ARE YOU PREPARED FOR NATURAL HAZARDS? – A LESSON IN RESILIENCE PREPAREDNESS

Tracey Mitchell (NewPlymouth District Council)

ABSTRACT (500 WORDS MAXIMUM)

In February 2018 ex-cyclone Gita swept across New Zealand, causing havoc across the lower North Island and upper South Island. Wind speeds of 104km/hour were recorded in Taranaki (the third highest since records began in 1972); New Plymouth District experienced wide spread power outages, landslips and felled trees. One of those trees became a very big problem for New Plymouth District Council and its potable water supply.

That tree smashed down through an aerial crossing that was 800m downstream from the main Water Treatment Plant. As existing levels in the reservoirs began to run out, it left 10,000 homes without water for three days and placed some 26,000 properties on a boil water notice. Schools and businesses closed and the estimated economic impact was $4.5million.

When that tree came down it exposed some short comings in our emergency preparedness. While we had spare pipe and fittings, it soon became apparent that they had not been maintained or updated in years. It was just one of those lower priorities in the daily mountain of work faced by operational staff.

This paper talks about readiness for three water reticulation repairs – do we have what we need for whatever nature throws at us?

New Plymouth District Council has since invested an extra $40 million into the resiliency of its three waters infrastructure, with some of this going towards revamping our “Reticulation Critical Spares”. After fixing the immediate problem and making sure we had replaced the obsolete asbestos pipes we had in store, we then carried out a complete overhaul of the reticulation spares we hold.

This paper describes the process we took and considerations we made to ensure we set ourselves right for future emergencies. We went back to basics to ensure we got it right; what did we consider to be a “critical spare”, where to store spares, how to store spares and are we using the best technology to carry out the repair… is there something better?

As part of this process, we discovered we had a lot of things right, we had some things to improve on, and we came to understand it is not possible to have every eventuality covered. The help provided by local suppliers was invaluable, as they became problem solvers and technical experts on fittings for odd-ball sized pipes.

We have advanced to a point we are building a new purpose built facility that will store strategic pipes and fittings with longevity in mind; and ensure easy access in the dead of night with no power, making it safer and quicker. We are developing a modern inventory system with scan

codes, electronic access to instructions and diagrams, and electronic asset life reminders for the perishable items held.

That one tree has helped us focus on our resilience and planning for the three water networks now and into the future.

KEYWORDS

Resilience, asset management, criticality management, emergency spares

PRESENTER PROFILE

Tracey Mitchell is a civil engineering technician with 30 years' experience in local government, both here and the UK. She is currently a project manager with New Plymouth District Council and enjoys working on a wider variety of projects; having been in charge of the three waters network in a previous role, this project is a particular favourite.

1. INTRODUCTION

In February 2018 ex-Cyclone Gita hit the Taranaki Coast. Wind speeds were recorded at 104km/h, the third highest since records began in 1972. On the afternoon of Tuesday 20 February the high winds uprooted a tree, causing it to fall onto a pipe bridge carrying the water feeder main that supplies the eastern zones of New Plymouth. Figure 1 shows the location of the pipe bridge in relation to the New Plymouth drinking water supply infrastructure.

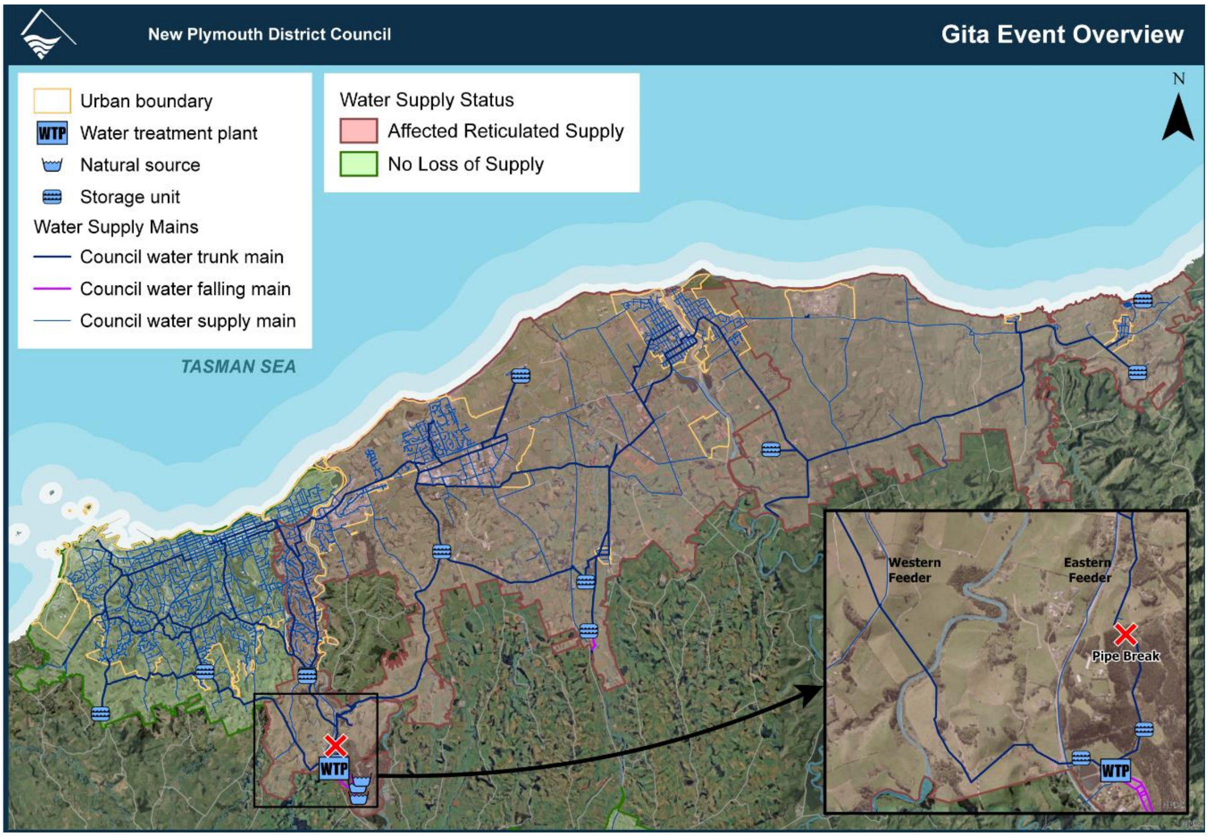


Figure 1: Location Map of emergency incident

The resulting damage to the pipe bridge and water main caused water to drain out of the reticulation network between the New Plymouth Water Treatment Plant and the Mangorei Reservoirs with water from the Mangorei reservoirs flowing back towards the pipe break.

With the water main ruptured, the majority of the city and outlying areas to the East were at risk of running out of potable water.

Our maintenance contractor mobilised to evaluate the damage to the pipe bridge and feeder main and to start the necessary repairs. We closed reservoir valves to stop treated water flowing back to the broken main and started up our emergency response team.

Photograph 1: Discovery of broken Pipe Bridge and water main

Over the following days, treated water stored in the reticulation reservoirs downstream of the damaged pipe bridge was progressively consumed and eventually exhausted. Approximately 25 hours later, Henwood Road, Mountain Road and Mangorei Road reservoirs were empty and the first reports of residential properties losing water supply were received.

In anticipation of the water supply drawing contaminants into the reticulation network as the water pressures dropped, a boil water notice was issued in order to protect public health.

About 52 hours after the pipe bridge and feeder main were damaged, the repairs were complete and water was reintroduced into the reticulation network. It then took a further two days to refill the reticulation network and reservoirs. The boil water notice was in place for a total of ten days.

Following the event, a high level assessment of the probable economic impact of this incident was carried out. This assessment is based on feedback provided by businesses and some broad assumptions. The total cost of the water supply interruption due to ex-Cyclone Gita is estimated at approximately $4.5m. It is important to note that this estimate has been prepared by NPDC engineering staff, not professional economists.

2. THE STATE OF OUR SPARES

2.1 READINESS FOR EX-CYCLONE GITA

When the contractor went to find the spare pipe to make the repair they discovered the pipe was not suitable to use and we had to source pipe from other parts of New Zealand.

Spares for the damaged components of the central feeder main were stored at the Water Treatment Plant; however, they were not suitable for use for these reasons:

- Spare pipe had been held in stock for an extended period of time and its condition had deteriorated considerably.
- Spare pipe was made of asbestos cement which was brittle and not able to self-support with the damaged/temporarily repaired bridge.
- Asbestos cement pipes also pose a health risk if it becomes friable when left exposed to the air and not buried.

Whilst critical spares were not immediately available, analysis completed after the event indicated that this did not have a material effect on the time taken to repair the damaged pipe bridge.

We got lucky! Our maintenance contractor and local suppliers were able to use their contacts to source the pipe and fittings needed. The pipe and fittings arrived 27 hours after the main break was first discovered, and this was just in time for the wind to die down and the rain to stop the following morning, making it safe to work in the forest and lay metal to get machinery in and make the repair to the pipe and bridge.

Photograph 2: Contractors repairing Pipe Bridge and water main

This was our recent experience and a big wakeup call. This paper is written as a “lessons learned” experience for others, not for the whole event, but for the critical spares component. This will hopefully help asset owners look and assess their preparedness before they are in the same position we were, and suggest how to create a tool kit and integrate it into existing asset management processes.

2.2 STOCKTAKE

Following the event and emergency response review, a project was created to bring our reticulation spares up to scratch, with a view to working on mechanical, and electrical spares in the near future.

The starting point was to focus on water main pipes and fittings, but keeping the three water networks in mind, find out what our gaps were and ensure if another main break happened we were prepared.

Photograph 3: Condition of existing stored pipe

Two questions at this stage summed up how to achieve this; “What do we have that is fit for purpose?” and “What do we need to ensure we are ready?” The best way to answer both questions is to get a picture of what we know.

A comprehensive stocktake was undertaken. This involved cleaning out the fittings shed which had become a convenient place for keeping odds and sods that we may need one day, but no idea when. The shed had to be put into some sort of order first to get access to all the fittings. I found pipe stored on three different sites (just by asking around) as it had been assumed all pipe was stored at the Water Treatment Plant.

Photograph 4:   Spare fittings Storage Shed – before

A lot of the gibaults were cast iron and of varying condition; we decided to keep the cast iron fittings that were in good condition, but purchase the modern equivalents as well. Sometimes the old fittings were better suited to the old pipes and if we scrapped the old there was no way we could purchase more.

We asked Todd Randel from Hynds to help do a visual assessment of the pipe and fittings held. Giving us methods of repairing minor damage and advising what was not worth keeping. A visit to our maintenance contractor's depot showed what pipes and fittings they contractually held for us, plus I found some 810mm diameter CLS pipe we didn't know we had. All the pieces of the puzzle were starting to come together, a spreadsheet aided in managing all the information collected.

It was time to work on the second question, what do we need? What was a critical spare?

3. ANALYSISING OUR NEEDS

3.1 WHAT IS A CRITICAL SPARE?

Some previous work had already been carried out on our water network defining criticality and the assets had been labelled in our GIS records. For the wastewater network criticality was defined as any gravity main 350mm and above, and any rising main. Storm water had no critically rating; it was decided that whatever stock we had for water and wastewater could be used along with concrete pipe and manholes held by local suppliers.

Pulling this information together gave me a large data base of pipes showing their diameter and material types. The sizes ranged from 0 – 966mm (zero being an unknown). In the water area alone there were 28 different pipe diameters and 12 different material types. By working out what local stockist, and our maintenance contractor held, I was able to eliminate anything 350mm diameter and below as being available to us and therefore not critical.

In Taranaki it is generally a minimum of 24 hours to order and transport in anything we need from Auckland or Wellington; however State Highway 3 can be unreliable during storm events with slips and flooding. Therefore anything that is not located in Taranaki and required to make a speed repair must be here.

The list was now at 18 different diameter pipes and 7 different material types; with this shorter list it became more like detective work. If there was a strange size was it an error? Some diameters were just millimetres apart; if there were short lengths did we need to have a spare as we could just match to the pipes either side? Was it an inside diameter (ID) or outside diameter (OD) measurements? Especially when it came to rising wastewater mains (wastewater is recorded as an ID and Water as an OD) and some records has not been correctly translated from as-built to GIS record. If it was a size and material type not listed in normal specifications then was it right? By doing this deep dive I was able to correct some data, eliminate some pipes based on not being critical, and combine some diameters as realistically the same when it came to making a repair.

This brought the list to 15 different diameter pipes made of 6 different material types.

All of this work was carried out without digging a single hole. What if our records were wrong, what if there was a pipe diameter we had missed? Looking at the data that had been collected and refined, I could see the range of diameters and materials and it was vast; then looking at the range of mechanical step couplers I could see that the range required and the tolerances within each fitting meant that we could cover every diameter between the known recorded diameters.

3.2 WHAT SHOULD BE IN OUR TOOLKIT?

The pipes in our water and wastewater network are generally made up of Asbestos Cement (AC), Polyvinyl Chloride (PVC) and Concrete Lined Steel (CLS); and Polyethylene (PE) for wastewater rising mains. We have small amounts of Steel and Concrete. It was not possible to source the exact pipe needed for each situation; but we did need to decide what pipe to hold as spares, that would be versatile and work in most situations. With the lack of PE in our water network it is mainly made up of ridged pipe systems, CLS became the obvious choice. CLS could be cut to the exact lengths needed and fittings still work, it was a structural pipe and the 12m lengths made it ideal to span poor ground or be above ground, and it could be stored outside easily for long periods of time. Repairs would also be permanent, no need to go back after the emergency and shut down again to make the final repair.

We decided on having three lengths of each CLS pipe in the different diameters available; we already had half the stock required. Three lengths gave us 36 metres, this meant we could replace a road crossing, span a stream, if an AC pipe failed and the joints at each end failed we could replace the three pipes needed. It was a case of how far do you go, we considered any bigger failure than this would be catastrophic and we were likely to have bigger problems that a simple pipe repair.

Once these decisions were made the rest became straight forward, a matrix of every possible combination of pipe joining the spare pipe was made (ensuring we had identified where restrained fittings were needed). There were only three from the total 32 joining combinations that were matching like diameter and material type to like. This meant the majority of fittings would be making a step change; a harder connection to make with more traditional gibaults.

Traditionally we had held gibaults and step-gibaults, and as advances were made, we brought in more mechanical couplers. Both had advantages; the mechanical couplers could be used in multiple situations and used with small lengths of PE pipe in the network. They are good at joining different material types, better with deflections and may not require additional thrusting support (depending on the situation). The gibaults are better for some of those tight situations where there is not much room to work and you are butting up against existing pipe to make the last connection, plus they are cheaper. To keep our tool kit as comprehensive as possible we decided to get both options.

	A	B	C	D	E	F
1	NPDC SPECS					
2	Water	WW Gravity	WW pressure	Pipe Diameter Range (OD)	Pipe Material	Existing stock
13	✓		✓	490/492-508	CLS to CLS	510-485 nylon coated step gibault set (new) x3
14		✓		497/505-508	AC to CLS	
16	✓			508-508	AC to CLS	510mm nylon coated x1, 510mm SS gibault set x2
17		✓	✓	508-508	PVC to CLS	510mm nylon coated x1, 510mm SS gibault set x3
18		✓	✓	508-500	PVC to uPVC	
19	✓	✓	✓	508-508	Steel & CLS to CLS	510mm nylon coated x1, 510mm SS gibault set x3
20	✓			558-558	CLS to CLS	
21	✓			565-558	PVC & CLS to CLS	567mm nylon coatred gibault x2
22	✓	✓		588-588	AC, PVC & CLS to CLS	582- 599 VJ maxifit coupler x2 (recently bought from Humes)
25				565 - 558	CLS to CLS	
26	✓			575-588	CLS to CLS	590mm CI gibaults x4
27	✓			630 PE-667	PE to CLS	
28				630PE - 630PE	PE to PE	
29	✓			650-667	AC to CLS	648-670mm nylon coated set (320mm long)x2
30		✓		657/664-667	AC to CLS	648-670mm nylon coated gibault set x2

Figure 2: Example of complied information to match pipes and fittings

Looking at the complexity of the matrix of 32 different coupler combinations, it was more beneficial to involve our local stockist and their technical staff to help ensure we had the right fittings; they know what is available and are the experts in ensuring a fitting will work. Both Hynds and Humes were happy to be involved and our field staff provided a quality check and assurance that we chose the best fittings for each situation.

3.3 WHAT ELSE COULD HELP US?

So far what we have chosen is pretty standard in the water industry, and has been available for some time. But, what was available now, what was around that could help our tool kit further?

Each time a trunk water main breaks it takes several hours to drain, make the repair, then several hours to fill and bleed the water network. It is also likely that there will be further leaks on the network as the pressure differential is enough to set off vulnerable parts of the surrounding network. What if we could make repairs without fully draining the pipe, then save time filling it as well? As you can see by the pipe bridge break, it took days to get the network back to normal, and any time saved becomes critical.

For small cracks and splits we purchased a set of Stainless Steel repair clamps for each of the water pipe diameters. These are a temporary fix as they are only guaranteed for 10 years; they will however be another part of our tool kit depending on the types of failures.

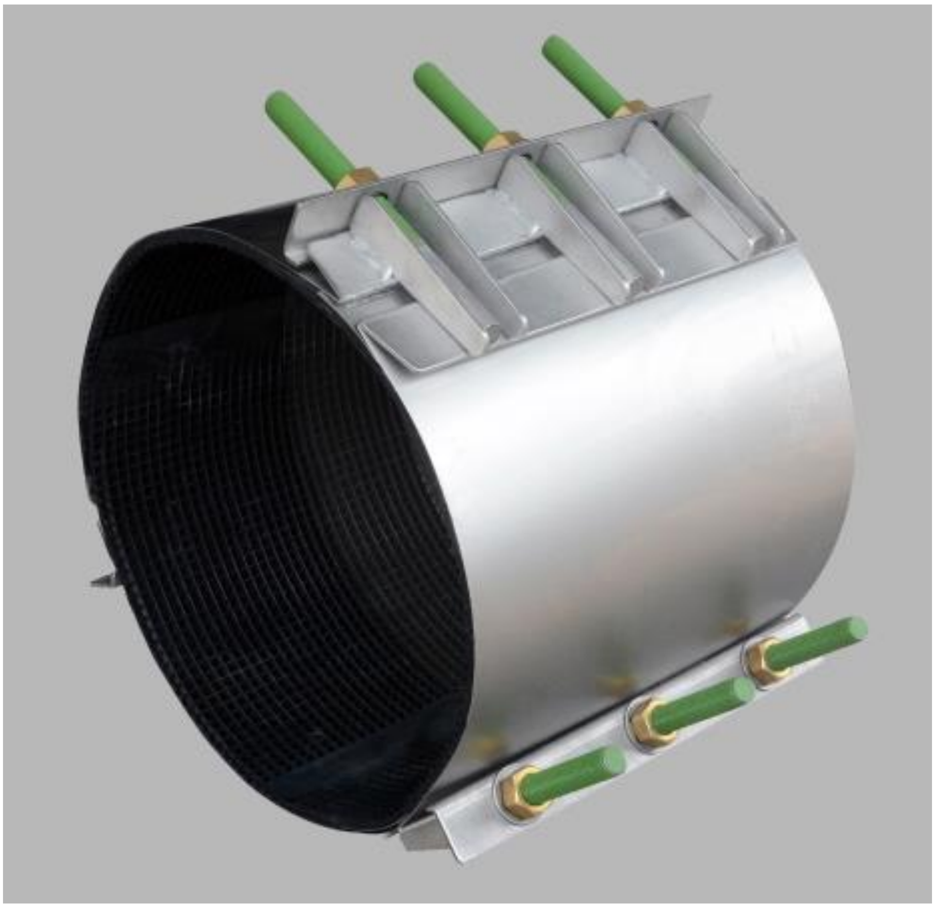


Figure 3: AVK SS Repair Clamp example

As a lot of our water and wastewater network is still AC pipe we find a lot of failures occur at the collar, necessitating removal and repair of two lengths of pipe. And a fair few failures on CLS pipe occur with movement at the gibaults, requiring the main to be drained before a repair can be carried out. We have purchased duofit repair couplers for each diameter water main in the largest sizes; these work as a clamp that can be placed over a live main and sealed. The sizes have been specifically made to go over collars or insitu gibaults. In the right situation we will be able to make a repair and water back to customers in 4-8 hours instead of 8-24 hours.

Figure 4: Duofit Repair coupler example

4. IMPLEMENTATION

4.1 WHERE TO STORE AND HOW TO STORE OUR SPARES?

As part of this project we needed to ensure the spares were stored where they were accessible during an emergency event, and that we had 24 hour access and power supply. Looking at our existing sites, the main water treatment plant was the most logical. It had good state highway access from two directions, was not low lying, or in a lahar zone. The existing shed and compound was located inside the plant and not large enough to store the additional spares required. A new shed and compound are currently being constructed next to the Water Treatment Plant. The power will be supplied from the Water Treatment Plant which is on an emergency generator system.

While the fittings and plastic pipes can be stored inside, the CLS pipe will need to be wrapped and stored outside. Purpose made tarpaulins will be used to individually wrap pipes to protect them from the elements, however we will leave the ends open to ensure the pipes don't sweat and then rust.

The 300m² shed and large compound is accessed separately from the Water Treatment Plant and under a different lock system. It has a new forklift with spreader bar to be able to lift the heaviest of our CLS pipe. The role of store person has been added to one of the existing staff to ensure these spares and future mechanical and electrical spares are part of the business and looked after properly.

Photograph 5: New Storage Shed and Compound under construction

4.2 STOCK VERSES ASSETS

Up until now the critical spares stock was recorded on a spreadsheet and it would be manually updated as needed. The only information recorded was a description, diameter, and how many of each item we held. We had no idea of age, location, material type, cost or any form of numbering; and there were many non-critical items in the area that were not recorded. When a pipe and/or fitting was used to make a repair it would be added to our GIS as a repair and given an assumed value. We had no way of disposing of stock off our financial books, as they didn't exist in the asset register.

We needed an inventory system. But we needed to understand the full asset life process and ensure it integrated into existing process such as capitalising assets, disposing of assets and stock control before we could build the inventory system.

Time was spent discussing with our assets team and finance team "What was an asset? If spare parts became a future asset, then how? The definition of a non-asset/consumable, how do we ensure these are captured?

We looked at existing software systems Council already operated, and found that the best solution was still a purpose built spreadsheet (for now). It is more critical that we capture all the data associated with the spare part, and that information is transferred as it becomes an asset. It is also important that the control of stock is easily managed, with Q codes we will tag all stock items, and metadata will be associated with each item. Where we have perishable items such as rubber rings and gaskets we will set expiry dates, and annual stocktakes will allow us to the monitor the condition of aging items. With some of the more complex fittings we will add further scanning codes to then access the specifications and installation instructions for the crews in the field.

The most challenging aspect of the whole project has been integrating the critical spares into existing practices and processes. Failing to do so could mean we end up doing the whole exercise again in several years' time. We are half way through the implementation and are working with different parts of Council to refine the processes. See appendix for a full scope.

CONCLUSIONS

When that tree came down we realised how vulnerable we were in an emergency situation without a reliable store of spares. In reviewing the state of our spares we found that we generally had most situations covered, but could do a lot better in our organisation and updating to more modern pipes, fittings and clamps.

As asset management practices had evolved over the last 30 years, our critical spares had not been included and had been left behind. Without having good asset management processes we would have a shed and compound of spares that would lapse back into a disorganised area of the business.

Our luck escape sets us up ready for the future and whatever may come with increased likelihood of events like ex-cyclone Gita.

ACKNOWLEDGEMENTS

As a Project Manager I am part of the wider Council team, and none of this work could have happened without the support of technical and operational staff. Special thanks to David Langford and others, authors of "Ex-cyclone Gita Response Review Report" forming a large part of the beginning of this paper. Lanne Torres, author of the "Critical spares inventory system scope". Lastly, the help of City Care Limited (our maintenance contractor) and Hynds and Humes staff has been invaluable. Suppliers form part of New Plymouth District Council's supply chain and are important to us to ensure we are using the best products available now and into the future.

APPENDIX

Critical Spares Water and Wastewater Project

PRJ0012073 - Inventory System

Budget

Project Capex	BAU Opex
$25k	$xx **

**Incremental system license & support cost

Potential Users

NPDC : 4	City Care: ~6
4 for Reticulation spares: * Jim * Rob * Other * Jamie (store person)	

NOTE: ~10 users to begin with but there will be other types of spares

Potential Timeline

Scoping	Solution Options	Process & Data Analysis	Procurement	System Configuration	User Training	System Roll-out	BAU Support Handover
Apr 2021	May 2021	Jun – Jul 2021	Jul 2021	Aug – Sep 2021	Oct 2021	Nov 2021	Dec 2021

Tactical Solution: Excel & Collaboration Site

High Level Requirements

Hardware Devices Required:
- o Barcode and QR code reader to scan stocks in and out of the store room
- o Durable Stickers that are water proof – liaise with Suppliers on what they use

Inventory System supported by BTG and made available via Sharepoint Colloboration
- o To track what has been used and what needs to be replaced
- o Reminder when the spares lifespan expires (replenish inventory)
- o Ability to re-tag if pipes are cut into parts - and link to original
- o Ability to do inventory check once a year
- o Works from remote locations and can be accessed from user's desktops
- o Accessible to City Care contractors and potential integration with City Care systems
- o Ability to report on data stored (Finance and Asset Data team)

Process Requirements
- o Once spare is installed this becomes asset (if Capex) and capitalised
- o If spare expires and if this was created as a draft asset, write-off process commence
- o If spare procured as Opex, ability to tag to an Asset

Out of Scope with the chosen Solution and process as per 26 May 2021 Meeting
- o Ability to put multiple items under one code (a package)
- o Manuals to have separate QR codes for scanning to Redeye
- o Nice to have the ability to access from mobile devices (e.g. phone)
- o Ability to upload after if there is no connection at the time of recording

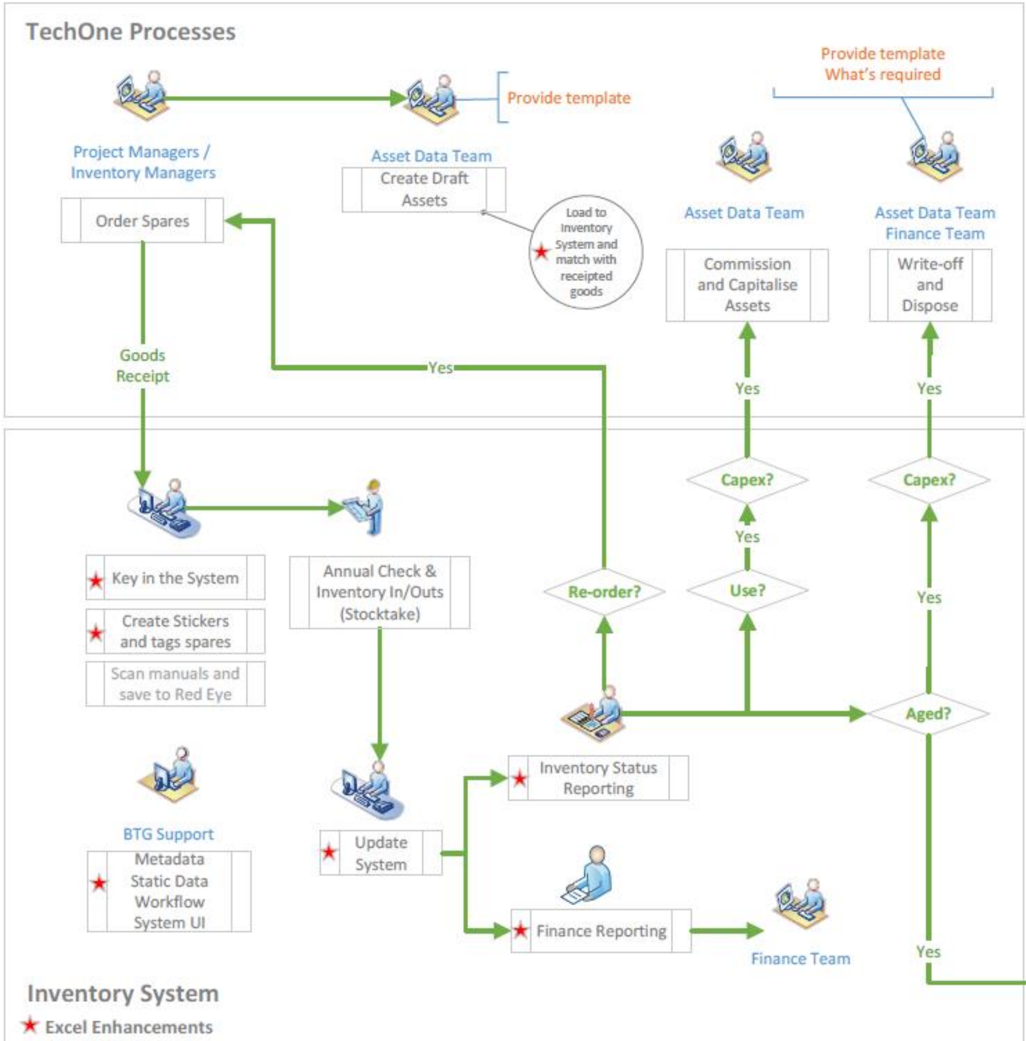
Required Metadata

- o Category: Pipes, Fittings, Consumables and Miscellaneous
- o Description
- o State: In stock, Disposed, Consumed (means became an Asset)
- o Age
- o Critical/Non-Critical Flag
- o Diameter
- o Length
- o Quantity
- o Stock Location (e.g. if multiple stockrooms or sheds)
- o Material
  - * Pipe: CLS, PVC, PE, Other
  - * Fittings: Mechanical, Gibaults, Clamps, Manholes
  - * Consumables: Bolts, Rubberings, Wrapping materials, Neoprene, Bending
  - * Miscellaneous: Barriers, Valves, potentially include non-critical spares

Additional fields as per the 26 May 2021 Meeting
- o Make
- o Model
- o Type
- o Manufacturer
- o Supplier
- o Location the spare was used for
- o TechOne Asset number it is intended to be used or TechOne Asset number it was actually used
- o Expense Type – Capex or Opex

Inventory Management System

Proposed High Level Process and Excel Enhancements



Process Options for Capitalisation

Option 1

Each Capex part to be purchased under a separate task, for easier capitalisation when installed. Admin heavy but clean to allocate and can be ring-fenced at the project level. Individual Projects could allocate budget to individual tasks.

Option 2

Capital task for all spares is ring-fenced WIP expected to always reconcile to the capex portion of the critical spares held in inventory.

1. One budget code for critical spares with one task for Capex.
2. A task is created in the WORKS system when spares are used also needed for installation costs and asset record would be attached to this task.
3. Journal is required from the Step 1 Capital task to the Step 2 Works task representing the cost of the items used against this task.
4. Advise AFA of the work being completed and task ready for capitalisation.

Note: Project managers to journal cost from their own project to Step 1 task

Option 3

Other Options – Lanne to further do feasibility analysis

System Requirements

* Metadata - e.g. Asset No, Make, Model, Product numbers, etc.
* City Care Contractor Access
* BTG Applications Support

Device and Labels

- o Weather Resistant Labels
- o Extended Range Scanner
- o Labeler

Storage Area

Physical Disposal

Components Classification

Non Asset (Opex)

- o Bolts, Rubber rings
- o Gasket sets (incl nuts & bolts)
- o Pipe bridge arches
- o SS clamps – TM to amend PO
- o PE Couplers, Tee, bend, riser

Asset (Capex)

- o Gibaults (of different values)
- o SS testing caps (tools?) – not relevant
- o Mechanical fittings (multifit couplers)
- o Pipe; CLS, PE, PVC
- o Manhole parts
- o Duo fit repair fittings

Asset (Capex) – Future Assets

- o Valves, Water meter
- o Water filling point cabinets
- o BFP device (RPZ), PE Manhole

Note: Further discussion required