Martin Marietta Materials

Asphalt Binder Modification with Ground Tire Rubber

Project Coordinator: Todd Genovese

Email: todd.genovese@martinmarietta.com

Phone: (303) 210-3804

Report Completed By: Todd Genovese

CMS Identification Number: 32162

Original Contract Routing Number: PO FAA EHS12032162

II. WORK PLAN

Deliverable	Completion Date	Comments (if deliverable was not completed, please explain why or what progress has been made)
Complete site preparations. Includes acquiring permits, utility locates and modifications, site grading, and slab work.	7/22/2011	
Create an acceptable design that includes GTR and meets applicable specs.	9/26/2011	
Install blending system.	8/27/2011	
Complete a paving project. Validate lab data through continued field performance monitoring.	11/11/2011	

III. PROJECT SUMMARY

1. Executive Summary

The scope of this project was to develop a cost effective means for utilizing Ground Tire Rubber (GTR) as a viable material for use in asphalt pavement mixtures. The project consisted of developing a means to blend GTR with asphalt cement (AC) used to produce hot mix asphalt (HMA), typically a mixture of aggregates and AC with sometimes other minor constituents for constructing pavements. Many highway and heavy arterial roadways have HMA mixtures that use a high performance AC, commonly referred to as polymer modified asphalt (PMA). The PMA is typically produced by blending costly manufactured polymer additives with the AC. Previous work has shown that use of the GTR can produce similar high performance properties, but variation of results and cost were among the leading factors contributing to a lack of wide scale acceptance and use. The principal goal for this project was to purchase equipment for the use of blending GTR into AC on a small scale, install the equipment and conduct a pilot project using the product as a starting point for evaluating performance. Ancillary goals include: evaluation of a less common process for blending GTR such that it can be used as a more cost effective modifier of AC; evaluation of the GTR's ability to enhance performance while improving the use of other recyclable materials; and provide a long lasting outlet for diversion of waste tires for which the end recycle use is also 100% recyclable.

The greatest challenge for this project, as well as for long term use of GTR in pavements, was and will be the acceptance of this material as providing a high performance pavement material that is cost effective. The acceptance of new or less commonly used materials for pavement construction is typically met with a great deal of scrutiny, and rightfully so. Most

new pavements are designed with a minimum 20-year life, and expect to have low to moderate levels of maintenance conducted throughout its life. However, acceptance for pavement materials often requires data collected over extended periods of time, typically on an annual basis. One of the key elements to performance is over a winter season which takes one year to evaluate each successive cycle. Development of good performance history tends to take longer in Colorado than many other geographic locations due to the environmental conditions which include fairly wide range of seasonal temperatures (sub-freezing in winter to very hot in the summer), number of freeze-thaw cycles in a single season, and high altitude (associated with elevated ultra-violet radiation). These types of elements contribute to moisture damage and oxidation of the pavement, which are among the most damaging from an environmental perspective. As such, this project will distinctly evaluate performance under conditions for which the same material and/or processes may be highly regarded in a location such as Arizona.

The project alone is a success whereby a process new to Colorado is being used for blending GTR. Most of the plans for this project carried out as expected with only minor changes (such as schedule and shifting of budget); however, the partnership with the City of Greeley resulted in a much better than anticipated pilot with regard to size and scope of work. The scope of the pilot project was expanded from not only evaluating the GTR test section versus a control section, but also incorporated the use of recycled asphalt shingles (RAS) and warm mix asphalt (WMA), both of which are currently regarded as new, green technologies that are also not widely accepted. It should be noted that both of these have been used on a much wider scale in Colorado than GTR. The results to date, while positive and promising, have yet to become part of a performance history portfolio. Evaluation of the project will be ongoing for the coming years and should be conducted at least annually for the next five years. Depending on performance to that point, the frequency of evaluation may be extended to a larger time period (every 2-3 years). It is expected though, that the first three years should be most telling, especially if there are going to be issues with long term performance. In the short term, more projects such as this one will provide limited diversion of waste tires as well as a less costly production of higher performing roadways. However, the success of this project can pave the way for long term waste diversion of tires and cost savings realized by end users that can be used to increase the amount of road work for the same spend as more conventional materials.

2. Project Description & Overview of Work Completed

This project was intended to install equipment that could be utilized for blending GTR with asphalt cement on a small scale, such that it would be economical enough to produce for individual hot mix asphalt plants without the capital investment required for equipment traditional used to blend at a terminal. The blended product is also designed to produce a modified asphalt cement that would provide high performance properties normally acquired by blended manufactured polymers, but at a lower cost.

The project consisted of designing a small scale blending plant, site preparation for the installation, installing the equipment, developing a blended product that would satisfy the specifications of a high performance product, partner with a customer to conduct the pilot project, and evaluate the performance throughout the life of the pavement. One of the projects identified as a suitable pilot was the City of Greeley Overlay (2011 contract). Upon formulating a successful blend, test data was submitted to the city engineer (Pat Hill) for

review. Preliminary review indicated a favorable response, which was followed by an inspection of the blend plant and materials. After reviewing the presented data and evaluating the materials and process, Mr. Hill determined that this project was worth further pursuit.

A meeting was held to plan the course of action for the project, particularly with determining what technologies were to be tested along with what controls would be employed and locating the streets for placement. The result of this meeting laid out a plan that would test three new technologies in conjunction with each other, all of which have recently gained ground in the paving industry as being "green", but all still lacking wide scale acceptance. The technologies selected were warm mix asphalt, recycled asphalt shingles, and ground tire rubber. Four mix designs were performed to study various combinations of the materials, and each were placed in approximately equal amounts across a six block section of 10th Avenue, from 10th Street south to 16th Street in Greeley, Colorado. The existing street was milled to accommodate the new pavement, a leveling course placed, covered with a paving mat, then overlayed with 2.5 inches of the test mixes.

The plan was communicated to a variety of agency engineers (from small city level up to CDOT) throughout Colorado as an open house event via an email announcement from the Colorado Asphalt Pavement Association. The project took 2 days to pave and also featured the use of TruPave® engineered paving mat by Owens Corning. The use of this product will provide a moisture barrier to the underlying pavement and also help prevent reflective cracking. Typically, a properly placed overlay will first exhibit signs of distress in the form of reflective cracking. However, it is commonly assumed that the problem is with the material newly placed. The issue with reflective cracking is cracks in the underlying pavement propagate through to the newly placed overlay often occurring shortly after the placement. The significance of the paving mat for this project is that aid in prevention of cracking will help to isolate performance of the actual material. The work for this project also included a leveling course, whereby a thinner layer of pavement was placed prior to the paving mat application to enable a good contact surface for the mat. This surface also provides a smoother, consistent under layer for compacting the overlay, which should contribute to the effectiveness of isolating material performance rather than process. When overlays are placed on a milled surface, particularly when the existing pavement is old and/or deteriorated, large chunks of pavement may break off below the milled surface which can create large variations in new pavement thickness and results in inconsistent compaction. Compaction is the most important property of the placed pavement. Inconsistencies with compaction can also result in poor pavement performance which may also be mistaken for poor material quality or performance.

Each section of the pilot project consisted of about 550 to 700 tons of mixture, enough to provide a sustained production time and obtain a representative sample of the material. During the construction phase of the pilot project, samples were obtained and tested for each mixture, the AC with GTR was sampled and tested, and the in-place pavement was tested as well. A table of results is included in the Appendix. The GTR selected for this project included an additional chemical additive. This additive was dosed in a very small amount (less than 1% of total blended asphalt), and we were also provided a proprietary blending process by the supplier (Modified Asphalt Solutions), which is available to any purchaser of the product. This unique process has never been tested in Colorado, and research of the available methods for GTR led Martin Marietta Materials to conclude this process was one valuable enough to test. The process and use of the additive are designed to improve the

dispersion of the GTR into the asphalt as well as enhance the physical properties that are of benefit by using GTR.

The total HMA tons placed for the pilot sections was about 2500 tons, of which there were 1361 tons using the GTR modified AC. Approximately 4 tons of GTR were used to produce the modified AC for this project, which can be approximated to about 400 waste tires. The remaining tonnage from the total used a PG 64-28 (performance grade asphalt cement) that satisfied standard CDOT specifications. The total 2500 tons would normally be considered a relatively small paving project. A similar type of pilot project conducted by CDOT in 2009, also using GTR, was approximately 3000 tons in total. The project was constructed on US 34 in Greeley, Colorado. There were three sections for that project, each of about 1000 tons. The sections included one control with a standard PG 64-28, and two others with GTR utilizing a different blending process for each. That project is still under evaluation. However, the findings of this project should be considered complimentary to the work done on US 34, as this project employed the use of a third process for blending GTR.

This project and the long term results can offer a significant impact to the Colorado community as a whole. While 93% of the Colorado generated waste tires were recycled in 2010, an influx of waste tires from neighboring states has resulted in an increased amount of stored tires, according to the 2010 Annual Report to the House Transportation Legislation Review Committee. Also stated in that report is crumb rubber provides the third most used outlet of recycled tires, with one of its uses being in roadways. Ironically, from 2011-2012, about 40% of the waste tires used for producing HMA in the state of Colorado came from use of the equipment obtained through this grant project. During that time, about 17.5 tons of GTR were processed through this blend plant (equivalent to about 1600 waste tires). Positive perceptions of the Greeley pilot project resulted in additional use in the City of Greeley as well as for Weld County in 2012. Successful performance will serve to promote the use of GTR in Colorado; thereby creating a new outlet for use in Colorado roadways that is currently not realized other than small test projects.

3. Summary of Findings and Results

The work completed indicates that GTR modified AC can be produced on a small scale at a lower cost than the conventional PMA. It has been estimated that the cost to produce utilizing direct labor and equipment cost, heating cost, plus materials is nearly 8% less than that of the conventional PMA as compared the GTR process used for this project. The assumed equipment cost for the blending equipment was based on a straight-line depreciation for a 10-year life at the full cost of the project (grant plus in-kind funds). Cost savings would be variable depending on end location of the HMA plant as haul of the conventional PMA was included with the price of this comparison. For this project, the blending equipment is also only several hundred feet from the HMA plant where the pavement mixture was produced. Regardless, this is still very encouraging as compared to other evaluations of GTR blending cost, especially given the relatively low volume of tons produced for a small pilot project. This point does lead to the comparison of material properties.

The first comparison is of the AC (also referred to as binder) testing alone. The PG, or Performance Grade, system was derived from the Strategic Highway Research Program established by Congress in 1987 as part of a five year research program intended to improve the performance and durability of the roadways in the United States. The major premise behind the system is based upon environmental factors that equate to the grade designation.

For example, a PG 64-28 can be specified based on statistical geographical weather data, whereby the seven-day maximum average is used for the high temperature grade (64ºC) and the low temperature grade is determined by a one-time event (-28ºC). Other project or location parameters may be considered for determining grade of asphalt such as traffic loading, but this essentially defines the meaning of the grade. Laboratory tests are used to evaluate the temperature grades and are typically compared to Table 1 of the AASHTO M320 specification. However, other specifying agencies such as CDOT often augment the AASHTO specification with tests referred to as "plus" tests. In the case of this example, Table 702-1 from the CDOT Standard Specification contains plus properties for the binders graded as PG 64-28 or higher. For a PG 64-28 though, there are additional plus specs that are not included with the grades higher such as PG 76-28. This is the result of a grandfathered material (previously known as AC-20R) that was modified with a specific type of polymer. The properties of this product were found to be very desirable to CDOT for particular applications, therefore it received different plus specs than the other grades higher on the table. For the case of this project, the City of Greeley recognized the AASHTO M320 Table 1 specification along with the Elastic Recovery plus spec applied to the higher grades. However, as the specification currently stands for CDOT, the GTR method could not be used to achieve the PG 64-28 (although it could for PG 70-28 and PG 76-28). Detailed binder test results for the GTR blend are in the Appendix. Standard PG grading defines the high and low temperatures in 6 degree increments. The test data submitted provides the true temperature grade (the temperatures at which the tests failed) in an effort to identify where in the incremental range the blend landed. As can be seen from the data, this blend of material nearly graded as a PG 70-28 (PG 69.7-29.8). The next lowest grade for the low temperature would be a -34, so the result indicates a solid -28 on the low end, with a very strong 64 for the high grade. The plus test of Elastic Recovery was 52.5% (minimum 50% required).

TS-2b

Table 1—Performance-Graded Asphalt Binder Specification

Performance Grade	PG 46			PG 52							PG 58					PG 64					
	34	40	46	10	16	22	28	34	40	46	16	22	28	34	40	10	16	22	28	34	40
Average 7-day max pavement design temp, °C[a]	<46			<52							<58					<64					
Min pavement design temperature, °C[a]	>-34	>-40	>-46	>-10	>-16	>-22	>-28	>-34	>-40	>-46	>-16	> 22	>-28	>-34	>-40	>-10	>-16	>-22	>-28	>-34	>-40
Original Binder																					
Flash point temp, T 48, min °C	230																				
Viscosity, T 316:[b] max 3 Pa·s, test temp, °C	135																				
Dynamic shear, T 315:[c] G*/sinδ,[d] min 1.00 kPa test temp @ 10 rad/s, °C	46			52							58					64					
Rolling Thin-Film Oven Residue (T 240)																					
Mass change,[e] max, percent	1.00																				
Dynamic shear, T 315: G*/sinδ,[d] min 2.20 kPa test temp @ 10 rad/s, °C	46			52							58					64					
Pressurized Aging Vessel Residue (R 28)																					
PAV aging temperature, °C[f]	90			90							100					100					
Dynamic shear, T 315: G* sinδ,[d] max 5000 kPa test temp @ 10 rad/s, °C	10	7	4	25	22	19	16	13	10	7	25	22	19	16	13	31	28	25	22	19	16
Creep stiffness, T 313:[g] S, max 300 MPa *m*-value, min 0.300 test temp @ 60 s, °C	–24	–30	–36	0	–6	–12	–18	–24	–30	–36	–6	–12	–18	–24	–30	0	–6	–12	–18	–24	–30
Direct tension, T 314:[g] Failure strain, min 1.0% test temp @ 1.0 mm/min, °C	–24	–30	–36	0	–6	–12	–18	–24	–30	–36	–6	–12	–18	–24	–30	0	–6	–12	–18	–24	–30

[a] Pavement temperatures are estimated from air temperatures using an algorithm contained in the LTPP Bind program, may be provided by the specifying agency, or by following the procedures as outlined in M 323 and R 35.
[b] This requirement may be waived at the discr etion of the specifying agency if the supplier warrants that the asphalt binder can be adequately pumped and mixed at temperatures that meet all applicable safety standards.
[c] For quality control of unmodified asphalt binder production, measurement of the viscosity of the original asphalt binder may be used to supplement dynamic shear measurements of G*/sinδ at test temperatures where the asphalt is a Newtonian fluid.
[d] G*/sinδ = high temperature stiffness and G* sinδ = intermediate temperature stiffness.
[e] The mass change shall be less than 1.00 percent for either a positive (mass gain) or a negative (mass loss) change.
[f] The PAV aging temperature is based on simulated climatic conditions and is one of three temperatures, 90°C, 100°C, or 110°C. Normally the PAV aging temperature is 100°C for PG 58-xx and above. However, in desert climates, the PAV aging temperature for PG 70-xx and above may be specified as 110°C.
[g] If the creep stiffness is below 300 MPa, the direct tension test is not required. If the creep stiffness is between 300 and 600 MPa, the direct tension failure strain requirement can be used in lieu of the creep stiffness requirement. The m-value requirement must be satisfied in both cases.

M 320-4

AASHTO

Table 702-1

SUPERPAVE PERFORMANCE GRADED BINDERS

Property	Requirement for PG Binder						AASHTO
	58-28	58-34	64-22	64-28	70-28	76-28	Test No.
Original Binder Properties							
Flash Point Temp., °C, minimum	230	230	230	230	230	230	T 48
Viscosity at 135 °C, Pa•s, maximum	3	3	3	3	3	3	T 316
Dynamic Shear, Temp. °C, where G*/Sin δ @ 10 rad/s ≥ 1.00 kPa	58	58	64	64	70	76	T 315
Ductility, 4 °C (5 cm/min.), cm minimum	-	-	-	50		-	T 51
Toughness, joules (inch-lbs)	-	-	-	12.4 (110)		-	CP-L 2210
Tenacity, joules (inch-lbs)	-	-	-	8.5 (75)		-	CP-L 2210
Acid or Alkali Modification (pass-fail)	Pass	Pass	Pass	Pass	Pass	Pass	CP-L 2214

Table 702-1 (continued)

Property	Requirement for PG Binder						AASHTO
	58-28	58-34	64-22	64-28	70-28	76-28	Test No.
RTFO Residue Properties							
Mass Loss, percent maximum	1.00	1.00	1.00	1.00	1.00	1.00	CP-L 2215
Dynamic Shear, Temp. °C, where G*/Sin δ @ 10 rad/s ≥ 2.20 kPa	58	58	64	64	70	76	T 315
Elastic Recovery, 25 °C, percent min.	-	-	-	-	50	50	T 301
Ductility, 4 °C (5 cm/min.), cm minimum	-	-	-	20	-	-	T 51
PAV Residue Properties, Aging Temperature 100 °C							R 28
Dynamic Shear, Temp. °C, where G*•Sin δ @ 10 rad/s ≤ 5000 kPa	19	16	25	22	25	28	T 315
Creep Stiffness, @ 60 s, Test Temperature in °C	-18	-24	-12	-18	-18	-18	T 315
S, maximum, MPa	300	300	300	300	300	300	T 313
m-value, minimum	0.300	0.300	0.300	0.300	0.300	0.300	T 313
**Direct Tension, Temperature in °C, @ 1 mm/min., where failure strain ≥ 1.0 %	-18	-24	-12	-18	-18	-18	T 314
**Direct tension measurements are required when needed to show conformance to AASHTO M 320.							

The second measure for comparison was the mixture properties evaluated for both laboratory and field tests. Each of these types of tests reflects material quality in regard to process control. Standard mix testing was conducted to determine the %AC, gradation of the aggregates, volumetric properties (percent air voids, percent VMA/Voids in Mineral Aggregate, and percent VFA/Voids Filled with Asphalt), Hveem Stability, Tensile Strength Ratio, and Dust to Asphalt Ratio. The Asphalt Pavement Analyzer was also used to evaluate rutting resistance. Field compaction was measured and recorder in two sections. Each section represents one strip, or paver pull, as it took two pulls or paver widths to complete one full section halfway across the road. Initial evaluation of the results provides the following conclusions:

- Most results are within production tolerances and can generally be described as that seen with normal production.
- Section 2 had slightly lower air voids which resulted in a high %VFA. The Maximum Theoretical Specific Gravity (Gmm) does appear to be unusually low with regard to the other results and considering the gradation and %AC are close to target. Later sampling from the roadway to re-evaluate may be necessary.
- Section 3 had the lowest %AC and was evident during compaction processes. The %AC was adjusted 0.1% higher for the second strip of the section and compaction results are reflective of that change. A sample of the mix was not tested after the change. The other three sections appear to have done well with compaction, although

the possibly skeptical Gmm value for Section 2 would be expected to be higher in value which would result in a lower calculated percent compaction. Cores may need to be taken to determine actual density.

- Section 4 had a fine gradation (out of tolerance on one sieve by 2%), resulting in a high D/A. The Tensile Strength Ratio was also considerably lower than the other samples, perhaps a result of the combined fine gradation and RAS. A fine gradation increases the amount of surface area of aggregate to coat with the AC, thereby reducing the film thickness of the AC and ability to bind the mixture together.
- All mixes appear to perform fairly well with respect to rutting resistance. Mixes that demonstrate performance issues tend to be reflective of APA test results being 6mm or greater. It is noteworthy to mention that the two RAS mixes performed the best, being relatively close to one another. This is a result that should be expected as the asphalt from the tear-off shingles tends to be extremely oxidized and makes HMA mixtures stiffer in nature. Otherwise, the lowest rut resistant mix is from Section 1. This mix did not have shingles and used the conventional CDOT specified PG 64-28. This may be a result of the conventional version of that grade being somewhat softer. This is evident in the Stability results and could have been expected, but typically this type of modified AC has lower Stability results as it is designed to be elastic (will deform under stresses, but also have the ability to recover).

The third measure for evaluation is field observations during paving and nearly one year after. Copies of the hand written field notes from the technician are included. The comments are reflective of the field compaction results and fairly consistent with the mix results and how they would influence compaction. The project was walked on 8/11/2012 and pictures are included in the Appendix. Overall, all of the sections appeared to be in good condition with a tight surface, no reflective cracking. There were a few observations made during the visit:

- No evidence of rutting or shoving.
- Check cracking was observed primarily in Sections 1 & 4. Both instances were near to the concrete drain pan. Check cracking appears as usually small transverse cracks closely spaced from each other (maybe an inch apart). Can be the result of a "tender" mix (one that does not bind up quickly or is sensitive to temperature), a mix lox in AC (or "dry" mix), in adequate bond to the underlying layer.
- Raveling along the longitudinal joints appeared evident in all Sections. Section 4 also showed some cracking along the longitudinal joint between 13th and 15th Streets. This may suggest an inadequate paving/compaction process. It is common that joints are made to look good such that the matching edges are flush with each other when compaction is completed. However, not enough material on the "hot" side of the joint can result in the compaction creating a flat joint prior to the material being compacted adequately. Once flat, the drum from the roller rides on the "cold" side of the joint (the pavement that is cold and already compacted), causing the drum to bridge across the freshly placed asphalt immediately at the joint.

4. Summary of Unanticipated Outcomes or Roadblocks

From a raw project perspective of installing the equipment, there were relatively minor unanticipated issues. One was a part supplier for the mixer in the day tank was delayed getting the mixer to D&H Equipment. This resulted in delayed delivery of that component of the system and therefore needed to cover the cost of an additional day of crane time adding $1,280.00 to the installation cost. This cost was a minor increase, but it was decided that

electrical and plumbing work could done for the other components while awaiting delivery of that tank. Otherwise, waiting for the whole system to be installed at a later date may have delayed or caused the pilot project to cancel. The only other unanticipated issue that may have impacted project progress was the inability to heat the tanks to the necessary temperatures to make the blended product. Due to the increased length of piping, the efficiency of the existing pump along with the additional heat loss resulted in adding a small booster pump for the heating oil. This additional cost was $1,874.21 plus the plant crew's time to install (2 people for about 3 hours).

The outcome of greatest significance not anticipated was the utilization of three "green" technologies not originally planned. The original grant project was intended to be focused on the use of GTR in asphalt pavement; however, through great leadership from the City of Greeley, the project was also able to incorporate the other two technologies into the test sections for performance evaluation.

The warm mix asphalt (WMA) was utilized for four sections of the project. Although most references throughout this report use the term HMA, all mixes used the WMA technology of foaming the asphalt with the Maxam AQUABlack® system. Normally, this application is considered to be warm mix if the production temperature is considerably lower than normal HMA production. For this project, there may have been a 10-20ºF reduction in temperature from the normal HMA production, but the primary benefit of the WMA technology intended to be captured was improved compactibility. Mixtures with PMA and RAS tend to be a little more difficult to compact. The addition of the WMA to this project was to assist with potential compaction issues. However, that does not take away from the chance to evaluate its use with the other technologies.

Again, the greatest roadblock will be acceptance of the materials based on many influencing variables, the end result of the project and the time it will take to truly evaluate performance. When new materials are tested, they can be over evaluated to the extent that anything unanticipated gets blamed on the new item.

One additional "roadblock" that is not directly related to the project was the acquisition of the Lafarge Colorado Front Range business by Martin Marietta Materials, Inc. The contract originally was executed with Lafarge West, Inc., but the assets and personnel tied to this project became a part of the acquisition. However, Martin Marietta Materials, Inc. shares the same commitment to being an environmentally responsible producer, and as such, assumed assignment of this contract. A copy of the letter requesting reassignment is included in the Appendix.

5. Communication of Project Findings

When the one year follow up review of the project is completed, a brief interim report will be drafted and findings shared via an article in "Behind the Paver", an electronic publication distributed to a wide readership through the asphalt and paving industry by the Colorado Asphalt Pavement Association. The distribution reaches producers, contractors, engineers and other agency officials, many of which are involved with writing specifications. Todd Genovese also actively speaks at the Rocky Mountain Asphalt Equipment Show where hundreds of industry and agency people attend each year. The option of speaking in an open forum may be best saved for at least one to two more years of performance.

The second objective for communicating results will be to actively share and compare data from the CDOT US 34 pilot project. This will help to put all of the different processes side by side for evaluation. A conversation was had with Roberto DeDios with the CDOT Applied Research and Innovation Branch. A copy of CDOT's interim report has already been shared with Martin Marietta Materials Inc. Communication of successful results to CDOT is another step toward wider acceptance. Many smaller municipalities, who utilize CDOT specifications for construction, often wait for CDOT to accept new products for use as the smaller agencies often do not have the resources to evaluate on their own.

6. Future Impact of the Project

The future impact has the potential of influencing the paving industry throughout Colorado as well as neighboring states. Again, referencing the difficulty with implementing new technologies in Colorado due to extreme climatic conditions, small local agencies as well as neighboring states may ride on the coat tails of CDOT. The first step for getting a pilot project with the process used for this project has been completed. Annual follow up to evaluate and document performance is the key to providing CDOT the information required to consider a new product.

While acceptance through CDOT does provide a forum for wider acceptance, continued progress can also be achieved through partnering with mid-sized agencies such as the City of Greeley who have a progressive outlook on new technologies. Cities such as Denver, Aurora, Colorado Springs, Pueblo and counties such as Douglas, Jefferson, Weld, and Arapahoe are among several along the Front Range that may specify and/or use modified grades of asphalt for their roadways. Partnering with smaller agencies will also provide opportunities for evaluation.

We also participate in many industry task forces, specification committees and other industry functions where communication with other members can help drive the effort to expand the research needed for acceptance. Even if a fraction of the pavement placed with modified asphalt uses GTR, there is still the potential for additional tens of thousands of tires to be recycled and used in Colorado.

As with any production process, the key to driving cost down is increasing the volume of use. Similar discussions have been had through the years with changes within the industry including RAP, RAS, and WMA. Cost will also be a driver to acceptance, but as with this project, there seems to be a great potential for GTR as a cost effective alternative to PMA. Discussions to date have indicated interest from CDOT, but as with the other new technologies, there needs to be a means for control of use. Recent discussions have been had with Michael Stanford of the CDOT Materials and Geotechnical Branch along with Edward Trujillo of the CDOT Binder Laboratory. We have requested that consideration be given to evaluation of the specification and should be a discussion point at the next MAC (Materials Advisory Committee) meeting in September. The consideration requested revolves around the amended AASHTO M320 specification, where the MSCR (Multiple Stress and Creep Recovery) test is used to classify and grade asphalt cements. The new specification is more complex, but it is a system that could alleviate the use of certain plus specifications and open the door for different types of PMA's. CDOT is also currently involved with the Rocky Mountain User/Producer Group in evaluating past test data with regard to the MSCR test for the intent of unifying specifications across the Rocky Mountain states. Findings from that

study may help provide specifications more suitable for use of materials like GTR as a modifier. As has been described recently, CDOT also is currently struggling with whether to treat GTR as a filler material or the blended product as one that is homogeneous and consequently approved the same as other PMA's.

7. **Financial Summary –** Below is the Grant Budget Table as requested.

Martin Marietta Materials Grant Budget Table

Description	Grant Funds Spent	Matching/In Kind Amount (if any)	Total Amount
Personnel Salaries	$0.00	$20,421.00	$20,421.00
Fringe Benefits	$0.00	$0.00	$0.00
Tuition/Fees	$0.00	$0.00	$0.00
Travel Costs	$0.00	$0.00	$0.00
Materials/Supplies/Equipment (under $5000)	$0.00	$2220.00	$2220.00
Equipment Purchases (over $5000)	$188,750.00	$148,110.00	$336,860.00
Contractors/Subcontractors	$0.00	$36,430.00	$36,430.00
Consultants	$0.00	$3,100.00	$3,100.00
Training/Education	$0.00	$0.00	$0.00
Marketing/Advertising	$0.00	$0.00	$0.00
Other Direct Costs	$0.00	$36,729.00	$36,729.00
Indirect Costs	$0.00	$0.00	$0.00
Total Project Cost:	$188,750.00	$247,010.00	$435,760.00

Total award amount: $188,750.00

The table above reflects the current allocated funds based on invoices submitted. **You currently have $0.00 remaining in your grant award budget.**

Overall, the project cost completed 4.25% over original estimate. The majority of difference between cost versus estimate resulted from the following:

- Freight cost of delivering the equipment to the site was not included with the original quote.
- Due to minimum order requirements from the GTR supplier, the size of the shed needed to be much larger than planned.
- Otherwise, the rest of the project cost was within an acceptable range compared to the estimate.

8. Conclusion

Ground Tire Rubber has been utilized successfully for many years as an additive and/or modifier for asphalt pavement mixtures. However, there still remains a stigma regarding it's use. Possible reasons for this are probably due to geographic location and environmental conditions that effect perception of performance as well as a variety of processes and GTR used. Another factor is the variety of other materials used such as asphalt cement, aggregates and RAP which may have an impact on the results. As such, there have been a wide range performance results that should not be used to categorize GTR as a whole. It is with great hope that this project will yield results using local materials in a local environment that will help to generate greater local acceptance of GTR use.

9. Appendix

a. **Grant Metrics Table** – The table was completed as it was designed. There were a few areas that appear unusual that should be noted. The Average Monthly Customers for FY 2011 equated to 0.17 as there were only two customers for the year. The estimated Average Monthly Customers for FY 2012 was projected to be three, then divided by 12 months for the Average Monthly Amount as 0.25. Because of the nature of the work done for paving roadways, a customer is regarded as one specific project. It is difficult to predict the total number, but with this customer concept, there is typically a high volume of material used per customer. The expectation is that we can increase the number projects won via the low bidder process with the future goal of increasing the amount tons allowed to be used.

Grant Metrics

Date project fully operational: November-12

(Based on deliverables- month that impact of grant would have changed volumes/job creation/participants)

Diversion Rates:

(Choose one material per box. Only list those collected over the grant cycle. Must be listed as "tons". See tab labeled "Conversion Tables" if needed.)

Material Diverted #1: Other (pls describe below)

	Tons Diverted
July-11	
August-11	
September-11	
October-11	
November-11	4
December-11	
January-12	
February-12	
March-12	
April-12	
May-12	
June-12	13.5
Total	17.5

Other div. material: Waste Tires

Material Diverted #2: Other (pls describe below)

	Tons Diverted
July-11	
August-11	
September-11	
October-11	
November-11	37
December-11	
January-12	
February-12	
March-12	
April-12	
May-12	
June-12	
Total	37

Other div. material: Tear-off asphalt shingles

Material Diverted #3:

	Tons Diverted
July-11	
August-11	
September-11	
October-11	
November-11	
December-11	
January-12	
February-12	
March-12	
April-12	
May-12	
June-12	
Total	0

Other div. material:

Material Diverted #4:

	Tons Diverted
July-11	
August-11	
September-11	
October-11	
November-11	
December-11	
January-12	
February-12	
March-12	
April-12	
May-12	
June-12	
Total	0

Other div. material:

Material Diverted #5:

	Tons Diverted
July-11	
August-11	
September-11	
October-11	
November-11	
December-11	
January-12	
February-12	
March-12	
April-12	
May-12	
June-12	
Total	0

Other div. material:

Material Diverted #6:

	Tons Diverted
July-11	
August-11	
September-11	
October-11	
November-11	
December-11	
January-12	
February-12	
March-12	
April-12	
May-12	
June-12	
Total	0

Other div. material:

Material Diverted #7:

	Tons Diverted
July-11	
August-11	
September-11	
October-11	
November-11	
December-11	
January-12	
February-12	
March-12	
April-12	
May-12	
June-12	
Total	0

Other div. material:

Material Diverted #8:

	Tons Diverted
July-11	
August-11	
September-11	
October-11	
November-11	
December-11	
January-12	
February-12	
March-12	
April-12	
May-12	
June-12	
Total	0

Other div. material:

End use of diverted materials:
(Describe where materials are going
[e.g., MRF, new products, reuse])

Used to produce new asphalt mixtures for paving roadways.

Number of Permanent Jobs Created:
Include full-time & part time paid positions.
1 FTE = 40 Hours Per Week

1

Type of Permanent Job(s) Created:
(Provide titles of jobs created)

Area QC Manager (new title yet to be determined as this role will be combined QC and operational role)

Average Salaries of Jobs Created:
(Average of all jobs created)

$60,000+

Average Monthly Customers for FY 2011:
(July 1, 2011 - June 30, 2012)

0.17

Average Monthly Customers for FY 2012:
(Estimate or customer lists)

	Avg. Monthly Amount
July-12	0.25
August-12	0.25
September-12	0.25
October-12	0.25
November-12	0.25
December-12	0.25
January-13	0.25
February-13	0.25
March-13	0.25
April-13	0.25
May-13	0.25
June-13	0.25
Ave. / FY 12	**0.25**

b. Community Leader Contact Information

Pat Hill
Pavement Management Coordinator, City of Greeley
Phone: (970) 350-9540
Email: pat.hill@greeleygov.com

Tom Peterson
Executive Director, Colorado Asphalt Pavement Association (CAPA)
Phone: (303) 741-6150 extension 152
Email: tompeterson@co-asphalt.com

Tom Clayton
Director of Training and Member Services, CAPA
Phone: (303) 741-6150 extension 151
Email: tomclayton@co-asphalt.com

Roberto DeDios
Research Engineer, CDOT-DTD Applied Research and Innovation Branch
Phone: (303) 757-9975
Email: roberto.dedios@dot.state.co.us

Edward Trujillo
Binder Lab Manager, CDOT Materials and Geotechnical Branch
Phone: (303) 398-6530
Email: edward.a.trujillo@dot.state.co.us

c. Project Pictures

The blending equipment was installed adjacent to the Martin Marietta Materials AC storage tank. The blending equipment consists of the two smaller tanks to the left with the red ladders.

A one ton sack of GTR to be hoisted by the loader over the feeder.

The sack of GTR will be torn at the bottom so it can fall into the feeder.

A little help is needed to coax the GTR out of the sack.

The bottom of the sack clumps from compacting under its own weight, but breaks apart into a its original fine grind (minus 30 mesh sized particles).

The GTR is placed into the gray feeder, then augered through the tube into the top of the smaller blend tank. Once blended, the material is transferred to the taller of the two tanks and cured until ready for use.

Inside view of the larger of the two tanks – there are three tiers of mixing paddles with the hot oil heating coil at the bottom of the tank. This where the blended product is mixed and cured until ready for use.

The storage shed is behind and to the right of the tank in the foreground. The white sacks of GTR can be seen on the left inside the shed.

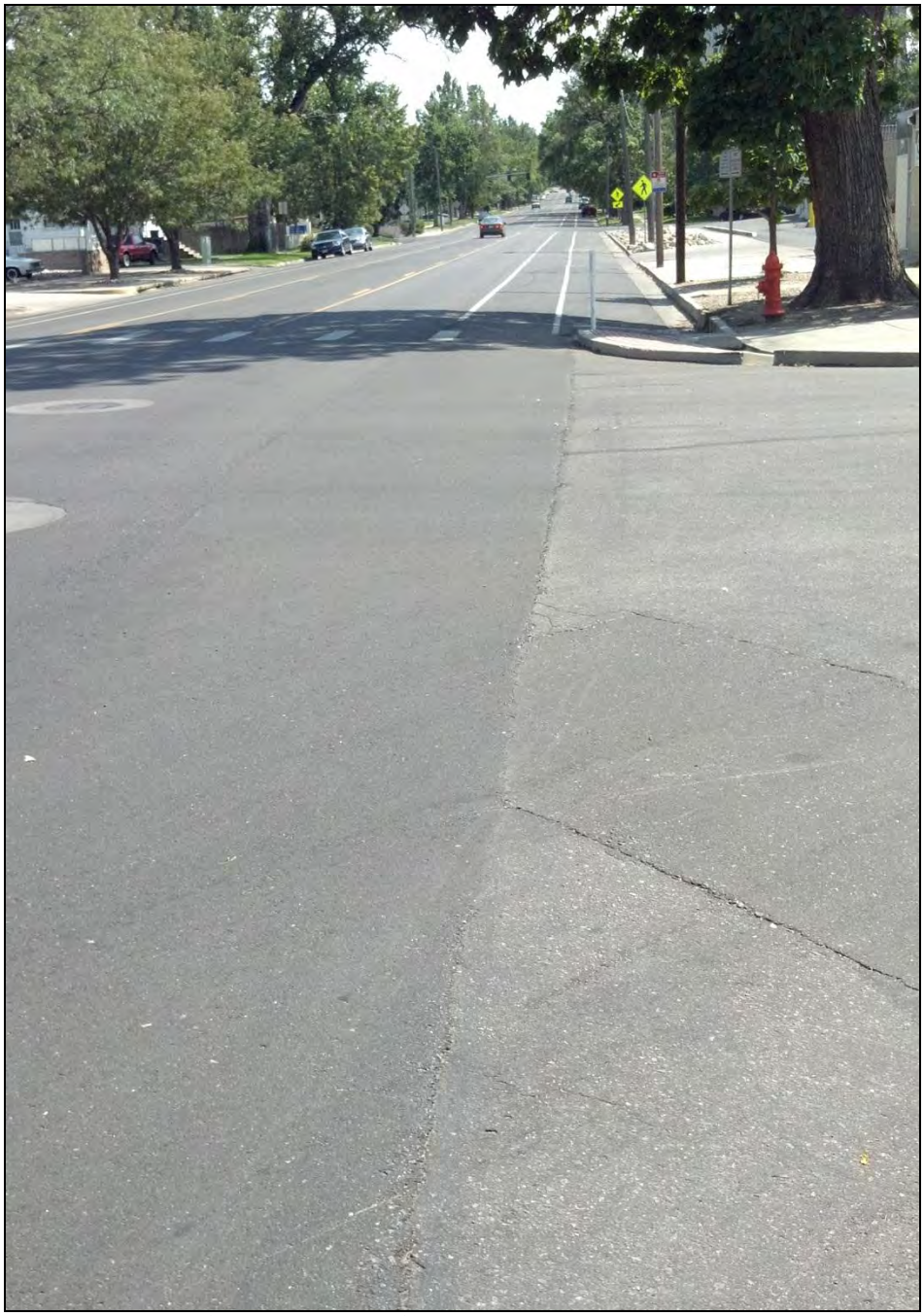
Paving the GTR pilot Section 3.

Intermediate pneumatic (rubber tire) roller compacting the mix. This type of roller typically assists compaction by kneading the mixture together. There are often times concerns with using this type of roller on mixes with PMA because the sticky nature of the PMA causes sticking to the tires of the roller and pieces of the mat to peel off. As can be seen, the pavement surface is in good condition.

Section 3 after the finish roller completed compaction.

North end of the project at 10th Avenue and 10th Street, 10 months after placement.

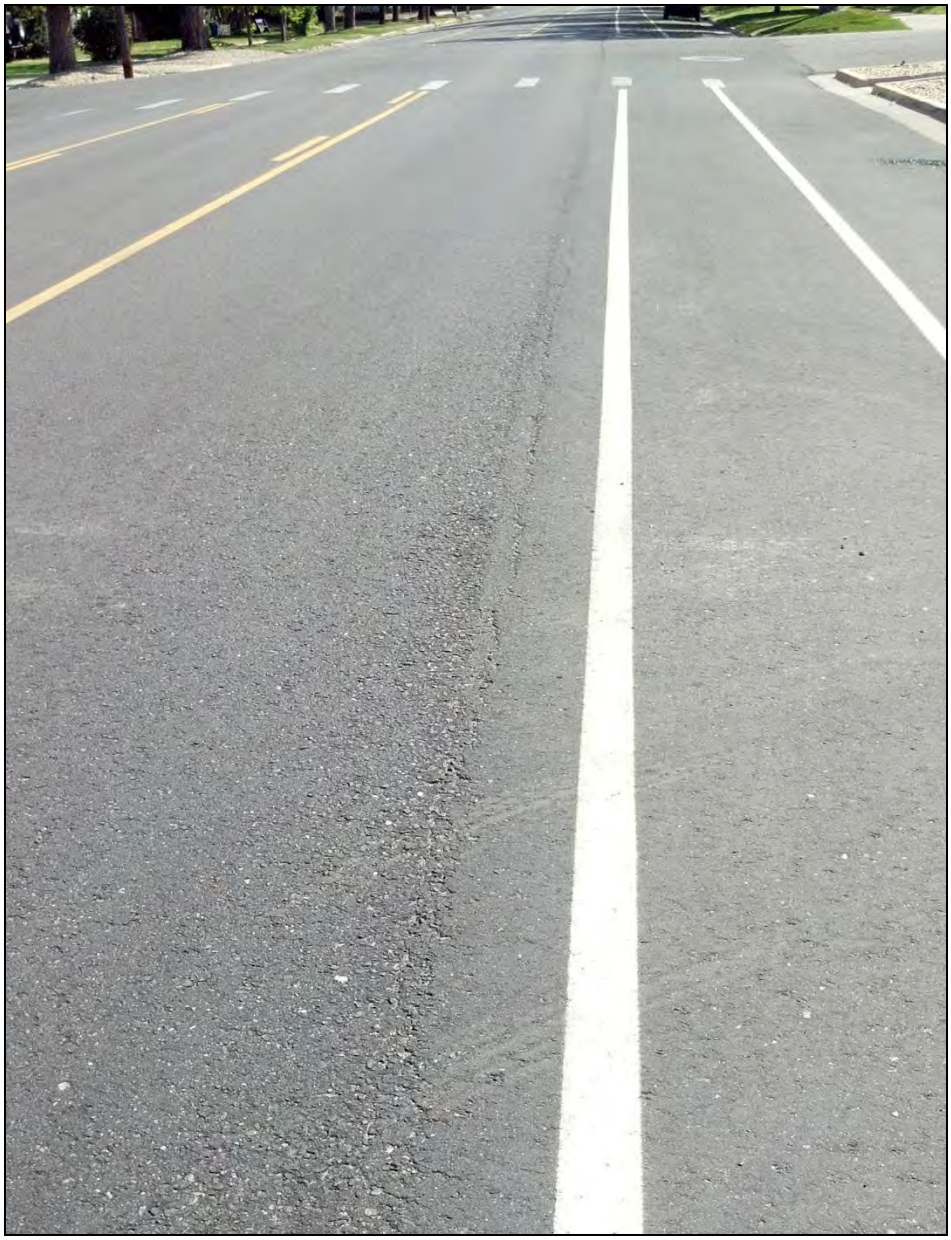
Looking south on 10th Avenue from 10th Street. Section 1 is to the left of the double yellow line and Section 2 is to the right in this picture.



Intersection of 10th Avenue and 11th Street (Section 1 left of center of turn lane, Section 2 right), looking south. A common location, especially intersecting a patch as seen to the right, of where cracking will begin to occur.

Intersection of 10th Avenue and 12th Street (Section 1 left, Section 2 right), looking south.

Intersection of 10th Avenue and 14th Street (Section 3 left, Section 4 right of center of road), looking south. Shadowy or darker appearance of longitudinal joint (running along length of pavement between manholes) due to loss of finer aggregate on surface. This was evident throughout all Sections.

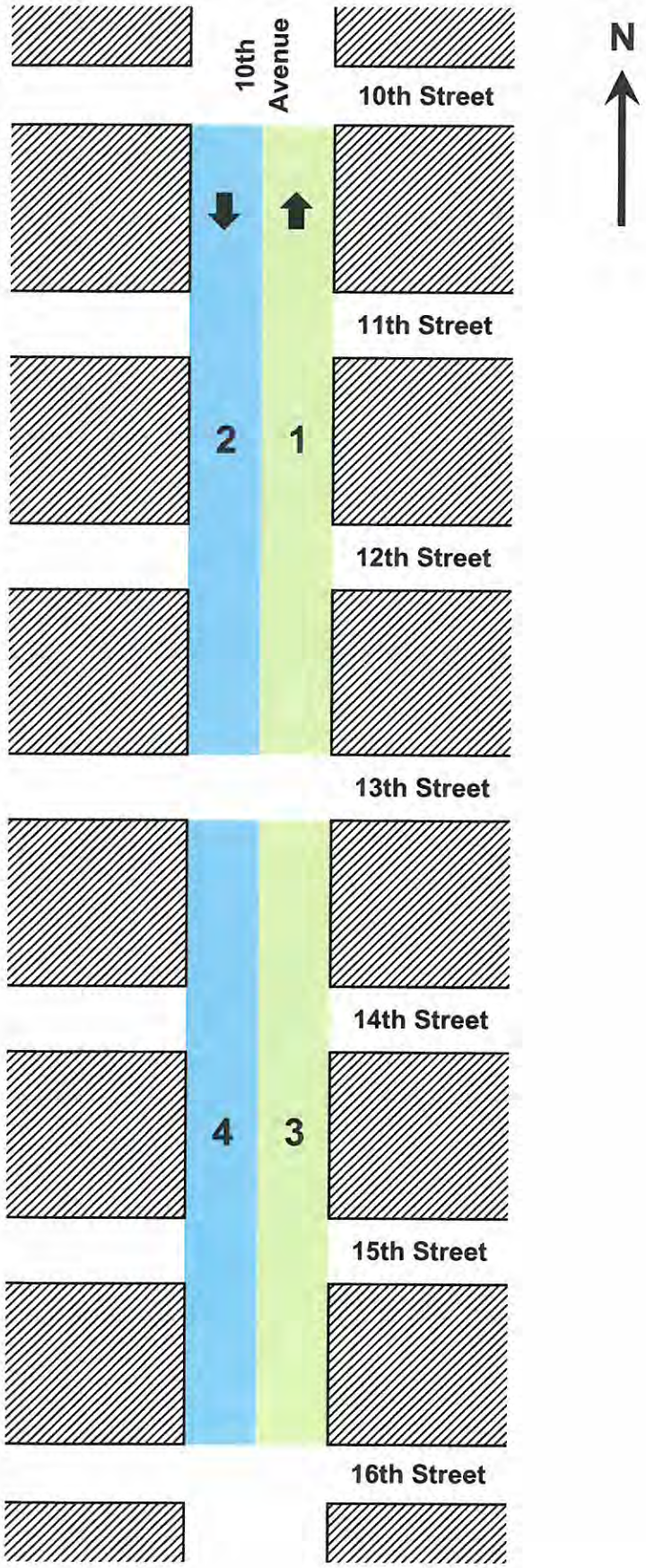


Better view of the longitudinal joint – shadowy appearance caused by the loss of finer aggregate which results in a rougher surface texture. This is Section 4 between 13th and 14th Streets.

Check cracking observed in mostly in Sections 1 and 4. This picture shows the most obvious location in Section 1.

d. Test Data and Field Notes

Project Diagram with Brief Description of Mixes



Section 1

Mix Design Number 72235311

* PG 64-28 conventional PMA
* 20% RAP

Section 2

Mix Design Number 72225411

* PG 64-28 conventional PMA
* 20% RAP
* 3% RAS

Section 3

Mix Design Number 72230311

* PG 64-28 using GTR
* 20% RAP

Section 4

Mix Design Number 72220411

* PG 64-28 using GTR
* 20% RAP
* 3% RAS

Mixture Test Results

Test Section	1		2		3		4	
Mix Number	72235311		72225411		72230311		72220411	
Constituents	PG 64-28/RAP		PG 64-28/RAP/RAS		GTR/RAP		GTR/RAP/RAS	
	Result	*Spec*	Result	*Spec*	Result	*Spec*	Result	*Spec*
Sieve Analysis								
3/4"	100	*90-100*	100	*90-100*	100	*90-100*	100	*90-100*
1/2"	89	*81-93*	88	*83-95*	89	*81-93*	93	*83-95*
3/8"	81	*71-83*	78	*72-84*	79	*71-83*	82	*72-84*
#4	65	*55-65*	59	*51-61*	62	*55-65*	63	*51-61*
#8	52	*43-53*	47	*41-51*	49	*43-53*	51	*41-51*
#16	38		36		37		38	
#30	27	*20-28*	24	*19-27*	25	*20-28*	27	*19-27*
#50	17	*11-19*	16	*11-19*	16	*11-19*	17	*11-19*
#100	10		10		10		11	
#200	6.8	*4.7-8.7*	6.8	*5.2-9.2*	6.4	*4.7-8.7*	7.3	*5.2-9.2*
Mix Properties								
%AC	5.36	*4.5-5.3*	5.33	*4.8-5.6*	4.95	*4.5-5.3*	5.37	*4.8-5.6*
%Voids	2.8	*2.4-4.8*	2.1	*2.3-4.7*	4.2	*2.3-4.7*	3.9	*2.5-4.9*
%VMA	13.2	*12.1-14.5*	13.3	*12.2-14.6*	14.1	*12.0-14.4*	14.4	*12.8-15.2*
%VFA	78.6	*65-75*	84.2	*65-78*	70.4	*65-75*	73.2	*65-78*
D/A	1.23	*0.6-1.2*	1.23	*0.6-1.2*	1.26	*0.6-1.2*	1.33	*0.6-1.2*
Gmb	2.380		2.378		2.346		2.348	
Gmm	2.449		2.429		2.448		2.442	
Stability	44	*30 min.*	43	*28 min.*	48	*30 min.*	46	*28 min.*
%TSR	88	*80 min.*	87	*80 min.*	82	*80 min.*	67	*80 min.*
ITS (wet)	79		84		62		66	
ITS (dry)	90	*30 min.*	96	*30 min.*	75	*30 min.*	99	*30 min.*
Rut Depth (mm)								
1	3.63		1.81		2.30		2.43	
2	3.06		2.03		2.55		2.04	
3	2.90		1.91		2.88		1.95	
Average	3.20	*N/A*	1.92	*N/A*	2.58	*N/A*	2.14	*N/A*
Mat Densities								
1-1	93.40	*92-96*	93.60	*92-96*	91.40	*92-96*	92.90	*92-96*
1-2	94.30	*92-96*	93.20	*92-96*	91.80	*92-96*	93.60	*92-96*
1-3	93.10	*92-96*	94.10	*92-96*	92.20	*92-96*	93.40	*92-96*
1-4	94.00	*92-96*	93.50	*92-96*	91.60	*92-96*	94.40	*92-96*
1-5	94.40	*92-96*	94.30	*92-96*	91.10	*92-96*	-	*92-96*
1-6	94.20	*92-96*	-	*92-96*	-	*92-96*	-	*92-96*
Average	93.90	*92-96*	93.74	*92-96*	91.62	*92-96*	93.58	*92-96*
2-1	94.30	*92-96*	93.00	*92-96*	92.20	*92-96*	94.60	*92-96*
2-2	94.00	*92-96*	93.40	*92-96*	92.60	*92-96*	94.00	*92-96*
2-3	94.20	*92-96*	93.90	*92-96*	92.90	*92-96*	95.00	*92-96*
2-4	93.80	*92-96*	93.50	*92-96*	92.50	*92-96*	94.00	*92-96*
2-5	93.80	*92-96*	94.30	*92-96*	93.20	*92-96*	94.90	*92-96*
Average	94.02	*92-96*	93.62	*92-96*	92.68	*92-96*	94.50	*92-96*

WESTEST
SPECIALISTS TO THE PAVING INDUSTRY
845 Navajo Street
Denver, CO 80204
303.975.9959 • Fax: 303.975.9969

Test Report
Binder Grade Determination AASHTO M320

Sample Number: 95
Sample Description: GLAT 11-10-11
Report Date: 11/18/2011
Date Received: 11/15/2011
Date Tested: 11/16/11 - 11/18/11
Sampled By: Client
Tested By: Brice Croswell

Westest Project No: 299511

Client: Lafarge
Mr. Todd Genovese, P.E.
10170 Church Ranch Way, Suite #200
Westminster, CO 80021

(PG High 69.7, PG Low -29.8)

Test Parameter	UOM	Test Method	PG Min	PG Max	Test Temp	Result
Flash Point, COC	(°C)	T 48	230°C	---	---	283
Rotational Viscosity	(Pa-s)	T 316	---	3	135°C	0.619
Dynamic Shear, G*/sin δ @ 10 rad/s	(kPa)	T 315	1.00	---	64°C 70°C	1.79 0.97

Tests on Residue from Rolling Thin Film Oven, AASHTO T240

Mass Change	(wt %)	T 240	---	1.00	163°C	-0.149
Dynamic Shear, G*/sin δ @ 10 rad/s	(kPa)	T 315	2.20	---	70°C 76°C	2.48 1.34
Elastic Recovery	(%)	CDOT CPL 2211 Method A	---	---	25°C	52.5

Tests on Residue from Pressure Aging Vessel, AASHTO R-28 PAV Test Temperature = 100°C

Dynamic Shear, G*/sin δ @ 10 rad/s	(kPa)	T 315	---	5,000	16°C 13°C 10°C	3,630 4,990 6,770
Creep Stiffness (BBR)						
"S-value" @ 60s	(Mpa)	T 313	---	300	-12°C -18°C	56 123
"m-value" @ 60s	---	T 313	0.300	---	-12°C -18°C	0.348 0.311

* Denotes deviation from specification.
The test results indicated in this report were obtained from selected samples of this product. Actual test results for any particular batch may vary from the indicated test results obtained for this Test Report.

#1

BREAKDOWN	1½ PASSES	MEDIUM VIBE
SAKAI	2½ PASSES	½ STATIC 2 VIBE
434 FINISH	2 PASSES	STATIC

THIS MIX PERFORMED NORMALLY. NO DELAMINATION OF THE MAT AT ALL. FINAL APPEARANCE OF MAT LOOKED GOOD

#2

BREAKDOWN	534	2 PASSES MED VIBE
SAKAI		3 PASSES ½ STAT 2½ VIBE
FINAL	434	2 PASSES STATIC
3X5		2 PASSES CLEAN-UP AFTER BREAKDOWN

BREAKDOWN: TEMP ZONES 290° - 275° RESULTS OK
NO CRACKING OF MAT DENSITIES 89 - 90.5 %
RUBBER TIRE: MAX TEMPERATURE 190°
FINAL: MAX TEMP 160°

MAT LOOKED OKAY BUT DENSITIES WERE LOWER.

#3

AFTER THE FIRST 275 TONS J. RUNNER RAISED AC A TENTH. THIS MADE A DIFFERENCE DURING BREAKDOWN THE MIX FROM 290°-260° SHOWED CHECKING, SHOWING EXCESSIVE CRACKING. LOWERED BREAKDOWN TEMP TO 250°. BROUGHT SAKAI PASSES UP TO HEAL THE MAT. THE FINAL PRODUCT LOOKED AVERAGE. LOWER DENSITIES

BREAKDOWN	1½ PASSES MED VIBE (ONE PASS RESULTED IN 87.5-88 %)
SAKAI	4 PASSES 3 VIBE 1 STATIC
434	2 PASSES STATIC

#4

BREAKDOWN	534	2 PASSES MED VIBE
SAKAI		3/ PASSES 1/2 STATIC 2 1/2 VIBE
FINAL	434	2 PASSES STATIC

THIS MIX WAS PRETTY STIFF, BUT PERFORMED VERY WELL. BREAKDOWN TEMP ZONES 290°-260° W/ RESULTING DENSITIES OF 90%-91%. THERE WAS NO SHOVING OR CRACKING. MORE MECHANICAL MANIPULATION WAS NEEDED BUT OVERALL THE FINAL RESULT WAS VERY GOOD.

e. Mix Design for Section 1

4/29/2011

1800 N. Taft Hill Road
Fort Collins, CO 80521

Attn: Mr. Jerimy Runner

Re: Hot Mix Asphalt Mix Design

Grading:	S (3/4 in. Nominal)
Compaction:	Superpave 100
Aggregate:	35th Avenue/RAP
Mix Design No.:	72235311
Q2C No.:	AS4495

This letter represents the results of a hot mix asphalt mixture design by the Superpave Method, utilizing 100 gyrations at 1.25° in accordance with Colorado Department of Transportation Manual of Test Procedures and as outlined by Asphalt Institute Manual, Series No.2 (SP-2).

The 35th Avenue/RAP aggregates and Suncor PG 64-28 asphalt cement used in this mix design were proportioned in accordance with your request as detailed in the blend table of this design.

Properties of this mixture are:

Percent Asphalt:	4.9
Air Voids, %	3.6
VMA, %	13.3
VFA, %	72.9
Hveem Stability	46
Max. Theoretical Specific Gravity (Rice)	2.455

The aggregate blend sheet, mix design physical properties, mix design property curves, and combined aggregate properties are presented on the enclosed forms.

Please do not hesitate to contact Engineering Services with any questions concerning this report.

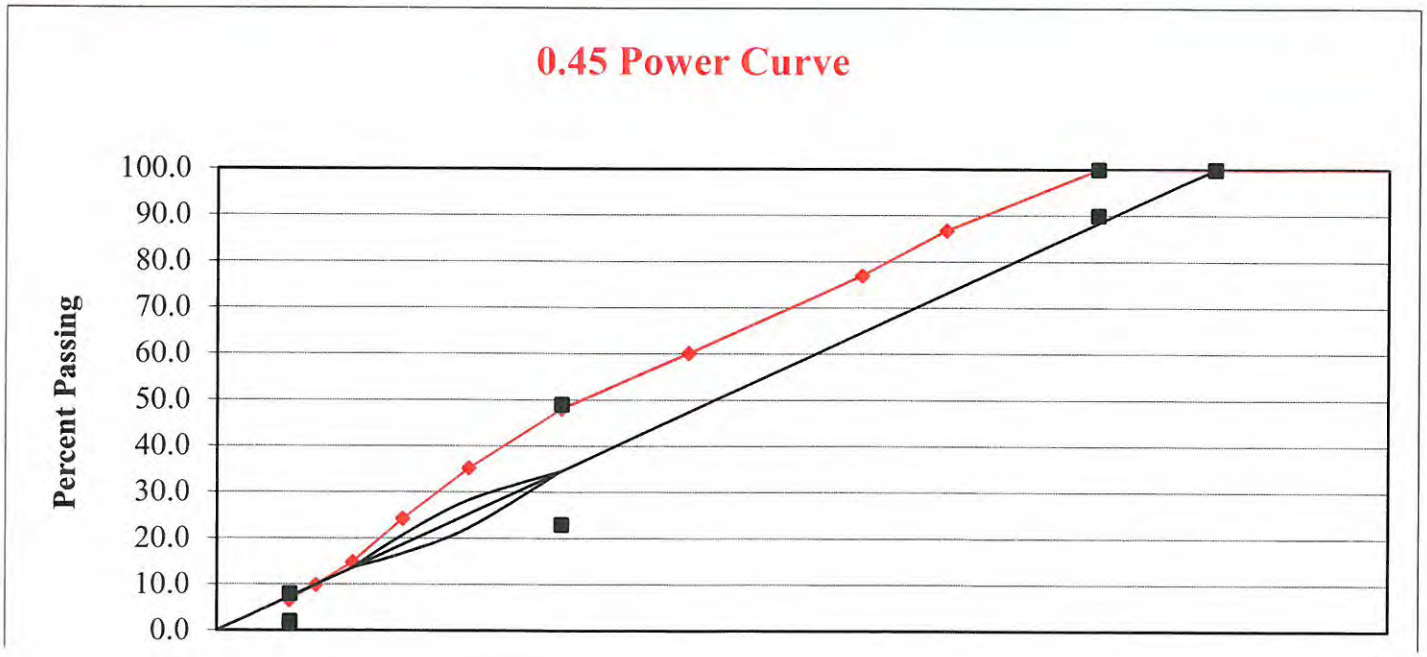
Sincerely,

An AASHTO Accredited Lab

Todd M. Genovese, P.E.
Metro Denver QC Manager
Enclosures

Date:	4/29/2011	**Client:**	Northern
Design Number:	72235311	**Binder:**	PG 64-28
Grading:	S (3/4 in. Nominal)	**Supplier:**	Suncor
Design Type:	Superpave 100	**Specific Gravity:**	1.031
Aggregate Source:	35th Avenue/RAP	**Additive:**	Lime

% Material Used:	35%	21%	10%	13%		20%	1%	**100% JMF**	**Control Points**
Material Type:	3/4" Rock	Crusher Fines	Native Fines	Concrete Sand		Crushed RAP	Hydrated Lime		
Material Source:	35th Ave	35th Ave	35th Ave	35th Ave		35th Ave	Pete Lien		
1-1/2" (37.5 mm)	100	100	100	100		100	100	100	
1" (25.0 mm)	100	100	100	100		100	100	100	100
3/4" (19.0 mm)	100	100	100	100		100	100	100	90-100
1/2" (12.5 mm)	65	100	99	100		96	100	87	
3/8" (9.5 mm)	42	100	95	100		89	100	77	
#4 (4.75 mm)	9	96	80	100		74	100	60	
#8 (2.36 mm)	6	68	63	97		59	100	48	23-49
#16 (1.18 mm)	4	47	47	70		46	100	35	
#30 (600 µm)	4	33	32	38		34	100	24	
#50 (300 µm)	3	21	20	13		24	100	15	
#100 (150 µm)	3	13	14	3		17	100	10	
#200 (75 µm)	1.9	8.4	9.5	1.7		10.5	98.0	6.7	2.0-8.0
Bulk Specific Gravity	2.605	2.577	2.526	2.604		2.637	2.380	**2.595**	
App. Specific Gravity	2.669	2.649	2.639	2.670		2.637	2.380	**2.652**	
Eff. Specific Gravity	2.656	2.634	2.616	2.657		2.637	2.380	**2.641**	
Percent Asphalt in RAP						3.29			



HOT MIX ASPHALT MIX DESIGN PHYSICAL PROPERTIES

Client:	Northern		
Mix Grading:	S (3/4 in. Nominal)		
Aggregate Source:	35th Avenue/RAP		
Asphalt Cement Source:	Suncor		
Asphalt Cement Grade:	PG 64-28	***Asphalt Cement Specific Gravity:***	1.031
Additive Type:	Lime		
Compaction Method:	Superpave		
Temperature Mixing (°F) =	325	***Compaction (°F) =***	300

Asphalt Content (%):	**4.5**	**5.0**	**5.5**	**6.0**
Bulk Sp. G.:	2.345	2.374	2.381	2.390
Maximum Sp. G.:	2.469	2.451	2.434	2.416
Theoretical Max Unit Wt. (pcf):	154.1	152.9	151.9	150.8
Air Voids (%) @ N-Initial:	12.3	10.3	9.5	8.1
Air Voids (%) @ N-Design:	5.0	3.1	2.2	1.1
VMA (%):	13.7	13.1	13.3	13.4
Voids Filled (%):	63.3	76.0	83.6	92.0
Dust to Asphalt Ratio:	1.3	1.1	1.0	0.9
Hveem Stability:	46	48	41	38

	Properties at Optimum	***Specifications***
Asphalt Content (%):	**4.9**	
Bulk Sp. G.:	**2.366**	
Maximum Sp. G.:	**2.455**	
Max. Theoretical Unit Wt. (pcf):	**153.2**	
Air Voids (%) @ N-Initial:	**10.9**	
Air Voids (%) @ N-Design:	**3.6**	***3.5 to 4.5***
VMA (%):	**13.3**	***13.3 min. @ 3.6 voids***
Voids Filled (%):	**72.9**	***65-75***
Hveem Stability:	**46**	***30 min.***
Dust to Asphalt Ratio:	**1.2**	

Effect of Moisture on Asphalt Paving Mixtures

CDOT CP-L 5109, Method B

Asphalt Content (%):	**4.9**	
Additive Type:	***Lime***	
Air Voids (%):	**6.5**	***6 to 8***
Saturation (%):	**94.7**	
Indirect Tensile Strength (Wet)(psi):	**99**	
Indirect Tensile Strength (Dry)(psi):	**97**	***30 min.***
Tensile Strength Ratio (%):	**102**	***80 min.***

Optimum properties are based on a best fit curve of all data points.

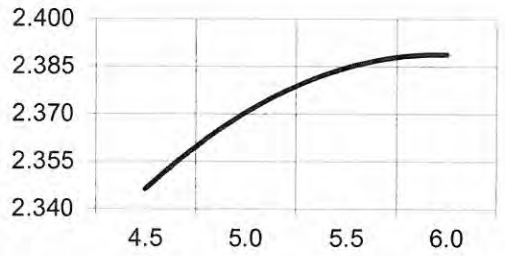
Design # 72235311

TEST PROPERTY CURVES

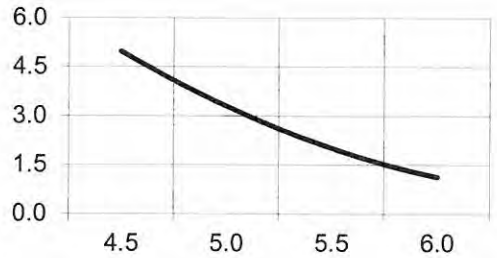
Client: *Northern*
Grading: *S (3/4 in. Nominal)*
Agg Source: *35th Avenue/RAP*

Asphalt Cement Content (%):	4.9
Lab Bulk Sp. Gr.:	2.366
Maximum Sp. G.:	2.455
Theoretical Max Unit Wt. (pcf):	153.2
Air Voids (%) @ N-Initial:	10.9
Air Voids (%) @ N-Design:	3.6
V.M.A. (%):	13.3
Voids Filled (%):	72.9
Hveem Stability:	46

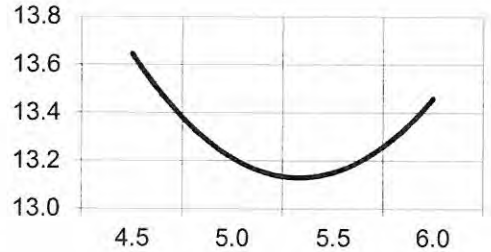
BULK SPECIFIC GRAVITY



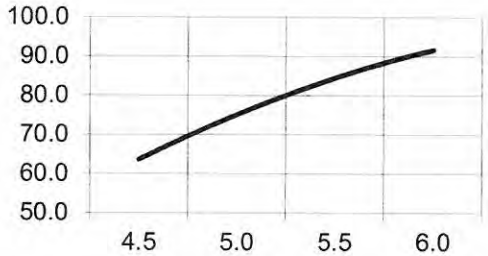
AIR VOIDS (%)



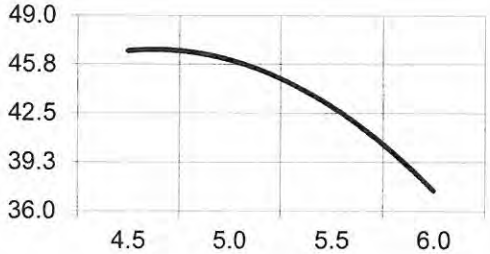
VMA (%)



VFA (%)



HVEEM STABILITY



Design # 72235311

AGGREGATE PHYSICAL PROPERTIES
(does not include Lime or RAP)

Client:	*Northern*
Aggregate Source:	*35th Avenue/RAP*
Grading:	*S (3/4 in. Nominal)*

		Combined Blend	***Specifications***
Bulk Specific Gravity (Agg):	*CDOT (CP-L 4102 & 4103)*	2.597	
Apparent Specific Gravity (Agg):		2.655	
Effective Specific Gravity (Agg):		2.644	
Bulk Specific Gravity Plus #4 (Agg):		2.604	
Bulk Specific Gravity Minus #4 (Agg):		2.575	
Combined Blend Absorption (Agg):		1.06	
L.A. Abrasion Plus 4 Material (%):	*AASHTO (T-96)*	28	***45 max.***
Sodium Sulfate Soundeness (%):	*AASHTO (T-88)*	2.5	***12 max.***
Fractured Faces (2 or more) (%):	*CDOT (CP 45)*	94	***80 min.***
Fine Aggregate Angularity, Method A:	*CDOT (CP-L 5113)*	45	***45 min.***
Plasticity Index:	*AASHTO (T-90)*	NP	***Non-plastic***
Sand Equivalent:	*ASTM (D 2419)*	56	***45 min.***
Flat and Elongated Particles (%):	*CDOT (CP 33)*	1.5	***10 max.***
Adherent Fines (%):	*ASTM (D 5711)*	0.40	***0.5 max.***
Micro-Deval (%):	*CDOT (CP-L 4211)*	10.3	***18% max.***

Design # 72235311

f. Mix Design for Section 2

9/26/2011

1800 N. Taft Hill Road
Fort Collins, CO 80521

Attn: Mr. Jerimy Runner

Re: Hot Mix Asphalt Mix Design

Grading:	S (3/4 in. Nominal)
Compaction:	Superpave 75
Aggregate:	35th Avenue/RAP/RAS
Mix Design No.:	72225411
Q2C No.:	AS4354

This letter represents the results of a hot mix asphalt mixture design by the Superpave Method, utilizing 75 gyrations at 1.25° in accordance with Colorado Department of Transportation Manual of Test Procedures and as outlined by Asphalt Institute Manual, Series No.2 (SP-2).

The 35th Avenue/RAP/RAS aggregates and Suncor PG 64-28 asphalt cement used in this mix design were proportioned in accordance with your request as detailed in the blend table of this design.

Properties of this mixture are:

Percent Asphalt:	5.2
Air Voids, %	3.5
VMA, %	13.4
VFA, %	74.0
Hveem Stability	46
Max. Theoretical Specific Gravity (Rice)	2.455

The aggregate blend sheet, mix design physical properties, mix design property curves, and combined aggregate properties are presented on the enclosed forms.

Please do not hesitate to contact Engineering Services with any questions concerning this report.

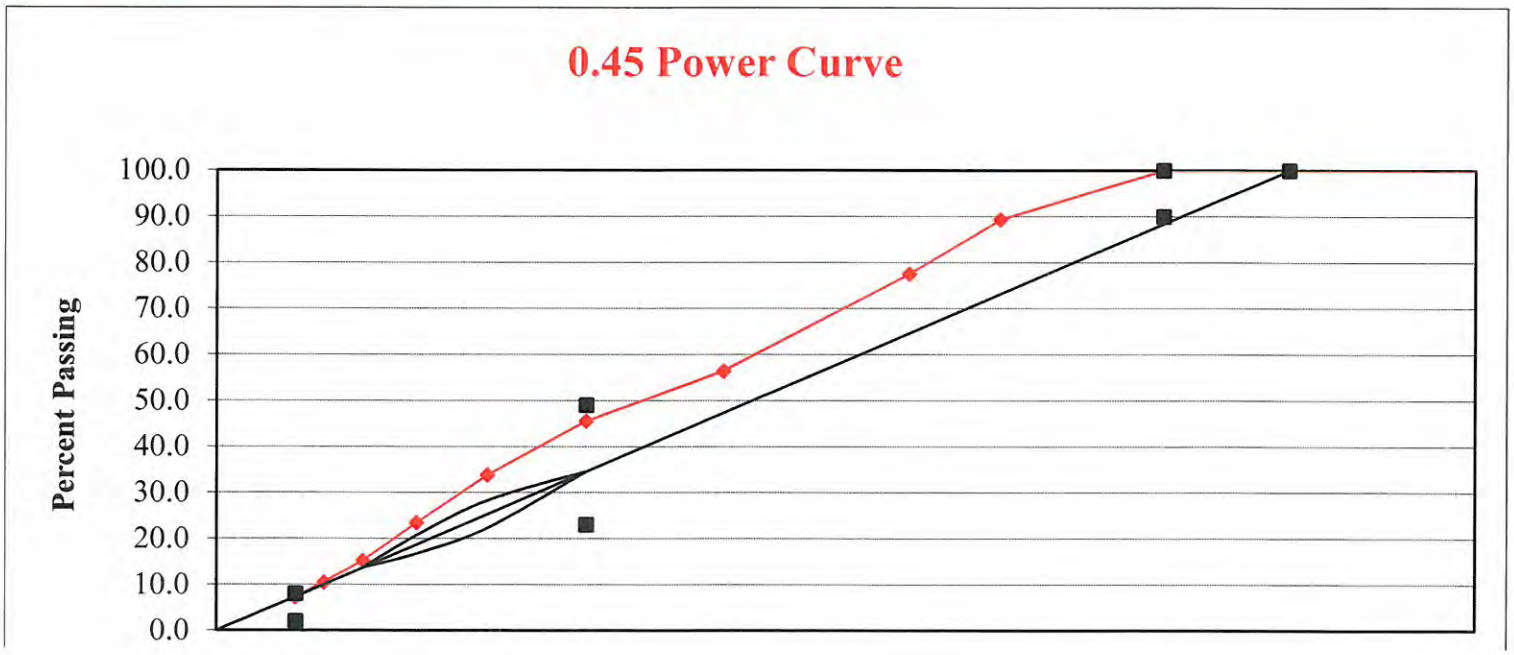
Sincerely,

An AASHTO Accredited Lab

Todd M. Genovese, P.E.
Metro Denver QC Manager
Enclosures

Date:	9/26/2011	**Client:**	Northern
Design Number:	72225411	**Binder:**	PG 64-28
Grading:	S (3/4 in. Nominal)	**Supplier:**	Suncor
Design Type:	Superpave 75	**Specific Gravity:**	1.040
Aggregate Source:	35th Avenue/RAP/RAS	**Additive:**	Lime

% Material Used:	27%	12%	16%	11%	10%	3%	20%	1%	**100% JMF**	**Control Points**
Material Type:	3/4" Rock	1/2" Rock	Crusher Fines	Native Fines	Concrete Sand	3/8" RAS	Crushed RAP	Hydrated Lime		
Material Source:	35th Ave	35th Ave	35th Ave	35th Ave	35th Ave	Hugo	35th Ave	Pete Lien		
1-1/2" (37.5 mm)	100	100	100	100	100	100	100	100	100	
1" (25.0 mm)	100	100	100	100	100	100	100	100	100	100
3/4" (19.0 mm)	100	100	100	100	100	100	100	100	100	90-100
1/2" (12.5 mm)	65	98	100	99	100	100	96	100	89	
3/8" (9.5 mm)	42	67	100	95	100	100	89	100	78	
#4 (4.75 mm)	9	9	96	80	100	100	74	100	56	
#8 (2.36 mm)	6	5	68	63	97	100	59	100	46	23-49
#16 (1.18 mm)	4	4	47	47	70	80	46	100	34	
#30 (600 µm)	4	3	33	32	38	54	34	100	23	
#50 (300 µm)	3	3	21	20	13	47	24	100	15	
#100 (150 µm)	3	2	13	14	3	38	17	100	11	
#200 (75 µm)	1.9	1.7	8.4	9.5	1.7	29.7	10.5	98.0	7.2	2.0-8.0
Bulk Specific Gravity	2.605	2.609	2.577	2.526	2.604	2.628		2.380	**2.595**	
App. Specific Gravity	2.669	2.674	2.649	2.639	2.670	2.628		2.380	**2.650**	
Eff. Specific Gravity	2.656	2.661	2.634	2.616	2.657	2.628		2.380	**2.639**	
Percent Asphalt in Recycle Material:						24.36	3.29			



HOT MIX ASPHALT MIX DESIGN PHYSICAL PROPERTIES

Client:	Northern		
Mix Grading:	S (3/4 in. Nominal)		
Aggregate Source:	35th Avenue/RAP/RAS		
Asphalt Cement Source:	Suncor		
Asphalt Cement Grade:	PG 64-28	***Asphalt Cement Specific Gravity:***	1.040
Additive Type:	Lime		
Compaction Method:	Superpave		
Temperature Mixing (°F) =	325	***Compaction (°F) =***	300

Asphalt Content (%):	**3.8**	**4.8**	**5.8**	**6.8**
Bulk Sp. G.:	2.285	2.351	2.387	2.390
Maximum Sp. G.:	2.500	2.464	2.429	2.395
Theoretical Max Unit Wt. (pcf):	156.0	153.8	151.6	149.4
Air Voids (%) @ N-Design:	8.6	4.6	1.7	0.2
VMA (%):	15.3	13.7	13.3	14.2
Voids Filled (%):	43.7	66.6	87.0	98.5
Dust to Asphalt Ratio:	1.6	1.3	1.1	0.9
Hveem Stability:	37	47	42	32

	Properties at Optimum	***Specifications***
Asphalt Content (%):	**5.2**	
Bulk Sp. G.:	**2.369**	
Maximum Sp. G.:	**2.455**	
Max. Theoretical Unit Wt. (pcf):	**153.2**	
Air Voids (%) @ N-Design:	**3.5**	***3.5 to 4.5***
VMA (%):	**13.4**	***13.2 min. @ 3.5 voids***
Voids Filled (%):	**74.0**	***65-78***
Hveem Stability:	**46**	***30 min.***
Dust to Asphalt Ratio:	**1.2**	

Effect of Moisture on Asphalt Paving Mixtures

CDOT CP-L 5109, Method B

Asphalt Content (%):	**5.2**	
Additive Type:	***Lime***	
Air Voids (%):	**6.1**	***6 to 8***
Saturation (%):	**90.1**	
Indirect Tensile Strength (Wet)(psi):	**86**	
Indirect Tensile Strength (Dry)(psi):	**91**	***30 min.***
Tensile Strength Ratio (%):	**95**	***80 min.***

Optimum properties are based on a best fit curve of all data points.

Design # 72225411

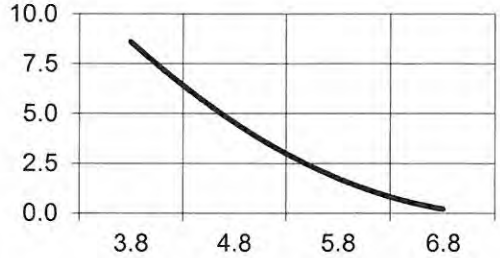
TEST PROPERTY CURVES

Client: *Northern*
Grading: *S (3/4 in. Nominal)*
Agg Source: *35th Avenue/RAP/RAS*

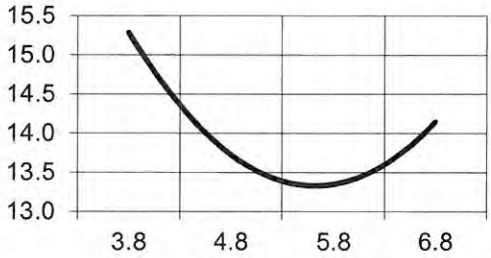
Asphalt Cement Content (%):	5.2
Lab Bulk Sp. Gr.:	2.369
Maximum Sp. G.:	2.455
Theoretical Max Unit Wt. (pcf):	153.2
Air Voids (%) @ N-Design:	3.5
V.M.A. (%):	13.4
Voids Filled (%):	74.0
Hveem Stability:	46

BULK SPECIFIC GRAVITY

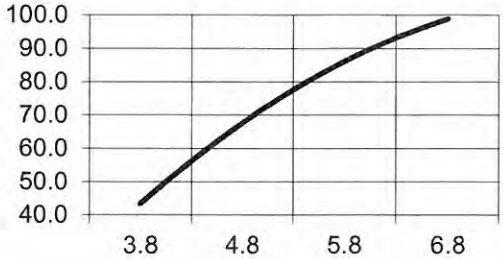
AIR VOIDS (%)



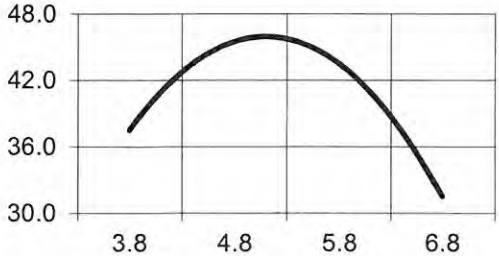
VMA (%)



VFA (%)



HVEEM STABILITY



Design # 72225411

AGGREGATE PHYSICAL PROPERTIES
(does not include Lime or RAP)

Client:	*Northern*
Aggregate Source:	*35th Avenue/RAP/RAS*
Grading:	*S (3/4 in. Nominal)*

		Combined Blend	***Specifications***
Bulk Specific Gravity (Agg):	*CDOT (CP-L 4102 & 4103)*	2.590	
Apparent Specific Gravity (Agg):		2.660	
Effective Specific Gravity (Agg):		2.646	
Bulk Specific Gravity Plus #4 (Agg):		2.605	
Bulk Specific Gravity Minus #4 (Agg):		2.572	
Combined Blend Absorption (Agg):		1.07	
L.A. Abrasion Plus 4 Material (%):	*AASHTO (T-96)*	28	***45 max.***
Sodium Sulfate Soundeness (%):	*AASHTO (T-88)*	2.3	***12 max.***
Fractured Faces (2 or more) (%):	*CDOT (CP 45)*	94	***80 min.***
Fine Aggregate Angularity, Method A:	*CDOT (CP-L 5113)*	45	***45 min.***
Plasticity Index:	*AASHTO (T-90)*	NP	***Non-plastic***
Sand Equivalent:	*ASTM (D 2419)*	56	***45 min.***
Flat and Elongated Particles (%):	*CDOT (CP 33)*	1.3	***10 max.***
Adherent Fines (%):	*ASTM (D 5711)*	0.42	***0.5 max.***
Micro-Deval (%):	*CDOT (CP-L 4211)*	9.1	***18% max.***

Design # 72225411

g. Mix Design for Section 3

9/26/2011

1800 N. Taft Hill Road
Fort Collins, CO 80521

Attn: Mr. Jerimy Runner

Re: Hot Mix Asphalt Mix Design

Grading:	S (3/4 in. Nominal)
Compaction:	Superpave 100
Aggregate:	35th Avenue/RAP/GTR
Mix Design No.:	72230311
Q2C No.:	AS4352

This letter represents the results of a hot mix asphalt mixture design by the Superpave Method, utilizing 100 gyrations at 1.25° in accordance with Colorado Department of Transportation Manual of Test Procedures and as outlined by Asphalt Institute Manual, Series No.2 (SP-2).

The 35th Avenue/RAP/GTR aggregates and PG 64-28 asphalt cement with GTR used in this mix design were proportioned in accordance with your request as detailed in the blend table of this design.

Properties of this mixture are:

Percent Asphalt:	4.9
Air Voids, %	3.5
VMA, %	13.2
VFA, %	73.4
Hveem Stability	46
Max. Theoretical Specific Gravity (Rice)	2.454

The aggregate blend sheet, mix design physical properties, mix design property curves, and combined aggregate properties are presented on the enclosed forms.

Please do not hesitate to contact Engineering Services with any questions concerning this report.

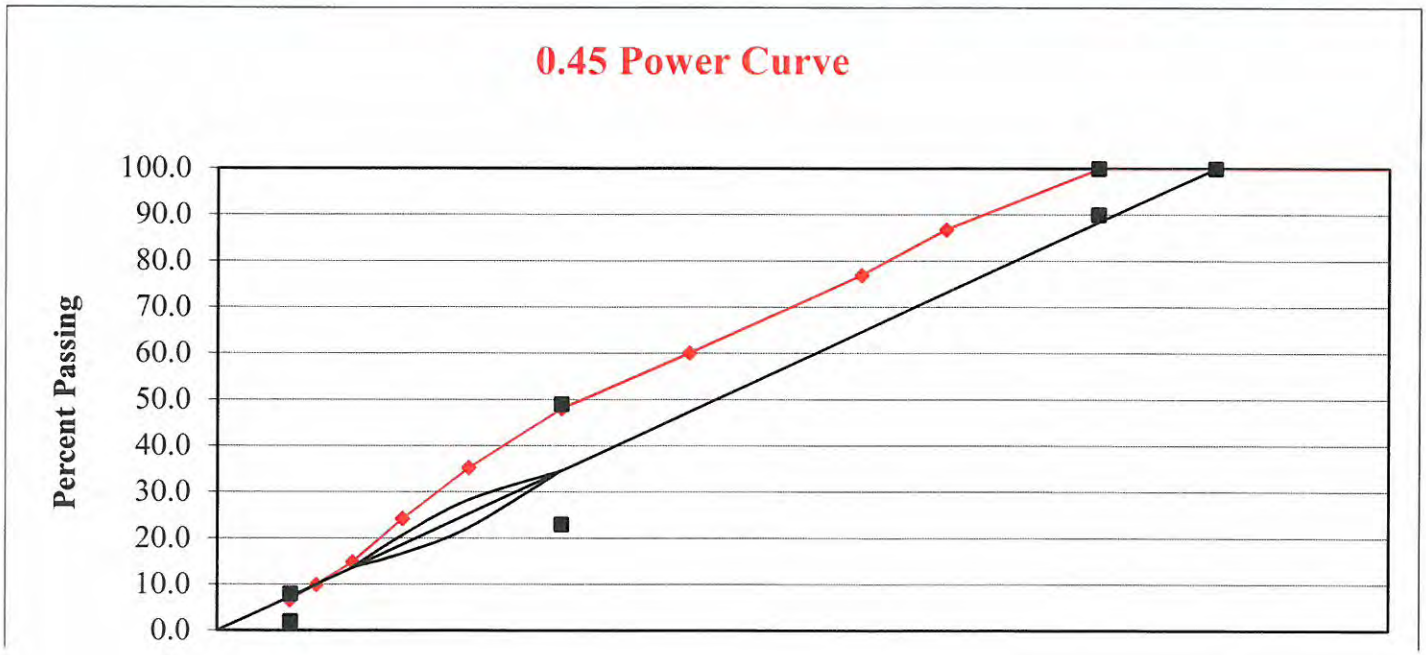
Sincerely,

An AASHTO Accredited Lab

Todd M. Genovese, P.E.
Metro Denver QC Manager
Enclosures

Date:	9/26/2011	**Client:**	Northern
Design Number:	72230311	**Binder:**	PG 64-28
Grading:	S (3/4 in. Nominal)	**Supplier:**	
Design Type:	Superpave 100	**Specific Gravity:**	1.031
Aggregate Source:	35th Avenue/RAP/GTR	**Additive:**	Lime

% Material Used:	35%	21%	10%	13%		20%	1%	**100% JMF**	**Control Points**
Material Type:	3/4" Rock	Crusher Fines	Native Fines	Concrete Sand		Crushed RAP	Hydrated Lime		
Material Source:	35th Ave	35th Ave	35th Ave	35th Ave		35th Ave	Pete Lien		
1-1/2" (37.5 mm)	100	100	100	100		100	100	100	
1" (25.0 mm)	100	100	100	100		100	100	100	100
3/4" (19.0 mm)	100	100	100	100		100	100	100	90-100
1/2" (12.5 mm)	65	100	99	100		96	100	87	
3/8" (9.5 mm)	42	100	95	100		89	100	77	
#4 (4.75 mm)	9	96	80	100		74	100	60	
#8 (2.36 mm)	6	68	63	97		59	100	48	23-49
#16 (1.18 mm)	4	47	47	70		46	100	35	
#30 (600 µm)	4	33	32	38		34	100	24	
#50 (300 µm)	3	21	20	13		24	100	15	
#100 (150 µm)	3	13	14	3		17	100	10	
#200 (75 µm)	1.9	8.4	9.5	1.7		10.5	98.0	6.7	2.0-8.0
Bulk Specific Gravity	2.605	2.577	2.526	2.604		2.637	2.380	**2.595**	
App. Specific Gravity	2.669	2.649	2.639	2.670		2.637	2.380	**2.652**	
Eff. Specific Gravity	2.656	2.634	2.616	2.657		2.637	2.380	**2.641**	
Percent Asphalt in RAP						3.29			



HOT MIX ASPHALT MIX DESIGN PHYSICAL PROPERTIES

Client:	Northern		
Mix Grading:	S (3/4 in. Nominal)		
Aggregate Source:	35th Avenue/RAP/GTR		
Asphalt Cement Source:			
Asphalt Cement Grade:	PG 64-28	***Asphalt Cement Specific Gravity:***	1.031
Additive Type:	Lime		
Compaction Method:	Superpave		
Temperature Mixing (°F) =	325	***Compaction (°F) =***	300

Asphalt Content (%):	**4.5**	**5.0**	**5.5**	**6.0**
Bulk Sp. G.:	2.350	2.374	2.387	2.393
Maximum Sp. G.:	2.474	2.456	2.439	2.421
Theoretical Max Unit Wt. (pcf):	154.4	153.3	152.2	151.1
Air Voids (%) @ N-Design:	5.0	3.3	2.1	1.2
VMA (%):	13.5	13.1	13.1	13.3
Voids Filled (%):	62.9	74.5	83.7	91.3
Dust to Asphalt Ratio:	1.3	1.1	1.0	0.9
Hveem Stability:	43	47	42	39

	Properties at Optimum	***Specifications***
Asphalt Content (%):	**4.9**	
Bulk Sp. G.:	**2.369**	
Maximum Sp. G.:	**2.454**	
Max. Theoretical Unit Wt. (pcf):	**153.1**	
Air Voids (%) @ N-Design:	**3.5**	***3.5 to 4.5***
VMA (%):	**13.2**	***13.2 min. @ 3.5 voids***
Voids Filled (%):	**73.4**	***65-75***
Hveem Stability:	**46**	***30 min.***
Dust to Asphalt Ratio:	**1.2**	

Effect of Moisture on Asphalt Paving Mixtures

CDOT CP-L 5109, Method B

Asphalt Content (%):	**4.9**	
Additive Type:	***Lime***	
Air Voids (%):	**6.7**	***6 to 8***
Saturation (%):	**91.5**	
Indirect Tensile Strength (Wet)(psi):	**91**	
Indirect Tensile Strength (Dry)(psi):	**95**	***30 min.***
Tensile Strength Ratio (%):	**96**	***80 min.***

Optimum properties are based on a best fit curve of all data points.

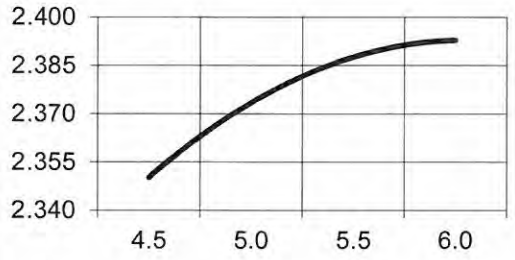
Design # 72230311

TEST PROPERTY CURVES

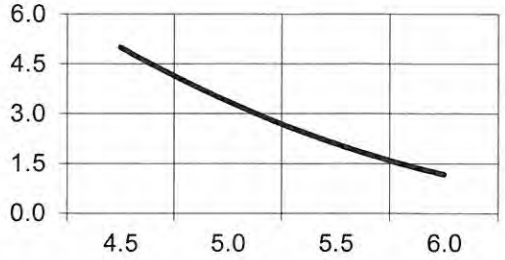
Client: *Northern*
Grading: *S (3/4 in. Nominal)*
Agg Source: *35th Avenue/RAP/GTR*

Asphalt Cement Content (%):	4.9
Lab Bulk Sp. Gr.:	2.369
Maximum Sp. G.:	2.454
Theoretical Max Unit Wt. (pcf):	153.1
Air Voids (%) @ N-Design:	3.5
V.M.A. (%):	13.2
Voids Filled (%):	73.4
Hveem Stability:	46

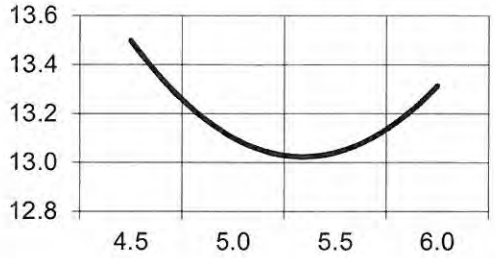
BULK SPECIFIC GRAVITY



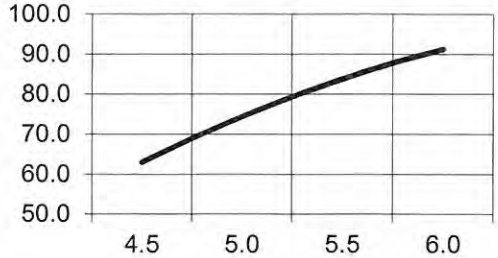
AIR VOIDS (%)



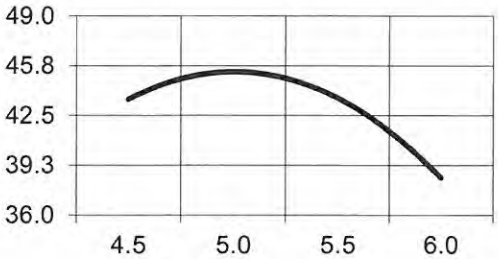
VMA (%)



VFA (%)



HVEEM STABILITY



Design # 72230311

AGGREGATE PHYSICAL PROPERTIES
(does not include Lime or RAP)

Client:	*Northern*
Aggregate Source:	*35th Avenue/RAP/GTR*
Grading:	*S (3/4 in. Nominal)*

		Combined Blend	***Specifications***
Bulk Specific Gravity (Agg):	*CDOT (CP-L 4102 & 4103)*	2.597	
Apparent Specific Gravity (Agg):		2.655	
Effective Specific Gravity (Agg):		2.644	
Bulk Specific Gravity Plus #4 (Agg):		2.604	
Bulk Specific Gravity Minus #4 (Agg):		2.575	
Combined Blend Absorption (Agg):		1.06	
L.A. Abrasion Plus 4 Material (%):	*AASHTO (T-96)*	28	***45 max.***
Sodium Sulfate Soundeness (%):	*AASHTO (T-88)*	2.5	***12 max.***
Fractured Faces (2 or more) (%):	*CDOT (CP 45)*	94	***80 min.***
Fine Aggregate Angularity, Method A:	*CDOT (CP-L 5113)*	45	***45 min.***
Plasticity Index:	*AASHTO (T-90)*	NP	***Non-plastic***
Sand Equivalent:	*ASTM (D 2419)*	56	***45 min.***
Flat and Elongated Particles (%):	*CDOT (CP 33)*	1.5	***10 max.***
Adherent Fines (%):	*ASTM (D 5711)*	0.40	***0.5 max.***
Micro-Deval (%):	*CDOT (CP-L 4211)*	10.3	***18% max.***

h. Mix Design for Section 4

9/26/2011

1800 N. Taft Hill Road
Fort Collins, CO 80521

Attn: Mr. Jerimy Runner

Re: Hot Mix Asphalt Mix Design

Grading:	S (3/4 in. Nominal)
Compaction:	Superpave 75
Aggregate:	35th Avenue/RAP/RAS/GTR
Mix Design No.:	72220411
Q2C No.:	AS4353

This letter represents the results of a hot mix asphalt mixture design by the Superpave Method, utilizing 75 gyrations at 1.25° in accordance with Colorado Department of Transportation Manual of Test Procedures and as outlined by Asphalt Institute Manual, Series No.2 (SP-2).

The 35th Avenue/RAP/RAS/GTR aggregates and PG 64-28 asphalt cement with GTR used in this mix design were proportioned in accordance with your request as detailed in the blend table of this design.

Properties of this mixture are:

Percent Asphalt:	5.2
Air Voids, %	3.7
VMA, %	14.0
VFA, %	73.6
Hveem Stability	55
Max. Theoretical Specific Gravity (Rice)	2.445

The aggregate blend sheet, mix design physical properties, mix design property curves, and combined aggregate properties are presented on the enclosed forms.

Please do not hesitate to contact Engineering Services with any questions concerning this report.

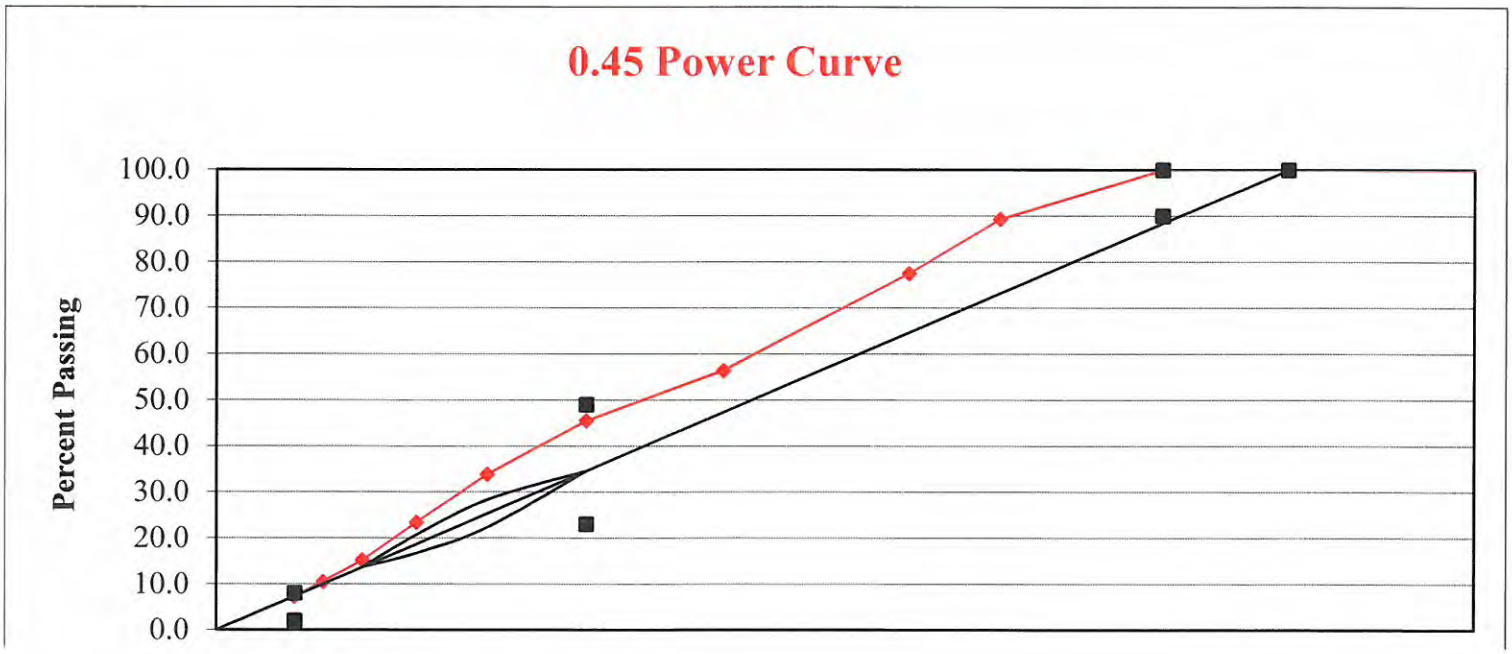
Sincerely,

An AASHTO Accredited Lab

Todd M. Genovese, P.E.
Metro Denver QC Manager
Enclosures

Date:	9/26/2011	**Client:**	Northern
Design Number:	72220411	**Binder:**	PG 64-28
Grading:	S (3/4 in. Nominal)	**Supplier:**	
Design Type:	Superpave 75	**Specific Gravity:**	1.049
Aggregate Source:	35th Avenue/RAP/RAS/GTR	**Additive:**	Lime + GTR

% Material Used:	27%	12%	16%	11%	10%	3%	20%	1%	**100% JMF**	**Control Points**
Material Type:	3/4" Rock	1/2" Rock	Crusher Fines	Native Fines	Concrete Sand	3/8" RAS	Crushed RAP	Hydrated Lime		
Material Source:	35th Ave	35th Ave	35th Ave	35th Ave	35th Ave	Hugo	35th Ave	Pete Lien		
1-1/2" (37.5 mm)	100	100	100	100	100	100	100	100	100	
1" (25.0 mm)	100	100	100	100	100	100	100	100	100	100
3/4" (19.0 mm)	100	100	100	100	100	100	100	100	100	90-100
1/2" (12.5 mm)	65	98	100	99	100	100	96	100	89	
3/8" (9.5 mm)	42	67	100	95	100	100	89	100	78	
#4 (4.75 mm)	9	9	96	80	100	100	74	100	56	
#8 (2.36 mm)	6	5	68	63	97	100	59	100	46	23-49
#16 (1.18 mm)	4	4	47	47	70	80	46	100	34	
#30 (600 µm)	4	3	33	32	38	54	34	100	23	
#50 (300 µm)	3	3	21	20	13	47	24	100	15	
#100 (150 µm)	3	2	13	14	3	38	17	100	11	
#200 (75 µm)	1.9	1.7	8.4	9.5	1.7	29.7	10.5	98.0	7.2	2.0-8.0
Bulk Specific Gravity	2.605	2.609	2.577	2.526	2.604	2.628		2.380	**2.595**	
App. Specific Gravity	2.669	2.674	2.649	2.639	2.670	2.628		2.380	**2.650**	
Eff. Specific Gravity	2.656	2.661	2.634	2.616	2.657	2.628		2.380	**2.639**	
Percent Asphalt in Recycle Material:						24.36	3.29			



HOT MIX ASPHALT MIX DESIGN PHYSICAL PROPERTIES

Client:	Northern		
Mix Grading:	S (3/4 in. Nominal)		
Aggregate Source:	35th Avenue/RAP/RAS/GTR		
Asphalt Cement Source:			
Asphalt Cement Grade:	PG 64-28	***Asphalt Cement Specific Gravity:***	1.049
Additive Type:	Lime + GTR		
Compaction Method:	Superpave		
Temperature Mixing (°F) =	325	***Compaction (°F) =***	300

Asphalt Content (%):	**3.8**	**4.8**	**5.8**	**6.8**
Bulk Sp. G.:	2.261	2.315	2.362	2.366
Maximum Sp. G.:	2.489	2.453	2.418	2.384
Theoretical Max Unit Wt. (pcf):	155.3	153.1	150.9	148.8
Air Voids (%) @ N-Design:	9.2	5.6	2.3	0.8
VMA (%):	16.2	15.1	14.2	15.0
Voids Filled (%):	43.4	62.7	83.7	95.0
Dust to Asphalt Ratio:	1.6	1.3	1.1	0.9
Hveem Stability:	42	56	51	39

	Properties at Optimum	***Specifications***
Asphalt Content (%):	**5.2**	
Bulk Sp. G.:	**2.354**	
Maximum Sp. G.:	**2.445**	
Max. Theoretical Unit Wt. (pcf):	**152.6**	
Air Voids (%) @ N-Design:	**3.7**	***3.5 to 4.5***
VMA (%):	**14.0**	***13.4 min. @ 3.7 voids***
Voids Filled (%):	**73.6**	***65-78***
Hveem Stability:	**55**	***30 min.***
Dust to Asphalt Ratio:	**1.2**	

Effect of Moisture on Asphalt Paving Mixtures

CDOT CP-L 5109, Method B

Asphalt Content (%):	**5.2**	
Additive Type:	***Lime***	
Air Voids (%):	**7.2**	***6 to 8***
Saturation (%):	**92.5**	
Indirect Tensile Strength (Wet)(psi):	**87**	
Indirect Tensile Strength (Dry)(psi):	**94**	***30 min.***
Tensile Strength Ratio (%):	**93**	***80 min.***

Optimum properties are based on a best fit curve of all data points.

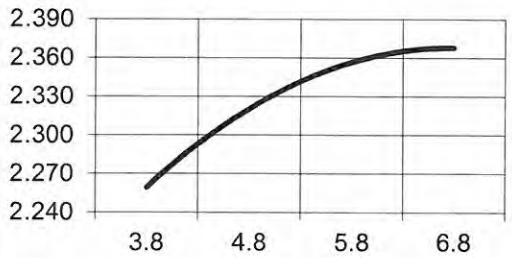
Design # 72220411

TEST PROPERTY CURVES

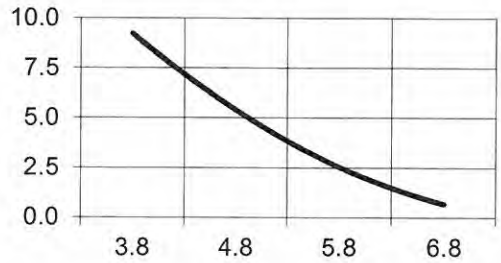
Client: *Northern*
Grading: *S (3/4 in. Nominal)*
Agg Source: *35th Avenue/RAP/RAS/GTR*

Asphalt Cement Content (%):	5.2
Lab Bulk Sp. Gr.:	2.354
Maximum Sp. G.:	2.445
Theoretical Max Unit Wt. (pcf):	152.6
Air Voids (%) @ N-Design:	3.7
V.M.A. (%):	14.0
Voids Filled (%):	73.6
Hveem Stability:	55

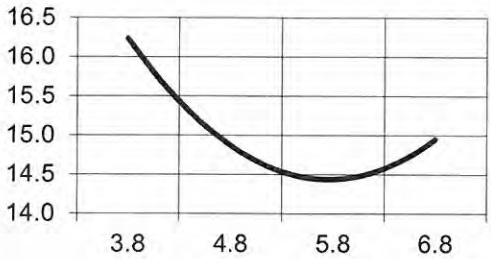
BULK SPECIFIC GRAVITY



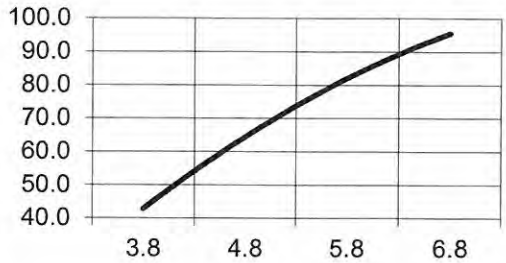
AIR VOIDS (%)



VMA (%)



VFA (%)



HVEEM STABILITY

Design # 72220411

AGGREGATE PHYSICAL PROPERTIES
(does not include Lime or RAP)

Client:	*Northern*
Aggregate Source:	*35th Avenue/RAP/RAS/GTR*
Grading:	*S (3/4 in. Nominal)*

		Combined Blend	***Specifications***
Bulk Specific Gravity (Agg):	*CDOT (CP-L 4102 & 4103)*	2.590	
Apparent Specific Gravity (Agg):		2.660	
Effective Specific Gravity (Agg):		2.646	
Bulk Specific Gravity Plus #4 (Agg):		2.605	
Bulk Specific Gravity Minus #4 (Agg):		2.572	
Combined Blend Absorption (Agg):		1.07	
L.A. Abrasion Plus 4 Material (%):	*AASHTO (T-96)*	28	***45 max.***
Sodium Sulfate Soundeness (%):	*AASHTO (T-88)*	2.3	***12 max.***
Fractured Faces (2 or more) (%):	*CDOT (CP 45)*	94	***80 min.***
Fine Aggregate Angularity, Method A:	*CDOT (CP-L 5113)*	45	***45 min.***
Plasticity Index:	*AASHTO (T-90)*	NP	***Non-plastic***
Sand Equivalent:	*ASTM (D 2419)*	56	***45 min.***
Flat and Elongated Particles (%):	*CDOT (CP 33)*	1.3	***10 max.***
Adherent Fines (%):	*ASTM (D 5711)*	0.42	***0.5 max.***
Micro-Deval (%):	*CDOT (CP-L 4211)*	9.1	***18% max.***

Design # 72220411

i. Modified Asphalt Solutions Brochure

IT'S OUR PEOPLE THAT SET US APART!

Modified Asphalt Solutions is the industry leader in Terminally Blended GTR Modified Asphalt Technologies

- **Our knowledgeable staff of respected industry professionals sets us apart from our competition.**
- **We combine 75 years of collective experience in the rubber and chemical industries with over 50 years of collective asphalt and pavement design experience.**
- **We specialize in cradle-to-grave customer service and hands-on technical consulting.**
- **Compare us to the competition, we are prepared to earn your business!**

For additional technical information,
or to contact one of our regional consultants,
please visit our website:

www.modifiedasphaltsolutions.com

modified asphalt solutions™

Ground Tire Rubber Modified Asphalt

A cost-effective alternative that meets the performance of conventional polymer or rubber modified asphalt

modified asphalt solutions™

GTR Modified Asphalt is Environmentally Friendly

- Recycles used tires and frees landfills
- 10-15% reduction in plant emissions
- Reduced fumes at plant and jobsite
- Reduced use of truck bed release agents
- Improved performance at lower temperatures
- Improved Public Relations and Acceptance

Waste tire disposal has been a controversial environmental issue for decades.

Modified Asphalt Solutions teams with GTR producers to provide a useful product and market for recycled tire rubber.

The result, as the time lapse photos show, is a cleaner environment and improved hot mix and chip seal performance for your customers.

From environmental problem to high-performance pavement solutions

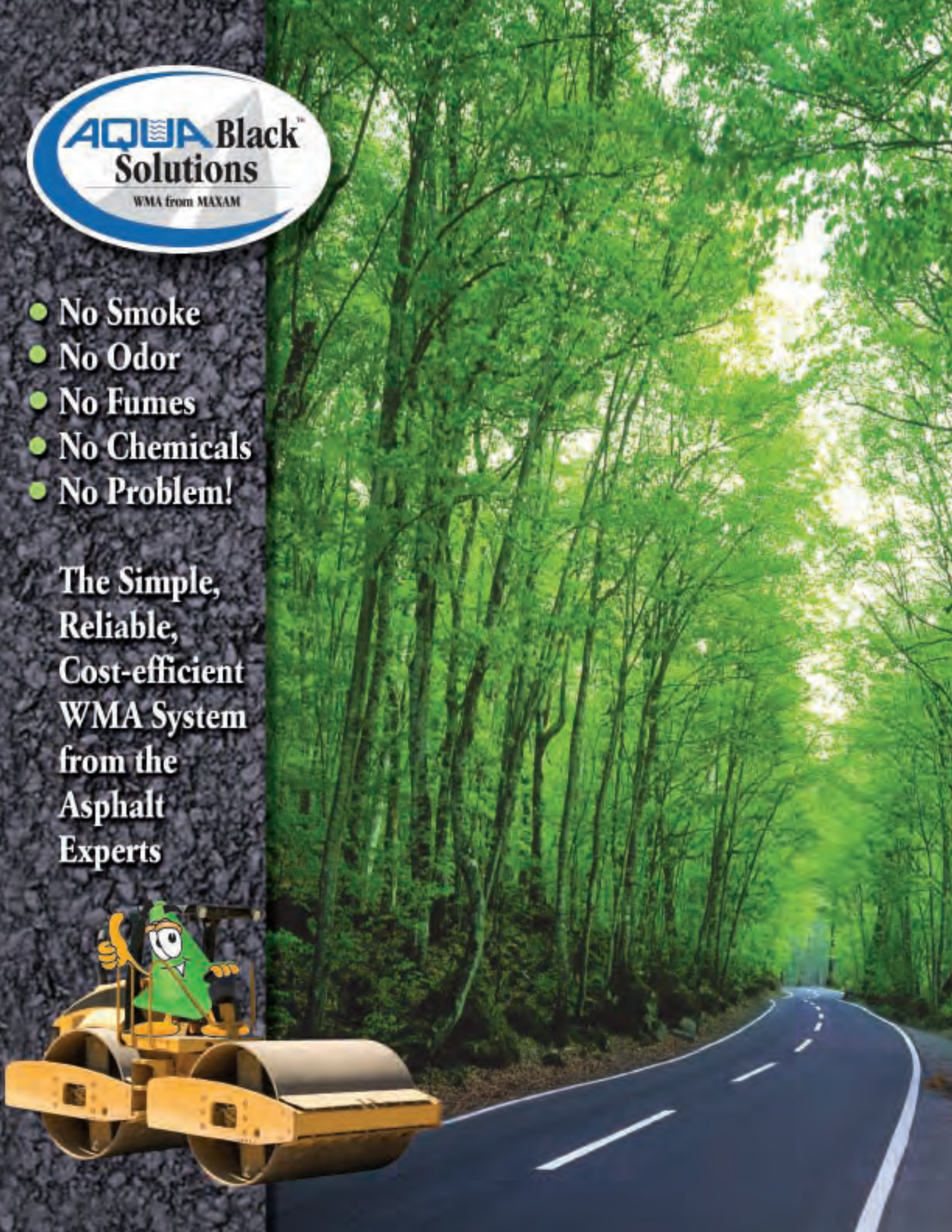
GTR Modified Asphalt Enhances Mix Performance

- Improved mix workability at lower temperatures
- Improved compaction
- Improved joint construction
- Improved rut resistance
- Improved thermal cracking resistance
- Reduced road noise

GTR Modified Asphalt is a Proven Technology

- Specified by several DOTs and tollway authorities
- Successful partnerships in warm mix industry
- Successful partnerships in the recycled shingle industry
- Successful partnerships with academic and federal testing programs
- Numerous partnerships with well-respected terminals across USA

j. Maxam AQUABLACK™ System Brochure


AQUA Black™
Solutions
WMA from MAXAM
No Smoke
No Odor
No Fumes
No Chemicals
No Problem!
The Simple, Reliable, Cost-efficient WMA System from the Asphalt Experts

Benefits:

- No smoke - no odor
- Quick & easy installation
- Retrofit ANY plant
- Easy to operate
- Lower fuel costs
- Reduce labor costs
- Improve worker safety
- Reduce emissions
- Run more RAP

Purchase for Less
The AQUABLACK™ System costs significantly less than most of the WMA systems currently available. In some cases, half the price. It is designed with simplicity and reliability in mind by the world's foremost experts in asphalt plant retrofit applications - MAXAM.

Quick and Easy Installation
The flexible system retrofits onto any plant and can easily be installed over a weekend. We send a Field Technician to your site for two days to help. Your own maintenance crew can do it, or you can have MAXAM do it for you.

The unit comes completely assembled. Simply attach it to your A/C line, hook it up to a water source, install the control panel, and you're ready to go.

Training takes only about an hour since operation is so simple. Once it's set up, you simply turn it on or off as needed.

Hot Mix Asphalt

Warm Mix Asphalt

Run More RAP
Lower temperatures means you can run more RAP and stay within the temperature limits of your baghouse.

Save Time
In field tests, AQUABLACK™ warm mix asphalt consistently reaches targeted compaction rates with fewer roller passes. It also enables paving in cooler weather, extends the paving season, and permits faster release of the pavement to traffic. As the air bubbles created in the foaming process are completely removed during the rolling and compaction process, superior in-place densities are achieved with less rolling effort. In some cases, 25% less.

Reduce Fuel Consumption
Lower temperatures means lower fuel consumption. Often as much as 15%. It also means the exhaust fan doesn't have to work as hard, saving energy spent on moving air.

Reduce Emissions
Lower fuel consumption translates directly into lower emission of greenhouse gases at the plant from drying and heating of the aggregate. The fumes and smoke at the plant load-out, and at the laydown site, are also eliminated.

Simplify Maintenance
Some WMA systems use 10 or more solenoids to control critical components. We thought simpler was better. We thought you'd rather be running your plant than running to get replacement parts.

Extend Equipment Life
Lower temperatures reduces the wear and tear on equipment; extends maintenance intervals and reduces overall maintenance costs.

Stainless Steel
Foaming Gun

Components:

PLC Based Touch Screen Control Panel
The touch-screen Control Panel is mounted in the control house and easily connected to the metering system using multi-conductor cable. When the operator sets max tons on the control panel, the system automatically calculates the correct amount of water to be injected into the WMA, and sets the water pump drive to the proper output rate. A flow meter monitors flow rate and sounds a warning if it goes out of the optimum range.

High-pressure Variable Speed Metering System
The high-pressure variable speed metering system comes completely pre-piped and prewired, and is enclosed in a weather tight enclosure. The enclosure allows for heating of the system in cold weather to prevent freezing. The system is equipped with an automatic compressed air purge that cleans water out of the delivery line upon shutdown.

AQUABLACK™ Foaming Gun
The AQUABLACK™ Solutions unique and patented* foaming gun surpasses all others in performance. Any system can foam asphalt, but the key is to form and entrain micro bubbles that are retained throughout the mixing process. The large bubbles that are formed by just adding water to liquid asphalt are not beneficial to the process. They quickly dissipate and leave an unmodified binder that won't perform well at Warm Mix temperatures.

Water jets are easily accessed from the outside so maintenance is quick and easy.

Features:

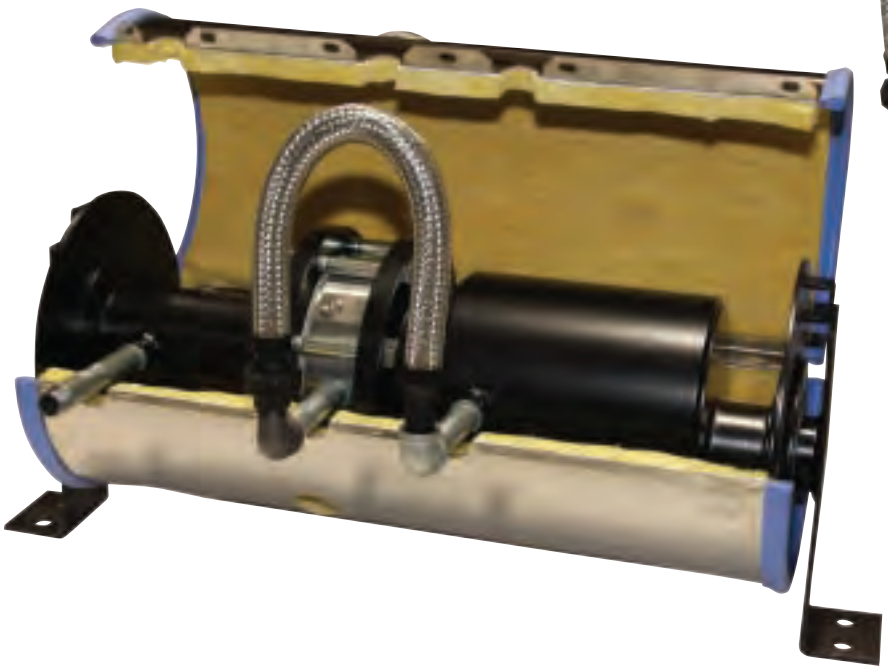
Center convergence nozzle design provides more efficient foaming. It reduces the number of nozzles and the maintenance related to each.

The high-pressure system enables low water-to-liquid-asphalt ratio during foaming.

There are no moving parts in the foaming gun. We do not give each nozzle it's own solenoid because fewer solenoids means fewer maintenance issues.

The stainless steel mixing diffuser provides even distribution of the water throughout the liquid asphalt. Once again - no moving parts.

*patent pending



Will you go back and forth between hot and warm mix asphalt?

If so, you need to take precautions to protect your baghouse. Here's why: The lower exhaust temperature from WMA can cause condensation in the baghouse, creating acid rain that will damage your equipment, and mudding bags - saddling you with high replacement costs and unnecessary down-time. You need an effective way to control the stack temperature to protect your baghouse. The answer is the patented MAXAMizer® Heat Recovery System. It automatically maintains proper stack temperature +/-5°, and typically saves 5-to-10% in fuel consumption.

Being More Competitive in a Go Green Business Climate

Go Green or Go Home

More and more jobs are being specified with a WMA option. If you can't offer WMA, you may not qualify to even bid on a lot of jobs in the future. You don't have to be on the outside looking in. The AQUABLACK™ WMA System easily retrofits onto any manufacturer's asphalt plant, and it can be installed on yours in just two days.

Going Green is Good Business

The AQUABLACK™ WMA System opens doors by allowing you to bid on jobs specified as WMA only. It makes your company more neighborhood friendly by reducing fumes and pollutants. It makes you a more responsible/credible member of the business community; and it helps you attract and retain good employees. If you had your choice of working on a HMA crew or a WMA crew, which would you choose?

Protect Workers and Your Business

While the adverse affects of breathing asphalt fumes are negligible, OSHA, NIOSH and the EPA continue to conduct studies to gauge its affect on health. NIOSH says additional studies are needed to better characterize occupational exposures to asphalt fumes, vapors and aerosols. Why wait? Move to WMA now with the easy-to-implement system - AQUABLACK™.

MAXAM Equipment, Inc.

1575 Universal Avenue • Kansas City, MO 64120 **800•858•6070**

AQUA Black™ Solutions
WMA from MAXAM

090205

k. TruPave® Brochure

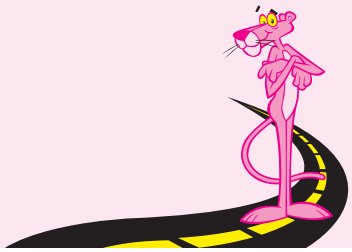
Trumbull™

OWENS CORNING™

INNOVATIONS FOR LIVING™

TRUPAVE® ENGINEERED PAVING MAT

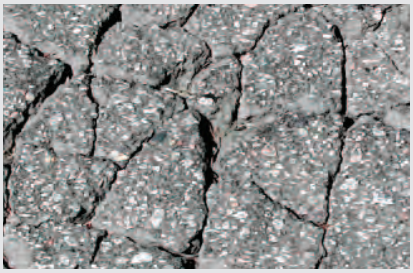
CHANGING THE RULES OF THE ROAD



Next time use TruPave®

THE TRUPAVE® ENGINEERED PAVING MAT ADVANTAGE

Pavement doesn't last forever. But a surface with *TruPave* engineered paving mat from Owens Corning Trumbull ensures staying power well beyond the current standards. From superhighways to small business lots, paved areas both public and private, *TruPave* engineered paving mat is the advantage. The reasons: *TruPave* engineered paving mat delays reflective cracking and offers a superior moisture barrier. A two-in-one package available only through Owens Corning. What's more, it's fully millable and recyclable, assuring full use of your reclaimed asphalt pavement (RAP)—thus eliminating extra costs.



DELAYS REFLECTIVE CRACKING

Pavement overlays that do not include *TruPave* engineered paving mat will typically show reflective cracks within several months. With low elongation and immediate tensile strength, *TruPave* engineered paving mat delays reflective cracking, extending the life of your pavement and dramatically lowering repair and maintenance costs.

PROVIDES A MOISTURE BARRIER

Adding a moisture barrier under your hot-mix asphalt (HMA) overlay is one of the best ways to protect and prolong the life of your pavement structure. Commonly, paving fabrics are constructed from materials that can suffer damage from exposure to high temperatures. *TruPave* engineered paving mat is a non-woven fiber glass/polyester hybrid mat designed to withstand today's higher hot-mix asphalt temperatures (up to 495°F). This stability provides a continuous, non-deforming water-resistant barrier.

FULLY MILLABLE AND RECYCLABLE

By design, *TruPave* engineered paving mat is millable and recyclable. When milled, it is reduced to tiny fibers that can actually enhance the performance of RAP. Other paving fabrics can sometimes clog the milling equipment and cause costly delays.

TruPave engineered paving mat is recyclable—easily milled and reused in asphalt mixes.

A DIMENSIONALLY STABLE PRODUCT

Doesn't shrink—*TruPave* engineered paving mat holds its shape and does not shrink under the temperatures encountered in today's hot-mix asphalt mix-designs.

Doesn't stretch—*TruPave* engineered paving mat does not stretch or deform during installation.

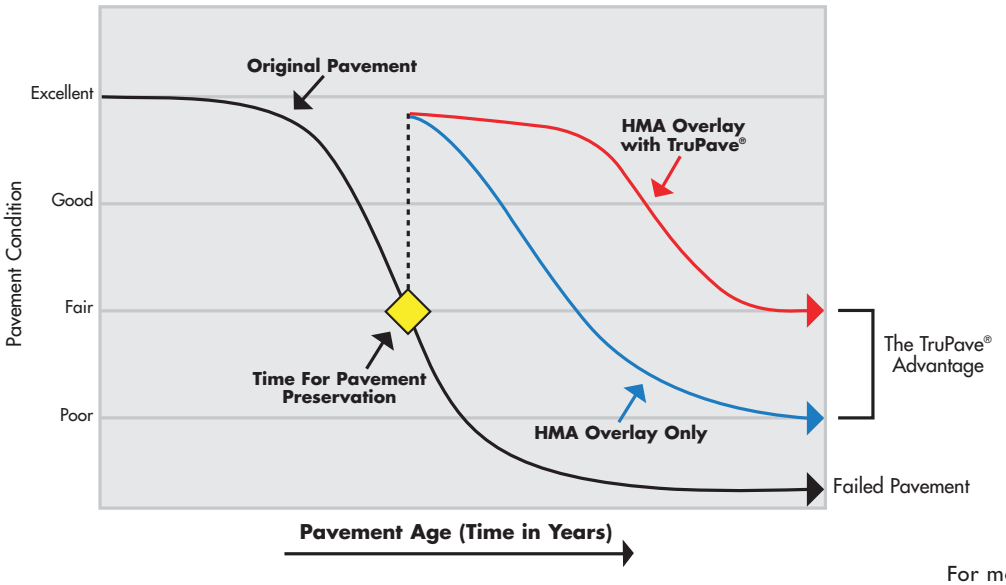
Withstands high temperatures—*TruPave* engineered paving mat is stable up to 495°F, therefore it does not melt or become brittle when the HMA overlay is applied.

PHYSICAL PROPERTIES OF TRUPAVE® ENGINEERED PAVING MAT

Property	Test method	Units	Typical value
Mass per unit area	ASTM D5261	g/m^2 (oz/yd^2)	136 (4.0)
Tensile strength, MD	ASTM D4595	kN/m (lb/in)	6.1 (35)
Elongation at max. load, MD	ASTM D4595	percent	1.5
Tensile strength, CD	ASTM D4595	kN/m (lb/in)	5.3 (30)
Elongation at max. load, CD	ASTM D4595	percent	1.5
Melting point	ASTM D276	°C (°F)	>230 (>450)
Asphalt retention	ASTM D6140	gal/yd^2	0.21
Shrinkage	Tex-616-J	percent	0

Note: Conditions for tensile strength measurements
Sample width: 8 inches — Gage length: 4 inches
Sample length: 8 inches — Crosshead speed: 0.4 in/min

TYPICAL PAVEMENT DETERIORATION CURVE



For more information about the full family of *TruPave* engineered paving mat products, please contact your Authorized Owens Corning *TruPave* Dealer.

Trumbull™

OWENS CORNING™
INNOVATIONS FOR LIVING™

OWENS CORNING WORLD HEADQUARTERS
ONE OWENS CORNING PARKWAY
TOLEDO, OHIO, USA 43659
www.owenscorning.com/trupave
1-800-GET-PINK

Pub. No. 5-TA-45119-B. Printed in U.S.A. January 2004. THE PINK PANTHER™ & ©1964-2004 Metro-Goldwyn-Mayer Studios Inc. All Rights Reserved. The color PINK is a registered trademark of Owens Corning. ©2004 Owens Corning.

DEALER IMPRINT HERE

l. CAPA Announcement for Pilot Project

For Immediate Release:

The Colorado Asphalt Pavement Association is pleased to announce, Lafarge West in conjunction with the City of Greeley will be constructing a Sustainable Asphalt pavement test strip on Monday, October 31, 2011 and Tuesday, November 1, 2011 (weather permitting). The area where the materials will be placed in located on 10th Avenue in Greeley, Colorado. Placement will begin each day at approximately 10:00 am.

In preparation for the placement of the Sustainable Asphalt Pavement, the existing asphalt will be milled 2 ½", Tru-Pave™ will be installed, and a leveling course will be placed. The wearing course (test strip section) will consist of four (4) different mix designs which will include recycled asphalt pavement (RAP), ground tire rubber (GTR), and Recycled asphalt shingles (RAS). The four mix designs are the following:

1) S100 Rap 20% - PG 64-28
2) S75 Rap 20% - 3% Shingles - PG 64-28
3) S100 Rap 20% - GTR - PG 64-28
4) S75 Rap 20% - GTR – 3% Shingles - PG 64-28

Mix Designs 1 and 2 will be constructed on 10th Avenue between 10th Street and 13th Street. Mix Designs 3 and 4 will be constructed on 10th Avenue between 13th Street and 16th Street. Each of the constructed test sections will be approximately 600-700 tons which is an estimated 1500 feet long.

The project will be open for visitors to come and observe the different materials as they are placed. This is an active construction project so Lafarge is recommending the use of all PPE including reflective vests, proper foot wear, eye protection, and hard hats. Visitors who do not have proper PPE ***MUST*** remain in the public right-of-way and not enter the construction zone.

Please feel free to contact Barb, City of Greeley at (970) 350-9881 on either of the scheduled paving days to confirm the placement of the asphalt for the test section will be occurring as scheduled.

m. 2010 Annual Report to the House Transportation Legislation Review Committee

Colorado Department of Public Health and Environment

Status of Waste Tire Recycling in Colorado

2010 Annual Report to the House Transportation Legislation Review Committee

Executive Summary

Calendar year 2010 marks the seventh year the Colorado Department of Public Health and Environment (the Department) has compiled data related to the number of waste tires collected at processing facilities and waste tire monofills in Colorado. We anticipate the tires stored in the monofills will be reused at a later date for tire-derived fuel; rubber crumb for roadways and molded rubber products, playgrounds, and sports fields; or for other uses. Therefore, placing tires in monofills for storage does not constitute final waste tire disposal. This conclusion is supported by information from the owners of the two largest waste tire monofills in Colorado: one intends to produce crumb rubber products, while the other will use the tires for tire-derived fuel. In addition, Senate Bill 09-289 requires that all Colorado waste tire monofills be eliminated by 2019.

This 2010 calendar year annual report on waste tire recycling in Colorado is being transmitted to the House Transportation Legislation Review Committee (the Committee) as required by House Bill 04-1428 and section 25-17-202.7, C.R.S. The statute requires the Department to issue a report to the Committee on or before July 1st each year that includes the total number of waste tires recycled in the state. This information is submitted to the Department pursuant to the Regulations Pertaining to Solid Waste Sites and Facilities (6 CCR 1007-2, Sections 8.4.1(B), 10.3.6, 10.5.7, 10.6.7 and 10.7.7).

Placing tires in monofills for storage does not constitute final waste tire disposal.

The Department gathers this information through annual reporting from waste tire collection, recycling and storage facilities. To improve the data we receive, the Department continued outreach efforts to educate tire facilities regarding their compliance and reporting responsibilities.

Colorado Department of Public Health and Environment
Hazardous Materials and Waste Management Division
Solid Waste and Materials Management Program

Principal Author:
Shana Baker, Environmental Protection Specialist

Contributing Authors and Technical Assistance:
Charles G. Johnson, Solid Waste and Materials Management Program Manager
Joe Schieffelin, Solid and Hazardous Waste Program Manager
David Snapp, Environmental Protection Specialist
Nicholas Boudreau, Environmental Protection Specialist

Statute: Section 25-17-202.7, C.R.S.

Date: July 1, 2011

For additional information or copies:
Charles G. Johnson
Solid Waste and Materials Management Program
Hazardous Materials and Waste Management Division
Colorado Department of Public Health and Environment
4300 Cherry Creek Drive South
Denver, Colorado 80246-1530
(303) 692-3348

Waste Tire Update

Data submitted to the Department indicates there were 4,829,711 waste tires generated in the state of Colorado during calendar year 2010. Approximately 571,000 of the waste tires generated in Colorado were hauled to a recycling facility in Utah. Conversely, 293,771 waste tires were shipped to Colorado waste tire facilities from out of state sources.

Colorado waste tire processors recycled a total of 4,485,777 tires in 2010, which amounts to 93 percent of the tires generated by Colorado sources that year. This figure represents an increase from the 92 percent recycling rate achieved in 2009 (based on an estimate using 2008 data for one waste tire monofill) and an overall increase in the number of tires recycled. In 2010, the remaining 7 percent were stored at waste tire facilities that includes waste tire monofills and processing facilities.

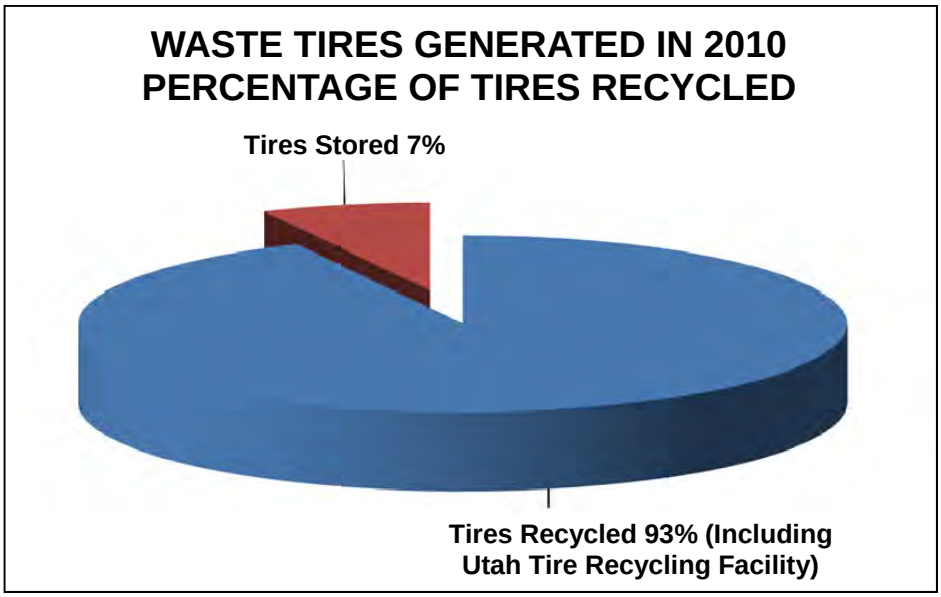


Figure 1

Figure 2

The 93 percent recycling rate described in Figure 1 (top left) is based on waste tire processing facilities in Colorado and surrounding states processing waste tires that are generated in Colorado. However, these same waste tire processors only had the capacity to recycle 87.5 percent of the total influx of tires generated in-state and those sent to Colorado from states to the east and northeast.

Figure 2 (bottom left) provides an annual comparison of Colorado's waste tire recycling rates for the last seven years. The waste tire recycling rates remained relatively consistent each year until 2009 when the recycling rate moved up sharply to levels above 90 percent. This increase can be attributed to more accurate data collection methods, identification of an out of state recycler of Colorado tires, and an increase of use of tires as tire derived fuel.

Based on the reported number of waste tires received by waste tire facilities, about 4,829,711 waste tires were generated in Colorado during calendar year 2010. Considering Colorado's latest population estimate of 5,029,196 people, this rate of waste tires generated is slightly

Continued on next page...

Waste Tire Update

Continued from previous page...

less than the accepted nationwide industry standard that predicts a waste tire generation rate of one waste tire/person/year.

Figure 3 (below) captures the top nine end use markets for waste tires recycled during calendar year 2010. Of the nine end use markets identified, the top five waste tire end use markets included burning waste tires as tire derived fuel, the use of tire shreds as the leachate drainage layer in private and government-owned sanitary landfills, the processing of waste tires into crumb rubber for use in roadways and molded rubber products, resale tires, and use of tire shreds as alternative daily cover at sanitary landfills.

The top five waste tire end use markets included burning waste tires as tire derived fuel, the use of tire shreds as the leachate drainage layer in private and government-owned sanitary landfills, the processing of waste tires into crumb rubber for use in roadways and molded rubber products, resale tires, and use of tire shreds as alternative daily cover at sanitary landfills.

Figure 4 (opposite top) reflects the number of waste tires in storage at designated waste tire facilities statewide at the end of calendar year 2010. The on-site waste inventory increased by 519,484 tires during the year. As

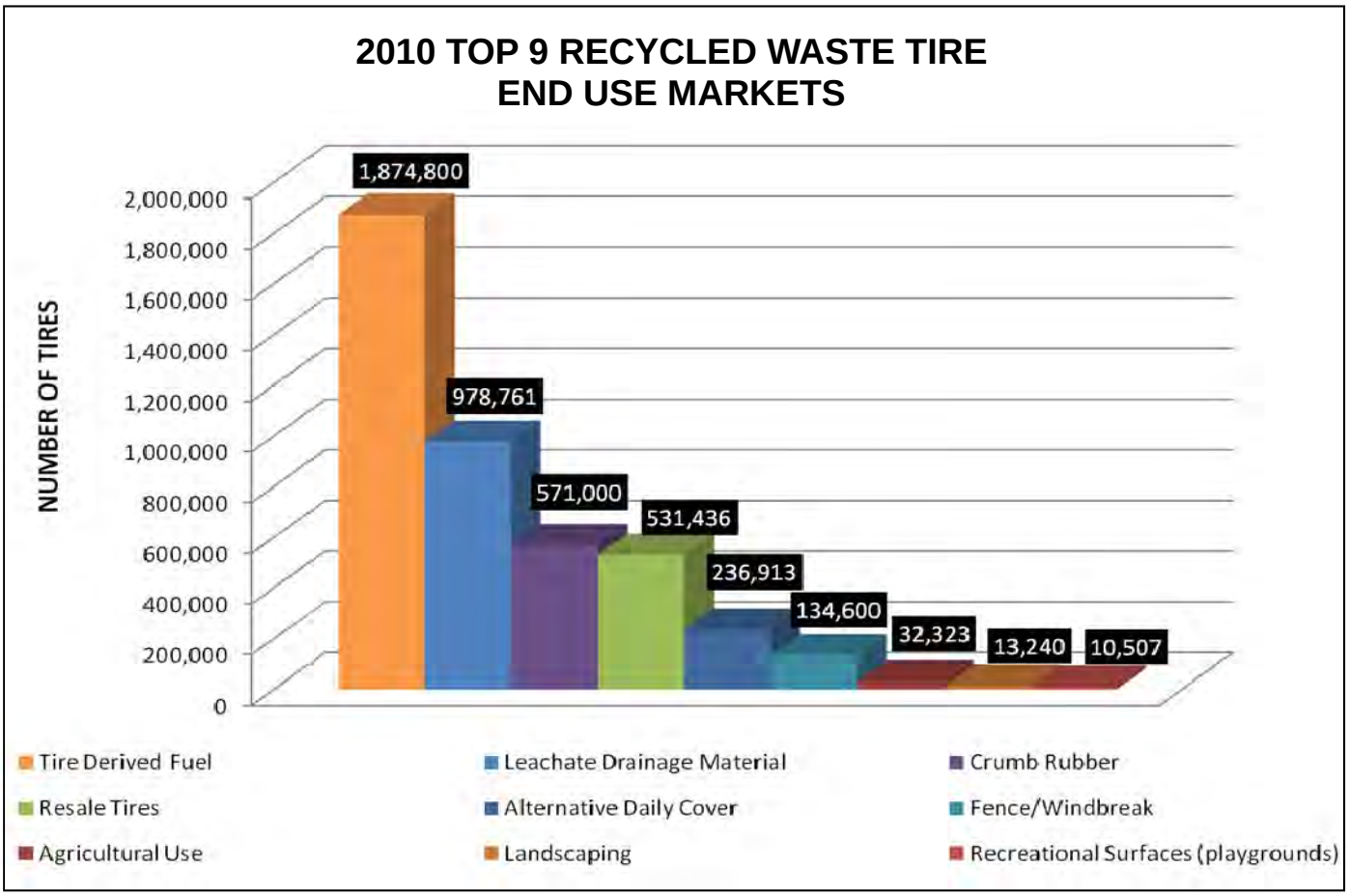


Figure 3

Waste Tire Update

of 2010, 57,361,045 waste tires are stored in waste tire monofills while 4,832,830 waste tires are stored temporarily at waste tire processing facilities.

Some tire handling facilities in the state increased their storage inventories while awaiting further processing and development of end use markets. Other tire facilities decreased their storage inventory by shipping tires offsite for reuse in end use markets. Figure 5 (bottom) illustrates the amount of waste tires that are end used. In 2009, 4,182,329 tires went to final end use markets, based on an estimate using 2008 data for one waste tire monofill. In 2010, that figure

Continued on next page...

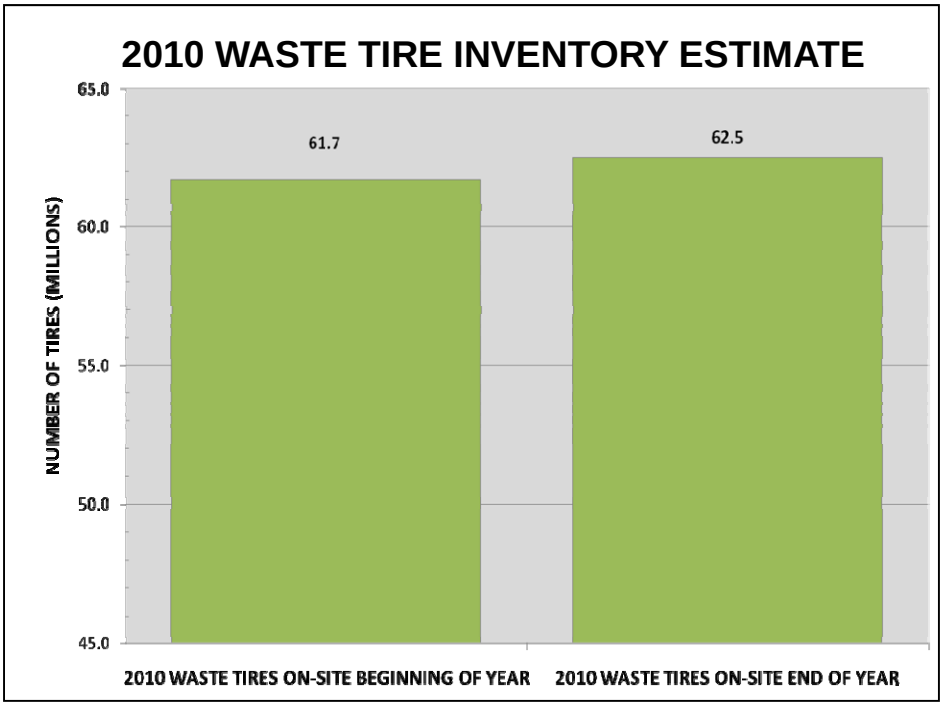


Figure 4

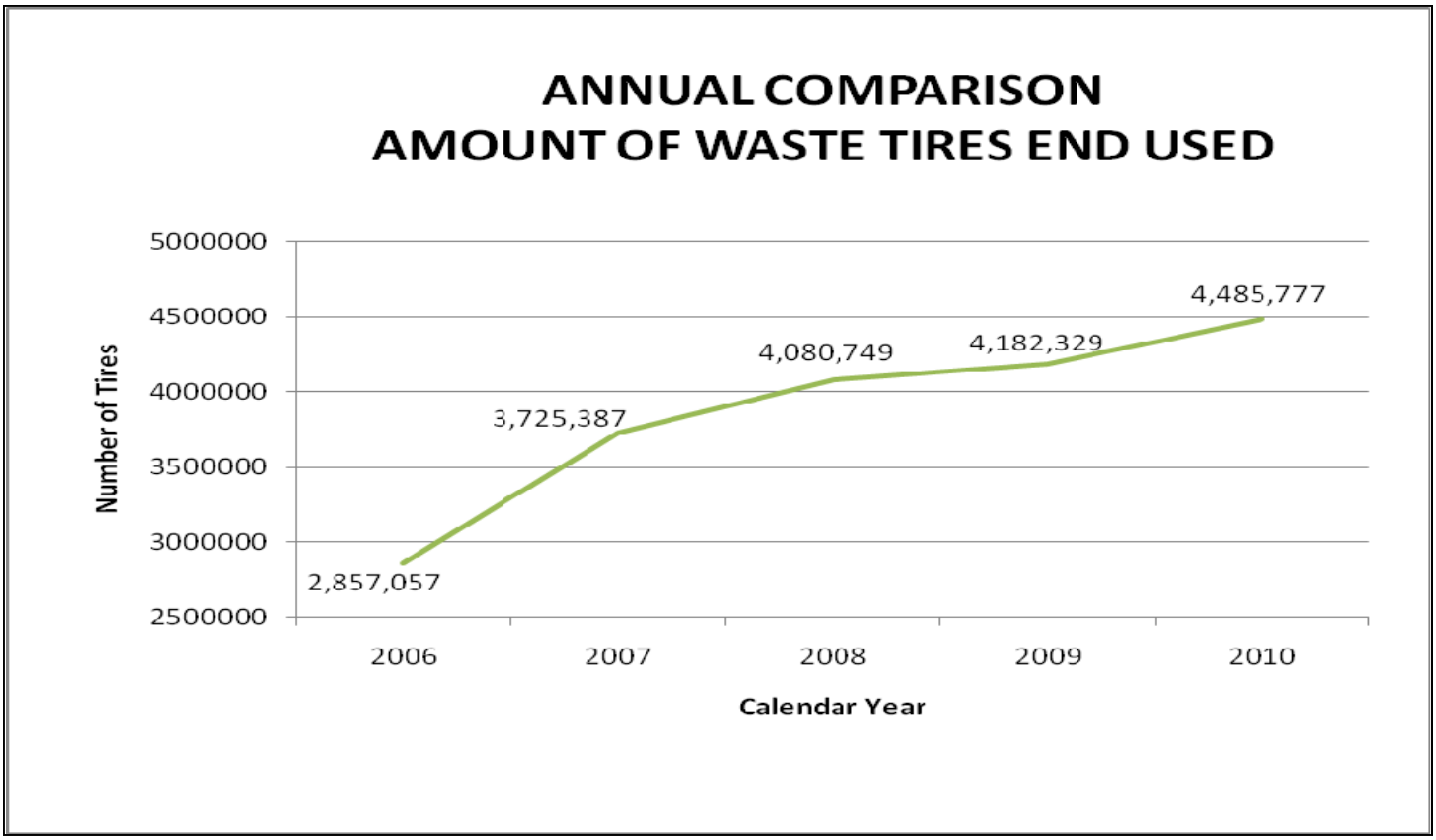


Figure 5

Waste Tire Update

Waste Tires: The Facts

Using waste tires as tire-derived fuel prevented the use of 63,620 tons of coal, or enough energy to power 9,912 homes for one year, and diverted 1,874,800 tires from monofill disposal.

■■■■■

Approximately 280 million waste tires are produced each year by replacement of old tires on consumer cars.

■■■■■

On average, one waste tire is generated for each Colorado resident each year.

■■■■■

Improperly disposed tires can become a breeding ground for mosquitoes and rodents, potential carriers of disease.

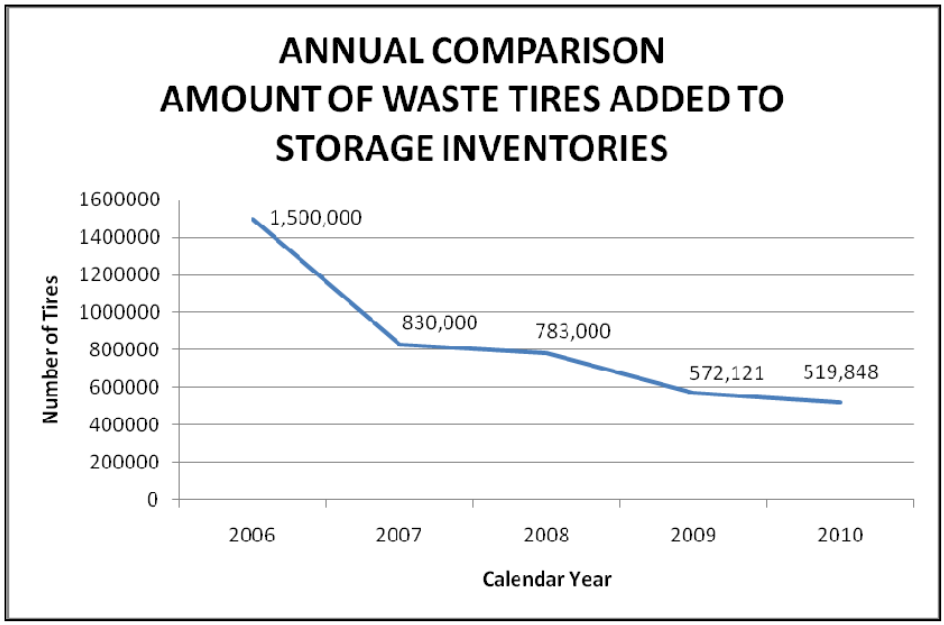


Figure 6

Continued from previous page...

grew to 4,485,777, a 7.3 percent increase in the number of tires going to final end use markets. The number of tires going to end use markets increased by 9.5 percent in 2008 and by 2.5 percent in 2009. This increase represents a continuing trend of more waste tires going to end use markets in Colorado.

In contrast, as described in Figure 6 (above), we observed a further decline in the number of waste tires added to waste tire storage inventories in 2010. During 2007, 830,000 waste tires entered the waste tire storage inventory, compared to 783,000 tires entering waste tire inventory in 2008 and another decline to 572,121 tires in 2009. The Department observed another decline in 2010 with only 519,848 waste tires entering waste tire storage inventories.

House Bill 10-1018 requires waste tire haulers to register with the Department and the use of uniform manifests to track waste tire shipments from the generator to the waste tire destination facility.

Future Data Collection Methods

The waste tire facility and waste tire hauler registration requirements of House Bill 10-1018 and the new Waste Tire Facilities and Waste Tire Haulers Regulations require all waste tire haulers and waste tire facilities, except for tire retailers, wholesalers and fleet service facilities, to submit an annual report to the Department.

The Department anticipates an increase in the number of waste tire facilities and haulers reporting for CY 2011. The Department will provide the necessary resources, including guidance and training, to assist facilities and haulers with the completion of the reporting form.

House Bill 10-1018 requires the use of uniform manifests to track waste tire shipments from the waste tire generator to the waste tire destination facility. During the waste tire regulations stakeholder process, Department staff worked with stakeholders and developed a Uniform Waste Tire Manifest (WT-2) that incorporates elements from a traditional cradle-to-grave process, similar to those used for hazardous waste, but allows the manifest to account for resale tires (re-use or salvage tires) that are removed during waste tire hauler pickups or consolidation. The Department plans on updating the 2011 waste tire hauler and waste tire facility reporting forms to achieve reporting consistency and accuracy between the reporting forms and the Uniform Waste Tire Manifest (WT-2), including having an area on the waste tire hauler form to report the number of resale tires (re-use or salvage tires).

The Department will provide the necessary resources, including guidance and training, to assist facilities and haulers with the completion of the reporting form.

The waste tire facility reporting form will be revised to include a requirement that all waste tire monofills submit a Waste Tire Inventory Reduction Plan that includes arrangements for the processing into tire-derived product at least 75 percent of the three-year rolling average amount of waste tires that the waste tire monofill accepted during the previous three calendar years.

The waste tire facility reporting form will also be revised to include a requirement that all waste tire processors and end users submit evidence establishing that during the previous calendar year the waste tire processor or end user processed or end used at least 75 percent of the waste tires accepted during the previous three years into tire derived product or into an end product.

The Waste Tire Advisory Committee provides technical advice to the Department regarding specific waste tire issues such as waste tire disposal, storage, and transportation and waste tire related funding.

2005-2010 Tire Legislation

Two bills were passed during the 2005 legislative session that directly affected the management of waste tires in Colorado. The Waste Motor Vehicle Tire Hauler Act (HB 05-1126) requires the registration of commercial transporters of waste motor vehicle tires. The intent of this legislation is to ensure transportation and delivery of waste tires to proper storage and recycling facilities and to minimize the illegal dumping of tires.

Senate Bill 05-141 regulates the disposal of residentially generated waste tires. Effective July 1, 2007, this bill limits the disposal of residentially generated tires in landfills.

Senate Bill 09-289 was passed during the 2009 legislative session. Among other things this bill reallocated collection of the tire fee to the point of sale at tire retailers instead of the point of disposal, thereby improving the collection of the funds. This bill also required facilities to use only commercial tire haulers registered with the state to transport waste tires, required the state to develop a plan for the elimination of tire monofills within 10 years, and required the Department to implement an outreach and education program for facilities handling tires. The combined result of this bill is to ensure waste tires are commercially transported to appropriate facilities, and that more of these tires are ultimately recycled.

House Bill 10-1018 was passed during the 2010 legislative session and provides a cradle-to grave or cradle-to-cradle-regulatory approach for waste tires. This bill specifies new registration, decal and manifest requirements for waste tire haulers and waste tire facilities. The bill also requires waste tire monofills to submit an inventory reduction plan to the Department as a part of the facility Certificate of Designation. House Bill 10-1018 places administrative authority for the waste tire funds with the Department, and allocates resources for new personnel to manage the fund and provide program enforcement.

New regulations went into effect April 1, 2011 to implement the requirements of HB10-1018 by setting up a cradle-to-grave management construct for waste tires to ensure that all newly generated waste tires are accounted for and properly recycled or dispositioned. These new regulations set out the requirements for each type of facility or entity within the waste tire lifecycle — tire retailers and wholesalers that generated waste tires as they replace old tires with new tires on vehicles; waste tire haulers and waste tire collection facilities that manage waste tires in transit; waste tire processors and end users that either manufacture waste tires into new products or turn waste tires into useable feedstocks; and waste tire monofills that store waste tires for extended periods.

n. Letter of Contract Assignment (to account for Lafarge references)

Martin Marietta Materials, Inc.
2710 Wycliff Road
Raleigh, North Carolina 27607

November 11, 2011

Mr. Eric Heyboer
Colorado Department of Public Health and Environment
Division of Environmental Health and Sustainability
DEHS B-2
4300 Cherry Creek Drive South
Denver, CO 80246

Re: Contract Number PO FAA EHS12032162 between Lafarge West, Inc. and the State of Colorado dated as of July 1, 2011 (the "**Agreement**")

Dear Mr. Heyboer:

On September 30, 2011, Martin Marietta Materials, Inc. and certain of its affiliates (collectively, "**MMM**") and Lafarge North America, Inc. and certain of its affiliates including Lafarge West, Inc. (collectively, "**Lafarge**") agreed to exchange certain of their business operations (the "**Asset Exchange**"). We expect to close the Asset Exchange on or about November 30, 2011.

As part of the Asset Exchange, Lafarge intends to assign the Agreement to MMM, and MMM intends to assume it from Lafarge. Additionally, Lafarge will transfer to MMM the GTR Blending Skid and associated equipment related to the Agreement and located at Lafarge's Greeley, CO facility. The Agreement provides that your written consent is required for such an assignment. We are requesting your consent to the assignment of the Agreement from Lafarge to MLM, at which time MLM will assume all future obligations under the Agreement.

Based on your email to Todd Genovese of Lafarge, we understand the State prefers to use its own form of Consent to Assignment. Please provide a copy of this document, along with any other items required to complete the process, to MMM's legal counsel by email or fax at your soonest convenience: Michael Gurion at Sutherland Asbill & Brennan LLP, michael.gurion@sutherland.com or (404) 853-8806. We will review and respond promptly upon receipt.

Thank you for your assistance in this matter.

Sincerely,
Martin Marietta Materials, Inc.

By: _____
Name: Zigurds R. Vitols
Title: District Vice President / General Manager

Cc: Todd Genovese, Lafarge
Michael Gurion, Sutherland Asbill & Brennan LLP
David A. Little, Martin Marietta Materials

15239182.1

Grant Metrics

Date project fully operational: November-12

(Based on deliverables- month that impact of grant would have changed volumes/job creation/participants)

Diversion Rates:

(Choose one material per box. Only list those collected over the grant cycle. Must be listed as "tons". See tab labeled "Conversion Tables" if needed.)

Material Diverted #1: Other (pls describe below)

	Tons Diverted
July-11	
August-11	
September-11	
October-11	
November-11	4
December-11	
January-12	
February-12	
March-12	
April-12	
May-12	
June-12	13.5
Total	**17.5**

Other div. material: Waste Tires

Material Diverted #2: Other (pls describe below)

	Tons Diverted
July-11	
August-11	
September-11	
October-11	
November-11	37
December-11	
January-12	
February-12	
March-12	
April-12	
May-12	
June-12	
Total	**37**

Other div. material: Tear-off asphalt shingles

Material Diverted #3:

	Tons Diverted
July-11	
August-11	
September-11	
October-11	
November-11	
December-11	
January-12	
February-12	
March-12	
April-12	
May-12	
June-12	
Total	**0**

Other div. material:

Material Diverted #4:

	Tons Diverted
July-11	
August-11	
September-11	
October-11	
November-11	
December-11	
January-12	
February-12	
March-12	
April-12	
May-12	
June-12	
Total	**0**

Other div. material:

Material Diverted #5:

	Tons Diverted
July-11	
August-11	
September-11	
October-11	
November-11	
December-11	
January-12	
February-12	
March-12	
April-12	
May-12	
June-12	
Total	**0**

Other div. material:

Material Diverted #6:

	Tons Diverted
July-11	
August-11	
September-11	
October-11	
November-11	
December-11	
January-12	
February-12	
March-12	
April-12	
May-12	
June-12	
Total	**0**

Other div. material:

Material Diverted #7:

	Tons Diverted
July-11	
August-11	
September-11	
October-11	
November-11	
December-11	
January-12	
February-12	
March-12	
April-12	
May-12	
June-12	
Total	**0**

Other div. material:

Material Diverted #8:

	Tons Diverted
July-11	
August-11	
September-11	
October-11	
November-11	
December-11	
January-12	
February-12	
March-12	
April-12	
May-12	
June-12	
Total	**0**

Other div. material:

End use of diverted materials:
(Describe where materials are going
[e.g., MRF, new products, reuse])

Used to produce new asphalt mixtures for paving roadways.

Number of Permanent Jobs Created: 1

Include full-time & part time paid positions.
1 FTE = 40 Hours Per Week

Type of Permanent Job(s) Created:

(Provide titles of jobs created)

Area QC Manager (new title yet to be determined as this role will be combined QC and operational role)

Average Salaries of Jobs Created: $60,000+

(Average of all jobs created)

Average Monthly Customers for FY 2011: 0.17

(July 1, 2011 - June 30, 2012)

Average Monthly Customers for FY 2012:

(Estimate or customer lists)

	Avg. Monthly Amount
July-12	0.25
August-12	0.25
September-12	0.25
October-12	0.25
November-12	0.25
December-12	0.25
January-13	0.25
February-13	0.25
March-13	0.25
April-13	0.25
May-13	0.25
June-13	0.25
Ave. / FY 12	**0.25**