Business Case – Capital Expenditure

Encroachment High Consequence

Business Case Number 230

1 Project Approvals

TABLE 1: BUSINESS CASE – PROJECT APPROVALS

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2 Project Overview

TABLE 2: BUSINESS CASE – PROJECT OVERVIEW

Description of Issue/Project	The project is to ensure the safety of the public and the pipeline by reducing the risks associated with third party interference causing damage to high pressure pipelines. Some of the VTS pipelines need physical or operating changes to ensure risk levels are acceptable due to urban encroachment. These pipelines involve those with the high consequence surroundings associated with fully developed urban areas, proposed urban development areas and areas with specific sensitivity.
Options Considered	The following options have been considered: 1. Option 1: Do Nothing Option 2. Option 2: Protective slabbing 3. Option 3: Lower the pressure of the pipeline to reduce the consequences and modes of failure 4. Option 4: Combination of option 2 & 3 5. Option 5: Replace the pipeline
Estimated Cost	$25m
Consistency with the National Gas Rules (NGR)	The capital expenditure complies with the new capital expenditure criteria in Rule 79 of the NGR because: • it is necessary to maintain and improve the safety of services and maintain the integrity of services (Rules 79(2)(c)(i) and (ii)); and • it is such as would be incurred by a prudent service provider acting efficiently, in accordance with accepted good industry practice, to achieve the lowest sustainable cost of providing services (Rule 79(1)(a)). • To comply with a regulatory obligation or requirement (Rules 79(2)(c)(iii))
Stakeholder Engagement	Stakeholders involved with urban encroachment and the risks associated are • Australian Energy Market Operator • Landowners • Energy Safe Victoria • Local Councils • Victorian Planning Authority

3 Background

3.1 Transmission Pipelines

Transmission Pipelines have an Australian Standard for design and construction, AS2885.1. This standard requires physical and procedural mitigation measures to be applied to 'external interference' or mechanical damage threats to the pipeline (eg auger, excavators, horizontal directional drills). This requirement is in place because external interference threats are the greatest contributor to loss of pipeline containment incidents. The number of physical and procedural measures required depends on the primary or secondary location classification.

Each pipeline segment is primarily classified as either: T1, T2, R1 or R2. This classification is based on the land use within the 'Measurement Length' (ML). The ML is the distance from the pipeline that an ignited full bore rupture would affect the surrounding area. The ML is dependent on maximum operating pressure and diameter of the pipeline, thus each pipeline has a different ML.

The AS2885 definitions for primary location classes T1, T2, R1 or R2 and secondary location classes in sections 4.3.4 and 4.3.5 and repeated here;

> *"Rural (R1) Land that is unused, undeveloped or is used for rural activities such as grazing, agriculture and horticulture. Rural applies where the population is distributed in isolated dwellings. Rural includes areas of land with public infrastructure servicing the rural use; roads, railways, canals, utility easements.*
>
> *Rural residential (R2) Land that is occupied by single residence blocks typically in range 1 ha to 5 ha or is defined in a local land planning instrument as rural residential or its equivalent. Land used for other purposes but with similar population density shall be assigned rural residential location class. Rural residential includes areas of land with public infrastructure servicing the rural residential use; roads, railways, canals, utility easements.*
>
> *Residential (T1) Land that is developed for community living. Residential applies where multiple dwellings exist in proximity to each other and dwellings are served by common public utilities. Residential includes areas of land with public infrastructure servicing the residential use; roads, railways, recreational areas, camping grounds/caravan parks, suburban parks, small strip shopping centres. Residential land use many include isolated higher density areas provided they are not more than 10% of the land use. Land used for other purposes but with similar population density shall be assigned Residential location class.*
>
> *High Density (T2) Land that is developed for high density community use. High Density applies where multi storey development predominates or where large numbers of people congregate in the normal use of the area. High density includes areas of public infrastructure serving the high density use; roads, railways, major sporting and cultural facilities and land use areas of major commercial developments; cities, town centres, shopping malls, hotels and motels.*
>
> *Sensitive use (S) The sensitive use location class identifies land where the consequences of a failure may be increased because it is developed for use by sectors of the community who may be unable to protect themselves from the consequences of a pipeline failure. Sensitive uses are defined in some jurisdictions, but include schools, hospitals, aged care facilities and prisons. Sensitive use location class shall be assigned to any portion of pipeline where there is a sensitive development within a measurement length. It shall also include locations of high environmental sensitivity to pipeline failure."*

The standard states for new pipelines in section 4.7.2: *"In Residential (T1), High Density (T2), Industrial (I), and Sensitive (S) location classes the pipeline shall be designed such that rupture is not a credible failure mode."*

A requirement of AS2885 clause 4.7.2 is that the Critical Defect Length (CDL) is required to be at least 1.5 times the maximum damage length from credible threats. The critical defect length is dependent on pipeline pressure and other factors. The definition of CDL is "The length of a through wall axial flaw that, if exceeded, will grow rapidly and result in pipeline rupture…"

Another AS2885.1 retrospective requirement is to assess the Maximum Energy Release Rate in section 4.7.3. This is defined as;

- For general residential areas (T1), maximum energy release rates must be less than 10 GJ/s
- For high density areas (T2) and residential but Sensitive (T1-S) locations, maximum energy release rates must be less than 1 GJ/s

Generally, the VTS pipelines are not at risk of releasing 10 GJ/sec from the largest leak prior to rupture. Typical release rates from credible threats on VTS pipelines are up to 8 GJ/s. The requirement for less than 1GJ/s release rate in T2 or T1-S locations is very difficult to achieve and generally removing the threat with an additional protective measure is the only practical alternative.

In an effort to enforce this section, and to clarify, AS2885.1 section 1.4 states; *"Each existing pipeline shall be assessed against the requirements of Clauses 4.7.2 and 4.7.3. Where the existing pipeline does not comply with either Clause, mitigation shall be applied in accordance with Clause 4.7.4 regardless of whether or not there has been a land use change."*

Change in Location Class section 4.7.4: *"Where there are changes in land use planning (or land use) along the route of existing pipelines to permit Residential, High Density, Industrial, or Sensitive development or Heavy Industrial development in areas where these uses were previously prohibited, a safety assessment shall be undertaken and additional control measures implemented until it is demonstrated that the risk from a loss of containment involving rupture is ALARP."*

Almost all pipelines within the VTS are capable of rupture if severely damaged. The assessment of compliance to the standard mainly revolves around the credibility of the hazards that could create a rupture. Primarily this is the credibility of certain types of excavation equipment being used in certain environments. For an extreme example; a 100 tonne excavator is capable of causing rupture on a pipeline in question, it is not credible that 100 tonne excavator would be used by an individual to excavate a hole for a swimming pool in a typical suburban property as an excavator of that size is not practical in such an environment hence rupture is not credible from this particular threat.

Where the environment is conducive to threats that have the potential to rupture or cause a large leak in the pipeline, and that environment is or will become a High Consequence Area (HCA) (T1, T2, I or S) either additional physical or procedural measures need to be implemented until the residual risk can be lowered to As Low As Reasonably Practical (ALARP) or Low or Negligible and thus acceptable. Similar logic applies to any threat in a High Consequence Area (HCA).

3.2 APA and ALARP

Since the publication of AS2885.1 in 2007 and the revisions in 2012, APA has been required to assess the safety of pipelines retrospectively for sections 4.7.2 and 4.7.3. For many pipelines in specific urban areas the risk was determined to be Intermediate. AS2885 states that Intermediate is only acceptable risk ranking if ALARP is demonstrated. ALARP is defined in AS2885 Appendix F, F5.2 "ALARP is achieved when the cost of further risk reduction measures is grossly disproportionate to the benefit gained…".

3.2.1 APA's Approach to ALARP

APA's approach to ALARP reflects an appropriate balance to the likelihood of an event and its consequences. The approach appropriately accounts for low likelihood, high consequence outcomes. The obvious example of the strengths of the APA approach is it would avoid the incident that occurred in Ghislenghien, Belgium.

In 2004 in Ghislenghien, Belgium earthmoving equipment damaged a transmission pipeline sufficiently to cause a full bore rupture of the pipeline. The rupture ignited and killed 24 people and injured a further 132 in an industrial region. The similarities with the pipelines in this business case is, that they are in HCA, rupture is possible and there are credible earthmoving and excavation threats to cause rupture in these areas.

The APA approach is consistent with the work that the Australian and international pipeline industry has developed in its approach to risk assessment and ALARP analysis. The Australian Pipeline and Gas Association's (APGA) Research and Standards Committee (RSC) and the Energy Pipelines Cooperative Research Centre (EPCRC) have invested significantly in this area, particularly for high-consequence, low-likelihood risks such as pipeline failures. This topic has featured at prominent Australian and international industry and research conferences. ALARP guidelines have been developed to enable Licensees to better understand and demonstrate that further risk reduction measures would incur costs grossly disproportionate to their incremental benefit.

The final report – Project RP4.21A: Understanding ALARP and • Interim Report One - Project 4.20A Third Party Risks to Pipelines were utilised in understanding the technical obligations imposed by ALARP. These reports are attached [CONFIDENTIAL].

APA has been advised that the above research will be included in the next revision of AS2885 which will have a new part, solely focussed on risk. The release of this edition is expected in the next few years.

The concern is a less sophisticated approach to ALARP would have designated the residual risk of the Belgium incident as an acceptable level of risk due to the relatively low likelihood not being appropriately appreciated for the significance of the consequences. Such an outcome is clearly and demonstrably incorrect. The APA approach is consistent with industry practice of assessing the existing pipeline risk and mitigating where necessary approaching to a similar risk of a new pipeline with respect to AS2885.1 clause 4.7.2 and 4.7.3.

The approach APA is now undertaking assessment of risks and mitigations that effect those risks that are triggered by land use and land use changes around each pipeline. For example, the assessment of ALARP is not contained to just the affected pipeline segment (land use change) but adjoining pipeline segments that are also affected by land use changes.

Previously, APA's approach was typical of the pipeline industry at the time and used the Maximum Justifiable Spend (MJS) assessment (reference 2011 VTS SMS report). The MJS analysis is a Cost Benefit Analysis (CBA) technique that determines if proposed costs for effective mitigation would greatly exceed the benefit gained for each mitigation measure.

The result of the MJS process typically found the justifiable spend to be trivial, therefore supporting no further action or very small expenditure of risk mitigation to be undertaken. APA used the MJS as its sole method to demonstrate ALARP. This method of using MJS or CBA as a deterministic method is no longer appropriate. This is discussed in RP4.21A: "…'A CBA cannot form the sole argument of an ALARP decision nor can it be used to undermine existing standards and good practice'.(HSE, 2015)" from ALE, B. J. M., HARTFORD, D. N. D. & SLATER, D. 2015. Industry good practice now, is to assess the existing pipeline risk and mitigate where necessary approaching to a similar risk of a new pipeline with respect to AS2885.1 clause 4.7.2 and 4.7.3. The outcome of these assessments is likely to result in more mitigation measures than what a MJS could justify.

The MJS method is further hindered by the approach taken by the urban planning process administered by Government. Each Precinct Structure Plans (PSP) that has a pipeline traversing its area is assessed in isolation. Whereas strong and effective mitigation measures such as pressure reduction, that are assessed by MJS may affect the entire length of the pipeline that spans multiple PSP. The assessment is flawed as the benefits of the mitigation measure cannot be determined as the land use changes in adjoining PSPs cannot be appreciated (and benefit realised) as they are unknown.

A problem with a less sophisticated risk assessment is that mitigation measures that affect the long lengths of the pipeline will almost always have a cost that cannot be justified for high consequence low likelihood events unless excess capacity can allow reduction in pressure without any significant revenue or customer affect. In addition, pipeline replacement with heavy wall pipe for short sections that traverse the PSP do not take advantage of economies of scale should long lengths of pipeline be replaced and thus the cost of that and similar mitigation measures are artificially inflated due to the segmented approach taken for each PSP.

3.3 Urban Growth

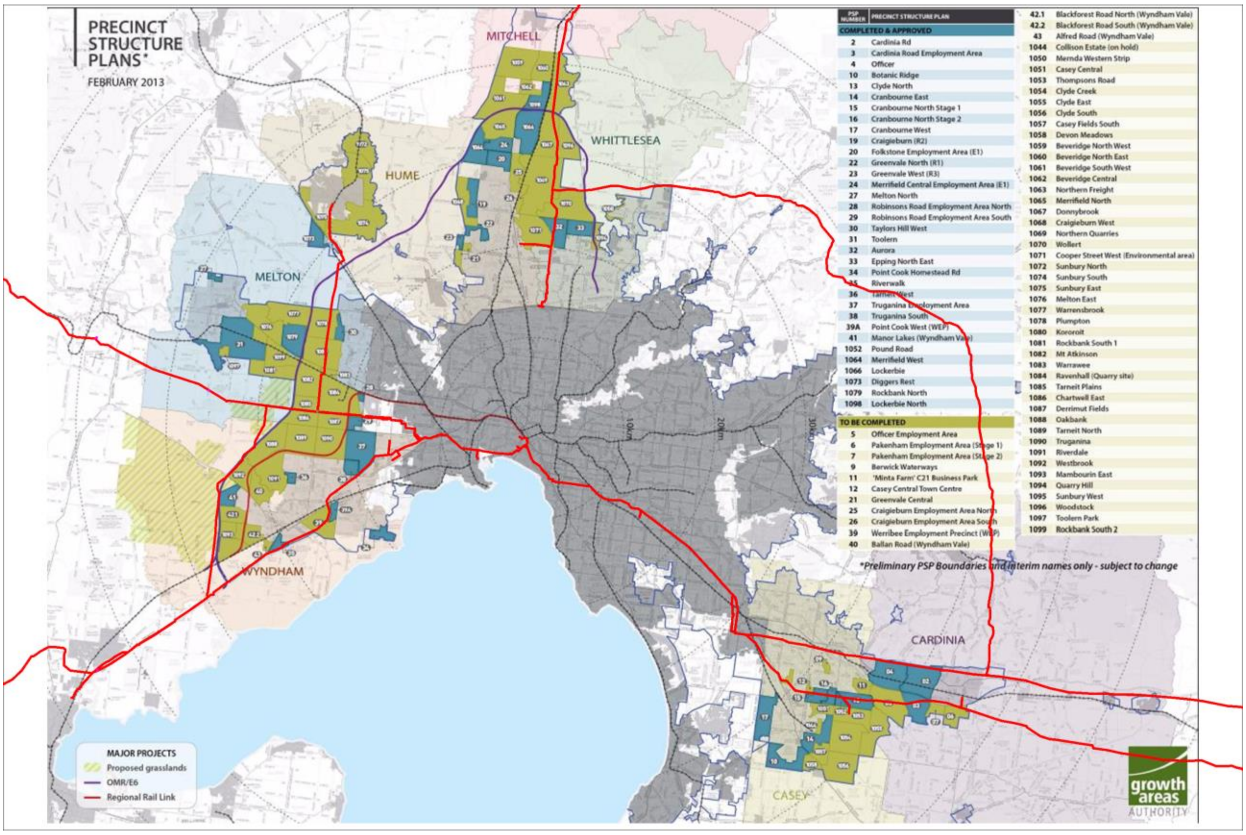
The Victorian Government moved the urban boundary in 2011 to make metropolitan Melbourne larger. This boundary is known as Melbourne 2030 boundary. The expansion alters the land use from rural to urban in areas where APA has pipelines not designed for urban areas.

The boundaries have been divided into Precinct Structure Plans (PSP) and are progressed through planning stages individually. The Victorian Government's Victorian Planning Authority (VPA) and local Councils manage the PSP approval process which includes basic structure design such as roads, land uses and institutions, employment areas and applies various Government policies for town planning applicable at the time.

APA is not currently a Referral Authority at the planning level and thus has very limited rights to influence the land use changes within any PSP. This has two major problems for APA and transmission pipelines, firstly APA is not required to be notified of a land use change and second APA's ability to object to a land use change is very minimal. As a result, APA is not able to modify the land use planning to suit the safety or asset management requirements stated in AS2885 and thus the license requirements set by the Victorian Government on APA.

APA is a Referral Authority at the sub-division level. This is too late in the process as the land has already been rezoned and objection powers are very limited.

The map below shows the PSPs to be developed in relation to the VTS pipeline system (in red). In almost all circumstances the entire urban growth boundary can be considered as a minimum T1 and in certain locations, T1-S.



3.4 Acts and Regulations

There are many legislative instruments associated with natural gas infrastructure that are utilised to enforce safety to personnel and the public. The following table lists each Victorian Act or Regulation that directly or indirectly relates to the urban encroachment of pipelines.

Act or Regulation	Reference	Particulars
Gas Safety Act 1997	Part 3, Division 1, S32	A gas company must manage and operate each of its facilities to minimise as far as practicable— (a) the hazards and risks to the safety of the public and customers arising from gas;
Gas Safety (Safety Case) Regulations 2008	Part 2, Division 4, Section 25(2)(d)	a description of technical and other measures undertaken, or to be undertaken, to reduce that risk as far as practicable
Pipeline Act 2005	Part 8, Division 1, S109	A licensee must ensure that the pipeline to which the licence applies is operated in accordance with— (a) any standards, specifications and conditions that are prescribed; and (b) any standards, specifications and conditions that are included in the licence
Pipeline Regulations 2007	Part 5, S21(2)	For the purposes of section 109(a) of the Act, a pipeline must be operated in accordance with AS 2885.2—2002 and AS 2885.3—2001
Pipeline Act 2005	Part 9, Division 2, S129	In carrying out a pipeline operation, a licensee must ensure that the operation is carried out in accordance with the Safety Management Plan accepted by Energy Safe Victoria in relation to the pipeline operation.
Pipeline Regulations 2007	Part 6, S32	The Safety Management Plan must contain a safety assessment of the pipeline operation that is consistent with the description of the pipeline in regulation 31 and that— (b) identifies all of the hazards and risks arising from the pipeline operation that have the potential to cause a safety incident; and (c) contains a detailed assessment of those risks; and (d) describes the measures undertaken, or proposed to be undertaken, to eliminate or minimise those risks as far as practicable.

4 Risk Assessment

The risks associated with urban encroachment are varied. The worst consequence that could materialise is the inadequate pipeline protection leading to rupture. Refer to the 2016 VTS Safety Management Study and ALARP assessments in Appendix A.

The below risk table is based on AS2885 risk matrix. Intermediate risks are only acceptable if ALARP is demonstrated.

"Where the risk rank cannot be reduced to 'low' or 'negligible', action shall be taken to—
(a) remove threats, reduce frequencies and/or reduce severity of consequences to the extent practicable; and

(b) demonstrate ALARP"

TABLE 3: RISK RATING

Risk Area	Risk Level
Health and Safety	**Intermediate**
Environment	**Low**
Operational	**Intermediate**
Customers	**Intermediate**
Reputation	**Intermediate**
Compliance	**Intermediate**
Financial	**Intermediate**
Final Untreated Risk Rating	**Intermediate**

5 Options Considered

The encroachment problem is not solved with the same solution in each occasion. Each identified area of land where the land use changes need to be assessed individually and the options available, feasible and prudent are unique to each affected area.

The pipelines listed below demonstrate the affected length of pipeline of Existing High Consequence areas and Proposed High Consequence. The tables demonstrate the pressure reduction affects and its relationship to the possibility of rupture or leak.

The options available to reduce the risk of change in land use are listed in AS2885.1 section 4.7.4:

a. MAOP reduction (to a level where rupture is non-credible)
b. Pipe replacement (with no rupture pipe)
c. Pipeline relocation (to a location where the consequence is eliminated)
d. Modification of land use (to separate the people from the pipeline)
e. Implementing physical and procedural protection measures that are effective in controlling threats capable of causing rupture of the pipeline.

The above options are considered, however they can be extremely expensive for the benefit gained, or outside of APA's legal authority (relocating the land use) as described;

Lowering the pipeline pressure (a) is a credible solution as it is effective for eliminating rupture for almost all credible threats in most environments. However, the consequences of smaller losses of containment are unlikely to be significantly reduced. The entire pipeline must be assessed and not just the isolated area of land use change. Otherwise this option is unlikely to be economically justifiable in many locations within the VTS. Often substantial augmentation of the VTS will be required to meet customer requirements should pressure reduction be implemented.

Pipeline replacement (b) will satisfy the requirements as the new pipeline can be designed for the high consequence area. The cost of this option will be similar to pipeline relocation and could be greater than $150m to replace the 39.5km of affected pipeline.

Pipeline relocation (c) in most circumstances is not practical as the pipelines are constructed to supply gas consumers within the urban boundary. To supply these customers from outside the urban boundary will require enormous effort and could cost upwards of $500m. This figure is based on relocating all pipelines in this business case to outside the urban boundary.

Changing the land use (d) is not within APA's legal ability and will cost more than pipeline replacement.

The selected option for most pipelines in most locations is to implement a physical protection measure (e) in the form of protection slabbing. This technique is utilised as a standard design for road and rail crossing for decades in Victoria.

Increase procedural protection (e) will reduce likelihood of an incident however cannot prevent rupture from a particular threat to be non-credible without any additional physical protection. Current procedural measures in high consequence areas include daily (5 days per week) pipeline road patrol; landowner and 3rd party liaison, community awareness and dial before you dig, pipeline marker signage and aerial patrols.

APA considers that all effective procedural controls are already in place notwithstanding that improvements are always possible and are ongoing at the time of this business case. Possible additional procedural controls include:

- Increased patrol activity beyond once per day, e.g. two or three times per day
- Increased surveillance by other means such as CCTV, satellite imagery, drone or helicopter patrol
- Remote intrusion monitoring using fibre optic cables

These options are unlikely to provide any substantial additional risk mitigation, but may reduce the likelihood but have no effect in the all controls-fail scenario when 3rd party works are not detected.

5.1 Option 1 – Do Nothing

This business case describes each affected pipeline, but in all cases the Do Nothing option is the same.

The Do Nothing option is not acceptable as the risk level isn't appropriate and under these circumstances would not be compliant with AS2885, the Pipeline License and the NGR.

The Belgium incident and recent studies performed by other business units show the Do Nothing option is unacceptable.

5.1.1 Cost/Benefit Analysis

The benefit of the Do Nothing option is the avoidance of capital and operational expenditure. The value of deferred capital is in the forecast expenditure for the proposed solutions.

The costs of the Do Nothing option are to accept the risk of a full bore rupture of a pipeline occurring in an urban environment resulting from an unauthorised excavation with its obvious consequences for public safety and a possible long term interruption to the provision of pipelines services.

To quantify the catastrophic event, the most recent pipeline failure that best represents a full bore rupture of a pipeline in an urban environment is that of the San Bruno incident in California. The rupture killed eight people and destroyed many assets and buildings in the vicinity. The cost of the explosion including fines and compensation claims is greater than US$2,000 million (reference Organisational Lessons for the Australian Pipeline Industry from the San Bruno Pipeline Rupture. Dr Jan Hayes)

The other costs of the Do Nothing option are to accept the risks from a lesser event caused by the same threat (a significant pipeline leak). That is, the consequences from vertical external interference that would have been prevented by protective slabbing. The likelihood of these events is greater than the likelihood of full bore rupture.

5.2 Project 1 – T24 Brooklyn-Corio

The Brooklyn – Corio pipeline (T24) operates at 7,400 kPa and has two wall thicknesses of 5.56mm and 6.35mm and was constructed in 1971. The PSP that affect the T24 are 35, 39 and 39A. The land the pipeline route traverses is renowned for rock and large excavators are commonly used for earth moving activities in the area.

The excavators credibly to be used in vicinity of the pipeline would be equipped with either twin tiger teeth or penetration teeth both of which are capable of penetrating the pipeline in such a manner that would produce a rupture.

The following table demonstrates the 6.35mm susceptibility to penetration from 20 tonne to 40 tonne excavators with the two different tooth types.

The maximum credible excavator size for this pipeline is 40 tonne.

MAOP	CDL	hoop stress	40t	35t	30t	25t	20t	40t	35t	30t	25t	20t
kPa	mm	%	Twin Tiger					Penetration				
			120	110	95	85	80	135	125	110	100	95
7400	124	50	Rupture	Rupture	Rupture	Rupture	NP	Rupture	Rupture	Rupture	Rupture	Rupture
CDL ratio			1.03	1.13	1.31	1.46	1.55	0.92	0.99	1.13	1.24	1.31
6000	161	47	Rupture	Rupture	Leak	Leak	NP	Rupture	Rupture	Leak	Leak	Leak
CDL ratio			1.34	1.46	1.69	1.89	2.01	1.19	1.29	1.46	1.61	1.69
5150	194	41	Leak	Leak	Leak	Leak	NP	Rupture	Leak	Leak	Leak	Leak
CDL ratio			1.62	1.76	2.04	2.28	2.43	1.44	1.55	1.76	1.94	2.04

The following table shows the effected pipeline lengths by wall thickness in high consequence areas and the length of protective slabbing proposed:

	6.35mm wall thickness
Existing affected length (km)	5.65
Proposed development length (km)	3.53
Total (km)	9.18

The cost of the protective slabbing for this pipeline that is required is $5.6m. However not all of this slabbing is required immediately.

Protective slabbing is the preferred option for this pipeline.

5.2.1 Alternative to Protective Slabbing – Pressure Reduction

The BCP is a pipeline supplied from both ends; this enables the conceptual possibility of segregating the pipeline into two, with different Maximum Allowable Operating Pressure (MAOP). The urban portion of the BCP would need to have a MAOP limit of 5,100 kPa for the pipeline to be protected from catastrophic failure mode from a 40 tonne excavator.

This alternative would consist of the following:

1. Installation of line valve at the eastern side of branch valve 09

2. Installation of Pressure Reduction Station (PRS) at new line valve
3. Slabbing of 2,500m between new line valve and the end of the urban boundary
4. Augmentation of seven custody transfer meters (CTM)
5. Augmentation of BCP City Gate at Brooklyn
6. ~~Augmentation of Laverton North City Gate~~
7. Changes to the Service Envelope Agreement (SEA) and minimum contractual pressures with AEMO
8. Augmentation of the BCP to sustain gas delivery at lower pressures (4km between KP 16-20)

The conservative cost of the above project is in the below table

Item	Quantity	Unit Cost	Total
1	1	$1,040,000	$1,040,000
2	1	$1,700,000	$1,700,000
3	2500	$580 per metre	$1,450,000
4	7	$330,000	$2,300,000
5 ~~& 6~~	1	$720,000	$720,000
8	4	$1,900,000	$7,600,000

This alternative would cost at least $14.8m. The benefits of this option are the elimination of the consequence of rupture for the high consequence areas and the reduction of consequences from a leak are also marginally reduced.

Additional costs for this option include the ongoing operational cost from inspections and maintenance for the new pressure reduction station and line valve.

Whilst the pressure reduction option is valid the costs are not prudent compared to protective slabbing. The other risk associated with the pressure reduction approach is the Victorian Government can extend the urban boundary incrementally in the future leading to more slabbing.

5.2.2 Snowy Hydro resupply and Pressure Reduction

Another alternative is to lower the pressure of the T24 to 5,100kPa for the entire pipeline length. This would negate the need for additional pressure reduction facilities. However the Snowy Hydro gas fired power plant will not be able to be supplied from the T24 pipeline. A new pipeline, 3.5km in length will need to be constructed from the Brooklyn-Lara pipeline and connect into the Snowy Hydro lateral. The effect of this additional load on the Brooklyn-Lara pipeline has not been assessed.

The cost of this alternative will be approximately $10m for the new pipeline and $1.8m for items 4, 5 & 6 in the above table.

The benefits of this alternative compared to the previous two, are the entire pipeline pressure is lowered, so further changes to the urban boundary will not affect the pipeline. The solution does not require protective slabbing which is a physical measure and the consequences of a large leak are reduced.

A lower pipeline pressure and stress level will also increase the corrosion allowance and thus the life of the T24 pipeline which is currently 45 years of age.

This alternative is not considered to be ideal as the cost is greater than protective slabbing.

5.3 Project 2 – T74 Wollert – Wodonga

The Wollert to Wodonga pipeline (T74) operates at 8,800 and 7,400 kPa and has two wall thicknesses of 7.55mm and 6.35mm and was constructed in 1976. The PSP that affect the T74 are 1063, 1067, 1096, 1069 and 1070. The land the pipeline route traverses is renowned for rock and large excavators are commonly used for earth moving activities in the area. APA recently looped this pipeline and the contractor used an 80 tonne excavator and multiple excavators of mass greater than 55 tonnes.

The excavators credibly to be used in vicinity of the pipeline would be equipped with either twin tiger teeth or penetration teeth both of which are capable of penetrating the pipeline in such a manner that would produce a rupture.

The following table demonstrates the 7.55mm susceptibility to penetration from 20 tonne to 40 tonne excavators with the two different tooth types. (NP means no penetration of the pipeline is possible from that threat)

The maximum credible excavator size for this pipeline is 40 tonne.

MAOP	CDL	hoop stress	40t	35t	30t	25t	20t	40t	35t	30t	25t	20t
MPa	mm	%		Twin Tiger					Penetration			
			120	110	95	85	80	135	125	110	100	95
8800	110	59%	Rupture	Rupture	Rupture	NP	NP	Rupture	Rupture	Rupture	Rupture	Rupture
CDL ratio			0.92	1.00	1.16	1.29	1.38	0.81	0.88	1.00	1.10	1.16
7400	138	50%	Rupture	Rupture	Rupture	NP	NP	Rupture	Rupture	Rupture	Rupture	Rupture
CDL ratio			1.15	1.25	1.45	1.62	1.73	1.02	1.10	1.25	1.38	1.45
6500	162	44%	Rupture	Rupture	Leak	NP	NP	Rupture	Rupture	Rupture	Leak	Leak
CDL ratio			1.35	1.47	1.71	1.91	2.03	1.20	1.30	1.47	1.62	1.71
5500	199	37%	Leak	Leak	Leak	NP	NP	Rupture	Leak	Leak	Leak	Leak
CDL ratio			1.66	1.81	2.09	2.34	2.49	1.47	1.59	1.81	1.99	2.09

The following table demonstrates affected lengths by future encroachment and existing encroachment.

	T74 pipeline
Existing affected length (km)	0.5
Proposed development length (km)	13.2
Total (km)	13.8

The total required length of protective slabbing for the T74 pipeline is 13.8 km. The location of these areas is discontinuous and is spasmodic across the full length of the pipeline. The cost to slab this pipeline is $8.1m and is the preferred option.

5.3.1 Alternative to Protective Slabbing

An alternative to protective slabbing is pressure reduction for the first 27 km from Wollert to Wandong. This would remove the need for slabbing in the first 27 km of the pipeline. This part of the pipeline is looped by the recently constructed T120 that operates up to 15,300 kPa. At Wandong is a PRS that permits system flexibility by creating a pressure bias towards Wollert. This creates higher utilisation of Wollert Compressor Station rather than Brooklyn, to supply Bendigo and Ballarat for operational reasons. This station will need to be retained.

The alternative is to lower the pressure of the T74 from Wollert to Wandong to 5,500 kPa and segregate the pipeline at Wandong with a new line valve and PRS, to maintain reliability and security of supply north of Wandong. The northern section of the pipeline from Wandong to Euroa will then be able to operate at full MAOP of 8,800 kPa and supplied by a PRS connected from the T120 at Wandong or Euroa. This approach would result in Wollert Compressor Station A being less critical and a higher reliance on the compression from Station B and the T120 pipeline.

The Wollert Station A would most likely be not required and demolished.

This alternative is summarised below

	Pressures	Cost
T74 Line Valve and PRS south of Wandong City Gate	Inlet: 8,800 kPa Outlet: 5,500 kPa	$1,200,000 + $2,040,000
T120 to T74 PRS at either Wandong, Seymour, Broadford or Euroa	Inlet: 15,300 kPa Outlet: 8,800 kPa	$2,040,000
Demolition of Wollert Compressor Units 1, 2 and 3.		$2,200,000
Alteration to the existing PRS at Wollert into T74.	Inlet: 10,200 - 15,300 kPa Outlet: 5,500 kPa	$900,000
Meter replacement at Wallan and Beveridge	5,500 kPa	$670,000

The cost of this project is likely to be at least $7m. The pipeline section would also be at a hoop stress of 40% of SMYS, approaching the theoretical threshold of rupture capability and lowering the likelihood of pipeline failure and failure consequence for 25km.

The downgrade of pipeline pressure will reduce pipeline capacity. This may initiate augmentation works should the local gas demand grow sufficiently with the expected urban expansion. The installation of PRS requires ongoing maintenance and replacement costs. In addition, the PRS will create another load on the T120 Victorian Northern Interconnect thus increasing the usage on Wollert Compressor Station B and reducing the capacity available for export into New South Wales. The affect that this option would have on the capacity of the T120 pipeline will be extensive.

The alternative to protective slabbing is not considered prudent at this time. Whilst the actual costs to implement are similar, the reduction in capacity on two pipelines would create the need for augmentation.

5.4 Project 3 – Brooklyn to Lara

The Brooklyn to Lara pipeline (T112) operates at 10,200 kPa and has wall thicknesses of 7.9, 9.0 and 11.1mm and was constructed in 2007. The land the pipeline route traverses is renowned for rock and large excavators are commonly used for earth moving activities in the area.

The excavators credibly to be used in vicinity of the pipeline would be equipped with either twin tiger teeth or penetration teeth both of which are capable of penetrating the pipeline in such a manner that would produce a rupture in some locations.

This pipeline was designed and constructed in 2007 and designed based on the knowledge of the urban expansion available at the time. As described in section 3.3, the urban boundary was changed in 2011. The effected length of urban encroachment is dominated by the PSP areas 29, 42, 42.1, 1084, 1085, 1086, 1087, 1088, 1092, 1093, 1093.1.

The following table demonstrates the 7.9mm susceptibility to penetration from 20 tonne to 55 tonne excavators with the two different tooth types. When this pipeline was constructed, multiple large excavators were utilised.

The maximum credible excavator size for this pipeline is 40 tonne.

MAOP	CDL	55t	40t	35t	30t	25t	20t	35t	30t	25t	20t
kPa	mm	Twin Tiger						Penetration			
		145	135	125	110	100	95	125	110	100	95
10200	101	Rupture	NP	NP	NP	NP	NP	Rupture	Rupture	Rupture	Rupture
CDL ratio		0.7	0.7	0.8	0.9	1.0	1.1	0.8	0.9	1.0	1.1
8000	145	Rupture	NP	NP	NP	NP	NP	Rupture	Rupture	Leak	Leak
CDL ratio		1.0	1.1	1.2	1.3	1.5	1.53	1.2	1.3	1.5	1.5

This pipeline is greatly affected by the change in urban boundary. Alternatives to protection slabbing includes pressure reduction, however is not viable as the loss of capacity is not able to be mitigated efficiently. The cost of protective slabbing the necessary portions of the BLP is $10.9m

	T12 pipeline
Existing affected length (km)	1.0
Proposed development length (km)	15.6
Total (km)	16.6

5.5 Summary of Pipelines Affected

The following table quantifies the lengths of pipeline that require further risk mitigation. Some pipelines are not capable of rupture from a credible excavator threat or do not traverse existing or future urban development.

Pipeline	Total Affected Length (km)	Proposed Development Length (km)	Road Crossings	Cost
Brooklyn-Corio	9.18	3.53	11	$5,623,115
Wollert-Wodonga	13.7	13.2		$8,095,806
Brooklyn-Lara	16.6	15.6		$10,916,595
Lara - Iona	0	0	5	$58,063
Total Lengths	39.5	32.3	16	$24,693,579

6 Proposed Solution

6.1 Proposed Solution - Protection Slabbing

The affected pipelines as described above require either protection slabbing, pressure reduction within capacity constraints or a combination of both in order to satisfy the requirements of the Safety Case, AS2885, the Pipelines Act and Regulations and the Gas Safety Act and Regulations.

The intent of the proposal is to achieve compliance with the 'No Rupture' credibility assessment requirements of AS2885.1.

The assessment of the pipeline to determine which locations require slabbing was conducted with Graphical Information System (GIS) which displays aerial photography imagery of the pipeline environment.

The assessment of locations to have protective slabbing was in reference to the APA philosophy *Physical Barrier Selection and Design for Existing Pipelines*. Essentially this means that all HCA locations where excavator or auger access is credible, including road reserve, local council reserves, private properties other than suburban residential yards, throughout the gazetted urban development zone, depicted in the picture in section 3.3.

6.2 Why are we proposing this solution?

The threat to the pipeline being mitigated by the works is from unauthorised excavation by vertical boring and excavators. AS2885.1 section 4.7.2 requires that for new pipelines rupture a non-credible risk in high consequence area (T1 or T2). Clause 1.4 states "…each existing pipeline shall be assessed against the requirements of Clauses 4.7.2 and 4.7.3. Where the existing pipeline does not comply with either Clause, mitigation shall be applied in accordance with Clause 4.7.4 regardless of whether or not there has been a land use change".

The pipelines described above are capable of rupture and traverse high consequence areas. The assessment of credibility is the most important factor when considering compliance and consequence.

In the past, APA has considered the likelihood of certain size excavators within the vicinity of the pipeline, and not necessarily the credibility of certain sizes when assessing an in-service pipeline. However, when designing a new pipeline, the pipeline wall thickness has been often determined by the credibility of excavator threats. An example of this differential view is the newly constructed looping of the T74 Wollert – Wodonga pipeline called the T120 Victorian Northern Interconnect (VNIE). The new loop has been designed for excavators greater than what was previously determined for a pipeline that shares the same easement and is approximately 7m away in parallel. For

APA to maintain a position that has been held and submitted to the AER in the past (that protective slabbing is not required), whilst neglecting its own conclusions for a new pipeline laid in parallel since the previous Access Arrangement submission, would be viewed as an incredulous position in the opinion of society, technical regulators and potentially judges of courts of law if any future pipeline incident on the T74 due to external penetration was to occur.

There is a clear responsibility for implementing this solution. The Gas Safety Act and the Pipelines Act require APA as owner of these pipelines to minimise risks as far as practicable. The Acts and Regulations also demand adherence to AS2885 which demands a similar risk tolerance.

6.2.1 Consistency with the National Gas Rules

Rule 79(2)(c)(iii)

The capex is necessary to comply with a regulatory obligations described in section 3. The obligations in each Act and Regulation prescribe the reduction of risk to as low as practicable. In previous submissions to the AER, APA has not proposed works similar to this proposal. Those conclusions were drawn on the application of AS2885.1 Appendix G which is heavily guided by the UK Health and Safety Executive, "Guidance on 'As Low As Reasonably Practicable' Decision in Control of Major Accident Hazards (COMAH)" and the UK Court of Appeal case of Edwards v The National Coal Board. The research reported by RSC has demonstrated that reliance on these two references alone and use of the MJS which is no longer Industry Best Practise (see section 3.2).

APA's continual adoption of Industry Best Practise, consistent with NGR 79 (1)(a), yields conclusions different from what has been presented to the AER in the past. The capital expenditure described in this business case is required to meet the regulatory obligations in the Gas Safety Act and the Pipelines Act and thus meets NGR rule 79(2)(c)(iii).

Rule 79(1)

Consistent with the requirements of Rule 79 of the National Gas Rules, APA considers that the capital expenditure is:

- Prudent – The expenditure is necessary in order to maintain and improve the safety of services and maintain the integrity of services to customers and personnel and is of a nature that a prudent service provider would incur.
- Efficient – The field work will be carried out by the external contractor that has been used to date, who has demonstrated specific expertise in completing the installation of the facilities in a safe and cost effective manner. The design of the protection slabbing has been modified to enable the most efficient construction without jeopardising effectiveness of the control measure. The expenditure can therefore be considered consistent with the expenditure that a prudent service provider acting efficiently would incur
- Consistent with accepted and good industry practice – Addressing the risks associated external interference and the reduction of risk to as low as reasonably practicable in a manner that balances cost and risk is consistent with Australian Standard AS2885.
- To achieve the lowest sustainable cost of delivering pipeline services – The sustainable delivery of services includes reducing risks to as low as reasonably practicable and maintaining reliability of supply.

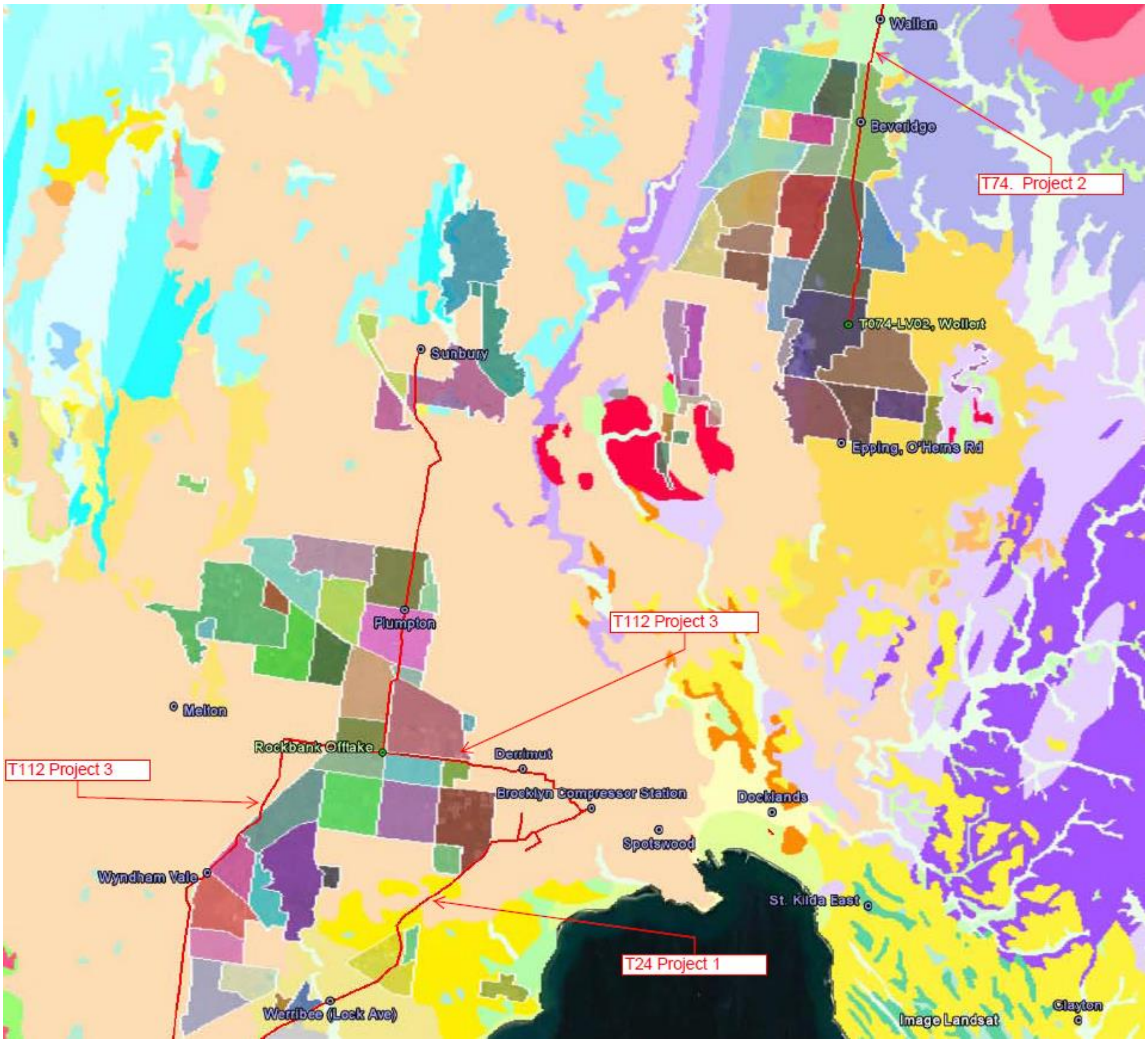
6.3 Forecast Cost Breakdown

The high volume nature of the protection slabbing leads to a unit rate cost estimation. The variances in unit rate will be due to economies of scale for short lengths, ground conditions and reinstatement variables such as asphalt roads, driveways or natural surface.

The following image is supplied by the Victorian Government with APA's pipelines and PSP areas over laid. The PSP areas are the small coloured shapes with white outline. APA's pipelines are the red continuous lines.

The colours represent typical earth formations such as sand/loam, rock and other organic features.

The areas of land identified for urban growth and pipeline protection are mainly north of the Wollert Compressor Station and west of Brooklyn Compressor station. These areas are dominated by volcanic basalt (rock) and will have significantly higher excavation costs than typical eastern areas of Melbourne.



Newer Volcanic Group - stony rises basalt (Neo2): generic

Field Name	Field Value
Unit name/code: descriptive name	Newer Volcanic Group - stony rises basalt (Neo2): generic

Newer Volcanic Group - basalt flows (Neo):

Field Name	Field Value
Unit name/code: descriptive name	Newer Volcanic Group - basalt flows (Neo): generic

Deutgam Silt(Nxe): generic

Field Name	Field Value
Unit name/code: descriptive name	Deutgam Silt(Nxe): generic
Unit description	Silt, minor sand and gravel

windblown silt (Nxl): windblown silt

Field Name	Field Value
Unit name/code: descriptive name	windblown silt (Nxl): windblown silt
Unit description	silt, fine-grained sand

Appendix A – Risk Assessment

See Victorian Transmission System five yearly Safety Management Study conducted in 2016.