APPLICATION OF BIM IN GAS PIPELINE CONSTRUCTION

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Abstract

Given the expected gas shortage on Australia's east coast market and the future shutdown of fossil fuel power facilities, the Australian gas industry is undergoing yet another rush in infrastructure growth. Gas has been identified as transition energy to bridge the existing gap and enable a long-term shift to green energy. To accommodate this demand the industry has announced significant new Gas Pipelines and facilities across the continent in recent months.

Ensuring efficient delivery of these infrastructures to achieve investment decisions is critical, given competing markets, environmental constraints, social license and various third-party requirements. BIM (building information modelling) is a proven methodology that allows careful assessment and simulation of the works for Gas Pipelines and Facilities Engineering, Construction and Operation. Key benefits for the construction sectors include the opportunity to simulate the works which can improve safety, accurate assessment of environmental constraints to develop construction methodology and developing accurate quantities for earthworks, take-offs and materials. BIM enables project team members to create a 3D virtual model of the project and all of its systems and communicate that information with one another. It allows the project team to quickly identify design and construction issues and resolve them in a virtual environment prior to the start of the actual construction phase. BIM techniques address the issues by utilising standardised interchange formats such as Industry Foundation Classes (IFCs) to ensure that all models and information sources within a project are communicating in a consistent manner. BIM models organise data on a geometrical and geographical level, and they can readily add project-specific aspects to a core model by altering IFCs. BIM is a potential breakthrough in Gas Pipelines Engineering, Construction and Operation.

This paper discusses the application of BIM for underground Gas Pipelines. The creation and progressive update of BIM for constructed Gas Pipelines ensure that as-built data on the structures is available and can be used throughout its lifetime for the purpose of asset management. BIM for underground applications integrates data on surface structures, such as existing assets, and subsurface infrastructures, such as pipes, along with details of the surrounding ground, environmental and cultural heritage constraints, the associated soil and rock properties and groundwater regime into a single framework. This approach is demonstrated by applying it to open cut or trenchless construction operations. The data from this extended BIM concept can be interactively used with analysis packages to conduct risk assessments for new construction activities. It also shows how BIM for the underground Gas Pipelines can be used throughout the planning, construction and post-construction stages of a project, and, importantly, how this information can be available for future projects.

Nacap has successfully utilised the BIM system for several tenders/ contracts, and the BIM system saved valuable time and cost for the client. In this paper, the author from Nacap, shares Nacap's experiences and lessons learnt on the benefits of BIM throughout the tendering, planning, construction and post-construction stages of a project.

Introduction

In the pipeline design and construction process, attention should be paid to the open cut and trenchless crossing options. Based on the characteristics of BIM, this paper explores the role of BIM in creek crossing modelling and estimation, and the simulation of the construction process during tendering stage. In this paper, 12D, Navisworks Simulate and cmBuilder software are used to simulate the construction method. The construction process, LECH (Lands, Environment & Cultural Heritage) constraints, risks, schedule, and cost are analysed. The three-dimensional model is created with the construction schedule and resource plan to select the best creek crossing option.

BIM Construction of Open Cut Crossing

12D software has been used for earthwork modelling of the open cut trench. 12d Model is a powerful terrain modelling, surveying and civil engineering software package. It allows quick and high quality earthwork analysis in a wide variety of projects. The 12d Model base product contains all the options necessary to produce a digital terrain model (DTM or TIN), including fast triangulation, contouring and sectioning routines. It is graphically interactive to give immediate feedback to the user. The result of the 12D analysis, is then, exported to Navisworks Simulate. Autodesk Navisworks Simulate software (commonly referred to as Navis) provides comprehensive project review, 5D analysis, quantification and communication capabilities that assist users in demonstrating design intent and simulating construction. It is a project review software that allows Architecture, Engineering and Construction professionals holistically review integrated models and data with stakeholders during preconstruction to better control project outcomes.

The establishment of the 12D model to create the 3D Earthwork model follows the following steps: create surface tin from surface contours → import pipeline alignment from Google Earth alignment → create super alignment → create 3D open cut trench from super alignment → assign Right of Way (ROW) width → create super tin of the design surface → export the super tin to Navisworks software. The construction 3D model is shown in Figure 1.

An open cut creek crossing step by step construction and the logistic plan have been created using cmBuilder. cmBuilder is a 100% web-based, 3D editor + viewer that provides fast and easy to use tools for creating intelligent site logistics plans. cmBuilder models and simulates a holistic view of the excavation lifecycle by adding cut + fill volumes, ramps, creating sequences, and extracting quantity take-offs of cut and fill volumes in real-time directly on the web browser.

The resulted stepped trench profile and the cmBuilder 3D construction model are shown in Figures 2 and 3.

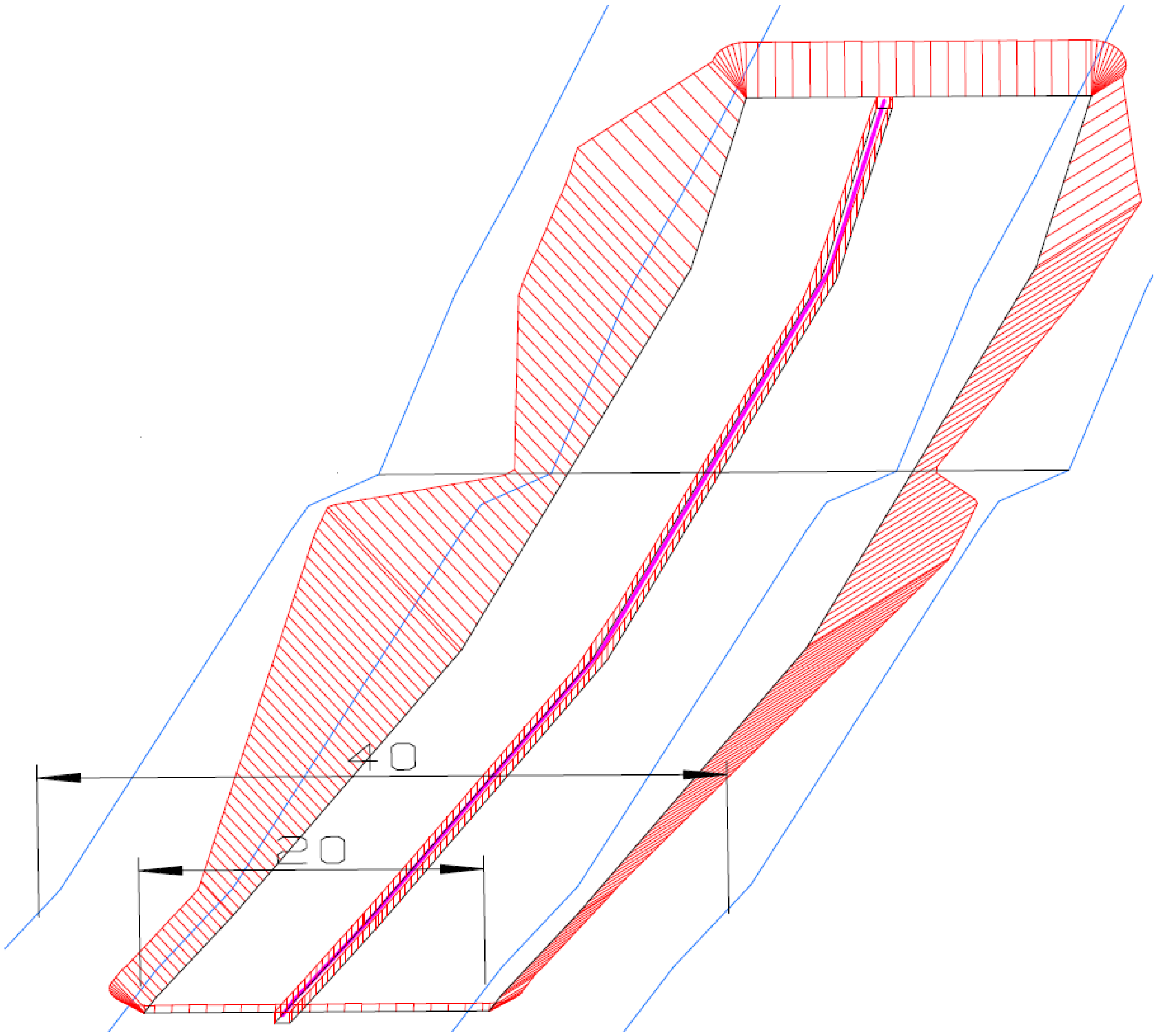

Figure 1: 3D model of Open Cut Crossing

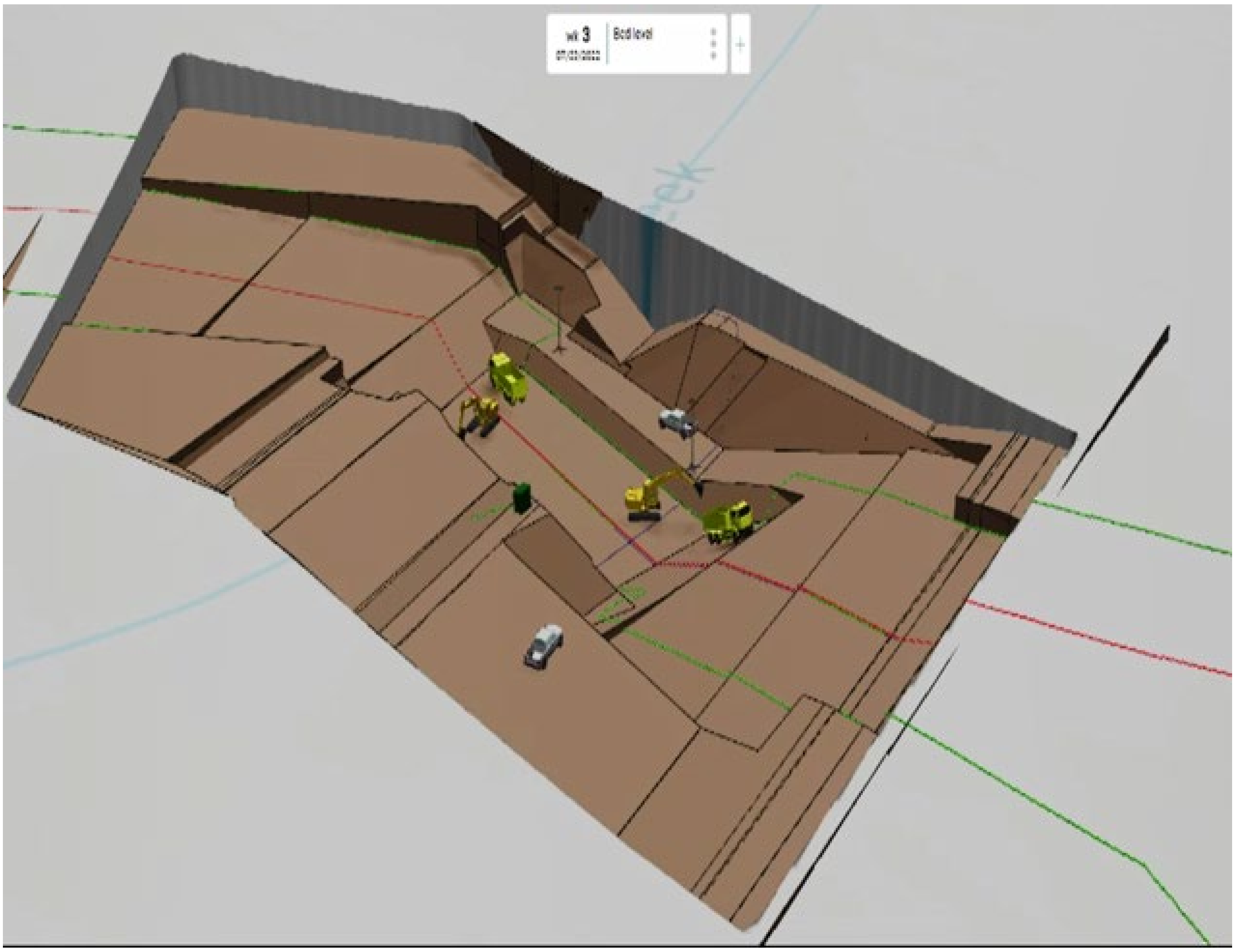

Figure 2: Stepped Trench Profile

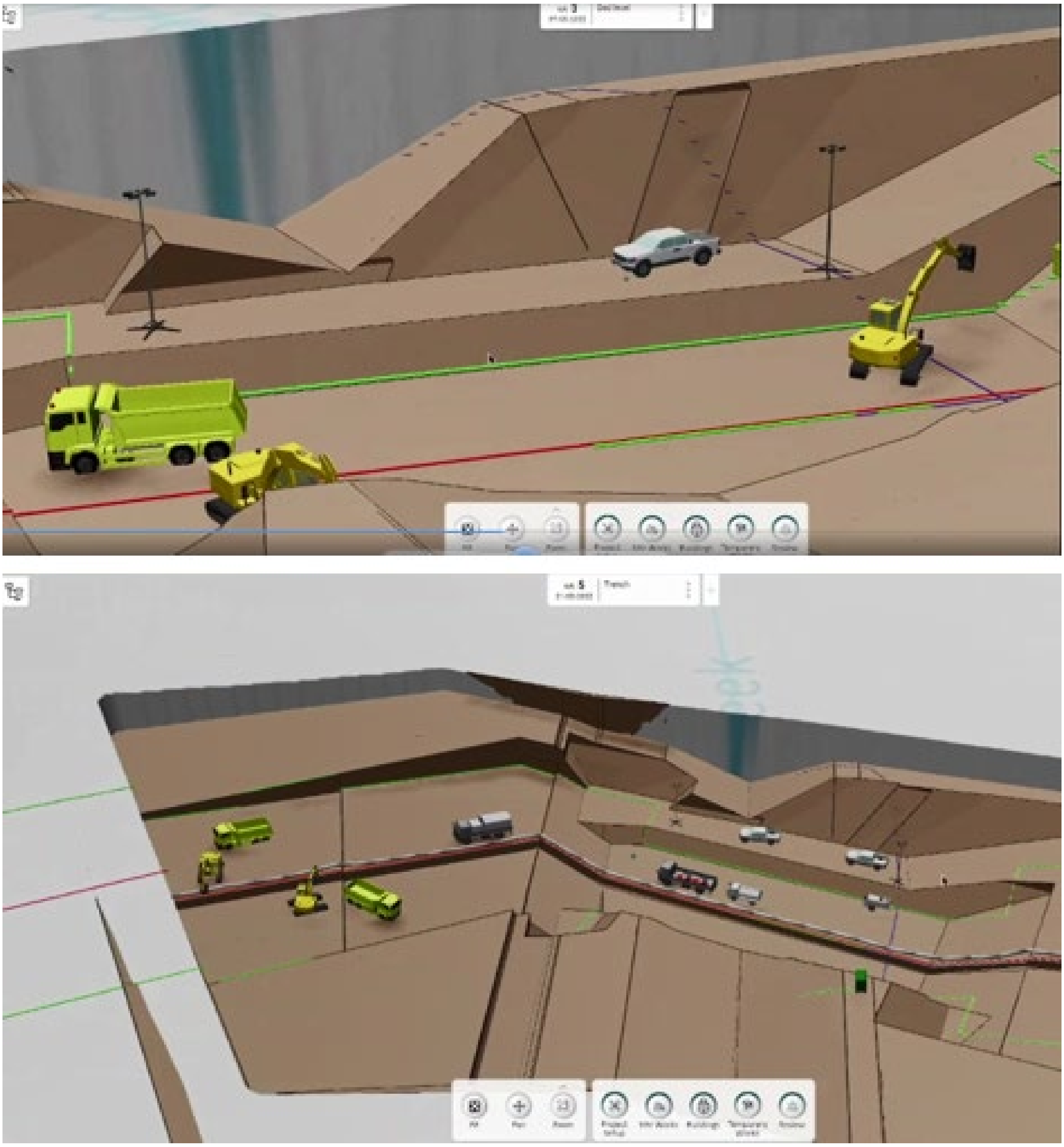

Figure 3: cmBuilder 3D construction model

Open Cut Key Considerations

A detailed assessment of the layouts, available works spaces, and profiles of current ROW boundaries have been undertaken. Open cut construction from within excavated work platform with battered trenches and ramps/gradient to allow for equipment to track across has been analysed.

Open Cut Key Considerations are summarised in Table 1.

Item	Parameters	Open Cut
1	ROW width at the base of the excavation	20m
2	ROW width at top of excavation / trench	40-50m required to work safely with excavation profile
3	Depth of cut to the working platform	8m vertical southside, 6m vertical northside (maximum)
4	Depth of excavation for pipe invert (trench profile)	10m southside, 8m northside
5	Restrictions of working dates	Limited construction window
6	Impact to current works program and forecast completion dates	Yes, based on limited access dates and up to 6 week construction period (including night shifts), plus out off sequence hydrotest program
7	Extra work spaces	100mx100m (x 2) South and North sides to stockpile excavated embankment and trench materials
8	Flumed crossing and bypass pumping	Yes
9	Tree removal	Yes
10	Trench breakers	Yes
11	LECH	Yes, Cultural Heritage area on northside of creek
12	Flooding of Trench	Yes, (Preparedness and responsiveness to unexpected flows i.e. trench backfill within 24 hours, diversion of flows and storage of rock beaching for protection)
13	Bypass Pumping	Yes
14	Reinstatement	Higher risk - sloping terrain and soil (dispersion on the northern side) - Reduced stability due to vegetation removal and timing of reestablishment
15	frac-out	No

Table 1- Open Cut Key Considerations

Open Cut Excavation Consideration

Open cut excavation requirements are as follows:

1. Requirement to have minimum 2m cover between the bottom of creek and top of the pipe.
2. Installation of 2 x 18m straight lengths of concrete coated pipe under creek per alignment sheets.
3. Cross section profile developed, excavation depths on the southside up to 8m.

Open Cut cross section analysis are illustrated in Figure 4 and Figure 5.

SOUTH SIDE OF CREEK						
Chainage	Surface Level	Top of Pipe	Invert of Pipe	Minimum Cover	Actual cover	Depth of trench
0	129.82	128.62	128.12	1.2	1.20	1.70
5.2	129.50	127.64	127.14		1.86	2.36
9.2	128.98	126.89	126.39		2.09	2.59
9.6	128.93	126.81	126.31		2.12	2.62
11.6	128.62	126.43	125.93		2.19	2.69
24.5	125.28	124.00	123.50		1.28	1.78
63	123.55	114.96	114.46	2	8.59	9.09
65.6	123.27	114.96	114.46	2	8.31	8.81
66.3	123.19	114.96	114.46	2	8.23	8.73
78.1	116.96	**114.96**	114.46	2	2.00	2.50
91.1	120.91	114.96	114.46	2	5.95	6.45
100.9	121.57	114.96	114.46	2	6.61	7.11
101.6	121.64	114.96	114.46	2	6.68	7.18
110.9	122.75	116.35	115.85		6.40	6.90
111.2	122.77	116.39	115.89		6.38	6.88
161.4	125.09	123.89	123.39	1.2	1.20	1.70
NORTH SIDE OF CREEK						

Figure 4: Open cut cross section analysis

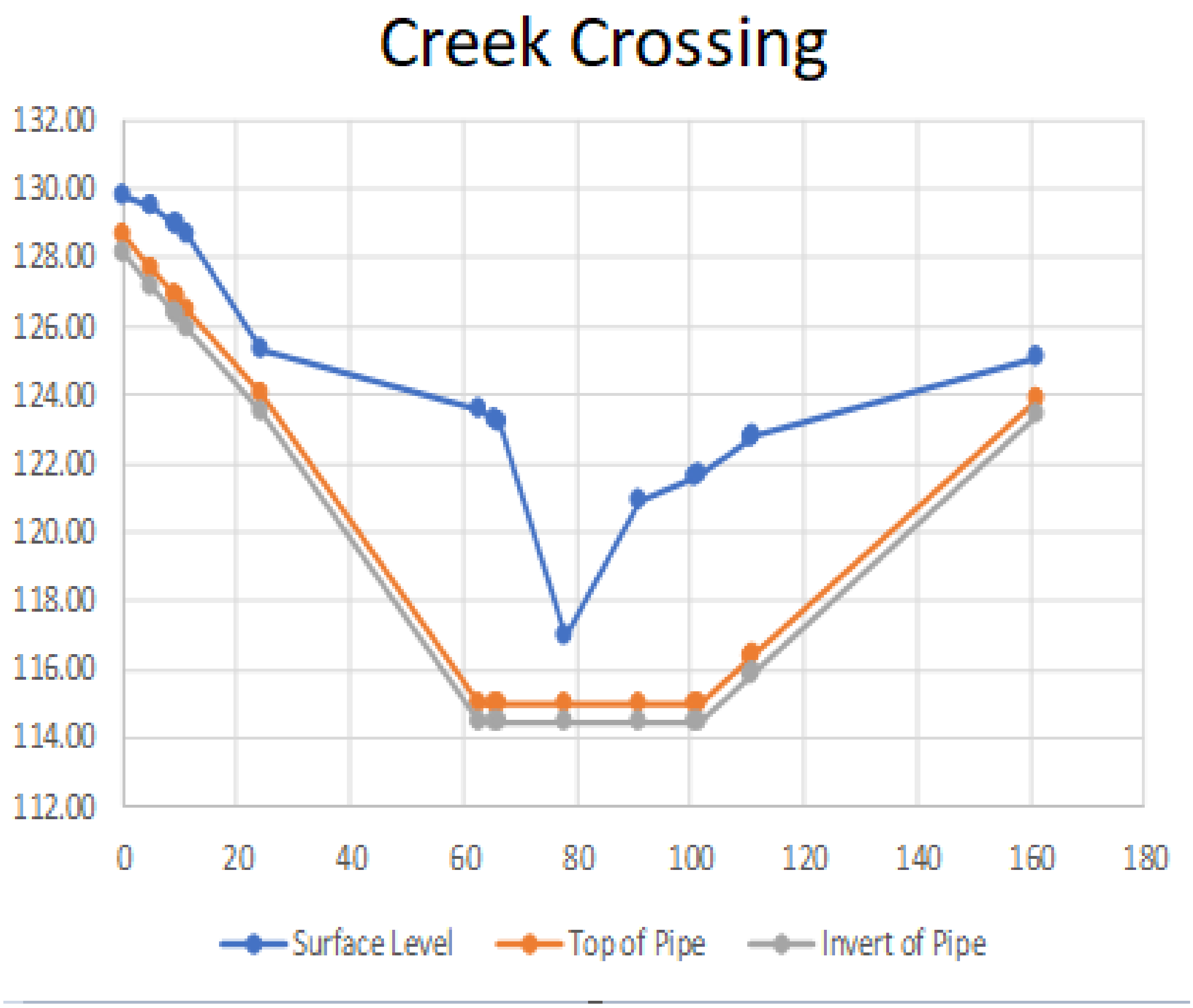

Figure 5: Open cut elevation diagram

Open Cut LECH (Lands, Environment & Cultural Heritage) Constraints

The following LECH constraint are considered for the open cut option:

1. Cultural Heritage / Salvage (Blue Zone)
2. Native vegetation, plus additional trees outside 20m Construction right of way (CROW) at Creek for safety
3. Extent of subsoil (bed) and groundwater contamination treatment/management arising from contamination assessment
4. Environmental Management Plan (EMP) requirements

- Wet weather preparedness and response – works limited to the capacity to backfill with 24 hours
- Capacity to manage diversion of unexpected flows
- Sufficient stockpiles of rock beaching to protect exposed trench (additional Extra work Space (EWS) requirements)
- Significant restoration requirements including geomorphology and hydraulic habitat which will extend beyond the CROW project area
- 24 x month post rehabilitation monitoring program
- Additional mitigation and monitoring likely prescribed by The Department of Environment, Land, Water and Planning (DELWP) should open trenching be preferred.

5. Environmental Management Measures (EMM)
    - The constraints to undertaking works to avoid peak juvenile nesting September to March (impact upon completion date with open cut method)
    - Pre construction survey for burrows
    - Use of flume pipe configuration to enable platypus movement.
    - Risks and limitations to replicating the natural geomorphology and habitat structure during rehabilitation which may lead to non-compliance outcomes derived from the expected monitoring prescribed in the EMP (in the absence of knowledge of the habitat structure) and expectations arising from public inquiry in the event that open cut is preferred methodology.

Trenchless Key Considerations

Horizontal directional drilling (HDD) is the most commonly used trenchless system for installing gas pipelines. HDD is an integral part of the oil and gas pipeline industry. With increased governmental regulations concerning environmental protection, drilling below creeks and other sensitive terrain is sometimes the only way to install new pipelines.

One major risk during Horizontal Directional Drilling (HDD) is the release of drilling fluid to the surface which is referred to as a hydraulic fracture, or “frac-out”. hydraulic fracture creates project delays and poses a high risk in environmentally sensitive areas. A hydraulic fracture model based on mechanical and civil engineering principles shall be developed to mitigate the risk of frac-outs. It is important to monitor the annular pressure and ensure it does not exceed the maximum allowable pressure in the borehole during HDD operations.

Trenchless Key Considerations are summarised in Table 2 and the Horizontal directional drilling (HDD) Profile is illustrated in Figure 6.

Item	Parameters	Trenchless (HDD)
1	ROW width at the base of the excavation	Not Applicable
2	ROW width at top of excavation / trench	Not Applicable
3	Depth of cut to the working platform	Not Applicable
4	Depth of excavation for pipe invert (trench profile)	Not Applicable
5	Restrictions of working dates	Program risk eliminated
6	Impact to current works program and forecast completion dates	No
7	Extra work spaces	For string preparation and pullback
8	Flumed crossing and bypass pumping	Not Applicable
9	Tree removal	Not Applicable
10	Trench breakers	Not Applicable
11	LECH	avoided
12	Flooding of Trench	Not Applicable
13	Bypass Pumping	Not Applicable
14	Reinstatement	Not Applicable
15	frac-out	Yes, but considered low based on the depth of cover at 14.75m

Table 2- Trenchless Key Considerations

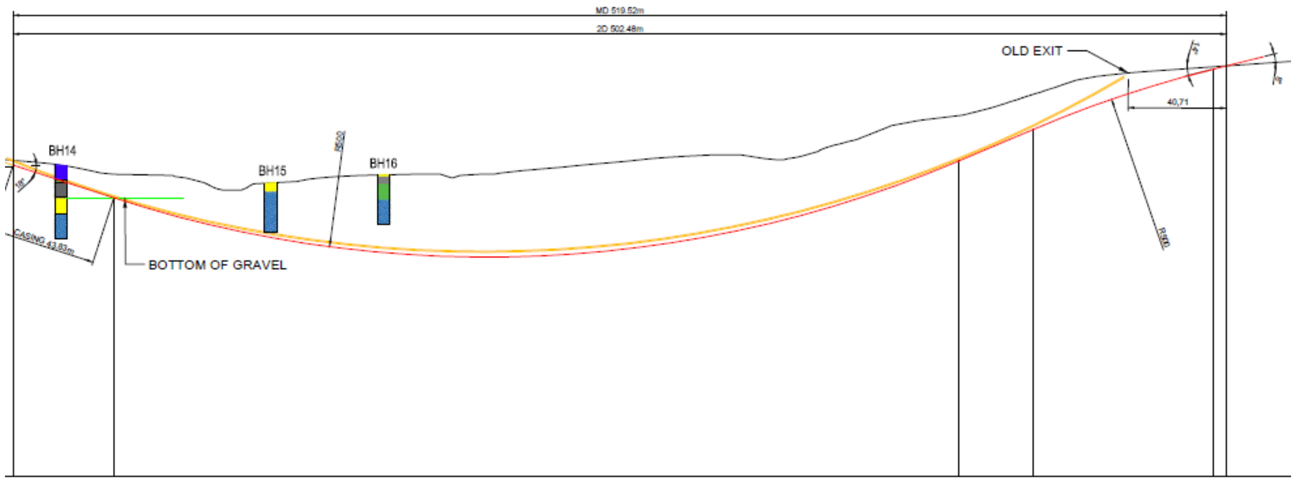

Figure 6: Horizontal directional drilling (HDD) Profile

Conclusion

The application of BIM Technology in the pipeline crossing analysis can find out the best option in earlier stages of the project. The result of 3D modelling shows direct costs for HDD to be lower than the Open Cut option when considering the extent of earthworks, inclusion of trench breakers and reinstatement aspects. In addition, the HDD method offers less disturbance to traffic, and the public, lower restoration cost, less noise and minimum import/export of the construction materials.

The trenchless crossing method does not require invasive excavations and soil replacement, allowing the preservation of the landscape, the topsoil, and a decrease in the rehabilitation time. The open cut option provides a higher risk profile with regards to safety and environment considering the Risk Matrix Profile. Construction by the HDD method will engineer these risks out. Ongoing reinstatement and erosion control of slopes during the Defects Liability Period (DLP) are not quantifiable for the Open Cut option. HDD system will ensure Long term integrity of the pipe itself (floods, erosion).