# $R^4H_2O$: R for Water Professionals: Session 1

Dr Peter Prevos

# Online Sessions

Case Study 1: Exploring and analysing water quality data

1. Introduction to R
2. Visualising and communicating results

Case Study 2: Cleaning, exploring and analysing a customer survey

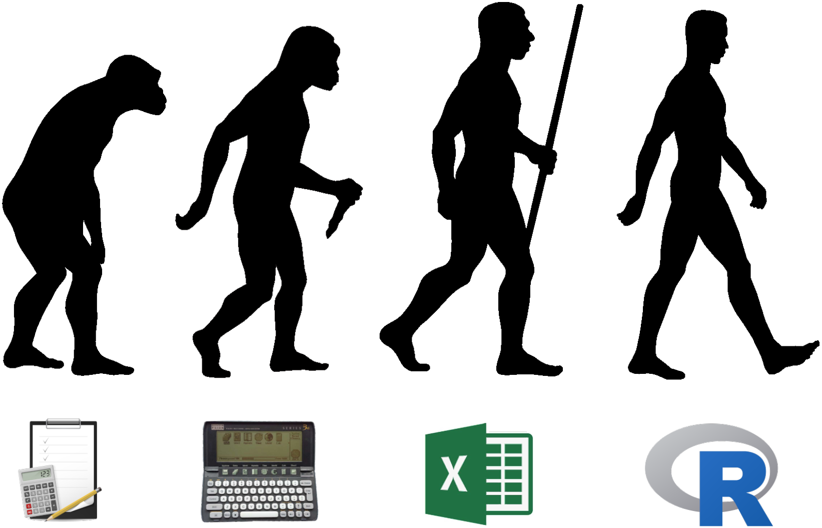
3. Cleaning and exploring data
4. Analysing and communicating results

# Session 1 Program

- Introduction
- Principles of Data Science
- Introduction to R
- Exploring Data
- Descriptive Statistics

Figure 1: R for Water Professionals workshop (Melbourne, 2019).

# My Data Science Evolution



# Resources

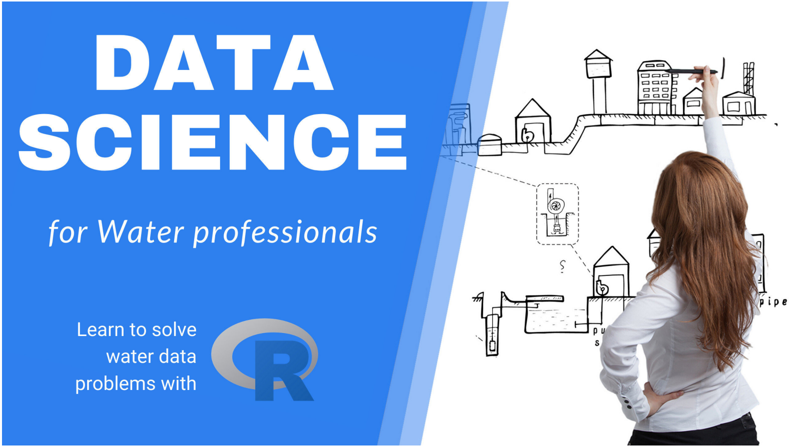
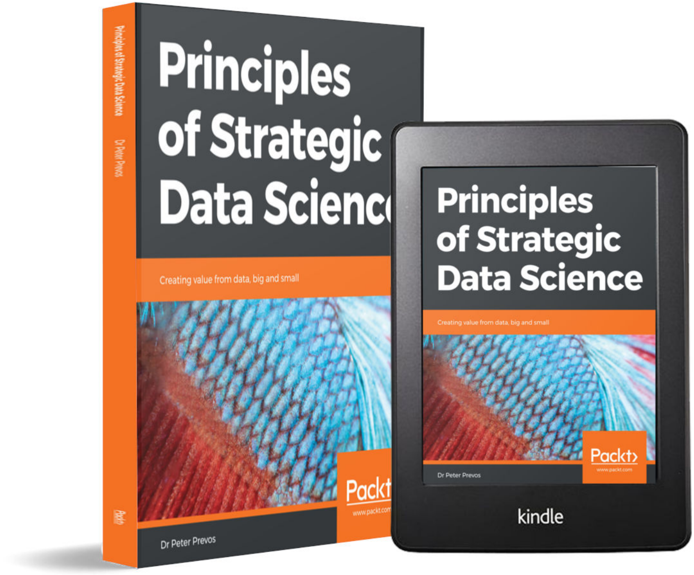


Figure 2: Register to get access to the on-line syllabus:
https://leanpub.com/c/R4H2O/c/esc-vic

# Principles of Data Science


Principles of Strategic Data Science
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Principles of Strategic Data Science
Creating value from data, big and small
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# What is Data Science?

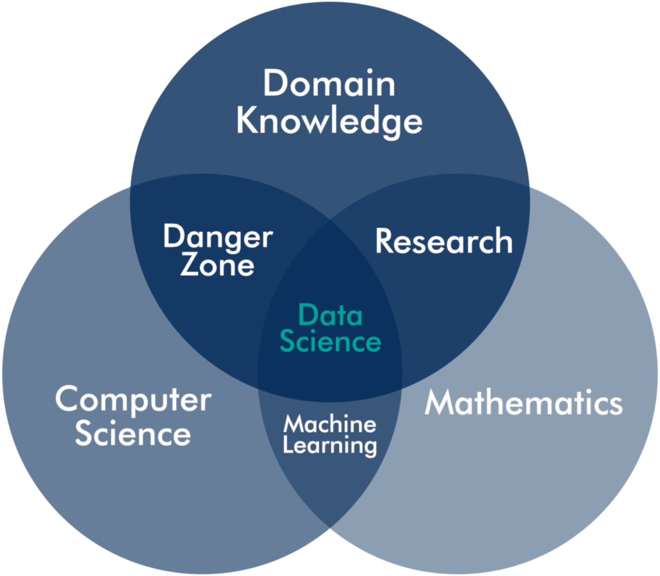


Figure 3: The Conway Venn Diagram (Drew Conway, 2013).

# What is good data science?

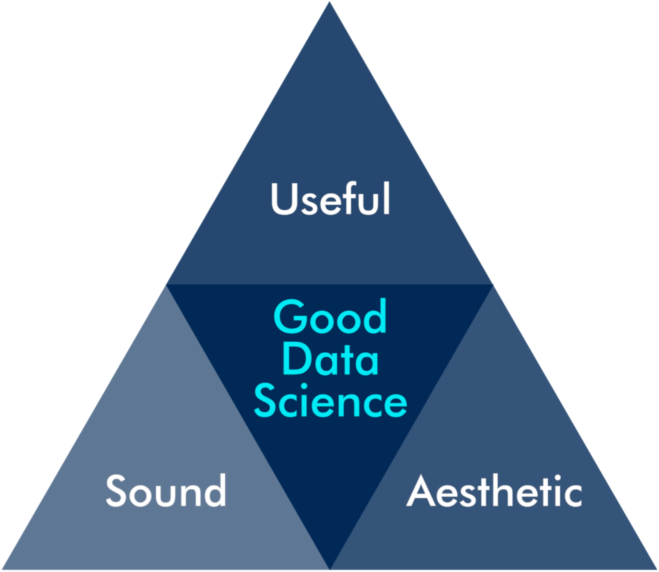


Figure 4: The Vitruvian triangle of good data science.

# What is useful data science?

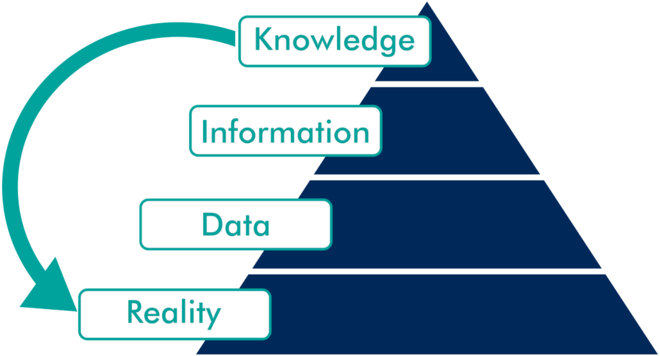


Figure 5: Modified version of the DIKW model.

# What is sound data science?

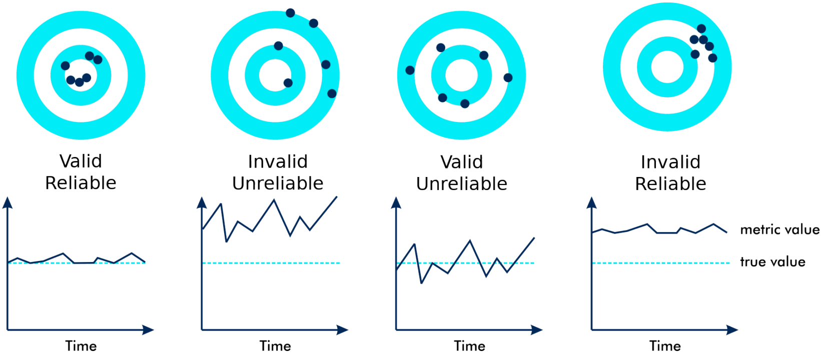


Figure 6: Validity and reliability.

# What is sound data science?

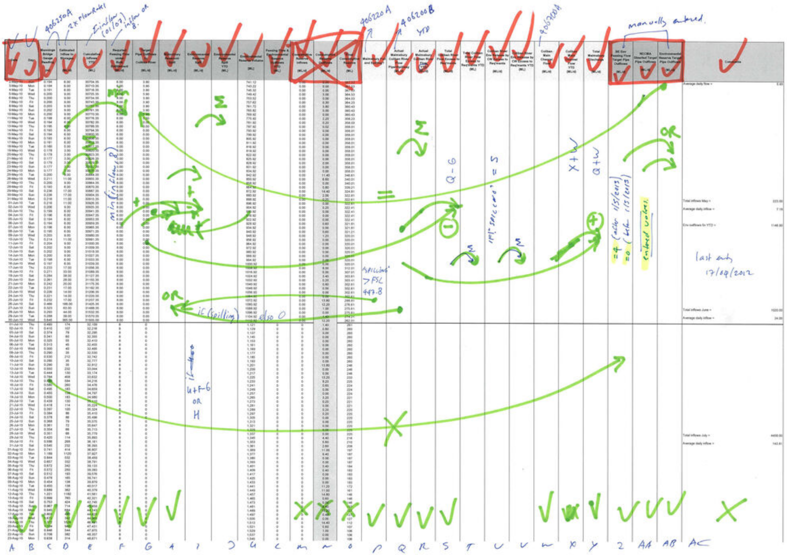

406250A
2x flowRate
E inflow (01/07)
inflow at B
406220A
406200B
YTD
406200A
manually entered
Σ
min(inflow, 8)
Q-G
=5
X+W
Q+W
OR
=4 (after 1/5/2013)
=0 (before 1/5/2013)
entered values
last entry 17/09/2012
Spilling >FSL 447.8
OR
if (Spilling) else 0
if =400
U+F-6
OR
H
A B C D E F G H I J K L M N O P Q R S T U V W X Y Z AA AB AC

Figure 7: Reverse-engineering a spreadsheet

# What is sound data science?

Reproducible code:

```r
reservoirs %>%
    select(Date, River_Flow, Natural_Flow, ERV) %>%
    mutate(Date = as.Date(Date, format = "%d %m %Y")) %>%
    gather(Source, Value, -Date) %>%
    mutate(type = factor(Source == "ERV"),
           type = fct_recode(type, Flow = "FALSE",
                             Volume = "TRUE")) %>%
    ggplot(aes(Date, Value, col = Source)) +
    geom_line() +
    facet_grid(type~., scales = "free_y")
```

# What is aesthetic data science?

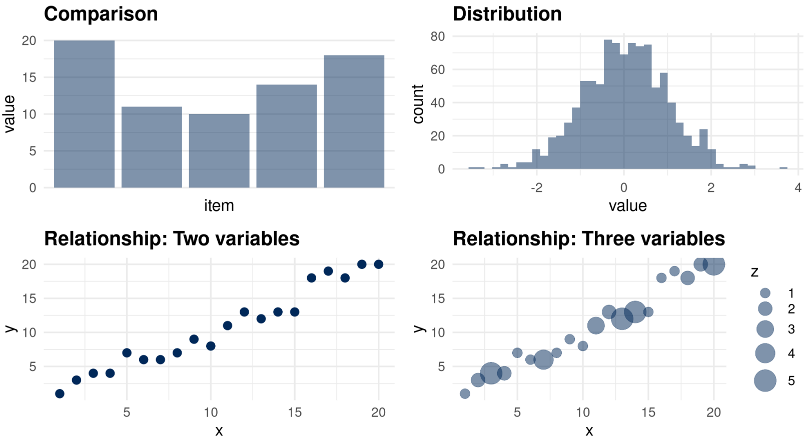


Figure 8: Data visualisation is about telling stories.

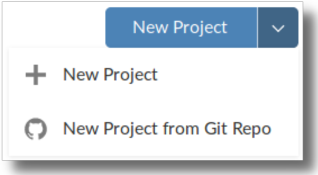
# Configure R Studio

**Desktop**

- Install R and RStudio
- Download materials: `https://github.com/pprevos/r4h2o`
- Unzip folder
- *File > Open Project*
- Open the `r4h2o.Rproj` file in the downloaded folder

**Cloud**

- Sign-up at: `rstudio.cloud`
- *New Project > New Project from Git Repo*



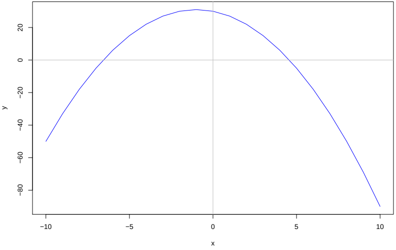
- Enter GitHub URL

# Console exercise

1. Enter sample code into the console (see syllabus for examples)
2. Observe the output in the console
3. Observe the environment
4. Use ↑↓ to scroll history
5. Use TAB for completion
6. Play with variations

```
x <- -10:10
y <- -x^2 -2 * x + 30

plot(x, y, type = "l",
     col = "blue")
abline(h = 0, col = "grey")
abline(v = 0, col = "grey")
```



# R is Meme-Proof

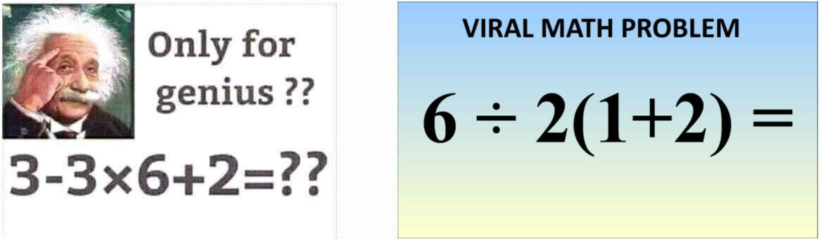


Figure 9: Aritmetic memes.

# Quiz 1: Calculate Channel Flows

Determine the flow in a channel. Go to exercise 1 and answer the questions.

$$q = \frac{2}{3} C_d \sqrt{2g}\ bh^{3/2}$$

- $q$: Flow $[m^3/s]$.
- $C_d \approx 0.6$: Constant.
- $g = 9.81 m/s^2$
- $b$: Width of the weir $[m]$
- $h$: Water depth over weir $[m]$

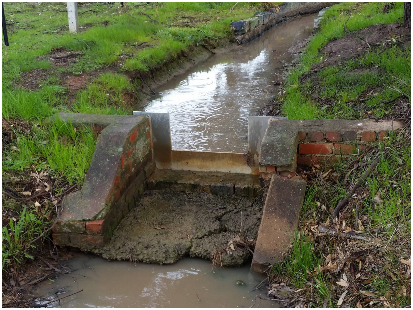


Figure 10: Channel with weirplate (Photo: Coliban Water).

# Scripts versus Console

- Store all code in a text file with `.R` extension
- Output in console, plots and viewer
- Use comments (start with #) to explain the code
- *File > New File > R Script*
- Open the `channel_flow.R` script in `inroduction` folder.
- Reverse-Engineer the code

```r
## Question 2
h <- c(150, 136, 75) / 1000 # Create a vector
q <- (2/3) * Cd * sqrt(2 * 9.81) * b * h^(3/2)
mean(q) * 1000 # Convert to l/s
```

# Reproducible Code

- Give meaningful names
- Use a consistent method, e.g.:
  - Only lower case: `channelflow`
  - Underscore for spaces: `channel_flow`
  - Camel case: `ChannelFlow`
- Use comments to explain the process
- Add links to documentation
- Automate as much as possible

# The Tidyverse

An opinionated collection of R packages optimised for data science. All packages share an underlying design philosophy, grammar, and data structures.

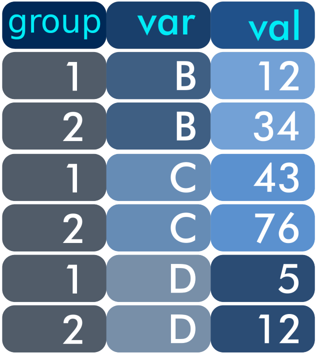
```r
install.packages("tidyverse")
library(tidyverse)
```

Load the `casestudy1.R` script in the `casestudy1` folder.

# Data frames or 'tibbles'

- Rectangular data
- Variables in columns
- Observations in rows
- One variable in R environment
- Tidy data
- Read data:

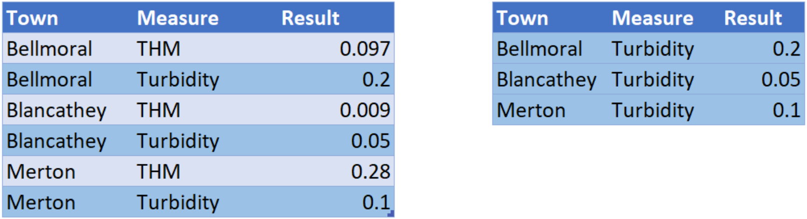
```
dataframe <- read_csv(filename)
```



| group | var | val |
|---|---|---|
| 1 | B | 12 |
| 2 | B | 34 |
| 1 | C | 43 |
| 2 | C | 76 |
| 1 | D | 5 |
| 2 | D | 12 |

Figure 11: Data frame structure.

# Filter a data frame



| Town | Measure | Result |
|---|---|---|
| Bellmoral | THM | 0.097 |
| Bellmoral | Turbidity | 0.2 |
| Blancathey | THM | 0.009 |
| Blancathey | Turbidity | 0.05 |
| Merton | THM | 0.28 |
| Merton | Turbidity | 0.1 |

| Town | Measure | Result |
|---|---|---|
| Bellmoral | Turbidity | 0.2 |
| Blancathey | Turbidity | 0.05 |
| Merton | Turbidity | 0.1 |

Figure 12: `filter(gormsey, Measure == "Turbidity")`

# Quiz 2: Explore data

- Load the CSV file for the Gormsey system in the `casestudy1` folder.
- Explore the data.
- Answer the questions in Exercise 2 in your syllabus.
- You can cheat by opening the `quiz_02.R` script.

# Descriptive Statistics

Safe Drinking Water Regulations 2015:

> *"the 95th percentile of results for samples in any 12 months must be less than or equal to 5.0 Nephelometric Turbidity Units."*

Guidance document:

> *"The method recommended by the department is described as the Weibull method and is the method adopted by the National Institute of Standards and Technology (NIST)."*

# Percentiles

1. The data are placed in ascending order: $y_1, y_2, \ldots y_n$.
2. Calculate the rank of the required percentile

- Weibull: $r = p(n+1)$
  - Excel: $r = 1 + p(n-1)$
  3. Interpolate between adjacent numbers: $X_p = (1 - r_{frac}) Y_{r_{int}} + r_{frac} Y_{r_{int+1}}$

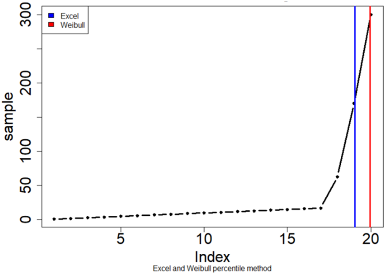
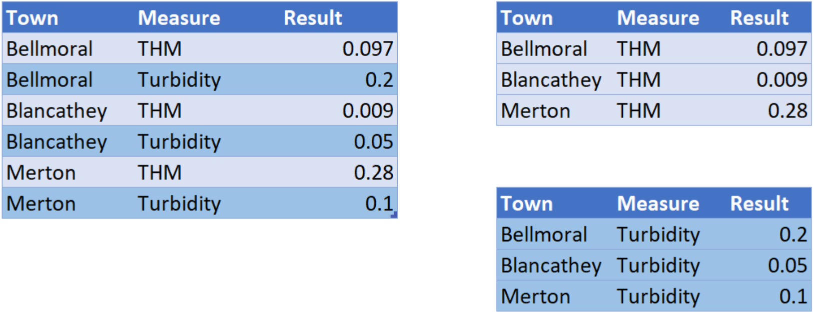


Figure 13: Explore the `percentiles.R` script in the `casestudy1` folder.

# Grouping



| Town | Measure | Result |
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| Town | Measure | Result |
|---|---|---|
| Bellmoral | Turbidity | 0.2 |
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| Merton | Turbidity | 0.1 |

Figure 14: `group_by(gormsey, Measure)`