EXTREME ENGINEERING IN WATER RESOURCES FROM THE ARCTIC TO SOUTH AMERICA

Wim M. Veldman

M.Sc., FEIC., P.Eng.

Vice President

April 15, 2010

Matrix Solutions Inc.
ENVIRONMENT & ENGINEERING

Canadian Society for Civil Engineering

OVERVIEW

1. IMPORTANCE OF DATA
2. TRADITIONAL KNOWLEDGE
3. WHAT IF
4. CHALLENGE THE CONVENTIONAL
5. LIFE CYCLE APPROACH
6. EXTREME EVENTS
7. CLIMATE CHANGE

IMPORTANCE OF DATA

1. *REALITIES*

- Never enough data:
  - ✓ Trans Alaska Pipeline (1973)
  - ✓ Rose Creek Diversion, Yukon (1979)
  - ✓ GasAtacama, Argentina (1997)
  - ✓ Baffin Island Railway (2008)
  - ✓ Bolivia Pipeline (2010)

IMPORTANCE OF DATA - PIPELINES

	Low	Medium	High
Streamflow			
Peak	X →	X	-
Low	X	-	-
Water Level			
Open Water	X →	X	-
Ice	X →	X	-
Bed Scour			
General	-	X	X
Local	-	-	X
Bank Erosion	-	-	X

IMPORTANCE OF DATA - BRIDGES AND CULVERTS

	Low	Medium	High
Streamflow			
Peak	-	X →	X
Low	X →	X	-
Water Level			
Open Water	-	X →	X
Ice + Flow	-	-	X

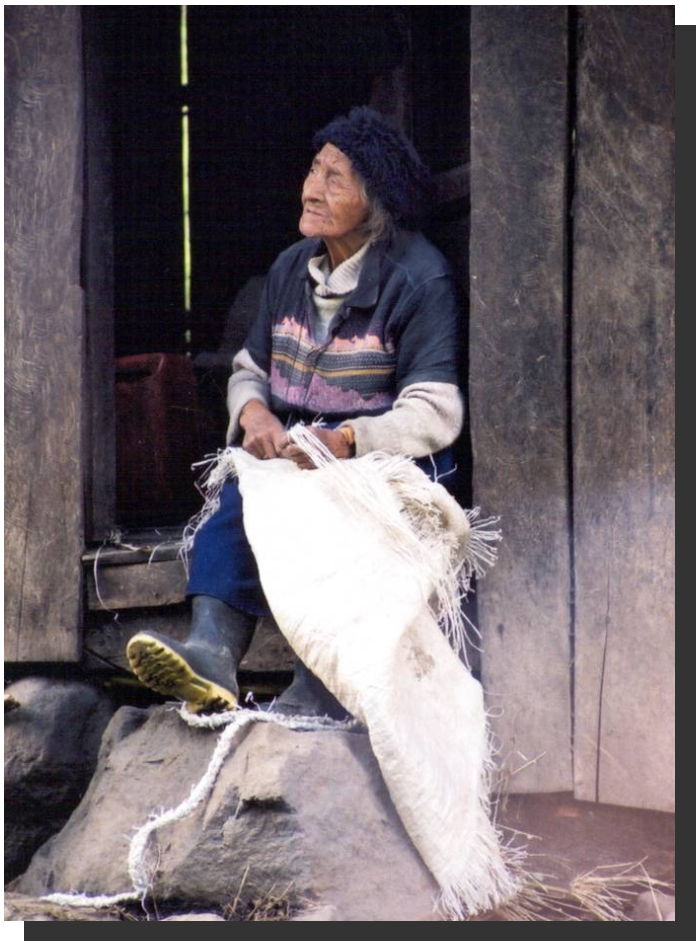
IMPORTANCE OF DATA - WATER SUPPLY

	Low	Medium	High
Availability			
Peak Flow	-	-	-
Low Flow	-	-	X
Pipeline Hydrostatic Testing			
Peak Flow	-	-	-
Low Flow	-	-	X

2. TRADITIONAL KNOWLEDGE

1. OAK LAKE / PLUM CREEK, MANITOBA (1966)
2. FLOOD LEVELS, SRI LANKA (1987)
3. GASATACAMA, ARGENTINA (1999)
4. OCP ECUADOR (2000)

TRADITIONAL KNOWLEDGE



Ecuador – OCP Pipeline – Rio Quijos – Local expert

TRADITIONAL KNOWLEDGE

Argentina - GasAtacama – Local Professional Experts

3. WHAT IF

- Impact on design criteria
  - ✓ TAPS in different regions (1973)
  - ✓ 1992 Sag River Flood
- Droughts more sustained than historic data – Bow City Thermal
  - ✓ Impact on storage requirements
- Design and operations Uncertainly – Nova Scotia

WHAT IF – SHUBENACADIE R. INTAKE

WHAT IF – SHUBENACADIE RIVER

WHAT IF	HOW DETERMINED	IMPACT ON OPERATION	IMPACT ON THE ENVIRONMENT	POTENTIAL MITIGATIVE MEASURES – IF NECESSARY
1. Silt or sand deposits in the Mixing Channel	From surveys and visual observations, the latter best done in non-tidal and low river flow periods.	Could reduce flow in the mixing channel – a bar would have a minimal impact on the flow. However, deposition across the full width of the channel could reduce flow during low flow conditions. This is expected to have little or no impact on the available flow for water withdrawal or the performance of the outfall.	A significantly reduced flow would increase salinity concentrations in the channel. Depending on the natural salinity in the river, the resultant salinity in the channel would still be expected to be well below the maximum natural salinity values in the river.	Remove the deposited material using a backhoe or small portable dredge. Undertake the work in the least sensitive period (from an aquatic viewpoint).
2. Scour of the bottom or erosion of the banks develops in the Mixing Channel	From surveys and visual observations – best done in non-tidal and low river flow periods.	Expected to have little impact on the magnitude of flow in the mixing channel and thus the operation of the intake and outfall.	Expected to have little impact if the scour and bank erosion is limited. Significant bank erosion could alter velocity patterns which could lead to non-uniform mixing of the flow in the channel.	Place more and/or larger armour material on the bed and banks of the mixing channel.
3. Mixing of the Brine Water with the flow in the Mixing Channel is not as modelled	Salinity measurements in the channel upstream and downstream of the outfall are higher than predicted herein.	None, except in the instance where the outfall flow affects the salinity of the water withdrawal from the channel. This could reduce the efficiency of the brining process.	Depending on the magnitude and spatial extent of the variance – actual versus modeled results – there could be a minor to moderate environmental impact.	Modify the outfall structure or add additional air lines to ensure full mixing of the brine and mixing channel flow. In an extreme nonconformance case, that can not be remediated by modifying the outfall structure, the magnitude of outflow might need to be reduced at certain times.

Client's Concerns **Regulatory Concerns** **Joint Concerns**

4. CHALLENGE THE CONVENTIONAL

1. TAPS Oil Pipeline(1973)
   - Elevated pile design / heat pipes
   - Environmental
2. GASATACAMA PIPELINE (1997)
   - Instream alignment for 80 Km
3. OCP Oil Pipeline ECUADOR (2000)
   - Mindo Ridge

CHALLENGE THE CONVENTIONAL

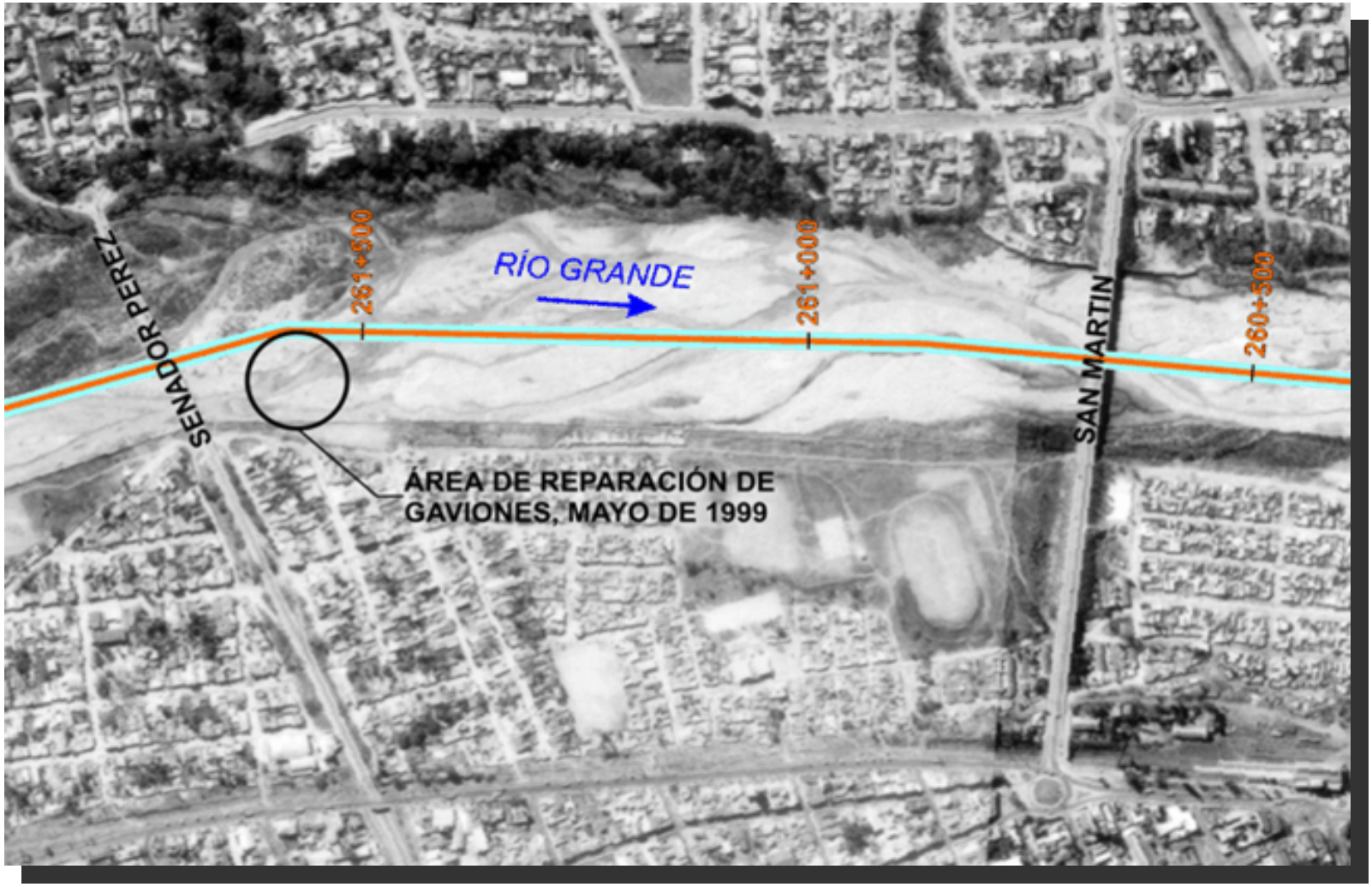
Trans Alaska Oil Pipeline

CHALLENGE THE CONVENTIONAL

"Gentlemen, do you know what 'Tsina' River means?"

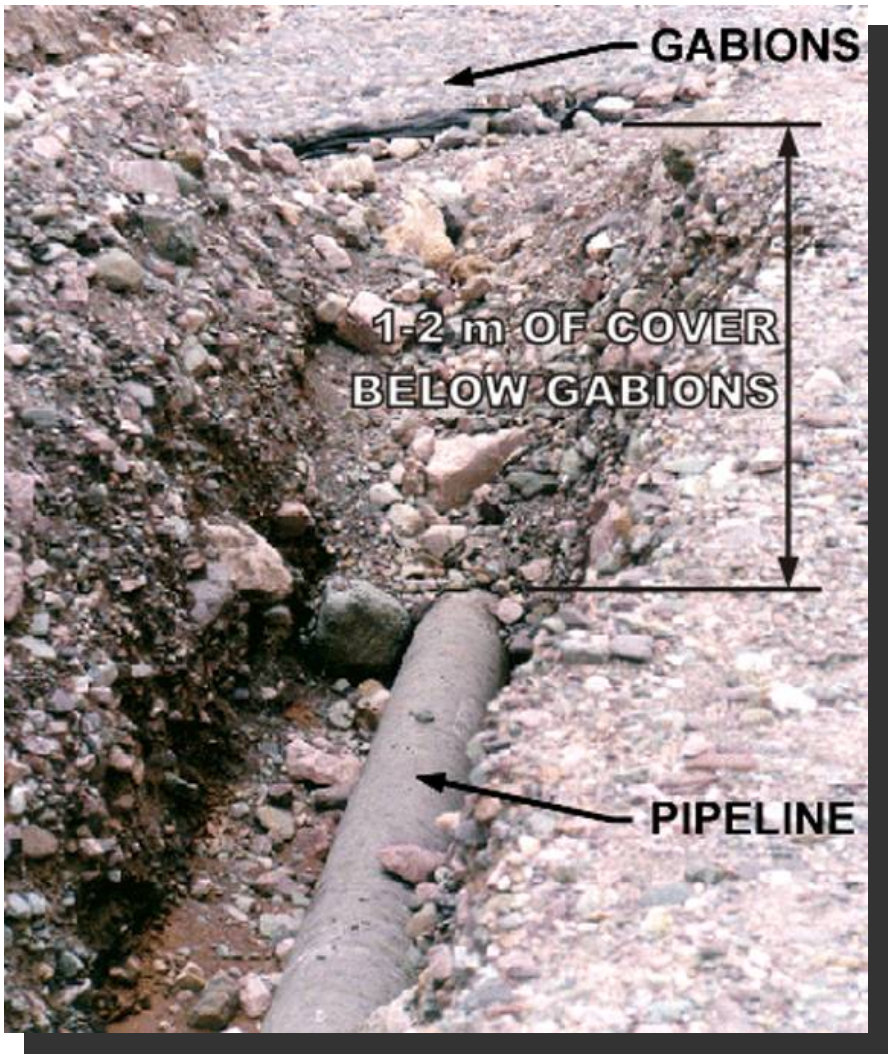
Ralph Jackson
1975
TAPS

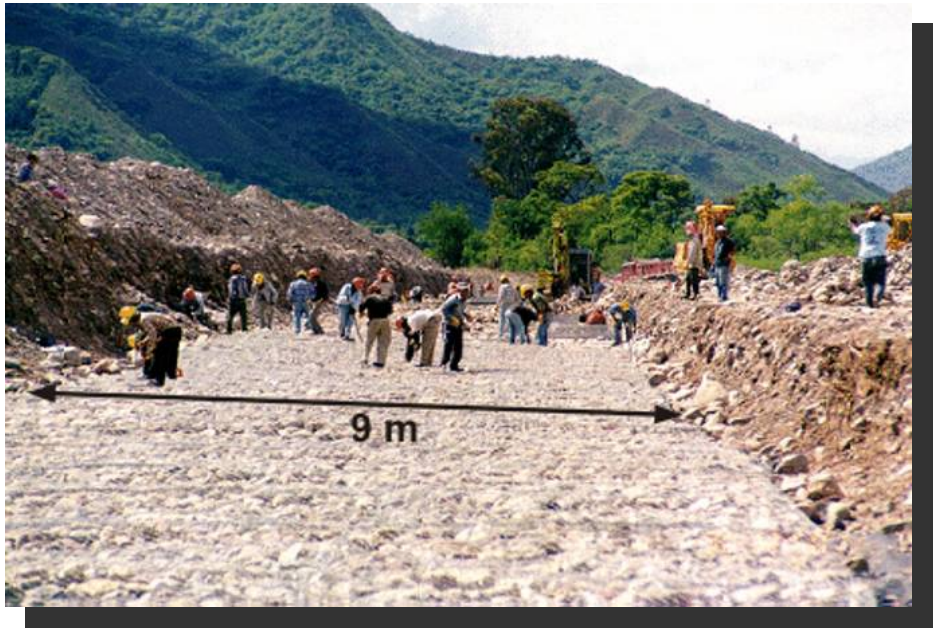
CHALLENGE THE CONVENTIONAL



Argentina - Atacama - Few Route Options Available

CHALLENGE THE CONVENTIONAL





Gabions

Argentina - Atacama - Extra Pipeline Protection

CHALLENGE THE CONVENTIONAL

Ecuador - OCP - Towers/Cable/Handwork

CHALLENGE THE CONVENTIONAL

Ecuador - OCP
550 People for 8 km

5. LIFE CYCLE APPROACH

1. INTERRELATIONSHIPS OF
    - Design
    - Permitting
    - Construction
    - Monitoring
2. WALK – AWAY VERSUS POSSIBLE MAINTENANCE
    - “To design for all eventualities is easy. To develop a practical yet sound and adequate design is much tougher” (Wim)

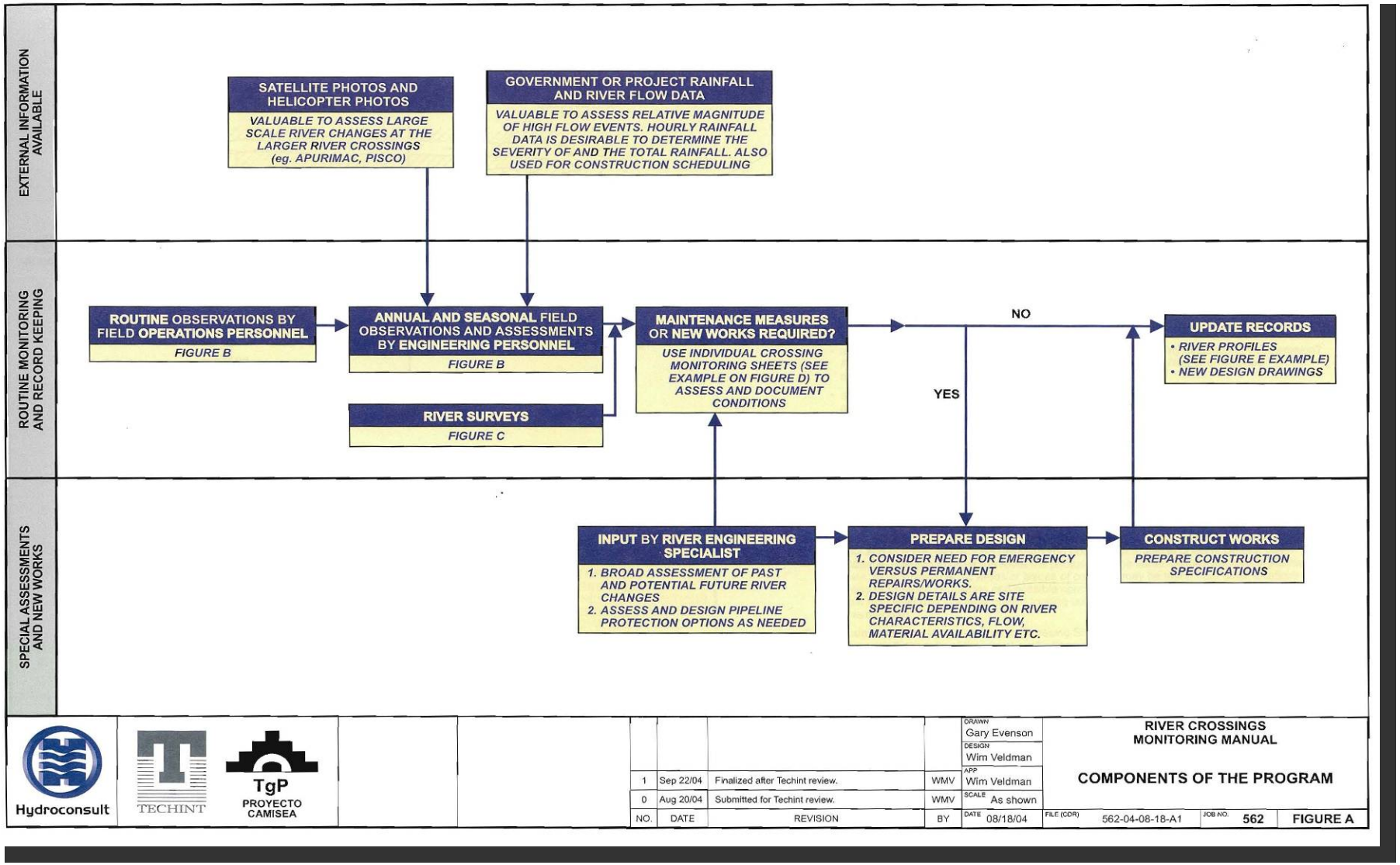
LIFE CYCLE

LIFE CYCLE - OPERATIONS

TAPS - Alaska

OCP - Ecuador

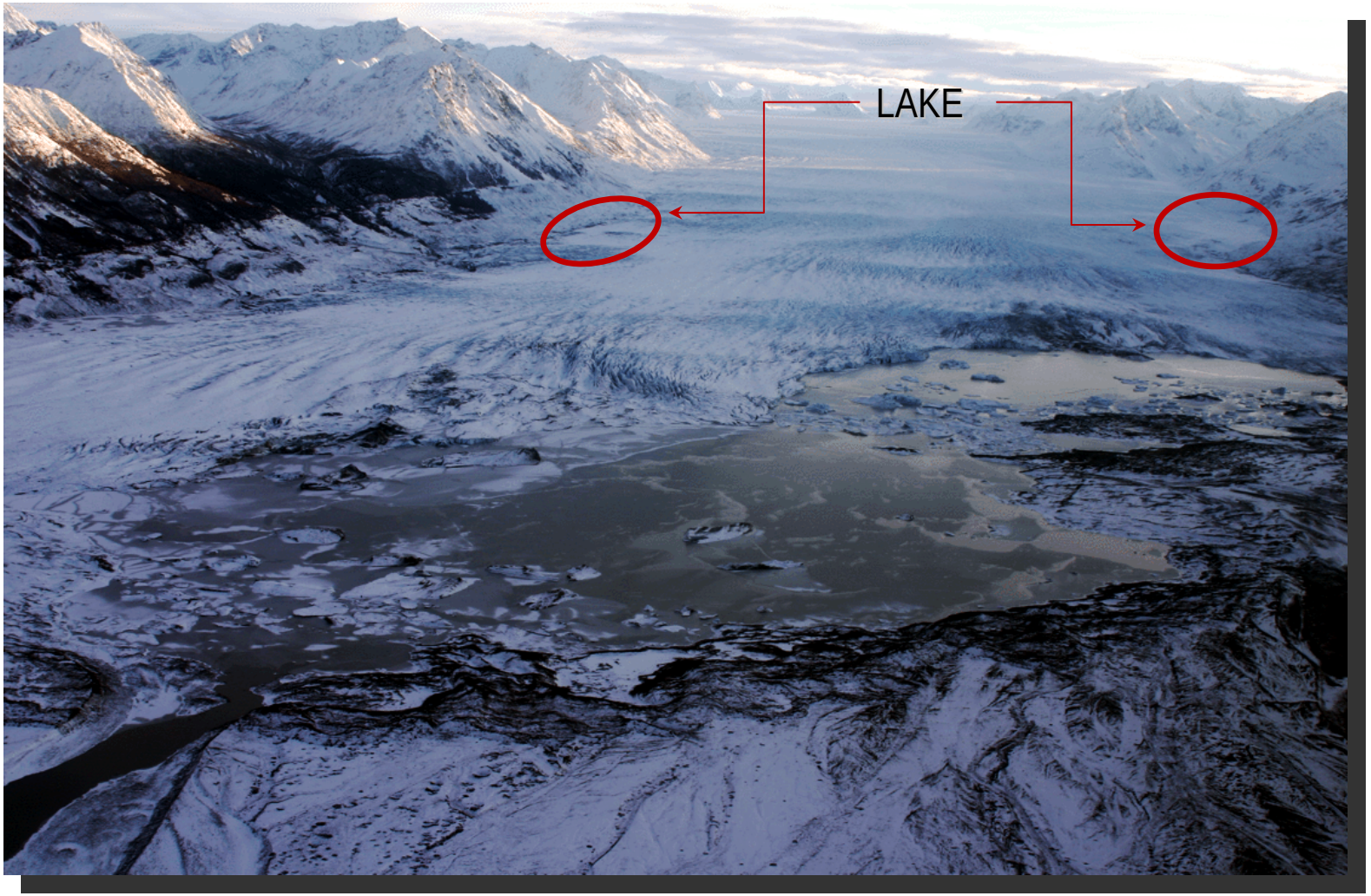
LIFE CYCLE - OPERATIONAL MONITORING



6. EXTREME EVENTS

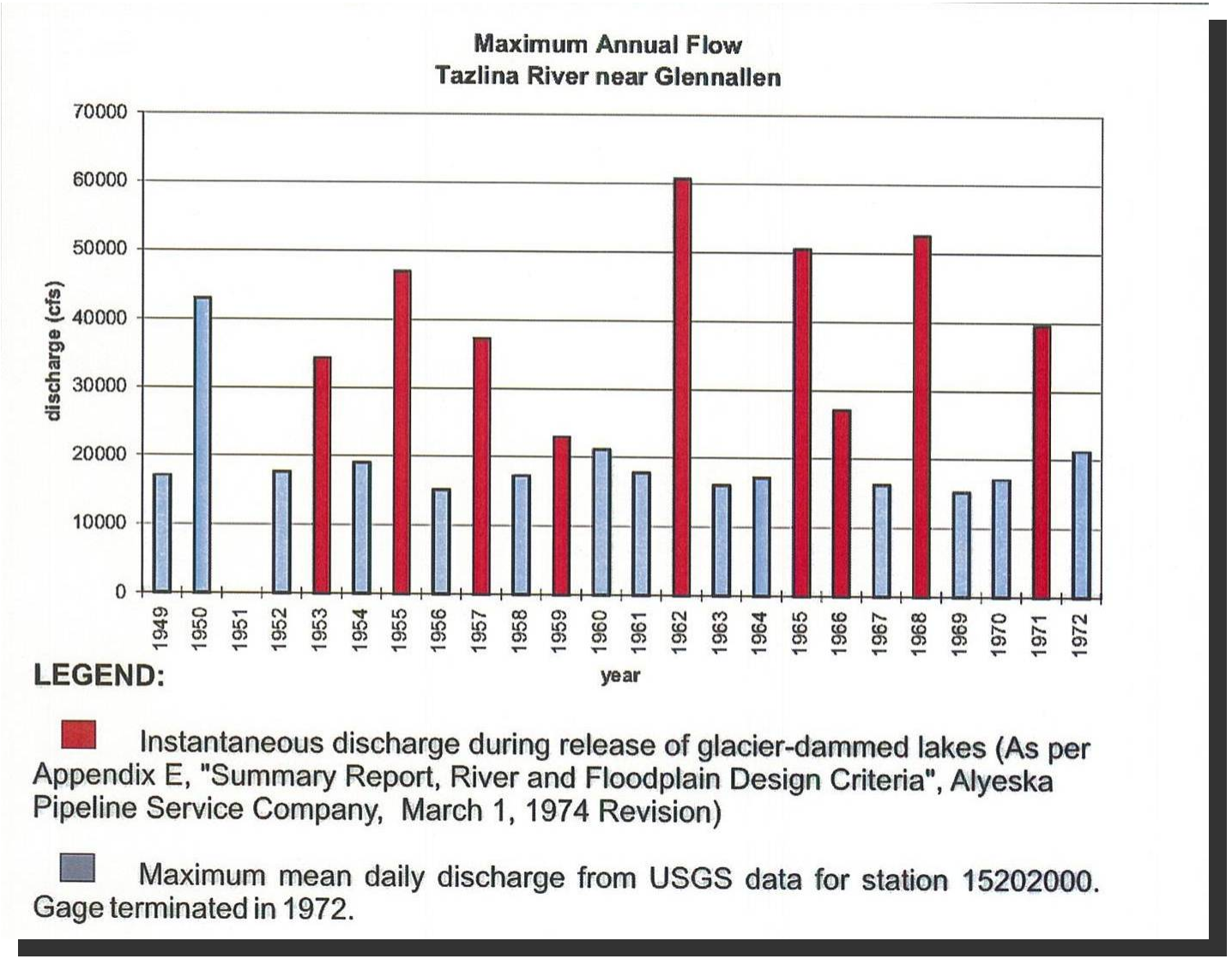
1. TAPS, ALASKA (1997, 2006)
2. OCP ECUADOR (2002)
3. NORANDINO, ARGENTINA (2000)

EXTREME EVENTS - GLACIER DAMMED LAKES



Alaska

EXTREME EVENTS - IMPACT OF LAKE RELEASES

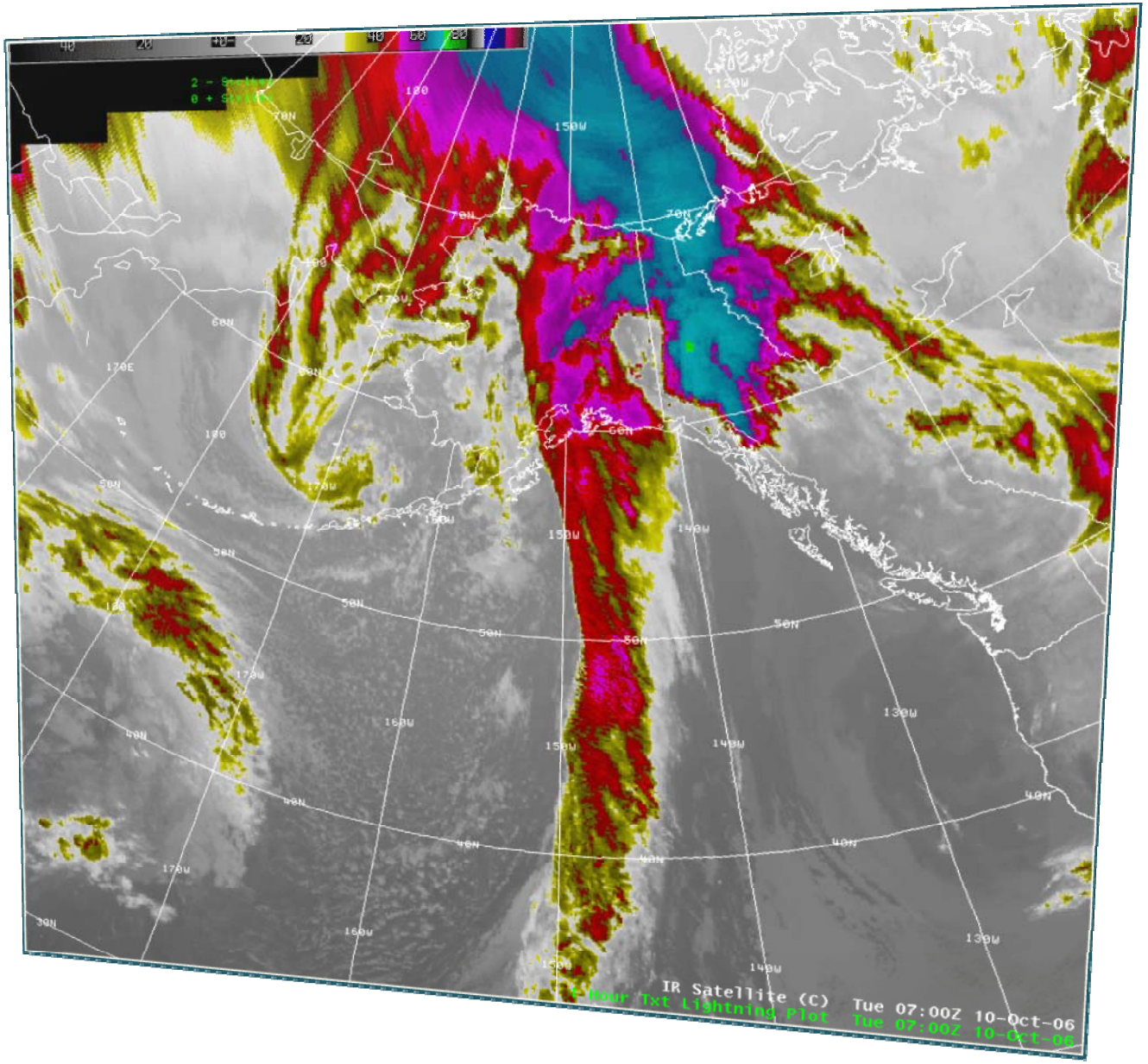


EXTREME EVENTS - A BREAKUP AT -40°

TAPS - TAZLINA RIVER

EXTREME EVENT

Value of personally experiencing an extreme event – TAPS Alaska



EXTREME EVENT - BEFORE

Ecuador - OCP - Rio Montana pre Nov. 3, 2002

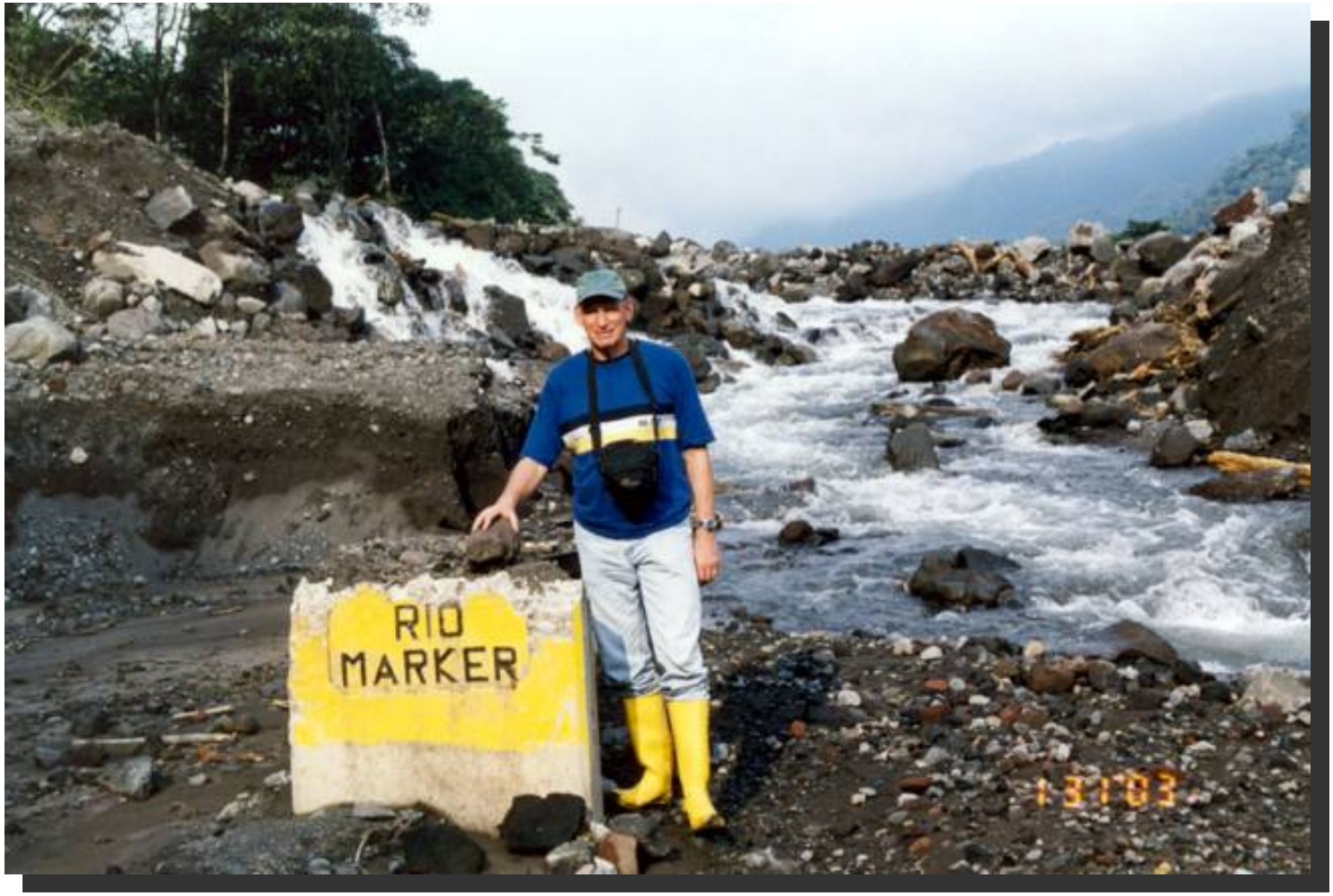
EXTREME EVENT

Ecuador - OCP
El Reventador, Nov. 3, 2002

EXTREME EVENT – THE IMPACT

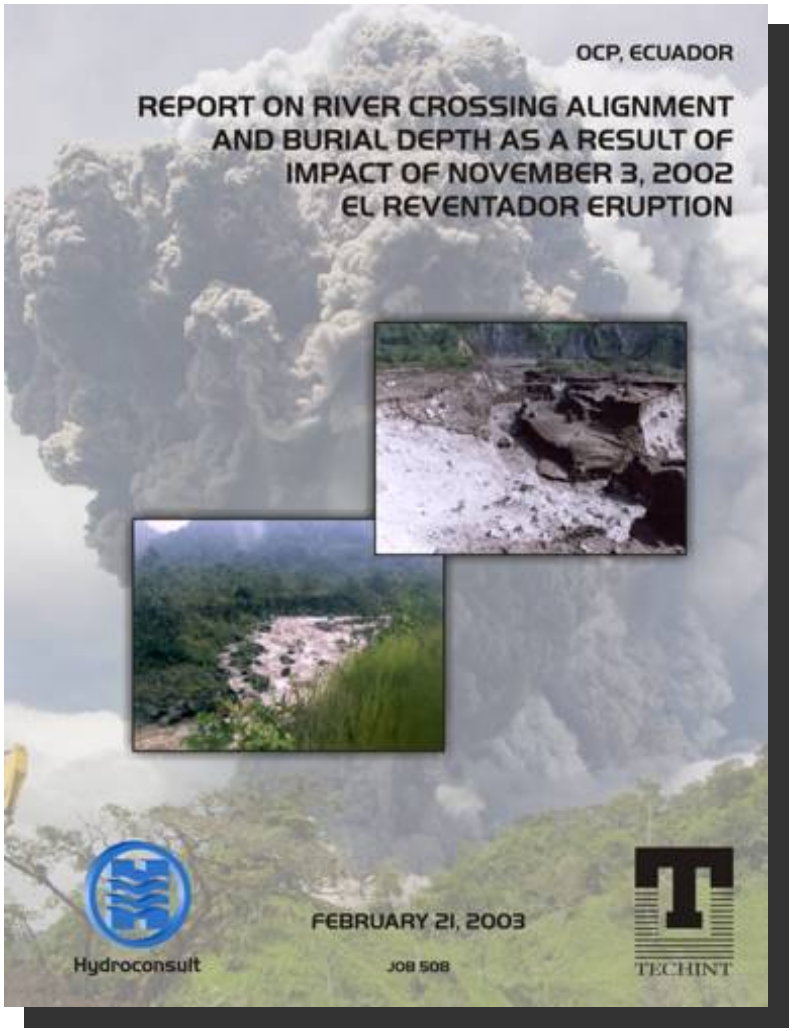
Ecuador - OCP - Rio Montana post Nov. 3

EXTREME EVENT – THE IMPACT



Ecuador -OCP - What Highway Bridge?

EXTREME EVENT – DESIGN / CONSTRUCTION RESPONSE



Ecuador - OCP

EXTREME EVENT – BURIED HOMES

Ecuador - OCP - Deadly Landslides, June 2001

EXTREME EVENT - UNIQUE SOLUTIONS

Ecuador - OCP - Landslides – Re-route Assessment

EXTREME EVENT – THE IMPACT

Argentina - NorAndino - Debris Flows

EXTREME EVENT– REDESIGN

Argentina - NorAndino - Realignment/Non-Rock

7. CLIMATE CHANGE

1. ANALYSIS OF HISTORIC DATA
   - Temperature
   - Flow
2. EXTRAPOLATE TO THE FUTURE
   - Impact on project design
     - Mackenzie Gas Pipeline (2005)
     - Bow City Coal / Thermal Project (2004)
3. USED AS A "CRUTCH" IN FAILURES / IMPACTS
   - Saint John River, NB – Ice Jams – Railway Bridges – 1980's
   - Peace – Athabasca Delta, AB / NWT – Impact of Bennett Dam (2004)

IMPORTANCE OF DATA

	Low	Medium	High
Streamflow			
Peak	-	X →	X
Low	X →	X	-
Water Level			
Open Water	-	X →	X
Ice + Flow	-	-	X

TRADITIONAL KNOWLEDGE

WHAT IF

WHAT IF	HOW DETERMINED	IMPACT ON OPERATION	IMPACT ON THE ENVIRONMENT	POTENTIAL MITIGATIVE MEASURES – IF NECESSARY
1. Silt or sand deposits in the Mixing Channel	From surveys and visual observations, the latter best done in non-tidal and low river flow periods.	Could reduce flow in the mixing channel – a bar would have a minimal impact on the flow. However, deposition across the full width of the channel could reduce flow during low flow conditions. This is expected to have little or no impact on the available flow for water withdrawal or the performance of the outfall.	A significantly reduced flow would increase salinity concentrations in the channel. Depending on the natural salinity in the river, the resultant salinity in the channel would still be expected to be well below the maximum natural salinity values in the river.	Remove the deposited material using a backhoe or small portable dredge. Undertake this work in the least sensitive period (from an aquatic viewpoint).
2. Scour of the bottom or erosion of the banks develops in the Mixing Channel	From surveys and visual observations – best done in non-tidal and low river flow periods.	Expected to have little impact on the magnitude of flow in the mixing channel and thus the operation of the intake and outfall.	Expected to have little impact if the scour and bank erosion is limited. Significant bank erosion could alter velocity patterns which could lead to non-uniforms mixing of the flow in the channel.	Place more and/or larger armour material on the bed and banks of the mixing channel.
3. Mixing of the Brine Water with the flow in the Mixing Channel is not as modelled	Salinity measurements in the channel upstream and downstream of the outfall are higher than predicted herein.	None, except in the instance where the outfall flow affects the salinity of the water withdrawal from the channel. This could reduce the efficiency of the brining process.	Depending on the magnitude and spatial extent of the variances – actual versus modeled results – there could be a minor to moderate environmental impact.	Modify the outfall structure or add additional air lines to ensure full mixing of the brine and mixing channel flow. In an extreme nonconformance case, that can not be remediated by modifying the outfall structure, the magnitude of outflow might need to be reduced at certain times.

Client's Concerns | Regulatory Concerns | Joint Concerns

CHALLENGE THE CONVENTIONAL

LIFE CYCLE - APPROACH

EXTREME EVENT

THANK YOU – WIM VELDMAN