OPERATION AND MAINTENANCE OF MOUNTAIN PIPELINES

Manuel Ponce, Andrés Mellace and Martín Carnicero

INDEX

- TGN
- Mountain Pipelines
- Andes mountains
- Mountain Pipeline: Main Geohazards. (Landslides and River crossings)
- Analysis and examples of mitigation works
- O&M Mountain Pipelines- Peculiarities

TGN

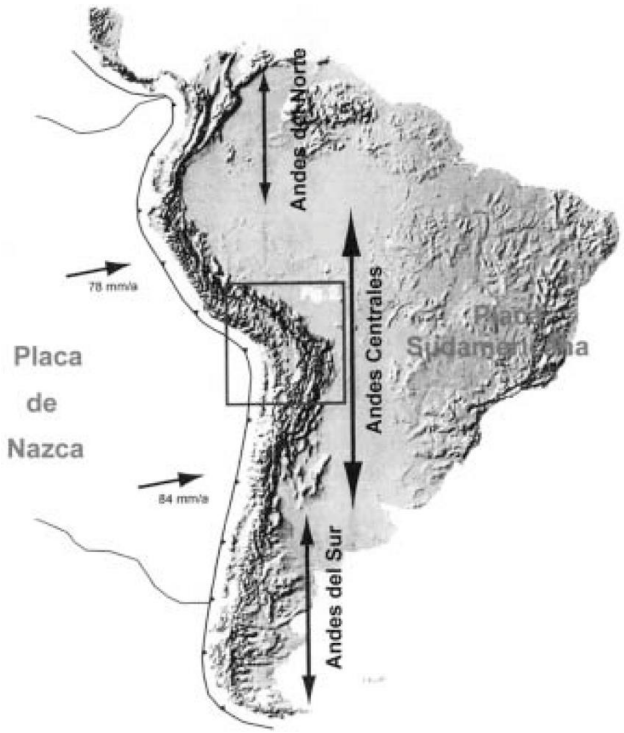
- TGN is one of the main natural gas transportation Companies in Argentina and South American.
- It operates and maintains more than 11,000 kilometers of natural gas pipelines for its own system and associated clients.
- 20 Compressor stations and 60 MMm3/d transportation capacity

TGN : Pipeline Mountains

- TGN operates and maintains approximately 1,000 km of natural gas mountain pipelines in the north and south of the country.
- Natural gas pipelines cross the Andes mountain range from east to west.
- In the northern zone, TGN operates in both Argentina and Chile.

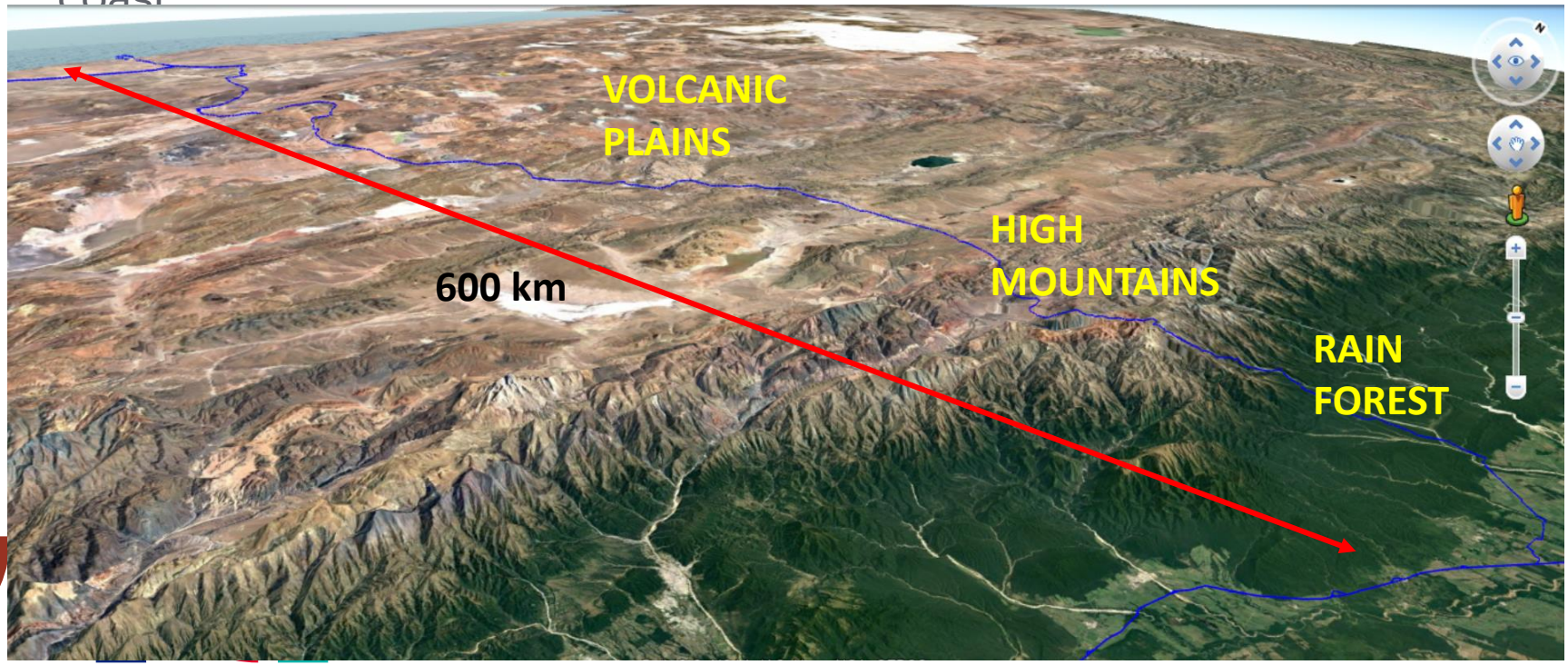
Andes Mountains

- Andes mountain range, 8500 km long, is the longest on the planet and the second highest after the Himalayas system .
- It has a variable width between 250 and 700 km and an average height between 3000 and 4000 m , with a maximum of 6963 m.
- It is made up of various types of climates and geomorphological environments.



Example Andes Mountains Pipeline

- The gas pipeline crosses the entire mountain range, crossing rain forest, high mountains and volcanic plains until it reaches the Pacific Ocean coast



Geohazards

Main features-Rain forest: Heavy rainfall, highly weathered soils, saturated soils:

associated geohazards: meandering rivers, translational and rotational Landslide, creep, subsidence and elevated seismic dangerousness

Main features-High mountains: steep slopes, heavy colluvial layer, river mountain, wide thermal range:

associated geohazards: translational Landslide, Rock Falls, topple, scour, longitudinal and transversal erosion, debris flows, and elevated seismic dangerousness

Main features-Volcanic plains: desert environment, poor rainfall, scarce vegetation, highly erodible soils.

associated geohazards: mud flows, longitudinal and transversal erosion and moderate seismic dangerousness

Geohazards Control (Landslides)

TGN is involved in:

Risk analysis (determination of the landslide hazard based on classifications by different authors)

POF (Probability of failure, interaction pipe-soil).

Control and Monitoring

- ILI (in line inspection):
- Inertial tool, Pipeline movement, bending strain)
- Field survey
- Geodetic measurement
- Inclinometers
- Rock extensometers
- Pluviometer
- Strain Gauges

Geohazard Characterization Activity
Review of technical literature
Evaluation of maps and imagery
Prelim. determination of design parameters
Probabilistic seismic hazard assessment
Remote sensing imagery interpretation
Field reconnaissance
Geologic and geomorphological mapping
Topographic profiling
Soil stratigraphic analysis to date landforms
Subsurface geotechnical exploration
Paleoseismic trench excavation
Dating of geologic deposits
Final determination of displacement parameters

Geohazards Control (Landslides)

TGN is involved in:

Mitigation and remediation works

- Route Change
- Stress Relief
- Tunneling
- Slope stabilization

Geohazards Control (Landslides)

Example Mitigation and remediation work

- Route Change and tunneling

Geohazard: Traslational landslide

In very fractured quartzite and Ph

Blocks.

Movement evidenced by:

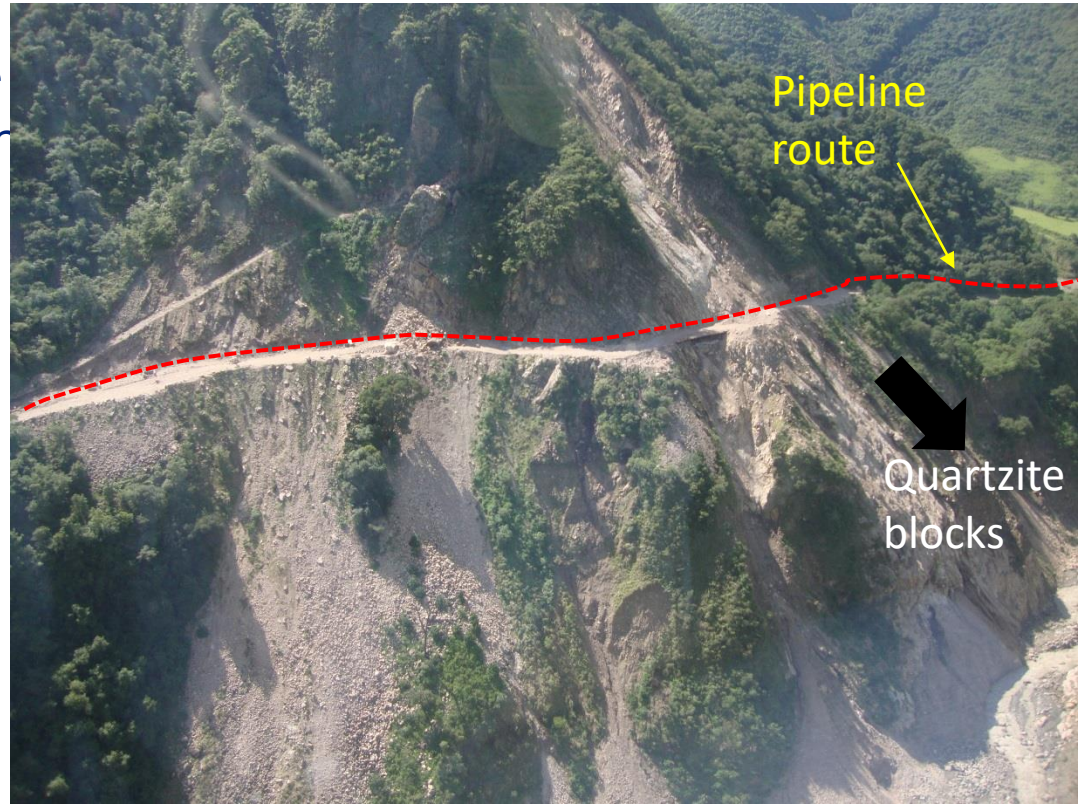
Inclinometer

Strain gauges

Geodetic measurement

ILI

Rock extensometers

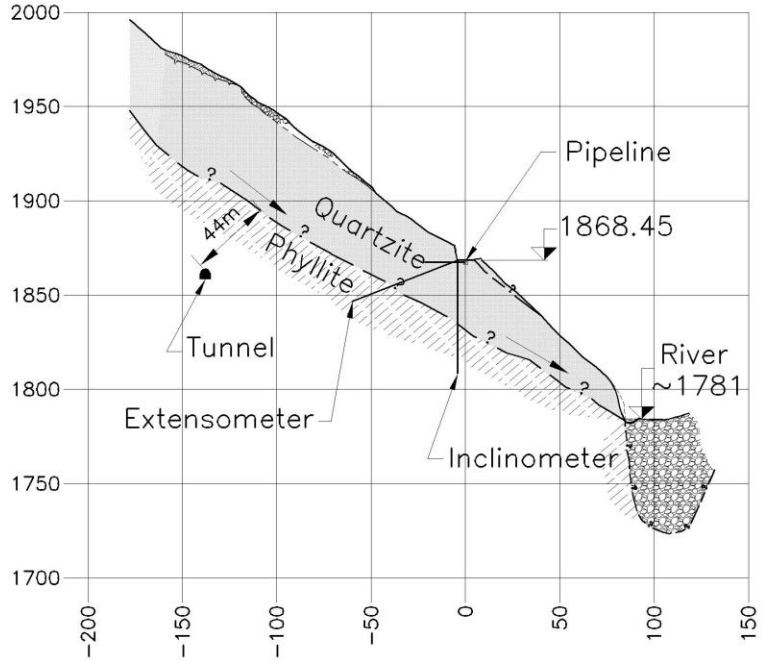


Geohazards Control (Landslide)

Example Mitigation and remediation work

- Change of route and tunneling

Construction of a 750 m long tunnel, section (2.5 m x 2.5 m) with a radius of curvature of 1000 m. The types of rocks excavated are phyllites and quartzites.



Geohazards Control (Landslide)

Views of the construction of the tunnel and placement of the pipeline

Geohazards Control (Slow Landslide, localized creep)

Example Mitigation and remediation work

Stress relief

Geohazard: CREEP (Localized slow landslide) on thick alluvial deposit

.

Movement evidenced by:

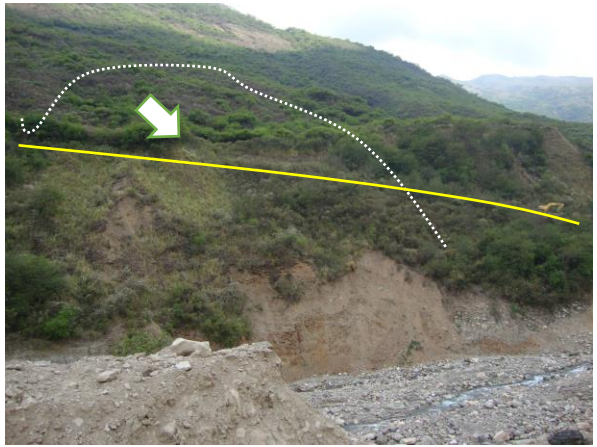
ILI

Geodetic measurement

Direct observation of pipeline through measurement chamber.

Geohazards Control (Slow Landslide, localized creep)

Stress relief :Excavation, stress relief, pipe insulation using steel rings, periodic measurements.



River crossings: context

- TGN did not participate in the design of the pipeline

- TGN is involved in:
  - Monitoring
  - Risk analysis
  - Definition of remediation works

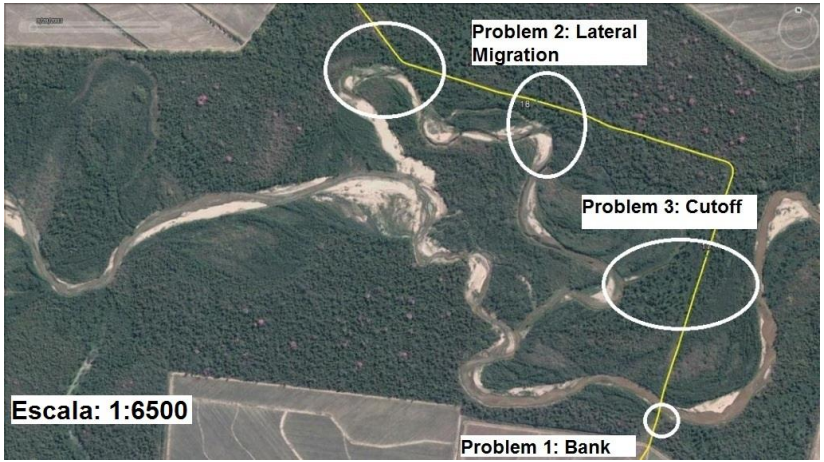
- Owner becomes its own contractor company for remediation works

River crossings

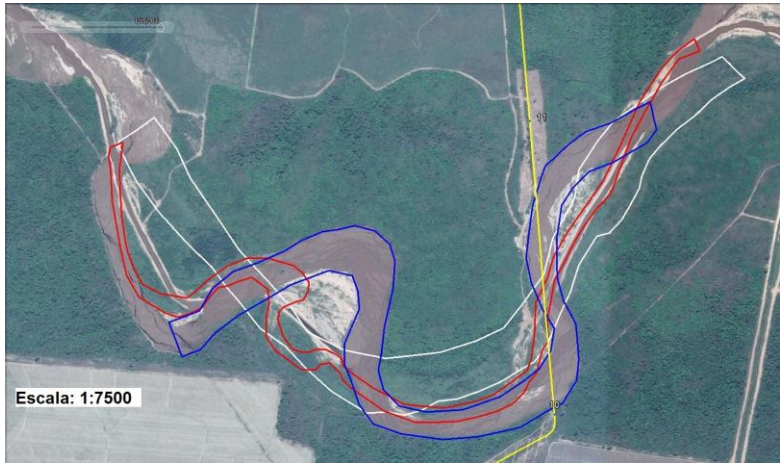
- Four different environments that control river-pipeline interaction:
  - Foothills: intermediate to low slope, rivers characterized by lateral migration of meanders
  - Braided rivers: intermediate slope, affecting mainly river banks
  - Mountain range rivers: very high slope (high water velocity), triggering vertical scour and bed degradation + debris flows
  - Deserts: minimum rain triggers flush floods

Meanders at foothills

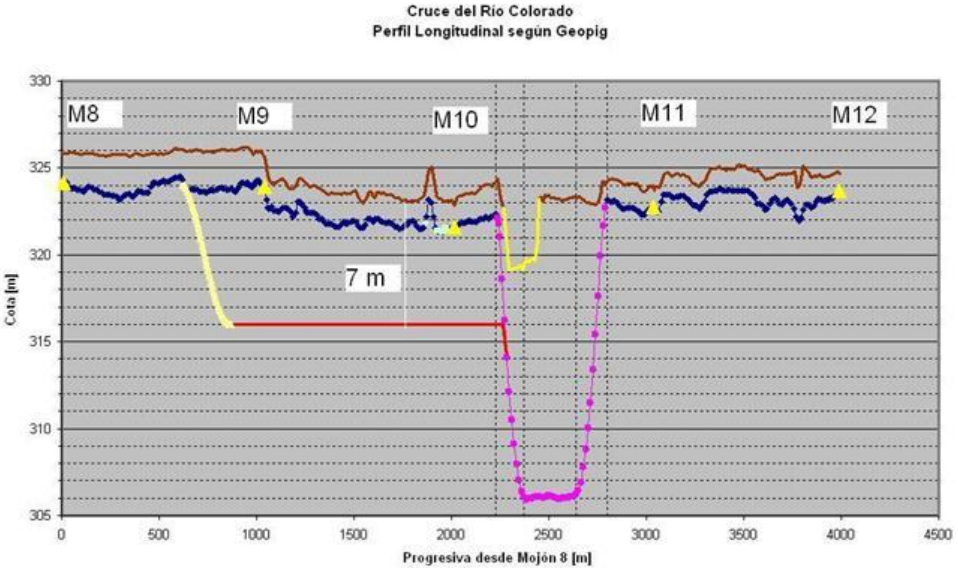
Santa María River



Colorado River (HDD)



Solution: in-service pipeline lowering by natural flexion



Braided rivers: bank restitution by series of jetties

Blanco River eroding banks

Series of spurs

Mountain rivers: debris flow

Mountain rivers: steep gradient + high water velocities + debris flows
Route change to wider river section + pipeline deepening (6 m +)

Original route at a narrow

New route, upstream, at a wider river section ay 6m+ depth

Mountain rivers: steep gradient + high water velocities + debris flows
Aerial crossing

Rivers at Atacama desert: mean annual precipitation ~ 42 mm
Solution: in-service pipeline lowering by natural flexion

Monitoring

- Monitoring team present at camps during rainy season (December-April) sending a daily report (pictures, rainfall measurements, depth of cover)
- Periodic visits by integrity natural hazards specialists
- Frequency: every month + visits after a 60 mm event + at the end of the rainy season (report)
- Depth of cover measurements when water discharges are low + at the end of the rainy season
- Geo-referenced topographic measurements
- Helicopter flights to identify landslide dams and lakes

O&M Mountain Pipelines- Peculiarities

- Difficult accessibility during rainy season
- Greater risk of damage due to climatic phenomena or geological effects
- Greater probability of requiring emergency operation in gas pipeline valves
- Requirement of vehicles with higher performance
- Work at geographical height (more than 4000 meters above sea level)
- No electrical power

Difficult accessibility during rainy season

Permanent base

Transient camp (rainy season December-April)

- Trained staff
- Communications systems
- Mobility
- In-situ heavy equipment

Difficult accessibility during rainy season

In-situ heavy equipment assistance ensures accessibility during rainy season

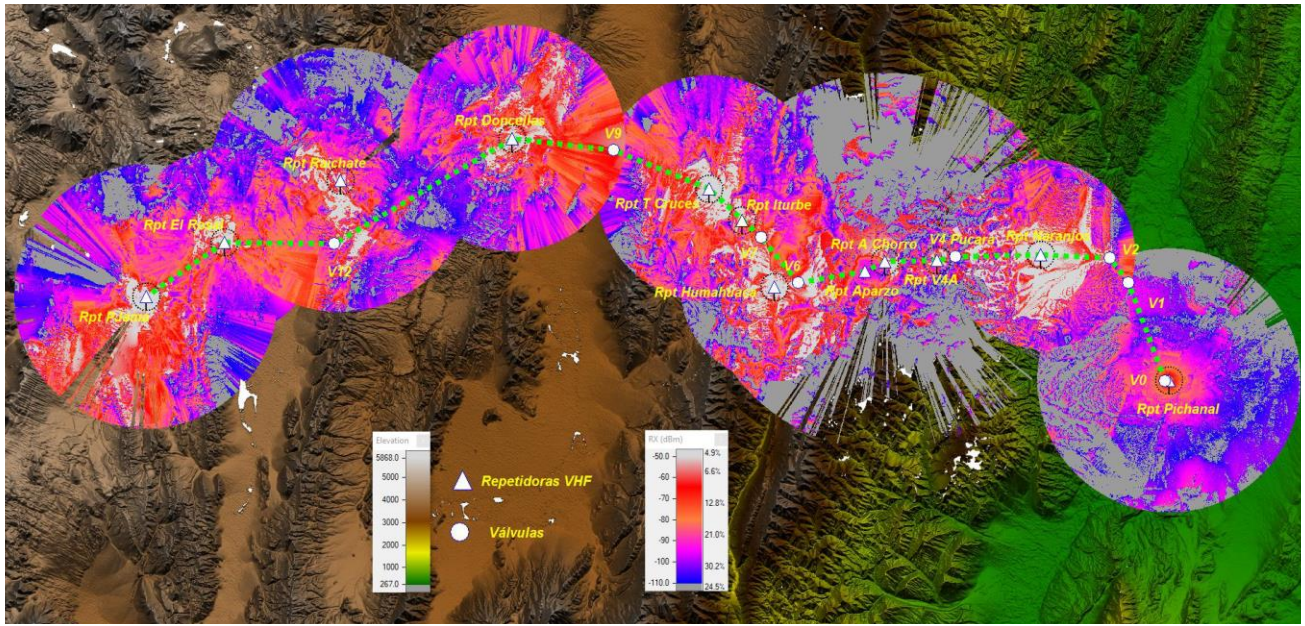
Greater probability of requiring emergency operation in gas pipeline valves

- Remote control of line valves
- VHF

11 Communications Stations in Argentina and 17 in Chile supplied by solar or thermal energy

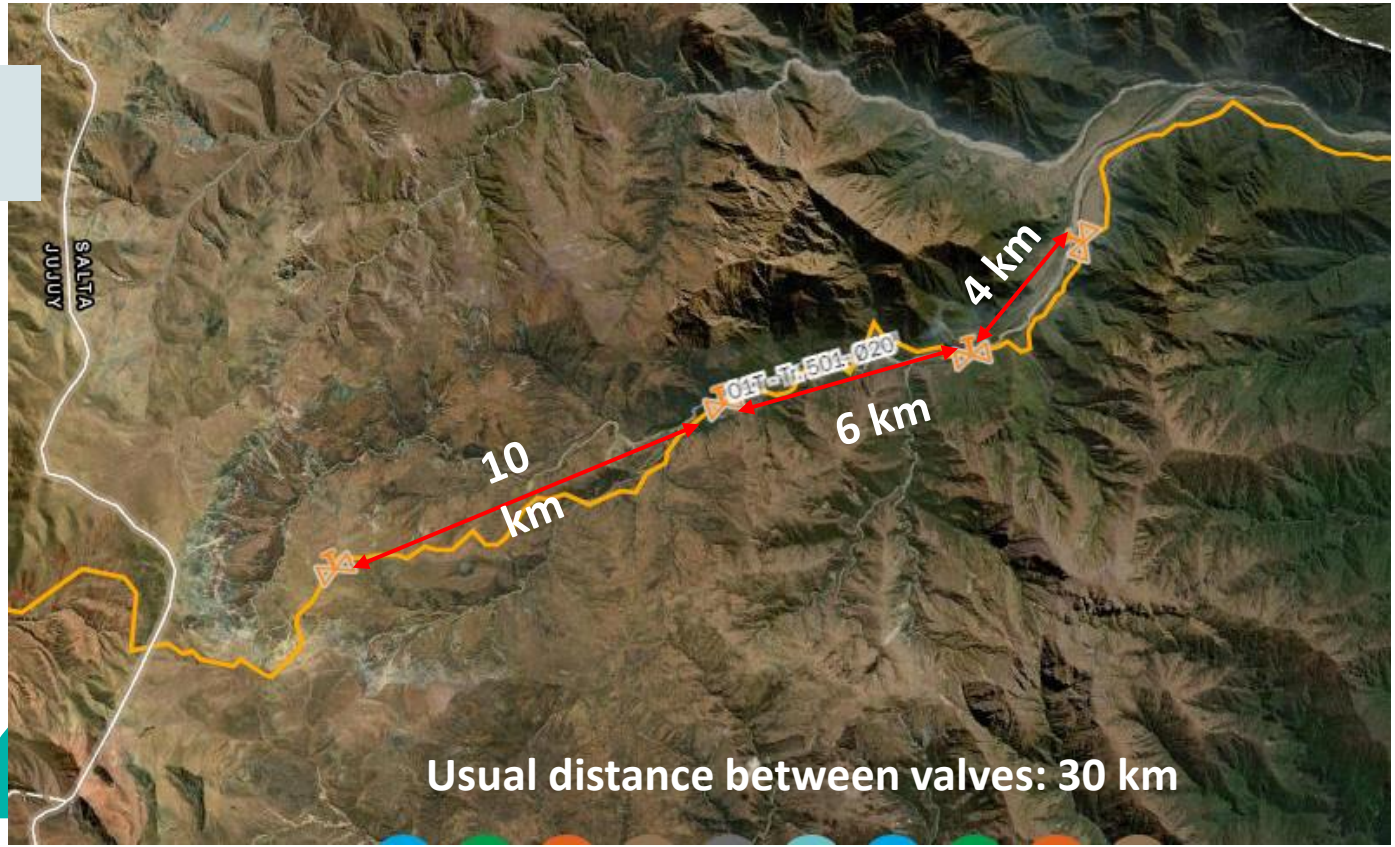
Greater probability of requiring emergency operation in gas pipeline valves

VHF range



Greater probability of requiring emergency operation in gas pipeline valves

Shorter distance between valves



Thank you very much !!!

Contacts

- Andres Mellace (O&M General Manager)

  Andres.MELLACE@tgn.com.ar

- Manuel Ponce, Geologist, Senior Integrity Geologist, Natural Hazards

  Manuel.Ponce@tgn.com.ar

- Martin Carnicero, Hydraulic Engineer, Senior Integrity Engineer, Natural Hazards

  Martin.CARNICERO@tgn.com.ar

RELATED PAPERS

RIO PIPELINE

- 2003: IBP505_03: RIVER CROSSINGS: A DECISSION MAKING SCHEME FOR THE EXECUTION OF PROTECCION WORKS”
- 2007: IBP1217_07: RIVER CROSSINGS: MONITORING OF GREAT RIVERS
- 2009: IB1346_09: RIVER CROSSINGS: COMBINING BASIC HYDRAULICS WITH PIPE PROTECTION
- 2011: IBP1297_11: RIVER CROSSINGS: A SIMPLE METHOD TO ASSES PROBLEMS BASED ON RIVER WATERSHED AND SLOPE
- 2011: IBP1309_11: RIVER CROSSINGS: MAINTENANCE OF HIGH-SLOPE MOUNTAIN RIVERS
- 2019: IBP1368_19 LOWERING AN-IN SERVICE PIPELINE AT THE LEFT BANK OF COLORADO RIVER

ASME INTERNATIONAL PIPELINE GEOTECHNICAL CONFERENCE

- IPG2013-1923: A RATING METHOD FOR ASSESSMENT RISK AT RIVER CROSSINGS
- IPG2013-1969: GEOTECHNICAL ASPECTS OF THE NORANDINO PIPELINE AT MAL PASO
- IPG2015-8512: RIVER CROSSINGS: LESSONS LEARNED FROM LOWERING PIPELINES BY NATURAL FLEXION
- IPG2017-2546: RIVER CROSSINGS: EVALUATION OF MEANDER MIGRATION AS AN INTEGRITY HAZARDD
- IPG2019-5320: RIVER CROSSINGS: DEVELOPING A MOBILE GIS APPROACH TO MONITORING ACTIVITIES