

Geotextile Container Dewatering of Slurry Waste

Chris Lawson

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References

- Lawson, C.R. (2008). Geotextile containment for hydraulic and environmental engineering, *Geosynthetics International*, Vol. 15, No. 6, Thomas Telford, 55pp.
- Lawson, C.R. (2006). Geotextile containment for hydraulic and environmental engineering, Giroud Lecture, Proceedings Eighth International Conference on Geosynthetics, Yokohama, Japan, September, Millpress, Vol. 1, pp. 9-50.



Contents

- Introduction – types of geotextile containment units
- Geotextile containment for the dewatering of slurry waste and contaminated sediments
- Conclusions

Introduction - geotextile tubes



- Geotextile tubes used to dewater slurry wastes
 - Large reduction in volume
 - Dewatered waste becomes manageable
- Geotextile tubes laid out and filled onsite
- Slurry waste pumped directly into the tubes
- Tube diameters 4 to 10 m

Introduction - geotextile bags



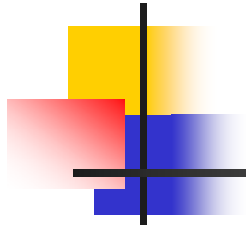
- Geotextile bags used to dewater slurry wastes
 - Same as geotextile tubes but handle smaller waste volumes
- Geotextile bags laid out and filled onsite
- Slurry waste pumped directly into the bags
- Bag volumes range from 1 m³ to 3 m³



Introduction - geotextile containers



- Geotextile containers used for controlled offshore disposal of contaminated sediments
- Containers installed and then filled in split-bottom barges
- Containers normally 300 to 700 m³ in volume (but up to 1,000 m³ have been installed)



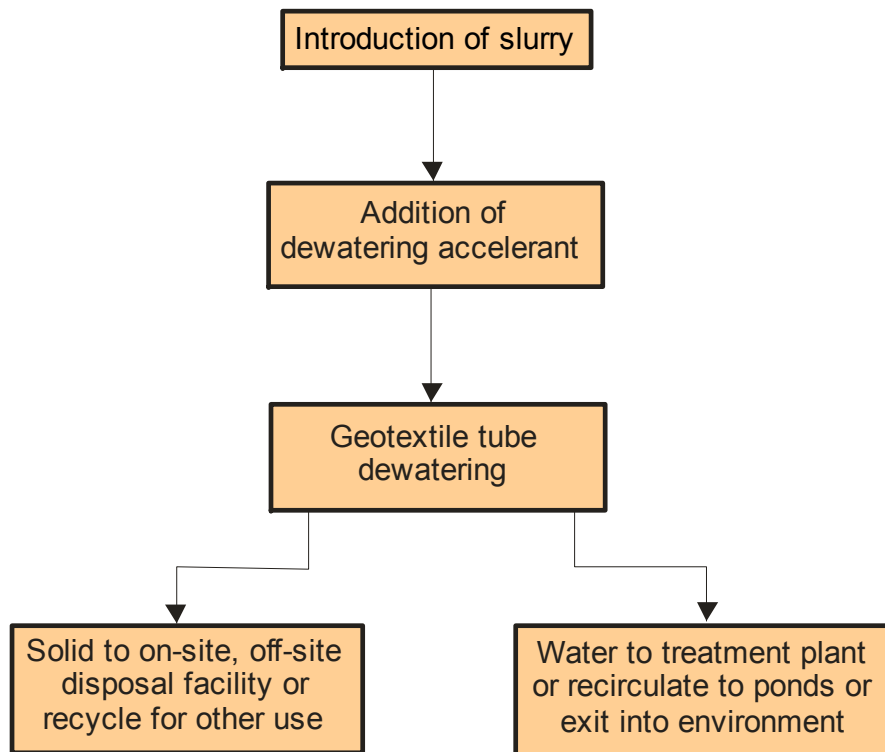
Geotextile tubes and bags for
dewatering slurry waste
streams and contaminated
sediments

Geotextile tubes & bags for dewatering waste

- Many industries utilize water for processing, movement and storage of by-products and waste
- Over time, slurry waste impoundments have to be cleaned out, or sludge has to be prevented from entering streams and rivers
- Dewatering reduces significantly the volume of slurry waste and renders the retained material in a solid form that can be disposed of easily
- Geotextile tubes can be made in a variety of sizes to suit dewatering needs and be employed in a variety of numbers



The dewatering "process"



- There are several steps to the dewatering process
- The geotextile tubes & bags are just one part of the overall "system"
- The slurry is introduced into the geotextile containers and allowed to dewater
 - The water is taken to treatment plant or exits to environment
 - The solid is disposed of on-site, off-site or recycled

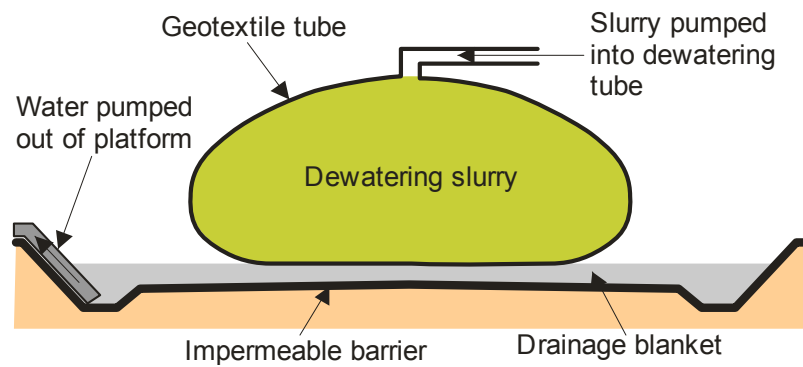
The waste slurry source



The waste slurry introduction and accelerant addition



Geotextile tube dewatering platform





Dewatering drainage platform



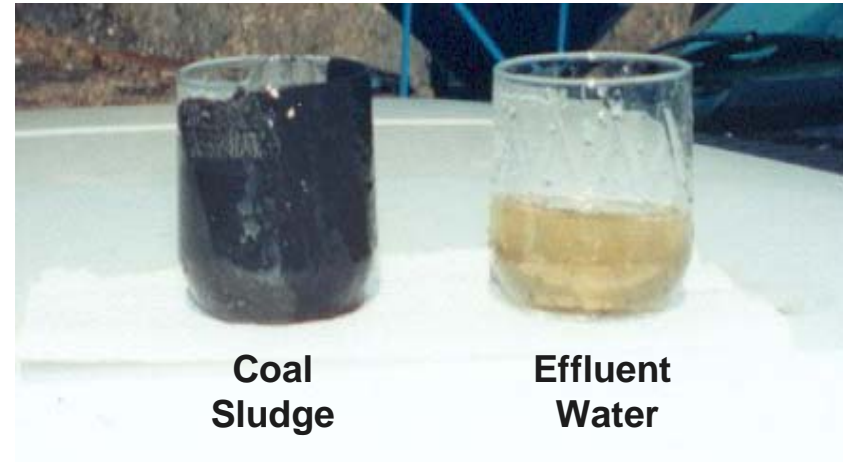
Variety of scale of tube & bag dewatering systems



Geotextile tube dewatering performance



Benthic waste from aquaculture



Coal Sludge

Effluent Water



Sewage digester sludge

Handling of effluent water

Water
treatment
plant

Direct to environment



Handling of dewatered waste



Recycled



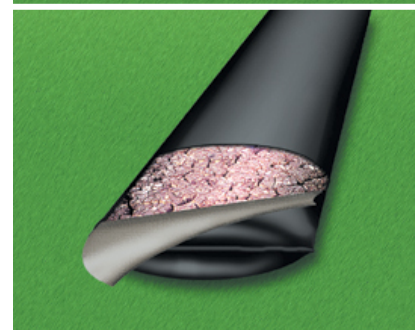
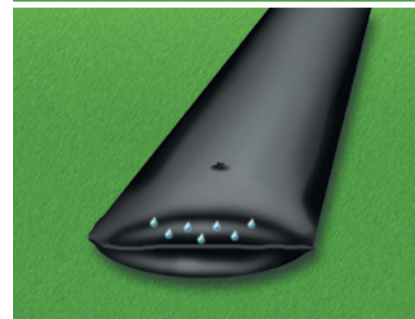
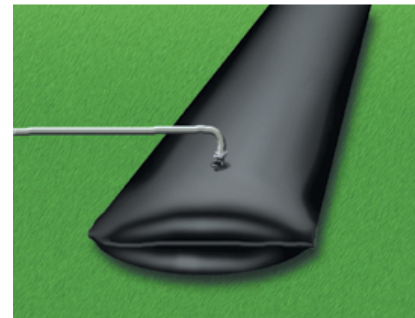
Off-site disposal

On-site disposal

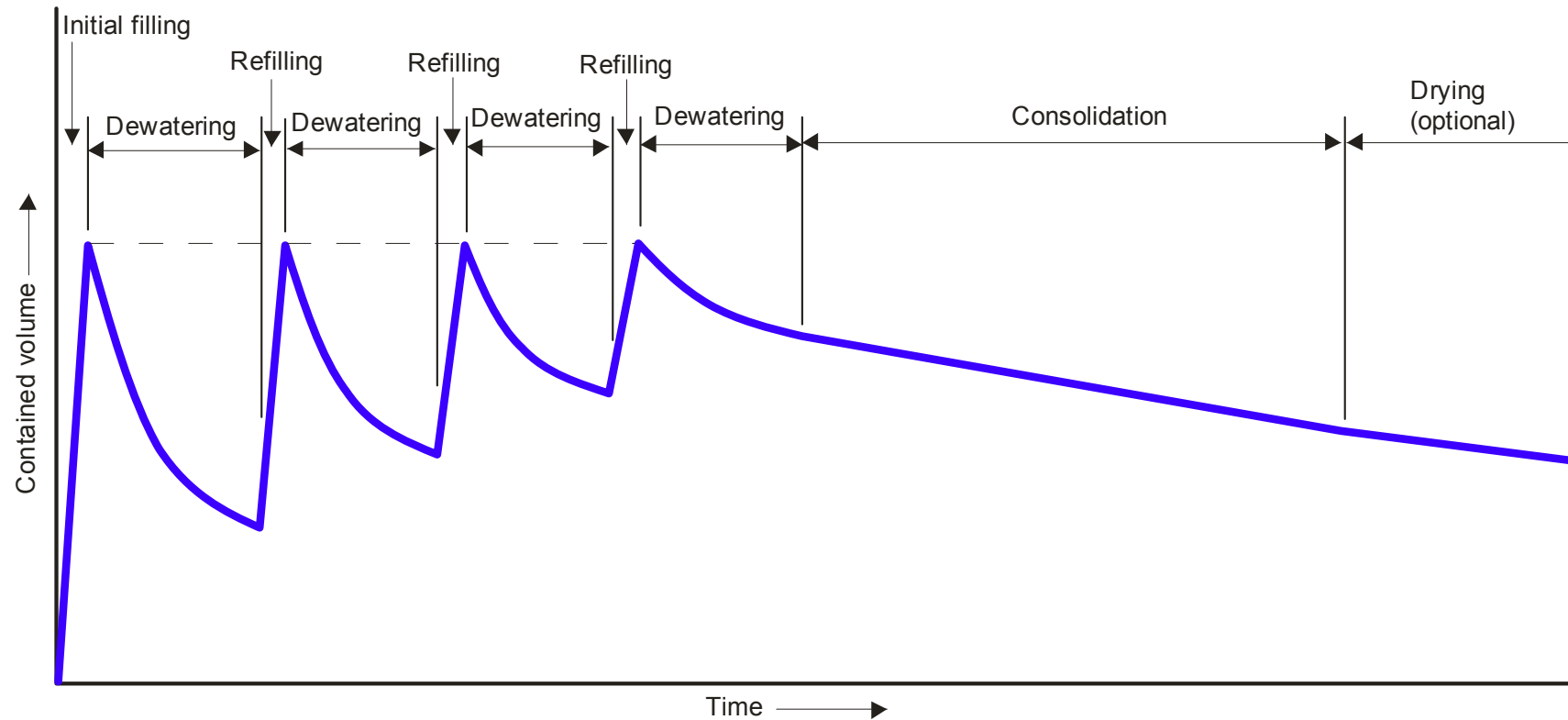


The dewatering stages

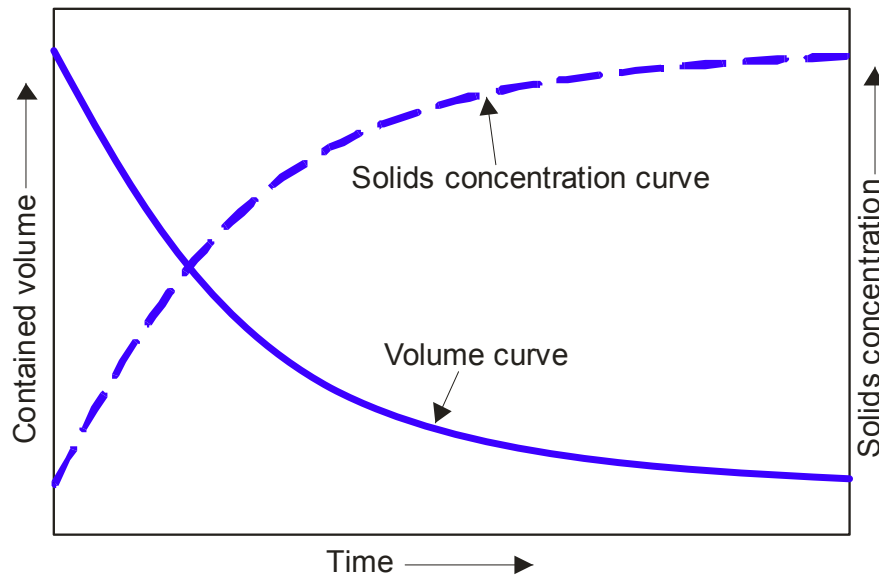
- ***Containment stage:***
 - Filling of tubes with slurry waste
 - Tube must have strength to resist tensile stresses
- ***Dewatering stage:***
 - Drainage of *free* water from tube
 - Large volume reduction
- ***Consolidation stage:***
 - Drainage of *pore* water from tube
 - Desiccation of contained fill
- May be several containment and dewatering stages before a final consolidation stage



Typical filling, dewatering and consolidation stages



Geotextile tube dewatering fundamentals



- **Primary effect:**
- After placed inside the geotextile tube the slurry waste dewater
 - Large decrease in contained volume
 - Increase in solids concentration
- Solids concentration increase and volume decrease reduces over time
- Volume decrease and solids concentration increase are inter-related
- **Secondary effect:**
 - Retention of contaminants within the geotextile tube
 - Effluent water relatively clean



Typical initial and final solids concentrations

Waste material	Initial solids concentration, S_o	Final solids concentration, S_f
Biosolids	1% to 4%	15% to 25%
Agriculture	2% to 4%	20% to 25%
Mineral processing	3% to 10%	40% to 70%
Industrial by-products	4% to 10%	25% to 75%
Contaminated sediments	10% to 14%	35% to 70%

- To facilitate filling slurry is pumped into tubes at low solids concentrations
- After dewatering, contained waste should be solid or gelatinous in consistency for handling and transport
- Final solids concentrations depend on:
 - Type of waste
 - Time for dewatering
 - Use of accelerants

Three overall performance criteria for dewatering waste

- There must be a significant reduction in the contained volume (and a comparable increase in solids concentration), and this must occur over a relatively short time period
- There can be an initial loss of solids through the geotextile tube but this must stop a relatively short period after dewatering begins
- The effluent water quality must remain constant with time



Evaluating geotextile tube performance



Cone test



Full-scale prototype test



Hanging bag test



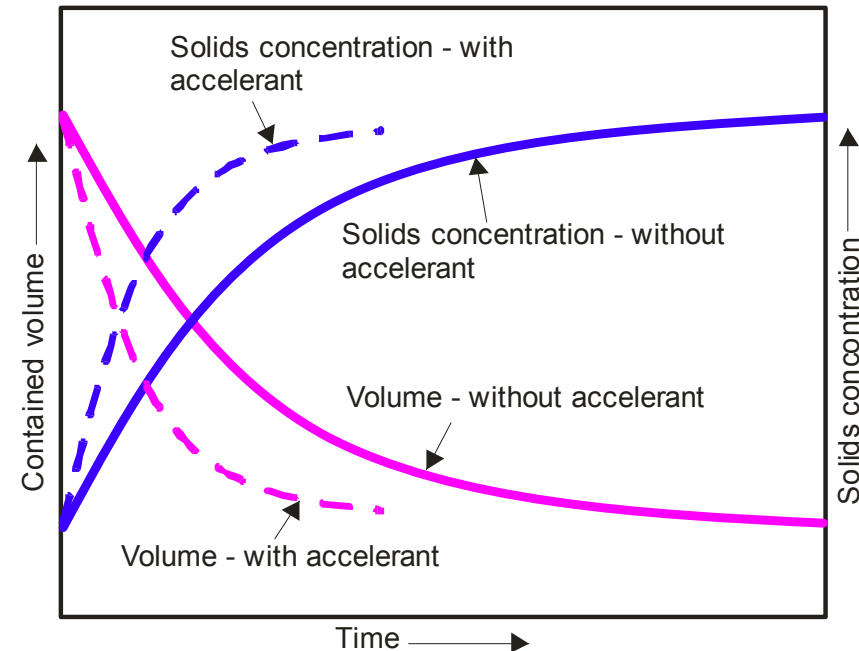
Use of dewatering accelerants



- Normal dewatering times maintained between 1 to 2 months
 - Longer times constrain speed of waste processing
- Waste slurries are highly variable and can consist of large amounts of suspended solids, colloids and suspended organic matter
- To dewater efficiently, solids must be retained as well as any heavy metals or organic contaminants, and water must pass quickly
- This has lead to the use of chemical dewatering accelerants as part of the dewatering process

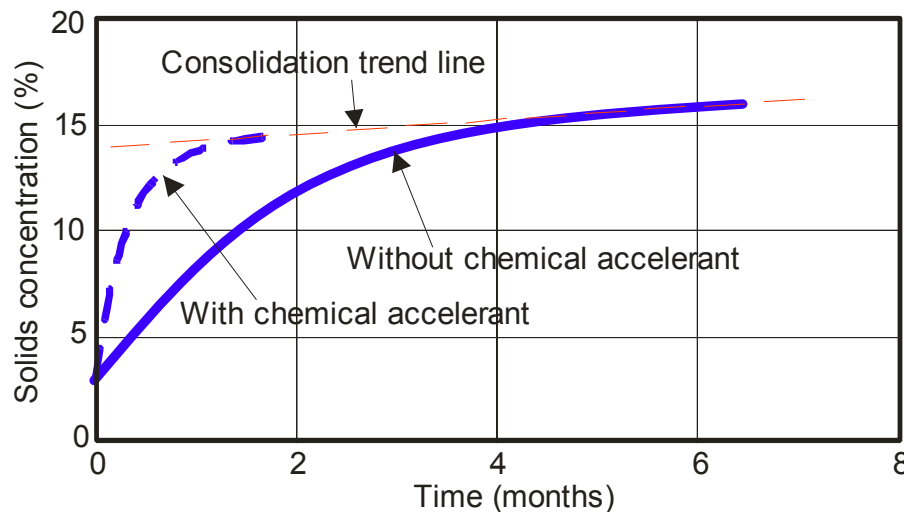
Effect of chemical dewatering accelerants

- Chemical dewatering accelerants collapse the structure of the slurry waste thereby freeing water
 - Also trap contaminants within the collapsed structure
- Water-soluble polyelectrolytes are most commonly used chemical accelerants
 - Cationic, anionic, non-ionic
 - Performance varies according to dosage rate
 - Determined through experimental screening
- Chemical accelerants increase rate of dewatering but do not increase the ultimate level

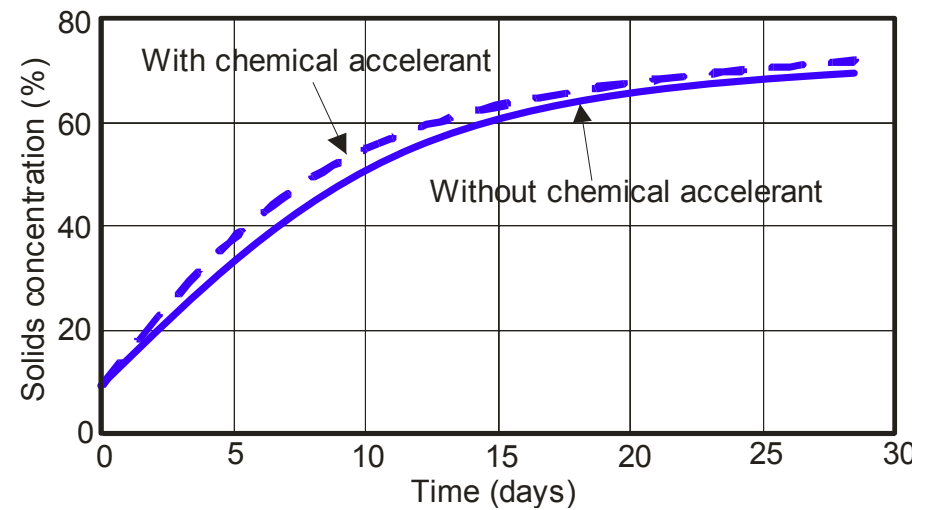


Effect of chemical dewatering accelerants (cont.)

Sewage sludge



Fly ash slurry

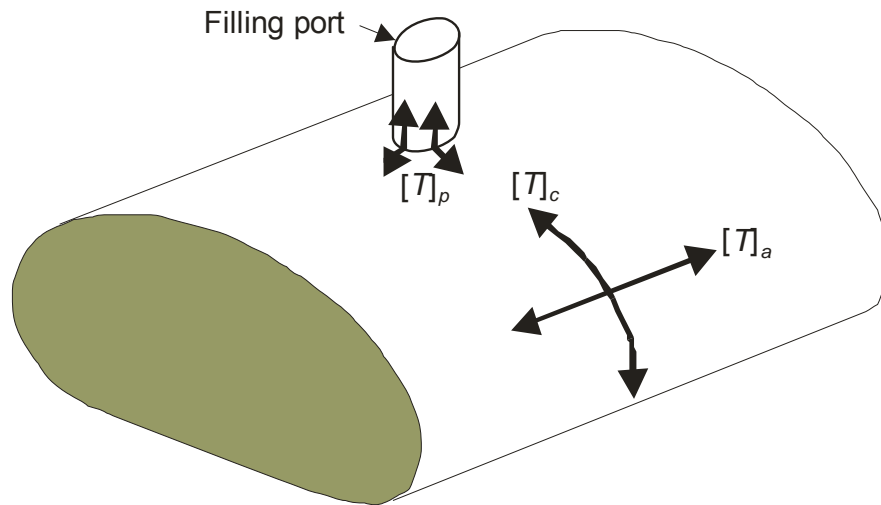


The hydraulic design process – dewatering volumes and flow rates

- Geotextile tubes must be designed hydraulically (according to volumes and flow rates) and structurally (for strength)
- The characteristics of the slurry should be known
 - Specific gravity, solids concentration, target solids concentration, dewatering rate, concentration of coarse material
- Can then determine dewatered solids volume and rate of effluent water production
- Quantity and size of geotextile tubes
 - Tube diameters, lengths, heights and strengths

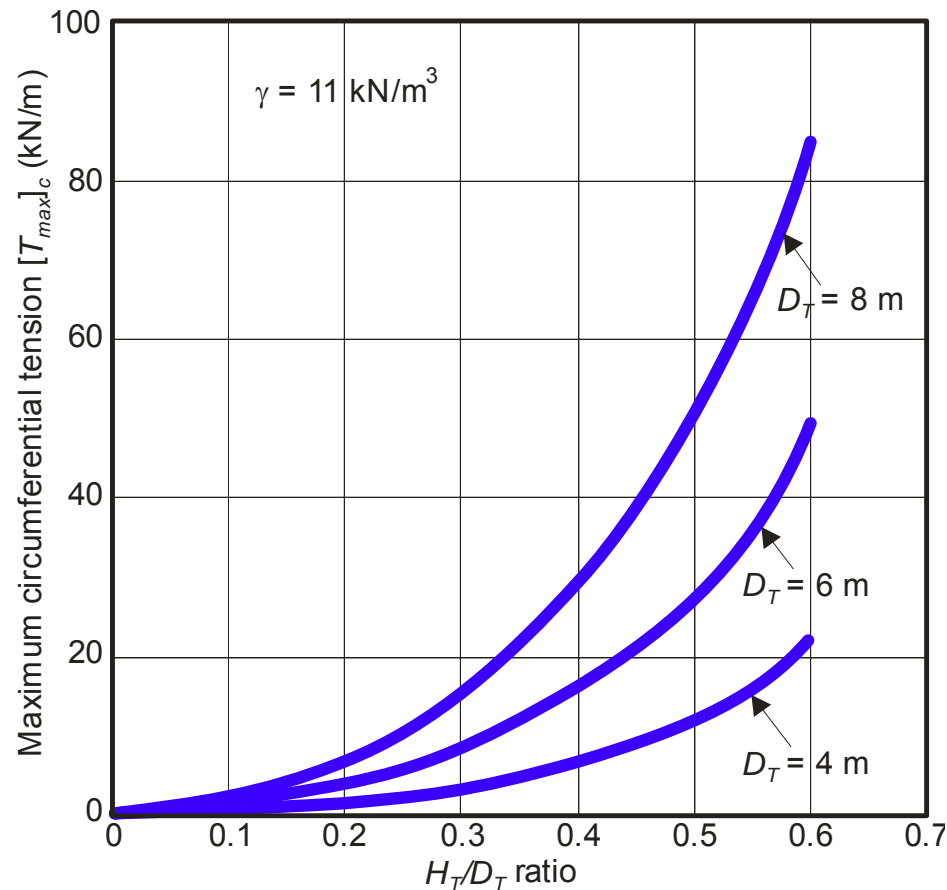


The structural design process – tensions generated



- Tensions generated at 3 locations – circumferential, axial and at filling port connections
- Tensions generated depend on size of tube and degree of filling
- First determine circumferential tensions, then axial tensions, and finally filling port connection tensions
- Recently, polymer ring connections have been used at filling ports to reduce localised tensions and increase fill heights

Maximum circumferential tensions in geotextile tubes

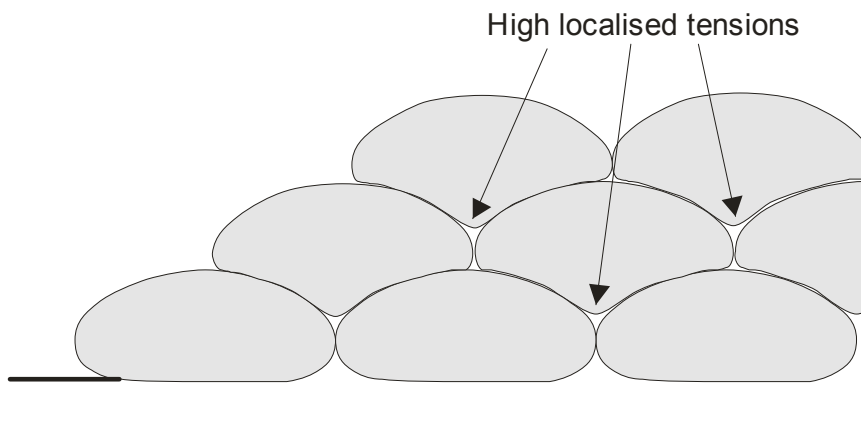


- The tensions generated in the tubes are a function of tube diameter and filling height
- As filling height increases, geotextile tension increases
 - Filling volume increases
- Methods using membrane theory used in analysis
- As well as circumferential tensions, longitudinal tensions and tensions at the filling ports are generated
 - Geotextile strengths and seam strengths are critical

Importance of filling height control



Stacking of geotextile tubes

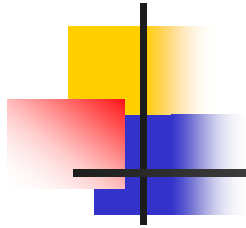


- Where dewatering platform is limited, or where volume to be dewatered is large, stacking of geotextile tubes may be required
 - Bottom layers consolidating while upper layer is dewatering
- Loads exerted by upper layers need to be taken into account when assessing tensions in lower layer(s)
- Stacking of tubes also generates localised tensions at base of upper tubes, which must be taken into account



Dewatering applications with geotextile tubes

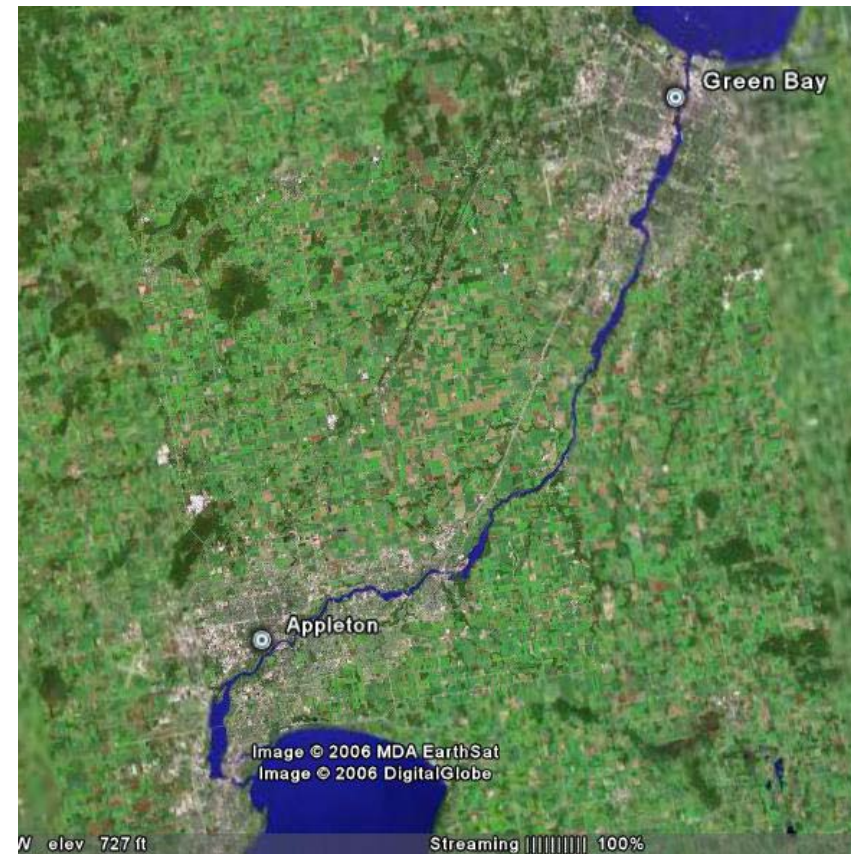
- Any industry that generates slurry waste can utilise geotextile tubes for dewatering
- Municipal waste and water treatment
 - From anaerobic ponds, clarifiers, digestors, etc.
 - Outflow from septic tanks
 - Water treatment sludge, e.g. alum sludge
- Agricultural animal waste
 - From cattle, chicken and hog farms
 - Solids recycled as fertiliser
- Food processing
 - Vegetable cleaning, cheese processing, wine processing, abattoirs
 - Aquaculture – generation of benthic waste
- Mining waste
 - Tailings, mineral fines, processing sludge
- Industrial waste
- Construction waste
 - Drilling, grouting and diaphragm wall muds
- Contaminated sediments
 - Environmental dredging and disposal



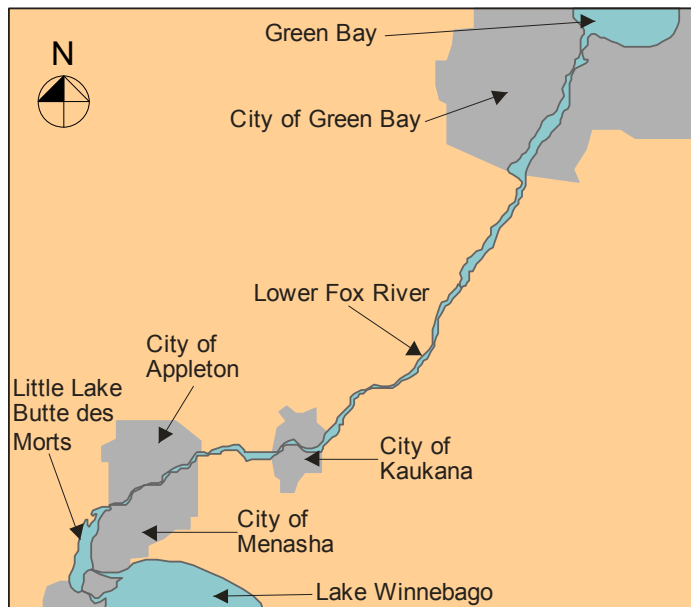
Case study 1: Geotextile tubes for dewatering contaminated sediments

Little Lake Butte des Morts, Fox River,
Wisconsin, USA

Lower Fox River location – Wisconsin, USA



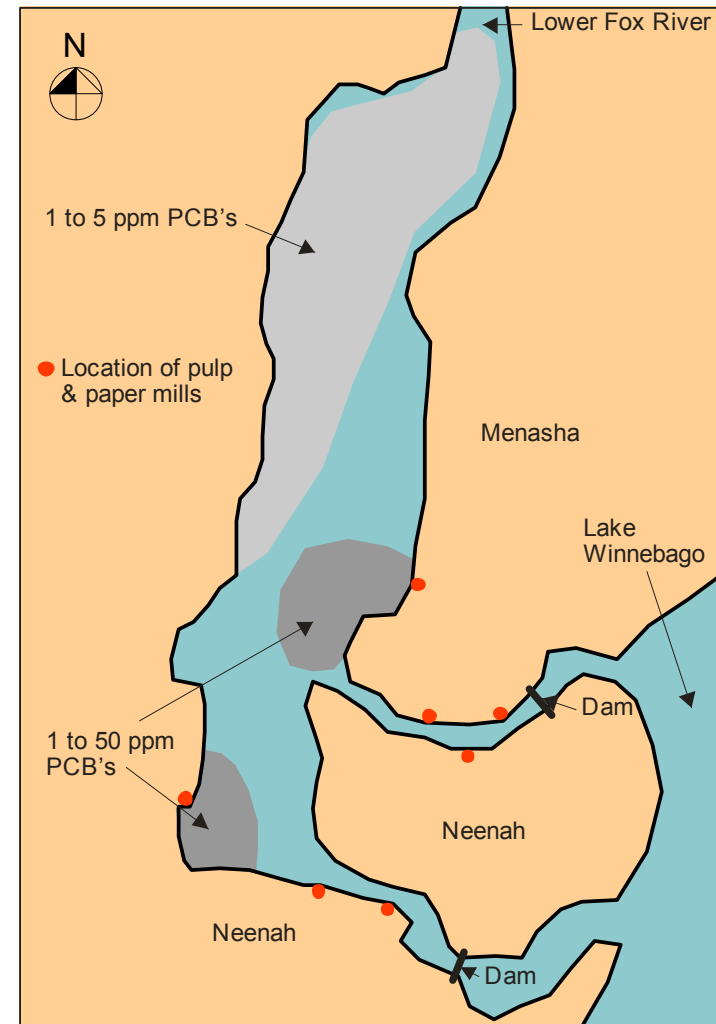
Lower Fox River - history



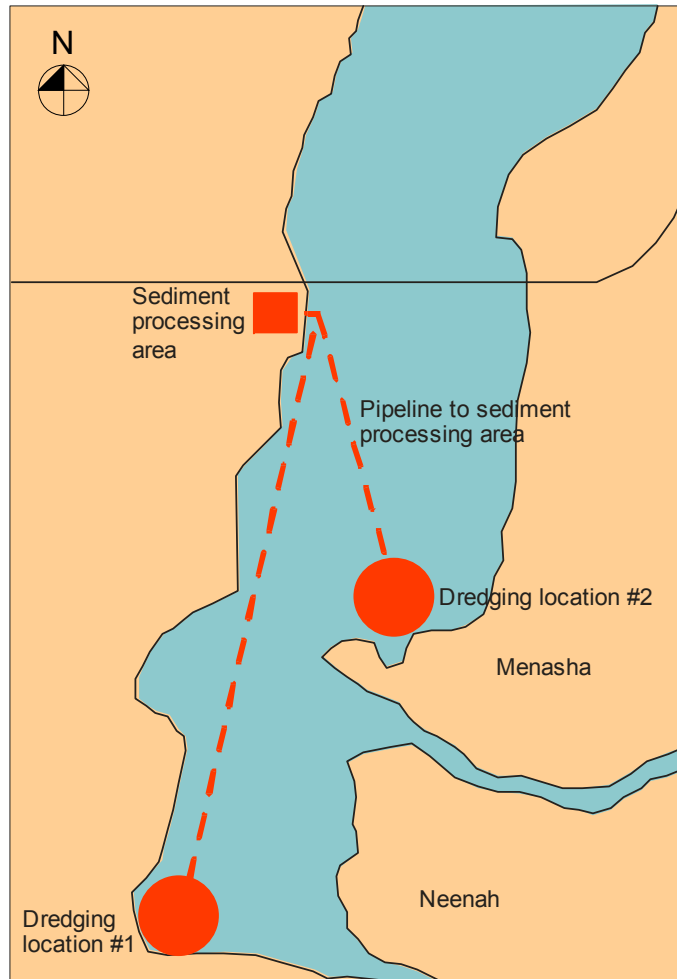
- During late 19th, early and mid 20th centuries many pulp and paper mills established along Lower Fox River
- From 1954 to 1971 paper mills produced carbonless copy paper using PCB coated emulsions
 - Estimated some 350 tonnes PCB discharged into river
- After 1971, recycling of PCB coated paper also generated discharges
- Lower Fox River rated one of two most polluted rivers in USA
- In late 1990's decided to remediate Lower Fox River – EPA Superfund
 - Divided into number of regions
 - LLBdM at upper reaches is first to undergo remediation

Little Lake Butte des Morts with PCB concentrations

1970



Little Lake Butte des Morts (LLBdM) – planned remediation



- Dredge contaminated sediment and dispose to off-site facility
- Target PCB level ≤ 1 ppm
- 98% of PCB's lie in upper 1 metre of sediment
- Requires dredging of 600,000 m³ contaminated sediments (approx. 1,700 kg of PCB's) over a 6 year seasonal period
- Main dredging located in highest PCB concentration areas
- Dredges were special, small-scale cutter-suction dredges that created minimal sediment disturbance during operation
- Contaminated sediment pumped to sediment processing area for treatment prior to off-site disposal

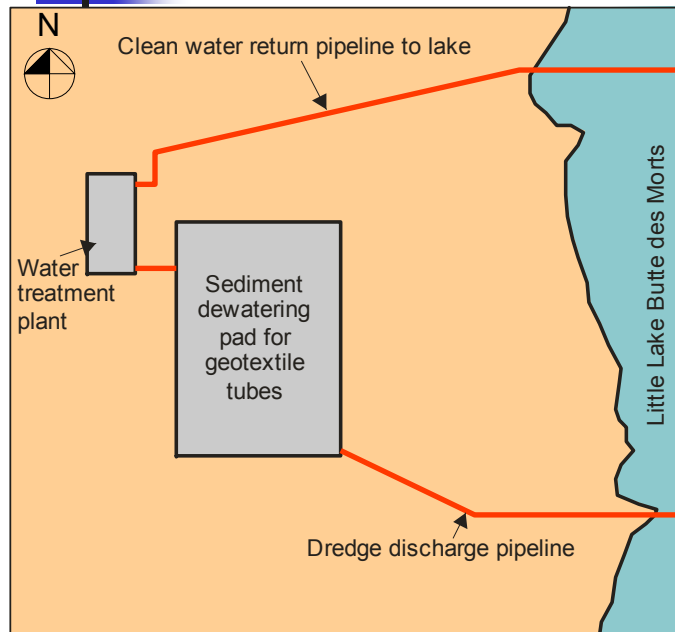


LLBdM – dredging equipment



- Dredging accuracy:
 - Horizontal accuracy within 1 m
 - Vertical accuracy within 0.1 m
- Dredging capacity between 4.5 to 5.5 m³/min (for 2 dredges)
- Special dredging head for low disturbance

LLBdM – sediment treatment facility



- Sediment treatment facility has two components:
 - Sediment dewatering pad
 - Water treatment plant
- Capacity suited to dredging operation
- Treatment is a “clean” operation and wholly self-contained – close to residential areas

LLBdM – sediment dewatering platform



- Compacted clay/geomembrane lined platform
- Geotextile protection layer
- Gravel drainage blanket
- Pump installed at low-point to remove effluent water to water treatment plant

Dewatering platform – multiple geotextile tube layers



Geotextile tube inlet feeds and effluent water extraction

Geotextile tube inlet feeds



Effluent water extraction



LLBdM – effluent water treatment

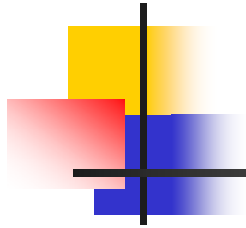


- Because of political sensitivity of remediation project it is assumed that geotextile tube dewatering does not trap any of PCB's from effluent water
- Water treatment consists of:
 - Dissolved air flotation combined with sand filtration
 - Activated carbon filtration
- Clean water then returned to lake

LLBdM – removal of dewatered sediment



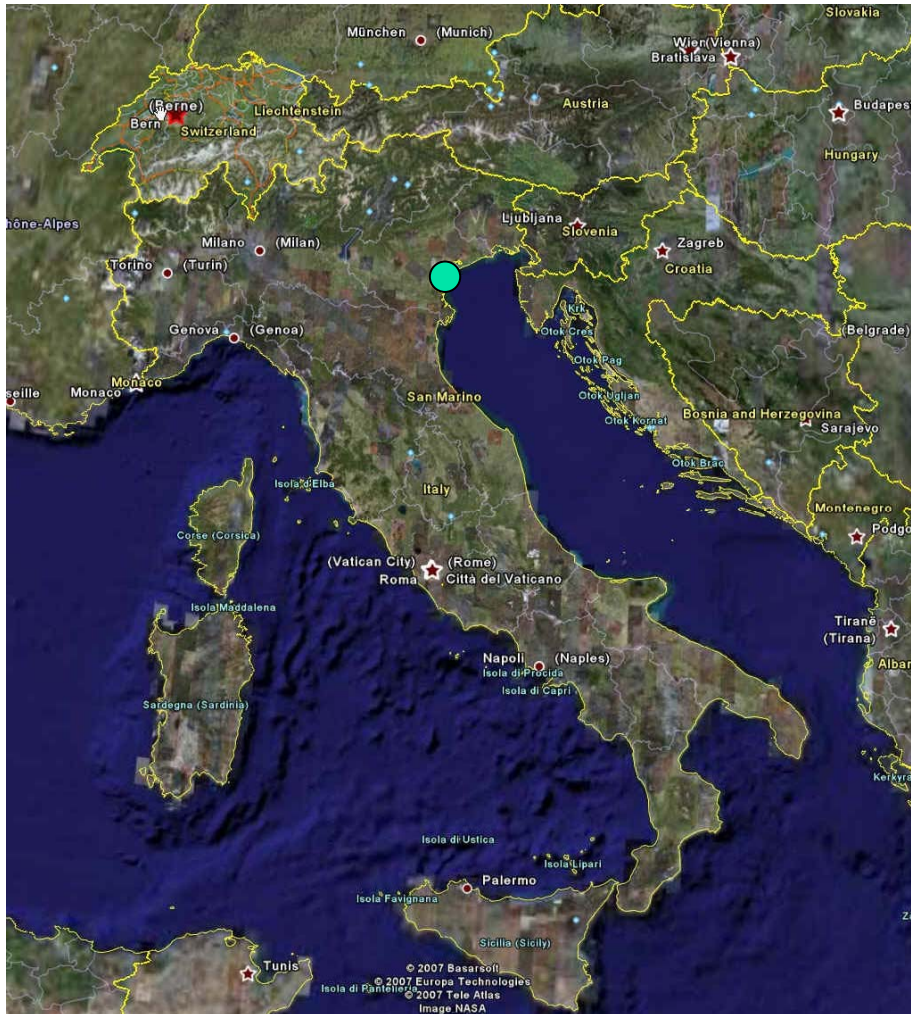
- After dewatering, geotextile tubes cut open and sediment removed
 - Solids concentration varied from 35% to 80% (60% to 85% volume reduction)
- Sediment placed in lined dump trucks and transported to an off-site permitted landfill for disposal



Case study 2: Geotextile tubes for dewatering contaminated sediments

Porto Marghera, Veneto Region, Italy

Porto Marghera location

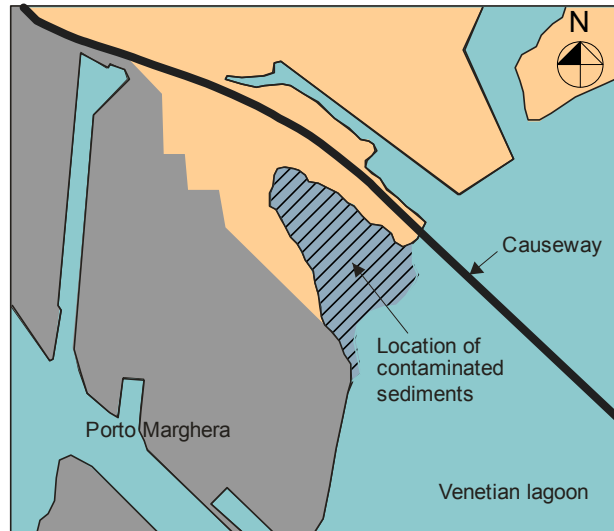


Porto Marghera – location and history



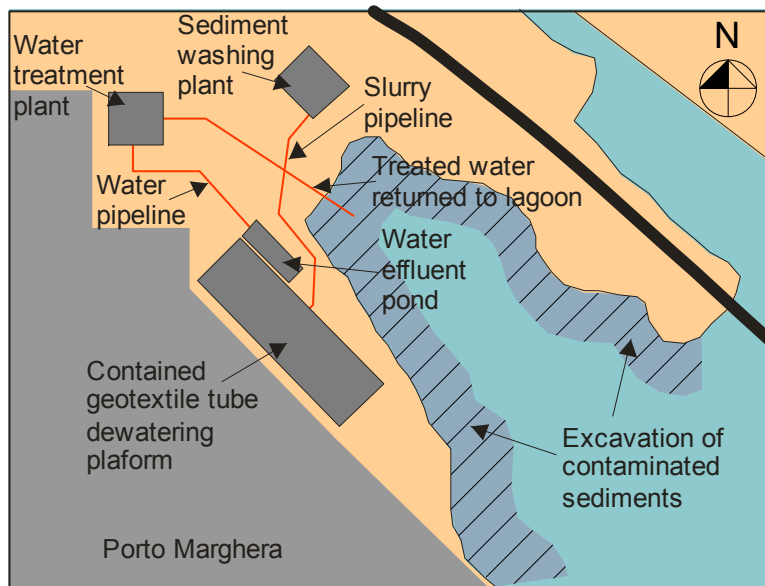
- Porto Marghera is one of the most important industrial and commercial ports in Italy
- Development began in early 20th century
 - Many chemical and petrochemical industries established between the 1950's and 1980's
- As a consequence, high levels of heavy metals (Hg, Cd, Pb, Ar, Cs) and non-soluble organic compounds (PAH, HCB, PCB, PCDD, PCDF) occur in ground and sediments of the area
 - These contaminant levels have made Porto Marghera one of the most polluted sites in Europe
- EU program to remediate the whole area in stages

Remediation of Pili area



- Area immediately to North of Porto Marghera (known as “Pili”) was to be remediated and developed
- Low-lying, tidal inlet area which had become a site for the dumping of industrial waste from Porto Marghera – around 800,000 m³ waste dumped here
- Contaminants present include heavy metals (Hg, Cd), organic compounds (benzo-pirene, PCB’s) and radioactive substances (radon 222)
 - These have been leached into the sediments of the inlet, and into the Venetian lagoon
- Excavate the contaminated sediments and process as part of development of area

Details of dewatering process layout



- Excavation of 80,000 m³ of contaminated sediments from a 50 m wide strip around the edge of the Pili inlet
- Sediment passed through a washing plant where valuable component (aggregates) is separated out can be reused elsewhere
- Sediment slurry then dewatered by use of geotextile tubes
- Effluent water collected and further treated, and then returned to Venetian lagoon
- Dewatered sediment later removed and disposed of in nearby landfill

Excavation and transport to washing plant



- Contaminated sediment excavated and transported by dump truck to washing plant
- Approximately 400 m³/day excavated

Washing of aggregate and separation of contaminated fines slurry



- At washing plant aggregate separated and cleaned for alternative use
- Remaining fines slurry maintained in suspension until it could be pumped to dewatering area
- Pumping rate to dewatering area was approximately 1,200 m³/day

Chemical accelerant addition



- The slurry was dosed with a chemical accelerant prior to entering the dewatering area

Dewatering platform



- Dewatering platform consisted of a compacted soil containment area with a HDPE geomembrane liner
- In the base of this containment facility a 300 mm thick gravel drainage blanket was placed to enable effluent water to drain to side drains at the base of the facility

Geotextile tube dewatering



- The slurry fines, dosed with the chemical accelerant, was pumped into the geotextile tubes positioned on the drainage platform
 - Each filling cycle raised the filled height of the tubes to 1.4 m
- The tubes were allowed to dewater, and then the filling process was repeated
- Following the completion of dewatering the tubes were cut open and the dewatered sediment was removed and disposed of in a landfill site nearby

Effluent retention and treatment



- The effluent water was collected in a retention pond next to the dewatering platform
- From here, the effluent water passed through a water treatment plant on site for further cleaning
- Then the water was returned to the Venetian lagoon



Conclusions

- Geotextile tubes and bags provide an efficient medium for the dewatering of slurry waste streams and contaminated sediments
 - Simple process
 - Efficient
 - Can be easily scaled to suit treatment volumes
- It is important to remember that geotextile tubes and bags are one component of the “dewatering system”
 - All components must be considered to obtain an acceptable solution
- Geotextile tubes and bags must be designed ***hydraulically*** and ***structurally***