In [1]:
```
# Basic Libraries
import numpy as np
import pandas as pd

# Feature Scaling
from sklearn.preprocessing import RobustScaler

# Visaulization
import matplotlib
import matplotlib.pyplot as plt
import seaborn as sns

# Classifier (machine learning algorithm)
from sklearn.linear_model import LogisticRegression
from sklearn.neighbors import KNeighborsClassifier
from sklearn.svm import SVC
from sklearn.naive_bayes import GaussianNB
from sklearn.tree import DecisionTreeClassifier
from sklearn.ensemble import RandomForestClassifier
from sklearn import metrics
from sklearn.metrics import classification_report
from sklearn.discriminant_analysis import LinearDiscriminantAnalysis as LDA
from sklearn.linear_model import Ridge, RidgeCV
from sklearn.model_selection import LeavePOut
from sklearn import linear_model
from sklearn.ensemble import AdaBoostClassifier
from sklearn.model_selection import RandomizedSearchCV

# Evaluation
from sklearn.model_selection import cross_val_score, cross_val_predict

# Parameter Tuning
from sklearn.model_selection import GridSearchCV

# Settings
pd.options.mode.chained_assignment = None # Stop warning when use inplace=True
 of fillna

train = pd.read_csv("sfpd-dispatch/sfpd_dispatch_data_subset.csv", index_col=0
)
#train.head()
# test = pd.read_csv("test_final.csv", index_col=0)
```

In [2]:
```
train.describe()
```

Out[2]:

	call_number	incident_number	zipcode_of_incident	station_area	box
count	1.000000e+04	1.000000e+04	10000.000000	10000.000000	10000.000000
mean	1.801872e+08	1.800791e+07	94113.473000	18.066600	4019.476500
std	3.457123e+04	1.417024e+03	10.490342	14.350699	2327.782885
min	1.801300e+08	1.800543e+07	94102.000000	1.000000	131.000000
25%	1.801537e+08	1.800669e+07	94103.750000	5.000000	2117.000000
50%	1.801902e+08	1.800793e+07	94110.000000	14.000000	3426.000000
75%	1.802201e+08	1.800914e+07	94121.000000	32.000000	5667.000000
max	1.802442e+08	1.801035e+07	94158.000000	51.000000	8871.000000

In [3]:
```
train.isnull().sum()
```

Out[3]:
```
call_number                         0
unit_id                             0
incident_number                     0
call_type                           0
call_date                           0
watch_date                          0
received_timestamp                  0
entry_timestamp                     0
dispatch_timestamp                  0
response_timestamp                261
on_scene_timestamp               1915
transport_timestamp              7031
hospital_timestamp               7087
call_final_disposition              0
available_timestamp                 0
address                             0
city                               18
zipcode_of_incident                 0
battalion                           0
station_area                        0
box                                 0
original_priority                   0
priority                            0
final_priority                      0
als_unit                            0
call_type_group                     4
number_of_alarms                    0
unit_sequence_in_call_dispatch      0
fire_prevention_district            0
supervisor_district                 0
neighborhood_district           10000
location                            0
row_id                              0
latitude                            0
longitude                           0
unit_type                           0
dtype: int64
```

In [4]:
```
# This fills all the nan spots with the text 'nan'
train = train.fillna('nan')
```

In [5]:
```
# takes about 4 minutes
#Dictionary the values for processing

train['call_type'] = train['call_type'].map({'Medical Incident' : 0, 'Alarms'
: 1, 'Structure Fire' : 2, 'Traffic Collision' : 3, 'Outside Fire' : 4, 'Othe
r' : 5, 'Train / Rail Incident' : 6, 'Citizen Assist / Service Call' : 7, 'Ele
ctrical Hazard' : 8, 'Elevator / Escalator Rescue' : 9, 'Fuel Spill' : 10, 'Ga
s Leak (Natural and LP Gases)' : 11, 'Water Rescue' : 12, 'Vehicle Fire' : 13,
 'Smoke Investigation (Outside)' : 14, 'Odor (Strange / Unknown)' : 15, 'HazMa
t' : 16 }).astype(int)
train['call_final_disposition'] = train['call_final_disposition'].map({'Code 2
 Transport' : 0, 'Fire' : 1, 'Code 3 Transport' : 2, 'Patient Declined Transpo
rt' : 3, 'No Merit' : 4, 'Medical Examiner' : 5, 'Against Medical Advice' : 6,
 'Cancelled' : 7, 'Unable to Locate' : 8, 'SFPD' : 9, 'Gone on Arrival' : 10,
'Other' : 11}).astype(int)
train['city'] = train['city'].map({'nan' : 0, 'San Francisco' : 1, 'Presidio'
: 2, 'Treasure Isla' : 3, 'Yerba Buena' : 4, 'Hunters Point' : 5, 'Fort Mason'
 : 6 }).astype(int)
train['battalion'] = train['battalion'].map({'B99': 0, 'B01': 1, 'B02': 2, 'B0
3': 3, 'B04': 4, 'B05': 5, 'B06': 6, 'B07': 7, 'B08': 8, 'B09': 9, 'B10': 10
}).astype(int)
train['original_priority'] = train['original_priority'].map({'I' : 1, '2' : 2,
 '3' : 3, 'A' : 4, 'B' : 5, 'C' : 6, 'E' : 7}).astype(int)
train['priority'] = train['priority'].map({'I' : 1, '2' : 2, '3' : 3, 'E' : 4
}).astype(int)
train['als_unit'] = train['als_unit'].map({True : 1, False : 0}).astype(int)
train['call_type_group'] = train['call_type_group'].map({'nan' : 0, 'Non Life-
threatening' : 1, 'Potentially Life-Threatening' : 2, 'Alarm' : 3, 'Fire' : 4
}).astype(int)

#Create a travel duration column
for k in range(0,train.shape[0]):
    train['call_date'][k] = int(train['call_date'][k][2:4])
    train['watch_date'][k] = int(train['watch_date'][k][2:4])

    timestamps = ['received_timestamp','entry_timestamp','dispatch_timestamp',
'response_timestamp','on_scene_timestamp','transport_timestamp','hospital_time
stamp','available_timestamp']

    for stamp in timestamps:
        if train[stamp][k]=='nan':
            train[stamp][k] = 0
        else:
            train[stamp][k] = int(train[stamp][k][17:19]) + 60 * int(train[sta
mp][k][14:16]) + 3600 * int(train[stamp][k][11:13]) + 3600 * 24 * int(train[st
amp][k][8:10])

train['unit_type'] = train['unit_type'].map({'ENGINE' : 0, 'MEDIC' : 1, 'PRIVA
TE' : 2, 'TRUCK' : 3, 'CHIEF' : 4, 'RESCUE CAPTAIN' : 5, 'RESCUE SQUAD' : 6,
'SUPPORT' : 7, 'INVESTIGATION' : 8 }).astype(int)
```

In [6]:
```
#remove noisy data such as neighbouhood_district and call_number for faster
 processing
drop_elements=['call_number','incident_number','call_date','watch_date','nei
ghborhood_district','zipcode_of_incident','station_area','address','city','l
ocation','supervisor_district']
train = train.drop(drop_elements, axis = 1)
```

In [7]:
```
#encode missing times as 99999, will be used for checks
train['travel_duration'] = train['on_scene_timestamp']-train['dispatch_timesta
mp']
for k in range(0, train.shape[0]):
    temp = int(train['travel_duration'][k])
    if (temp > 1500):
        train['travel_duration'][k] = 99999
    if (temp <= 0):
        train['travel_duration'][k] = 99999
```

In [8]:
```
#set bins for graph
ranges = list(np.arange(0,2000,60))
incidences_per_unit_type = pd.DataFrame(train.groupby(pd.cut(train.travel_dura
tion, ranges)).count()["unit_type"])
incidences_per_unit_type.columns = ["count"]

#set parameters for plot
ax = incidences_per_unit_type.plot.bar(figsize=(15,12), fontsize = 12, legend
= False, color = "palegreen")#counts per elevation
ax.set_xlabel("Time to Arrive (s)", fontsize = 16)
ax.set_ylabel("Count of Fire Department Calls", fontsize = 16)
ax.set_title("Count of Fire Department Calls to Response Time", fontsize = 20)
plt.savefig("bin_check.png")
```

In [9]:
```
def get_cat(col, cat):
    for token in col:
        if(token > 2000):
            cat.append('Other')
        else:
            chunks = []
            temp = int(int(token)/60)
            min = temp * 60
            max = min + 60
            chunks = ['(', str(min), ', ', str(max), ']']
            category = ''.join(chunks)
            cat.append(str(category))

Response_time = []

get_cat(train["travel_duration"].tolist(), Response_time)
train["response_cat"] = Response_time

train['response_cat']
```

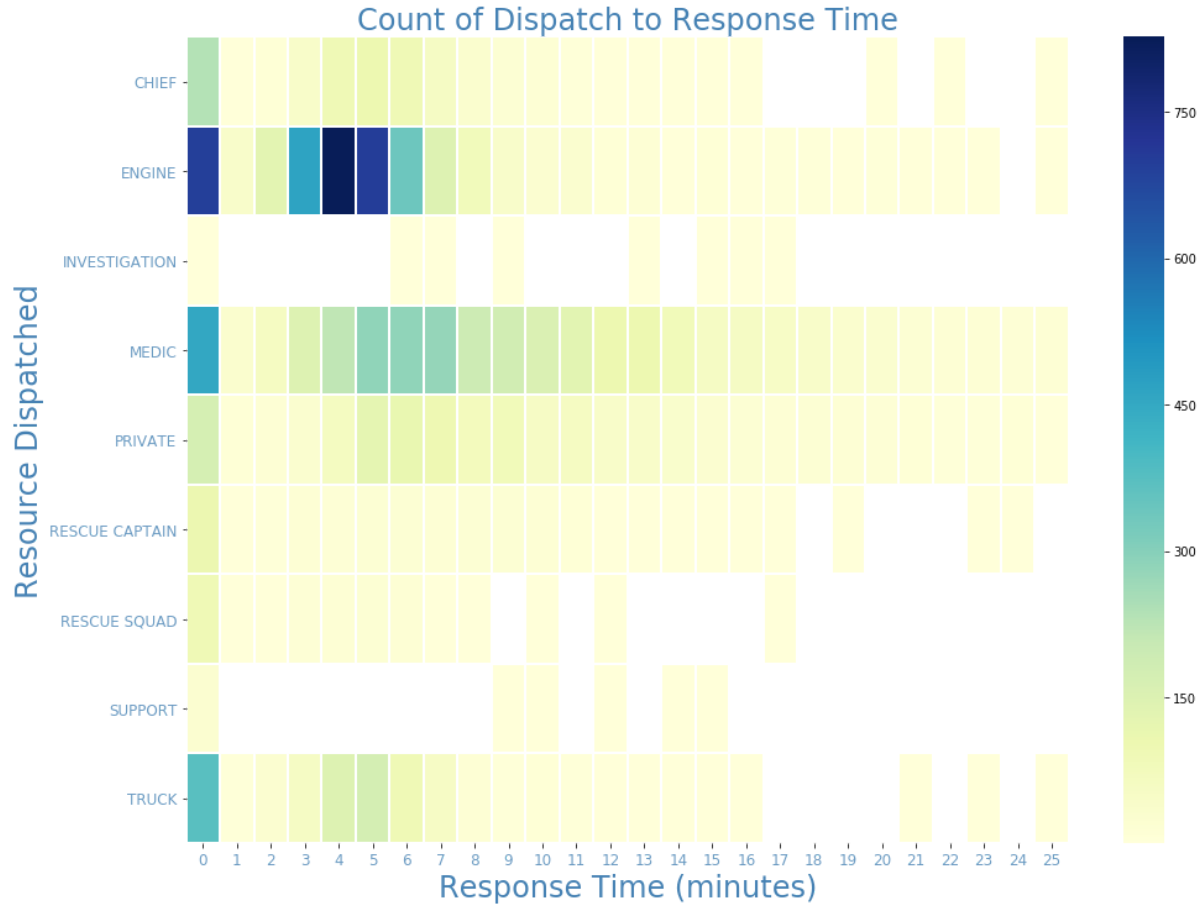
Out[9]:

	temp
MEDIC	(840, 900]
MEDIC	(780, 840]
ENGINE	(180, 240]
ENGINE	(120, 180]
CHIEF	(180, 240]
ENGINE	(180, 240]
ENGINE	(480, 540]
MEDIC	(360, 420]
ENGINE	(240, 300]
MEDIC	(240, 300]
MEDIC	(960, 1020]
MEDIC	(360, 420]
ENGINE	(180, 240]
PRIVATE	(540, 600]
MEDIC	(240, 300]
RESCUE SQUAD	(300, 360]
ENGINE	(300, 360]
ENGINE	(300, 360]
MEDIC	(300, 360]
TRUCK	Other
MEDIC	(300, 360]
ENGINE	(180, 240]
ENGINE	(180, 240]
ENGINE	(120, 180]
MEDIC	(360, 420]
MEDIC	(300, 360]
MEDIC	(180, 240]
MEDIC	Other
MEDIC	(420, 480]
ENGINE	(0, 60]
	...
ENGINE	(180, 240]
ENGINE	(240, 300]
MEDIC	(480, 540]
TRUCK	Other
RESCUE CAPTAIN	(60, 120]
PRIVATE	(480, 540]
ENGINE	(240, 300]
PRIVATE	(660, 720]
ENGINE	(240, 300]
ENGINE	(180, 240]
ENGINE	(180, 240]
MEDIC	(300, 360]
PRIVATE	Other
PRIVATE	(240, 300]
MEDIC	(480, 540]
RESCUE CAPTAIN	(240, 300]
ENGINE	Other
ENGINE	(180, 240]
MEDIC	(480, 540]
MEDIC	(300, 360]
ENGINE	Other
MEDIC	(240, 300]
ENGINE	Other
MEDIC	(60, 120]
ENGINE	Other

```
ENGINE             (120, 180]
ENGINE             (180, 240]
ENGINE                  Other
SUPPORT                 Other
MEDIC              (420, 480]
Name: response_cat, Length: 10000, dtype: object
```

In [10]:
```
#set minute categories
train['response_cat'] = train['response_cat'].map({'(0, 60]' : 1, '(60, 120]'
: 2, '(120, 180]' : 3, '(180, 240]' : 4, '(240, 300]' : 5, '(300, 360]' : 6,
'(360, 420]' : 7, '(420, 480]' : 8, '(480, 540]' : 9, '(540, 600]' : 10, '(60
0, 660]' : 11, '(660, 720]' : 12, '(720, 780]' : 13, '(780, 840]' : 14, '(840,
 900]' : 15, '(900, 960]' : 16, '(960, 1020]' : 17, '(1020, 1080]' : 18, '(108
0, 1140]' : 19, '(1140, 1200]' : 20, '(1200, 1260]' : 21, '(1260, 1320]' : 22,
 '(1320, 1380]' : 23, '(1380, 1440]' : 24, '(1440, 1500]' : 25, '(1500, 1560]'
 : 26, 'Other' : 0 }).astype(int)
```

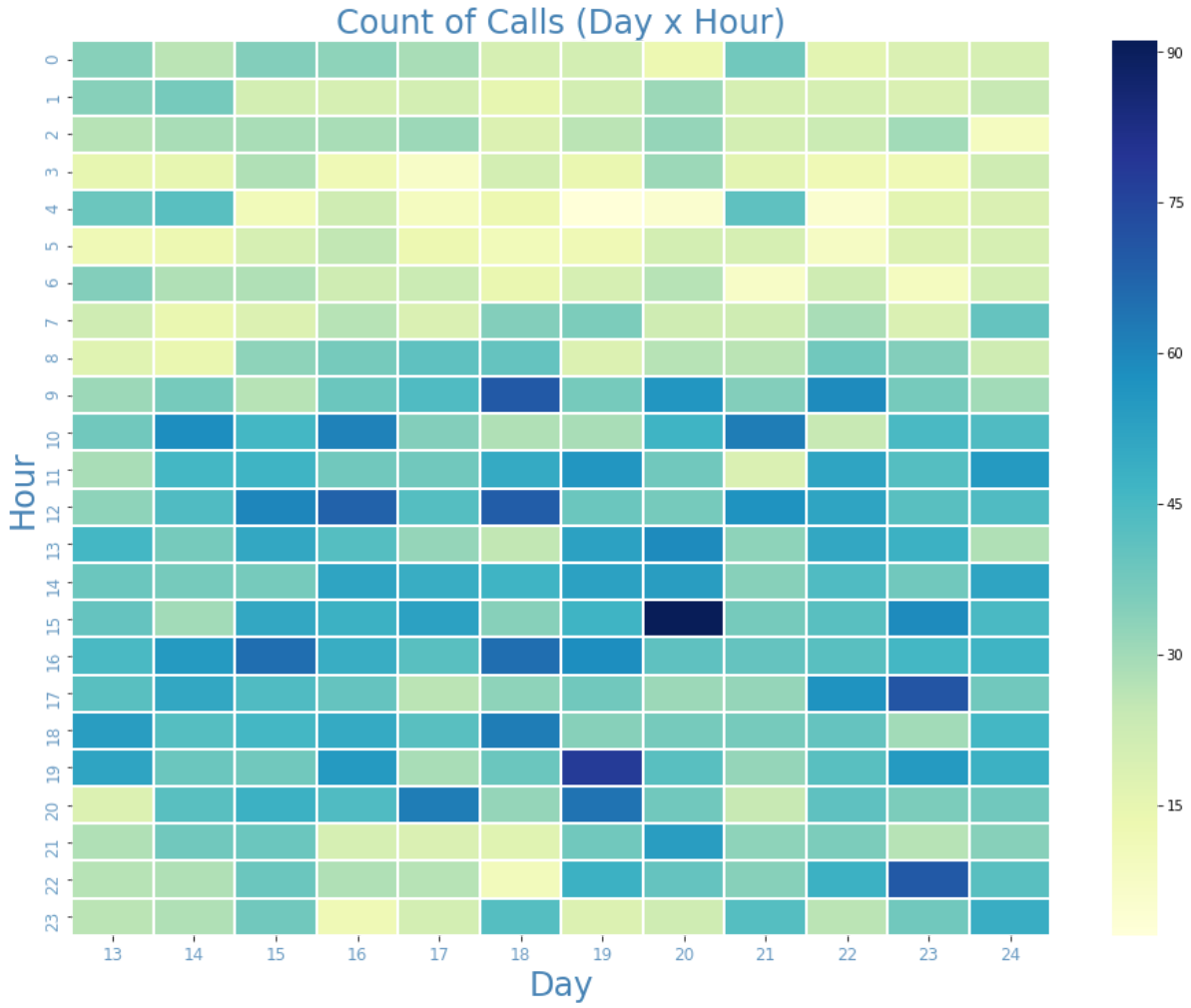
In [11]:
```
%matplotlib inline
plt.figure(figsize=(16,12))
incidence_count_matrix_long = pd.DataFrame({'count' : train.groupby( [ "temp", "response_cat"] ).size()}).reset_index()
incidence_count_matrix_pivot = incidence_count_matrix_long.pivot("temp","response_cat","count")
ax = sns.heatmap(incidence_count_matrix_pivot, annot=False, fmt="d", linewidths=1, square = False, cmap="YlGnBu")
ax = plt.xticks(fontsize = 12,color="steelblue", alpha=0.8)
ax = plt.yticks(fontsize = 12,color="steelblue", alpha=0.8)
ax = plt.xlabel("Response Time (minutes)", fontsize = 24, color="steelblue")
ax = plt.ylabel("Resource Dispatched", fontsize = 24, color="steelblue")
ax = plt.title("Count of Dispatch to Response Time", fontsize = 24, color="steelblue")
plt.savefig('Dispatch_response.png')
```



In [12]:
```
train_original = pd.read_csv("sfpd-dispatch/sfpd_dispatch_data_subset.csv", index_col=0)
```

In [13]:
```
def get_day_time(col, days, hours, months, years):
    for token in col:
        day = int(token.split()[0].split("-")[2])
        month = int(token.split()[0].split("-")[1])
        year = int(token.split()[0].split("-")[0])
        hour = int(token.split()[1].split(":")[0])
        days.append(day)
        months.append(month)
        years.append(year)
        hours.append(hour)

hours = []
days = []
months = []
years = []

get_day_time(train_original["received_timestamp"].tolist(), days, hours, mon
ths, years)
train_original["received_hour"] = hours
train_original["received_day"] = days
train_original["received_month"] = months
train_original["received_year"] = years
```

In [14]:
```
%matplotlib inline
plt.figure(figsize=(16,12))
incidence_count_matrix_long = pd.DataFrame({'count' : train_original.groupby(
[ "received_hour","received_day"] ).size()}).reset_index()
incidence_count_matrix_pivot = incidence_count_matrix_long.pivot("received_hou
r","received_day","count")
ax = sns.heatmap(incidence_count_matrix_pivot, annot=False, fmt="d", linewidth
s=1, square = False, cmap="YlGnBu")
ax = plt.xticks(fontsize = 12,color="steelblue", alpha=0.8)
ax = plt.yticks(fontsize = 12,color="steelblue", alpha=0.8)
ax = plt.xlabel("Day", fontsize = 24, color="steelblue")
ax = plt.ylabel("Hour", fontsize = 24, color="steelblue")
ax = plt.title("Count of Calls (Day x Hour)", fontsize = 24, color="steelblue"
)
plt.savefig("call_day.png")
```



In [15]:
```
train.head()
```

Out[15]:

	unit_id	call_type	received_timestamp	entry_timestamp	dispatch_timestamp	
temp						
MEDIC	84	0	2136976	2137101	2137181	2
MEDIC	61	0	2099105	2099105	2099131	2
ENGINE	E22	0	2081061	2081137	2081164	2
ENGINE	E03	1	2145855	2145912	2145924	2
CHIEF	B03	1	2145788	2145936	2145957	2

5 rows × 27 columns

In [42]:
```
def get_hour(col, hours):
    for token in col:
        hour = int(token.split()[1].split(":")[0])
        hours.append(hour)

#knn_data_subset.csv is a cleaned up data set only containing unit_type, latit
ude, longitude, and received_timestamp
hours = []
train_knn = pd.read_csv("sfpd-dispatch/knn_data_subset.csv", index_col=0)
get_hour(train_knn["received_timestamp"].tolist(), hours)
train_knn["hour"] = hours
```

In [43]:
```
y = train_knn.unit_type
train_knn = train_knn.drop("received_timestamp", axis = 1)
train_knn = train_knn.drop("unit_type", axis = 1)
X = train_knn
X.head()
```

Out[43]:

	longitude	hour
latitude		
37.774442	-122.504679	17
37.774095	-122.420001	7
37.755218	-122.475540	2
37.790319	-122.423163	20
37.777328	-122.393089	20

In [163]:
```
from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size = 0.8)
```

In [164]:
```
print ("\nX_train:\n")
print(X_train.head())
print (X_train.shape)
print ("\nX_test:\n")
print(X_test.head())
print (X_test.shape)
```

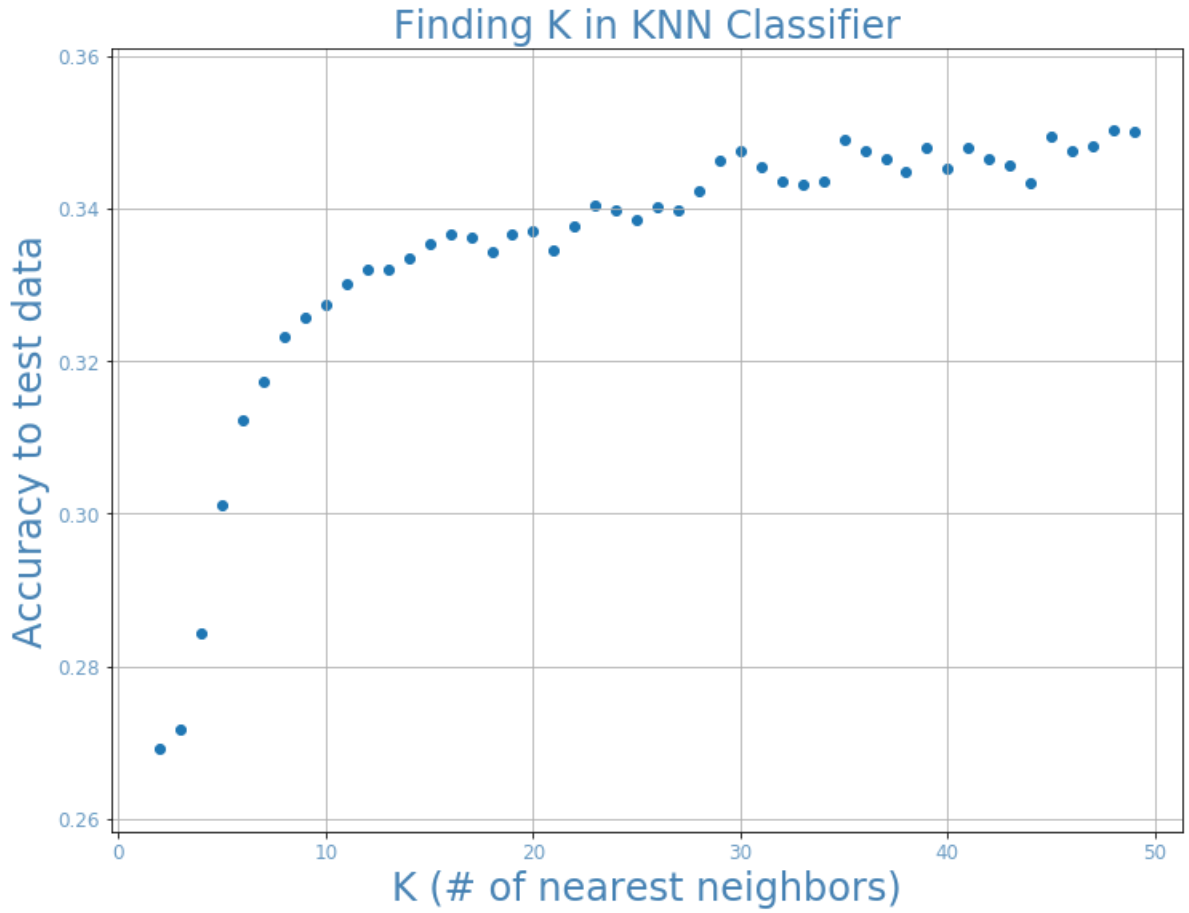
```
X_train:

            longitude  hour
latitude
37.781217 -122.457001    15
37.782724 -122.396168    10
37.797865 -122.396701    19
37.751994 -122.409123    11
37.709148 -122.419780    13
(2000, 2)

X_test:

            longitude  hour
latitude
37.752373 -122.416266    14
37.777624 -122.399981    12
37.764138 -122.402572    19
37.788945 -122.426252    16
37.734027 -122.432838    11
(8000, 2)
```

In [170]:
```
#odd number, cho
from sklearn.neighbors import KNeighborsClassifier
from sklearn.metrics import accuracy_score
def get_k(X_train, y_train, X_test, k, acc):
    knn = KNeighborsClassifier(n_neighbors=k)
    knn.fit(X_train, y_train)
    predictions = knn.predict(X_test)
    acc.append(accuracy_score(y_test, predictions))
```

In [171]:
```
k = []
acc = []
for i in range(2, 50):
    get_k(X_train, y_train, X_test, i, acc)
    k.append(i)
print(k)
print(acc)
```

```
[2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22,
23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 4
2, 43, 44, 45, 46, 47, 48, 49]
[0.269125, 0.27174999999999999, 0.28437499999999999, 0.30112499999999998, 0.3
1225000000000003, 0.31737500000000002, 0.32324999999999998, 0.325625, 0.32737
500000000003, 0.330125, 0.33200000000000002, 0.33200000000000002, 0.333500000
00000002, 0.33537499999999998, 0.33650000000000002, 0.33612500000000001, 0.33
424999999999999, 0.33650000000000002, 0.33712500000000001, 0.33450000000000002, 0.33774999999999999, 0.34037499999999998, 0.33975, 0.33850000000000002, 0.
34012500000000001, 0.33975, 0.34237499999999998, 0.34625, 0.34762500000000002, 0.34549999999999997, 0.34362500000000001, 0.34312500000000001, 0.343500000
00000003, 0.34899999999999998, 0.34762500000000002, 0.34637499999999999, 0.34
487499999999999, 0.34787499999999999, 0.34525, 0.34787499999999999, 0.3463749
9999999999, 0.34562500000000002, 0.34337499999999999, 0.34949999999999998, 0.
34749999999999998, 0.34812500000000002, 0.35025000000000001, 0.34999999999999
998]
```

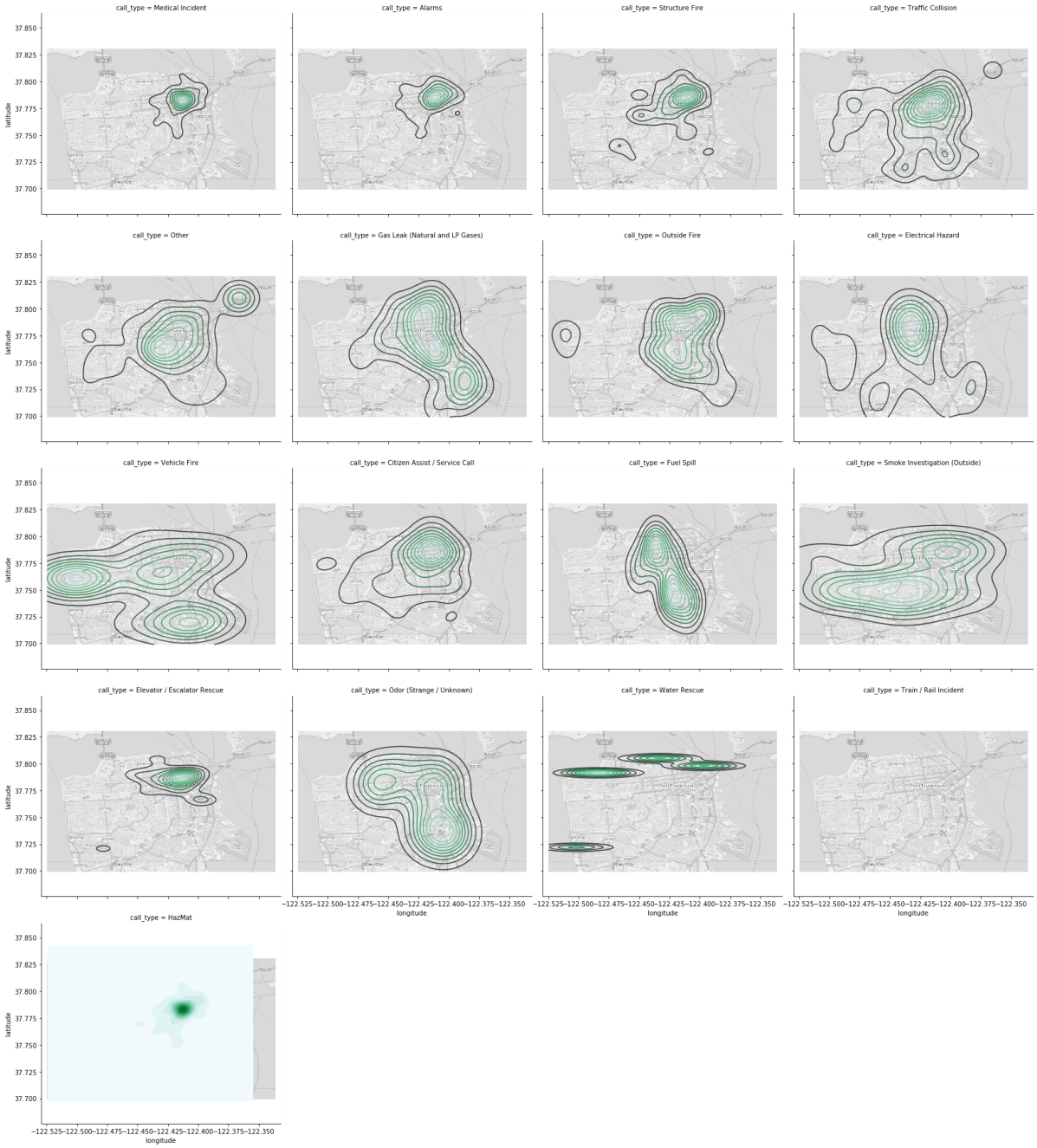
In [178]:
```
plt.figure(figsize=(12,9))
plt.scatter(k,acc)
ax = plt.xticks(fontsize = 12,color="steelblue", alpha=0.8)
ax = plt.yticks(fontsize = 12,color="steelblue", alpha=0.8)
ax = plt.xlabel('K (# of nearest neighbors)', fontsize = 24, color="steelblue"
)
ax = plt.ylabel('Accuracy to test data', fontsize = 24, color="steelblue")
ax = plt.title('Finding K in KNN Classifier', fontsize = 24, color="steelblue"
)
plt.grid(True)
plt.savefig("knn.png")
```



In [16]:
```
import numpy as np
import matplotlib.pyplot as plt

mapdata = np.loadtxt("sfpd-dispatch/sf_map_copyright_openstreetmap_contributor
s.txt")
asp = mapdata.shape[0] * 1.0 / mapdata.shape[1]
lon_lat_box = (-122.5247, -122.3366, 37.699, 37.8299)
clipsize = [[-122.5247, -122.3366],[ 37.699, 37.8299]]
```

In [18]:
```
# trainP = train[train.call_type == 'Medical Incident']
np.seterr(divide='ignore', invalid='ignore')
trainP = train_original.dropna()
```

In [179]:
```
import warnings
warnings.filterwarnings("ignore")
g= sns.FacetGrid(train_original, col="call_type", col_wrap=4, size=5, aspect=1
/asp)

#Show the background map
for ax in g.axes:
    ax.imshow(mapdata, cmap=plt.get_cmap('gray'),alpha = 0.6,
              extent=lon_lat_box,
              aspect=asp)
#Kernel Density Estimate plot
sns.kdeplot(train_original.longitude, train_original.latitude, shade = True)
g.map(sns.kdeplot, "longitude", "latitude", clip=clipsize)
plt.savefig('call_density_plot.png')
```



In [ ]:
```
#Create a gif using the 25 images created to show heatmap over response tim
e!

my_list=list(range(1,27))

for x in range(1, 27):
    trainP = train[train['response_cat'] == x]
    plt.figure(figsize=(20,20*asp))
    plt.title('Response within ' + str(x) + ' minutes', fontsize = 48, color
="steelblue")
    try:
        ax = sns.kdeplot(trainP.longitude, trainP.latitude, clip=clipsize)
    except ZeroDivisionError:
        print("\n")
    ax.imshow(mapdata, cmap=plt.get_cmap('gray'),
              extent=lon_lat_box)
    plt.savefig(str(x)+'_density_plot.png')
```

In [27]:
```
sum = 0
count = 0
for i in train['travel_duration'].tolist():
    if(i > 1500):
        continue
    else:
        sum += i
        count += 1
print("avg response time is " + str(sum/count) + "seconds")
```

```
avg response time is 381.4806784848871seconds
```

In [28]:
```
sum = 0
count = 0
trainc = train[train.unit_type == 0]
for i in trainc['travel_duration'].tolist():
    if(i > 1500):
        continue
    else:
        sum += i
        count += 1
print("avg engine response time is " + str(sum/count) + "seconds")
```

```
avg engine response time is 262.61057360055287seconds
```

In [29]:
```
sum = 0
count = 0
trainc = train[train.unit_type == 1]
for i in trainc['travel_duration'].tolist():
    if(i > 1500):
        continue
    else:
        sum += i
        count += 1
print("avg medic response time is " + str(sum/count) + "seconds")
```

```
avg medic response time is 496.4316877152698seconds
```