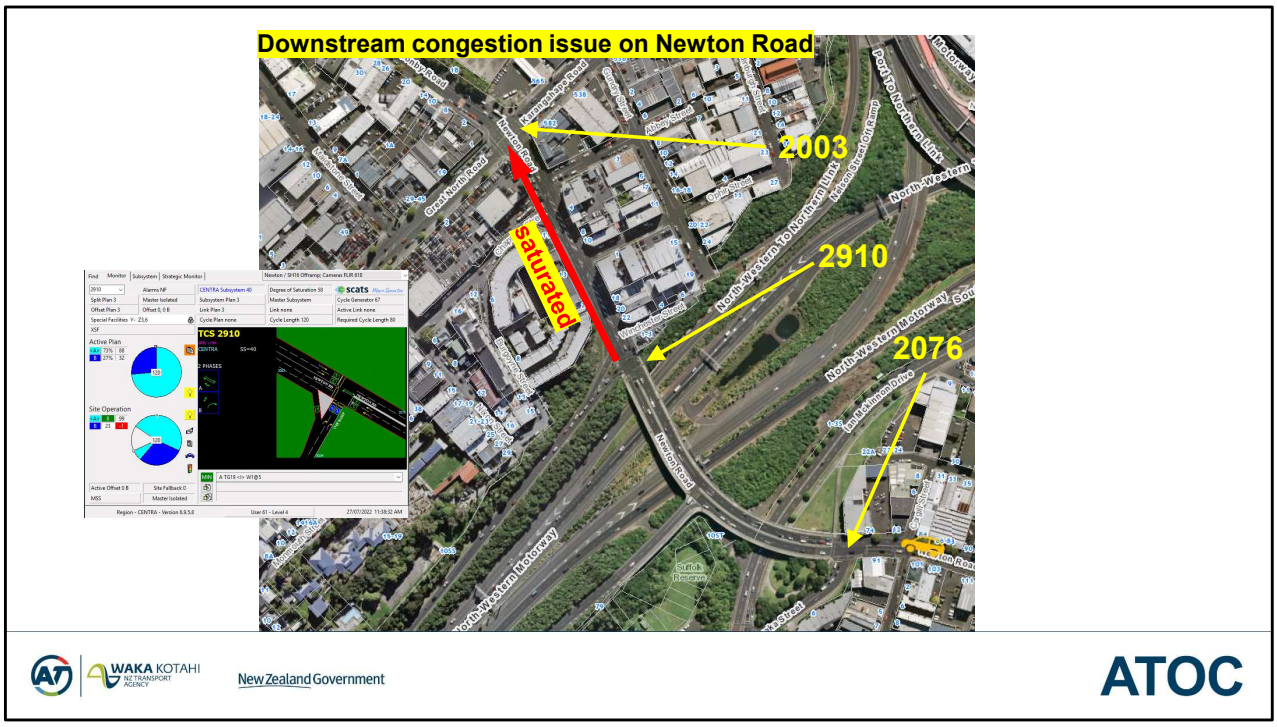
Why the need to detect downstream congestion?

In SCATS, there are times when we need to detect downstream block and take appropriate actions in a timely manner to improve operation efficiency as well as safety

From an intersection, downstream congestion can be detected relatively easily if there is a departure loop but the problem in Auckland is that most sites only have stop line detector loops

Let's look at a real example



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This is Newton Road.

This is intersection 2003 in SCATS. It is a very busy intersection.

This is intersection 2910. It's an off ramp of SH16. We will look at some data in more detail on this intersection in later slides. Here I show the SCATS graphic representation of 2910.

This is intersection 2076.

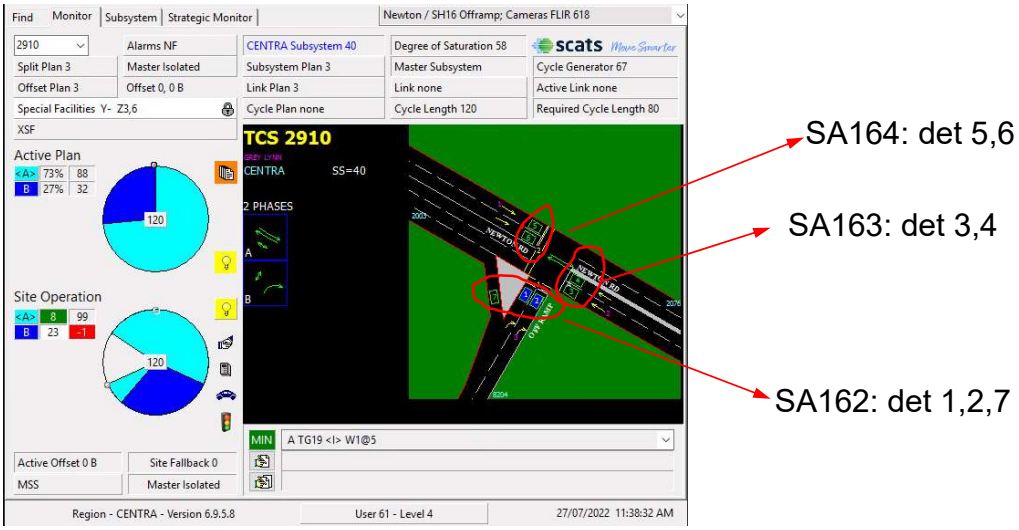
Sometimes, the section between 2003 and 2910 would become fully saturated but SCATS would continue to extend stretch phase at 2910

When this happens, stretch phase may be running for a long time at 2910 while nobody is able to move due to downstream block. Meanwhile, offramp motorists become frustrated and has a tendency to take risk to run red light.

Impact on safety and operation efficiency

There is a need to detect downstream congestion at 2910 to stop stretch phase from running for a long time and to shorten the wait time for off ramp vehicles

Strategic approaches in SCATS at intersection 2910



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Let's take a look at the strategic approaches for 2910
SA162, SA163, SA164

We are interested to look at the data collected by SA163 (det 3,4) to get a clue of the downstream congestion

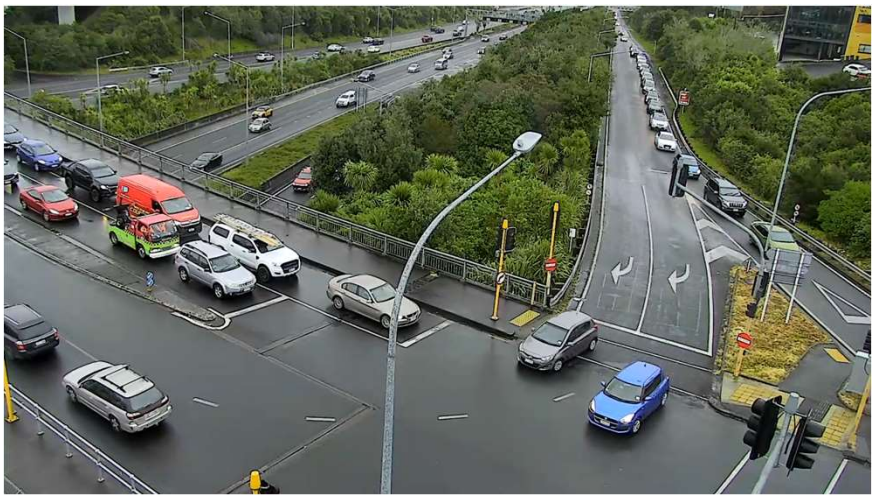
Some congestion indicators in SCATS

- Degree of Saturation (DS)
- VK/VO ratio*
- ~~Required cycle length~~
- ~~Nominal cycle length~~
- ~~Elapsed time of a strategic input (also known as measured green time, SIg)~~

Which is better?

**Note:*

VK = reconstituted volume (expected number of vehicles)
VO = original volume (measured number of vehicles)



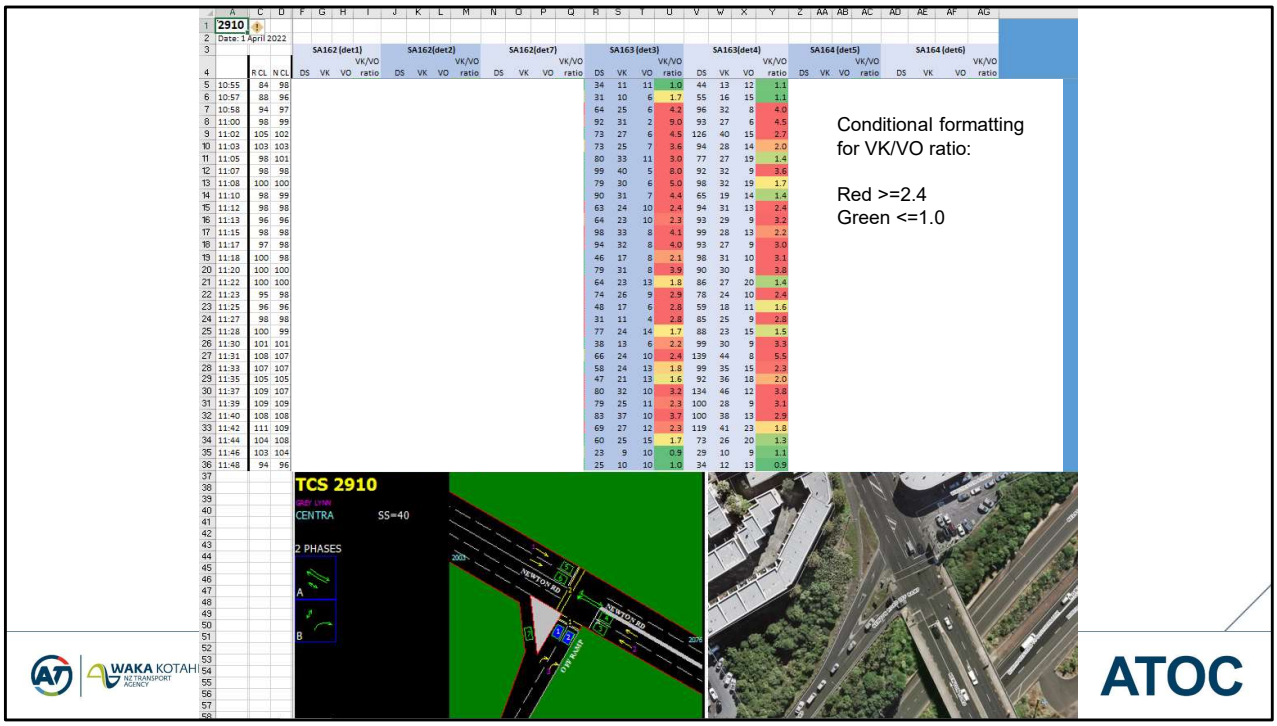
This short video was taken last Tuesday. There was a downstream congestion. If nothing was done to SCATS, the stretch phase would run for a very long time. This could cause massive queueing on the off ramp. In this instance, I have implemented a detection mechanism for this condition and automatically reduce the cycle time significantly so that off ramp vehicles did not have to wait for too long.

Digesting the data SCATS Strategic Monitor Screen

```
Friday 01-April-2022 10:56 SS  40   PL 4.3  PV 0.3 CT   98 +0 RL 84' SA 416 DS 116
 Int   SA/LK     PH  PT!  DS  VO  VK!  DS  VO  VK!  DS  VO  VK!  DS  VO  VK! ADS
 2910 SA 162  '   B  23!  39   4   4!  65   4   5!  21   2  2!   -       -!   70
 2910 SA 163  '   A  68!  34  11  11!  44  12  13!   -       -!   -       -!   45
 2910 SA 164  '   A  68!  90  26  25!  37  11  10!   -       -!   -       -!   78
 2910 LK  79 ^'   A  68!  90  26  25!  37  11  10!   -       -!   -       -! 1240
 2910 LK 101 ^'   A  68!  34  11  11!  44  12  13!   -       -!   -       -!  900
A=<75>  B=25
Friday 01-April-2022 10:57 SS  40   PL 3.3  PVa6.3 CT   96 +0 RL 88' SA 162 DS 90
 Int   SA/LK     PH  PT!  DS  VO  VK!  DS  VO  VK!  DS  VO  VK!  DS  VO  VK! ADS
 2910 SA 162  '   B  25!  59   6   6!  52   4   4!  90   6  9!   -       -!   81
 2910 SA 163  '   A  68!  31   6  10!  55  16  16!   -       -!   -       -!   49
 2910 SA 164  '   A  68!  54  16  15!  72  20  20!   -       -!   -       -!   76
 2910 LK  79 ^'   A  68!  54  16  15!  72  20  20!   -       -!   -       -! 1320
 2910 LK 101 ^'   A  68!  31   6  10!  55  16  16!   -       -!   -       -!  940
A=<72>  B=28
Friday 01-April-2022 10:58 SS  40   PL 4.3  PVa3.3 CT   97 +0 RL 94' SA 415 DS 99
 Int   SA/LK     PH  PT!  DS  VO  VK!  DS  VO  VK!  DS  VO  VK!  DS  VO  VK! ADS
 2910 SA 162  '   B  28!  75   7   8!  39   4   3!  86   3  8!   -       -!   83
 2910 SA 163  '   A  78!  64   6  25!  96   8  32!   -       -!   -       -!   71
 2910 SA 164  '   A  78!  48  16  15!  45  14  14!   -       -!   -       -!   65
 2910 LK  79 ^'   A  78!  48  16  15!  45  14  14!   -       -!   -       -! 1220
 2910 LK 101 ^'   A  78!  64   6  25!  96   8  32!   -       -!   -       -! 1480
A=<74>  B=26
Friday 01-April-2022 11:00 SS  40   PL 3.3  PVa6.4 CT   99 +0 RL 98' SA 416 DS 99
 Int   SA/LK     PH  PT!  DS  VO  VK!  DS  VO  VK!  DS  VO  VK!  DS  VO  VK! ADS
 2910 SA 162  '   B  26!  78   9   9!  70   7  6> 132   6  13!   -       ->  108
 2910 SA 163  '   A  67!  92   2  21!  93   6  27!   -       -!   -       -!   86
 2910 SA 164  '   A  67!  48  13  13!  53  15  14!   -       -!   -       -!   56
 2910 LK  79 ^'   A  67!  48  13  13!  53  15  14!   -       -!   -       -! 1080
 2910 LK 101 ^'   A  67!  92   2  31!  93   6  27!   -       -!   -       -! 1860
A=<71>  B=29
Friday 01-April-2022 11:02 SS  40   PL 4.3  PVa5.4 CT  102 +0 RL105' SA 155 DS 140
 Int   SA/LK     PH  PT!  DS  VO  VK!  DS  VO  VK!  DS  VO  VK!  DS  VO  VK! ADS
 2910 SA 162  '   B  28!  78   9   9!  49   5   5!   0   0   0!   -       -!   88
 2910 SA 163  '   A  74!  73   6  27> 126  15  40!   -       -!   -       ->  109
 2910 SA 164  '   A  74!  36  10  12!  30   9   9!   -       -!   -       -!   44
 2910 LK  79 ^'   A  74!  36  10  11!  30   9   9!   -       -!   -       -!  900
 2910 LK 101 ^'   A  74!  73   6  27> 126  15  40!   -       -!   -       -! 2260
A=<74>  B=26
Friday 01-April-2022 11:03 SS  40   PL 4.3  PVa1.4 CT  103 +0 RL103' SA 163 DS 94
 Int   SA/LK     PH  PT!  DS  VO  VK!  DS  VO  VK!  DS  VO  VK!  DS  VO  VK! ADS
 2910 SA 162  '   B  22!   0   0   0!  54   5   4!  81   4  7!   -       -!   91
 2910 SA 163  '   A  70!  73   7  25!  94  14  28!   -       -!   -       ->  104
 2910 SA 164  '   A  70!  43  12  12!  35  10  10!   -       -!   -       -!   43
 2910 LK  79 ^'   A  70!  43  12  12!  35  10  10!   -       -!   -       -!  920
 2910 LK 101 ^'   A  70!  73   7  25!  94  14  28!   -       -!   -       -! 2100
A=<75>  B=25
Friday 01-April-2022 11:05 SS  40   PL 4.4  PV 0.4 CT  101 +0 RL 98' SA 415 DS 91
 Int   SA/LK     PH  PT!  DS  VO  VK!  DS  VO  VK!  DS  VO  VK!  DS  VO  VK! ADS
 2910 SA 162  '   B  24!  57   4   6!  72   6   6!   0   0   0!   -       -!   76
 2910 SA 163  '   A  83!  80  11  33!  77  19  27!   -       -!   -       -!   96
 2910 SA 164  '   A  83!  42  15  14!  52  17  17!   -       -!   -       -!   46
 2910 LK  79 ^'   A  83!  42  15  14!  52  17  17!   -       -!   -       -!  900
```

Microsoft Excel Worksheet

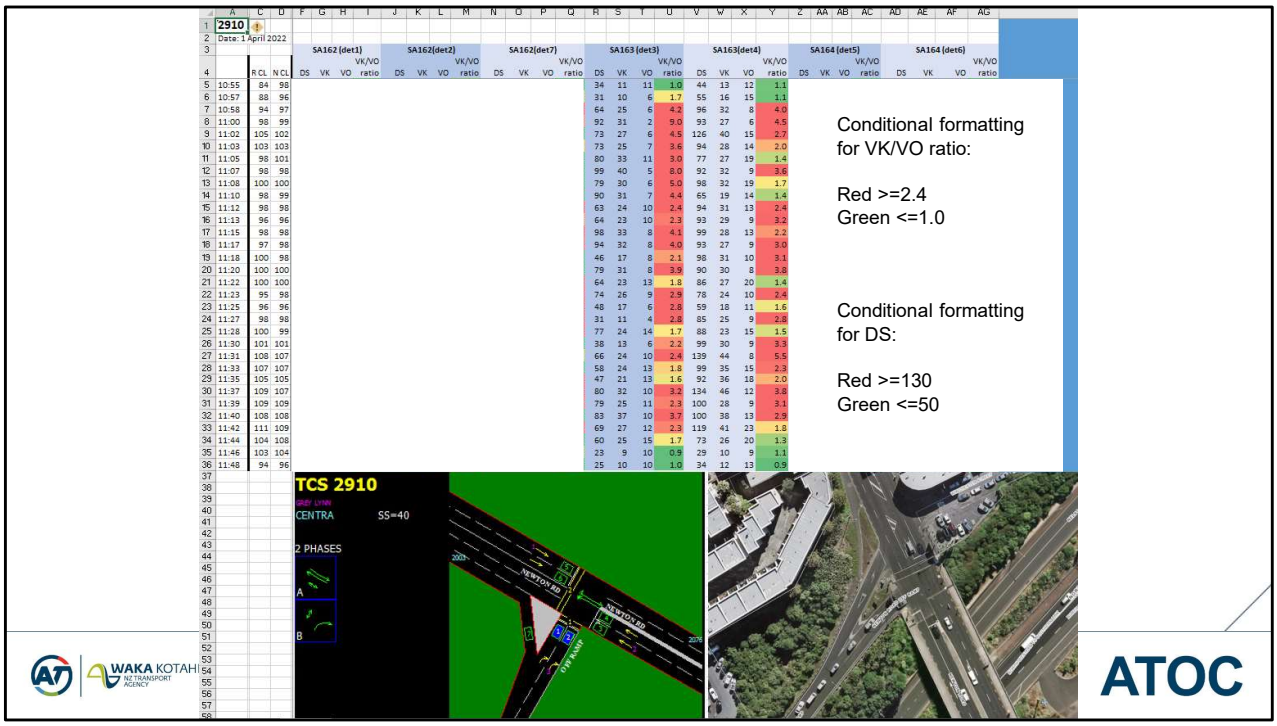
The strategic monitor screen in SCATS shows information of all strategic approaches and detectors. They are very difficult to read. I have converted them to an Excel spreadsheet for ease of reading.



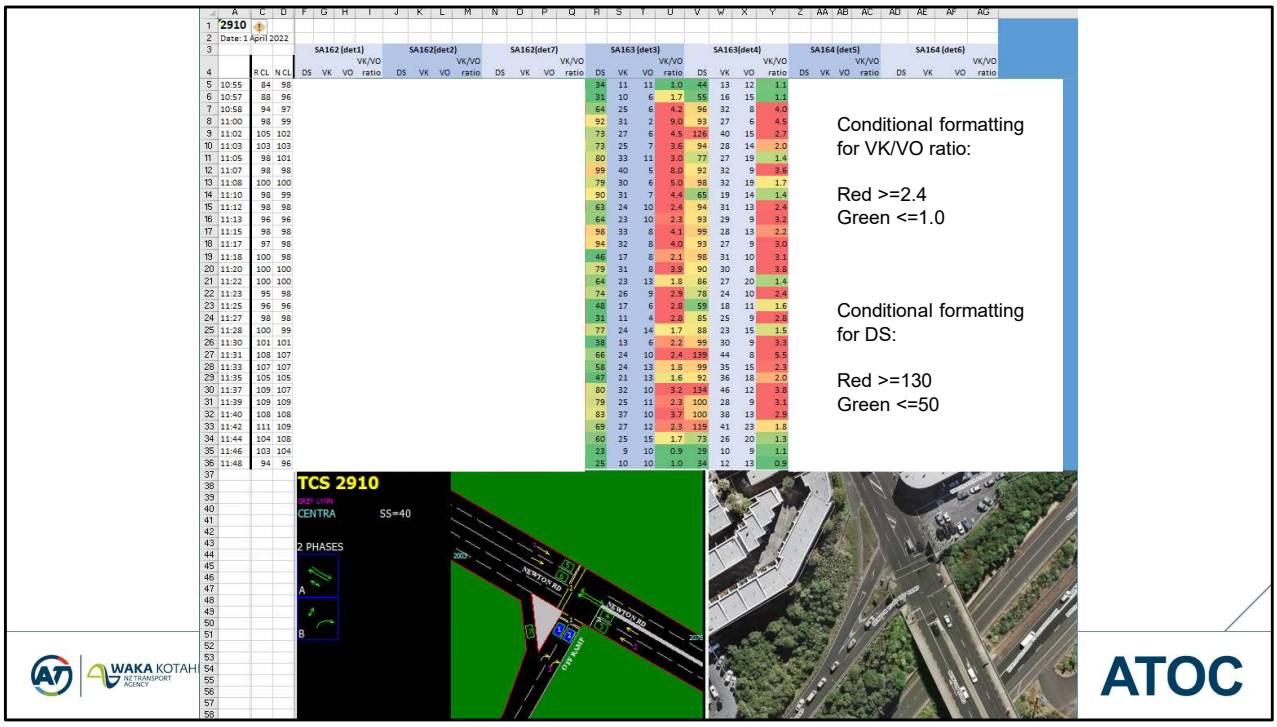
This spreadsheet tabulates all strategic approach data at 2910 between 11am-12pm on 1st April 2022. The left hand column shows the time. This is the time when I happened to be on site and witnessed the saturation of the section between 2003 and 2910. The saturation started from around 11am and lasted for about 50 minutes on that day.

We are interested to look at only SA163 data.

VK/VO ratio is conditionally formatted.

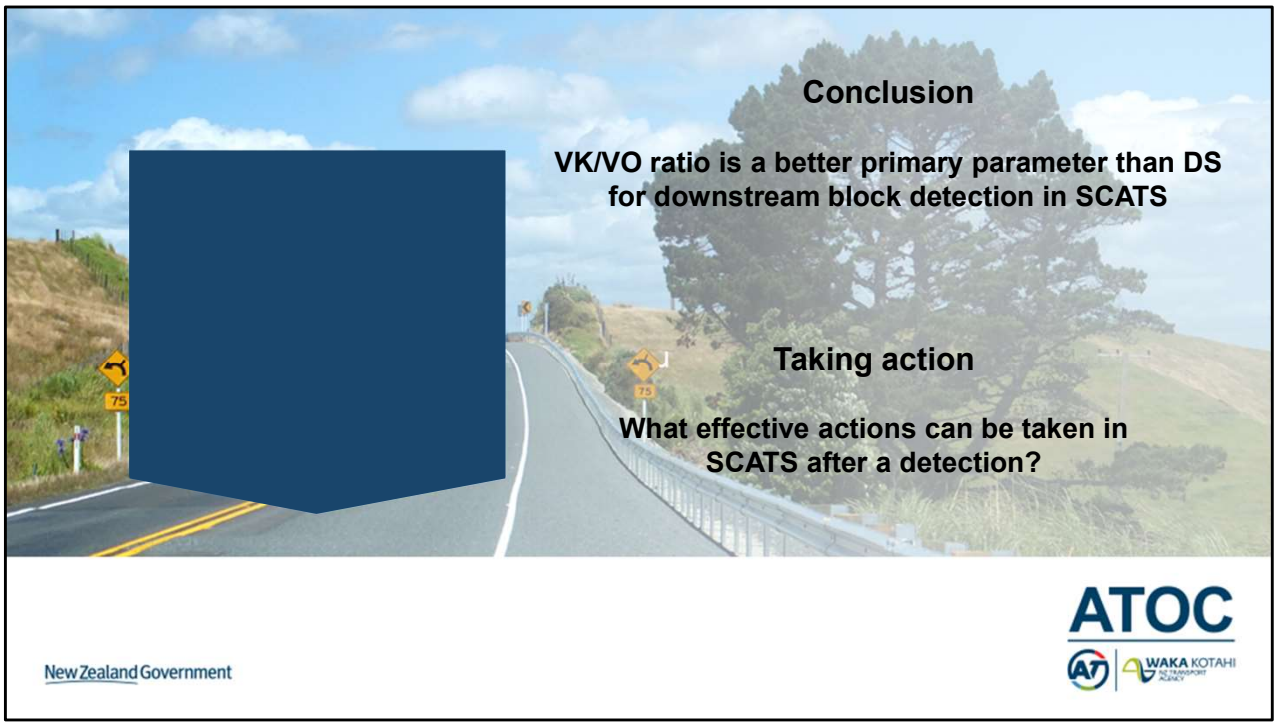


Now let's add in some conditional formatting for the DS column and see how that compares with VK/VO ratio



We can see that DS values were all over the place while VK/VO ratio gave a more consistent and timely alert to the condition of a downstream congestion.

A picture speaks a thousand words. Between VK/VO ratio and DS, VK/VO ratio is obviously the better indicator for downstream congestion.



Conclusion

VK/VO ratio is a better primary parameter than DS for downstream block detection in SCATS

Taking action

What effective actions can be taken in SCATS after a detection?

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Additional slides

Digesting the formulas

$$VK = \frac{DS \times MF \times g}{3600}$$

where:

VK = Reconstituted volume
DS = Degree of saturation
MF = Maximum flow a.k.a. saturation flow (vehicles per hour)
g = Green time (seconds)

$VK \propto DS$ **VK** is directly proportional to **DS**

$\frac{VK}{VO}$ ratio has another amplifying denominator **VO**

because when there is a downstream block, VO < VK