BRASS

1st International Seminar

on Design and Operation of Long-Distance Transportation Pipeline Systems

26th & 27th September 2024

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Mining Industry – Fluid Transport Integrity Management System

Pipeline Integrity Management System (PIMS)

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In mining industry, pipeline systems are critical assets for the business, therefore, failures/downtime has a profound impact. There are two main reasons for this high-risk level:

- Human error (operating the pipeline out of its operating range that can cause either accelerated wear or plugging).
- Susceptible to pilferage and sabotage.

As an effect, any pipeline failure will impact Community's Safety and threaten Environmental contamination.

Thus, the integrity management system strives to provide tools that allow control and risk relieving, addressing holistically and systematically all the threats that may impact the systems integrity, ensuring a safe operation during its lifespan.

We Want to Avoid

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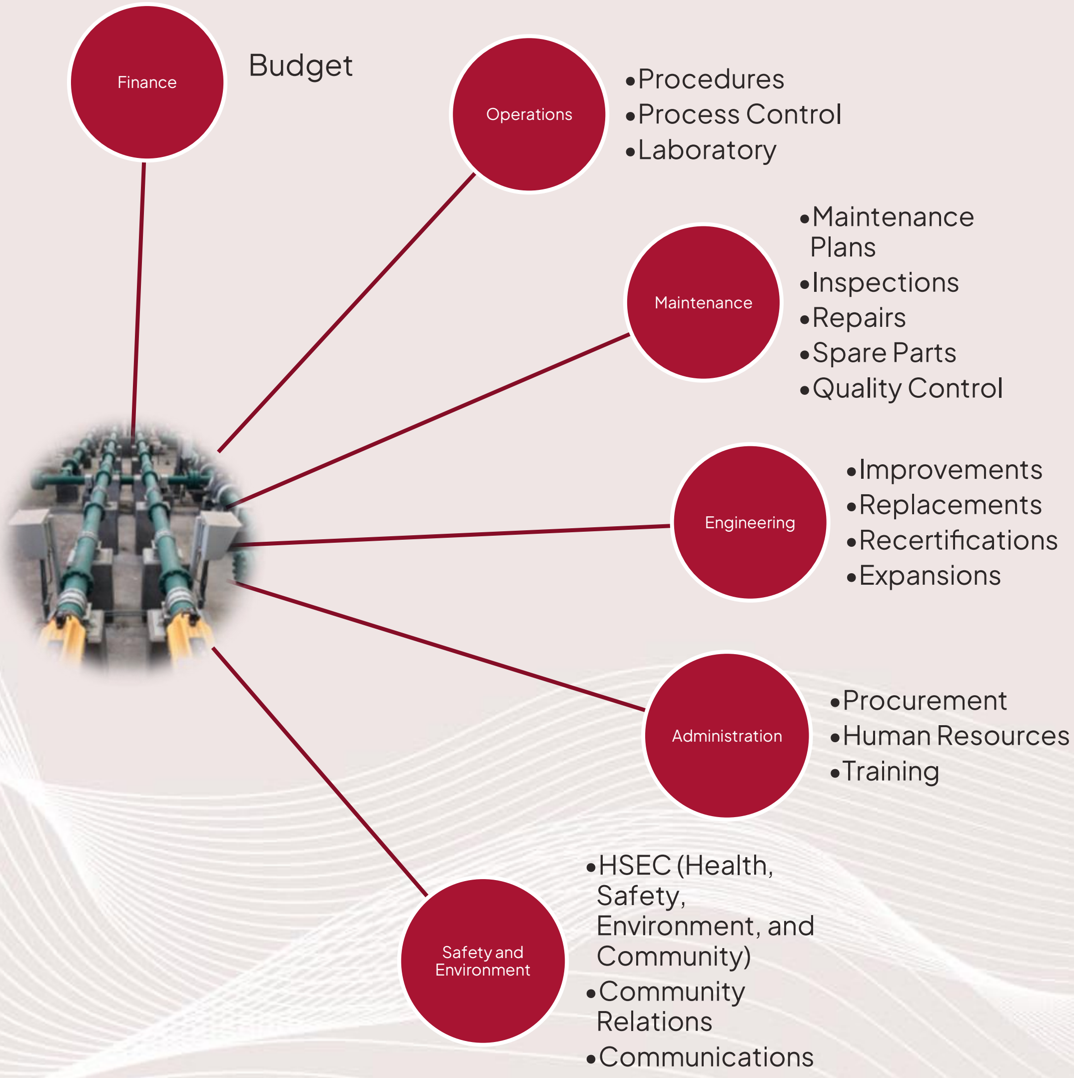
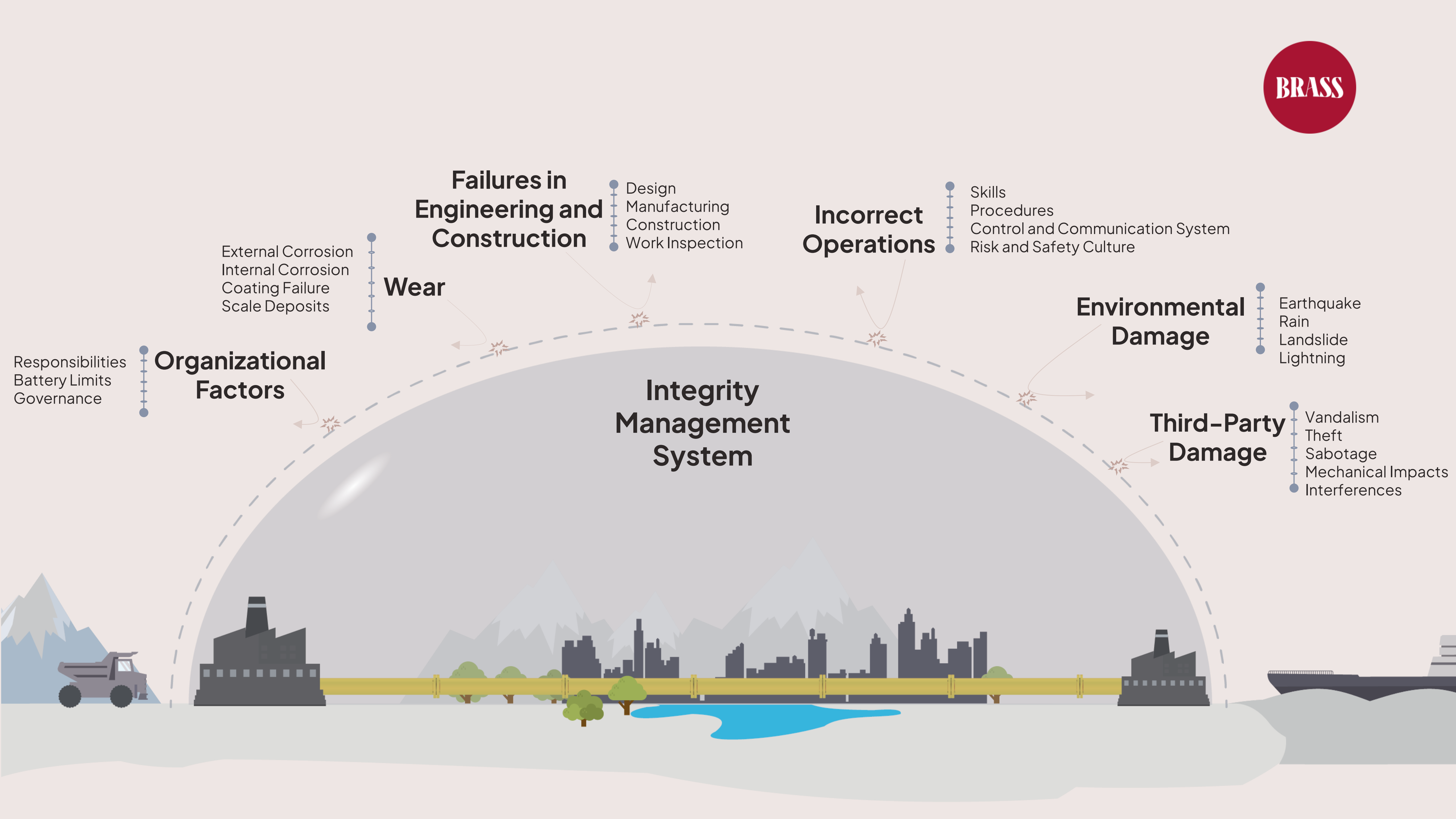
- Community Disruption
- Environmental Contamination
- Safety Issues
- Legal Issues
- Financial Issues
- Erosion of Reputation

Pipeline Integrity Management System

The PIMS is a set of policies, processes, and procedures developed to ensure the operational continuity of Fluid Transportation Systems throughout its life cycle. The aim is to minimize risks associated with operational losses, environmental impact, and community disruption.

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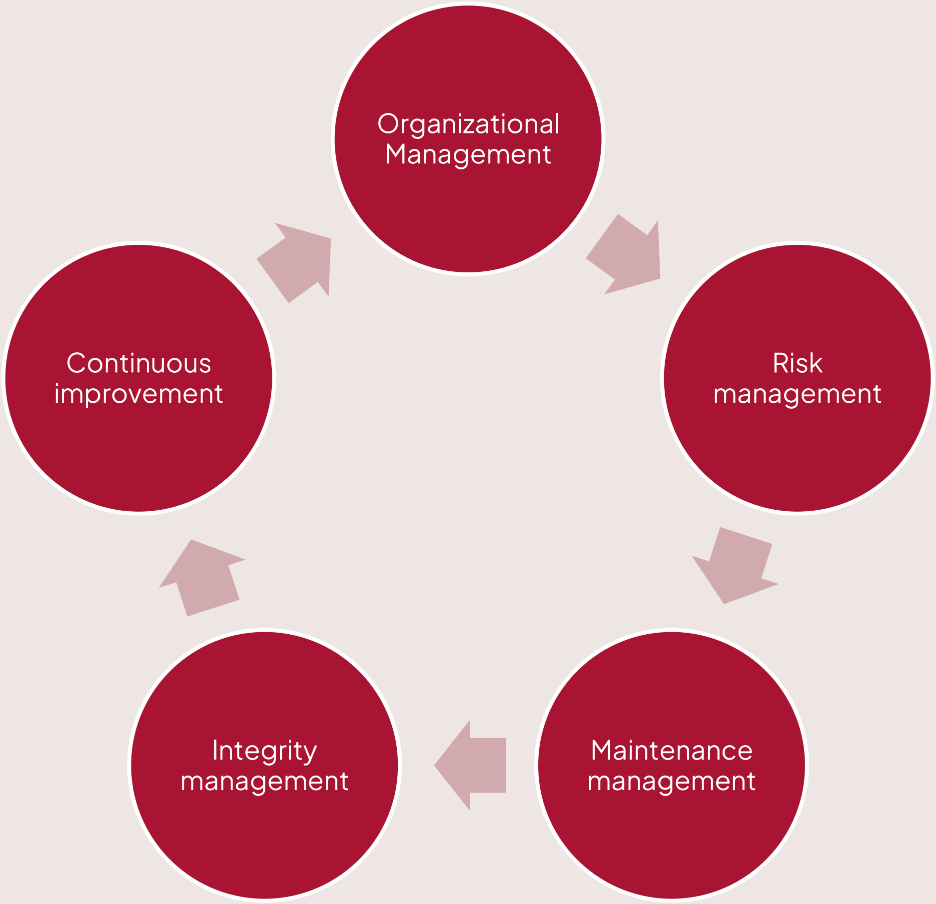
Failures in Engineering and Construction
Design
Manufacturing
Construction
Work Inspection
Incorrect Operations
Skills
Procedures
Control and Communication System
Risk and Safety Culture
External Corrosion
Internal Corrosion
Coating Failure
Scale Deposits
Wear
Environmental Damage
Earthquake
Rain
Landslide
Lightning
Responsibilities
Battery Limits
Governance
Organizational Factors
Integrity Management System
Third-Party Damage
Vandalism
Theft
Sabotage
Mechanical Impacts
Interferences

Pipeline Integrity Management System

1. **Identify, assess, and manage threats** of all Fluid Transport System components, establishing necessary actions to ensure the integrity of these systems and mitigate the risks of failure occurrence.
2. Define the **governance and specific responsibilities** of all stakeholders, providing a clear organizational structure.
3. Define the **battery limits** of each System to ensure that each control is under specific responsibilities, and that those responsible are fully aware of their duties and obligations.
4. Establish **key indicators** to measure and evaluate the integrity of the Systems.
5. Keep risk owners **informed**, senior management, and all stakeholders regarding **management of controls** related to identified vulnerabilities.



Key elements of the Pipeline Integrity Management System

1. **Reliable Design**: Ensure optimal design standards from the project's inception by selecting appropriate materials and establishing robust operational and maintenance procedures.

2. **Comprehensive Commitment**: Promote active collaboration across all company areas to maintain the integrity of fluid transport systems.

3. **Continuous and Evolving Process**: Constantly adapt the system to operational, physical, and environmental changes over time. Integrate all relevant information to make timely and effective decisions in risk detection and mitigation.

4. **Information Integration**: Collect, analyze, and integrate all relevant information to make timely and effective decisions in risk detection and mitigation.

5. **Risk-Based Management**: Use risk analysis to identify threats, assess their probability and severity, and establish a prioritized response plan.

6. **Performance Evaluation**: Conduct regular assessments to monitor and continuously improve the management of duct integrity.

PIPELINE INTEGRITY MANAGEMENT PLAN

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BRASS METHODOLOGY FOR DEVELOPING THE INTEGRITY MANAGEMENT PLAN

Step 1	Step 2	Step 3	Step 4	Step 5
Threat Identification	**Risk Assessment**	**Integrity Management Plan**	**Execution**	**Evaluation**
Background Events Threats	Classification Probability Consequence	Controls Prevention Mitigation	Frequency Responsible Parties Criteria	Audit Performance Gap Plan

Diagnosis	Development	Execution and Control

THREAT IDENTIFICATION

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Step 1

Threat Identification

Background
Events
Threats

Threats Identified by ASME B31.8S:

1. External corrosion
2. Internal corrosion
3. Defective seam pipe
4. Defective pipe
5. Defective circumferential pipe weld
6. Defective fabrication weld
7. Wrinkles and/or bends in the pipe
8. Poorly designed joints (steel pipe and HDPE)
9. Direct damage caused by second or third parties
10. Previous damage to the pipe (delayed failure modes)
11. Pipe body failures, coupling joint failures
12. Vandalism
13. Incorrect operational procedures
14. Fatigue
15. Extremely cold or hot environment
16. Lightning (strikes)
17. Heavy rains or floods
18. Ground movements (earthquakes)

Threats Identified for Slurry Transport Systems:

1. Scale formation
2. Internal wear due to abrasion
3. Wear on valves and chokes
4. Joint failures
5. Liner failure (HDPE)
6. Rheology/Granulometry parameters out of specs
7. Pipeline Leak
8. Plugging
9. Loss of seal in emergency ponds
10. Vandalism

RISK ASSESSMENT

Step 2

Risk Assessment

Classification
Probability
Consequence

Risk is the combination of the Probability of Failure (PoF), an event occurring during a specified period of interest and the usually negative consequences of Failure (CoF).

The objective of Risk Analysis is to determine the event that leads to loss of containment and with what probability. Mathematically speaking, risk is expressed as:

$$\text{Risk} = \text{PoF} \times \text{CoF}$$

Pipeline Segmentation

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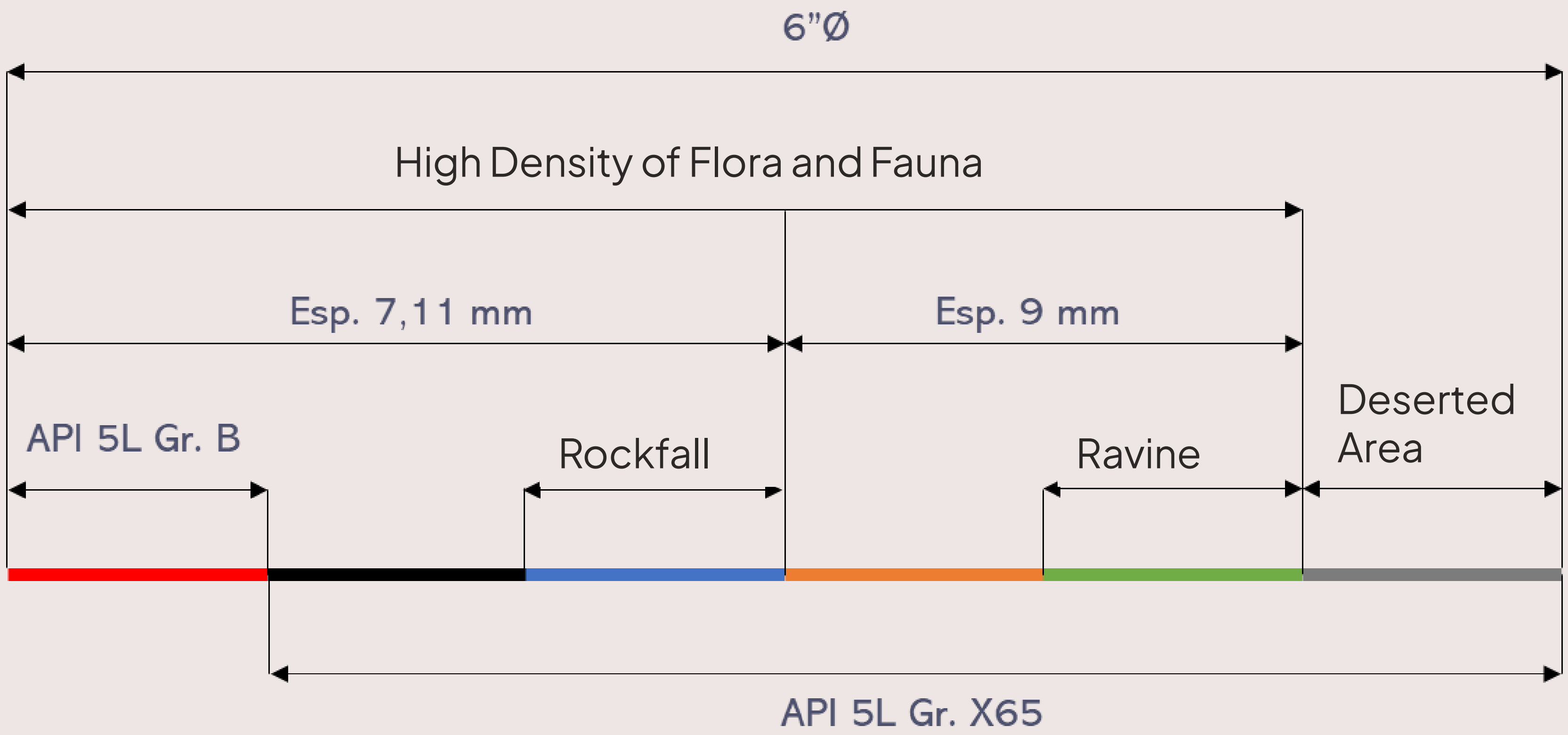

The aqueduct was divided into 44 segments, broken down by sectors as follows:

Sector **2000**
15 segments

Sector **3000**
16 segments

Sector **5000**
13 segments

ESTIMATION OF PROBABILITY OF FAILURE

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$$Risk = PoF \times CoF$$

$$PoF = (\% \times \text{Project}) + (\% \times \text{Wear}) + (\% \times \text{External Damage}) + (\% \times \text{Incorrect Operations})$$

PoF_Project	
Variable	**%**
Design	
Manufacturing	
Construction	
Work Inspection	

PoF_Wear	
Variable	**%**
External Corrosion	
Internal Corrosion	
Internal Erosion	
Cracking	

PoF_External Damage	
Variable	**%**
Environmental Damage	
Third-Party Damage	

PoF_Op. Incorrectas	
Variable	**%**
Procedures	
Competency Management	
Risk and Safety Culture	
Communications	
Inspection	
Integrity Validation	
Operations Management	

ESTIMATION OF PROBABILITY OF FAILURE

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Risk= PoF x CoF

PoF = (% x **Project**) + (% x **Wear**) + (% x **External Damage**) + (% x **Incorrect Operations**)

FACTORS FOR PROBABILITY OF FAILURE DUE TO DETERIORATION		POINTS	%
A	EXTERNAL CORROSION		40
A.1	Soil Condition	0 - 20	
A.2	Coating	0 - 10	
A.3	Cathodic Protection	0 - 10	
	External Corrosion Factor		
B	INTERNAL EROSION		50
B.1	Presence of solids in the fluid	0–30	
B.2	Changes in geometry and/or conditions	0–20	
	Internal Erosion Factor		
D	CRACKING		10
	Cracking Factor		

A.1	Soil Condition	POINTS
Resistivity	> 10.000 ohm/cm	
	10.000 – 2.000 ohm/cm	
	< 2000 ohm/cm or unknown	
pH	> 7,5	
	6,5 - 7,5	
	< 6,5 or unknown	
Sulfates	0 – 150 ppm	
	> 150 ppm or unknown	
Chlorides	0 – 100 ppm	
	> 100 ppm or unknown	
Presence of Carbonates	No.	
	Yes or unknown	
Humidity	≤ 20%	
	> 20% or unknown	
REDOX Potential	> 400 mV	
	< 400 mV or unknown	
Presence of Microorganisms	No	
	Yes or unknown	

ESTIMATION OF CONSEQUENCE OF FAILURE

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$$\text{Riesgo} = \text{PoF} \times \text{CoF}$$

$$\text{CoF} = (\% \times \textbf{People}) + (\% \times \textbf{Property}) + (\% \times \textbf{Environmental}) + (\% \times \textbf{Operation})$$

CoF_People	
Variable	**%**
Leak Detection	
Population Density	
Proximity	
Emergency Procedure	
Response Time	
Flow Cut Operations	
Health and Safety	

CoF_ Property	
Variable	**%**
Number of Residences	
Leak Detection	
Property Zones	
Infrastructure	
Emergency Procedure	
Response Time	
Flow Cut Operations	
Containment Measures	
Extent of Impact	

CoF_ Environmental	
Variable	**%**
Toxicity	
Leak Detection	
Spilled Volume	
Agricultural or Protected Area	
Wildlife Area	
Emergency Procedure	
Response Time	
Flow Cut Operations	
Containment Measures	
Watercourses	

CoF_ Operational	
Variable	**%**
Production Impact	
Leak Detection	
Financial Impact	
Sanction Detainment	
Emergency Procedure	
Response Time	
Flow Cut Operations	
Containment Measures	
Reputation	

ASSESMENT OF CONSEQUENCE OF FAILURE

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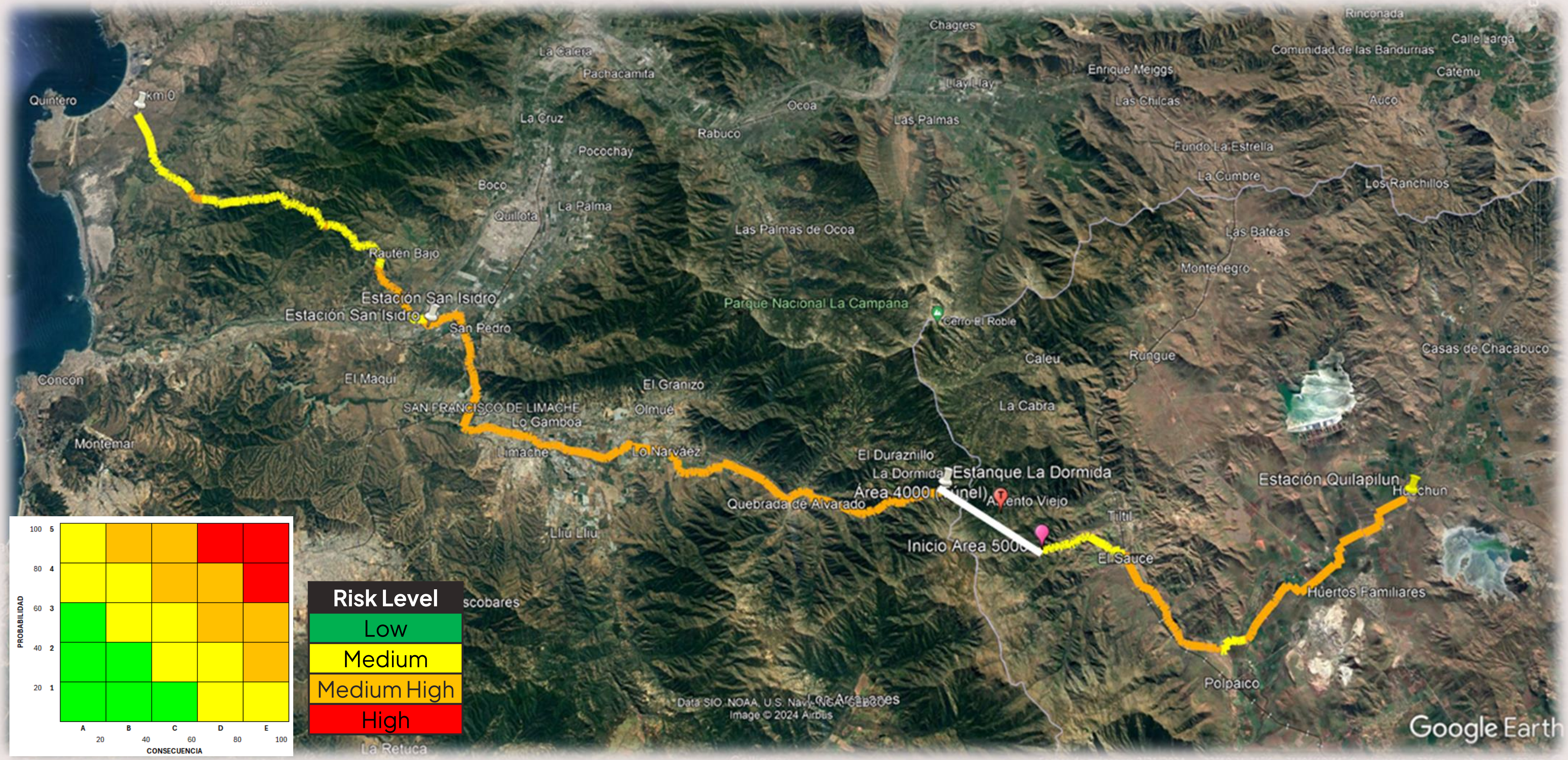
Risk= PoF x CoF

CoF = (% x **Safety**) + (% x **Environment**) + (% x **Community**) + (% x **Reputation**) + (% x **Legal**) + (% x **Economic Impact**)

FACTORS FOR CONSEQUENCE OF FAILURE		POINTS	%
B	ENVIRONMENT		
B.1	Spilled Volume	0 – 2	
B.2	Agricultural Area	0 – 6	
B.3	Wildlife	0 – 6	
B.4	Watercourses or Rivers	0 – 6	
	ENVIRONMENTAL FACTOR		

B.4	Watercourses or Rivers	POINTS
Route	Does not pass through rivers or watercourses	
	Passes through watercourses/rivers or unknown	
Vicinity	No rivers in the vicinity of the route	
	Next to, below, or above the river with containment	
	Next to, below, or above the river without containment	

RISK MAP


Quintero
km 0
La Calera
Pachacamita
La Cruz
Pocochay
Boco
Quillota
La Palma
Rabuco
Ocoa
Chagres
Llay Llay
Las Palmas
Enrique Meiggs
Las Chilcas
Rinconada
Comunidad de las Bandurrias
Calle Larga
Catemu
Auco
Fundo La Estrella
La Cumbre
Los Ranchillos
Las Bateas
Montenegro
Las Palmas de Ocoa
Parque Nacional La Campana
Cerro El Roble
Rautén Bajo
Estación San Isidro
Estación San Isidro
San Pedro
Concon
El Maqui
SAN FRANCISCO DE LIMACHE
Lo Gamboa
Limache
El Granizo
Olmué
Lo Narváez
Montemar
Caleu
Rungue
La Cabra
Casas de Chacabuco
El Durazrillo
La Dormida
Estanque La Dormida
Área 4000
Quebrada de Alvarado
Lliu Lliu
Inicio Area 5000
Tiltil
El Sauce
Estación Quilapilun
Huertos Familiares
Polpaico
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image © 2024 Airbus
La Retuca
Google Earth
PROBABILIDAD
100 5
80 4
60 3
40 2
20 1
A B C D E
20 40 60 80 100
CONSECUENCIA
Risk Level
Low
Medium
Medium High
High

RISK MAP

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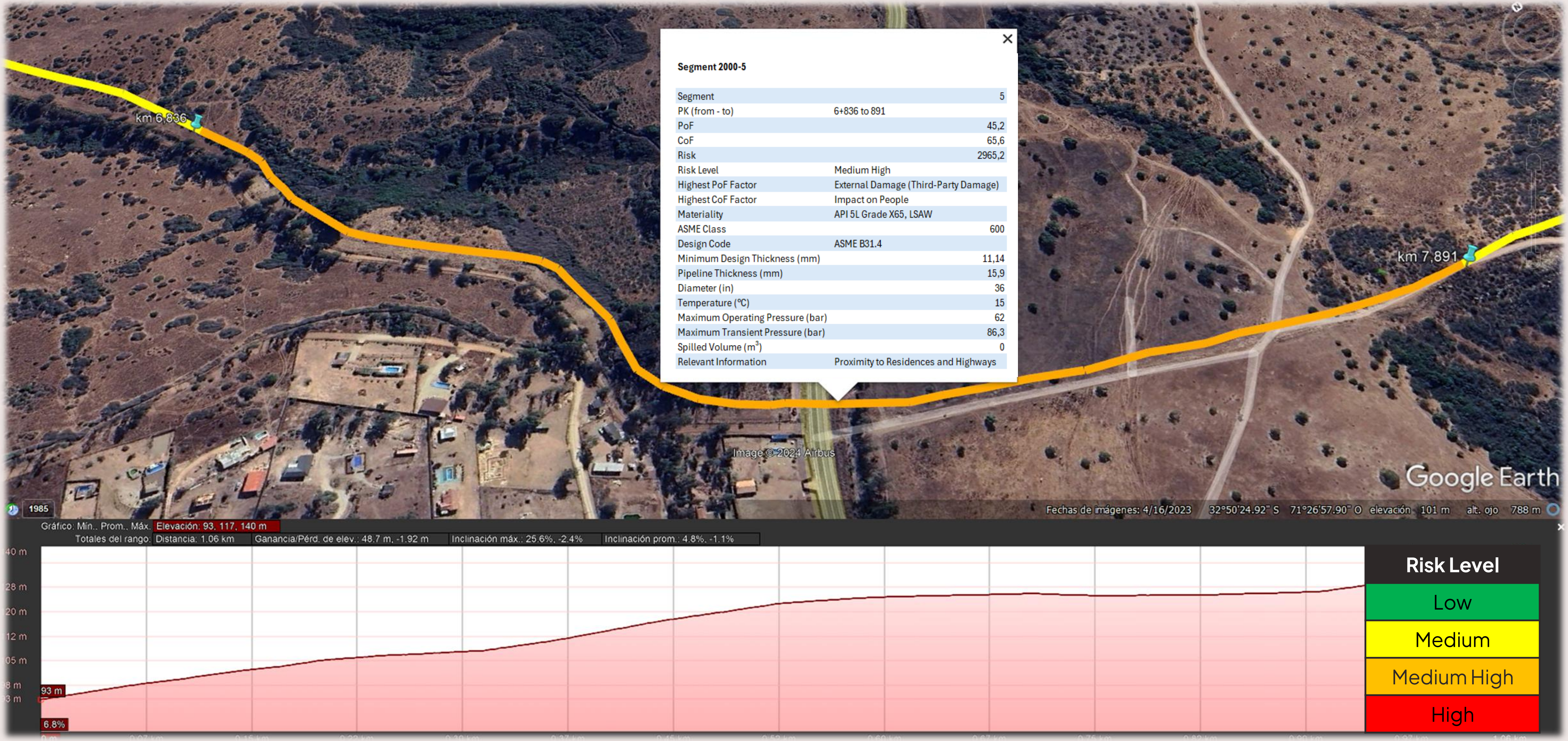

Segment 2000-5

Segment	5
PK (from - to)	6+836 to 891
PoF	45,2
CoF	65,6
Risk	2965,2
Risk Level	Medium High
Highest PoF Factor	External Damage (Third-Party Damage)
Highest CoF Factor	Impact on People
Materiality	API 5L Grade X65, LSAW
ASME Class	600
Design Code	ASME B31.4
Minimum Design Thickness (mm)	11,14
Pipeline Thickness (mm)	15,9
Diameter (in)	36
Temperature (°C)	15
Maximum Operating Pressure (bar)	62
Maximum Transient Pressure (bar)	86,3
Spilled Volume (m^3)	0
Relevant Information	Proximity to Residences and Highways

Risk Level
Low
Medium
Medium High
High

RISK ASSESSMENT

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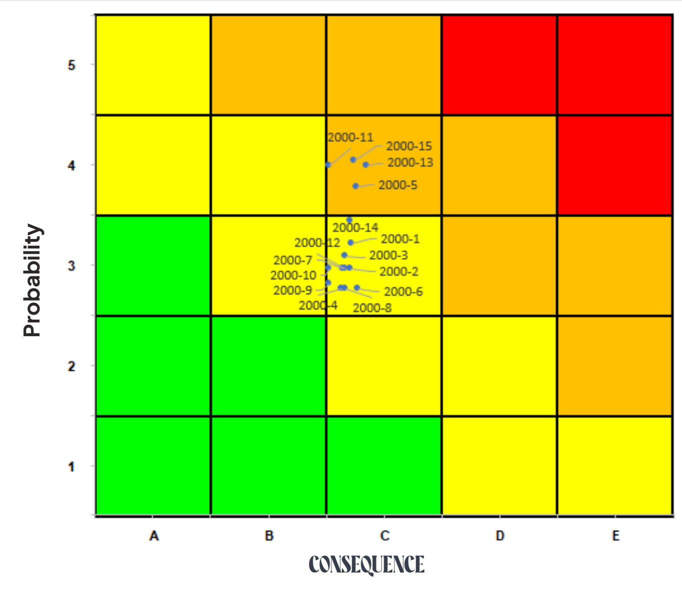

Example of Mitigation Activities by Risk Level

Activity	Location	Frequency - Risk Level			
		Slow	Medium	Medium High	High
Thickness Measurement (UT)	Stations	Annual	Annual	Semi-annual	Quarterly
External Visual Inspection	Stations - Aerial Sections	Annual or Biennial	Annual or Biennial	Annual or Biennial	Annual or Biennial
ILI	Entire Route	Every 4 years	Every 4 years	Every 3 years	Every 2 years
DCVG	Entire Route	Every 3 years	Every 3 years	Every 2 years	Every 2 years
CIPS	Entire Route	Every 3 years	Every 3 years	Every 2 years	Every Year
ON Potential Survey	Entire Route	Bi-monthly	Bi-monthly	Bi-monthly	Bi-monthly
SPC Inspection and Maintenance	Entire Route	Annual	Annual	Annual	Annual
Patrolling	Entire Route	Fortnightly	Fortnightly	Weekly	Daily
Water Quality	Sampling Points	Monthly	Monthly	Fortnightly	Weekly
MIC Analysis	Sampling Points	Quarterly	Quarterly	Bi-monthly or Monthly	Bi-monthly or Monthly
Corrosion Coupon Installation/Monitoring	Stations	Quarterly	Quarterly	Quarterly	Quarterly
Operational Monitoring	Stations/Control Room	Daily	Daily	Daily	Daily

THREAT CONTROL MATRIX

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Step 3

Integrity Management Plan

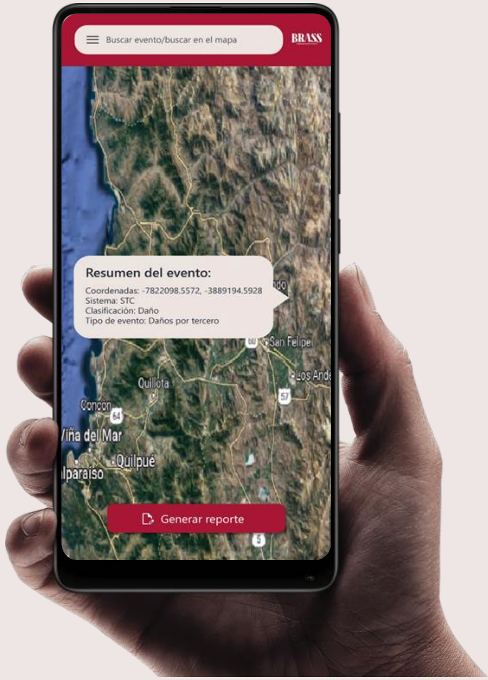
Controls
Prevention
Mitigation

THREATS	FAILURE MODE	DAMAGE MECHANISM	CONTROL METHOD			FREQUENCY PIPELINE	FREQUENCY STATIONS	CRITERIA	RESPONSIBLE AREA
External Corrosion	Localized and/or generalized thickness loss Pitting	**M1.1** Failure in external coating and/or shrinkable wraps **M1.2** SPC Failure **M1.3** Atmospheric Corrosion **M1.4** Galvanic Corrosion **M1.5** Soil Corrosion **M1.6** Corrosion from stray currents **M1.7** Corrosion under insulation	DETECTION	1.1	Inspection by DCVG **(M1.2, M1.6)**	Every 2 years	-	NACE TM0109 NACE SP0207	Electrical Maintenance
				1.2	Inspection by CIPS **(M1.2, M1.6)**	Every 2 years	-	NACE SP0207 NACE SP0169	Electrical Maintenance
				1.3	Inspection by GWUT/LRUT **(M1.1, M1.5, M1.7)**	Every 2 years	-	ASME B31G	Pipeline Integrity
				1.4	Thickness measurement by UT **(M1.3, M1.4, M1.5, M1.7)**	Every time thickness loss is identified	Every 3 months	ASME B31G	Pipeline Integrity
				1.5	ECDA Methodology **(M1.1, M1.2, M1.3, M1.4, M1.5, M1.6, M1.7)**	As required	-	NACE SP0502 NACE TM0106	Pipeline Integrity
			PREVENTION	1.6	Design of cathodic protection system **(M1.4, M1.5, M1.6)**	-	-	NACE SP0169 NACE SP0177	Pipeline Integrity
				1.7	Maintenance of cathodic protection system **(M1.2)**	Annual	-	NACE SP0169 NACE SP0207 NACE SP0107	Electrical Maintenance
				1.8	Installation of corrosion protection system on Kleerband flanged joints **(M1.3)**	-	As required	API RP 574 NACE SP0286	Mechanical Maintenance
				1.10	Installation of shrinkable wraps for corrosion protection on welded joints **(M1.3, M1.4, M1.5, M1.6, M1.7)**	Every time steel may be exposed to external corrosion	-	ASME B31.4 NACE RP0303	Mechanical Maintenance

B-PIMS®

Digitize, Connect, and Analyze Data for Optimal Pipeline Integrity Management.

B-PIMS® is a powerful platform that integrates all the data and information generated throughout the lifecycle of pipelines into a single location, enabling efficient and secure management of the operation and maintenance of these systems.



Georeferenced Visualization

B-PIMS® provides a comprehensive view of all information on a single interactive georeferenced map, allowing the identification of critical areas and enabling informed decision-making to optimize resource use in pipeline maintenance.

Inspectors 2.0

Digital Transformation with B-PIMS®

With B-PIMS, we have brought routine inspections into the digital age, enabling real-time reporting right at your fingertips.

Thanks to georeferencing, inspectors can select their location and add information directly on the map.

This feature not only streamlines the identification and response to issues but also allows more efficient collaboration between teams and supervisors.

With B-PIMS®, not only are isolated events visualized, but a comprehensive understanding of their context and evolution over time is also achieved. This enables informed and strategic decision-making, which is crucial for proactive maintenance and highly effective integrity management.

EPILOG

The success of B-PIMS® lies in the full commitment of the whole Corporate Structure from the Board of Directors to the lowliest layman.

THANK YOU FOR YOUR ATTENTION