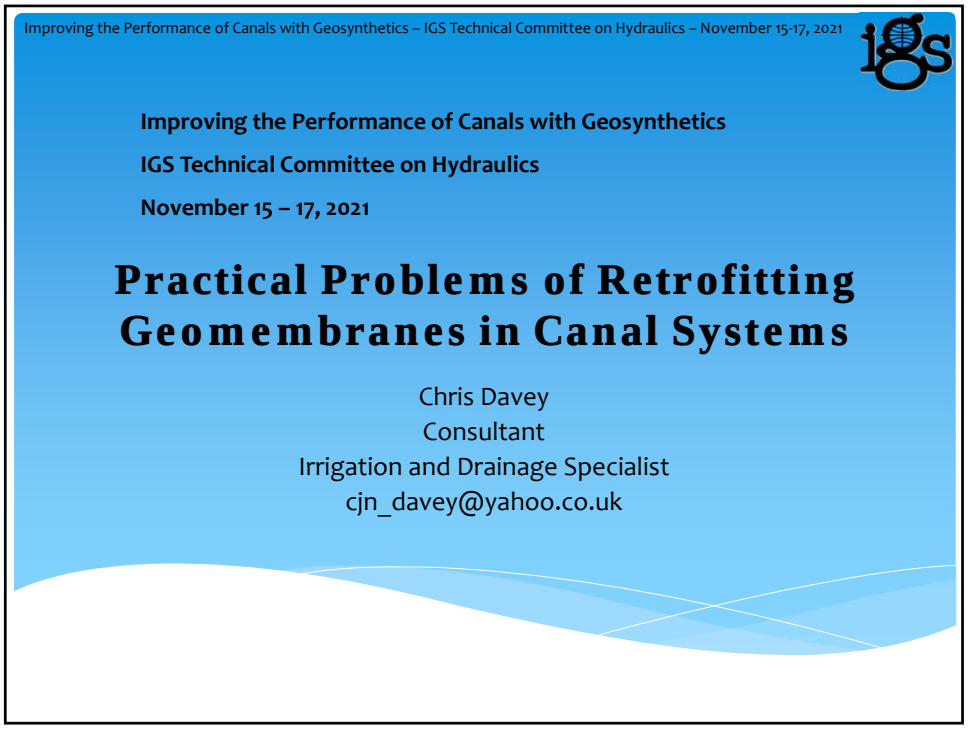
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Improving the Performance of Canals with Geosynthetics
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November 15 – 17, 2021
Practical Problems of Retrofitting Geomembranes in Canal Systems
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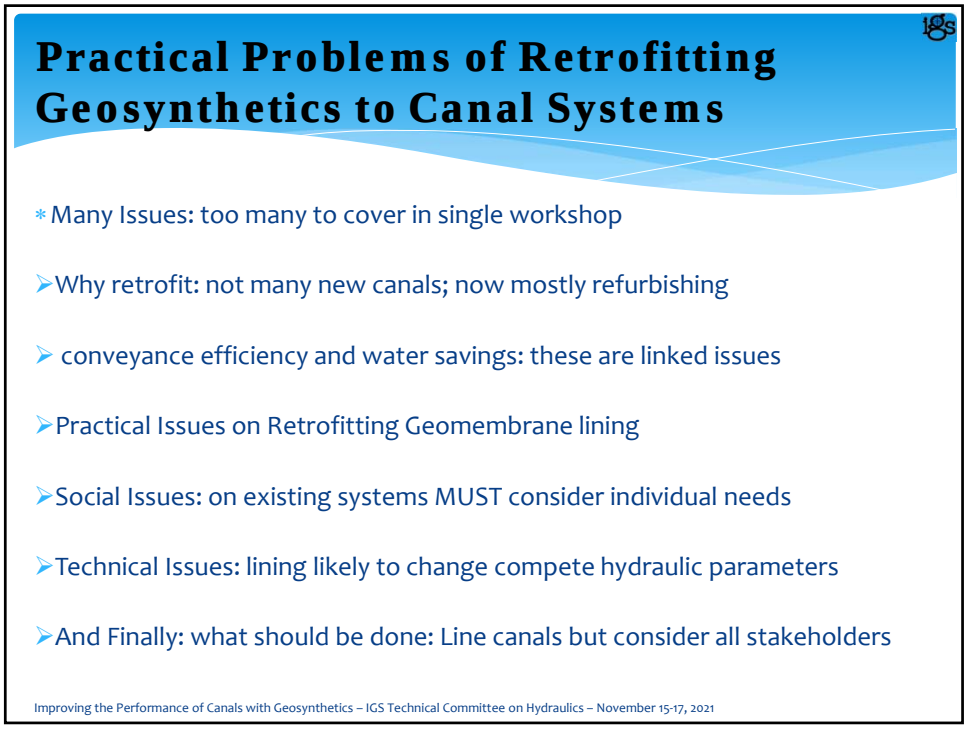
Practical Problems of Retrofitting Geosynthetics to Canal Systems
Many Issues: too many to cover in single workshop
Why retrofit: not many new canals; now mostly refurbishing
conveyance efficiency and water savings: these are linked issues
Practical Issues on Retrofitting Geomembrane lining
Social Issues: on existing systems MUST consider individual needs
Technical Issues: lining likely to change compete hydraulic parameters
And Finally: what should be done: Line canals but consider all stakeholders
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Why retrofitting

- Why retrofit canals?
  - Major canal systems are constructed (eg Nile Delta, Indus canals etc); not many new canals; huge benefits in upgrading and retrofitting old canals. Therefore need to focus on upgrading and retrofitting geomembranes on existing canal systems
  - Climate change; affects water supplies; hence need to improve efficiency
  - Water shortages; other users also need water!
- Which canals
  - Water losses in major canals generally about 20%. Egypt emphasis is being given to lining existing major and distributary canals
  - Water losses in distributary, minors and field canals are about 30% ; upgrading at that level also possible eg FIMP project

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Table 1: Available and Used Irrigation Water Resources

Source	Usage		Availability	
	Billion m^3/Annum	%	Billion m^3/Annum	%
Nile Water	51.70	82.59	55.50	75.20
Groundwater	5.20	8.30	11.30	15.30
Drainage Water	3.70	5.91	5.00	6.80
Treated Sewage Water	1.50	2.40	1.50	2.03
Rain	0.50	0.80	0.50	0.67
Total	**62.60**		**73.80**	

Source: compiled by the authors from different sources.

If savings of just 10% can be made, this equated to over 5 Billion m3.
This is more water than water allocated to industry and household use in Egypt.
Where can these savings be made?
Look at the figures for efficiencies in the lower part of the system, as shown in the following table.

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Conveyance Efficiency

Conveyance Efficiency under Egyptian Conditions

Types of Marwa	Conveyance Efficiency	
	Summer	Winter
Earthen Canal	59.6	65.1
Lined Canal	87.1	92.2
Buried Pipe	98.7	98.7

Ref: Improving Irrigation Water Conveyance and Distribution Efficiency using Lined Canals and Buried Pipes under Egyptian Conditions : E. A. M. Osman*; G. A. Bakeer**; M. E. Abuarab*** and M. T. Eltantawy: Misr Journal of Agricultural Engineering · October 2016

- Agricultural Engineering Faculty, Cairo University ;
- ** IInstitute of Agricultural Engineering Research

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Typical Distributary Canal in Egypt

This is a typical distributary canal. Minimal access makes upgrading and retrofitting geomembranes difficult, specially if the canal must operate continuously

* Typical canal section in Egypt

6

Unlined marwa in Egypt

This is a typical example of an unlined open marwa canalwith losses estimated at 40%.
Water is pumped into marwas, often by numerous individual farmers.
Marwas discharge into open drains at tail.

Each marwa can serve 40 to 100 ha.

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Brick lined marwas in Egypt

Upgrading to brick lined marwas can have initial savings of about 30%.
But looking at the quality of lining and plaster work, the losses of about 40% will return.
If the upgrading to brick lined marwa could include a geomembrane, then the water savings could continue for longer period until the brickwork failed.

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New Buried Marwas in Egypt

Under the FIMP and IIIMP projects supported by World Bank and AFD, a new system with a single Mesqa pump station serving perhaps 6 marwas and area of between 40 and 100 ha has been completed covering about 100,000 ha.
Water User Associations are formed ot operate and maintain the system.
Water savings of about 40% achieved.

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Status of Irrigation in Egypt

* General comments on the status of irrigation in Egypt

The overall irrigation efficiency in Egypt is very low about 40–60%, due to evaporation, seepage, deep percolation, and transpiration from aquatic crops in irrigation canals.

The cultivated area in Egypt is only 7.9 million feddan, about 3.3% from the total land area.

* Efficient and Effective Canal lining can reduce the seepage and deep percolation losses.
* The water savings can insure that the present irrigated area in Egypt can be maintained and water requirements satisfied even with possible reductions of water availability from the Nile

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Practical issues on Retrofitting geomembranes

- Issues can be divided into three areas
  - Social Issues
  - Technical Issues
  - Financial Issues
    - Who should pay? In Egypt the farmers are prepared to pay the cost of the installation of the marwas through the land tax system. The operation and maintenance costs are paid directly to the Water User Association who employ the pump operator etc. But this is possible since all the irrigation water must be pumped from the Distributary Canal.
    - Allocating costs in other countries with gravity flow systems may be more difficult.

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Social and Environmental Issues

- Some of the social and environmental issues include:
- Land tenure
- Traffic movement during construction
- Spillage of oils, fuels or other pollutants
- Overall hygiene in construction camps
- Protection of children

Land tenure and the generally small size of individual land holdings on the major irrigation projects impacts the process of upgrading existing canal networks and retrofitting geomembranes. The possible impact of any disruption or possible land loss on these small landowners needs to be evaluated.

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Land Tenure

- Many farmers have holdings of less than 0.5 feddan (0.25 ha)
- Farmers depend on their crops for their livelihoods to feed themselves and their family
- Even small deductions of land are critical
- Water supplies are critical
- Rotations are fixed and farmers rely on this water supply

Unless the farmers and other stakeholders support the upgrading of the canal network including retrofitting geomembranes, there may be disruption and delays during the construction process

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Other social and environmental issues

- Water quality for drinking
  - With improved efficiency water quality in tail end of systems will improve
- Water quality for agriculture
  - With improved efficiency more area will be irrigated with good quality water
    - Use of drain water will decrease
    - Use of saline water at tail of system will decrease

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Technical aspects of Retrofitting canals

- Retrofitting Canals with Geomembrane has major impact on system:
  - If existing canal already lined, benefits include reducing seepage losses and eliminating waterlogging and salinity problems. Will only need to make provisions to maintain water supplies during construction
  - If existing canal unlined, then retrofitting canal with a protected geomembrane will require complete system redesign. Benefits still include reducing seepage losses and eliminating waterlogging and salinity problems. Contractor will need to maintain water supplies during construction to the same canal water levels,
- Design aspects
- Construction aspects
- Maintenance aspects

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Design Aspects

- **Farmer / Stakeholder participation**
- Awareness programme; Regular meetings with Water User Association and other stakeholders are necessary, to ensure agreement reached at each stage of system redesign.
- Integrated into survey and data collection;
  - Farmers and stakeholders know precisely their boundaries and border lines, including the exact locations needed for any outlets . Similarly the discharges expected by farmers at their outlets are known.

Unless the farmers and stakeholders participate fully at this stage, problems can escalate.

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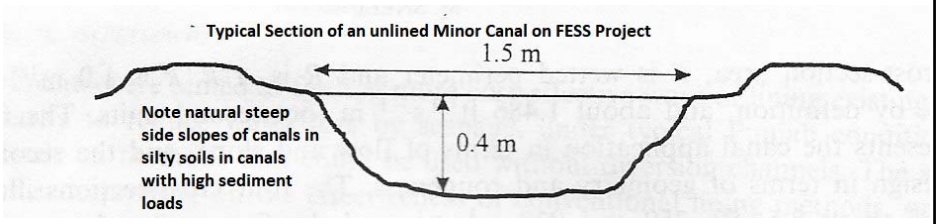
Typical Unlined Canal Section



Note: Canal side slopes in delta area in Egypt have similar sections.

No geomembrane can be placed until the canal is reprofiled, with a design section where the protective cover can be placed on the geomembrane.

Design Aspects

- Change in canal section
  - Land tenure problems – more space for gradual side slopes
  - Right of ways – now almost non-existent due to gradual farmer creep
- Change in canal profile (not problem in Main and Distributary Canals in Egypt since water generally pumped to feed mesqas and marwas). But for the marwas and mesqas:
  - Manning friction factor will change from 0.25 to perhaps 0.12, affects velocities, and flow depths etc
  - Can affect water levels through system
    - Affect outlet discharges which all need recalibrating
    - Water Levels maintained to control outlet discharges – open flumes, pipe outlets etc
- Social facilities for access –washing, animal access etc
  - Not present in older channels
  - If not provided, farmers may damage canals to get access

Contractual Aspects

- Stakeholder participation required to formalise their participation in the construction stage
  - Farmer meetings etc to discuss their involvement (since they will pay the costs!)
  - Will farmers have any authority during construction?
- Clarity required in responsibilities and interaction between all parties – contractor, stakeholders, and construction supervisor
  - What are the role of the stakeholders and farmers during construction?
  - What Is the process of interactions?
  - Who approves ongoing work?
  - etc

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Contractual Aspects

- Construction activities will disturb farming activities
- Contract must include compensation
- Contract could include:
  - Farmer Awareness sessions
  - Provisions to recruit locals for the construction
  - A Disputes Mechanism
  - Process for payment of any compensation

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Construction Aspects

When modernising existing systems and retrofitting geomembranes,must always consider the need to maintain water supplies to individual farmers!

- Need to Maintain critical water supplies, therefore work use:
  - Closure period working
  - Extended closure periods
  - Working during rotation or extended rotations
- Diversions may need to be considered to extend working periods.
  - Costly but critical
  - Poor farmers cannot afford crop losses due to water failures.
- Concrete Cover: If concrete used, then can decide how it can be placed.
  - Cast in Situ
  - Precast Units

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Site access and Choice of Lining

- **Large canals**
  - may have
    - Rights of Way
    - Inspection and Non-Inspection paths
    - Long Distance between bridges and other structures

All these make access and working easier for modernising existing system

- If available, then use of paver or other system convenient to use

- **Smaller Canals on existing systems**
  - Rights of way probably consumed over time
  - Farmers cultivate to canal edge to maximise crops
  - No inspection or non-inspection paths
  - Structures and crossing more frequent

- Contractor may consider precast panels more convenient to use

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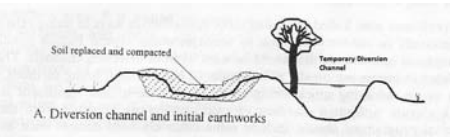
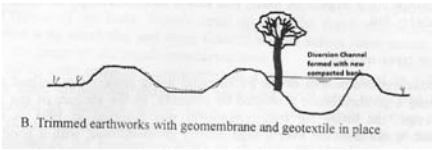
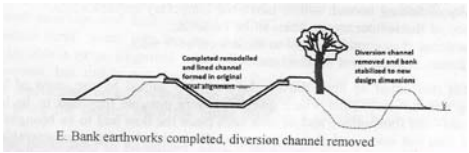
Construction Aspects

- Stakeholder awareness and participation. Construction team and contractor must involve all stakeholders in all aspects of work, including planning.
- Scheduling construction to meet stakeholders needs. Liaison meetings with stakeholders will help improve progress and avoid disruption
- Certainty of water supplies for irrigation schedules. With schedules agreed with the stakeholders, individuals can also plan cropping patterns based on expected water deliveries. There must be a process of compensation for failing to deliver water on schedule.

Typical Diversion Scenario with Small Channels







Diversion works on IIIMP in Egypt

The following pictures show works on canal lining and retrofitting geomembranes on existing canals in Egypt and in Pakistan

Figure 2: Canal diversion on IIIMP in Egypt while constructing a U-Section concrete lining

Figure 1Diversion channel running parallel to canal lining works

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Precast slabs on geomembrane

FESS Project Pakistan: Placing precast slabs on bed and precast side panels

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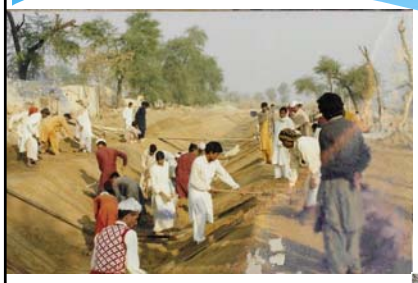

Hand dressing of minor canal before laying geomembrane

FESS Project : Placing geomembrane

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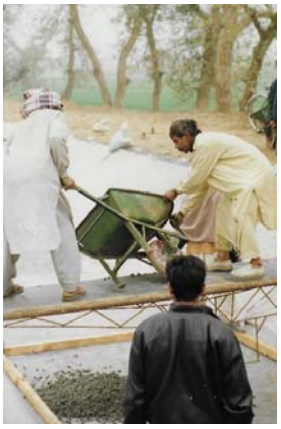

Cast in situ concrete on geomembrane lining in Pakistan

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FESS Project

Minor Canal lined with geomembrane and covered with cast insitu concrete cover

Small minor canal lined with geomembrane and precast slabs after 15 years operation

29

Canal lined with geomembrane covered with cast in situ in bed and precast concrete panels on sides after 15 years

30

Canal lined with geomembrane covered with precast vertical wall units, after 15 years in operation

31

Geomembrane canal lined with concrete after 15 years operation

32

Damaged sections of lined channels

Farmer discussion essential to avoid unnecessary damage. Here on the left a farmer wanted easy access for buffaloes to gain access to wallow in the canal. On the right similar access wanted for smaller animals.

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Finally

1. Global warming and climate change will reduce water available for irrigation
2. Retrofitting irrigation canals with geomembranes to reduce seepage losses could result in significant water savings and reduce waterlogging and salinity problems
3. The process of Retrofitting canals with geomembranes will have a significant impact on all stakeholders who must be consulted at each stage
4. Technical impacts of remodelling canals for geomembranes will change the operating regime
5. Successful implementation of retrofitting a geomembrane canal lining will depend on interaction and support of all stakeholders

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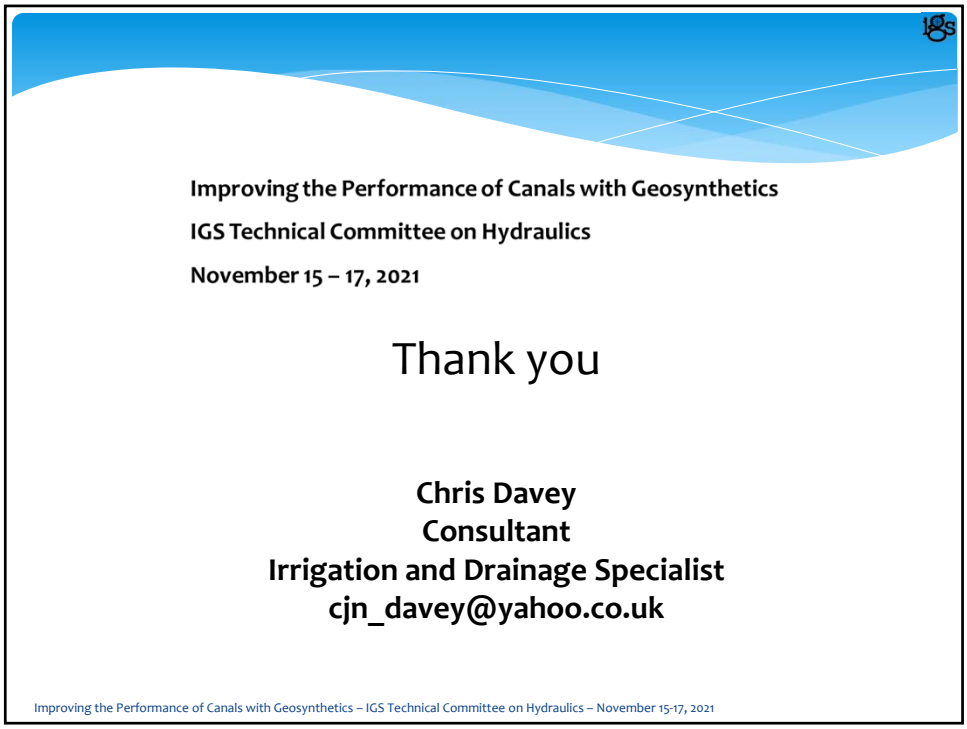
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