PAPER INDUSTRY BYPRODUCTS

Generation, Characteristics, and Road-Related Applications

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The Industrial Materials Conference
The Use of Industrial Materials in Highway and Road Construction

U.S. Department of Transportation
Federal Highway Administration

Austin, TX
Nov. 1 & 2, 2010

Industrial Resources Council

Presentation Coverage

- **Introduction to NCASI**
- **Background on the U.S. pulp and paper industry**
- **Review of the generation, characteristics, and management of byproduct solids**
- **Discussion of specific road construction and related applications**

NCASI
National Council for Air and Stream Improvement

- **Non-profit technical organization focusing on environmental issues of the forest products industry**
- **Member companies represent >90% of the pulp and paper and a large fraction of wood products produced in U.S.**
- **NCASI activities include research and information gathering, technical assistance and mill support, and education and training**
- **For its members NCASI produces technical reports, newsletters, regulatory alerts, handbooks, meeting proceedings, webinars, and podcasts**

…environmental research for the forest products industry since 1943

U.S. Pulp and Paper Industry

- 360 pulp & paper mills operating at present
- National annual capacity, 2009: 94 million tons of paper, paperboard, and market pulp

- Mills are located in 40 states. Top 10 states in 2000:
  GA AL LA SC VA WA OR WI MI ME
- Variety of mill capacities, manufacturing processes, raw materials, fuels, and end products

Byproduct Generation

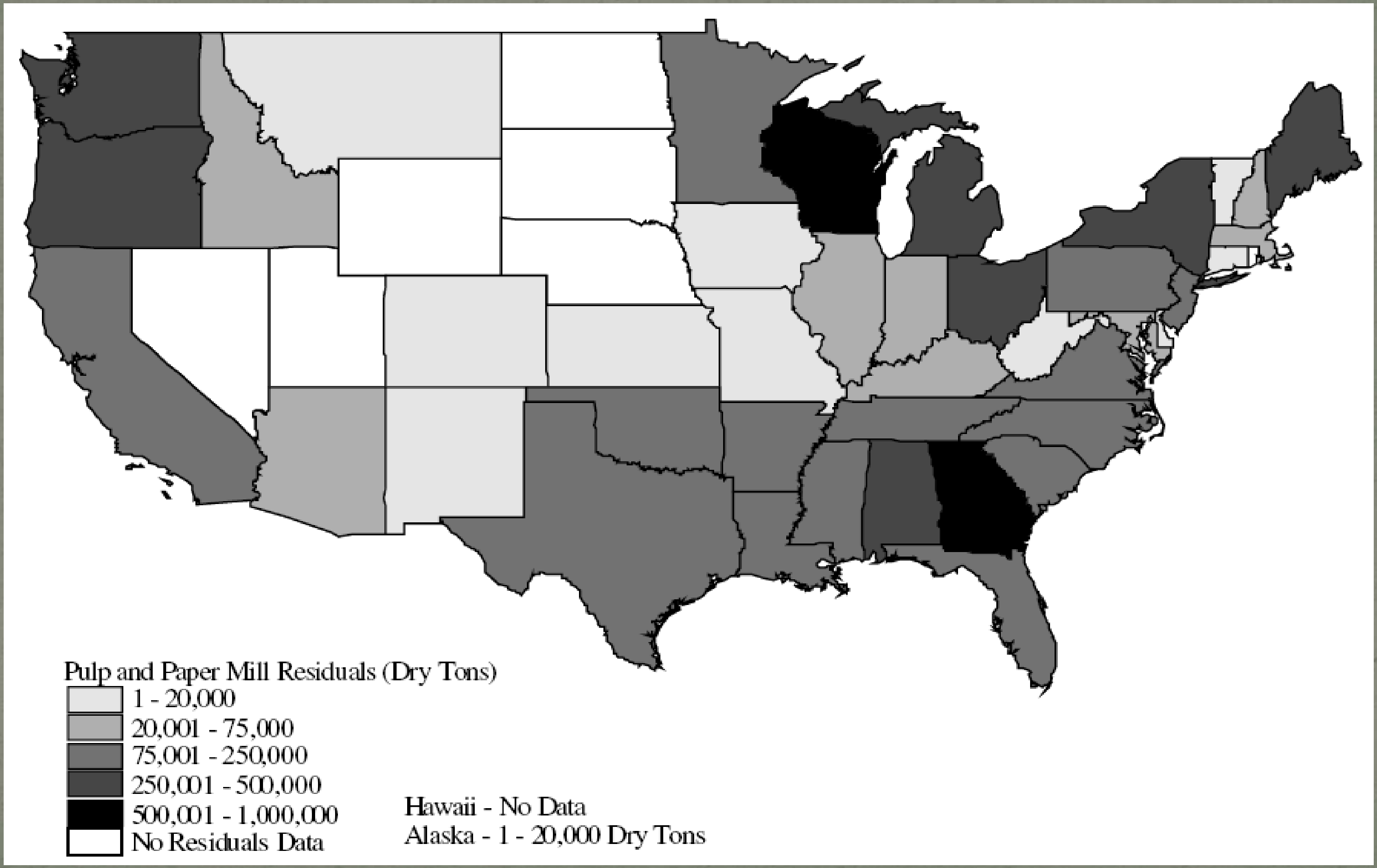
- **Annual generation of byproduct solids and solid wastes by the U.S. pulp and paper industry:**

  15 million dry tons

- **Including two major materials**
  - **Wastewater treatment plant (WWTP) residuals ("paper mill sludge")**
  - **Boiler ash**

- **This presentation will review these two materials with an emphasis on WWTP residuals**

Annual Generation of WWTP Residuals by State (1995)



WWTP Residuals

- ≈ 5.5 million dry tons annually
(≈ 16 million wet tons/year)
- Types
  - Primary (including deinking residuals) – Solids from settling of raw wastewater
  - Secondary (waste activated sludge) – Solids from settling of biologically treated wastewater
  - Combined primary and secondary
  - Dredged
- Mechanical dewatering is the norm, with a solids content typically 30-40%, range 20-60%*
- Very small number of mills dry residuals (70-95% solids)

** Solids content expressed on total-weight basis*

Primary WWTP Residuals

- **Primary WWTP residuals consist mainly of**
  - **Wood fiber and wood fines**
  - **Mineral or inorganic matter (e.g., kaolin clay, $CaCO_3$, TiO_2)**

- **"Ash" (mineral) content of primary WWTP residuals ranges from <10% to >70% (dry wt. basis)**

- **At typical solids contents, residuals are characterized by high compressibility and low shear strength**



WWTP Residuals - Environmental

Potential Environmental Issues (Chemical Constituents)

- Heavy metals and trace elements: Concentrations tend to be similar to or below those in municipal biosolids
- Dioxins: A historical issue for residuals from bleached-kraft pulp mills, with current concentrations comparable to those in municipal biosolids
- PCBs: Also a historical issue, as their use in carbonless copy paper was banned in 1971, and levels in deinking residuals (certain recycling mills) declined precipitously
- Hazardous waste: Not hazardous based on Toxicity Characteristic Leaching Procedure (TCLP)

WWTP Residuals – Beneficial Uses

- **Significant outlets are agricultural uses and onsite combustion for energy recovery**

- **To date, transportation-related uses have mostly been confined to**
  - **Research and demonstration projects**
  - **Established programs involving a limited number of mills**
  - **R&D and experience outside the U.S.**

WWTP Residuals at the Roadside

Potential Roadside Uses

- Promotion of vegetation growth
  - Soil conditioner (organic matter)
  - Fertilizer (plant nutrients)
  - Liming agent (soil pH)
- Erosion control
  - Incorporated into the soil
  - Surface application (mulch)

Documentation of vegetation growth (agricultural settings) is extensive

Documentation of erosion control is limited but growing

Municipal Landfill Closure with Mill WWTP Residuals

WWTP Residuals in Soil Stabilization & Road Construction

- **Starting in 1977, loose-sand roads in the Chequamegon National Forest, WI, were stabilized with residuals**
- **Incorporation was done at a rate of about 5%dry-wt. to a depth of about 6 inches**
- **The mixture formed a stable surface, substantially reducing erosion**
- **Rutting could occur in low-lying areas with poor drainage and during heavy rain**
- **Residuals addition was reserved for lower-volume roads in areas deficient of readily available aggregate**
- **Cost-per-mile was ≤15% than that for using aggregate**

WWTP Residuals in Asphalt

- The Department of Science and Technology in the Philippines evaluated four WWTP residuals as the fiber in stone mastic asphalt (SMA)
- The residuals, first dried and ground, differed in ash (mineral) content and fiber length distribution
- Marshall specimens were prepared with bitumen ranging from 4.5 - 6.5% and residuals from 0.2 - 0.5%
- Stability was improved with residuals addition
- SMA was obtained that met stability, flow and air voids specifications for medium and heavy traffic roads

WWTP Residuals in Concrete

- Fibrous WWTP residuals might be used in structural concrete to enhance flexural strength and cracking resistance

- Research at Univ. of Wisconsin-Milwaukee found that small amounts (0.5-1% by wt.) of residuals can improve freeze-thaw, salt-scaling, and abrasion resistances and flexural strength of ready-mix concrete

- The research also showed problems can arise with water demand, fluidity, and setting time, resulting in 10-20% lower compressive strength

WWTP Residuals in Concrete

- **Most recent work has examined WWTP residuals in concrete containing high-carbon coal fly ash, which is becoming more common as utilities install low-NOx burners**
- **The residuals are intended to replace air-entrainment chemicals and impart resistance to freeze-thaw cracking**
- **Work to date demonstrates that residuals are capable of providing high resistance to freeze-thaw cracking**

Ash or Slag from WWTP Residuals

- **Thermal treatment of WWTP residuals can produce material ("PSA") high in limestone, lime and/or metakaolin, depending on residuals composition and combustion conditions**
- **PSA ("TopCrete") produced from four deinking mills in Holland is successfully marketed as a cement substitute**
- **UK Environmental Agency has a "quality protocol" (favorable beneficial use determination) on PSA use in concrete and other applications**

Ash or Slag from WWTP Residuals

- An engineering company in Georgia is pursuing the commercialization of PSA in the U.S.
- One issue: US mills often burn WWTP residuals along with wood or coal
- There have been instances of residuals going to U.S. cement plants as raw material
- In Wisconsin, Thermagen Power produces glass aggregate for use in asphalt and concrete, among other applications, from burning WWTP residuals in a cyclone boiler

Boiler Ash

- ≈ 4 million dry tons annually
- Types (based on fuel)
  - Wood including bark
  - Coal
  - Wood and coal
  - Wood, coal, or both with miscellaneous solid fuels
- Wood ash
  - Often high in unburned carbon
  - Often high in calcium
  - Usually cementitious or pozzolanic
  - Particles are angular or irregular

Wood Ash – Beneficial Uses

- Significant outlets are agricultural applications and earthen construction

- To date, transportation-related uses have mostly been confined to
  - Research and demonstration projects
  - Established programs involving a limited number of mills
  - R&D and experience outside the U.S.

Wood Ash in Soil Stabilization & Road Construction

Canada

- **Laboratory research at Univ. of Guelph demonstrated that a wood fly ash (LOI = 21%, Ca = 250 mg/kg) could improve the strength and stiffness of soil**
- **The lab work was confirmed in field research by treating a landfill haul road having clayey soil, which resulted in reduced rutting**
- **Subsequently, the pulp mill involved in the research began to routinely treat forest haul roads with the fly ash**
- **The treated roads have an increased allowable load during the winter**

Wood Ash in Soil Stabilization & Road Construction

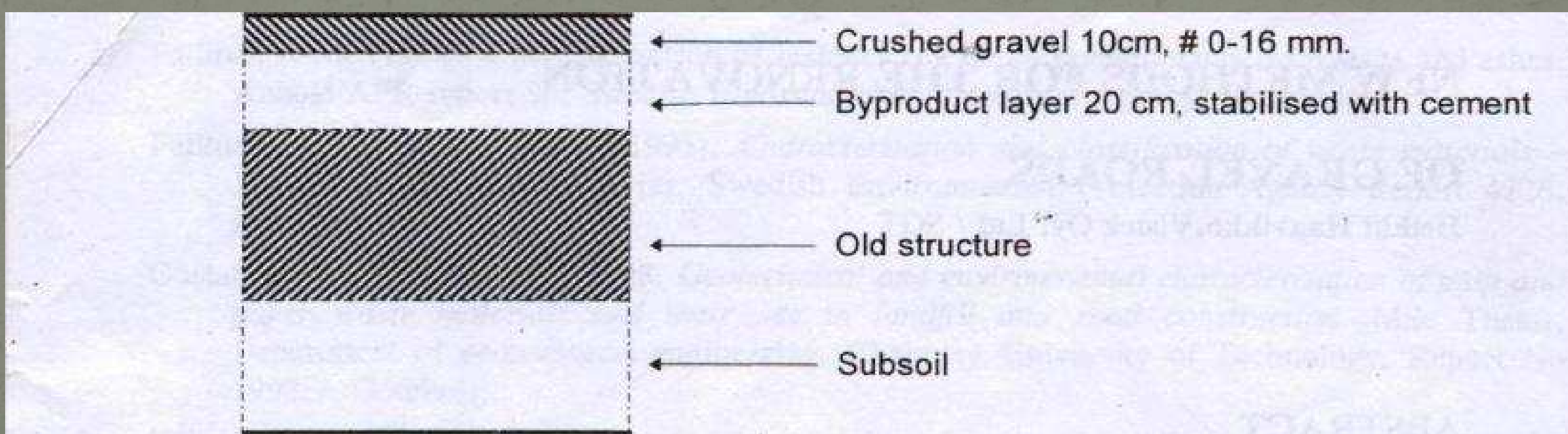
Finland

- **Fly ashes (wood and wood-peat) and ash-WWTP residuals mixtures have been used in demonstration projects to renovate unpaved and low-volume paved roads**
- **A mixture of WWTP residuals and fly ash* yields a material with good frost insulation, bearing capacity and workability**
- **The residuals-ash mixture was also a fill material in the construction of shoulders on a narrow gravel road**
- **Sampling of groundwater during several years for various inorganic parameters indicated "no risk to the environment."**

**** Binder (cement, lime or gypsum) at 1% to 2% may also be added.***

Wood Ash in Soil Stabilization & Road Construction

- This work has lead to some routine use of wood ash and residuals-ash mixtures in road construction
- Similar activity is occurring in Sweden, and Finland is assisting Russia to develop demonstration projects



Wood Ash in Concrete

- Use of wood (and other biomass) fly ash in concrete is a subject of research, e.g., Brigham Young University, University of Wisconsin-Milwaukee
- Issues with wood ash in concrete include:
  - Technical standards that are material specific (coal ash)
  - Requirement for low-carbon ash (freeze-thaw resistance)
- Southeastern pulp mill has its coal-wood fly ash state-DOT approved (designated Class F) and used in concrete for highways and bridges
- Ash from a wood-fired boiler at the mill is injected into a coal-fired boiler, providing better use of wood for energy and producing a low-carbon combined ash
- Coal-wood bottom ash from the mill employed as aggregate in asphalt mixes and in concrete blocks

Questions and Comments

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