Environmental Benefits of Using Recycled Materials

Recycled Materials Resource Center
University of Wisconsin-Madison

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Recycled Materials in Roadways:
Improving Sustainability, Quality and Service Life

- Promote **safe** and **wise** use of recycled materials in construction of transportation infrastructure through education, technology transfer, and applied research.
Current Practice

- Various recycled materials and industrial byproducts are used in highway construction applications

- Engineering properties and environmental suitability issues relevant to various applications, incorporated design guidelines and construction specifications

- Benefits?
So What’s Missing?

- Direct information on sustainability assessment characteristics

- Tracking is a challenge

- Cannot readily calculate the benefits accrued by substitution of these materials for conventional materials
Quantifying Sustainability

- Life Cycle Cost Analysis (LCCCA)
- Equitable
- Social
- Sustainable development
- Viable
- Bearable
- Environment

2/20/2017

Wisconsin Concrete Pavement Association
February 16, 2017
Pavement Life Cycle

- Extraction
- Production
- Transport

Traffic Delay
- Equipment

Rolling Resistance

Traffic Delay
- Production
- Transport

Salvage
- Transport

Materials ➔ Construction ➔ Use ➔ Maintenance ➔ End of Life

Courtesy NCAT
Calculating LCA vs LCCA: Materials

• Life Cycle Analysis
  • How much energy is required to extract, process, and transport aggregate and cement?
  • How much $CO_{2e}$ is produced during this process?
  • How much energy is used and $CO_{2e}$ is produced at the plant?

• Life Cycle Cost Analysis
  • How much does it cost to buy the cement and the aggregate and produce a mixture?
Objectives

• State DOTs seeking a quantitative and transparent manner in which to clearly convey the benefits in using recycled materials.

• Adopt, improve and use a tool to calculate the life cycle benefits associated with incorporating these materials in highway construction.

• Develop fact sheets on recycled materials and industrial by-products being used in highway construction.
Common Recycled Materials

• Most state DOTs use:
  1. Reclaimed Asphalt Pavement (RAP)
  2. Fly Ash

• Other common materials:
  1. Reclaimed Asphalt Shingles (RAS)
  2. Recycled Concrete Aggregate (RCA)
  3. Crumb Rubber
  4. Tire Derived Aggregate
  5. Bottom Ash
  6. Foundry Sand
  7. Foundry Slag
  8. Iron Slag
How Are We Doing?

**Tons (Millions)**

- **GDOT**: 1.74
- **IDOT**: 1.81
- **MnDOT**: 0.63
- **PennDOT**: 0.58
- **WisDOT**: 1.89
- **VDOT**: 1.05

<table>
<thead>
<tr>
<th>Recycled Material</th>
<th>Number of States</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fly Ash</td>
<td>5.57</td>
</tr>
<tr>
<td>RAP</td>
<td>5.00</td>
</tr>
<tr>
<td>RAS</td>
<td>4.80</td>
</tr>
<tr>
<td>RCA</td>
<td>4.72</td>
</tr>
<tr>
<td>Rubber</td>
<td>3.50</td>
</tr>
<tr>
<td>Blast Furnace Slag</td>
<td>2.67</td>
</tr>
<tr>
<td>Steel Slag</td>
<td>1.96</td>
</tr>
<tr>
<td>By-Product Lime</td>
<td>1.87</td>
</tr>
<tr>
<td>Glass Beads</td>
<td>1.83</td>
</tr>
<tr>
<td>Microsilica</td>
<td>1.78</td>
</tr>
<tr>
<td>Steel Reinforcement</td>
<td>1.45</td>
</tr>
</tbody>
</table>
2013 Statewide Data: WisDOT Recycled Material Profile

Total tons of recycled material: 1,894,542

- RCA: 50%
- RAP in HMA: 28%
- RAS: 17%
- Fly Ash: 3%
“Recycled” – impact of total recycled material quantities tracked and reported by 6 DOTs in 2013

“Reference” – impact of hypothetical, equivalent virgin material quantities (1:1 replacement)

90% of recycled material from existing pavement (RAP & RCA)
Quantitative Impact

**Energy**
- Virgin: 6,390 TJ
- Recycled: 1,180 TJ

**Water Consumption**
- Virgin: 1,990 Mg
- Recycled: 59 Mg

**CO₂ Emissions**
- Virgin: 355,000 Mg
- Recycled: 52,600 Mg
Case Study: Interstate 94 Reconstruction

Kenosha County, Wisconsin
LCA/LCCA Goal

- Determine environmental and economic benefits of recycled materials in highway construction
- Analyze 1-mile stretch of I-94 North-South corridor in Kenosha County, WI
  - Constructed in 2013
  - Expansion and full pavement reconstruction
  - Targeted for unique use of recycled materials
- LCA and LCCA
  - Data collected post-construction
Schematic of Reconstruction

12” Portland Cement Concrete (PCC):
~32,000 CY
- 30% of cementitious material is fly ash

3” Asphalt base (mainline only): ~5,700 CY

6” Aggregate Base: ~19,000 CY
- 55% Recycled asphalt pavement (RAP)

13” Subbase: ~39,000 CY
- 40% Recycled concrete aggregate (RCA)

Embarkment: ~235,000 CY
- 70% bottom ash
- 5% foundry sand
- 25% native clays

- Reconstruction included:
  - Mainline
  - 4 Ramps
  - STH 142

- Material quantities calculated from design plans
Methods: LCA Tools

• BE²ST-in-Highways
  • Comparison methodology
    • Virgin design (hypothetical, no recycled materials)
    • Recycled design (actual design, with recycled materials)
  • Benefit: created specifically for road LCAs
  • Support program – PaLATE
    • Evaluates environmental impacts
      • Material production, material transportation, and construction processes
    • Two analysis phases: initial construction and maintenance
Methods: LCA Tools

SimaPro

• Commercially available tool used widely in research and industry
• Extensive inventory and popular assessment methods
  • TRACI impact assessment
  • Single issue impacts

*Not all road construction processes or recycled materials included in SimaPro industry*
## Results: BE$^2$ST-In-Highways

<table>
<thead>
<tr>
<th>Environmental Criteria</th>
<th>Virgin</th>
<th>Recycled</th>
<th>Savings</th>
<th>Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy Use (GJ)</td>
<td>195,000</td>
<td>124,000</td>
<td>71,000</td>
<td>37%</td>
</tr>
<tr>
<td>Water Consumption (kg)</td>
<td>52,900</td>
<td>39,800</td>
<td>13,100</td>
<td>25%</td>
</tr>
<tr>
<td>CO$_2$ Emissions (Mg)</td>
<td>13,100</td>
<td>7,930</td>
<td>5,170</td>
<td>39%</td>
</tr>
<tr>
<td>Solid Waste (kg)</td>
<td>824,000</td>
<td>604,000</td>
<td>220,000</td>
<td>27%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Recycling</th>
<th>Virgin</th>
<th>Recycled</th>
<th>Material Recycled</th>
</tr>
</thead>
<tbody>
<tr>
<td>In Situ Recycling (CY)</td>
<td>0</td>
<td>24,960</td>
<td>7%</td>
</tr>
<tr>
<td>Total Recycling (CY)</td>
<td>0</td>
<td>202,200</td>
<td>57%</td>
</tr>
</tbody>
</table>
### Project Estimated Unit Costs

<table>
<thead>
<tr>
<th>Category</th>
<th>Material</th>
<th>Unit Cost</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Concrete</strong></td>
<td>Fly ash</td>
<td>$55.00/ton</td>
<td>We Energies</td>
</tr>
<tr>
<td></td>
<td>Portland Cement</td>
<td>$105.00/ton</td>
<td>WCPA</td>
</tr>
<tr>
<td><strong>Base Aggregate</strong></td>
<td>RAP onsite</td>
<td>$6.00/ton</td>
<td>WisDOT</td>
</tr>
<tr>
<td></td>
<td>RCA onsite</td>
<td>$5.50/ton</td>
<td>WCPA</td>
</tr>
<tr>
<td></td>
<td>Virgin base aggregate</td>
<td>$10.00/ton</td>
<td>WisDOT</td>
</tr>
<tr>
<td><strong>HMA</strong></td>
<td>Mix with RAP</td>
<td>$49.47/ton</td>
<td>WAPA</td>
</tr>
<tr>
<td></td>
<td>Mix without RAP</td>
<td>$42.75/ton</td>
<td>WAPA</td>
</tr>
<tr>
<td><strong>Embankment/Fill</strong></td>
<td>Bottom ash</td>
<td>$4/CY</td>
<td>WeEnergies</td>
</tr>
<tr>
<td></td>
<td>Foundry sand</td>
<td>$4/CY</td>
<td>WisDOT</td>
</tr>
<tr>
<td></td>
<td>Virgin granular fill</td>
<td>$6.50/CY</td>
<td>WisDOT</td>
</tr>
</tbody>
</table>

- Most unit costs are state-wide averages from WisDOT bid item lists and quoted by industry (WAPA, WCPA)
Initial Construction Estimated Savings

• For one-mile, 8-lane reconstruction:

<table>
<thead>
<tr>
<th>Material Category</th>
<th>Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fly ash for cement</td>
<td>$131,000</td>
</tr>
<tr>
<td>RAP/RCA for virgin aggregate</td>
<td>$200,000</td>
</tr>
<tr>
<td>Bottom ash/foundry sand for virgin embankment</td>
<td>$440,000</td>
</tr>
<tr>
<td>Total Initial Construction</td>
<td>$771,000</td>
</tr>
</tbody>
</table>

• Over $96,000 per lane-mile
Key Takeaways

• Use of recycled material reduced environmental and economic impact of highway over lifetime
  • Much of the economic and environmental benefits stem from use of bottom ash – use what’s locally available (fly ash, bottom ash, RAP, RCA)

• Estimated quantities led to some overgeneralizations and many assumptions on material use
  • Seek to correct this by explicitly tracking material in future projects
Case Study:
Beltline Highway Reconstruction
Dane County, Wisconsin
Project Background

- Analyze 1.5-miles of Eastbound Beltline Highway Reconstruction
- 2 to 3 lane expansion and full reconstruction of the highway

Typical recycled material use:
- RAP, RAS, fly ash, RCA

LCA and LCCA:
- Data collected from designs and during construction
Beltline Highway

**HMA Pavement used in various locations (shoulders, medians, temporary pavement, etc.)**

- **11” Portland Cement Concrete (PCC):**
  - ~17,000 CY
  - 26% of cementitious material is fly ash

- **3” Asphalt base (varies)**

- **6” Aggregate Base Course:**
  - ~32,000 CY
  - 60% Recycled concrete aggregate (RCA)
    - 50% of RCA recycled on-site
  - 32% Recycled asphalt pavement (RAP), on-site

- **16” Subbase - Select Crushed Material (SCM):**
  - ~27,000 CY
  - 41% RCA (off-site)

For all HMA pavement:
- ~16,000 CY
- 5% asphalt content
  - 8% RAP, 14% RAS
  - 78% asphalt cement
- 95% aggregate
  - 15% FRAP
  - 3% Recycled asphalt shingles (RAS)
  - 83% virgin aggregate
Data Collection Methodology Comparison

Summary of Initial Construction Material Quantities

<table>
<thead>
<tr>
<th>Material</th>
<th>Designed (CY)</th>
<th>Constructed (CY)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Concrete</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cement</td>
<td>2,453</td>
<td>3,106</td>
</tr>
<tr>
<td>Fly ash</td>
<td>936</td>
<td>742</td>
</tr>
<tr>
<td>Slag</td>
<td>0</td>
<td>22</td>
</tr>
<tr>
<td>PCC aggregate</td>
<td>20,703</td>
<td>26,289</td>
</tr>
<tr>
<td>PCC mix water</td>
<td>3,560</td>
<td>4,575</td>
</tr>
<tr>
<td><strong>Bridge concrete total</strong></td>
<td>3,788</td>
<td>3,977</td>
</tr>
<tr>
<td><strong>Pavement concrete total</strong></td>
<td>23,865</td>
<td>31,197</td>
</tr>
<tr>
<td><strong>HMA</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RAP binder</td>
<td>4</td>
<td>14</td>
</tr>
<tr>
<td>RAS binder</td>
<td>20</td>
<td>40</td>
</tr>
<tr>
<td>Asphalt binder</td>
<td>73</td>
<td>296</td>
</tr>
<tr>
<td>FRAP</td>
<td>269</td>
<td>516</td>
</tr>
<tr>
<td>RAS</td>
<td>58</td>
<td>114</td>
</tr>
<tr>
<td><strong>HMA aggregate</strong></td>
<td>1,588</td>
<td>2,216</td>
</tr>
<tr>
<td><strong>HMA total</strong></td>
<td>2,022</td>
<td>3,181</td>
</tr>
<tr>
<td><strong>Bases</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>On-site RAP</td>
<td>3,280</td>
<td>9,973</td>
</tr>
<tr>
<td>On-site RCA</td>
<td>3,246</td>
<td>9,870</td>
</tr>
<tr>
<td>Imported RCA</td>
<td>5,527</td>
<td>9,280</td>
</tr>
<tr>
<td><strong>Imported virgin aggregate</strong></td>
<td>1,595</td>
<td>3,933</td>
</tr>
<tr>
<td><strong>Virgin subbase</strong></td>
<td>9,130</td>
<td>11,823</td>
</tr>
<tr>
<td><strong>RCA subbase</strong></td>
<td>17,883</td>
<td>16,628</td>
</tr>
</tbody>
</table>

- Two data collection methodologies
  1. **Designed Method** - Material quantities estimated from pre-construction designs and average mix ratios
  2. **Constructed Method** – Material quantities explicitly tracked and collected during construction
Life Cycle Assessment Tools and Inputs

• Two tools were used to conduct LCAs
  • **PaLATE:**
    • Pavement Life-Cycle Assessment Tool for Environmental and Economic Effects
    • A spreadsheet program for analyzing both environmental (LCA) and economic (LCCA) effects of pavement and road construction
  • **SimaPro:**
    • Leading software program for LCA studies, used worldwide
    • Not specific to road construction projects, LCA only

• Comparison methodology
  • Reference **Virgin Design** – use only virgin materials
  • Actual **Recycled Design** – incorporates the quantities of recycled materials either from Designed or Constructed Methods
LCA Results: PaLATE Impact % Reductions

- Energy: Designed 17%, Constructed 13%
- Water: Designed 15%, Constructed 12%
- CO₂: Designed 17%, Constructed 12%
- NOₓ: Designed 5%, Constructed 2%
- PM₁₀: Designed 21%, Constructed 24%
- SO₂: Designed 1%, Constructed 1%
- CO: Designed 4%, Constructed 2%
- Hg: Designed 9%, Constructed 5%
- Pb: Designed 11%, Constructed 8%
- Hazard Waste: Designed 13%, Constructed 8%
## PaLATE vs. SimaPro Environmental Results

<table>
<thead>
<tr>
<th></th>
<th>PaLATE</th>
<th>SimaPro</th>
<th>Average Redux</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Recycled</td>
<td>Virgin</td>
<td>Saved</td>
</tr>
<tr>
<td>Designed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy (GJ)</td>
<td>76,700</td>
<td>99,200</td>
<td><strong>22,500</strong></td>
</tr>
<tr>
<td>CO₂ (Mg)</td>
<td>5,380</td>
<td>6,980</td>
<td><strong>1,600</strong></td>
</tr>
<tr>
<td>Constructed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy (GJ)</td>
<td>97,100</td>
<td>118,000</td>
<td><strong>20,900</strong></td>
</tr>
<tr>
<td>CO₂ (Mg)</td>
<td>6,930</td>
<td>8,300</td>
<td><strong>1,370</strong></td>
</tr>
</tbody>
</table>
### Project Estimated Unit Costs

<table>
<thead>
<tr>
<th>Category</th>
<th>Material</th>
<th>Unit Cost</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Concrete</strong></td>
<td>Fly Ash</td>
<td>$75.00</td>
<td>WCPA</td>
</tr>
<tr>
<td></td>
<td>Portland Cement</td>
<td>$105.00</td>
<td>WCPA</td>
</tr>
<tr>
<td><strong>Base Aggregate</strong> (including SCM)</td>
<td>RAP onsite</td>
<td>$6.00</td>
<td>WisDOT</td>
</tr>
<tr>
<td></td>
<td>RCA onsite</td>
<td>$5.50</td>
<td>WCPA</td>
</tr>
<tr>
<td></td>
<td>RCA offsite</td>
<td>$9.00</td>
<td>WCPA</td>
</tr>
<tr>
<td></td>
<td>Virgin Base Aggregate</td>
<td>$10.00</td>
<td>WisDOT</td>
</tr>
<tr>
<td><strong>HMA</strong></td>
<td>Mix with RAP</td>
<td>$49.47</td>
<td>WAPA</td>
</tr>
<tr>
<td></td>
<td>Mix without RAP</td>
<td>$42.75</td>
<td>WAPA</td>
</tr>
<tr>
<td></td>
<td>RAS</td>
<td>$0</td>
<td>NAPA</td>
</tr>
<tr>
<td></td>
<td>Aggregate</td>
<td>$10.00</td>
<td>WisDOT</td>
</tr>
<tr>
<td></td>
<td>Virgin binder</td>
<td>$450.00</td>
<td>WisDOT</td>
</tr>
</tbody>
</table>

- Most unit costs are state-wide averages from WisDOT bid item lists and quoted by industry (WAPA, WCPA)
Initial Construction Estimated Savings

• For 1.5-mile, 3-lane reconstruction:

<table>
<thead>
<tr>
<th>Material Category</th>
<th>Designed Savings</th>
<th>Constructed Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fly ash for cement</td>
<td>$61,800</td>
<td>$48,900</td>
</tr>
<tr>
<td>RAP/RCA for virgin aggregate in base</td>
<td>$95,700</td>
<td>$133,000</td>
</tr>
<tr>
<td>RAP/RAS for aggregate and binder in HMA</td>
<td>$25,000</td>
<td>$57,800</td>
</tr>
<tr>
<td><strong>Total Initial Construction</strong></td>
<td><strong>$182,500</strong></td>
<td><strong>$239,700</strong></td>
</tr>
</tbody>
</table>

• Designed: $40,600 per lane-mile
• Constructed: $53,300 per lane-mile
Comparison

- **Designed vs. Construction Method**
  - Design data over-generalizes the actual materials use
  - Constructed data found greater material quantities, led to greater absolute environmental impacts
  - Average difference between proposed design and constructed reductions was 9% for one case study
  - Greater quantities predicted for Constructed vs Designs
    - Things change as construction happens, design data collection method misses these changes
  - Results predicted by two tools were of similar order of magnitude – validates impact results
Key Takeaways

- **Constructed Method** – more accurate method for analyzing environmental and economic benefits
- **Design Method** – acceptable method for estimating impacts
  - If it is not feasible to explicitly track material use during construction, Design Method is acceptable alternative

- LCA tool matters less than data collection method

- Focus future effort on material tracking for LCAs and LCCAs when these issues are critical

- Most DOTs do not have a means of explicitly tracking recycled material use in projects
RMRC Recycled Materials Tracking Tool

- Developed by the RMRC for DOTs to track the use of recycled material in specific construction projects

- Allows the materials engineers to track and organize quantities of recycled materials used in various projects

- Available at the RMRC website: www.rmrc.wisc.edu
Material Tracking Tool

In order to promote the tracking of recycled materials used in DOT projects, the Recycled Materials Resource Center (RMRC) developed a Microsoft Excel based spreadsheet to track recycled materials. The spreadsheet is designed to track bituminous materials, pavement mix designs in order to calculate the tons of recycled materials used in individual project basis; the resulting quantities are then used in LCA, the resulting total quantities can be used in LCA and cost comparisons using the same methodology as in this study. The RMRC tracking tool is based upon the WisDOT system of payment for measured quantities of bid items (bid price indices). The bid items represent a material or processed used in construction.

Download file

[Click Here to Download Tool]

Download User Manual

User Manual

The user is able to modify the tracking tool to fit their system or use it in scale or on an individual project.

[Click Here to Download User Manual]
### Enter bid item quantity

Enter the bid item and quantity as follows:

<table>
<thead>
<tr>
<th>Project #</th>
<th>Material Type</th>
<th>Bid Item</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1234-56-78</td>
<td>Asphalt_HMA</td>
<td>HMA Pavement Type E-10 (TON)</td>
<td>1000 TON</td>
</tr>
</tbody>
</table>

### Enter % of recycled material

Enter the percentage of recycled material for each material type:

- Baghouse Fines: 0.00%
- Blast Furnace Slag: 0.00%
- Coal Bottom Ash: 0.00%
- Coal Fly Ash: 0.00%
- Foundry Sand: 0.00%
- Kiln Dust: 0.00%
- Mineral Processing Waste: 0.00%
- MSW Combuster Ash: 0.00%
- Nickel Slag: 0.00%
- Copper Slag: 0.00%
- Phosphorus Slag: 0.00%
- Lead, Lead-Zinc and Zinc Slag: 0.00%
- Reclaimed Asphalt Pavement: 15.00% (Total 150.00 TON)
- Recycled Asphalt Shingles: 3.00% (Total 30.00 TON)
- Reclaimed Concrete Material: 0.00%
- Scrap Tires: 0.00%
- Sewage Sludge Ash: 0.00%
- Reinforcing Steel: 0.00%
- Steel Slag: 0.00%
- Sulfate Wastes: 0.00%
- Waste Glass (Fine): 0.00%
- Waste Glass (Coarse): 0.00%

Total recycled material: 18.00%
Looking Ahead

• RMRC Executive Board is seeking new research ideas and partners RMRC-4G Pooled Fund Solicitation #1431
  • http://www.pooledfund.org/Details/Solicitation/1431
• Reuse of Waste Quarry Fines, Concrete Grinding Residue and Diamond Grind Slurry
• Neutralization of High pH, RCA Leachate by Subgrade Soils
• Analysis of Field Emplaced Recycled Concrete Aggregate (RCA) to Determine Physical and Chemical Factors Controlling the pH of Leachate
• Performance of Full-Scale MSE Walls Constructed with Recycled Backfill Materials
• Recycled Material Web Map: Connecting Consumers with Producers – full scale launch
Recycled Materials for MSE Wall Backfill

- Cost – Effective
- Flexible
- Feasible > 30m
- Eliminates space and material
Leaching of Alkaline Substances and Heavy Metals from RCA Used as Unbound Base Course

- **Recycled Concrete Aggregate (RCA)**
  - Demolition of concrete pavement, bridge structures, roadway structures, airport runways

- **Uses**
  - Infrastructure backfill; e.g., pavement base course

- **Advantages**
  - Excellent mechanical properties
  - Significant life cycle benefits
  - Widely available and used

[Images of recycled materials and equipment related to concrete pavement and aggregate]
Problem Statement

Environmental Issues

• High Alkaline Leachate
  - Cement-based material
  - Wide pH range (7.5 to 13) in field studies

• Leaching of Heavy Metals

Iowa DOT (1999)
Recycled Materials Webmap Tool

Recycled Materials Web Map

1. Select your search options:
   - State: No State Selected
   - Material Types:
     - Select All Material Types
     - Waste glass
     - Fly ash
     - Slag
     - Recycled base and crushed aggregate
     - Coal Combustion Products
     - Geo-tong
     - Foundry Sand
     - Scrap Tires
     - FGD Sludge
     - Cement Kiln Dust
     - Lime Kiln Dust
     - Iron Slag
     - Ferrous Slag
     - Ferrous Dust
     - Scrap Metal

2. Search using selected state/materials

3. Ctrl-Left-click on the map to do a radius search within 100 miles of where I click.

Selected Providers | Selected Stockpiles | Selected Case Studies
--- | --- | ---
Provider | Contact | Phone | Email | Address | City | State | Zip
Roanoke Quarry | Gary Hallbard | (540) 774-1806 | Email | 4754 Old Rocky Mount Road | Roanoke | VA | 24014
Oak Creek Power Plant | | | | 4754 Old Rocky Mount Road | Oak Creek | WI | 53154
Valley Power Plant | | | | 4754 Old Rocky Mount Road | Milwaukee | WI | 53233
www.TRB-ADC60.org

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THANK YOU WCPA!

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