Troubleshooting Tools and Techniques

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Troubleshooting Tools and Techniques

Tony Sceviour P.Tech (Owner of TBS Consulting Inc.)

- 40+ years of experience and counting in automation and control
- 6-Sigma Black Belt training
- Statistical Process Control Modeling and Control
- Offering Project Management, automation and control as well as troubleshooting and testing services.
- Servicing heavy industry, commercial and municipalities
- Some of my clients:
  - Exploits Regional Water Supply
  - Rio Tinto IOC
  - Towns of Botwood, Bishops Falls, Grand Falls, Leading Tickles, Phillips Head, Point Leamington, Summerford ….
  - Cottles Island Lumber Company

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Troubleshooting Tools and Techniques

Wikipedia defines troubleshooting as:

“In general, troubleshooting is the identification or diagnosis of "trouble" in the management flow of a system caused by a failure of some kind. The problem is initially described as symptoms of malfunction, and troubleshooting is the process of determining and remedying the causes of these symptoms.”

A couple of key points from this definition:

- Identification of trouble. How do you know when you really have a problem? What is the failure??

- Do you have a plan to remedy this problem??

- How do you know that your problem is fixed??

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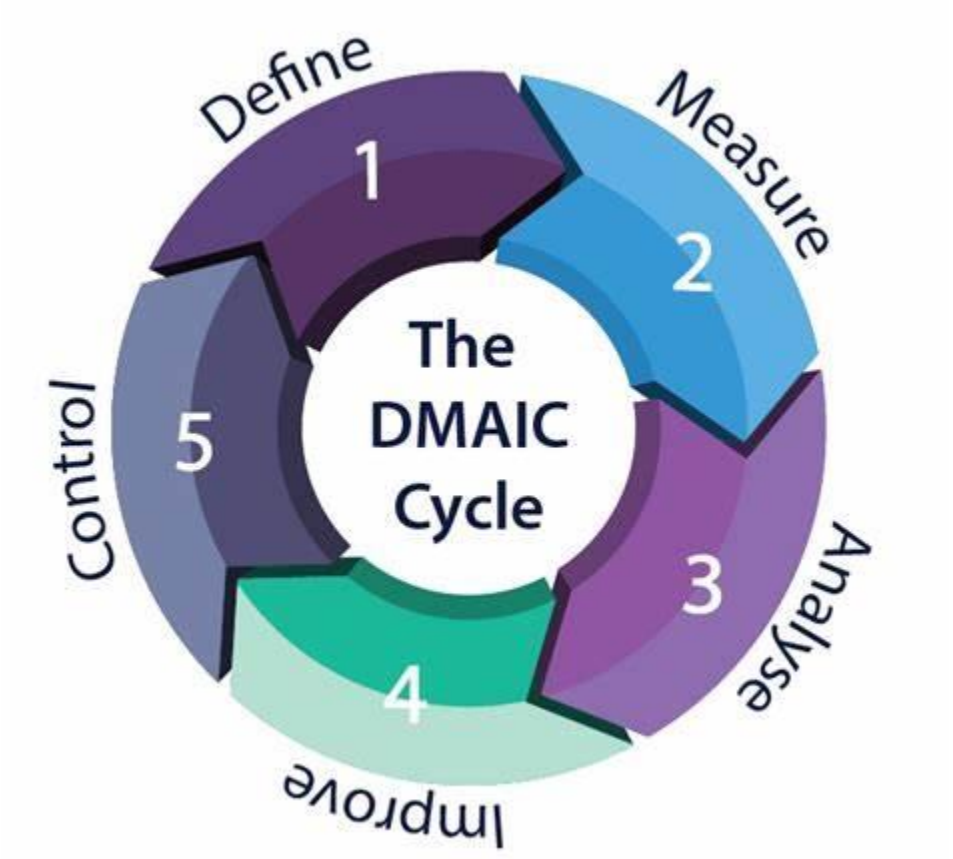
The DMAIC approach to troubleshooting.

DMAIC is a 6-sigma tools used for process improvement



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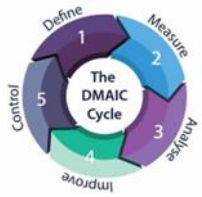

Troubleshooting Tools and Techniques

Define: (What does good look like)

Most problems evolve over time. A systems performance degraded slowly and we learn to adapt until the system gets to a point where it cannot supply the demand or need it was designed for.

- Your snow machine doesn't pull like it used to, until you can't pull a load.
- You take longer to get wood, only when you put a new chain on your saw you realize how bad it was cutting.
- Your second water supply pump runs more often until it's running full time.
- Your reservoir is not filling like it should until you can't fill it at all

How to establish "What good looks like"

The ideal time to define what good looks like is when a system is first installed but it can be done at anytime.

- Use established standards
- Use supplier documentation
- Comparisons to similar systems
- Design specifications

""Do not assume there was no problem when the system was installed,, There could be a problem that has existed since the beginning " – This is referred to as a <u>DAY ONE DEVIATION</u>""

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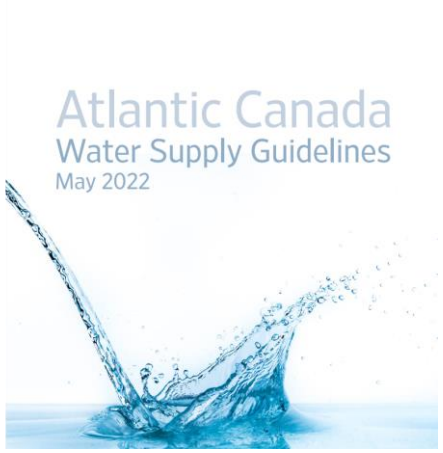
Troubleshooting Tools and Techniques

Define: (What does good look like):



*Storage / supply capacity = Fire Fighting Storage
+ Peak Balance Storage (25% of daily demand)
+ Emergency Storage (15% of daily demand)

* In some systems there is no reservoir therefore there should be sufficient pumping capacity to match this formula

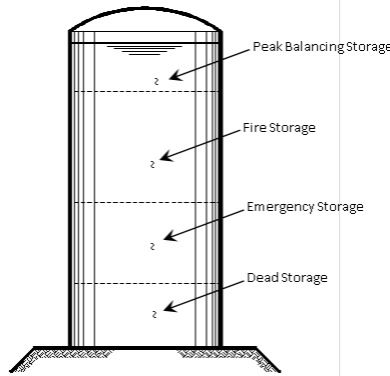


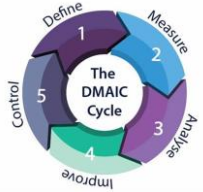
Figure 7.4: Sizing of Water Storage

Table 8.2: Commercial & Industrial Water Demands

Commercial and tourist areas	28 m^3/(ha·d)
Shopping centres (based on total floor area)	2,500 - 5,000 L/(m^2·day)
Hospitals	900 - 1,800 L/(bed·day)
Schools	70 - 140 L/(student·day)
Travel trailer parks (minimum with separate hook-ups)	340 L/(space·day) - 800 L/(space·day)
Campgrounds	225 - 570 L/(campsite·day)
Mobile home parks	1,000 L/(space·day)
Motels	150 - 200 L/(bed-space·day)
Hotels	225 L/(bed-space·day)

Household demand:
Per-capita demand 350 l/d
With a range of 270 – 450 l/d

Systems Pressure:
Normal operating pressure 50 to 70 psi
Minimum at any point in the system > 40 psi
Maximum should never exceed 100 PSI
Fire flow pressure > 22 psi at the hydrant



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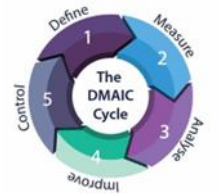

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Define: (What does good look like):

Water usage / load profile for NFLD town

		Uasge factors from (ACWWA)				Low daily usage			Average daily usage			High daily usage		
Domestic Usage	Population	Low	Average	High	Conversion	Liters/ day	USG/day	USG/min	Liters/ day	USG/day	USG/min	Liters/ day	USG/day	USG/min
	3500	270	350	450	0.2641721	945000.00	249642.59	173.36	1225000.00	323610.76	224.73	1575000.00	416070.98	288.94
Commercial														
Retirement Home	250	270	350	450	0.2641721	67500.00	17831.61	12.38	87500.00	23115.05	16.05	112500.00	29719.36	20.64
School	100	70	100	140	0.2641721	7000.00	1849.20	1.28	10000.00	2641.72	1.83	14000.00	3698.41	2.57
Hospital	150	900	1350	1800	0.2641721	135000.00	35663.23	24.77	202500.00	53494.84	37.15	270000.00	71326.45	49.53
Camp ground	50	225	398	570	0.2641721	11250.00	2971.94	2.06	19900.00	5257.02	3.65	28500.00	7528.90	5.23
Total Daily Usage							**304986.63**	**211.80**		**408119.40**	**283.42**		**528344.10**	**366.91**

Reservoir capacity						**US gallons**
Peaking Capacity	25%	of daily demand				102030
Emergency Capacity	15%	of daily demand				61218
Fire fighting Capacity	((600 USG/min for 2 hours ** minimum))					72000
Minimum required reservoir capacity						235248

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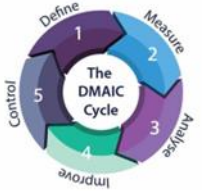
Measure: (Average usage and usage profile)

Now that we have established what good looks like, we can start measuring the performance of the system to see if we do indeed have a problem.

We have established that our NFLD town should have a maximum average usage of 370 USG/min

To get an accurate picture of our usage we need to consider the average flow rate and the usage profile.



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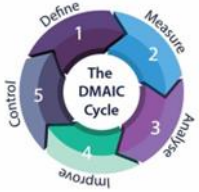

Troubleshooting Tools and Techniques

Measure: (“A picture is worth a thousand words”)

Most systems should have a way to measure the flow in the system. Without a way to measure flow there is no may to monitor the health of your system except – The Call ”Water is coming up through the ground”

<u>In addition to the instantaneous flow, we also need to understand the flow profile.</u>

In our NFLD town at 1 am when everyone is in bed and no major industrial client running our usage should drop significantly, in the order of 10% of our average flow or less.

Date	Time	NFLD Town
05/28/2022	0:00:30	5
05/28/2022	0:05:30	24
05/28/2022	0:10:30	1
05/28/2022	0:15:30	0
05/28/2022	0:20:30	2
05/28/2022	0:25:30	3
05/28/2022	0:30:30	2
05/28/2022	0:35:30	0
05/28/2022	0:40:30	0
05/28/2022	0:45:30	0
05/28/2022	0:50:30	2
05/28/2022	0:55:30	2
05/28/2022	1:00:30	2
05/28/2022	1:05:30	0
05/28/2022	1:10:30	0
05/28/2022	1:15:30	-4
05/28/2022	1:20:30	-1
05/28/2022	1:25:30	2
05/28/2022	1:30:30	0
05/28/2022	1:35:30	1
05/28/2022	1:40:30	3
05/28/2022	1:45:30	2
05/28/2022	1:50:30	3
05/28/2022	1:55:30	2
05/28/2022	2:00:30	1
05/28/2022	2:05:30	4
05/28/2022	2:10:30	3
05/28/2022	2:15:30	3
05/28/2022	2:20:30	0
05/28/2022	2:25:30	1
05/28/2022	2:30:30	3
05/28/2022	2:35:30	0
05/28/2022	2:40:30	0
05/28/2022	2:45:30	1
05/28/2022	2:50:30	3
05/28/2022	2:55:30	2
05/28/2022	3:00:30	3
05/28/2022	3:05:30	0
05/28/2022	3:10:30	0
05/28/2022	3:15:30	3
05/28/2022	3:20:30	1
05/28/2022	3:25:30	-1
05/28/2022	3:30:30	1
05/28/2022	3:35:30	0
05/28/2022	3:40:30	1
05/28/2022	3:45:30	3
05/28/2022	3:50:30	0
05/28/2022	3:55:30	2
05/28/2022	4:00:30	3
05/28/2022	4:05:30	0
05/28/2022	4:10:30	3
05/28/2022	4:15:30	0
05/28/2022	4:20:30	0
05/28/2022	4:25:30	1
05/28/2022	4:30:30	3
05/28/2022	4:35:30	0
05/28/2022	4:40:30	4

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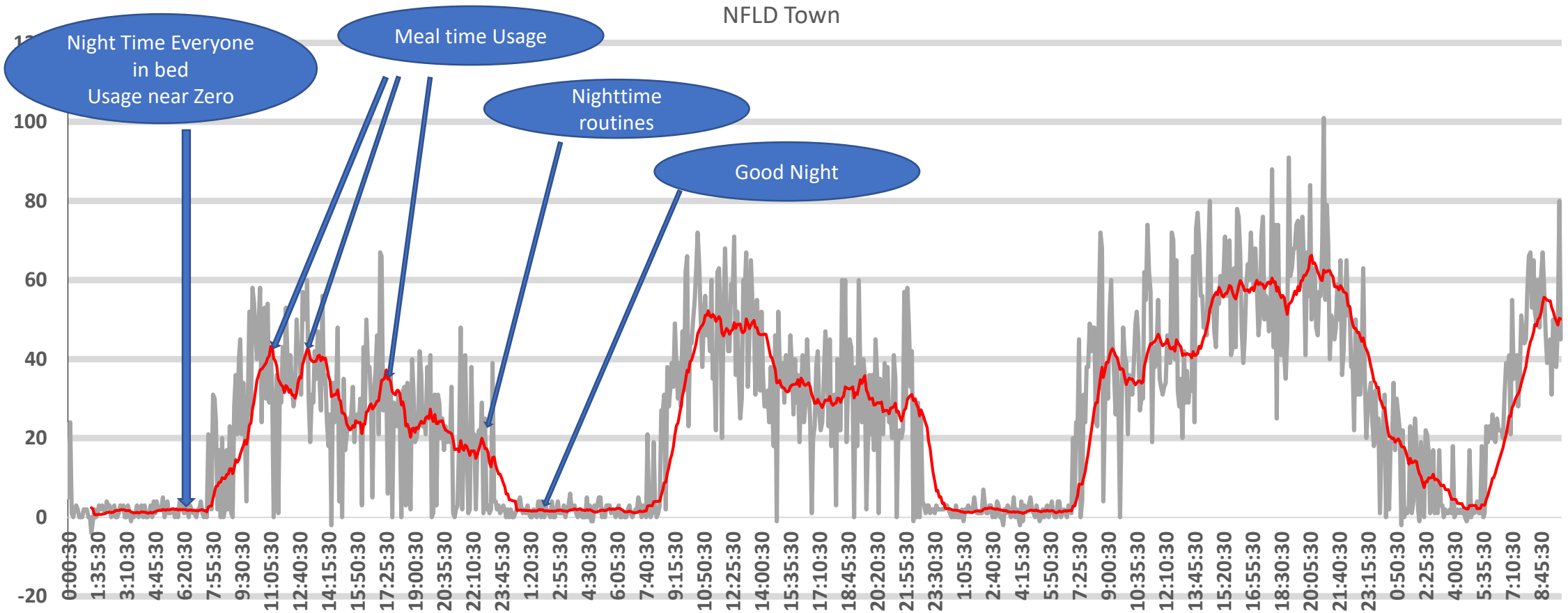
Troubleshooting Tools and Techniques

Measure: (“A picture is worth a thousand words”)



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Measure: “Methods”

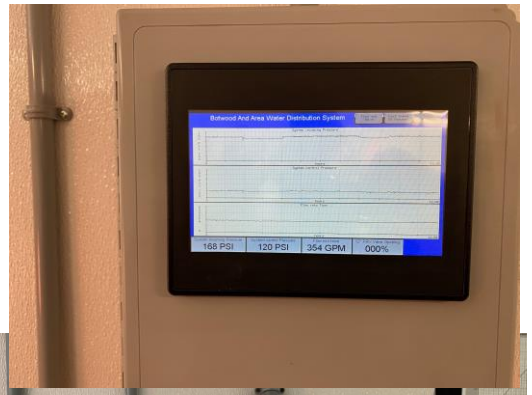
To have an accurate picture of the performance of your system you will need a way to measure the flow and to plot the trend of the flow in a 24 hour period.

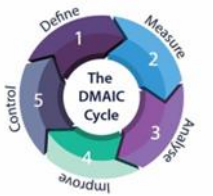
- By far the most accurate way is to have a flow meter and trend display installed. Most systems today have a flow meter used for chlorine metering. It would be a very small step to install a trending display to this meter.

- Temporary ultrasonic flow meters can be installed on a pipe for troubleshooting and measurement

- Flow can be estimated using valve opening and or pump load measurement.

- Reservoir outage is a very easy and accurate method of flow measurement.





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Measure: “Methods” – “Reservoir outage “

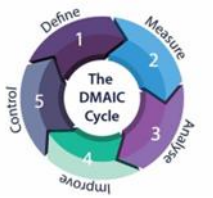
On systems with a reservoir it can be relatively simple to characterize the flow profile of your system

1. Fill the reservoir to a known level and record.
2. Shut down the supply of water into your system and run off the reservoir for a fixed period of time
3. Record the level in the reservoir at the end of the period

Reservoir (Volume calculator)			
Reservoir dimensions		**Factor (Cu inch to USG)**	**Surface area (square inches)**
		0.004329	
Diameter (Inches)	360		101784.6
Maximum Height (inches)	480		
Minimum Height (Inches)	0		
Total Volume	211500		

In this example we are using
293 USGPM overnight
Not good – we probably have
a 250 gallon leak

Reservoir (Outage Calculator)					
		Outage (Inches)	**Outage Time (Minutes)**	**Outage (USG)**	**Outage (USG/min)**
Level at start of test (inches)	300	200	300.00	88125.1	293.8
Time of start of test	1:00:00 AM				
Level at the end of test (inches)	100				
Time at the end of the test	6:00:00 AM				



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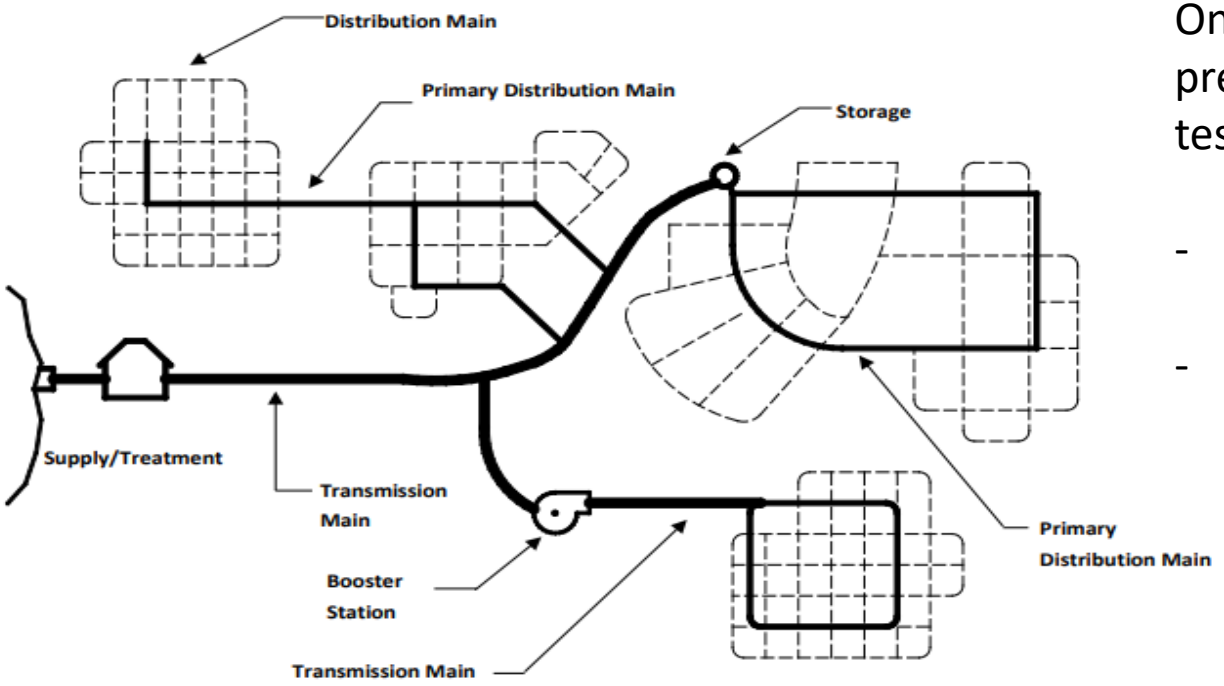
Analyse (Plan)

So far we have defined our system and measured the high level performance and in the last slide we have identified that we have a 250 + gallon leak in our NFLD system.

Now we can start the analysis phase and narrow in on the probable area.



One of our best analysis tools as we discussed previously is to trend the flows or to run the outage test on our reservoir overnight.

- Very little impact on our towns and give us definitive results in terms of the size of the leak.
- By repeating these tests by isolation different areas of our system we can quickly identify and narrow in on the most likely area of our issue

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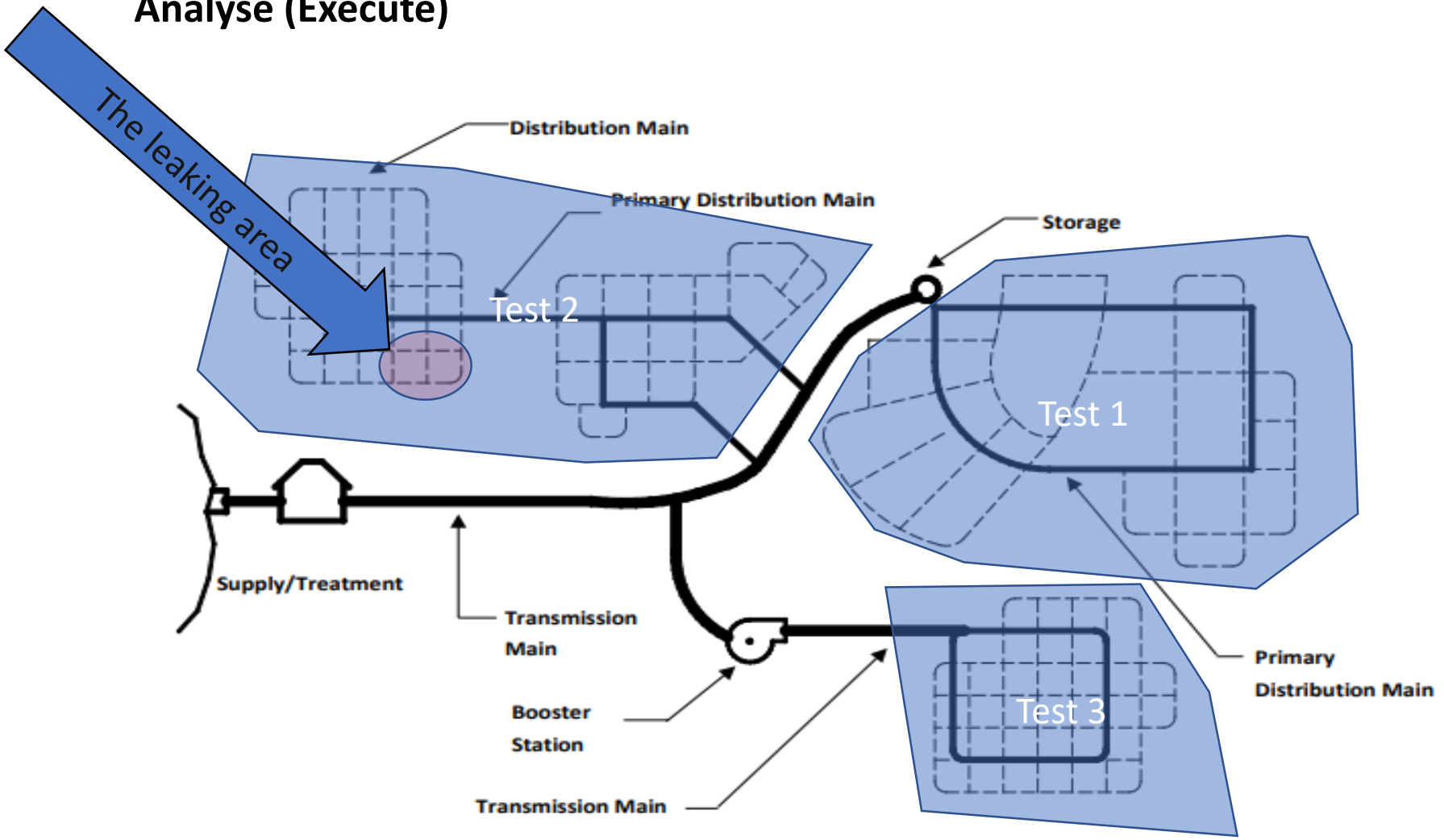
Analyse (Execute)



NFLD town – leak down testing

- Test 1 , night 1 , results no change in flow
- Test 2, night 2, results flow dropped by 150 USGPM
- Test 3, night 2, results flow dropped by 20 USGMP

Our leak is in the test 2 area. We will continue to isolate areas within this zone. By manipulating valves in the system we have narrowed the search area down to the area noted.

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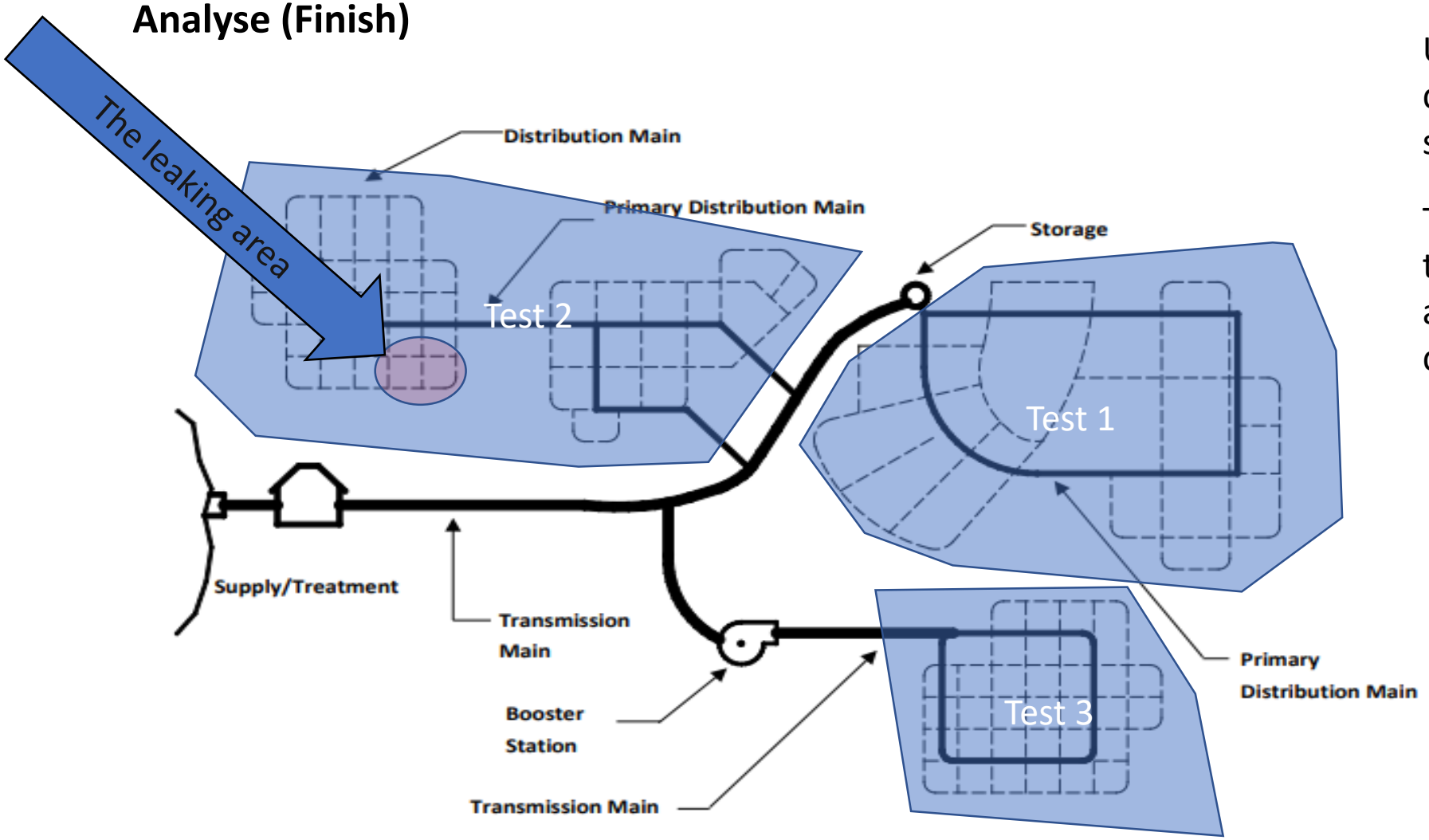
Analyse (Finish)



Up to this point in time we have not dug on any lines and have not seriously disrupted the system.

There are a number of tools open to us at this time to continue to analyse the problem without digging holes.

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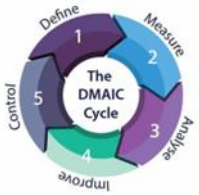

Troubleshooting Tools and Techniques

Analyse (Analytical tools)

Before we dig:

1. Acoustic microphones, these devices listen to the water flow and may indicate if you are close to a break.
2. Leak Correlators, use 2 or more microphones to triangulate the leak using the difference in the time it takes the noise from the leak to reach each of the microphones

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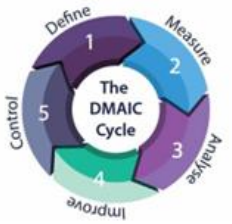
Troubleshooting Tools and Techniques

Analyse (Analytical tools)

After we dig on a dry hole

So we have dug a dry hole and exposed the water line, which direction do we dig in now?? To eliminate the guess work a portable ultrasonic flow meter works great. It will tell you the direction of flow and the velocity of that flow. By manipulating isolation valves the ultrasonic flowmeter will pinpoint the leak between any two isolation valves.



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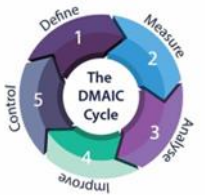


Troubleshooting Tools and Techniques

Improvement

We fix the leak.

Now that we have the line exposed and the leak is fixed we need to think beyond the fix.

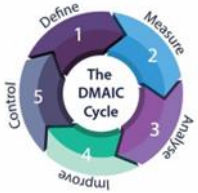
- Is the line the same as on our drawings, Type , size etc.? If not now is the time to correct the error.
- Take pictures and file them for later reference.
- Can you see any obvious reason for the break?
- If we had problems finding any of the isolation valves now is the time to document their location on our drawings.

Troubleshooting Tools and Techniques

Control

Our leak is fixed,,--- We are not done yet ---

- We should run one last test or monitor our 24 hour trends to confirm that there are no other leaks and to verify the “as built” flow and pressure numbers and flow profiles for our town.
    - This will be a very valuable reference when diagnosing future water supply system issues.
- Schedule a yearly audit of the system performance against the established as built numbers.



Troubleshooting Tools and Techniques

Questions