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Welcome to ITRC's Internet-Based Training Program

Thank you for joining us. Today's training focuses on the ITRC Technical and Regulatory Guidance Document entitled:

" Design, Installation and Monitoring of Alternative Final Landfill Covers"

The training is sponsored by: ITRC & the EPA Office of Superfund Remediation and Technology Innovation

Creating Tools & Strategies to Reduce Technical & Regulatory Barriers for the Deployment of Innovative Environmental Technologies

Solid and hazardous waste landfills are required by federal, state, and/or local regulations to cover waste materials prior to or as part of final closure. The ITRC Alternative Landfill Technologies team believes that the solid and hazardous waste regulations clearly provide a mechanism to permit, design, construct, and maintain landfills with alternative cover design. Several primary types of alternative landfill covers have been proposed for solid, hazardous, and mixed waste landfills; however, the design is in the science and engineering and should not be categorized or prescriptive. Alternative covers have been constructed and are fully operational at industrial waste, construction debris, municipal solid waste, and hazardous waste landfills. Alternative final covers (AFCs) may be used on bioreactor, conventional, or other types of landfills. Types of AFCs may include, but are not limited to, asphalt covers, concrete covers, capillary barrier covers, and evapotranspiration (ET) covers.

This training and associated guidance focus on ET covers and the decisions associated with their successful design, construction, and long-term care. ITRC developed the guidance document Technical and Regulatory Guidance for Design, Installation and Monitoring of Alternative Final Landfill Covers (ALT-2, 2003) and this associated training course to provide tools and resources when considering the application of alternative final landfill covers. The ITRC guidance and training course focus on a class of landfill final covers ('alternative' covers) as integral parts of an overall landfill system that differ in both design and operational theory from those designs prescribed in RCRA regulations.

ITRC (Interstate Technology and Regulatory Council) www.itrcweb.org

Training Co-Sponsored by: EPA Office of Superfund Remediation and Technology Innovation (www.clu-in.org)

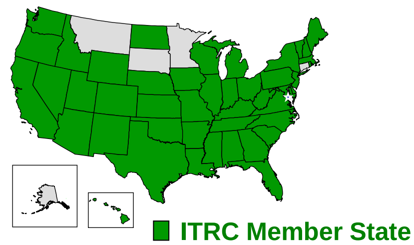
ITRC Course Moderator: Mary Yelken (myelken@earthlink.net)

ITRC (www.itrcweb.org) – Shaping the Future of Regulatory Acceptance

- Network
  - State regulators
  - Federal government
  - Industry
  - Consultants
  - Academia
  - Community stakeholders
- Documents
  - Technical and regulatory guidance documents
  - Technology overviews
  - Case studies
- Training
  - Internet-based
  - Classroom

Host Organization ECOS

ITRC State Members



Federal Partners

DOE DOD EPA

The Interstate Technology and Regulatory Council (ITRC) is a state-led coalition of regulators, industry experts, citizen stakeholders, academia and federal partners that work to achieve regulatory acceptance of environmental technologies and innovative approaches. ITRC consists of 45 states (and the District of Columbia) that work to break down barriers and reduce compliance costs, making it easier to use new technologies and helping states maximize resources. ITRC brings together a diverse mix of environmental experts and stakeholders from both the public and private sectors to broaden and deepen technical knowledge and advance the regulatory acceptance of environmental technologies. Together, we're building the environmental community's ability to expedite quality decision making while protecting human health and the environment. With our network approaching 7,500 people from all aspects of the environmental community, ITRC is a unique catalyst for dialogue between regulators and the regulated community.

For a state to be a member of ITRC their environmental agency must designate a State Point of Contact. To find out who your State POC is check out the "contacts" section at www.itrcweb.org. Also, click on "membership" to learn how you can become a member of an ITRC Technical Team.

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ITRC – Course Topics Planned for 2006

Popular from 2005

- Alternative Landfill Covers
- Constructed Treatment Wetlands
- Environmental Management at Operational Outdoor Small Arms Ranges
- DNAPL Performance Assessment
- Mitigation Wetlands
- Perchlorate Overview
- Permeable Reactive Barriers: Lessons Learn and New Direction
- Radiation Risk Assessment
- Radiation Site Cleanup
- Remediation Process Optimization
- Site Investigation and Remediation for Munitions Response Projects
- Triad Approach
- What's New With In Situ Chemical Oxidation

New in 2006

- Characterization, Design, Construction and Monitoring of Bioreactor Landfills
- Direct-Push Wells for Long-term Monitoring
- Ending Post Closure Care at Landfills
- Planning and Promoting of Ecological Re-use of Remediated Sites
- Rads Real-time Data Collection
- Remediation Process Optimization Advanced Training
- More in development…….

Training dates/details at: www.itrcweb.org
Training archives at: http://cluin.org/live/archive.cfm

More details and schedules are available from www.itrcweb.org under "Internet-based Training."

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Design, Installation and Monitoring of Alternative Final Covers

Logistical Reminders

- Phone Audience
  - Keep phone on mute
  - * 6 to mute your phone and *7 to un-mute
  - Do NOT put call on hold
- Simulcast Audience
  - Use ? at top of each slide to submit questions
- Course Time = 2 ¼ hours
- 2 Question & Answer Periods
- Links to Additional Resources
- Your Feedback

Presentation Overview

- What are alternative landfill cover designs?
- Why are they different than conventional cover systems?
- Is equivalency a question?
- Are there unique monitoring requirements?
- Are there regulatory barriers to their use?
- Are there limitations?
- Are there advantages to their use?

No associated notes.

Meet the ITRC Instructors

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Charles G. Johnson is and Environmental Protection Specialist at the Colorado Department of Public Health and Environment. With a background in geology and civil engineering he has worked with the Hazardous Materials and Waste Management Division since 1991. He has issued hazardous waste operating and post-closure permits as well as overseen corrective action site inspections and characterization, remediation, and post-closure care projects. Charles has been active in the Interstate Technology and Regulatory Council (ITRC) for four years. He initially acted as Colorado's Point of Contact, and as a DNAPLS Surfactant and Cosolvent subteam leader. He currently is the team leader for the ITRC Alternative Landfill Technologies team.

Bill Albright is an Associate Research Hydrogeologist in the Reno office of the Desert Research Institute (DRI) at the University of Nevada with 20 years of research experience in environmental science. His research interests have included arid lands soil physics, regional air pollution, atmospheric chemistry and weather modification, plant ecological physiology. Bill Albright is a principle investigator for the USEPA's Alternative Cover Assessment Program (ACAP). The primary goal of ACAP is to establish a cooperative program with federal, state, and private sector entities to conduct a regional evaluation of landfill cover facilities based on field-scale testing of landfill covers at 12 sites across the country. A draft of the ACAP final report is currently in review. Dr. Albright is an active member of the Interstate Technology and Regulatory Council's (ITRC) Alternative Landfill Technologies Team.

Steve Wampler is Vice President and Director of Engineering for AquAeTer, Inc. an environmental engineering and science consulting firm. Based in Denver, Colorado, he works as a principal geological engineer and hydrogeologist responsible for corporate quality assurance, strategic planning, and project technical oversight and review. He has 30-years experience in engineering geology, hydrogeology, geotechnical engineering, and environmental consulting, with much of that experience dealing with the management of solid, hazardous, and radioactive waste materials and response to releases of hazardous and radioactive constituents into the environment. He has been involved with the ITRC Alternate Landfill Technologies team since the start of the team's efforts concerning alternate final covers, and has coordinated the efforts of a small group focusing on cover construction. He holds B.S. and M.S. degrees in geological engineering from the University of Missouri at Rolla and is registered professional engineer and geologist.

Michael F. Houlihan, P.E. Mr. Houlihan is a Principal with GeoSyntec Consultants in Columbia, Maryland. He has over 16 years of experience in the design of municipal and hazardous waste landfills, including design and performance evaluations of closure systems, design and construction of alternative cover systems, contract research related to bioreactors and landfill liner system performance, long-term geotechnical stability of landfills, forensic analyses of liner and cover systems, and monitoring of the performance of liner and cover systems. In the past several years, the focus of his practice has been on the development of designs for alternative covers in both wet and dry climates, as well as the application of bioreactor technology at municipal solid waste landfills. He is currently the project manager for the Environmental Research and Education Foundation (EREF) study "*Evaluation of Post-Closure Care at MSW Landfills*" and is the lead engineer for the design of an evapotranspirative alternative cover at the Welsh Road Landfill Superfund Site in Pennsylvania. In addition, Mr. Houlihan is an active member of the ITRC Alternative Landfill Technologies Team.

ITRC Alternative Landfill Technology Team Composition

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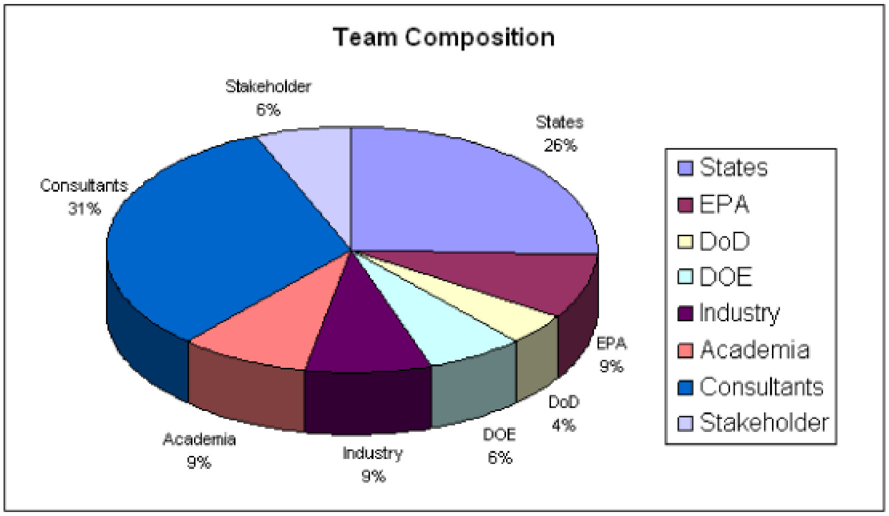

12 States; North, South, East, West,

This gives a perspective of the ITRC Alternative Landfill Technologies Team representation.

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Purpose and Applicability

- Provide adequate guidance to owners, operators, consultants and regulators to review, evaluate and approve alternative final landfill covers
  - There are no rules or guidance to follow when reviewing an application which incorporates AFC
- Potential Cost Savings
- Applicability
  - Pre-RCRA
  - Subtitle D and Subtitle C
  - CERCLA
  - Mixed Waste Facilities

- Publish the Alternative Landfill Covers Case Studies Document Aside from this training the technical and regulatory guidance document for alternative final covers may be obtained at www.itrcweb.org, and then got o the guidance document button.
- Implement internet training for the Alternative Landfill Cover Guidance Document

1) Covers built north, south, east, west, wet dry, warm, and cold.
2) Technology Overview Using Case Studies of Alternative Landfill Technologies and Associated Regulatory Topics. (March 2003)
3) Majority of the team believes that if a location is sites, then an alternative cover can be designed for the setting that will be protective of human health and the environment. The question is whether materials are available and it fits the economic requirements.

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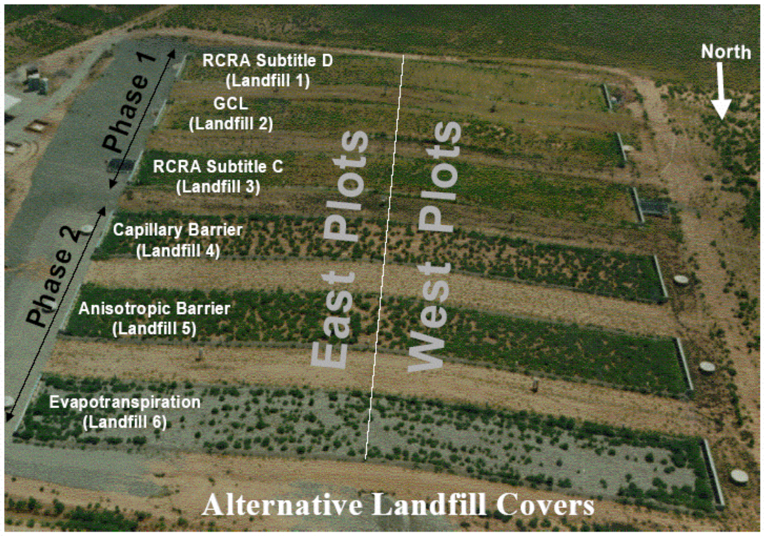
Potentially Build a Better Cover



1) Rocky Mountain Arsenal: Side by side test pad study indicates that AFC design outperformed conventional RCRA cover design
2) Sandia National Laboratory: Test plot study indicated that AFC design outperformed conventional Solid Waste and Hazardous Waste cover designs
3) Some research demonstrates that convention covers with compacted clay coves has significant potential to fail.

Alternative Landfill Cover Demonstration,

Stephen F. Dwyer1 and Bruce Reavis2

Sandia National Laboratories

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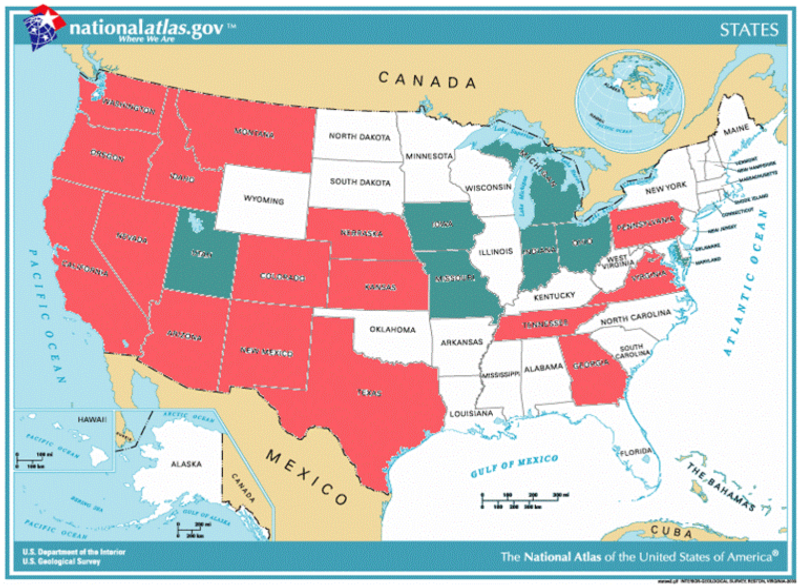
STATES WITH DEMONSTRATION (BLUE) OR FULL SCALE (RED) ET COVERS



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INFORMATION RESOURCES

1) www.itrcweb.org
2) http://cluin.org/products/altcovers
3) Desert Research Institute
4) Other research organizations

Advantages

- Reduced construction costs associated with:
  - Locally available cover soils,
  - Reduced soil engineering or required energy (mixing, wetting, compacting) to achieve low permeability specifications,
  - Reduced or eliminated cover elements (geosynthetics),
  - Reduced Quality Control/Quality Assurance testing due to the elimination of the number of required cover elements or the use of indexing techniques, and
  - Reduced construction time due to the reduced number of cover elements

No Associated Notes

Advantages

- Reduced Long Term Stewardship Liabilities:
  - Low maintenance related to reduced erosion related to established plant communities,
  - Permeable covers that do not trap gas may be more beneficial in reducing impacts to groundwater,
  - Lower maintenance related to lack of potential geosynthetic failure,
  - Increased stability reduces the potential for cover failure and releases that impact human health and the environment,
  - Less energy is placed into the cover construction, constructed closer to equilibrium (less dewatering of clays that are compacted wet of optimum to achieve the low permeability specification), and
  - Reduced long term monitoring cost related to progressive monitoring plans based on continued stability of the covers.

No associated notes.

Disadvantages

- Regulatory Acceptance
- Creative Design
- Potential Increased Cost (limited or no gas revenue)
- Potential need to manage generated landfill gas in accordance with local regulatory requirements
- Lack of Regulatory Familiarity
- Requires Regulatory Evaluation of Unique Site Specific Design
- No Easy HELP Model Evaluation

No associated notes.

ITRC Technical & Regulatory Guidance Document

- Regulatory Barriers
  - Acceptance and Implementation
- Cover Concepts
- Design Products
  - Drawings
  - Construction Specifications
  - Quality Assurance Plan
- Construction and Post-Closure Care
  - Materials
  - Methods
  - Quality
- Post-Closure Care
  - Purpose, Plans, and Duration
  - Activities and Costs

•Alternative Landfill Covers Guidance Document

✓Scope: Solid Waste, Hazardous Waste, Mixed Waste

✓Identify regulatory requirements and barriers

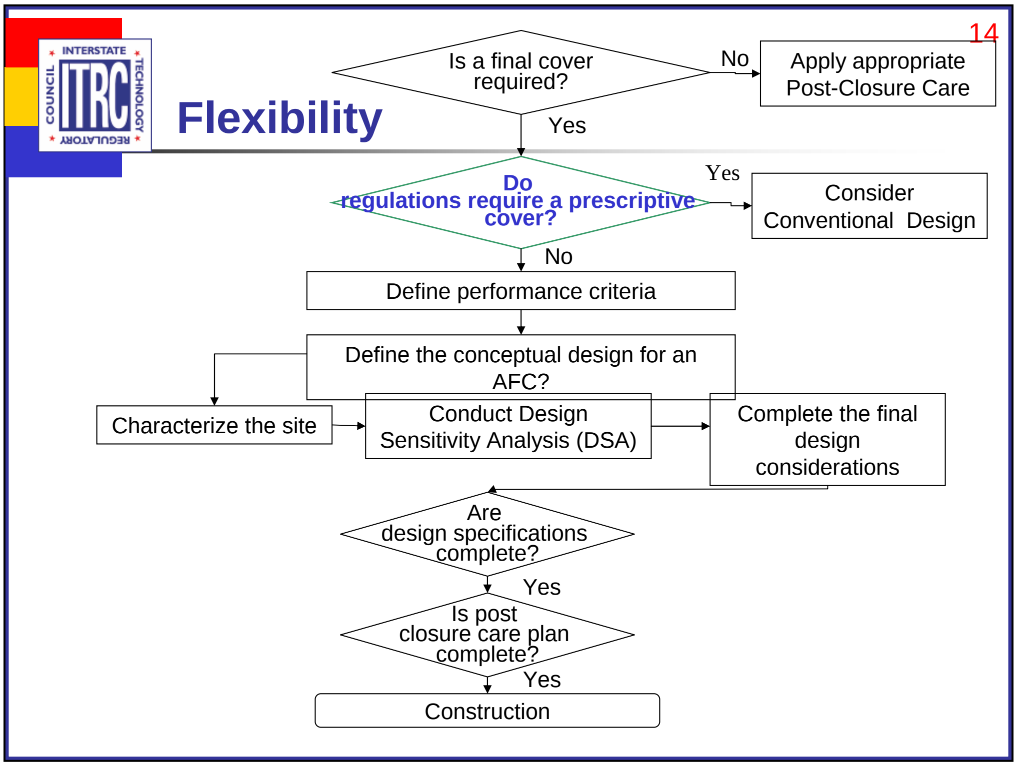
▪Work with decision makers impacting regulations Industry, DOD, DOE, EPA, States,

▪Review existing regulations and applicable guidance

•Identify Opportunities for Regulatory Flexibility

•Translate the regulatory flexibility into landfill design and construction guidance

•Integrate the landfill design and construction aspects into long term operation and maintenance criteria



See ITRC document at www.itrcweb.org

Technical and Regulatory Guidance for Design, Installation and Monitoring of Alternative Final Landfill Covers (ALT-2, 2003)

Regulatory Barriers - Fact or Fiction?

- United States Federal Hazardous Waste Regulations (RCRA)
  - Over 71% of responding authorized states polled by the ITRC adopted the following federal regulation allowing department managers the flexibility to implement alternative design and operating landfill requirements
    - Fact

      264.301 Design and operating requirements.

      (b) The owner or operator will be exempted from the requirements of paragraph (a) of this section if the Regional Administrator finds, based on a demonstration by the owner or operator, that **alternative design and operating practices**, together with location characteristics, will prevent the migration of any hazardous constituents (see § 264.93) into the ground water or surface water at any future time. In deciding whether to grant an exemption, the Regional Administrator will consider:

1) ITRC Questionnaire
    a) Sent to 41 ITRC member states
    b) Results included as appendix to tech/reg guidance document
2) RCRA & RCRA is CERCLA ARAR
3) New landfills: RCRA landfill construction regulations indicate that …

Regulatory Barriers - Fact

- The United States Federal Hazardous Waste Regulations (40 CFR) state in Section 264.110(c) pertaining to Closure and Post-Closure Standards that:
  - (c) The Regional Administrator may **replace all or part of the requirements** of this subpart (and the unit-specific standards referenced in § 264.111(c) applying to a regulated unit), with alternative requirements set out in a permit or in an enforceable document (as defined in 40 CFR 270.1(c)(7)), where the Regional Administrator determines that:
  - (2) It is not necessary to apply the closure requirements of this subpart (and those referenced herein) because the **alternative requirements will protect human health and the environment** and will satisfy the closure performance standard of § 264.111 (a) and (b).

1) Closure regulations: Existing or historic landfill regulations allow for replacement of the conventional landfill requirements so long as they alternative requirements are protective

Regulatory Barriers - Fact

- United States Federal Solid Waste Regulatory Flexibility

§ 258.60 Closure criteria.

(b) The Director of an approved State **may approve an alternative final cover design** that includes:

(1) An infiltration layer that achieves an equivalent reduction in infiltration as the infiltration layer specified in paragraphs (a)(1) and (a)(2) of this section, and

(2) An erosion layer that provides equivalent protection from wind and water erosion as the erosion layer specified in paragraph (a)(3) of this section.

1) Solid Waste Regulations allow for alternative designs

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Regulatory Barriers: % of States Using Design Criteria

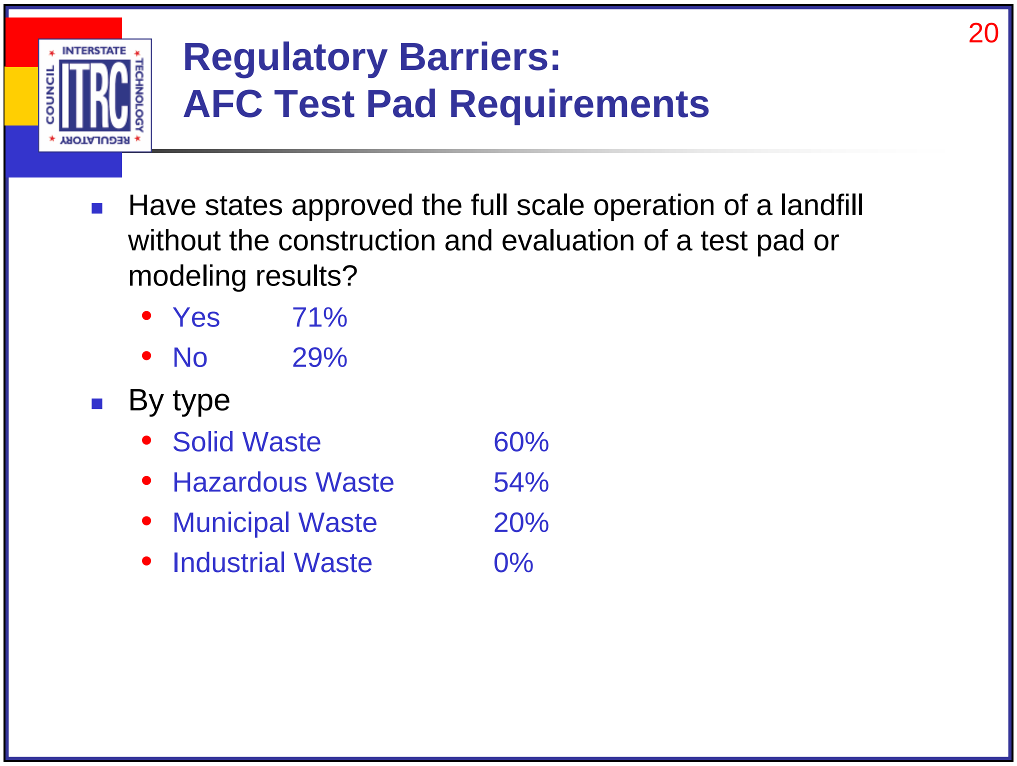
	Hazardous	Solid
• Flux Through the Cover	100%	75%
• Total Leachate Collection	67%	75%
• Liner Leakage Rate	67%	87%
• Groundwater Monitoring	33%	37%

1) Landfill System Performance
   a) Regulators not just looking at the material properties and conventional design configurations
   b) Regulators evaluating landfill as a system with expected performance that protects human health and the environment
   c) Note the system elements listed above

Regulatory Barriers: AFC Performance Requirements

- Do states consider site characteristics to establish landfill performance requirements?
  - Yes 78%
  - No 22%

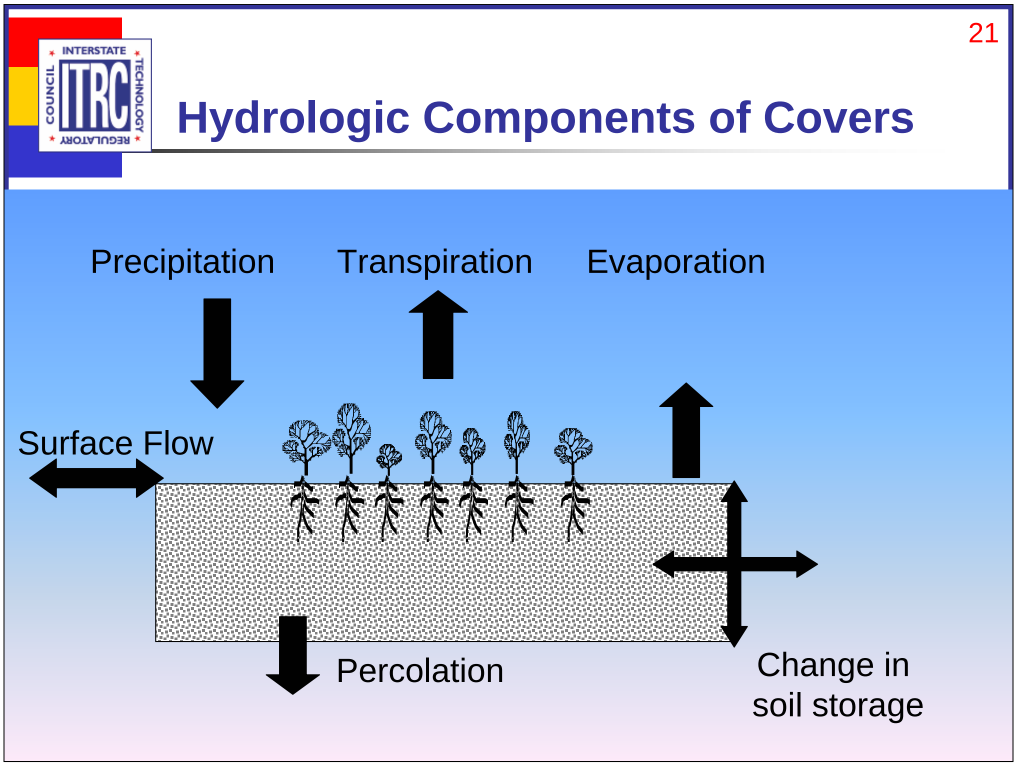
1) Given: Regulatory flexibility to use alternative landfill covers
2) Integrate: Site specific data as indicated from survey
3) Results: Highest probability of designing and alternative cover with the greatest chance of success



Test pads is a test section or plot that typically acts like a drainage lysimeter.

While some states do not require a test pad, they are a means of integrating the allowed regulatory flexibility with site specific conditions to gain information about the potential performance of the proposed design configuration.

Results in gaining design information that can be sued to help generate a final design that will likely succeed in protecting human health and the environment.



Cover Concepts - Physics of Water Movement

Discuss key drivers & abstractions:

Ability of soil to store water when precipitation rate exceeds ET rate is critical to AFC performance

Saturated and unsaturated properties of soil important to accurate simulation of cover designs

Important that soil data are derived from laboratory analysis of actual borrow soil, not from soil surveys

Cover Concepts - Hydraulic Conductivity

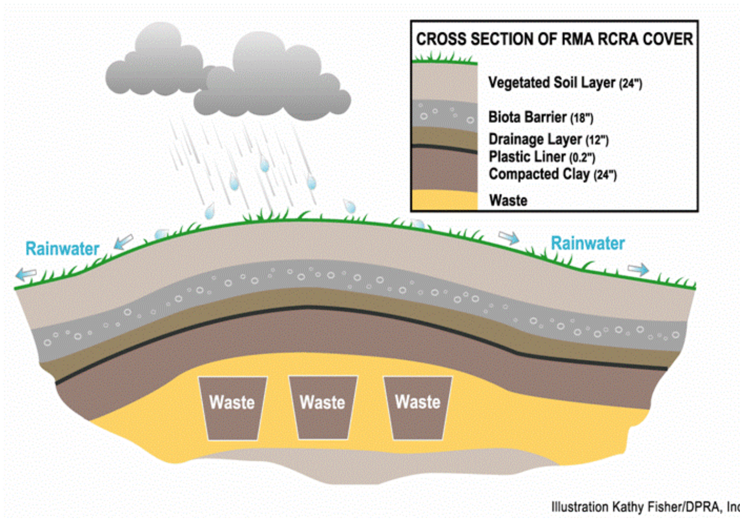
Hydraulic conductivity (K) of a soil relates the driving force (hydraulic gradient) to the actual flow of water through the soil

K is greater for sands than for clays

K decreases rapidly (and non-linearly) as moisture content decreases

K can be determined from laboratory or field analysis

Rocky Mtn Arsenal
RCRA Landfill Final Covers



No Associated Notes

Rocky Mtn Arsenal
RCRA Alternative Landfill Final Covers

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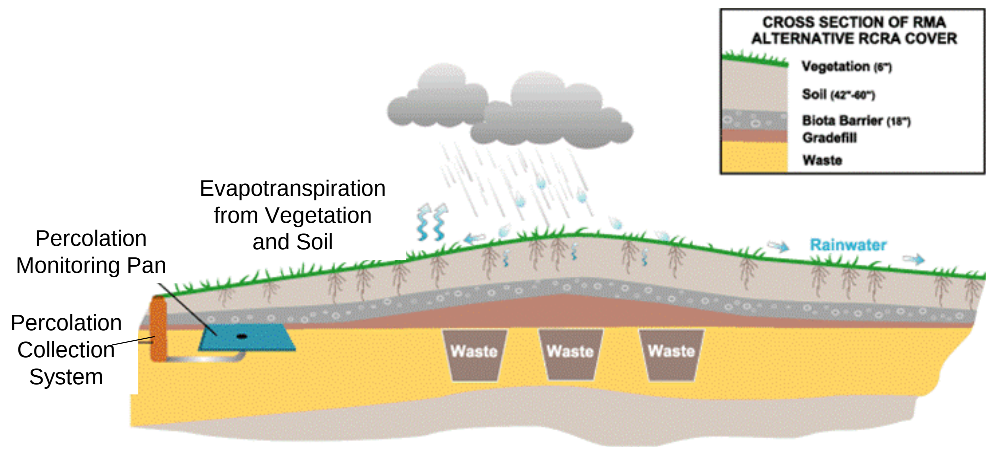


No Associated Notes

Types of Covers

- Single Vegetated Soil Layer (Evapotranspiration Cover)
- Addition of a capillary barrier
  - Dry Barrier
  - Biota barrier
- Monolithic Soil design

Rather than naming various standard types of Alternative cover designs and implying standardization and possibly prescription, the **creativity necessary in the design process** warrants a thorough understanding of the expected outcome and the local climatic conditions.

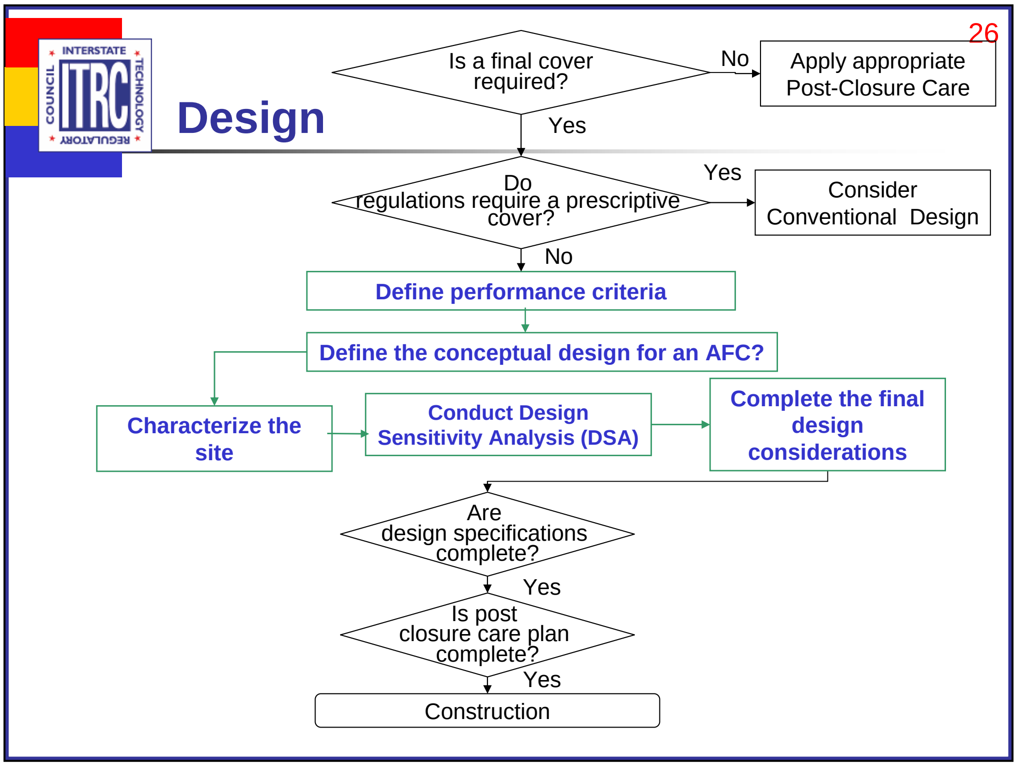
Several types of alternative covers as listed above.

This document focuses on ET covers.

Subsystem Performance

- Describe total system performance through identification of risk and exposure limits
- Identify mechanisms of exposure by evaluation of:
  - Releases from engineered system
  - Controls on release by natural systems
  - Exposure limit via Institutional Controls
- Define required performance of each subsystem
  - Expected performance
  - Design margin
  - Performance trends over time
  - Performance indicators and evaluation

Ties regulations to protection of human health and the environment to design to construction to post-closure care.



No Associated Notes

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Design Process

- Select performance criteria
- Establish conceptual design validity
  - Natural analogs
  - Representative test plot data
  - Nearby site data
- Preliminary design
  - Soil and climate analysis
  - Describe initial soil profile
  - Cost analysis
- Site characterization
  - Soil, climate, plants
- Refine design through modeling
  - Perform design sensitivity analysis
  - Include environmental stresses
- Final design and considerations

No Associated Notes

Performance Criteria

- Conventional covers typically required to meet material specifications, but not subjected to performance criteria
  - Assumption that low-permeability materials can be placed over large area and will maintain parameter values for extended period of time
- Performance criteria will determine alternative cover design
  - Covers can be designed to minimize percolation
  - Covers can be designed to regulate flux to prescribed level (i.e. for bioreactor application)
- Performance criteria depend on application and on conventional design appropriate to the site

No Associated Notes

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Conceptual Design

- Natural analogs
  - Long-term
  - Can include assessment of plant succession, climate change, pedogenesis, disturbance by animals
  - Basis for communication with public
- Representative test section data
  - Certain measurement
  - Evaluates actual design
- Nearby site data
  - Leachate collection data
  - Incorporates overall landfill performance – not just cover

No Associated Notes

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Preliminary Design

- Site screening
  - Evaluate possible borrow sources
  - Evaluate design climatic events
- Determine initial soil profile
  - Calculate required soil depth to store design precipitation event
- Conduct cost analysis

No Associated Notes

Preliminary Design: Site Screening

- Survey sources of borrow soil
  - Proximity
  - Initial assessment of soil moisture storage capacity
    - ✓ Soil surveys may provide adequate data for this step
- Determine design climatic event
  - Period of record?
  - X-year event
  - Seasonality important
  - Important regulatory decision – advise prior agreement

No Associated Notes

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Preliminary Design: Determine Initial Soil Profile

1) Determine water storage capacity of available borrow soil (meters of water / meter of soil) (a)
   - (see explanation of water storage capacity)
2) Determine design precipitation event (meters of water) (b)
   - Seasonal for locations with cold winters
   - Short-term for warmer locations
3) Calculate required depth of soil for water storage

$$\frac{b}{a} = \text{meters of soil}$$

No Associated Notes

Preliminary Design: Cost Analysis (See Section 4.13)

- Initial estimate of AFC cost
  - Soil volume
  - Transportation and construction costs
- Determine cost of RCRA design or other alternative
- Account for maintenance and other associated costs
- Alternatives are not always less expensive

No Associated Notes

Site Characterization - Soil

- Hydrologic parameters
  - Unsaturated, retention properties
  - Saturated properties
- Agronomic properties
  - Fertility
  - Contaminants
- Geotechnical properties
  - Shrink / swell
  - Erosion resistance
  - Slope stability

No Associated Notes

Soil Properties: Primary Hydrologic, Engineering and Agronomic Parameters

- Engineering
  - Particle size distribution
  - Bulk density
  - Porosity
  - Atterberg limits
  - Soil strength
- Agronomic
  - Fertility
  - Nutrient supply
  - Tilth
  - Toxic substances
  - pH
  - Salinity
- Hydrologic
  - Water holding capacity
  - Saturated hydraulic conductivity
  - Unsaturated flow parameters

See Table 4-1 & 4-2 in the document for a more complete listing of important properties

No Associated Notes

Site Characterization - Climate

- Precipitation
  - Daily values
  - Which data used for modeling?
- Potential evapotranspiration (PET)
  - Pan evaporation data
  - Calculated from Penman / Monteith equation
- Temperature
  - Low temperature limits to transpiration capability
  - Freeze / thaw effects on soil profile
  - Influence on ET

No Associated Notes

Site Characterization – Plant Community

- Species selection
  - Timing of transpiration – long season is desirable
  - Root depth / density
- Mixed community
  - Stability
  - Full season transpiration
- Native species
  - Adapted to site conditions
  - Meet environmental concerns
- Modeling data
  - Percent cover
  - Leaf Area Index
  - Wilting point

No Associated Notes

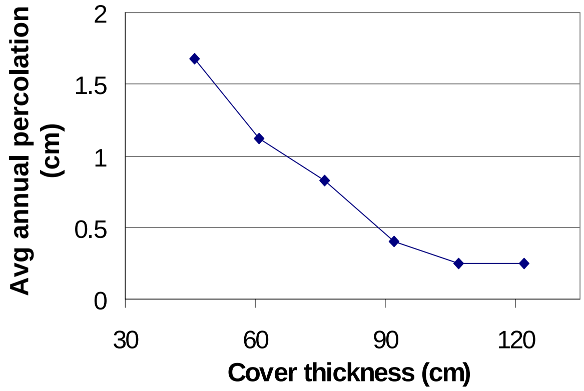
Design Sensitivity Analysis (DSA) and Predictive Modeling

- What is DSA?
  - Model performance as systematic changes are made to a single design parameter
  - Show DSA results as performance as a function of changes in multiple design or environmental parameters
- Why DSA?
  - No model alone gives results with sufficient accuracy for regulatory decisions.
  - Emphasis should not be on absolute determinations of flux
  - The best application of simulated performance is to understand the system

No Associated Notes

DSA Example #1

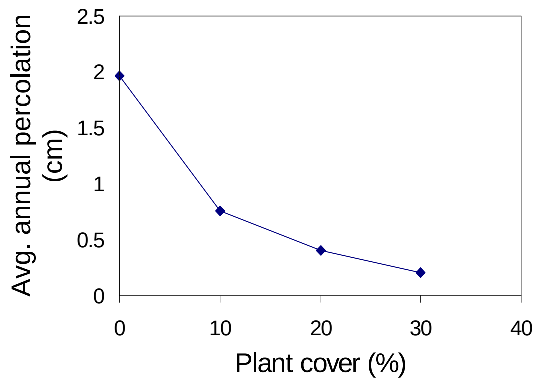
- Evaluate effect of variable cover thickness



No Associated Notes

DSA Example #2

- Site: southeast California, arid, hot, sparse vegetation
- Evaluate effect of variable plant coverage



No Associated Notes

Stressors and Failure Modes

- Climatic
  - Precipitation: erosion, excess infiltration
  - Transpiration factors: temperature, humidity, wind
- Biologic
  - Burrowing animals: excavation
  - Plants: macroporosity
  - Plant community succession: erosion, ET capacity
  - Microbes: alter capillary structure
- Structural
  - Erosion (water and wind): plant viability. cover thickness
  - Seismic: slope stability
  - Subsidence: local ponding, shearing
  - Pedogenesis: change in soil hydraulic properties

No Associated Notes

Final Design

- Select final cover profile (soil and plants)
- Additional important factors
  - Surface runoff control
  - Biota barriers
  - Test sections
  - Borrow source description
  - Cost analysis
  - Landfill gas
  - Maintenance plan
  - Final cost analysis
  - Design deliverables – specifications, CQA plan

No Associated Notes

Surface Water Runoff (SRO)

- SRO mainly a stability issue
- Increased SRO reduces the volume that must be stored in the cover
- All landfills require engineering of surface water drainage features to reduce erosion
  - Channels
  - Detention ponds
- Estimation techniques
  - Results depend on precipitation data
  - Choice of method is important regulator decision

No Associated Notes

Factors affecting the amount and rate of Surface Water Runoff

Soil	Surface	Other factors
Infiltration rate	Surface crust and tilth	Rainfall intensity
Water content	Plant type (sod or bunch grass etc.)	Time of high intensity
Particle size distribution	Cover density	Storm duration
Frozen soil	Growth rate	Interception by plants
Bulk density	Stage of annual growth cycle	Soil surface depressions
Clay mineralogy	Biomass production	Litter on the soil surface
Macro porosity	Roughness and storage	Land slope

No Associated Notes

Test Sections

- Used to help demonstrate the performance of a proposed cover design
  - Includes construction methods
- Considerable time required for data collection
- Range of meteorological conditions tested is limited
- Results of a properly conducted demonstration provide the best data to support final design
  - Validity of data depends on careful consideration of both cover and test section design
  - Excellent data to support additional numerical simulations

No Associated Notes

Test Sections

No Associated Notes

Borrow Sources

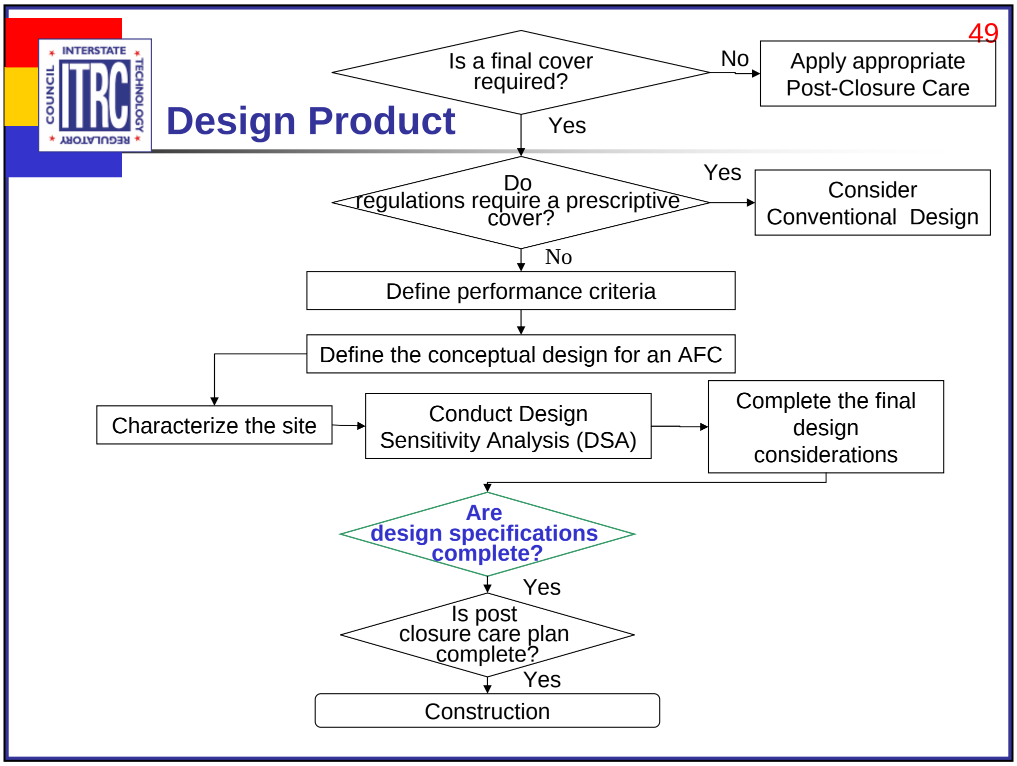
- Quantity available
  - Areal extent
  - Depth (consider various soil horizons)
- Evaluate range of soil properties
  - Sampling schedule and methodology
- Tied to construction QA
- Transportation cost – distance to site

No Associated Notes

Cost & Cost Savings

- Conventional designs generally more expensive
  - Avoids geomembrane cost
  - Avoids clay barrier installation cost
  - Needs no drainage layer
  - QC is less complicated and costly
  - Maintenance often less costly
  - Landfill gas and groundwater concerns
- However, a site having abundant clay but not adequate soil may display a cost advantage in the direction of a conventional cover

No Associated Notes



No Associated Notes

Questions & Answers

No Associated Notes

<u>AFC Construction is concerned with:</u>

1. Confirming that the **materials to be used are acceptable;**

2. Confirming that the **construction methods to be used are appropriate;** and

3. Confirming that the materials & methods **then ARE properly used** to construct the cover.

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Cover Construction Materials

The AFC Design will include specific requirements – *specifications* -for AFC construction materials

- Physical Properties
- Chemical Properties

Material properties must be verified before and during construction

Testing Methods – there are several sources of acceptable methods that can be used to measure materials properties; such as:

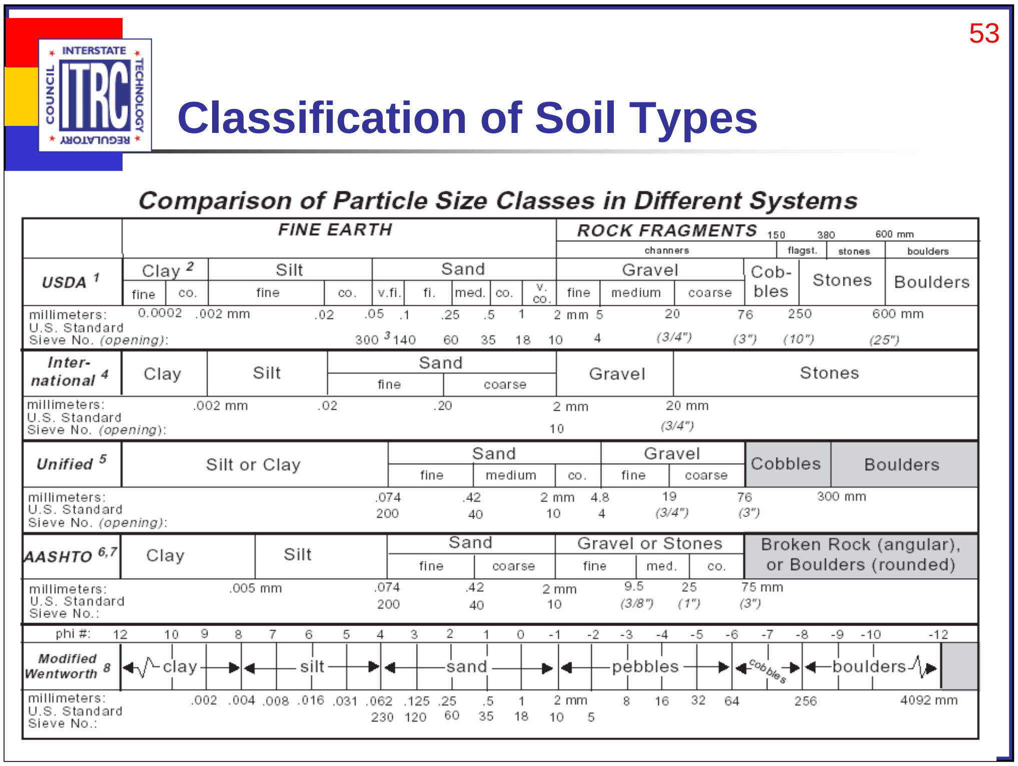
American Society for Testing and Materials (ASTM) www.astm.org

U.S. Department of Agriculture (USDA) www.usda.gov

Soil Science Society of America (SSSA) www.soils.org

American Society of State Highway and Transportation Officials (AASHTO) www.aashto.org

U.S. Army Corps of Engineers (USACE) www.usace.army.mil/publications/eng-manual/cecw.htm



As we noted on the previous slide, several methods are available to AFC designers for specification of soil materials to be used in cover construction. This slide further shows how one aspect of soil type classification – particle size - differs between agronomic, engineering, and geologic classification schemes.

Each of these classification schemes is correct, but we recommend that AFC regulators, designers, and constructors use a consistent methodology through the design and construction process to avoid confusion or misunderstanding on the part of any of the parties.

LINKS

2002 Field Book for Describing and Sampling Soils, Version 2. National Soil Survey Center/NRCS/USDA

ftp://ftp-fc.sc.egov.usda.gov/NSSC/Field_Book/FieldBookVer2.pdf

Material Properties Confirmation

Natural Materials top soil moisture storage layer capillary break layer other components	***Physical Properties:*** *available volume, bulk density, particle-size gradation, compaction properties, electrical conductance, hydraulic conductivity, moisture content, moisture retention properties, plasticity, soil classification, strength properties, wilting point* ***Chemical Properties:*** *cation exchange capacity, micronutrients, nitrogen, organic matter content, pH, phosphorus, potassium sodium adsorption ratio, sulfur.*
Vegetation Materials seed mixtures soil amendments	***Seed types*** ***Nutrients*** *(potassium. phosphorus, nitrogen)* ***Organic amendments*** *(such as biosolids, manure, humic substances, poultry waste, grass hay, oil seed meal, brewing by-products)*

Properties such as those listed likely will be important to any AFC construction project, but the materials and testing requirements for each AFC will be design-specific and site-specific.

Other types of materials might be including in the used, such as:

Geosynthetic materials (liners, fabrics, etc.)

Drainage (run-on/run-off) control materials (drain pipes, culverts, concrete, etc.)

Erosion control materials (rip rap, concrete, etc.)

Landfill gas control measures

The use of these kinds of materials or constructed items is not unique to an AFC and are thoroughly covered in the technical literature, agency guidance documents, and elsewhere.

For example, see:

Bonaparte, R., D.E. Daniel, and R.M. Koerner, 1999, Assessment and Recommendations for Optimal Performance of Waste Containment Systems, Grant No. CR-821448, Final Report to Mr. D. A. Carson, U. S. EPA, ORD, Cincinnati, OH.

Koerner, R. M., 1998, Designing with Geosynthetics, 4th Ed., Prentice Hall Publishing Company, Englewood Cliffs, NJ.

Index Properties

- Some properties are not easily measured in the field
- These could be important to AFC performance
- Develop correlations to more easily measured properties

For example:

- Important moisture retention properties
  - Wilting point, field capacity, or unsaturated hydraulic conductivity
- Could correlate to index properties
  - Density, moisture content, grain-size, or plasticity

No Associated Notes

Construction Methods

- Construction methods can strongly affect - positively & negatively - long-term AFC performance

More

more clay, more thickness, more compaction, more water

isn't always better

- Communication of this sensitivity to construction crews is important
- Verification that proper construction methods are used is a QC objective as important as achieving numerical specifications

No Associated Notes

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Construction Equipment

- Construction Equipment
  - Common equipment can be used, BUT…
  - If test pads are used, use the same equipment
- Construction Methods
  - Place soil in thick lifts
  - Place dry-of-optimum
  - Achieve proper compaction
  - Identify and correct over-compaction

This is a “different kind of cover” and requires that some construction methods or equipment be used differently than they are for a conventional earthwork project.

Consider building small test sections of the cover before full-scale construction to determine the appropriate combination of:

- equipment type,
- lift thickness,
- moisture content, and
- number of equipment passes.

Soil Compaction

- Low permeability soil *is not* an AFC objective
- Place soil “dry-of-optimum”
  - dry soil is not easily over-compacted
  - improves rooting and plant success
- Achieve a low soil density
  - Growth Limiting Bulk Density concept
  - determine the GLBD during Design

“Dry-of-optimum” is a reference to ASTM D698, moisture-density relations using 5.5-pound rammer and 12-inch drop, also called standard proctor compaction.

Growth Limiting Bulk Density (GLBD) is a threshold soil bulk density value for each soil texture beyond which root growth is impeded because of the high mechanical resistance of soils resistance of soil.

GLBD objectives typically are in the range from 1.1 to 1.5 grams/cubic centimeter (70 to 95 pounds per cubic foot, dry) which corresponds to 75% to 85% standard proctor maximum dry density for soil types often used in an AFC.

Cover Slope Stability

- Slope instability problems can affect any landfill cover
- Problems usually are moisture-related, but could be caused by over-compaction
- Reducing over-compaction can improve slope stability.
- Simple steps preserve slope stability
  - Use small, wide track dozers
  - Construct from the bottom up
  - Avoid hard braking or turns while moving on slopes

Slope instability is one of the most common problems with all types of landfill final covers.

Alternative landfill covers may be susceptible to slope stability problems because of steep slopes, lower soil placement densities (or drier soil), and effects of moisture from rainfall/snowmelt or thaw.

References include:

Bonaparte, R., B.A Gross, D.E. Daniel, R.M. Koerner, and S. Dwyer, April 2002, Draft Technical Guidance For RCRA/CERCLA Final Covers, U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response. Washington D.C.

Koerner, R. M., 1998, Designing with Geosynthetics, 4th Ed., Prentice Hall Publishing Company, Englewood Cliffs, NJ.

Drainage and Erosion Control

Ditches, swales, armored channels, etc.

- these features perform the same functions on an AFC as on a conventional cover

They are constructed to

- reduce erosion on large or steep covers
- reduce water accumulation

They do cause temporary surface water accumulation

- designed to prevent infiltration

The drainage and erosion controls used for AFCs are the same as those used for Conventional Covers.

References include:

American Society of Civil Engineers, 1996, Hydrology Handbook, ASCE Manual 28.

Chow, V.T., D.R. Maidment, and L.W. Mays, 1988, Applied Hydrology, McGraw-Hill Book Company, New York.

Linsley, R.K., M.A. Kohler, and J.L.H. Paulhus, 1982, Hydrology for Engineers, McGraw-Hill Book Company, New York.

Soil Conservation Service, 1972, National Engineering Handbook, Section 4, Hydrology. U. S. Department of Agriculture, SCS, Washington, DC.

Construction Methods – DON'Ts & DOs

DON'T	DO
deviate from specifications	adhere to specifications
over-compact soil layers	loosen over-compacted areas
use heavy wheeled equipment.	use light or tracked equipment
run equipment at high speeds, make sharp turns, and stop short	run equipment slowly, make wide turns, and avoid quick starts/stops
run equipment over the completed cover unnecessarily	rip and loosen over-compacted roads and tracks
over-moisten soil when being placed	allow soil to dry to below optimum moisture contents before being placed
stockpile materials on the cover	stockpile construction materials elsewhere

DON'T practices could reduce an AFC's capacity to hold water and support vegetation because of **OVER-COMPACTION.**

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Vegetation Placement

- Use the proper equipment
- Use the equipment in the proper way
- Vegetation placement methods
  - Hydroseeding
  - Solid sod application and sprigging
  - Broadcast seeding on the surface
  - Drill seeding in bare soil
  - Drill seeding in standing crop residue
  - Seedling planting

COVER DESIGN will identify the proper vegetation mix.

COVER CONSTRUCTION must properly place it on the cover and provide the conditions needed for vegetation to grow and thrive.

Initial Vegetation Establishment

- Most AFCs won't function as intended until vegetation is well-established
- Methods to improve initial vegetation establishment
  - mulching, fertilizing, and irrigation
- In dry areas, irrigation can be very important
- Frequent irrigation needed to establish native grasses
  - Should maintain wet conditions for at least two weeks
  - Followed by longer duration and less frequent watering will help drive roots deeper

Vegetation should become self-sustaining as quickly as possible, to achieve the desired AFC performance and, sometimes, to comply with regulatory requirements.

But, in arid regions where vegetation might take many seasons to become well-established, it can important that the AFC perform acceptably <u>without plant transpiration</u>.

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Construction Quality

***Quality Assurance* = the MANAGEMENT SYSTEM that can assure quality**

***Quality Control* = the ACTIVITIES that can measure performance**

- Regulations require documentation of the quality of materials and workmanship
- AFC Design Documents include QA/QC requirements
  - Drawings & Specifications identify the numerical measures
  - CQA Plan lays out the QA/QC system

The primary QA/QC document identified in the guidance document is the CQA PLAN, a document that is specifically required under U.S. federal and State RCRA regulations.

The guidance document gives deserved emphasis to the importance of verifying and documenting conformance to approved AFC design documents.

No conflict is intended between the way QA/QC and related terms are used in these training slides and the guidance document or the way they are used by regulatory agencies and others interested in AFCs.

Construction Quality Responsibilities

TITLE	AFFILIATION	RESPONSIBILITIES
Owner / Operator	Facility Owner/Operator	Final responsibility for compliance with regulatory requirements.
Engineer	Consulting engineer hired by facility owner/operator.	Responsible for the specification, drawings, modifications.
CQA Consultant	Independent third party hired by the owner operator	Confirms that the CQA activities are done in accordance with CQA Plan.
Contractors	Could be independent or affiliated with Owner/Operator.	Provide materials, equipment, and personnel to construct the project per plans and specifications.
QC Laboratories	Independent of the contractor(s) and material supplier(s)	Conduct specified tests to measure material properties for comparison to specifications

QA/QC responsibilities for AFC construction do not differ from those applicable to construction of any landfill cover or major soil construction project.

The position titles, etc. in the slide table are not provided as definitions, but are intended only as examples.

Construction Quality - Soil

- Verify soil properties ***before*** placement
- Verify soil properties ***after*** placement
- Verify the geometry of placed soil layers
  - Area covered
  - Layer thickness and uniformity
- Respond to out-of-specification instances

Responses to soil construction conditions that are identified as "out-of-specification" might include:

- Loosening an over-compacted soil layer and re-measuring
- Adding/removing soil where layers are too thin/thick and re-measuring
- Allowing an overly wet soil layer to dry and re-measuring
- Removing and/or replacing the out-of-compliance material
- Seeking the Design Engineer's determination that the out-of-compliance situation will be acceptable as-is (i.e., can be left in-place and will not be detrimental to AFC performance)

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Construction Quality - Cover Geometry

- Measure final AFC surface geometry – confirm the *as-built shape* of the AFC
  - Usually done by surveying
  - Other methods also can be used
- Compare to requirements
  - Is the covered area correct?
  - Are final elevations correct?
  - Are slopes correct?
  - Are surface features (ditches, erosion protection, etc.) as designed?
- Respond to out-of-specification instances

Responses to cover geometry (shape) conditions that are identified as "out-of-specification" might include:

- Re-grading existing material to achieve the desired shape
- Adding or removing material to obtained the desired shape
- Seeking the Design Engineer's determination that the out-of-compliance situation will be acceptable as-is (i.e., can be left in-place and will not be detrimental to AFC performance)

Construction Quality - Vegetation

- Confirm seed type
- Purity
- Weeds - prohibited or restricted noxious plant seeds
- Sealed seed container labels should include
  - Seed mix name
  - Lot number
  - Total weight and weight of each seed type
  - Percent purity & germination
  - Seed coverage
  - Percent weed seed
- Respond to out-of-specification instances

Responses to vegetation conditions that are identified as “out-of-specification” might include:

- Adding a seed type that is missing or present in insufficient quantity
- Removing and/or replacing seed (difficult to do)
- Seeking the Vegetation Specialist’s determination that the out-of-compliance situation will be acceptable as-is (i.e., can be left in-place and will not be detrimental to AFC performance)

Construction Quality – Response

Making the proper response to out-of-specification situations is a critical part of QA/QC

- Identify the problem
- Take the action dictated by the situation
- Retest to verify that the situation is corrected
- Document the process

The combination of QA/QC measurements, decisions, and responses should provide a final project that is:

1. Constructed using the proper materials,

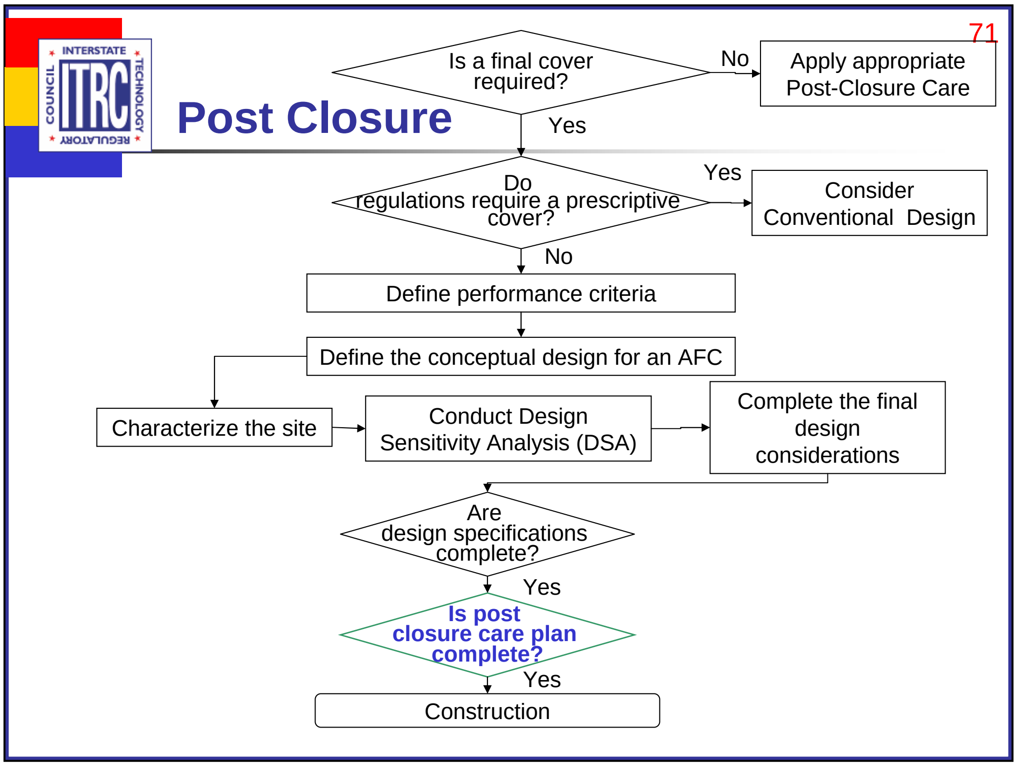
2. Constructed using the proper methods, and

3. Judged to be in satisfactory compliance with the Design Documents.

Documentation and Certification

- Documentation
  - Always thoroughly document all steps in the AFC construction process
  - File and protect these records
- Completion Certification
  - Usually required by the regulatory agency
  - Usually must be provided by a State-registered engineer

No Associated Notes



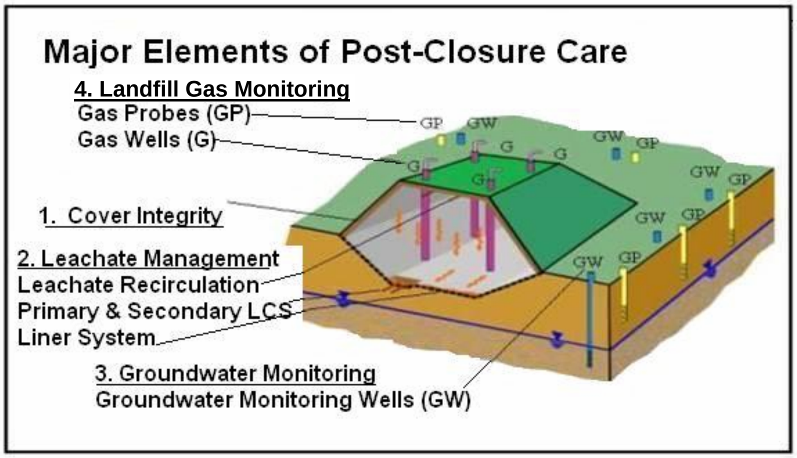
No Associated Notes

Post-Closure Care

1. Performance Requirements for Post-Closure Period
2. Post-Closure Care Plans
   a. Contents
   b. Specific PCC Concerns
3. Post-Closure Care Costs for Alt. Covers
4. Post-Closure Care Duration

No Associated Notes

Post-Closure Care Elements



No Associated Notes

1. Performance Requirements for Post-Closure Care

Media to be Contained	**Indicators of Containment**
Waste	• Stability • Excessive Settlement • Erosion Prevention • Prevention of Animal Intrusion • Vandalism or Uncontrolled Access
Leachate	• Seeps • Leachate Quality • Leachate Quantity
Landfill Gas	• Vegetative Stress • Off-Site Migration • Odors

No Associated Notes

2a. Post-Closure Care Plans: Recommended Contents

1. Institutional Information
   - Site Information
   - Design Basis
2. Post-Closure Use
   - Description
   - Special Design Considerations
3. Performance Requirements
   - Current Requirements
   - Updating the Requirements
4. Monitoring Plan
   - Cover System
   - Leachate
   - Landfill Gas
   - Groundwater
5. Maintenance Plan
   - Cover System
   - Non-Cover Containment Features
6. Contingency Plan

No Associated Notes

2b. Specific Concerns: Cover Flux Monitoring

- Description: Measurement of liquid flow through the cover (units = mm/yr or gallons per acre per day)
- Can be used during construction as a quality assurance tool
- Data can be used to verify that landfill cover is performing as designed

No Associated Notes

2b. Specific Concerns: Cover Integrity Monitoring

- Used to:
  - Detect problems with containment or liquids management
  - Identify areas that don't comply with the design
  - Identify problems that need to be remediated
- Settlement
- Erosion
- Vegetation
  - Sampling may be required

No Associated Notes

2b. Specific Concerns: Cover Monitoring Examples

Vegetation Quality Evaluation

Erosion/Stability Assessment

Plant Community Survey

No Associated Notes

2b. Specific Concerns: Leachate Management

- Leachate Quality
  - Should improve over time if cover performs as designed
  - Decrease in quality could indicate breach in cover
  - Trend in leachate quality is good overall of cover performance
- Leachate Quantity
  - Should remain constant or decrease over time (or significantly, immediately after cover construction) if cover performs as designed
  - Increase in quantity could indicate breach in cover
  - Trend in leachate quantity is a good overall indicator of cover performance
- Leachate Seeps
  - Primary pathway of leachate release to environment
  - Indicates sources of leachate behind cap
  - Likely to continue unless remediated

No Associated Notes

2b. Specific Concerns: Groundwater Monitoring

- Detect harmful releases from a facility as soon as possible
- Necessary component of post-closure care

With this in mind the groundwater monitoring system for a facility with an alternative Final Cover is no different than that at a facility with a prescriptive cover system

No Associated Notes

2b. Specific Concerns: Landfill Gas Monitoring

- Minimize vegetative stress
  - Key consideration for vegetative alternative covers
  - Monitoring performed visually (density, coverage, etc.)
- Minimize odors
  - Odor problems are compounded when gas is concentrated, e.g. at a crack in a cover
  - After active extraction ends, problem sometimes worsens for covers with no barrier layer
- Prevent off-site migration of gas
  - Landfills (especially MSW) generate gas for many years after closure
  - Perimeter monitoring and monitoring in buildings needed as long as landfill is generating gas

No Associated Notes

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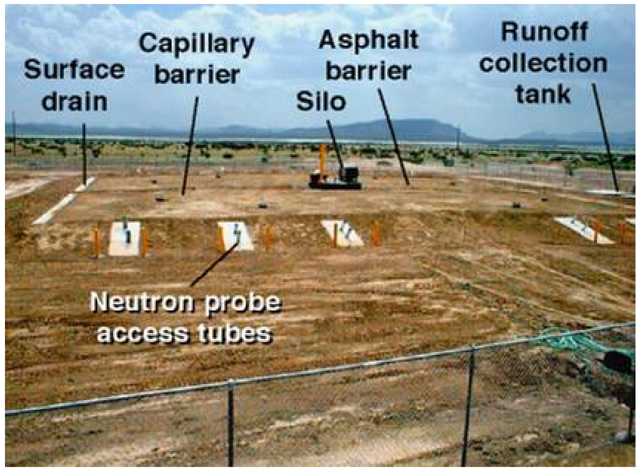
Example: Integrated Closure System Monitoring Program

Sierra Blanca Site, TX

- Purpose: Confirm Water Balance Prediction
- Components of Monitoring:
  - Precipitation
  - Soil Moisture
  - Runoff
  - Evapotranspiration
  - Infiltration



No Associated Notes

3. Post-Closure Care Cost Comparisons for Alt. Cover Landfills

Considerations:

- Barrier layers are expensive
- "Impermeable" barrier layers must be overlain by a drainage layer, which can be expensive
- Barrier layers must be overlain by enough soil to support the entire rooting zone, which may:
  - require that a thick layer of rooting zone soil be used; or
  - limit the types of vegetation that can be used
- Shallow-rooted vegetation (which is usually required on conventional covers) typically requires more care in the very long term than deep-rooted climax vegetation
- Over long term, most cost-effective cover may not be the cheapest one

No Associated Notes

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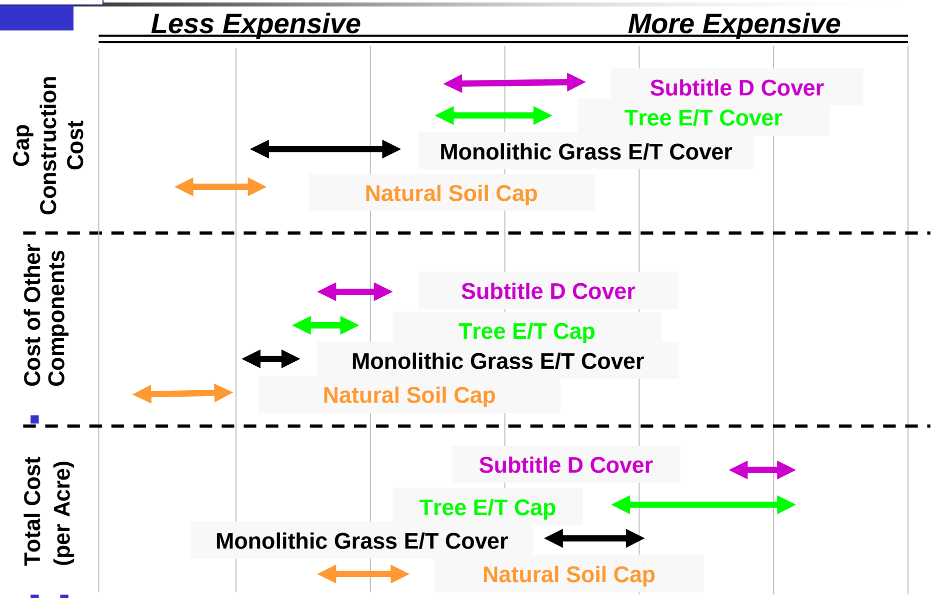
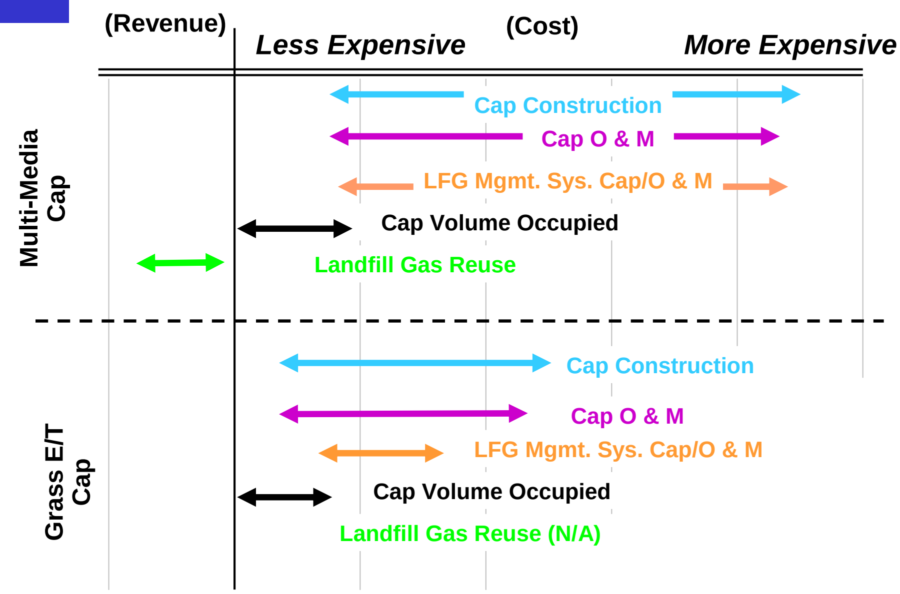
Capital Cost Comparison: Alternative Covers versus Subtitle D (Conventional) Covers



No Associated Notes

Life-Cycle Cost Comparison: Grass ET Cover vs. Conventional Covers

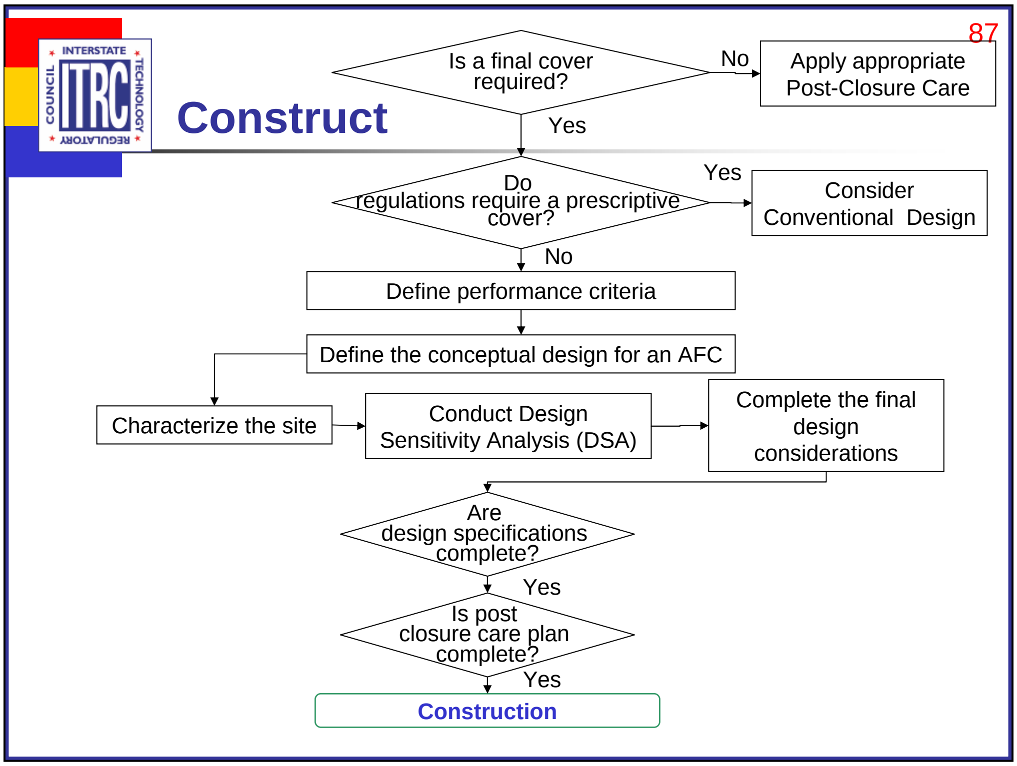


No Associated Notes

Post-Closure Care Duration - Approach

- Current regulations generally take prescriptive approach to duration of PCC and are not performance-based
- Current regulations provide no clear direction on how to end/exit post closure
- No guidance is available on how to define length of PCC or to evaluate the performance of a PCC program
- Many alternative cover designs offer faster reduction in risk than conventional cover designs
- Alternative approach to evaluation of Post-Closure Care:
  - Define performance requirements
  - Predict ability of closure system to meet requirements in the future
  - Confirmation and surveillance monitoring to confirm outcome
  - Approach lends purpose to post-closure duration, provides much-needed guidance, and incentive to owners to actively mitigate risks associated with contained materials

No Associated Notes



No Associated Notes

Current ITRC Projects

- Bioreactors
- Post-Closure Care

No Associated Notes

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Thank you for your participation

Links

To

Resources

Links to additional resources: http://www.clu-in.org/conf/itrc/alt/resource.cfm

Your feedback is important – please fill out the form at: at http://www.clu-in.org/conf/itrc/alt/

The benefits that ITRC offers to state regulators and technology developers, vendors, and consultants include:

•helping regulators build their knowledge base and raise their confidence about new environmental technologies

•helping regulators save time and money when evaluating environmental technologies

•guiding technology developers in the collection of performance data to satisfy the requirements of multiple states

•helping technology vendors avoid the time and expense of conducting duplicative and costly demonstrations

•providing a reliable network among members of the environmental community to focus on innovative environmental technologies

•**How you can get involved in ITRC:**

•Join a team – with just 10% of your time you can have a positive impact on the regulatory process

•Sponsor ITRC’s technical teams and other activities

•Be an official state member by appointing a POC (Point of Contact) to the State Engagement Team

•Use our products and attend our training courses

•Submit proposals for new technical teams and projects

•Be part of our annual conference where you can learn the most up-to-date information about regulatory issues surrounding innovative technologies