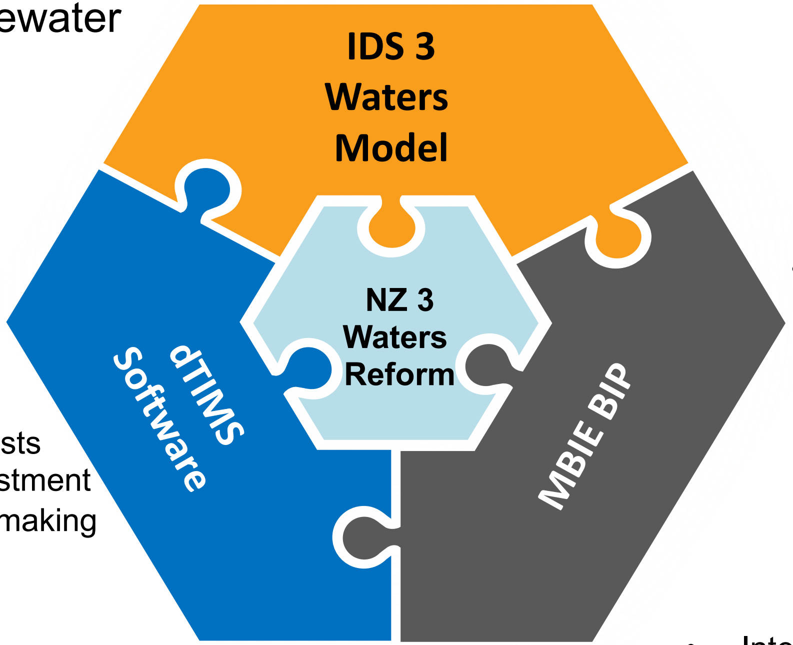
Infrastructure Decision Support

IDS 3 Waters Modelling in dTIMS Pipe Renewal Forecasts

November 2022

IDS 3 Waters Modelling

- IDS Water (Wai) / Wastewater deterioration models
- Inputs, outputs, calibration

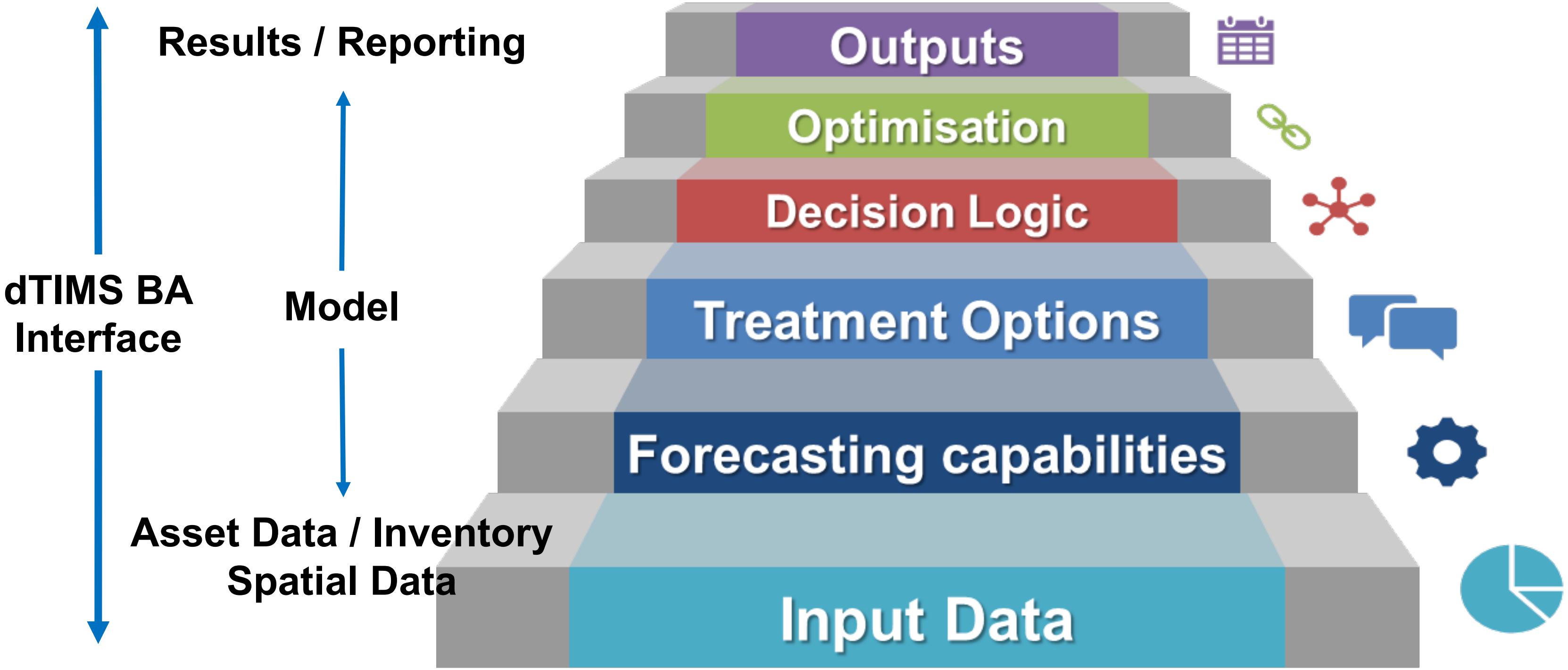


- Model customisation
- Maintenance / Replacement Costs
- Existing budgets / planned investment
- Operational rules and decision-making

- Input data
  - Data requirements
  - 'Standardised' data
- Pipe Portal and Code of Practice
  - Data collation, cleaning, and analysing to address gaps

- Outputs
  - Interpreting outputs and telling the story
  - Reporting of long-term programmes and budgets, focussed on Pipe Renewal and Replacement Forecasts

Components of dTIMS Analysis



dTIMS Analytics Overview

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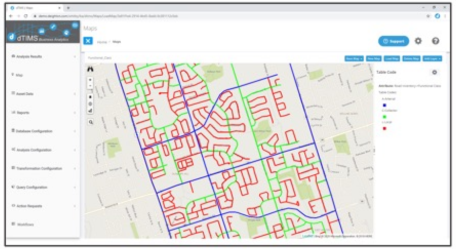
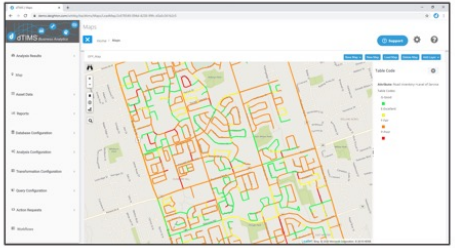
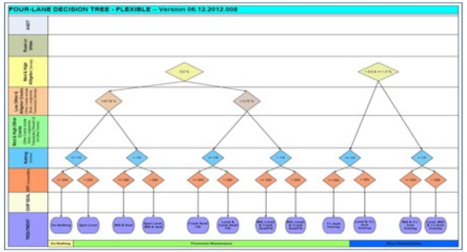
Network Inventory



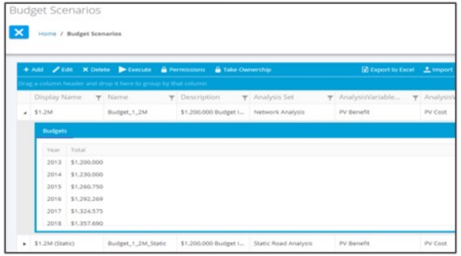
Current Condition



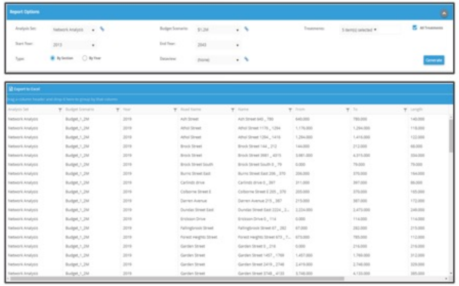
Decision Trees



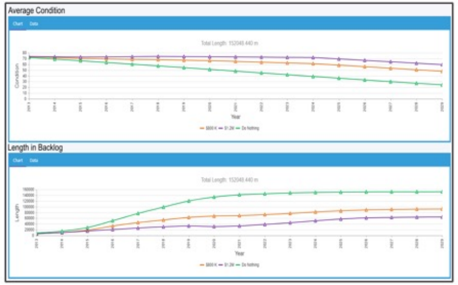
Budget Analysis



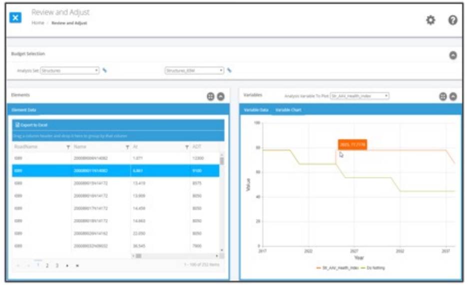
Programming



Reports



Review & Adjust

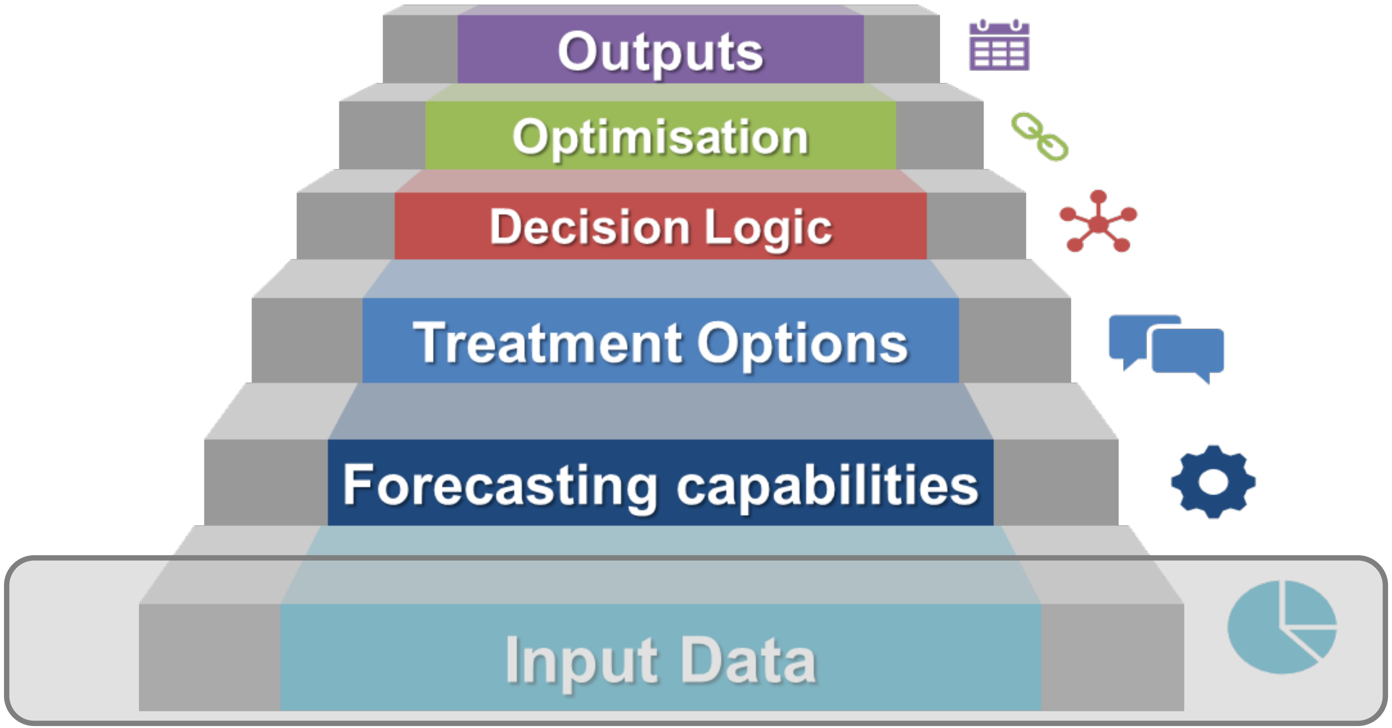


Trade-Off Analysis

IDS Technical Consortium

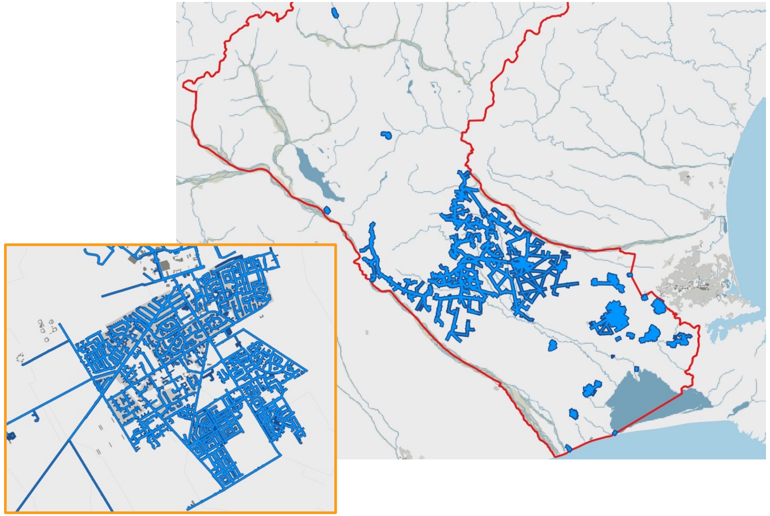
- New members are joining this Financial Year, increasing the capacity and knowledge base

Input Data


Outputs
Optimisation
Decision Logic
Treatment Options
Forecasting capabilities
Input Data

Input Data – Spatial Water Supply and Wastewater Network

- A standard data template, combined with IP to calibrate both network-specific and NZ data, supports modelling development



From	To	Name	AGE_CORRECTED	AREA	ASSET_ID	CAPACITY_NEED	COM_COST	COM_TRTE	COM_USE_ANC	COM_USE_SUB	COM_YEAR	CRITICALITY	DISTRICT	INSTALL_DATE	PIPE_CONDITION	PIPE_CONDITION_DATE	PIPE_CONFIDENCE_DATE	PIPE_COVER	PIPE_DEPTH	PIPE_DIAMETER	PIPE_LENGTH	PIPE_MATERIAL	PIPE_PRESSURE	PIPE_TYPE	STREET_NAME
0	500	20070515090004us_a		Water Patearoa		4						2	Maniototo	1/11/1976	1	2016-12-20				40	500	uPVC	77.23485565	Principle Main	
0	100.93	20030902145038		Water Cromwell		4						4	Cromwell	1/03/1978	1	2016-12-20				375	100.93	AC	78.42653656	Trunk Main	Alpha Street
0	84.98	20040810091031us		Water Cromwell		4						2	Cromwell	1/11/1978	1	2016-12-20				200	84.98	AC	57.07539749	Principle Main	Jollys Road
0	125.24	20060328110432		Water Alexandra		4						2	Alexandra	1/07/2005	1	2016-12-20				50	125.24	uPVC	62.15842438	Rider Main	Briar Crescent
0	20.17	20110401164819		Water Roxburgh		4						2	Teviot Valley	1/09/2010	1	2016-12-20				100	20.17	mPVC	81.0129776	Principle Main	Selkirk Place

- More benefits from existing data
- Data review is a critical part of the process

Input Data – Inventory

- Capture, store and maintain asset data
  - Recording information that describes, measures, and locates the asset base (for the purposes of reporting, asset valuation, customer levels of service, etc.)
  - Ensuring key information is managed and kept up-to-date
  - Technical capability and capacity to access, use, and retain knowledge
- Manage the outputs from information
  - Making data available for asset owners' reporting and planning
  - Identifying and refining the network assets where extra AM effort is valuable
  - Providing data to customers and external stakeholders
- Key to determining condition rating and assessment programmes
  - Tracking what assets look like and how they perform now
  - Supporting some core asset operations and renewals plans

Physical Asset Properties, Condition, Capacity, Usage, and Criticality

DATA ITEM	DESCRIPTION	IMPORTANCE	DATA SOURCE
Water Supply Pipe ID	Asset ID	High: Not required for modelling but important for linking back to asset data.	GIS/Asset Register
Length	Length of Pipes	High: Length is important for calculating breaks per km as well as treatment costs. Ensure pipe lengths are not too long or too short. Recommend breaking long pipes into shorter sections.	GIS/Asset Register
Capacity Need	*Capacity need (1-4):* 1. Pipe is under capacity and needs to be replaced immediately. 2. Pipe is under capacity and needs to be replaced when replacement becomes an option because of breaks. 3. Pipe has no capacity issues. 4. Unknown.	Medium: If unknown, pipes will not be replaced for capacity reasons. Pipes with an immediate need (category 1) are triggered for pipe replacement based upon capacity alone. Pipes with no capacity need are triggered for pipe replacement only when the break rate exceeds the established thresholds. The model can be set to prioritise category 2 pipes over category 3. When a pipe has been replaced, the capacity need is set to 3 which indicates no capacity issues.	Hydraulic Modelling
Criticality	Consequence of failure on a scale of 1-5 where 5 is most critical and 1 is least critical.	High: Used in logical decisions for inspections and replacements. The model prioritises renewal of higher criticality pipes over low.	Criticality study. Should be recorded in GIS/Asset Register
Installed Date	Date the pipe was installed	High: Used to calculate age. Age is an input to both the Probability of Failure and Break Rate models.	GIS/Asset Register
Pipe Condition	Lastest pipe condition	Optional: Can be used to adjust the age value of the pipes to reflect actual condition if known, for input into the deterioration curves.	Outputs of condition inspections
Condition Assessment Date	Date Condition was recorded	Optional	Outputs of condition inspections
Place Holder for Age	Adjusted age of pipe	Optional: If this is populated it is used as the pipe age, otherwise the age is calculated from the install date. *(See Pipe Condition)*	Age from condition assessment
Pipe Diameter	Diameter of the pipe in mm	High: Diameter is an input to the Probability of Failure model and treatment costs.	GIS/Asset Register
Material	Material of the pipe	High: Pipe material is used in models, triggers, costs.	GIS/Asset Register
Pressure	Operating pressure of the pipe (m)	High: Pressure is an input to the Probability of Failure and pipe break models.	Hydraulic Modelling
Pipe Type	e.g. service, main, truck etc.	Optional: For reporting.	GIS/Asset Register

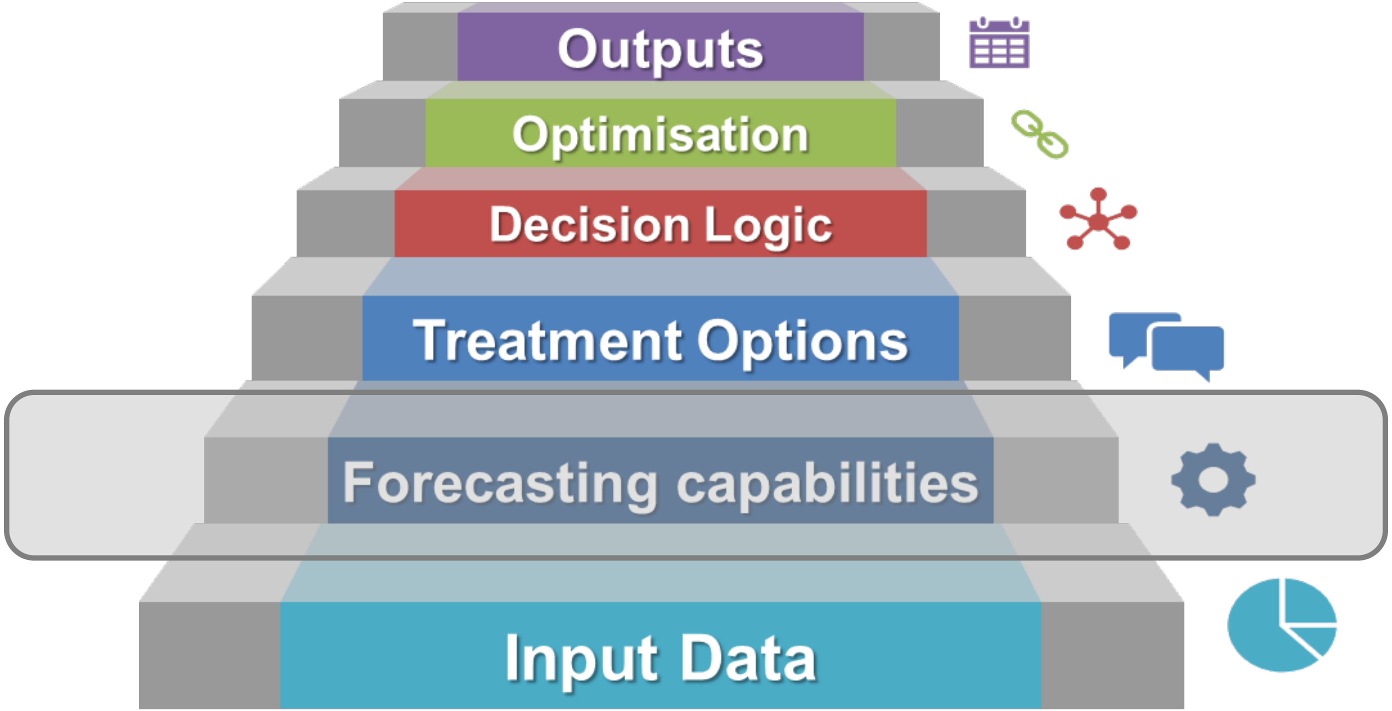
Physical Asset Properties, Condition, Capacity, Usage, and Criticality

- How reliable is the inventory data we are using?
  - Network data has been collated in **current** formats to give a reliable baseline for a whole range of activities
  - Has the dataset been around for a long time? Has it been updated as practice has evolved?
  - Were the assets measured in the field at the time they were constructed, has the data been collected later on, or been populated using assumptions?
  - Are the uncertainties and challenges in creating and maintaining the dataset understood?
- At what level of detail is pipe condition data collected and recorded?
  - Faults data can be understood at an asset level (i.e. breaks on a particular pipe, or a work order/job record)
  - Age-based condition rating is managed across the activities to ensure a high degree of consistency
  - How fast are individual assets deteriorating through inspection/testing?
  - What condition were assets in at the point where they were replaced?
  - How old were my assets when they required replacing?
- Is capacity data an integrated part of network management and modelling requirements?
- Are usage and criticality directly aligned to the assets?
  - AM and Operations planning have considered the impact of an asset failing
  - are there contingency plans in place for repair / replacement within an acceptable timeframe, or linked to Levels of Service?

Input Data – Work Completed and Dollars Spent

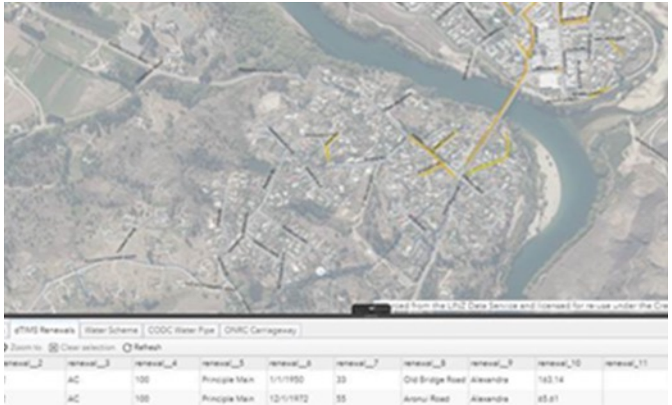
OTHER DATA REQUIREMENTS FOR MODELLING	
Treatment Costs	Typically a table of $/lineal metre for each pipe material/diameter but can be modified to suit any calculation. Treatment costs could be influenced by other factors such as the surface material above the pipe and the depth of pipe.
Annual Budgets	Annual CAPEX and OPEX budgets for pipe replacements. Historic information is useful for model calibration and predicted future investment is used for scenario testing.
Break Rates	Any historical data relating to breaks in the network. Used for model calibration. Ideally this will be at a pipe level, but models can be calibrated at a network level. If no break history is available, calibration from previous IDS analysis on other networks can be used.

Forecasting Capabilities

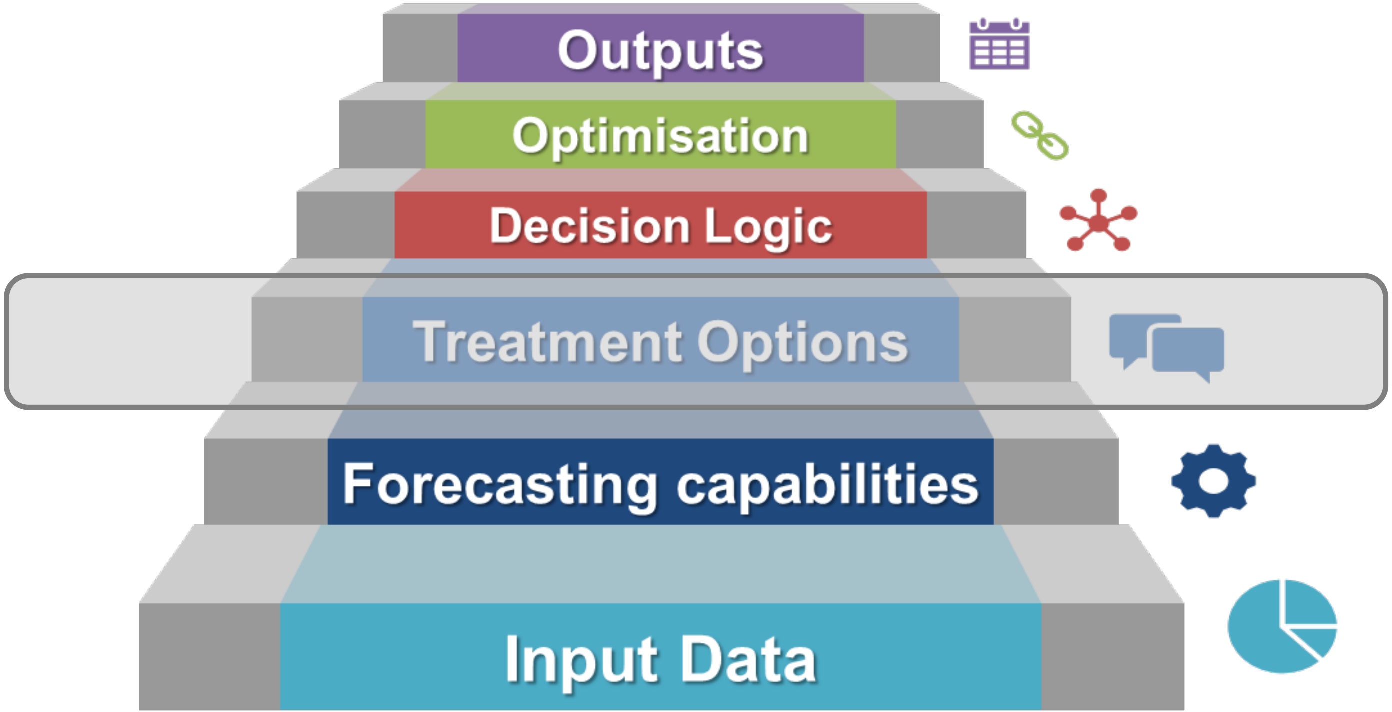


Starting to Predict the Future - Pipe Renewal Forecasts

- How fast are assets deteriorating?
- What are the failure modes?
- When do we prioritise work on an asset?
  - Failed? Condition? Political? Age? Unknown?
  - Translate into measurable triggers
- What is a failed asset?
- Integration of maintenance and operations
  - Where and when this is most likely to happen in future?
- What solutions are available? What do they cost?
- How much do we have to spend?
  What do we need to spend?

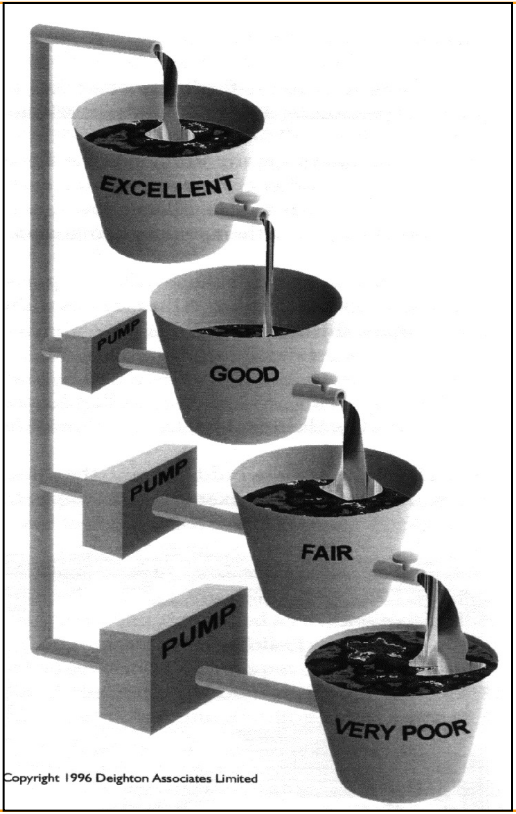


Treatment Options



Maintenance, Operational, and Renewal Activities - Treatments

- Action taken on an asset to
  - repair effects of deterioration (reaction)
  - slow deterioration at a network level (prevention)
  - replace assets at the end-of-life (renewal)
- Is some action which
  - has a trigger/condition state at which it will occur,
  - has a cost, and,
  - provides a benefit. Defined in the way the treatment modifies the service delivery of the asset
- The 3 Waters model considers pipe breakage / loss of service potential when an asset fails



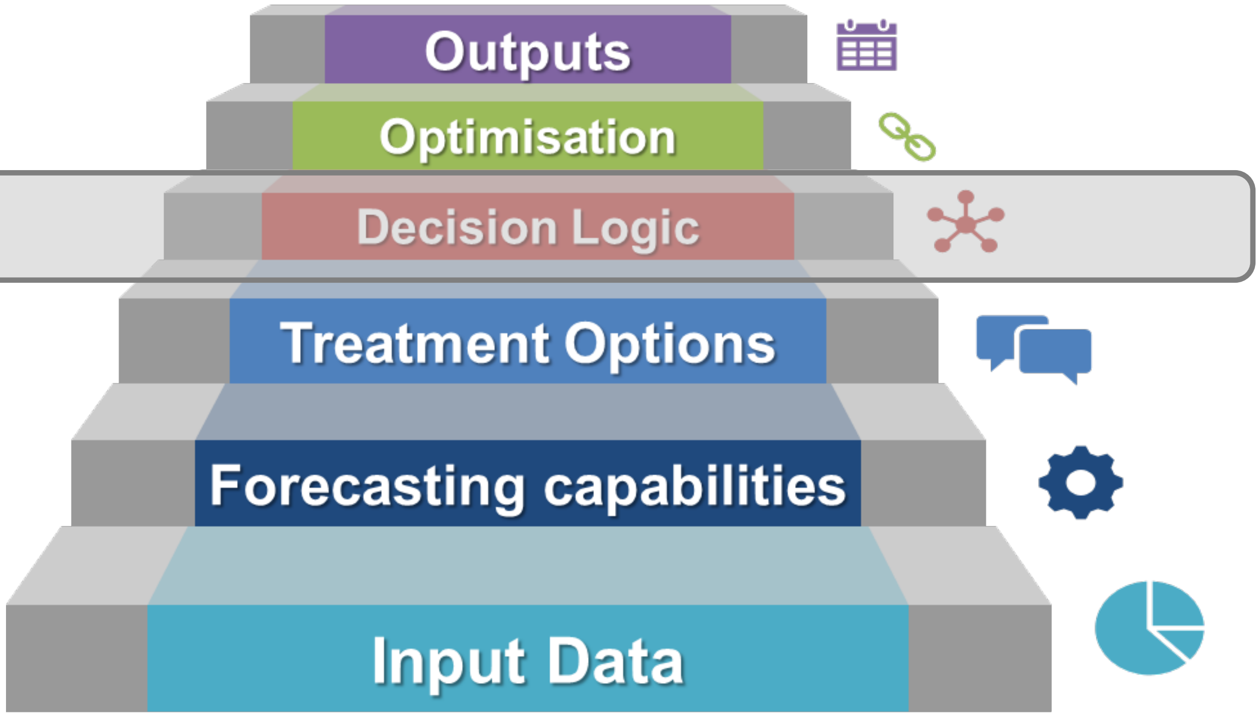
Model Treatments – Work Activities and Triggers

- Inspection/Reactive Maintenance
- Renew due to breaks
- Renew due to capacity
  - **Hydraulic modelling of surcharged pipes**
- Reactive maintenance (break rate)
- Materials grouped into
  - **AC, PE, PP, PVC (calibrated Raw Base costs)**
  - **DI, EW, ST (calibrated All-In Base costs)**

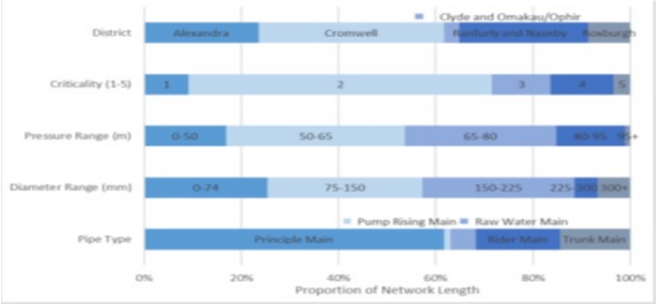
System	Treatment	DN mm	Material_ Type
WW	REACTIVE		
WW	REPLACE	40	AC_PE
WW	REPLACE	50	AC_PE
WW	REPLACE	65	AC_PE
WW	REPLACE	80	AC_PE
WW	REPLACE	90	AC_PE
WW	REPLACE	100	AC_PE
WW	REPLACE	125	AC_PE
WW	REPLACE	150	AC_PE
WW	REPLACE	200	AC_PE
WW	REPLACE	225	AC_PE
WW	REPLACE	250	AC_PE
WW	REPLACE	300	AC_PE
WW	REPLACE	350	AC_PE
WW	REPLACE	375	AC_PE
WW	REPLACE	400	AC_PE
WW	REPLACE	450	AC_PE
WW	REPLACE	500	AC_PE
WW	REPLACE	525	AC_PE
WW	REPLACE	600	AC_PE

SYSTEM	MATERIAL_ TYPE	CRITICALITY	TREATMENT	LOWER	UPPER	POF
WS	PE_AC	5	REPLACE	0.08	0.33	80
WS	ST	5	REPLACE	0.08	0.33	80
WS	PE_AC	4	REPLACE	0.08	0.42	90
WS	ST	4	REPLACE	0.08	0.42	90
WS	PE_AC	3	REPLACE	0.17	0.58	>99
WS	ST	3	REPLACE	0.17	0.58	>99
WS	PE_AC	2	REPLACE	0.25	0.67	>99
WS	ST	2	REPLACE	0.25	0.67	>99
WS	PE_AC	1	REPLACE	0.33	0.75	>99
WS	ST	1	REPLACE	0.33	0.75	>99

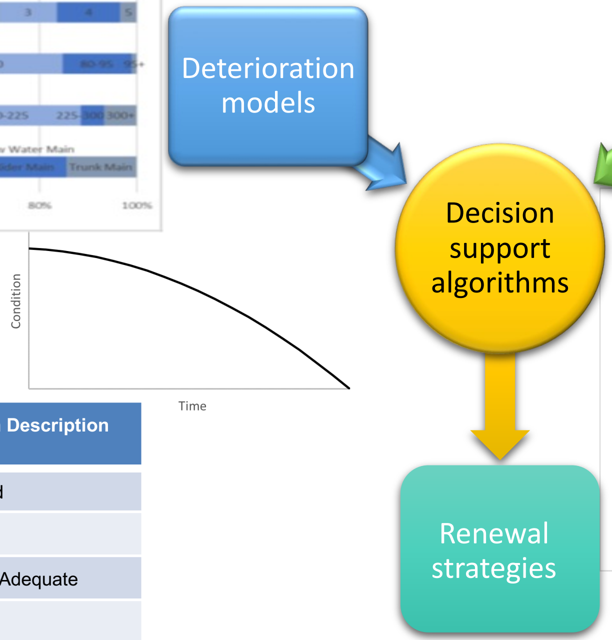
Decision Logic

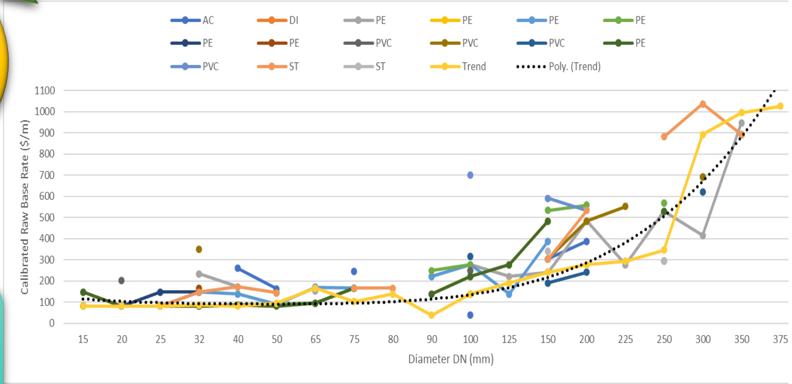


How Decision Support Informs Better Decision-Making



How many failures? How much do they cost?

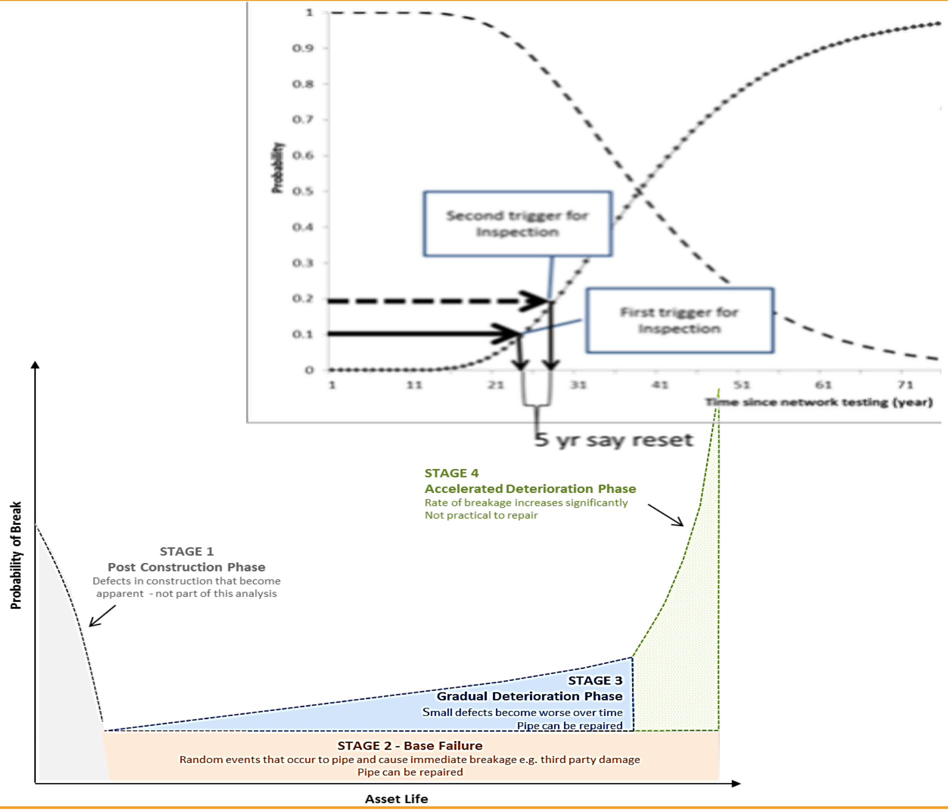




Condition Grade	Remaining Useful Life Range		Condition Description
1	75%	>75%	Very Good
2	50%	>74%	Good
3	25%	46%	Moderate/Adequate
4	3%	24%	Poor
5	≤0%	2%	Very Poor

How to work under a limited budget?

NZ-Calibrated Deterioration and Intervention Options



Trigger 1 at threshold say 10% in example (Inspection)

90% OK

Trigger again after next threshold level (say 5 years)

Trigger 2 at time it takes to next threshold (e.g. 5 years) then trigger full inspection again

Cost – full inspection cost

Benefit – "life gained e.g. 5 years"

10%

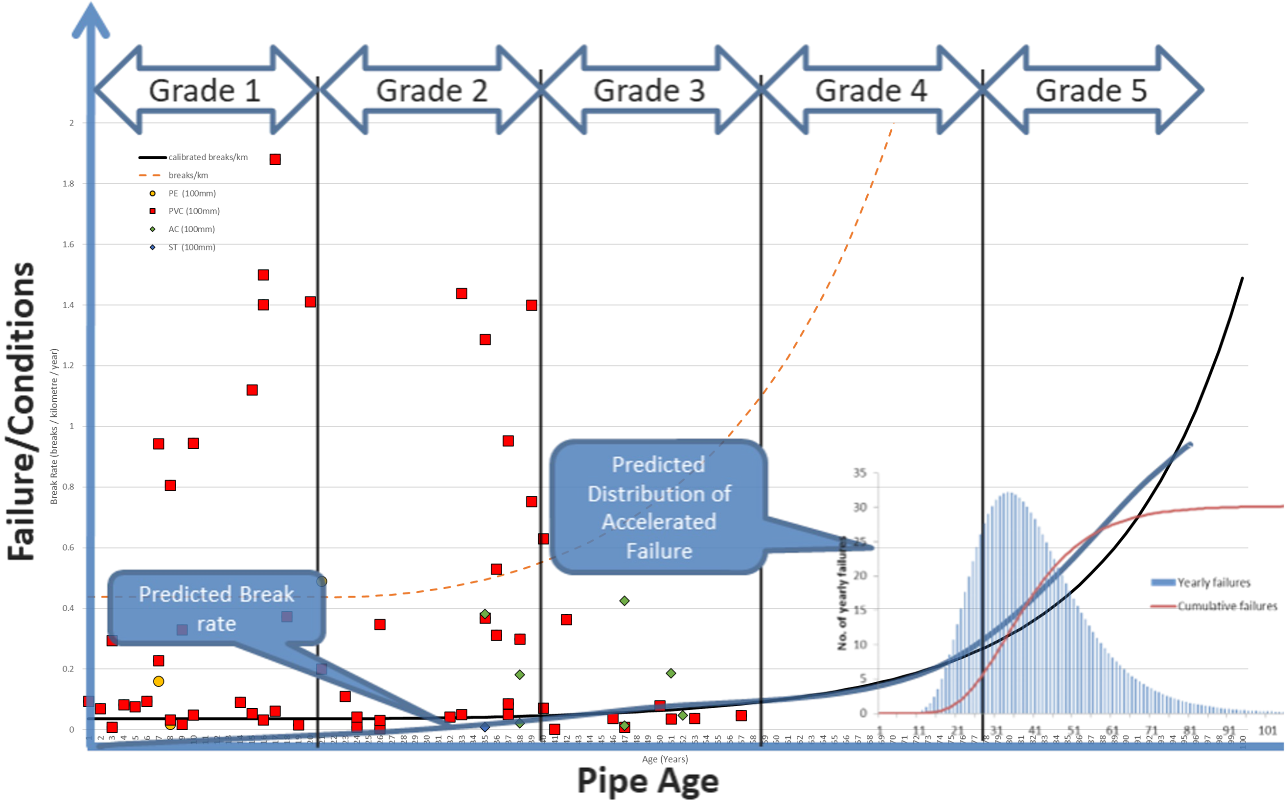
Bad condition have to replace

Cost = full inspection + full replace costs

Benefit, full life restore

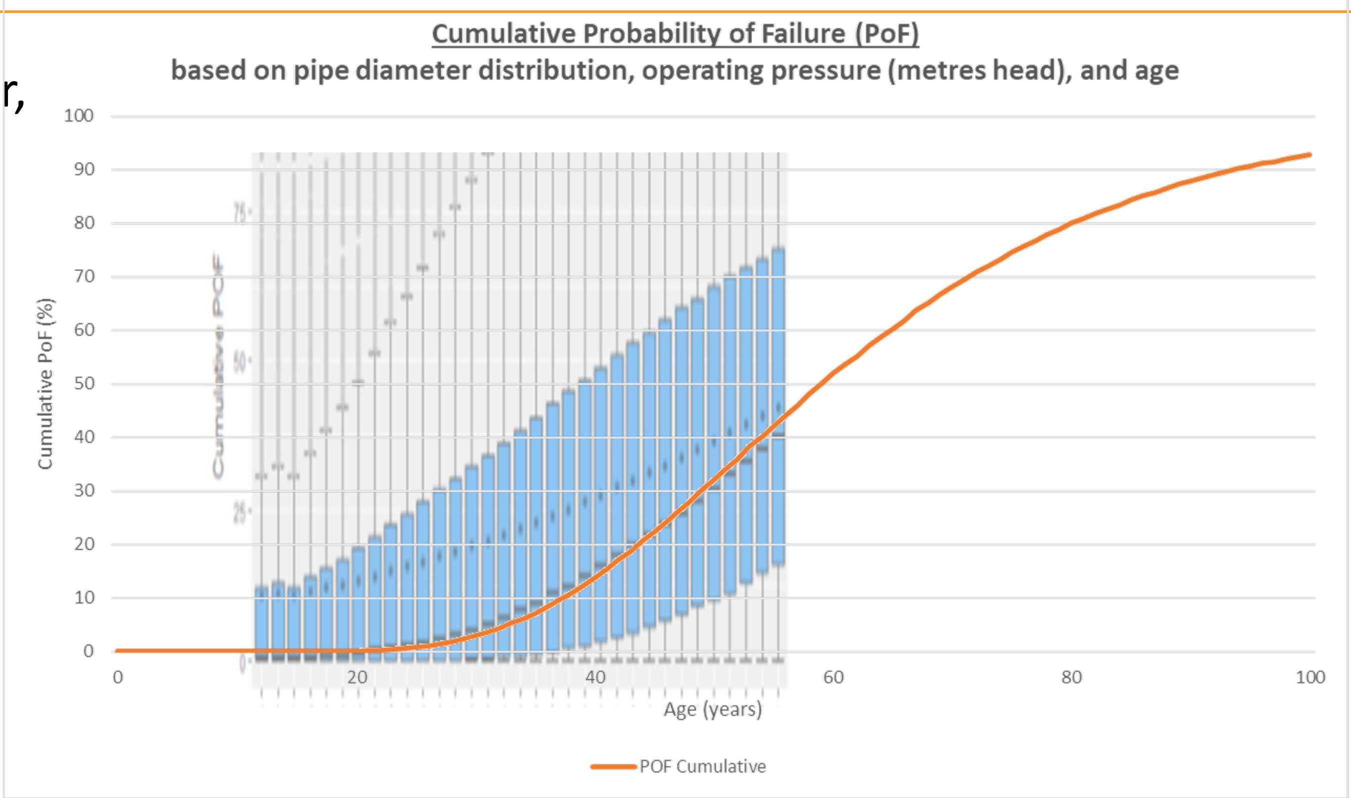
Pipe Model Forecasting – Break Rates

- Calibration of data covering Works activities on pipe assets repairs and replacements
- Pipe Material
- DN50, 100, and 150 Pipe Diameter
- Length-weighted to validate breaks/km/year

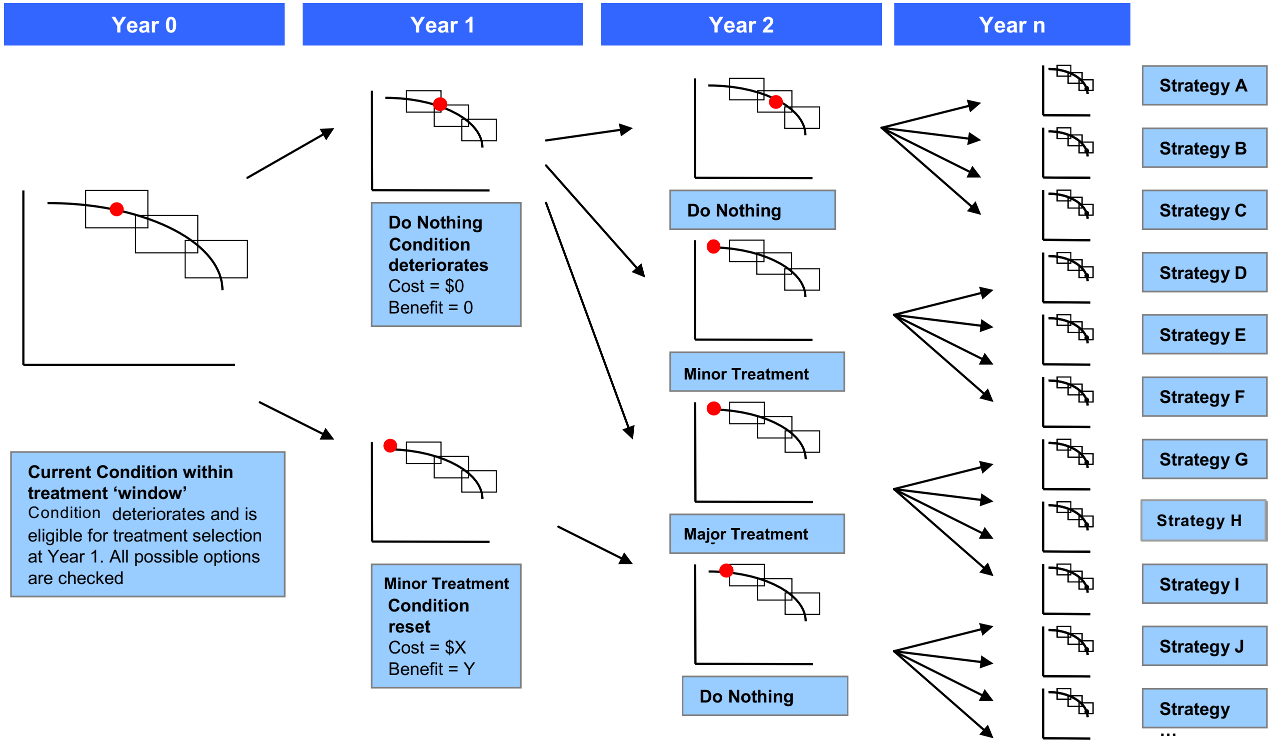


Forecasting – Probability of Failure

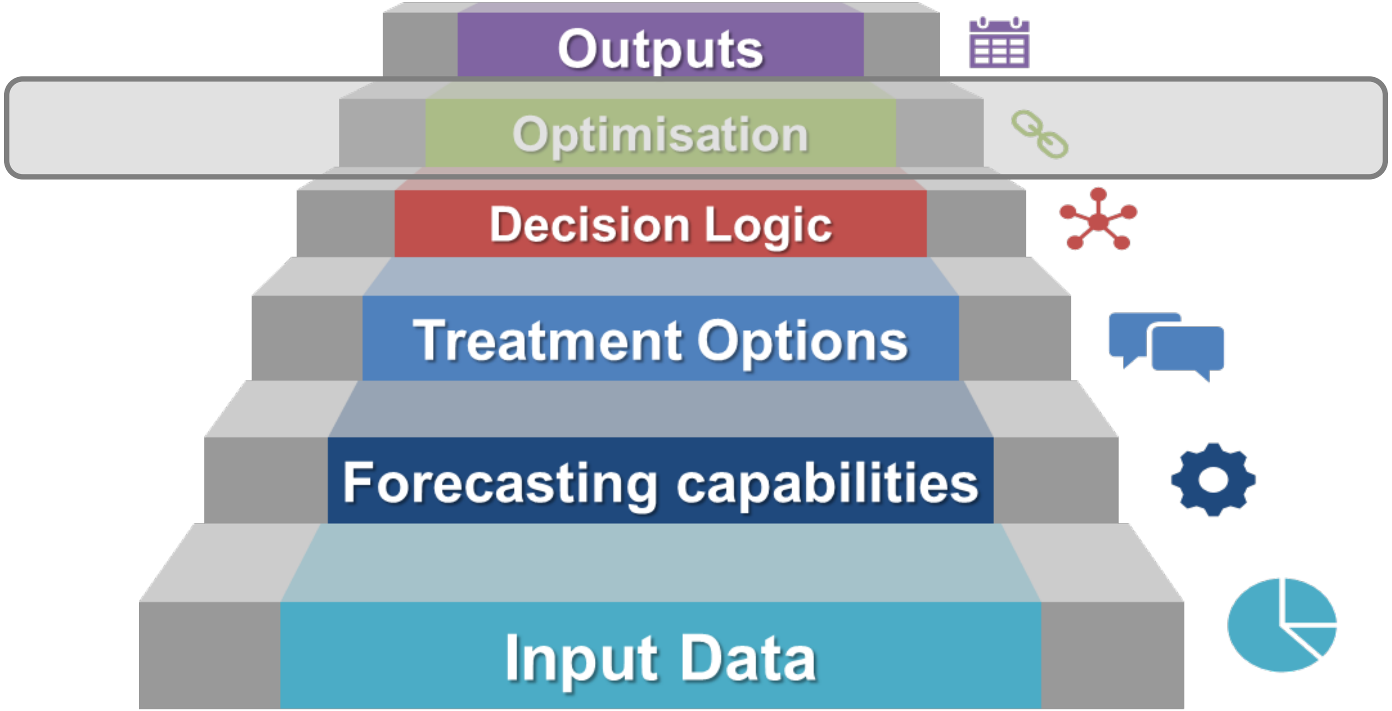
- Function of diameter, pressure, and age
- Calibration of pressure and age for ranges
  - <40m
  - 40-60m
  - >60m
- Average pipe ages 25-45 years



Strategy Generation – Responding to Predicted Asset State



Optimisation

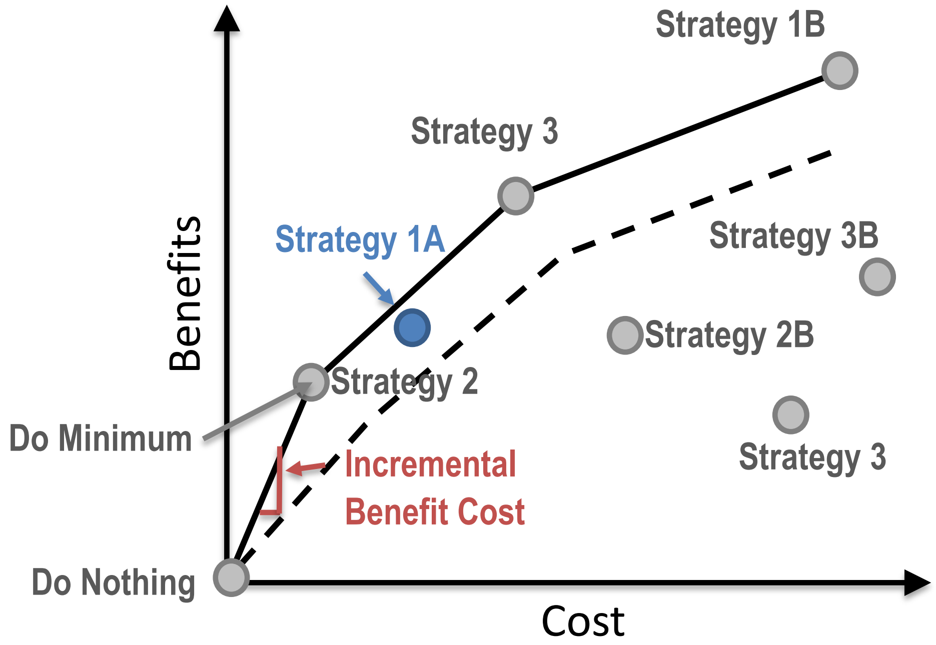


What is Optimisation?

- Optimum
  - Best compromise between opposing tendencies

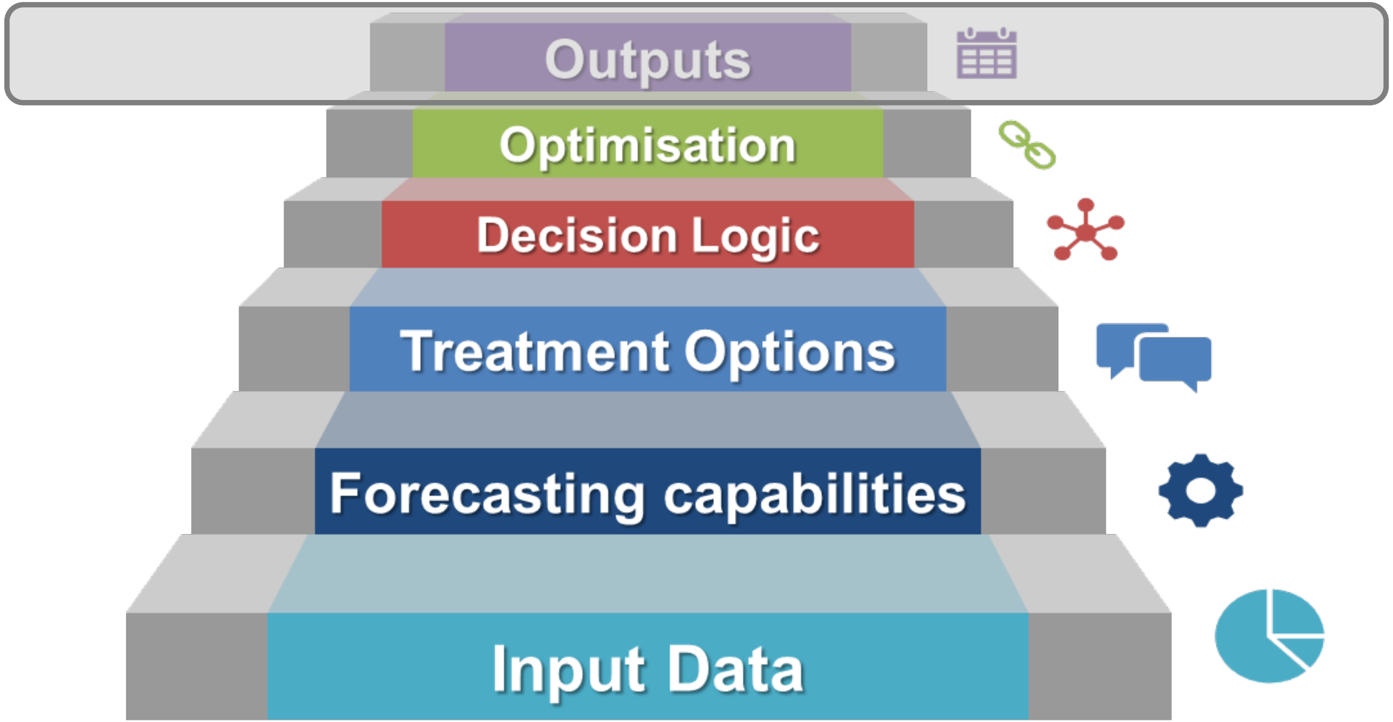
- What are our opposing tendencies?
  - Condition, Money, Service Risk, Social (Customer Outcomes), Environmental Impacts, Critical Asset Failure, Reputational Risk…
  - Must be quantifiable, but doesn't need to be monetized
  - 3 Waters Model optimizes analysis of costs, breaks, and pipe lengths at risk of failure

Strategy Efficiency



Asset	STRAT	IBC	Cost
~~1~~	~~Least~~		~~$10,000~~
~~2~~	~~Least~~		~~$5,000~~
~~3~~	~~Least~~		~~$20,000~~
~~2~~	~~A~~	~~4.0~~	~~$10,000~~
1	**A**	**1.5**	**$20,000**
2	B	1.3	$50,000
3	A	1.0	$60,000
1	B	0.8	$80,000
3	B	0.5	$80,000

Outputs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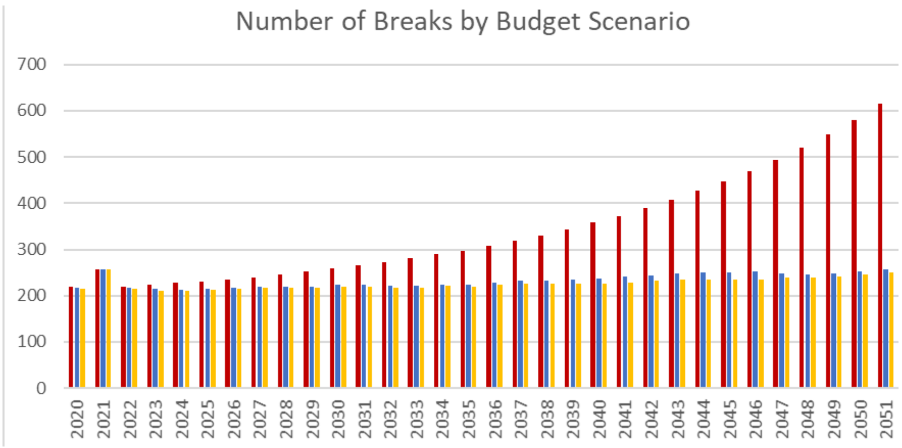
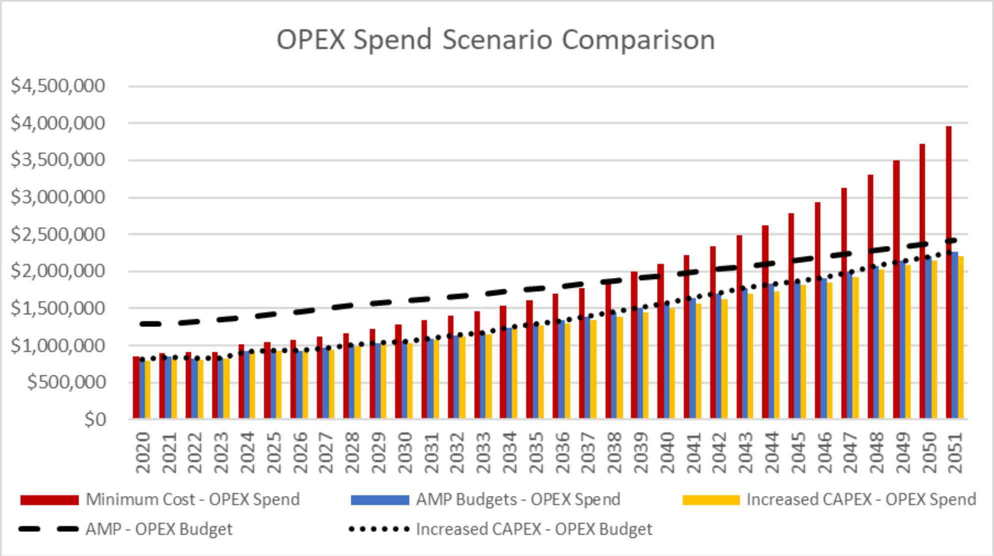
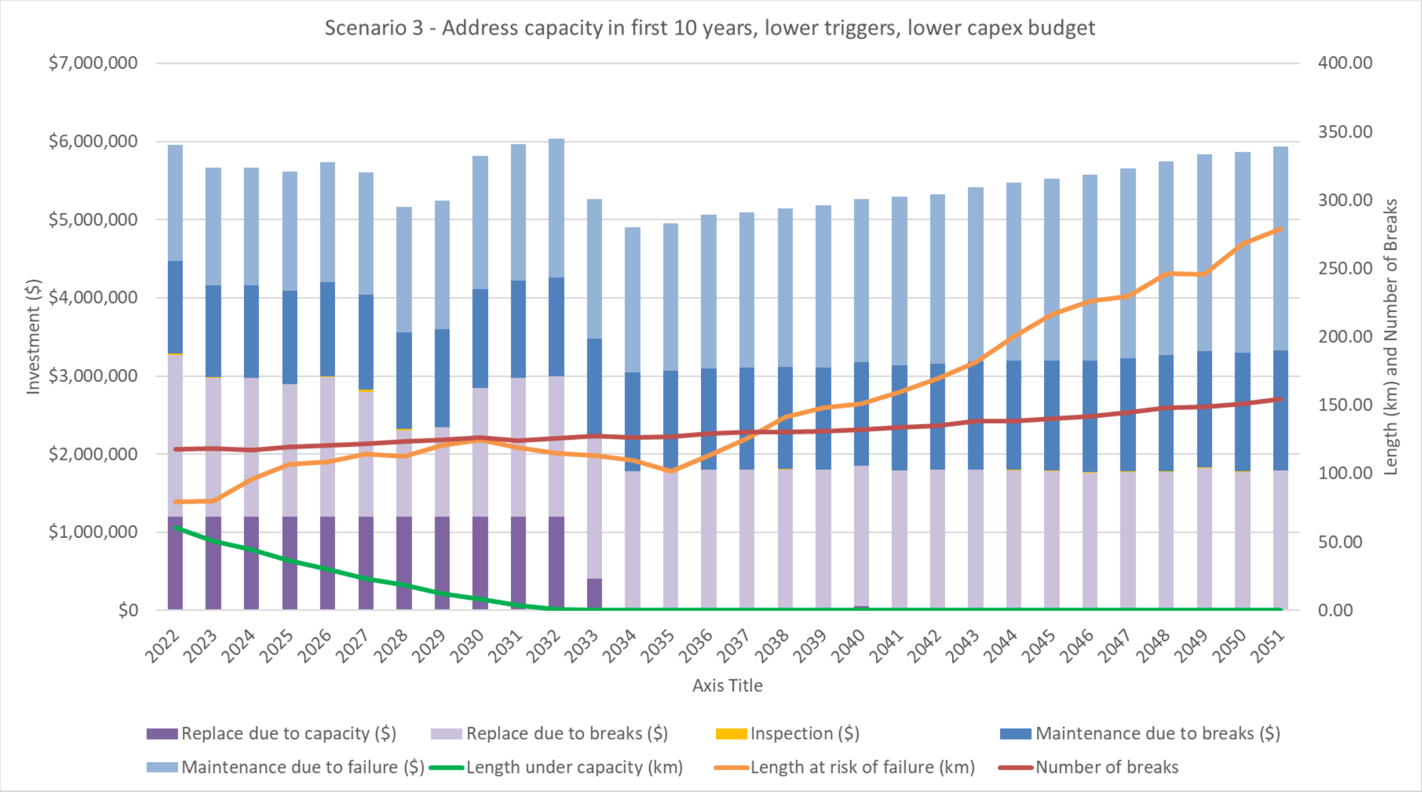
Input Data

Outputs – Outcomes for Investment Scenarios





Outputs – Water Supply Optimised Budget Scenarios



Outputs – Wastewater Optimised Budget Scenarios