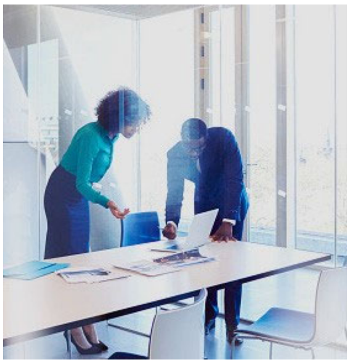
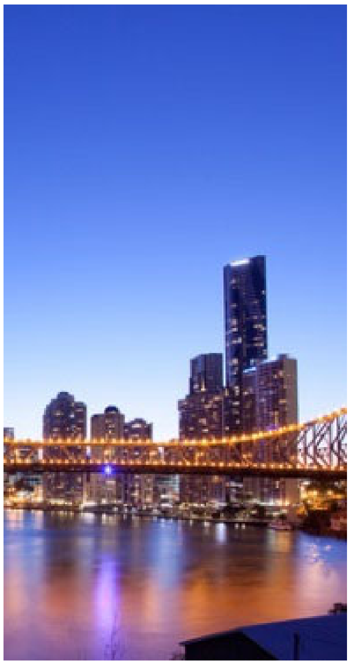
Appendix E – Quantitative Risk Assessment

GHD Advisory





Springdale Solar Farm Supplementary Gas Pipeline QRA

RES Australia Pty Ltd

28 May 2020

GHD

Contents

Figures

Tables

Appendices

1. Executive summary

RES Australia Pty Ltd (RES) has taken over the development assets of the Springdale Solar Farm from Renew Estate, who previously submitted a Development Application (DA) for the Springdale Solar Farm located approximately 7 kilometres north-west of Sutton Village, within the Yass Valley Council Area, New South Wales. The Department of Planning, Industry and Environment (DPIE) have responded to the Environmental Impact Statement (EIS) submission with a request to conduct a Quantitative Risk Assessment (QRA) to assess the impacts to the solar farm from the existing APA Dalton to Canberra gas pipeline traversing the proposed site. As there are no existing QRA studies for the Dalton to Canberra Pipeline, the DPIE has specified that a QRA approach utilising the information from the Young to Bomen Looping Pipeline QRA (Planager, 2009) can be used to assess the risks associated with the Springdale Solar Farm, commenting on the differences between the Young to Bomen Looping Pipeline and the Dalton to Canberra Pipeline.

This report addresses the request from DPIE to undertake a QRA in order to sufficiently demonstrate that the proposal will comply with the Department's Hazardous Industry Planning Advisory Paper (HIPAP) No. 4 Risk Criteria for Land Use Safety Planning and HIPAP No. 10 Land Use Safety Planning with regards to the Dalton to Canberra Pipeline traversing the Springdale Solar Farm site.

This supplementary gas pipeline QRA utilised the information presented in the PHA conducted for the Young to Bomen Looping Pipeline (Planager, 2009), a pipeline approximately 125 km to the West of the Dalton to Canberra Pipeline. The PHA conducted in 2009 for the Looping Pipeline (referred to as the Looping Pipeline PHA) presented the relevant individual fatality, injury and property damage and accident propagation risk transects.

There is an APA Mainline Valve (MLV) site adjacent to Tallagandra Lane, south of the Springdale Solar Farm solar panel site boundary. Additional QRA modelling was conducted on the MLV to assess the cumulative risk from the buried pipeline and associated surface equipment.

This assessment has been conducted assuming that the Dalton to Canberra Pipeline has the same consequence and risk as the Looping Pipeline, even though there are differences in the pipelines. These differences including diameter, operating pressure, pipeline wall thickness and depth of cover have been discussed to assess the impacts of these differences on the level of risk. In addition, the Looping Pipeline PHA utilised failure frequency data based on European statistics up to 1992. However, more recent Australian data is available that indicates much lower failure frequencies, therefore the cumulative risk results assessed are conservative.

The key infrastructure on the proposed solar farm site includes the control building and substation. These represent locations where personnel would predominantly be located and infrastructure that has the potential to escalate gas loss of containment risks. Analysis of the consequence effect distances found that some loss of containment events from the pipeline, in particular the larger diameter releases of 100 mm and full bore ruptures could lead to jet fire, flash fire and explosion overpressure effects at the control building location. The consequence effects of the loss of containment events are not likely to reach the substation area.

By using the risk results of the Young to Bomen Looping Pipeline in conjunction with an analysis of the risk from the MLV to assess the cumulative risk for the Dalton to Canberra Pipeline, it was determined that all HIPAP No. 4 risk criteria are met for the control building and substation areas. This includes the cumulative risk for the individual fatality risk, injury risk and the property damage and accident propagation risk. In addition, the maximum risk posed to any location within the solar farm site is below the HIPAP No. 4 risk criteria.

Although it has been demonstrated that the cumulative risk from the pipeline and MLV is sufficiently low and below the relevant HIPAP No. 4 risk criteria, the prevention of pipeline damage is vital and therefore the design and all construction activities must take into account the presence of the gas pipeline. As identified in the pipeline SMS (Sage Consulting, 2018a), the following recommendations apply to minimise pipeline threats:

- The pipeline must be positively located prior to detail design being undertaken.
- Electrical studies in accordance with AS 4853 and AS 2832 are required.
- Crossings design (vehicle or cable) must be approved by APA.
- During construction, the easement must be delineated on site and marked as a no-go zone.
- All plans must have the easement clearly identified so that contractors are aware of it.
- Access to the easement by APA Operations personnel must be maintained at all times.
- An update to the APA SMS database spreadsheet must be undertaken.
- Potholing to verify depth of cover at Tallagandra Road crossing is to be coordinated via APA.
- The RFQ documentation for the EPC contract shall address the restrictions and requirements identified in the SMS.
- For works on the easement, an APA third party works authorisation must be in place, and onsite supervision arranged.
- MLV site is left clear and unimpeded during construction and operation of solar farm – this is not a laydown area for solar farm material and equipment.

This report is subject to, and must be read in conjunction with, the limitations set out in section 2.3 and the assumptions and qualifications contained throughout the Report.

2. Introduction

2.1 Background

RES has taken over the development assets of the Springdale Solar Farm ("the proposal") from Renew Estate, who previously submitted a Development Application (DA) for the solar farm. The Springdale Solar Farm is located approximately 7 kilometres north-west of Sutton Village, within the Yass Valley Council Area, New South Wales. The Department of Planning, Industry and Environment (DPIE) have responded to the Environmental Impact Statement (EIS) submission by RES with a request to conduct a Quantitative Risk Assessment (QRA) to assess the impacts to the solar farm from the APA Dalton to Canberra gas pipeline traversing the proposed site.

The Springdale Solar Farm is similar in nature to the Bomen Solar Farm and both sites have high pressure gas pipelines in the vicinity of the proposed development. The DPIE has specified that a QRA approach similar to that used for the Bomen Solar Farm assessment (GHD, 2018) can be used to assess the risks associated with the Springdale Solar Farm. Specifically, this involves using the risk results from the Young to Bomen Looping Pipeline QRA (Planager, 2009), and commenting on the differences between the pipelines, combined with additional analysis of the surface infrastructure of the Dalton to Canberra Pipeline in vicinity of the Springdale solar farm site.

2.2 Purpose of this report

The purpose of this report is to address the request from DPIE to undertake a QRA in order to sufficiently demonstrate that the proposal can comply with the Department's Hazardous Industry Planning Advisory Paper (HIPAP) No. 4 Risk Criteria for Land Use Safety Planning and HIPAP No. 10 Land Use Safety Planning with regards to the Dalton to Canberra Pipeline traversing the site.

2.3 Scope and limitations

The scope of the QRA is to assess the risks associated with loss of containment events from the APA Dalton to Canberra high pressure gas pipeline that traverses the proposed Springdale Solar Farm site. The scope is specifically limited to the impacts from loss of containment events in the pipeline sections within the solar farm site and excludes analysis of the remainder of the pipeline. As per the requirements outlined by DPIE, the QRA takes into account site specific features, including but not limited to pipeline ancillary equipment (main line valve) along Tallagandra Lane.

The scope of the assessment includes a desktop analysis, incorporating a review of the Preliminary Hazard Analysis (PHA) conducted in 2009 for the Young to Bomen Looping Pipeline. Further QRA modelling is included for the above ground facilities that do not have an existing analysis. The assessment includes consequence analysis of jet fire heat radiation, flash fire and explosion overpressure. It also includes risk analysis against the individual fatality, injury, property damage and accidental propagation risk criteria outlined in HIPAP No. 4, based on the cumulative risk from the pipeline.

This supplementary gas pipeline QRA is not intended to be a complete analysis of the hazards and risks associated with the Dalton to Canberra Pipeline or the proposed Springdale Solar Farm development. Reference should be made to the Springdale Solar Farm EIS (AECOM, 2018) and the Preliminary Hazard Analysis of the Springdale Solar Farm Safety Management Study Report (Sage Consulting, 2018a) for further details and analysis of other hazards.

Additionally, this report: has been prepared by GHD for RES Australia Pty Ltd and may only be used and relied on by RES Australia Pty Ltd for the purpose agreed between GHD and the RES Australia Pty Ltd as set out in section 2.2 of this report.

GHD otherwise disclaims responsibility to any person other than RES arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by RES Australia Pty Ltd and others who provided information to GHD, which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

GHD has not been involved in the preparation of the Preliminary Hazard Analysis of the Natural Gas Delivery Pipeline between Young and Bomen in NSW (Planager, 2009). GHD has had no contribution to the Preliminary Hazard Analysis of the Natural Gas Delivery Pipeline between Young and Bomen in NSW (Planager, 2009) other than to apply the information available from that report into this report. GHD shall not be liable to any person for any error in, omission from, or false or misleading statement in, any part of the Preliminary Hazard Analysis of the Natural Gas Delivery Pipeline between Young and Bomen in NSW (Planager, 2009). Additionally, GHD's scope is based on the approach used for the Preliminary Hazard Analysis of the Natural Gas Delivery Pipeline between Young and Bomen in NSW (Planager, 2009). GHD disclaims liability arising from this approach being rejected by DPIE.

3. Project and pipeline summary

3.1 Overview

The methodology applied for the supplementary gas pipeline QRA is a desktop analysis incorporating a review of:

- The PHA conducted in 2009 as part of the Young to Bomen Looping Pipeline EIS (Planager, 2018),
- The Springdale Solar Farm Environmental Impact Statement (AECOM, 2018),
- The Springdale Solar Farm Safety Management Study Report (Sage Consulting Solutions Pty Ltd, 2018a), and
- Additional consequence and quantitative risk assessment modelling conducted for ancillary pipeline equipment located in proximity to the solar farm site.

The Dalton to Canberra Pipeline is a 273 mm diameter steel pipeline with 6.2 MPa Maximum Allowable Operating Pressure (MAOP)[1]. The pipeline traverses the proposed Springdale Solar Farm site.

The QRA information for the Young to Bomen Looping Pipeline traversing the Bomen Solar Farm is used as the basis for the Dalton to Canberra Pipeline, as communicated by DPIE (DPIE, 2018). Assumptions used to assess the risks of the Dalton to Canberra Pipeline, and differences compared to that of the Young to Bomen pipeline are documented throughout the report for clarity.

3.2 Solar farm project summary

RES has taken over the development assets from Renew Estate and are proposing the construction, operation and decommissioning of a 120 megawatt (direct current) (MWdc) solar farm and associated infrastructure for the Springdale Solar Farm. The proposed solar farm has 100 megawatts of export capacity (alternating current) (MWac). The Springdale Solar Farm site is a greenfield site and is located approximately 3.5 kilometres north of the Australian Capital Territory (ACT) border, and approximately 7 kilometres north-west of the Sutton Village in New South Wales (AECOM, 2018).

The primary components of the proposal include:

- Photovoltaic (PV) solar modules on a single-axis tracking system mounted on steel piles
- Approximately 22 containerised power conversion stations, containing electrical switchgear, inverters and transformers
- An electrical switchyard and substation that would be connected to the existing 132 kilovolt (kV) TransGrid transmission line that traverses the Site
- Direct Current (DC) and Alternating Current (AC) cabling for electrical reticulation
- A control building including office, supervisory control and data acquisition (SCADA) systems, operation and maintenance (O&M) facilities, staff amenities, and associated carpark
- Two meteorological stations
- Internal all-weather access tracks
- Security fencing
- Landscaping

[1] Used as the basis of this assessment. Refer to Section 3.3 for additional details.

- Subdivision of Lot 209 DP754908 to create a new lot for the proposed substation (AECOM, 2018).

There is no planned storage of batteries on site at the Springdale Solar Farm.

The APA Dalton to Canberra Pipeline traverses the proposed site as shown in Figure 1.

The operational lifetime of the solar farm is approximately 35 years. Decommissioning at the end of the operational life of the solar farm would remove all above ground infrastructure and rehabilitate the site to return it to its predevelopment condition (AECOM, 2018).

The construction period is likely to be in the order of 12 months and it is anticipated there may be a peak of up to 200 personnel on site. During operations, there may be 2-5 people on site daily, predominantly within the control building area and intermittently throughout the remainder of the site.

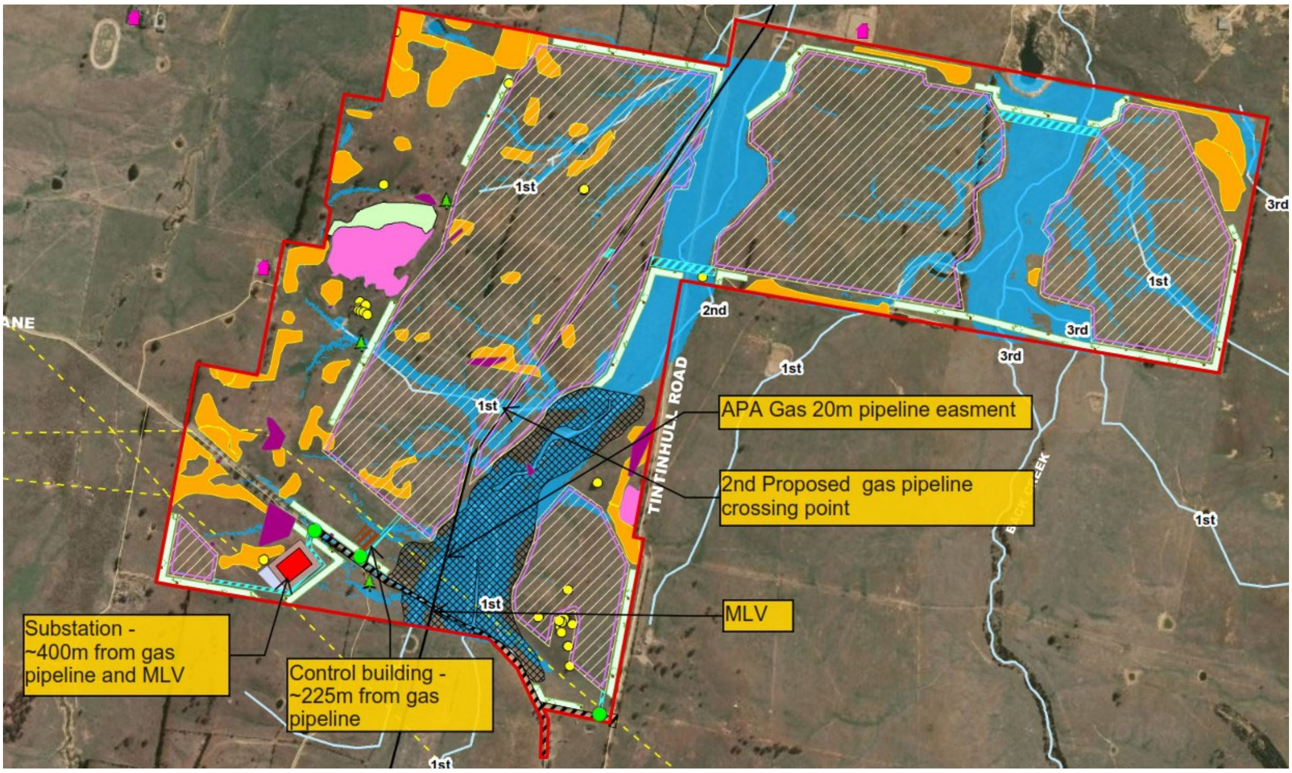


Figure 1 Proposed site and location of Dalton to Canberra Pipeline (RES, 2020)

3.3 Pipeline details

The Dalton to Canberra Pipeline is owned and operated by APA. The pipeline specifications are summarised in Table 1 comparing the Dalton to Canberra and Young to Bomen Looping Pipeline. The information for the Young to Bomen Looping Pipeline has been reproduced from the Bomen Solar Farm Safety Management Study Report (Sage Consulting Solutions, 2018b). The details of the Dalton to Canberra Pipeline represents the characteristics of the pipeline within the location of the proposal site (reproduced from the Springdale Solar Farm Safety Management Study Report (Sage Consulting Pty Ltd, 2018a).

Table 1 Pipeline specifications

Solar Farm Site	Springdale	Bomen
Pipeline Name	**Dalton to Canberra**	**Young to Bomen Looping**
Constructed/Commissioned	1981	~2010
Outside Diameter	273 mm	457 mm
Wall Thickness	6.4 mm	6.8 mm 9.7 mm at crossings
Pipe specification	API 5L Grade X46	API-5L Grade X70
MAOP	6.2 MPa*	10.2 MPa
Depth of cover (to be confirmed)	900 mm 1.2 m under road	1.2 m
Measurement Length	212 m	452 m
Critical Defect Length	149.97 mm	89.2 mm

* The MAOP is actually 7.8 MPa. This pressure cannot, however, be reached on the pipeline unless a gas compression station is added to the pipeline as the pipeline is supplied from the Moomba to Wilton Natural Gas Pipeline which has a MAOP of 6.2 MPa at the supply point for the Dalton to Canberra Pipeline.

As indicated in Figure 1, the pipeline runs diagonally across the proposal site with two vehicle crossing points across the pipeline, the proposed control building approximately 225 metres from the pipeline, and the proposed substation approximately 400 metres from the pipeline. Approximately 2.9 km of pipeline traverses the site between APA kilometre point (KP) markers 44 and 46.9.

Within the project site and immediately adjacent to the site, the pipeline is buried. There is an APA Mainline Valve (MLV) site adjacent to Tallagandra Lane, south of the solar panel site boundary. The site may be used for venting gas from the pipeline (infrequently, if ever). A planned release will be communicated to the community prior to venting, and an unplanned release may be noisy. Pressure at the Tallagandra MLV is likely to be around 5.6 MPa but is dependent on seasonal and operational conditions, therefore a conservative approach of using 6.2 MPa as the MAOP has been applied. All line valves on the Dalton to Canberra Pipeline (including Tallagandra Lane) are fitted with a rate of pressure change shutdown system (ALB). The rate of pressure change set pressure of each valve from the Dalton to Canberra is 1.67 kPa/sec for 1 minute. Although this mitigation measure is in place, no credit has been taken for it, therefore consequence and risk results represent a conservative approach.

The location class of the pipeline within the area of the solar farm was determined as R1 / HI (with equivalent protections to an R2 designation) in the most recent SMS (Sage Consulting, 2018a), where R1 is Rural (unused, undeveloped, agricultural, grazing), R2 is rural residential and HI is Heavy Industrial.

The orientation of the solar panels will avoid construction activities over the pipeline easement, whereby the solar development areas are outside of a 20 m wide corridor from the pipeline. There will be requirements for cable crossings of the easement from power conversion stations (inverters and medium voltage transformers) to the onsite substation (33kV and communications) (Sage Consulting Pty Ltd, 2018a).

4. Risk criteria

The *HIPAP No 4 – Risk Criteria for Land Use Safety Planning* (DPE, 2011) provides criteria for individual, societal and property damage risks. The criteria are used as a conservative tool for assessing these risks.

Individual risk is a measure of the risk to an individual continuously exposed at a specific location within the effect zone of a hazardous incident. The individual and property damage risk criteria for fires and explosions listed in Table 2 are suggested in HIPAP No. 4. The risk level represents the frequency at which the relevant exposure type should not be exceeded.

As the scope of this supplementary gas pipeline QRA is focussed on the risk from the pipeline to the proposal site and personnel on site, only the individual fatality and property damage and accident propagation criteria are relevant (DP&E, 2018), however the injury risk at residential locations is also included for consistency with the Young to Bomen pipeline PHA. For clarity, the HIPAP No. 4 criteria that are not relevant to this study have been indicated in grey text.

Table 2 HIPAP No. 4 risk criteria

Category	Exposure Type	Maximum tolerable risk
Fatality	Hospitals, schools, child-care facilities and old age housing developments	Half in a million per year (0.5×10^{-6} per year)
Fatality	Residential developments and places of continuous occupancy (hotels/resorts)	One in a million per year (1×10^{-6} per year)
Fatality	Commercial developments, including offices, retail centres, warehouses with showrooms, restaurants and entertainment centres	Five in a million per year (5×10^{-6} per year)
Fatality	Sporting complexes and active open space areas	Ten in a million per year (10×10^{-6} per year)
Fatality	Industrial sites	Fifty in a million per year (50×10^{-6} per year)
Injury	4.7 kW/m^2 incident heat flux radiation at residential and sensitive use areas	Fifty in a million per year (50×10^{-6} per year)
Injury	7 kPa incident explosion overpressure at residential and sensitive use areas	Fifty in a million per year (50×10^{-6} per year)
Injury	Toxic concentrations in residential and sensitive use areas should not exceed a level which would be seriously injurious to sensitive members of the community following a relatively short period of exposure	10 in a million per year (10×10^{-6} per year)
Irritation	Toxic concentrations in residential and sensitive use areas should not cause irritation to eyes or throat, coughing or other acute physiological responses in sensitive members of the community	Fifty in a million per year (50×10^{-6} per year)
Property damage & accident propagation	23 kW/m^2 incident heat flux radiation at neighbouring potentially hazardous installations or at land zoned to accommodate such installations	Fifty in a million per year (50×10^{-6} per year)
Property damage & accident propagation	14 kPa incident explosion overpressure at neighbouring potentially hazardous installations, at land zoned to accommodate such installations or at nearest public buildings	Fifty in a million per year (50×10^{-6} per year)

The effects of heat radiation and explosion overpressure are described in Table 3 and Table 4 (DP&E, 2011), as used for the basis of the HIPAP risk criteria in Table 2.

Table 3 Heat radiation effects

Heat radiation (kW/m^2)	Effect
1.2	Received from the sun at noon in summer
4.7	Will cause pain in 15-20 seconds and injury after 30 seconds’ exposure (at least second degree burns will occur)
12.6	Significant chance of fatality for extended exposure. High chance of injury Causes the temperature of wood to rise to a point where it can be ignited by a naked flame after long exposure Thin steel with insulation on the side away from the fire may reach a thermal stress level high enough to cause structural failure
23	Likely fatality for extended exposure and chance of fatality for instantaneous exposure Spontaneous ignition of wood after long exposure Unprotected steel will reach thermal stress temperatures which can cause failure Pressure vessel needs to be relieved or failure would occur
35	Cellulosic material will pilot ignite within one minute’s exposure. Significant chance of fatality for people exposed instantaneously

Table 4 Explosion overpressure effects

Overpressure (kPa)	Effect
3.5	90% glass breakage. No fatality, very low probability of injury
7	Damage to internal partitions & joinery 10% probability of injury, no fatality
14	Houses uninhabitable and badly cracked
21	Reinforced structures distort, storage tanks fail 20% chance of fatality to person in a building
35	Houses uninhabitable Wagons & plant items overturned. Threshold of eardrum damage 50% chance of fatality for a person in a building, 15% chance of fatality for a person in the open
70	Threshold of lung damage 100% chance of fatality for a person in a building or in the open Complete demolition of houses

5. Cumulative risk assessment

The following risk results are reproduced from the Preliminary Hazard Analysis of the Natural Gas Delivery Pipeline between Young and Bomen in NSW (Planager, 2009) (referred to as the Looping Pipeline PHA) and represents the relevant information utilised in assessment of the risks to the Springdale Solar Farm site. Discussion of the differences between the Looping Pipeline and the Dalton to Canberra Pipeline is included in subsequent sections, as well as the effect on the risk results.

5.1 Input summary

The pipeline design assumptions used as the basis for the Looping Pipeline PHA, compared to that of the Dalton to Canberra Pipeline are summarised in Table 5 and are consistent with the information available for the 'as constructed' pipeline details provided in Table 1.

Table 5 Looping Pipeline PHA assumptions & Dalton to Canberra Pipeline detail comparison

Pipeline Details	Young to Bomen Looping	Dalton to Canberra
Pipeline diameter	450 mm	273 mm
Wall thickness	6.8 mm 9.7 mm at crossings	6.4 mm
Pipe length	130 km	58 km
Pipe specification	API-5L Grade X70	API 5L Grade X46
MAOP	10.2 MPa	6.2 MPa
Depth of cover	At least 900 mm	900 mm, 1.2 m under road
Temperature	25°C	25°C

A number of specific assumptions were made in the QRA for the Young to Bomen Looping Pipeline. Reference should be made to the Looping Pipeline PHA (Planager, 2009) for details on these assumptions.

For ease of assessment, it is assumed that the risk results from the Looping Pipeline are reflective of the risk results from the Dalton to Canberra Pipeline. However, it should be noted that in reality, the risk between the two pipelines differs – in particular the pipeline diameter, and MAOP of the Looping Pipeline are such that the Looping Pipeline would pose a greater risk than the Dalton to Canberra Pipeline. However, the smaller wall thickness and depth of cover of the Dalton to Canberra Pipeline poses a greater risk than that of the Looping Pipeline due to the relatively higher frequency of failure. Where this assumption influences the risk results, specific discussion is provided within each section below.

5.2 Hazards identified

The Looping Pipeline PHA identified 10 potentially hazardous scenarios that could lead to a loss of containment of gas from the pipeline. It is assumed that 9 of the 10 hazardous scenarios are relevant for the Dalton to Canberra Pipeline and include:

1. Mechanical damage to the pipeline
2. Corrosion
3. Nearby explosion at neighbouring natural gas pipeline (*not relevant for the Dalton to Canberra Pipeline as there are no neighbouring gas pipelines*)
4. Pressure excursion
5. Spontaneous loss of integrity of pipe (rupture)
6. Erosion
7. Land subsidence
8. Aircraft, train or heavy vehicle crash
9. Damage to pipeline through terrorism / vandalism
10. Neighbouring bush fire.

These hazardous scenarios represent the potential events that could lead to an impact on the solar farm site and personnel. It is assumed that the same hazardous scenarios apply to the Dalton to Canberra Pipeline – this is justified on the basis that both are owned and operated by APA and are within similar location classes.

In addition to the 10 hazardous scenarios identified in the Looping Pipeline PHA, some credible threats were identified to the Dalton to Canberra Pipeline in the SMS conducted as part of the proposal EIS. The specific features of the solar farm site and construction activities that will be required were discussed and documented as the basis for the SMS (refer to Sage Consulting Solutions Pty Ltd, 2018a). The SMS also incorporated the presence of the MLV within the easement. It is considered that this detailed assessment is sufficient to demonstrate that the specifics of the solar farm site have been considered concerning potential causes of loss of containment from the pipelines. A summary of the credible threats identified in the SMS include:

- HDD cable installation punctures pipeline
- Earthworks with pile-driver punctures pipeline
- Post hole installations punctures pipeline
- AC/DC electrical interference to pipeline
- Marker signs removed

On the basis that both the Dalton to Canberra SMS and Looping Pipeline PHA have identified a similar suite of loss of containment causes, it is considered reasonable that the loss of containment leak frequencies presented in the Looping Pipeline PHA are representative of the location specific frequencies for the buried pipeline section within the solar farm site. The differences between the pipelines that influence release frequency are discussed in Section 5.4. Additional loss of containment frequency analysis has been performed for the Tallagandra line valve, as ancillary pipeline equipment specific to the Springdale location.

5.3 Consequence analysis

The below summary represent the heat radiation, flash fire and explosion overpressure results calculated in the Looping Pipeline PHA (Planager, 2009). A discussion on the similarities and differences between the results for the Looping Pipeline and the Dalton to Canberra Pipeline is also included, with a focus on the potential impacts of those loss of containment events to the Springdale Solar Farm site.

QRA modelling was undertaken for the MLV component of the Dalton to Canberra Pipeline using DNVGL's SAFETI program (version 8.22). The heat radiation and explosion overpressure results are also included in the subsequent sections. The assumptions and methodology for the MLV modelling are included in Appendix A. The full bore (guillotine) rupture cases for the MLV are considered to be 273 mm vertical release from within the valve pit and the smaller releases are horizontal.

The approximate distances from the Dalton to Canberra Pipeline to key infrastructure on site is outlined in Table 6.

Table 6 Distances from Dalton to Canberra Pipeline to key site infrastructure

Site infrastructure of interest	Distance from Dalton to Canberra Pipeline (m)
Control building (includes operation and maintenance facilities, staff amenities, and associated carpark)	~225
Substation	~400

5.3.1 Jet fires

Table 7 presents the heat radiation distances produced by jet fires from immediate ignition of gas released from the Looping Pipeline (Planager, 2009), and the Tallagandra Lane MLV.

Table 7 Jet fire heat radiation distances

Hole size	Young to Bomen Looping Pipeline[(a)]			Tallagandra Ln Mainline Valve[(b)]		
	Distance to heat radiation (metres)					
	4.7 kW/m^2	12.5 kW/m^2	23.5 kW/m^2	4.7 kW/m^2	12.5 kW/m^2	23.5 kW/m^2
Small leak (5 mm)	6	4	3	6	6	N/A
Intermediate leak (25 mm)	30	18	14	35	29	27
Massive leak (100 mm)	120	74	55	140	110	96
Full bore (guillotine)	525 361[(b)]	310 239[(b)]	240 107[(b)]	170	33	N/A

[(a)] Based on modelling at 10.2 MPa (Planager, 2009)

[(b)] Based on modelling at 6.2 MPa

The information regarding the distance to key infrastructure provided in Table 6 and jet fire heat radiation effects in Table 7 indicates the following:

- All key site infrastructure, as identified in Table 6, is outside of the jet fire heat radiation effect zones from small, intermediate and massive pipeline leaks (5 mm, 25 mm and 100 mm hole sizes).
- Full bore (guillotine) rupture of the pipeline would impinge on all the key infrastructure listed in Table 6 to some extent based on the consequence results from the Looping Pipeline PHA. The substation is unlikely to be exposed to heat radiation greater than 4.7 kW/m^2, but all other key infrastructure may be exposed to heat radiation up to 23.5 kW/m^2.
- All key site infrastructure is outside of the jet fire heat radiation effect zones from all MLV leaks (5 mm up to and including full bore rupture of the MLV). The jet fire consequence distances are typically greater for an above ground section (such as a MLV), as releases are not impinged by the ground / soil. However, the modelling for the Tallagandra Lane MLV was conducted at a lower operating pressure than the results presented for the Looping Pipeline.

Consequence impact distances of gas releases are heavily influenced by the parameters of the pipeline. In the case of jet fires, the pressure of the gas at the time of release plays a significant part in the distance the flame can travel. For large bore releases, there is typically a rapid pressure loss that also influences the extent of the flame. When considering the results presented in Table 7 with regards to the same loss of containment events from the Dalton to Canberra Pipeline, the lower pressure of 6.2 MPa compared to 10.2 MPa for the Looping Pipeline would mean that the heat radiation distances would be substantially less. In effect, this would mean that for the small to massive (5 mm, 25 mm and 100 mm) releases, it is unlikely there would be any effects that extend close to key infrastructure. As the results from the Looping Pipeline PHA indicate a potential for the pipeline ruptures to reach key infrastructure, additional consequence modelling was performed for the lower pressure Dalton to Canberra Pipeline ruptures, as reported in Table 7. The analysis indicates no jet fire impacts will be observed at the substation, however 4.7 kW/m^2 and 12.5 kW/m^2 heat radiation impacts can reach the control building.

Although there is potential for some heat radiation effects to reach the location of the control building and extend across the solar farm site, including impact on solar panels, the likelihood of a large release occurring that could extend such distances is relatively low, as discussed in Section 5.4.

5.3.2 Flash fires

Table 8 presents the heat radiation distances produced by flash fires from delayed ignition of gas released from the Young to Bomen Looping Pipeline (Planager, 2009) and the Tallagandra Lane MLV.

Table 8 Flash fire heat radiation distances

Hole size	Distance to LFL (100% fatality) (metres)	
	Young to Bomen Looping Pipeline[a]	Tallagandra Ln Mainline Valve[b]
Small leak (5 mm)	12	7 m at a height of 0.5 m N/A at a height of 1.5 m
Intermediate leak (25 mm)	30	49 m at a height of 0.5 m 47 m at a height of 1.5 m
Massive leak (100 mm)	70	239 m at a height of 0 m 238 m at a height of 1.5 m
Full bore (guillotine)	250	930 m at a height of 100 m 1 m at a height of 1.5 m[c]

[a] Based on modelling at 10.2 MPa (Planager, 2009)

[b] Based on modelling at 6.2 MPa

[c] Modelled as a vertical release

The information regarding the distance to the key infrastructure provided in Table 6 and flash fire effects in Table 8 indicates the following:

- All key site infrastructure is outside of the flash fire effect zones from all pipeline leaks and full bore rupture.
- A massive leak from the Tallagandra Lane MLV leading to a flash fire would impinge on the control building area, but not the substation. Under this scenario, the key infrastructure may be exposed to gas concentrations within the flammable limit. If personnel were present in the vicinity at the time of the flash fire there is a 100% chance of fatality in these locations.
- Full bore (guillotine) rupture of the Tallagandra Lane MLV would not impinge on key infrastructure. This is because the release is likely to be a vertical release from the valve pit (whereas the smaller leaks are likely to be horizontal leaks), and due to the high pressure of the pipeline and buoyant nature of methane, the gas cloud would extend in a vertical direction to well above the height of where personnel may be located.

The Looping Pipeline PHA does not indicate the height at which the flash fire results are reported. Upon release, an unignited gas cloud will rise rapidly and disperse into a concentration below the flammable limit. If the results have been reported in the Looping Pipeline PHA at the cloud centreline, this will be at a height typically above the location of where personnel would be present and therefore represents a conservative effect distance. To be conservative, it is assumed that the flash fire results are reported at a height in which personnel may be located.

As with jet fires, the flash fire effects are influenced by the pressure of the gas and diameter of the pipeline. Therefore, a loss of containment from the Dalton to Canberra Pipeline would have reduced flash fire distances as compared to those provided for the Young to Bomen Looping Pipeline in Table 8 based on the lower pressure of the pipeline. On this basis, the location of key site infrastructure would most likely be outside all flash fire effect distances from the Dalton to Canberra Pipeline.

Although there is potential for some flash fire effects to reach the location of the key infrastructure and extend across the solar farm site, the likelihood of a large release occurring that could extend such distances is relatively low, as discussed in Section 5.4.

5.3.3 Explosions

Table 9 presents the overpressure distances produced by explosions resulting from delayed ignition of gas released from the Young to Bomen Looping Pipeline (Planager, 2009) and Tallagandra Lane MLV.

Table 9 Explosion overpressure distances

	Young to Bomen Looping Pipeline[a]			Tallagandra Ln Mainline Valve[b], [c]		
Hole size	Distance to explosion overpressure (metres)					
	7 kPa	14 kPa	70 kPa	7 kPa	14 kPa	70 kPa
Small leak (5 mm)	30	25	15	N/A	N/A	N/A
Intermediate leak (25 mm)	120	75	40	44	N/A	N/A
Massive leak (100 mm)	300	200	75	248	N/A	N/A
Full bore (guillotine)	450	380	220	958	N/A	N/A

[a] Based on modelling at 10.2 MPa (Planager, 2009)

[b] Based on modelling at 6.2 MPa

[c] Modelled with two confined areas – the substation and control building

The information regarding the distance to the key infrastructure provided in Table 6 and explosion overpressure in Table 9 indicates the following:

- All key site infrastructure is outside of the explosion overpressure effect zones from small and intermediate pipeline leaks (5 mm and 25 mm leak sizes).
- The substation is located outside all explosion overpressure effect distances. The control building and associated infrastructure has the potential to be exposed to explosion overpressures up to 7 kPa as a result of a massive (100 mm) pipeline leak. Explosion overpressures greater than 7 kPa resulting from a massive pipeline leak are unlikely to reach any of the key infrastructure listed in Table 6.
- Explosion overpressures up to 14 kPa resulting from a full bore (guillotine) rupture of the pipeline has the potential to impinge on key infrastructure listed in Table 6. Explosion overpressures greater than 14 kPa resulting from a full bore (guillotine) rupture of the pipeline are unlikely to impinge on any key infrastructure.
- Small and intermediate MLV leaks (5 mm and 25 mm hole sizes) are unlikely to result in explosion overpressures that would impinge on any key infrastructure listed in Table 6.
- Massive MLV leaks (100 mm) have the potential to result in up to 7 kPa explosion overpressures that would impinge on for the control building and associated infrastructure but not the substation.
- Full bore (guillotine) MLV leaks have the potential to result in explosion overpressures up to 7 kPa that could impinge on all key infrastructure.

Although the explosion overpressure results are provided and assessed, it must be noted that for an explosion to occur, a loss of containment must occur, followed by dispersion of the gas and accumulation in a confined / congested area and the gas must contact an ignition source. Within the solar farm site, the only credible location of accumulation and confinement of gas would be the control building and substation. The LFL flash fire results presented in Table 8 indicate the gas cloud could travel up to 238 m within flammable concentrations due to a full bore rupture (at a height where personnel are present). This means that there is no risk of explosion at the substation as it is outside the flammable cloud footprint. However, there is potential for the gas to accumulate leading to an explosion at the control building location.

As with jet fires and flash fires, although there is potential for some explosion effects to reach the location of key infrastructure and extend across the solar farm site, the likelihood of a large release occurring that could extend such distances is relatively low, as discussed in Section 5.4.

5.4 Frequency analysis

The frequencies used for the Looping Pipeline PHA were based on incident statistics between 1988 and 1992, gathered by the European Gas Pipeline Incident Data Group (EIGPIDG) (Dawson, 1994). That data was selected at the time of the Looping Pipeline PHA, based on the statistical significance of the data available compared to Australian data. The EIGPIDG data only provided details of leak rates for small and large holes, therefore rupture frequency data was taken from the British Gas failure data (Fearnehough, 1992).

The resulting failure frequencies used for the Looping Pipeline PHA are provided in Table 10 (Planager, 2009), reporting the 6.8 mm pipeline wall thickness results for consistency with the 6.4 mm Dalton to Canberra Pipeline. It is assumed that the same failure frequencies apply for the Dalton to Canberra Pipeline.

As noted in Section 5.2, key causes of loss of containment events are associated with external interference, particularly during construction activities nearby to the pipeline. The frequency data utilised in the Looping Pipeline PHA was based on incident history, and therefore incorporates failures caused by mechanical damage from construction activities.

Additional failure frequencies were calculated for the Tallagandra Lane MLV, as shown in Table 10. The failure rates were calculated by a parts count of the MLV assembly (APA, 1981) combined with failure frequency data obtained from the UKHSE Hydrocarbon Release Database (UKHSE, 2017).

Table 10 Failure frequencies

	Looping Pipeline (Planager, 2009)	**Mainline Valve**
Type of failure	Failure rate (per 1000 km per year)	Failure rate (per year)
<20 mm hole	5.50E-02	8.46E-04
<80 mm hole	1.38E-01	1.64E-05
Guillotine failure (full bore)	1.50E-03	6.84E-06
Total	**1.94E-01**	**8.69E-04**

5.4.1 Dalton to Canberra vs Looping Pipeline frequencies

As noted in Table 1, the Dalton to Canberra Pipeline has a smaller diameter and wall thickness compared to the Young to Bomen Looping Pipeline and also a reduced depth of cover. These factors influence the likelihood of a loss of containment event and are discussed below.

The Looping Pipeline PHA reported failure data for both 6.8 mm and 9.7 mm wall thickness. The 6.8 mm wall thickness results from the Looping Pipeline PHA are used as the basis for the Dalton to Canberra Pipeline which has a wall thickness of 6.4 mm and therefore on the basis of only a 0.4 mm difference, is considered comparable.

The diameter of the Dalton to Canberra Pipeline is 273 mm versus the 457 mm Young to Bomen Looping Pipeline. The latest EIGPIDG data (EGIG, 2018) indicates that the failure frequency of the Dalton to Canberra Pipeline is slightly greater than that of the Young to Bomen Looping Pipeline when considering the pipe diameter, as highlighted in Figure 2.

The depth of cover of the Dalton to Canberra Pipeline a minimum of 900 mm versus 1.2 m for the Young to Bomen Looping Pipeline. The latest EIGPIDG data (EGIG, 2018) indicates that for the most part, the Dalton to Canberra Pipeline has a higher failure frequency compared to that of the Looping Pipeline when considering the depth of cover, as shown in Figure 3. However, at the road crossings the two pipelines have the same failure frequency based on the same depth of cover.

The presence of the MLV at Tallagandra Lane also slightly increases the overall frequency failure of the Dalton to Canberra Pipeline compared to that of the Young to Bomen Looping Pipeline.

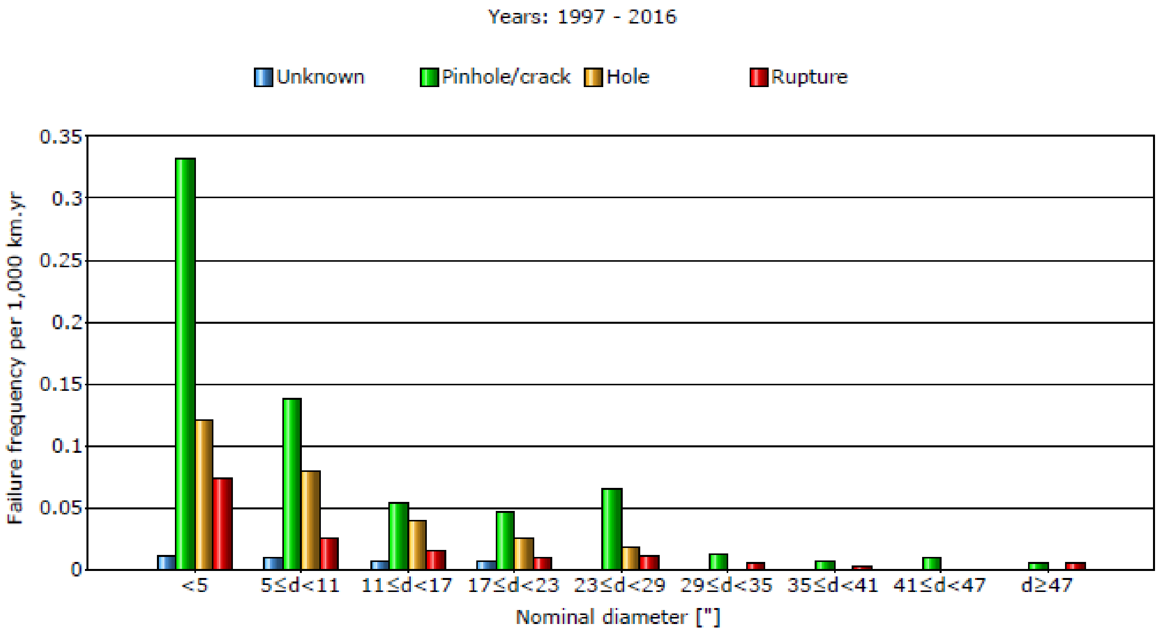


Figure 2 Relationship between diameter class and size of leak (EGIG, 2018)

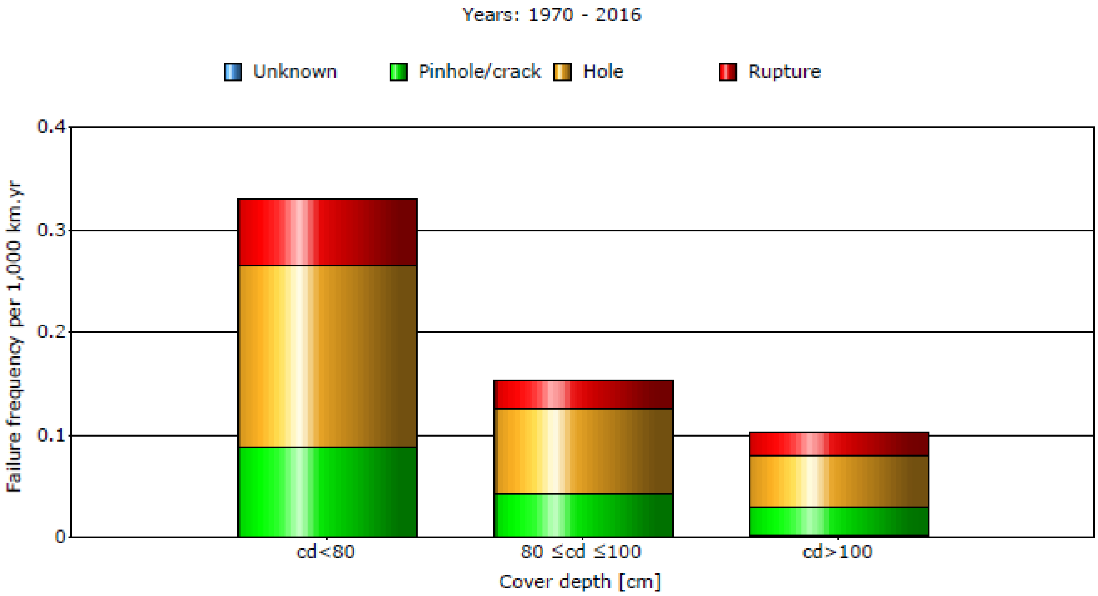


Figure 3 Relationship between depth of cover and frequency of failure (EGIG, 2018)

Taking into account the above EIGPIDG data, it is concluded that the Dalton to Canberra Pipeline has a slightly higher failure frequency compared to that of the Young to Bomen Looping Pipeline. The presence of the MLV on the Dalton to Canberra Pipeline also increases the overall failure frequency of the pipeline in the area of interest for this analysis.

5.4.2 Comparison to recent Australian data

As noted above, the Looping Pipeline PHA used data for a period from 1988 to 1992. Numerous data sources are available with information on loss of containment frequencies from more recent time periods and there has been substantial improvements in the data available for Australian pipelines.

A paper comparing international pipeline failure rates was presented at the 2013 Joint Technical Meeting between APIA, the European Pipeline Research Group and the Pipeline Research Council International (Tuft & Cunha, 2013). This paper suggests, that although there are significant differences between the Australian and international pipeline failure frequencies, the Australian data is valid. The failure frequencies assessed in the paper are based on the data reported through the Australian Pipelines and Gas Association (APGA) for buried steel pipes.

The APGA reported for buried steel pipes an average loss of containment frequency of 0.034 per 1000 km per year (Tuft & Cunha, 2013). This figure is based on the 2002 to 2012 period as it is conservative, and it reflects the time period in which data collection has been soundly based. Furthermore, an analysis of the loss of containment events that occur within Australia undertaken by Tuft and Bonar (Tuft & Bonar, 2009), estimated that 27% of the loss of containment events have been ruptures and 73% have been leaks. A summary of the Australian failure frequencies is provided in Table 11.

Table 11 Failure frequencies for Australian pipelines

Type of failure	Failure rate (per 1000 km per year)
Leak	0.0248
Rupture	0.0092
Total	0.034

Comparing the data in Table 10 and Table 11, it can be seen that the Australian statistics of buried pipeline releases are significantly lower than the European data used in the Looping Pipeline PHA. Therefore, although the results from the Looping Pipeline PHA are used in this assessment (in conjunction with additional MLV failure data), they represent a conservative analysis of the risks associated with the Dalton to Canberra Pipeline.

5.1 Risk assessment

A summary of the risk results provided in the Looping Pipeline PHA (Planager, 2009) and those calculated for the MLV are tabulated below. The results are reported at distances representative of the location of the control building and substation for the Springdale Solar Farm site and adjacent to the MLV, representing the location on site with the highest level of risk. The risk results for the Dalton to Canberra Pipeline are based on the 6.8 mm pipe thickness results reported in the Looping Pipeline PHA. The risk results for the Tallagandra Lane MLV were calculated using DNV GL Safeti Software Version 8.22.

Table 12 shows the cumulative individual fatality risk of the pipeline (Planager, 2009) and the Tallagandra Lane MLV. It highlights that the risk at the control building and substation locations are negligible and both are below the fifty in a million per year (5×10^{-5} per year) individual fatality criteria for industrial sites as specified in HIPAP No. 4 (Table 2). Similarly, for personnel traversing the solar farm site, the maximum cumulative fatality risk exposure from the buried pipeline and MLV is below the HIPAP No. 4 industrial risk criteria.

Table 12 Cumulative individual fatality risk

Section	Risk of fatality (per year)			Looping Pipeline PHA Reference
	Control building	Substation	Adjacent to MLV	
Pipeline	2.0E-07	Below minimum risk reported	9.0E-07	Figure 3 (6.8 mm wall thickness)
MLV	2.7E-07	4.0E-08	9.0E-07	N/A
Total	**4.7E-07**	**4.0E-08**	**1.8E-06**	

Table 13 shows the cumulative injury risk of the pipeline (Planager, 2009) and the Tallagandra Lane MLV. It highlights that the risk at the control building and substation is below the combined heat radiation and explosion overpressure injury risk criteria of 1×10^{-4} per year (for residential developments) specified in HIPAP No. 4. Similarly, for personnel traversing the solar farm site, the maximum cumulative injury risk exposure from the buried pipeline and MLV is below the HIPAP No. 4 injury risk criteria. Although not defined within the Looping Pipeline PHA, it is assumed that the injury risk results presented are based on the cumulative heat radiation and explosion overpressure risks from the pipeline.

Table 13 Cumulative injury risk

Pipeline	Risk of injury (per year)			Looping Pipeline PHA Reference
	Control building	Substation	Adjacent to MLV	
Pipeline	1.0E-10	Below minimum risk reported	1.3E-06	Figure 5 (6.8 mm wall thickness)
MLV	3.0E-07	4.5E-08	1.0E-06	N/A
Total	**3.0E-07**	**4.5E-08**	**2.3E-06**	

Table 14 shows the cumulative property damage and accident propagation risk of the pipeline (Planager, 2009) and Tallagandra Lane MLV. It highlights that the risk at the control building and substation is below the combined heat radiation and explosion overpressure property damage and accident propagation risk criteria of 1 x 10^{-4} per year at neighbouring potentially hazardous installations as specified in HIPAP No. 4. Although not defined within the Looping Pipeline PHA, it is assumed that the property damage and accident propagation risk results presented are based on the cumulative heat radiation and explosion overpressure risks from the pipeline.

Table 14 Cumulative propagation risk

Pipeline	Risk of property damage or accident propagation (per year)		Looping Pipeline PHA Reference
	Control building	Substation	
Pipeline	1.0E-12	Below minimum risk reported	Figure 7 (6.8 mm wall thickness)
MLV	2.5E-07	4.0E-08	N/A
Total	**2.5E-07**	**4.0E-08**	

6. Conclusions and recommendations

Using the information presented in a previous PHA study conducted for the APA Young to Bomen Looping Pipeline, and the additional QRA modelling conducted on the MLV for the Dalton to Canberra Pipeline the following conclusions are made:

- The use of the consequence results from the Looping Pipeline PHA is a conservative approach to estimating the consequences from the Dalton to Canberra Pipeline due to the differences in pressure and pipeline diameter.
- There is potential for some jet fire, flash fire and explosion overpressure consequence distances as a result of a pipeline leak or rupture to reach the control building in the unlikely event of loss of containment.
- Results from the additional QRA modelling undertaken on the Tallagandra Lane MLV indicate that there is potential for some jet fire, flash fire and explosion overpressure consequence distances to reach the control building in the unlikely event of loss containment.
- The differences between the Young to Bomen Looping Pipeline and the Dalton to Canberra Pipeline have been discussed and their impact on failure frequency assessed.
- The Looping Pipeline PHA utilised failure frequency data based on European statistics up to 1992, however more recent Australian data is available that indicates much lower failure frequencies, therefore the cumulative risk results assessed are conservative.
- The cumulative individual fatality risk at the location of the control building, substation and adjacent to the MLV is below the HIPAP No. 4 risk criteria.
- The cumulative injury risk at the location of the control building, substation and adjacent to the MLV is below the HIPAP No. 4 risk criteria.
- The cumulative property damage and accident propagation risk at the location of the control building and substation is below the HIPAP No. 4 risk criteria.

Although it has been demonstrated that the cumulative risk from the pipeline and MLV is sufficiently low and below the relevant HIPAP No. 4 risk criteria, the prevention of pipeline damage is vital and therefore the design and all construction activities must take into account the presence of the gas pipeline. As identified in the pipeline SMS (Sage Consulting, 2018a), the following recommendations apply to minimise pipeline threats:

- The pipeline must be positively located prior to detail design being undertaken.
- Electrical studies in accordance with AS 4853 and AS 2832 are required.
- Crossings design (vehicle or cable) must be approved by APA.
- During construction, the easement must be delineated on site and marked as a no-go zone.
- All plans must have the easement clearly identified so that contractors are aware of it.
- Access to the easement by APA Operations personnel must be maintained at all times.
- An update to the APA SMS database spreadsheet must be undertaken.
- Potholing to verify depth of cover at Tallagandra Road crossing is to be coordinated via APA.
- The RFQ documentation for the EPC contract shall address the restrictions and requirements identified in the SMS.
- For works on the easement, an APA third party works authorisation must be in place, and onsite supervision arranged.
- MLV site is left clear and unimpeded during construction and operation of solar farm – this is not a laydown area for solar farm material and equipment.

7. References

AECOM, Springdale Solar Farm – Environmental Impact Statement, 29 June 2018

APA, Dalton to Canberra Natural Gas Pipeline Talagandra Road Line Valve LV4 Assembly (As Built), Drawing Number: DC04-0007 Rev A, 15/04/1981

Bureau of Meteorology, Climate Statistics for Australian Locations: Canberra Airport Comparison – Monthly climate statistics, accessed: 22/05/2020

Dawson F. J., *Gas Pipeline Incidents*, EIPIDG – European Gas Pipeline Incident Data Group, as presented at the International Gas Union Conference, Milan, Italy, June 1994

European Gas Pipeline Incident Data Group (EGIG) Gas Pipeline Incidents 10th Report of the European Gas Pipeline Incident Data Group (period 1970 – 2016), 2018

Fearnehough, G. D. *Pipeline Safety*, Pipeline Technology Conference, Royal Flemish Society of Engineers, Oostende, Belgium, 1990; and Fearnehough, G. D. & Corder, I, *Application of Risk Analysis Techniques to the Assessment of Pipeline Routeing and Designs Criteria,* International Conference on Pipeline Reliability, Calgary, Canada, 1992

GHD, Bomen Solar Farm PHA Supplementary Assessment for Renew Estate Pty Ltd, 2018

New South Wales Department of Planning and Environment (DP&E), Hazardous Industry Planning Advisory Paper No 4 – Risk Criteria for Land Use Safety Planning, 2011

New South Wales Department of Planning, Industry and Environment (DPIE) Email from Nicholas Hon DP&E RE: Springdale Solar (SSD8703) – Exhibition, 5 October 2018

Pipeline Construction (Dalton to Canberra) Act 1980

Planager, Preliminary Hazard Analysis of the Natural Gas Delivery Pipeline between Young and Bomen in NSW, 2009

RES Australia Pty Ltd, *Springdale SF – QRA Plan 2*.pdf (email: from Steven Reid, Development Project Manager, RES Australia Pty Ltd, 14/05/2020)

Sage Consulting Solutions Pty Ltd, Springdale Solar Farm Safety Management Study Report, 29 June 2018(a)

Sage Consulting Solutions Pty Ltd, Bomen Solar Farm Safety Management Study Report, 20 June 2018(b)

Tuft, P. and Bonar, C., (2009). *Experience with the pipeline incident database,* APIA Convention 2009

Tuft, P. and Cunha, S., (2013) Comparing International Pipeline Failure Rates, Presented at the Joint Technical Meeting between APIA, the European Pipeline Research Group and the Pipeline Research Council International, Australian Pipeliner, 2013

United Kingdom Health and Safety Executive, (2017). *Hydrocarbon releases system* http://www.hse.gov.uk/offshore/statistics.htm

GHD Advisory

Appendices

Appendix A – QRA modelling for Tallagandra Lane Mainline Valve

Methodology

QRA modelling for the Tallagandra Lane MLV was performed using DNV GL Safeti Software Version 8.22. For the modelling, various leak scenarios are used to evaluate the consequences and risk of the leaks from the MLV.

Input Data & Assumptions

Material of Release

As a conservative estimate, pure methane was used in the modelling. For the flash fire results, the lower flammability limit (LFL) of 44,000 ppm was used to assess the consequences of a release of methane.

A pressure of 6.2 MPa was used for each of the release cases.

It was assumed that the operating temperature of the gas is 25°C.

Release Cases

Four release cases were considered in the modelling and are listed in Table 15. All releases were treated as outdoor releases. The height of interest for reporting results was 1.5m (the average height of a person who may be exposed to the release).

Table 15 Tallagandra Lane MLV release cases

Scenario No.	Scenario	Leak hole size (mm)	Height of release (from ground level) (m)	Release direction	Comment
1	Small leak	5	0.5	Horizontal	Leak of this size is likely to occur from an above ground section of the assembly, and for conservancy a horizontal release is modelled
2	Intermediate leak	25	0.5	Horizontal	Leak of this size is likely to occur from an above ground section of the assembly, and for conservancy a horizontal release is modelled
3	Massive leak	100	0.5	Horizontal	Leak of this size is likely to occur from an above ground section of the assembly, and for conservancy a horizontal release is modelled
4	Full bore (guillotine)	273	0	Vertical	Rupture of this size can only occur from a buried section, and release is likely to be vertical from the valve pit

An additional jet fire consequence analysis was performed for the rupture of the buried pipeline. This was conducted assuming an impinged 45 degree angled release at a height of 0m from ground.

Weather

The modelling requires information on the various meteorological parameters such as temperature, atmospheric stability and wind conditions. The stability conditions and wind speed at the time of the release have an influence on the extent of a flammable region following a release. The Pasquil stability scheme is commonly used to describe the amount of turbulence in the atmosphere for consequence modelling.

One weather condition was considered in the modelling to report results. The Category 1.5/F weather was selected (wind speed 1.5m/s, stable – night with moderate clouds and light/moderate wind). This weather category was selected as a standard weather condition used in QRA modelling as no assumptions regarding weather were specified in the Looping Pipeline QRA (Planager, 2009).

The ambient atmospheric conditions listed in Table 16 were used in the modelling. Atmospheric pressure, temperature and humidity are used to determine the properties of the atmosphere for the dispersion and discharge calculations. Surface temperature is the temperature of the surface over which the release occurs and is used to calculate how much heat is transferred from the ground surface into the gas cloud. Surface roughness describes the roughness of the surface over which the release occurs (i.e. greater roughness, more resistance to dispersion of the release). Solar radiation is the radiation received from the sun, which has been excluded from this analysis.

The direction of the wind at the time that a release occurs also has an influence on the extent and direction of a flammable region of gas. Wind roses are a standard method of graphically representing wind conditions, direction and speed at a specific location. In QRA it is used to quantify the likelihood of the release dispersing in particular directions. The wind rose for the Canberra Airport Comparison (Site No. 070014) was used in the modelling. This is the closest weather station to the Springdale Solar Farm site with wind rose data available (BoM, 2020). The wind rose data used in the modelling is outlined in Table 17.

Table 16 Atmospheric conditions

Parameter	Value	Comment
Atmospheric Pressure	1.01325 bar	
Atmospheric Temperature	19.7°C	Based on the mean annual maximum temperature at the Canberra Airport Comparison (Site No. 070014) (the closest weather station to the site) (BoM, 2020)
Surface Temperature	19.7°C	Assumed to be the same as atmospheric temperature
Atmospheric Humidity	59.5%	Based on the annual mean humidity at the Canberra Airport Comparison (Site No. 070014) (the closest weather station to the site) (BoM, 2020)
Surface roughness factor	0.3 m	Open flat terrain; grass, few isolated objects (based on a review of Google Earth images of site location)
Solar radiation	N/A	Excluded from this analysis

Table 17 Probability of wind direction at the Springdale Solar Farm site (BoM, 2020)

Wind direction[(a)]	Probability of wind in direction (fraction)
North	0.12
North-East	0.06
East	0.09
South-East	0.10
South	0.10
South-West	0.03
West	0.17
North-West	0.33

[(a)] Taken as an average between 9am and 3pm wind directions at the Canberra Airport Comparison weather station (Site No. 070014), and normalised to account for calm wind periods

Explosion parameters

For conservancy in the modelling it was assumed that the control building and the substation each represent a confined source for an explosion. Additionally, it was assumed that if a release were to occur and disperse enough to reach either the substation or control building, 10% of the volume of gas released would fill the buildings with gas and have the potential for ignition. In Safeti, the strength of the confined source is the degree of confinement in the area or source, described by an integer between 3 (lowest) and 10 (highest), with values of 8 or 9 typically used for process units. For the purposes of the modelling, a strength of 4 was selected for both the control building and substation.

Failure frequencies

The failure frequencies for the Tallagrandra Lane MLV was calculated by undertaking a parts count of the MLV assembly (APA, 2020) and applying failure rates for each of the parts using release data supplied by the UK-HSE (UKHSE, 2017).

Failure frequency data was available for the following leak sizes:

- ≤5mm
- 5 – 10mm
- 10 – 25mm
- 25 – 50mm
- 50 – 75mm
- 75 – 100mm
- >100mm.

Failure frequencies for the MLV presented in Table 10 (Section 5.4) were calculated assuming the following:

- Failure frequency for <20 mm hole size includes the sum of failure frequencies for ≤5 mm, 5 – 10mm and 10 – 25mm leaks.
- Failure frequency for <80 mm hole size includes the sum of failure frequencies for 25 – 50mm, 50 – 75 mm and 75 – 100mm leaks.
- Failure frequency for full bore ruptures includes the >100 mm leak failure data.

Level 9 145 Ann Street Brisbane QLD 4000 Australia
GPO Box 668 Brisbane QLD 4001 Australia

61 7 3316 3000
advisory@ghd.com

\\ghdnet\ghd\AU\Brisbane\Projects\91\12530512\Tech\Springdale Report\12530512-REP-0-Springdale Solar Farm Supplementary QRA.docx

Rev.No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0	E. Killoran	R. Freeman		R. Mills	R.C. Mills	28/05/2020

GHD
Advisory

SAFETY MANAGEMENT STUDY REPORT

RENEW ESTATE PTY LTD

SPRINGDALE SOLAR FARM

PREPARED BY: SUSAN JAQUES

SAGE CONSULTING SOLUTIONS PTY LTD
BRISBANE, AUSTRALIA

Revision	Date	Description	By
0	29/06/2018	Issued for Use	SAJ

Disclaimer

TABLE OF CONTENTS

SUMMARY

This report constitutes the summary of the facilitated Safety Management Study (SMS) workshop held on June 7th, 2018, for the development of the Springdale Solar Farm around APA's existing Dalton to Canberra gas pipeline near Sutton, NSW.

The assessment for the Springdale Solar Farm was held in conjunction with the SMS workshop held for the Bomen Solar Farm development, due to the similarities of development. The Bomen Solar Farm evaluation is provided in a separate report specific to that site.

The focus of this safety study was on raising awareness of the requirements to be met for the continued safe operation of the natural gas pipeline, to the Australian Standard AS 2885.

The proposed Springdale Solar Farm plan shows no impedance over the pipeline easement and the design shows no solar panel structures being constructed over the pipeline. The final location and design of access road crossings and cable crossings of the pipeline were not available at the time of the workshop, and the location and design of these must be reviewed and approved by APA.

The action items agreed to during the workshop are summarised on the next page.

The key outcomes discussed were:

- Design for crossings (roads or cables) of the pipeline easement must be approved by APA.
- The design and methodology should minimise works over and across the pipeline and prevent unauthorised crossing of the easement during solar farm construction and operation.
- Provided the action items are completed, and the APA requirements are adhered to, all threats were considered controlled, and therefore As Low As Reasonably Practicable (ALARP), for this development.

ACTION ITEMS – SPRINGDALE SOLAR FARM

#	Description	By Whom	What does completion look like?	Consequence if not completed	Expected Completion Date
1	The pipeline must be positively located prior to detail design being undertaken	Joint / Coordinated	Pipeline depth of cover and alignment within the easement is verified within the property	If the pipeline is not at the expected depth or location, some of the 'controlled threat' conclusions of this study may be invalid.	
2	Electrical studies in accordance with AS 4853 and AS 2832 are required	Renew Estate	Studies completed, documented and endorsed by APA Group. Recommended actions are implemented.	Long term issues with electrical interference could result in either accelerated corrosion issues on APA's pipeline or safety risk to personnel working on the pipeline.	
3	Crossings design (vehicle or cable) must be approved by APA.	Submitted by Renew to APA	Approved crossing designs are available and on file.	APA could delay the project or stop construction if there are concerns with the crossings if not approved.	
4	During construction, the easement must be delineated on site and marked as a no-go zone	Renew Estate	Easement boundaries clearly delineated so all construction personnel are aware of its existence.	Unapproved activities over the pipeline easement could affect the integrity of the pipeline, leading to leaks or ruptures.	
5	All plans must have the easement clearly identified so that contractors are aware of it	Renew Estate	Construction plans and documents refer to the pipeline easement so that there is full awareness	Unapproved activities over the pipeline easement could affect the integrity of the pipeline, leading to leaks or ruptures.	
6	Access to the easement by APA Operations personnel must be maintained at all times	Renew Estate	APA personnel can access the pipeline at any time.	Destruction of property to get access to easement, if required.	
7	Update the APA SMS database spreadsheet	APA	The APA SMS database for this pipeline shows the revised location class designation, and a reference to this report for clarity.	Information is inaccurate, and the incorrect requirements are applied at this location.	
8	Potholing at Tallagandra Road	APA / Renew	Potholing to verify depth of cover at Tallagandra Road is completed safely.	Risks of external impact if location is not verified.	

#	Description	By Whom	What does completion look like?	Consequence if not completed	Expected Completion Date
	crossing is to be coordinated via APA				
9	The RFQ documentation for the EPC contract shall address the restrictions and requirements identified in this study.	Renew Estate	Documentation is clear, in particular the crossing locations, cable conduit design, and requirements for APA approval of design of works on the easement.	EPC Contractor is unaware of requirements and puts in claims for compensation.	
10	For works on the easement, an APA third party works authorisation must be in place, and onsite supervision arranged.	Renew Estate	Agreements are in place, and supervision is on site. A minimum 2 weeks' advance notice is requested; APA approvals may take up to 1 month to obtain.	Unapproved activities over the pipeline easement could affect the integrity of the pipeline, leading to leaks or ruptures.	
11	Awareness of the mainline valve (MLV) site at the Tallagandra Road Crossing – this is not a laydown area for solar farm material and equipment	Renew Estate	MLV site is left clear and unimpeded during construction and operation of solar farm	Unapproved activities over the pipeline easement or near the MLV could cause damage if solar farm personnel are unaware of consequences.	

1. SCOPE

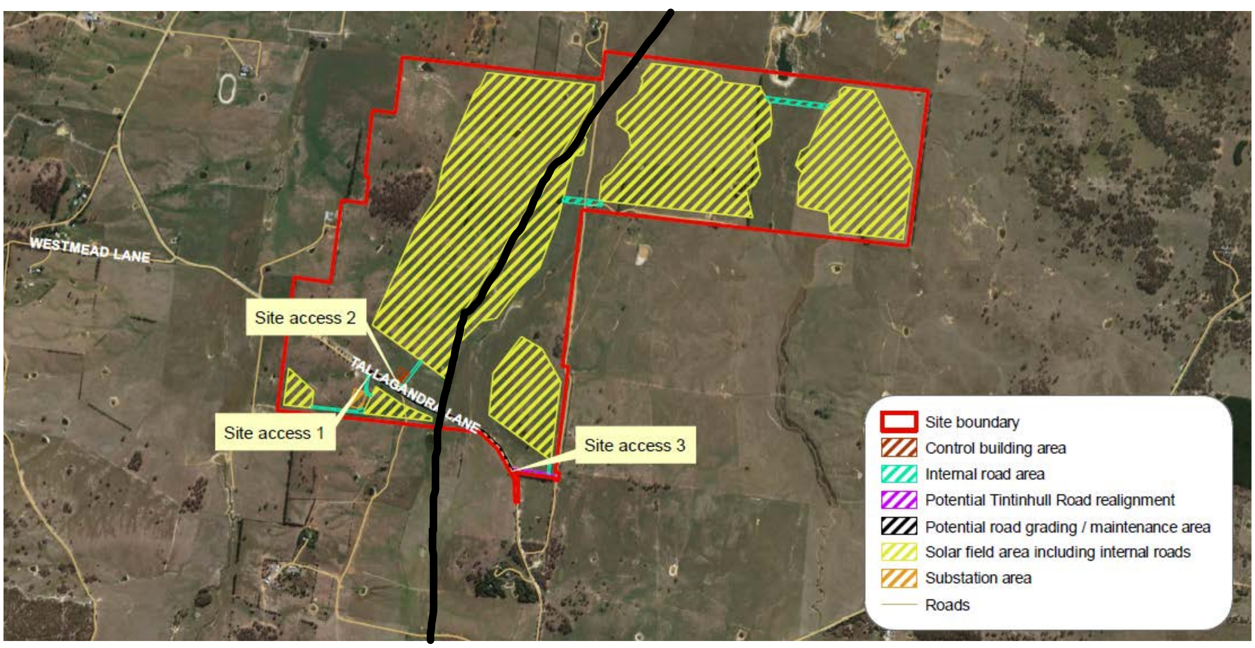
The scope of this facilitated SMS workshop was to review the proposed development of a solar farm in Sutton, NSW, located approximately between Kilometre Post (KP) 44.0 and KP 46.9 of APA's Dalton-Canberra natural gas pipeline. This review was conducted in conjunction with a review for the Bomen Solar Farm development, also by Renew Estate. There were synergies in reviewing both sites concurrently, even though the design for this site, Springdale, was not as far advanced as Bomen.

Currently this site for Springdale Solar Farm is vacant open grazing land.

The SMS workshop included review of the proposed solar farm design, construction, and operation in the future, and its effect on the existing pipeline.

The scope of a SMS to AS 2885 does not include occupation health and safety or workplace safety assessments; the focus here is on pipeline integrity and maintaining safe operation of the pipeline.

The image below, excerpted from the AECOM drawing "Figure 3 Springdale Solar Farm development envelope" dated 19/04/2018 (also in Appendix A), shows the pipeline location sketched in black and the Springdale Solar Farm outline in red. Further details are provided in Section 4.



2. PURPOSE

The purpose of a Land Use Change SMS and facilitated workshop, according to AS 2885.6 (draft as at time of writing) Section 6.5.2 is to:

- To inform the stakeholders of the requirements of AS 2885.
- Review proposed development plans to determine whether they can be optimised to minimise impacts to the pipeline.
- Manage construction activities near the pipeline.
- Identify additional protective measures, if any, that might be required so risk remains As Low As Reasonably Practicable (ALARP) with changed surroundings.

The purpose of an Encroachment SMS and facilitated workshop (AS 2885.6 (draft as at time of writing) Section 6.5.3) is to:

- Generate requirements for third-party work to comply with AS 2885.3
- Review proposed development plans to determine whether they should be modified to minimise impacts on the pipeline system
- Identify new threats and protective measures required so that risk remains As Low As Reasonably Practicable (ALARP) during encroachment and throughout the pipeline life.
- Identify effects of the encroachment on pipeline integrity management activities during encroachment works and for the life of the pipeline.

Note that AS 2885.6 is expected to be formally published in Q4 2018. The text above is from the public comment version of the Standard, dated 12 July 2017, and is not expected to change prior to publication.

3. ABBREVIATIONS

Abbreviations	
ALARP	As low as reasonably practicable
CP	Cathodic Protection
EIS	Environmental Impact Statement
EPC	Engineer-Procure-Construct (Contract)
HDD	Horizontal Directional Drill
KP	Kilometre Point
MAOP	Maximum Allowable Operating Pressure
MLV	Mainline Valve
SMS	Safety Management Study

4. INPUTS TO THE SMS

4.1. Documents

Documents reviewed for this study included:

- Project drawings (indicative) provided by Renew Estate
- Preliminary Environmental Assessment for Springdale Solar Farm dated Sept 2017
  - Accessed during June 2018 via: http://www.majorprojects.planning.nsw.gov.au/
- APA letter to Renew Estate, dated 24 April 2018 (Ref 20180424_LO_439701), regarding the Bomen site; assumed to apply similarly to Springdale Solar Farm
- APA SMS Report – Dalton to Canberra 2015, Rev 1.1, Document 320-RP-AM-0208
- APA SMS Database excel spreadsheet titled "SMS Database Dalton to Canberra 2015 Rev A2.xls"
- APA Springdale Alignment Sheets: DC80-0016 Rev D and DC80-0017 Rev C

4.2. Proposed Solar Farm Development

Renew Estate Pty Ltd is proposing to develop a 120-megawatt (MW) DC solar farm near Sutton NSW, approximately 3.5km northeast of the ACT border. The site will be approximately 370 hectares in size of which approximately 190 hectares would be occupied by the solar farm and associated infrastructure.

The solar farm consists of approximately 400,000 photovoltaic solar modules and about 4,500 trackers comprising single axis framing systems mounted on steel piles, a control building, and other facilities and developments required for a solar farm.

The indicative layout in *Appendix A – Indicative Site Layout* shows the relation of the solar panels substation area to the existing APA pipeline.

The orientation of the solar panels will avoid construction activities over the pipeline easement. There will be requirements for cable crossings of the easement from power conversion stations (inverters and medium voltage transformers) to the onsite substation (33 kV and communications).

The interaction between solar panels and the APA pipeline is minimised with the indicative site layout. There is an APA Mainline Valve site adjacent to Tallagandra Lane, south of the solar panel site boundary, just outside of the assessment area for this review, however the site was discussed during the workshop.

The project has not yet received planning approval and a detailed design has not been produced at this stage. An EPC contract will be executed in the future, at which time the detail design will commence.

4.3. Pipeline Characteristics

4.3.1. Pipeline details

The Dalton to Canberra Natural Gas Pipeline is approximately 57.85km long.

The alignment drawings for this pipeline indicate that the property for this development is approximately between

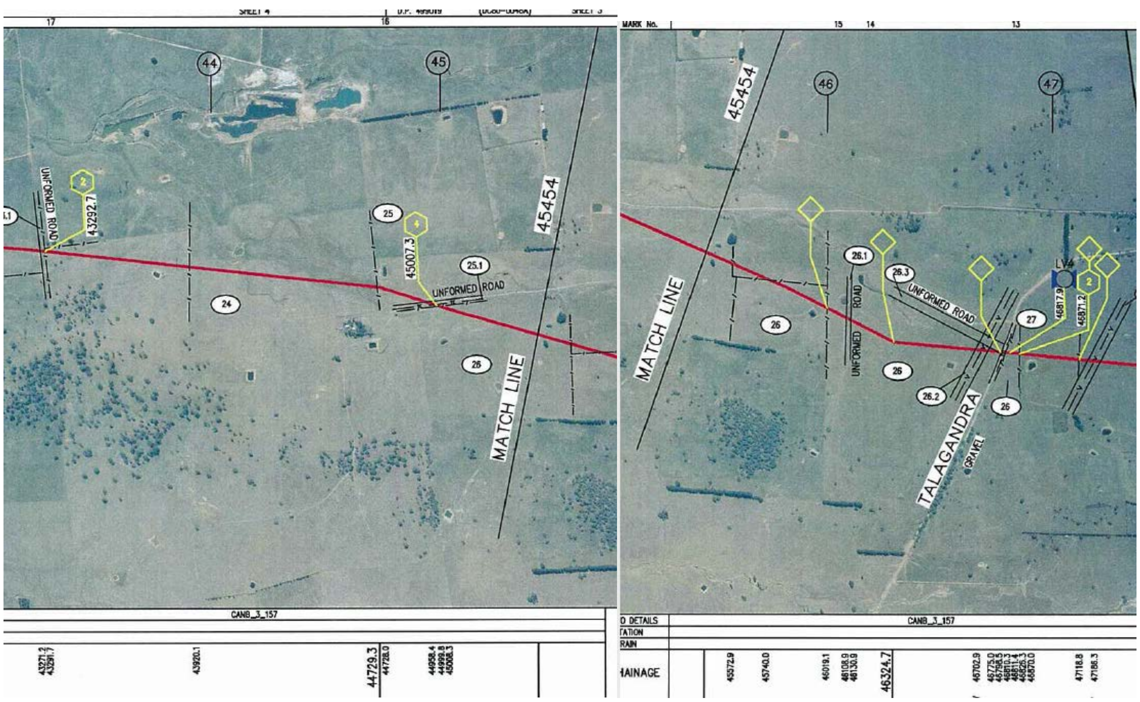
KP (APA's Kilometre Points) 44.0 to 46.9 (which spans across alignment sheets #16 and #17).

Taking into account the pipeline measurement length of 212m (reference pg36 of APA SMS Report), the assessed section of pipeline extends from:

KP 43.8 to KP 47.1

It is noted that the Tallagandra Line Valve is located south of the Tallagandra Road, at KP 46.8, within the solar farm property.

The proponents in the workshop were made aware that the site may be used for venting gas from the pipeline (infrequently, if ever). A planned release will be communicated to the community; an unplanned release could be very noisy. Additionally, discussion included that the proponents should not use the valve site area for laydown or other activities that may interfere with the valve site (ie cranes toppling over).



Excerpts from APA pipeline alignment sheets DC80-0016 and DC80-0017

Summary of the pipeline characteristics:

Name	Dalton to Canberra
Constructed/Commissioned	1981
Outside Diameter	273mm
Wall Thickness	6.4mm
Pipe specification	API 5L Grade X46
MAOP	6.2 MPa

Depth of cover (from alignment sheets, at this location; to be confirmed)	900mm 1.2m under road
Measurement Length	212m
Critical Defect Length	149.97mm

4.3.2. Puncture Resistance

Because one of the main causes of pipeline failures is by impact from machines such as excavators or HDDs, there is a focus on the material characteristics of the pipeline, compared to the expected or anticipated size of machinery, to determine whether the pipeline will withstand the impact, leak, or rupture.

The calculations provided by APA in the SMS Report are provided via excerpt in *Appendix C – Pipeline Puncture Resistance* for review and input to this SMS.

4.3.3. Previous SMS Reports

The APA SMS report for the Dalton to Canberra Natural Gas Pipeline, dated 18-May-2018, was reviewed in preparation for the workshop. The excel spreadsheet database titled "SMS Database Dalton to Canberra 2015 Rev A2.xls" was also reviewed.

The APA alignment sheets indicate that this development lot applies to the pipeline, from KP 44.0 – KP 46.9. Allowing for a 212m measurement length, the affected KPs are KP 43.8 to KP 47.1.

4.3.4. Operating procedures / patrols

The SMS report advises that patrolling is undertaken in this area by aerial survey fortnightly, and yearly ground survey. Marker signs, landowner liaison and on-call service (DBYD) are in place as required by AS 2885. No records were checked for this SMS to verify this claim.

4.3.5. Pipeline integrity / corrosion management

No specific information was reviewed regarding current pipeline integrity or corrosion management. These controls should be in place regardless of this development.

4.3.6. Pipeline management system reviews and audits

No specific information was reviewed regarding existing pipeline management system reviews or audits.

5. SMS WORKSHOP

Review of the input documents was completed in preparation for the validation workshop. There was limited detail information on the plans for this solar farm development, but it was determined that there were sufficient inputs available for this review to proceed, particularly since having the SMS discussion this early in the development would allow for the design to accommodate requirements from the pipeline safety assessment, if any. Detailed analysis and information exchange was completed in the workshop environment.

The approach of performing the bulk of the safety management study in the facilitated workshop has the advantage that the external stakeholders are fully involved in the process and therefore able to both understand the pipeline safety concern and to contribute to prompt resolution of risks through awareness and adjustments to the design of the development.

The workshop was held at APA Group's Sydney office on George Street, in conjunction with the review of the Bomen Solar Farm site, commencing at 10:00am and finishing by 3pm.

The workshop attendees included representatives from:

- the proponent (Renew Estate Pty Ltd),
- a construction contractor familiar with solar farms (RCR),
- pipeline owner (APA Group)
- pipeline operator (APA Group)

The signed list of attendees and the agenda is included in Appendix B - Workshop Agenda and Attendees.

The workshop facilitator, Susan Jaques, is independent of the other participants, and represented a thorough familiarity with the pipeline safety management process required by the AS 2885 series of Standards.

As an introduction to the workshop, for the informational benefit of the proponent, a presentation was given on the risk management approach by the hydrocarbon pipeline industry as described in AS 2885.6. During the presentation, the group discussed and agreed on the understanding of the concepts of AS 2885 terminology of threats, controls, measurement length, and ALARP.

6. OUTPUTS

6.1. Location classification

Referring to the AS 2885 definitions of the primary location classifications (summarised as R1 – Rural, R2 – Rural Residential, T1 – Residential, T2 – High Density), which apply to the land within the measurement length (212m), the following assessment was made for the section between KP 43.8 to KP 47.1.

The latest operational SMS report (320-RP-AM-0208 Rev 1.1) categorised the pipeline from KP 0 to KP 49.7 as R1, Rural (unused, undeveloped, agricultural, grazing).

At the SMS workshop for this development, the attendees agreed that the appropriate new designation for between KP 43.8 to KP 47.1, due to the solar farm development, should be now:

R1 (Primary) / HI (Secondary)

The "HI" ("Heavy Industrial") secondary location class recognises that there will be development in this area, but that the development does not quite reflect the similar Industrial (I) secondary class, which applies to a site having an increase in people and industrial activity adjacent to the pipeline while not being residential as such. The HI secondary location class was applied to recognise that this area is not just "Rural" anymore, and that there is further development beyond rural which is not exactly 'industrial' either since there will be few people congregating on site.

In the case of the Springdale Solar Farm development, there will only be a modest increase in the number of people once operational (the EIS for the similar development at Bomen states three to five full time positions on site), otherwise it is only solar farm infrastructure that is new within the measurement length.

In fact, the solar farm arrangement may make external interference more unlikely at these locations, because access to the easement with a large machine will be even more difficult than before the solar panels were installed.

When applying the HI secondary location class, the site is assessed specifically to determine whether the industry or the surroundings include features that contain unusual threats to the pipeline (not in this case) or contain features that may mean in the case of a pipeline failure (loss of containment) consequences would escalate either in terms of fire, or for the potential release of toxic or flammable materials into the environment. Depending on the assessed severity of the design, requirements of R2 (rural residential), T1 (residential) or T2 (high density) shall be applied.

The consequence assessment discussion during the workshop concluded that the assessed severity of a release event would likely be minor or trivial, with only the solar farm affected, and so it was decided that the protections afforded by equivalent protections to an R2 designation is suitable.

Therefore, the new location class for KP 43.8 to KP 44.1 is:

R1 / HI (with equivalent protections to an R2 designation)

[Action Item: APA to update the corresponding spreadsheet database between KP 43.8 to KP 47.1]

6.2. Features and potential threats

In preparation for this SMS workshop, some basic pipeline and site information was reviewed. This site was not remarkable in terms of the pipeline safety approach (no significant development nearby) and had no features to cause it to be mentioned it the operational SMS, which it wasn't.

Brainstorming during the workshop was undertaken to discuss possible new threats to the pipeline during construction of the solar farm, and also once the farm is in operation.

One of the key steps in the pipeline risk assessment process is identifying and clearly describing the anticipated threats to the pipeline. Threats are all those activities or conditions that may directly or indirectly contribute to the release of gas and subsequent possible ignition, or disruption of supply to the end user, or damage to the environment.

For effective control and assessment, threat identification must be deeply considered, comprehensively detailed, and it must contain assessable details such as anticipated machinery size (for external interference threats), rather than just describing 'rupture due to third party excavation'.

Below are brief descriptions of the features or aspects that may establish threats to the pipeline, which were then assessed for controls in the threat register in *Appendix E – Threat Register*.

All threats were considered controlled, and therefore ALARP, for this development.

6.2.1. Access roads and crossings

According to the development plan and discussions at the workshop, Tallagandra Road will be used as an access route to the site. During construction it is anticipated that heavy equipment like B-double trucks hauling equipment and supplies will be using the road and therefore crossing the pipeline, but at an established road crossing. During operations, only light vehicles are expected to use the roads.

By the alignment drawings, the depth of cover to both pipelines at this road crossing meets the requirements of 1.2m. An action item was identified that the pipeline depth should be verified by potholing, which is typically done whenever there is construction activity around the pipeline, to confirm the expected location.

From a solar farm construction methodology point of view, a ring road was recommended. This will result in additional road crossings of the pipeline easement where it enters and exits the property. If a ring road is built, these crossings will require assessment and approval by APA.

APA will not necessarily refuse crossings (roads or cables), as long as they are designated and designed properly. The number of crossings should be minimised.

To prevent vehicular crossing the easement at non-designated locations, the easement should be flagged and signed as agreed with APA personnel.

Equipment heavier than 8 tonne axle load crossing the pipeline requires discussion with and approval from APA.

6.2.2. Earthworks over easement

There is no anticipated earthworks or drainage contouring over the pipeline easement.

It was agreed in principal that there shall be no removal of cover over the easement. Should there need to be earthworks, APA approval prior to commencing, and onsite supervision during, is required.

It is recommended that excavator activity within 15m of the pipeline be restricted to 20 tonne or less with general purpose teeth only.

There is no blasting expected on the property.

6.2.3. Marker signage installation

Signage marking the location of the pipeline easement should be installed according to discussions with APA.

It is recommended that the easement boundaries be flagged throughout the site, and access prevented to the extent possible.

6.2.4. Fencing

A 2m chain-link security fence in anticipated to be installed permanently around the perimeter of the property.

Vehicle gates across the pipeline easement will be required to be installed with APA-keyed locks.

6.2.5. Cable installation

Cable conduit crossings of the pipeline easement will be required.

The workshop participants discussed the possible installation methods of trenching, or HDD. The construction representative provided good insights and documentation of recent experience in Queensland where cable conduits were installed by HDD across pipeline easements. This is a recommended method; however, APA approval is required prior to any easement crossing.

6.2.6. Landscaping

It was agreed that there will be no trees planted on the pipeline easement. If there are plans for screening tree rows to be planted, the pipeline easement crossing should be left open without trees.

Vegetation management will be surface cutting only; no moving dirt is anticipated during operational phase.

6.2.7. Erosion / land movement / subsidence

There is no anticipated threat from erosion or land movement during construction or operation of the solar farm development.

If unexpected subsidence occurs on the pipeline easement, APA personnel should be contacted right away.

6.2.8. Substation Area / Control Hut

The Springdale substation area is outside of the assessment zone for this SMS.

6.2.9. Lithium Ion Batteries

The initial plans do not refer to battery storage at Springdale. For the fullness of information for this SMS report, the information below is provided anyway.

The EIS for the Bomen development describes a risk from lithium-ion batteries due to the flammable electrolyte contained within. If there is battery storage proposed, it is recommended that it be located outside of the 212m measurement length from the pipeline.

6.2.10. Electric and magnetic fields

Electrical hazards and interference studies shall be completed to ensure that the cathodic protection corrosion control for the pipeline is not rendered ineffective. AS 2885.1 (2012) Clause 2.3.3.3 (and Appendix R) refers to designing for induced voltage and fault current protection for sections of pipeline affected by these conditions, and that they shall be designed for in accordance with AS 4853.

[ACTION ITEM: Renew Estate]

6.2.11. Installation of steel piles for tracker units

The installation of the steel piles for solar panel tracker units was described and discussed in detail. The layout of the panels and trackers will avoid the easement and so there was no reason identified for the pile machine to be over the pipeline.

Marker signs should be installed at regular intervals to remind the operators of the hazardous work area above the pipeline.

6.2.12. Solar Panels

The solar panels themselves were not seen to create any new risks.

The consequences of an event were discussed; the workshop attendees were advised that solar panels can be damaged by fire but are not combustible.

No new threats identified.

6.2.13. Access to easement for patrols

The proponents were made aware the perpetual access to the pipeline easement by APA is required, during construction and during operations.

6.2.14. Anode Bed

There is no anode bed in the vicinity of this development.

7. EXISTING THREAT CONTROLS

APA has provided to Renew Estate a letter dated 24 April 2018 which outlines requirements summarised below. The guideline outlines requirements which have been discussed already in this report, such as:

- The pipeline must be positively located prior to detail design being undertaken
- Electrical studies in accordance with AS 4853 and AS 2832 are required
- Crossings design must be approved by APA prior to commencing
- No buildings to be constructed on the easement
- During construction, the easement must be delineated and marked as a hazardous work zone
- All plans must have the easement clearly identified as described in the letter
- Access to the easement by APA Operations personnel must be maintained at all times.

In relation to the requirements from AS2885.1 pipeline design for external interference, existing design and operational controls in place at this location include these listed below.

Physical	**Controls**	**Location class R1/HI (determined equivalent to R2 requirements)**
Wall thickness	6.4mm	Determined by design. See puncture resistance section.
Depth of cover	900mm	750mm
Procedural	**Controls**	
Right-of-Way Patrol	Operational procedures indicate patrolling is undertaken in this area fortnightly by aerial survey, and an annual ground survey In attendance at the SMS workshop was an APA operational representative who was familiar with the pipeline location and operational activities.	As required
Dial-before-you-dig	This is in place, and will be important to prevent incidents in the future	As required
Landowner Liaison	APA will update database for liaison with the final owner of the site.	As required
Procedural	**Comment**	
Marker Signs	Marker signs during construction and after completion are required to be maintained.	250m or as agreed

8. RISK EVALUATIONS

The attached threat list (Appendix E – Threat Register) provides details on the scenarios discussed during the workshop.

No threat items were taken through to risk assessment, as they were all determined to be non-credible, or sufficiently controlled (provided described controls are in place).

9. FORMAL ALARP ASSESSMENTS

9.1. During Construction

The conclusion of the workshop participants was that the threats have been well-identified and can be controlled. Therefore, no ALARP assessments were identified for the encroachment portion of the works.

9.2. During Operation

No uncontrolled threats unique to this solar farm development were identified that required an ALARP assessment.

This conclusion assumes that the electrical interference studies are completed, and any action outcomes are adhered to.

APPENDIX A – INDICATIVE SITE LAYOUT

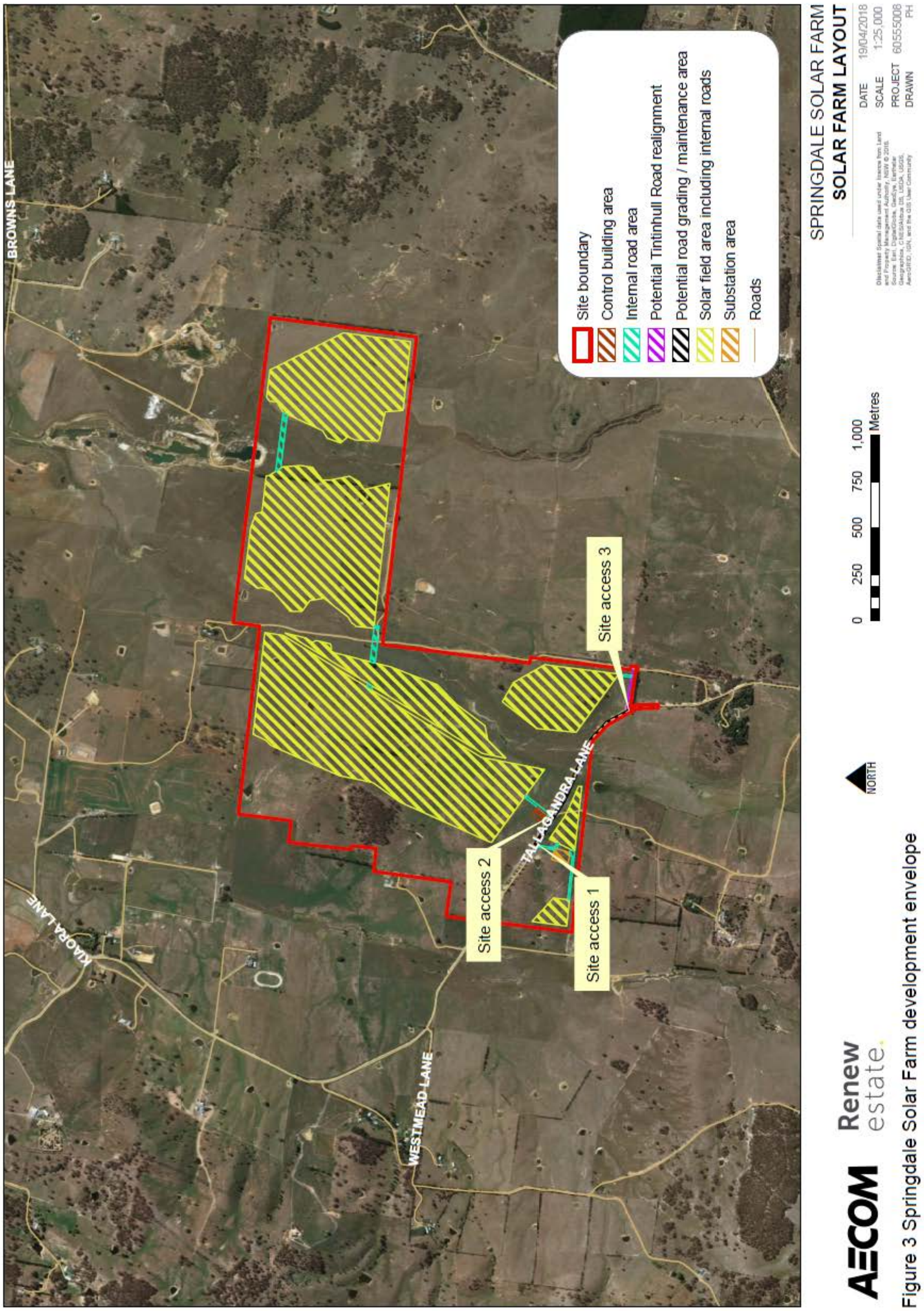


Figure 3 Springdale Solar Farm development envelope

APPENDIX B - WORKSHOP AGENDA AND ATTENDEES

SMS WORKSHOP AGENDA

WIRSOL Energy Pty Ltd – Bomen + Springdale Solar Farms (APA Pipelines)
SMS Type: Land Use Change/Encroachment
Workshop Held: APA Offices, George Street Sydney
Thursday June 7, 2018

	9:30am: Arrival and set up	Susan Scott (APA)
10:00	Meeting commences Introductions	Susan / All
10:15	Description of AS 2885 Risk Approach – the SMS process	Susan
10:30	Project Description: WIRSOL – solar installations outline 1) Bomen Solar Farm (20mins) 2) Springdale Solar Farm (10mins)	Will Stone / WIRSOL
11:00	Pipeline description and operations: APA 1) Young-Wagga Wagga Pipeline 2) APA Pipeline at Springdale -	Scott Mitchell/ APA
11:20	Short morning break	
11:30	Location analysis; confirm Location Class 1) Bomen Site 2) Springdale Site	All
11:40	Brainstorming of Potential Threats – general for both sites Consider Pre / During / Post - construction	All
12:30	Short lunch break	
12:45	**Site Specific: Bomen** Threats / Controls; Complete Risk Register Risk assessment of residual threats (if any)	All
14:00	**Site Specific: Springdale** Threats / Controls; Complete Risk Register Risk assessment of residual threats (if any)	All
14:45	Agreements / actions	All
15:00	Close	

SMS WORKSHOP - MEETING ATTENDEES

WIRSOL Energy Pty Ltd – Bomen + Springdale Solar Farms (APA Pipelines)
SMS Type: Land Use Change/Encroachment
Workshop Held: APA Offices, George Street Sydney
Thursday June 7, 2018

	Name (Company)	Position / Role	Signature
1.	Susan Jaques (Sage Consulting)	Facilitator	Jaques
2.	SCOTT MITCHELL	PIPELINE ENG	SAn
3.	Darrel Lal	Albury Tech (RCR)	
4.	GREG WOODWARD	CONSTRUCTION MGR	
5.	Will Stone	Development Mgr	
6.	Andrew Barson	Technical Mgr.	
7.	Tom Harrison	Dev Mngr	
8.	Bill Henningham	Corridor Protection NSW/QLD	
9.			
10.			
11.			
12.			
13.			
14.			
15.			
16.			
17.			
18.			
19.			
20.			

APPENDIX C – PIPELINE PUNCTURE RESISTANCE

Data from Page 23 of APA report 320-RP-AM-0208 Rev 1.1, SMS Report Dalton to Canberra Natural Gas Pipeline:

Table 8 Pipeline Penetration with Excavator

	Wall Thickness 6.35mm
Single point penetration	
Penetration Likely (B = 0.75)	25T
Penetration Not Credible (B = 1.3)	10T
Double point penetration	
Penetration Likely (B = 0.75)	>55T
Penetration Not Credible (B = 1.3)	25T

APPENDIX D – RISK EVALUATION TABLE

AS 2885.6 (Public Comment Draft Version) - publication 07/2018

	Dimension		Severity class				
			Catastrophic	Major	Severe	Minor	Trivial
SEVERITY	People		Multiple fatalities result	One or two fatalities; or several people with life-threatening injuries	Injury or illness requiring hospital treatment	Injuries requiring first aid treatment	Minimal impact on health and safety
	Supply		Widespread or significant societal impact, such as complete loss of supply to a major city for an extended time (more than a few days)	Widespread societal impact such as loss of supply to a major city for a short time (hours to days) or to a localized area for a longer time	Localized societal impact or short-term supply interruption (hours)	Interruption or restriction of supply but shortfall met from other sources	No loss or restriction of pipeline supply
	Environment		Impact widespread; viability of ecosystems or species affected; or permanent major changes	Major impact well outside pipeline corridor or site; or long-term severe effects; or rectification difficult	Localized impact, substantially rectified within a year or so	Impact very localized and very short-term (weeks), minimal rectification	No effect; or minor impact rectified rapidly (days) with negligible residual effect
FREQUENCY	Frequent	Expected to occur once per year or more	Extreme	Extreme	High	Intermediate	Low
	Occasional	May occur occasionally in the life of the pipeline	Extreme	High	Intermediate	Low	Low
	Unlikely	Unlikely to occur within the life of the pipeline, but possible	High	High	Intermediate	Low	Negligible
	Remote	Not anticipated for this pipeline at this location	High	Intermediate	Low	Negligible	Negligible
	Hypothetical	Theoretically possible but would only occur under extraordinary circumstances	Intermediate	Low	Negligible	Negligible	Negligible

APPENDIX E – THREAT REGISTER

Location = **SPRINGDALE SOLAR FARM**

Threat ID #	Feature/Aspect	Threat Description	Threat Credible? / if not, why not	Detail Damage Description or describe why not credible	Prevention/Controlled by Design and / or Procedures	Physical Protection	Procedural Protection	Are these controls effective?	Failure Possible (y/n)	Additional Controls?	Now controlled?	Failure scenario	Further details	Severity	Frequency	Risk Ranking	ALARP?	Comments	Action
1 - Threats associated with **Construction** of solar farm, including prepartory works				Note - there should be no uncontrolled threats during construction (encroachment).							Note - there should be no uncontrolled threats during construction (encroachment).								
	access road improvements (Tallagandra Road)	To be determined, upgrade not designed yet.	maybe	Access to the site will use the established Tallagandra Lane. The pipeline crosses Tallagandra Lane at KP 46.8. Road upgrades at this location require APA notification.															
	Heavy equipment crossing pipeline	Not applicable, not expected	No																
	Earthworks over easement	Posts and bunding will be installed to prevent access to easement No earthworks expected over easement	No	Earthworks over easement can only be performed with the approval of APA Induction procedures															
	Stormwater drainage	No change to current flows; Construction windrows not significant No threat	No																
	Marker signage installation	Install bunting or similar across right of way to prevent inadvertent access	No																
	Turning vehicles	Not a threat	No	not applicable															
	Installation of perimeter fencing (permanent installation)	Fencepost installation	No	Gates to be installed at right-of-way crossings (2 off), no posts in easement Permitted activity to be coordinated with APA															
	Cable installation	HDD	Yes	HDD goes off course and punctures pipeline, results in leak	experienced HDD contractor review methodology Permitted event - supervisor must be present														
	Excavation / earthworks	Pile-driver goes off design and ends up over the pipeline	Yes	roped and flagged parallel to RoW QA would have to fail															
	Excavation / earthworks	Pile-drivers cause more vibration than expected	No	APA to measure on site; will depend on location of closest pier to pipeline															
	Excavation / earthworks	Excavation parallel to easement deviates, impacting on the pipe.	No	not applicable															
	Excavation / earthworks	Depth of cover reduction during construction	No	no works over pipeline except crossings which will be managed separately															
	Excavation / earthworks	35T excavator with Tiger Teeth excavates over pipeline	No	Maximum 20T excavator on site stipulated by APA Inductions / info session permitted activity															
	Garden / Landscaping	New tree planted near pipeline; during installation the location of pipeline is not allowed for.	No	no trees to be planted on easement															
	Landscaping - tree choice	Tree installation - root system associated with tree choice (TEE on landscaping drawings) affects pipeline	No	short trees only near pipeline															
	Vehicular traffic	Vehicle crosses easement at non-designated crossing	No	easement flagged and inaccessible															
	Vehicular traffic	Heavy vehicle crosses, exceeding allowable limit	No	Design for heaviest expected vehicle or max road allowable															
	Erosion / land movement during construction	Heavy rain during construction result in land movement affecting pipe	No	erosion & sediment control plans															
	Vehicular traffic	Bogged vehicle in wet weather; spins wheels and contacts pipe.	No	No crossing of easement except at all-weather crossings.															
	Installation of Control building	no new threat	No																
	Landscaping / post holes for fencing	Post holes installation punctures pipeline	Yes	Installation of postholes punctures pipeline	yes	depth of cover, wall thickness	Permitted, controlled activity	yes	no										
	cable installation	HDD	Yes	HDD goes off course and punctures pipeline, results in leak	Experienced HDD contractor APA to review methodology Permitted event - supervisor must be present	nil	Permitted, controlled activity	yes	no										
	Marker signs	marker signs removed during construction		Inductions Patrols															
	Unauthorised compaction over easement	Compaction vehicles run over pipeline; threat of ovality	No																
	electrical interference	intereference AC/DC	Yes	Study to be completed by Renew Estate	Typical outcomes = 1) ok no change 2) separation distance 3) sacrificial zinc ribbon														
	MLV Site nearby	Venting (OHS)	No	No laydown area for materials															
2 - Threats associated with ongoing operation of pipeline **after construction** of solar farm																			
21	External Load	Additional external load on pipe	No	No infrastructure on easement															
22	APA unable to access to pipeline easement	No threat identified	No	no change to easement Gates in fencing with APA locks															
23	Vehicular traffic	Vehicular accident / plowing into easement	No	No new threat due to this development															
25	Failure of utilities services / repair work impinges on pipeline	Transgrid - at substation	No	No third party crossings of pipeline easement															

Location = **SPRINGDALE SOLAR FARM**

Threat ID #	Feature/Aspect	Threat Description	Threat Credible? / if not, why not	Detail Damage Description or describe why not credible	Prevention/Controlled by Design and / or Procedures	Physical Protection	Procedural Protection	Are these controls effective?	Failure Possible (y/n)	Additional Controls?	Now controlled?	Failure scenario	Further details	Severity	Frequency	Risk Ranking	ALARP?	Comments	Action
26	Subsidence	Due to construction works and soil disturbance, land subsides and pipe is deflected/strained	No	Stable soil in this area															
27	Marker signs	Marker signs removed by Solar Farm personnel	Yes	Induction material to advise (0 - 15 max on site)															
3 - Corrosion																			
31	External corrosion	A future anomaly requires direct access inspection to assess defect for possible repair	n/a	Not a threat - access is not impeded to investigate.															
32	Corrosion	Existing flaw is undetected, grows to be a through-wall crack	No	APA integrity management program for pipeline; no change due to this development															
4- Check robustness: all controls fail																			
33	HDD installation goes off course and punctures pipe	Pilot hole drill bit diameter 75mm	Yes	HDD drills hole in pipe, gas escapes and catches fire, HDD operator fatalites + APA fellow.	nil	nil	nil	no	y	Distance to cribb hut installation at low numbers	no	HDD drills hole in pipe, gas escapes and catches fire, HDD operator fatalites + APA fellow.		hypothetical	major	low	ALARP		