Proactive By Design.
Our Company Commitment

The Importance of Geotechnical Engineering Design of Excavated Ponds and Embankments

John M. Siwula, PE, D GE
GZA GeoEnvironmental, Inc.

GOALS OF PRESENTATION

1. Define and Illustrate

General Geotechnical Issues Affecting Earthen Surface Tailings Impoundments/Embankments

GOALS OF PRESENTATION

2. Illustrate

General Types and Methods of Tailings Impoundment Structure Construction and Remedial Measures to Address Instability and Seepage

Why are Tailings Impoundments Of Concern ?

MSHA Investigations From 1990 through 2010
Failure Of 5 Tailings Structures Cited as a Primary Reason to Develop New Regulations

1990	Puerto Rico	Limestone Mine	100' High
1992	Wisconsin	Andesite Quarry	70' High
1997	Arizona	Copper Mine	Unspecified Height
2002	Georgia	Sand & Gravel Mine	30' High
2007	California	Sand & Gravel Mine	Unspecified Height

Consequences

- Release 200 M gals. water and tailings
- Moderate to Extensive Damages to Operations, Plant, Equipment, Property, Environment
- Several Injuries
- No Loss Of Life most occurred off – hours

Primary Factors Affecting Five Mining Failures

1. Lack of Design By a Knowledgeable Engineer, and/or

2. Lack of Understanding of Geotechnical and Dam Engineering Principles

Failure Of Coal Ash Dredge Spoil Cell
December, 2008 Harriman, Tennessee

Harriman, Tennessee - Release of 200,000 Cubic Yards of Stored Coal Ash

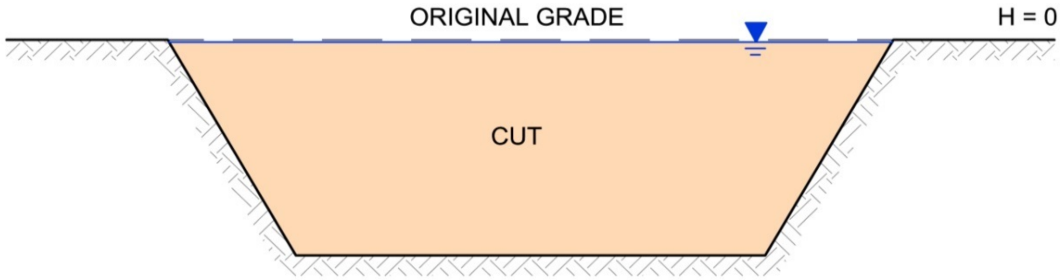
Geotechnical Environmental Ecological Water Construction Management

1 Billion Gallons of Flow, Much into Emory River

Alton, New Hampshire
1996
Privately Owned
Impoundment Failure

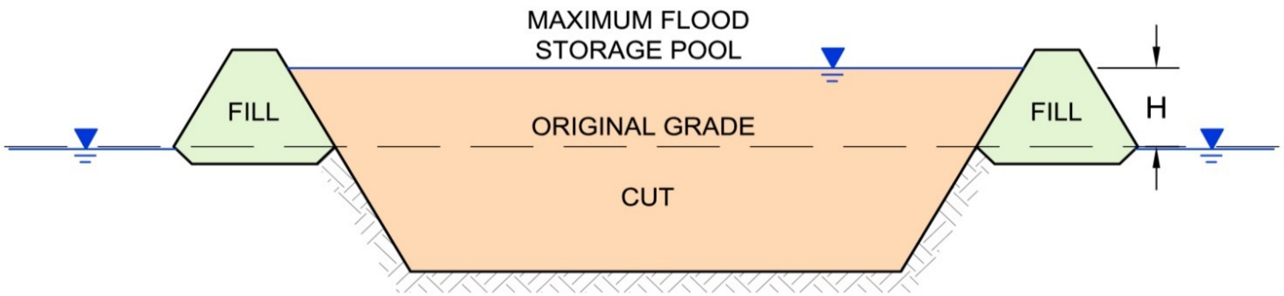
General Types of Impoundments

INCISED SURFACE IMPOUNDMENT



GEOTECHNICAL ENVIRONMENTAL ECOLOGICAL WATER CONSTRUCTION MANAGEMENT

PARTIALLY INCISED SURFACE IMPOUNDMENT



Dam Size Classification Corps of Engineers

Often Varies by State:

But size does not matter per MSHA and Corps

Category	Storage (acre-feet)	Height (feet)
Small	≥ 15 and < 50	≥ 6 and < 15
Intermediate	≥ 50 and < 1,000	≥ 15 and < 40
Large	≥ 1,000	≥ 40

Typical Dam Hazard Classification (Varies By State)

Hazard Classification	**Hazard Potential**
High	Probable loss of life Major economic losses
Significant	Possible loss of life Major economic losses
Low	Loss of life not expected Minimal property damage

General Methods Of Construction Tailings Impoundments

Ref. Klohn, E. "Taconite Tailings Disposal Practices", Geotechnical Practices in Mine Waste Disposal, A.S.C.E., New York, NY, 1979, pp 202 – 241.

Geotechnical Environmental Ecological Water Construction Management

Depending on the mining operation tailings can consist of a wide range of particle sizes ranging from

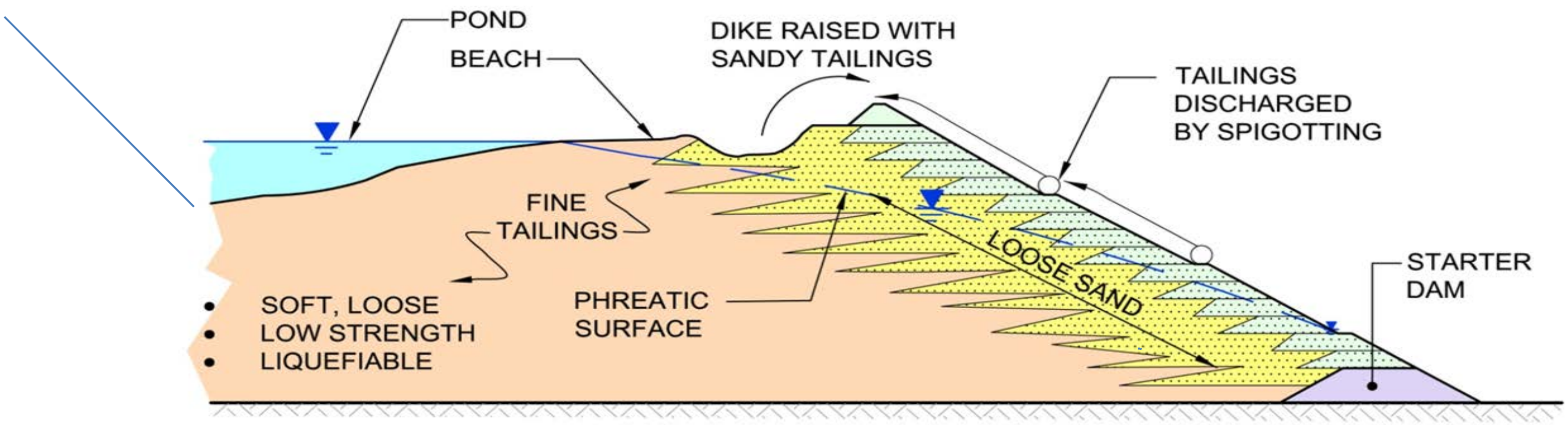
Sand - 0.075 mm to 4.75 mm

Silt – 0.002 mm to 0.075 mm

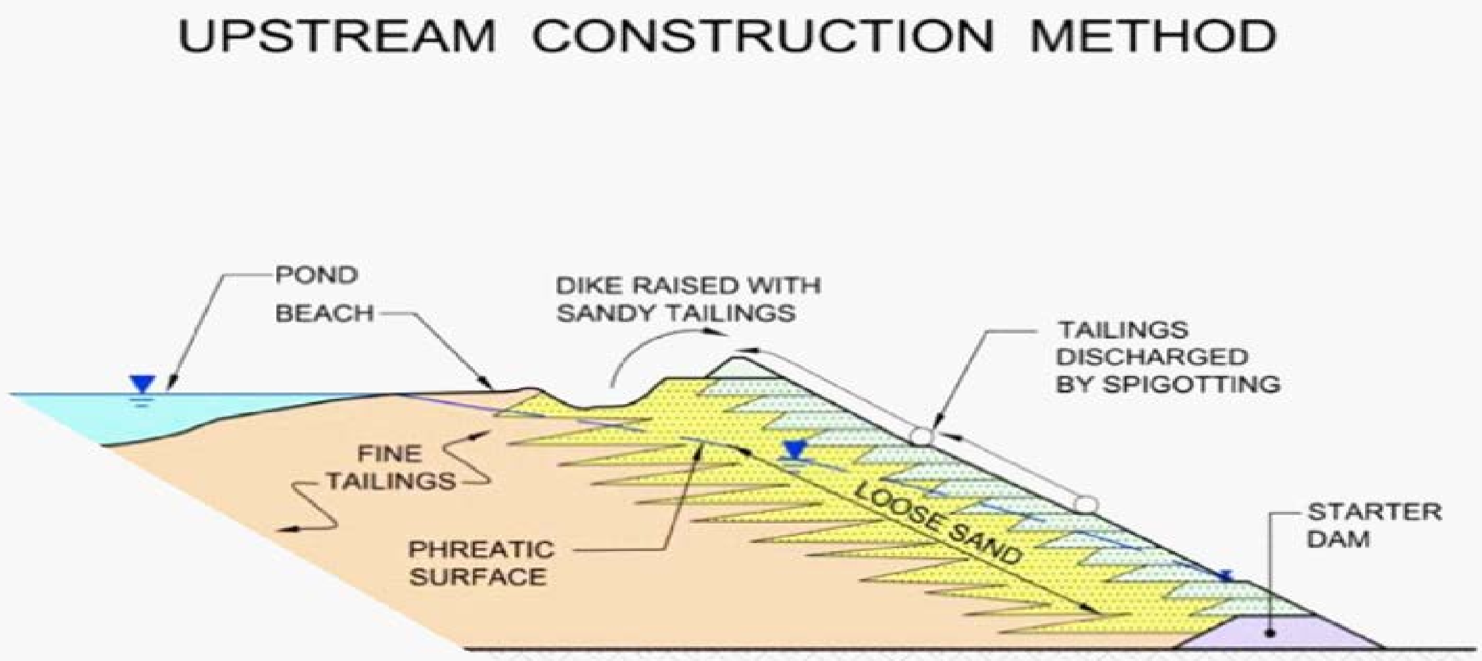
Clay - <0.002 mm

Source AASHHTO

UPSTREAM CONSTRUCTION METHOD



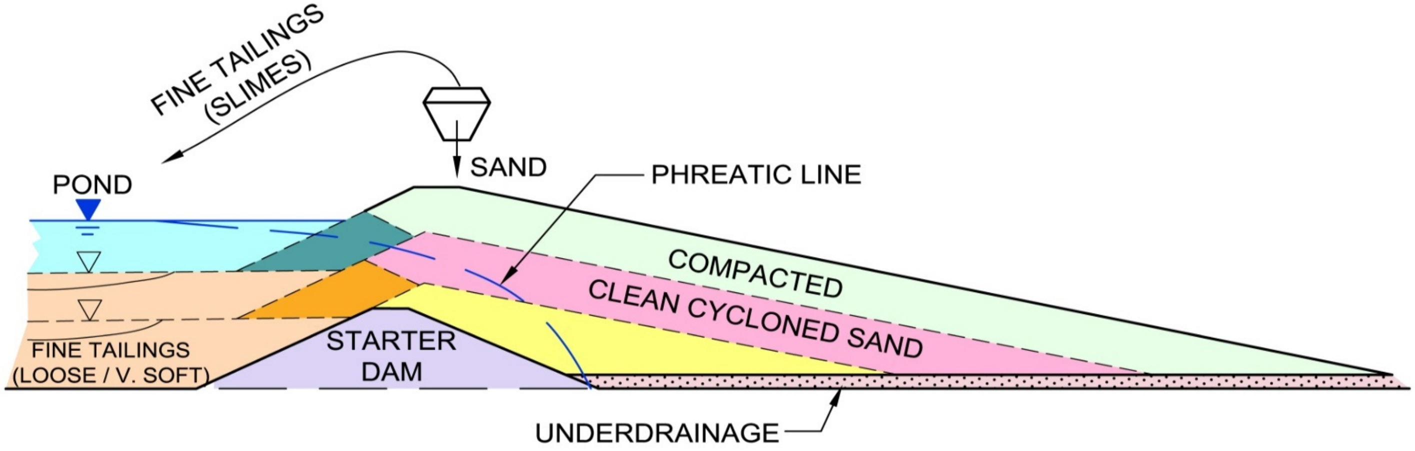
Use of Tailings is practical but it creates stability and seepage concerns



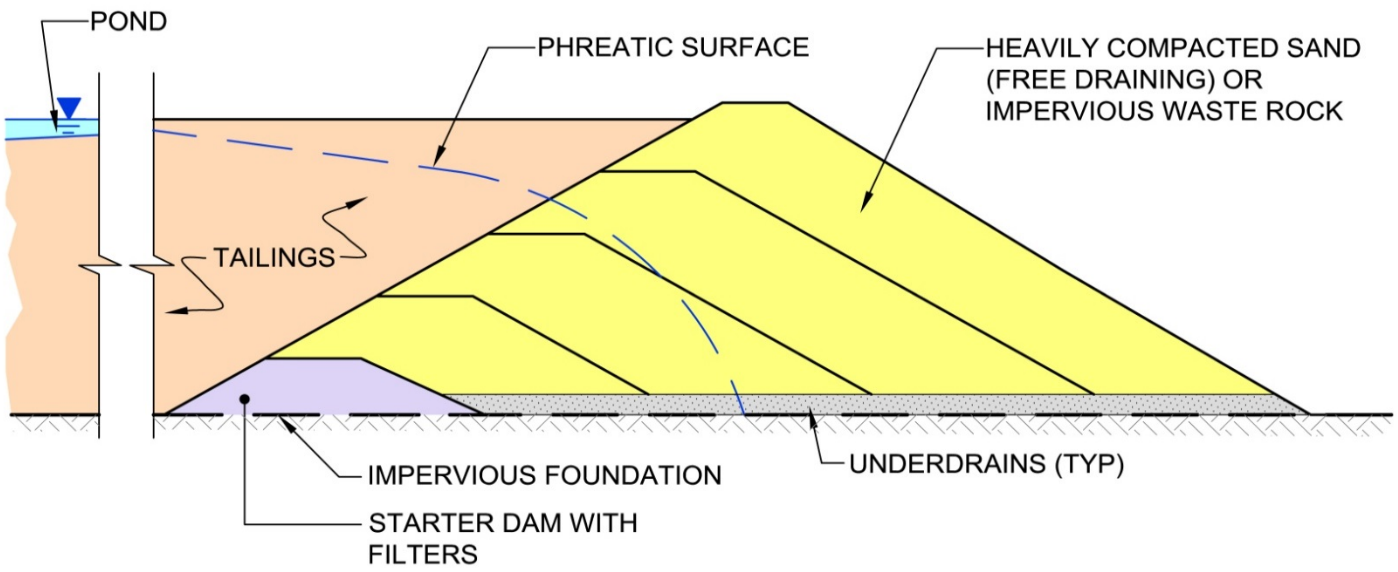
Geotechnical Issues

- Low Shear Strength Tailings – Soft, Loose
- No Internal Drainage – High Water Pressures
- Poor Compaction of Fill Materials
- Steep Side Slopes
- Weak Foundation
- Liquefiable Soils Under Seismic Loads

CENTERLINE CONSTRUCTION METHOD



DOWNSTREAM CONSTRUCTION METHOD



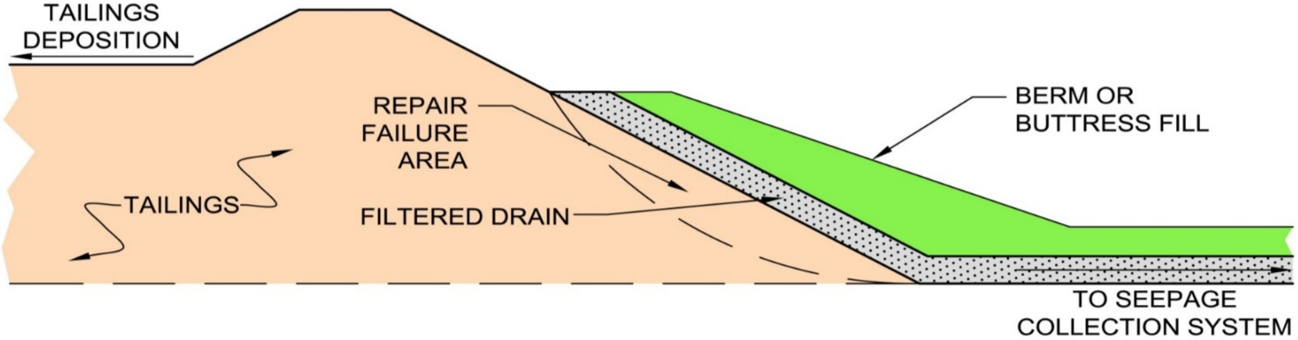
Classical Rotational Dam Failure

DeKalb County, Georgia
Multi-Jurisdictional Hazard Mitigation Plan, February 2011

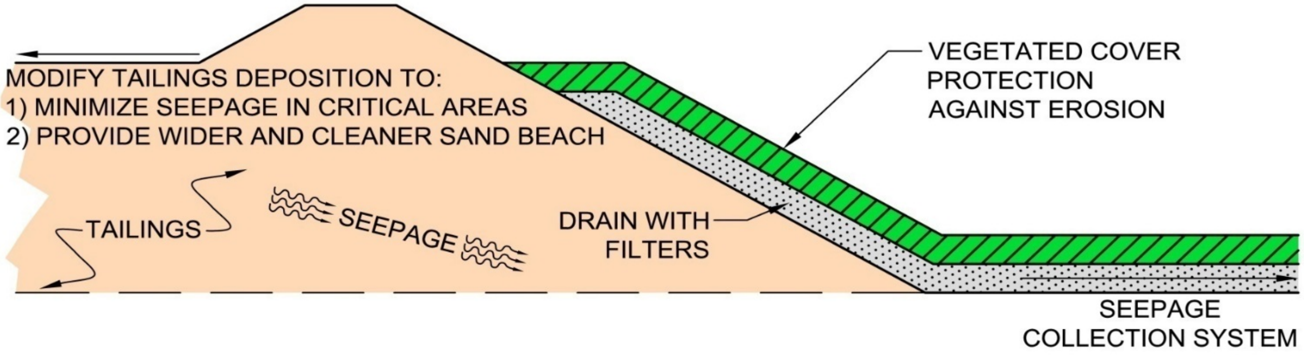
Classical Rotational Failure With Liquefaction

Merriespruit Tailings Dam Failure 1994, Virginia, South Africa

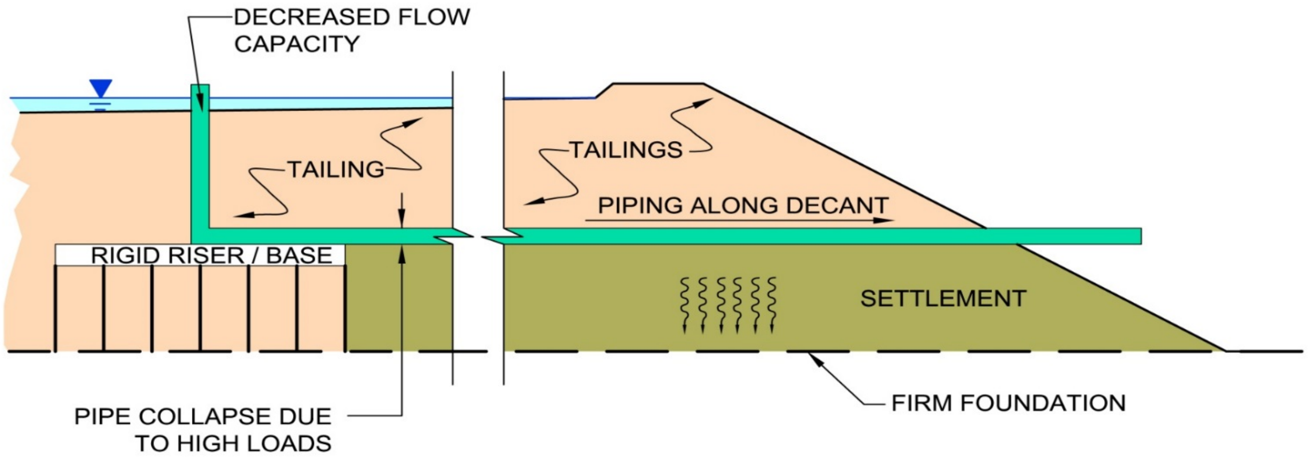
IMPROVEMENT OF SLOPE INSTABILITY



IMPROVEMENT OF SEEPAGE CONTROL



DECANT PIPE FAILURE MECHANISMS (TYPICAL)



Main Points

- Most Failures of Earth Impoundment Structures Due to Misunderstanding of Geotechnical Issues
- Involve a Knowledgeable Geotechnical Engineer in Design, Construction, Operation and Maintenance of Impoundment Structures
- Address MSHA Regulations
- Increased focus by MSHA due to two recent deaths that MSHA attributed to embankment failure

Proactive By Design.
Our Company Commitment

John M. Siwula, PE, D GE
Associate Principal/Geotechnical Engineer
GZA GeoEnvironmental, Inc.
20900 Swenson Drive, Suite 150
Waukesha, WI 53186
262-754-2576
414-412-9286
John.siwula@gza.com