

GEOSYNTEC | MMI | SIREM | GSM

GEAG

Geoenvironmental Action Group



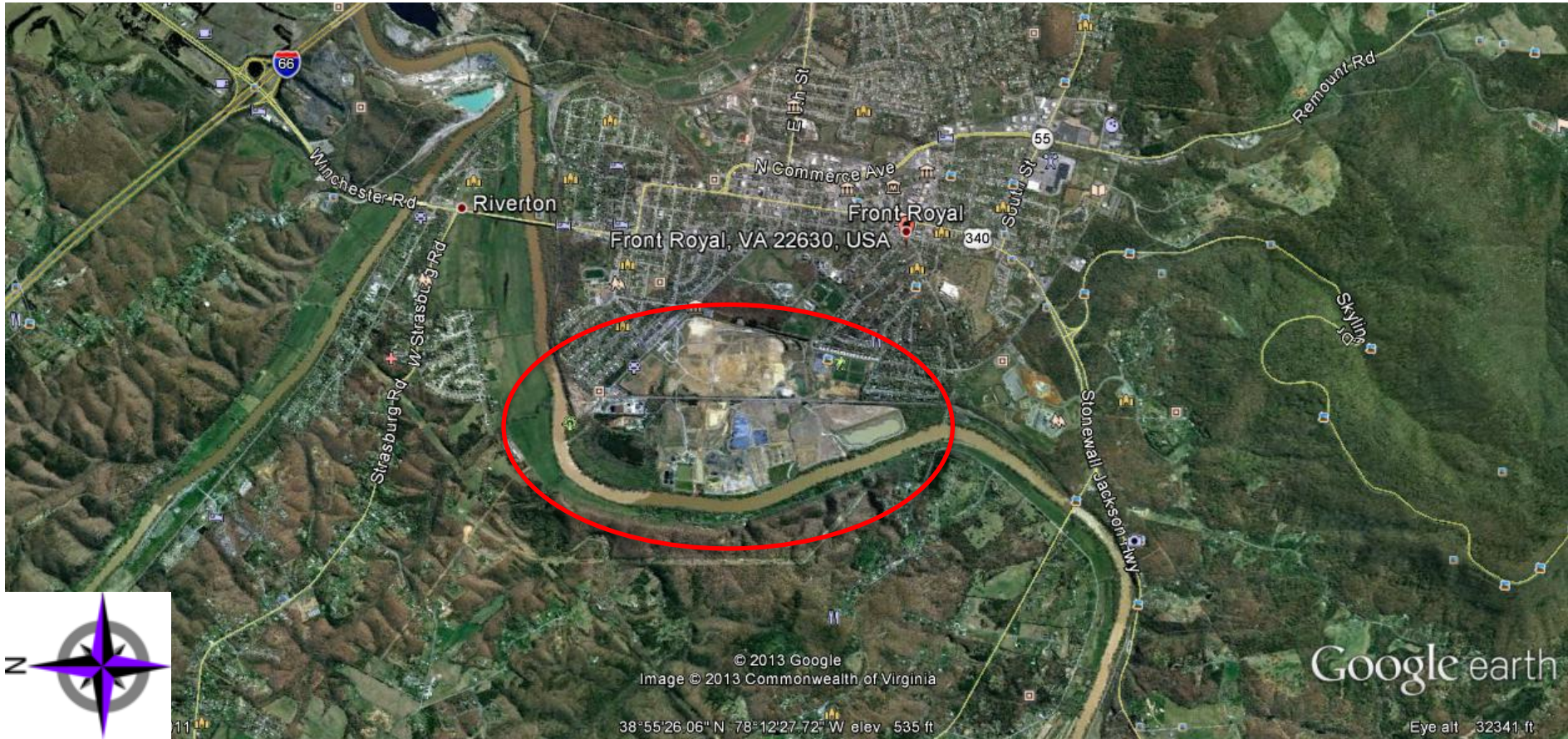
Closure Design and Construction of Contaminated Soft Sludge Lagoons: A Tale of Innovation, Poor Field Execution and Final Redemption

PURDUE GEOTECHNICAL SOCIETY

David Espinoza
Washington DC, USA

AVTEX SUPERFUND SITE

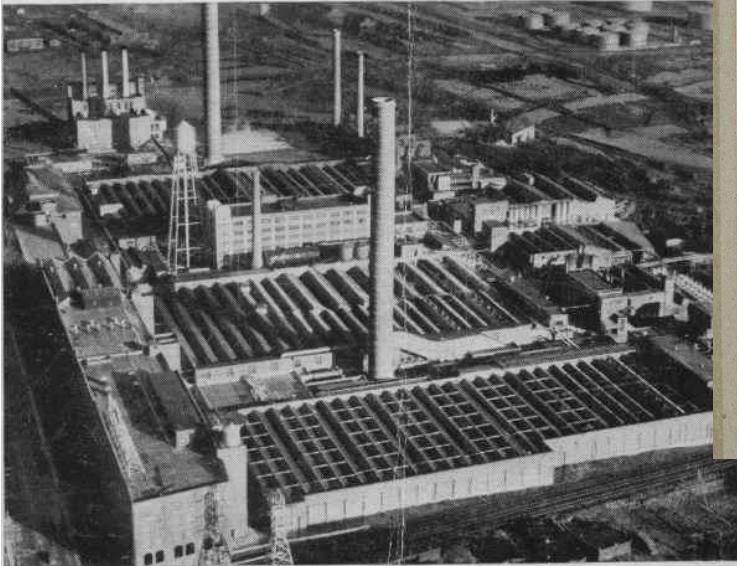
**Located in the Shenandoah valley
(62 miles west of DC)**



A LITTLE HISTORY...

America's first rayon plant

established in 1910 and still going strong!



AMERICAN VISCOSE CORPORATION
America's largest producer of rayon
MARCUS HOOK, PA.

Reprinted from "True Comics" Magazine.

MAN-MADE MIRACLE

MAN IS ALWAYS SEEKING WAYS TO MAKE LIFE BETTER. TODAY ON THE THRESHOLD OF THE CHEMICAL AGE, WE HAVE MAN-MADE CHEMICAL MIRACLES THAT FULFILL HUMAN NEEDS. ONE OF THE MOST MIRACULOUS OF THESE IS RAYON.

MODERN RAYON IS ONLY ABOUT 20 YEARS OLD, BUT THE IDEA FOR A MAN-MADE TEXTILE FIBER WAS CONCEIVED OVER 200 YEARS AGO BY AN ENGLISH NATURALIST.

THERE MUST BE A WAY FOR MAN TO MAKE A THREAD!

I have thought what might be a way for me to make an artificial thread - light as wool, but stronger than any existing fiber. I've some material to prove my invention. I hope some day I'm making it.
Robert Hooke
1664

TECHNICAL DATA SUPPLIED BY AMERICAN VISCOSE CORPORATION



Crown Tested Rayon Fabrics

Two-piece... an important theme for fall and winter... is a Crown Tested Rayon Crispe, the top stitched with gold-order metal thread, the skirt pleated to hang slowly straight. Sizes 12 to 16. Under \$25. In far stores everywhere, including:

- | | | | |
|------------------------|---------------|---------------------------|--------------------|
| Brooks | New York City | The William Horner Co. | Buffalo, N.Y. |
| Straussberg & Clothier | Philadelphia | D.H. Halton Co., Ltd. | New Orleans, La. |
| J.L. Hudson Co. | Detroit | John Taylor Dry Goods Co. | Kansas City, Mo. |
| The May Co. | Los Angeles | H.P. Warren & Co. | Indianapolis, Ind. |
| Hyde Co. | Cleveland | The Dreyfus Dry Goods Co. | Denver, Colo. |
| Joseph Horne Co. | Pittsburgh | Rich's, Inc. | Atlanta, Ga. |

AMERICAN VISCOSE CORPORATION
World's Largest Producer of Rayon Yarn • 330 Fifth Avenue, New York City
THE FIRST NAME IN RAYON... THE FIRST IN TESTED QUALITY

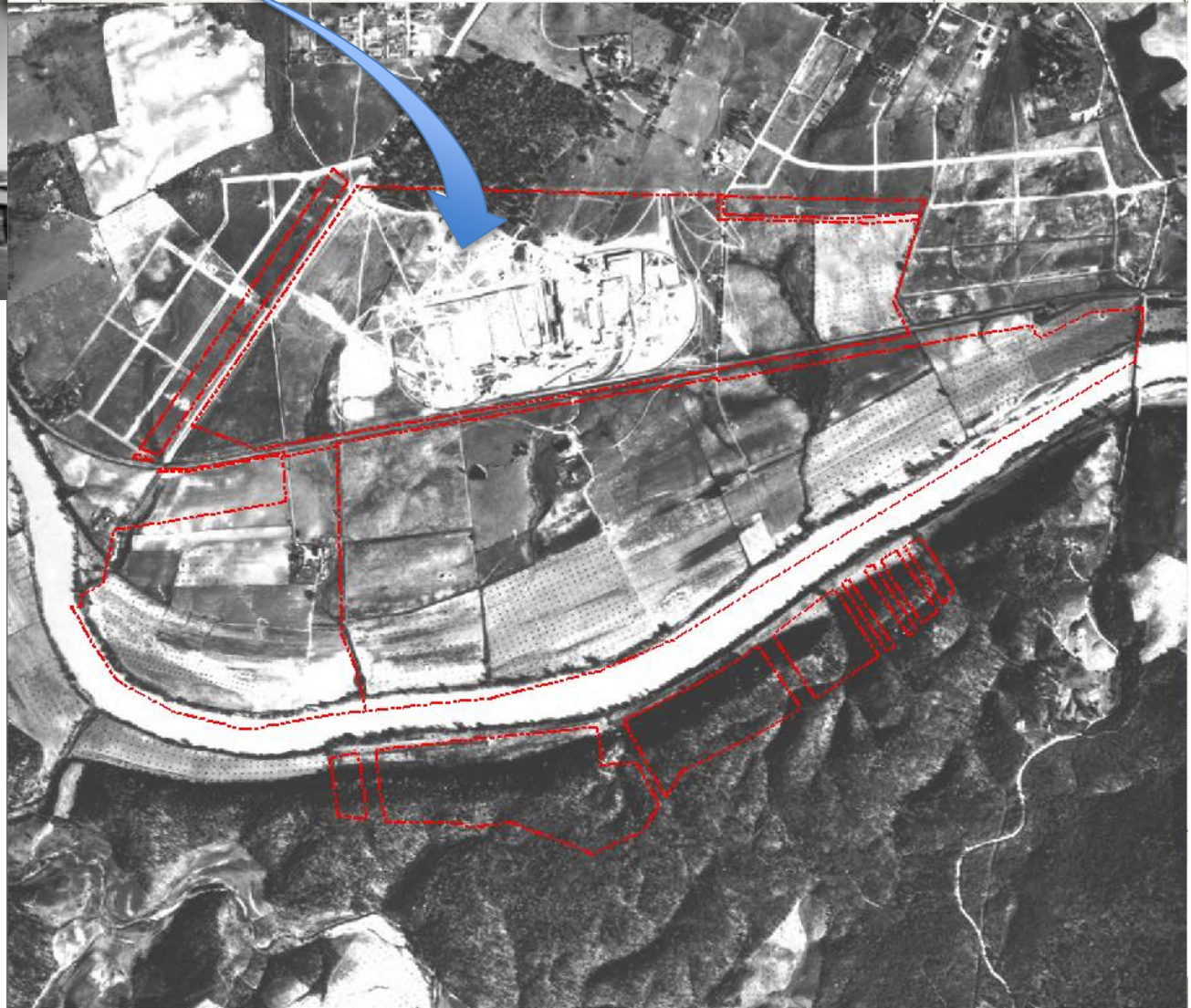
"WHAT DOES CROWN TESTED MEANT? It means that this fabric has been woven and finished according to actual high standards for consistent satisfaction, and that samples of this fabric have been tested and approved by the Better Fabrics Testing Bureau, official laboratory of the National Retail Dry Goods Association for tensile strength, seam strength, color-fastness and dye-bleedability."

mycomicshop

ONCE UPON A TIME...



**Plant built
in 1937**





Avtex Fibers Interpretation

Manufacturing Era (1940 - 1989)



Age of Rayon - Manufacturing Process & History



Plant Construction and Periods of Ownership

AMERICAN VISCOSE CORPORATION
World's Largest Producer of Rayon Fibers - Lenoir, North Carolina, 1940-1989



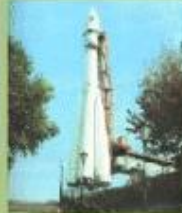
Manufacturing Lifestyle



FMC worldwide



Norfolk and Western Railroad



Rayon's Many Uses - Defense Industry and Everyday Objects

EDAW



www.avtexfibers.com

SUPERFUND RECIPE

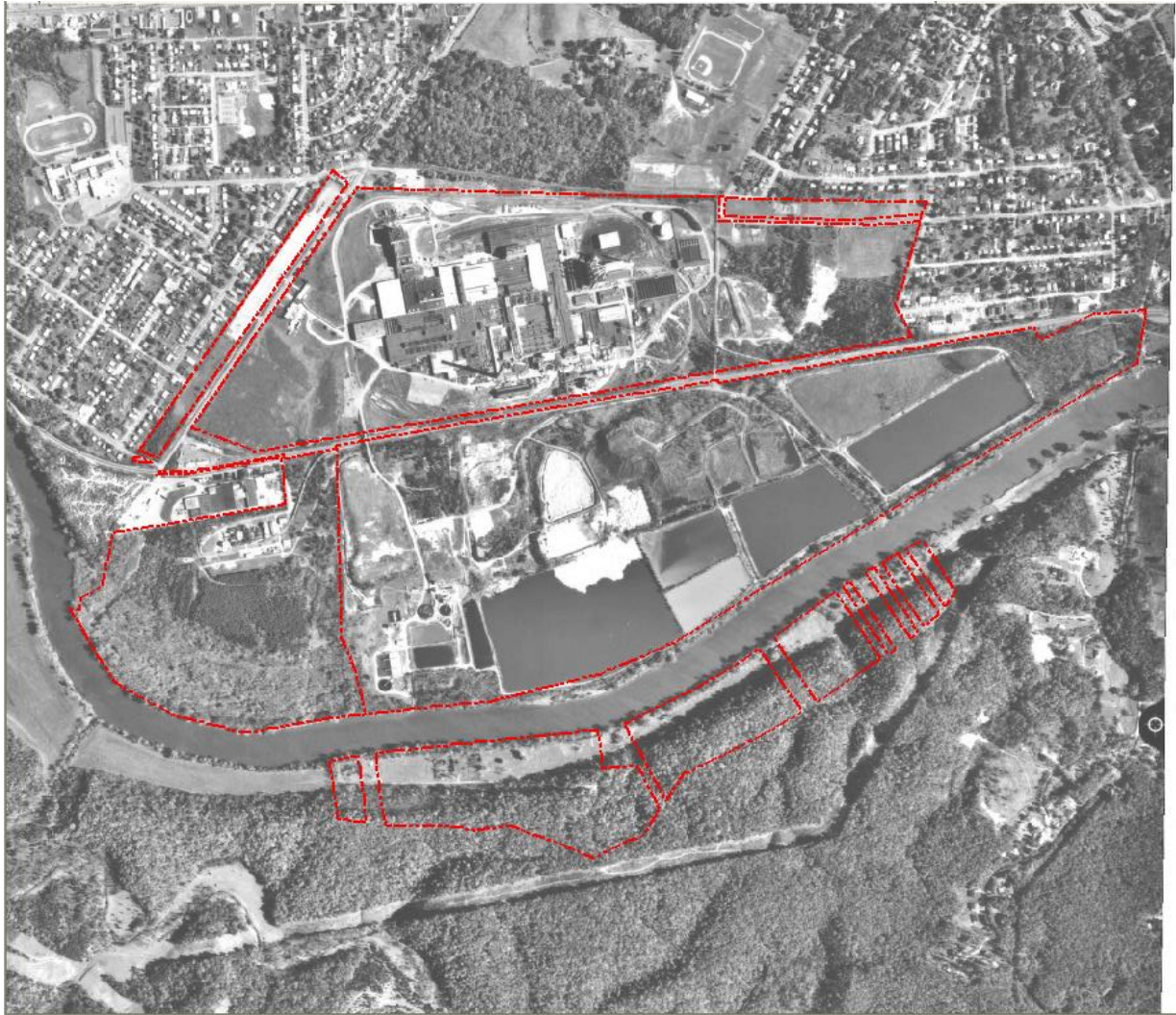
Ingredients:

- Caustic soda
- Sulfuric acid
- Carbon disulfide



1950s

PRODUCE SOME MORE...



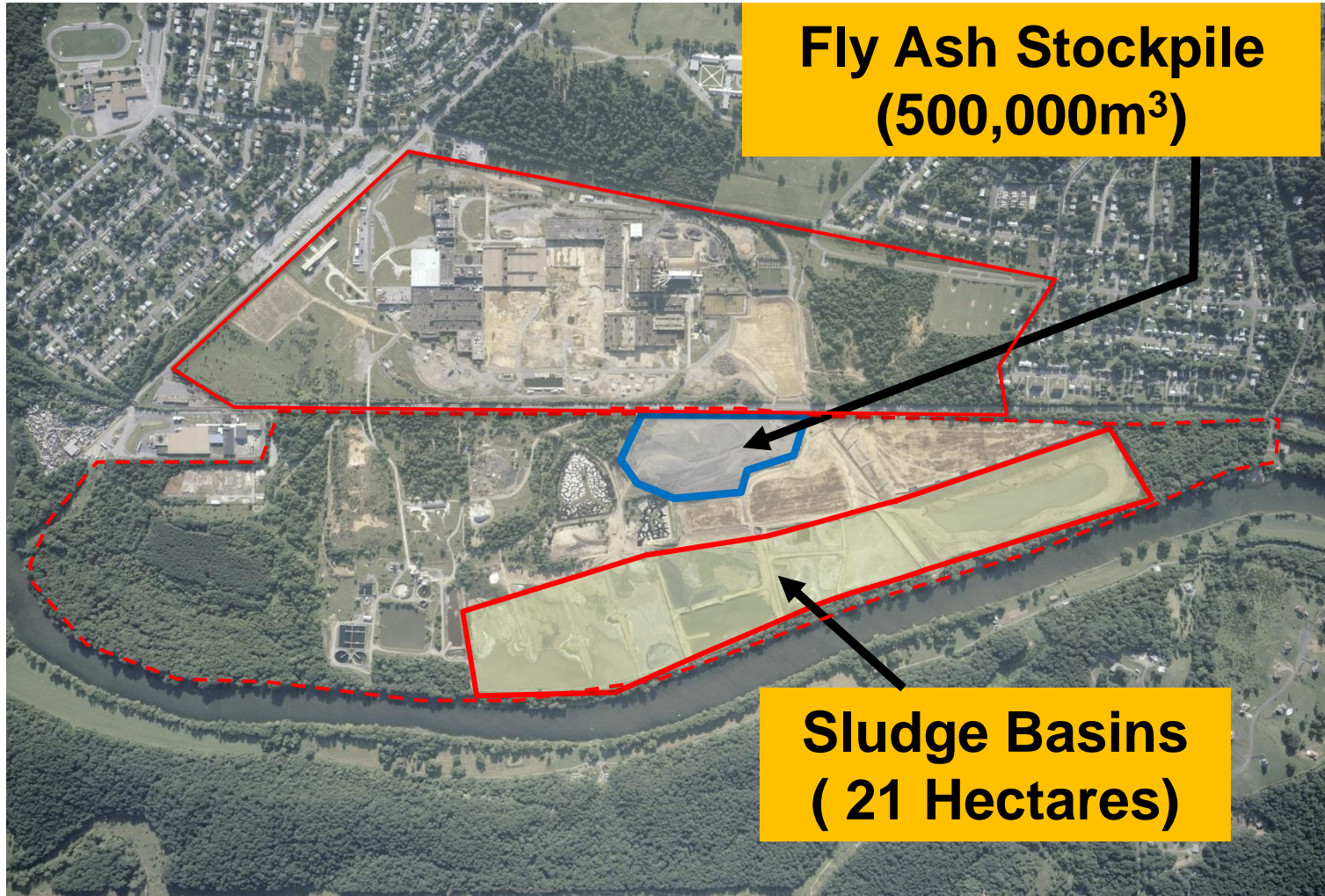
1970s



ET VOILÀ (1990's)...

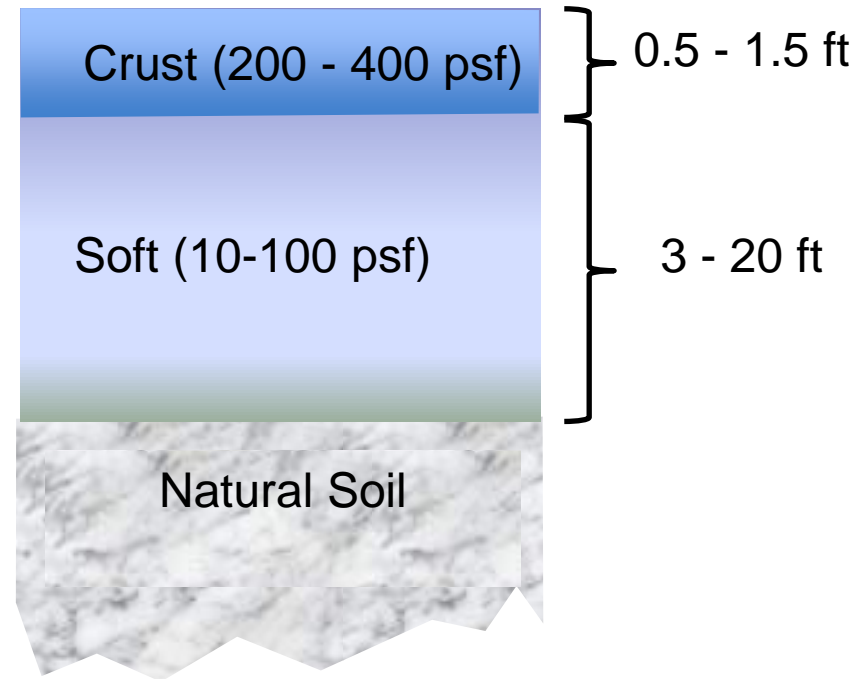


PROJECT BACKGROUND



Fly ash was recommended to close the lagoon (260,000 m³)

- **Leave in place and cap 5 sulfate sludge basins (~50 acres)**
- **Capping implied: 4 ft – 10 ft surcharge**





- **Perm 10^{-7} to 10^{-8} cm/s**
- **Unit Weight: 10 pcf to 50 pcf**
- **Moisture Content: 90% to 800%**
- **Shear Strength: 10 psf to 100 psf**



HOW SOFT IT IS 10-100 PSF?

An average person weighs 180 lb

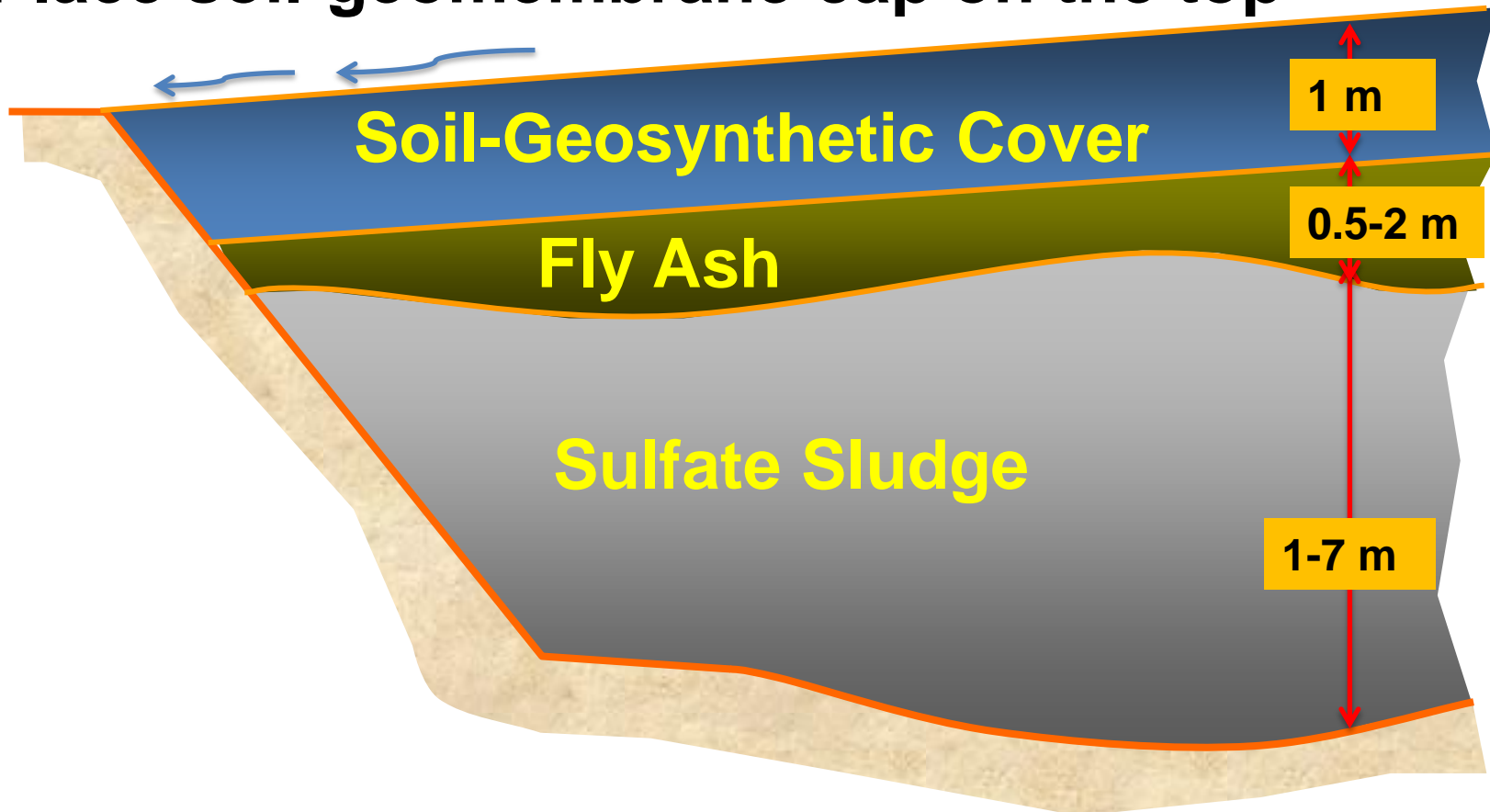
Average shoe size: 10 (~ 0.75 ft²)

240 psf



Use fly ash as grading fill

Place soil-geomembrane cap on the top



Surplus of fly ash available on site (240,000 m³)

THE \$1M QUESTION IS:



© Ron Leishman * www.ClipartOf.com/438643



How to over build a 10 PSF soft sludge lagoon?



ANSWER: BROMS (1987)

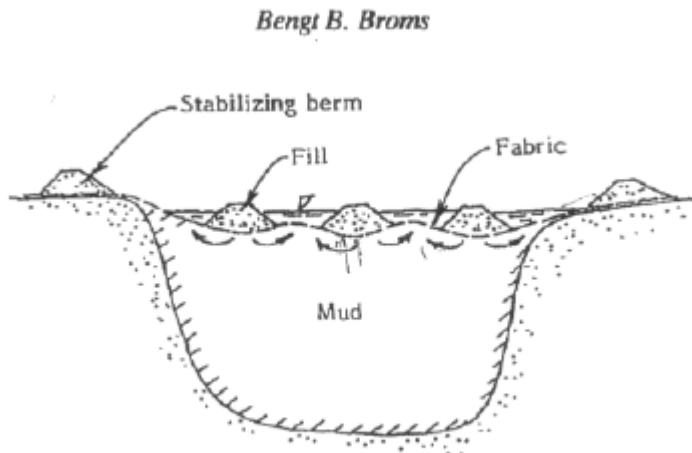


Fig. 2. Stabilization of very soft clay (mud) with geofabric.

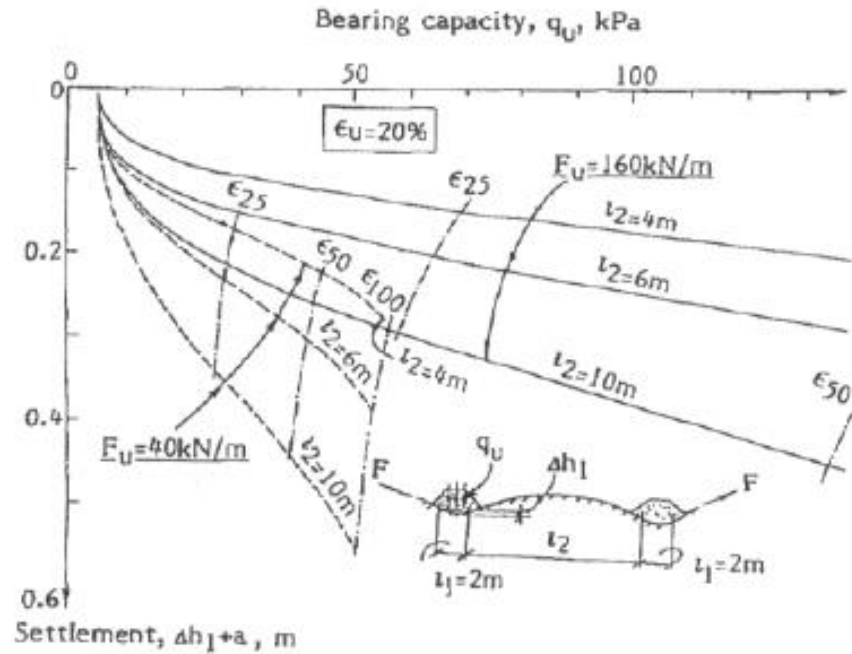


Fig. 6. Bearing capacity of fabric ($l_1 = 2$ m).

Stabilization of Very Soft Clay using Geofabric
Geotextiles and Geomembranes Vol. 5, pp 17-28



HOW DOES IT WORK?

LAGOON TO BE STABILIZED
(SOFT SLUDGE)

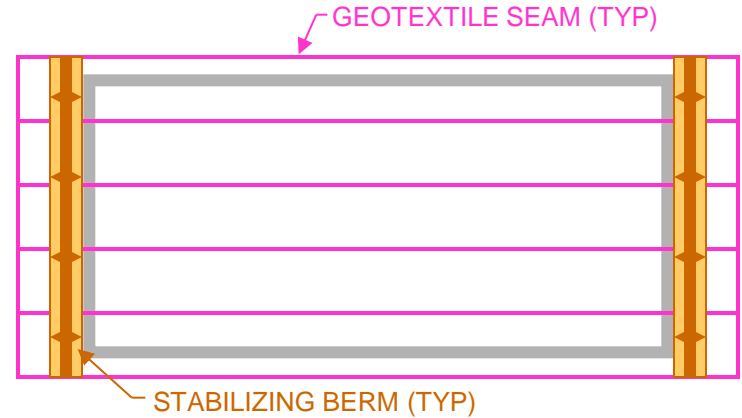
A. Lagoon Filled with Soft Sludge



CONSTRUCTION SEQUENCE



A. Lagoon Filled with Soft Sludge



B. Install Geotextile over Lagoon
and Place Stabilizing Berms



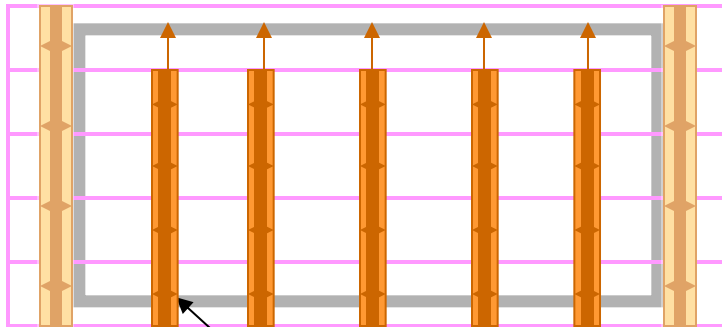
CONSTRUCTION SEQUENCE



A. Lagoon Filled with Soft Sludge



B. Install Geotextile over Lagoon
and Place Stabilizing Berm



INTERMEDIATE BERM
PERPENDICULAR TO SEAMS (TYP)

C. Construct Intermediate Berms



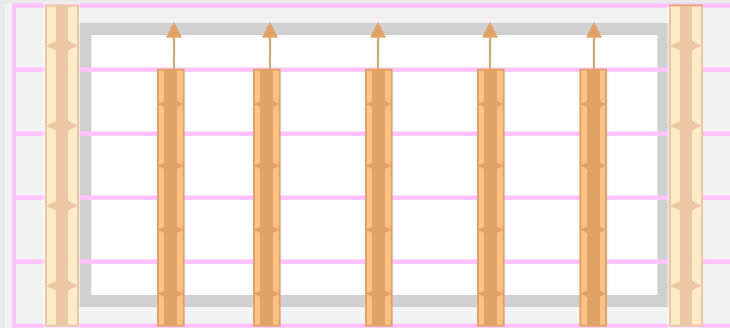
CONSTRUCTION SEQUENCE



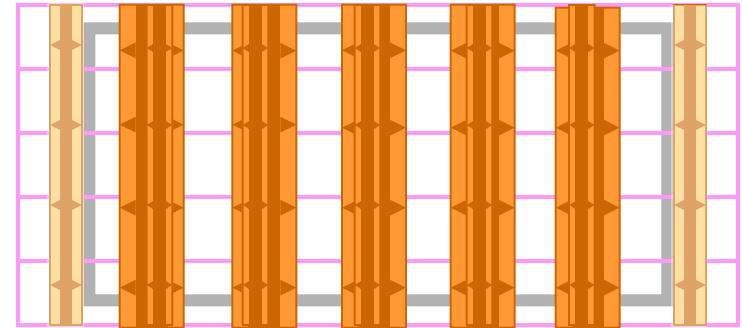
A. Lagoon Filled with Soft Sludge



B. Install Geotextile over Lagoon and Place Stabilizing Berm



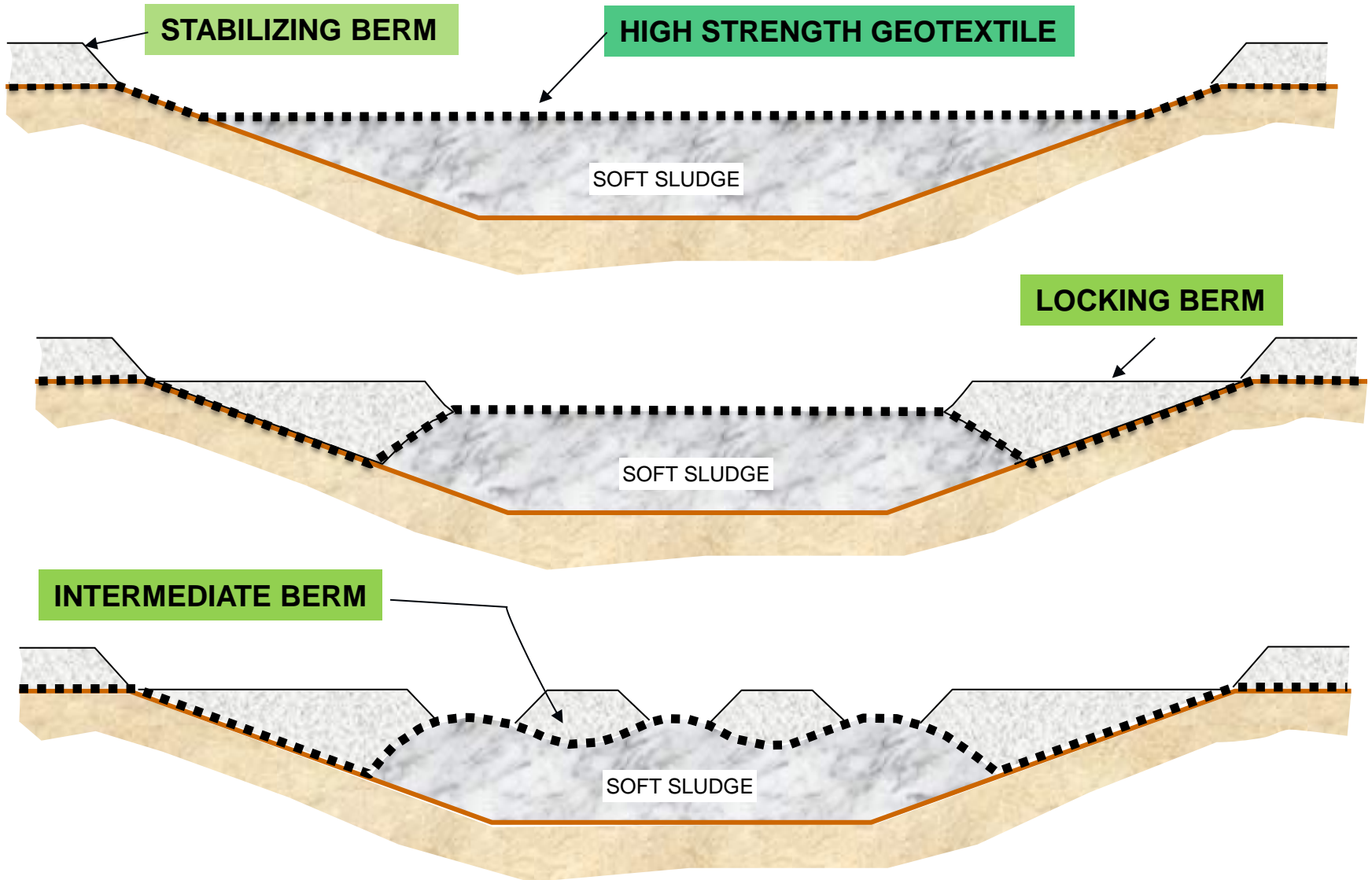
C. Construct Intermediate Berms



D. Widen Intermediate Berms

Construction involves a step-wise procedure to be followed in the field

CLOSURE METHOD

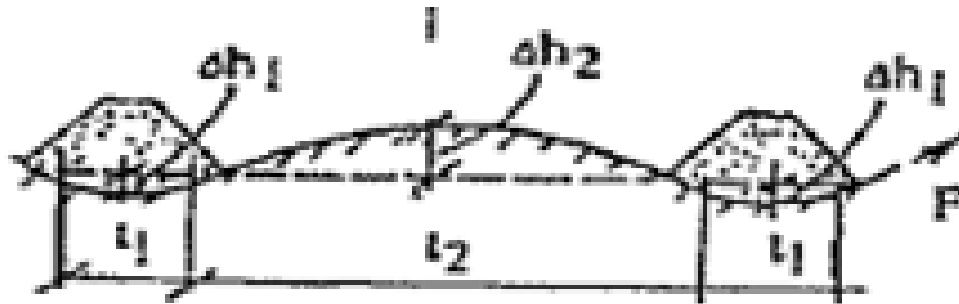


Excerpts from Page 23:

For the tensile forces F_1 and F_2 in the fabric to be equal then $\epsilon_1 = \epsilon_2$ and $\Delta h_1/l_1 = \Delta h_2/l_2$. Thus the axial strain in the fabric will depend only on the ratio $\Delta h_1/l_1$ and $\Delta h_2/l_2$. If, for example, $l_2 = 5l_1$ then $\Delta h_2 = 5\Delta h_1$ so that $F_1 = F_2$. The heave will in this case be five times larger than the settlement within the loaded area for the force in the fabric to be constant ($F_1 = F_2$).

Hypothesis:

$$\frac{\Delta h_1}{l_1} = \frac{\Delta h_2}{l_2}$$



For example:

$$l_2 = 5l_1$$

$$\Delta h_2 = 5\Delta h_1$$

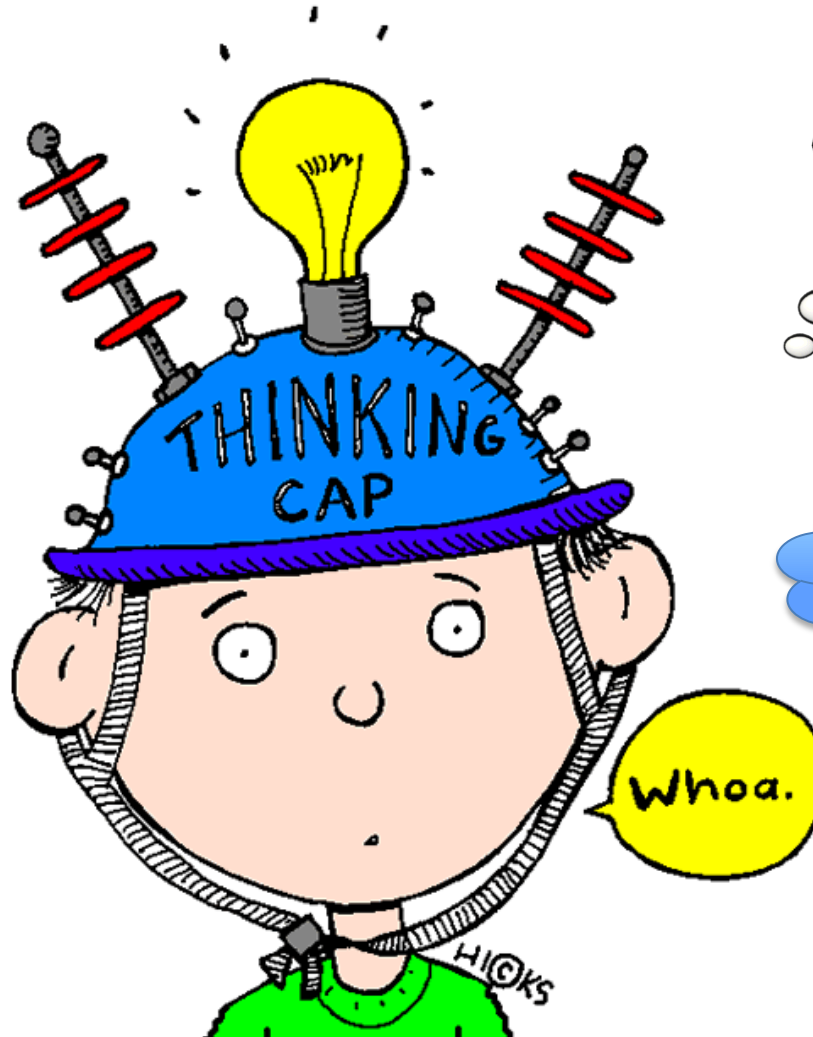
$$l_1 = 10\text{ft}; \quad l_2 = 5(10\text{ft}) = 50\text{ft}$$

$$\Delta h_1 = 1\text{ft}; \quad \Delta h_2 = 5(1\text{ft}) = 5\text{ft}$$

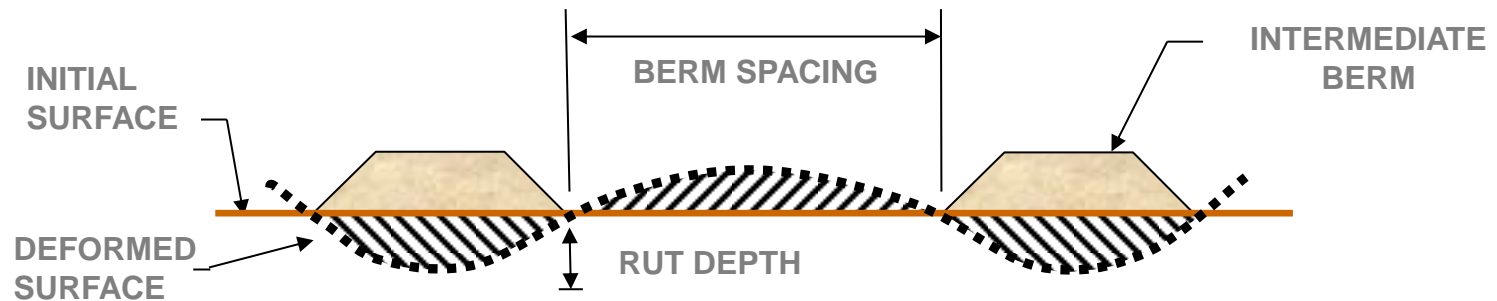
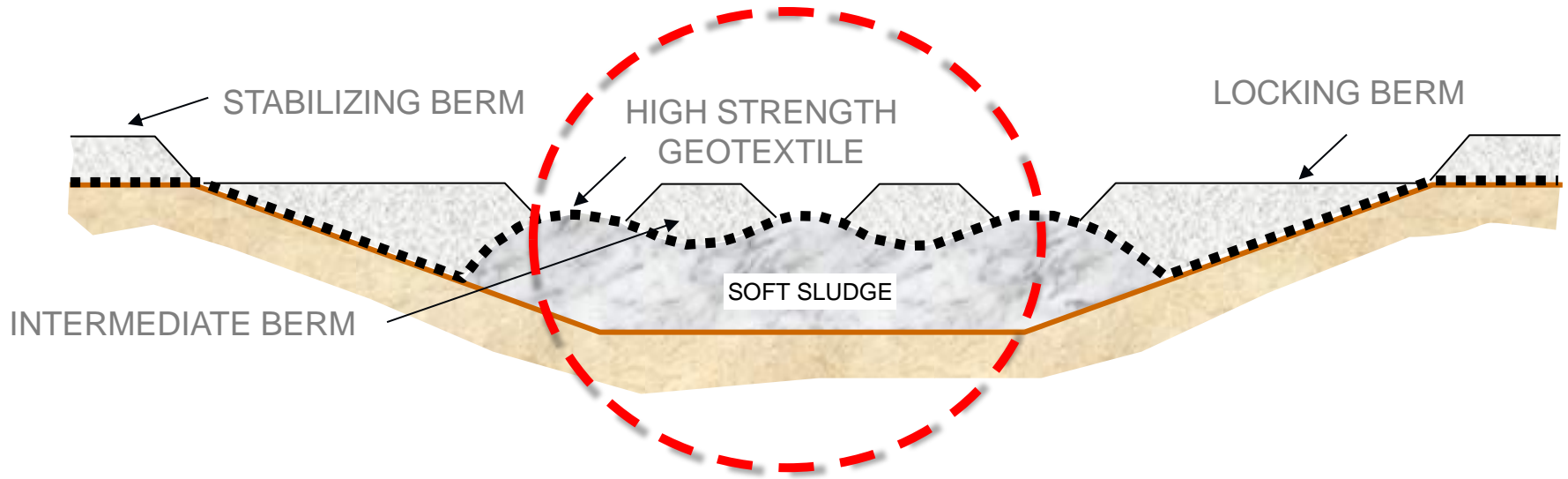
NEW APPROACH (2000)!

CE68901

CE48300



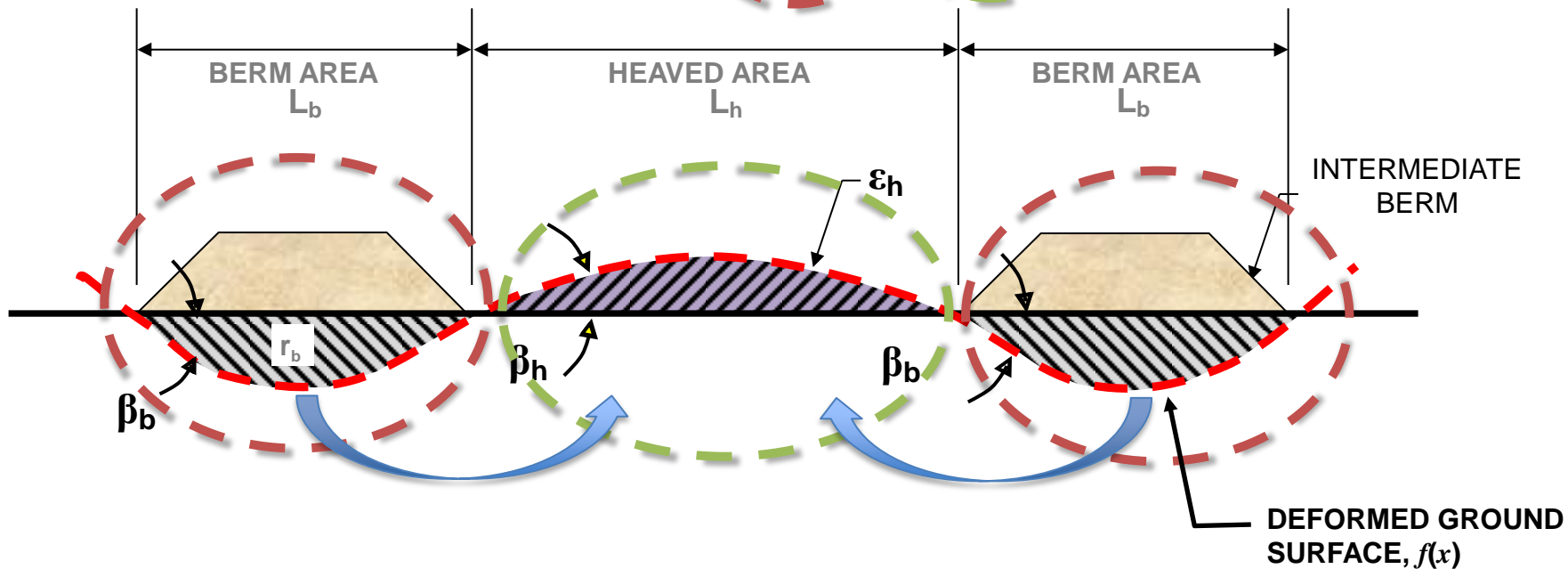
MA161000



Bearing Capacity Analysis

Ultimate Reinforced Bearing Capacity of Soil, q_{ur} (Membrane Effect from High Strength Geotextile)

$$q_{ur} = cN_c (+q_{gb}) (+q_{gh})$$



 A_b = Volume of soft sludge displaced under an intermediate berm

 A_h = Volume occupied by soft Sludge heave between intermediate berms

$$q_{ur} = c N_c + q_{gb} + q_{gh}$$

$$q_{gb} = \frac{J}{L_b} \int_{-L_b/2}^{L_b/2} \varepsilon(x) [1 + f'(x)^2]^{-1/2} f''(x) dx$$

q_{avg}

$$q_{gh} = \frac{2J}{L_c} \int_{L_b/2}^{L_b/2 + L_h/2} \varepsilon(x) [1 + f'(x)^2]^{-1/2} f''(x) dx$$

Data required: Modulus (J) and shape of deformation $f(x)$



Deformed shape approximated by parabolas (Giroud and Noirey, 1981)

$$\lambda_q = \frac{q_{avg}}{(2J/L_b)} = \varepsilon_{avg} \left[\ln(\tan \beta_b + \sec \beta_b) + \frac{1}{\rho} \ln(\tan \beta_h + \sec \beta_h) \right]$$

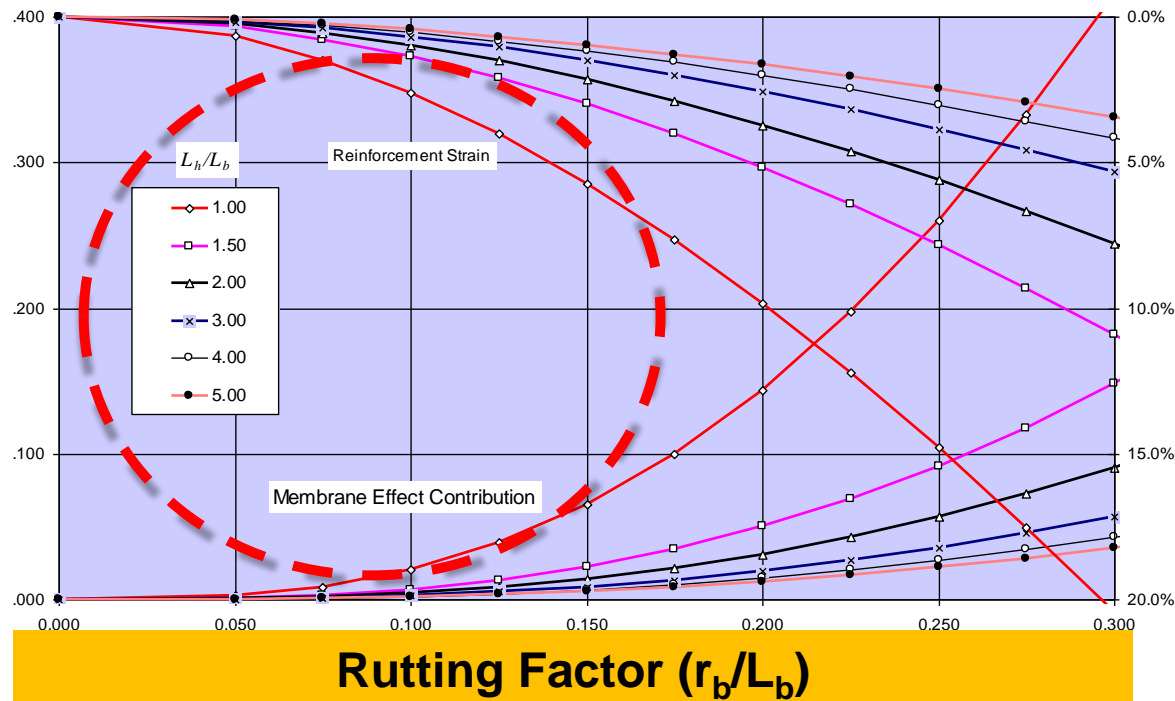
$$q_{avg} = q_{gb} + q_{gh}$$

$$\varepsilon_{avg} = \frac{\varepsilon_{gb} + \rho \varepsilon_{gh}}{1 + \rho}$$

$$\rho = \frac{L_h}{L_b}$$

Additional Bearing Capacity Provided by Reinforcement

Membrane Contribution
 $\lambda = q_{ur} J(2J/L_b)$



Average Strain (%)

Using this chart, the effect of geotextile contribution can be quantified

Unreinforced Case

Sludge Thickness = 0.3m

Undrained shear strength = 0.5 kPa

Equipment CAT D3C-LGP-5II = 29.6 kPa

$$q_u = c N_c = 0.5 \times 5.14 = 2.5 \text{ kPa}$$

$$FS = \frac{q_u}{q_{equipment}} = \frac{2.5}{29.6} = 0.08 \lll 1.0$$

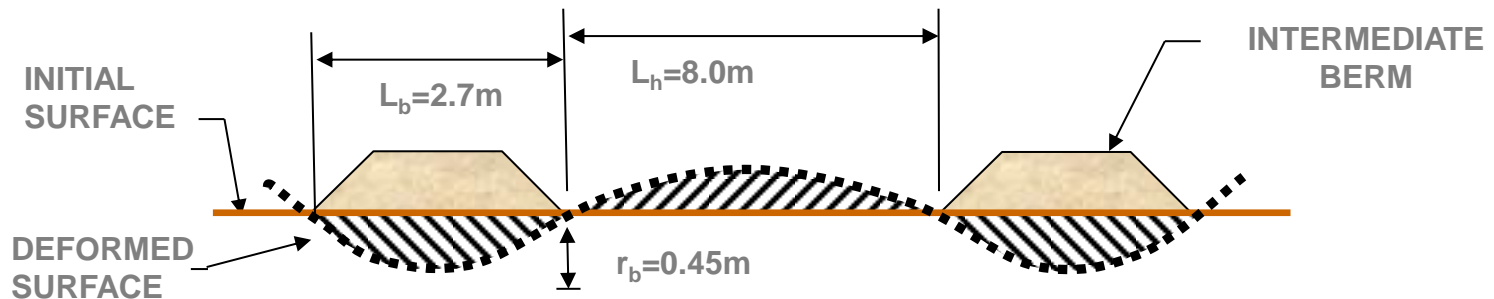
Reinforced Case with Berms

For Berm Deflection $r_b = 0.45 \text{ m}$

Berm spacing $L_h = 8.0 \text{ m}$

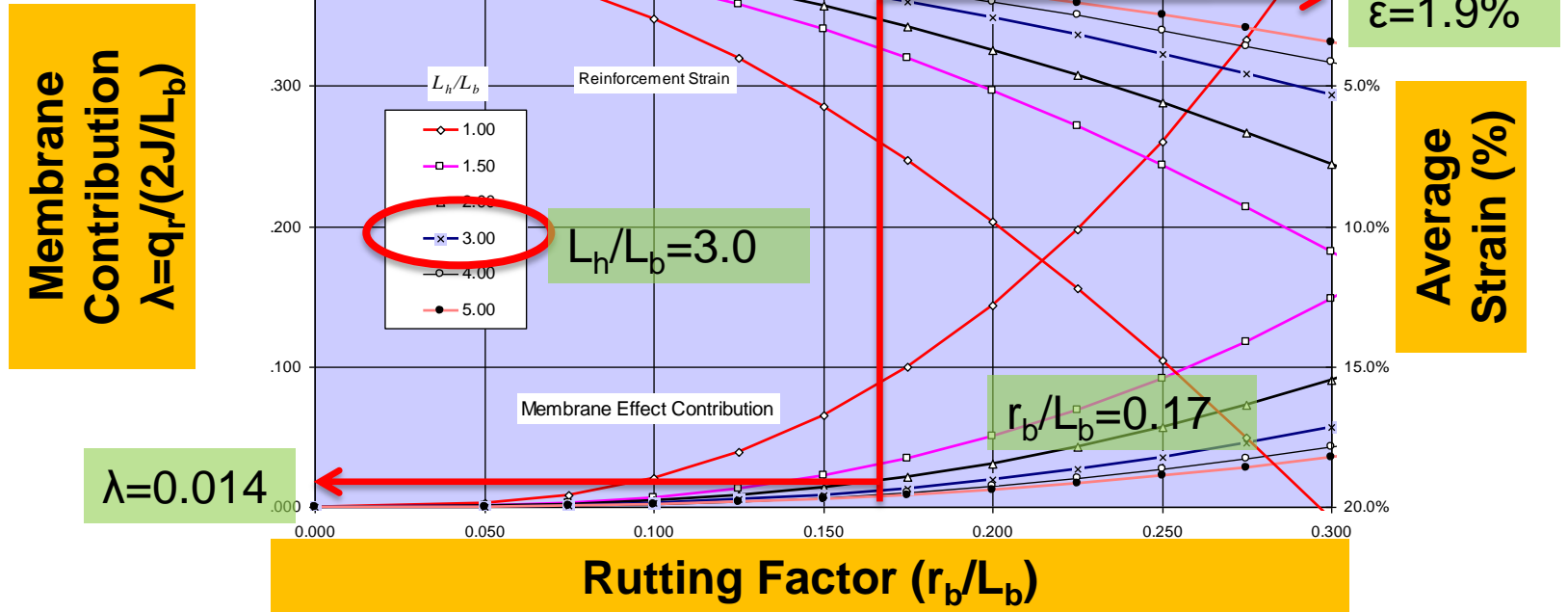
Berm width $L_b = 2.7 \text{ m}$

$$\frac{L_h}{L_b} = 3.0, \frac{r_b}{L_b} = 0.17$$



GEOTEXTILE CONTRIBUTION

Calculating factors using the proposed chart



Geosynthetic Contribution

With $\epsilon = 1.9\%$ and $q_r = 27.1$ kN/m then $J = 2540$ kN/m

Working tensile strength = $(2,540 \text{ kN/m}) \times 1.9\% = 48.25$ kN/m

For FS = 2, $\epsilon_u = 3.8\%$, $T_u = 96.5$ kN/m



- **Develop construction details**
- **Specifications**
 - **High strength geotextile ($T_u = 96.5$ kN/m and $\varepsilon_u = 3.8\%$)**
 - **Sequence of construction**
 - **Equipment (D5G-LGP)**



CLOSURE IMPLEMENTATION

Fill Placement to slow and time consuming



Specified Equipment (e.g., D5H-LGP) too small for production

Interesting but no, thanks

Use large equipment to push fly ash over sludge to “save” the cost of geotextile and construction time



(2002-2008)



After all it is just a dirt job...

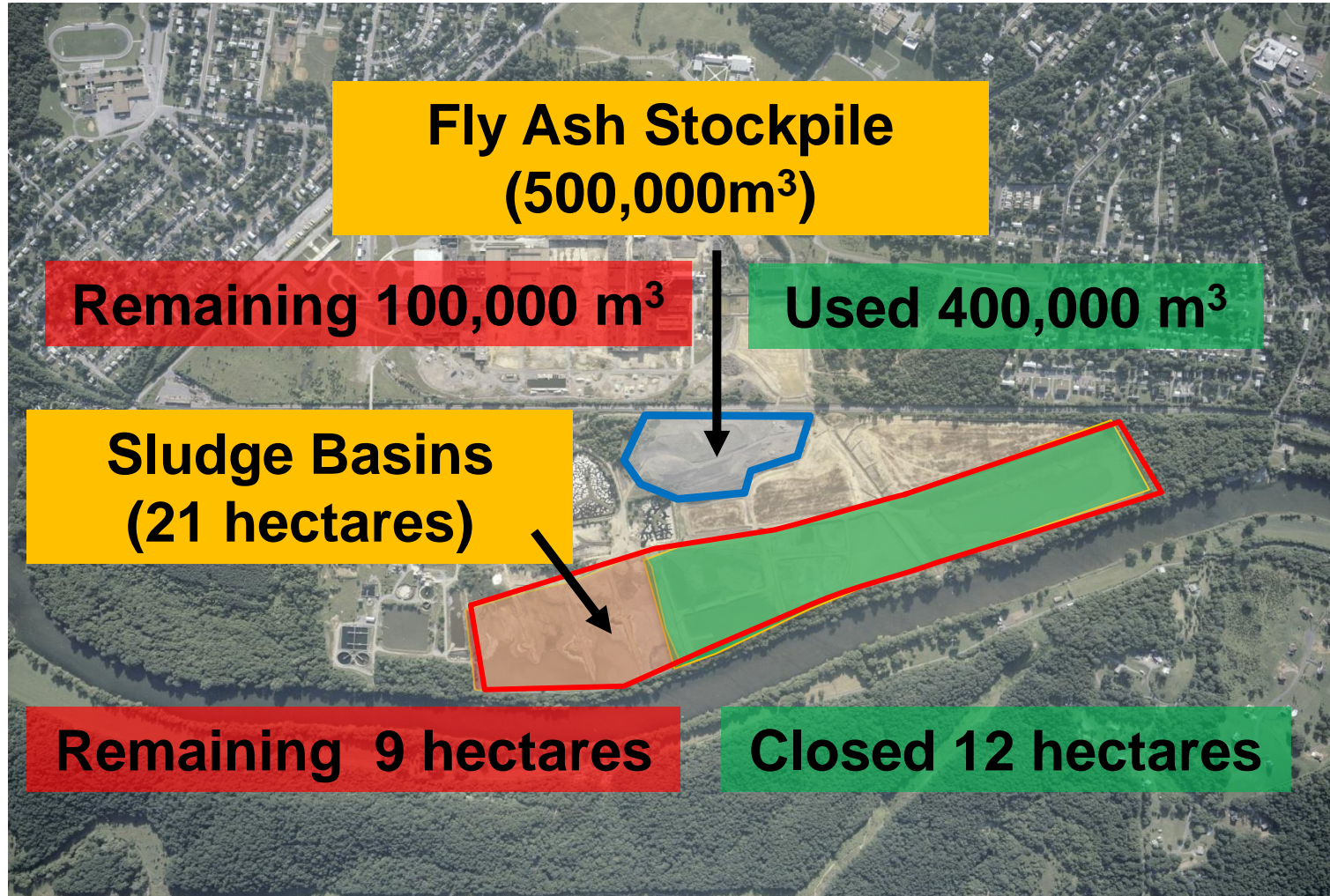
**Crust
Displacement**



**Mixing lots
of fill with
sludge**



9 Years later (2009)...



Slow rate of closure and fly ash deficit for remaining work



FINAL REDEMPTION

Maybe the
consultant is not as
dumb as he looks

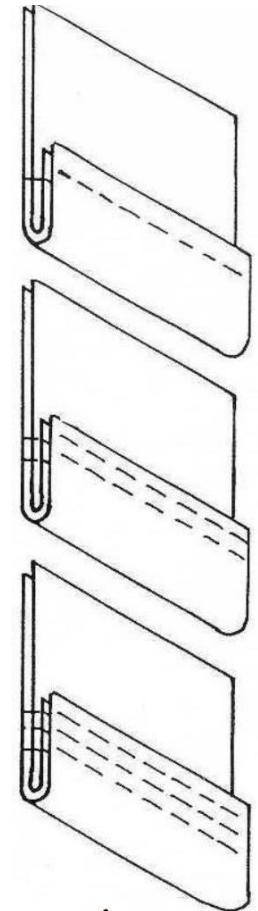


SEAMS FOR GEOTEXTILES

HAND SEAMING



J SEAM



Field panels seamed in accordion manner in the field



Geotextile installed rapidly in the field



Minimal slack following deployment of the seamed geotextiles



Fly ash layer placement perpendicular to geotextile seams



Ease of placement of fly ash material over sludge using equipment on site



Parallel berms provided confinement to the sludge



Increased bearing capacity due to membrane effect of geotextile



FIELD CONSTRUCTION

Series of parallel berms were constructed



Reduced construction time to one month to cover one hectare of basin

Problems occurred when the contractor tried to use oversized equipment



Geotextile was torn and patched in place



Intermediate space between berms was filled



Fill thickness of 1-3 m was achieved with remaining fly ash



LESSONS LEARNED

Printed \neq correct

TO RELIEVE FATIGUE —

get a Lift with a Camel!

Copyright, 1935
R. J. Reynolds Tobacco Company
Winston-Salem, N. C.

DRAFTSMAN. Franklin Donnick: "Camels bring back the mental alertness that a draftsman needs."

STORE MANAGER. G. F. Stafford: "When I am tired, I smoke a Camel and my energy revives."

TREE SURGEON. H. L. Vaughn says: "Camels relieve tiredness and they never jangle my nerves."

• Above: Jack Shea, who scored brilliant victories in the 500 and 1500 meter Olympic events. He says: "Any one who goes in for speed skating needs an abundant supply of stamina and energy. Naturally, I feel pretty well used up after the last hard sprint to the tape. Camels restore my 'pop.' The 'lifting' effect is noticeable in a very few minutes. And they taste so good. For sheer pleasure, there is nothing like a Camel."

TOBACCO EXPERTS SAY:

"Camels are made from finer, More Expensive Tobaccos—Turkish and Domestic—than any other popular brand."

For Your Pleasure!
THE CAMEL CARAVAN
featuring
WALTER O'KEEFE
ANNETTE HANSHAW
GLEN GRAY'S
CASA LOMA ORCHESTRA

TUESDAY	THURSDAY
10:00 P. M. E. S. T.	9:00 P. M. E. S. T.
9:00 P. M. C. S. T.	8:00 P. M. C. S. T.
8:00 P. M. M. S. T.	9:30 P. M. M. S. T.
7:00 P. M. P. S. T.	8:30 P. M. P. S. T.

Over Coast-to-Coast WABC-Columbia Network

MRS. WILLIAM T. WETMORE, young society leader, says: "A Camel never makes my nerves jumpy."



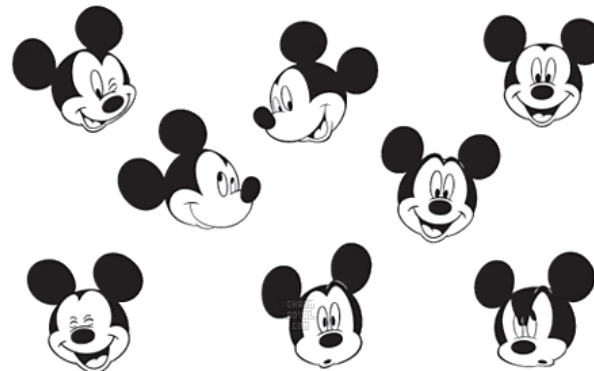
- **Developing good engineering solutions is not always sufficient**
- **Convey the risks associated with potential alternatives**

We CANNOT focus in our mouse traps...



Remember, our clients don't care about our mouse traps...

They care about having less mice





Questions?

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(Ph: 410-381-4333)