight of water (at room temperature) required,

4) Expansion ratio and half-life characteristics and temperature of asphalt binder at the time of dosage into foaming chamber (for mixtures using foamed asphalt), minimum curing time/set time for the asphalt emulsion and temperature of asphalt emulsion at the time of dosage into the mixture (for mixtures using asphalt emulsion), and

5) Target gradation (including any aggregate to be added).

If a change in source materials is made during construction, a new JMF(s) shall be established and submitted to the Engineer for Department approval prior to use on the project. The JMF(s) shall meet the criteria of Table 4 at the approved stabilizing agent(s) content.

TABLE 4 – CPR MIX DESIGN REQUIREMENTS			
Item	**Test Method**	**Criteria**	**Fabrication / Conditioning Procedure**
Asphalt Emulsion Stabilized Materials			
1	Moisture Density Relations AASHTO T 180	Determined by Design	
2	Marshall Stability Test ASTM 5581 (6 inch specimens), AASHTO T 245 (4 inch specimens)	2500 lbs minimum (6 inch (150mm) diameter specimen), or 1250 lbs (4 inch (100mm) diameter specimen)	Three (3) specimens shall be produced at 75 blows per side (or 30 gyrations per AASHTO T 312) and cured at 60 °C to constant mass, hold specimens at 40 °C for 2 hours in a forced draft oven immediately prior to testing.
3	Retained Stability ASTM 5581 (6 inch specimens), AASHTO T 245 (4 inch specimens)	70% of results of #2	An additional three (3) specimens shall be produced at cured at 60 °C to constant mass. Specimens shall then be vacuum saturated to 55-65%, 25 °C water bath for 23 hours and 40 °C water bath for an additional hour immediately prior to testing
4	Raveling Stability (ASTM D 7196)	Maximum 2%	Specimens shall be produced using a gyratory at 20 gyrations and cured at 10°C for 4 hours at 50% humidity.
5*	Thermal Cracking (Indirect Tensile Test, AASHTO T 322)	The critical cracking temperature must be less than or equal to the pavement temperature given for the project climate area and pavement depth by LTPPBind.	See Notes 1 through 7 below.
6	Resilient Modulus (ASTM D 7369)	150,000 psi minimum	Same as Item 2.
Foamed Asphalt Stabilized Materials			
8	Moisture Density Relations AASHTO T 180	Determined by Design	
9	Dry Indirect Tensile Strength (ITS), AASHTO T 283 Section 11	45 psi minimum	Three (3) specimens shall be produced using 75 blows per side (or 30 gyrations per AASHTO T 312) compacted at or below OMC and cured as follows: 4 inch (100 mm) diameter specimens, oven dry at 40 °C for 72 hrs and cool to ambient temperature for 24 hrs; 6 inch (150 mm) diameter specimens, air dried for 24 hours, then an additional 48 hours at 40 °C in sealed plastic bag, cool to ambient temperature for 24 hrs.

10	Retained Indirect Tensile Strength, AASHTO T 283 Section 11	Minimum, 70% of the Dry ITS from Item 9	An additional three (3) specimens shall be produced and cured according to Item 9, and then submerged in 25 °C water bath for 24 hours prior to testing.
11	Resilient Modulus ASTM D 7369	150,000 psi minimum	Same as Item 9.
All materials (asphalt emulsion and foamed asphalt) shall be controlled following Item 12.			
12	Materials Gradation Test (AASHTO T 27), prior to stabilization	Coarse and fine gradation to control field production.	

* 1. Specification temperature shall be chosen using current FHWA LTPPBind software, using the weather station closest to the project. The required temperature shall be the coldest temperature at the top of the recycled layer, using 98% reliability.
2. Samples shall be compacted to 150 mm diameter and at least 115 mm height, compacted to within 1% of design air voids at the design stabilizing agent content. Compacted samples shall be cured at 60 °C no less than 48 hours. Before testing, sample mass shall be checked every two (2) hours until change in mass between successive checks does not exceed 0.05%. After curing, two (2) specimens shall be sawcut from each compacted sample to 50 mm in height. Perform bulk density testing after sawcutting.
3. Three (3) specimens are required at each of the three (3) testing temperatures.
4. Select two (2) testing temperatures that bracket the specification temperature above. For example, if the specification temperature is -25 °C, then two (2) of the selected testing temperatures shall be -20 °C and -30 °C. A temperature of -10 °C or -40 °C shall be used as the third testing temperature.
5. The tensile strength test shall be performed on each specimen directly after the tensile creep test (at the same temperature as the creep test).
6. The critical cracking temperature is defined as the temperature at the intersection of the thermal stress curve (derived from the creep data) and the tensile strength line (the line connecting the average tensile strengths at the three testing temperatures).
7. To meet this specification, the critical cracking temperature predicted by the Indirect Tensile Test must be less than or equal to the pavement temperature given for the project climate area and pavement depth by LTPPBind.

IV. EQUIPMENT

(a) **CPR** – The CPR work shall be completed with the following required equipment.

A plant shall be used that is capable of homogeneously incorporating all stabilizing agent(s) and materials up to the sizes shown in **TABLE 3**. The plant shall be capable of delivering the amount of additives to within +/- 0.2% of the required amount by weight of the pulverized bituminous material, except that a capability of adding up to 5% water by weight of the pulverized bituminous material is mandatory. Automated systems shall be used to regulate the application of stabilizing agent(s) and water and shall adjust automatically to the mass of the material being processed. When using foamed asphalt, the plant shall also be outfitted with a test or inspection nozzle at one end of the spray bar that can produce a representative sample. The plant shall be capable of maintaining the temperature of the liquid asphalt at a minimum of 300°F. The plant shall be equipped with the means for the operator to verify the stabilizing agent(s) and water are being evenly distributed and that the correct dosage rates of each are being applied. The plant shall

have the ability to print out stabilizing agent(s) and water quantities used during production. The equipment shall be operated in accordance with the manufacturers' recommendations.

The CPR material shall be paved using a paver that meets the requirements of Section 315.03(b) of the Specifications.

(b) **Rollers** – All rollers shall be self-propelled. At least one pneumatic tire roller shall have a minimum gross operating weight of not less than 50,000 lbs. (22,600 kg). At least one double steel-wheeled vibratory roller shall have a gross operating weight of not less than 24,000 lbs. (10,800 kg) and a width of 78 inches (2.0 meters). All rollers must have properly working scrapers and water spraying systems.

V. Test Strip

One week before planned start of full production, stabilize a 2,500 foot long test strip, one-lane wide, at the designated thickness and designed optimal stabilizing agent(s) content provided in the approved job mix design. Construct the test strip on the project at an approved location.

Construct the test strip using construction procedures intended for the entire project. Cease production after construction of the test strip until the test strip is evaluated and accepted. Payment will follow the payment tables established in this specification

VI. CONSTRUCTION METHODS

a) Grass and other vegetation shall be removed from the edge of the existing pavement to prevent contamination of the pulverized bituminous material during the milling operation.

b) The existing bituminous pavement shall be milled to the required depth and width as indicated on the plans. Recycling shall be performed in a manner that does not disturb the underlying material in the existing roadway. The milling operation shall be conducted so that the amount of fines occurring along the vertical faces of the cut shall not prevent bonding of the CPR materials. If needed, the CPR materials shall be processed by crushing or sizing to the required gradation specified in **TABLE 3.**

c) When a paving fabric is encountered during the CPR operation, the Contractor shall make the necessary adjustments in their equipment or operations so that at least ninety percent (90%) of the shredded fabric in the recycled material is no more than the particle size specified in Section II.c herein. These changes may include, but shall not be limited to: adjusting the milling rate, the milling depth, and/or adding or removing screens in order to obtain the specified recycled material. The Contractor will be required to waste material containing over-sized pieces of paving fabric as directed by the Engineer. The Contractor will not receive additional payment for the necessary adjustments to his equipment or CPR operations to accommodate the presence and processing of the paving fabric.

d) Compaction of the recycled mix shall be completed using rollers meeting the requirements of Section IV.c. herein. The Contractor shall establish rolling patterns to achieve the density target as determined by nuclear density testing. Final rolling to eliminate pneumatic tire marks and to achieve density shall be done by double drum steel roller(s), either operating in a static, oscillating or vibratory mode. Oscillating and vibratory mode should only be used if it is shown to not damage the pavement. Rolling shall be performed until the material reaches a density of 98% the maximum theoretical density as measured via a nuclear density gauge. Rolling shall start no more than 30 minutes after initiation of paving. Finish rolling shall be completed no more than one hour after paving is completed, unless otherwise approved by the Engineer. When possible, rolling shall not be started or stopped on uncompacted material but performed with rolling

patterns established so that they begin or end on previously compacted material or the existing pavement.

e) After compaction of the recycled material, a fog seal shall be applied to the recycled surface at a uniform application rate of 0.05 gal/sy. The fog seal shall be a CSS-1h, CQS-1h, or Non Tracking Tack Coat conforming to the requirements of Section 210 of the Specifications or the Special Provision For Non tracking Tack Coat included in the Contract. A light grit may be applied to reduce raveling. After fog sealing, no traffic, including the Contractor's equipment, will be permitted on the completed recycled material for at least two (2) hours. After two hours rolling traffic may be permitted on the recycled material. This time may be adjusted by the Engineer to allow establishment of sufficient cure so traffic will not initiate raveling. After opening to traffic, the surface of the recycled pavement shall be maintained in a condition suitable for the safe movement of traffic. All loose particles that may develop on the pavement surface shall be removed by power brooming.

f) Any damage to the completed CPR material shall be repaired by the Contractor at their expense prior to the placement of the asphalt concrete surface course(s), or other applicable surface treatment, and as approved by the Engineer. Damage unrelated to Contractor's construction procedures or quality of work, such as due to poor base conditions, shall be paid for as described in the VDOT Special Provision For *Surface Preparation and Restoration Prior to Plant-Mix Overlay* included in the Contract.

g) Before placing the asphalt concrete surface course(s), or other applicable surface treatment, the CPR material shall be allowed to cure until the moisture of the material is a maximum of 50% of the optimum moisture content or until approval of the Engineer is received. Moisture content shall be measured per AASHTO T 329 on samples (immediately placed in sealed plastic bag) taken from two stratified random locations as determined by the Engineer per each production day. Other methods and sampling rates may be used if supplied in the Contractor's Quality Control Plan and approved by the Engineer. Split samples may be taken at the direction of the Engineer.

VII. ACCEPTANCE TESTING

(a) **Field Compaction** –A nuclear density gauge conforming to the requirements of VTM-10 shall be used for determining mat density by the Direct Transmission method. The Contractor's nuclear density gauge shall have been calibrated within the previous 12 months by an approved calibration service. In addition, the Contractor shall maintain documentation of such calibration service for the 12-month period from the date of the calibration service and furnish the same to the Engineer if requested. The Contractor shall determine a roller pattern and construct a control strip in accordance with the requirements of VTM 10. Density test locations shall be marked and labeled in accordance with the requirements of VTM-76. The control strip will be acceptable if the field proctor (AASHTO T 180) is at least 98% of the target density from the approved job mix design. The required density of the compacted CPR course shall not be less than 98.0 percent of the target density from the approved job mix design.

Test section (lot) – For the purposes of acceptance, each day's production will be considered a lot unless the paving length is less than 3,000 linear feet or greater than 7,500 linear feet. When paving is less than 3,000 feet, it shall be combined with the previous day's production or added to the next day's production to create a lot as described below.

The standard size of a lot shall be 5,000 linear feet, with 1,000 linear foot sublots, of any pass 6 feet or greater made by the paving train for the thickness of the course. When a partial lot occurs at the end of a day's production or upon completion of the project, the lot shall be 1) added to the previous lot if the partial lot contains one or two sublots or 2) redefined to be an entire lot if the partial lot contains three or four sublots.

Each lot shall be tested for acceptance for density by taking a nuclear density reading from two random test sites selected by the Engineer within each sublot. Test sites shall not be located within 18 inches of the edge of any application width of CPR mixes.

The average of the sublot density measurements will be compared to the target nuclear density established by the approved job mix design to determine the acceptability of the lot. Once the average density of the lot has been determined, the Contractor will not be permitted to provide additional compaction to raise the average. If two consecutive sublots produce density results less than 98 percent of the target density, the Contractor shall immediately notify the Engineer and institute corrective action to bring lot density to at least 98% of the target density. By the end of the day's operations, the Contractor shall furnish the test data developed during the day's recycling to the Engineer. The Contractor shall verify their results every lot by performing a field proctor (AASHTO T180). The field proctor shall be at least 98% of the target density from the approved mix design.

The tonnage or square yards of each lot will be based on the lot's width and length and the mixture application rate as designated in the Contract or as revised by the Engineer. Payment will be made in accordance with the requirements of **TABLE 5.**

TABLE 5 - Payment Schedule for Lot Densities

% of Target Control Strip Density	% of Payment
98.0 or greater	100
97.0 to less than 98.0	95
96.0 to less than 97.0	90
Less than 96.0	75

(b) **Material Composition** – The Contractor shall determine material composition properties by obtaining samples and testing ITS/Stability in the lab. Testing ITS/stability values shall be conducted twice per lot.

The minimum ITS/stability value shall be a minimum of 95% of the approved JMF and maintain a retained ITS/stability value of 60% for field produced, laboratory compacted samples. Six ITS/Stability specimens shall be produced in accordance with the requirements of TABLE 4. Payment for that lot will be based on **TABLE 6**.

Table 6 – ITS/Stability Pay Adjustments

ITS/stability, % of approved JMF	% of Payment
95% or greater	100
90% to 95%	90
80% to 90%	80
Less than 80% and greater than 45 psi/2500 lbs	50
Less than 80% and less than 45 psi/2500 lbs	0

In the event the Contractor disputes the ITS/stability value results, the Contractor, under the supervision of the Engineer, shall obtain 6 cores (randomly stratified) for the lot in question. Payment for that sublot in question will be based on **TABLE 6.**

(c) **Gradation** – For CPR, the Contractor shall verify that the unstabilized gradation conforms to the JMF once per day of production.

(d) **Depth Check** – Depth checks shall be performed by the Contractor at a rate of twice per 5,000 linear feet after compaction and placement of the first lift of asphalt by coring in accordance with VTM-38. Depth checks shall be taken at the Engineer's direction. Depth check cores will be retained by the Department.

Acceptance of CPR course for depth will be based on the mean result of measurements of samples taken from each lot of material placed.

A lot will be considered acceptable for depth if the mean result of the tests is within the tolerance of the plan depth for the number of tests taken as shown in **TABLE 7**.

TABLE 7 – PROCESS TOLERANCE FOR DEPTH CHECKS

Plan Depth, inches	Tolerance, inches			
	1 test	2 tests	3 tests	4 tests
≤ 4	0.6	0.45	0.35	0.30
>4 ≤ 8	0.9	0.65	0.50	0.40
>8 ≤ 12	1.0	0.90	0.70	0.50
>12	1.2	1.00	0.80	0.60

If an individual depth test exceeds the tolerance for one test, that portion of the lot represented by the test will be excluded from the lot. If an individual test result indicates that the depth of material represented by the test is more than the tolerance for one test, the Contractor will not be paid for that material in excess of the tolerance throughout the length and width represented by the test. If an individual test result indicates that the depth of the material represented by the test is deficient by more than the tolerance for one test, correction of that portion of the lot or lot of CPR course represented by the test shall be made as specified hereinafter.

If the mean depth of a lot of material is excessive, the Contractor will not be paid for that material in excess of the tolerance throughout the length and width represented by the tests.

If the mean depth of a lot of material is deficient by more than the allowable tolerance for the plan depth specified, correction will not normally be required and the Contractor will be paid for the quantity of material that has been placed in the lot.

For excessive depth CPR courses, the rate of deduction from the tonnage allowed for payment as CPR course will be calculated based on the JMF weight per square yard per inch of depth in excess of the tolerance for the plan depth and the number of tests taken as specified in **TABLE 7** or the Department can require excessive material to be removed at the Contractor's expense

For sections of CPR course that are deficient in depth by more than the tolerance for one test and less than 1.50 inches, the Contractor shall furnish and place material specified for the subsequent course to bring the deficient CPR course depth within the tolerance for the specified plan depth. This additional material will be furnished and placed at the Contractor's expense.

If the deficiency is more than 1.50 inches, the Contractor shall furnish and place additional CPR course material to bring the thickness within the tolerance for the specified plan depth. Corrections for deficient CPR course depth shall be made in a manner as to provide a finished pavement that is smooth and uniform. Sections requiring significant grade adjustments that have

been previously identified and documented by the Engineer and are outside of the control of the Contractor will be exempt from deduction or corrective action.

(e) **Stabilizing Agent Dosage Rate** – The Contractor shall verify the stabilizing agent dosage rate by reading a calibrated meter ten times per lot. The dosage rate shall be within 0.20 percentage points of the approved JMF. If the dosage rate is outside 0.20 percentage points, then paving/production shall stop and the Contractor shall take corrective measures to bring the dosage rate within tolerance of the approved JMF. The Department will calculate the yield at the end of each production day.

(f) **Construction Records** – The Contractor shall prepare separate test reports meeting the requirements of AASHTO R 18 or may use the current appropriate VDOT forms. Records documenting the dosage rate of stabilizing agent(s) and other test results from **TABLE 4** shall be provided to the Engineer, unless specified otherwise.

VIII. WEATHER LIMITATIONS

Recycling operations shall be completed when the atmospheric temperature and material to be processed (measured in the shade and away from artificial heat) is a minimum 50°F (10 °C). The weather forecast shall not call for freezing temperature within 48 hours after placement of the CPR material on any portion of the project.

IX. MEASUREMENT AND PAYMENT

Cold Plant Recycling (CPR) will be measured by the square yard (or square meter) of the completed sections for the depth specified in the plans and will be paid for at the Contract unit price per square yard (square meter) of depth. This price shall be full compensation for removal and processing of the existing pavement; for preparing, hauling, and placing of all materials; furnishing stabilizing agents, fog seal, grit and additives), for all freight involved; for all manipulations, including removal of grass and other vegetation, rolling and brooming, for testing and documentation, asphalt supplier services, and for all labor, tools, equipment and incidentals necessary to complete the work.

Liquid Asphalt (Emulsion) will be measured and paid for at the Contract unit price per ton (Metric ton). This price shall be full compensation for furnishing and incorporating the emulsion into the mixture. An emulsion content of 3.0% by weight of the milled bituminous material shall be used for bidding purposes prior to the completed/accepted job mix design. The actual emulsion content will be adjusted based on the quantity necessary to meet the design requirements in **TABLE 4.**

Liquid Asphalt (Foamed) will be measured and paid for at the Contract unit price per ton (Metric ton). This price shall be full compensation for furnishing and incorporating the foamed asphalt into the mixture. A foamed asphalt content of 2.5% by weight of the milled bituminous material shall be used for bidding purposes prior to the completed mix design. The actual foamed asphalt content will be adjusted based on the quantity necessary to meet the design requirements in **TABLE 4**.

Additional Crushed RAP if required to meet the contract requirements will be measured and paid for at the Contract unit price per ton (Metric ton). This price shall be full compensation for furnishing and incorporating the additional RAP into the mixture. The additional RAP must meet the requirements of Section II (e) herein for payment purposes.

Additional Aggregate, if required, to achieve the accepted JMF(s) in accordance with the requirements in TABLE 4 and other contract requirements**,** will be measured and paid for at the Contract unit price per ton (Metric ton). This price shall be full compensation for furnishing and incorporating the additional aggregate material into the mixture. The additional aggregate material must meet the requirements of Section II (f) herein for payment purposes.

Payment will be made under:

Pay Item	Pay Unit
Cold Plant Recycling (CPR) (Depth)	Square Yard
Liquid Asphalt (Emulsion)	Ton
Liquid Asphalt (Foamed)	Ton
Additional Crushed RAP	Ton
Additional Aggregate	Ton

VIRGINIA DEPARTMENT OF TRANSPORTATION
DRAFT SPECIAL PROVISION FOR
FULL-DEPTH RECLAMATION (FDR)

November 6, 2012

I. DESCRIPTION

Full-depth reclamation (FDR) is defined as those processes in which all of the asphalt pavement layers and some portion of the underlying unbound layers are pulverized, stabilized, and compacted in place. This is most commonly performed using hydraulic cement, lime, foamed asphalt or asphalt emulsion as the primary stabilizing additives and to a typical depth of 6 to 12 inches.

The Contractor shall furnish all labor, materials and equipment required for completing the work. The Contractor shall select the final mix design (job mix formula- JMF) and construction methods to meet the performance requirements specified herein. The Contractor shall also be responsible for developing and implementing a Quality Control Plan to ensure that operational techniques and activities provide integral and finished material of acceptable quality. Contractor sampling and testing shall be performed to control the processes and ensure material compliance with the requirements of the Contract. The Contractor shall provide their Quality Control Plan and Job Mix Formula(s) to the Engineer for Department approval no less than thirty (30) calendar days prior to the start of FDR operations.

For each recycling project, the Contractor is required to furnish a project specific Quality Control Plan that shall include, at a minimum, the following information:

A description of the Contractor's Quality Control organization, including the number of full-time employees or Sub-Contractors with specific Quality Control responsibilities, including an organizational chart showing lines of authority and reporting responsibilities.

A list by discipline of the names, qualifications, duties, responsibilities and authorities for all persons proposed to be responsible for construction Quality Control;

A Quality Control Sampling, Testing and Analysis Plan with methods that include a description of how random locations for testing and sampling are determined;

Identification and description of the laboratory(s) to be used for each type of testing;

Specifics of the documentation for QC activities;

Procedures to meet contract requirements for corrective action when QC criteria are not met.

Procedures to protect stabilized material from receiving excessive moisture from weather events (i.e. rain, fog, etc.) and corrective actions when criteria is not met.

The Contractor is required to have a technical representative on the site at all times during the mixing and placement operations. At a minimum, this person must:

Have 2 years minimum experience with the FDR process,

Have personally supervised a minimum of 5 successful FDR projects,

Have personal experience in developing FDR mix designs,

Have the experience to perform and supervise field process control testing, and

Submit a list of references, with current telephone numbers, who are able to verify the experience required herein

The Contractor may use consultants or manufacturers' representatives to satisfy the requirements of this section provided they meet the requirements above and are on-site at all times construction operations are being performed.

II. MATERIALS

Stabilizing Agent(s) – The amount of stabilizing agent(s) to be used shall be determined by the Contractor by means of a mixture design process. Hydraulic cement shall conform to the requirements of Section 214 of the Specifications. Lime shall conform to the requirements of Section 240 of the Specifications. Fly ash shall conform to the requirements of Section 241 of the Specifications. All liquid asphalts used for stabilizing agents shall be emulsions and PG binders on the VDOT Approved List for emulsions and PG binders, Approved List 50 and 50.1. Liquid asphalts not currently on the Approved List shall be submitted to VDOT for approval. Asphalt emulsions shall conform to the requirements of Section 210 of the Specifications; liquid asphalts shall meet the requirements of Section 211.02 (a) of the Specifications.

a) **Water** – Any water used for mixing shall meet the requirements of Section 216 of the Specifications.

b) **FDR** – The FDR material shall have 100% of all particles passing the 2.0 inch (50mm) sieve size and 55% of all particles passing the 3/8inch (9.5mm) sieve size prior to the addition of any stabilizing agents.

c) **Other Additives** – If necessary, additional additives may be used by the Contractor to meet the requirements in **TABLE 3**. In the case where an additional additive is used, the type and dosage must be described in the JMF(s) submitted to the Engineer. For FDR using asphalt emulsion, hydrated lime shall be added according to the requirements in Section 211.02(i) of the Specifications.

d) **Addition of Crushed Reclaimed Asphalt Pavement (RAP) Material** – RAP material may be added by the Contractor and shall meet the requirements of Section 211.02(j) of the Specifications and **TABLE 1.**

TABLE 1 – ADDITIONAL CRUSHED RAP

Tests	Method	Limit
Deleterious Materials: Clay Lumps and Friable Particles in Aggregate	AASHTO T 112	0.2% maximum
Maximum Sieve size, 2.0 inches (50 mm)	AASHTO T 27	100% passing

e) **Additional aggregate** – Based on the results of the mixture design or other requirements, the Contractor shall determine if additional aggregate is required. If the Contractor determines additional aggregate is required any additional aggregate shall meet Section 203 of the Specifications and the requirements in **TABLE 2**, and it shall be graded to produce a product which meets the requirements given in **TABLE 3**.

TABLE 2 – ADDITIONAL AGGREGATE

Tests	Method	Limit
Los Angeles Abrasion Value	AASHTO T 96	45% maximum loss
Sand Equivalent	AASHTO T 176	60% minimum
Maximum size, 100% Passing, Sieve Size	AASHTO T 27	2.0 inches (50 mm)
Water absorption	AASHTO T 85	3% maximum

f) **Handling and Storage** – Store cement to prevent moisture degradation and partial hydration. Do not use cement that has become hard, caked or lumpy. Store aggregates and RAP so that segregation and inclusion of foreign materials are prevented. Do not use the bottom six (6) inches of aggregate or RAP piles in contact with the ground.

iii. Job Mix Formula (JMF)

(a) **Mixture Designs** – FDR mix design(s) in the form of a job-mix formula (JMF) shall be submitted to the Engineer for the Department's approval no less than 30 calendar days prior to the start of FDR operations, more than one JMF may be required. The gradation of each JMF shall have a minimum 100% passing the 2.0-inch (50 mm) sieve with a minimum 55% passing the 3/8-inch (9.5 mm) sieve.

The Contractor shall obtain sufficient samples of the material to be reclaimed directly from the project site for laboratory testing and mix design analysis. Samples shall be obtained from every 2500 linear feet, within each lane and to the proposed total recycling depth with a minimum of six (6) locations for each mix design. Additional locations may be selected based on pavement conditions and variability.

(b) **Mixture Designs Submittal** – The design shall be performed by the Contractor in accordance with these specifications and submitted to the Engineer for approval thirty (30) working days prior to the planned start of the work. The mix design submittal shall include, at a minimum, the following information:

1) Target field density,

2) Percent by weight of all stabilizing agent(s) to be added to the recycled mix,

3) Percent by weight of water (at room temperature) required,

4) Expansion ratio and half-life characteristics and temperature of asphalt binder at the time of injection into foaming chamber (for mixtures using foamed asphalt), minimum curing time/set time for the asphalt emulsion and temperature of asphalt emulsion at the time of incorporating into the mixture (for mixtures using asphalt emulsion), and

5) Target gradation (including any aggregate to be added).

TABLE 3 – FULL-DEPTH RECLAMATION MIX DESIGN REQUIREMENTS

Test	Test Method	Criteria
Liquid Limit, Plastic Limit, and Plasticity Index of Soil	VTM-7	Report
Dry Preparation and Mechanical Analysis of Soils, Select Material, Subbase and Aggregate Bases	VTM-25	Report

Classification of Soils	AASHTO M 145	Report
Moisture-Density Relations of Soil-Cement Mixtures	AASHTO T 134	Report
Moisture Density Relations for Bituminous Stabilizing Agents	AASHTO T 180	Report
Compressive Strength of Soil-Cement Cylinders	ASTM D 1633	Min. 250 psi (Max. 450 psi) at seven (7) days
Determining the Strength of Soil-Lime Mixtures	VTM-11	Min. 150 psi
Dry Indirect Tensile Strength (ITS) for Foamed Asphalt Stabilizing Agent	AASHTO T 283 Section 11*	45 psi minimum
Marshall Stability Test for Asphalt Emulsion Stabilizing Agent	ASTM 5581 (6 inch specimens), AASHTO T 245 (4 inch specimens)**	2500 lbs minimum (6 inch (150mm) diameter specimen), or 1250 lbs (4 inch (100mm) diameter specimen)

* Three (3) specimens shall be produced using 75 blows per side (or 30 gyrations per AASHTO T 312) compacted at or below OMC and cured as follows: 4 inch (100 mm) diameter specimens, oven dry at 40 °C for 72 hrs and cool to ambient air temperature for 24 hrs; 6 inch (150 mm) diameter specimens, air dried for 24 hours, then an additional 48 hours at 40 °C in sealed plastic bag, cool to ambient air temperature for 24 hrs.

** Three (3) specimens shall be produced at 75 blows per side (or 30 gyrations per AASHTO T 312) and cured at 60 °C to constant mass, hold specimens at 40 °C for 2 hours in a forced draft oven immediately prior to testing.

If a change in source materials is made during construction, a new JMF(s) shall be established and approved by the Engineer prior to use on the project. The JMF(s) shall meet the above criteria at the approved stabilizing agent(s) content.

X. EQUIPMENT

a) **Pulverizing** – The equipment used to reclaim existing pavements shall be capable of pulverizing existing pavement, as well as any additional materials, to meet the gradation provided in the approved job mix design, for the widths provided in the Plans, to the depth specified in the approved pavement design.

b) **Stabilizing** – The equipment used to stabilize the pulverized materials shall be capable of incorporating the stabilizing agent(s) at the rate provided in the approved job mix design, automatically metering dosage and mixing the full depth and width of pulverized material to a homogenous mixture.

c) **Grading** – The equipment used to grade the stabilized material shall be capable of working within the constraints of the excavation and grading the full width of stabilized material in conformity with the lines and grades provided in the Plans.

d) **Compacting** – The equipment used to compact the stabilized material shall be capable of working within the constraints of the excavation and compacting the stabilized material in conformity with the lines and grades provided in the Plans, as well as in conformity with the density requirements provided in the approved job mix design.

XI. Test Strip

One week before planned start of full production, stabilize a 2,500 foot long test strip, one-lane wide, at the designated thickness and designed optimal stabilizing agent(s) content provided in the approved job mix design. Construct the test strip on the project at an approved location.

Construct the test strip using construction procedures intended for the entire project. Cease production after construction of the test strip until the test strip is evaluated and accepted. Payment will follow the payment tables established in this specification

XII. CONSTRUCTION METHODS

a) **Grass and Other Vegetation** – All grass and other vegetation shall be removed from the edge of the existing pavement to prevent contamination of the pulverized bituminous material during the milling operation.

b) **FDR** – Recycling shall be performed to the depth provided in the plans, while simultaneously incorporating stabilizing agent(s), mineral filler, additional aggregate and water. Mixing shall continue until, and the speed of the recycling unit adjusted to ensure, a homogenous mixture of the above materials and pulverized materials is achieved.

   a. The application rate of all stabilizing agents shall be continuously monitored using calibrated, automatic meters. The application rate shall be within 0.20 percentage points of the optimal stabilizing agent(s) content provided in the approved job mix design. If the measured application rate falls outside the above tolerance, then the recycling operations shall be stopped and corrected before proceeding.

   b. The water content of the stabilized material shall be monitored closely to ensure conformance with the approved job mix design within ± 2 percentage points of optimum and to ensure proper compaction.

   c. Longitudinal joints between adjacent stabilization passes shall be overlapped at least four (4) inches. Transverse joints created by the recycling process shall be sawcut, if necessary, to provide a vertical, clean face to ensure proper compaction.

c) **Grading and Compacting** – The grading and compacting shall be performed within the constraints of the excavation and the stabilized material shall be compacted in conformity with the lines and grades provided in the Plans. Compaction shall progress across the full width of the stabilized area until maximum density is achieved.

   a. Once the entire working width (full lane width plus affected shoulder width) has been stabilized and only after primary compaction has been completed, the entire working width shall be graded to the required profile and cross-slope. Disturbance to the stabilized and primarily compacted material shall be kept to a minimum during this grading and shaping operation.

   b. Any additional water required to achieve maximum density shall be applied by spraying the surface of the stabilized material with light applications. Care shall be taken not to over-apply additional water to any areas of stabilized material.

d) **Surfacing** – The surface of the compacted material shall be kept moist until covered with an asphalt-based layer in the case of cement stabilized materials. For bituminous stabilized materials, the FDR shall be allowed to cure until the moisture of the material is a maximum of 50% the optimum moisture content or until approval of the Engineer is received. Subsequent asphalt-based layers can be placed any time after finishing, as long as the FDR is sufficiently able to support the required construction equipment without marring or permanent distortion of the surface.

XIII. ACCEPTANCE TESTING

a) **Field Compaction** – Den sity shall be determined with a nuclear gauge operating in direct transmission mode conforming to the requirements of VTM-10 to the full depth of the FDR layer. The Contractor shall have had the gauge calibrated within the previous 12 months by an approved calibration service. In addition, the Contractor shall maintain documentation of such calibration service for the 12-month period from the date of the calibration service.

The project will be divided into lots by the Engineer for the purpose of defining areas represented by each series of tests.

Lot – For the purposes of acceptance, each day's production shall be considered a lot unless the paving length is less than 3,000 linear feet or greater than 7,500 linear feet. When paving is less than 3,000 feet, it shall be combined with the previous day's production or added to the next day's production to create a lot as described below.

For the purposes of acceptance, the size of a lot shall be 5,000 linear feet, with 1,000 foot sublots, the full width of the lane (including any affected shoulder width). When a partial lot occurs upon completion of the project, the lot shall be added to the previous lot if less than 3,000 linear feet or considered a separate lot if greater than 3,000 linear feet.

Each lot shall be tested for density by taking a nuclear density reading from two stratified-random test sites selected by the Engineer within each sublot. Test sites shall not be located within 18 inches of any longitudinal joint.

The average of the sublot density measurements will be compared to the maximum density from the approved mix design to determine the acceptability of the lot. Once the average density of the lot has been determined, the Contractor will not be permitted to provide additional compaction to raise the average. If two consecutive sublots produce density results less than 97.0 percent of the target density, the Contractor shall immediately notify the Engineer and institute corrective action. By the end of the day's operations, the Contractor shall furnish the test data developed during the day's production to the Engineer.

Payment will be made in accordance with the requirements of **TABLE 4**.

TABLE 4 - PAYMENT SCHEDULE FOR LOT DENSITIES

% of Density from Approved Mix Design	% of Payment
97.0 or greater	100
96.0 to less than 97.0	95
95.0 to less than 96.0	90
Less than 95.0	75

b) **Depth Check** – Depth checks shall be performed by the Contractor twice per lot after compaction and prior to the placement of the next pavement layer. The depth checks shall be performed twice per lot following VTM-38B.

Acceptance testing of FDR for depth will be based on the mean result of measurements of samples taken from each lot of material placed.

A lot will be considered acceptable for depth if the mean result of the tests is within the tolerance of the plan depth for the number of tests taken as shown in **TABLE 5.**

TABLE 5 – PROCESS TOLERANCE FOR DEPTH CHECKS

Plan Depth, inches	Tolerance, inches			
	1 test	2 tests	3 tests	4 tests
>6 ≤ 8	0.9	0.65	0.5	0.4
>8 ≤ 12	1	0.9	0.7	0.5
>12	1.2	1	0.8	0.6

If an individual depth test exceeds the tolerance for one test, that portion of the lot represented by that test will be excluded from the lot. If an individual test result indicates that the depth of material represented by the test is more than the tolerance for one test, the Contractor will not be paid for that amount of material in excess of the tolerance throughout the length and width represented by the test. If an individual test result indicates that the depth of the material represented by the test is deficient by more than the tolerance for one test, correction of the base course represented by that test shall be made by the Contractor as specified hereinafter.

If the mean depth of a lot of material is excessive, the Contractor will not be paid for that amount of material in excess of the tolerance throughout the length and width represented by the tests. The Department can require excessive material to be removed at the Contractor's expense.

If the mean depth of a lot of material is deficient by more than the allowable tolerance, correction will not normally be required and the Contractor will be paid for the quantity of material that has been placed in the lot. The Contractor will be required to furnish and place material specified for the subsequent course to bring the deficient CIR course depth within the tolerance. This additional material will be placed at the Contractor's expense.

c) **Gradation** – The Contractor will check the unstabilized gradation twice per day.

d) **Stabilizing Agent Dosage Rate** – Contractor shall verify the dosage rate ten times per lot. The dosage rate shall be within 0.20 percentage points of the approved mix design. If the dosage rate is beyond this tolerance, then paving shall stop and the contractor shall take corrective measures.

e) **Construction Records** – The Contractor shall prepare separate test reports meeting the requirements of AASHTO R 18 or may use the current appropriate VDOT forms. Records documenting the dosage rate of stabilizing agent(s) and other test results from Table 3 shall be provided to the Engineer, unless specified otherwise.

XIV. WEATHER LIMITATIONS

Recycling operations shall be completed when the atmospheric temperature and material to be processed (measured in the shade and away from artificial heat) is a minimum 40°F (4 °C). The weather forecast shall not call for freezing temperature within 48 hours after placement of any portion of the project.

XV. MEASUREMENT AND PAYMENT

Full Depth Recycling (FDR) will be measured by the square yard of the completed sections for the depth specified in the plans and paid for at the Contract unit price per square yard of depth. This price shall be full compensation for removal and processing of the existing pavement; for preparing, hauling, and placing all materials; furnishing additives (including RAP and aggregates if required but not including stabilizing agents), for all freight involved; for all manipulations, including removal of grass and other vegetation, rolling and brooming, testing, stabilizing agent supplier services, and for all labor, tools, equipment and incidentals necessary to complete the work.

Stabilizing agents will be paid as follows:

Liquid Asphalt (Emulsion) will be paid for at the Contract unit price per ton. This price shall be full compensation for furnishing and incorporating the emulsion into the mixture. An emulsion content of 3.0% by weight of the reclaimed material shall be used for bidding purposes prior to the completed design. The actual emulsion content will be adjusted based on the quantity necessary to meet the design requirements in Table 3.

Liquid Asphalt (foamed) will be paid for at the Contract unit price per ton. This price shall be full compensation for furnishing and incorporating the foamed asphalt into the mixture. A foamed asphalt content of 2.5% by weight of the reclaimed material shall be used for bidding purposes prior to the completed mix design. The actual foamed asphalt content will be adjusted based on the quantity necessary to meet the design requirements in Table 3.

Hydraulic Cement w ill be paid for at the Contract unit price per ton. This price shall be full compensation for furnishing and incorporating the hydraulic cement into the mixture. A cement content of 5.0% by weight of the reclaimed material shall be used for bidding purposes prior to the completed design. The actual cement content will be adjusted based on the quantity necessary to meet the design requirements in Table 3.

Lime will be paid for at the Contract unit price per ton. This price shall be full compensation for furnishing and incorporating the lime into the mixture. A lime content of 5.0% by weight of the reclaimed material shall be used for bidding purposes prior to the completed design. The actual lime content will be adjusted based on the quantity necessary to meet the design requirements in Table 3.

Other Cementitious Material will be paid for at the Contract unit price per ton. This price shall be full compensation for furnishing and incorporating the cementitious into the mixture. A cementitious content of 5.0% by weight of the reclaimed material shall be used for bidding purposes prior to the completed design. The actual cementitious content will be adjusted based on the quantity necessary to meet the design requirements in Table 3.

Payment will be made under:

Pay Item	**Pay Unit**
Full-Depth Reclamation (Depth)	Square Yard
Liquid Asphalt (Emulsion)	Ton
Liquid Asphalt (Foamed)	Ton
Hydraulic Cement	Ton
Lime	Ton
Other Stabilizing Materials	Ton