Maps of SWMM Results

This is code to create maps from the output files generated in Results_Graphs (Note: You must run Results_Graphs before this)

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NOTE: -tmap_save() and st_write() are functions to export tmap outputs as images (such as .png) and to export shapefiles, respectively.
-Something about these functions sometimes returns an error which stops the code from running, BUT they still create outputs -They have been annotated out of this code, so if you wish to export the outputs then simply remove the "##" from those lines of code

-Maps will be hidden from knitted markdown.

Code setup - Load packages

```
library(tidyverse) #For data wrangling
library(sf) #For shapefiles
library(tmap) #For mapmaking
library(tmaptools) #For mapmaking
library(here) #For loading shapefiles
library(janitor) #For cleaning names
```

Maps for dry storm hotspots

```
results_dry<- read_csv("results_dry.csv") ##read in file from 4.Results_Maps

#Combine subcatchments outline with dry storm results
subcatch_dry <- read_sf(dsn = here("5.Results_Maps","shapefiles"),
                        layer = "subcatch_outline") %>%
  st_transform(crs = 4326) %>% #Set coordinate system
  clean_names() %>% #Clean the names of columns
  select(subcatchment = objectid_1) %>%
  merge(results_dry) %>% #Merge the subcatchment outlines to the SWMM results for
  #the dry storm (from Results_Graphs)
  filter(subcatchment != "5") #Remove subcatchment 5 which is a mistake (overlaps another
  #subcatchment)


#  Map total volume hotspots
hotspots_dry_total <- tm_basemap("OpenStreetMap.Mapnik") +
  tm_shape(subcatch_dry, unit = "Miles") +
  tm_polygons("runoff_coeff", alpha = 0.8, palette = "Blues", style = "cont", n=8,
              title = "Runoff Coefficient") +
  tm_layout(title = "December 2010 storm", inner.margins=c(.05, .05, 0.1, .53),
```

```
            legend.position =  c(.6,.63), legend.title.size = 1.4, legend.text.size = 1) +
  tm_text("subcatchment", size = 0.3) +
  tm_scale_bar(position = c(.6,.58), breaks = c(0, 0.2, 0.4, 0.6, 0.8,1)) +
  tm_compass(position = c(.58,.51))
tmap_save(hotspots_dry_total, here("5.Results_Maps", "output_maps",
                                   "hotspots_dry_total.png"))

#  Map peak flow hotspots
hotspots_dry_peak <- tm_basemap("OpenStreetMap.Mapnik") +
  tm_shape(subcatch_dry, unit = "Miles") +
  tm_polygons("peak_runoff_cfs", alpha = 0.75, palette = "Greens", style = "cont", n=8,
              legend.hist = TRUE, title = "Peak Discharge (cfs)") +
  tm_layout(title = "December 2010 storm", inner.margins=c(.05, .05, 0.1, .53),
            legend.position =  c(.6,.35), legend.title.size = 1.4, legend.text.size = 1) +
  tm_text("subcatchment", size = 0.3) +
  tm_scale_bar(position = c(.6,.61), breaks = c(0, 0.2, 0.4, 0.6, 0.8,1)) +
  tm_compass(position = c(.58,.54))
##tmap_save(hotspots_dry_peak, here("5.Results_Maps", "output_maps","hotspots_dry_peak.png"))
```

Maps for wet storm hotspots

```
results_wet<- read_csv("results_wet.csv") ##read in file from 4.Results_Maps

#Combine subcatchments outline with wet storm results
subcatch_wet <- read_sf(dsn = here("5.Results_Maps","shapefiles"), layer = "subcatch_outline") %>%
  st_transform(crs = 4326) %>%
  clean_names() %>%
  select(subcatchment = objectid_1) %>%
  merge(results_wet) %>%
   filter(subcatchment != "5")

#  Total volume hotspots
hotspots_wet_total <- tm_basemap("OpenStreetMap.Mapnik") +
  tm_shape(subcatch_wet, unit = "Miles") +
  tm_polygons("runoff_coeff", alpha = 0.8, palette = "Blues", style = "cont", n=8,
              legend.hist = TRUE, title = "Runoff Coefficient") +
  tm_layout(title = "March 2009 storm", inner.margins=c(.05, .05, 0.1, .53),
            legend.position =  c(.6,.32), legend.title.size = 1.4, legend.text.size = 1) +
  tm_text("subcatchment", size = 0.3) +
  tm_scale_bar(position = c(.6,.59), breaks = c(0, 0.2, 0.4, 0.6, 0.8,1)) +
  tm_compass(position = c(.58,.52))
##tmap_save(hotspots_wet_total, here("5.Results_Maps", "output_maps","hotspots_wet_total.png"))


#  Peak flow hotspots
hotspots_wet_peak <- tm_basemap("OpenStreetMap.Mapnik") +
  tm_shape(subcatch_wet, unit = "Miles") +
  tm_polygons("peak_runoff_cfs", alpha = 0.75, palette = "Greens", style = "cont", n=8,
              legend.hist = TRUE, title = "Peak Discharge (cfs)") +
  tm_layout(title = "March 2009 storm", inner.margins=c(.05, .05, 0.1, .53),
            legend.position =  c(.6,.27), legend.title.size = 1.4, legend.text.size = 1) +
  tm_text("subcatchment", size = 0.3) +
  tm_scale_bar(position = c(.6,.54), breaks = c(0, 0.2, 0.4, 0.6, 0.8,1)) +
```

```
  tm_compass(position = c(.58,.47))
##tmap_save(hotspots_wet_peak, here("5.Results_Maps", "output_maps","hotspots_wet_peak.png"))
```

Maps for top 20 hotspots commonly found between the dry storm and the wet storm

```
#Top 20 of total volume
top20_dry_total <- subcatch_dry %>%  #Find top 20 hotspots for the dry storm
  arrange(-runoff_coeff) %>%
  head(20)

top20_wet_total <- subcatch_wet %>% #Find top 20 hotspots for the wet storm
  arrange(-runoff_coeff) %>%
  head(20)

#Find the top 20 hotspots that occur in both storms
common_total_vector <- as.data.frame(intersect(top20_dry_total$subcatchment,
                                               top20_wet_total$subcatchment))
colnames(common_total_vector) <- c("subcatchment")

#Select the top 20 hotspots
common_total <- subcatch_dry %>%
  mutate(hotspot = case_when(
  subcatchment == "21" |
  subcatchment == "22" |
  subcatchment == "23" |
  subcatchment == "29" |
  subcatchment == "40" |
  subcatchment == "45" |
  subcatchment == "46" |
  subcatchment == "47" |
  subcatchment == "49" |
  subcatchment == "51" |
  subcatchment == "54" |
  subcatchment == "59" |
  subcatchment == "60" |
  subcatchment == "63" |
  subcatchment == "65" |
  subcatchment == "67" |
  subcatchment == "68" |
  subcatchment == "71" |
  subcatchment == "89" ~ "Hotspot"))

common_total$hotspot <- as.factor(common_total$hotspot)

#Create a map of the top 20 hotspots
top20_total_map <- tm_basemap("Hydda.Base") +
  tm_shape(common_total, unit = "Miles") +
  tm_polygons("hotspot", title = "Legend", textNA = "Subcatchment", palette="#045a8d",
              alpha = 0.8)+
  tm_layout(inner.margins=c(.05, .05, .05, .52), legend.position =  c(.56,.8),
            legend.title.size = 1.4, legend.text.size = 1) +
  tm_text("subcatchment", size = 0.3) +
```

```
  tm_scale_bar(position = c(.56,.75), breaks = c(0, 0.2, 0.4, 0.6, 0.8,1)) +
  tm_compass(position = c(.54,.68))

tmap_save(top20_total_map, here("5.Results_Maps", "output_maps","top20_total_map.png"))


#Top 20 of peak volume
top20_dry_peak <- subcatch_dry %>%
  arrange(-peak_runoff_cfs) %>%
  head(20)

top20_wet_peak <- subcatch_wet %>%
  arrange(-peak_runoff_cfs) %>%
  head(20)

common_peak_vector <- as.data.frame(intersect(top20_dry_peak$subcatchment,
                                              top20_wet_peak$subcatchment))
colnames(common_peak_vector) <- c("subcatchment")

common_peak <- subcatch_dry %>%
  mutate(hotspot = case_when(
  subcatchment == "1" |
  subcatchment == "2" |
  subcatchment == "3" |
  subcatchment == "7" |
  subcatchment == "11" |
  subcatchment == "23" |
  subcatchment == "28" |
  subcatchment == "38" |
  subcatchment == "42" |
  subcatchment == "58" |
  subcatchment == "62" |
  subcatchment == "63" |
  subcatchment == "74" |
  subcatchment == "75" |
  subcatchment == "76" |
  subcatchment == "78" |
  subcatchment == "79" |
  subcatchment == "89" |
  subcatchment == "94" ~ "Hotspot"))

common_peak$hotspot <- as.factor(common_peak$hotspot)

top20_peak_map <- tm_basemap("Hydda.Base") +
  tm_shape(common_peak, unit = "Miles") +
  tm_polygons("hotspot", title = "Legend", textNA = "Subcatchment", palette="#006d2c",
              alpha = 0.8)+
  tm_layout(inner.margins=c(.05, .05, .05, .52), legend.position =  c(.56,.8),
            legend.title.size = 1.4, legend.text.size = 1) +
  tm_text("subcatchment", size = 0.3) +
  tm_scale_bar(position = c(.56,.75), breaks = c(0, 0.2, 0.4, 0.6, 0.8,1)) +
  tm_compass(position = c(.54,.68))
```

```
tmap_save(top20_peak_map, here("5.Results_Maps", "output_maps","top20_peak_map.png"))
```

Export the results as shapefiles (e.g. For use in other map software like ArcGIS or Google Earth Pro)

```
#Keep the common hotspots only
common_peak_only <- subcatch_dry %>%
  filter(
  subcatchment == "1" |
  subcatchment == "2" |
  subcatchment == "3" |
  subcatchment == "7" |
  subcatchment == "11" |
  subcatchment == "23" |
  subcatchment == "28" |
  subcatchment == "38" |
  subcatchment == "42" |
  subcatchment == "58" |
  subcatchment == "62" |
  subcatchment == "63" |
  subcatchment == "74" |
  subcatchment == "75" |
  subcatchment == "76" |
  subcatchment == "78" |
  subcatchment == "79" |
  subcatchment == "89" |
  subcatchment == "94" )

#Export as .shp
##st_write(common_peak_only, here("5.Results_Maps", "output_shapefiles", "common_peak.shp"))

#Keep the common hotspots only
common_total_only <- subcatch_dry %>%
  filter(
  subcatchment == "21" |
  subcatchment == "22" |
  subcatchment == "23" |
  subcatchment == "29" |
  subcatchment == "40" |
  subcatchment == "45" |
  subcatchment == "46" |
  subcatchment == "47" |
  subcatchment == "49" |
  subcatchment == "51" |
  subcatchment == "54" |
  subcatchment == "59" |
  subcatchment == "60" |
  subcatchment == "63" |
  subcatchment == "65" |
  subcatchment == "67" |
  subcatchment == "68" |
  subcatchment == "71" |
  subcatchment == "89")
```

```
#Export as .shp
##st_write(common_total_only,  here("5.Results_Maps", "output_shapefiles","common_total.shp"))
```