meridian

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EVALUATION OF MERIDIAN ENERGY'S ASSET MANAGEMENT PROCESS

ENMG608: REPORT

MASTER OF ENGINEERING IN MANAGEMENT

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Abstract

Title

Evaluation of Meridian Energy's Asset Management Process.

Abstract

Meridian Energy Ltd (Meridian) is a leading generator of renewable energy and retailer of electricity to customers in New Zealand and Australia. Meridian's Asset Management (AM) is essential to realise value from its assets. This project report evaluates the planning accuracy of timing, duration and costs of non-annualised major projects within Meridian's hydro AM. It aims to give recommendations for actions in the areas of improvement. Meridian's AM is divided into the AM planning process and the project delivery. Specifically, in the Asset Management Plan (AMP), the CAPEX and time estimates for major projects are widely underestimated. There are various technical, psychological and political-economic root causes that create these inaccuracies. In the initial AM planning, for the project delivery and the feedback loop, mitigation techniques to tackle the underlying factors of inaccurate planning data in the AMP were found. The key benefits of improving AMP estimates are to encourage the present continuous improvement culture as a whole and to maintain the good relationships with the executive team.

Key Words

Power Industry – Electricity Industry – Hydro – Hydro Station – Asset – Asset Management – ISO 51001 – Risk Management – Asset Management Plan – Project Management – Process Improvement – Forecasting – Cost – Time – Feedback Loop

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Executive Summary

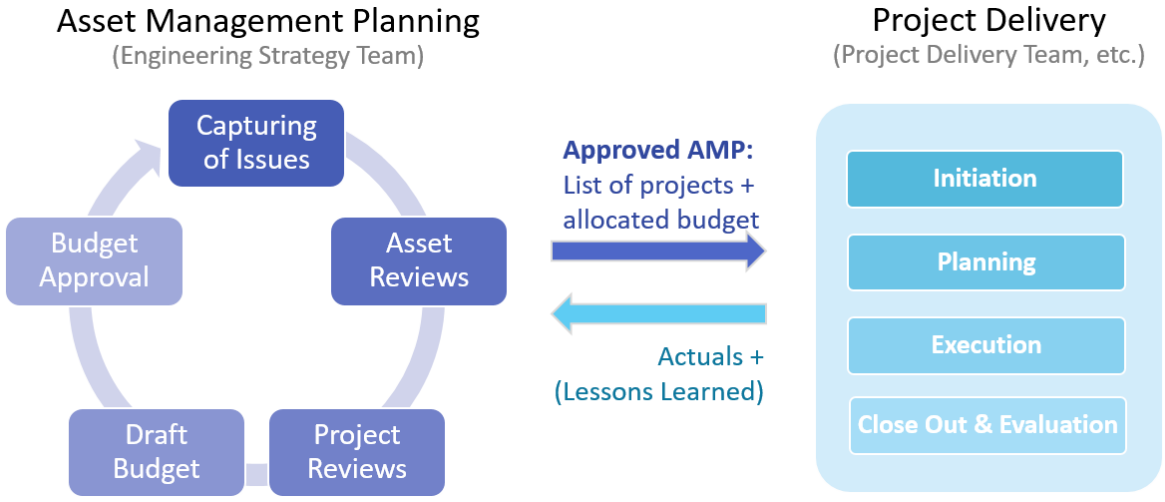
Project Background

Project Title	Evaluation of Meridian's Asset Management Planning Process
Project Summary	This project determines factors that streamline Meridian's asset investment planning success and will offer solutions for the indicated root causes for time and cost differences between certain process stages. It will deliver: • Root causes for time and cost inaccuracies at different stages in Meridian's Asset Management (AM) process, and • Areas of improvement for the process to mitigate the underlying issues. This will ensure the ability to manage expectations of Meridian's CFO and CEO to deliver as planned, while maintaining the flexibility within the AM group with regard to how it structures its capital programme for optimised decision making. The Six Sigma methodology 'DMAIC'[1] was used as a project structure.

Meridian's Asset Management Process

Meridian's AM process is aligned in accordance with ISO51001. As visualised below, it is divided into the AM planning and the project delivery:

- The Asset Management Plan (AMP) provides a broad 20-year view on how to maintain the hydro assets' value and a more detailed plan of prioritised projects for the next three years. It follows a risk-based approach. The Engineering Strategy Team (EST) is responsible for this.
- The Project Delivery Team (PDT) is mostly responsible for the project delivery of major projects (>$250k), however, depending on the complexity some projects are also led by engineers from the EST or Tactical Engineering Team (TET). The approved AMP is the input for the project delivery, where a business case is then developed for the initiation of a major project.



Magnitude of Estimate Inaccuracies

Timing Inaccuracies	Duration Inaccuracies	Cost Inaccuracies
• Projects are included in the AMP late: 67% identified in the AMP before start date and 29% two years beforehand. • Start dates get deferred year by year.	• End dates often get deferred; thus, the duration is underestimated. • Delays are key issues in delivering the plan.	• Overall AMP is mostly underspent in one FY. • Major projects' CAPEX clearly underestimated. • Major projects' OPEX mostly overestimated.

[1] Define-Measure-Analyse-Improve-Control

General insights of the data analysis on inaccuracies:

- Many projects from the AMPs are consolidated or superseded by new projects.
- There is a big disconnection between the AMP tools and project delivery tools.

Root Causes for Estimate Inaccuracies

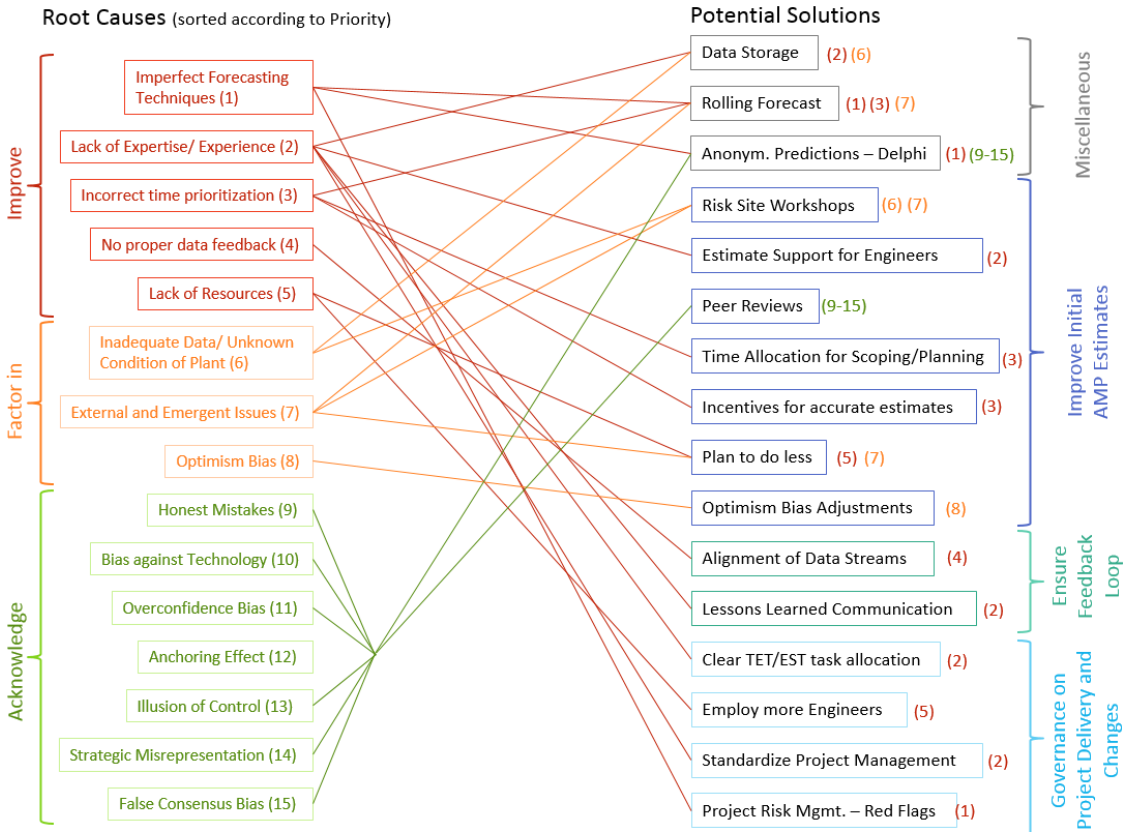
The literature review on root causes for project underestimation showed that there are three explanations:

- technical,
- psychological (decreases with organisational pressure), and
- political-economic (increases with organisational pressure).

For the identification of root causes for inaccuracies at Meridian, AM planning meetings were observed, seven case studies of major projects were conducted, and several internal employees were interviewed. It was found that most issues are with the forecasting of the initial AMP estimates. There are many external factors that can influence the project delivery which cannot be controlled by Meridian.

Potential Solutions to mitigate Root Causes

The root causes were prioritised due to their level of impact and the influence Meridian has on them. The corresponding potential solutions for the identified root causes are shown in the following:



Recommendations

- Before implementing all solutions at the same time, it has to be made sure that they are easy to be measured and reviewed separately.
- Change Management is critical for the implementation of certain solutions, e.g. rolling forecast. Strong leadership is required here.
- The collaborative and open-minded office culture shall be embraced and maintained.
- Keep getting external people on board to receive an outside view on internal operations.

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Glossary

Abbreviation	Explanation
AM	Asset Management
AMP	Asset Management Plan
AMS	Asset Management System
AVI	Aviemore Power Station
BC	Business Case
BEN	Benmore Power Station
BP	Business Plan
CAPEX	Capital Expense
COM	1. Common (in AMP project ID – when more than one station is involved) 2. Commercial Team
EST	Engineering Strategy Team
FTE	Full-Time Equivalent
FY	Financial Year
GIT	Gas Insulated Transformer
HAM	Hydro Asset Maintenance
HM	Her Majesty
IIMM	International Infrastructure Management Manual
LL	Lesson Learned
MAN	Manapōuri Power Station
MEL	Meridian
NA	Non-Applicable
OHA	Ōhau A Power Station
OHB	Ōhau B Power Station
OHC	Ōhau C Power Station
OPEX	Operating Expense
P-E	Political-Economic
PDT	Project Delivery Team
PLC	Programmable Logic Controller
PM	Project Management
Ps	Psychological
SAM	Strategic Asset Management
T	Technical
TET	Tactical Engineering Team
TLC	Te Anau Lake Control
VE	Value Engineering
VSD	Variable Speed Drive
WBS	Work Breakdown Structure
WTK	Waitaki Power Station

1. Introduction

This chapter is part of the Define section of the DMAIC[2] methodology. The introduction gives an overview on both the company and project. The specific aim of the project is introduced to identify the importance of this work. Furthermore, the project's outline and strategy to achieve the desired purpose is presented.

1.1. Meridian Energy

Meridian generates 100% renewable energy, trades and retails electricity in New Zealand and Australia. The Meridian Energy Group has a revenue of about NZ$2.8 billion (FY2018) and is the fourth-largest company on the New Zealand Stock Exchange (NZX). Meridian provides 29% of New Zealand's electricity generation; about 13,000 GWh in FY2018 of which more than 85% is generated by their hydro stations. Electricity cannot be stored efficiently, energy can be lost during transmission and blackouts must be avoided – therefore the balance between consumption and generation must be maintained. A physical constraint with generating electricity is that generation plants are expensive and require many years to build. Meridian's Asset Management (AM) is essential to realise value from its assets (NZX Energy, 2011) (Meridian Energy, 2018a).

Meridian's purpose is a "*Clean Energy for a fairer and healthier world*" (Meridian Energy, 2018b). Refer to Appendix A.1 for Meridian's strategy.

1.2. Project Purpose

Within Meridian's hydro AM, there are some issues that continue to materialise. These issues are:

1. The hydro AM consistently fails to spend the allocated capital expenditure.
2. There are consistent delays to the project execution timeframe.
3. Continued failure to deliver the plan as set out at the start of the financial year erodes confidence and credibility. This will make securing funds increasingly difficult in the future.

Mitigation procedures have been put in place to limit the impact of the above, but the root causes still need to be identified and addressed. The major objective of this project is to provide a critical analysis of Meridian's AM planning and budgeting process, and from that determine the factors which will streamline its success. To ensure the project is executed as planned, solutions for these factors shall be found. Key goals are to:

- Be able to ensure delivery of the plan set out at the start of each FY to manage expectations of Meridian's CEO and CFO.
- Maintain the flexibility within the AM group regarding how it structures its capital programme for optimised decision making.

1.3. Project Scope

This project will determine factors to help streamline Meridian's hydro asset investment planning success. It will also offer solutions for the indicated root causes for time and cost differences between certain process stages. When potential solutions to mitigate the root causes are presented, required actions for implementation will be provided, however no allocated quantified costs are required. This project concentrates on major projects of the hydro AM process that are non-annualised and above $250k. Meridian's AM will be compared with other companies in the electricity industry.

The project's methodology and the included sections in the report are outlined in the following chapter.

[2] DMAIC – Define-Measure-Analyse-Improve-Control (see section 1.4)

1.4. Project Methodology and Structure

For this project, the Define-Measure-Analyse-Improve-Control (DMAIC) method was used as outlined below. It is a data driven improvement cycle that is used for optimising business processes, which is a core tool to drive Six Sigma projects (Go Lean Six Sigma, n.d.).

Define	Measure	Analyse	Improve	Control
Contents • Purpose • Scope • Background **Report Sections** 1. Introduction 2. Meridian's Asset Mgmt.	**Contents** • Magnitude of the problem • Current performance. **Report Sections** 3. Data Analysis of Inaccuracies	**Contents** • Root Causes • Focus of effort **Report Sections** 4. Root Cause Analysis of Inaccuracies	**Contents** • Review of potential solutions • Recommendation **Report Sections** 5. Recommended Solutions	**Contents** • Maintain the solution **Report Sections** -Not required-

FIGURE 1: DMAIC METHODOLOGY (GO LEAN SIX SIGMA, N.D.)

Each chapter starts with the followed approach and concludes with a section on key insights.

2. Meridian's Asset Management

This chapter is part of the Define Section of the DMAIC methodology. It gives the background on Meridian's AM and compares it to other companies. In this way, an overview on the business environment is given.

2.1. Approach

First, a literature review was conducted to get an overview on AM principles. To gain an understanding on Meridian's AM, internal documents regarding the AM strategy and processes were reviewed. In addition, AM planning workshops were attended and observed, and project managers were accompanied to review their practices and communications. Refer to Appendix A.1 for a map with Meridian's assets in New Zealand and an overview on Meridian's hydro stations.

2.2. AM Process

The following figure outlines the AM process, which aligns with the ISO55001 standard.

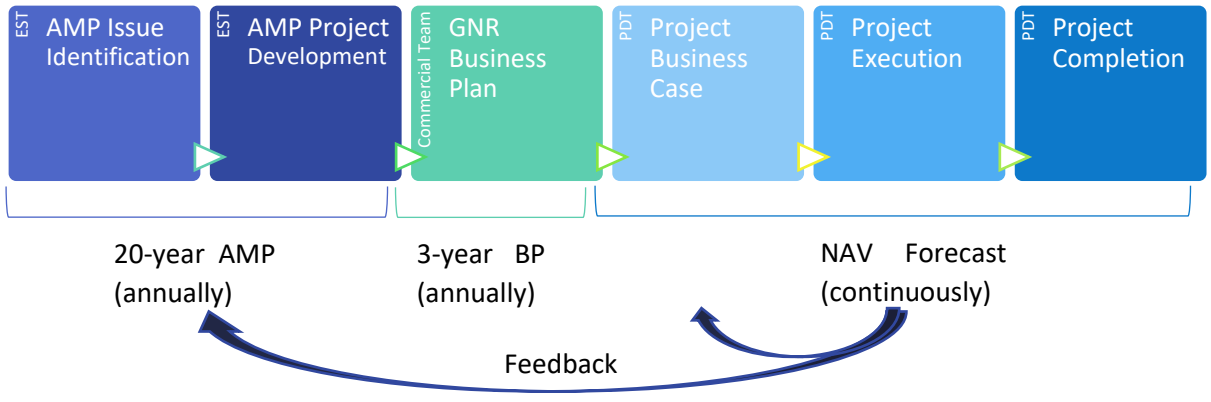


FIGURE 2: MERIDIAN'S HYDRO ASSET MANAGEMENT PROCESS

Refer to Appendix A.3 for Meridian's organisational structure and an explanation of the Strategic Asset Management (SAM), Hydro Asset Maintenance (HAM), and the Commercial (COM) team. Refer to Appendix B.1 for Meridian's Organisational Plan and Asset Strategy.

2.3. AM Planning

In the AM planning process visualised in Figure 3, the AMP is developed and from this the budget is generated. The EST is responsible for the overall process. The capture of issues, the pre-AMP workshop, AMP workshop and post-AMP workshops are facilitated within the AMP Database which is accessible via the 'Hub' by all Meridian Hydro AM staff. The business planning is facilitated with external tools, e.g. NAV (sole point of truth).

FIGURE 3: HYDRO ASSET MANAGEMENT PLANNING STEPS

Capturing of Issues[3]: When an issue was identified, it shall be immediately entered into the AMP database (if it does not exist in the AMP database yet). The risk score[4] is selected in the AMP risk matrix from 1 being the lowest risk to 25 being the highest risk. The risk is then assigned to a project and an expenditure profile is added.

Pre-AMP Workshop: The risks of the different hydro station issues get reviewed often where risk scores can be edited, and actions are assigned to investigate risks if applicable.

AMP Workshops: One-day workshops take place in the following order: Civil – 3 Portfolio (mech./elec. focus) – Engineering (review project scope, cost & timing).

Post-AMP Workshops: The projects get reviewed according to the assigned actions. Cost certainty is defined per project prior to the Delivery Workshop[5], in which allocation of resources get reviewed.

Business Planning: The budget gets reviewed by the executives and the board; if applicable they are edited before approval. The COM team creates projects in NAV and allocates budgets to departments.

[3] Note: Any issue that requires immediate attention or maintenance should be dealt with external to the AMP planning process. For immediate actions, the budget from the current year is used.

[4] Risk types are: Health & Safety risk, financial risk, and environmental risk.

[5] Introduced in FY2018 for AMP planning FY2019

2.4. AM Project Delivery

This section focuses on the delivery of major projects. The following figure shows the basic project management lifecycle.

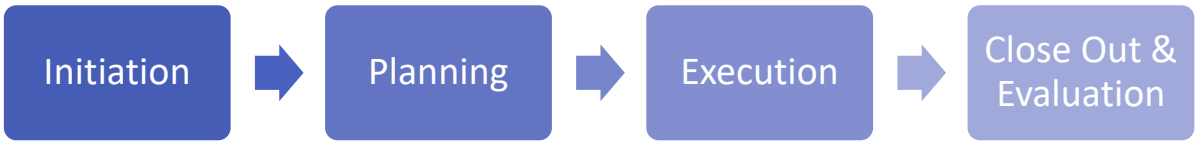


FIGURE 4: PROJECT MANAGEMENT LIFECYCLE

The lifecycle phases are fluid and may overlap, e.g. the planning stage is an on-going activity throughout the life of the project. The initiation of AM projects is mostly done by the EST in order to mitigate risks in the AMP process (see section 2.3). In this stage the project managers support the strategic engineers if applicable. Once the AMP is approved, the responsibility switches to the project manager. A business case is developed as a second step of initiation. Major projects usually have a formal project manager from the PDT team and an engineering lead from the EST team. Some major projects are also managed by the TET team with an integrated engineering lead. The delivery of a project is very dependent on the type of project, its complexity, if a tender is involved, etc. Refer to Appendix B.2 for the specific activities in the lifecycle stages, allocated to different topics.

2.5. Comparison to other Companies

The key similarities and differences of Meridian compared to Transpower, Genesis and Unison Networks is shown in the following table:

TABLE 1: OVERVIEW ON AM PROCESS COMPARISON BETWEEN MERIDIAN AND TRANSPOWER, GENESIS AND UNISON NETWORKS

	Transpower	Genesis	Unison Networks
Key Activities (In NZ Electricity Industry)	Electricity Transmission	Energy Generation, Retail, Trading	Electricity Distribution
Key Similarities to Meridian's AM	• ISO 55001 Standard • Annual AMP review • Various contractors • 3y detailed planning	• ISO 55001 Standard • Various contractors • No cost estimation tool is used • 3y detailed planning	• ISO 55001 Standard • 3y detailed planning
Key Differences to Meridian's AM	• 1 integrated tool for AM planning & delivery • 50y long-term view • Cost estimation tool is used (building block approach) • Projects are similar and easily comparable	• 1 integrated tool for AM planning & delivery • Up to 60y long-term view (very basic) • AMP based on Bow Tie Risk Analysis • Quarterly review of AMP	• AMP twice a year • 10y long-term view • 1 integrated tool for AM planning&delivery • Cost estimation tool is used (but always manually reviewed) • Delivery through one sole contractor (in Unison Group) • Projects' duration only 1-2 months

Refer to Appendix B.3 for a list of external interviewees.

2.6. Key Insights

TABLE 2: KEY INSIGHTS REGARDING MERIDIAN'S ASSET MANAGEMENT

Topic	Insights from Data Analysis
General	• The company culture is good (friendly and supportive) and enables a collaborative environment. • The processes are all aligned with AM principles (ISO 55001). • The EST and PDT are not sufficiently connected.
AM Planning	• The AM planning follows a clear allocated process. • In the beginning, only a "wild ass guess" is given when it comes to project costs and durations. Later, these numbers lead to an anchoring effect and newly set numbers are very close to the initial estimate. • There are frequent small process changes as people have the desire to improve their processes. The Delivery Workshop was only included to the AM planning process last year. • EST engineers are occupied with the project delivery and do not spend much time on strategic activities.
Project Delivery	• Project management principles are used but the project delivery guidelines are very flexible. • Good 'Lessons Learned' approach. However, there are too many entries in the database which makes the later review difficult to view.
Other companies	• **Transpower** is rigid and conservative in their processes, and due to the different context of their AMP work (repeating tasks), they are able to standardise their estimations to a huge extent. This will not be possible at Meridian due to the differences in the type of work implemented. • **Genesis** follows a very simple bow tie risk management approach, which gets more regularly reviewed. Condition based maintenance is also followed within both Genesis and Meridian, which leads to the fact that issues are recognised at a later stage. Also, resource constraints here are recognised as a problem in the industry in general. • **Unison Networks** outsourced the complete delivery of their projects to another company that lies within the same "mother" company. Projects are reviewed in a way that first identifies the consolidation projects before the completion of the AMP. Targets are in place for the accuracy of cost estimations. New customer-driven work is a big factor regarding delays.

3. Data Analysis of Inaccuracies

This chapter is part of the Measurement section of DMAIC. The Data Analysis identifies the timing, duration and cost inaccuracies, and seeks to identify the magnitude of the perceived problem.

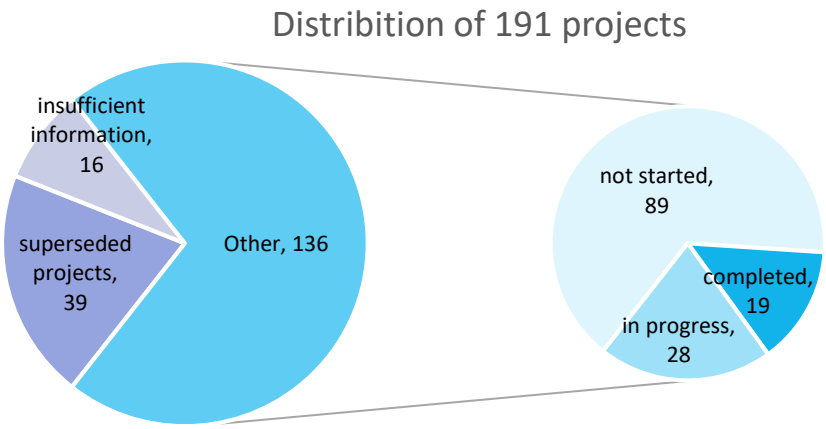
3.1. Approach

The following table shows the different data systems used in the AM process:

TABLE 3: DATAFLOW IN A FINANCIAL YEAR (JULY-JUNE)

	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
AMP Database						Hydro AMP				reconcile		
AMP Spreadsheet								GNR budget				
Cognos										MEL budget		
NAV												→

For the data analysis of inaccuracies, the AMP spreadsheets from AMP 2013 to AMP 2019 were filtered for non-annualised major projects (>$250k). Of these projects, NAV IDs were identified through lists from the COM team and from asking the project owners. Then the planned data was connected to the actuals. Figure 5 visualises the distribution of the 191 projects that were perceived as relevant for the data analysis from AMPs 2013 to 2019. Refer to Appendix C.1 for general information on the projects.



Insufficient information: no NAV ID was found, or the actual data did not seem right; wrong NAV ID?

Superseded projects: Projects were delivered under a different project or were consolidated.

Not started: Is planned for later and therefore has not started yet.

In progress: Project has started and is still ongoing.

Completed: Project was already delivered and is completed.

FIGURE 5: DISTRIBUTION OF 191 PROJECTS THAT WERE PERCEIVED AS RELEVANT

3.2. Timing Inaccuracies

The data analysis for the duration of a project was carried out with a sample of 47 undergoing projects shown in section **Error! Reference source not found.**. The graph in Figure 6 shows the planning timing difference to the actual start date when coming closer to the actual start date.

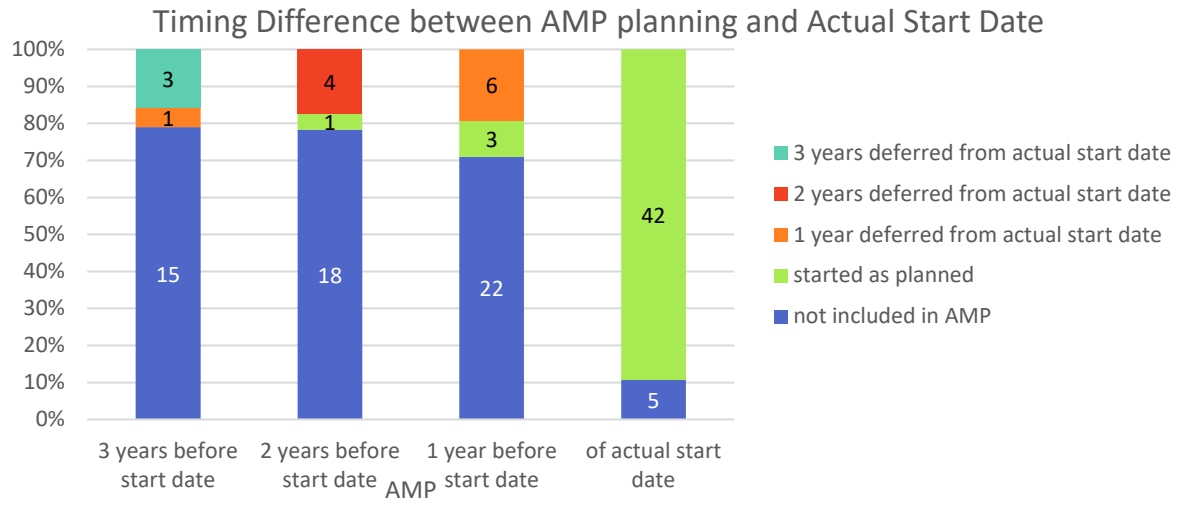


FIGURE 6: PROJECTED TIMING DIFFERENCE BETWEEN AMP AND ACTUAL

Only 71% of the 31 projects that were started between 2014 and 2018 were included within the AMP one year before. This suggests that there is a high uncertainty on which major planned projects are done in two years' time. A brief review of the 71% of projects not being included in the AMP one year before, shows that close to half of the projects (10/22) are managed by the PDT team. The others (12/22) by the TET team in Twizel.

The reasons for the sudden appearance of projects are (amongst others):

- Issue suddenly discovered due to condition monitoring,
- Issue was discovered in a study, and
- Issue was found during the execution of a different project.

The graph also shows that a lot of projects are deferred to the following year.

3.3. Duration Inaccuracies

The data analysis of the duration inaccuracies was carried out with the 19 completed projects. The following graph shows the difference between AMP planning duration estimate and the actual duration in years for each project when getting closer to the end date.

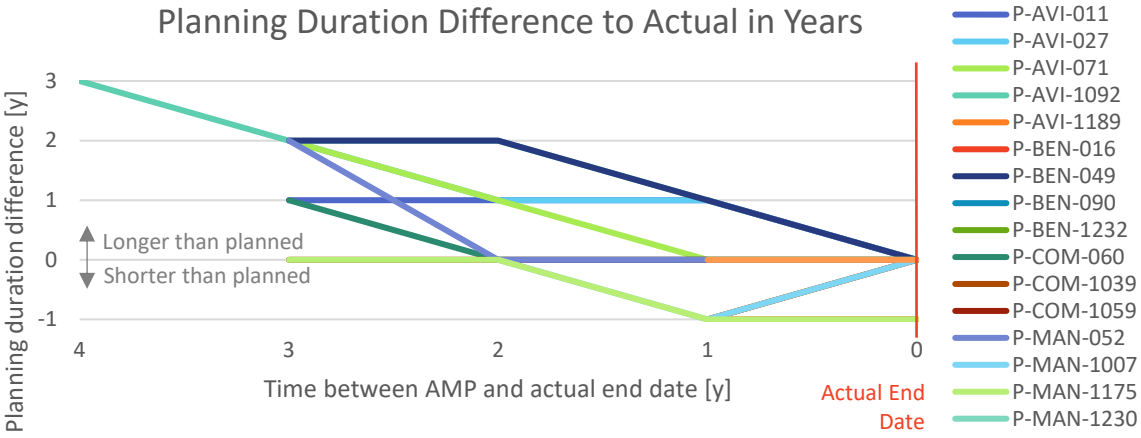


FIGURE 7: PLANNING DURATION DIFFERENCE TO ACTUAL IN YEARS WHEN GETTING CLOSER TO THE ACTUAL END DATE

It visualises that most project durations are underestimated as the projects take longer than planned (above the zero line in the chart); only two projects are overestimated. It also shows how projects were meant to be completed the next year but were delayed again and again.

3.4. Cost Inaccuracies

The data analysis of the cost inaccuracies was carried out with the 19 completed projects. The following two graphs show the planning inaccuracy between the AMPs expenditure and the actual expenditure when coming closer to the end date. The percentages relate to the deferral to the actual expenditure (planned cost ±X% = actual cost):

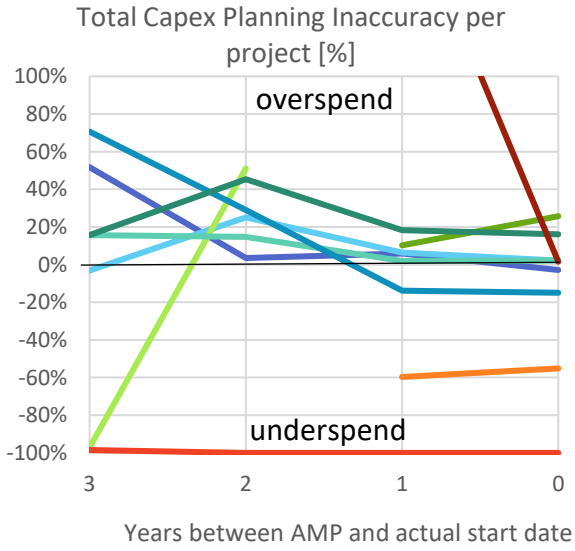


FIGURE 8: TOTAL CAPEX PLANNING INACCURACY PER COMPLETED PROJECT WHEN GETTING CLOSER TO THE ACTUAL END DATE

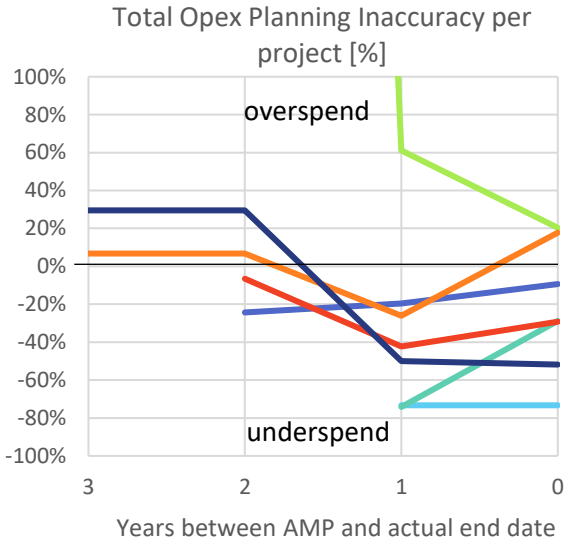


FIGURE 9: TOTAL OPEX PLANNING INACCURACY PER COMPLETED PROJECT WHEN GETTING CLOSER TO THE ACTUAL END DATE

There is a slight but unclear trend indicating the planning data of a project will become more accurate closer to the actual end date. However, especially in the AMP of the end date year, more than half of the projects OPEX are overestimated more than 20%. CAPEX is mostly underestimated and therefore overspent.

3.5. Key Insights

The key insights taken from the data analysis are listed in the following table:

TABLE 4: SUMMARY OF DATA ANALYSIS RESULTS[6]

Topic	Insights from Data Analysis
General	• There is a big disconnection between AMP and delivery tools. It is not simple to connect AMP planning data with the actual data due to the usage of different tools and project IDs. Therefore, it is hard to measure the accuracy and effectiveness of the AMP planning. In some cases, there was insufficient data on a project to be able to compare the planned data with actual numbers. • Quite a few projects from the AMPs are consolidated or superseded by new projects. • Major projects (>$250k) were often managed by the TET or EST team instead of the PDT team.
Timing	• Projects are identified/included in the AMP quite late; 67% of the analysed projects undergoing were identified in the previous AMP (e.g. AMP FY2015 for FY2015) and only 29% identified two years beforehand (e.g. in AMP FY2014 for start in FY2015) • The start dates for many projects get deferred year by year.
Duration	• More projects take longer than planned rather than being shorter than planned. • End dates often get deferred and thus the duration is underestimated.
Costs	• Trend for increasing AMP budgets and expenditures. • Overall actual AMP cost close to budget in FY2018. • 'Major projects' (in this case >$100k) in total AMP clearly underspent in FY2018. • Capex mostly underestimated in the AMP. • Opex mostly overestimated in the AMP. • Slight trend observed to become more accurate when getting closer to the projects' end date.

4. Root Cause Analysis of Inaccuracies

This chapter is part of the analysis section of the DMAIC methodology. The root cause analysis builds on the data analysis and provides the underlying issues of the identified inaccuracies.

4.1. Approach

A literature review of explanations for project underestimations was conducted (see Appendix D). For the subsequent root cause analysis of inaccuracies, a qualitative approach was used. Individual projects were chosen for case studies to review the root causes of their inaccuracies using the 5-Whys method. Furthermore, several additional interviews were conducted.

The following projects were used for the case studies due to their diverse reasons for inaccuracies:

- Aviemore PLC Upgrade (completed)
- Ōhau Chain Program
- Benmore Cooling Water Replacement
- Manapōuri T8 & T9 Replacement
- Aviemore Local Service Replacement
- Te Anau Lake Control
- Ōhau B Penstock Seismic Strengthening (cancelled)

Refer to Appendix E for the case studies. Refer to Appendix F for the list of interviewees and the list of relevant mentioned points. The root causes were noted in an Ishikawa diagram (fishbone) which divided it into technical, psychological and political-economic explanations relating to the literature review.

[6] Note: Due to the difficulty with sourcing data and the following approach to manually link AMP projects with NAV, projects and actual numbers lead to many possible sources of error. In addition, the data analysis only represents a small portion of the AMP, focusing on major complex projects. These insights cannot be transferred one to one in the overall AMP (except for the first two points under the topic costs in Table 4).

4.2. Overview on identified Root Causes

The following figure summarises the root causes for the inaccuracies of estimates in the project delivery of the case studies in an Ishikawa Diagram:

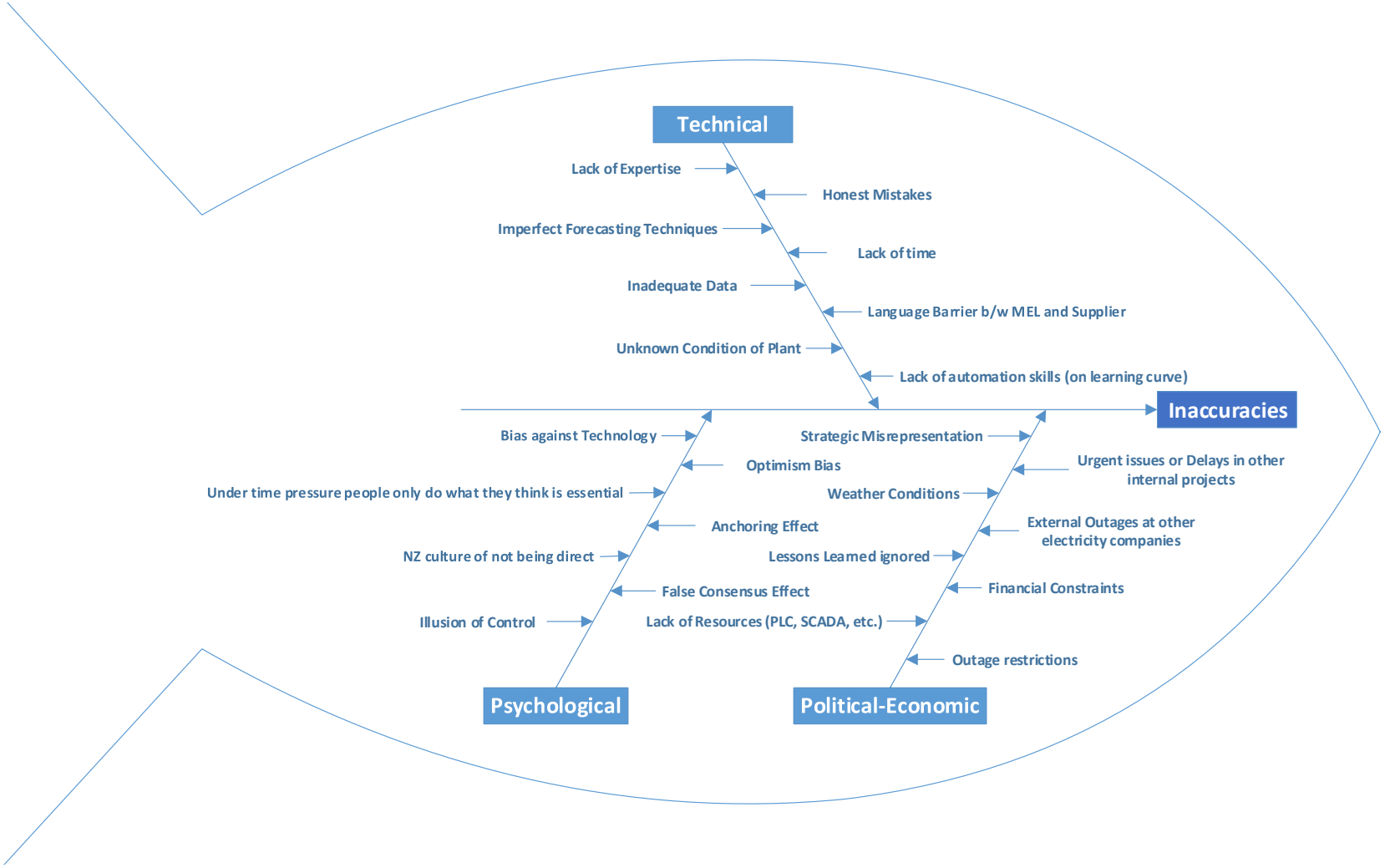


FIGURE 10: ISHIKAWA DIAGRAM OF ROOT CAUSES FOR INACCURACIES IN THE PROJECT DELIVERY OF CASE STUDIES

4.3. Key Insights

The impact of the root causes on the accuracy of the estimates and the influence of Meridian on these identified root causes vary. Especially during the project delivery, there are many external issues that are hard to influence. The following figure shows the impact of the root causes for estimate inaccuracies and the influence of Meridian on these root causes:

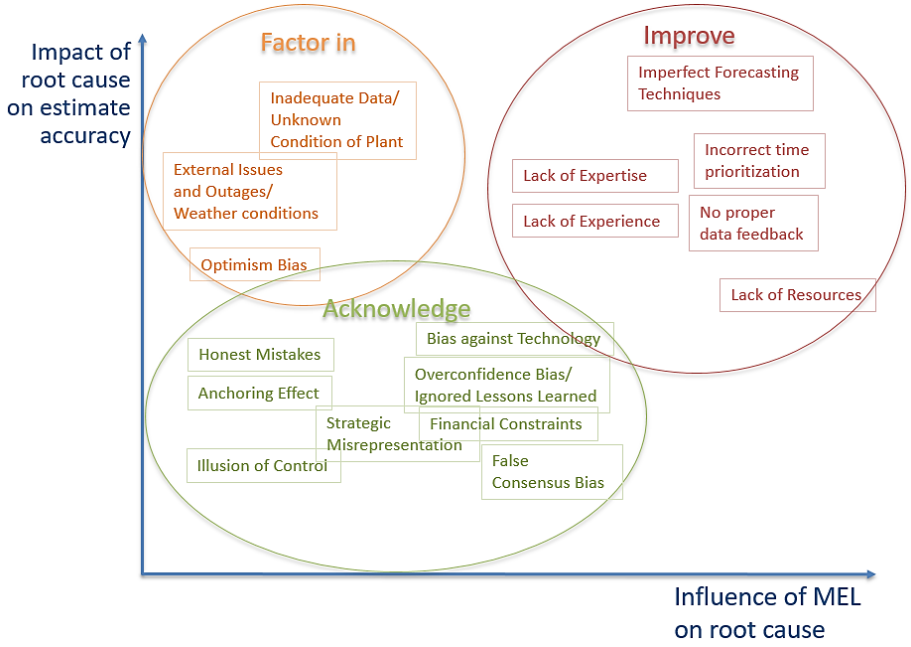


FIGURE 11: IMPACT OF ROOT CAUSES ON ACCURACY AND INFLUENCE OF MERIDIAN ON ROOT CAUSE

The factors that have a high impact on the estimate accuracy and which can be influenced well by Meridian should be improved. The factors that have a high impact but cannot be influenced should be factored in during the planning process. The factors that have a low impact and cannot be influenced well should be acknowledged, however no actions will be taken.

5. Recommended Solutions

This chapter is part of the Improve and Control section of the DMAIC methodology. Here, the recommended solutions for cost and time inaccuracies are outlined and actions that must be taken in order to improve, including the action holder, are proposed.

5.1. Approach

The following figure visualises Meridian's annual AM process steps from the initial AMP planning to the project's execution. The three starting points to mitigate the root causes for the inaccuracies between what is planned and what is delivered are added to the figure in red:

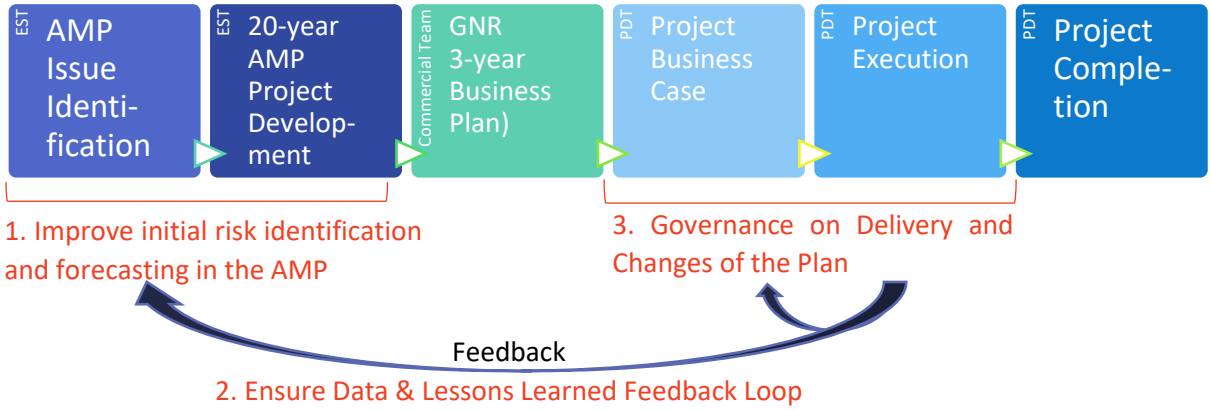


FIGURE 12: MERIDIAN'S ASSET MANAGEMENT PROCESS STEPS AND AREAS FOR IMPROVEMENT

For each solution, actions/requirements were identified with corresponding levels of initial effort and operational (oper.) effort. In addition, a risk score was added in terms of being able to deliver the action, e.g. how much change management is involved. Costs for the implementation of solutions was not required by the sponsor. Actions are assigned to different stakeholders. The following action holders are present:

- Richard Griffiths (RG) – Strategic Asset Manager
- Brent Wilson (BW) – Engineering Strategy Manager
- Nick Horswell (NH) – Project Delivery Manager
- Norman Geary (NG) – Tactical Engineering Manager
- Sarah Grimes (SG) – Finance Analyst for Hydro
- Site Managers

It is recommended to refer to Appendix G for the discussions of the individual solutions.

5.2. Improving Initial Data in the AMP

Please refer to Appendix G.1 for more information on the individual solutions to improve the initial data in the AMP.

5.2.1. Risk Identification Site Workshops

TABLE 5: ACTIONS FOR THE IMPLEMENTATION OF RISK IDENTIFICATION SITE WORKSHOPS

Action ID	Description	Benefits/ Tackled root causes	Initial Effort	Oper. Effort	Risk	WHO?
5.2.1.1	Risk Identification Site Workshops shall be implemented prior to the Pre-AMP Workshops to capture as many risks as possible.	Improved knowledge of risks. Mitigate emergent issues.	Low	Mode-rate	Low	BW
5.2.1.2	Actions shall be allocated early in the Risk Identification Workshops to investigate risks further.	Improved knowledge of risks. More clear defined scope. Mitigate emergent issues.	Low	Mode-rate	Low	BW

5.2.2. Support for estimating Costs

TABLE 6: ACTIONS FOR SUPPORT FOR ESTIMATING COSTS

Action ID	Description	Benefits/ Tackled root causes	Initial Effort	Oper. Effort	Risk	WHO?
5.2.2.1	Cost estimate checklists should be implemented to make sure cost estimates include key factors.	More objective and repeatable cost estimates.	Low	Mode-rate	Low	NH
5.2.2.1	Project managers should get involved in a project for next FY with the complexity level (retrieved from scope), cost and time.	Improve the estimate accuracy in AMP. Close gap between AMP and delivery.	Low	Mode-rate	Mode-rate	BW

5.2.3. Peer Reviews of Scoping and Estimates

TABLE 7: ACTIONS FOR IMPLEMENTING PEER REVIEWS OF SCOPING AND ESTIMATES

Action ID	Description	Benefits/ Tackled root causes	Initial Effort	Oper. Effort	Risk	WHO?
5.2.3.1	Compulsory peer reviews should be implemented to find honest mistakes and strategic misrepresentation.	Acknowledges honest mistakes and mitigates strategic misrepresentation.	Low	Mode-rate	Low	BW

5.2.4. Time Allocation for Scoping and Planning Activities

TABLE 8: ACTIONS FOR TIME ALLOCATION FOR SCOPING AND PLANNING ACTIVITIES

Action ID	Description	Benefits/ Tackled root causes	Initial Effort	Oper. Effort	Risk	WHO?
5.2.4.1	For projects that are two years ahead, allocate time and money for the FY before the start date.	Improves time prioritisation for planning before the AMP is finalised.	Low	Low	Low	BW
5.2.4.2	SAM, EST, and PTD managers should embrace that determining the scope and planning projects with a risk score of 10+ which are of a certain level of complexity, may be started before the AMP gets approved.		Low	Low	High	BW
5.2.4.3	Guesses or basic estimates which are done in a few hours are not allowed for major projects over a risk score of 10+ happening in the following FY.		Low	Mode-rate	Mode-rate	BW, NG, NH, Site Managers

5.2.5. Incentives for accurate Estimates

TABLE 9: ACTIONS FOR INCENTIVES FOR ACCURATE ESTIMATES

Action ID	Description	Benefits/ Tackled root causes	Initial Effort	Oper. Effort	Risk	WHO?
5.2.5.1	Rewards should be given out to estimators that have done accurate estimates, e.g. with an accuracy of +-10%.	Gives incentives to prioritise time for planning.	Low	High	Low	RG, BW, NH
See 5.3.1.1	The AMP's past estimate accuracy (broken down on a per-project basis) should be recorded and openly shown.		Mode-rate	Low	Mode-rate	SG

5.2.6. Plan to do Less

TABLE 10: ACTIONS FOR PLAN TO DO LESS

Action ID	Description	Benefits/ Tackled root causes	Initial Effort	Oper. Effort	Risk	WHO?
5.2.6.1	Plan to do less projects to allow for emergent issues.	Mitigates lack of resources. Factor in emergent issues Ensures that high risks are mitigated.	Mode-rate	Low	Mode-rate	BW
5.2.6.2	Managers must emphasise a project's delivery according to risk score.		Low	Low	Mode-rate	BW, NG,

5.2.7. Reference Class Forecasting

No recommendations regarding Reference Class Forecasting made.

Refer to the Reference Class Forecasting section of Appendix G.1 for more information.

5.2.8. Optimism Bias Adjustments

TABLE 11: ACTIONS FOR OPTIMISM BIAS ADJUSTMENTS

Action ID	Description	Benefits/ Tackled root causes	Initial Effort	Oper. Effort	Risk	WHO?
5.2.8.1	Optimism Bias adjustments should be made for the duration of projects, starting at the upper bound.	Factor in optimism bias of estimations. Factor in emergent issues.	Low	Low	Low	BW, NH
5.2.8.2	Optimism Bias adjustments should be made for the capex of projects, starting at the upper bound, if it is ensured there are enough resources/ time for the projects planned.		Low	Low	Mode-rate	NH

5.3. Enable the Feedback Loop

Please refer to Appendix G.2 for more information on ensuring the feedback loop – the key principle of cybernetics.

5.3.1. Alignment of Data Streams

TABLE 12: ACTIONS FOR ALIGNMENT OF DATA STREAMS

Action ID	Description	Benefits/ Tackled root causes	Initial Effort	Oper. Effort	Risk	WHO?
5.3.1.1	A VBA Code should be created to extract measurements for accuracies and deviations of project estimates.	Measurement of inaccuracies, which is a key requirement to improve accuracy. Increase transparency.	Mode-rate	Low	Low	SG, BW
5.3.1.2	Create code (e.g. SQL) to automatically update monthly estimates for projects in the AMP database with NAV estimates.	Save time. Increase of accuracy in the AMP.	High	Low	Mode-rate	SG

5.3.2. Lessons Learned Communication

TABLE 13: ACTIONS FOR LESSONS LEARNED COMMUNICATION

Action ID	Description	Benefits/ Tackled root causes	Initial Effort	Oper. Effort	Risk	WHO?
5.3.2.1	The LLs register should get reviewed for relevance and filtered through.	Better communication of LLs.	Mode-rate	Low	Low	NH
5.3.2.2	A priority score should be added to the LLs and the lessons learned register should be sorted in that way.	Easier finding of most relevant data.	Mode-rate	Low	Low	NH
5.3.2.3	Quarterly EST, TET and PDT "lessons learned" discussion (may be included in team meeting) on previous lessons learned. (Rule: each member must prepare at least one lessons learned). Most relevant ones will be documented in register.	Ensures LLs feedback loop of all teams. Oral discussions are easier to remember.	Low	Mode-rate	Low	BW, NG, NH

5.4. Governance for Project Delivery and Changes

Please refer to Appendix G.3 for more information on the governance for project delivery and project changes.

5.4.1. Clear Allocation of Team Tasks and Responsibilities (TET-EST)

TABLE 14: ACTIONS FOR CLEAR ALLOCATION OF TEAM TASKS AND RESPONSIBILITIES

Action ID	Description	Benefits/ Tackled root causes	Initial Effort	Oper. Effort	Risk	WHO?
5.4.1.1.	Redefine and clarify the tasks of the TET and EST team with a clear allocation of projects for one or the other.	Play to strengths.	Mode-rate	Low	Mode-rate.	NG, BW

5.4.2. Employ more Engineers

TABLE 15: ACTIONS FOR EMPLOYING MORE ENGINEERS

Action ID	Description	Benefits/ Tackled root causes	Initial Effort	Oper. Effort	Risk	WHO?
5.4.2.1	Employ another automation engineer (FTE is already approved).	Mitigate lack of resources. Mitigate bias against technology.	High	Mode-rate	Mode-rate.	BW

5.4.3. Standardise Project Management

TABLE 16: ACTIONS FOR STANDARDISE PROJECT MANAGEMENT

Action ID	Description	Benefits/ Tackled root causes	Initial Effort	Oper. Effort	Risk	WHO?
5.4.3.1	Mapping out the Meridian's basic PM process in the generation business.	Mitigate lack of expertise and experience.	High	Low	Low	NH
5.4.3.2	Investigate the potential usage of PM tools.		High	Low	Low	NH

5.4.4. Project Risk Management – Pay Attention to Red Flags

TABLE 17: ACTIONS FOR PROJECT RISK MANAGEMENT – PAY ATTENTION TO RED FLAGS

Action ID	Description	Benefits/ Tackled root causes	Initial Effort	Oper. Effort	Risk	WHO?
0.1	"Red Flags" for project underestimation should be reviewed when planning and delivering a project.	Acknowledge complexity. Factor in emergent issues.	Low	Low	Low	NH, BW
0.2	Risk management should be reviewed regularly. Managers should emphasise the importance of keeping risks up to date. – More formalised Risk Mgmt. sessions.		Low	Low	Low	NH, BW

5.5. Miscellaneous

Please refer to Appendix G.4 for more information on miscellaneous solutions.

5.5.1. Project Data Storage Improvements

TABLE 18: ACTIONS FOR DATA STORAGE IMPROVEMENTS

Action ID	Description	Benefits/ Tackled root causes	Initial Effort	Oper. Effort	Risk	WHO?
5.5.1.1.	Review of the availability, location and access of data.	Improved Risk Management; reasoning on facts rather on opinions. Mitigate scope creep.	High	Low	Low	BW

5.5.2. Rolling Forecast

TABLE 19: ACTIONS FOR ROLLING FORECAST IMPLEMENTATION

Action ID	Description	Benefits/ Tackled root causes	Initial Effort	Oper. Effort	Risk	WHO?
5.5.2.1	In NAV, forecasting after the end of the FY must be made accessible.	The rolling forecast improves time prioritisation (balances when to plan and deliver) and improves the forecasting technique.	Low	Low	Low	SG
5.5.2.2	PMs must forecast throughout the year.		Low	High	Low	NH
5.5.2.3	The COM team must manually re-enter estimates in NAV in July.		Low	Mode-rate	Low	SG
5.5.2.4	Culture change of not thinking in 1-year budgets – Start with manager's way of thinking.		High	High	High	RG, SG, NH

5.5.3. Anonymous Predictions – The Delphi Method

TABLE 20: ACTIONS FOR ANONYMOUS PREDICTIONS – THE DELPHI METHOD

Action ID	Description	Benefits/ Tackled root causes	Initial Effort	Oper. Effort	Risk	WHO?
5.5.3.1	Start using the Delphi Method for decision making - scoping.	Improve forecasting. Acknowledge false consensus bias.	Low	Mode-rate	Low	NH

5.6. Key Insights

The modified GIDA analysis on the right visualises the potential solutions according to their impact (as an opportunity or thread) and the amount of effort. Three key strengths of Meridian that were observed and are worth mentioning are added in light blue in the figure.

The solutions should be prioritised regarding the lowest effort and the highest opportunity or highest thread. However, the rolling forecast requires a higher effort but has a very high opportunity regarding the AM and the whole business which should be considered. In some cases, a higher effort is justified for long-term gains.

It is essential that the outcomes of the different changes can be monitored separately from the outcomes of other solutions. With the implementation of each recommendation, it is important that the output is monitored and reviewed. If Meridian wants to improve its planning accuracy in the AMP, it is essential that the accuracy can be clearly monitored and evaluated.

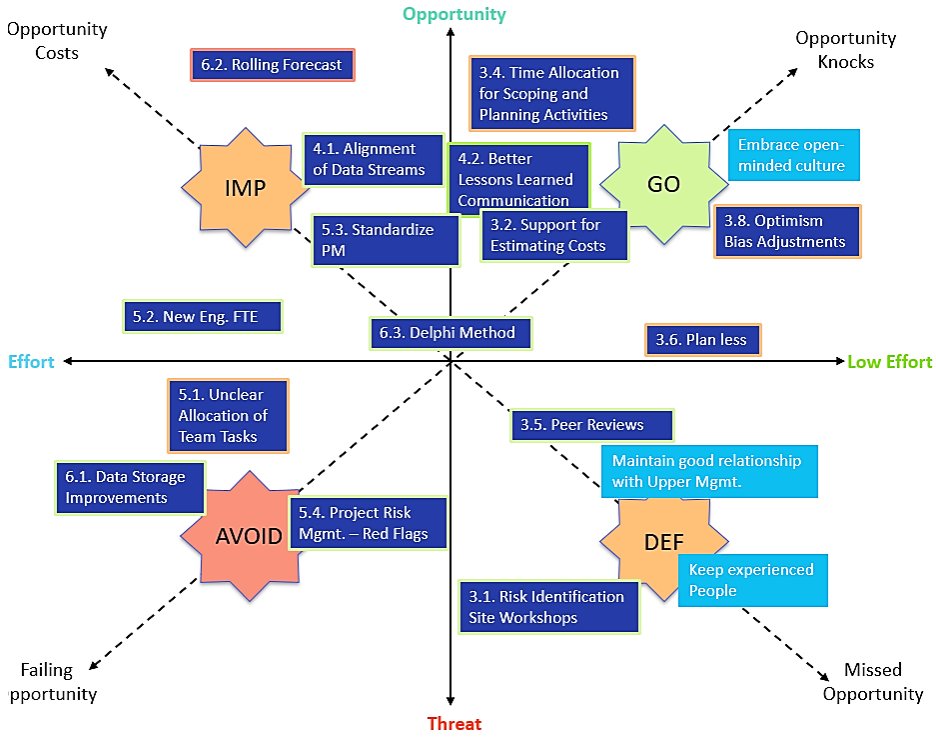


FIGURE 13: MODIFIED GIDA ANALYSIS FOR THE RECOMMENDED SOLUTIONS[7]

[7] Legend: Dark blue shape fill: Weakness, Light blue shape fill: Strength, Green shape outline: Low risk, Orange shape outline: Moderate risk, Red shape outline: High risk

6. Conclusions and Outlook

The aim of this project is to ensure the AM planning aligns with what is delivered in terms of expenditure, timing and duration to manage the CEO's and CFO's expectations.

In order to achieve that, this report:

- ✓ Provided a background and understanding on Meridian Energy and its hydro AM.
- ✓ Investigated the magnitude of timing, duration and cost inaccuracies of non-annualised major projects.
- ✓ Determined technical, psychological and political-economic factors that streamlined Meridian's hydro asset investment planning success. These factors were prioritised according to their impact on time inaccuracies, cost inaccuracies and Meridian's influence on the root cause.
- ✓ Offered solutions for the indicated root causes for time and cost differences at different process stages; the initial planning, the project delivery and the feedback, which is a key principle of cybernetics.

It was found that for the implementation of solutions, change management is a critical factor, especially for solutions that have a huge impact, e.g. the implementation of a rolling forecast or a better time allocation for scoping and planning activities. A different behaviour must be incentivised and embraced by managers as often as possible – strong leadership is required. It was observed that the employees in the SAM team are open-minded to change and improving processes. Frequent open discussions in the teams will embrace the culture and an open attitude which will help with the cultural change.

Internal employees tend to have some blind spots regarding internal processes as they are already used for certain operations. Especially as Meridian has a low turnover rate it does not naturally gain frequent external input. Additionally, Meridian employees feel that they do not have sufficient time to investigate improvement opportunities. In the last few years, SAM temporarily got external people in to review Meridian's processes as they were seeking further ideas for improvement, e.g. the project at hand. This is the best practice and should be maintained.

Regarding this project's objective, it is hard to measure the benefits of accuracies. If the finance team can better foresee at which time they need to seek for external funds, the finance team might be able to get funds in a better and cheaper way. Currently, getting external funding spontaneously is expensive for Meridian. This monetary benefit of accurate estimates per month only occurs if Meridian falls below the level of sufficient funds, which may occur when the following factors align in a month:

- Low generation levels at Meridian (dependent on weather conditions, outages, etc.)
- Low electricity prices (interconnected with the generation levels)
- High expenditure for AM

However, improving the cost and time estimates will create intangible benefits. This allows for the good culture with a thrive for improvement. It also aids in maintaining the trust of the executives towards doing the right thing as the work is at the highest level possible.

"THINGS THAT MATTER MOST SHOULD NEVER BE AT THE MERCY OF THINGS THAT MATTER LEAST" GOETHE

As mentioned previously, it is essential for Meridian to maintain the value of its assets. The most essential thing for the AM process is to manage the risk in an effective way. Due to the trust by the upper management into the SAM team, it is easy to get the funding which is required. A higher accuracy is relevant for proper finance management; however, the SAM team does not seem to have significant financial constraints. While the accuracy of estimates should be improved, it is important that the mitigation of risks stays of the highest priority.

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Appendix A. Background on Meridian Energy

Appendix A.1. Meridian's Strategy

The outcomes Meridian wants to achieve are the protection and growth of shareholder value. However, Meridian's purpose, the big 'Why', is "*Clean Energy for a fairer and healthier world*" (Meridian Energy, 2018b):

- Meridian has a relentless focus on customer experience,
- Meridian develops and operates 100% renewable generation, and
- Meridian creates sustainable, strong shareholder returns.

How the purpose can create shareholder value is shown in the following figure:

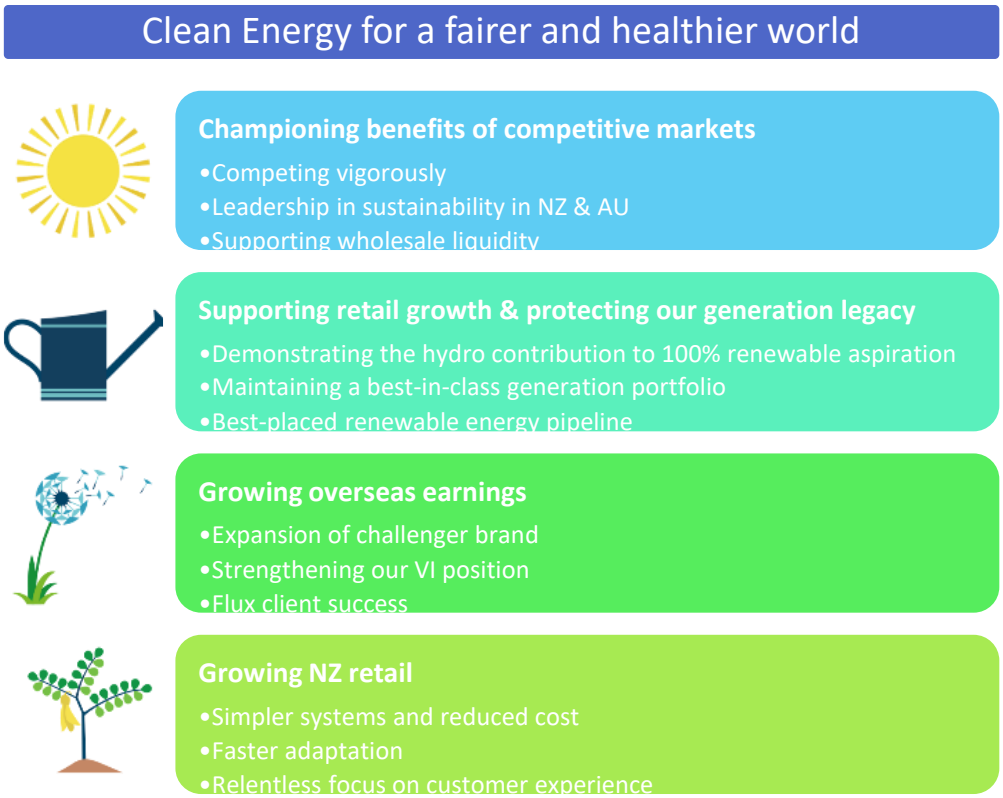

FIGURE 14: MERIDIAN'S STRATEGIC THEMES, EDITED FROM (MERIDIAN ENERGY, 2018B) AND (MERIDIAN ENERGY, 2018A)

In Meridian's eyes, people make the difference. The following table below outlines the behaviour of Meridian's employees and Meridian's values, which help Meridian tackle their key challenges:

TABLE 21: MERIDIAN'S VALUES AND 'HOW TO BE' (MERIDIAN ENERGY, 2018C)

OUR PURPOSE Clean energy for a fairer and healthier world		
WHAT WE VALUE Customers – Safety – Sustainability – People		
OUR BEHAVIOURS		
Be gutsy ✓ Dare to challenge the norm and do better ✓ Be courageous and make it happen ✓ We're honest and rigorous about performance	**Be a Good Human** ✓ We're inclusive and kind ✓ We have each other's backs ✓ We give our all and pursue success	**Be in the Waka** ✓ We share the load and get there as a team ✓ We collaborate for the greater good ✓ We're a community - In it together

Appendix A.2. Meridian's Assets

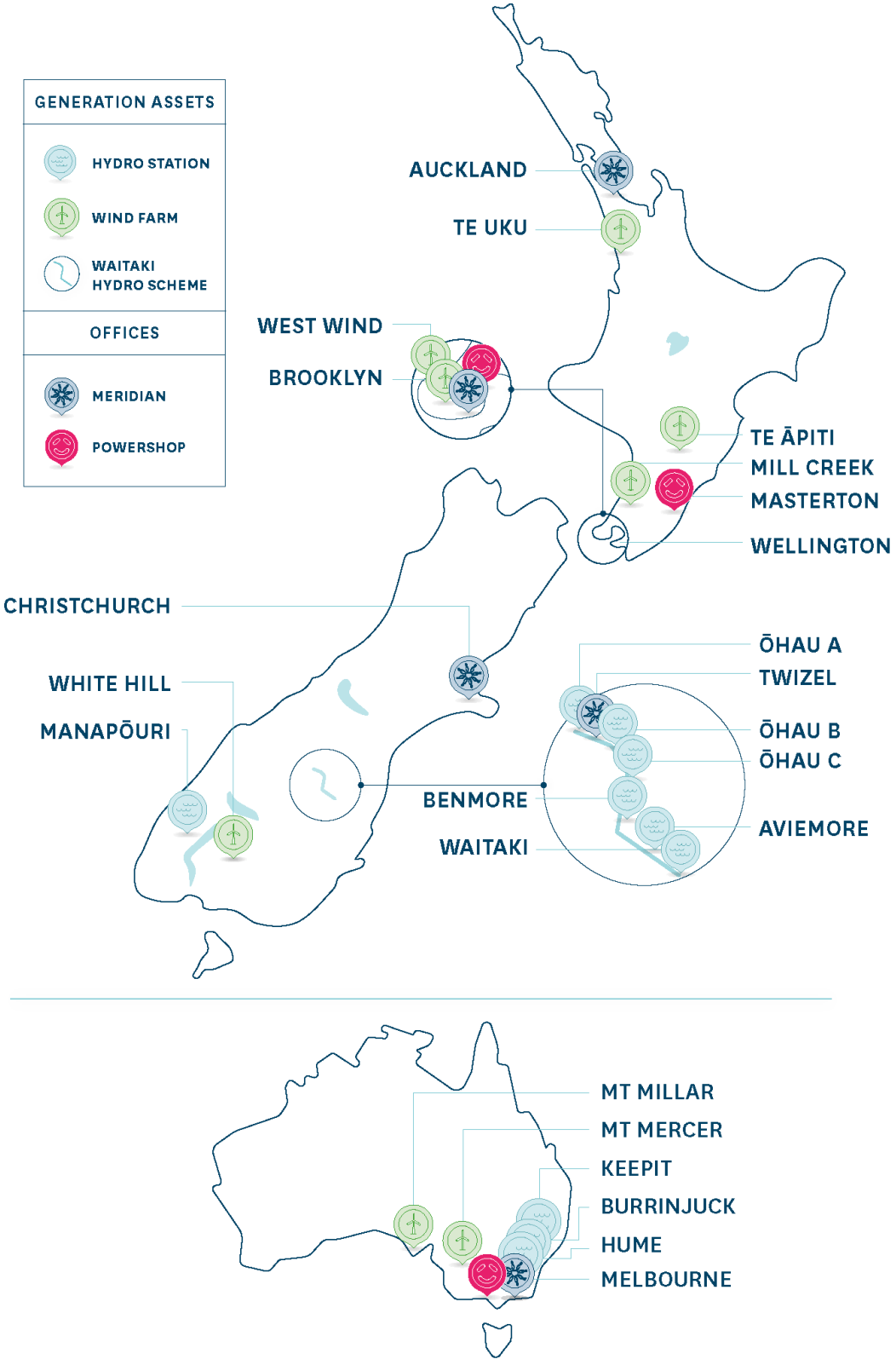

FIGURE 15: MAP OF MERIDIAN'S ASSETS (MERIDIAN ENERGY, 2018D)

Most of Meridian's electricity is generated by its hydro stations. This project focuses on hydro generation in New Zealand and therefore on the following hydro generating assets:

TABLE 22: MERIDIAN'S HYDRO STATIONS IN NEW ZEALAND, DERIVED FROM (MERIDIAN ENERGY, 2018E)

Hydro Station	Operational since	Units	Output/ Unit	Total Output
Waitaki Hydro Scheme (a series of interconnected lakes)				
Ōhau A (OHA)	1979	4	66 MW	264 MW
Ōhau B (OHB)	1984	4	55.5 MW	212 MW
Ōhau C (OHC)	1985	4	55.5 MW	212 MW
Benmore (BEN)	1965	6	90 MW	540 MW
Aviemore (AVI)	1968	4	55 MW	220 MW
Waitaki (WTK)	1954	7	15 MW	105 MW
Manapōuri (MAN)	1972	7	122 MW	800 MW

In the hydro stations, electricity is made from the energy of falling water. A diagram of a hydroelectric generating station is visualized in the following figure:

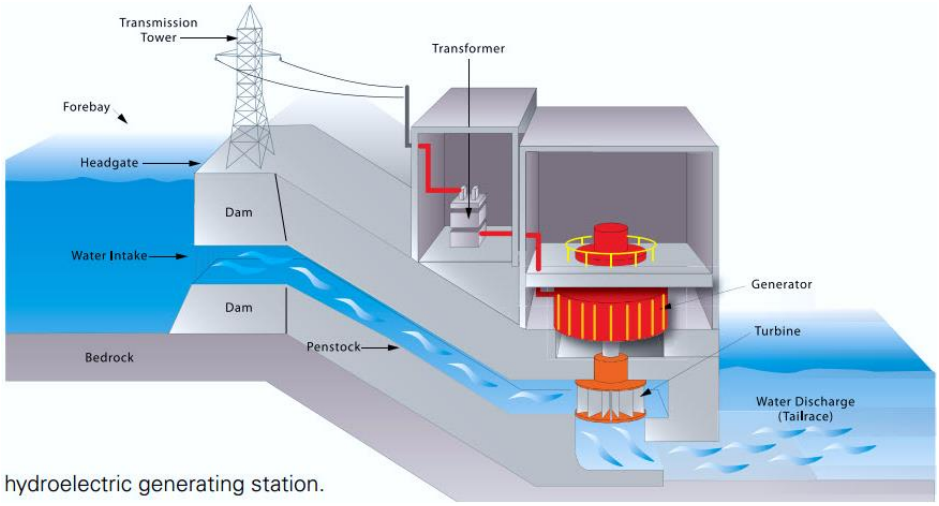

FIGURE 16: DIAGRAM OF A HYDROELECTRIC GENERATING STATION (OPG, 2010)

Meridian uses various water reservoir types: dams, canals, or tunnels. From there, water is falling through a pipe called 'penstock' and pushes the blades of a turbine, which makes the turbine spin. The spinning turbine spins the generator, which generates electricity. Large amounts of electricity cannot be stored; however, it is possible to store water in dams

Appendix A.3. Meridian's Organisational Structure

Overview on Meridian's Functions

Neal Barclay is the CEO of Meridian. Figure 17 outlines Meridian's functional diagram of the executive team and further of the Generation and Natural Resources (GNR) team:

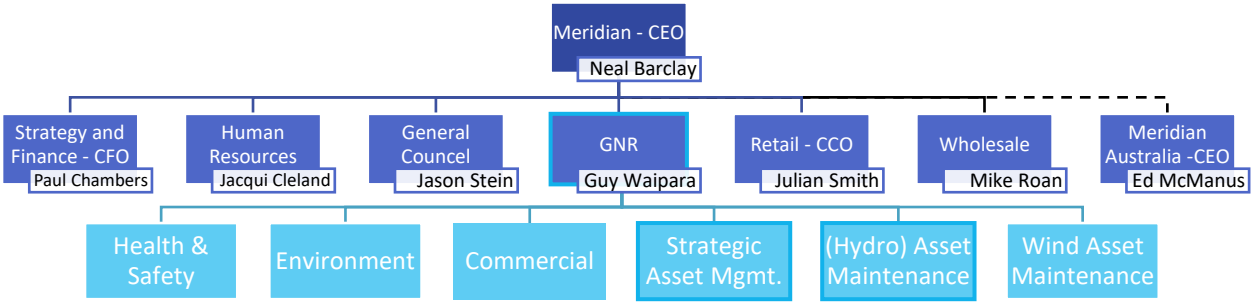

FIGURE 17: MERIDIAN FUNCTIONAL DIAGRAM (MERIDIAN ENERGY, 2018F)

Strategic Asset Management Team

The **SAM Team** (32 employees) provides a long-term planning function and has primary responsibilities for strategy development, risk management, engineering investigations, maintenance strategies, condition monitoring, asset management process improvement, major refurbishments and replacement of assets. The majority of the team is located in Christchurch (Griffiths, 2018).

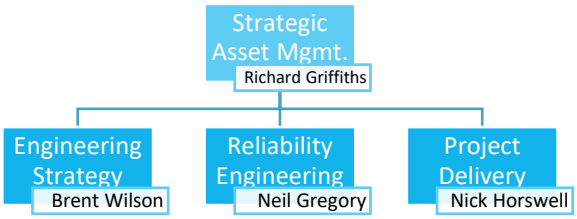

FIGURE 18: FUNCTIONAL DIAGRAM OF THE STRATEGIC ASSET MGMT. TEAM

The **Engineering Strategy Team** has a long-term focus to ensure that Meridian's plant and property assets achieve and maintain a capability commensurate with the company's present and future business needs. One of its primary responsibilities is to maintain the asset management plan (AMP).

The **Reliability Engineering Team's** focus is to monitor the condition of the assets and provide advice and recommendations to the maintenance and engineering teams that will ensure the required plants' performance are achieved as efficiently as possible.

The **Project Delivery Team** is responsible for the execution of all major projects, typically complex projects over $250k and managing the time, cost, quality, risk and safety elements of the project using both internal and external resources. Part of its primary responsibilities is the continuous improvement of processes to ensure best practice project delivery.

Hydro Asset Maintenance Team

The HAM Team (68 employees) has a day-to-day, tactical focus and is responsible for operations and maintenance of the plant. The majority of the team is located in Twizel or directly at the site.

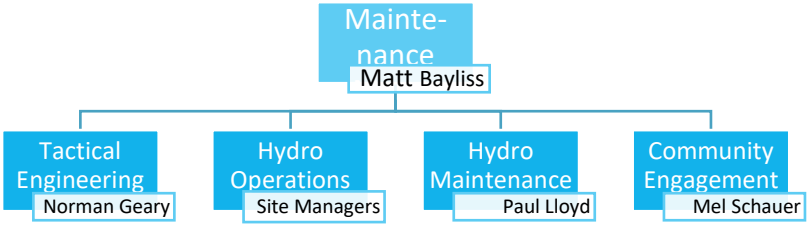

FIGURE 19: FUNCTIONAL DIAGRAM OF THE HYDRO ASSET MAINTENANCE TEAM

The **Tactical Engineering Team** assesses plant condition and maintenance practices and provides tactical and operational support to the maintenance teams. Technical support is also provided to major project initiatives implemented by the Project Delivery Team.

The **Hydro Operations Team** enables the maintenance teams to be able to undertake their responsibilities efficiently and effectively, e.g. planning routine maintenance and providing resources.

The **Hydro Maintenance Teams** comprise three groups located at each of the operating sites. The team manages the implementation of a maintenance schedule and public safety on and around the assets.

Commercial Team

The Commercial team provides financial and commercial support to the GNR team and fulfils the back-office role for the wholesale function. The support services include procurement, governance systems and processes, reporting, commercial analysis, compliance assurance, and business plan programme management to the GNR leadership team. Furthermore, the team is involved in the business planning step of the AMP process.

Appendix B. Meridian's Asset Management Processes

Appendix B.1. Asset Management Planning

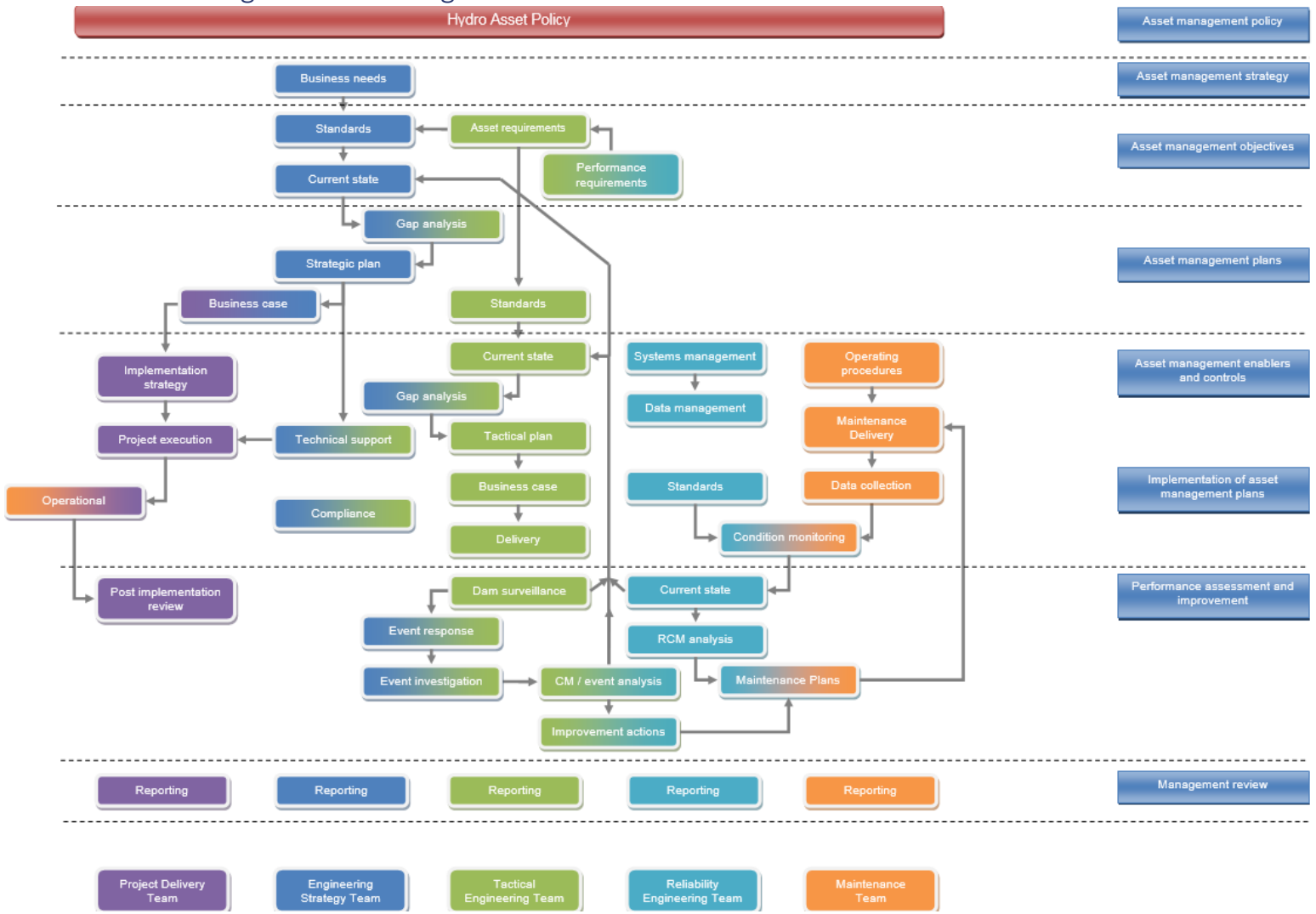

FIGURE 20: MERIDIAN'S ORGANISATIONAL PLAN AND ASSET STRATEGY (WILSON, 2018)

Appendix B.2. Project Management Activities

TABLE 23: PM ACTIVITIES THROUGHOUT THE PROJECT LIFECYCLE (HORSWELL, 2016)

Topic	Initiating	Planning	Executing & Controlling	Closing	Evaluation
Integration	• Project Feasibility Study • Business Case • Project Charter	• Project Mgmt. Plan	• Direct, Manage & Control Execution	• Close Project/ Phase/ Contract	PIR
Scope		• Collect Requirements • Define Scope • Create WBS	• Verify Scope • Control Scope		
Time		• Define Activities • Sequence Activities • Estimate Activity Resources • Estimate Activity Durations • Develop Schedule	• Control Schedule		
Cost		• Determine Budget • Refine Cost Estimates	• Set Up Cost Documentation • Control Costs		
Quality		• Plan Quality	• Perform Quality Assurance & Control		
Human Resource		• Develop HR Plan	• Acquire, Develop and Manage Project Team		
Communications	• Identify Stakeholders	• Plan Communications	• Distribute Information • Manage Stakeholder Expectations • Report Performance		
Risk		• Risk Mgmt. Plan • Identify Risks • Perform Qualitative & Quantitative Risk Analysis • Plan Risk Responses	• Managing Risks		
Procurement		• Plan Procurement	• Conduct/ Administer Procurement	• Close Procurement	
Health & Safety		• Plan H&S Mgmt.	• H&S Mgmt. (Design Stage, Procurement Stage, Contractor)	• Close H&S	
Administration					

Appendix B.3. List of external Interviewees for AM Comparison

TABLE 24: LIST OF EXTERNAL INTERVIEWEES FOR AM COMPARISON

Name	Company	Role	Date of Interview
Andrew Gatland	Unison Networks	AMS Programme Manager	2nd Nov 2018
Jaclyn Hankin	Unison Networks	Network Investment & Delivery Manager	9th Nov 2018
Andy Peacock	Genesis Energy	Project Delivery Manager	20th Nov 2018
Francois van Dyk	Transpower	Asset Management Manager	12th Nov 2018

Appendix C. Data Analysis

Appendix C.1. Information on Projects

Superseded projects

TABLE 25: GENERAL INFORMATION ON RELEVANT PROJECTS OF THE DATA ANALYSIS THAT WERE SUPERSEDED

	Project_ID	Station	Title	Project Owner/Manager (manually updated)
1	**P-COM-875**	COM	Transformer fire separation OHA	Paul Churton
2	**P-MAN-037**	MAN	Unit 220kV CTs	Scott Jesen
3	**P-MAN-1056**	MAN	Manapouri Spare Transformer Modifications to Make Serviceable	Mark Williams
4	**P-OHB-018**	OHB	Refurbish Transformers	Mark Williams/ ackson C
5	**P-OHC-017**	OHC	Refurbish Transformers	Mark Williams/ ackson C
6	**P-WTK-020**	WTK	Waitaki Station Refurbishment & Upgrade	Caroline Rea
7	**P-WTK-083**	WTK	DSAP - SSE Stage 3 - Seismic Upgrade	Jim Walker Caroline Rea
8	**P-AVI-1110**	AVI	Intake screens - spare set	Steve Taylor
9	**P-BEN-1208**	BEN	Intake Screen spare set & screen refurbishment	Steve Taylor
10	**P-OHA-018**	OHA	Generator assessment	Caroline Rea
11	**P-OHA-023**	OHA	Excitation replacement	Paul Churton
12	**P-OHA-029**	OHA	220kV CT replacement	Caroline Rea
13	**P-OHA-1095**	OHA	PLC replacement	Paul Churton
14	**P-OHA-1096**	OHA	Turbine refurbishment	Caroline Rea
15	**P-OHA-1097**	OHA	BPV operational review	Caroline Rea
16	**P-OHA-1127**	OHA	Protection replacement	Paul Churton
17	**P-OHA-932**	OHA	SSE Ohau Chain Stg 3 - Evaluation	Nick Horswell/ Jim Walker
18	**P-OHA-947**	OHA	SSE PKI Stg 3 - Evaluation	Nick Horswell/ Jim Walker
19	**P-OHB-025**	OHB	Protection replacement	Paul Churton
20	**P-OHB-1005**	OHB	Excitation replacement	Paul Churton
21	**P-OHB-1093**	OHB	PLC replacement	Paul Churton
22	**P-OHC-022**	OHC	Protection replacement	Paul Churton
23	**P-OHC-1006**	OHC	Excitation replacement	Paul Churton
24	**P-OHC-1094**	OHC	PLC replacement	Paul Churton
25	**P-OHA-1247**	OHA	Transformer fire separation	Paul Churton
26	**P-OHB-1248**	OHB	Transformer fire separation	Caroline Rea
27	**P-OHC-1249**	OHC	Transformer fire separation	Caroline Rea
28	**P-WTK-1260**	WTK	Site refurbishment project	Caroline Rea
29	**P-MAN-1242**	MAN	Transformer HV Bushing On Line PD Monitoring	mark Williams
30	**P-MAN-1316**	MAN	Intake screen condition assessment	Steve Taylor
31	**P-OHC-1350**	OHC	Transformer GSU LV bushings replacement	mark Williams
32	**P-OHA-1333**	OHA	Turbine bearing cooler cleaning	Caroline Rea
33	**P-MAN-1394**	MAN	Protection local service review and replacement	Paul Churton
34	**P-MAN-1428**	MAN	Comms fibre optic patch panel replacements	Paul Churton
35	**P-COM-1609**	COM	Intake screen upgrade	Steve Taylor
36	**P-OHA-1422**	OHA	Station services refurbishments	Paul Churton
37	**P-OHC-1126**	OHC	Headgate refurbishment	Prakash Gautam
38	**P-COM-1003**	COM	Powerhouse roof painting	Norman Geary
39	**P-OHA-009**	OHA	Wicket gate seal & bush replacement	Steve Taylor

Projects with insufficient information

TABLE 26: GENERAL INFORMATION ON RELEVANT PROJECTS OF THE DATA ANALYSIS THAT HAVE INSUFFICIENT INFORMATION

	Project_ID	Station	Title	Project Owner/Manager (manually updated)
1	**P-AVI-1071**	AVI	Install Lake Level Stilling Well	Mark Williams
2	**P-BEN-921**	BEN	DSAP - BEN SSE Stg 2 - Dam Characterisation	Jim Walker
3	**P-MAN-109**	MAN	110V & 24V System investigation	Rowan Sinton
4	**P-MAN-799**	MAN	Governor pump & unloader valve replacement	Steve Taylor
5	**P-MAN-956**	MAN	Cooling water embedded pipework inspection & strategy	Steve Taylor
6	**P-OHA-834**	OHA	Gate 19 operation at high PKI levels	Steve Taylor
7	**P-OHB-005**	OHB	Lake Ruataniwha Emergency Spill gate Control System Review and Replace	Jade Lloyd
8	**P-OHB-1204**	OHB	Gate 22 Bottom Seal Leakage	Steve Taylor
9	**P-OHA-882**	OHA	Intake screen refurbishment	Steve Taylor/ Jade
10	**P-MAN-105**	MAN	Cooling water pumps replacement	Brett Horwell
11	**P-BEN-1064**	BEN	Auxiliary generator stator winding replacement	Mark Williams
12	**P-OHA-946**	OHA	SSE - PKI Dam - Stg 1 - Materials Characterisation	Jim Walker
13	**P-OHA-1216**	OHA	Penstock seismic strengthening - preliminary design	Neil Sutherland
14	**P-BEN-1379**	BEN	PLC - hydraulic structures replacement	Mark Hurley
15	**P-COM-1197**	COM	BPV Operation - Ohau Chain	Caroline Rea
16	**P-OHA-002**	OHA	Transformer Installation	Mark Williams

Non-started Projects

TABLE 27: GENERAL INFORMATION ON RELEVANT PROJECTS OF THE DATA ANALYSIS THAT HAVE NOT STARTED

	Project_ID	Station	Title	Project Owner/Manager (manually updated)	Status
1	**P-MAN-042**	MAN	Local Service Transformers	Aaron Forde	Not started
2	**P-MAN-1028**	MAN	Generator Transformer Online DGA replacement	Mark Williams	Not started
3	**P-MAN-1031**	MAN	Shear Pin Re-Design and Installation	Steve Taylor	Not started
4	**P-OHB-035**	OHB	220kV CTs	Mark Williams	Not started
5	**P-AVI-030**	AVI	Mid-life refurbishment investigation	Prakash Gautam	Not started
6	**P-AVI-043**	AVI	220kV CT replacement	Mark Williams	Not started
7	**P-AVI-1140**	AVI	Generator - stator & core replacement	Mark Williams	Not started
8	**P-AVI-1141**	AVI	Protection replacement	Graeme McNabb	Not started
9	**P-BEN-022**	BEN	Penstock internal corrosion repair	Neil Sutherland	Not started
10	**P-BEN-056**	BEN	Generator - stator replacement	Mark Williams	Not started
11	**P-BEN-1132**	BEN	PLC replacement	Graeme McNabb	Not started
12	**P-BEN-920**	BEN	SSE Stg 4 - Upgrade	Jim Walker	Not started
13	**P-BEN-922**	BEN	SSE Stg 3 - Evaluation	Jim Walker	Not started
14	**P-MAN-087**	MAN	Head gate refurbishment	Steve Taylor	Not started
15	**P-MAN-1041**	MAN	Corrosive sulphur treatment	Norman Geary	Not started
16	**P-MAN-1079**	MAN	Station Maintenance Outage/Dewater	Brett Horwell	Not started
17	**P-MAN-1133**	MAN	PLC replacement	Graeme McNabb	Not started
18	**P-MAN-1135**	MAN	Protection replacement	Graeme McNabb	Not started
19	**P-OHA-046**	OHA	Auxiliary generator option investigation	Graeme McNabb	Not started
20	**P-OHA-061**	OHA	Governor system refurbishment	Steve Taylor	Not started
21	**P-OHA-930**	OHA	SSE Ohau Chain Stg 4 - Upgrade	Nick Horswell/ Jim Walker	Not started
22	**P-OHA-948**	OHA	SSE PKI Stg 4 - Upgrade	Nick Horswell/ Jim Walker	Not started
23	**P-OHB-1125**	OHB	Head gate refurbishment	Kenton Winkles	Not started
24	**P-OHC-008**	OHC	220kV CB replacement	Mark Williams	Not started
25	**P-OHC-009**	OHC	220kV CT replacement	Mark Williams	Not started
26	**P-OHC-025**	OHC	Diesel gen set replacement	Mark Allen	Not started
27	**P-MAN-1134**	MAN	Excitation replacement	Aaron Forde	Not started
28	**P-OHA-1285**	OHA	220kV CB replacement	Mark Williams	Not started
29	**P-OHA-084**	OHA	Diversion culvert - plug or upgrade	Jim Walker	Not started
30	**P-OHB-014**	OHB	Turbine refurbishment	Kenton Winkles	Not started
31	**P-OHB-015**	OHB	Draft tube concrete erosion repair	Steve Taylor	Not started
32	**P-OHB-1098**	OHB	BPV refurbishment/enhancement	Kenton Winkles	Not started
33	**P-OHB-1100**	OHB	Generator refurbishment	Kenton Winkles	Not started
34	**P-OHB-1269**	OHB	Generator stator replacement	Mark Williams	Not started
35	**P-OHC-014**	OHC	Turbine refurbishment	Kenton Winkles	Not started
36	**P-OHC-1069**	OHC	Generator refurbishment	Kenton Winkles	Not started
37	**P-OHC-1099**	OHC	BPV refurbishment/enhancement	Kenton Winkles	Not started
38	**P-OHC-1124**	OHC	Draft tube concrete erosion repair	Steve Taylor	Not started
39	**P-OHC-1268**	OHC	Generator stator replacement	Mark Williams	Not started
40	**P-WTK-1261**	WTK	Unit upgrade	Malcolm Preston	Not started
41	**P-COM-1304**	COM	Intake screen refurbishment OHB & OHC	Steve Taylor	Not started
42	**P-OHA-1352**	OHA	Local service 400V review	Mark Williams	Not started
43	**P-COM-1353**	COM	Local service switchboards review - Ohau chain	Mark Williams	Not started

Please turn over

	Project_ID	Station	Title	Project Owner/Manager (manually updated)	Status
44	**P-OHB-1264**	OHB	220kV CB replacement	Mark Williams	Not started
45	**P-WTK-1321**	WTK	Unit 4 runner cav repair, cracking repair, shaft seal replacement, wg bush replacement	Steve Taylor	Not started
46	**P-MAN-1393**	MAN	Lift shaft platform seismic and structural upgrade	Neil Sutherland	Not started
47	**P-MAN-1397**	MAN	Lift shaft cable ladder replacement	Malcolm Preston	Not started
48	**P-MAN-1430**	MAN	11kV ST1 and ST2 cable replacement	Mark Williams	Not started
49	**P-COM-1443**	COM	220kV and 33kV switchyard ground anchor replacement	Tim Mills	Not started
50	**P-BEN-1432**	BEN	220kV CB replacement	Mark Williams	Not started
51	**P-COM-1584**	COM	Canal Water Level Telemetry Replacement	Graeme McNabb	Not started
52	**P-AVI-1424**	AVI	Generator heater replacement	Mark Williams	Not started
53	**P-MAN-1114**	MAN	Generator heater replacement	Mark Williams	Not started
54	**P-COM-1578**	COM	Inergen Selector Valve Testing	Steve Taylor	Not started
55	**P-COM-1500**	COM	Intake gate trip circuit enhancement	not yet	Not started
56	**P-BEN-1406**	BEN	Local service investigation and project	Rowan Sinton	Not started
57	**P-OHA-1404**	OHA	Local service strategy and upgrade	Rowan Sinton	Not started
58	**P-MAN-1485**	MAN	MLC downstream gravel removal	Tim Mills	Not started
59	**P-COM-1518**	COM	Penstock internal corrosion protection	Norman Geary	Not started
60	**P-OHC-1415**	OHC	Penstock seismic strengthening implementation	Neil Sutherland	Not started
61	**P-OHB-1416**	OHB	Penstock seismic strengthening implementation	Neil Sutherland	Not started
62	**P-OHA-1417**	OHA	Penstock seismic strengthening implementation	Neil Sutherland	Not started
63	**P-COM-1465**	COM	Process Safety - alarm rationalisation	Norman Geary	Not started
64	**P-BEN-1521**	BEN	Protection replacement (generator)	Graeme McNabb	Not started
65	**P-OHA-1585**	OHA	Relocate Kelman unit from MANT8&T9 and Install 2 more DGA unit on OHA Tx	Neil Gregory	Not started
66	**P-COM-1503**	COM	Revenue metering remnant life replacement	Mark Williams	Not started
67	**P-COM-1586**	COM	Safe Transformer Access Design	Steve Taylor	Not started
68	**P-AVI-1590**	AVI	Servo motors in need of an overhaul.	Steve Taylor	Not started
69	**P-COM-1456**	COM	Station lighting replacement	mark Williams	Not started
70	**P-AVI-1520**	AVI	Thrust & guide coolers, pipework at end of life.	Steve Taylor	Not started
71	**P-MAN-1527**	MAN	Transformer GSU HV bushing (WTC Txx3)_Install bushings with test taps	Aaron Forde	Not started
72	**P-AVI-1513**	AVI	Transformer maintenance access platform	Steve Taylor	Not started
73	**P-BEN-1623**	BEN	Turbine wicket gate stiction remedial works	Steve Taylor	Not started
74	**P-MAN-1784**	MAN	220kV cable clamp replacement	Steve Taylor	Not started
75	**P-MAN-1692**	MAN	Not general site upgrade	Brett Horwell	Not started
76	**P-MAN-1615**	MAN	220kV cable sheath earthing modification	Rowan Sinton	Not started
77	**P-MAN-1626**	MAN	Turbine guide bearing clearances to spec	Steve Taylor	Not started
78	**P-BEN-1767**	BEN	PLC - station services replacement, WLS and comms upgrade	Nick Horswell	Not started
79	**P-WTK-1628**	WTK	Minor refurbishment project	Steve Taylor	Not started
80	**P-BEN-1755**	BEN	Thrust & guide bearing cooler replacement	Steve Taylor	Not started
81	**P-COM-1701**	COM	Investigate filtration system for OHB/C Shaft Seal cooling water (SSCW)	Steve Taylor	Not started
82	**P-MAN-1620**	MAN	Transformer GSU cable box maintenance access platform	Steve Taylor	Not started
83	**P-AVI-1678**	AVI	Powerhouse seismic strengthening options assessment	Neil Sutherland	Not started
84	**P-COM-1613**	COM	33KV Cable Replacement	Mark Williams	Not started
85	**P-WTK-1732**	WTK	11kV GCB replacement	Mark Williams	Not started
86	**P-WTK-1738**	WTK	PLC - local services replacement	Graeme McNabb	Not started
87	**P-AVI-985**	AVI	Auxiliary generator AVR, governor and protection replacement	Rowan Sinton	Not started
88	**P-OHA-1560**	OHA	PLC - Gate 20 replacement	Mark Hurley	Not started
89	**P-MAN-1313**	MAN	Local service upgrade - below ground	Nick Horswell	Not started

Projects in Progress

TABLE 28: GENERAL INFORMATION OF STARTED (IN PROGRESS/ NON-COMPLETED) PROJECTS OF THE DATA ANALYSIS

	Project_ID	Station	Title	Project Owner/Manager (manually updated)	Status	CP NAV ID 1	CP NAV ID 2	OP NAV ID 1	OP NAV ID 2
1	P-BEN-029	BEN	Cooling water pump refurbishment	Alex Martin	in progress	C14039	C12252	0	0
2	P-COM-829	COM	Stoplog Maintenance	Steve Taylor	in progress	0	0	R13510	0
3	P-MAN-1109	MAN	False Ceiling Integrity	Tim Mills	in progress	C16056	0	R13515	0
4	P-OHA-1030	OHA	Repair Draft Tube Park Shelf Cavitation	Steve Taylor	in progress	C13438	0	R16050	0
5	P-AVI-1050	AVI	Local Service switchboard and lighting review & upgrade	Alex Martin	in progress	C15050	C16917	0	0
6	P-COM-1159	COM	Stoplog Crane Refurbishments	Steve Taylor	in progress	C14023	0	R14106	0
7	P-COM-1209	COM	Embedded pipe condition investigation and remediation	Steve Taylor	in progress	C16052	0	R14042	0
8	P-COM-133	COM	Steel Penstock Condition Assessment	Prakash Gautam	in progress	0	0	R13533	R16129
9	P-MAN-803	MAN	De-water & drainage pumps	Steve Taylor	in progress	C13442	C46294	R11012	0
10	P-OHA-1190	OHA	Gate 19 Spillway Chute concrete repairs	Tim Mills	in progress	0	0	R14064	0
11	P-OHA-931	OHA	SSE Ohau Chain Stg 1 - Dam Characterisation	Nick Horswell/ Jim Walker	in progress	0	0	R16073	0
12	P-MAN-1244	MAN	Turbine Facing Plate Damage	Derek Pritchard	in progress	C16926	0	R13547	0
13	P-COM-1368	COM	Facilities management - remedial works	Paul Lloyd	in progress	0	0	R16026	0
14	P-COM-1367	COM	Oil Replacement	Steve Taylor	in progress	0	0	R15057	0
15	P-MAN-1356	MAN	TLC gate ratings and WLS upgrade	Grant Amos	in progress	C16046	0	0	0
16	P-MAN-1312	MAN	Transformer GSU replacement	Scott Jesen	in progress	C16925	0	0	0
17	P-BEN-1558	BEN	Crane - head gate crane overhaul	Grant Amos	in progress	C18079	0	R18082	0
18	P-COM-1487	COM	Gate structure boom installation	Tim Mills	in progress	C17089	0	0	0
19	P-AVI-1589	AVI	Head gate crane in need of an overhaul	Grant Amos	in progress	C18078	0	R18081	0
20	P-MAN-1524	MAN	Intake structure concrete repair	Tim Mills	in progress	0	0	R18033	0
21	P-MAN-1419	MAN	Local service controls upgrade	Paul Churton	in progress	C17051	0	0	0
22	P-COM-1569	COM	Ohau Chain Program	Caroline Rea	in progress	C16881	0	R17881	0
23	P-OHA-1434	OHA	Transformer LV and HV bushings replacement	Ackson Chikoma	in progress	0	0	R18022	0
24	P-WTK-1493	WTK	WLS - HWL new installation	Grant Amos	in progress	C18022	0	0	0
25	P-MAN-1654	MAN	220kV CT replacement	Scott Jesen	in progress	C18090	0	0	0
26	P-MAN-865	MAN	Transformer LS T8 & T9 Replacement	Scott Jesen	in progress	C15078	0	0	0
27	P-MAN-046	MAN	Lift Replacement	Brett Horwell	in progress	C18020	C18100	0	0
28	P-WTK-1258	WTK	Head gate brakes and limit switches	Steve Taylor	in progress	C16050	0	0	0

Completed Projects

TABLE 29: GENERAL INFORMATION OF COMPLETED PROJECTS OF THE DATA ANALYSIS

	Project_ID	Station	Title	Project Owner/Manager (manually updated)	Status	CP NAV ID 1	CP NAV ID 2	OP NAV ID 1	OP NAV ID 2
1	P-AVI-027	AVI	Excitation replacement	Paul Churton	completed	C14061	C12251	0	0
2	P-AVI-071	AVI	Replace spillway gate brgs & seals	Steve Taylor	completed	C12216	0	R13564	0
3	P-AVI-1092	AVI	C&I Replacement	Paul Churton	completed	C13451	0	0	0
4	P-BEN-049	BEN	Investigate sluice gate seal replacement	Steve Taylor	completed	C13434	0	R13506	0
5	P-BEN-090	BEN	Final Configuration Project	Alex Martin	completed	C92785	0	0	0
6	P-COM-060	COM	Oil Interceptor System - Investigation & remedial	Steve Taylor	completed	C13440	0	0	0
7	P-COM-1039	COM	Replacement of Governor TSH Valves	Steve Taylor	completed	C13408	0	0	0
8	P-MAN-052	MAN	Ventilation Upgrade & Refurbishment	Brett Horwell	completed	C14060	C11107	R10712	0
9	P-MAN-1007	MAN	Stator Radiator End Caps & drains	Steve Taylor	completed	0	0	R13513	0
10	P-OHA-839	OHA	Main unit CW strainer replacement	Steve Taylor	completed	C12273	0	R12235	0
11	P-AVI-1189	AVI	Dam Right Abutment Seepage Monitoring	Tim Mills	completed	C14024	0	0	0
12	P-BEN-016	BEN	Spillway chute maintenance	Tim Mills	completed	0	0	R17162	R14039
13	P-BEN-1232	BEN	Pole 1 decommissioning - redundant equipment removal	Tony	completed	0	0	R14098	0
14	P-MAN-1230	MAN	Transformer HV bush replacement	Brett Horwell	completed	C14058	0	R14091	0
15	P-OHA-879	OHA	PKI Dam Face rip rap enhancement remediation	Tim Mills	completed	C11106	0	0	0
16	P-OHB-1188	OHB	Head pond G-W Monitoring	Tim Mills	completed	C14031	0	0	0
17	P-AVI-011	AVI	Governor system pump replacement	Steve Taylor	completed	C16049	0	0	0
18	P-MAN-1175	MAN	Turbine shaft seal replacement	Steve Taylor	completed	0	0	R14045	R19033
19	P-COM-1059	COM	Review Flood Criteria for TLC & MLC	Jim Walker	completed	0	0	R16077	0

Appendix C.2. Timing Difference

TABLE 30: PLANNING DIFFERENCE TO ACTUAL START DATE IN YEARS WHEN GETTING CLOSER TO THE ACTUAL START DATE

		Time of AMP to actual start date				
Start Date	**AMP IDs**	**4 years**	**3 years**	**2 years**	**1 year**	**0 years**
2014	**P-AVI-1189**				#N/A	0
2014	**P-BEN-1232**				#N/A	0
2014	**P-COM-1159**				#N/A	0
2014	**P-MAN-1175**				#N/A	0
2014	**P-MAN-1230**				#N/A	0
2014	**P-MAN-803**				1	0
2014	**P-OHA-1190**				#N/A	0
2014	**P-OHB-1188**				#N/A	0
2015	**P-AVI-1050**			#N/A	1	0
2015	**P-BEN-016**			#N/A	1	0
2015	**P-COM-1367**			#N/A	#N/A	#N/A
2015	**P-MAN-865**			#N/A	#N/A	0
2016	**P-AVI-011**		#N/A	#N/A	0	0
2016	**P-COM-1059**		#N/A	#N/A	0	0
2016	**P-COM-1368**		#N/A	#N/A	#N/A	0
2016	**P-MAN-1312**		#N/A	#N/A	#N/A	0
2016	**P-MAN-1356**		#N/A	#N/A	#N/A	0
2016	**P-OHA-931**		#N/A	0	0	0
2017	**P-COM-1209**	#N/A	3	2	1	0
2017	**P-COM-1487**	#N/A	#N/A	#N/A	#N/A	#N/A
2017	**P-MAN-1419**	#N/A	#N/A	#N/A	#N/A	#N/A
2017	**P-OHA-1030**	4	1	2	1	0
2018	**P-AVI-1589**	#N/A	#N/A	#N/A	#N/A	0
2018	**P-BEN-1558**	#N/A	#N/A	#N/A	#N/A	0
2018	**P-MAN-046**	#N/A	#N/A	#N/A	#N/A	0
2018	**P-MAN-1524**	#N/A	#N/A	#N/A	#N/A	0
2018	**P-MAN-1654**	#N/A	#N/A	#N/A	#N/A	#N/A
2018	**P-OHA-1434**	#N/A	#N/A	#N/A	#N/A	0
2018	**P-WTK-1258**	#N/A	3	2	#N/A	0
2018	**P-WTK-1493**	#N/A	#N/A	#N/A	#N/A	0

Appendix C.3. Duration Inaccuracies

TABLE 31: PLANNING DURATION DIFFERENCE TO ACTUAL PER PROJECT WHEN GETTING CLOSER TO THE ACTUAL END DATE (VISUALISED IN FIGURES)

	Number of years to the actual end date					
	5	4	3	2	1	0
P-AVI-011 (2016 - 2018)						
Duration difference [y]			1	1	1	0
Duration difference [%]			50%	50%	50%	0%
P-AVI-027 (2014 - 2018)						
Duration difference [y]	3	3	3	2		
Duration difference [%]	150%	150%	150%	67%		
P-AVI-071 (2013 - 2017)						
Duration difference [y]		3	2	1	1	
Duration difference [%]		150%	67%	25%	25%	
P-AVI-1050 (2015 - 2018)						
Duration difference [y]		2	3	2		-1
Duration difference [%]		100%	300%	100%		-20%
P-AVI-1092 (2013 - 2017)						
Duration difference [y]		3	2	2	1	
Duration difference [%]		150%	67%	67%	25%	
P-AVI-1189 (2014 - 2016)						
Duration difference [y]				0	1	
Duration difference [%]				0%	50%	
P-BEN-049 (2013 - 2018)						
Duration difference [y]	4	4	3	2		
Duration difference [%]	200%	200%	100%	50%		
P-BEN-090 (2013 - 2017)						
Duration difference [y]		4	3			
Duration difference [%]		400%	150%			
P-BEN-1232 (2014 - 2017)						
Duration difference [y]			2	2		
Duration difference [%]			100%	100%		
P-COM-060 (2013 - 2018)						
Duration difference [y]	3	2	2	2		
Duration difference [%]	100%	50%	50%	50%		
P-COM-1039 (2013 - 2018)						
Duration difference [y]	3	4				
Duration difference [%]	100%	200%				
P-COM-1059 (2016 - 2018)						
Duration difference [y]			0	0	0	
Duration difference [%]			0%	0%	0%	
P-COM-1197 (2017 - 2017)						
Duration difference [y]			-1			
Duration difference [%]			-50%			
P-MAN-052 (2014 - 2018)						
Duration difference [y]	3	2	2	2		
Duration difference [%]	150%	67%	67%	67%		
P-MAN-1007 (2013 - 2016)						
Duration difference [y]			1	0	1	
Duration difference [%]			33%	0%	33%	
P-MAN-1175 (2014 - 2017)						
Duration difference [y]			0	0	-1	-1
Duration difference [%]			0%	0%	-20%	-20%
P-MAN-1230 (2014 - 2015)						
Duration difference [y]					1	
Duration difference [%]					100%	
P-OHA-839 (2013 - 2015)						
Duration difference [y]				1	1	
Duration difference [%]				50%	50%	
P-OHA-879 (2013 - 2013)						
Duration difference [y]						0
Duration difference [%]						0%
P-OHB-1188 (2014 - 2017)						
Duration difference [y]			3			
Duration difference [%]			300%			

Appendix C.4. Cost Inaccuracies

TABLE 32: HYDRO AMP OPEX EXPENDITURE SUMMARY FY2016-2021 (MERIDIAN ENERGY, 2018G)

AMP Category	2016 Actual	2017 Actual	2018 Budget	2018 Re-cut AMP	2018 Actual	2019 Budget	2020 Budget	2021 Budget
Access to Fuel	298	295	855	855	351	649	745	980
DSAP	1,585	1,761	2,002	1,952	1,340	2,055	2,225	2,385
Facilities Management	3,688	3,752	3,871	3,871	3,781	4,177	4,706	4,488
Maintenance	2,042	2,530	1,887	2,484	1,688	1,687	1,746	2,055
Major Project	2,381	2,271	5,458	5,106	4,573	10,115	11,020	7,088
Minor Project	1,174	1,401	897	1,127	1,626	1,818	2,146	2,598
Other Annualised	-	363	578	533	367	470	535	535
Budget Reduction				(380)		(2,800)	(4,157)	(17)
Grand Total	**11,168**	**12,372**	**15,548**	**15,548**	**13,726**	**18,171**	**18,966**	**20,113**

TABLE 33: HYDRO AMP CAPEX EXPENDITURE SUMMARY FY2016-2021 (MERIDIAN ENERGY, 2018G)

AMP Category	2016 Actual	2017 Actual	2018 Budget	2018 Re-cut AMP	2018 Actual	2019 Budget	2020 Budget	2021 Budget
Access to Fuel	6	6	250	50	(19)	275	265	185
DSAP	73	569	853	703	301	887	1,280	1,240
Facilities Mgmt	-	95	150	50	(4)	608	379	150
Maintenance	210	291	227	50	451	345	310	225
Major Project	16,709	12,331	24,152	24,014	16,813	17,713	21,453	20,849
Minor Project	2,484	5,584	2,672	1,583	6,247	4,397	3,947	2,647
Other Annualised	174	83	175	155		80	95	110
Budget Reduction	-		(4,000)	(2,125)		(3,340)	(7,000)	(4,004)
Grand Total	**19,656**	**18,959**	**24,479**	**24,479**	**23,790**	**20,965**	**20,729**	**21,402**

Hydro AMP Category Explanation

- **Access to Fuel** – covers PKI lake shore erosion, weed & vegetation control, Water Level Site calibration & maint.
- **DSAP (Dam Safety Assurance Programme)** – covers Dam Safety monitoring, annual Dam Safety Reviews, Deformation surveys of hydraulic structures, dam surveillance instrumentation restoration and general canal & culvert monitoring, inspections & maintenance
- **Facilities Management** – FM Contract, Real Journeys contract for boat & hostel, road maintenance
- **Maintenance** - Scheduled and unscheduled maintenance across the hydro fleet
- **Major Projects** – large value projects (>$100) to address known plant issues or part of large program of work
- **Minor Projects** – variety of low value (typically <$100k) across fleet
- **Other Annualised** - common projects or contracts covering revenue metering, emergency response, GCS UPS battery mtce, consumables

Appendix D. Literature Review on Project Underestimation

Appendix D.1. Overview

According to Flyvbjerg (2002), cost underestimation occurs across the globe. It is important to understand that these overruns stem from the relationship between the time, cost, and work parameters of a project. If one of these parameters is underestimated, the effects propagate to the others. This is evident in Figure 21, where real work indicates the difference between underestimation and correct estimation.

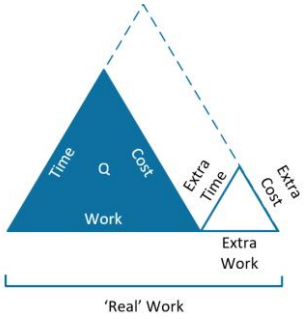

FIGURE 21: ESTIMATION PYRAMID, WHERE REAL WORK IS OFTEN UNDERESTIMATED (BEUKMAN, 2018)

While this data is freely available and not difficult to find, project estimation has not seen significant improvements for the past 70 years (Weyer, 2011). This suggests either that projects are underestimated on purpose or that the root cause of underestimation is yet to be addressed. There is documented evidence that for more than 70 years projects have been underestimated around the world, regardless of size or sector. This leads to financial losses, risk expenditure, and losses in the reputation and credibility of the involved stakeholders.

There are three main root causes that lead to projects being underestimated, which are:

- Technical
- Psychological
- Political-economic

the different factors for project underestimation have different levels of explanatory power and relevance. It is highly unlikely that unintentional technical errors or inexperience of forecasters explain cost underestimation on its own, as the same mistakes were continually made over a 70 years period (Flyvbjerg, Skamris Holm, & Buhl, 2002). The explanatory power of political-economic and psychological factors is highly dependent on the political and organizational pressure, which is visualized in **Error! Reference source not found.**.

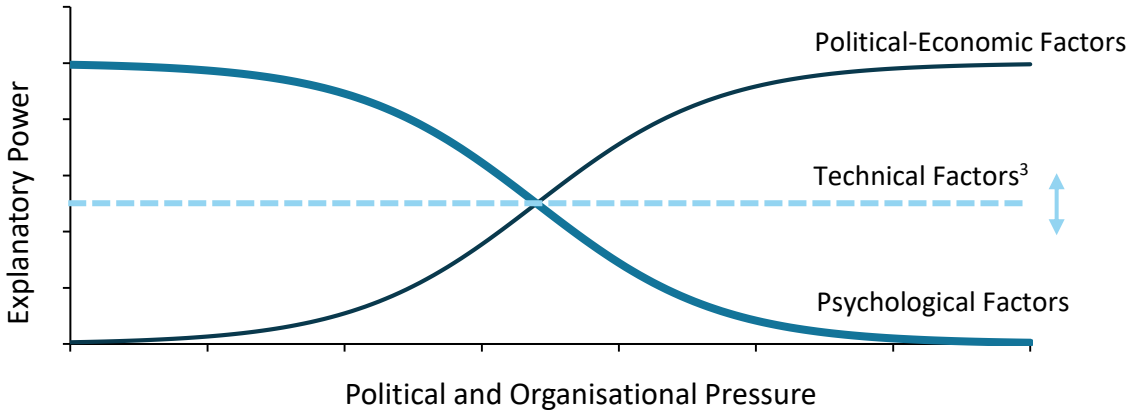

FIGURE 22: EXPLANATORY POWER OF POLITICAL-ECONOMIC AND PSYCHOLOGICAL FACTORS OVER POLITICAL AND ORGANISATIONAL PRESSURE, EDITED FROM (FLYVBJERG, 2008)

[8] The explanatory power of technical factors increases with a higher level of novelty, technology, pace and complexity (see Appendix D.2 Technical Explanations)

Appendix D.2. Technical Explanations

Technical factors are the most common explanation for the inaccuracy of estimates and refer to imperfect forecasting techniques, honest mistakes, inadequate data, lack of forecaster experience and immanent issues with predicting the future (Flyvbjerg, 2007). The risk of project underestimation increases with a higher level of the project dimensions, which are shown in Figure 23:

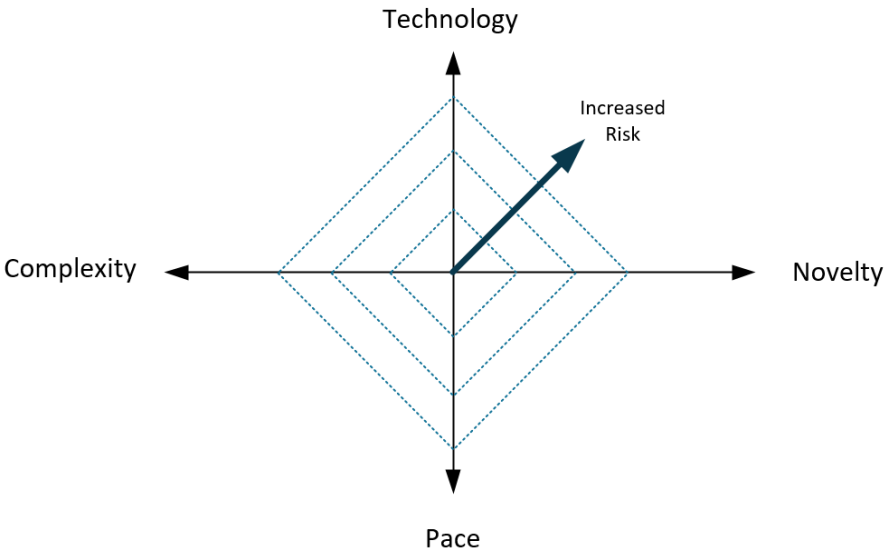

FIGURE 23: PROJECT DIMENSIONS, CF. (BEUKMAN, 2018)

Table 34 shows the influence of the project dimensions on the technical factors. The technical factors are increased with a higher level of the project dimension.

TABLE 34: INFLUENCE OF THE PROJECT DIMENSIONS ON TECHNICAL FACTORS

Project Dimension	Influence on Technical Factors	Outcomes
Technology	• Amount of inadequate data • Issues of predicting the future	• **Overlooked system properties** • **Inaccuracy of assumptions** • **Scope creep** • **Rushing** • **Communication failure** • **Unknown risks** • **Non-linear connections**
Novelty	• Lack of experience • Issues of predicting the future	
Pace	• Honest mistakes • Increase in the issues of predicting the future	
Complexity	• Relevance of a suitable forecasting technique • Relevance of transparency	

Appendix D.3. Psychological Explanations

Related to project underestimations, planning fallacies[9] are the main psychological explanation. Table 35 explains the different psychological biases and planning fallacy effects:

[9] *"In the grip of the planning fallacy, planners and project promoters make decisions based on delusional optimism, rather than on a rational weighting of gains, losses and probabilities."* (Flyvbjerg, 2007).

TABLE 35: PSYCHOLOGICAL FACTORS FOR PROJECT UNDERESTIMATION

Factor	Definition	Related to Project Management
Optimism Bias	*"A cognitive bias that causes a person to believe that they are at a lesser risk of experiencing a negative event compared to others"* (Weinstein, 1980)	Project managers often make decisions based on delusional optimism rather than taking a realistic approach to gains and losses of the project (Flyvbjerg, 2011). They believe that potential benefits outweigh the project risks by far (Weyer, 2011).
Dunning-Kruger Effect	"*People of little competence believe that they are more competent than they really are. People overestimate their competence."* (Kruger & Dunning, 1999).	The first stage of a project has a high influence on the outcome. Especially in the beginning, the incompetent is overconfident in knowledge and experience. Therefore, critically analysing the ability of oneself for a task can be difficult.
Illusion of Control	*"The tendency for people to overestimate their ability to control events; for example, it occurs when someone feels a sense of control over outcomes that they demonstrably do not influence."* (Thompson, 1999)	When project managers have an illusion of control, the risk assessment and mitigation might be conducted in a less extensive way.
Anchoring Effect	*"Cognitive bias that describes the common human tendency to rely too heavily on the first piece of information offered (the "anchor") when making decisions."* (Marques & Dhiman, 2018)	Initial plans serve as an anchor for project managers. During the project, adjustments are necessary. However, the initial plan is still seen as realistic. Following, insufficient adjustments are made.
False Consensus Effect	"*Egotistic bias to believe that others in a group of which one is a member will respond like oneself"* (Dawes, 1990)	When project team members believe, others have the same understanding, access to information and/or would decide in the same way they do. This could lead to a lack of transparency and communication.
Sunk Cost Bias	"Throwing good money after bad." (Moore, 2016)	Due to adding up all the money already spent on a project, managers conclude it is too costly to simply abandon it.

We have to admit that everybody is a potential victim to psychological factors, as they are unintentional or ingrained. The outcomes of these unconscious psychological factors, which lead to time and cost underestimation, are:

- Insufficient risk management,
- Less project monitoring
- Poor communication and transparency,
- Estimations, which are made too close to initial planning, and
- Overlooked system properties.

Appendix D.4. Political-Economic Explanations

Psychological and technical factors might be a good explanation for cost overruns when political and organizational pressures are low, but as soon as they get higher, political explanations have more power (Ubani, Omajeh, & Okebugwu, 2015).

On the Sydney Opera House, Kim Utzon said: *"It was a political decision to publicize a low budget for the building, which was expected to gain approval in the political system, but which very quickly was exceeded. So even if the cost overrun turned out to be 1,400% in relation to the publicized budget, this budget was an eighth of the real budget for the building. So, the real cost overrun is only 100%. The rest was politics."* (Flyvberg, 2005)

That indicates that strategic misrepresentation[10] of facts, especially budget, is a reasonable political-economic explanation for the blowout of projects. The two reasons for strategic misrepresentation are self-interest and public interest. In a company, only self-interest is relevant, which is Intentionally underestimating the project so that the company with your vested interest is awarded the contract, to generate profits (Awosina, 2017) (Ubani, Omajeh, & Okebugwu, 2015).

Political or economic pressures can cause temptation for project promotors to strategically misrepresent the estimates for a project, as their incentives are to cut costs and provide benefits. Project benefits are often overestimated, while the project costs are underestimated. This leads to a trend of common worst practise, where project promoters are fully aware of their deceptive behaviour (Ubani, Omajeh, & Okebugwu, 2015) (Weyer, 2011).

Figure 24 summarises the incentives for project underestimation:

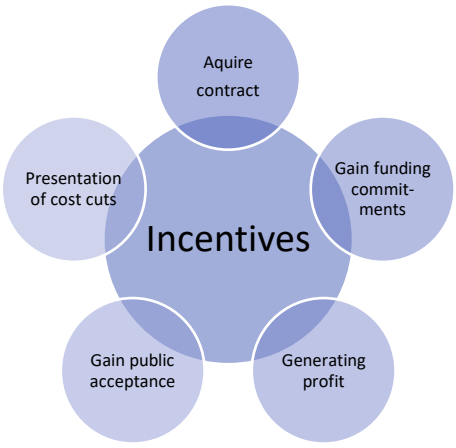

FIGURE 24: INCENTIVES FOR PROJECT UNDERESTIMATION

During the project execution, to cover strategic misrepresentation, salami tactics are often used. This method describes the behaviour of introducing project risks and components in a slice by slice format. These well-explained and relatively small bits catch less attention for the project sponsor, who will happily approve them. The realization of the project consuming much more costs than initially planned comes too late (Ubani, Omajeh, & Okebugwu, 2015).

Finally, lying and the salami tactics pay off for the project promoter. There are no incentives or measures of accountability in place to be honest about the benefits and risks of the project. Therefore, strategic misrepresentation can be seen as a '*predictable response to the incentive structure of the budgetary game*' (Jones & Euske, 1991) (Flyvbjerg, 2007).

[10] "Strategic misrepresentation is the planned, systematic distortion or misstatement of fact —lying—in response to incentives in the budget process." (Jones & Euske, 1991)

Appendix E. Case Studies for Root Cause Analysis

Appendix E.1. Overview

The following table shows the chosen projects that are used as case studies:

TABLE 36: PROJECTS USED FOR THE ROOT CAUSE ANALYSIS

Title	Project Manager	Status	Inaccuracies	NAV ID(s)
Aviemore PLC Upgrade	Paul Churton (PDT)	completed	P-AVI-1092	C13451
Ohau Chain Program	Mechanical/ Overall: Caroline Rea (PDT) Electrical: Paul Churton (PDT)	In progress	P-COM-1569	-C15057 for OHA -C16881 for OHB &OHC -R17881
Benmore Cooling Water Replacement	Alex Martin (PDT)	In progress	P-BEN-029	C14039
Manapōuri T8 & T9 Replacement	Scott Jesen (PDT)	In progress	P-MAN-865	C15078
Aviemore Local Service replacement	Alex Martin (PDT)	In progress	P-AVI-1050	C16917
Te Anau Lake Control (TLC)	Grant Amos (PDT)	In progress	P-MAN-1356	C16046
Ohau B Penstock Seismic Strengthening	Neil Sutherland (EST)	cancelled	P-OHB-1416	/

For each case study, the AMP estimates are compared with the actual spend. Then the issues in the initiation/planning stage and execution stage are outlined. These were identified through interviews with responsible project managers and engineers, and the review of the lessons learned database. In each case study the summary of the issues and root causes are visualized. The root causes have a preceding letter (or two), referring to the type of root cause:

- **T**echnical (T)
- **Ps**ychological (Ps)
- **P**olitical**- E**conomic (P-E)

For more background information on the projects please refer to milestone report 3.

Appendix E.2. Aviemore PLC Upgrade

The following figure shows the comparison between planned costs over the years per FY and the actual costs per FY.

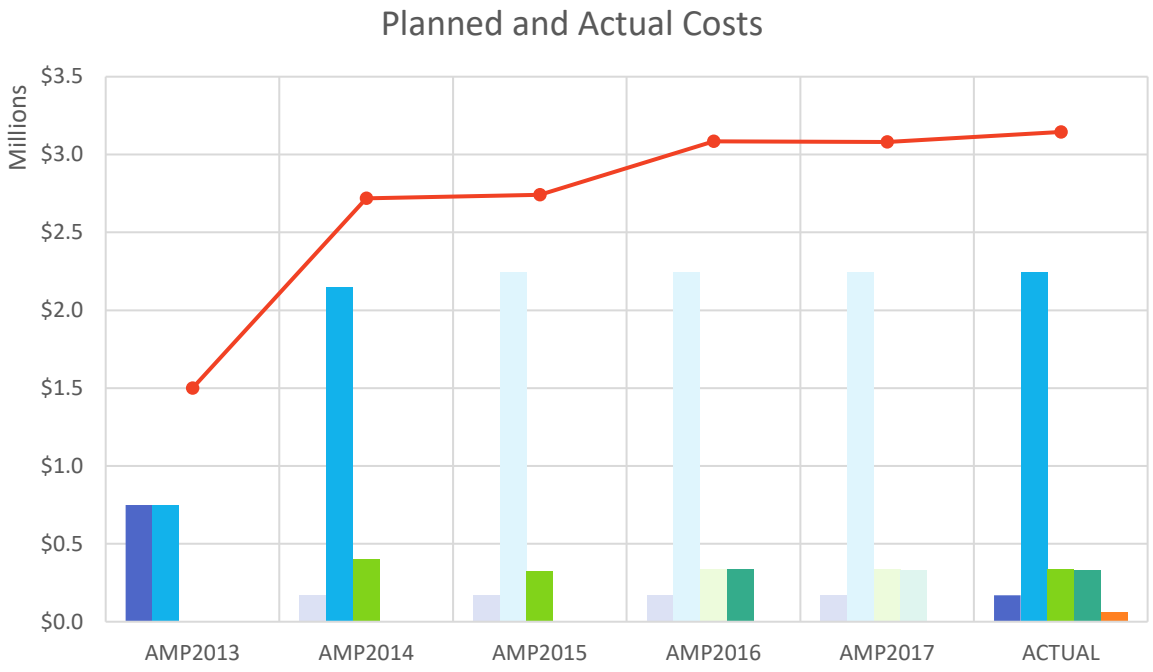

FIGURE 25: PLANNED AND ACTUAL COSTS PER FINANCIAL YEAR OF THE AVI PLC REPLACEMENT PROJECT

Figure 26 shows the planned and actual end date and duration of the project.

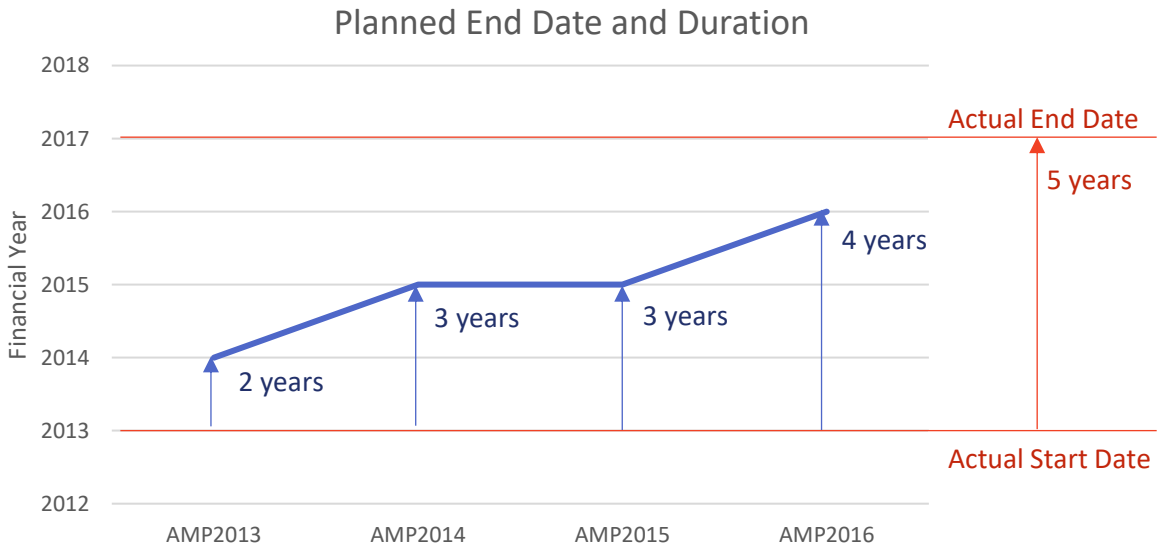

FIGURE 26: PLANNED END DATE AND DURATION OF THE AVI PLC REPLACEMENT PROJECT

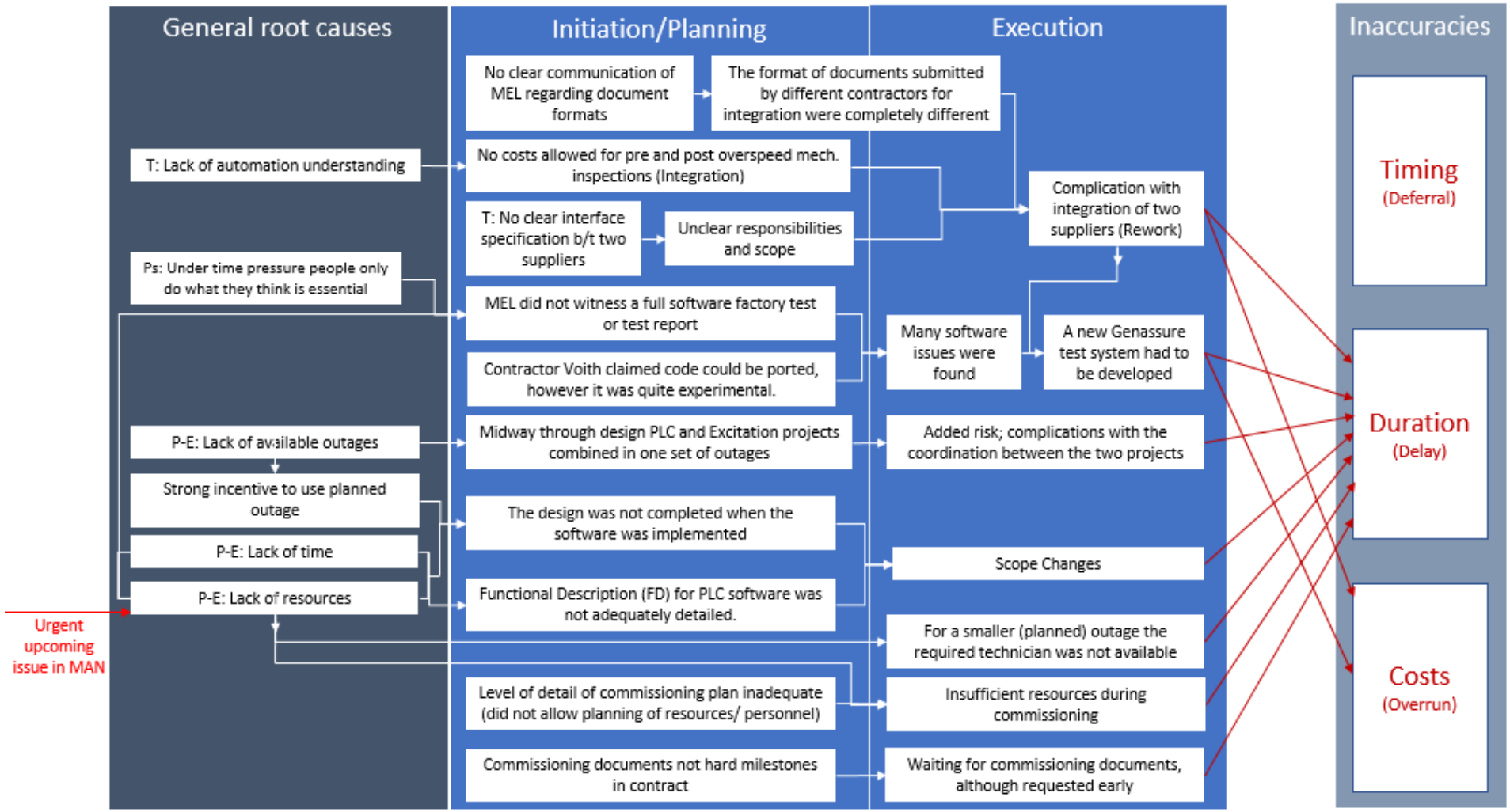

FIGURE 27: SUMMARY OF ISSUES AND ROOT CAUSES FOR INACCURACIES AT THE AVI PLC UPGRADE PROJECT

Appendix E.3. Ohau Chain Program

The following graph visualizes the planned and actual expenditure per FY:

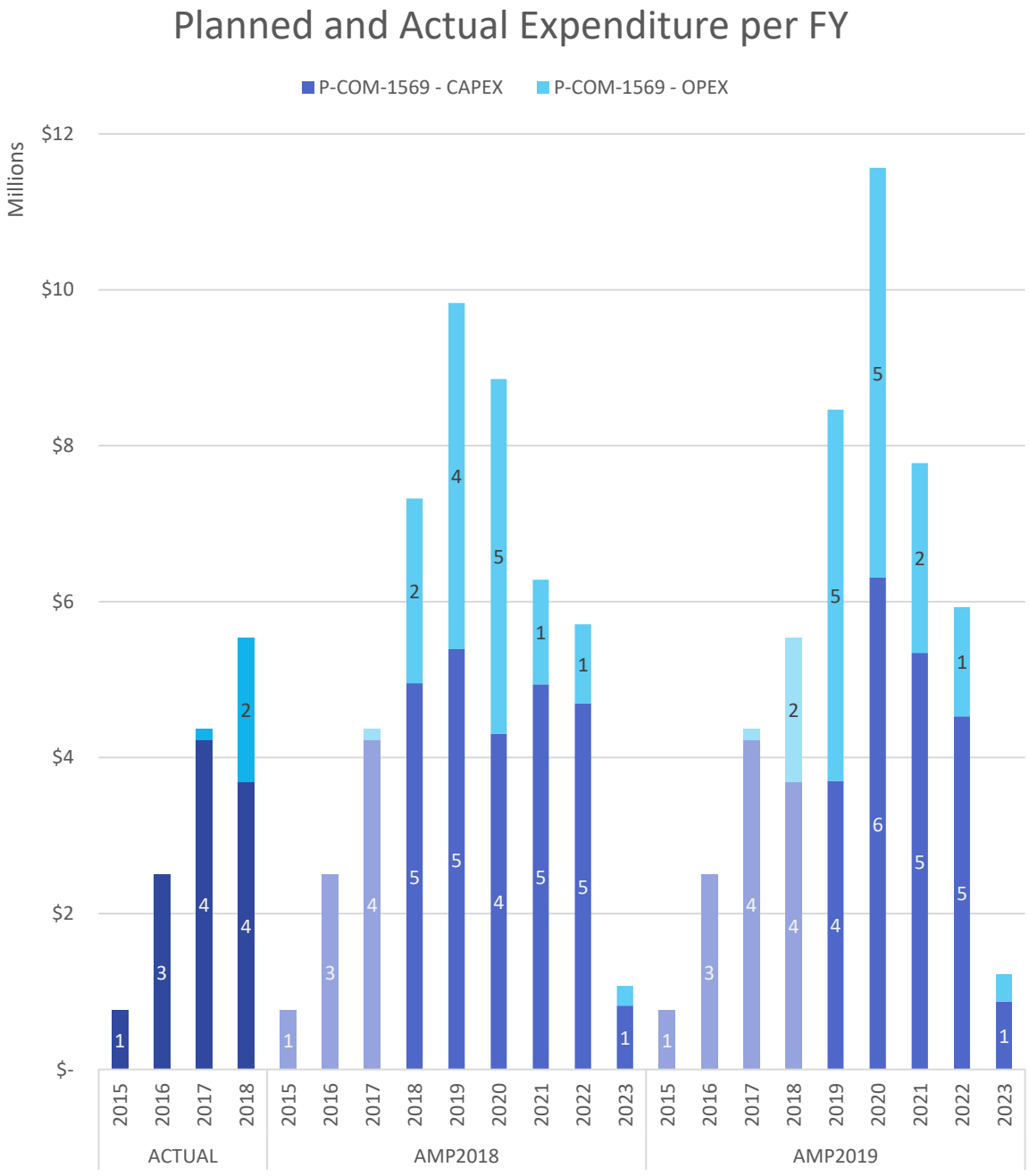

FIGURE 28: PLANNED AND ACTUAL EXPENDITURE PER FY OF THE OHAU CHAIN PROGRAM

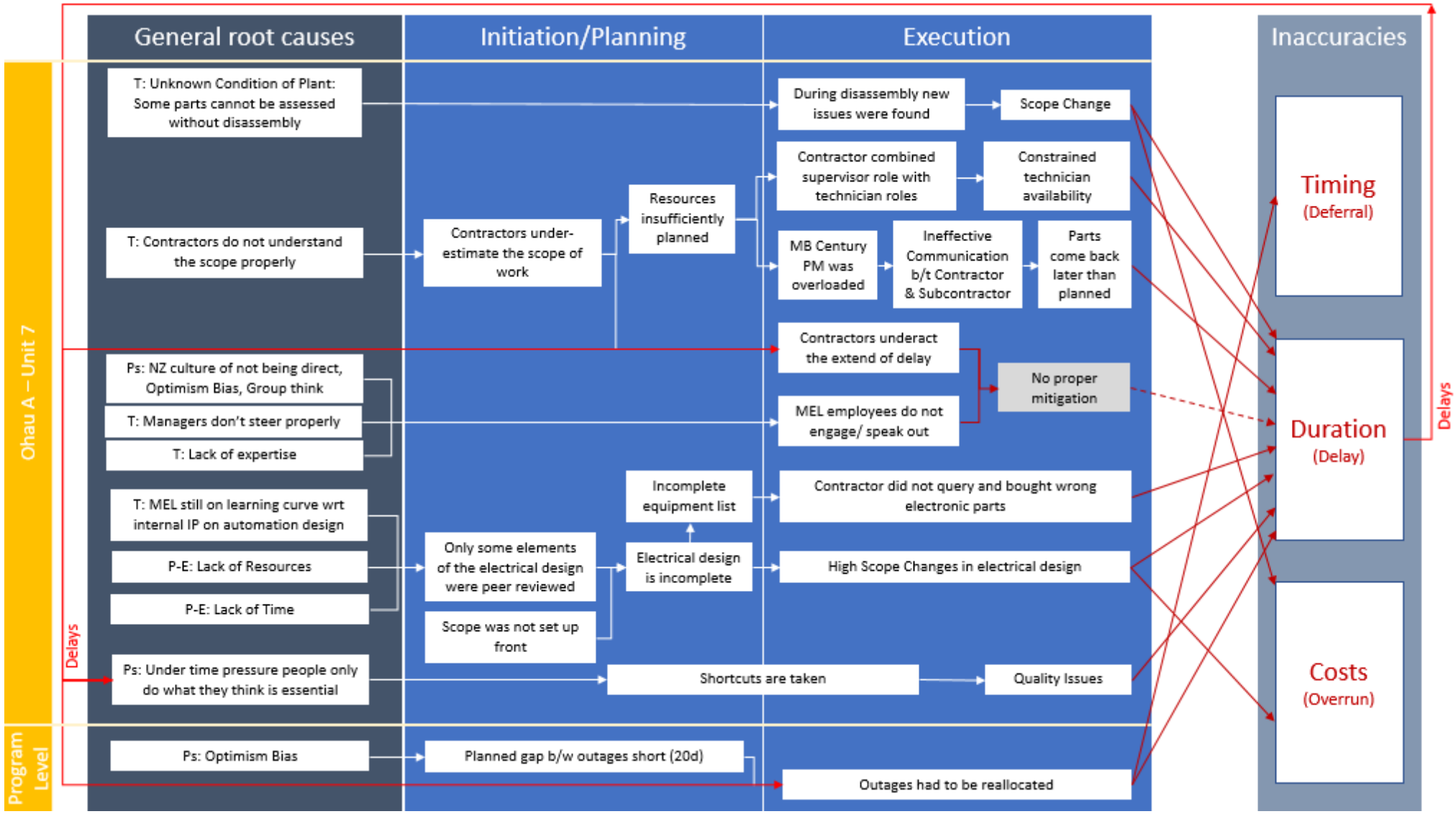

FIGURE 29: SUMMARY OF ISSUES AND ROOT CAUSES FOR INACCURACIES AT THE OHAU CHAIN PROGRAM

Appendix E.4. Benmore Cooling Water Upgrade

The following graph shows the planned and actual costs in total and per financial year:

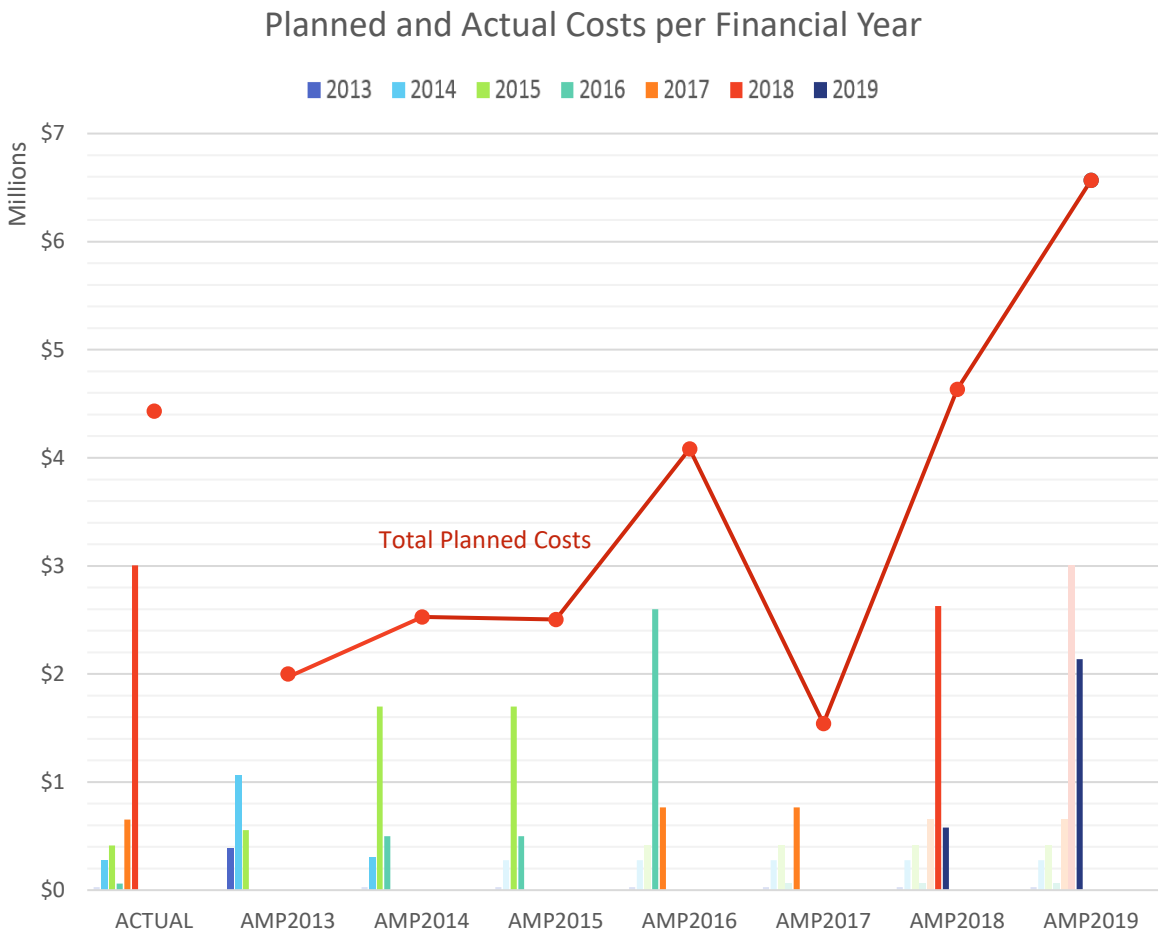

FIGURE 30: PLANNED AND ACTUAL COSTS PER FY OF THE BEN COOLING WATER REPLACEMENT PROJECT

New estimates of the BC from June 2014 should have been included in the AM planning for FY2016, however, the planned costs between the AMP and BC for FY2017 differ nearly $500k.

The following graph shows the planned end date and duration of the project. Here, the start date is the financial year in which the first money was spent on the project.

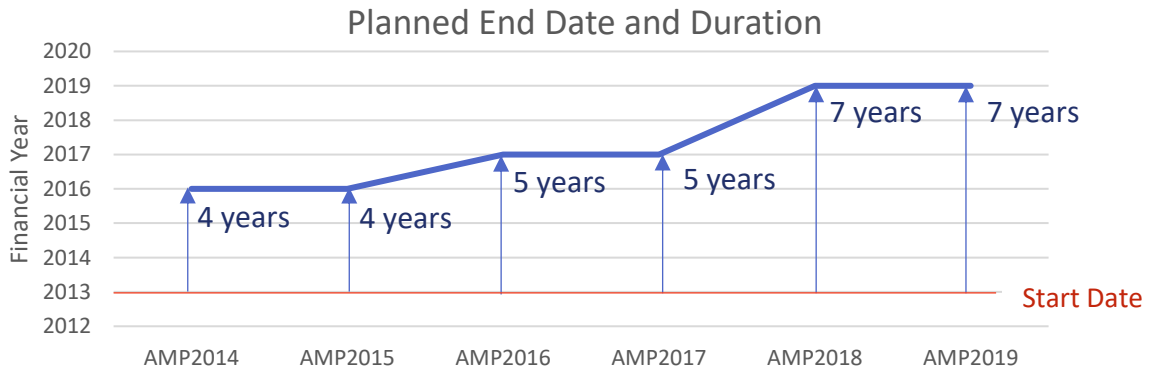

FIGURE 31: PLANNED END DATE AND DURATION OF THE BEN COOLING WATER UPGRADE PROJECT

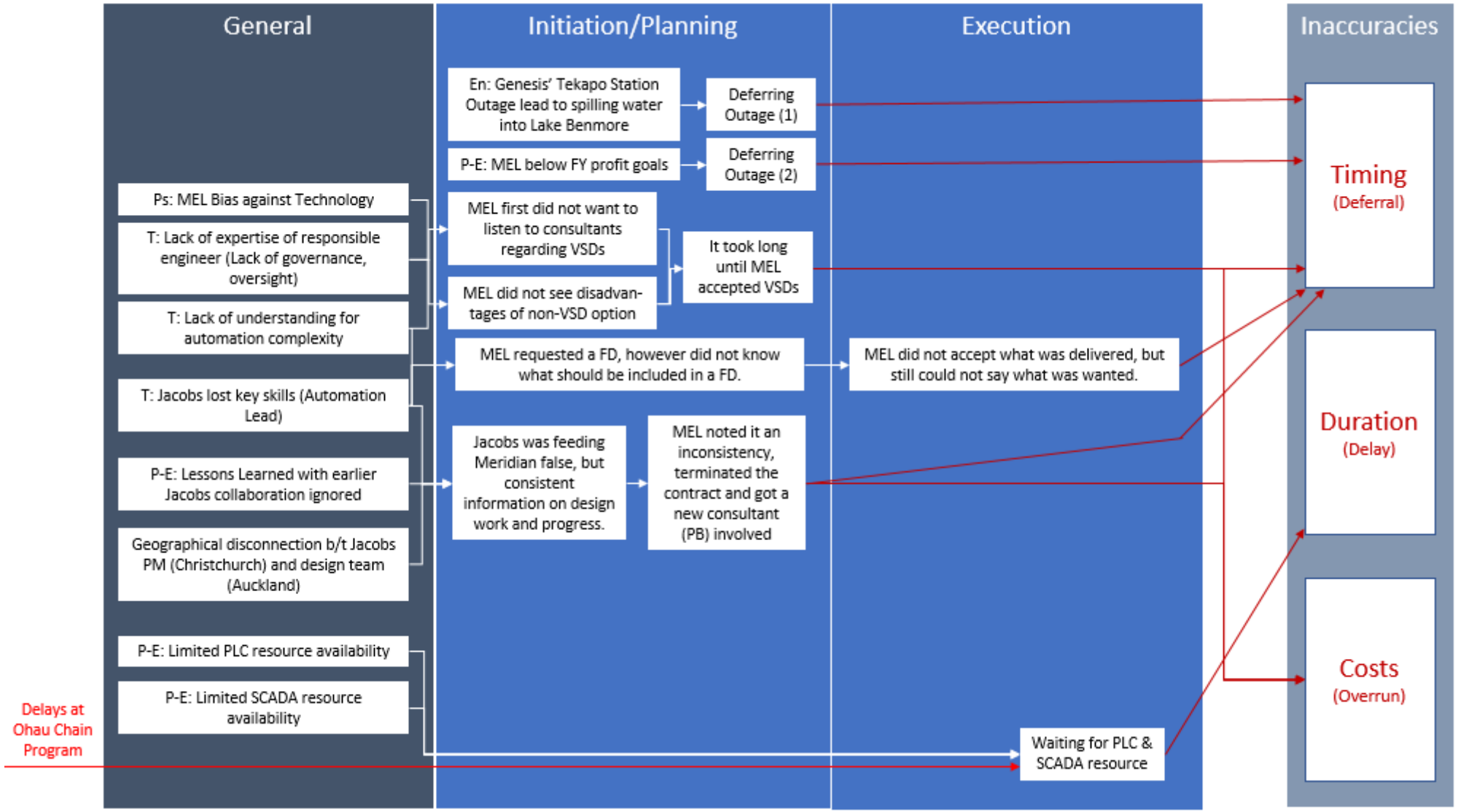

FIGURE 32: SUMMARY OF ISSUES AND ROOT CAUSES FOR INACCURACIES AT THE BEN COOLING WATER UPGRADE

Appendix E.5. Manapouri T8 & T9 Replacement

The following graph shows the actual costs up to FY2018 and the planned costs per AMP and financial year:

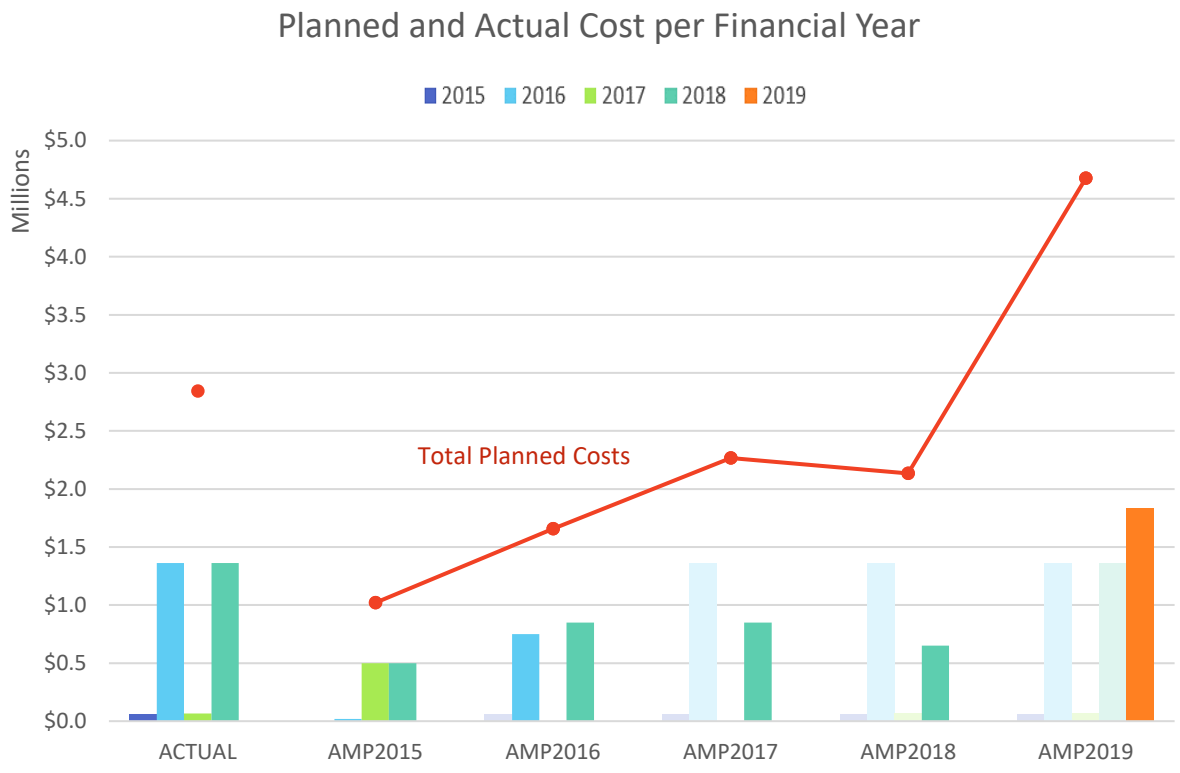

FIGURE 33: PLANNED COST AND ACTUAL COST UP TO FY2018 OF THE MAN T8&T9 REPLACEMENT PROJECT

The following figure shows the planned duration of the different AMPs over time:

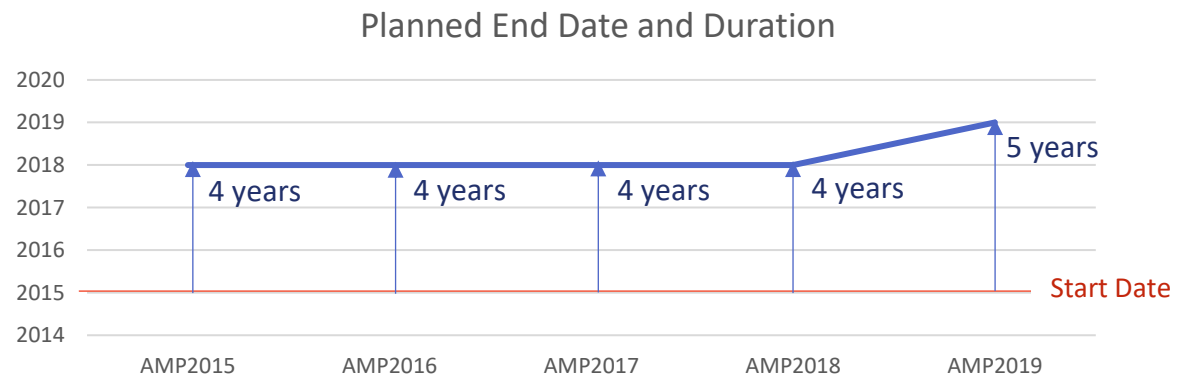

FIGURE 34: PLANNED DURATION OF THE MAN T8&T9 REPLACEMENT PROJECT

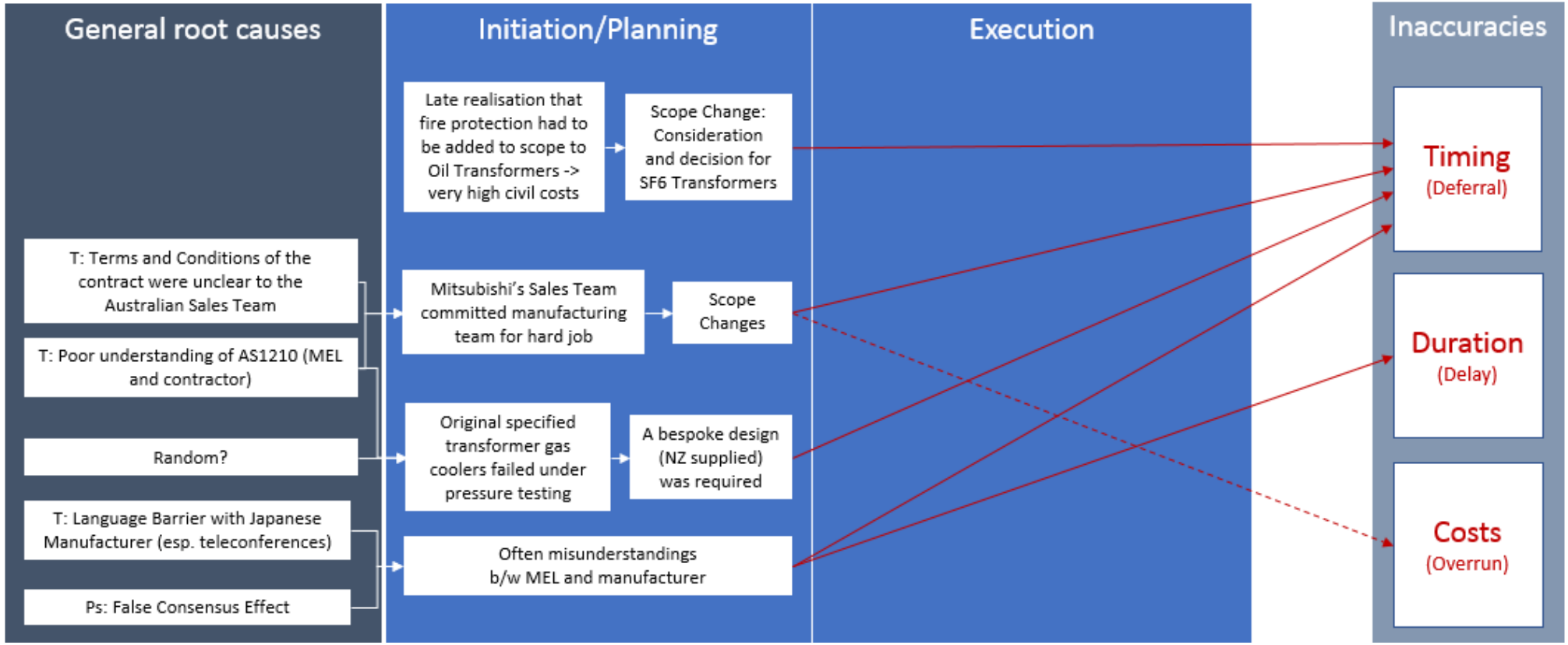

FIGURE 35: SUMMARY OF ISSUES AND ROOT CAUSES FOR INACCURACIES AT THE MAN T8&T9 REPLACEMENT PROJECT

Appendix E.6. Aviemore Local Service Replacement

The following graph shows the actual costs up to FY2018 and the planned costs per AMP and financial year. As the project is not completed, the actual costs cannot be seen as the total expenditure of the project:

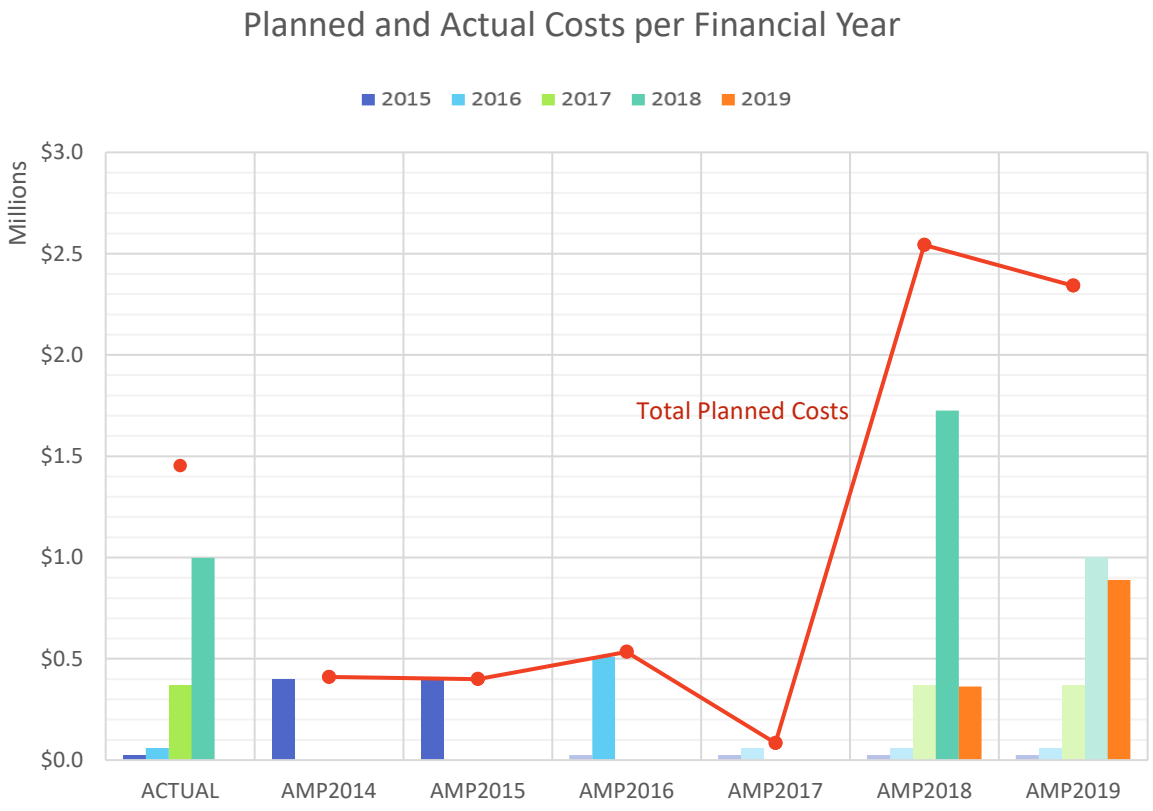

FIGURE 36: PLANNED AND ACTUAL COSTS PER FY FOR THE AVI LOCAL SERVICE REPLACEMENT PROJECT

The following graph shows the planned start date, end date and duration of the different AMPs over time:

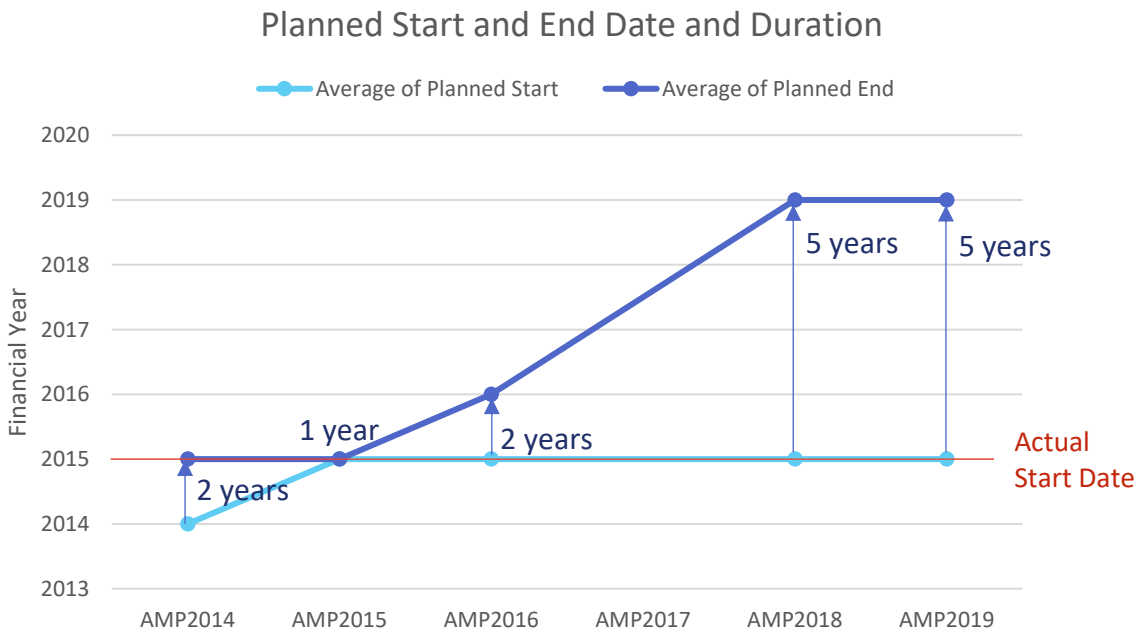

FIGURE 37: PLANNED START AND END DATE AND DURATION OF THE AVI LOCAL SERVICE REPLACEMENT PROJECT

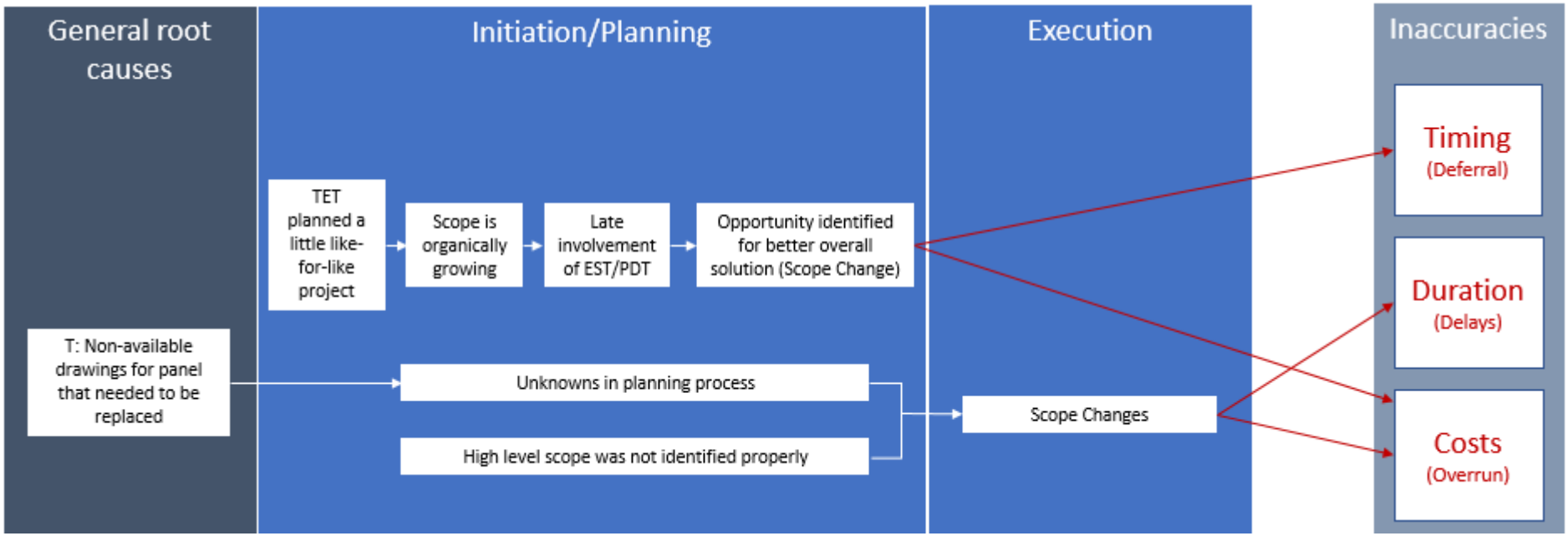

FIGURE 38: SUMMARY OF ISSUES AND ROOT CAUSES FOR INACCURACIES AT THE AVI LOCAL SERVICE REPLACEMENT PROJECT

Appendix E.7. Te Anau Lake Control

The following graph shows the actual costs up to FY2018 and the planned costs in the AMPs per FY:

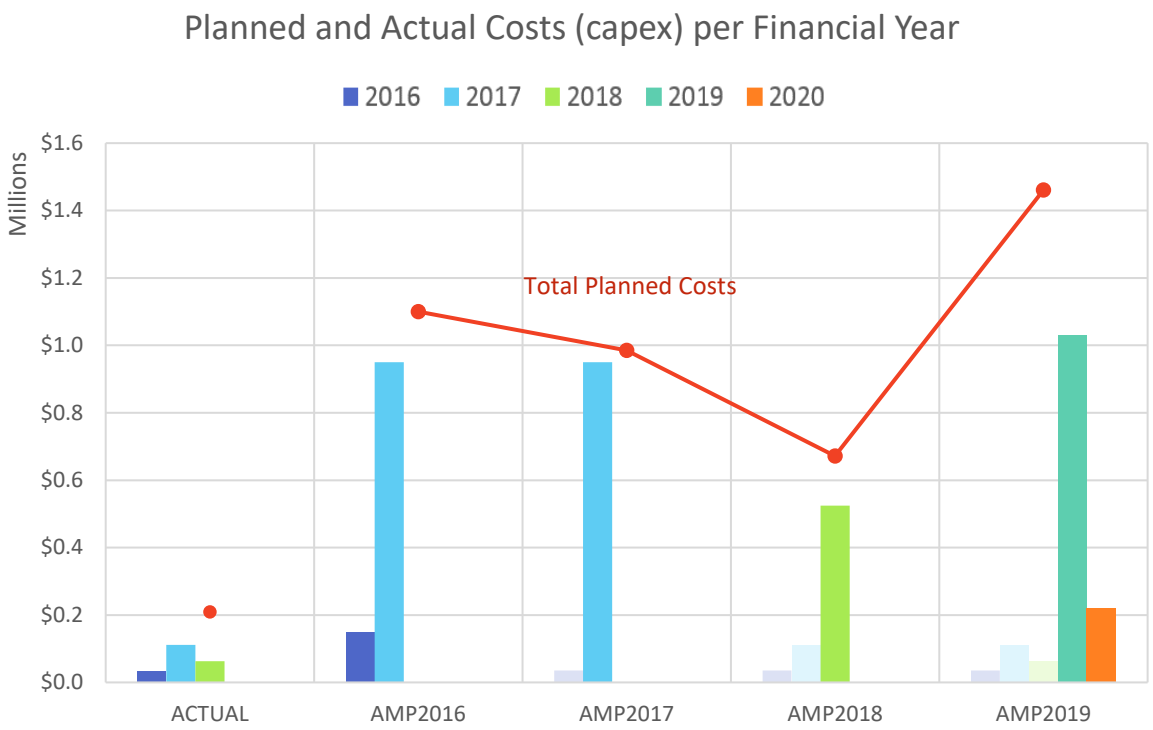

FIGURE 39: PLANNED AND ACTUAL COSTS PER FINANCIAL YEAR FOR THE TLC PROJECT

The following graph visualizes the planned end date and the duration of the project:

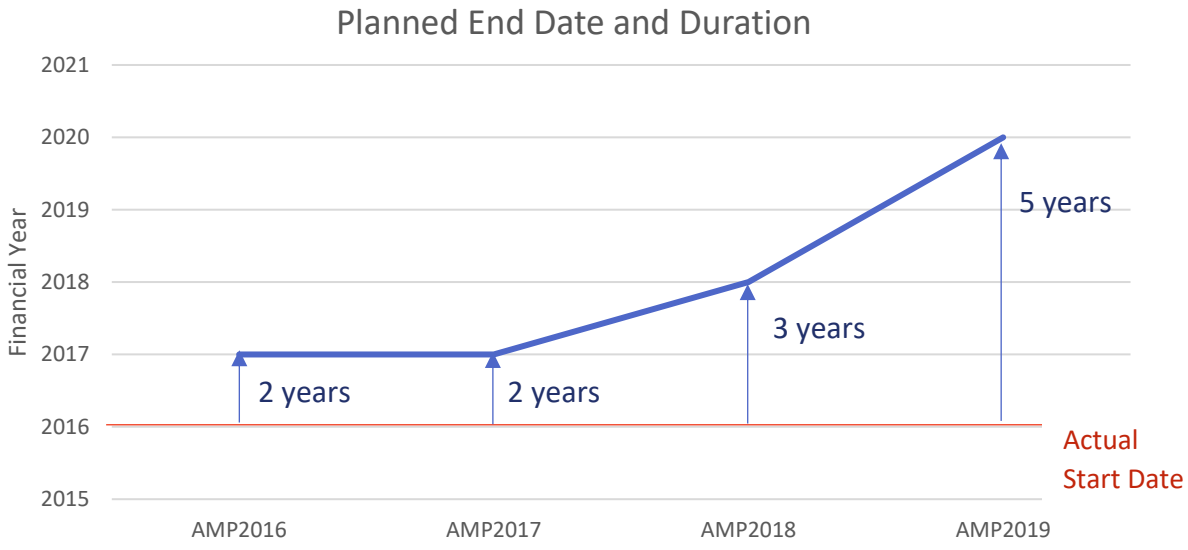

FIGURE 40: PLANNED END DATE AND DURATION OF THE TLC PROJECT

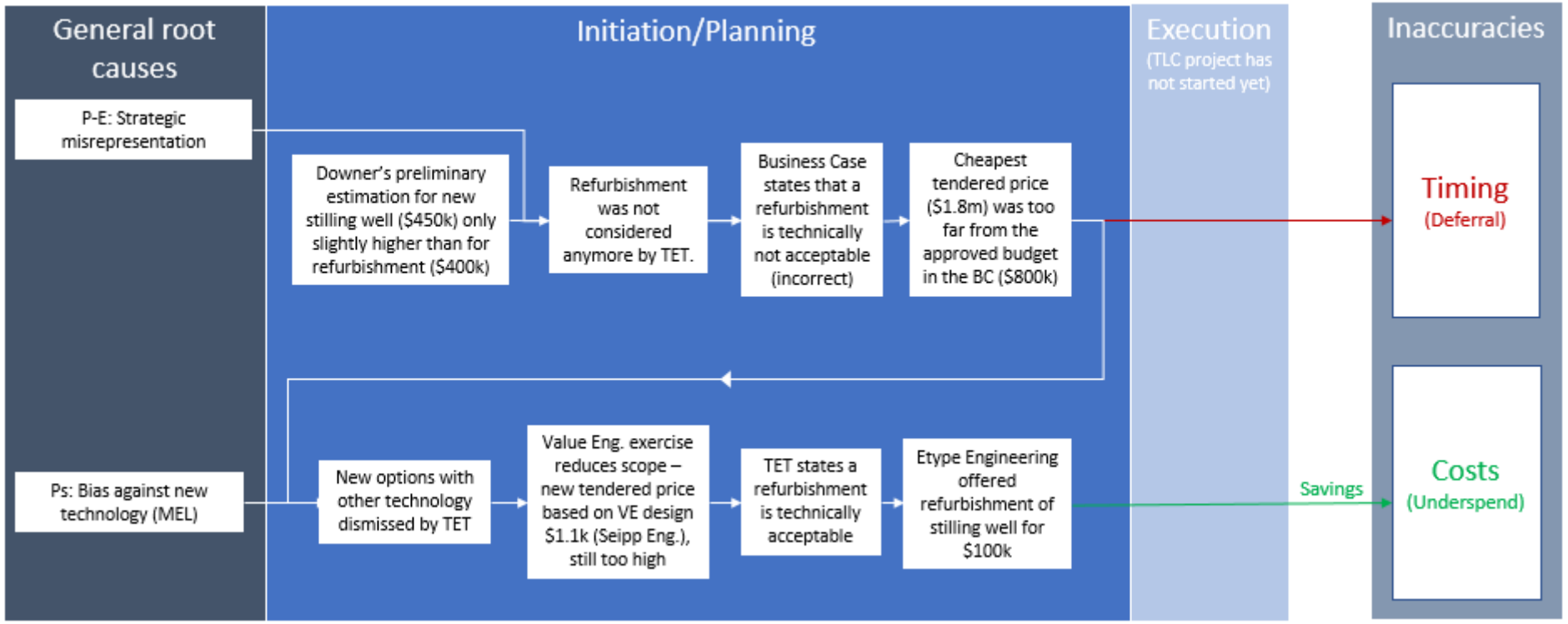

FIGURE 41: SUMMARY OF ISSUES AND ROOT CAUSES FOR INACCURACIES AT THE TLC PROJECT

Appendix E.8. Ohau B Benstock Seismic Strengthening

it was decided to make sure Meridian's penstocks are okay seismically. Part of that project was to determine what the performance standard is and to initially test all penstocks at all sites. This was the procedure for each plant:

1. Initial screening: certain stations okay, others not. We had a closer look at not so good stations
2. Conceptual design projects for each of these sites: Basic level of analysis
3. Final design and physical works

The following graph shows the planned costs per FY:

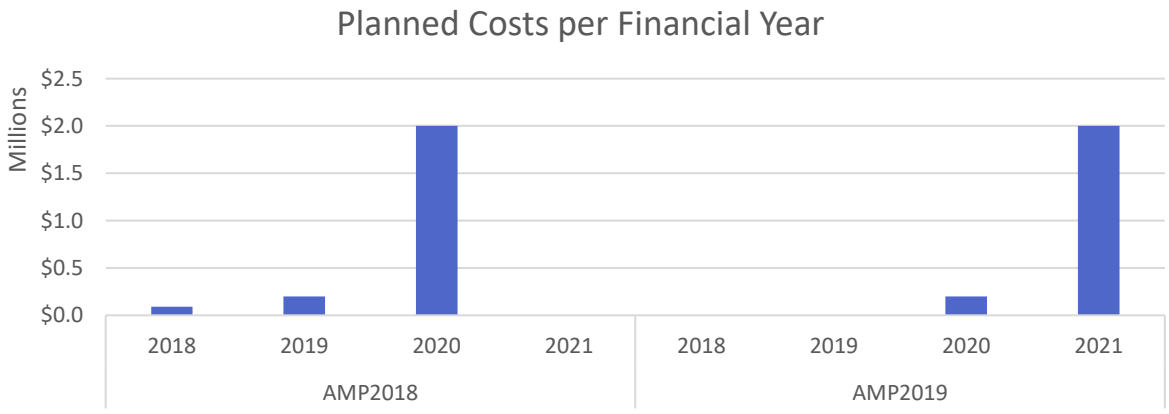

FIGURE 42: PLANNED COSTS PER FY FOR THE OHB PENSTOCK SEISMIC STRENGTHENING PROJECT

The estimations of AMP2018 and AMP2019 are identical. About $2.2m were estimated for the project at Ohau B, incl. $2m for FY2020. However, the execution of the project, which was meant for FY2020, will not happen and was dismissed.

In the preliminary design, the question was raised, if everything might be okay. No failure mode (bursting, flexing to breaking, jumping off, etc.) might okay. If the slopes underneath the penstocks would move – we did not know enough about ground below to make a judgement. A penstock slope stability investigation was carried out with the conclusion that the slope is stable enough. Relative movement of the slope wouldn't buckle or move off their pedestal. Therefore, no work was needed at the Ohau B penstocks. There was more penstock movement possible than initially expected and the project could be dismissed.

This project shows, that there are cases, in which a lot less money is spend due to the realization that the risk is lower than expected.

Appendix F. Interviews

Appendix F.1. List of internal Interviewees

TABLE 37: LIST OF INTERNAL INTERVIEWEES

Name	Department	Role	Date of Interview
Richard Griffiths	SAM	Strategic Asset Manager	throughout
Brent Wilson	EST	Engineering Strategy Manager	throughout
Jim Walker	EST	Senior Dam Safety & Civil Engineer	20th Nov 2018
Aaron Forde	EST	Strategic Electrical Engineer	23rd Nov 2018
James McDowall	EST	Electrical Engineer	23rd Nov 2018
Yanosh Irani	EST	Electrical Engineer	29th Nov 2018
Ethan Lancaster	EST	Automation Project Engineer	30th Nov 2018
Neil Sutherland	EST	Dam Safety & Civil Engineer	5th Dec 2018
Rowan Sinton	EST	Electrical Engineer	8th Nov 2018
Nick Horswell	PDT	Project Delivery Manager	throughout
Nicola Ponsonby	PDT	Project Administrator	18th Oct 2018
Paul Churton	PDT	Project Manager	24th Oct 2018 & 3rd Dec 2018
Caroline Rae	PDT	Senior Project Manager	25th Oct 2018 & 4th Dec 2018
Scott Jesen	PDT	Project Manager	28th Nov 2018
Grant Amos	PDT	Project Manager	30th Oct 2018 & 3rd Dec 2018
Alex Martin	PDT	Project Manager	3rd Dec 2018
Neil Gregory	RET	Reliability Engineering Manager	3rd Oct 2018
Perri Randle	RET	Reliability Engineer	4th Oct 2018
Ian Gardiner	COM	Maintenance Performance Analyst	25th Oct 2018
Sarah Grimes	COM	Finance Analyst - Hydro	26th Oct 2018
Peter Johnson	COM	Procurement Specialist	29th Oct 2018
Paul Lloyd	HM	Hydro Maintenance Manager	25th Oct 2018
Graham White	HM	Maintenance Planner	25th Oct 2018
Jacinda Burke	HM	Maintenance Planner	25th Oct 2018
Jade Lloyd	TET	Project Manager TET	25th Oct 2018

Appendix F.2. Overview on mentioned Points

TABLE 38: OVERVIEW OF RELEVANT MENTIONED POINTS IN INTERVIEWS

Type	Category	Title	Description
Positive	People	Good culture at Meridian	Good working together and collaboration
	People	High level of professionalism	Meridian employees are good in what they do
	Other	Continuous improvements throughout the years	Meridian has made a good effort to improve their processes continuously
Negative	Processes	Limited PLC and SCADA Resources	Piet as PLC specialist and SCADA trained people are very limited
	Processes	Lost confidence in project planning	related to timing and duration
	Systems	Number of Systems for PMs is too high	
	Systems	No proper system for financial modelling	Excel is used for forecasting
	Processes	Process mapping not available for PMs	more difficult start for newcomers, leads to self-doubt and insecurities
	Processes	Process guidelines are too flexible	Projects can be handled as the PM wants to, high level of flexibility leads to non-standardised procedures that take longer.
	Other	KPIs might give wrong Incentives	KPIs of Hydro Maintenance Team refer to lengths of outages. If they want to meet KPIs they work against PMs and might work against firm objectives.
	Processes	Which projects get included in AMP is arbitrary	No firm rules what gets included in the AMP
	Processes	Cost estimates are very dependent on person	As the cost estimations are mostly guessed and very subjective
	Processes	Arbitrary which projects get done	No firm rules what gets included and what does not, sometimes everything is dropped for another project
	Processes	Estimates are subjective	Estimates are guesses and very dependent on the estimator, there is no clear forecasting method.
	Communi-cation	Too many lessons learned - too time consuming to find little diamonds	Little diamonds in lessons learned have to be better communicated
	Communi-cation	Every person documents projects in a different way - hard to understand	hard to retrace information from earlier projects if you were not involved, even well documented projects
	Processes	No redundancy in staffing	No back up for Richard to sign off projects
	People	Internally, people are not demanding enough to get what is needed	
	Processes	Risk Management is not followed through properly	There is no focus on Risk Management once the project has started, and no one would realise if a PM does not do it properly.
	People	Anchoring Effect to earlier inaccurate estimates	People get numbers stuck in their head, new estimates too close to old estimates

Appendix G. Recommended Solutions

Appendix G.1. Improving initial data in AMP

> "Those who plan do better than those who do not plan even though they rarely stick to their plan." – Winston Churchill

Risk Identification Site Workshops prior to Pre-AMP Workshops

IMPROVE KNOWLEDGE OF RISKS, MITIGATE EMERGENT ISSUES

As 71% of major projects were only included in the AMP before (58%) or not even included in an AMP before the start (13%) (see milestone report 2), it should be ensured that risks are identified as soon as possible and especially that all the risks are captured. Currently, the risks are collected throughout the year in the AMP database, which is good. However, some things might get missed during that process.

To ensure that as many risks as possible in one plant are identified and captured, **risk identification site workshops should be implemented.** The people that are regularly at the site and know it best should take part in it – the site manager is here responsible for setting the date and the invitation. At these workshops, **actions can be allocated to investigate the risk further**. At the Pre-AMP Workshops, the results of investigations can be discussed, and risk scores can be confirmed or adjusted. The risk identification workshops should be implemented in the next AMP-Planning process for FY2021 and its results reviewed afterwards.

Support for estimating costs

IMPROVE LACK OF EXPERTISE/EXPERIENCE

Currently, estimates are all done in different ways – within engineers but also within project managers. In addition, the engineers often miss certain costs in a project, as e.g. capitalized salary, which leads to major inaccuracies in the AMP planning. In the following, different options for supports for project estimates are presented:

- **Cost Estimate Checklists**
  A quite simple option would be to implement cost estimate checklists and templates for AMP estimates, however also for business cases later.

- **Early Project Manager Involvement**
  For major projects, project managers should get involved as soon as the project makes the cut in the AMP and the scope is defined – before approval of the AMP. The PM can support the engineers with the cost estimates in the AMP.

- **Professional Estimator**
  This option would require an additional financial resource that would be responsible for the EST and PDT teams in Christchurch supports in building up estimates and interprets the numbers. It is the best way to get accurate data, however requires high costs.

Peer Reviews of Scoping and Estimates

ACKNOWLEDGE HONEST MISTAKES AND STRATEGIC MISREPRESENTATION

The estimates in the AMP are mostly subjective. The estimate is always different depending on the person who puts up the estimation. This is mainly because there are no clear processes on how to estimate properly and it is mostly done by one person alone. In the AMP workshops, the projects' estimates are quickly scanned through. It does not allow enough time to review them properly.

To mitigate the issue described above, **compulsory peer reviews**[11] should be implemented for AMP estimates to make sure the estimates are reasonable, and nothing is missed.

Time Allocation for Scoping and Planning Activities

IMPROVE TIME PRIORITIZATION FOR PLANNING

In the initial AMP, the scope of a project is unclear, and costs and duration are guessed. A lot of scope changes happen after estimates are put in and the AMP got approved. Proper scoping and planning, as done for the business case, are essential to get more accurate estimates. To ensure that people scope and plan properly, for major projects **time and money should be allocated for detailed planning for the year before the project is meant to start**. In this way, the estimates can be improved a year before you start in a clear allocated time. It is not intended to do the planning right on the spot if the project shall happen in two years or even further away as still a lot of things could change, e.g. projects often get deferred, because the risk is not as high as initially thought.

However, it was found that only 29% of non-annualized major projects are identified minimum in two AMPs before, e.g. identified in AMP2016 for start in FY2017 (see milestone report 2). So, only in these cases time and money can specifically allocated for the year before start date. Thus, for the other projects that are only included in the AMP one year before start date, planning activities only take place in the same FY as the start date – the estimates for these projects in the AMP are highly inaccurate. Before the AMP approval, no real planning gets done for the following reasons:

- Especially in the second half of the FY, engineers are busy with projects' execution. Currently time is not prioritized for planning activities, especially before the AMP approval.
- In the planning process, contractors or consultants are often asked to give a free estimate on the proposed work. Without approval of the AMP, people do not like to ask for this free service.

Incentives should be given for the allocation of more time for scoping and planning activities before the AMP approval (see section 0). It has to be made clear that **no guesses** without clear a small investigation regarding the scope and corresponding costs **are allowed to be put into the AMP** for a major project with a risk score higher than 10, specifically when the project is supposed to happen in the next FY.

The point that the project in the AMP above a risk score of 10 is not approved yet and therefore planning activities have not started is rather an excuse. The SAM team is empowered to make the decision on which projects will be delivered and which ones not. When they make the cut in the AMP planning, and the strategic engineers agree on its importance, it will not be pushed out of the AMP. It is and should be highly encouraged to start planning for a project happening next FY if it was not approved yet in the AMP. In case, the responsible person still feels uncertain, they provide the external party with some money for the estimates.

[11] *"[A Peer Review is] a process by which something proposed […] is evaluated by a group of experts in the appropriate field."* (Merriam-Webster, n.d.)

Give Incentives for accurate Estimates

IMPROVE TIME PRIORITIZATION AND MITIGATE STRATEGIC MISREPRESENTATION

Theory

> "People respond to incentives" Greg Mankiw

From an economic viewpoint, there is little incentive to the individual making the estimates, to do it correctly. In fact, there is a large incentive for the individual to underestimate project duration and costs. Underestimating on a project takes less time and could be classified as easier; meaning less work for the individual for the same financial benefit.

Application at Meridian

At Meridian, no real incentives are present to get the estimates in the AMP right. The managers do not emphasize its importance, and high inaccuracies of the project estimates in the AMP do not actually lead to financial constraints in the project. There is a consensus that these estimates are not accurate, and nobody expects them to be accurate. To get people to prioritize time for proper planning, incentives should be given. At Meridian possible incentives could be:

- A reward, in some form, e.g. the best estimator of the FY award, to be given out if the AMP estimate is within a certain degree[12] of the actual costs and duration.
- Record of AMP's and projects' past estimate accuracy – KPIs.

The incentives can be given for project managers and engineers. When the project managers have a higher incentive in getting AMP estimates right, it might close the gap between asset management planning and the project delivery. The responsibility of precise estimates in the AMP should, however, still lie with the EST team.

Plan to do less

FACTOR IN EMERGENT ISSUES, MITIGATE LACK OF RESOURCES

Currently, often projects are deferred. Reasons for that are that the risk is not as high as thought, or in other cases emergent projects come up and people do not find the time to do them. Furthermore, it was found that the projects that are deferred and managed are not always the ones with the lowest risk score, rather the more complicated projects.

It is unlikely that no emergent issues will occur in the future, as Meridian does not have a high influence on a lot of factors in the project delivery and also on weather conditions or other external issues. Thus, Meridian should **allow contingency for emergent issues and projects**, and make the **cut in the AMP at a slightly higher risk score**. This is a good way to ensure that the projects with the highest risk scores are done and the overall AMP estimate might be more accurate, as the number of projects that are delivered are closer to the estimate in the beginning.

If Meridian does not feel comfortable with not including projects with a certain risk score or in case that there is still more work than what could be done, it should at least be made sure that the **projects' delivery is prioritized according to the risk scores**. If the managers do not show interest in the sequence of project delivery, the engineers will most likely prioritize their projects according to the least effort that is involved. The managers should emphasize in the beginning of the FY, which project(s) the engineers should drop first if they do not find enough time during the FY. After each FY it should be reviewed which projects got done and which ones not and if it was according to the prioritization score.

[12] An internal committee could determine acceptable degree of estimate accuracy or allowance.

Reference Cast Forecasting

IMPROVE FORECASTING TECHNIQUES AND MITIGATE LACK OF EXPERIENCE

Theory

This method takes an 'outside view' – basing forecasts on actual performance of comparable past projects rather than focusing only on the project in progress (Eythorsdottir, 2012). In comparison to the 'outside view' approach, taking an 'inside view' tends to result in overconfidence and biases through human judgement. In reference class forecasting, it is not tried to forecast specific uncertain events affecting a project, instead the project is positioned into statistical distribution of outcomes, which relates to the same reference class of projects (Kahneman & Tversky, 1979).

Reference class forecasting requires the following three steps for a specific project:

1. **Identify a relevant reference class**
   The class must be broad enough to be statistically meaningful but narrow enough to be truly comparable with the specific project.
2. **Establish a probability distribution for the selected reference class**
   This requires access to credible empirical data for a sufficient number of projects.
3. **Compare the specific project with the reference class distribution**
   To establish the most likely outcome for the specific project, as shown in Figure 43

The 'uplift' referred to in Figure 43, corresponds to the amount of extra cost that needs be added to the proponent estimate to ensure a 50% likelihood of the project finishing on budget. Ideally, the mean of the proponent forecast should sit to the right of the reference forecast's mean. In other words, there will be a negative 'uplift', which would correspond to an added contingency.

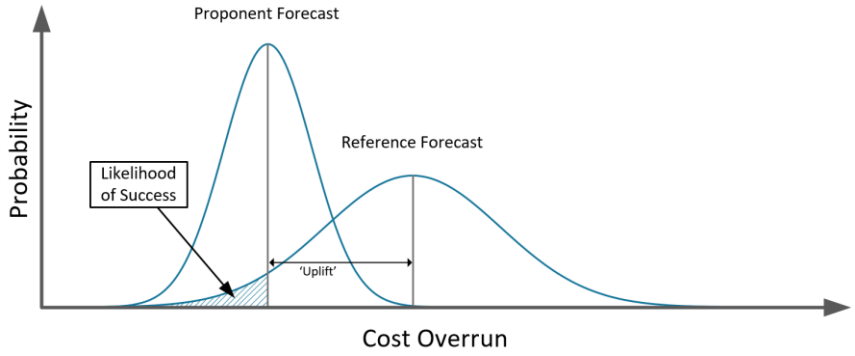

FIGURE 43: PROJECT COMPARISON TO REFERENCE CLASS TO DETERMINE THE LIKELIHOOD OF SUCCESS

Application at Meridian

As mentioned before, the estimations at Meridian are subjective and not reproducible. The method of reference class forecasting has proved in other industries to increase the accuracy of estimates. However, regarding major projects at Meridian, it is hard to find a relevant reference class that is statistically meaningful and narrow enough to compare a project with it (see step 1 above). Parts are replaced every 5 to 20 years or even later with a preceding refurbishment. Each site has different characteristics and obstacles. Even if the projects at the different sites could be added to the same reference class, as many years lie between the statistics of the reference class and

Optimism Bias Adjustments

Factor in Optimism Bias

Theory

Her Majesty's (HM) Treasury issued "The Green Book", which provides guidance for government officials in the UK to develop objective and transparent appraisals and evaluations of proposals. A supplementary to the Green Book guidance deals with the optimism bias[13]. It was demonstrated that there is a systematic tendency for project appraisers to be over-optimistic about their estimations. As the optimistic estimates can result in commitments to undeliverable targets it is recommended to make adjustments to the project's costs, benefits and duration. The following table presents the recommended adjustment ranges for the optimism bias (HM Treasury, 2018a) (HM Treasury, 2018b):

Table 39: Recommended Adjustment Ranges (HM Treasury, 2018b)

Project Type	Optimism Bias (%)			
	Works Duration		Capital Expenditure	
	Upper	Lower	Upper	Lower
Standard Buildings	4	1	24	2
Non-standard Buildings	39	2	51	4
Standard Civil Engineering	20	1	44	3
Non-Standard Civil Engineering	25	3	66	6
Equipment/ Development	54	10	200	10
Outsourcing	N/A	N/A	41*	0*

*The optimism bias for outsourcing projects is measured for operating expenditure

The upper bound percentages in Table 39 present the average historic optimism bias for projects at the business case stage that are traditionally procured. Therefore, it provides a reasonable first starting point.

In the following the different steps for the implementation of the adjustments are listed:

1. **Decide which project type(s) to use**
   See **Error! Reference source not found.** for the definitions of the project types in Table 39. Project types may be combined.
2. **Always start with the upper bound**
   After reviews it might be lowered towards the lower bound.
3. **Consider whether the optimism bias factor can be reduced.**
   The main strategies for reducing optimism bias are:
   - Full identification of stakeholder requirements (including consultation);
   - Accurate costing; and
   - Project and risk management.
4. **Apply the optimism bias factor**
   The present capital cost and duration estimation should be multiplied by the optimism bias factor. The result can then be added to the total net present cost.
5. **Review the optimism bias adjustment**
   Before the optimism bias factor is reduced clear and tangible evidence for the mitigation have to be observed.

[13] *"Optimism bias […] is the proven tendency for appraisers to be too optimistic about key project parameters, including costs, duration and benefits delivery."* (HM Treasury, 2018a)

Application at Meridian

It was shown that the major projects at Meridian are mostly highly underestimated in duration and costs (see milestone report 2). The longer duration of the projects shifts the completion to the back. Meridian is quite risk-averse, and it is important to the company to get the timing of their projects right. This proves that optimism bias adjustments are necessary to increase the estimation accuracies in the AMP and in the BCs.

However, the costs for major projects in the AMP in one FY are mostly overestimated. The main reason for that is that some projects that were planned for are not undertaken (see milestone report 2). Thus, the optimism bias adjustments to capital expenditure might lead to even higher underspending of the overall AMP budgets, it would lead to more accurate total costs of individual projects though. Optimism bias adjustments to the cost estimates are still encouraged to increase the estimate accuracy of individual projects, if it is made sure that all the projects can be delivered in the next year – either through planning to do less (see section 0) or employing further engineers (see section 0).

Appendix G.2. Ensure the Feedback Loop

> "Mistakes should be examined, learned from, and discarded; not dwelled upon and stored." – Tim Fargo

A key fundamental cybernetic principle is feedback. With feedback it is possible to control the behavior of a system in a manner which is desired. The desired behavior is compared with the actual behavior from the negative feedback loop by the controller, who then influences the system to control the input producing stability (Kongsberg, 2012).

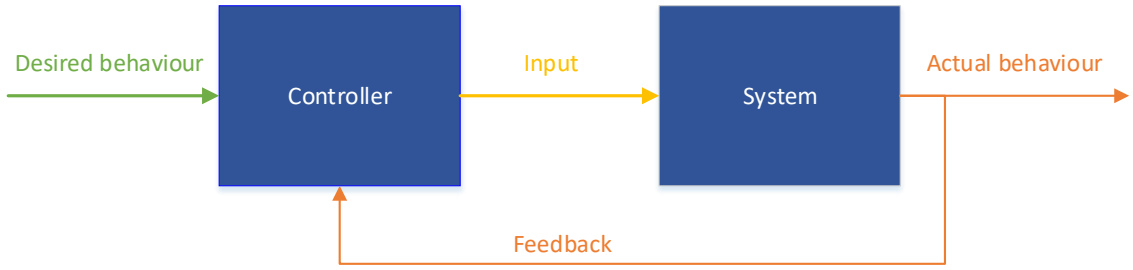

FIGURE 44: BASIC CYBERNETIC CAUSALITY

Alignment of Data Streams

IMPROVE DATA FEEDBACK AND INCREASE TRANSPARENCY

The following table shows the different data systems used in the AM process:

TABLE 40: DATAFLOW IN A FINANCIAL YEAR (JULY-JUNE)

	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
AMP Database						Hydro AMP				reconcile		
AMP Spreadsheet								GNR budget				
Cognos										MEL budget		
NAV												→

Up to January the risks and projects are managed within the AMP database. Then, the list of AMP projects that made the cut are exported from the database into an excel spreadsheet. From February to March in the approval process for the GNR budget slight changes might be made. These get

reconciled after that back into the AMP database. At the same time the Meridian Group budget is generated in Cognos, which is a reporting tool. In June, the COM team creates all the new projects that made the cut into the FY budget into NAV[14]. The project IDs in the AMP Database and NAV are different and not directly connected. The COM team now adds the NAV ID into the AMP spreadsheet with the AMP IDs that they received. In NAV, only the recent estimates (not AMP estimates) are being compared with the actual expenditure.

Two issues were noted at Meridian regarding the non-alignment of the AMP and the recent forecasts and actuals in NAV:

- **Measuring AMP estimates' accuracy**

  > "You cannot manage what you do not measure." – Peter Drucker

  In the data analysis, there were particular difficulties with connecting the AMP projects, which were documented for each year in AMP spreadsheets. If the accuracies of the project estimates in the AMP shall be improved, it must be able to measure it in a clear and tangible way.

  It would be a huge effort to implement another tool that would implement both functions, as NAV is used within the whole company. It is not possible to add the functions of the AMP database in NAV. However, for measuring purposes it should be possible to write a Visual Basics for Applications (VBA) code with referral to the IDs in the AMP Spreadsheet and obtaining the estimates from the different AMP spreadsheets and the more recent estimates and actual expenditure from NAV. It might take one to five full days for one person who has created VBAs before (time dependent on experience level), to program the code. A person should be identified that is able to create VBAs or has the interest and time to acquire the knowledge himself/herself (IT person or graduate).

- **Adopting recent estimates of Projects to the AMP**

  > "If it is not documented, it doesn't exist … As long information is retained in someone's head, it is vulnerable to loss." – Louis Fried

  In the case studies for the root cause analysis it was found that some estimates of the Business Cases (BCs) were not included in the new AMPs. Thus, the AMP was more inaccurate than necessary.

  Since the AM planning this year (for FY2020), the EST manager started to review the recent estimates of the major projects managed by the PDT team. He then manually updated the estimates in the AMP Database. Internally, it is seen as a good process as the EST manager is aware of all the key changes and why, however it is not transparent throughout. Estimates for all projects could be updated automatically and a deviation report could then be created to provide transparency regarding the major changes made by the project managers.

[14] Note that this process was only adapted this FY (2019). Before that projects were only created in NAV as soon as they started, and when costs were allocated.

Improve Communication of Lessons Learned

MITIGATE LACK OF EXPERTISE/EXPERIENCE

Theory

"A lesson learned is a knowledge or understanding gained by experience. The experience may be positive, as in a successful test or mission, or negative, as in a mishap or failure. Successes are also considered sources of lessons learned. A lesson must be significant in that it has a real or assumed impact on operations; valid in that is factually and technically correct; and applicable in that it identifies a specific design, process, or decision that reduces or eliminates the potential for failures and mishaps or reinforces a positive result." (Secchi, Ciashi, & Spence, 1999)

FIGURE 45: LESSONS LEARNED PROCESS

Application at Meridian

At Meridian, a lesson learned (LL) process is in place. The LLs are captured in a LL register, in an excel spreadsheet (structure shown in **Error! Reference source not found.**) with currently 328 entries mainly by project managers. The project managers have a KPI that requires that they enter min. one LL in one quarter, which then get reviewed and approved by the PDT manager. The project managers also have to review the LLs when planning new projects.

However, the reviews of LLs are quite cumbersome as there are a huge number of entries and it takes a while to review them. The register has to get reviewed for relevance. Some LLs should be able to be joined together in one LL to reduce the amount of entries. In the same process, a priority score should be added to the LLs as it makes it easier and more effective for people to have a look at and review the LLs.

The engineering teams currently do not discuss LLs. It was found that they rather talk about their experiences when they casually see each other in the office, however these do not get documented or shared with the whole group. Quarterly, in the team meeting, time should be allocated for the discussion of LLs, which should be documented afterwards.

Appendix G.3. Governance for Project Delivery and Changes

> "A good plan can help with risk analyses, but it will never guarantee the smooth running of the project." – Bentley & Borman

Clear Allocation of Team Tasks and Responsibilities (TET-EST)

IMPROVE ALLOCATION OF EXPERTISE AND RESOURCES

It was found that there is no clear allocation between the Tactical Engineering Team (TET) based in Twizel and the Engineering Strategy Team (EST) based in Christchurch. Regarding to major projects, a lot of projects were initially managed by the TET team, although strategic projects are meant to be handled by the EST or PDT team. In the case studies (see milestone report 3), it was found that a lot of the projects started as TET managed projects, however got EST and PDT involved later as engineering and project manager lead respectively. In general, it was found that many major projects are actually managed by the TET, which does not play to their strengths.

If the tasks are allocated in a clearer way the projects could have been allocated more adequately right from the beginning which could have saved time, as the scope might have been more clear right from the beginning.

Employ more Engineers – additional FTEs

IMPROVE AUTOMATION EXPERTISE AND LACK OF RESOURCES

Currently, a lot of engineers do not find the time to conduct all the projects they are assigned to. One additional FTE as an automation engineer was now already approved. This should loosen the schedule of the EST team and might improve the lack in automation expertise. No further actions are recommended so far. The TET team is still overwhelmed with the amount of work, which could be mitigated through action 5.1.1. However, it is always an option to employ more people. The prioritization of time has a higher factor though

Standardize Project Management

MITIGATE LACK OF EXPERTISE/EXPERIENCE

There are a lot of issues in the project management that are hard to be influenced. It was found that project managers who are the project management lead for the first time, tend to have difficulties. Each industry and company does project management in a different way. There are PM guidelines in place that are comprehensive, inaccurate and not up to date. It would be a very high effort to update all the standards, however, a process map with distinctive gateways that happen in most projects would ease the start in Meridian's PM in the AM.

In addition, currently no PM tools are used. PM tools might support the project manager in the project planning and delivery. Especially with tracking progress and transparency. It should be investigated; what technology is available to better help manage jobs.

Project Risk Management – Pay Attention to Red Flags

IMPROVE FORECASTING TECHNIQUE AND FACTOR IN EMERGENCE

Theory

Every project contains risk, which could include financial, time, security, reputation, and safety risks. It is vital to identify as many of the risks as possible before commencing the project. Risk management is "*coordinated activities to direct and control and organization with regard to risk – the effect of uncertainty on objectives.*" (ISO, 2018) Table 41 shows a way to identify risks corresponding to the Work Breakdown Structure (WBS). Once identified the risks can be accessed and controlled via the appropriate means.

TABLE 41: A TEMPLATE FOR IDENTIFYING THE RISKS AT EACH DECOMPOSED WORK PACKAGE, WITH THE RISK RATING BEFORE AND AFTER THE CONTROL PROTOCOLS ARE IMPLEMENTED.

Sequence of Works	What are the risks?	Initial Risk	What controls are required?	Residual Risk
Work breakdown from WBS	List the risks identified in each step of the process.	L x S	Hierarchy of risk control: (Elimination – Substitution – Isolation – Engineering Controls – Administration – Personal Protective Equipment)	L' x S'
1. Activity				
1.1 Task				
1.1.1 Sub-Task				
1.1.2 Sub-Task.				

The risk of project underestimation increases with a higher level of the technical project dimensions shown in Figure 46 on the right:

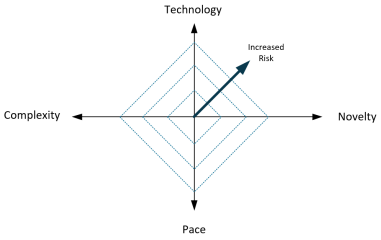

FIGURE 46: PROJECT DIMENSIONS, CF. (BEUKMAN, 2018)

Application at Meridian

Regarding the underestimation of major projects at Meridian the following technical red flags were identified:

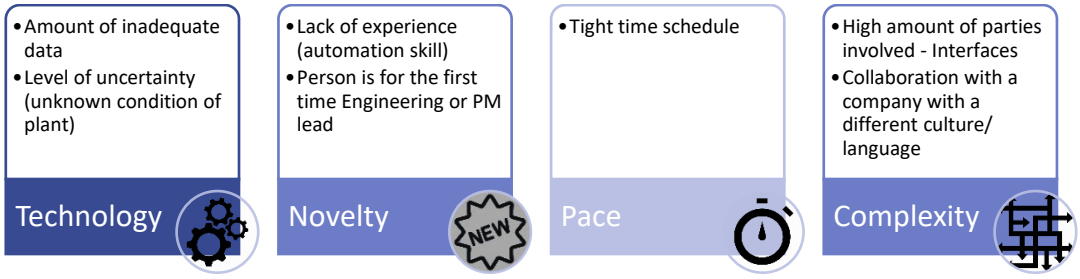

FIGURE 47: EARLY INDICATORS FOR COST OVERRUNS AND DELAYS

These red flags should be reviewed specifically when planning and delivering a project.

It was found that risk management within projects is not reviewed regularly. It is not emphasized by the managers to keep it updated properly, which gives the PMs less incentives to do so.

Appendix G.4. Miscellaneous

Data Storage Improvements

MITIGATE LACK OF EXPERTISE/TRANSPARENCY, MITIGATE INADEQUATE DATA

At Meridian, the expertise mostly lies within people and not always in a documented way. It was found that it is very hard to find information when investigating a risk, etc. There are several different locations for information in terms of work orders (MAXIMO), station manuals (file site – now share point) or drawings (plant docs), etc. In addition, some information is missing, or it is very hard to find it, e.g. because they were part of another job. Especially for newcomers it is hard to find facts and often facts by word of mouth are used to reason recommendations made.

If this current state stays the same, risks are that information is lost on people and risks are not understood in the right way. The completeness of data should be reviewed and organized in an easily accessible way.

Rolling Forecast

IMPROVE TIME PRIORITIZATION & FORECASTING TECHNIQUE AND FACTOR IN EMERGENCE

Theory

Midway through the year when mid-year financial results are compared to the original budget, the budget is often getting obsolete because of changing business conditions. Companies do not put enough work into making mid-course corrections. To tackle this issue, many companies are implementing a rolling forecast – budget assumptions can be periodically updated throughout the year, resources are reallocated, and there are more accurate results that predict the future (Host Analytics, 2017).

In contrast to revised forecasts or budgets a rolling forecast looks beyond this financial year. The rolling forecast includes min. 12 forecast periods (months), however can also have 18, 24 or more. As soon as the forecast 'rolls' forward, the same number of forecast periods has to be included. The following figure visualizes a rolling forecast (Strategic Focus, 2019):

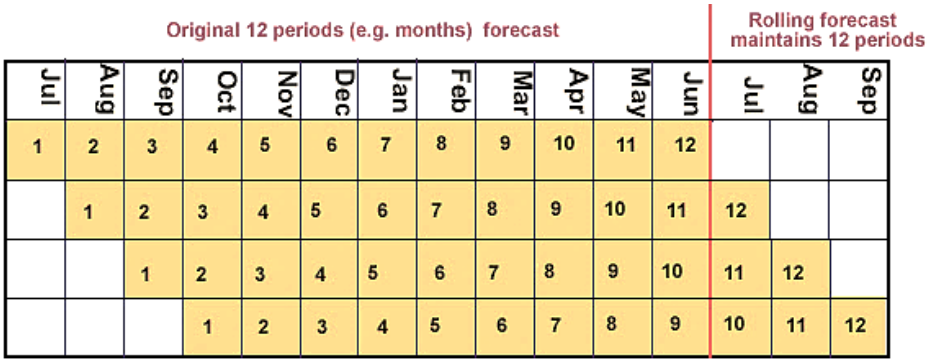

FIGURE 48: ROLLING FORECAST PERIODS (CASH FOCUS, N.D.)

The following benefits of using a rolling forecast are shown (CFI, 2019):

- Improved risk analysis:
  Enablement of quick responses to changing economic and industry conditions
- Increased accuracy in financial planning:
  Having an accurate handle on likely future cash flows in the business

The following factors steer the success of a rolling forecast implementation (Melnychuk, 2013):

1. **Culture:** Support from Top Management, Acceptance by Participants
2. **Systems***:* Total forecast= Base line (Driver-Based rolling forecast) + Projects (Separate planning)
3. **People:** Analytical
4. **Process:** Quick and flexible, allow for collaboration and good communication, minimize non-value adding activities, Allocate roles and responsibilities
5. **Design:** Time Frame (decision making lead times), Time Increments/ Frequency (rate of change in the environment), Details (depending on time frame, frequency & dynamics)

As a best practice, a rolling forecast is not tried to be implemented across the entire company at the beginning. A better approach is to start in one department, prove the success, and then expand into other departments (Host Analytics, 2017).

Application at Meridian

Currently, the graph showing the projects' **expenditure throughout a financial year looks like a hockey stick**:

1. In the beginning of the financial year, some projects will be completed that did not finish as planned in the FY before – *moderate expenditure*.
2. Then, new projects are planned for the next couple of months – *low expenditure*.
3. Mid way through it is realized that there is not enough time left in the FY to spend the allocated money – the *expenditure rises dramatically* with the attempt to meet the targets for the allocated budgets.[15]

[15] As an example, midway through the FY 2019 $15k of allocated $39k were spent. Now, the management pushes to spend the remaining $24k.

For funding reasons, the finance team at Meridian is interested in the monthly expenditure rather than the annual expenditure. The company has to keep a headroom of $200m at all times. If in one month a lot of money was spent for the AMP and at the same time it is very dry, and it cannot have generated and sold as much electricity as expected, the available money might decrease below $200m. In this case, Meridian has to buy new money to get Meridian's liquidity up to the limit, which is very costly. A rolling forecast within the project planning promises a better alignment with financial view. The risk reviews and strategic project reviews of the asset management planning would still need to be revised every year.

Through implementing a rolling forecast the delivery of the Asset Management Plan could benefit in the following points:

+ Higher certainty
+ Better alignment with financial view: For funding reasons next month is important
+ Higher level of flexibility/agility – rapid responses to emergence

The implementation of a rolling forecast for the AMP would affect the EST, PDT, TET, and COM team. The following requirements to make the change initially exist:

- In NAV, forecasting after the end of the FY has to be made accessible (easy change)
- In July, the COM team will have to re-enter manually the estimates that have been made for after the current FY as NAV is set to 0.
- High level of transparency is required – Upper management has to show upfront and honest how much funding they've got and how much is guaranteed.
- Culture Change –Management must get away from the one-year goal focus

The level of transparency is already quite high between the upper management and SAM team – a budget for the AMP for a three-year period was promised, which can be allocated as desired within that time frame. It will be very hard to erase the idea of a fixed budget per FY completely, as the shareholders at Meridian will continue to think in one-year steps and outages of the whole industry have to be communicated as well. The culture change must be tried to be driven by the management – the team members will follow automatically.

The SAM department would be suitable place to start implementing the rolling forecast, as the AMP and the team gain a lot of trust from the upper management and the transparency level is already quite high.

The financial team wanted to implement a rolling forecast about 10 years ago, however, it was blocked by the chairman. The current chairman is stepping down in 2019, which could work in favour of the implementation of a rolling forecast.

Anonymous Predictions – The Delphi Method

IMPROVE FORECASTING TECHNIQUE AND MITIGATE FALSE CONSENSUS BIAS/ OVERCONFIDENCE BIAS

Theory

The Delphi Method, as illustrated in Figure 49, is one method for reducing bias through anonymous predictions of several expert personal. The predictions are iterated through the panel until a consensus is reached, with feedback given to the panel each time to aid the convergence of the panel's predictions. The Delphi Technique can be used for creating Work Breakdown Structures (WBS), identifying risks and opportunities, compiling lessons learned and anytime when you usually do a brainstorming session (Cantrill, Sibbald, & Buetow, 1996).

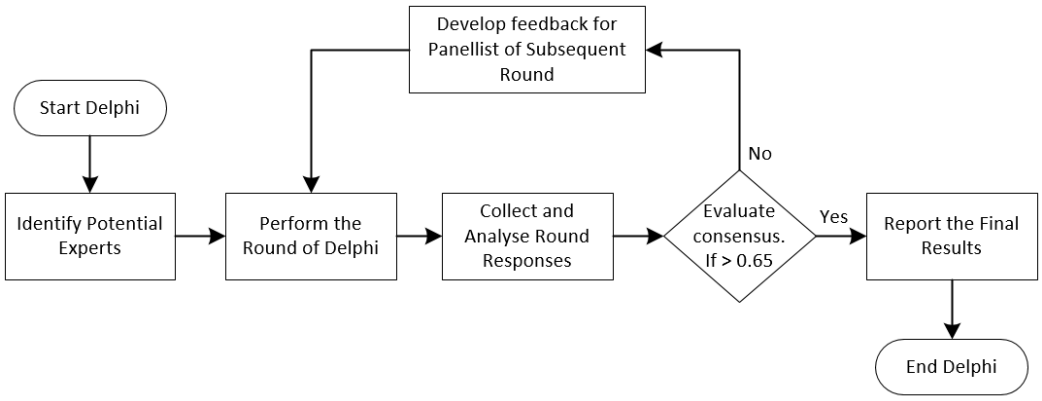

FIGURE 49: FLOW CHART ILLUSTRATING THE PROCESSES STEPS INVOLVED IN THE DELPHI METHOD. NOTE: IN THIS INSTANCES 65% CONSENSUS IS THE TOLERANCE FOR ACCEPTANCE

It is encouraged to do at least one or two feedback rounds before you agree on a response (Cantrill, Sibbald, & Buetow, 1996).

"If everyone is thinking alike, someone isn't thinking." General George Patton Jr

Application at Meridian

The Delphi Method could be adopted for different areas in the AM process. It might be used for the scoping of projects or for the risk management in the beginning of projects, however, as well for various decisions in the project delivery. It would mitigate the false consensus bias and mitigate the groupthink in the NZ culture.

Appendix H. Reflective Summary

The following table summarises my personal insights during this project:

TABLE 42: PERSONAL REFLECTIONS

Personal Insight	Description
A good culture is essential, and it is strongly influenced by the leaders	A collaborative work environment has a positive effect on the employees. It kept me motivated even when I felt stuck. Additionally, I felt very dedicated towards achieving for the whole team. People in the team agreed that the type of leadership in the team has a strong influence on the culture.
Quickly bouncing off ideas with peers helps.	During my work at Meridian, another engineer was sitting at the table behind me, who was always open for a chat. I felt that it was very useful to bounce off ideas and to quickly ask questions that came to mind. It prevents that you get stuck too long with one idea that is not suitable because you miss an important point.
Include stakeholders as soon as possible for the development of solutions, specifically if it involves cultural change.	People are more invested in ideas, if they get involved early and can be part of the development of a solution. In this way, people do not have the feeling of getting solutions forced upon them – It is a collaborative approach. If people do not stand behind an idea, cultural change might even be impossible.
Proper time management is key.	You can spend ages analysing certain factors. To stay within the time limit it is important to move on at some point and not to get in unnecessary detail. Reviewing the time plan regularly helps with that.
Nothing is as simple as it seems.	At first, when looking at a system, it seems quite easy to handle. After a certain time, you get to know the different interactions between the system parts and you begin to realise that a more holistic approach is required. Systems thinking and cybernetics seem to become relevant again and again.
Even within one industry there are different backgrounds and circumstances	Coming from a completely different industry (aerospace), I naively assumed at first that companies within the power industry in New Zealand would operate in the same way and would have similar constraints. However, I found that the conditions of the different companies are quite different, and it is not possible to always adapt successful tools from a different environment. (applicable technology-technology transfer)
There are always trade-offs.	It is not possible to find the perfect solution. When you discuss your ideas with people, there will always be some negative aspects raised. It is essential to be clear about priorities and how much you are willing to sacrifice to achieve a certain goal.
Do not jump to conclusions!	A few times, I was asked to talk about the solutions in a very early stage of the project. As being a structured person, I liked to stick to my set DMAIC methodology, allowing enough time for a data analysis and root cause analysis. Coming to the end of the project, it was found that a lot of factors that streamline the success of the project would not have been identified.