BENEFICIAL REUSE OF COAL COMBUSTION BYPRODUCTS AS GEOTECHNICAL CONSTRUCTION MATERIAL

July 29, 2009

12:00 – 12:30	Lunch, Introductions, Agenda Review	Bob Spoerri & Eric Schaeffer
12:30 – 12:50	History and current utilization of CCPs as Geotechnical Construction Material	Tom Adams
12:50 – 1:20	Technical overview of CCP use as Geotechnical Construction Material	Dr. Craig Benson
1:20 – 1:40	Perspective on Wisconsin's experience with CCPs, including NR538 regulatory structure	Paul Koziar
1:40 – 2:00	Experience with CCP use as Geotechnical Construction Material in the Midwest and Southeastern US	Bob Spoerri and Bob Waldrop
2:00 – 2:15	Break (Time Permitting)	
2:15 – 3:00	Presentations Q&A	
3:00 – 3:45	Discussion of standards framework for using CCPs as Geotechnical Construction Materials	
3:45 – 4:00	Next steps, Summary and Close	Bob Spoerri & Eric Schaeffer

Agenda

WHY FIND BENEFICIAL USES FOR CCPS?

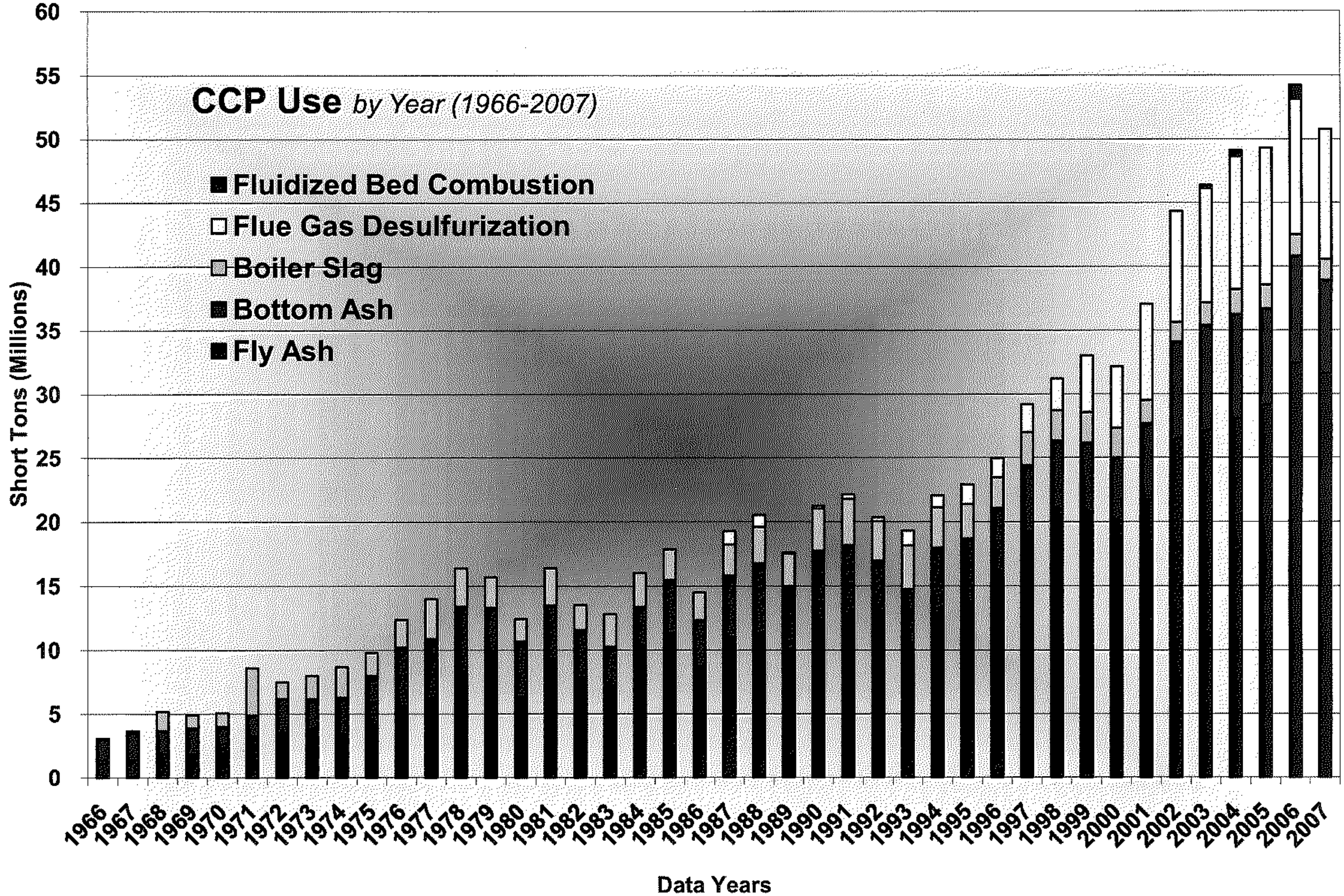
Thomas H. Adams
Executive Director
American Coal Ash Association

ACAA

Background

- Coal fueled generation will continue for the foreseeable future
- Byproducts of the generating process create mineral resources that must be disposed – or used
- Historically both production and beneficial use have increased each year in the last ten
- EPA, DOE and industry have set the goal of 50% utilization of all CCPs by the year 2011

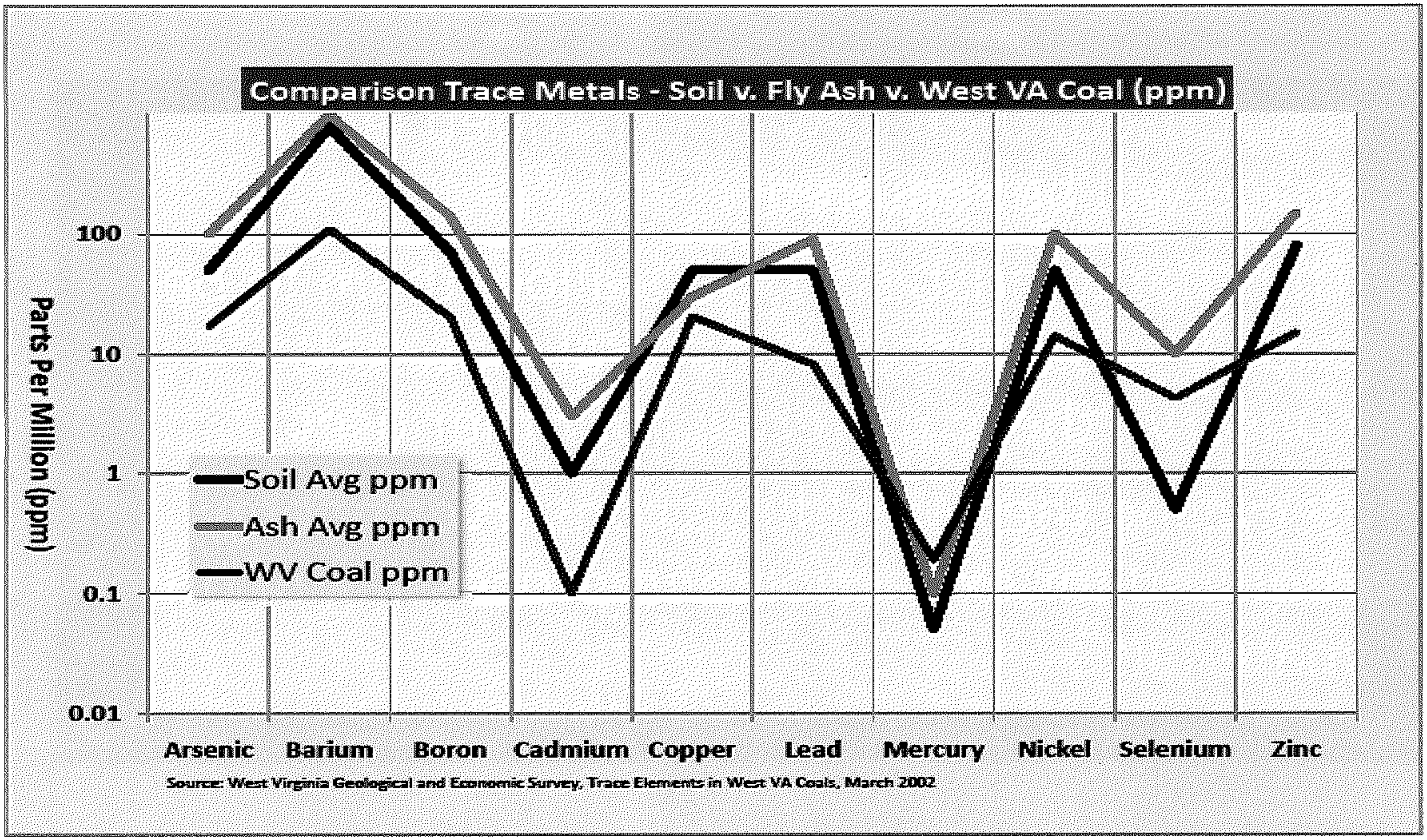
Production and Use over the Years



Constituents in CCPs

- CCPs contain the same heavy metals as found in coal, but in slightly more concentrated forms
- The concentrations are comparable to other products, such as portland cement, lime, etc.
- CCPs create no greater risks than commonly used products found in commercial applications
- The metals are very similar to the ranges found in soils, typically in low parts per million

Sample Concentrations in FA



Why Find Beneficial Uses?

- If not used, then new or expanded landfill space will be required.
- The characteristics of CCPs allow them to be widely substituted for natural materials – conserve these materials for other uses.
- Recycling these residuals conserves energy required for extraction and processing of other materials

Other Considerations

- Properly characterized and placed using environmentally appropriate procedures will not cause adverse impact
- By beneficial use, this industry DOES NOT mean disposal by another name
- It is essential for this nation to wisely use its available mineral resources, including recycling industrial residues
- We need to reduce our carbon footprint by sound beneficial use

Disposal Will Continue

- Not all CCPs are useable with *current* technologies
- Depending on location, transportation options and competition, applications may be limited
- Plant by plant, utilization vs. disposal must be evaluated
- Almost certainly, additional landfill space will be required to address new byproducts from plant scrubber systems unless appropriate beneficial uses can be identified

Conclusions

- U.S. CCP industry is evaluating future options as regulations and technologies change
- Conservation of natural resources through recycling CCPs makes environmental and technical sense
- Building understanding with government agencies, NGOs, academia and industry is one path toward addressing diverse viewpoints
- In times of economic challenge, ash reuse makes $ense

Conclusions

- Beneficial use of CCP should be encouraged to lessen the need for disposal
- Properly *engineered* and *managed* applications will achieve desired physical, environmental, economic and social results
- We cannot ignore the impacts of inefficient resource management on our environment and society
- Zero-waste target – done safely

Thank You

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ACAA

CCPs as Geotechnical Construction Materials

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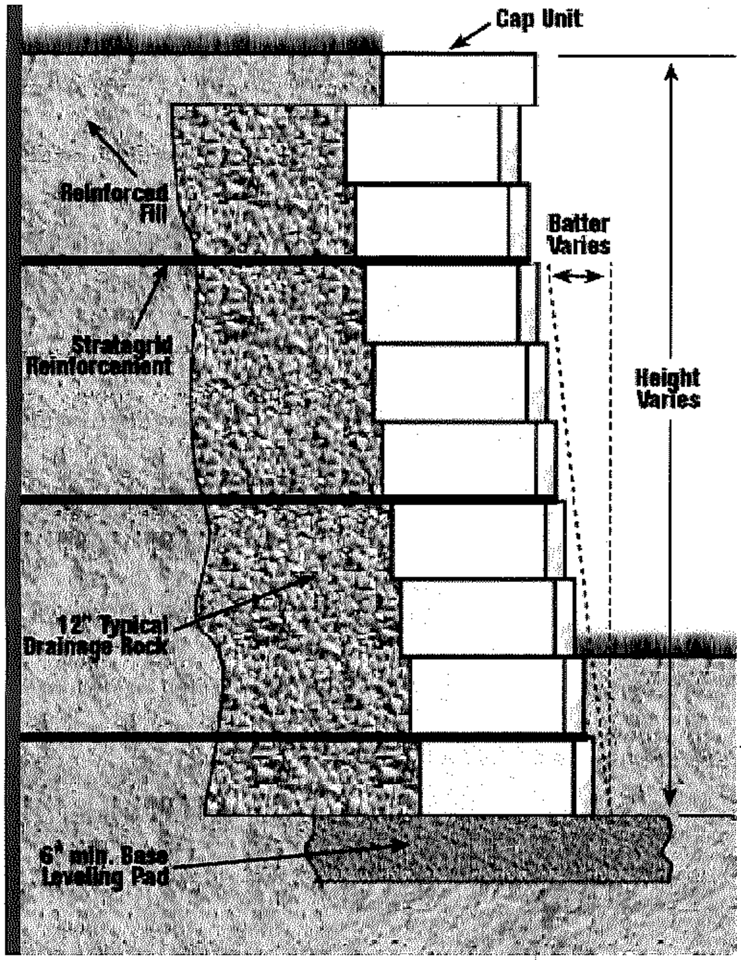
RMRC

THE UNIVERSITY of WISCONSIN MADISON

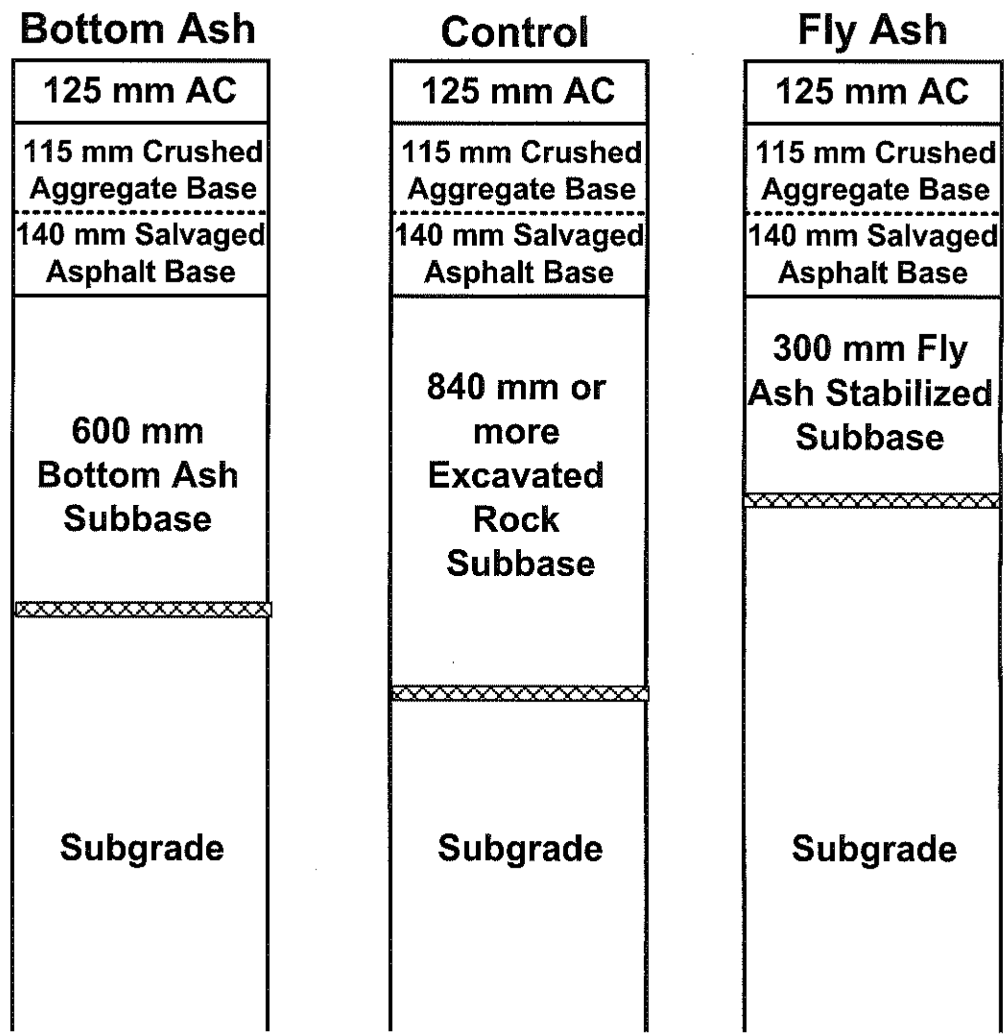
Applications

- Fly ashes
  - Structural fill (e.g., embankments)
  - Drying agent for wet soils (e.g., wet subgrades)
  - Strengthening agent for subgrades and bases
- Bottom ashes
  - Structural fill (e.g., retaining wall backfill)
  - Base course for pavements
  - Drainage layers

Structural Fill



Pavements



Why use CCPs in Lieu of Earthen Materials or Chemical Stabilizers?

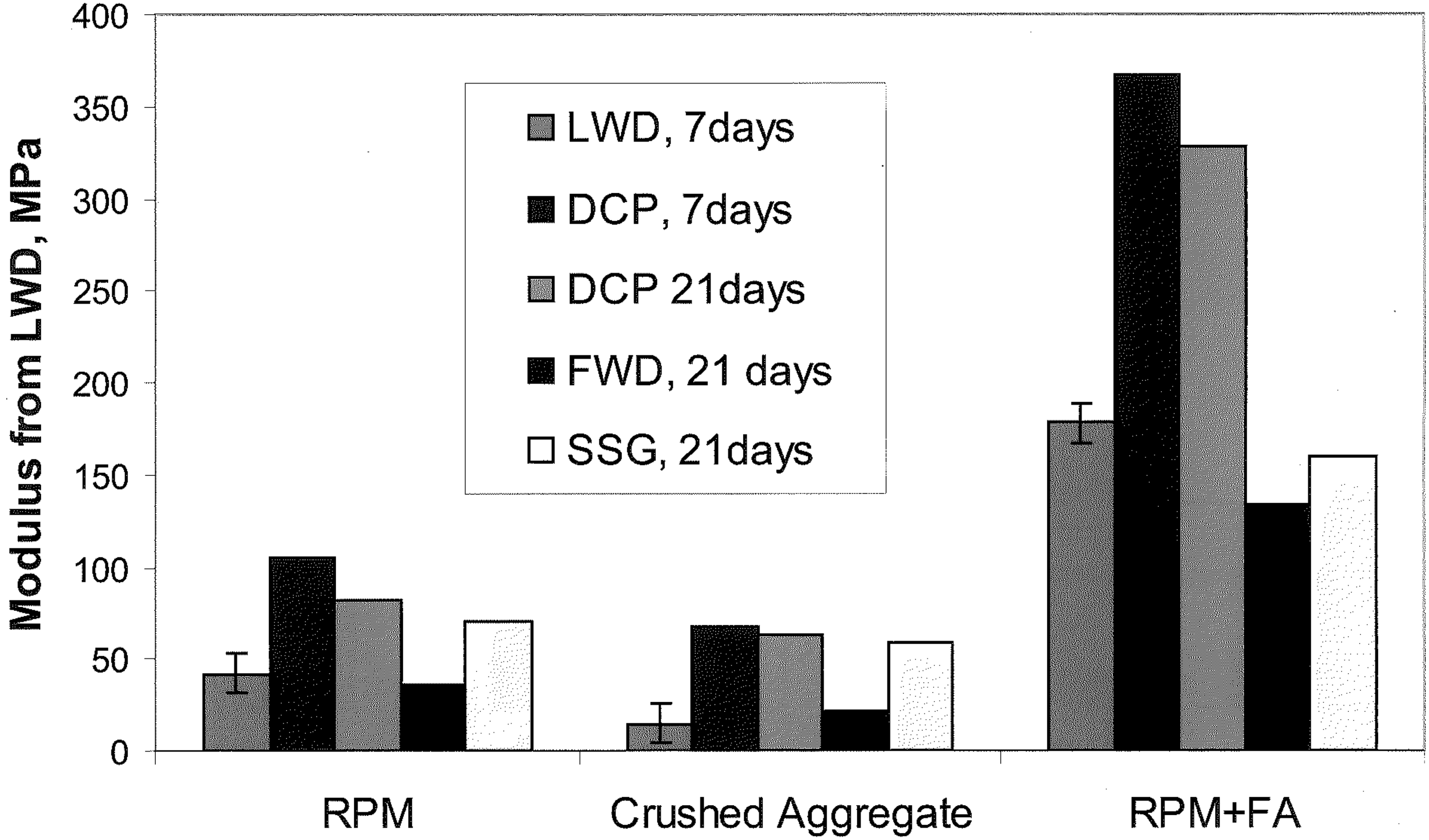
- Many behave like soils
- Avoid borrow source problems
- Reduced energy consumption
- Lower greenhouse gas emissions
- Improved performance and service life
- Cost savings

Two Byproducts → High Quality Product

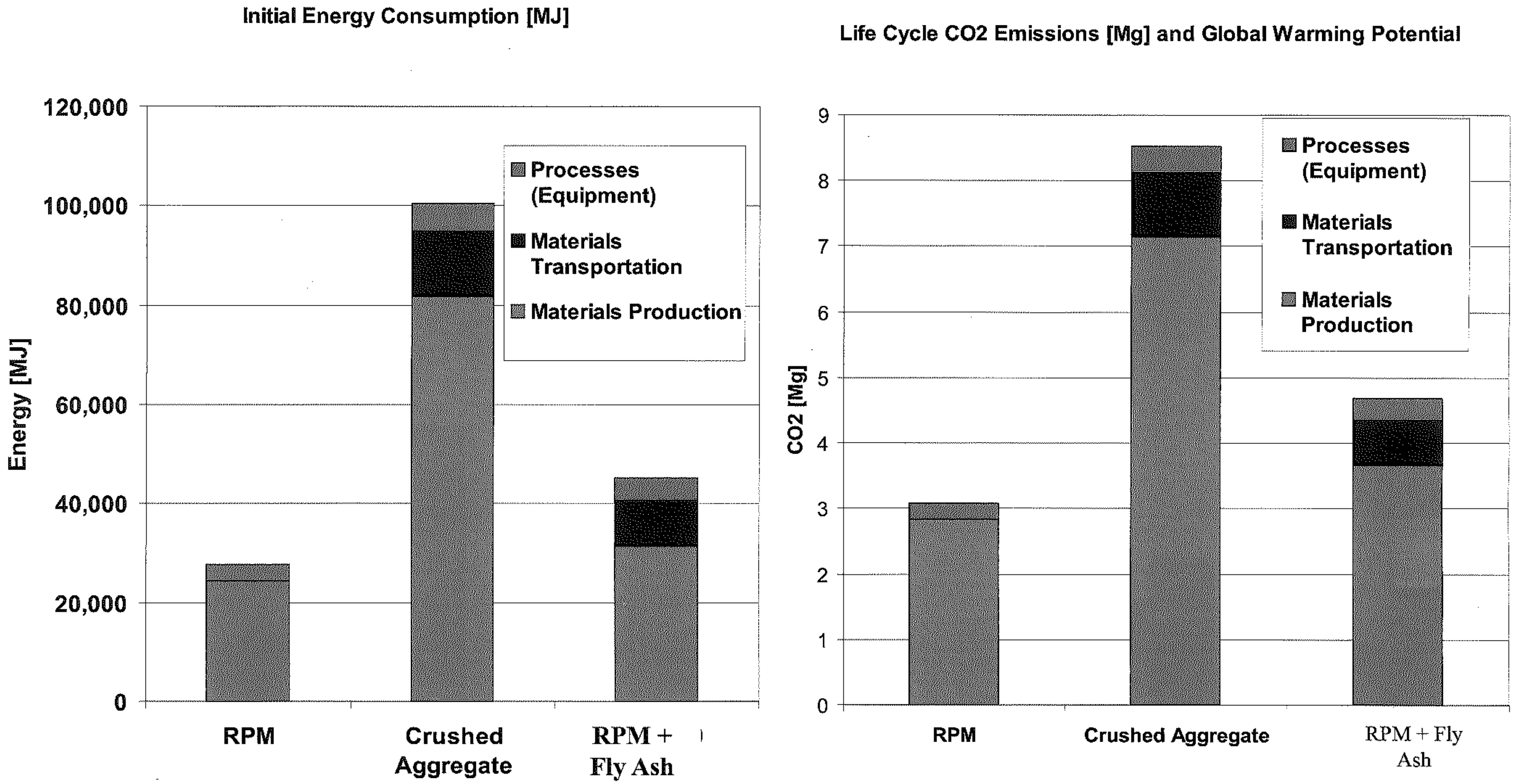
RPM + High Carbon Fly Ash

= high modulus and durable base

Creating a Superior Roadway with CCPs

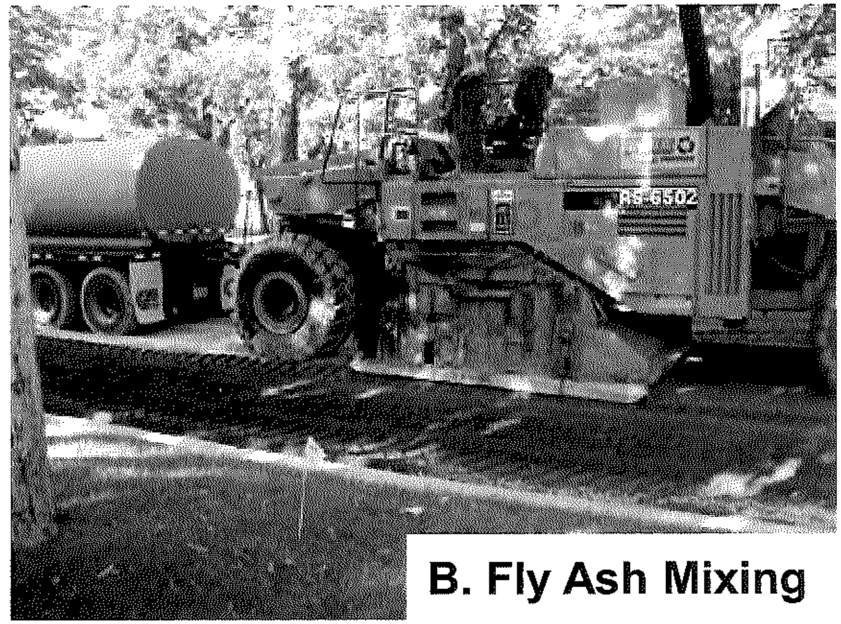


Life Cycle Analysis – Energy and GHG Emissions

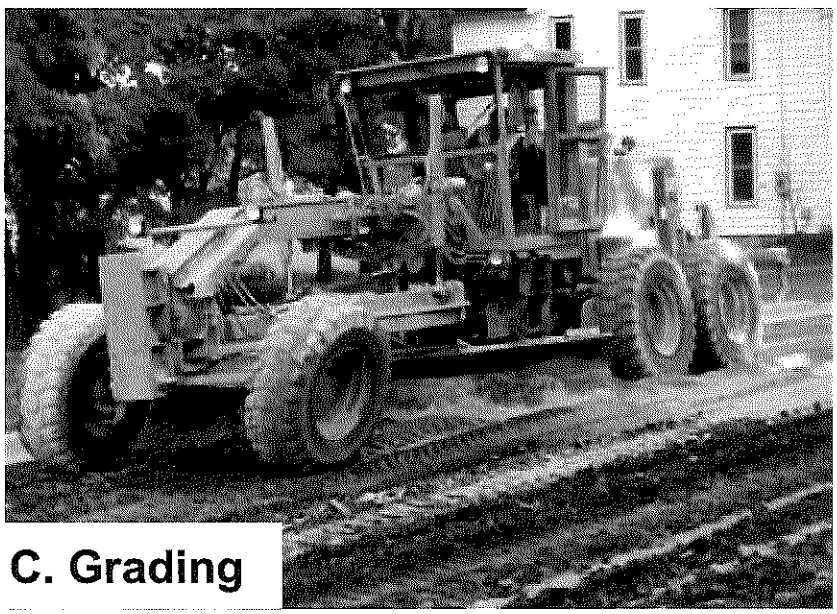


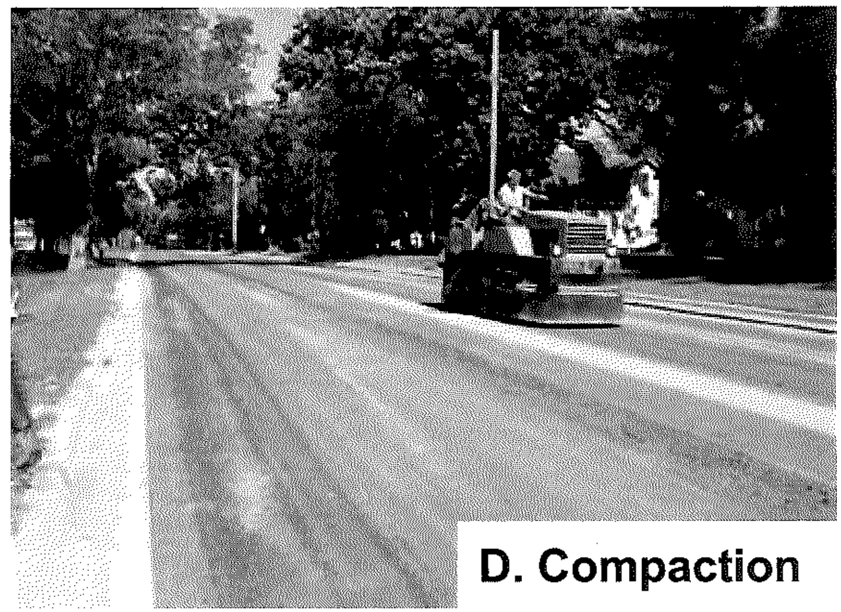
Subgrade Stabilization


A. Spreading Fly Ash



B. Fly Ash Mixing


C. Grading


D. Compaction

What about impacts to ground water?

- CCPs elute a variety of trace elements, as do nearly all granular construction materials.

- Systematically evaluate whether use of materials impacts the environment.

- Code vs. site-specific analysis.

Wisconsin NR 538 Code

Chapter NR 538

BENEFICIAL USE OF INDUSTRIAL BYPRODUCTS

NR 538.01 Purpose. The purpose of this chapter is to allow and encourage to the maximum extent possible, consistent with the protection of public health and the environment and good engineering practices, the beneficial use of industrial byproducts in a nuisance–free manner. The department encourages the beneficial use of industrial byproducts in order to preserve resources, conserve energy, and reduce or eliminate the need to dispose of industrial byproducts in landfills. This chapter is adopted under ss. 289.05, 289.06, 289.43 (4), (7) and (8), Stats. and 227.11, Stats.

History: Cr. Register, December, 1997, No. 504, eff. 1–1–98.

NR 538.02 Applicability. (1) Except as otherwise provided, this chapter governs the beneficial use of industrial byproducts, except hazardous waste and metallic mining waste.

(2) This chapter does not apply to the design, construction or operation of industrial wastewater facilities, sewerage systems and waterworks treating liquid wastes approved under s. 281.41, Stats., or permitted under ch. 283, Stats., nor to facilities used solely for the disposal of liquid municipal or industrial wastes which have been approved under s. 281.41, Stats., or permitted under ch. 283, Stats., except facilities used for the disposal of solid waste.

Note: The landspreading of wastewater treatment sludge is regulated under chs. NR 204 and 214. The landspreading of solid waste is regulated under ch. NR 518.

History: Cr. Register, December, 1997, No. 504, eff. 1–1–98.

NR 538.03 Definitions. The following definitions as well as the definitions in ch. 289, Stats., and s. NR 500.03 are applicable to the terms used in this chapter unless the context requires otherwise.

(1) "Base course" means the layer or layers of specified or selected material of designated thickness placed on a subbase or subgrade to support a pavement or other structure.

(2) "Industrial byproduct" means papermill sludge, coal ash including slag, foundry excess system sand, foundry slag or other non–hazardous solid waste with similar characteristics as determined by the department.

(3) "Residential area" means properties that are zoned as residential, are in areas planned for residential zoning under a master plan approved or adopted by a local municipal authority or those portions of properties on which there is a residence for human habitation that are within 300 feet of the residence.

(4) "Subbase" means the layer or layers of specified or selected material placed on a subgrade to support a base course.

(5) "Subgrade" means the top soil surface upon which a subbase or base course are placed.

(6) "Subgrade fill" means the layer or layers of material placed above the natural ground surface to achieve a subgrade.

History: Cr. Register, December, 1997, No. 504, eff. 1–1–98.

NR 538.04 Performance standards. No person may store, handle or beneficially use an industrial byproduct in a manner that may cause any of the following:

(1) A significant adverse impact on wetlands.

(2) A significant adverse impact on critical habitat areas.

(3) A detrimental effect on any surface water.

(4) A detrimental effect on groundwater quality or will cause or exacerbate an attainment or exceedance of any preventive action limit or enforcement standard at a point of standards application as defined in ch. NR 140.

(5) The migration and concentration of explosive gases in any structures, or in the soils or air at or beyond the project property boundary in excess of 25% of the lower explosive limit for the gases at any time.

(6) The emissions of any hazardous air contaminant exceeding the limitations for those substances contained in s. NR 445.03.

Note: The placement of materials in a floodplain where an obstruction to flood flows or an increase in regional flood elevation or an adverse effect upon a drainage course is regulated under ch. NR 116.

Note: The emissions of particulates and volatile organic compounds are regulated under s. NR 415.03 and chs. NR 419 to 424.

History: Cr. Register, December, 1997, No. 504, eff. 1–1–98.

NR 538.05 Solid waste rules exemption. (1) GENERAL. Persons who generate, use, transport or store industrial byproducts that are characterized and beneficially used in compliance with this chapter are exempt from licensing under s. 289.31, Stats., and the regulatory requirements in chs. NR 500 to 536.

(2) EXISTING EXEMPTIONS. This chapter does not abrogate, rescind or terminate an approval or grant of exemption in effect on January 1, 1998 that was issued under s. 289.43 (7) or (8), Stats. Nothing in this subsection limits the authority of the department to modify, terminate or rescind any approval or grant of exemption as provided by law.

History: Cr. Register, December, 1997, No. 504, eff. 1–1–98.

NR 538.06 Industrial byproduct characterization. (1) GENERAL. Industrial byproducts that are beneficially used under this chapter shall be characterized as specified in this section to determine their appropriate categorization under s. NR 538.08. The results of this characterization shall be reported to the department as specified in s. NR 538.14. The testing program for materials not specifically listed in tables 1A to 3 shall be approved by the department prior to characterization. For those materials not listed in tables 1A to 3 the department may modify the list of parameters required to be analyzed for and may establish standards on a material specific basis for additional parameters.

(2) INITIAL CHARACTERIZATION. A representative sample of an industrial byproduct shall be properly characterized prior to beneficial use to determine its category under s. NR 538.08.

(3) CHARACTERIZATION METHODS. (a) The limits of detection used in the characterization shall be at or below the concentration listed in tables 1A to 3 for each parameter for the specific target category where possible. When a limit of detection at or below a target category standard is not achievable, or if no concentration is listed, the method that will achieve the lowest detection limit shall be used. All material sampling, total elemental analyses and analyses of eluate from leach testing shall be performed using

- Evaluate byproducts based on total elemental analysis and water leach tests.
- Define byproduct categories based on test data.
- Define suitable application based on category.

Applications Based on Category

Table 4

Beneficial Use Methods

	Industrial Byproduct Category				
	5	4	3	2	1
(1) Raw Material for Manufacturing a Product	X	X	X	X	X
(2) Waste Stabilization / Solidification	X	X	X	X	X
(3) Supplemental Fuel Source / Energy Recovery	X	X	X	X	X
(4) Landfill Daily Cover / Internal Structures	X	X	X	X	X
(5) Confined Geotechnical Fill (a) commercial, industrial or institutional building subbase (b) paved lot base, subbase & subgrade fill (c) paved roadway base, subbase & subgrade fill (d) utility trench backfill (e) bridge abutment backfill (f) tank, vault or tunnel abandonment (g) slabjacking material		X	X	X	X
(6) Encapsulated Transportation Facility Embankment		X	X	X	X
(7) Capped Transportation Facility Embankment			X	X	X
(8) Unconfined Geotechnical Fill			X	X	X
(9) Unbonded Surface Course				X	X
(10) Bonded Surface Course				X	X
(11) Decorative Stone				X	X
(12) Cold Weather Road Abrasive				X	X
Note: General beneficial use in accordance with s. NR 538.12 (3)					X

Note: Refer to s. NR 538.10 for description of each beneficial use

History: Cr. Register, December 1997, No. 504, eff. 1–1–98.

Lower category number provides more stringent limits on leaching characteristics.

Water Leach Test Criteria – NR 538

Category 4 ASTM Water Leach Test

Standard (mg/l)	Parameter	Ferrous Foundry Excess System Sand	Ferrous Foundry Slag	Coal Ash	Other[1]
0.03	Antimony (Sb)				X
0.25	Arsenic (As)				X
10	Barium (Ba)	X			X
0.02	Beryllium (Be)				X
0.025	Cadmium (Cd)	X	X	X	X
2500	Chloride (Cl)				X
0.5	Chromium, Total (Cr)			X	X
6.5	Copper (Cu)				X
1	Total Cyanide				X
20	Fluoride (F)				X
3	Iron (Fe)	X	X		X
0.075	Lead (Pb)	X	X		X
0.5	Manganese (Mn)				X
0.01	Mercury (Hg)	X	X		X
0.5	Nickel (Ni)				X
50	Nitrite & Nitrate (NO_2+NO_3–N)				X
30	Phenol				X
0.25	Selenium (Se)			X	X
0.25	Silver (Ag)			X	X
2500	Sulfate			X	X
0.01	Thallium (Tl)				X
50	Zinc (Zn)				X

1 As provided under s. NR 538.06 (1), the testing program for materials other than ferrous foundry system sand, ferrous foundry slag and coal ash must be approved by the department prior to characterization. For other materials the department may modify the list of parameters required to be analyzed for and may establish standards on a material specific basis for additional parameters.

Note: All testing is to be conducted on a representative sample of a single industrial byproduct prior to commingling with other materials, unless otherwise approved by the department.

- Contaminants of concern depend on byproduct being considered.
- Category 1 has the most test requirements.

No Code / Site-specific Analysis

- Are leached concentrations higher than those from accepted construction materials?

- No: use CCP without further analysis

- Yes: conduct additional analysis to evaluate impact
  - Leach testing
  - Predictive modeling
  - Monitoring

Methods to Assess Leaching

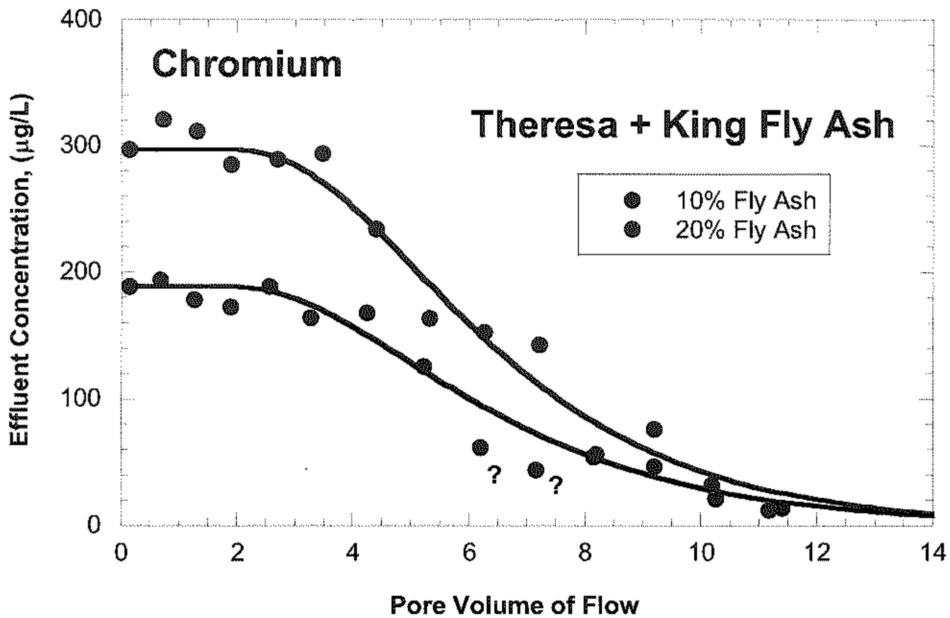
- Batch tests (TCLP, SPLP, WLT):

- solid and liquid in a vial
- tumbled to ensure well mixed
- supernatant analyzed for contaminants of concern

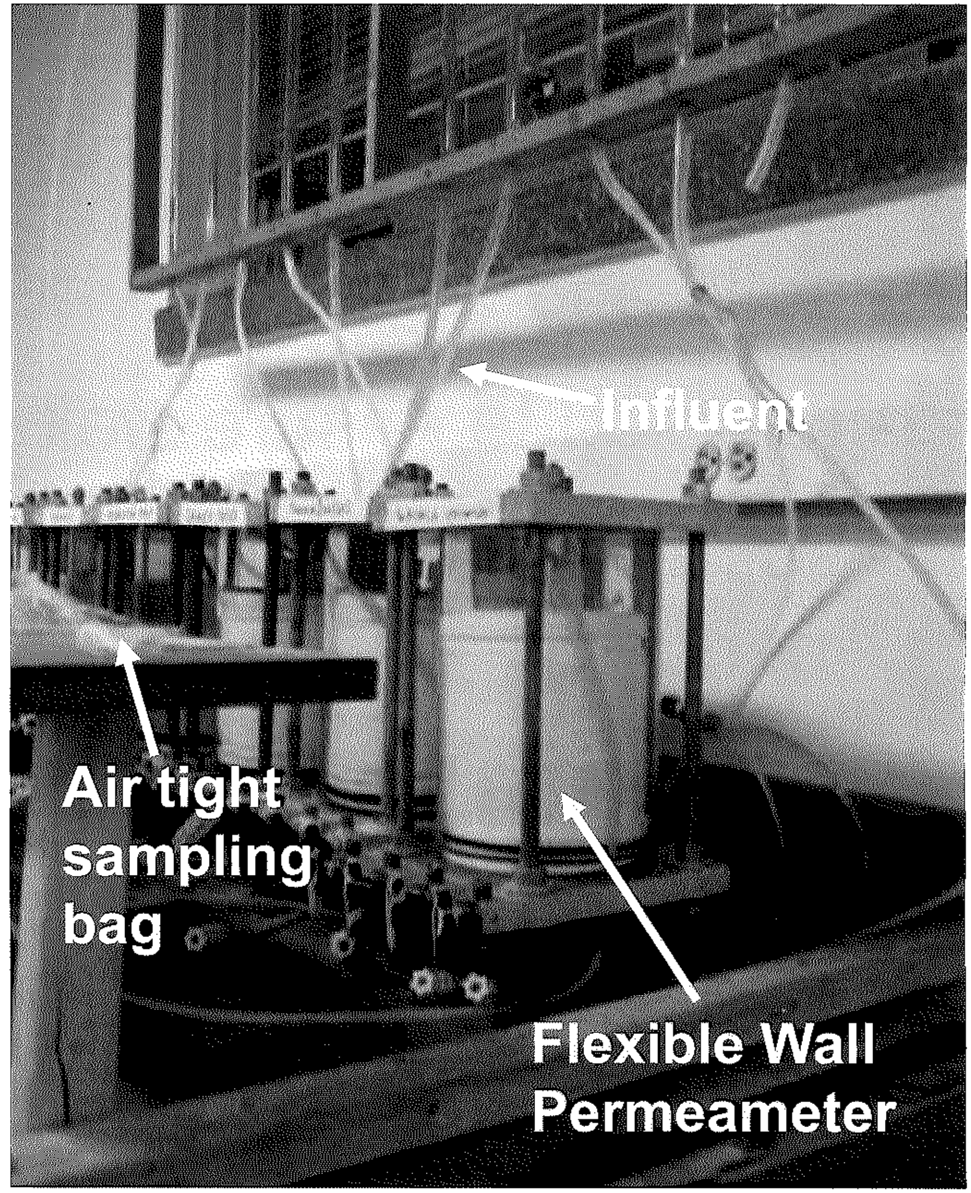
- Column tests:

- flow through experiment simulating field scenario
- effluent analyzed for contaminants of concern.

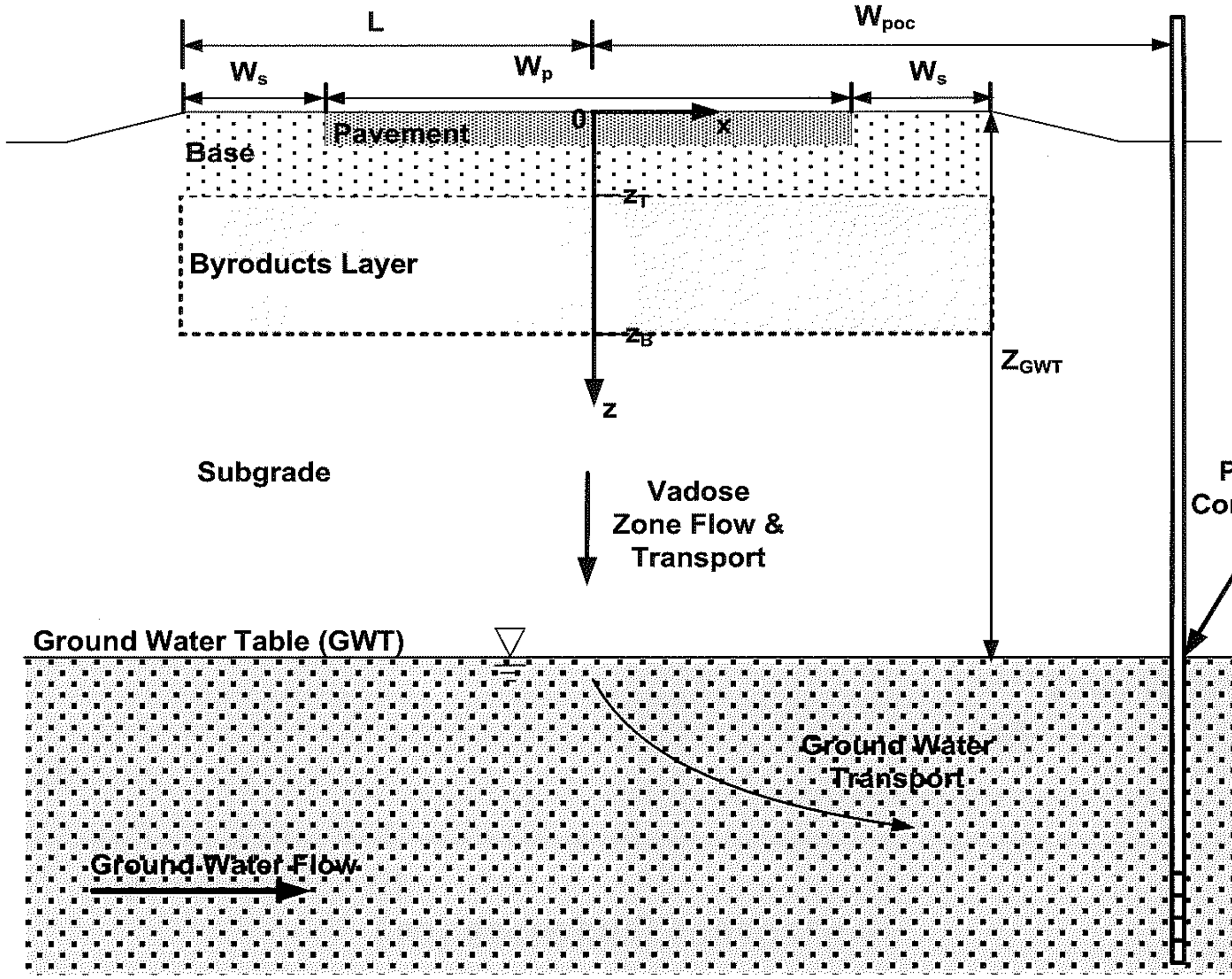
Laboratory Column Leach Tests



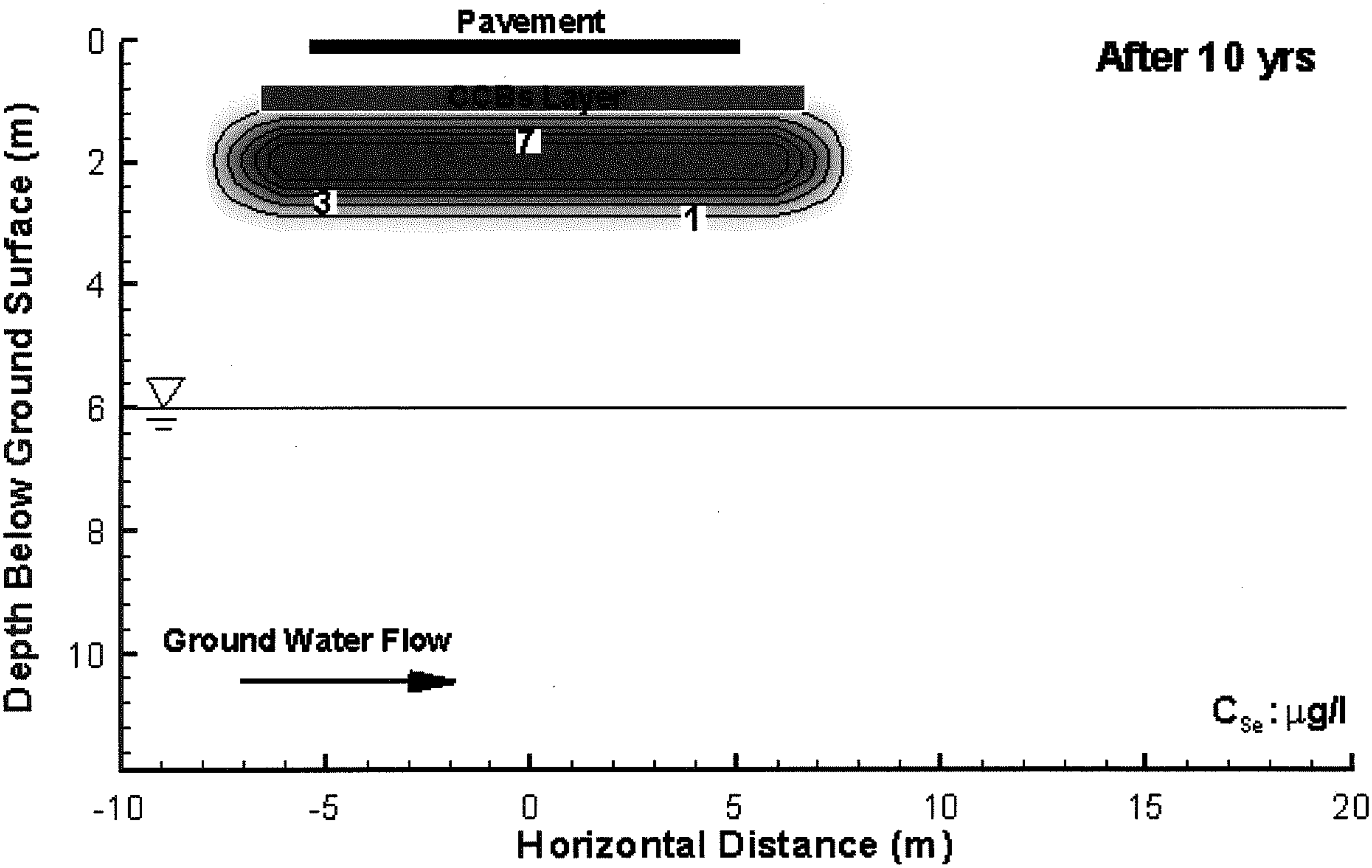
Provides flow-through data simulating field.



WiscLEACH Model

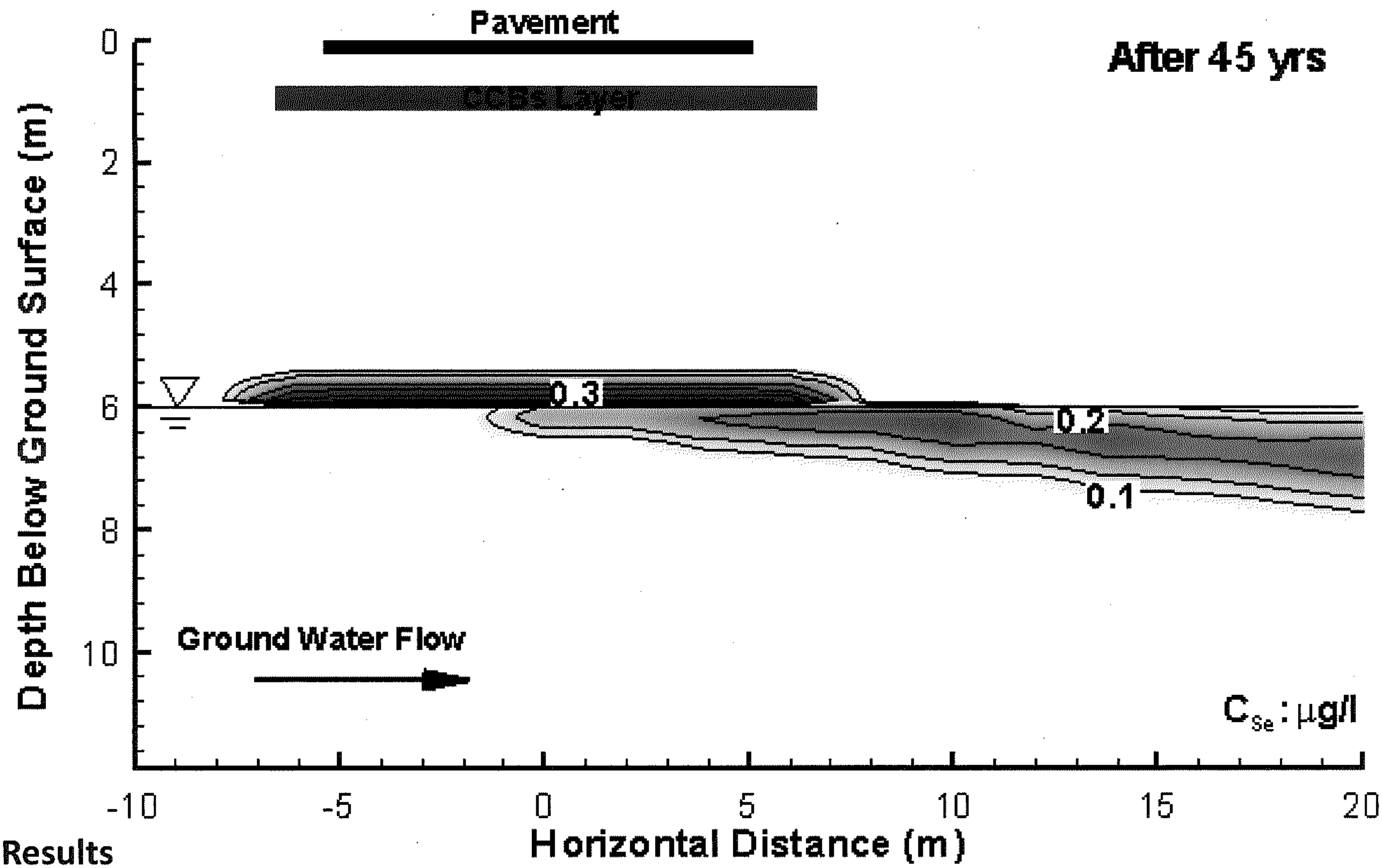


Typical Output: Se Concentration - 10 yr



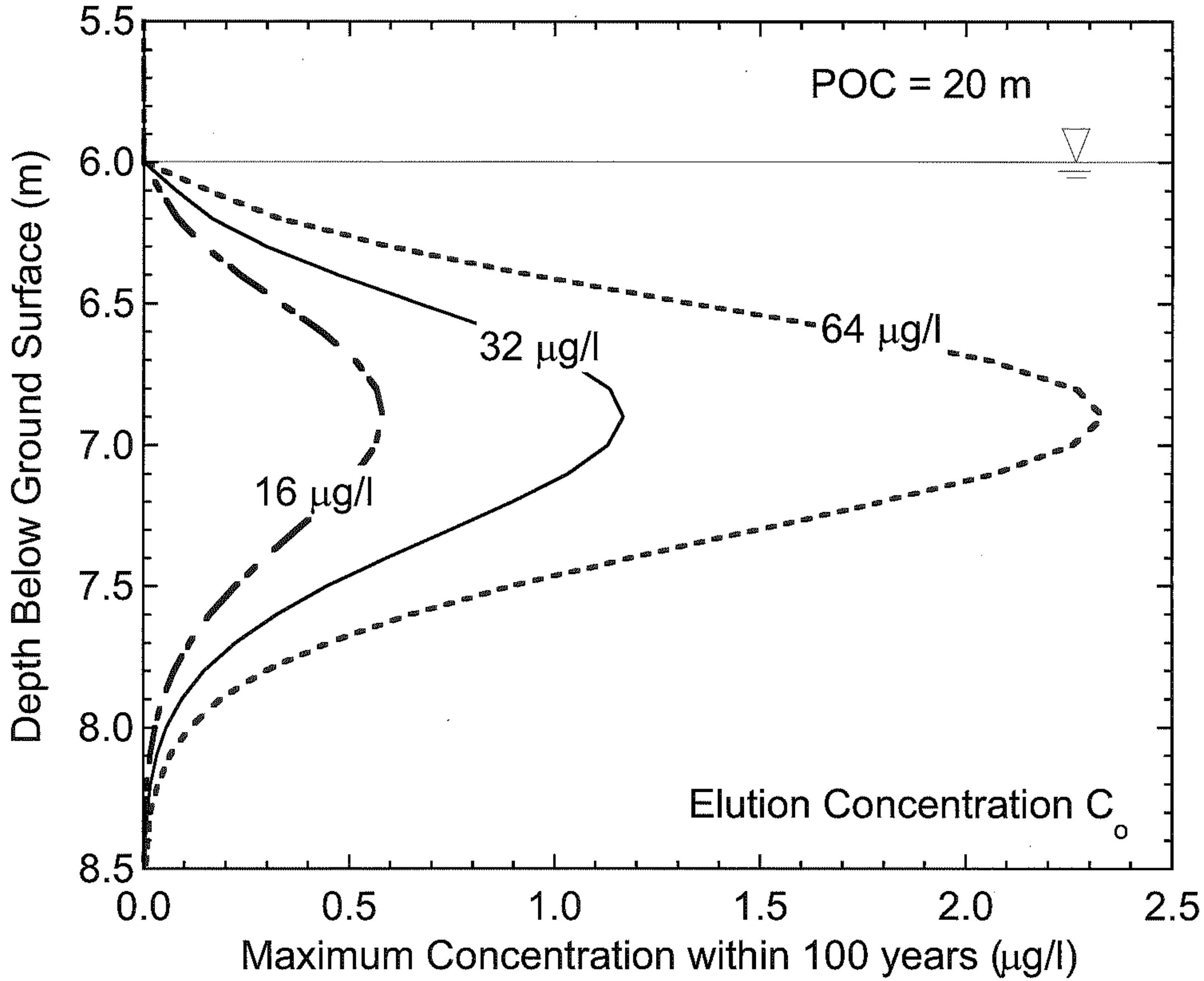
Results

Typical Output: Se Concentration - 45 yr

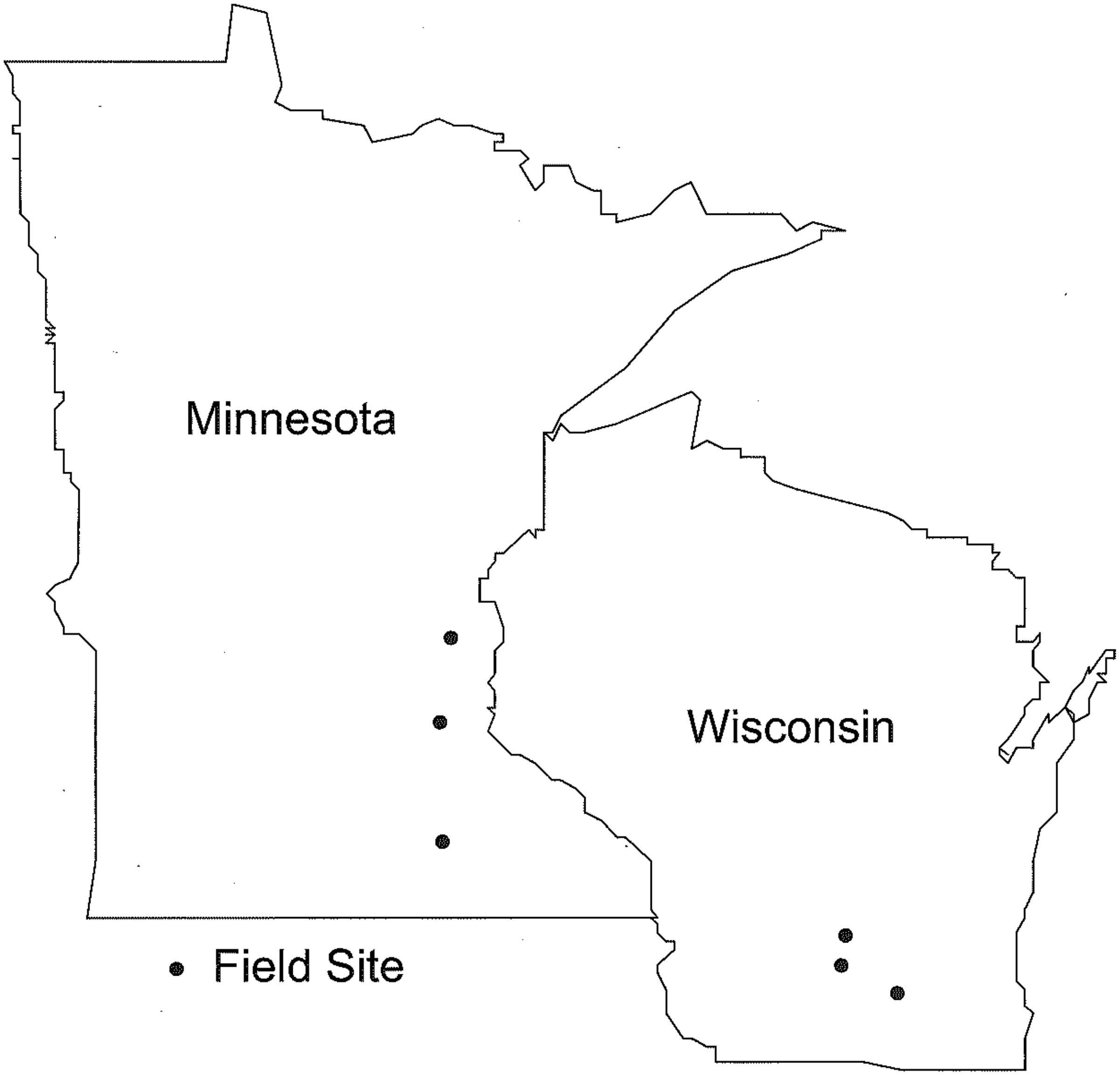


Results

Predictions at Edge of Right of Way



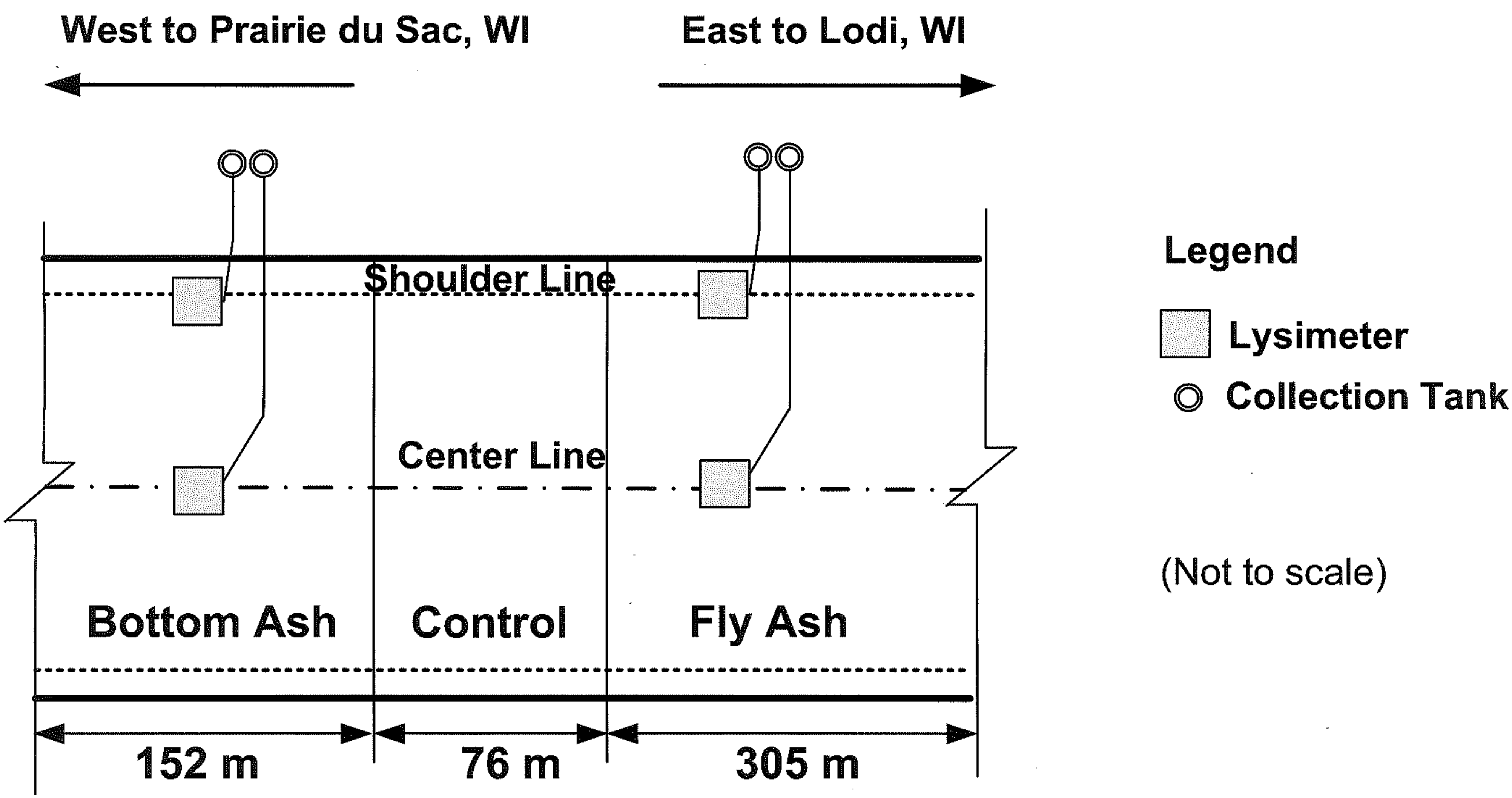
What do we see in the field?

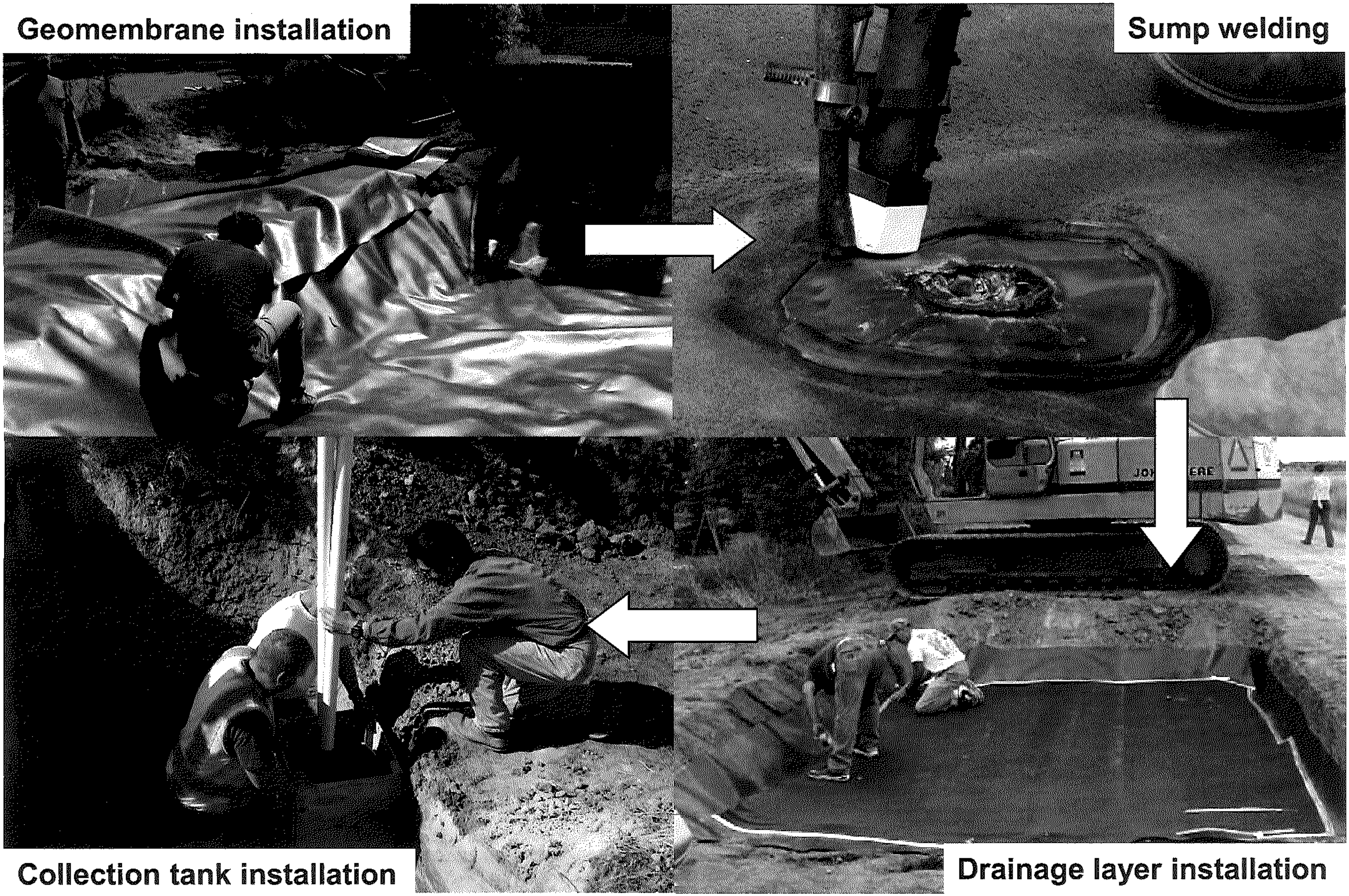


Monitoring Sites:

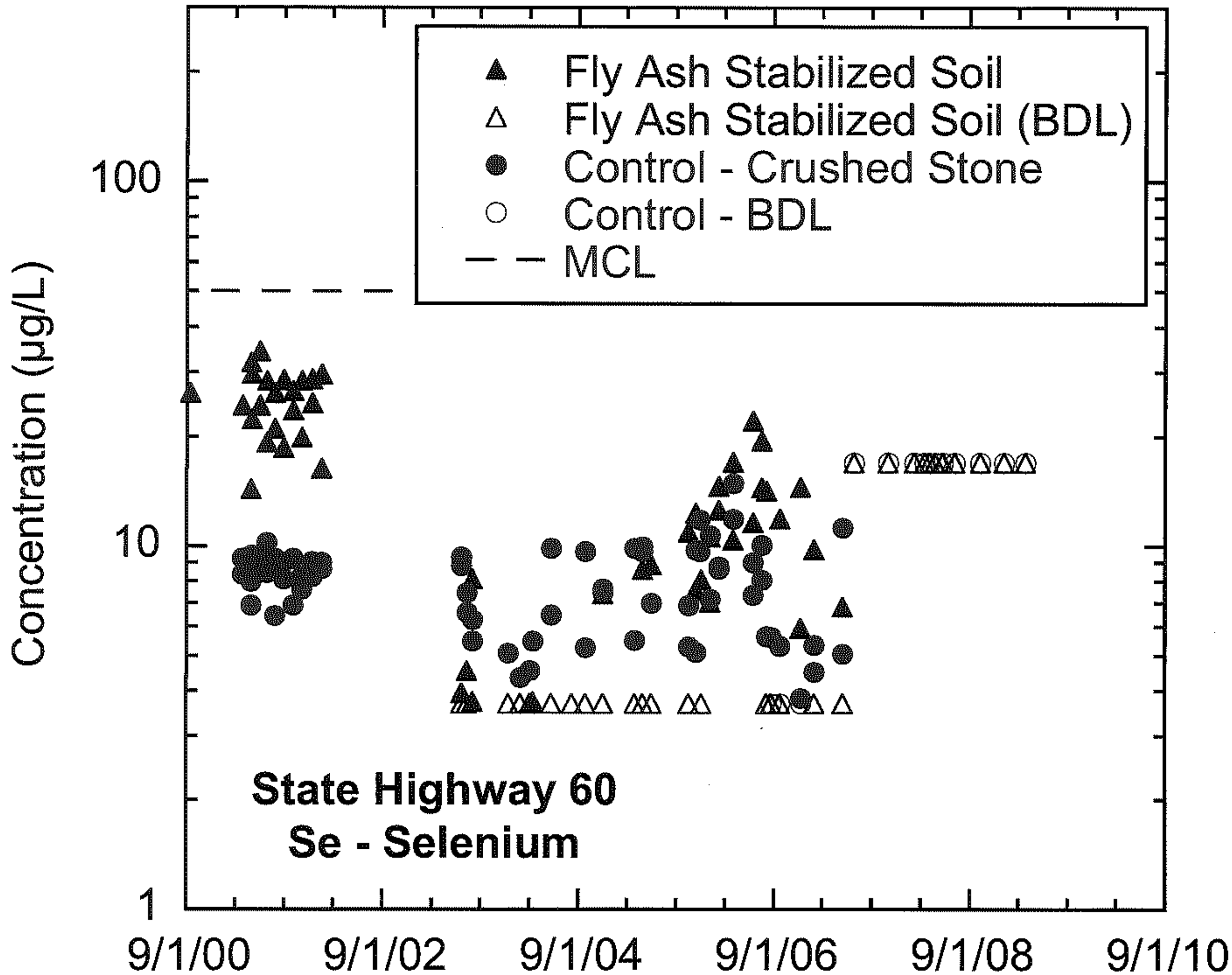
Waseca, MN (1)
Chisago Cty, MN (1)
Lodi, WI (10)
Cross Plains, WI (1)
Ft. Atkinson, WI (3)
MnROAD (5)

Lysimeter Layout: STH 60



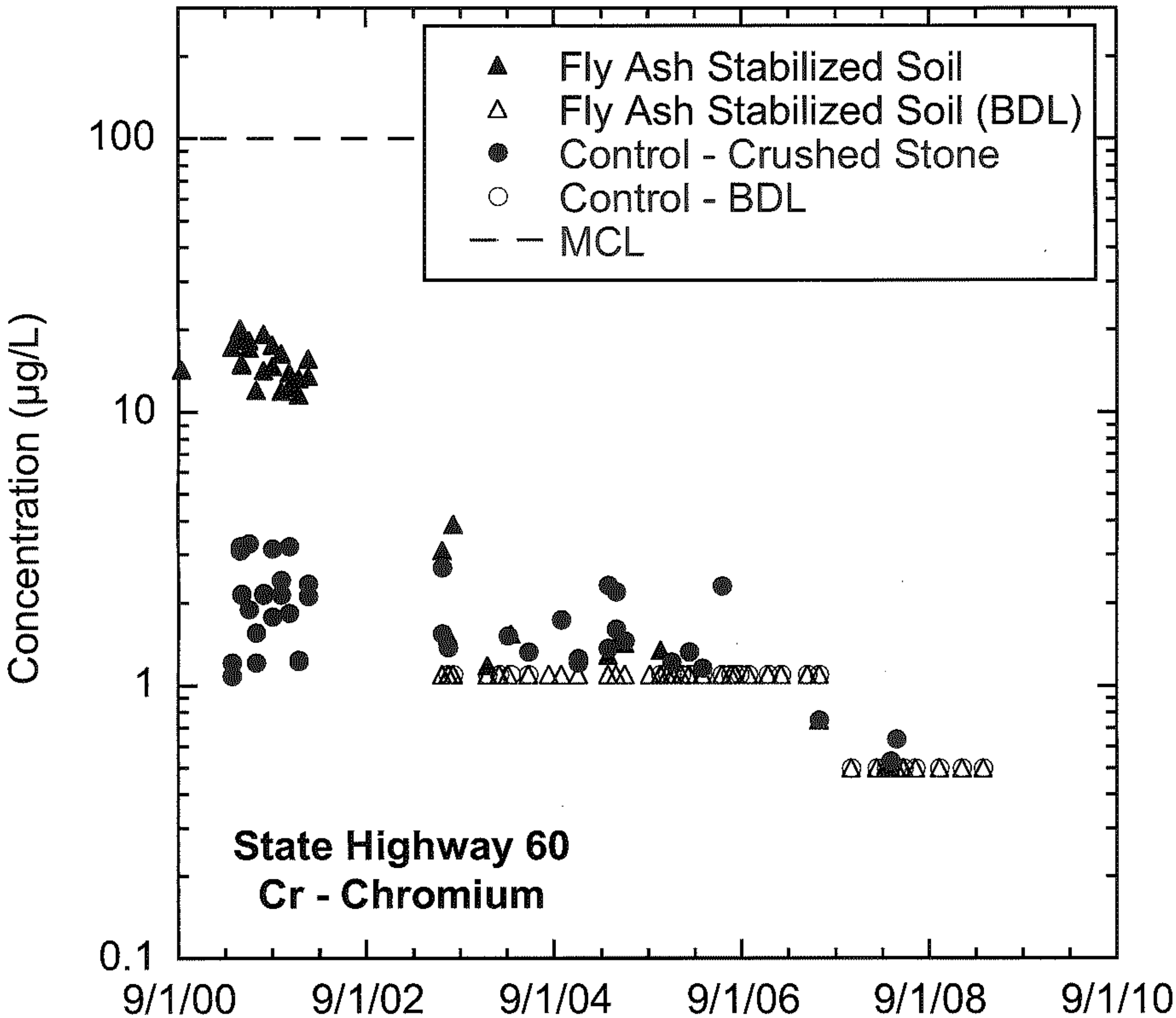

Geomembrane installation
Sump welding
Drainage layer installation
Collection tank installation

Wisconsin STH 60 Lysimeters: Selenium (Se)



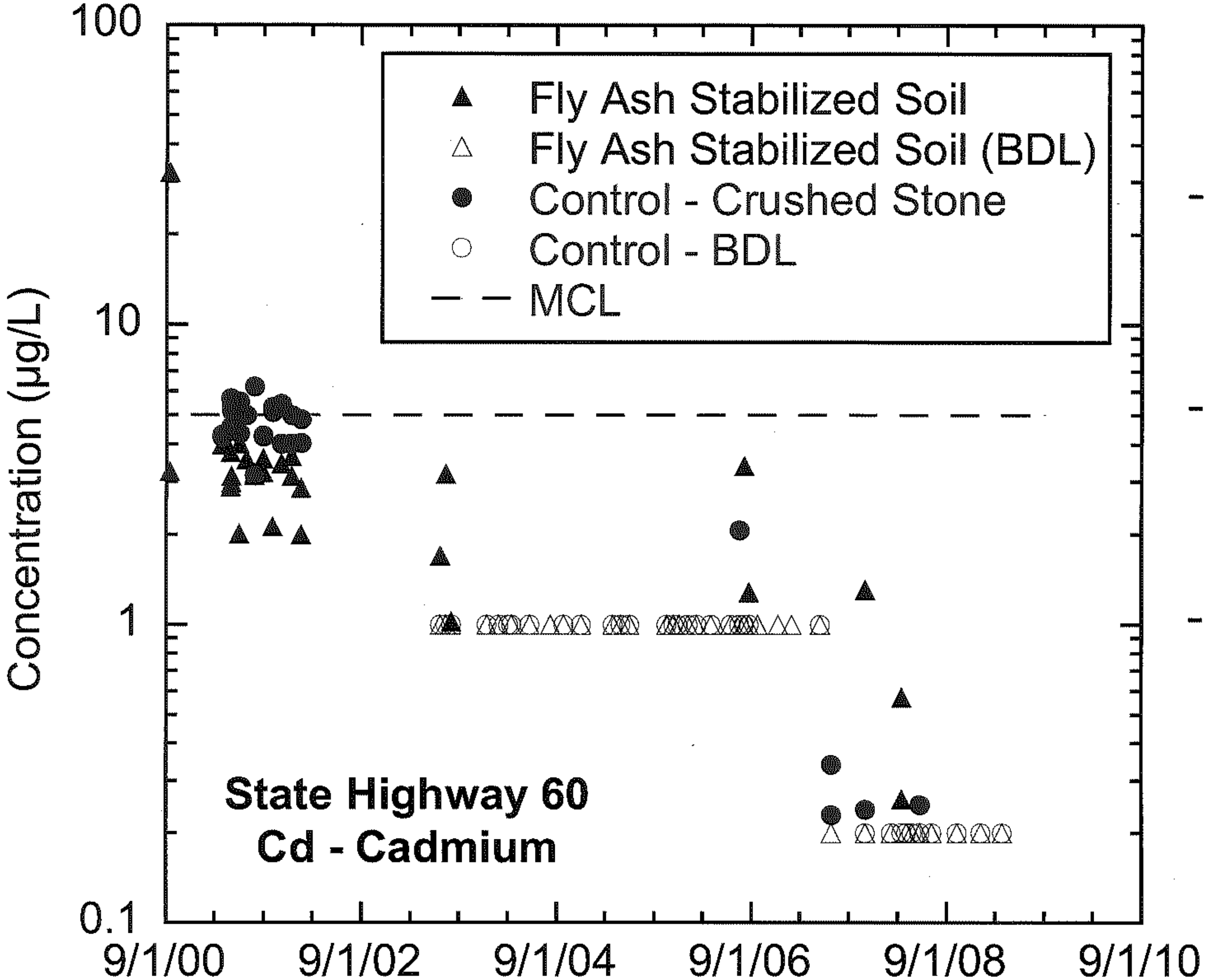
- Se higher from fly-ash stabilized soil initially
- Se comparable within 3 yr.
- Se always below MCL

Wisconsin STH 60 Lysimeters: Chromium (Cr)



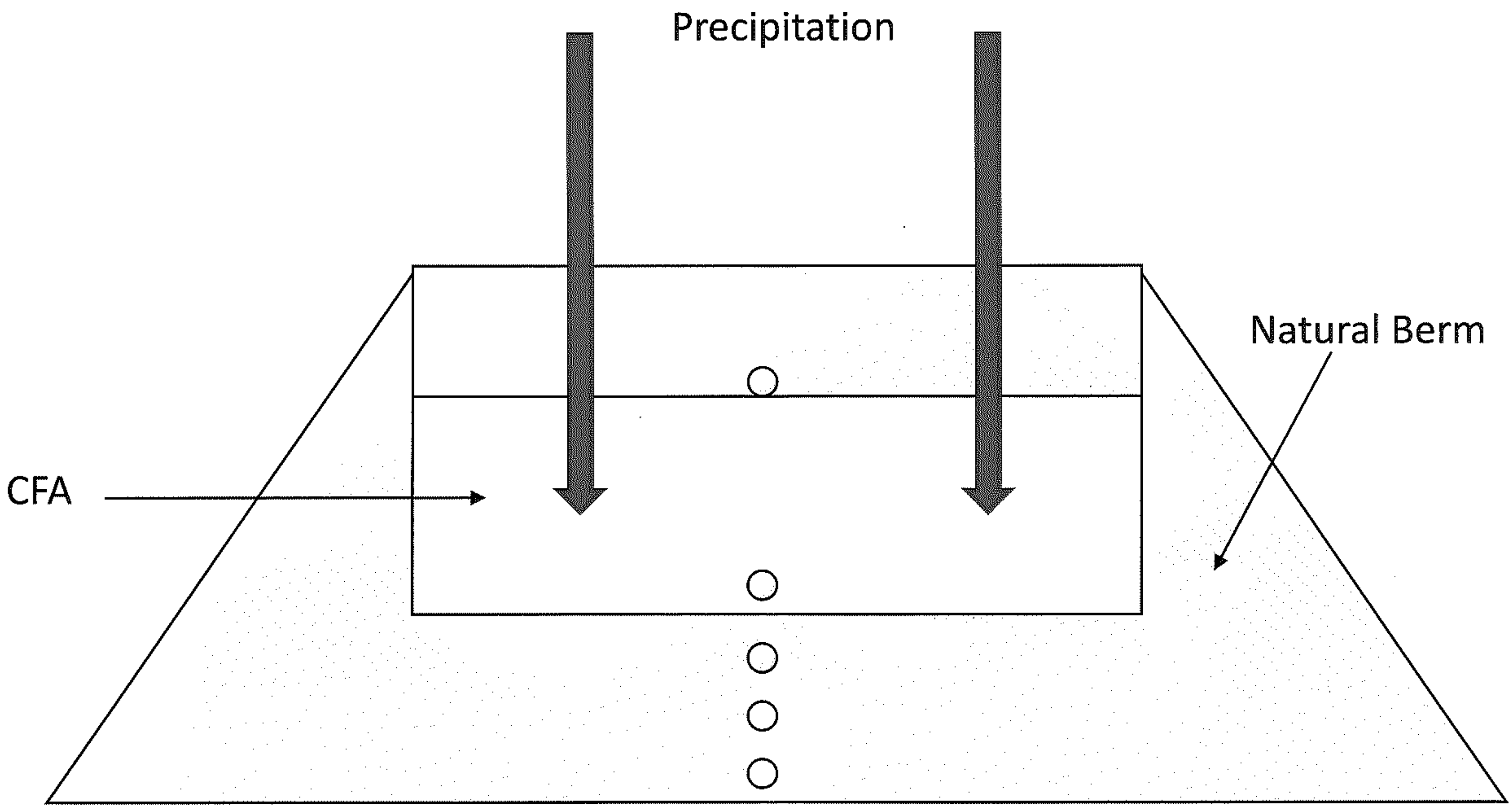
- Cr higher from fly-ash stabilized soil initially
- Cr from fly ash comparable *or lower* within 3 yr.
- Cr always below MCL

Wisconsin STH 60 Lysimeters: Cadmium (Cd)



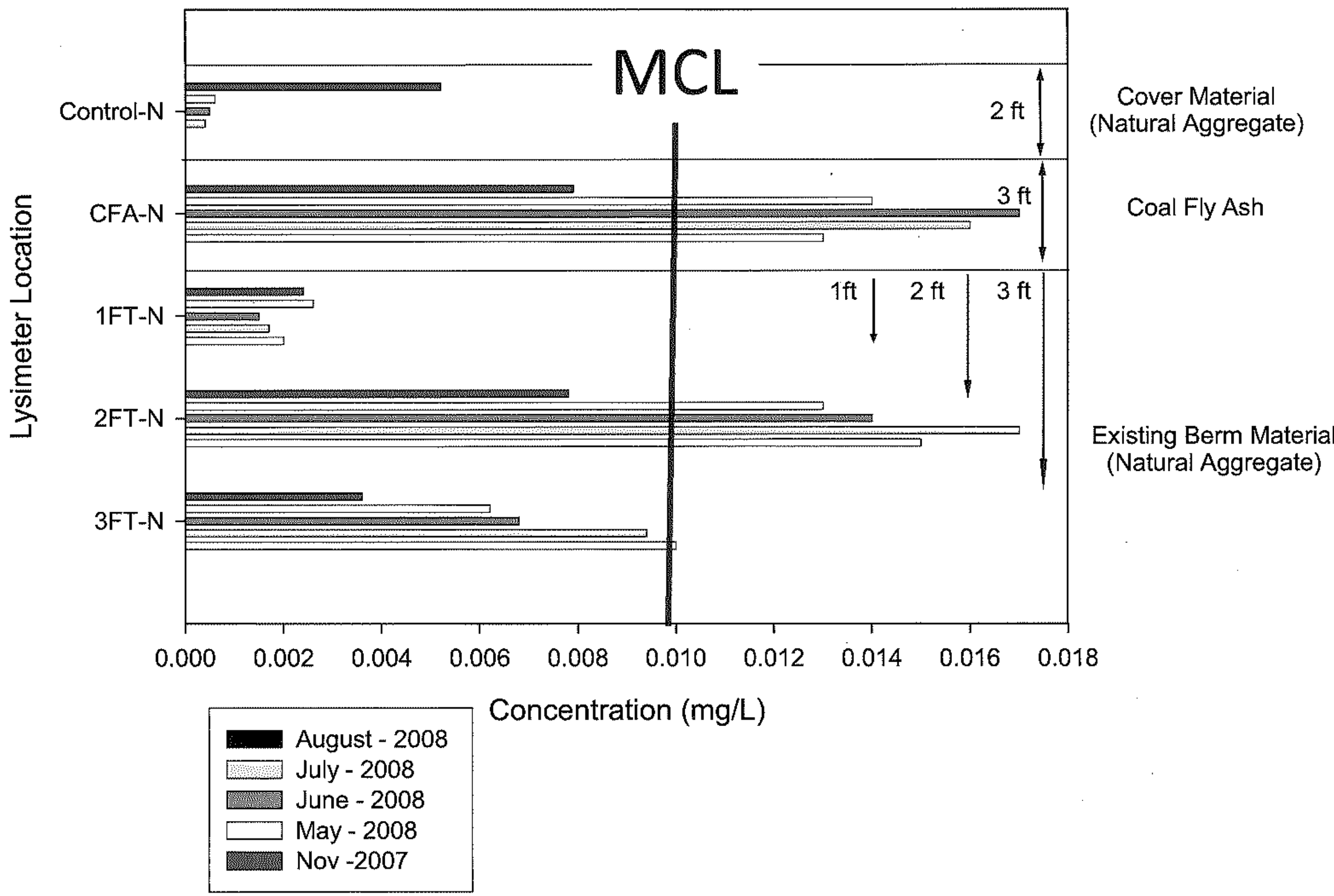
- Cd higher from control initially
- Cd comparable within 3 yr.
- Cd above MCL initially, *esp. for control*

UNH Colebrook Embankment



○ Porewater Monitoring Locations

Colebrook Arsenic Concentrations



Colebrook Mercury Concentrations

Natural Aggregate

- 0.70 ng/L, 0.51 ng/L

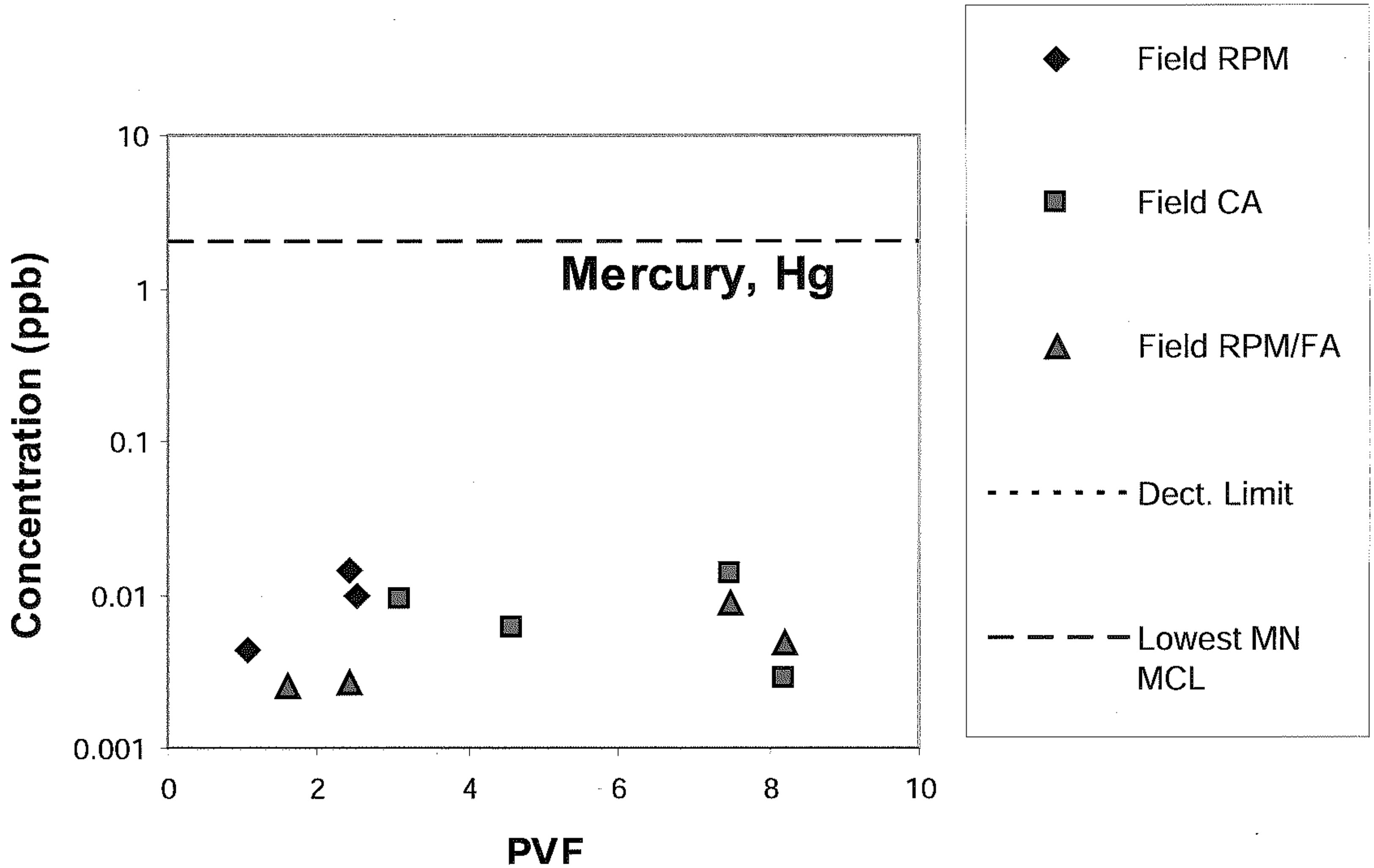
Coal Fly Ash

- 0.44 ng/L, 1.08 ng/L

MCL = 2 μg/L

Mercury eluted from coal fly ash is not different from natural aggregate, and well below MCL.

Mercury in MnROAD Leachate



Mercury from conventional aggregate (CA) and recycled pavement material (RPM) ***higher*** than from fly ash section.

Final Remarks

CCPs can be used to make geotechnical construction more ***sustainable*** (energy, emissions, life cycle) … it's not just about getting rid of ash.

CCPs can elute elements of concern like nearly all construction materials. Evaluate potential impact in a systematic manner ***in context of accepted risks***.

Need to develop ***consistent*** codes, methods of chemical analysis, and evaluation techniques that can be applied nationwide to ensure ***safe and wise use*** of CCPs in geotechnical construction.

Wisconsin's Industrial Byproduct Beneficial Use Program

Presented by:
Paul Koziar
Paul Koziar Consulting LLC

Overview of Presentation

- Historical Development of WI Program
- Key Elements of the Program (Chapter NR 538)
- Example of the Geotechnical Fill Requirements
- Review of reuse under NR 538

Chapter NR 538
Program Development

- Case-by-case approvals prior to 1998
- Ch. NR 538 Wis. Adm. Code
  - Technical Advisory Committee

NR 538 Program Summary
Key Program Elements

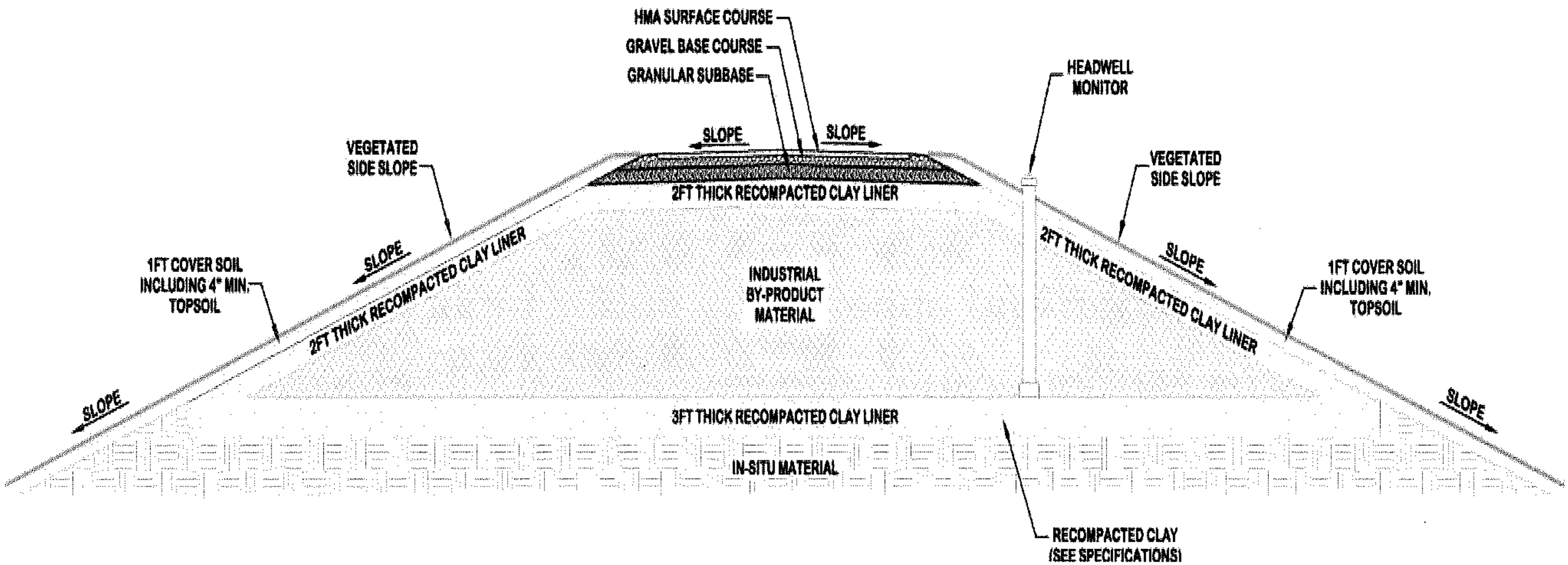
- Applicable to 2 major industrial byproducts
- Establishes 5 categories for industrial byproducts
- Categories established through the comparison of the results of waste characterization tests and existing groundwater and direct contact standards.
- Specifies beneficial uses allowed for each category matching their suitability for placement in the environment

Key Program Elements
Geotechnical Construction Material

- Self-implementation for projects < 5000 cu yds. after initial waste characterization
- General and specific engineering and environmental standards for each type of geotechnical fill based on the category from 1 to 5
- Storage and transportation standards
- Notification and approval by WDNR for projects > 5000 cu yds
- Public notification and opportunity public input
- Property owner notification for geotechnical fill projects
- Environmental monitoring of large projects

Example of Geotechnical Fill Construction Under Chapter NR 538

TRANSPORTATION FACILITY ROADWAY DESIGN STANDARDS
WISCONSIN DEPARTMENT OF TRANSPORTATION
INDUSTRIAL BYPRODUCT USE UNDER NR 538.10(6)



Review of reuse under NR 538

- Reuse rate for Coal ash > 80%
- Specific requirements for environmental and engineering controls have encouraged more reuse
- Concrete/cement and geotechnical fills largest uses
- To date, most geotechnical fills for roadways and airports
- Approximately 100 projects for coal ash
- Required monitoring of large projects has shown no potential detrimental effect on groundwater quality
- New air emission controls changing the physical character of coal ash

Beneficial Reuse Management

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Beneficial Reuse Management

What We Do

- **Concept:** Create partnerships between industrial companies that generate materials suitable for beneficial reuse and land owners and others that can utilize these materials in compliance with regulatory and technical requirements
- **Current Materials:** Foundry sand, coal ash, FGD Gypsum and paper processing residuals
- **Current Types of Projects:**
  - Sub-grade fill for a wide variety of construction projects such as new buildings, road and parking lot construction, and roadside sight & sound barriers
  - Agricultural and horticultural applications including soil amendment and manufactured soils
- **Benefits to:**
  - **Industrial Partners:** Reduced costs relative to the alternative cost of land fill disposal. Reduced need for expanded wet impoundments.
  - **Project Partners:** Reduced costs versus using new virgin materials.
  - **The Environment:** Conservation of natural resources, preservation of landfill space, and Reduced CO2 emissions
  - **The Economy:** Enhanced economic viability for public projects, small business expansion, agricultural infrastructure & property development. Conversion of marginal land into productive, taxable use. Creation of new jobs.

Environmentally Friendly Reuse Solutions

Reusable Waste Streams

- Foundry Sand
- Coal Combustion By-Products
- Paper Mill Residuals
- FGD Gypsum
- Construction & Demolition Waste
- Bio-Solids
- Dredged Materials
- Other Manufacturing By-Products

Beneficial Reuse Management

Capabilities:

- Materials Technology
- Regulatory Expertise
- Project Management
- Market Knowledge & Insight

User Markets

Construction

- Geotechnical Fills
- Building Materials

Agriculture

- Soil Amendment
- Soil Nutrients

Materials Supply

- Manufactured Soils

Consumer

- Lawn & Garden

Renewable Energy

- BioEnergy

Since 1999, Beneficial Reuse Management has completed more than 200 beneficial reuse projects and has diverted more than 2 million tons of industrial byproducts from landfills.

The Process

Feasibility

- Materials testing and technical evaluation
- Project/Product identification
- Evaluation of reuse economics

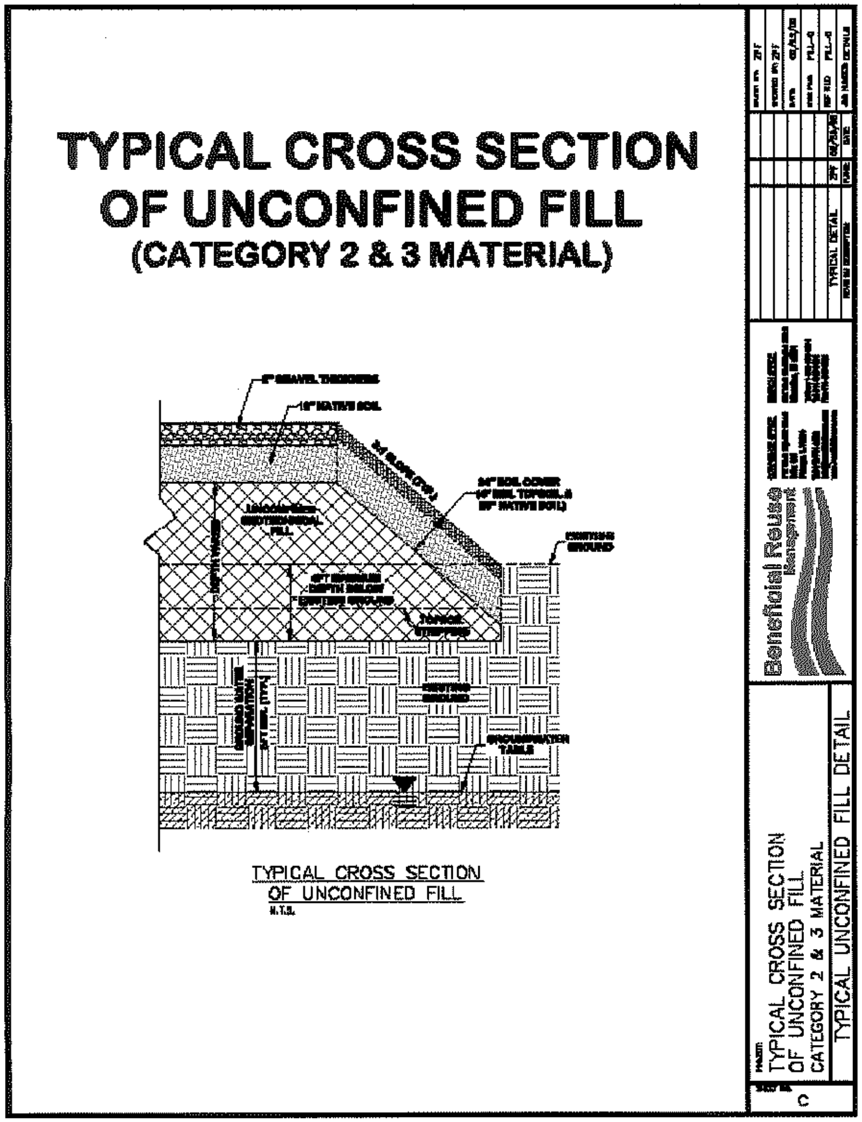
Design and Approval

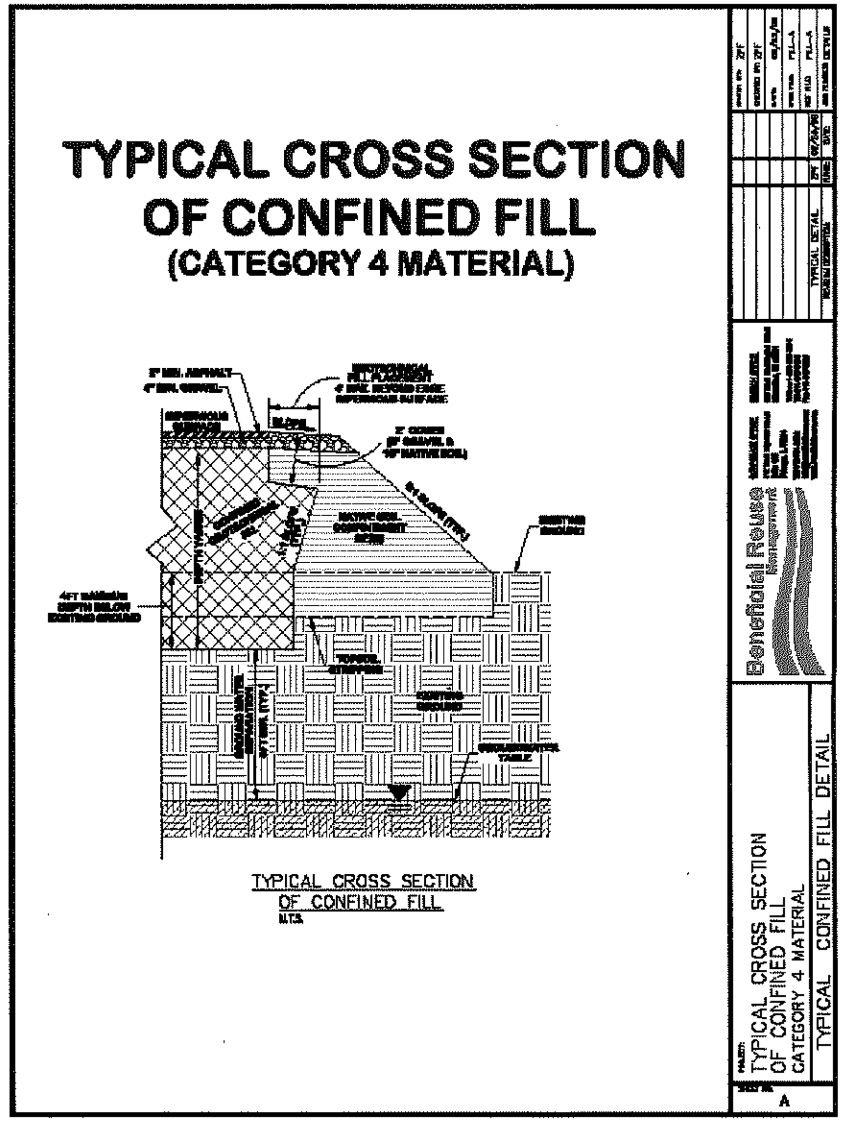
- Project design and engineering
- Regulatory submittal, review and approval
- Project permits, notices and public meetings

Implementation

- Subcontractor selection and contract negotiation
- Project Management & Oversight
- Project documentation and completion

Typical Fill Cross Sections





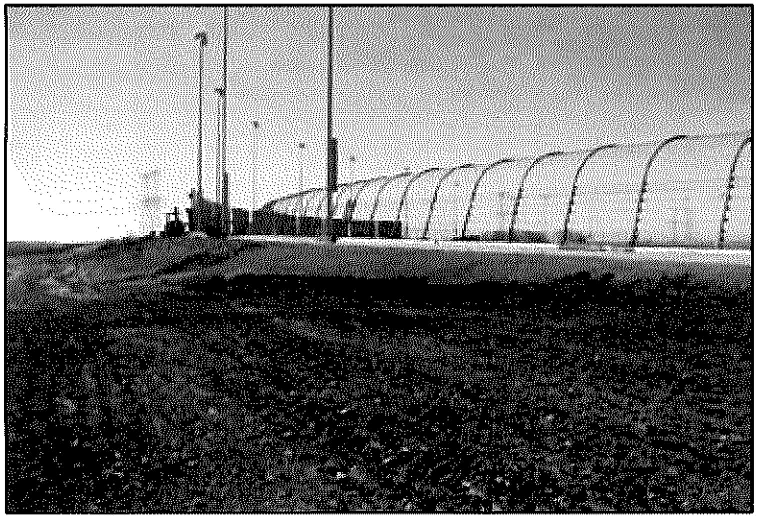
Business Expansion
Indianapolis Power & Light/TKO Graphics - Indianapolis, Indiana

Before

During

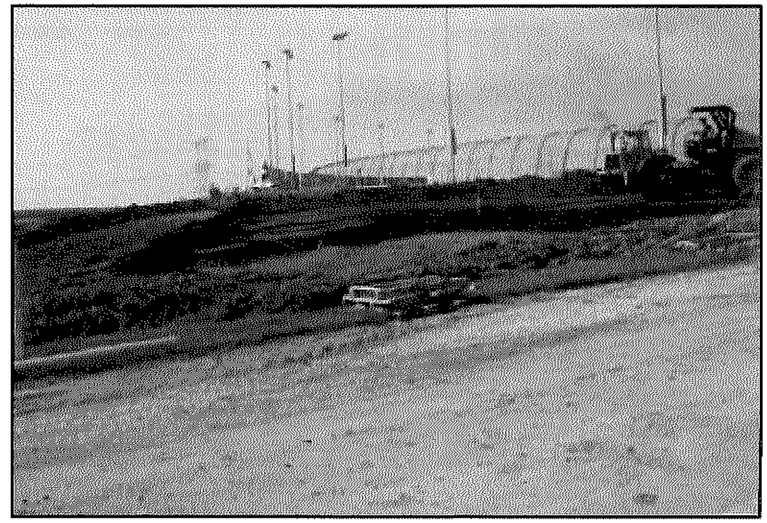
Completed Project: 30,000 Yd^3 Coal Ash

Public Infrastructure
Midwest Generation/Chicago Land Speedway – Joliet, IL



Before

During

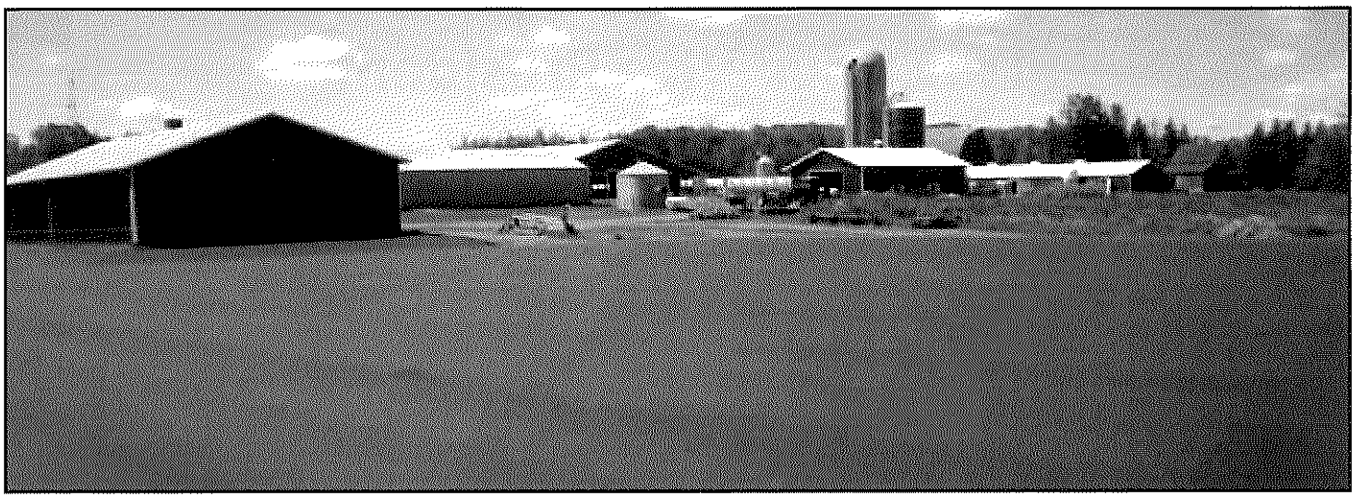


Completed Project: 12,000 tons Coal Ash

Agricultural Infrastructure
Xcel Energy/Grubisic Farms, Inc. - Mason, WI

Before ←

During →



Completed Project: 12,575 Yd^3 Coal Ash

←

Full Circle Solutions, Inc.
35 North Main Street, Suite A
Jasper, Georgia 30143

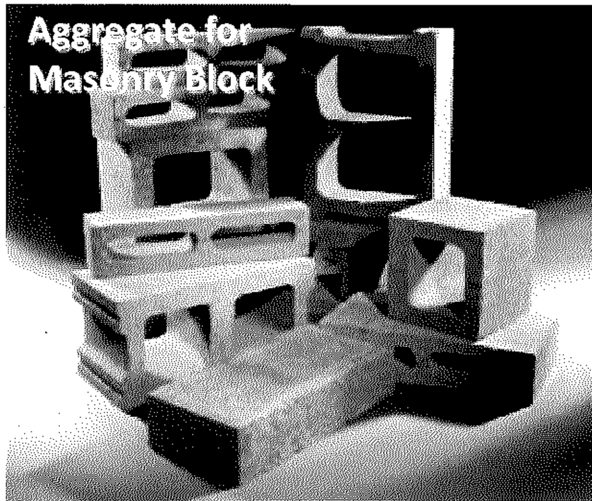
Bob Waldrop
Executive Vice President

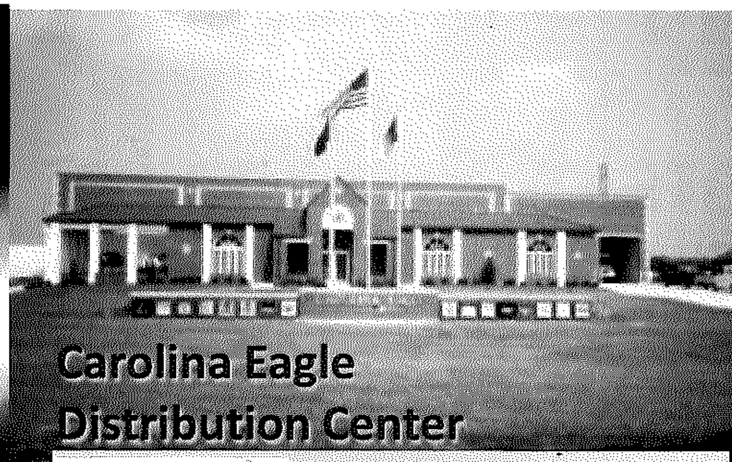
Full Circle Solutions, Inc.

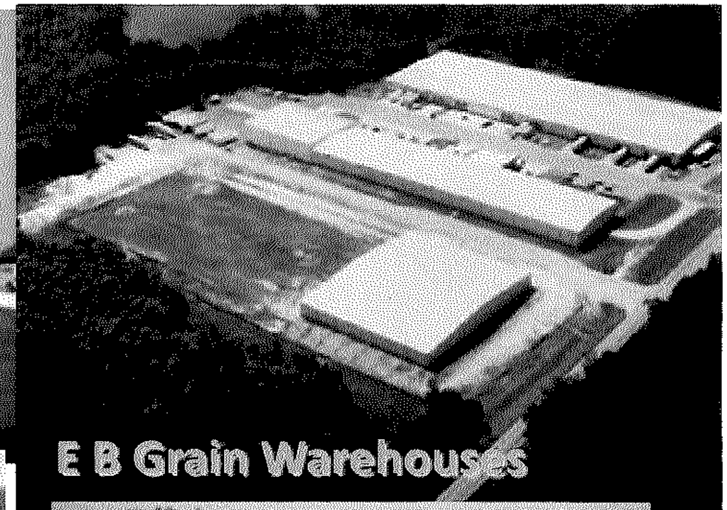
20 + Years of Service to:

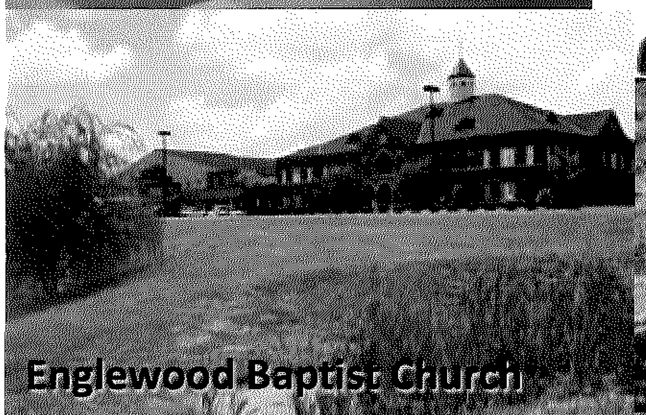
- Independent Power Producers
- Small Coal-Fired Industries
- Utilities

Over 10 Million Tons of CCPs Beneficially Reused

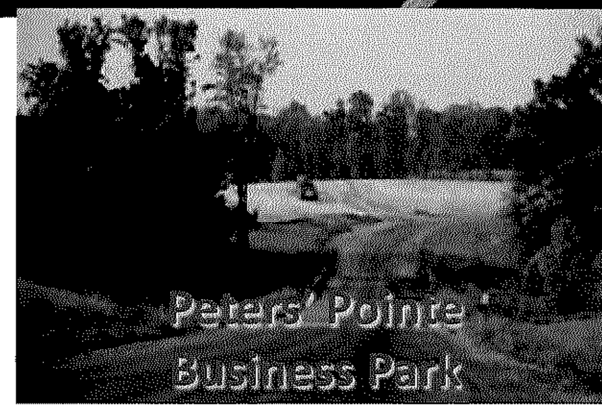

Aggregate for
Masonry Block


Carolina Eagle
Distribution Center

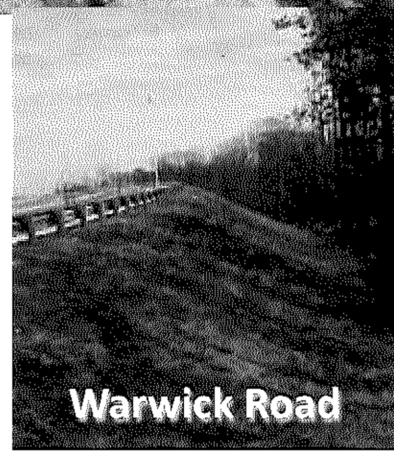

E B Grain Warehouses

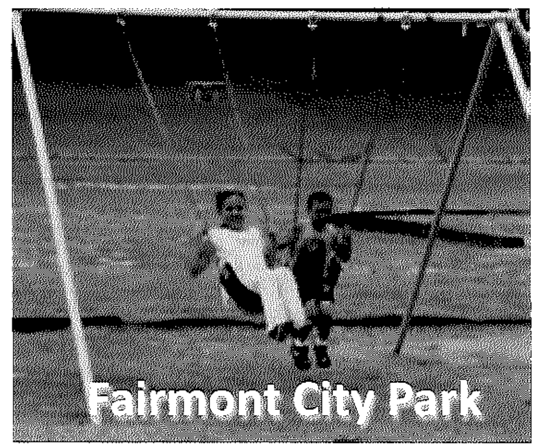

Englewood Baptist Church


CalciPlast™ Agricultural
Product


Peters' Pointe
Business Park

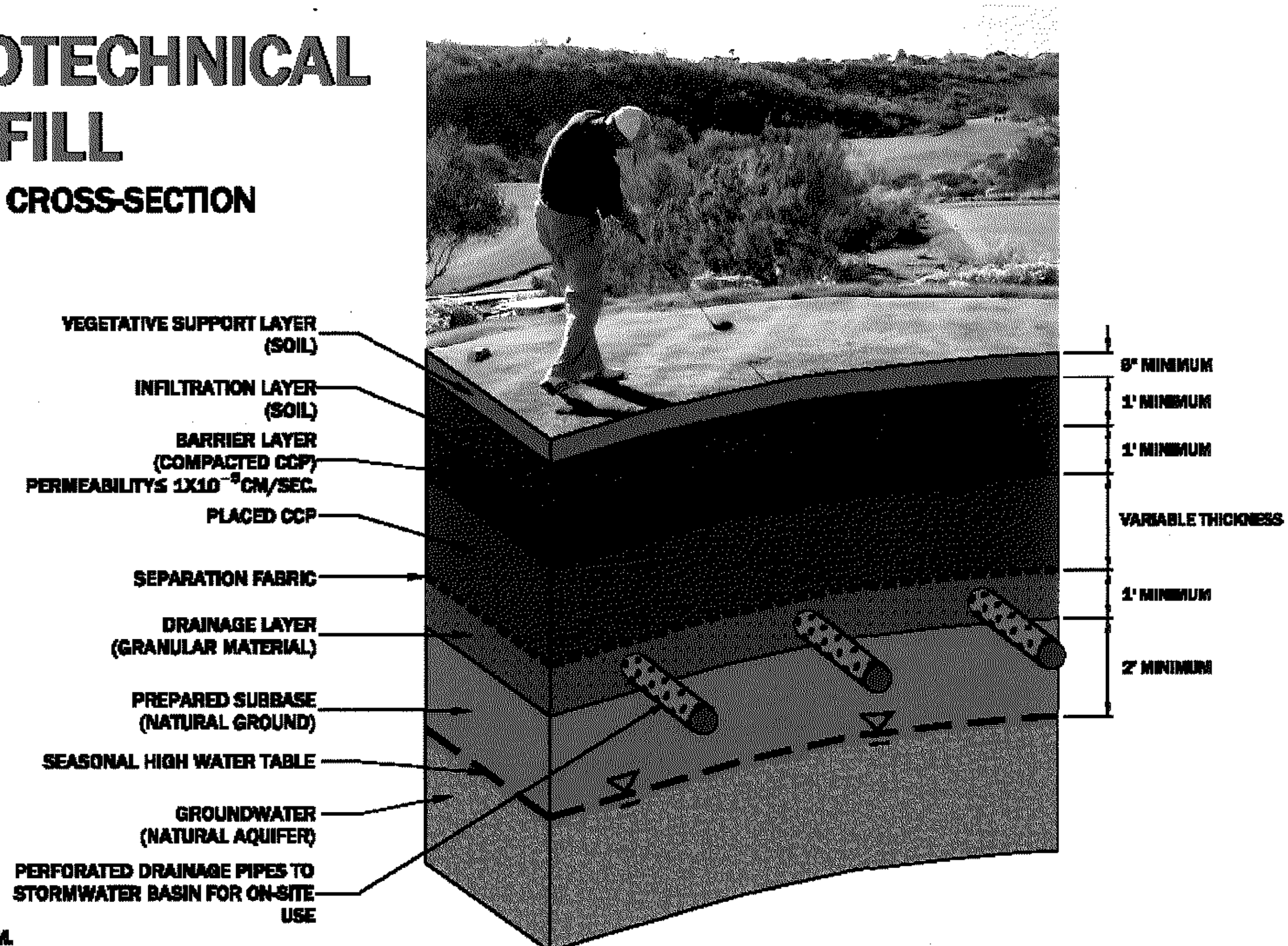

Constitution Park


Warwick Road


Fairmont City Park

CCP GEOTECHNICAL FILL

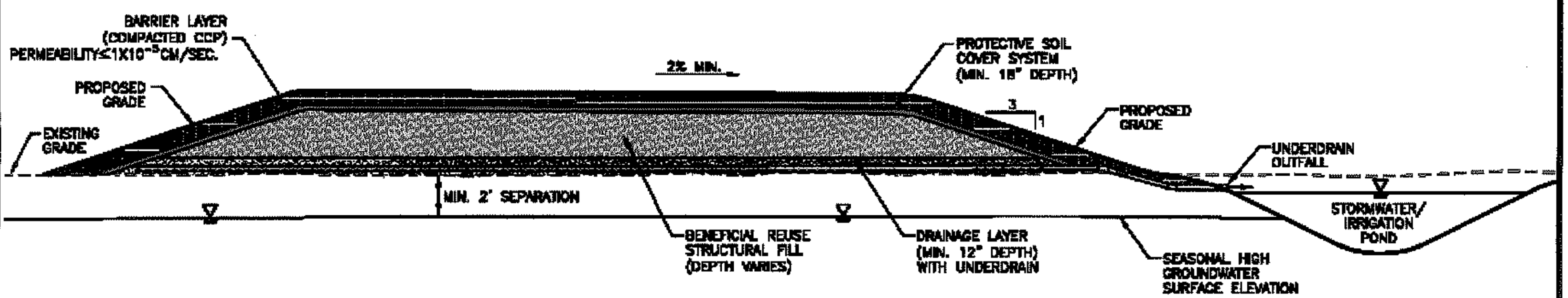
TYPICAL CROSS-SECTION



NOTE: TOP SLOPE 2% MINIMUM.
SIDESLOPES 3:1 MAXIMUM.

CCP GEOTECHNICAL FILL

TYPICAL CROSS-SECTION



TYPICAL CROSS-SECTION
NOT TO SCALE

DISCUSSION:

Q & A

THANK YOU