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MATH3001: Assessing and communicating mitigation of river floods to policy makers and the general public

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Contents

1 Introduction

Floods have been documented in multiple historic and contemporary sources. To those raised with an understanding of Abrahamic religion the most recognisable documentation of a flood is probably the Noah narrative of Genesis 6-8. The tale is similar to the Crucifixion of Jesus narrative in that it seems to detail a metaphorical 'cleaning of the slate' for humankind (Matthew 27:32-28:20; Genesis 6-8). This similarity heightens the significance of the Noah and the flood narrative. Primarily, the Noah narrative seems to be a story of divine strength, morality, and forgiveness. Upon second examination, it appears to highlight the power of water. Water can cause mass destruction, like God. This is evidenced contemporarily in media outlets (British Broadcasting Coorporation, 2014). Returning to the Noah narrative, if one truly believes God was responsible for the flood of Noah's generation, then the flood could not be mitigated. Whereas, the floods of today can be mitigated. This essay will focus on flooding and its mitigation. The history and importance of flood mitigation will be briefly discussed. The history section is planned for the final essay, but not included in this interim report. The causes of river's susceptibility to flooding will be explored. In addition, the preparation for the River Thames study will be mentioned. Subsequent to this, one shall introduce the River Thames, and the 2014 River Thames flooding localised in Datchet. Moreover, proposed mitigation projects for the Datchet region will be investigated. The section of the report that is focused on the River Thames will be a preview of the final essay due to lack of data. Once the proposed mitigation projects for the Datchet region have been discussed, one shall mention alternative mitigation projects.

1.1 Definitions

Before studying the mitigation of flooding, one shall take time to define some hydrological terms. Firstly, one shall define the terms cloudburst and 'rain bomb'. The term cloudburst has been in the scientific lexicon since the early 1900s and its definition has evolved since the coining of the term (Harris & Lanfranco, 2015, pp. 155-156). For this essay, the modern scientific definition of a cloudburst will be used. It is the expulsion of all water within a cloud; during a cloudburst the air pressure drops (Harris & Lanfranco, 2015, pp. 155-156). A 'rain bomb' seems to be the popularised term for a cloudburst. Secondly, the term flashiness shall be defined. A river is said to be flashy if water levels rise quickly after rainfall (Gooley, 2017, pp. 62-63). Thirdly, the definition for flood-excess volume will be given. Flood-excess volume is the quantity of water that exceeds the height of a riverbank (Bokhove, et al., 2018a, p.6). It is estimated by summing the chosen time interval multiplied by chosen values of the rating curve minus "the threshold discharge" (Bokhove, et al., 2018a, p.7). Fourthly, annual exceedance probability can be defined as the prospect of a sizeable flood occurring each year (Gordon, et al., 2004, p. 215). Finally, a flood channel can be defined as a watercourse that redirects a rivers excess water when it has reached full capacity (BBC Bitesize, c.2018, p. 3).

1.2 A brief history of flood mitigation

1.3 The importance of studying floods and their mitigation

The flood documented in Genesis 7 was punishment for the atrocities of man, which could also be said for contemporary flood events though one might argue these flood events are not a result of divine intervention. It is likely that all of us have experienced the effects of flooding either first hand or via a news outlet. Therefore, the more obvious answer to the posed question is to prevent the destruction of property, and loss of economic productivity – a cost of around £1 billion (Environment Agency, 2018). However, the more imperceptible answer is that the risk of flooding is larger in the future. According to Al Gore, a result of global warming will be an increased amount of 'rain bombs'/cloudbursts (An Inconvenient Sequel: Truth to Power, 2017, 00:50:40-00:51:43). Scientists predict that extreme rain events, like cloudbursts, could increase by 1 to 2 percent "per 1°C warming" of the average atmospheric temperature (Trenberth, 2011, p. 133). In addition, it is predicted that the atmosphere will be able to hold 7 percent more water "per 1°C warming"

(Trenberth, 2011, p. 123). So one might surmise that the severity of cloudbursts will increase. A ramification of cloudbursts is flooding (Harris & Lanfranco, 2015, p. 156); thus, a 1 to 2 percent increase of cloudbursts could roughly equate to a 1 to 2 percent increase of flooding worldwide. Therefore, the current and ongoing study of floods and their mitigation will help combat rising flood risks. The extremity of future flooding could be reduced, as could the destruction of property, and loss of productivity.

1.4 What types of rivers are flashy?

Tristan Gooley (2017, p. 19) suggests there are two factors that can cause a river to be described as flashy: soil that is silt or clay based; and/or, a drop in air pressure – as the soil cannot sustain the additional water deposit.

2 Preparation for the River Thames Study

In preparation for the investigation of the 2014 River Thames flood one had learn elements of R in order to plot graphs and create the rating curve. In my bachelor's degree, I primarily used MATLAB as a programming tool. When I looked into programming in R and python, R felt familar. My choice of software was also motivated by the fact I had to learn R for statistics. In order to learn the elements of R needed to plot graphs and create the rating curve, I scanned through books, the Rstudio help section, and watched a youtube video. The books are referenced in the code and bibliography. Since this was preparation for study of the 2014 River Thames flood, the task was to recreate the supervisor's (Thomas Kent and Onno Bokhove) graphs. An example of my recreation of the River Calder graph is displayed on the next page.

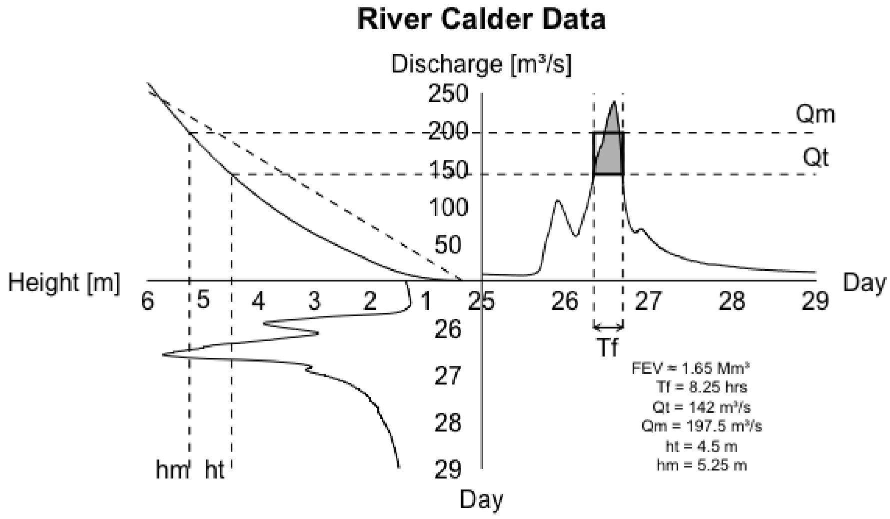

Figure 1: My recreation of the River Calder quadrant plot first created by Thomas Kent and Onno Bokhove. To provide a brief explanation of the graph, flooding of the River Calder occurs when the following happens: the height of the river exceeds the chosen ht; and, the discharge of the river exceeds the corresponding Qt (Bokhove, et al., 2018b, p.5). Tf represents the period of time that flooding occured; the label hm describes the mean height for the River Calder and Qm describes the corresponding mean discharge (Bokhove, et al., 2018b, p.5). It should be noted that the linear approximation of the rating curve (top left quadrant) is yet to be refined for this graph. Additionally, I am yet to learn how to program subscript in R - for some reason it is harder than programming superscript.

Some hurdles were encountered in the creation of the quadrant plots. These hurdles involved the use of the polygon function and the creation of the rating curve equation. For the polygon function I found that a combination of methods were required. Initially, I used

$$polygon(cbind(0.3359375, tC\_sc, 27/64), cbind(0.568, QC\_sc, 0.568), col = "grey")$$

to create the shading on the graph (Lillis, 2014, pp.50-58). However, this failed to restrict the shading to the desired area on the quadrant plot. For some reason, the use of Lillis' (2014, pp.50-58) approach worked for the mitigation plot. A fellow group member suggested using specific coordinates instead. This method refined the final outcome, but yet again failed to restrict the shading to the desired area. So, I decided to combine the different approaches,

$$polygon(cbind(0.3359375, tC\_sc[128:163], 27/64), cbind(0.568, QC\_sc[128:163], 0.568), col = "grey")$$

and this produced the shading in figure 1 (Lillis, 2014, pp.50-58).

The problems with the rating curve revolved around the rating curve equation and the for loop required to create the new discharge data. The problem with the equation was based in a lack of understanding of the equation. Initially, it was thought that we (the group) use the height data given by Environment Agency. However, Tom (supervisor) suggested that we generate new height data by programming a sequence. The problem that I encountered with the for loop was due to a simple misplacement of the empty discharge matrix.

In this section, I have also placed my recreation of Tom and Onno's square lake plot for the River Calder which details the percentage of flood-excess volume mitigated.

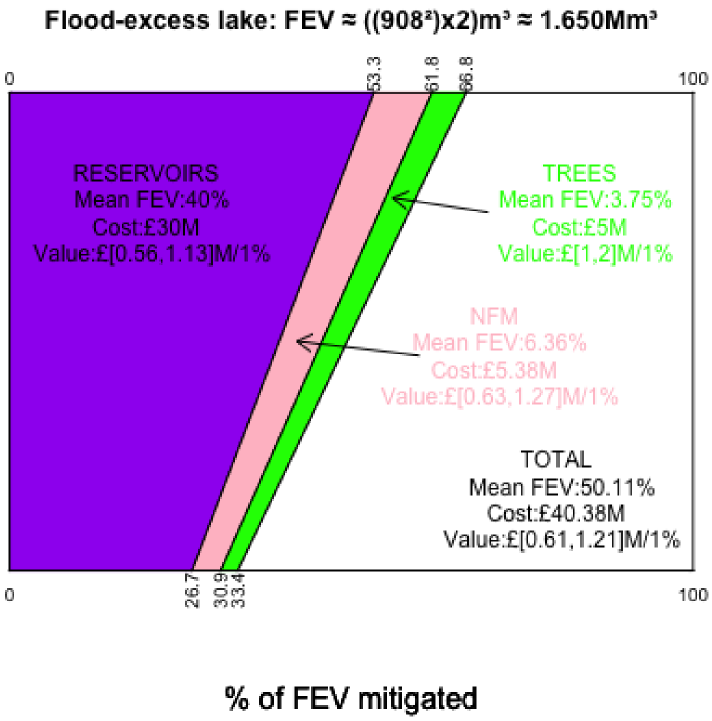

Figure 2: My recreation of the River Calder flood-excess volume mitigation plot first created by Thomas Kent and Onno Bokhove.

3 The mitigation of flooding. A case study: River Thames.

3.1 Introduction to the River Thames

One might argue that the River Thames England's most well-known river. It is the river that winds its way through London like a snake in the sand. It is the scenery presented in EastEnders opening credits, and it is the foreground of the London New Year's celebration (Eastenders Theme Tune, 2009; London Fireworks 2016 - New Year's Eve Fireworks - BBC One, 2015). It seems that the Thames is broadcast around the world as London's river, however it also flows outside of the city limits. According to the British Broadcasting Company (BBC; 2009), the non-tidal section of the River Thames spans between Teddington Lock (London) and Cirencester (Gloucestershire). However, the area surrounding the Thames that concerns this paper its historic town of Datchet. In 2014, Datchet experienced two devastating floods in January and February respectively. The floods were result of extensive rainfall and strong winds (British Broadcasting Company, 2014). Sadly, as a consequence about 47 percent of Datchet homeowners experienced damage to their properties (percentage formed from data presented in government documents: Environment Agency, 2018; Royal Borough of Windsor and Maidenhead, 2016, p.2).

3.2 The River Thames' susceptibility to flooding

The Datchet section of the River Thames is flashy. It is stated within the Environment Agencies Strategy Appraisal Report (2010, p.1) that the lower Thames region, spanning between Teddington Lock and Datchet, has an annual exceedance probability of 0.5 percent. This implies that the likelihood of a significant flood event occurring in the lower Thames region is 1:200 years (Environmental Agency, 2010, p.2). However, the annual exceedance probability is 0.5+ percent higher in Datchet (GOV.UK, 2018). This 'flashiness' can be attributed to two things: the clay based riverbed; and, the lack of flood defences (Environment Agency Thames Region, c.1996, p.4; Environment Agency, 2018).

3.3 Details of the Thames 2014 flood located in Datchet

This section will assess extremity of the flooding in Datchet experienced in 2014 by plotting the flood data in a quadrant plot, calculating the flood-excess volume, and possibly by plotting a hydrograph. As of the 6th December, the flood data has been received. Due to timing, this section is yet to be fully written up. However, one shall note that upon first glance at the data there seems to be some missing data points. It is commented in the data that the discharge anomaly is due to the extent of the 2014 flooding (Environment Agency, no date). Approximately 14 days of discharge data is missing; the discharge data for January is intact, the data for

February is corrupted (Environment Agency, no date). An email has been sent to the Environment Agency to discern whether this discharge data could be formed by the rating curve equation. Otherwise, these anomalies indicate that the study should focus on the flood data from January. In addition to correspondence with the Environment Agency, I have contacted the Met Office to find out the quantity of rain that fell in the day(s) running up to the flood and they have responded with an Excel sheet of said data. A decision on where to place the hydrograph plot is yet to be made. The debate is whether to place it in this section or the one before it. The graph(s) and flood-excess volume of the Datchet flood will also be explained in this section.

3.4 Proposed mitigation projects: The River Thames Scheme and the River Basin Management Plans

Government data states that – by 2050 – the United Kingdom will experience a 15 percent increase in extreme winter rainfall (Royal Borough of Windsor and Maidenhead, 2014, p.45). This combined with the potential threat of cloudbursts suggests that without action the flood risk of central Datchet will rise. Evidently, areas of Datchet with a high flood risk will be affected more by the change than those with a lower risk. Luckily, there are plans to mitigate future flooding in Datchet (Environmental Agency, 2010; Department of Environment, Food, and Rural Affairs & Environment Agency, 2015).

3.4.1 The River Thames Scheme

According to the Environmental Agency (2010, p.3), the scheme involves the creation of three flood channels with a capacity of $150m^3$. It is noted that the capacity of the River Thames between Datchet and Walton Bridge is in the range of $250m^3$ and $300m^3$ (Environmental Agency, 2010, p.3). The Datchet channel will flow between

Datchet and Egham (Environmental Agency, 2009, p.10). As stated in the 2010 report produced by the Environment Agency (pp.5-6), the flood water will flow through 'gravel pits' within the flood channel and biodiversity will encouraged.

It should be mentioned that there are two drawbacks of this system – cost and the risk of the channel itself flooding (BBC Bitesize, c.2018, p. 3). So the percentage of the flood-excess volume that will be mitigated by the River Thames Scheme could decrease in the future due to the rise in cloudbursts. This hypothesis is confirmed by the Environment Agency (2010, p.50). Therefore, other mitigation projects may need to be planned and executed.

3.4.2 The River Basin Management Plan

As detailed by the Department of Environment, Food, and Rural Affairs (DEFRA) and the Environment Agency (2015, p.42 & p.54), the plan centres on the installation of sustainable drainage systems in new developments and areas of outfalls. The authorial combined report does not detail the effects of the sustainable drainage system installation (Department of Environment, Food, and Rural Affairs & Environment Agency, 2015).

When the flood-excess volume is calculated for the Datchet floods, one should calculate the percentage of the flood-excess volume that will be mitigated by both mitigation projects.

3.4.3 The Paris Agreement

While the Paris Agreement is focused on reducing the impact of global warming not the mitigation of flooding, it seems that the reduction of the impact of global warming would help mitigate future flooding (United Nations Framework Convention on Climate Change, 2018). Therefore, I wish to explore the agreement in more depth in the final report.

3.5 Alternative mitigation projects

O eport of the Environment Agency (2018), other methods of flood mitigation were considered. In an email to the Environment Agency, I asked what the other mitigation projects were and why they were abandoned. They sent through the a link to the aforementioned Strategy Appraisal Report (2010, pp.19-20), which detailed some of the other methods of flood mitigation that was considered. These considerations will be delved into in the final report.

It should be noted that flood mitigation projects d ave to be the sole work of the government. There seems to be multiple projects with the aim to reduce the impact of climate change. However, ject that might provide householder with more security is swapping out the paved/concrete driveway for a permeable drive or perhaps a front garden (Great British Garden Revival, 2013, 00:29:51-00:40:25). It may seem peculiar, but a paved/concrete driveway does more damage than perceived. Flood water will sit on a paved/concrete driveway because it cannot be absorbed by the soil (Great British Garden Revival, 2013, 00:35:10-00:37:21). Research suggests that the planting of trees has to be sizeable to mitigate flooding (Bokhove, et al., 2018b, p.15), thus it is acknowledged that a permeable drive or front garden will not stop flood water entering a house if the flood is large enough. Though it still remains that permeable drive or a front garden is better, let alone prettier, than a paved/concrete driveway.

4 Conclusion

To summarise, some rivers are more susceptible to flooding than others and the threat of global warming implies that the flashiness of rivers will increase in the future. Luckily for those that live in the Lower Thames region there are mitigation projects in place to reduce this risk. These mitigation projects will be fully discussed in relation to the 2014 Datchet flood in the final report. This flood was introduced and a quadrant plot will be produced at a later date. Research into mitigation reports has begun and will continue into the second semester. A full conclusion will be given in the final report.

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A Use of appendices

The first code is for the Calder quadrant plot. The second is for the mitigation plot for Calder. For both code, superscipt was used when ∧ 3 is presented in the code below. LaTeX would not print the superscript. Additionally, it would not print ≈ so the LaTeX code for ≈ is substituted in.

```
library(readr)
River_Calder_Data <- read_csv("Desktop/University_of_Leeds/R/
    River_Calder_Flow&StageData_25DecTo29Dec.csv",
                                                    col_types = cols(Flow = col_
                                                        double(),
                                                                  Height = col_
                                                                      double(),
                                                                      Time = col_
                                                                      double()))
tC=River_Calder_Data$Time
QC=River_Calder_Data$Flow
hC=River_Calder_Data$Height

library(readxl)
Rating_Curves <- read_excel("Desktop/University_of_Leeds/R/
    Rating Curves.xlsx",
                                                    sheet = "Sheet2", col_types = c("
                                                        skip",
                                                    "skip", "skip", "skip", "skip",
                                                    "skip", "skip", "numeric", "
                                                        numeric",
```

```
                                    "numeric", "skip", "skip", "skip
                                       ",
                                    "skip", "skip"))

Calder_C=Rating_Curves$Calder_C
# simplifying Rating Curve data names
Calder_a=Rating_Curves$Calder_a
Calder_b=Rating_Curves$Calder_b

hc=seq(from=0.35, to=6, by=0.01)

QCald=matrix(nrow=566, ncol=1)
# (R Tutorial - Learn How to Create and Name Matrices in R,
   2015)

for(i in 1:566){
  if(hc[i]<2.107)
    QCald[i,1]=Calder_C[1]*(hc[i]-Calder_a[1])^Calder_b[1]
  if(2.107<=hc[i] & hc[i]<3.088)
    QCald[i,1]=Calder_C[2]*(hc[i]-Calder_a[2])^Calder_b[2]
  if(3.088<=hc[i])
    QCald[i,1]=Calder_C[3]*(hc[i]-Calder_a[3])^Calder_b[3]
  # (Verzani, 2014, p.470)
}

tC_min=25
# Setting the min and max points for tC, hC, QC
tC_max=29
```

```
QC_min=0
QC_max=250
hC_min=0
hC_max=6

tC_sc=(tC-tC_min)/(tC_max-tC_min)
# Creating the scaled vectors of tC, hC, QC
QC_sc=(QC-QC_min)/(QC_max-QC_min)
QCald_sc=(QCald-QC_min)/(QC_max-QC_min)
hC_sc=(hC-hC_min)/(hC_max-hC_min)
hc_sc=(hc-hC_min)/(hC_max-hC_min)

plot(0,0, xlim=c(-1,1), ylim=c(-1,1), type="l", axes=FALSE,
   xlab="", ylab="")
# creating an empty plot (Verzani, 2014, pp.104-105)

lines(x=tC_sc, y=QC_sc, type="l")
# Notified of lines function by John Verzani (2014, p.105).
   Looked at RStudio help section
lines(x=-hc_sc, y=QCald_sc, type="l")
lines(x=-hc_sc, y=(1.073754)*hc_sc-(0.062635), lty=2)
# y found by two equations; (1) 0.956 = 0.94866667m+c, (2)
   6.829635e-07 = 0.05833333m+c
# SSS (1)-(2) => m=1.073754, c=-0.062635;
# (1) 0.956 = max(QC_sc), 0.94866667 = max(hC_sc), (2)
   6.829635e-07 = min(QCald_sc), 0.05833333 = min(hc_sc)
lines(x=-hC_sc, y=-tC_sc, type="l")
```

```
polygon(cbind(0.3359375, tC_sc[128:163], 27/64), cbind(0.568,
    QC_sc[128:163], 0.568), col="grey")
# tC_sc[128:163] and QC_sc[128:163] describes the coordinates
    of the x, y vectors used to create the shading
# Use of specific coordinates suggested by fellow group
   member.
# (Lillis, 2014, pp.50-58).

segments(-0.875, 0.79, 1, 0.79, lty=2)
# 0.79 = 197.5/250; -7/8 = -(5.25)/(6)
# Notified of segments function by fellow project member.
# Looked at RStudio help section for structure.
segments(-3/4, 0.568, 1, 0.568, lty=2)
# 0.568 = 142/250; -3/4 = -(4.5)/(6)
segments(27/64, -1/4,27/64, 1, lty=2)
# 27/64=(26.6875-25)/(29-25); for Tf boundaries
segments(0.3359375, -1/4,0.3359375, 1, lty=2)
# 0.3359375=(26.34375-25)/(29-25)
segments(0.3359375, 0.79, 27/64, 0.79, lty=1, lwd=2)
# creating FEV box
segments(0.3359375, 0.568, 27/64, 0.568, lty=1, lwd=2)
segments(27/64, 0.79, 27/64, 0.568, lty=1, lwd=2)
segments(0.3359375, 0.79, 0.3359375, 0.568, lty=1, lwd=2)

segments(-7/8, -1, -7/8, 127/160, lty=2)
segments(-3/4, -1, -3/4, 14/25, lty=2)
```

```
axis(1, at = NULL, labels = FALSE, tick = TRUE, pos = 0,0,
   lwd.ticks=0)
axis(2, at = NULL, labels = FALSE, tick = TRUE, pos = 0,0,
   lwd.ticks=0)
# Adding axis. Found function via RStudio help section

mtext("Day", 1)
# Adding axis labels. Notified of mtext function by John
   Verzani (2014, p.105). Looked at RStudio help section
mtext("Discharge [m^3/s]", 3)
mtext("Height [m]", 2, las=1)
mtext("Day", 4, las=1)

text(1, 143/160, labels="Qm")
# Notified of text function by John Verzani (2014, p.105).
   Looked at RStudio help section
text(1, 0.656875, labels="Qt")
text(cbind(0,0.25,0.5,0.75,1),cbind(-0.1,-0.1,-0.1,-0.1,-0.1)
   , labels=cbind(25,26,27,28,29))
# Adding in axis points by text function.
text(cbind(-0.1,-0.1,-0.1,-0.1,-0.1),cbind(1/5,2/5,3/5,4/5,1)
   , labels=cbind(50,100,150,200,250))
text(6/16, -3.5/10, labels="Tf")
text(-37/40, -1, labels="hm")
text(-4/5, -1, labels="ht")
text(cbind(-0.1,-0.1,-0.1,-0.1), cbind(-0.25,-0.5,-0.75,-1),
   labels=cbind(26,27,28,29))
# Adding in axis points by text function.
```

```
text(cbind(-1/6,-2/6,-3/6,-4/6,-5/6,-1), cbind
    (-0.1,-0.1,-0.1,-0.1,-0.1,-0.1), labels=cbind(1,2,3,4,5,6)
    )
text(0.625, -0.71875, labels="FEV \approx 1.65 Mm^3
     Tf = 8.25 hrs
     Qt = 142 m^3/s
     Qm = 197.5 m^3/s
     ht = 4.5 m
     hm = 5.25 m", cex=0.65)
# As stated on Onno & Tom's poster (Bokhove, et al., 2018c).

arrows(0.3359375, -1/4, 27/64, -1/4, length=0.05) # Adding
    the double-ended arrow
# Notified of arrows function by Murrell (2016, p. 79)
arrows(27/64, -1/4, 0.3359375, -1/4, length=0.05)

title(main="River Calder Data")
# Notified of title function by John Verzani (2014, p.105)

## Code no. 2: mitigation plot code ##

x=0:1
y=((500/133)*x)-(267/266)

plot(x, y, type="l", xlim=cbind(0.035, 0.965), ylim=cbind
    (0.035, 0.965), xlab="% of FEV mitigated", ylab="", axes=
    FALSE) # (John Verzani, 2014, pp.104-105)
```

```
polygon(cbind(0,x,0), cbind(0,y,1), col="purple", border="
   black") # (Lillis , 2014, pp.50-58)
par(new=TRUE)  # (John Verzani, 2014, p.232)

a=0:1
b=((1000/309)*a)-1

plot(a,b, type="l", xlim=cbind(0.035, 0.965), ylim=cbind
   (0.035, 0.965), xlab="%␣of␣FEV␣mitigated", ylab="", axes=
   FALSE) # (John Verzani, 2014, pp.104-105)
polygon(cbind(0.309,x,0.618), cbind(0,y,1), col="pink",
   border="black") # (Lillis , 2014, pp.50-58)
par(new=TRUE)  # (John Verzani, 2014, p.232)

c=0:1
d=((500/167)*c)-1

plot(c, d, type="l", xlim=cbind(0.035, 0.965), ylim=cbind
   (0.035, 0.965), xlab="%␣of␣FEV␣mitigated", ylab="", axes=
   FALSE) # (John Verzani, 2014, pp.104-105)
polygon(cbind(0.334,a,0.668), cbind(0,b,1), col="green",
   border="black") # (Lillis , 2014, pp.50-58)
polygon(cbind(1,c,1), cbind(0,d,1), col="white", border="
   black") # (Lillis , 2014, pp.50-58)

arrows(0.6,0.45, 0.42, 0.48, length=0.1)
arrows(0.7,0.75, 0.56, 0.78, length=0.1) # Notified of arrows
    function by Murrell (2016, p. 79)
```

```
abline(h=0) # adding a border/line for y=0,1; border/line for
    x=0,1 added by polygon function.
abline(h=1) # Notified of abline function by John Verzani
   (2014, p.105)

# following text, mtext, and title as stated on the FEV
   Calder plot  by Onno Bokhove, et al. (2018c)
text(0.20025, 0.75,labels="RESERVOIRS
␣␣Mean␣FEV:40%
Cost:\pounds30M
␣␣Value:\pounds[0.56,1.13]M/1%", cex=0.75)
# Actual pound symbol used in code, but it wouldn't print out
    in LaTeX
text(0.709, 0.45,labels="NFM
␣␣Mean␣FEV:6.36%
Cost:\pounds5.38M
␣␣Value:\pounds[0.63,1.27]M/1%", cex=0.75, col="pink") #
   Notified of text function by John Verzani (2014, p.105)
text(0.834, 0.75,labels="TREES
␣␣Mean␣FEV:3.75%
Cost:\pounds5M
␣␣Value:\pounds[1,2]M/1%", cex=0.75, col="green")
text(0.79975, 0.15,labels="TOTAL
␣␣Mean␣FEV:50.11%
Cost:\pounds40.38M
␣␣Value:\pounds[0.61,1.21]M/1%", cex=0.75)
```

```
mtext("0", 1, at=0, cex=0.625) # Notified of mtext function
    by John Verzani (2014, p.105)
mtext("26.7", 1, at=0.267, cex=0.625, las=2)
mtext("30.9", 1, at=0.309, cex=0.625, las=2)
mtext("33.4", 1, at=0.334, cex=0.625, las=2)
mtext("100", 1, at=1, cex=0.625)
mtext("0",3, at=0, cex=0.625)
mtext("53.3", 3, at=0.533, cex=0.625, las=2)
mtext("61.8", 3, at=0.618, cex=0.625, las=2)
mtext("66.8", 3, at=0.668, cex=0.625, las=2)
mtext("100", 3, at=1, cex=0.625)
title("Flood-excess lake: FEV \approx ((908^2)x2)m^3 \approx 
    1.650Mm^3", cex.main=0.875) # Notified of title function
    by John Verzani (2014, p.105)
```