# Wahtoke Creek Bridge Traffic Network Emissions Analysis

Kellogg Honors College Capstone 2011
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## Objective

The purpose of this study is to investigate and quantify the relationship among varying traffic volumes, traffic control types, and greenhouse gas emissions in order to mitigate traffic at a proposed construction site.

## Background

### Site Location: Fresno, CA

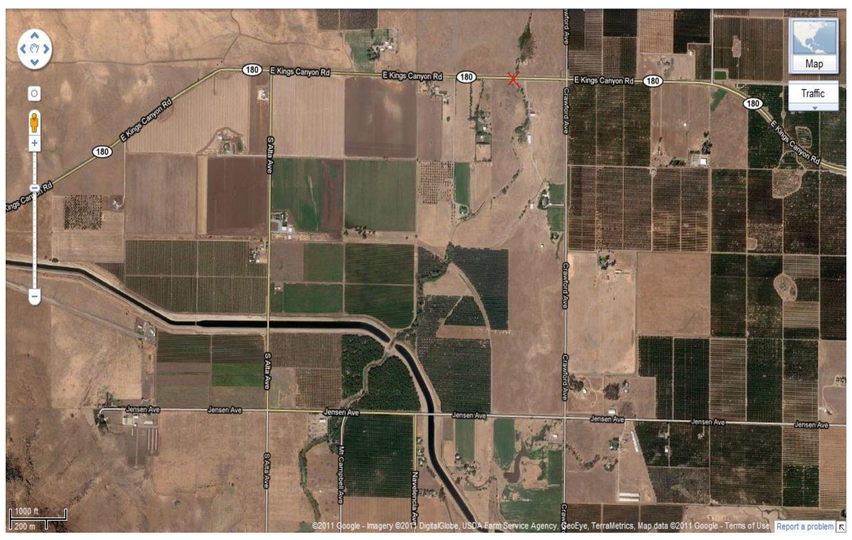


*Figure 1. Wahtoke Creek Traffic Network. The bridge location is marked with a red "X." Source: Google Maps.*

- Six intersections:
  - Jensen Avenue and South Alta Avenue
  - Jensen Avenue and Mt Campbell Avenue
  - Jensen Avenue and Navelencia Avenue
  - East Kings Canyon Road and South Alta Avenue
  - East Kings Canyon Road and Crawford Avenue
  - Jensen Avenue and Crawford Avenue

## Research Methodology

- Emissions analyzed:
  - Carbon monoxide (CO)
  - Nitrogen oxides (NOx)
  - Volatile organic compounds (VOC)
- Control types analyzed:
  - Yield
  - Stop
  - Free

The following procedure was implemented for Synchro analysis of the study area:

1. Create the traffic network in Synchro based on data observed on Google Maps.
2. Assign the different traffic control types to all intersection approaches, e.g.: yield control, stop control, and free control.
3. Input traffic volume data (100, 500, or 1000 vehicles per hour for through lanes and 10, 50, or 100 vph, respectively, for turn lanes) at all the intersections.
4. Run the simulation for all possible combinations of traffic control measures and traffic volumes. Create reports of simulation outputs containing CO emission, NOx emission, and VOC emission.
5. Analyze the outputs in the form of charts to quantify the relationship between gas emissions and various traffic control measures.

**Fuel consumption formula (gallons):**

$F = TT*d = k_1 - TD* k_2 + ST* k_3$

**Emissions formulas (grams):**

$CO = F*69.9\ g/gal$

$NOx = F*13.6\ g/gal$

$VOC = F*16.2\ g/gal$

Where $k_1 = 0.075283 - 0.0015892 * S + 0.000015066 * S^2$
$k_2 = 0.7329$
$k_3 = 0.0000061411 * S^2$
F = fuel consumption in gallons
S = cruise speed in mph
TT = vehicle miles traveled
TD = total signal delay in hours
ST = total stops in vehicles per hour

## Results by Traffic Volume

### 1000 Vehicles Per Hour

*Table 1. 1000 vph Emissions.*

| Control Type | Emission (kg) CO | NOx | VOC |
|---|---|---|---|
| Free | 6272.01 | 1220.31 | 1453.6 |
| Yield | 360.77 | 70.19 | 83.16 |
| Stop | 365.41 | 71.09 | 84.69 |

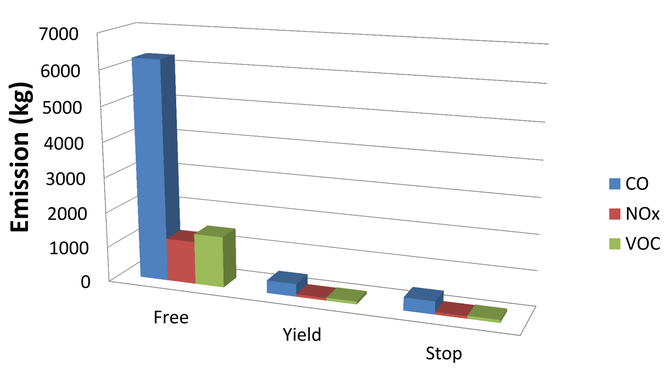


*Figure 2. 1000 vph Emissions vs. Traffic Control.*

### Free Control

*Table 2. Free Control Emissions.*

| Traffic Volume (vph) | Emission (kg) CO | NOx | VOC |
|---|---|---|---|
| 100 | 628.87 | 122.35 | 145.75 |
| 500 | 3131.38 | 609.25 | 725.73 |
| 1000 | 6272.01 | 1220.31 | 1453.6 |

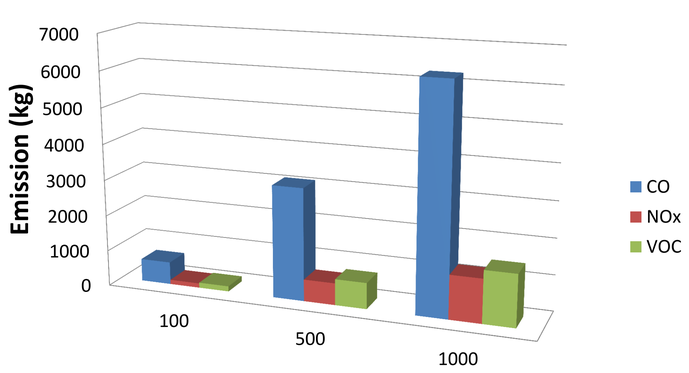


*Figure 3. Free Control Emissions vs. Traffic Volume.*

### Stop Control

*Table 3. Stop Control Emissions.*

| Traffic Volume (vph) | Emission (kg) CO | NOx | VOC |
|---|---|---|---|
| 100 | 5.63 | 1.09 | 1.3 |
| 500 | 70.79 | 13.77 | 16.41 |
| 1000 | 365.41 | 71.09 | 84.69 |

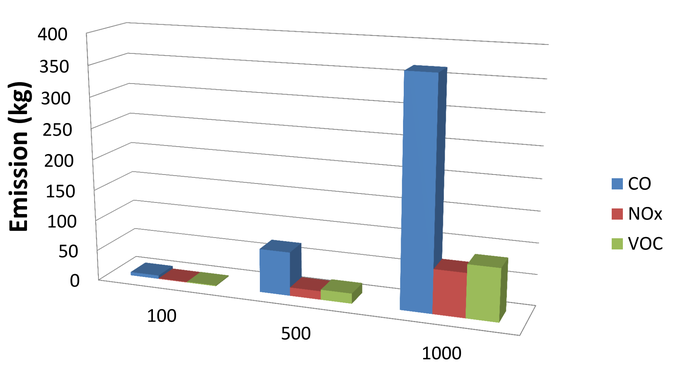


*Figure 4. Stop Control Emissions vs. Traffic Volume.*

## Conclusions

- Greenhouse gas emissions from vehicles consist mostly of carbon monoxide.
- Volatile organic compound emissions are slightly higher than nitrogen oxide emissions.
- Emissions are proportional to assumed traffic volume.
- Intersections with no traffic control produce much higher greenhouse gas emissions than those with yield control and stop control.
- Intersections with stop control produce slightly higher greenhouse gas emissions than those with yield control.

## Recommendations

- If necessary, free control would be best implemented and/or maintained at intersections with the least amount of existing traffic volume in order to minimize emissions:
  - Jensen Avenue and South Alta Avenue
  - Jensen Avenue and Mt Campbell Avenue
  - Jensen Avenue and Navelencia Avenue
- Either stop control or yield control would be appropriate at intersections with higher existing traffic volumes:
  - East Kings Canyon Road and South Alta Avenue
  - East Kings Canyon Road and Crawford Avenue
  - Jensen Avenue and Crawford Avenue