

## Chapter 12 Hazard Analysis and Risk Assessment (Unplanned Events)





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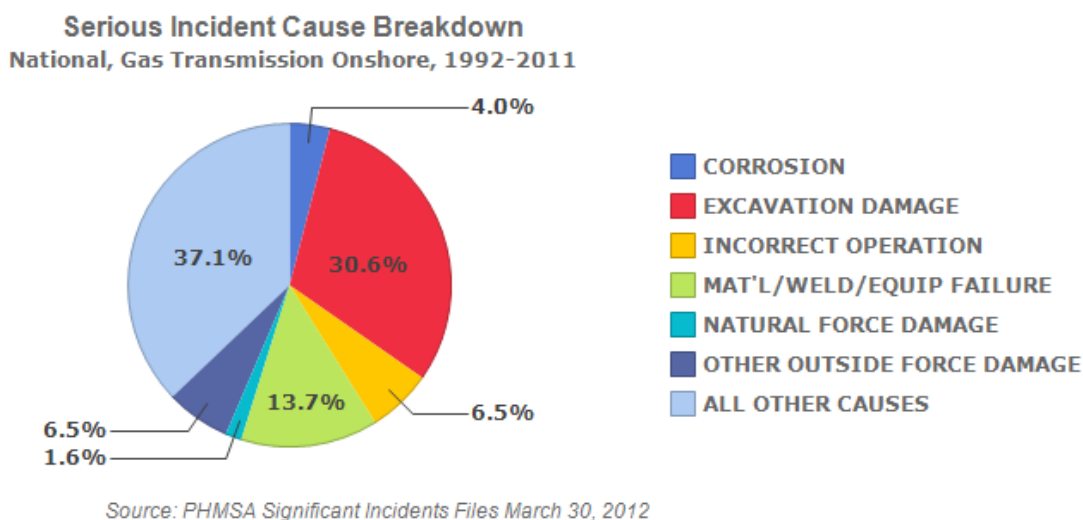
## 12 HAZARD ANALYSIS AND RISK ASSESSMENT

### 12.1 Introduction

This section summarises the hazard analysis and risk assessment studies carried out for the proposed SCPX Project concept that was described in Chapter 5. It describes and assesses unplanned events that could potentially cause risks to public safety and harm to the environment. It also outlines the proposed mitigation measures and the strategy proposed that aims to manage the risks potentially associated with the Project.

The European Commission Directorate-General Environment<sup>1</sup> has reported that there is a decreasing incident rate for both gas and oil pipelines in Europe. Years of experience of operating pipelines, including the existing South Caucasus Pipeline (SCP), Baku Tbilisi Ceyhan (BTC) pipeline and Western Route Export Pipeline (WREP) in Azerbaijan, has also contributed to the creation of potential improvements for the mitigation and management of the associated risks.

Because the SCPX Project will transport natural gas, the most serious type of unplanned event is considered a release of gas that ignites and causes a fire or explosion. Statistics compiled by the US Department of Transportation's Office of Pipeline Safety suggest that the most frequent causes of gas pipeline release scenarios are likely to be excavation damage followed by materials failure (see Figure 12-1).



**Figure 12-1: Causes of Serious Gas Transmission Incidents**

In addition to excavation damage and material failure, the SCPX Project has also taken the following causes of gas releases into consideration:

- SCPX construction close to live SCP, BTC and WREP pipelines and tie-ins into the live SCP pipelines and plant at the pigging station at KP0
- Pipeline rupture as a result of natural hazards
- External interference (including illegal hot tapping, or damage resulting from terrorism or war).

<sup>1</sup> <http://www.egig.eu> (accessed 04<sup>th</sup> April, 2012)

### **12.1.1 Principles of Hazard and Risk Management**

Risk is an expression of the likelihood that an event may occur and the magnitude of the potential consequences if it does occur. Risk can therefore be lowered by reducing the likelihood of occurrence and/or the severity of consequences. Preventing any initial failure occurring is arguably therefore the most effective way to reduce the risk of causing harm to people or to the environment. Risk assessment for gas pipelines and facilities focuses primarily on the estimation of risk to the public safety.

The development of comprehensive, internationally recognised codes and standards based on good engineering practice and operational experience has allowed for the design of inherently safer gas pipelines and facilities that are designed to include safety elements that are intended to reduce the potential for major accidents to occur. The SCPX Project design strategy has benefited from the experience gained from the design of the BTC and SCP pipelines and lessons learned from the construction, commissioning, operation and maintenance of these pipelines and facilities.

The industry applies hazard and risk management not just to the design process, but also during construction and operation of the pipeline and facilities. The industry accepted hazard and risk management approach seeks to demonstrate that safety risks have been reduced to a level considered as low as is reasonably practicable in the applicable circumstances. The use of the term 'as low as is reasonably practical' refers to its application within a hazard and risk management approach and does not refer to its use as a legal concept or standard.

### **12.1.2 Risk Assessment**

Risk assessment is both a design tool and a valuable tool for ranking potential risks during the lifetime of a gas pipeline or facility, prioritising operational efforts to reduce the likelihood of leakage, and guiding emergency planning. It can be used to assist decision-making on future land use in the vicinity of the pipelines and facility on the basis of pipeline safety.

A risk assessment has been undertaken to demonstrate the potential risk to the public from installation of the 56"-diameter SCPX pipe using a risk assessment methodology that draws extensively on published sources (e.g. Morgan and Hill, 1997; Morgan, 1995, 1989; Corder, 1995; Hill and Catmur, 1995; Carter, 1991) and the following documents:

- John Brown, 2002, Hydrocarbons Pipeline Risk Assessment, QRA Doc No. 410099/00/L/SA/RP/005 Rev D1
- Azerbaijan Strategic Performance Unit - Caspian Region (BTC/SCP) Pipeline Zones document UNIF-ENG-REP-027 Rev C2, 2010.

The main steps in the risk assessment process are shown in Figure 12-2 and are briefly discussed below.

#### **1. Identify potential failure causes**

The objective of this step is to identify potential failure causes for a natural gas pipeline system or facility.

#### **2. Estimate failure frequencies**

The objective of this step is to estimate the potential frequency of system failure for each failure cause. Historical accident data are used as a basis to estimate the generic failure frequencies that are adjusted for the specific features of the proposed system. For the SCP pipeline, failure frequencies have been based on those reported by European Gas Pipeline Incident Data Group (EGIG) website and have been compared with other sources of data (e.g. US Department of Transport (DoT) Gas Transmission Pipelines, and the UK Onshore Pipeline Operators Association (UKOPA)) to provide a cautious best estimate of the pipeline failure frequencies. The UKOPA data demonstrates much lower frequencies of failure, especially of rupture, than EGIG. This likely reflects the fact that pipelines in the UK are

typically newer and use more modern design codes than the ones reported by EGIG and US data. However, EGIG data has been conservatively adopted for the base-case generic frequencies because it is a much larger data source and covers a wider range of terrain.

The gas industry failure frequency assessment model FFREQ was also used as input for the assessment of external interference and third-party damage.

### **3. Identify potential release modes**

The objective of this step is to identify the potential modes in which gas may be released into the atmosphere following a system failure. The release modes may be characterised in terms of the hole size caused by the failure. For instance, small holes would be leaks with relatively low gas release rates and limited consequence distance. At the other end of the spectrum would be a full-bore pipeline rupture with a higher release rate and the ability to disperse gas some distance.

### **4. Estimate release frequencies**

The objective of this step is to estimate the frequency of release in each mode. This step combines the failure frequencies (from Step 2) with the hole size distribution given a failure owing to a specified cause. Again, historical failure data has been used to estimate generic release frequencies and Project-specific data used to adjust these frequencies as appropriate. This has included taking account of the reduction in major rupture frequencies due to lower design factors, increased pipeline wall thickness and deeper burial. It also included increased failure frequencies in regions prone to geohazards.

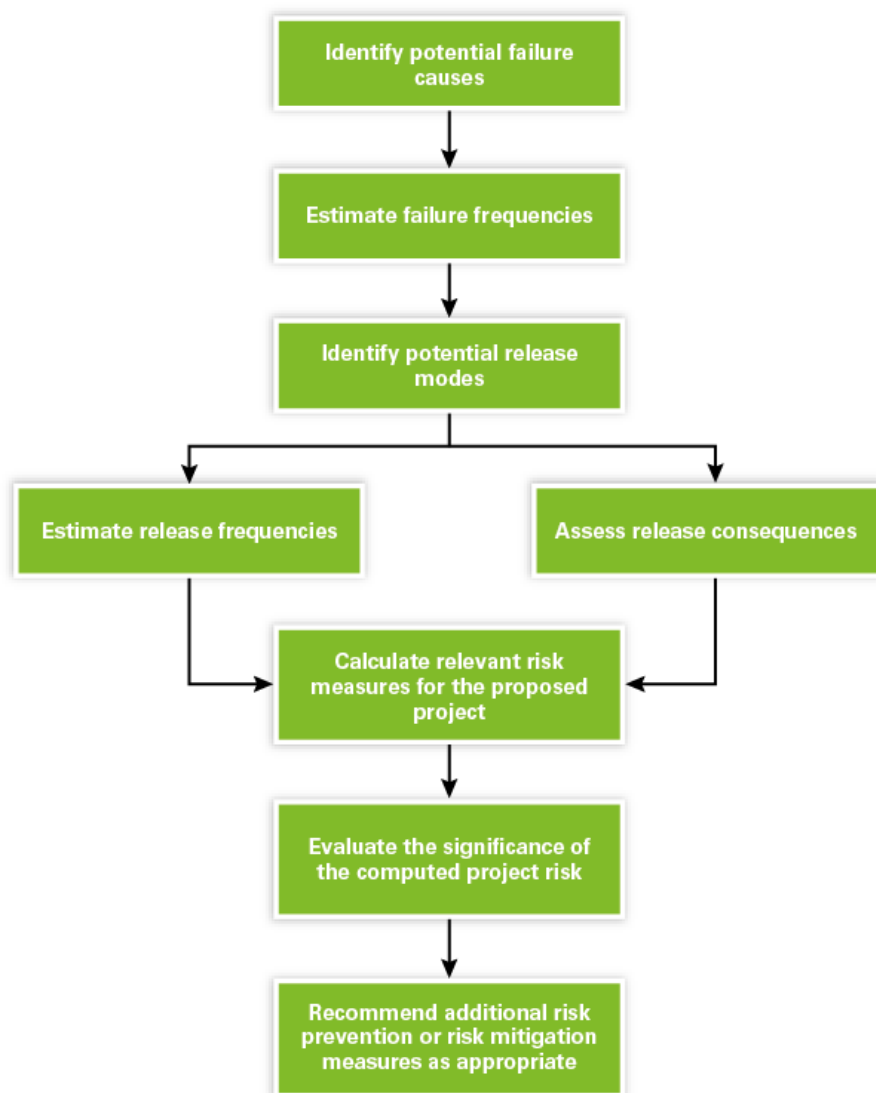
### **5. Assess release consequences**

The objective of this step is to assess the severity of consequences of a release in each mode. The potential consequences of the different kinds of release were calculated using established software models. In considering the potential effects of a release, different possible scenarios have been considered, such as whether a release is ignited immediately or after some delay.

### **6. Calculate risk to the public**

The objective of this step is to estimate the risk of the proposed pipeline or facility to the public living in the vicinity. A conservative approach was taken to estimating the risk to an individual, by assuming a base case of a hypothetical individual being present at a given location 24 hours a day, 365 days a year (an unrealistic assumption, but it builds conservatism into the calculation). This risk is expressed as the individual risk of fatality per year at a given distance from the pipeline. Clearly the actual risk to a real person is considered likely to be much less than this, as no individual stays in the same location permanently. Nonetheless, it is a frequently used comparative tool for pipeline risk assessment.

This risk calculation includes the previous steps discussed above and considers such factors as the likelihood of an ignition and whether the majority of releases disperse into the atmosphere harmlessly without being ignited.



**Figure 12-2: Risk Assessment Methodology**

#### **7. Assess the significance of the risk**

This step evaluates the significance of the estimated risk in light of well-established and published criteria of 'acceptable' risk (in a risk management context) for communities (see for example UK HSE, 2001), and common oil and gas industry practice for international operators.

#### **8. Identify and evaluate additional risk prevention or risk mitigation measures as appropriate, and recalculate risks**

The objective of this step is to assess the benefits of additional risk prevention or risk mitigation measures if necessary with the aim of further managing and mitigating potential risks. Section 12.2 discusses the design codes and standards that apply to the 56"-diameter SCPX pipe and the risk assessment studies that have been carried out for it.

## **12.2 Pipeline Design and Risk**

In Azerbaijan, the proposed SCPX route generally follows those of the existing BTC and SCP pipelines, avoiding existing development and local infrastructure as far as practicable. However, a number of communities are relatively close to the pipeline ROW.



The proposed SCPX design has located the SCPX route and block valve stations (BVR) where they can share utilities with existing BTC and SCP BVRs, while allowing sufficient distance between the proposed SCPX BVRs and the BTC and SCP BVRs, and sufficient separation from the existing BTC and SCP pipelines to minimise the likelihood of escalation in an accidental event (see Section 12.2.3 and Section 12.2.5).

### 12.2.1 Pipeline Design Codes and Standards

Table 12-1 presents design data for the 56"-diameter SCPX pipe.

**Table 12-1: Line Pipe Installation, Operational and Coating Data**

Data	Parameter	Value
Line pipe data	SCPX outer diameter 1	56"/1422mm
	Yield stress	485MPa
	Manufacturing tolerance	Nominal wall thickness +/-0.75mm
Operational data	Design life	30 years
	Design pressure	95.5 barg
	Maximum operating temperature	60°C
	Minimum operating temperature	-10°C
Coating data	External three-layer polyethylene thickness	3mm
	External three-layer polyethylene density	900kg/m <sup>3</sup>
	Factory-applied concrete-coating density Applied for specific hazards at river crossings etc., for anti-buoyancy reasons or local protection	3500kg/m <sup>3</sup>
	Field-applied concrete-coating density	2400kg/m <sup>3</sup>

A combination of a three-layer polyethylene coating, field joint coating and an integrated cathodic protection system aim to protect the pipeline from the risk of external corrosion. It is weight coated with concrete where negative buoyancy is needed in wet areas.

The 56"-diameter SCPX pipe is being designed in accordance with the latest version of the long-established American Society of Mechanical Engineers (ASME) B31.8 code for 'Gas Transportation and Distribution Piping Systems'. Other international standards including applicable American Petroleum Institute (API) standards have also been incorporated into the design.

ASME B31.8 bases its approach to public safety on design factors specifying the use of different classes of pipe depending on land use and population density (see Table 12-2). It implicitly mitigates the key risk associated with gas pipelines by specifying design factors that are intended to reduce the likelihood of pipeline ruptures in populated areas. The design factor is the ratio between the actual operating stress of the pipeline and the yield stress of the material from which it is made, and is an indicator of how much stress the pipeline could endure before it starts to deform. Increasing the pipeline wall thickness gives a greater margin between operating stress and yield stress and is considered to provide increased protection against mechanical impacts (e.g. from excavating and agricultural machinery), which are historically a major cause of major pipeline failures.

**Table 12-2: Summary of ASME B31.8 Land Use/Location Class Criteria for Design Factor**

Design Location Class	Land Use	Location Class (No. of Dwellings within 201m of pipeline)	Design Factor
1(Division 1)	Sparsely populated areas, wasteland, desert, mountain, grazing and farmland	< 10	Greater than 0.72 but equal to or less than 0.8
1 (Division 2)	Sparsely populated areas, wasteland, desert, mountain, grazing and farm land	< 10	≤ 0.72
2	Fringe areas around cities and towns, industrial areas, ranch or country estates	Greater than 10 and less than 46	0.6
3	Suburban housing developments, shopping centres, residential areas, industrial areas and other populated areas not meeting Class 4	Greater than 46	0.5
4	Any area where multi-storey buildings (4 or more floors) are prevalent and where traffic is heavy or dense and where there may be numerous other underground utilities	Any number	0.4

Note 1: In multi-storey units, each dwelling within the unit is considered as an independent dwelling.

Note 2: Pipelines in Location Class 1 or 2 passing near places of public assembly or concentrations such as schools, hospitals or recreational areas of an organised nature, including outside areas that are frequently used shall meet the requirements of Location Class 3

To comply with Section 840.2.2 of ASME B31.8, mechanical design calculations used the design factors shown in Table 12-3 to determine the applicable pipe wall thickness in areas where there are many existing dwellings, or where future development of communities and population growth are anticipated.

**Table 12-3: Location Classes, Design Factors and Wall Thicknesses**

Pipeline Outside Diameter Inches	Location Class	Basic Design Factor	Selected Nominal Wall Thickness (mm)
56" (SCPX)	Class 1 Division 2	0.72	19.5
	Class 2	0.60	23.4
	Class 3	0.50	28.1
42" (SCP re-route for tie-in at KP0)	Class 3	0.50	21.2

The number of properties close to the 56"-diameter proposed SCPX route in Azerbaijan varies in different parts of the ROW. To identify the design factor and wall thickness to be used along the proposed SCPX route in Azerbaijan, the Project carried out a desktop study and field verification exercise to determine the building density within a 200m zone and 500m zone either side of the route. The results of the building density study showed that approximately 378.3km of the proposed 390km SCPX route in Azerbaijan is designed to Class 1, 7.2km is Class 2 and 4.5km is Class 3. The locations within which areas of Class 2 and Class 3 pipe are required are shown in Table 12-4.

**Table 12-4: ASME31.8 Location Classes (II and III) on the Proposed SCPX Route in Azerbaijan**

Azerbaijan Section SCPX KP	ASME 31.8 Location Class	Comments on Building Proximity
KP0 to KP67.4	Class 2	Greater than 10 and less than 46 buildings within 200m of the pipeline
KP67.4 to KP68.5	Class 3	Greater than 46 buildings within 200m of the pipeline
KP68.5 to KP105.9	Class 2	Greater than 10 and less than 46 buildings within 200m of the pipeline
KP105.6	Class 3	Greater than 46 buildings within 200m of the pipeline
KP105.9 to KP118.8	Class 2	Greater than 10 and less than 46 buildings within 200m of the pipeline
KP117 to KP118.5	Class 3	Greater than 46 buildings within 200m of the pipeline
KP118.8 to KP122.9	Class 2	Greater than 10 and less than 46 buildings within 200m of the pipeline
KP122.9 to KP124.7	Class 3	Greater than 46 buildings within 200m of the pipeline
KP124.7 to KP133.1	Class 2	Greater than 10 and less than 46 buildings within 200m of the pipeline
KP133.1 to KP134.4	Class 3	Greater than 46 buildings within 200m of the pipeline
KP134.4 to KP143.8	Class 2	Greater than 10 and less than 46 buildings within 200m of the pipeline

As can be seen from Table 12-4, wherever practicable the proposed SCPX route has avoided populated or sensitive areas. Where it passes through more populated areas, the wall thickness has been increased in accordance with ASME B31.8, see Table 12-3.

In addition:

- An increased wall thickness with a design factor of 0.6 will be applied at road, railway and river crossings to meet the requirements of API RP 1102 (D5-034)
- There will be increased depth of cover is at crossings: road crossings will generally be installed with 2.0m cover; rail crossings have at least 3.0m cover and unpaved roads will have at least 1.5m cover (D11-02). Concrete slabs will be installed at open-cut road crossings to protect SCPX from future road construction activities and excavations along roads or the verges (D11-03).

The potential for the pipeline to fail as a full bore rupture (FBR) and crack open owing to accidental damage, or to leak without a full bore rupture occurring, has been assessed. The results of this assessment indicate that, provided the pipeline wall thickness is greater than 19.1mm, and the design factor is less than 0.5, the probability of an FBR occurring is very low. The risk of FBR is considered as low as reasonably practicable in risk assessment terms. The pipeline is more likely to fail by leaking without a rupture occurring.

### **12.2.2 Safety Risk Results and Discussion**

Consequence modelling techniques (the Process Hazard Analysis Software Tool (Phastt) and the BP Cirrus software programme) were used to predict the distance to heat radiation contours of the ignition of gas released from a 140mm-diameter hole in the buried 56"-diameter SCPX pipe and 42"-diameter SCP pipe. This is representative of a leak-before-rupture scenario and was used to ascertain its potential impact on dwellings, as required by ASME 31.8.

Table 12-5 presents the distance to thermal radiation contours of 6.3kW/m<sup>2</sup>, 12.5kW/m<sup>2</sup> and 35kW/m<sup>2</sup> from an ignited gas jet fire resulting from a 140mm-diameter leak.

**Table 12-5: Thermal Radiation Contours for Buried High-Pressure Pipelines**

Diameter	Leak Size (mm)	Flame Length (m)	Radiation Contours (either side of pipeline, m)		
			35kW/m <sup>2</sup>	12.5kW/m <sup>2</sup>	6.3kW/m <sup>2</sup>
56"SCPX pipe	140	96	87	140	182
42" SCP existing pipe	140	77	66	104	139

The modelling concluded that the majority of the pipeline route in Azerbaijan, the SCPX pipe is a Class 1, Division 2 pipeline and should have a design factor of 0.72 and a nominal wall thickness of 19.5mm. With this wall thickness, the pipeline is considered far less likely to rupture. A 140mm-diameter leak hole would be expected to reach a distance of approximately 180m from the pipeline before the thermal radiation reduced to a level at which personnel could escape (6.3kW/m<sup>2</sup>).

However, for the short sections where the ROW passes closer to houses, as shown in Table 12-4 the pipeline becomes a Class 2 or 3 pipe with a design factor of 0.6 and 0.5 and an increased wall thickness of 23.4 and 28.1mm, respectively. The increased design factor and increased pipeline wall thickness further reduces the probability of 'leak before rupture' occurring.

For SCP and BTC, risk transects were calculated for the four ASME B31.8 location classes (defined in Table 12-2) and risks were found to be within the well-established and published criteria of 'acceptable' risk (in a risk management context) for communities. For the 56"-diameter SCPX pipe, the increased wall thickness has a significant positive impact with regard to reducing the risk of failure frequency.

Considering the BTC, SCP, WREP and proposed SCPX pipes together slightly increases the overall risk levels, but even with the introduction of the SCPX pipe the risk levels are considered to remain extremely low. As long as adequate pipeline separation is implemented or additional protection measures included where the separation distance is reduced, an accidental event is considered unlikely to escalate to an adjacent pipeline in the ROW.

### **12.2.3 Separation Distances**

#### **12.2.3.1 Pipeline**

When routed on the right hand side of the ROW corridor, the proposed 56"-diameter SCPX route is adjacent to the SCP gas pipe; when routed on the left hand side, it is adjacent to the BTC oil pipeline.

Modelling studies comparing the results from two Pipeline Research Council International (PRCI) models, a BP model and industry data from incidents on similar pipeline were used to determine the minimum recommended distance between the SCPX pipe and one of the existing pipelines. The models simulated a full-bore rupture across the entire diameter of the SCPX pipe operating at 90 barg (the worst-case event and one which is considered unlikely owing to the design mitigations discussed in Section 12.2.1). The modelling provided an estimate as to whether the crater from an explosion would expose the adjacent pipeline, thereby potentially causing a loss of integrity, and whether heat radiation would be likely to affect the adjacent exposed pipeline.

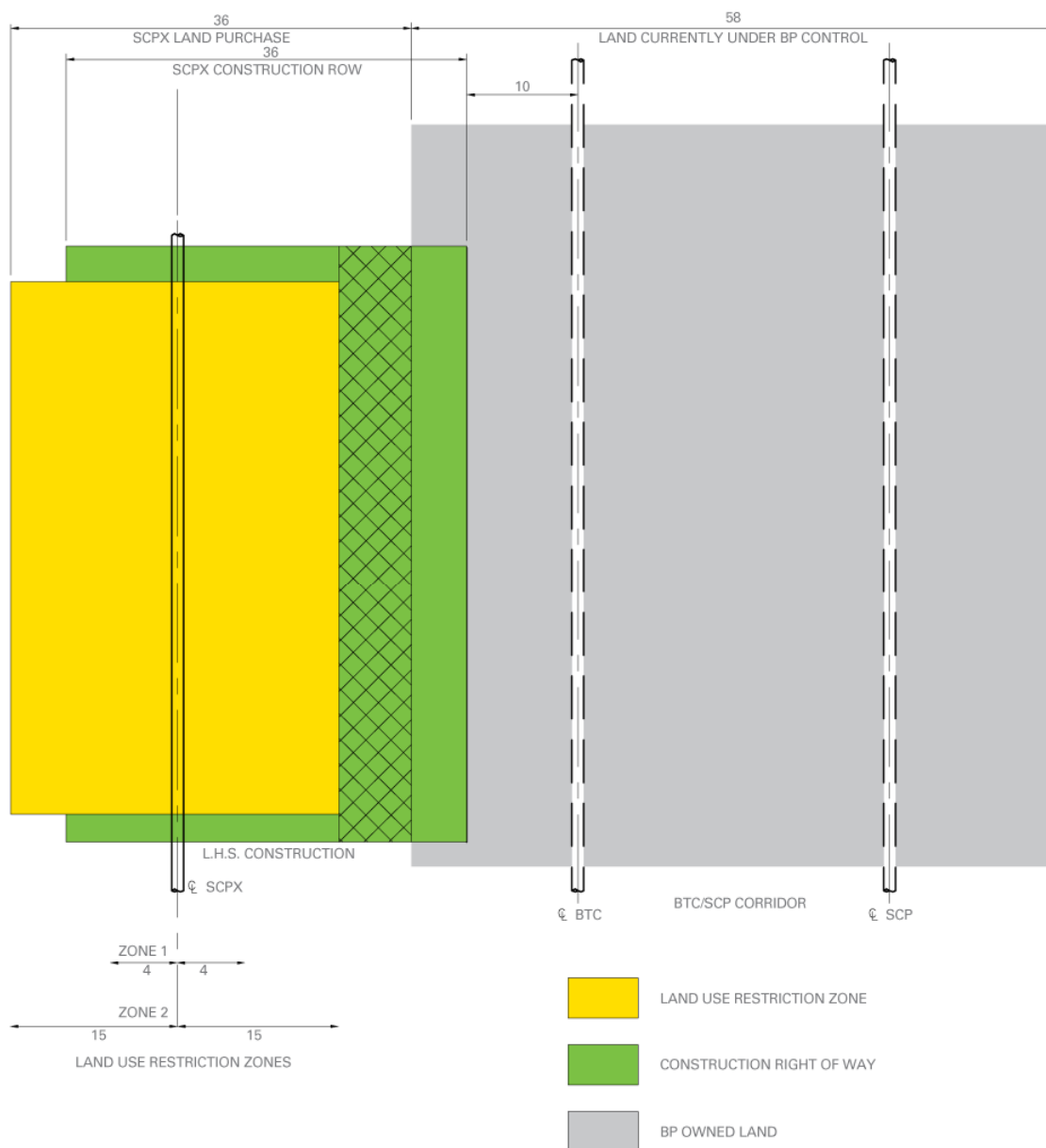
The largest crater radius from the modelling results was 18.4m produced by the BP model, which presents a worst-case scenario (i.e. a larger crater radius than the PRCI models and actual historical data). A general minimum separation distance of 20m is applied between

SCPX and SCP/BTC. At crossings, additional control of work measures will be applied (D11-04). When SCPX is adjacent to BTC to allow room for setting out and constructing the 56" pipeline, the actual separation distance will generally be in the region of 36m (Figure 12-3).

It should be noted, that the crater size resulting from a pipeline explosion is a function of the pressure (and not the flow rate) and thus the risk associated with the SCP sections of the pipeline does not change as the operating pressure remains at or below 90 barg pressure.

There are currently expected to be in the region of 30 points in Azerbaijan where the proposed SCPX route crosses under some or all of the existing BTC, SCP and WREP pipelines. Where the SCPX pipeline crosses buried services or pipelines, trenchless or open cut crossing methods will be adopted. A typical vertical separation between the SCPX pipeline and the existing service or pipeline will be 1500mm where trenchless techniques are used, and 900mm where open cut techniques are used (D5-010). Construction of crossings of the existing BTC and SCP pipelines will be controlled under the existing pipeline operations permit to work system and the activity subject to a specific risk assessment undertaken by both the construction contractor and BTC and SCP operations team (D5-011).

During the operational phase the pipelines, including crossings are subject to the operational monitoring described in Section 12.5.2.



**Figure 12-3: SCPX Separation from BTC Pipeline**

### 12.2.3.2 Block valves

Block valves (BVRs) allow sections of pipelines to be isolated from the rest of the pipeline to carry out maintenance or in response to an emergency. The distance between one BVR and the next on the SCP pipeline was determined using a risk-based approach consistent with the ASME B31.8 standard (2007) that considered:

- The amount of gas expected to be released for maintenance blowdowns, leaks or ruptures
- The time expected to be needed to blowdown an isolated section of the pipeline
- The potential impact in the area of the gas release.

As the maximum allowable operating pressure of the SCPX system (90 barg) will be the same as for the SCP system, the risk assessment concluded that the maximum distance between the proposed SCPX BVRs could be the same as that for the SCP BVRs, which are spaced, on average, 77km apart. It was also decided that the proposed SCPX BVRs would be most appropriately located close to the existing BTC and SCP BVRs so that they could share utilities and to reduce the small cumulative environmental impact associated with the additional land needed for the new BVRs. Therefore, in Azerbaijan, there are likely to be stand-alone block valves, close to the existing SCP and BTC block valves, at KP21, KP95, KP172, KP243 and KP334).

A risk analysis was then undertaken to evaluate the potential for a major accident at an SCPX block valve affecting a block valve on the SCP or BTC pipelines and to determine the appropriate separation distance of the pipelines at block valve stations. Modelling of a full bore rupture of the SCPX (i.e. the worst case) using the same methodology described above (Section 12.2.3.1) estimated that with 28m separation distance between pipelines at the block valves, the edge of the crater would not affect the foundation of the firewall at the block valve on the other pipeline.

Heat radiation from the jet fire caused by ignition of gas released from a full bore rupture of the 56"-diameter pipeline at a block valve is not expected to impact either pipeline, because it is protected by burial to a minimum depth of 1m. The heat radiation could damage aboveground elements of the other block valve, although the frequency of this type of event is very low and well below accepted industry standards.

Based on the above evaluation, it was determined that there needs to be a minimum of 3m separation distance between the edge of the largest crater that could be caused by an explosion at the SCPX block valve and the firewall at the SCP block valve. At the block valve sites the separation distance between the 56" SCPX pipeline and the 42" SCP pipeline and the SCPX block valves and the BTC/SCP block valves will be no less than 28m (D11-05).

#### **12.2.4 Pipeline Protection Zones**

The zones in which construction activities are prohibited or restricted and the zones in which developers must consult with the operators of pipeline prior to construction activities are presented in Table 12-6. These pipeline protection zones meet international design standards and engineering good practice, as required by the HGA. The same zones apply to the BTC and SCP pipelines.

**Table 12-6: Restriction and Consultation Zones – Pipeline**

Zones		Extent	Requirement
Restriction zones	Zone 1	4m either side of pipeline	Building construction, tree planting, deep ploughing and use of explosives is prohibited
	Zone 2	15m either side of pipeline	Construction of habitable buildings is prohibited
Consultation zones	Zone 3-1	385m either side of pipeline	All housing developments are subject to consultation with the pipeline operator
	Zone 3-2	Between 385m and 500m either side of pipeline	Major developments (hospitals, schools and large housing developments) are subject to consultation with the pipeline operator
		500m either side of pipeline	The Project has to be consulted regarding development applications to ensure minimal risk to the pipeline and to surrounding communities

#### **12.2.5 Fault Crossing Mitigations**

The proposed pipeline follows the SCP/BTC pipeline corridor, which was designed to take account of geological fault lines in Azerbaijan. The SCPX Project reviewed the active fault crossings for the existing SCP pipeline to confirm the results of the fault identification

process, and the methodology for determining the potential rupture zones and characterisation of the faults.

The SCPX route was started at SCP KP57 to avoid the following faults as well as other hazards (as discussed in Chapter 4, Alternatives):

- A fault zone (mud volcano fault) – SCP KP24.1
- Two faults at Hajigabul at SCP KP49.9 and KP50.9.

As a result, the proposed SCPX route does not cross any potentially active faults in Azerbaijan.

## 12.3 Impact Significance Assessment

### 12.3.1 *Potential Impacts of Unplanned Events: Construction*

In the construction phase, materials are stored that can potentially contaminate the soil, surface water and groundwater if not correctly stored and managed, including diesel fuel. The consequences of unplanned spillage of these materials are discussed in Section 10.3.3 as although any spillage of these substances would of course be an unplanned event, such an event is considered (in relative terms) to have a higher potential to occur than the low probability events discussed in this section.

Unplanned events during SCPX Project construction could affect community safety and security. Accidents at construction sites and Project-related road traffic accidents have been assessed in Section 10.12 (Community Health and Safety).

### 12.3.2 *Potential Impacts of Unplanned Events: Pipeline Operation*

In historic cases when pipeline integrity has failed and leaking gas has found a source of ignition and exploded, the following potential outcomes may occur:

- Crater formation close to the source of the leak
- A fireball
- An area of earth scorching around the crater
- A wider area in which vegetation, trees, crops and buildings could potentially be damaged by fire
- An even wider area in which noise from the explosion could potentially cause damage or disturbance to residents
- Release of greenhouse gases.

Where such an explosion occurs, the crater would be expected to cause an environmental impact of short duration.

The scorched earth would be anticipated to have no ground cover, facilitating a greater risk of erosion.

Certain sections of the proposed pipeline route parallels the main highway and railway line, and also passes in close proximity to dwellings. However, it primarily passes through arable farmland, grazing pasture, grassland, scrub and desert vegetation. In the event of an explosion, this landscape could potentially allow a fire to spread, at least until the emergency response plan is activated and action is taken to contain the fire. The route does not cross woodland so it is considered unlikely that a forest fire could be started by a pipeline failure and explosion.



Evidence exists of gas explosions being sufficiently powerful to cause superficial damage to buildings up to a distance of one kilometre from the source (MARS 8/1987). It is probable that the resulting noise immediately following an explosion would cause alarm to nearby residents in surrounding communities. Noise levels are expected to be reduced as the inventory of gas is released to the atmosphere and as the pipeline section is depressurised. Isolation of the pipeline section where the rupture occurs is anticipated to limit the duration of an incident to a few minutes.

Generally, the maximum distance between block valves on the SCPX pipeline in Azerbaijan will be approximately 77km, therefore, in the unlikely event of a full bore rupture, the largest gas release would be approximately 7900 tonnes of pipeline gas or 200,000 tonnes of CO<sub>2eq</sub>. If the released gas ignites, emissions would be approximately 22,594 tonnes of CO<sub>2</sub>.

**River crossing exposure**

A buried pipeline can be exposed at a river crossing due to the vertical lowering of the riverbed and/or lateral retreat of either of the riverbanks. Degradation is a general lowering of the channel bed elevation through time that may cause exposure of the pipeline. Bank retreat or lateral scour, is movement of the stream bank into the floodplain expected due to the evolution of the channel in dynamic equilibrium or unexpected bank-line shifting in response to disturbance of the fluvial system. Exposure of the pipeline leaves it vulnerable to potential interference and the potential for failure as described above.

## 12.4 Risk Assessment

Table 12-7 provides an assessment of the potential risks associated with unplanned events. The potential impact significance and potential event probability considers the potential impact and probability of an unplanned event if no mitigation had been incorporated into the Project design or operating procedures.

The residual impact significance and probability takes account of the design measures that aim to minimise the probability and consequences of an unplanned event and the proposed operational control measures that are discussed in Section 12.5. This gives an overall assessment of the residual risk.

The relevant tables from Chapter 3 have been used to assess the impacts. The impacts on community health and safety and the probability of the event occurring have been assessed using the health impact assessment methodology outlined in Chapter 3.

The residual risk has been evaluated based on the residual impact significance and event probability in accordance with the matrix presented in Figure 12-4.

Impact Significance/Severity	Probability							
	1	2	3	4	5	6	7	8
Very High	L	H	H	H	H	H	H	H
High	L	L	M	M	M	H	H	H
Medium	L	L	L	M	M	M	M	M
Low	L	L	L	L	L	M	M	M
Very Low	L	L	L	L	L	L	M	M
Overall significance: H = High, M = Medium, L = Low								

**Figure 12-4: Residual Risk Significance Matrix**

The results of the assessment are shown in Table 12-7.

**Table 12-7: Impact and Probability Assessment for Unplanned Events**

Issue		Potential Impacts	Potential Impact Significance	Potential Event Probability	Mitigations	Residual Event Probability	Residual Risk
Event: Gas release from pipeline with explosion							
A30	Community safety	Exposure to thermal radiation	Very high	5	D11-02, D11-03, D11-04, D11-05, D12-02, D12-03, D5-001, D-5010, D5-011, D5-034, 4-14, 36-02, OP20, OP121, OP123, OP124, OP125, OP128, OP129, OP130, OP131, OP132, OP133, OP136, OP140, OP143, X5-17, 32-07	3	Medium
A4	Loss of soil structure	Crater formation	C3 Medium				Low
A8	Visual intrusion	Visible fireball	B2 Low				Low
A3	Soil erosion	Ground cover removed where earth is scorched	B3 Low to Medium				Low
A17	Loss of habitat	Fire damage to vegetation	A2 Low				Low
A32	Loss of agricultural land	Damage to crops	B3 Low				Low
A35	Damage to third party infrastructure	Damage to buildings	B2 Low				Low
A25	Noise	Noise disturbance from major incident	C5 High				Medium
A31	Community health	Anxiety caused to residents in surrounding communities	Low				Low
A23	Release of gases to atmosphere	Greenhouse gas emission	C4 Medium	Low			

## 12.5 Mitigation Measures

The mitigation measures for unplanned events are generally:

- Design measures that limit both the impacts of the unplanned event and the probability that it may occur
- Operational monitoring activities that make an unplanned event less likely to happen, but do not affect the impacts if it does happen, or
- Operational response activities that limit the area impacted or the time for which the impact lasts.

### 12.5.1 Mitigation Measures Incorporated into the Design

The following measures that have been incorporated into the SCPX Project design are intended to reduce the likelihood of an unplanned event:

- The SCPX pipeline will be protected from corrosion by an impressed current cathodic protection system (D5-001)
- In specific areas, for example close to communities, heavier wall pipe will be used to reduce the risk of pipeline failure in accordance with international standard (ASME B31.8) (D12-02)

- An increased wall thickness with a design factor of 0.6 will be applied at major road, railway and river crossings to meet the requirements of API RP 1102 (D5-034)
- There will be increased depth of cover at crossings: road crossings will generally be installed with 2.0m cover; rail crossings have at least 3.0m cover and unpaved roads will have at least 1.5m cover (D11-02) over the pipeline
- Each major river crossing will have a site-specific design which will be set to account for the maximum flow rates (1:200 year storm event), sediment movement patterns, anticipated changes to the river bed contour and the predicted extent of lateral erosion (D12-06)
- Concrete slabs will be installed at open-cut road crossings to protect SCPX from future road construction activities and excavations along roads or the verges (D11-03)
- Where it is considered that there is a higher risk of the pipeline being damaged or interfered with, or where other services are crossed and at track and road crossings, the pipeline will be covered by concrete slabs at open cut crossings (D30-01)
- A general minimum separation distance of 20m is applied between SCPX and SCP/BTC. At crossings, additional control of work measures will be applied (D11-04)
- At the block valve sites the separation distance between the 56" SCPX pipeline and the 42" SCP pipeline and the SCPX block valves and the BTC/SCP block valves will be no less than 28m (D11-05)
- Where the SCPX pipeline crosses buried services or pipelines, trenchless or open cut crossing methods will be adopted. A minimum vertical separation between the SCPX pipeline and the existing service or pipeline will be 1500mm where trenchless techniques are used, and 900mm where open cut techniques are used (D5-010)
- Construction of crossings of the existing BTC and SCP pipelines will be controlled under the existing pipeline operations permit to work system and the activity will be subject to a specific risk assessment undertaken by both the construction contractor and BTC and SCP operations team (D5-011)
- A leak detection system is provided on the pipeline. Following detection of a leak, the block valves on either side of the leak will be remotely closed so that the volume of release will be limited by the distance between the two block valves (D12-03).

### **12.5.2 Operational Controls**

The mitigation measures that apply to unplanned spillage of hazardous materials in the construction phase are discussed in Section 10.3.4. The Project risk assessment have considered various security risks including military intervention and munitions risk.

The SCPX Project will apply the risk management principle of reducing the impacts to levels that are considered as low as is reasonably practicable in a risk management context by implementing the following measures:

- The 56"-diameter SCPX pipe is specified to have an electronic leak detection system that continuously monitors a number of pipeline parameters including pressure, flow-rate and temperature and can identify the source and size of leak (see Section 5.4.12)
- The pipeline and facilities will be regularly inspected and maintained (OP123) (see Section 5.9)
- In-line inspection pigging operations will be carried out on a regular basis to provide information on the line integrity (OP132)
- Monitoring of areas of geotechnical instability and erosion potential will be continued during operations (OP136)
- When the 56"-diameter pipeline is operating, regular patrols of the pipeline by ROW horse patrols, vehicular patrols (using existing access tracks) and security patrols will lessen the risk of third-party interference (OP121)

- ROW patrols will monitor river crossings to provide assurance of the integrity of any river protection works and river banks. This will include a visual inspection for river bank erosion or changes to channel morphology (OP131)
- An expert assessment of burial depths, set back measurements and pipeline protection works will be carried out at major river crossings annually (depending on the river characteristics and crossing technique) and after flood events exceeding a 1:100-year return period (OP143)
- Local residents will be advised of activities that could threaten the integrity of the pipeline, such as the extraction of aggregate (OP140)
- The Project will maintain liaison with all landowners along the pipeline route, and with authorities and utilities companies to track proposals for third party buildings activities that could affect the pipeline (OP133)
- In the case of an unplanned event, any damage will be reinstated and compensated where appropriate (4-14)
- The pipeline and facilities will be operated within the intended design conditions (OP124)
- The relevant authorities will be informed in the case of planned or actual third-party development within the relevant pipeline and facility protection zones (OP125)
- The entire pipeline will be walked or ridden periodically to provide assurance that no unauthorised activities are taking place that could damage or otherwise affect the integrity of the pipeline. Sensitive sections will be patrolled with the highest frequency (OP20)
- The project will inform land owners/users about any reuse restrictions that apply to land used by the project (32-07).

The State Authorities are responsible for security and responsibility to the pipeline in the Operational phase.

### **12.5.3 Emergency Response Capability**

#### **12.5.3.1 Emergency response plan**

The existing SCP pipeline has a Government-approved emergency response plan (ERP), which will be updated to integrate the SCPX pipeline and the new facilities before they become operational (OP128). The emergency response philosophy for SCPX will therefore be similar to that currently applied to SCP.

In accordance with Appendix 4 Clause 3.9(ii)(a) of the HGA, the revised ERP will be submitted to Government SCP Representative upon its completion (OP129). It will include:

- Environmental mapping of habitats vulnerable to potential natural gas leaks or emissions in the entire SCP system
- Situational scenarios of potential leaks, emissions, explosions, fires and responses, taking into consideration local circumstances
- Plans for the provision of relevant emergency response equipment, materials and services
- Plans for the deployment of relevant equipment and emergency response notification details of the organisation required to handle natural gas leaks, emissions, explosions and fires
- Plans for the evacuation and care for injured persons and the remediation, restoration of damaged property, and the treatment and disposal of any resulting contaminated materials.

All personnel are required to understand their roles and responsibilities described in the ERP and undertake training and instruction necessary such that they are competent to carry out their roles and responsibilities. Regular drills, musters and training are detailed in the

annual emergency response exercise programme that will be updated to include SCPX-specific training and emergency drills (OP130).

#### 12.5.3.2 *Priorities*

BP's incident management system aims to make best use of the available facilities and resources to respond to an accidental release of gas, should one occur, in a prompt and effective manner so as to minimise its consequences.

The 'Azerbaijan Operations Emergency Response Plan' is based on BP's '*Crisis Management Framework*' document that prioritises crisis management and emergency response in the following order:

1. People: Employees, contractors, suppliers, customers and communities
2. Environment: Air, water, land, spillages and areas of sensitivity
3. Property: BP, JV, contractors, communities and third-party facilities
4. Business: Supply, production and reputation

This approach implements an emergency response philosophy that encompasses overreacting, assessment, response and subsequent de-escalation.

#### 12.5.3.3 *Overreact*

The BP '*Crisis Management Framework*' document highlights the need to respond effectively to any emergency situation with the intention that it will be controlled as quickly and as efficiently as possible. The resources deployed can be increased or reduced by the On-scene Commander and Operations Section Chief at any time, as the situation becomes more clearly defined.

#### 12.5.3.4 *Tiered response*

To assure a consistent and effective response to unplanned events, a tiered response is adopted. The provision of resources to combat an emergency is divided into three categories or tiers of equipment provision. This system is internationally recognised as the most pragmatic approach, avoiding excessive costs and seeking shared resources for large, infrequent events.

- Tier 1 (minor events): defined as small local incidents requiring no outside intervention that can be dealt with on site by local staff without support from the incident management team (IMT).
- Tier 2 (emergency events): larger incidents that need additional local (regional) resources and manpower. This level of response needs the IMT to mobilise additional Azerbaijan Operations in-country manpower/resources
- Tier 3 (crisis events): very large, possibly ongoing incidents that need additional resources from outside Azerbaijan and Georgia. Such events are considered likely to be very rare, but could possibly include (for example) a full-diameter pipe rupture.

## 12.6 Residual Risk

Historically, large-diameter gas transmission pipelines have experienced fewer major accidents than medium-diameter gas distribution pipelines that deliver gas to residential areas. The social impacts of major accidents at large-diameter gas transmission pipelines and facilities have been limited by routing the pipelines away from residential areas.

Impacts of a major accident could be of high environmental or social significance with potentially high impacts on community safety and noise disturbance that occurs during major incidents. The probability of such events, however, is reduced considerably through the use of design standards and operational mitigation measures, thus reducing the overall risk.

The Project design and the operational control measures proposed are intended to reduce the impacts and probability of a major accident. As a risk management measure, the public will be excluded from the most hazardous areas, such as the pipeline BVRs. Any risk to the on-site workforce is intended also to be mitigated and managed to levels that are considered to be as low as reasonably practicable in a risk management context, by (for example) employing applicable facility design, by implementing safe working practices and through training of relevant personnel.

The overall assessment of residual risk is generally of low significance with a medium significance for the risks to community health and safety from unplanned events on the pipeline.