Driving Surface Aggregate (DSA) Handbook

May 16, 2016

This DSA Handbook is intended for use in Pennsylvania's Dirt, Gravel, and Low-Volume Road Maintenance Program.

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APPENDICES

What is DSA?

Driving Surface Aggregate (DSA) is a well-graded, unbound mixture of aggregate designed for use as a wearing course on unpaved roads. DSA is designed to achieve maximum density to resist erosion and traffic wear. Properly installed DSA roads will have greatly reduced sediment loss and maintenance cycles.

Driving Surface Aggregate (DSA) Handbook

This handbook was developed by the State Conservation Commission and the Center for Dirt and Gravel Road Studies at Penn State University. This handbook is intended as guidance and education only.

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1. Summary of Requirements & Recommendations

This table is meant to summarize requirements and recommendations about purchasing and placing DSA. Full details are contained in the rest of this Handbook.

PREPARATION	Required	Recommended	Notes
Address Drainage Issues	**X**		Program projects must address all necessary drainage issues before considering DSA.
Address Road Base Issues	**X**		Program projects must address all necessary base instability issues before considering DSA.
Center Notification of DSA Placements		**X**	Notify Center for Dirt and Gravel Roads at least 30 days prior to placement.
Quarry Contact and DSA testing	**X**		May be conducted by CDGRS, CD, or third party.
Use of Request for Proposal (RFP)		**X**	The included RFP sample is recommended to ensure all parties are aware of DSA requirements.
DSA Certification	**X**		Must accompany first load delivered.
Creating Paving Notches	**X**		Notches are required at the start and end of DSA placements for a smooth transition to the existing road.
Cutting "Keys"		**X**	~4" keys are recommended at the sides of DSA placement to support the aggregate edge.
Weather Limitations	**X**		If freezing temperatures or precipitation are forecast that may cause the material to freeze, or prevent the material from drying out, placement shall be postponed by the road owner, CD, or supplier.

PLACEMENT	Required	Recommended	Notes
Tarped Delivery Trucks	**X**		Trucks must be tarped to prevent excessive drying during transport.
Optimum Moisture	**X**		Optimum moisture (or up to 2% below) is required to achieve maximum compaction density.
Paver Placement	**>1,000 tons**	**all placements**	While paver placement is recommended on all jobs, it is required on projects and/or contracts placing over 1,000 tons of DSA. Track pavers are recommended.
Placement 6" to 8" loose depth	**X**		Placements outside this range make it difficult to achieve maximum compaction density.
Minimum surface-slope of 1/2" per ft	**X**		A crown or side-slope of 1/2" to 3/4" per horizontal foot (4%-6%) is required to ensure proper drainage.
10-ton Vibratory roller compaction	**X**		Required on all jobs to achieve proper compaction.
In-Place Density Testing		**X**	In-place density testing is the only way to determine compaction and moisture that is defensible.
Road Closure		**X**	When possible, new DSA placements should be closed to traffic until they are dry.

2. DSA Overview

From SCC DSA Standard and Specification:

I. Definition - *This document is for the purchase and placement of Driving Surface Aggregate (DSA) for the Pennsylvania State Conservation Commission's Dirt, Gravel, and Low-Volume Roads Maintenance Program (DGLVRMP). DSA is an aggregate mixture of crushed stone designed specifically as a surface-wearing course for unpaved roads. DSA provides a durable road surface with longer maintenance cycles than conventional road surface aggregates*

Throughout this handbook, you will find boxes such as the one above that quote sections of the State Conservation Commission DSA Specification. The handbook will provide more explanation on various aspects of this specification, and the complete standard and specification can be found in Appendix A.

DRIVING SURFACE AGGREGATE (DSA)

DSA is a mixture of crushed stone developed specifically as a surface wearing course for unpaved roads. DSA has a unique particle size distribution designed to maximize compaction density and produce a durable road surface that performs better than conventional aggregates. DSA must meet the State Conservation Commission's DSA Standards and Specification in Appendix A.

DSA KEY FACTS

- Designed for maximum compacted density.
- Contains 10%-15% "minus #200" fine material.
- Fine material must be composed of crushed rock, not silt or clay.
- Must be delivered at "optimum moisture".
- Has specs for pH, hardness and soundness.
- Should be placed using a motor-paver.
- Must be compacted with a minimum 10-ton vibratory roller.
- Must be placed at an uncompacted depth of 6"- 8".

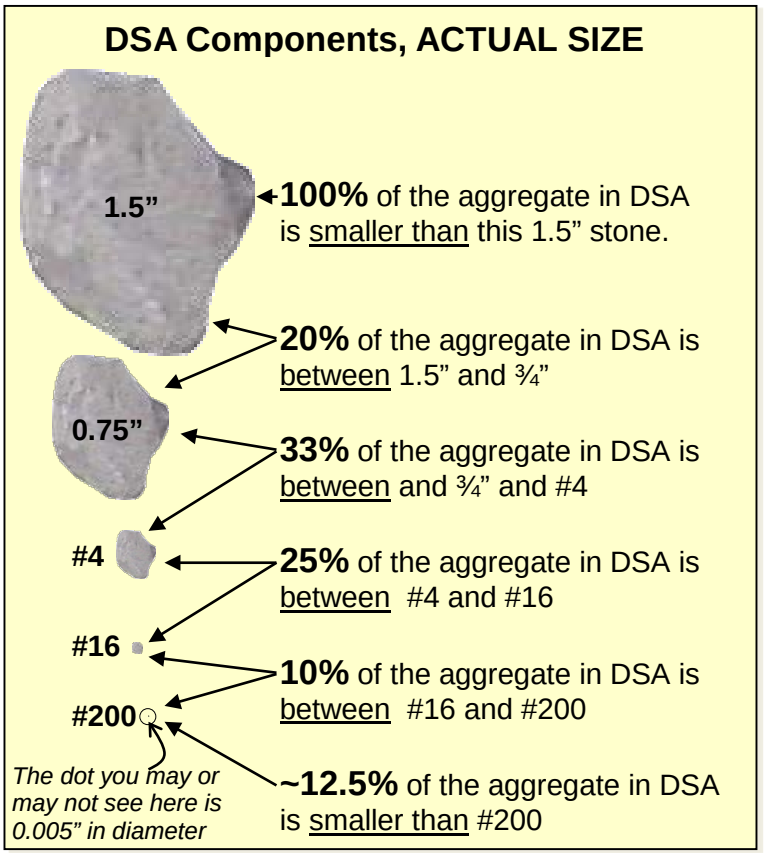

Figure 1. The specification is well graded from large pieces that give support, all the way down to the "fines", rock particles less than 1/300th of an inch. The illustration above shows the actual sizes of a "midline" or average DSA specification (roughly to scale when printed on 8.5" x 11" paper).

DSA APPLICABILITY (USE & OVERUSE)

The DGLVR Maintenance Program goal is to improve water quality. Since DSA was designed to resist erosion, it was originally intended to be placed on sections of road adjacent to streams where draining road runoff to the waterway is unavoidable. Over the years, DSA has evolved into a "standard practice" on projects in many Conservation Districts (CD), and is being overused. DSA is NOT a required component of every DGLVR project. The extent to which DSA is used on projects is at the discretion of individual Conservation Districts and Quality Assurance Boards. When DSA is used as part of a project, it should be the very last phase of the project. DSA alone does not constitute a comprehensive DGLVR Program project. All possible base and drainage improvements (new pipes, underdrain, road fill, French mattresses, etc.) must be completed first to reduce environmental impacts of the road and extend the longevity of the DSA. Avoid placing DSA on entrenched roads, or on roads where surface drainage issues are not resolved.

BENEFITS OF DSA

Properly purchased and placed DSA provides excellent service and long maintenance intervals. DSA has an engineered blend of particle sizes that provides maximum compaction density. This creates a durable road surface with extended service intervals, both desired characteristics of an unpaved road surface aggregate.

Because DSA is densely packed, less loose material is available to generate dust and sediment. Dust generation and dispersal is reduced because the fines in DSA are primarily crushed rock, which settles out of the air quicker than silt and clay. Preliminary studies completed by the Center have shown 80-90% reduction in sediment runoff from DSA compared to existing road surfaces, even after 3 years of exposure and use. DSA further reduces dust and sediment pollution by lengthening road maintenance cycles. Road maintenance loosens the aggregate surface, resulting in periods of increased dust and sediment loss through erosion.

From SCC DSA Standard and Specification:

III. Material - *DSA to be used on DGLVRMP projects shall be tested prior to delivery by an independent lab that has no affiliation with the source quarry. Samples shall be obtained by Conservation District (CD) Staff, Center for Dirt and Gravel Road Studies (CDGRS) staff or otherwise approved by the SCC.*

DSA Sampling and Testing

DSA must be sampled and tested by an independent lab before it is delivered to a project site. This pre-delivery testing is key to catching any potential problems with the aggregate before it is placed. This will require some advanced planning. Quarries must produce DSA piles in advance of delivery in order to allow time for sampling and testing (suggest 2 weeks minimum). Note that during busy periods, testing labs may become backlogged and require more time. **DSA sampling, testing, and approval is "pile-specific", not "quarry-specific".** Testing must be done on the aggregate pile that is directly supplying the job. Only complete piles should be tested (a 10 ton "sample" pile cannot be used to approve a 1,000 ton job). Per the SCC specification, DSA shall not be placed without pre-delivery sampling and testing.

Sampling can be done by conservation district representatives following the guidelines below. The costs of testing can be incorporated into project costs, or paid out of a district's admin/education funds. Sampling can also be done, free of charge, by the Center's "DSA Clearinghouse", covered later in this chapter.

Sampling Guidance

The procedure below describes sampling DSA from a stockpile for aggregate testing prior to placement. Sampling from a stockpile should always be done using a loader to separate out a small sampling pile. As the sampler, it is your job to witness the sample pile(s) being created from the DSA stockpile that will be used on the job. Sampling is equally as important as the testing, and the sampler shall use every precaution to obtain samples that will show the nature and condition of the materials which they represent.

1. Use the loader to re-blend any segregated material on the outside of the pile.
2. After blending, reenter the pile with the loader and obtain a fully loaded bucket. Exit the pile and slowly empty the bucket to form a small sampling pile at the base of the stockpile (*Figure 2*). If the sampling pile is not of sufficient size, multiple buckets shall be used.
3. Using the loader, create a flat surface (sampling pad) by dragging the bucket back across the small pile (*Figures 3 & 4*).
4. Divide the flat sampling pad into four quadrants *(Figure 4)* and sample equally from each quadrant. Avoid sampling within 1 foot of the pad edge and take care to avoid previous shovel holes.
5. Collect the samples by fully inserting a square shovel into the flat pile as vertically as possible (*Figure 5*). Roll back the shovel and lift the material of the pile slowly to avoid material rolling off the shovel. The sample should fill 2 five-gallon buckets approximately 2/3 full each. The quarry may ask to take a companion sample.
6. After sample collection, confirm with the quarry that the sampling met their requirements before leaving.

Figure 2. Forming the sampling pile

Figure 3. Forming the pad

Figure 4. Final sampling pad and quadrants

Figure 5. Sampling the pad

On stockpiles over 500 tons, multiple sample pads are recommended to insure the sample is more representative of the entire pile. Material from the separate pads can be combined into one composite sample to represent the entire pile. For more information and training on sampling practices please contact the Center. Additional information can be found in ASTM D75 – Standard Practice for Sampling Aggregate.

Testing Guidance

After collecting the samples, the buckets should be labeled, taped shut and shipped to an aggregate testing lab for analysis. See Appendix C for aggregate sample collection data sheet. Typically, the lab you have chosen will supply a testing request form that will accompany the sample containers. Contact the Center if guidance is needed identifying labs that provide the testing services listed below. **DSA sampling, testing, and approval is "pile-specific", not "quarry-specific".**

Required Tests: The three tests below must be run on every DSA sample collected from a stockpile as results can vary based on quarry conditions and procedures.

- **Sieve Analysis with Wash:** Analysis to show the percentages of the material passing the five sieve sizes. These gradations should fall within the corresponding specification range for each sieve size in accordance with the material specifications. (~$150, 2-3 days to run)
- **Standard Proctor Analysis:** Test to determine the optimum moisture and maximum density for the specific material, determined in accordance with Proctor Test ASTM D698, Procedure

C. Using this information, on-site compaction testing can be conducted. Information obtained from the Proctor analysis can be used to calibrate a Nuclear Density Meter in the field. Maximum densities of 95% or better (of theoretical maximum density determined during proctor test) should be realized on the aggregate in the field. (~$200, 2-3 days to run)

- **Plasticity:** Plasticity is an approximation of the amount of clay in an aggregate. DSA must not exceed a Plasticity Index (PI) rating of 6. The laboratory test required for these results is the ASTM-D4318. (~$175, 2-3 days to run)

Other Tests: These test must be run for "new" suppliers of DSA, but do not need to be run for every sample, since they are more a function of the source rock (not quarry operations), and typically do not vary a great deal over time for a particular source. They may also be run if there is suspicion of a problem with the material.

- **pH:** The pH of the material will be determined by EPA 9045C. (~$75, 1-2 days to run)
- **Abrasion Resistance:** The acceptable hardness as measured by weight loss is "less than 40% loss". Los Angeles Abrasion test, ASTM C 131 shall be used to determine this property. Existing data from tests made for and approved by PENNDOT will be accepted. (~$225, 2-3 days to run)
- **Soundness**: Determine the percentage of mass (weight) loss of each fraction of the coarse aggregate after fives cycles of immersion and drying using a sodium sulfate solution according to PTM No. 510. The maximum weighted percent loss allowed is 20%. The Conservation District may accept aggregate failing the soundness test if it can be demonstrated that the aggregate has a satisfactory service record. Existing data from tests made for and approved by PENNDOT will be accepted. (~$325, 5-7 days to run)

DSA CLEARINGHOUSE

The Center for Dirt and Gravel Road Studies (Center) maintains a "DSA Clearinghouse" that is designed to facilitate DSA purchasing and placements around the State by creating a central point of contact and information for aggregate suppliers and conservation districts. **DSA sampling, testing, and approval is "pile-specific", not "quarry-specific".**

PURPOSE

- Provide a central point of contact between conservation districts and DSA suppliers.
- Provide DSA testing services when needed.
- Provide DSA education to conservation districts.
- Provide a central repository of DSA testing and placement data for the state to serve as a reference and avoid duplication of testing.

CONSERVATION DISTRICT RESPONSIBILITY

If districts plan to use the DSA Clearinghouse, it is recommended that they contact the Center for Dirt and Gravel Road Studies when a potential DSA supplier is chosen, at least 30 days before placement. Notification can be made utilizing the DSA Purchase Notification Form, provided in Appendix D, or on the Center's website. **If districts choose to sample their own DSA, they should share testing results with the Center** in order to provide a more comprehensive statewide database and avoid duplicate testing.

POTENTIAL SERVICES PROVIDED

Services provided by the Center will depend on the level of service requested by the conservation district. The Center will train CD staff in proper sampling techniques if they wish to perform sampling and testing on their own. Districts that choose to test their own DSA should still notify the Center and share their results in order to maintain a full and current statewide database. The Center will incur the costs for pre-delivery testing for any sampling they perform.

Center services may include:

- Visiting and talking with quarries and CD to ensure they understand the DSA requirements.
- Collecting samples from the quarry and performing testing to ensure DSA meets all material requirements before delivery and placement.
- Providing contractor education on DSA.
- Providing on-site assistance during DSA placement.
- Education of Conservation District staff on DSA sampling, testing, and placement.
- Troubleshooting.
- Identifying potential DSA suppliers if you are having trouble finding DSA in your area.

4. Purchasing DSA

STEPS IN PURCHASING DSA

- Determine quantity of DSA needed (see formulas below).
- Determine quarry/supplier (consider township bidding etc.).
- Determine placement date.
- Perform sampling and testing of DSA to be used on the project (see chapter 3 of this handbook, and contact the Center's DSA Clearinghouse if needed).
- Prepare the road for DSA (see chapter 5 of this handbook).

PURCHASING INFORMATION

- Municipalities should follow their standard purchasing, bidding, and payment procedures when purchasing DSA.
- Prevailing wage applies to contracted labor on any Dirt, Gravel, and Low-Volume Road Program project **greater than $25,000 in total project value**.
- A sample Request for Quote (RFQ) is provided in Appendix E. Use of the RFQ is recommended in order to ensure that all potential suppliers know exactly what they are bidding on.
- Applicants and Conservation Districts are encouraged to include the cost of DSA testing and on-site compaction testing in the contract to be covered with Program funds.

DETERMINING DSA QUANTITY

The quantity of DSA to purchase must be determined prior to placing an order with a supplier. The quantity is dependent on the length of the project, width of the road, and the material placement depth. DSA must be placed in an 8" loose lift and compact to a finished depth of 6", or a 6" loose lift compacted to 4 1/2" depth. Figure 6 provides a quick guide to determining how many tons of DSA to order based upon placement thickness and road dimensions.

Placement Depth:

DSA must be placed at an uncomapcted depth of 6"-8". Placements less than 6" may not have enough depth of material to achieve proper compaction. Placements over 8" may also not be able to achieve maximum compacted density with a 10 ton roller. Districts should work with applicants to determine if a 6" or 8" DSA placement should be used. Some Considerations

- 6" placements will "stretch" your dollar and allow you to cover more road for the same up-front aggregate costs
- 8" placements will provide additional material when regrading or reworking the material years into the future

How much DSA should I order?

DSA Needed (tons) = **Road Width (ft)** x **Road Length (ft)** x **0.04** for 8" loose compacted to 6"

0.03 for 6" loose compacted to 4½"

Figure 6: Calculation of DSA required

UNDERSTANDING THE DSA MATERIAL SPECIFICATION

A detailed explanation of the DSA specification and the reason behind the requirements are detailed in this section. Understanding the specification will allow users to interpret laboratory testing results and prevent placement of inferior DSA.

From SCC DSA Standard and Specification:

III. Material: *Material must meet the following requirements:*

- *A.* ***Gradation****: The required sieve sizes and allowed ranges, determined by weight, for DSA components are shown in Table 1.*
- *B.* ***Abrasion Resistance****: The loss of mass (LA Abrasion) shall be less than 40%. Determine the resistance to abrasion using the Los Angeles Abrasion test, ASTM C 131.*
- *C.* ***pH****: Aggregate shall be in the range of pH 6 to pH 12.45 as measured by ASTM D4972.*
- *D.* ***Moisture****: Upon delivery to the site, material shall be well mixed and placed at optimum moisture content or up to 2% below that value as determined for that particular source. The optimum percentage moisture is to be determined using Proctor Test ASTM D698, Procedure C, Standard. Aggregate provider is encouraged to perform moisture testing prior to loading material for delivery.*
- *E.* ***Plasticity****: Material shall not exceed Plasticity Index (PI) of 6. The laboratory test required for these results is the ASTM D4318 – Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.*
- *F.* ***Soundness:*** *Determine the percentage of mass (weight) loss of each fraction of the coarse aggregate after fives cycles of immersion and drying using a sodium sulfate solution according to PTM No. 510. The maximum weighted percent loss allowed is 20%. The Conservation District may accept aggregate failing the soundness test if it can be demonstrated that the aggregate has a satisfactory service record.*
- *G.* ***Aggregate****: All Driving Surface Aggregate (DSA) shall be derived from natural rock formations that meet program specification for abrasion resistance, pH and freedom from contaminants.*
- *H.* ***Fines****: If fines need to be added to the aggregate to meet gradation requirements, the added material passing the #200 sieve must be derived from rock material that conforms to program specifications. No mineral clay or silt soil may be added. The amount of particles passing the #200 sieve shall be determined using the washing procedures specified in PTM No. 100.*
- *I.* ***Mixing****: DSA shall be properly mixed and at the proper moisture content before it is loaded onto the transport vehicles.*

A. **Gradation:** Gradation refers to the particle size distribution of the aggregate, and is one of the defining qualities of DSA. DSA is designed with a well-graded distribution that includes 10-15% fine material in order to achieve the highest possible compaction and density. This well-graded distribution is virtually impermeable, in contrast to another “PA Standard Aggregate”, PennDOT’s 2A specification, which is relatively open-graded with only 0-10% fine material.

B. **Abrasion Resistance:** Hardness is an indication of an aggregate resistance to degradation due to impacts, abrasion, and grinding. Hard aggregates will have a higher resistance to breakdown due to traffic, grading, and weather over time. The “LA Abrasion” test involves subjecting aggregate to impact by placing it in a cement-mixer-like apparatus along with steel spheres, and measuring the percent of aggregate that is degraded through the test. LA Abrasion is expressed as a “percent loss, with lower numbers meaning less of the aggregate was lost in the test, and a more durable material. DSA must have a loss of mass of 40% or lower in the LA Abrasion test.

C. **pH:** The pH requirement of DSA ensures that aggregate sources that are too acidic or basic are not placed on roadways next to streams. The allowable pH range is between 6 and 12.45 (agricultural lime).

D. **Moisture**: After gradation, moisture is probably the most important aspect of DSA. Without proper moisture, DSA will begin to segregate by size during transport, and achieving maximum compaction will be impossible. The term "optimum moisture" refers to the ideal amount of water in the aggregate that will allow it to achieve its maximum compaction density. Optimum moisture is determined by a proctor test in the lab, where a small "core" of aggregate is compacted at different moisture contents to establish a moisture density relationship curve. While optimum moisture will vary depending on source material and gradation, DSA typically has an optimum moisture content of 5-7% using the standard proctor procedure. As stated in the spec, DSA should be delivered at, or up to 2% below, optimum moisture.

E. **Plasticity:** While it is not a direct measurement, the "Plasticity Index" is the best indicator of the amount of clay present in an aggregate. Aggregates that are too high in clay are prone to several issues such becoming slippery or rutting in wet conditions, and excessive dustiness in dry conditions. The Plasticity Index for DSA can range from 0-6 (0 = "non-plastic").

F. **Soundness:** Soundness is an indication of an aggregate's resistance to weathering. This test simulates multiple freeze thaw cycles and is used to determine the percentage of mass loss of each fraction of the coarse aggregate. This test is conducted using a sodium sulfate solution and immersion and drying cycles according to PTM No. 510. The maximum weighted percent loss allowed is 20%, and lower numbers indicate more sound aggregate. However, certain aggregates, in particular those with silica, may produce falsely high soundness values. The conservation district may accept aggregate failing the soundness test if it can be demonstrated that the material (not necessarily DSA, but the source stone), has a satisfactory service record on past project. For example: If a certain material has a soundness of 30%, but has been used as "rip-rap" in the past and has shown no degradation due to weathering, the District may consider allowing DSA to be produced from the same parent material.

G. **Aggregate:** In addition to meeting the pH, abrasion resistance, and freedom from contamination specifications, all aggregate used to manufacture DSA must be derived from natural rock formations. This is to prevent DSA being made from recycled asphalt or reclaimed concrete, which will result in an inferior DSA that may contain contaminants.

H. **Fines:** The "fines" in DSA refer to material passing the #200 sieve. These fines, similar in appearance to "rough talcum powder" or Portland cement, comprise 10%-15% of DSA by weight and is key to binding the aggregate together. If fines need to be added to the aggregate to meet gradation requirements, the added material passing the #200 sieve must be derived from rock material that conforms to program specifications. No mineral clay or silt soil may be added.

I. **Mixing**: The aggregate should be well mixed, including water, before it is loaded for delivery. Mixing is key to providing a homogeneous aggregate at optimum moisture (*Figure 8*).

Figure 8. Mixing and adding moisture to a small DSA pile at a quarry.

5. Road Preparation for DSA

From SCC DSA Standard and Specification:

IV. Delivery and Placement

***A. Preparation of subgrade**: Unsatisfactory drainage and subgrade conditions shall be corrected prior to placement by scarifying, reshaping, and re-compacting, or by replacing or importing subgrade/sub-base. The subgrade/sub base shall be crowned or side sloped to ½ to ¾ inch per foot (4%-6% slope). Beginning and ending of DSA placements shall include a paving notch across the width of the subgrade. The paving notch shall have a minimum depth equal to the compacted DSA placement, and a sufficient length to facilitate transition into existing road surface.*

LOGISTICS

Some consideration for the local road-owning entity when scheduling DSA placement:

- Make provisions for road closure if possible, both during placement and afterwards to allow the DSA to dry.
- Alert any residents to the project, any inconveniences they may experience, and the long-term benefits they should see when complete.
- Be prepared with a backup placement date in case of heavy rains.

ROAD PREP – DRAINAGE AND BASE IMPROVEMENTS

Proper preparation and planning will minimize problems during and after installation as DSA will reflect the shape of the road base. Therefore preparation of the road is critical to a successful DSA application. Below are recommendations for preparing a road for application of DSA.

1. **Address Drainage Issues:** If DSA is used, it should be the last thing to be done on a project. DGLVR Program projects are first and foremost about drainage improvements to reduce environmental impacts from roads. Drainage improvements MUST be completed before application of DSA. The "Environmentally Sensitive Maintenance Practices" used to improve drainage vary widely, but may include the addition of: road fill to elevate an entrenched road, crosspipes or culverts to disperse drainage, underdrains and/or French mattresses to address subsurface water, addressing off right-of-way issues, and more.

2. **Address Base Issues:** The performance of any aggregate or pavement will be limited by the stability of the base it is placed on. Road base instability issues MUST be completed where needed before application of DSA. The "Environmentally Sensitive Maintenance Practices" used to improve road base vary widely, but may include: addition of competent material, use of geosynthetics (geotextiles, separation fabrics, etc.), addressing subsurface water issues with underdrains or French mattresses, replacement of incompetent material, and more. See note on geosynthetic use at the end of this chapter.

3. **Surface Features:** Address surface drainage structures, such as broad-based dips, grade breaks, crown, and side-slope. **Establish proper drainage in existing base** (*Figure 9*). Required crown or cross-slope is ½ to ¾ inch per horizontal foot (4% - 6% slope). If exposed bedrock or insufficient material prevents proper shaping of the road base, additional base material should be added before aggregate placement.

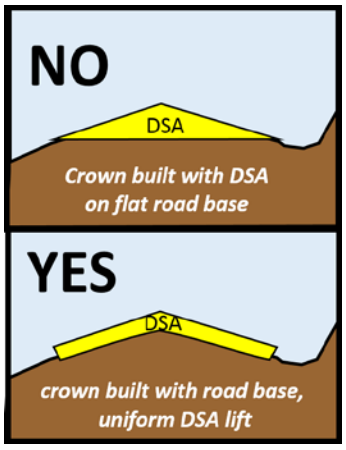

Figure 9. Road Base Preparation

ROAD PREP – IMMEDIATELY BEFORE PLACEMENT

1. **Ensure proper crown / cross-slope**: Grade the road if necessary to ensure the proper crown or cross-slope exists where you are placing DSA as described in Figure 3 above. Never place DSA on a flat surface or try to establish crown by varying DSA depth across road.

2. **Scratch surface if necessary:** If proper crown exists and grading is not necessary, tightly compacted existing road surfaces should be lightly scratched so the DSA will bind better with the base layer.

3. **Cut Key:** Immediately prior to DSA placement, a 3" - 4" "key" should be cut along the existing road edge where possible *(Figure 10)*. The key can be cut with the grader as part of the gradi ng process to prep the road for DSA. DSA should be placed against this key to support the aggregate edge, prevent a large drop-off, and facilitate compaction. If a key cannot be cut, it is recommended that fill material be placed along the edge of the DSA to provide support and prevent the edge from failing.

4. **Cut Paving Notch:** Immediately prior to DSA placement, a trench or notch MUST be cut in the roadway at the beginning and ending of DSA placement to allow for a full-depth lift of aggregate to be installed flush with the existing road surface *(Figure 11)*. Width of the trench should be wide enough to allow for a smooth transition from the existing road surface onto the DSA without causing traffic disruptions, wheel spin, or braking. It is advised that a notch or trench also be installed where DSA meets existing paving or where it is extended into driveways or turn offs. Without these notches, DSA placement would "tail off" and create an unstable seam that is likely to unravel.

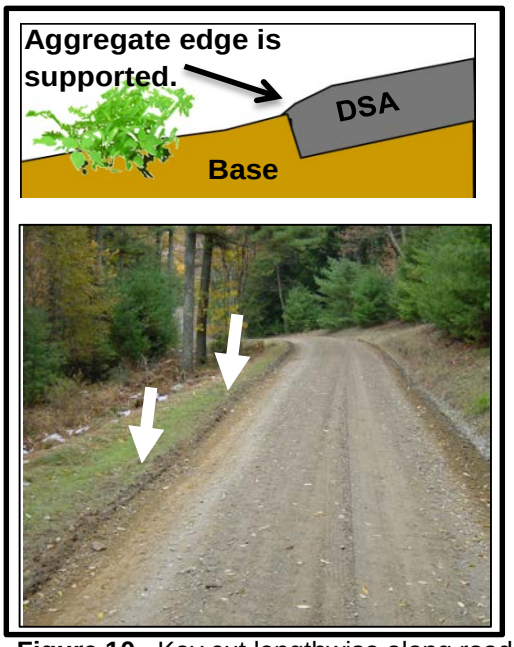

Figure 10. Key cut lengthwise along road prior to DSA placement

Figure 11. Key cut lengthwise along road prior to DSA placement

GEOSYNTHETIC USE

As mentioned in "2. Address Base Issues" above, geosynthetics may be used to stabilize the road base prior to DSA placement. Geo-synthetics include separation fabric, geo-grid, and geo-cell. Each type of geo-synthetic has specific uses and applications and their use must be based upon specific site conditions.

- **Separation fabrics** are used to separate aggregate from the underlying soil (*Figure 12*). Separation fabrics may be utilized where DSA is placed over unsatisfactory soils or anywhere that separation is desired. If used, separation fabrics should be covered with a minimum lift of 12-inches; therefore additional stone base is required underneath DSA placements (e.g. 6-inches of 2A stone with 8-inch loose lift of DSA). The edge of the fabric should be kept at least 2 feet from the edge of the roadway to minimize the chance of equipment snagging the fabric in the future.

Figure 12. Fabric

- **Geo-grid** is used to stabilize and strengthen unsatisfactory soil or sub-base (e.g. soft soils) by acting as a "snow-shoe" and distributing loads over a greater area (*Figure 13*). Geo-grid does not separate aggregate from the sub-base. There are many types of geo-grid sizes and patterns available and they must be installed in accordance with the manufacturers' specification.

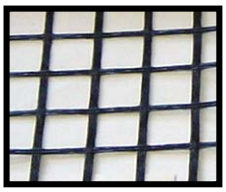

Figure 13. Geo-grid

- **Geo-cells** are 3-dimensional plastic grids that can be filled with material to stabilize surfaces (*Figure 14*). Cells may be filled with stone for support and drainage, or with soil for stabilization and to support vegetation. Geo-cells are intended to provide structural support. There are various types of geo-cells, and it is important to use the correct cell for the conditions encountered. Consult the manufacturer for application and installation specifications.

Figure 14. Geo-cell

6. Placement of DSA

From SCC DSA Standard and Specification:

IV. Delivery and Placement

B. Transport: *Tarps shall be used to cover 100% of the load's exposed surface from the time of loading until immediately before placement.*

C. Certification: *A properly executed SCC DSA Certification Form shall be provided at the time of initial delivery and subsequent certification forms shall be provided if quarry conditions change. This Certification Form is to apply to the specific stockpile of DSA material being delivered from the source. The form certifies that the DSA material meets all of the specifications and requirements.*

DSA TRANSPORT

Trucks transporting DSA from the quarry to the jobsite must remain covered, including wait time on-site. Because DSA is to be shipped at optimum moisture, excessive drying of the surface layer can occur on uncovered trucks, especially on longer hauls. This drying may lead to "dry pockets" in the DSA that are prone to segregation and will be difficult to compact. Optimum moisture must be obtained by adding water at the quarry, not at the project location.

DSA CERTIFICATION

Aggregate suppliers are required by the program to certify that the aggregate they deliver conforms to the Program specifications. A new certification is required for each project, or whenever the source of aggregate changes. The applicant must receive the SCC certification form with the first load of the project. A copy of the DSA certification form should be provided to the Conservation District and retained in project files. A blank Certification Form is provided in Appendix B.

From SCC DSA Standard and Specification:

IV. Delivery and Placement

D. Placement: *The use of a motorized paver is highly recommended for all DSA placements. For projects and/or contracts including over 1,000 tons of DSA, a motorized paver is required. A track mounted paver is preferred. DSA placements should be placed in a single pass. The crown or cross slope must range from ½ to ¾ inch per foot (4-6%). Material shall be placed in a single 6-8 inch loose lift. This lift is to be compacted with a vibratory roller as specified in Section IV Compaction. If freezing temperatures or precipitation are forecast that may cause the material to freeze, or prevent the material from drying out, placement shall be postponed by the road owner, Conservation District, or aggregate supplier.*

DSA PLACEMENT

Paver Placement: Paver placement is highly recommended on all projects, and required on any projects and/or contracts placing more than 1,000 tons of DSA. A track mounted paver is recommended. When using a paver, set the adjustments on the application thickness and width desired so it is unnecessary to use a grader after placement (*Figure 15*). When the paver is applying aggregate, care should be taken to keep the paver at or near capacity at all times. The paver will tend to segregate aggregate if it is "run dry". DSA should be placed in a single pass. Attempting to place aggregate "one lane at a time" on narrow roads typically results in trucks driving over freshly placed aggregate. In addition roads placed "one lane at a time" typically fail to mesh well in the middle and will develop potholes.

Paver placement of DSA provides many advantages over other methods such as "tailgating":

- Prevents segregation of aggregate by size (more homogeneous).
- Allows better control over application rate, width, and depth.
- Allows the crown or cross-slope to be set to the desired angle.
- Prevents "overworking" of aggregate which causes segregation.

Figure 15. Paver placement of DSA with proper crown.

- **"Lift" thickness**: A "lift" refers the thickness of a layer of aggregate placed on the ground. DSA is to be placed either at a loose depth of 6", and compacted to ~4.5"; or at a loose depth of 8" and compacted to 6". Lifts thinner than this range will not have sufficient depth to allow the aggregate mixture to bind together properly. Lifts thicker than this range may not be able to achieve maximum compaction. DSA should always be placed in one lift (i.e. one 8" layer, not two 4" layers). Placing aggregate in multiple lifts would mean that both lifts are too thin to bind properly, create a weak point where they meet, and require running equipment over the finished first lift to place the second.

- **Crown and Cross-slope:** The required crown or side slope is ½" to ¾" rise per horizontal foot (4%-6% slope). Cross-slope is to be achieved by properly preparing base and placing aggregate in a single uniform lift (*see Section 5. Road Preparation for DSA*). Crown and cross-slope become even more important as road slope increases, since water will have a greater tendency to run down the wheel tracks instead of off to the side. Steeper crowns may be considered on roads over an 8% grade.

- **Weather Limitations**: DSA should be allowed to dry or "cure" before being exposed to traffic, otherwise deformations or rutting may occur. If the weather is not conducive to drying for a few days after placement due to low temperatures or precipitation, placement shall be postponed by the road owner, Conservation District, or aggregate supplier, especially if traffic cannot be kept off the road during the drying period.

- **Other placement methods:** The use of a paver may not be possible on some job sites, or may be cost-prohibitive on smaller jobs due to mobilization costs. The use of a paver on jobs less than 1,000 tons is recommended, but is at the discretion of the local Conservation District.

    - **Other box spreaders:** Several other box spreading devices exist ("jersey spreaders", etc.) that can be used to place DSA on a road. The fundamental difference of these spreader boxes from a paver is that a paver has an auger to mix the aggregate into a homogeneous lift, and a paver has much better depth and crown control. Spreader boxes can be used, but are of limited benefit since they lack the control of a paver and still tend to segregate aggregate by size.

    - **Tailgating**: A typical "tailgating" practice is to spread the aggregate over the road out of a moving dump truck, and use a grader to move the material and establish the final road shape. The success of any tailgating placement is almost entirely dependent on the skill of the truck and grader operators. Every time the material is pushed or spread by a grader or other equipment, it tends to start segregating by size. The more the material is worked by equipment, the more it will segregate and the higher the likelihood of problems. Aggregate should be dumped in a relatively uniform layer over the road, not in a single pile. Grading passes should be kept to the minimum amount required to achieve road shape. The use of a carbide-tipped grader blade is recommended to reduce aggregate segregation (see

Maintenance section for more details on carbide-tipped blades). Other equipment such as bulldozers can be used to spread aggregate, but the same concerns exist of overworking and segregation by size.

From SCC DSA Standard and Specification:

V. Compaction

A. Vibratory Roller: *After placement, the material shall be compacted using a minimum ten-ton vibratory roller. DSA material shall be compacted to a minimum of 95% of the dry-mass (dry-weight) density, determined according to ASTM D698, Procedure C, Standard as determined by pre-sampling (refer to Materials, Section III.D). The road owner, or its designated representative, reserves the right to determine the in-place moisture and density according to ASTM D6938.*

DSA COMPACTION

DSA has a well-graded particle size distribution designed to maximize density through proper compaction. Achieving proper compaction is vitally important to ensure DSA functions as designed. **DSA is required to be compacted by a minimum 10 ton vibratory roller.** Rollers should be equipped with functional "scraper bars" to insure drum stays aggregate-free. Vibratory compaction of DSA placed at optimum moisture is essential to obtain maximum density. However, achieving proper compaction is not as simple as continuously running a roller over the material, as it is possible to over-roll DSA and compromise the aggregate. The following steps outline how to achieve proper compaction

1. **Moisture:** DSA must be compacted at optimum moisture to achieve maximum density. If clumps of aggregate adhere to the roller drum, the aggregate may be too moist for compaction. Allow time for the aggregate to dry before continuing to roll.

2. **First Pass:**
   a. **Supported Edge**: If edge of placed aggregate is supported by an existing bank or berm: First pass: Roll slowly in static mode on the outside edge of placed aggregate.
   b. **Unsupported Edge**: If the edge of the placed aggregate is not supported: First Pass: Roll slowly in static mode near but not over unsupported outside edges. Once that path is firm, move progressively closer to the outside edge with static passes until unsupported edge is firm.

3. **Compaction Sequence:** As in all rolling operations, compaction is achieved by making overlapping lengthwise passes beginning at the ditch or berm-side and working toward the crown or the top edge. In no case should the roller be run lengthwise on the top of the road crown.

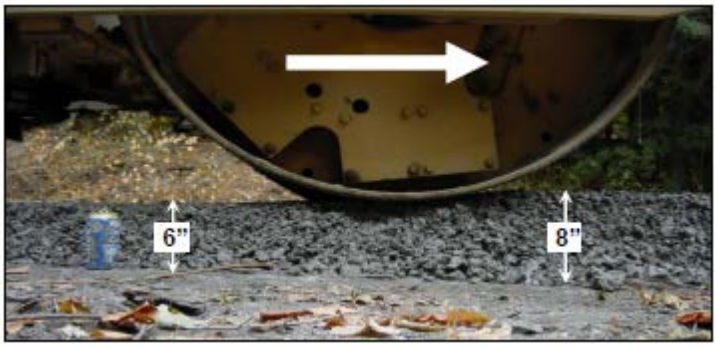

Figure 16. A roller moving from left to right compacts the 8" lift of loose DSA down to 6".

4. **Vibratory Roller:** The first roller pass over all aggregate should be done in static mode (vibration turned off) to "set" the aggregate, and successive passes should be done in vibratory mode. The final pass over each area should be made in static mode to remove all roller edge marks. Vibration should be turned off during steep downgrade passes to prevent creating a "wave" of aggregate

movement in front of the roller. Do not use the vibratory rolling mode if that action brings water to the surface of the aggregate, additional drying time may be required.

5. **Compaction Standards**: DSA is designed to be compacted to between 95% and 100% of the maximum dry-mass (dry-weight) density determined according to ASTM D698, Procedure C. Standard. Districts may require testing during placement to determine moisture content and compaction.

   a. A Standard Proctor Test to determine maximum density and optimum moisture content can be used to calibrate a Nuclear Density Gauge for on-site compaction testing. **On-site compaction testing is recommended to confirm actual moisture content and density *(Figure 17)*.** The costs of on-site density testing can be incorporated into the grant. Adequate compaction is achieved when the aggregate is at 95% of its maximum dry density.

   b. A visual indicator of adequate compaction is when the DSA shows no movement or depressions underneath the roller

   c. Over-rolling DSA can compromise the material and reduce the strength of the road surface. Visual indicators of over-compaction include: excessive aggregate fines and moisture migrating to the road surface (surface of road looks starts to look like finished concrete); shattering of larger stones on the surface; and a decrease in measured density.

Figure 17. Compaction Testing with Nuclear Density Gauge

OTHER FACTORS IN DSA PLACEMENT

Road Closure / Limiting Traffic: When possible, roads should be closed to traffic immediately following DSA placement. Heavy hauling on newly placed DSA should be avoided until the aggregate has had time to dry and cure. The period of closure depends on DSA moisture and weather conditions. Planning for road closure, and notifying motorists and residents, should be part of the DSA placement process.

DSA Optimum Moisture Field "Test": This is a **very informal** test to estimate the moisture content of uncompacted DSA. Grab a handful of DSA and make a ball with it. If the aggregate will not make a ball and falls apart, the material is likely too dry. A mushy, unstable ball indicates the aggregate is too wet. If the aggregate forms a tight ball that stays together then the moisture content should be close to optimum moisture. Examples are provided in Figure 18.

Figure 18. DSA Moisture Field "Test".

7. Maintenance of DSA

Note: Routine maintenance such as grading, ditch cleaning, and plowing are not to be funded through Dirt, Gravel, and Low-Volume Road Maintenance Funds. This section of the handbook is intended as guidance to local road owning entities in their ongoing maintenance of DSA placements.

DSA SURFACE MAINTENANCE

Maintenance of the road surface is periodic re-shaping of DSA to ensure proper drainage and traffic passage by incorporating loose material back into the road surface and re-establishing proper crown and cross-slope (*see Section 5. Road Preparation for DSA*). Proper grading techniques can improve road performance, lengthen maintenance cycles, reduce maintenance costs, and reduce pollution impacts.

Surface maintenance is cyclical. No matter how well maintenance is done, it will need to be re-done. Over time, the coarse stones, which provide the road's strength, are displaced by traffic and accumulate along the edge of the road in a windrow. This windrow traps water on the road surface which leads to saturating and softening of the driving surface and the road base, potentially causing rutting. Additionally, water accumulates on the road surface and flows toward the lowest point, typically following the wheel tracks. As water concentrated in the wheel track gains velocity and volume it erodes the driving surface. The process starts slowly, but if surface maintenance is not completed on a timely basis, the damage to the road can be severe.

DSA provides a durable road surface with longer maintenance cycles than traditional road aggregate, but it is not maintenance free. Maintenance is required when the road surface exhibits one or more of the following indicators:

- W-shaped road profile;
- Excessive dust;
- Significant loose stone on the surface;
- Loose stone developing in windrows along the edges of the road (*see Figure 19*);
- Water flowing parallel with the road in the wheel tracks (*see Figure 20*);
- Holes or potholes (*see Figure 21*);
- Ruts;

Figure 19. Stone windrow.

Figure 20. Water in wheel tracks.

- Wash-boarding; and
- Loss of crown.

Figure 21. Potholes.

DSA should not be graded unless one or more of the indicators listed above are present. Unlike other aggregates, **it is not recommended to grade DSA on a set maintenance cycle**.

GRADING DSA

The goals of maintenance grading are to re-establish the crown and blend the material into a homogeneous mixture. A number of factors influence the potential success of maintenance operations. They include:

- Moisture content at time of grading
- Percentage of fine particles present in aggregate mixture
- Graders ability to scarify the road surface
- Use of dust control materials
- Quality of sub-grade
- Use of a carbide-tipped blade
- Post-grading Compaction

DSA is a different type of material from other road surface aggregates, such as 2RC and 2A, and requires a different maintenance approach. DSA is designed to achieve maximum density, therefore adequate moisture, homogenous mixing, and compaction are crucial issues in DSA maintenance. Because uniform distribution of aggregate sizes is critical, loosening DSA to a depth of 3-4" during grading is very important to reestablish the proper blend of aggregate sizes and achieve maximum compaction density. The use of a "carbide-tipped grader blade" is highly recommended for maintenance grading as this reduces aggregate segregation that tends to occur with a straight grader blade. Proper maintenance includes the use of a grader equipped with a carbide-tipped grader blade and scarifier teeth, a 10-ton vibratory roller, and if needed a water truck with a spray bar to achieve optimal moisture.

Do not grade DSA when it is dry!
It will segregate and compaction will be impossible.

CARBIDE-TIPPED GRADER BLADE

Carbide-tipped blade systems have freely rotating carbide bits that offer several benefits when grading unpaved roads and for DSA maintenance.

Benefits of the Carbide-Tipped Blade System include the following:

- **Durability**: The individual carbide steel cutting bits are free to rotate with the vibration and abrasion of grading operations *(Figure 22)*. High quality carbide cutting bits will outlast traditional cutting edges by as much as thirty to one.

- **Cutting Effectiveness**: Compared with traditional straight blades, carbide-tipped blade systems are more effective in cutting hard surfaces and typically cut deeper with each pass. The carbide bits shatter rocks rather than pulling them up out of the road *(Figure 23).*

- **Increased Productivity:** Because the individual cutting bits shatter and chisel through rocks rather than aggressively hooking them, it is possible to safely and effectively grade at faster travel speeds. Final grooming of the graded road can be accomplished with the carbide-tipped blade system eliminating the aggregate segregation typically associated with raking.

- **Binding and Compaction:** A common problem with traditional grading equipment is failure of the freshly graded road material to stay in place. The carbide-tipped blade system helps enormously with this persistent difficulty. The cutting action of the blade creates grooves in the aggregate surface *(Figure 24).* The grooves eliminate shear planes and act as anchor points to bind graded road material in place and enhance compaction.

Figure 22. Individual carbide steel cutting bits

Figure 23. Shattered rocks.

Figure 24. Grooves within road surface.

- **Grading Under Wet Conditions:** The cutting action of the individual carbide bits allows for grading under high moisture conditions. The clumping or balling-up of fines that typically occurs under wet conditions with traditional blades does not occur with this system *(Figure 25)*. Grader operators should be careful not to disturb large sections of road because the material may dry faster than the operator can reshape the road.

Figure 25: Wet material rolling off blade.

- **Proper Blade Maintenance:** Inspect the blade before each use and replace lost, worn or broken teeth immediately. It is important to maintain the teeth of the grader blade so that they rotate freely by hand. If the tooth does not turn freely they can usually be freed by tapping with a soft-headed hammer. Clean the teeth and assemblies with a solvent based cleaner. Avoid using oil for cleaning as dirt will adhere to the teeth and prevent proper rotation.

Suggested Grading Sequence

Optimum moisture content is essential during DSA maintenance operations. The use of a water truck is recommended if grading operations are not carried out when there is adequate moisture in the road aggregate. The following sequence is suggested when maintaining road surfaces with DSA.

1. Pulling in the Road Edges: The accumulation of material along the outside edge of the road is a natural result of traffic. Pulling this material back into the center of the road is an important step in reincorporating material lost from the driving surface. Evenly blending this material back into the road is critical. If the large segregated aggregate is brought back to the center of the road without re-establishing a proper mixture of coarse and fine material, the road will unravel very quickly, causing dust and potholes. During this phase the blade should be rolled forward and the road center side of the blade tilted up slightly to cause the material to roll up the blade and fall onto itself, which helps to reincorporate the fines back into the larger aggregate *(Figure 26).* Care should be taken to limit the amount of organic material (e.g. soil, vegetation) being pulled back into the roadway. Ditch cleaning should not be part of road grading operations.

Figure 26. Large aggregate that has accumulated on the shoulder is pulled to the center of the road and mixed with fine aggregate particles as it rides up the blade. The blended aggregate is deposited in a wind-row in the center of the road. Note the high moisture content of the graded material.

2. Loosen the Road Surface: After pulling in the road edges, the next step in grading is to loosen the entire surface of the road to a depth of 3-4". Loosening the surface can be done with the grader blade or by using the scarifying teeth on the grader (Note: use extreme caution when loosening the road surface if separation fabric was placed during initial road construction). Experience has shown that on a dry road the scarifying teeth will need to be used to achieve the proper cutting depth *(Figure 27*). Failure to loosen the entire road surface when attempting to rebuild/repair crown is a recipe for potholes and wash-boarding. In addition to loosening the road surface, the scarifying/blading will mix the coarse aggregate that was pulled from the road edges.

Figure 27. Grader equipped with scarifier teeth.

Do not cut into the road base while loosening the road material to the proper depth. It is also particularly important to cut the road to the bottom of any washboards or shallow pot holes. Deep pot holes should be cut to the bottom with a grader-mounted scarifier or other equipment (backhoe) to destroy the shape of the hole and reduce the potential for re-occurrence.

3. Adding Moisture: Moisture is critical when working with DSA. Because the fines in DSA are primarily ground rock, they do not hold water like clay fines and they dry out quickly and are prone to separation under dry conditions. Grading DSA should be done when adequate moisture is present to minimize aggregate separation and maximize compaction density. Moisture content can be determined utilizing a Nuclear Density Gauge. Typically one pass across the entire road in each direction is sufficient to loosen the material and prepare the road to receive water if the road surface is at less than optimal moisture. The use of a spray bar equipped water truck is recommended when adding water to the road surface (*Figure 28*). Water should be added in two passes with the grader scarifying teeth used to mix the material between each pass.


Figure 28. Adding water to a dry road surface.

After adding water and mixing the material it is recommended to begin rebuilding the crown immediately to avoid drying of the surface material. It is recommended to work in segments less than ½ mile to avoid surface drying in the steps between loosening and compaction.

4. Rebuilding the Shape: In this step the aggregate is lightly pulled toward the centerline of the road and a crown of ½" – ¾" drop per foot (4-6% cross slope) is re-established (*see Figure 29*). Excess aggregate accumulated in the center of the road needs to be spread out. Spread the material leaving the center of the road 1" or 2" higher than the elevation desired at completion *(see Figures 30 & 31).* After this pass the road will have a slightly high flat center with a notch on both sides.

5. Groom the Road: Properly done, the final passes with the grader will have the same effect as raking the road without separating the aggregate. It is important that these passes are done with the grader in order to minimize segregation of the material that occurs with the use of a rake. A flat "A" shaped crown is desired. During these passes, the grader should not be carrying a lot of material *(Figure 32).* Any large rocks, roots, or chunks of vegetation should ride down the blade to the edge of the road. Avoid spreading the material too thin along the outside edge of the road. The replaced aggregate depth along the edge of the road should be no less than 2 ½ - inches thick.

6. Compact: The final stage of maintenance grading is compaction to maximum density. Always compact the road before the material dries. Rolling should begin from the road edge and work toward the centerline. When rolling the center of the road take care to avoid straddling the crown with the roller. In this grading operation a 10-ton vibratory roller is necessary to properly compact the loosened material (*Figure 33*).

WINTER MAINTENANCE

Winter maintenance is important but if done incorrectly can have a detrimental effect on a DSA road. Use extreme caution when plowing during the early and late winter when the road is not frozen and is most susceptible to rutting and most at risk for aggregate loss. Ensuring that the plow matches the road cross-slope is essential to avoid plowing out the crown, which reduces drainage capability and increases aggregate loss. It is highly recommended that the plow blade be fitted with a rubber cutting edge and skid shoes to prevent gouging and scraping of the road surface. Fitting the plow blade to the size of the travel lane is critical to ensure that the crown of the road in maintained. Where

Figure 29. Place grader on one side of crown for each pass.

Figure 30. Material is knocked down

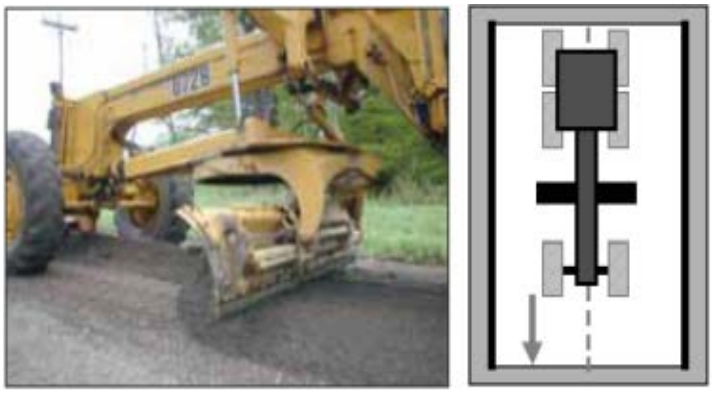

Figure 31. Grader leaving the road with a high flat center.

proper winter maintenance techniques cannot be utilized, DSA should not be placed. It is not recommended to use chloride based ice melt products (e.g. salts) on DSA roads as they may lead to softening of the road surface, rutting and excessive loss of material through plowing, and extends the “mud season” as it retains moisture in the road surface. If needed, use antiskid to increase traction on the driving surface and leave a layer of snow on the roadway rather than plowing to expose the aggregate, as this will provide an insulating layer that reduces freeze/thaw cycles and also minimizes aggregate loss from plowing. Snow fences can be used in strategic locations to minimize the amount of plowing needed in areas that are prone to blowing and drifting snow.

Figure 32. Grader grooming the road. Notice the grader blade is not carrying a lot of material.

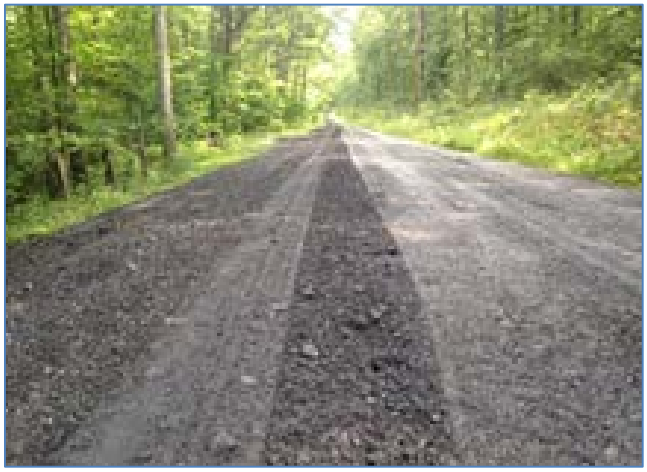

Figure 33. Before & after first pass of 10-ton roller.

8. Research

The Center has performed various research projects involving the use of DSA. A summary of some of that research is presented below. Full research documents are available on the Center's website: http://www.dirtandgravel.psu.edu.

Department of Energy Allegheny National Forest Study (2010-2012)

DSA was placed on two roads in the Allegheny National Forest. Before and after runoff testing using a rainfall simulator showed a 90% reduction in sediment generation from DSA compared to native surface materials.

Chesapeake Bay Commission Study (2006-2008)

A runoff study using a rainfall simulator before and after DSA placements. Results showed up to a 90% reduction in sediment runoff from DSA compared to the exiting road surfaces for at leat 3 years after placement. The study also showed there were no significant differences in performance or runoff from sandstone and limestone DSA material (materials has same hardness).

Crowfield Road (2003-2007)

Comparative study of DSA versus traditional 2A and 2RC aggregates. Study looked at rutting and surface longevity. Over three years, DSA performed better than 2A and significantly better than 2RC which rutted immediately and required re-grading.

References

A. State Conservation Commission Driving Surface Aggregate Certification Form. http://www.dirtandgravel.psu.edu/sites/default/files/General%20Resources/DSA/SCC_DSA_Spec_2014.pdf

B. ASTM C131 [AASHTO T96] - Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine. http://www.astm.org/Standards/C131

C. ASTM D4972 - Standard Test Method for pH of Soils. http://www.astm.org/Standards/D4972

D. ASTM D698, Procedure C, Standard [AASHTO T99] – Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3 (600 kN-m/m^3). http://www.astm.org/Standards/D698

E. ASTM D4318 [AASHTO T89/90] – Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils. http://www.astm.org/Standards/D4318

F. Pennsylvania Test Method No. 100. - Method of Test for amount of material finer than 75 µm (no. 200) sieve in aggregate. http://www.dot.state.pa.us/public/pdf/BOCM_MTD_LAB/PUBLICATIONS/PUB_19/PTM-100.pdf

G. Pennsylvania Test Method No. 510 – Method of Test for soundness of aggregate by use of sodium sulfate. http://www.dot.state.pa.us/public/pdf/BOCM_MTD_LAB/PUBLICATIONS/PUB_19/PTM-510.pdf

H. ASTM D6938 [AASHTO T310] – Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth). http://www.astm.org/Standards/D6938

APPENDIX A

State Conservation Commission DSA Standard and Specification

approved 5/10/2016

PA State Conservation Commission
Driving Surface Aggregate Standard and Specification

I. Definition - This document is for the purchase and placement of Driving Surface Aggregate (DSA) for the Pennsylvania State Conservation Commission's Dirt, Gravel, and Low-Volume Road Maintenance Program (DGLVRMP). DSA is an aggregate mixture of crushed stone designed specifically as a surface-wearing course for unpaved roads. DSA provides a durable road surface with longer maintenance cycles than conventional road surface aggregates.

II. Use - For the purposes of funding under the DGLVRMP, DSA must be used in areas where it will have an environmental benefit (reduced erosion, reduced runoff). DSA shall only be placed after drainage and subgrade issues have been addressed by utilizing practices that promote Environmentally Sensitive Maintenance. DSA was originally designed to reduce erosion and runoff on road segments close to streams where drainage improvements were limited. Surface aggregate is not required on every project.

III. Material - DSA to be used on DGLVRMP projects shall be tested prior to delivery by an independent lab that has no affiliation with the source quarry. Samples shall be obtained by Conservation District (CD) staff, Center for Dirt and Gravel Road Studies (CDGRS) staff, or otherwise approved by the SCC. Material must meet the following requirements:

A. **Gradation**: The required sieve sizes and allowed ranges, determined by weight, for DSA components are shown in Table 1.

Sieve Size	Percent Passing
1.5"	100
0.75"	65 – 95
#4	30 – 65
#16	15 – 30
#200	10 – 15

Table 1 – DSA Gradations

B. **Abrasion Resistance**: The loss of mass (LA Abrasion) shall be less than 40%. Determine the resistance to abrasion using the Los Angeles Abrasion test, ASTM C131.

C. **pH**: Aggregate shall be in the range of pH 6 to pH 12.45 as measured by ASTM D4972.

D. **Moisture**: Upon delivery to the site, material shall be well mixed and placed at optimum moisture content or up to 2% below that value as determined for that particular source. The optimum percentage moisture is to be determined using Proctor Test ASTM D698, Procedure C, Standard. Aggregate provider is encouraged to perform moisture testing prior to loading material for delivery.

E. **Plasticity**: Material shall not exceed a Plasticity Index (PI) of 6. The laboratory test required

for these results is ASTM D4318 – Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.

F. **Soundness**: Determine the percentage of mass (weight) loss of each fraction of the coarse aggregate after five cycles of immersion and drying using a sodium sulfate solution according to PTM No. 510. The maximum weighted percent loss allowed is 20%. The Conservation District may accept aggregate failing the soundness test if it can be demonstrated that the material has a satisfactory service record.

G. **Aggregate**: All DSA shall be derived from natural rock formations that meet program specification for abrasion resistance, pH and freedom from contaminants.

H. **Fines**: If fines need to be added to the aggregate to meet DSA gradation requirements, the added material passing the #200 sieve must be derived from rock material that conforms to program specifications. No mineral clay or silt soil may be added. The amount of particles passing the #200 sieve shall be determined using the washing procedures specified in PTM No. 100.

I. **Mixing**: DSA shall be properly mixed and at the proper moisture content before it is loaded onto the transport vehicles.

IV. Delivery and Placement

A. **Preparation of Subgrade**: Unsatisfactory drainage and subgrade conditions shall be corrected prior to placement by scarifying, reshaping, and re-compacting, or by replacing or importing subgrade/sub-base. The subgrade/subbase shall be crowned or sidesloped to ½ to ¾ inch per foot (4%-6% slope). Beginning and ending of DSA placements shall include a paving notch across the width of the subgrade. The paving notch shall have a minimum depth equal to the compacted DSA placement, and a sufficient length to facilitate transition into existing road surface.

B. **Transport**: Tarps shall be used to cover 100% of the load's exposed surface from the time of loading until immediately before placement.

C. **Certification**: A properly executed SCC DSA Certification Form shall be provided at the time of initial delivery and subsequent certification forms shall be provided if quarry conditions change. This Certification Form is to apply to the specific stockpile of DSA material being delivered from the source. The form certifies that the DSA material meets all of the specifications and requirements.

D. **Placement**: The use of a motorized paver is highly recommended for all DSA placements. For projects and/or contracts including over 1,000 tons of DSA, a motorized paver is required. A track mounted paver is preferred. DSA placements should be placed in a single pass. The crown or cross slope must range from ½ to ¾ inch per foot (4-6%). Material shall be placed in a single 6-8 inch loose lift. This lift is to be compacted with a vibratory roller as specified in Section V Compaction. If freezing temperatures or precipitation are forecast that may cause the material to freeze, or prevent the material from drying out, placement shall be postponed

at the discretion of the road owner, Conservation District, or aggregate supplier.

V. Compaction

A. **Vibratory Roller:** After placement, the material shall be compacted using a minimum ten-ton vibratory roller. DSA shall be compacted to a minimum of 95% of the dry-mass (dry-weight) density according to ASTM D698, Procedure C, Standard as determined by pre-sampling (refer to Materials, Section III.D). The road owner, or its designated representative, reserves the right to determine the in-place moisture and density according to ASTM D6938.

VI. Maintenance - Properly placed and compacted DSA provides a durable road surface with longer maintenance cycles than traditional aggregates, but it is not maintenance free. Refer to the Center for Dirt and Gravel Roads "Driving Surface Aggregate Handbook" for additional guidance on DSA maintenance.

VII. References:

A. State Conservation Commission Driving Surface Aggregate Certification Form. http://www.dirtandgravel.psu.edu/sites/default/files/General%20Resources/DSA/SCC_DSA_Spec_2014.pdf
B. Penn State Center for Dirt and Gravel Road Studies "Driving Surface Aggregate Handbook" http://www.dirtandgravel.psu.edu/general-resources/driving-surface-aggregate-dsa
C. ASTM C131 [AASHTO T96] - Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine. http://www.astm.org/Standards/C131
D. ASTM D4972 - Standard Test Method for pH of Soils. http://www.astm.org/Standards/D4972
E. ASTM D698, Procedure C, Standard [AASHTO T99] – Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3 (600 kN-m/m^3). http://www.astm.org/Standards/D698
F. ASTM D4318 [AASHTO T89/90] – Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils. http://www.astm.org/Standards/D4318
G. Pennsylvania Test Method No. 100. - Method of Test for amount of material finer than 75 µm (no. 200) sieve in aggregate. http://www.dot.state.pa.us/public/pdf/BOCM_MTD_LAB/PUBLICATIONS/PUB_19/PTM-100.pdf
H. Pennsylvania Test Method No. 510 – Method of Test for soundness of aggregate by use of sodium sulfate. http://www.dot.state.pa.us/public/pdf/BOCM_MTD_LAB/PUBLICATIONS/PUB_19/PTM-510.pdf
I. ASTM D6938 [AASHTO T310] – Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth). http://www.astm.org/Standards/D6938

APPENDIX B

State Conservation Commission

DSA Certification Form

5/2016

PA State Conservation Commission

Driving Surface Aggregate Certification Form

Company: _____

Plant Location: _____

Parent Stone Type: _____

Tonnage Represented: _____

Project: _____

This record is to certify that the aggregate shipped to the above-referenced job site meets all PA State Conservation Commission specifications and quality requirements.

Sieve Size	Specification Range % passing	Gradation for This Lot % passing
1.5”	100	
0.75”	65 – 95	
#4	30 – 65	
#16	15 – 30	
#200	10 – 15	

pH: _____ **L.A. Abrasion:** _____ **Plasticity Index:** _____ **Opt. Moisture %:** _____

Authorizing Agent Signature: _____ **Date:** _____

Print Name of Authorizing Agent: _____

Print Title of Authorizing Agent: _____

Note: The authorizing agent or responsible party should sign their name and print their name below their signature. If the signatory is a Penn-DOT certified Aggregate Technician, add the certification number on title line and no notary is required.

Sworn and subscribed before me:

This day: _____

Notary Public

My commission expires: _____

APPENDIX C

Aggregate Sample Collection Data Sheet

PA Dirt, Gravel, and Low-Volume Road Maintenance Program

Driving Surface Aggregate Sample Collection Data Sheet

Date collected:_____

Project name/number:_____

Road name/number:_____

Township: _____

Conservation District:_____

Sample collected by:_____

Was a companion sample collected by the quarry? Yes No
Was it a split sample? Yes No
(shared sample with quarry for duplicate testing)

Aggregate Source:

Manufacturer:_____

Quarry name:_____

Rock Type:_____

Total tonnage supplied:_____

Testing lab name/address:_____

_____

_____

Pile-Specific Required Tests: (run on all samples)

☐ Gradation/Washed ☐ Standard proctor ☐ Plasticity (PI)

Material-specific Tests: (existing test results can be used)

☐ LA Abrasion ☐ Sodium Sulfate ☐ pH

APPENDIX D

DSA Purchase Notification Form

5/2016

PA Dirt, Gravel, and Low-Volume Road Maintenance Program
Driving Surface Aggregate (DSA) Purchase Notification Form

This form is for Conservation Districts to provide notice to the PSU Center for Dirt and Gravel Road Studies (CDGRS) of upcoming DSA placement projects. The top portion of this form is to be completed and returned to dirtandgravel@psu.edu or fax: 814-863-6787.

County:_____ Township:_____ Today's Date:_____

Road Name/Number:_____

Official Name of Grant Applicant:_____

Applicant Contact:_____ Phone:_____Email:_____

Tons of DSA to be placed:_____ **Estimated Placement Date:_____**

Estimated DSA Cost (total) :_____

Placement Method (circle): *motor-paver* *other*_____

Quarry:_____Phone:_____Email:_____

Cons. District Contact:_____Phone:_____Email:_____

The Dirt and Gravel Road Program, through its designated representative, PSU's Center for Dirt and Gravel Road Studies should be notified before purchasing and placement of DSA. The Center should be notified by the Conservation District at least 30 days before expected placement in order to coordinate with the quarry and perform any quality control steps necessary prior to and during placement. This could include lab testing for plasticity index, gradation, proctor (for maximum dry density and optimum moisture content), LA Abrasion, pH, and field testing for moisture and compaction, as well as site visits during placement. If a Conservation District chooses to sample and test a DSA stockpile they must share the testing results with the Center for Dirt and Gravel Road Studies. This completed form is to be included with the certification from the quarry in the project file. Any entity producing DSA must obtain the components from a source or quarry that complies with the SCC DSA Standard and Specifications. **The Program or Center does not certify quarries, only specific stockpiles of DSA.**

CENTER USE ONLY:

Date notification Received:_____ Received by:_____

Discussed with CD: YES NO _____

Discussed with Quarry: YES NO _____

Visited Quarry: YES NO _____

Testing Done: YES NO _____

DSA is approved for use on this job: YES NO

Completed By:_____ Date Completed:_____

CENTER USE ONLY: Note below interactions with CD, interactions with Quarry, dates of any testing, etc.

DATE	INITIALS	NOTES

APPENDIX E

DSA Request for Quote Form / Quote Form

Note: the use of this RFQ is optional.

REQUEST FOR QUOTE (RFQ)

DELIVER, PLACE, AND COMPACT DRIVING SURFACE AGGREGATE (DSA)

_____
(ROAD NAME(S) & ID #)

_____
(NAME OF MUNICIPALITY & COUNTY)

1. SCOPE OF WORK:

_____ (hereinafter referred to as "Owner"), requires services to deliver, place and compact approximately _____ tons of DSA, to

_____

_____
(Project Location – describe exact location of placement)

2. CONTRACT TASKS:

A. Work shall include, but is not necessarily limited to, the furnishing of all labor, superintendence, materials, tools and equipment, miscellaneous items and performing all work necessary to complete all construction to the satisfaction of, and subject to the approval of, the Owner.

3. STATE CONVERSATION COMMISSION (SCC) DSA SPECIFICATIONS:

A. All components of the aggregate mix are to be derived by crushing parent rock material. Contractors **must provide a properly executed SCC DSA Certification Form (attached)** at the time their bid is submitted committing that they can provide DSA material that meets the following criteria.

B. Materials**:** Material to be used on the project shall be tested **prior to delivery** by an independent lab that has no affiliation with the source quarry. Samples shall be obtained by Conservation District (CD) Staff, Center for Dirt and Gravel Road Studies (CDGRS) staff or otherwise approved by the SCC. Material must meet the following requirements:

C. Gradation**:** The required amounts and allowed ranges, determined by weight, for various size particles are:

Passing Sieve	***Lower %***	***High %***
1 1/2 inch	100%	---
3/4 inch	65%	95%
#4	30%	65%
#16	15%	30%
#200	10%	15%

D. Abrasion Resistance: The loss of mass (LA Abrasion) shall be less than 40%. Determine the resistance to abrasion using the Los Angeles Abrasion test, ASTM C131.

E. pH: Aggregate shall be in the range of pH 6 to pH 12.45 as measured by ASTM D4972.

F. Moisture: Upon delivery to the site, material shall be well mixed and placed at optimum moisture content or up to 2% below that value as determined for that particular source. The optimum percentage moisture is to be determined using Proctor Test ASTM D698, Procedure C, Standard. Aggregate provider is encouraged to perform moisture testing prior to loading material for delivery.

G. Plasticity: Material shall not exceed a Plasticity Index (PI) of 6. The laboratory test required for these results is ASTM D4318 – Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.
H. Soundness: Determine the percentage of mass (weight) loss of each fraction of the coarse aggregate after five cycles of immersion and drying using a sodium sulfate solution according to PTM No. 510. The maximum weighted percent loss allowed is 20%. The Conservation District may accept aggregate failing the soundness test if it can be demonstrated that the material has a satisfactory service record.
I. Aggregate: All DSA shall be derived from natural rock formations that meet program specification for abrasion resistance, pH and freedom from contaminants.
J. Fines: If fines need to be added to the aggregate to meet DSA gradation requirements, the added material passing the #200 sieve must be derived from rock material that conforms to program specifications. No mineral clay or silt soil may be added. The amount of particles passing the #200 sieve shall be determined using the washing procedures specified in PTM No. 100.
K. Mixing: DSA shall be properly mixed and at the proper moisture content before it is loaded onto the transport vehicles.

The Conservation District (CD), the Center for Dirt and Gravel Road Studies (CDGRS) or the State Conservation Commission's (SCC) designated representatives shall perform quality assurance / quality control visits to the quarry to inspect the DSA before the project. This will include sampling and testing of the DSA stockpile for that project to ensure that it meets specifications. The Contractor shall provide transportation or escort the staff to the DSA load site over the duration of the project.

The Contractor is hereby informed that any DSA material, utilized for the purposed of this contract that does not meet specifications as determined by the Owner shall be rejected. Contractor will not receive payment for rejected loads.

4. DELIVERY OF DSA:

A. Preparation of subgrade: Unsatisfactory drainage and subgrade conditions shall be corrected prior to placement by scarifying, reshaping, and re-compacting, or by replacing or importing subgrade/sub-base. The subgrade/sub-base shall be crowned or side sloped to ½ to ¾ inch per foot (4%-6% slope).
B. Transport: Tarps shall be used to cover 100% of the load's exposed surface from the time of loading until immediately before placement.
C. Delivery shall be at a minimum average rate of _____ tons per day, plus or minus 10%.
D. Delivery shall continue on an uninterrupted basis.
E. **A properly executed SCC DSA Certification Form (attached)** is to be provided at the time of initial delivery and subsequent certification forms shall be provided if quarry conditions change. This Certification Form is to apply to the specific stockpile of DSA material being delivered from the source. The form certifies that the DSA material meets all of the specifications and requirements.
F. The Contractor shall coordinate with the material supplier to ensure the project is completed in a timely fashion.
G. The Owner is not responsible for delays or charges that are the responsibility of the Contractor or the material supplier. Delays incurred that are clearly the fault of the Owner must be documented and submitted to the Conservation District for approval for reimbursement.

5. PLACEMENT AND COMPACTION OF DSA:

A. Placement Method: DSA is to be placed using _____, as follows:
(motor-paver, tailgating, etc.)

1. DSA placements should be placed in a single pass.
2. The crown or cross slope must range from ½ to ¾ inch per foot (4-6%).
3. Material shall be placed in a single **6-8 inch** loose lift. This lift is to be compacted with a vibratory roller as specified in Section 5.F.

B. The DSA placement is to average _____ feet in width and _____ inches in uncompacted depth.
C. If freezing temperatures or precipitation are forecast that may cause the material to freeze, or prevent the material from drying out, placement may be postponed at the discretion of the road owner, Conservation District, or aggregate supplier.
D. Beginning and ending of DSA placements shall include a paving notch across the width of the DSA placement. Notch shall be a minimum depth equal to that of the compacted DSA placement and of a sufficient length to ensure a smooth transition into the existing road surface.
E. After placement, the placement shall be compacted using a minimum ten-ton vibratory roller. DSA material shall be compacted to a minimum of 95% of the dry-mass (dry-weight) density, determined according to ASTM D698, procedure C, Standard. The road owner, or its designated representative, reserves the right to determine the in-place moisture and density according to AASHTO T310.
F. Any area(s) which do not meet density, percent moisture or other requirements at time of placement shall be removed and replaced, or corrected in a manner acceptable to the Owner, at no expense to the Owner.

6. USE OF ROADS:

A. The Owner does not guarantee the successful Contractor the use of roads maintained by the Pennsylvania Department of Transportation (PennDOT), townships, or other municipalities, agencies or owners. Contractor must contact the PennDOT posted highway coordinator and officials of other said roads for possible weight or other restrictions that would prevent or restrict us. Contractor will be responsible for obtaining all necessary Road Use Permits and/or any associated Bonds from PennDOT, townships, or other municipalities, agencies or owners.

7. CONTRACT TERM:

A. The Contractor who receives the Notice of Award/Purchase Order through this RFQ process ("Selected Contractor") will make deliveries to meet the requirements of the Owner for the time period commencing on the Selected Contractor's receipt of a Notice of Award/Purchase Order, and expiring on _____. Selected Contractors prices shall remain firm through this period.
B. Project shall begin on _____ and shall be completed by_____.
C. Requests for time extensions shall be provided to the Owner in a written form. Owner may reject or approve requests at their discretion based upon supporting evidence provided by the Contractor.

8. ISSUING OFFICE:

A. This RFQ is issued by the Owner. The Issuing Office is the sole point of contact for this RFQ. Please refer all inquiries to:

Name: _____

Address: _____

Telephone: _____

Email: _____

Contact: _____

9. DATE AND TIME FOR SUBMISSION OF QUOTES:

To be considered, a quote must be received by the Owner by _____
(*Date & Time)*

10. SUBMISSION OF QUOTE:

A. Quotes are requested for the items described on the quote form, in accordance with the terms and conditions included in this RFQ. Contractors must complete the Quote Form including: name and address of contractor; contractor contact person; telephone and fax number; e-mail and web address; Source Quarry location; and Quote prices. The Quote Form must be signed by an authorized representative of the Contractor. Quotes can be mailed, faxed, or scanned and e-mailed to the information noted under Section 8.

B. Submission of Quotes. It is the responsibility of each Contractor to ensure that the Owner receives the quote prior to the Date and Time for Submission of Quotes, noted under Section 9. No quote shall be considered if it was sent or received after the Date and Time for Submission of Quotes.

C. Quotes must be firm. If a quote is submitted with conditions or exceptions or not in conformance with these terms and conditions, it shall be rejected. The quote shall also be rejected if the items offered by the contractor are not in conformance with the specifications as determined by the Owner.

D. Contractors must provide a properly executed SCC DSA Certification Form (attached) at the time their bid is submitted committing that they can provide DSA material that meets the specification requirements

E. For bids on projects with estimated costs in excess of $25,000.00, prevailing wage rates must be used in preparing the quote.

F. The Owner reserves the right to reject any and all quotes and to waive any technical defects, if it determines that it is in the best interest of the Owner.

G. No responsibility will be attached to any employee of the Owner for the premature opening of or the failure to open, a bid not properly addressed and identified, or for any reason whatsoever.

11. BID AWARD:

A. Bids will be awarded to the lowest responsible bidder, as determined by the Owner. The Owner reserves the right to reject any or all bids, and/or cancel the RFQ for any reason.

B. Quantities are estimated and may be increased or decreased to meet the requirements of the Owner.

C. Contractor shall be paid for actual quantities used, as determined by the price per ton provided on the Quote Form.

12. PAYMENT TERMS:

A. Payment shall be made upon satisfactory completion of project for actual services performed, which includes meeting the DSA aggregate specification.

13. SERVICE SLIPS:

A. To insure prompt payment, the Contractor must provide the service slip(s) (including tonnage) to the Owner after the completion of the project.

14. INVOICES:

A. All invoices for this contract **MUST** be sent to the address noted under Section 8.

15. MINIMUM WAGE SPECIFICATION

A. Requirements - The Contractor shall comply with the provisions of the Act of August 15, 1961 (P.L. 9 87), as amended, known as the “Pennsylvania Prevailing Wage Act” and the Regulations issued pursuant thereto by the Department of Labor and Industry. The Contractor shall include these requirements in all subcontracts for the project.

Attachments:

Quote Form
SCC DSA Certification Form

QUOTE FORM

DELIVER, PLACE, AND COMPACT DRIVING SURFACE AGGREGATE (DSA)

_____
(ROAD NAME(S) & ID #)

_____
(NAME OF MUNICIPALITY & COUNTY)

PROJECT LOCATION:

_____

_____
(Project Location – describe exact location of placement)

SUBMISSION DEADLINE (RFQ SECTION 9): _____
(*Date & Time)*

By Contractor

Contractor:

Mailing Address:

Contractor Contact Person:

Telephone Number:

Fax Number:

E-Mail and Web Address:

Source Quarry Location:

PROJECT REQUIREMENTS:
Price to include delivery, placement and compaction.

Material	Tonnage	X	Price per Ton	=	Total Price
DSA	_____	X	$_____	=	$_____

Project shall begin by _____ and shall be completed by_____.

Signature of Contractor: _____

Contractor's Name & Title: _____

Company Name: _____

APPENDIX F

Road Aggregates 101

Informational Bulletin

PA Road Aggregate 101

10/2012

Aggregate – A mixture of crushed rock or gravel separable by mechanical means. Focus on road applications.

Aggregate from sedimentary rock in SW PA

Source (Geologic Origin) – Most PA aggregates are mined from sedimentary rock such as limestone and sandstone. In the glaciated regions of NW and NE PA, aggregate is often mined glacial till, or pit-run gravel. In general, limestone is the hardest of the rocks, with shale being the softest, while pit-run varies widely in its usefulness as a road aggregate.

Gradation – The distribution by percent of weight of different sized stones comprising an aggregate. Determined by sieve separation and the loss by washing of material finer than the No. 200 sieve (~0.003 inches).

Aggregate sieves

AASHTO Number	Total Percent Passing													
	100 mm (4")	90 mm (3 1/2")	63 mm (2 1/2")	50 mm (2")	37.5 mm (1 1/2")	25.0 mm (1")	19.0 mm (3/4")	12.5 mm (1/2")	9.5 mm (3/8")	4.75 mm (No. 4)	2.36 mm (No. 8)	1.18 mm (No. 16)	150 µm (No. 100)	75 µm (No. 200) ***
1	100	90-100	25-60		0-15		0-5							

Aggregate specifications have an allowable range of different stone sizes, expressed as a percentage of the total weight of sample. This **gradation specification** is reported on a table or chart (see example above). The *nominal* maximum size of an aggregate specification is defined as the smallest sieve opening through which 100% of the aggregate can pass.

Open-graded

Open graded aggregates are "porous" with notable air voids between individual stones, and little to no "fines". These mixtures drain effectively, but do not compact well to form a dense conglomerate. Road applications include use as base material and for subsurface drainage.

Well-graded

Well graded aggregates are "dense" with few air voids between individual stones. These mixtures are not suitable for drainage, but are preferred for use as surface aggregates as they tend to compact well to maintain desired road shape, lengthening grading cycles. This is also a key component in extending the road life cycle for traffic support.

Aggregate Quality or Type is primarily based on the resistance to weathering (soundness), the resistance to traffic (abrasion) and the absence of extraneous undesirable material. For both soundness and abrasion the maximum allowable amount is expressed as a percentage (by weight) of material changed by specific tests. For undesirable material the maximum allowable amount is expressed as a percentage (by weight) of the total weight of the mixture. For these parameters a maximum allowable percentage is set for each aggregate Type (A,B & C). Lower numbers represent higher quality. Lower quality aggregates should be reserved for fill and sub-base applications only.

PennDOT	Type A	Type B	Type C
Soundness, Max %	10	12	20
Abrasion, Max %	40	45	55
Undesirable, Max %	2	2	15

PI, or Plasticity Index is a measure of the plasticity of a soil. *Soils with a high PI tend to be clay.* Ideally, surface aggregates should be non-plastic to slightly plastic with a PI of 6 or lower.

The publishers of this publication gratefully acknowledge the financial support of the PA State Conservation Commission and PA Bureau of Forestry. For additional information or assistance, contact: Center for Dirt & Gravel Roads Studies, Penn State University, 207 Research Unit D, University Park, PA 16802 (Toll-Free Phone: 1-866-668-6683, Fax: 814-863-6787, Email: dirtandgravel@psu.edu). Additional copies available on our website at: www.dirtandgravelroads.org.

Center for Dirt and Gravel Road Studies

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A PennDOT **Material Certification** is documentation attesting that a specific product meets the requirements for Gradation and Properties outlined in *PennDOT Publication 408, Section 703.* Tests and documentation must be completed by a PennDOT certified lab technician. For DSA used on Dirt and Gravel Road Maintenance Program projects, a certification must be delivered with the first load of material for each day of the project.

Common Course Aggregates for Road Applications in PA

	AGGREGATE SPECIFICATION		Common	General Size		TOTAL PERCENT PASSING													
						100mm	90mm	63mm	50mm	37.5mm	25mm	19mm	12.5mm	9.5mm	4.75mm	2.63mm	1.18mm	0.15mm	0.075mm
	AASHTO	PA	Name	Description	General Uses	4"	3.5"	2.5"	2"	1.5"	1"	3/4"	1/2"	3/8"	#4	#8	#16	#100	#200
open graded	#1	#4	ballast	4"- 3/4" clean	road base, buried drains	100	90-100	25-60		0-15		0-5							
	#3	3A		2.5" - 1/2" clean	haul road surface, choke			100	90-100	35-70	0-15		0-5						
	#57	2B		1.5" - 3/32" clean	buried drains					100	95-100		25-60		0-10	0-5			
	#8	1B		1/2" - 3/32" clean	chip surfacing								100	85-100	10-30	0-10	0-5		
	#10		grit, screenings	less than 3/8"	trail surface, anti-skid									100	85-100			10-30	
well graded		2A	modified?	2" - fine	road base, road surface				100			52-100		36-70	24-50	16-38	10-30		0-10
		2RC	misc., reclaim	varies widely	fill, pipe bedding, surface				100						15-60			0-30	
		DSA	driving surf. agg.	1.5" - fine	unbound road Surface					100		65-95			30-65		15-30		10-15
		TSA	trail surface agg.	1/2" - fine	unbound trail Surface								100	90-100	50-85	35-60	25-50		12-18

The AASHTO numbering system labels aggregate specifications from 1 to 10 according to the largest stone size in the mixture, with 1 being the largest (all material passing a 4" sieve opening) and 10 being the smallest (all material passing a 3/8" sieve opening). Multi-digit specifications represent a blend of one or more of the ten basic specifications (i.e. AASHTO 57 is a blend of AASHTO 5 and AASHTO 7). AASHTO Specifications are technically open graded aggregate.

Common Rip-Rap Specifications in PA

Rip-rap is a loose assemblage of larger stone that is most often used for bank and abutment protection at stream interfaces, for armoring and velocity checks in road ditches and outlets, and for slope protection on road banks. Specifications that begin with an "R" designation are set by the National Crushed Stone Association.

SPEC / NAME	Size Range	Average Size	General Uses	TOTAL PERCENT PASSING										
				42"	30"	24"	18"	15"	12"	9"	6"	4"	3"	2"
R-8	15-42"	28"	abutments	100		15-50		0-15						
R-7	12-30"	20"	streambanks		100		15-50		0-15					
R-6	9-24"	14"	streambanks			100		15-50		0-15				
R-5	4-18"	11"	streambanks / ditches				100			15-50		0-15		
R-4	3-12"	7"	ditches						100		15-50		0-15	
R-3	2-6"	3.5"	road subbase								100		15-50	0-15
Surge	10"-fine	*varies*	subbase / fill	Surge, Gabion, and Shot Rock are relatively loose terms with broader size ranges and no exact specification.										
Gabion	4-8"	*varies*	baskets / ditches											
Shot Rock	*varies*	24"	abutments											

What is a "modified" aggregate?

Technically PennDOT no longer has a "modified" specification. However, this term continues to be used by stone customers and suppliers. An aggregate is "modified" when fines (smaller than 0.075 mm (0.003") /No. 200 sieve) are blended into a standard aggregate specification to increase the fine content of the mix. "Modifying" can change an open graded aggregate to a well graded aggregate, enhancing its density and usefulness as a road surface material. In PA, the most common aggregate to "modify" is PennDOT 2A.

Terms to know:

- **Gravel** – naturally unconsolidated rock fragments
- **Stone** – rock crushed to a specific size and shape
- **Sand** – rock particles smaller than 3/8" (majority smaller than 3/16")
- **AASHTO** – American Association of State Highway and Transportation Officials
- **NCSA** – National Crushed Stone Association

APPENDIX G

Municipal Quick-Guide to Driving Surface Aggregate

Municipal Quick-Guide to Driving Surface Aggregate

The purpose of this document is to briefly outline the requirements and recommendations regarding placement of Driving Surface Aggregate (DSA) through the PA Dirt, Gravel, and Low Volume Road Maintenance Program (DGLVRP). Additional details can be found in the "DSA Handbook". Since the DGLVR Program emphasizes "local control", potential applicants should always check with their local Conservation District for county-specific policies regarding DSA and other aspects of the Program.

Pre-project Logistics *(Full Details in chapter 4 of DSA Handbook)*

- Notify Conservation District of intent to apply.
- Conduct pre-application site-visit with Conservation District.
- The DGLVR Program focuses on long-term road and environmental improvements. Projects are Required to focus on drainage, road base, and environmental issues prior to DSA placement. DSA is NOT required on every project.

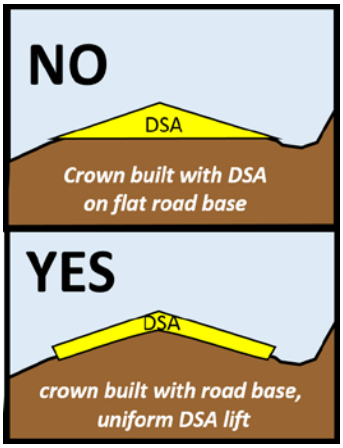
  Purchasing DSA:
  - Normal bidding procedures apply.
  - Prevailing Wage applies to DGLVR projects over $25,000. Required
  - Sample DSA "Request for Quote" in DSA handbook. Contact local Conservation District to determine any county specific requirements for DSA material or bidding procedures.
  - Notify Conservation District once DSA supplier is chosen. District and/or Program representative will test DSA to ensure it meets Program standards. Required

How much DSA should I order?

DSA Needed = (tons) **Road Width (ft)** x **Road Length (ft)** x **0.04** 8" loose depth compacted to 6" **0.03** 6" loose depth compacted to 4½"

Road Preparation *(Full Details in chapter 5 of DSA Handbook)*

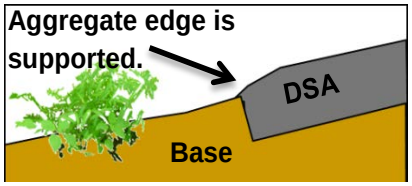
- Make provisions for road closure if possible (during placement and drying), and notify any residents.
- Drainage and base improvements must be done before DSA placement. Required
- Establish proper crown or cross-slope (½ to ¾ inch per horizontal foot (4% - 6% slope)) in the road base if necessary by grading. Required
- Scarify existing road if surface has adequate crown but is extremely tight.
- Cut 3"- 4" key along edge of DSA placement site to support the edge of aggregate when possible.
- Cut a "paving notch" across the road at ends of planned DSA placement to butt edge of DSA into existing road instead of trailing it off. Required
- Placement of DSA directly on separation fabric is not recommended. If fabric is used, consider placing a few inches of other aggregate before placing DSA.



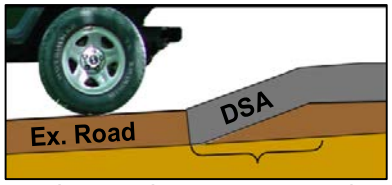
Reflect cross-slope in road base.

DSA Placement *(Full Details in chapter 6 of DSA Handbook)*

- Aggregate must be delivered at optimum moisture in tarped trucks. Required
- DSA Certification must accompany the first truck of aggregate to the jobsite. Required
- DSA should be allowed to dry or "cure" before being exposed to traffic, otherwise deformations or rutting may occur.
- If freezing temperatures or precipitation are forecast that may cause the material to freeze, or prevent the material from drying out, placement shall be postponed at the discretion of the road owner, Conservation District, or aggregate supplier. Required
- **Paver placement recommended on all jobs, and** Required **on jobs over 1,000 tons.**



Key cut lengthwise along road to support edge.



Paving notch cut across road to transition DSA to existing road.

Paver Considerations:

- Track pavers are recommended, especially on steeper slopes.
- Paver should be capable of placing entire road width in one pass. Avoid multiple lane placements if possible.
- Paver must be able to match crown or cross-slope previously established in road base (½ to ¾ inch per horizontal foot (4% - 6% slope)). Required
- Place DSA in one uniform lift. Required

Tailgating Considerations:

- Tailgate material in as uniform of a lift as possible, avoiding large piles.
- Handle the material as little as possible with grader in attempting to establish road shape. Overworking DSA will cause it to segregate by size and it will not perform as desired.

Paver placement of DSA.

DSA Compaction *(Full Details in chapter 6 of DSA Handbook)*

- Maximum compaction requires optimum moisture Required. Insure compaction occurs before aggregate dries out. If excess material sticks to the roller drum, it may be too wet and some drying time may be required before continuing compaction.
- A minimum 10-ton vibratory roller is required for DSA compaction.

  Compaction Sequence:
  - Initial passes should be done in static (non-vibratory) mode.
  - Subsequent passes should be done in vibratory mode.
  - Do not use vibratory mode when going down steep sections of road or if it brings excessive water and fines to the surface.
  - Overlap passes from the road edge towards the crown.
  - Compact the crown from both sides, but do not "straddle" the crown with the roller.
  - Compaction testing using a density gauge is recommended, and the cost of testing can be incorporated into the DGLVRP grant.

DSA Maintenance *(Full Details in chapter 7 of DSA Handbook)*

- **Grading**: DSA behaves differently than other materials and requires special considerations:
  - DSA requires adequate moisture to avoid segregation and insure proper compaction.
    - Grading **MUST** be done when adequate moisture is in the road.
    - Water should be added during grading if the road is too dry.
    - Compaction after grading is critical to ensure DSA functions as designed.
  - Carbide-tipped grader blades are highly encouraged for grading DSA
    - It provides extra cutting force to cut deeper into the tightly compacted surface.
    - It reduces aggregate segregation by size.
  - DSA should not be graded "on a schedule" if it is not necessary. The decision to grade DSA should be based on the condition of the road.
  - See "DSA Handbook" for grading sequence and additional information.
- **Winter Maintenance:**
  - **Plowing**:
    - Use shoes or a rubber blade when possible to avoid gouging the DSA surface.
    - Consider leaving a "skiff" of snow on less traveled roads.
    - Be sure to take crown or cross-slope into account while plowing. Avoid plowing straight down the middle of a crowned road.
  - **Salts**: The use of chloride-based ice melt products is not recommended on DSA or other aggregate roads if it can be avoided, as they will retain moisture, worsen freeze/thaw issues, and extend the "mud season".