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1 Summary

The Project's Cost Estimate, Schedule and Contingency are the foundation of the Base Case economics presented in the Snowy 2.0 Business Case. They represent an appropriate basis on which to seek Final Investment Decision (***FID***).

Since completion of the Feasibility Study in December 2017, these key Project deliverables have been updated for the key assumptions, qualifications and methodology improvements developed during the FID phase, which have come about primarily through the close interaction with Owner's advisers and the Contractor counterparties involved in the procurement process.

The independent expert involved in the Feasibility Study was re-engaged for FID to deliver the Cost Estimate, Project Schedule and Contingency output based on the binding bids received from tenders prior to FID. Snowy Hydro will continue to develop and derive value from this association, up to and including expected Engineering, Procurement and Construction (***EPC***) contract signing in March 2019.

As at FID, the Project procurement process reflects significant progress in negotiations over final pricing and design with Civil and Electrical/Mechanical (E***&M***) contracting parties. The Cost Estimate, Project Schedule and Contingency incorporate the latest available information and binding prices from the Civil and E&M contractors, including the tender submissions and subsequently agreed positions with those parties as part of the evaluation and negotiation phase.

It is on this basis that the Project's capital expenditure for the business case was developed and incorporated.

This chapter also outlines the process by which the Cost Estimate, Project Schedule and Contingency were developed, and notes the ongoing work program.

1.1 Introduction

1.1.1 Overview

An independent expert developed a Project Cost Estimate and Schedule which take into account the selected EPC contracting strategy and have been validated against information provided to date by Snowy Hydro's Contractors through the procurement process. The Estimate includes a Contingency provision, developed through a Quantitative Risk Analysis (**QRA**) process. This process takes into account material, quantifiable risks identified through the Pre-FID risk process managed by independent risk experts. See *Supporting Chapter Seventeen* for more discussion of risk.

In undertaking the Commercial investment decision due-diligence for FID, capital expenditure and transmission downside scenarios are tested as standalone cases. See Supporting *Chapter Nine - Scenario analysis* for more detail.

The feasibility estimate has been progressively updated to support the decision-making process for the Employer's Requirements (see *Chapter Twelve - Facilities*) and the tender price evaluation to understand any potential pricing strategies in tender responses.

Note that the focus of this chapter is on methodology. Estimate figures presented in this chapter, though considered robust and unlikely to change materially, represent a snapshot of a point of time in an ongoing process. They cannot be considered definitive until tender negotiations are finalised to improve the cost and risk allocation positions as reflected in the binding bids received from tenderers as at FID. This process remains on track to meet all commercial and Project requirements throughout the procurement of final EPC contracts and pricing. The process to date has provided sufficient confidence to proceed with FID and the assumed numbers in the Board-approved Snowy 2.0 Business Case.

The independent expert has provided an opinion that the Total Capital Cost Estimate is consistent with the Civil and E&M binding total pricing provided by the tenderers, and that the tendered schedules are "adequate and reasonable".

1.1.2 Key exclusions

The following items have been excluded from the estimating process for the base case Estimate:

1. Land and development costs;
2. Lease costs;
3. Foreign exchange fluctuations or hedging costs;
4. Funding or financing costs;
5. Operational ramp-up costs (recruitment and training of operational personnel and the like);
6. Operational spares; and
7. Goods and Services Tax (***GST***).

1.1.3 Estimate overview

The scope of work for each package is:

1. **Exploratory Works** - to undertake further investigation to confirm the final location and orientation of the cavern and to determine the geotechnical viability of the main project works. The outcome of the investigations will provide detailed information supporting a more refined project design; and
2. **Project Execution** - the full construction and commissioning of the Project following confirmation of the cavern location and orientation.

The Estimate will be summarised at Cost Breakdown Structure (***CBS***) level 2 as per Table 1.

Ref	Description
A	Civil Contractor Indirects
B	Exploratory drift/shaft
C	Power Waterway
D	Access Tunnels
E	Construction Access Tunnels & Construction Adits
F	Caverns
G	Enabling Works
H	Power Station
I	Switchyard/ Cable yard
J	Testing & Commissioning
K	Completion Works
L	Owner's Team Cost
M	Escalation and Contingency

Table 1: Estimate at CBS level 2

1.2 Activities undertaken

The independent expert developed the Project Estimate and Schedule for the Feasibility Study, and then refined and validated them for FID by assessing the options, the submitted tender schedules and pricing, with associated risks.

1.3 Approach and methodology

The general Estimate and Schedule development approach was to:

1. Update the Feasibility cost estimate;
2. Update the Feasibility schedule;
3. Develop a consolidated scenario and option model;
4. Prepare an input model for valuation (see *Chapter Eight - Valuation and selected business case*); and
5. Prepare Work Breakdown Structure (***WBS***), and CBS.[1]

A common WBS was developed to organise the Project into manageable objectives and to align the valuation model and Schedule for consistency.

The independent expert used in-house cash flow models to develop cash flow forecasts. Forecasts were prepared taking each activity in the Estimate and spreading the cost over time against the base case schedule. These cash flow forecasts will be validated against the tender responses, and may subsequently be further refined if required. As at the time of writing, the respective design teams and contracting parties were finalising the preferred design envelope to be used as the basis for the FID cash flow. The business case for FID has assumed a conservative total outturn dollar cost profile, in order to calculate the commercial parameters for the Project. (see *Core Chapter Two - Commercial business case* and the five Commercial Supporting Chapters (Five through Nine)).

The independent expert's approach considers both Inherent Risk,[2] and Contingent Risk.[3] The output from the QRA together with the detailed capital cost estimates were modelled to generate a project range against which a P50 and P90 Project Estimate could be determined (ie the level at which there is a 50% and 90% certainty of the Project Estimate not being exceeded). This output informed the process of assessing the Project contingency.

Due to the tender designs being structured differently by the tenderers, each tender response will have a different risk profile and QRA will be developed for each response as part of the normalisation process.

1.4 Estimating and scheduling basis

The FID Estimate and Master Schedule have been based on the major procurement packages plus several contracts from the Owner's Team. They

[1] Note: The Organisation breakdown structure (***OBS***) and control account structure for Project controls during execution will be developed Post-FID (see *Supporting Chapter Fourteen - Project controls*).
[2] The level of risk when no action has been taken to mitigate or reduce the risk, ie before any treatments or controls are applied. Inherent risks are certain to occur, though the consequences and impact may not be fully known.
[3] Risks attached to items outside the initial estimate that may occur but are not certain.

include battery limits, basis of design (taking tender submissions into account), treatment of approvals, long lead items, access roads, exploratory works versus main works, key project elements (intake structures, caverns etc), commissioning, resource pricing, allowances and provisional sums, indirects, overheads and profit.

The contracts will be awarded in March 2019. The Control Budget will be developed from the Final Estimate and Schedule in Q2 2019. The Final Estimate and Schedule will be a combination of the Exploratory Works - Roads (***EWR***) price,[4] the Civil price, the E&M price, the Owner's Team cost and Contingency.

A manpower schedule has been developed for the Owner's Team based on the planned team structure and current market rates have been applied to determine the Estimate with an allowance for expenses. Key interface milestones have been incorporated into the master Schedule.

1.5 Escalation and contingency

Escalation is based on assumed exchange rates, forecast real cash flow, development of escalation indices and an escalation model.

For contingency, risk adjusted total outturn cost models were developed based on QRA methodology using risk management processes and subsequent workshops with Snowy Hydro.

QRA was used to combine the effects of identified uncertainties in the Estimate and discrete risk events on the Project objectives taking into account the correlation between discrete risk events from risk identification high-level schedule uncertainties and cost uncertainties, indicating the degree of overall risk faced by the Project.

All uncertainty and risks that might have a cost impact were assessed. The risks were then included in the QRA Model. Based on the likelihood and consequence evaluated in the registers, the chance in percentage and cost impact was quantified.

The Geotechnical Baseline Report (***GBR***) contains the expected geological conditions and the pricing schedule details. A sensitivity model has been established to understand any potential changes in geological conditions and potential cost and time impacts.

1.6 Schedule

Key milestones were identified. The critical path runs broadly through:

1. Civil contract award;
2. Exploratory Works;
3. Construction adits;
4. Machine hall construction and fit-out; and

[4] See *Supporting Chapter Fourteen - Early and exploratory works* for scope.

5. Commissioning.

The critical path will challenge the proposed construction methodology and productivities from the tender responses. Interfaces between contracts on the critical path will be highlighted for management action during the execution phase.

1.7 Due diligence

The consolidated Project Estimate will be assessed to understand any areas that are significantly different to expectation and warrant further investigation.

Input was sought from Civil and E&M Contractors involved in the Early Contractor Consultation (***ECC***) process (see *Supporting Chapter Two - Procurement*).

Selected rates and prices were solicited from the Civil tenderers. These rates and prices were used as a check when building up the working estimate.

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2 Activities undertaken

The independent expert undertook the development of the Project Estimate and Schedule for Feasibility in 2017. They were re-engaged in 2018 to undertake a similar exercise for FID. Their scope (relevant to this chapter) comprised:

1. Options analysis;
2. Tender schedule and price review, analysis and risk-based normalisation;
3. Consolidation of tenders, options and scenarios schedule and cost; and
4. Estimate and schedule.

To inform FID, Snowy Hydro developed a Capital Cost Estimate (the ***Estimate***) and Project Schedule (the ***Schedule***) for the Project. To support this activity, Snowy Hydro engaged The independent expert to work collaboratively with SMEC and Snowy Hydro to deliver the Estimate. The independent expert also provided risk analysis services to support the development of the Estimate and Schedule.

The Estimate and Schedule were prepared for the base case design of the Facilities as described in detail in *Chapter Twelve - Facilities* and have been updated with information from the submitted tenders.

3 Approach and methodology

3.1 Overview

The *Estimate* and *Schedule* are inputs to the Commercial investment model.

To support the development of the Employer's Requirements in the tender documents a series of options were developed.

Tender document milestones were based on the schedule critical path key milestones and interface milestones.

The preferred contractors, options and scenarios will form the basis for the Estimate and Schedule, and will be updated based on contract award.

A QRA model will be used to present a risk-based forecast of contingency scenarios.

3.2 General approach

The general approach to the development of the Estimate and Schedule has been to:

1. Update the Feasibility Cost Estimate using proprietary estimating software supported by The independent expert's specific configuration and master libraries for the estimate. The Estimate reflects the contractors' design and construction methodology;
2. Update the feasibility schedule for near-critical and critical path activities in Primavera Enterprise (***P6***).[5]
3. Develop a consolidation model to model scenarios and options from tender price submissions to understand the price variance between scenarios and potential cost for preferred technical solutions.
4. Prepare an input model for the commercial investment model.

3.3 Work Breakdown Structure

A common WBS was developed to organise the Project into manageable objectives and to align the valuation model and Schedule for consistency. The levels (levels 1 to 3) are used for alignment between the Estimate and the Schedule and refer to the total Project. The WBS was developed in P6 and became more detailed under the work packages (levels 2 & 3) as indicated in Table 2.

See *Supporting Chapter Fourteen* for further discussion of the function of the WBS in the context of Earned Value Management (***EVM***).

Activity IDs in the Schedule have been coded for ease of reference. Each activity has a 12-character ID with the coding structure shown in Table 2.

WBS LEVEL 1	WBS LEVEL 2	WBS LEVEL 3
Milestones	Project Commencement	
	Environmental deliverables	
	Staged completions	
	1st Power	
Exploratory Works	Milestones	
	Engineering & design	Site investigation
		Engineering & design
	Mobilisation	
	Site establishment	Site office procurement
		Laydown & site office construction

[5] Oracle's Primavera P6 Professional Project Management.

		Water supply
		Communication infrastructure
	Construction camp	Camp procurement
		Camp construction
	Construction power	HV connection & reticulation
		Temporary construction power
	Marine works	Talbingo North wharf
		Talbingo South wharf
		Soil disposal Talbingo trials
	Access roads	Ravine road MC10
		Mine trail MC30
		Lobs Hole road MC40
		Wharf road MC50
		Spillway road MC61

	Exploratory tunnel (MT31)	Portal works
		Tunnel works
Main works	Engineering & design	Survey
		Detailed design
	Procurement	Electrical equipment
		Mechanical equipment
		Civil equipment
		Establishment facilities
	Mobilisation	Management Plans
		Recruitment
		Training & inductions
		Contractor permits & approvals
	Site establishment	Excavated rock disposal
		Potable water
		Wastewater treatment
		Warehouse & laydown
		Fuel farm
		Quarry
		Concrete batch plants
		Construction communication & IT
	Construction camp	Main camp - Ravine
		Main camp - Tantangara
	Construction power	HV connection
		Temporary construction power
	Demobilisation	
	Access roads	Ravine road (MCAO) upgrade / sealed
		Marica trail (MCBO) sealed
		Quarry trail (MCDO) unsealed
		Tantangara road (MCEO) unsealed
		Tantangara East road (MCFO) unsealed
		Tantangara camp road (MCPO) unsealed
		Marica West trail (MCGO) sealed
		Talbingo Intake road (MCJO) unsealed
		Talbingo Adit road (MCKO) unsealed
		Wallaces Creek road (MCLO) unsealed
		Public road upgrades
	Power Waterway	Tantangara Intake
		Talbingo Intake

		Headrace Tunnel (MT11)
		Tailrace Tunnel (MT20)
		Headrace surge tank
		Penstock guard valve chamber
		Distributor tunnels (MT13 A-C)
		High pressure shafts
		High pressure tunnels (MT15 A-C)
		Penstock Tunnels (MT16 A-F)
		Draft tube tunnels
		Collector tunnels (MT18 A-C)
		Tailrace surge tank
	Access Tunnels	Main access tunnel fit-out (MT31)
		Emergency egress, cable & ventilation tunnel (MT32)
		Cooling water tunnel
		Material access tunnel 2 (MT31A)
		MAT-ECVT cross tunnels
		Penstock guard value chamber access tunnel (MT33)
		TR surge tank access tunnel (MT34)
		Pressure shaft inspection chamber access tunnel (MT35)
	Construction access adits	Tantangara construction adit (MT51)
		Talbingo construction adit (MT52)
		Marica construction adit (MT53)
		Machine hall construction adit (MT55)
		Machine hall construction adit 2 (MT55A)
		Penstock construction adit (MT56)
		Collector tunnel construction adit (MT57)
		HR surge tank expansion construction adit (MT58)
	Power station	Machine hall
		Transformer hall
		IPB galleries
		IPB cross gallery
	Major equipment	Vertical reversible Francis pump turbines & generator
		Vertical generating units
		Transformers
		Reactor
		Static frequency converter
		Variable speed inverters
		Neutral earth resistor
	Balance of plant	Main inlet valve
		Draft tube valves and gates
		Switchgear
		Protection systems
		Control systems
		Control room equipment
		Communication systems
		Security system
		Fire detection & suppression system
		Compressed air systems
		Oil handling, transfer & treatment
		Heating, ventilation & air conditioning

		Cooling water system
		Potable water systems
		Sewage & waste disposal
		Dewatering system
		Vertical transportation
		Lighting & power
		Mobile plant & equipment
	Switchyard / Cableyard	Switchyard civils
		HV Switchyard / cableyard
	Testing & commissioning	Testing & commissioning
		Operational readiness
	Completion works	Punchlist & clean
		Site remediation
	Owner's Team cost	Employee costs
		Subcontract costs
		Associated costs
	Contingency and Escalation	Contingency for total Project
		Escalation for total Project

Table 2: WBS

3.4 Estimate

The Feasibility Estimate has been updated following input from the reference design, ECC, shortlisting, and tender consultation process to develop the Project Estimate. This reflects the forecast tender returns and pricing schedules.

The Estimate may be updated based on design pricing refinements. These have been normalised including owner's costs, escalation and contingency.

3.5 Preparation of cash flow forecasts

The independent expert used their own in-house cash flow models. Forecasts were prepared taking each activity in the Estimate and spreading the cost over time against the base case schedule. Depending on the nature of the activity, the cost was spread against the duration of the activity on a straight line, standard S-curve, front-end or back-end loaded distribution. The method of distributing the expenditure for each activity was determined on an activity-by-activity basis.

Cash flows were prepared on a monthly basis and summarised into an annual cash flow. They were presented in data form using Microsoft Excel and graphically in the form of an annual bar chart and cumulative histogram/S-curve.

These cashflow forecasts will be validated against the tender responses. As at the time of writing, the respective design teams and contracting parties were finalising the preferred design envelope to be used as the basis for the FID cash flow. The Snowy 2.0 Business Case for FID has assumed a conservative total outturn dollar cost profile, in order to calculate the commercial parameters for the Project. (see *Core Chapter Two* and the five Commercial Supporting Chapters (Five through Nine)).

3.6 Assessment of escalation

The Estimate was priced based on a base date of Q4 2018.

The independent expert's in-house construction economics advisory team developed escalation indices by assessing market conditions and making informed escalation provisions. The indices were assessed in the context of macroeconomic forecasts using several publicised indices, forecast interest rates, and the overall level of construction activity at a national, state, and local level. Using this information, a variable annual escalation percentage was determined for each year of the programme. Escalation indices were assessed at a commodity level and were then applied to the cash flow model on the same basis to assess the *Estimate* on a nominal basis.

In addition, for each commodity, a best-case, most likely and worst-case set of indices was determined. The resulting impact from the variability escalation indices was incorporated in the QRA process.

Allowances for escalation in the tender responses will be compared to the Project escalation model.

3.7 Contingency Calculations using QRA

The independent expert's methodology for calculating risk and contingency allowances is aligned to *AS/NZS ISO 31000:2009 Risk Management*.

The accuracy of the estimate prepared for any given stage of a project will be commensurate with the level of design information available and quality of pricing inputs. The independent expert has model estimating tolerance levels to account for discrepancies in design information, market conditions, supply chain performance and unknowns at the time of the estimate. The independent expert's approach considers both Inherent Risk and Contingent Risk.

Inherent Risk input was assessed at cost driver level to cover the uncertainty associated with the quantum and pricing (planned events). The assessment was made on the basis of an upper and lower confidence limit against the estimated cost of the activity after considering the level of uncertainty in the design and pricing information.

Contingent Risk input was determined by identifying and documenting the potential Project risks that are not currently covered in the estimate (unplanned events). The risks were identified in a workshop environment and the probability of the risk occurring assessed together with the cost impact on the project should the risk occur.

The output from the QRA together with the detailed capital cost estimates were modelled using Monte Carlo scenarios. This generated a project range against which a P50 and P90 Project Estimate could be determined (ie the level at which there is a 50% and 90% certainty of the Project Estimate not being exceeded). This output informed the process of assessing the Project Contingency.

A project-level QRA will also be completed post FID based on the preferred design option and scenario for the FID Estimate.

4 Estimating and scheduling basis

4.1 Overview

The basis of the Estimate and Schedule, including battery limits, basis of design (taking tender submissions into account), treatment of approvals, long lead items, access roads, exploratory works versus main works, key project elements (intake structures, cavers etc.), commissioning, resource pricing, allowances and provisional sums, indirects, overheads and profit are discussed in this chapter.

The key assumptions and exclusions are summarised in the next section of this chapter. This section discusses the basis of the Estimate and Schedule in further detail. Note that the Estimate is based on the construction methodology described below.

4.2 Basis of Estimate and Schedule

The Estimate has been based on a tenderer determined by the procurement evaluation process.

Major procurement packages that have been used in the Estimate and Schedule are:

1. EWR;
2. Civil Works - Exploratory Works; and Main Works; and
3. E&M Works.

Key third-party contracts provided by Snowy Hydro in relation to transmission (see *Chapter Sixteen - Transmission*) include:

1. Double-circuit Steel Tower (***DCST***) 330 kV lines;
2. 330 kV yard (Elliot Way); and
3. 500 kV yard (Elliot Way).

As part of the owner's team, a number of contracts and other costs have also been included in the Estimate and Schedule:

1. Geotechnical Investigation Programme (***GIP***) Phase Two;
2. Owner's Engineer (SMEC);
3. Specialist and independent advisors;
4. Accommodation for EWR contract; and
5. General project costs and expenses.

4.3 Owner's Team

A manpower schedule has been developed for the Owner's Team and current market rates have been applied to determine the Estimate.

4.4 Design development

Areas where the design may change include:

1. Unforeseen Planning Approval Requirements (***UPAR***) (see *Supporting Chapter Three - Contracts and legal*);
2. EWR;
3. Civil interface to accommodate E&M design;
4. Unplanned transmission requirement using asynchronous machines; and
5. GBR.

4.5 Interfaces

Tender documents contain a number of interface dates. Snowy Hydro milestones include:

1. Early 2020 (all contracts and separable portions);
2. Site access; and
3. EIS approvals.

Contract interface milestones are defined between:

1. EWR and Exploratory Works;
2. Civil works and E&M Works;
3. E&M Works and transmission connections; and
4. E&M works and Snowy Hydro operational assets.

These interface milestones have been incorporated into the Master Schedule.

5 Escalation and contingency

5.1 Overview

Escalation and contingency are based on the treatment of design growth, forecast real cash flow, development of escalation indices and escalation model. This section describes the QRA approach to contingency.

5.2 Real cash flow (excluding contingency)

The real cash flow has been provided at level 3 in the Estimate based on schedule start and finish dates. See *Chapter Fourteen* for cash flow reporting.

5.3 Escalation indices

5.3.1 Overview

This section describes how escalation indices were developed and then used to determine an annual escalation percentage.

The independent expert's in-house construction economics advisory team developed escalation indices by assessing market conditions and making informed escalation provisions. The indices were assessed in the context of macroeconomic forecasts using several publicised indices, forecast of interest rates together with the overall level of construction activity at a national, state and local level. Using this information, a variable annual escalation percentage was determined for each year of the programme. Escalation indices were assessed at commodity level and were then applied to the cash flow model on the same basis to assess the estimate on a nominal basis.

The independent expert provided cost escalation indices intended to capture cost movements for major cost items in the estimate. The indices provided, show likely annual cost increases across three scenarios:

1. **Most likely**;
2. **Optimistic** – costs do not rise as much as expected. This is most likely a result of slower economic activity in the wide economy, creating excess capacity in the construction supply chain; and
3. **Pessimistic** – costs increase more than expected as a result of higher levels of economic activity in the wider economy creating a shortage of spare capacity in the construction supply chain.

The indices take into account the different cost drivers and risk factors. The indices and some of the risk factors and cost drivers are as follows:

1. **Salaries – union** - This index assumes an Enterprise Bargaining Agreement (***EBA***) which includes annual wage increases per annum, in line with recent historical experience in the construction sector;
2. **Salaries – government** - This index assumes that the government sectors pay increases align with its intended target rate of inflation which is between 2 and 3% per annum;
3. **Salaries - consultants** - This index assumes that the construction consultancy sector continues to find the market relatively competitive and is unable to increase recoverable costs faster than the general rate of inflation in the economy;
4. **Buildings - architectural** - This index is intended for estimating cost escalation for building structures, using general building contractors, and construction trades. Currently, there is strong cost escalation in this sector caused by a shortage of skilled trades and high levels of activity in the Canberra and Sydney construction sectors;
5. **Civils** - This index is based on the cost of civil construction of roads, rail and bridges, including labour materials, plant and equipment. Higher cost escalation is anticipated later in the decade as major road and rail infrastructure projects in Sydney are underway;
6. **Electrical and communications** - This index is intended to cover the cost of procurement and installation of electrical, communications, instrumentation and IT systems;
7. **Construction plant and equipment** - This index is intended to cover the cost of Tunnel-boring Machines (***TBM***) procured from Europe, however, it

is noted that the TBMs could be procured from other locations. The source of TBM is still to be determined and procurement has not been initiated;

8. **Bulk power** - Power costs have been rising strongly in all states in recent times;
9. **Bulk construction materials** - This index is intended to cover the cost of imported steel, batched concrete and manufactured concrete panels. Recently global steel prices have been increasing strongly in response to higher Chinese demand, but steel is expected to settle at current levels drifting upwards rather than surging. Concrete prices have been increasing as concrete suppliers have been increasing prices in response to strong demand in the booming East Coast construction markets. Higher concrete prices look set to persist as strong levels of construction activity continue in Sydney and Melbourne; and
10. **Major E&M equipment** - This index is intended to cover imported equipment such as generators, transformers, turbines and other major electrical equipment, mostly purchased from Europe and Japan. The major risk factor with this index is the volatility of global copper prices. Copper prices are subject to strong demand from China where economic growth continues to surprise on the upside, driving copper prices high. The independent expert has aligned its escalation indices to the main commodities driving the estimate.

5.4 Contingency

5.4.1 Overview

QRA was used to combine the effects of identified uncertainties (accuracies on the Estimate) and discrete risk events on the Project objectives. This analysis took into account the correlation between discrete risk events from identified Project risks, high-level schedule uncertainties and cost uncertainties, indicating the degree of overall risk faced by the Project.

The findings here are based on a quantitative risk study. The approach and methodology adopted and sources of information used are outlined in this section.

5.4.2 Inputs

Inputs used in this analysis were captured in a workshop held in late 2018. The independent expert and all involved in the QRA process shared a commitment to collecting high-quality and unbiased data. Key personnel of the Project management and technical teams participated in the workshop to assess the uncertainty and risks. In undertaking this assignment, the independent expert relied on the expertise of the Project team to identify and assess relevant uncertainties and risks.

5.4.3 Discrete risks (Contingent Risks)

From all identified risks for the Project, those l risks that potentially have a cost impact on the Project were selected and . ncluded in the QRA Model developed.

Based on the likelihood and consequence of each risk,the teams have then quantified the change in percentage and its cost impact based on the information available at the time.

5.4.4 Sensitivity Analysis - GBR

The GBR contains the expected geological conditions and the pricing schedule details the basis for adjustment of the contract sum.

A sensitivity model has been established based on available geotechnical information to understand any potential changes in geological conditions and potential cost and time impacts. See *Chapter Three - Contracts and legal* for a discussion of the difference between GBR-A, GBR-B and GBR-C.

5.4.5 Cost Risk Model

The Cost Risk Model was developed based on the possible variation of quantities and rates.

6 Schedule

6.1 Overview

Describes the key Schedule milestones and the critical path.

6.2 Key milestones

Table 3 contains the key milestones included in the Schedule. For Pre-FID milestones relevant to the tender process, see *Chapter Two*.

Key Project Milestones
Award Civil EPC Contract
Award E&M EPC Contract
Commence On-Site - Civil Contractor
Civil Design Complete
E&M Design Complete
1st TBM On-Site
Access Roads Complete
Main Camp Fully Established
Temporary Power Available

Tantangara Intake Complete
Talbingo Intake Complete
Headrace Tunnel Complete
Tailrace Tunnel Complete
Commence Power Station Cavern
Complete Power Station Cavern
Commence Power Station Structure
Complete Power Station Structure
Commence Power Station E & M
Complete Power Station E & M
Power Waterway Ready for Water
Commence Power Station Commissioning
Commence Wet Commissioning
Generators 5 & 6 Available for Commercial Operation
Generators 4 & 3 Available for Commercial Operation
Generators 2 & 1 Available for Commercial Operation
Project Completion
Environmental Deliverables
Project Environmental Approval
TransGrid - Connection Process Agreement (CPA)
Design Deliverables
Civil Design Development-30% Design
E & M Design Development-30% Performance Spec

Table 3: Key Project milestones

6.3 Critical path

The base case Schedule shows the critical path running through:

1. Award Civil EPC Contract;
2. EWR;
3. Exploratory Tunnel;
4. Power station construction adit;
5. Machine hall cavern;
6. Machine hall structure;
7. Machine bay six and Service bay;
8. Machine bay four;
9. Mechanical;

10. Generator unit six;
11. Generator unit five;
12. Generator unit four;
13. Generator unit three;
14. Generator unit two;
15. Generator unit one;
16. System and loop tests;
17. Transformer testing unit one;
18. Equipment testing;
19. Turbine and generator dry test;
20. Turbine and generator dry test unit one;
21. Commissioning;
22. Turbine and generator wet test - no-load unit one;
23. Performance tests;
24. Turbine and generator wet test - under load unit one;
25. Generators 2 and 1 available for commercial operation;
26. Commissioning complete.

A separate schedule risk analysis workshop is planned to be carried out once the accepted schedules from the three contracts are aligned and consolidated into one Master Project Schedule, and separate management reserve will be allowed if deemed appropriate by Snowy Hydro. This will take place Post-FID.

This critical path will be compared to the tender responses to challenge proposed construction methodology and productivities; where the interfaces between contracts are on the critical path these will be highlighted to Snowy Hydro for management action during construction.

7 Due diligence

7.1 Overview

The consolidated Project Estimate will be assessed to understand any areas that are significantly different to expectation and warrant further investigation.

Input was sought from Civil and E&M Contractors involved in the ECC process.

Qualified bids including selected rates and prices were solicited from the Civil tenderers involved in the ECC. These rates and prices were used as a check when building up the estimate.

7.2 Reconciliation to Study estimates

The consolidated Project Estimate will be compared to the J5 Estimate to understand any areas that are significantly different to expectation and warrant further investigation.

7.3 Early Contractor Consultation

Snowy Hydro decided to involve potential contractors at an early stage of the Study as part of its ECC initiative (see Supporting Chapter Two). The purpose of this initiative was to draw on the construction experience and capabilities of contracting and manufacturing firms which could then flow into the feasibility design and later into the definition of the Employer's Requirements (see Supporting Chapter Twelve). Snowy Hydro provided technical information to prequalified Civil and E&M contractors as the feasibility design was being developed by SMEC and gave the contractors the opportunity to suggest modifications or alternatives which may lead to improved reliability or operability, cost savings or a reduction in the overall construction program.

Key involvement from ECC contractors included:

1. Site visit to further understand scope and associated constructability and logistics challenges;
2. Provision of quotations for key cost drivers on the Project;
3. Provision of advice on constructability;
4. Provision of advice on productivity; and
5. Provision of advice on value improvement opportunities.

7.4 Shortlisting

Snowy Hydro decided to involve potential contractors at an early stage of the Study as part of its ECC and subsequently requested offers from the shortlisted civil tenderers, in order to eliminate one tenderer before the final stage of tendering.

8 Definitions and abbreviations

CBS	Cost Breakdown Structure
EBA	Enterprise Bargaining Agreement
ECC	Early Contractor Consultation
EPC	Engineering, Procurement and Construction
EVM	Earned Value Management
EWR	Exploratory Works - Roads
FID	Final Investment Decision
GBR	Geotechnical Baseline Report
GIP	Geotechnical Investigation Programme
GST	Goods and Services Tax
QRA	Quantitative Risk Analysis
TBM	Tunnel-boring Machines
UPAR	Unforeseen Planning Approval Requirements
WBS	Work Breakdown Structure

9 Bibliography

There is no bibliography for this chapter.