A. RESEARCH

A.1 What should be considered as the key justifications with respect to US national and global interests, for investment of resources in expansion of research on Geoenvironmental materials?

Investment in research can lead to:

- Conserve Natural Resources
- Economical Considerations
- Sustainable Development/Construction
- Improved Performance of Infrastructure
- Public Health and Safety
- Promote Waste Management, Reuse and Recycling in Underdeveloped and Other Countries for Ultimate Enhancement in Global Sustainable Development
- International Collaboration

A.2 What are the geoenvironmental materials of interest?

- Fabricated Products
  - Polymeric
    - Geosynthetics
    - Synthetic Fibers
    - Nanomaterials
  - Non-Polymeric
    - Natural Fibers
- Natural Materials
  - Clean
    - Soil
    - Rock
  - Contaminated
A.3 What are the properties that should be targeted with respect to the evaluation of Geoenvironmental materials, and what is the state of knowledge on them?

- Physical (specific gravity, particle size distribution, pore size distribution, plasticity indices, particle shape, organic content, moisture content, microtexture, microcharacteristics)
- Mechanical (compaction, flowability, hydraulic conductivity, strength, and volume change characteristics)
- Chemical and Mineralogical (pH, elemental analysis, leachability, leachate analysis, solubility, sorption, volatility, toxicity, reactivity, corrosivity, flammability, BOD, COD)
- Durability (environmental and chemical exposure tests, creep, particle soundness, corrosion, radiation damage tests, UV radiation tests, microbe resistance tests)
- Compatibility (material)

Ref: EPA Report (Ahmet)

The following characteristics tend to simplify the amount of testing:
- Material Homogeneity
- Small Particle Size
Non-Toxic
Non-Reactive
Non-Combustible

A.4 Are current testing equipment and procedures capable of providing adequate information on the critical material characteristics?

- Testing equipment for characterization of fabricated materials improved considerably and is generally adequate. Long term durability tests on these materials still pose a problem.
- Current testing equipment and test procedures are adequate for characterizing majority of the natural materials. A few exceptions are fractured rocks and large boulders.
- Lack of information on the availability of the specialized equipment at particular laboratories is a barrier in testing some of the materials.
- Occupational barriers of certain specialized equipment is also another barrier

A.5 What analytical/numerical techniques are there or should be used in predicting the performance of Geoenvironmental materials?

- Risk Assessment and Material Reliability Methods (LRFD)
- Damage models (Freeze-Thaw, Drying-Wetting, Creep, Fatigue)
- Arrhenius Methods (Creep)
- Centrifuge Studies – Modeling of Experimental Studies or Models
- Simulated Studies (Flow)
- Probabilistic Methods (Analysis of Damage Scenarios)
- Others

A.6 Has enough advantage been taken of decades of research findings on soil characteristics, contaminant transport through geomedia in the soil and agricultural science areas? What techniques from those fields should be adopted to address contemporary issues that relate to Geoenvironmental materials?

- We have used research findings from other areas
- We still need to do more research
• Unsaturated Soil Mechanics (Soil Water Characteristic Curve and Suction Potentials)

A.7 What are the driving forces to funding?

- Economics (Owners, Manufacturers)
- Life Cycle Cost Benefits
- Interdisciplinary (Programs: Physics, Chemistry, Geosciences, Biology, International)
- Socio Economic (HUD)
- Security (DOD, DOJ, DOE, Homeland Security)
- Environmental (EPA, NIH, NRCS, USGS)

A.8 What are the critical and immediate research needs in Geoenvironmental Materials?

<table>
<thead>
<tr>
<th>Type of Geoenvironmental Material</th>
<th>Elemental Composition &amp; Characterization</th>
<th>Long Term Performance</th>
<th>Reuse Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biosolids</td>
<td>X</td>
<td>X</td>
<td>X (Amended Soils, Land Reclamation)</td>
</tr>
<tr>
<td>Mining Byproducts</td>
<td></td>
<td>X</td>
<td>X (Civil Works)</td>
</tr>
<tr>
<td>E-Waste</td>
<td>X</td>
<td>X</td>
<td>X (Additives/Amendments)</td>
</tr>
<tr>
<td>Contaminated Sediments</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>MSW</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Geosynthetics</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Scrap Tyres</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Smart Materials</td>
<td>X</td>
<td>X</td>
<td>X (Bio-inspired, Self Healing, Conducting and Self Sensing)</td>
</tr>
<tr>
<td>Hybrid/Admixtures</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Incinerator Ash</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>
B. PROFESSIONAL PRACTICE

B.1 What are the primary categories of projects that have potential to use Geoenvironmental materials?

Ground Modification, Flow Barriers, Landfills, Landscaping, Erosion Control, Impoundments, Dams, Civil Works

B.2 What compositional factors distinguish fabricated and industrial materials from geomaterials (rocks and soils) with respect to performance?

- Homogeneity and Heterogeneity
- Temporal Engineering Properties

B.3 Should the use of wastes as construction materials be considered to be an economically desirable and environmental sound means of managing high-volume wastes? What are the advantages and drawbacks?

Advantages:
- Conserves Natural Resources
- Economics
- Good Public Relations
- Good Environmental Stewardship
- Enhances Recycling Efforts
- Less Landfilling

Drawbacks:
- Liability
- Time, Space and Equipment Constraints
- Unpredictability of Performance
- Lack of Adequate Specifications and QA/QC Methods
B.4 What is the difference in the practice of materials science and engineering (M) within and outside the scope of professional activities that constitute “Geoenvironmental engineering” (G)? What areas of expertise are needed for practitioners involved in Geoenvironmental Materials?

Material Sciences and Engineering has greater involvement in the applied research and professional trade organizations.

- Material Property Documentation
- More Rigorous Quality Standards
- Technology Transfer
C. EDUCATION (INSTRUCTION)

C.1 Are students at the graduate level adequately prepared to address performance in Geoenvironmental materials? How much chemistry, thermodynamics, kinetics and mathematics is necessary?

Reasonably Adequate (Could be Better).

- Geoenvironmental Materials is too broad to enable the students to get the requirements for the preparation in all the necessary areas
- Need to know what they don’t know
- Preparation of Geoenvironmental Materials
  - Mineralogy and Microstructure (Mining, Mineral Processing)
  - Geo Chemistry (Geology, Chemistry)
  - Biological Process (Environmental Engg.)

C.2 How can the diverse field of Geoenvironmental engineering be segmented such that one of the segments could be a course that is deep in materials analyses?

It is difficult to offer a comprehensive course covering the Geoenvironmental materials. Perhaps, a more pragmatic approach is to offer the treatment of appropriate materials in speciality courses (eg. Coverage of Geosynthetic Properties in Waste Geotechnics).
C.3 Are there sufficient textbooks to support the education in Geoenvironmental materials?

Existing books cover only segments of the broad field of Geoenvironmental Materials.

C.4 Are alternative delivery methods appropriate for teaching Geoenvironmental Materials courses?

They are appropriate; however, laboratory experience is necessary.