I-25/Arapahoe Interchange

Environmental Assessment

# Environmental Resource Technical Memoranda

*July 2012*

I-25/Arapahoe Interchange
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FELSBURG HOLT & ULLEVIG

*engineering paths to transportation solutions*

December 19, 2011

**MEMORANDUM**

**TO:** Joseph Hart, David Evans and Associates Inc.

**FROM:** Dale Tischmak

**SUBJECT:** Historic Resources Evaluation for I-25/Arapahoe Road EA
FHU Reference No. 10-025-01

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An Environmental Assessment (EA) is being prepared for proposed improvements to the Interstate 25 (I-25) interchange at Arapahoe Road. As part of the EA, an evaluation of historic and cultural resources in the project area potentially impacted by the improvements was completed.

This evaluation built on information that was previously gathered for a corridor study documented in *Arapahoe Road Corridor Study, I-25 to Parker Road, Environmental Overview* (April, 2007). The research for the Overview assessed historic or cultural resources in the I-25 interchange area—none were identified. The interchange area has become a highly developed, urbanized area over the past several decades and there was essentially no undisturbed ground in the project area that had potential for archaeological resources. In addition, the buildings in the area have been constructed relatively recently—none in the immediate vicinity were identified as being at least 50 years old. Therefore, the Overview concluded that there were no known cultural or historic resources at the I-25 interchange in 2007.

Several years have passed since the Overview was completed, so the previous findings were reviewed and updated for the EA so that any changed conditions could be documented and addressed. For the archaeological resources, there have been no changes because there were no undisturbed areas in the project area. Essentially all of the ground in the interchange area has been disturbed by previous construction.

In terms of historic resources, the building records for Arapahoe County were reviewed to assess the age of buildings in the project area. Buildings at least 50 years old may need to be surveyed for historic eligibility under Section 106 of the National Historic Preservation Act. Arapahoe County's records indicated that the earliest buildings on properties that abut the roads affected by the project date from 1964 (Walnut Hills neighborhood). Consequently, there are no documented historic resources in the project area or any known potential historic resources that require further investigation or evaluation under Section 106 at this time.

Therefore, the proposed improvements would not impact historic or cultural resources. It should be noted that based on these data, some of the homes in Walnut Hills described above will begin turning 50 years old in 2014. At that time, it may become necessary to begin surveying these buildings for potential eligibility as historic resources for any future decisions or actions.

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I-25/Arapahoe Interchange

Environmental Assessment

# Air Quality Evaluation for I-25 / Arapahoe Road Interchange Improvements

**March 2012**

**Prepared for:**

Arapahoe County
Colorado Department of Transportation
Federal Highway Administration

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Arapahoe County Project C07-010
FHU Project No. 10-025

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# APPENDIX

# 1.0 INTRODUCTION

The National Environmental Policy Act (NEPA) of 1969 established a mandate for federal agencies to analyze the potential environmental consequences of their proposed actions, to document the analyses, and to make the information available to the public for comment prior to implementation. In accordance with NEPA and related regulations, the Federal Highway Administration (FHWA), as the Lead Agency, in cooperation with the Colorado Department of Transportation (CDOT) as a Joint Lead Agency, has prepared an Environmental Assessment (EA) for proposed improvements to the Interstate 25 (I-25) interchange with Arapahoe Road/State Highway (SH) 88 in Arapahoe County, Colorado (**Figure 1**). The project is sponsored by Arapahoe County in cooperation with the City of Centennial and the City of Greenwood Village.

## *1.1 Purpose*

The purpose of the air quality document is to present the overall analysis that was performed as part of the EA to assess potential air quality impacts from the proposed improvements. The overall analysis evaluates the emission levels of both criteria air pollutants and mobile source air toxics in accordance with the Clean Air Act and its amendments for designated nonattainment and/or attainment/maintenance areas. Emissions of these pollutants are a concern because of the potential risk to public health (**Section 2.0**).

For overall perspective, there has been a trend of decreasing total pollutant emissions nationwide from mobile sources for several decades, even when allowing for the growing number of vehicle miles of travel (VMT). These improving results are due to a number of successful emission control regulations. On-road sources account for varying amounts of the overall emissions but tend to be declining even though national VMT more than doubled over the past 30 years. Advances in vehicle technology as well as cleaner fuels have been major reasons for the improvements. Several recent federal regulations on vehicle emissions are expected to continue the trend of improvement and further lower vehicle emissions in the future.

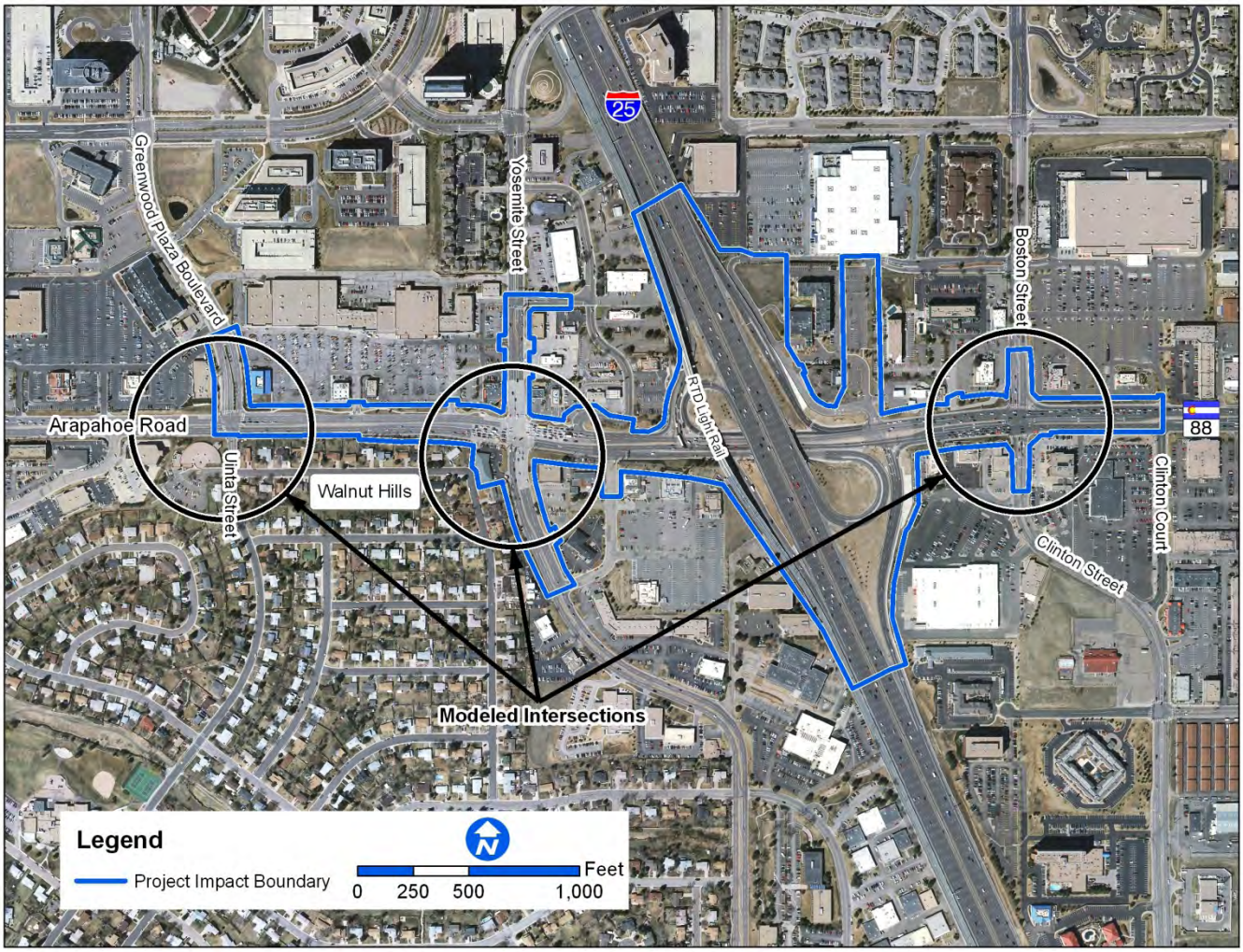
## *1.2 Project Description*

The purpose of the I-25/Arapahoe Road Interchange project is to reduce congestion and to improve functional deficiencies and operational and safety elements for the traveling public. The existing design and capacity of the interchange no longer accommodates traffic demands, and this will worsen in the future without action.

The study area straddles I-25 near Milepost 197 and is in both Centennial and Greenwood Village. The area includes residences, businesses and undeveloped areas abutting the streets and roads of interest for the project. The study area is nearly fully developed at present.

Two alternatives are being considered in the analysis: the No Action Alternative and the Action Alternative. The No Action Alternative (No Action) has no new road improvements as part of this project, though some changes to the current road network may be made by other projects. The Action Alternative was selected through a robust alternatives evaluation process. To summarize, the Action Alternative consists of replacing the I-25 bridge over Arapahoe Road and making numerous improvements to Arapahoe Road (between approximately Greenwood Plaza Boulevard and Clinton Court) and the interchange ramps that would result in an improved partial cloverleaf interchange configuration. For additional details on the alternatives and improvements, refer to the EA document.

**Figure 1 Study Area**




## *1.3 Analysis Approach*

A consultation and scoping meeting was held in May 2010 that included FHWA, CDOT, the Colorado Department of Public Health and Environment-Air Pollution Control Division (APCD) and the Denver Regional Council of Governments (DRCOG) to discuss air quality issues related to the project and to select the most appropriate approach for this study. The decision was made that the air quality analysis for the project should consist of several components:

- Review the regional conformity modeling for the current fiscally-constrained regional transportation plan (RTP) and transportation improvement program (TIP) to show and ensure that the alternatives are compatible with the State Implementation Plans (SIPs). (The conformity modeling is done by DRCOG and APCD as part of the regional planning and conformity demonstration activities.)
- A project-level hot spot analysis for carbon monoxide to show that the proposed action will not cause local violations of the National Ambient Air Quality Standards (NAAQS). Intersections that could be potential hot spots have been identified and analyzed for local conformity.

- Project-level qualitative analyses for particulate matter and toxic air pollutants.

## Regional Conformity

In air quality non-attainment and maintenance areas, the Clean Air Act requires that RTPs, TIPs and individual projects can not:

- cause new violations of a NAAQS
- increase the frequency or severity of existing violations of the NAAQS
- delay attainment of the NAAQS

The transportation conformity process is the mechanism used by the responsible metropolitan planning organization (DRCOG) to assure that the requirements of the Clean Air Act are met for planned transportation improvements within the region. The fiscally-constrained RTP and TIP must identify all projects that are expected to receive federal funds or that will require FHWA or Federal Transit Administration approval. These projects and other regionally-significant projects regardless of funding source must be included in a regional emissions analysis that demonstrates conformity to the SIPs to comply with the Clean Air Act.

Road improvement projects can not be built unless the regional road system in aggregate conforms to the regional SIPs. Individual projects can demonstrate regional conformity by being part of a conforming fiscally-constrained RTP, which looks at longer-range transportation planning, and either a TIP, which includes projects likely to proceed in the next few years, or the road network used for the RTP/TIP conformity document. The 2035 RTP (DRCOG, 2011d) and the 2012-2017 TIP (DRCOG, 2011a) are the adopted fiscally-constrained conforming plans for DRCOG. The proposed I-25 interchange improvements are included in the RTP (DRCOG, 2011d), and in the relevant conformity documents (DRCOG, 2011b; DRCOG, 2011c). Design activities and the EA for the interchange are included in the TIP. Construction of the modified interchange will need to be added to the TIP before actual construction can begin.

## Local Conformity

Individual projects within air quality nonattainment or maintenance areas, such as the Denver metropolitan area, must demonstrate that they will not cause violations of the NAAQS in localized areas known as hot spots. Three NAAQS pollutants are primary concerns for the Denver region (carbon monoxide [CO], suspended particulate matter [$PM_{10}$] and ozone [$O_3$]), but only two of these (CO and $PM_{10}$) are potential hot spot pollutants.

CO hot spots are most likely to be a concern where traffic is very congested and slow moving, such as at congested, high-volume intersections. The majority of $PM_{10}$ emissions from vehicles are from road dust, so a hot spot is most likely in areas with high traffic volumes traveling at relatively high speeds on unswept roads. In contrast, $O_3$ is influenced by regional pollutant emissions and is not a hot spot concern.

Hot spot modeling for CO was performed for the project (**Section 3.3**). In terms of $PM_{10}$, emissions from I-25 are not expected to be changed substantively by the project because I-25 capacity and operations would not be changed—the proposed I-25 improvements consist primarily of a bridge replacement and ramp realignments. Therefore, a qualitative analysis was performed for $PM_{10}$ (**Section 3.4**), as was decided at the agency consultation meeting. The analysis methods are described below.

### Carbon Monoxide

Areas likely to become CO hot spots are identified based primarily on traffic volumes and congestion, and a determination is then made whether a detailed analysis is needed. Generally, the need for CO hot spot analysis is assessed with respect to three criteria, as provided by the Environmental Protection Agency (EPA):

- The Level of Service (LOS) of a project intersection will be D, E or F
- The project affects locations identified in the SIP as sites of actual or potential violations of the CO NAAQS
- A project intersection is one of the top three in the SIP with respect to highest traffic volume or worst LOS

The goal of the intersection selection process is to choose the most congested and heavily trafficked intersections for CO analysis (**Section 3.3**), with these worst-case intersections also representing less congested intersections and areas. If an intersection does not meet any of the selection criteria, it is unlikely to be a hot spot and need not be assessed further. If an area intersection meets one of the criteria, it may be modeled for CO concentrations. If the congested intersections do not show hot spot pollution problems, less congested intersections will not either.

Particulate Matter

In 40 CFR 93.123(b)(2), the conformity rule requires hot spot analysis for "projects of air quality concern" within particulate matter non-attainment or attainment/maintenance areas. Projects of air quality concern are certain highway or transit projects that involve substantial levels of diesel vehicle traffic, or any other project that is identified in a SIP as a localized air quality concern. The 2005 SIP (CAQCC, 2005b) governs the applicability of the particulate matter hotspot requirements in the Denver metro area and an interchange on an interstate highway is a project of concern under these guidelines. Thus, a particulate matter hot spot analysis is needed for the proposed improvements and is provided below.

NAAQS violations for very fine particulate matter ($PM_{2.5}$) currently are not a concern anywhere in Colorado (**Section 2.2**), therefore $PM_{2.5}$ was not analyzed for the project.

The qualitative analysis for $PM_{10}$ follows both the procedures in the transportation conformity rule (EPA, 2006a) and the EPA/FHWA guidance (FHWA, 2006b). The guidance requires that $PM_{10}$ hot spot analyses address the following elements:

- Description of the project (location, design and scope; date project is expected to be open)
- Description of existing conditions and changes resulting from the project
- Contributing factors
    - Air Quality
    - Transportation and traffic conditions
    - Built and natural environment
    - Meteorology, climate and seasonal data
    - Adopted emissions control measures
- Description of analysis method chosen
- Description of type of emissions considered in the analysis (e.g., exhaust, road dust, construction emissions)
- Description of analysis years; consider full time frame of area's RTP, and examine year or years in which emissions are expected to peak
- Professional judgment of impact
- Evaluate both forms of $PM_{10}$ standard (24-hour and annual)—note: the annual NAAQS has since been revoked

- Discuss any mitigation measures
- Written commitments for mitigation
- Conclusion on how project meets the requirements of 40 CFR 93.116 and 93.123

These items are discussed in detail in **Section 3.4**.

# 2.0 AFFECTED ENVIRONMENT

The project is within the largest metropolitan area in Colorado. Based on the 2010 census, the 7-county Denver metropolitan area has approximately 2.8 million residents.

The primary air quality issues of concern for this project are pollutants associated with operation of vehicles on roadways. These issues include direct emissions of pollutants from vehicles, secondary pollutants formed from direct emissions, and road dust. Air quality issues related to road construction are also a potential short-term concern.

## *2.1 Local Setting*

The study area lies in the south central Denver metropolitan area. The study area elevation is approximately 5,800 feet above sea level. To the west is the much higher Front Range of the Rocky Mountains while to the east and lower in elevation is the Great Plains. The study area straddles a local topographic divide between the South Platte River and Cherry Creek drainages.

The coldest month for the study area usually is January, with an average daily temperature range of 20-48 degrees Fahrenheit. The warmest month usually is July, with an average daily temperature range of 55-90 degrees Fahrenheit. Thermal inversions are known to occur in the study area during times of low winds. The study area generally receives about 19 inches of precipitation annually, with the wettest months generally May and April. Prevailing winds in the study area can be somewhat variable due to local topography, but the prevailing winds near ground surface tend to be from the north and south (**Figure 2**).

## *2.2 National Ambient Air Quality Standards Overview*

The Clean Air Act of 1970 and its amendments led to the establishment by EPA of the NAAQS for the criteria air pollutants: CO, sulfur dioxide, $O_3$, $PM_{10}$, nitrogen dioxide and lead (**Table 1**). In 1997, EPA changed the $O_3$ standard (which was revised again in 2008) and added a new standard for $PM_{2.5}$, though implementation of these two NAAQSs was delayed until 2004. Motor vehicles are important contributors of CO, $O_3$, nitrogen dioxide and particulate matter, so only these criteria pollutants will be discussed in detail below.

Under the Clean Air Act, cities and regions were required to determine their compliance with the NAAQSs. Areas that met the NAAQS were classified as attainment areas while areas that did not meet a NAAQS were classified as nonattainment for that NAAQS. These classifications are long term and do not change often. The Denver metropolitan area has been in attainment of the sulfur dioxide, nitrogen dioxide and lead NAAQSs for more than 30 years. The Denver metropolitan area was a nonattainment area for CO, $O_3$ (1-hour), and $PM_{10}$ beginning in the early 1970's, so those three pollutants have historically been concerns in the Denver region. The region included in the nonattainment areas were all or parts of the following counties: Denver, Jefferson, Boulder, Adams, Arapahoe, Douglas and Broomfield.

A number of successful air quality improvement actions over many years resulted in cleaner air and the Denver region meeting all of the NAAQS that were in force in 2001. The Denver region was reclassified by EPA as attainment/maintenance areas in 2001 and 2002 for CO, $O_3$ (1-hour) and $PM_{10}$ and regional maintenance plans were developed for all three pollutants. The study area is within all three of these maintenance areas.

Nonattainment areas for the new $PM_{2.5}$ and 8-hour $O_3$ NAAQSs were designated by EPA in 2004. No areas in Colorado have been designated as nonattainment for $PM_{2.5}$, so it is not a major issue in the state. However, $O_3$ is again a concern in the Denver region. The Denver region officially became a nonattainment area for the 8-hour $O_3$ NAAQS on November 20, 2007.

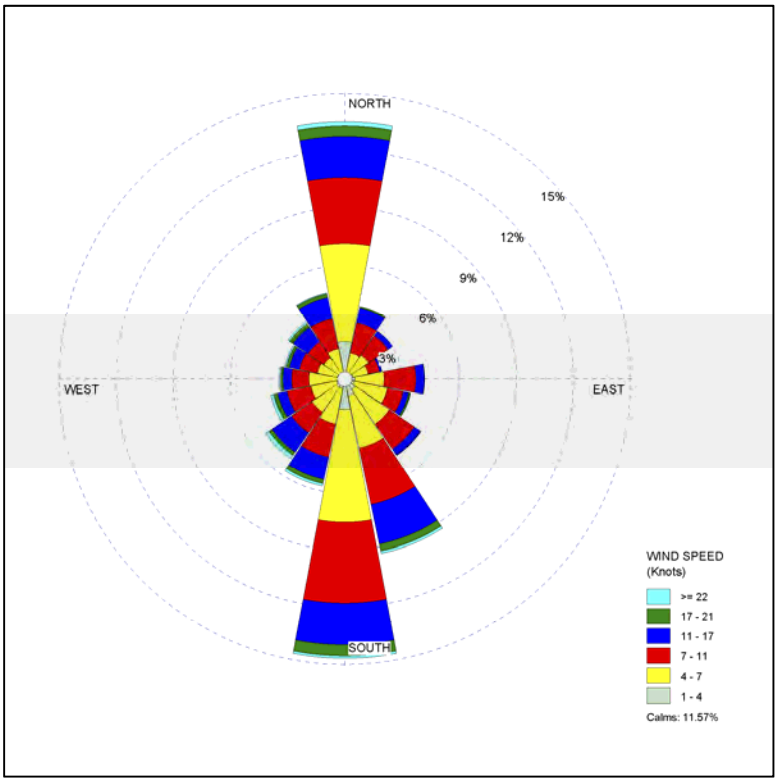
The 8-hour $O_3$ nonattainment area includes the 7-county metropolitan area plus parts of Larimer and Weld Counties.

**Table 1 National Ambient Air Quality Standards**

| Pollutant | Averaging Time | Primary Standard |
|---|---|---|
| Carbon Monoxide | 8 hours | 9 ppm |
| | 1 hour | 35 ppm |
| Sulfur Dioxide | Annual | 0.03 ppm |
| | 24 hours | 0.14 ppm |
| | 1 hour | 75 ppb |
| Ozone | 8 hour | 0.075 ppm |
| Particulate Matter <10 µm ($PM_{10}$) | 24 hours | 150 µg/$m^3$ |
| Particulate Matter <2.5 µm ($PM_{2.5}$) | Annual | 15 µg/$m^3$ |
| | 24 hours | 35 µg/$m^3$ |
| Nitrogen Dioxide | Annual | 53 ppb |
| | 1 hour | 100 ppb |
| Lead | Quarterly | 0.15 µg/$m^3$ |

Source: EPA, 2011.
Note: ppb = parts per billion
ppm = parts per million
µg/$m^3$ = micrograms per cubic meter
µm = micrometers

**Figure 2 Prevailing Winds, Centennial Airport Weather Station**




Source: National Weather Service, 2011.

### Carbon Monoxide

CO is an odorless, colorless gas that is most commonly formed by incomplete combustion of fuel. CO is dangerous because it interferes with the body's ability to absorb oxygen. High concentrations of CO can cause dizziness, headaches, loss of vision, impaired dexterity and even death, if the concentration is high enough. Major sources of CO include vehicle exhaust, coal burning and forest fires. CO is most commonly a concern in localized areas around the CO sources, such as near congested road intersections. CO can be a regional concern if concentrations are high enough and disperse into the surrounding area.

### Particulate Matter

Particulate matter (both $PM_{10}$ and $PM_{2.5}$) is a complex mix of very small solid particles and liquid droplets. Particulate matter is a concern because it can be inhaled deeply into the lungs and can interfere with lung function or lead to other health effects. Particulate matter can aggravate asthma, diminish lung capacity and cause lung or heart problems. Particulate matter can also cause haze. Sources of particulate matter include road dust, smoke and diesel engine exhaust. Particulate matter can be a concern around sources, but winds can disperse particulate matter over a larger area and cause regional concerns.

### Ground Level Ozone

Ground-level $O_3$ is a gas that is formed by chemical reactions between other pollutants in the atmosphere. Nitrogen oxides (NOx) and hydrocarbons in the presence of sunlight and certain weather conditions can form $O_3$. $O_3$ is a strong oxidizing agent and can damage cells in lungs and plants. $O_3$ can cause eye irritation, coughing and lung damage.

There are not specific sources of $O_3$ because it is rarely emitted directly. However, $O_3$ concentrations are affected through concentrations of the precursor pollutants NOx and hydrocarbons. Automotive sources of NOx include vehicle exhaust. Automotive sources of hydrocarbons include fuel evaporation and incomplete combustion of fuel. $O_3$ is a regional concern because it takes time for $O_3$ to form and the pollutants can drift a considerable distance in that time (California Air Resources Board [CARB], 2002). Rural/undeveloped areas can have $O_3$ problems because of transported pollutants, even if there are not major local emissions of the precursors (CARB, 2002).

### Nitrogen Dioxide

The atmosphere is approximately 80 percent nitrogen gas. When fuel is burned at high temperature in air, this nitrogen can react with oxygen that is also present in air to form gases such as nitrogen dioxide and other NOx compounds. NOx can contribute to $O_3$ formation, particulate matter formation and acid deposition. Common sources of nitrogen oxides are vehicles and coal-fired electrical power plants. Nitrogen dioxide can damage cells in lungs and plants and damage water quality. Nitrogen dioxide can be transported over great distances and is a regional concern.

## *2.3 NAAQS Monitoring Data Overview*

There are several air quality monitoring stations in the Denver region that measure the criteria air pollutants, however none are close to the study area. The closest active monitoring stations and the pollutant data used for the EA from each are:

- Chatfield monitor ($PM_{2.5}$)
- Southglenn monitor ($O_3$)
- 1300 Blake Street-Denver (CO)
- 678 S. Jason Street-Denver ($PM_{10}$)

- CAMP-downtown Denver (nitrogen dioxide)

Monitoring stations at other locations in the region have been active in the past. The stations listed above are outside the study area, but overall these stations provide the monitoring data nearest the study area.

The most recent complete data set from these stations available from the EPA website was for 2008. In 2008, none of the NAAQS levels were exceeded for CO, $PM_{10}$, $PM_{2.5}$ or nitrogen dioxide. The 8-hour $O_3$ NAAQS has been violated in the Denver region but the concentrations at Southglenn met the 2008 NAAQS. Monitoring data for the three pollutants subject to maintenance plans in the Denver region (CO, $PM_{10}$ and $O_3$) are summarized below.

### Carbon Monoxide

Measured concentrations of CO in the Denver region have not violated the NAAQS since 1995 (CAQCC, 2004a). For the Blake Street CO station, the 2008 measured values for NAAQS comparison for 1 hour and 8 hours are 4.5 ppm and1.9 ppm, respectively. These values are below their respective NAAQS (**Table 1**).

### Particulate Matter

For the Jason Street $PM_{10}$ station, the 2008 measured values for NAAQS comparison for 24 hours is 52 $\mu g/m^3$. Measured concentrations of $PM_{10}$ in the Denver region generally have not violated the NAAQS since 1993 (CAQCC, 2004a). For the Chatfield $PM_{2.5}$ station, the 2008 measured values for NAAQS comparison for 24 hours and annual were 16.2 $\mu g/m^3$ and 7.06 $\mu g/m^3$, respectively. These values are below their respective NAAQS (**Table 1**).

### Nitrogen Dioxide and Ozone

Nitrogen dioxide is a criteria pollutant and an $O_3$ precursor. For the CAMP nitrogen dioxide station, the 2008 measured value for NAAQS comparison for 1-hour and annually are 0.096 and 0.025 ppm, respectively. The other major $O_3$ precursor pollutant (hydrocarbons) is not a NAAQS pollutant.

For the Southglenn $O_3$ monitoring station, the 2008 measured value for NAAQS comparison for 8 hours is 0.059 ppm. The three-year average of the fourth-highest 8-hour $O_3$ concentrations at Southglenn was 0.072 ppm in 2008. These measured $O_3$ concentrations were below the $O_3$ NAAQS. Note that the highest $O_3$ concentrations have been in the western metropolitan area and have not been near the study area.

## *2.4 Transportation and Circulation System*

The transportation and circulation system evaluated for this report was the streets and highways within the study area (**Figure 1**) that were likely to be affected by changes in traffic patterns by the Action Alternative. This group of roads consisted of:

- I-25
- Arapahoe Road (SH 88)
- Yosemite Street
- Greenwood Plaza Boulevard/Uinta Street
- Boston/Clinton Street
- Dayton Street

Data pertaining to traffic volumes and LOS in this report are drawn from the traffic study (David Evans & Associates, 2011). The LOSs of the various intersections of interest to the project were assessed for morning and afternoon peak traffic hours (**Table 2**). LOSs provide an indication of

intersection congestion and likely hot spots for air pollutants from vehicles. LOS A describes the best traffic operation of free-flowing, light volume traffic and LOS F represents the worst condition of heavy traffic congestion.

**Table 2 Study Area 2035 Intersection Levels of Service (AM/PM)**

| Intersection | 2035 Action Alternative (AM/PM) |
|---|---|
| Southbound I-25 Interchange Ramps | C/C |
| Northbound I-25 Interchange Ramps | C/B |
| Arapahoe Rd. & Greenwood Plaza Blvd. | B/F |
| Arapahoe Rd. & Yosemite St. | E/F |
| Arapahoe Rd. & Boston St. | C/D |

I-25 is one of the largest freeways in Colorado and carries a corresponding volume of traffic. I-25 has five through lanes in each direction in the study area with additional merge/diverge lanes at the interchanges. I-25 currently carries a traffic load of about 210,000 vehicles per day in the study area.

Arapahoe Road is SH 88 east of I-25 and is an important east-west regional arterial in the study area. Arapahoe Road generally has three through lanes each direction with additional auxiliary lanes. Arapahoe Road currently carries a traffic load of about 60,000 vehicles per day.

Yosemite Street is an arterial in the study area with two through lanes in each direction with additional turn/auxiliary lanes. Yosemite Street currently carries a traffic load of about 20,000 vehicles per day.

Boston/Clinton Street is an arterial in the study area with two through lanes each direction with additional turn/auxiliary lanes. Boston/Clinton Street currently carries a traffic load of about 13,000 vehicles per day.

## 2.5 Sensitive Receptors

Locations where people spend extended periods of time are likely to be the most sensitive receptors. The receptors most likely to be directly affected by pollutants from project roads are those sensitive receptors closest to the roads. These types of locations in the study area include homes and businesses. There are approximately 31 developed properties within about 100 feet of the major roads that were examined within the study area.

## 2.6 Other Air Quality Considerations

Two other air quality topics that were considered were toxic air pollutants and general construction activities.

### Toxic Air Pollutants

FHWA has released interim guidance on when and how to analyze Mobile Source Air Toxic pollutants (MSATs) in the NEPA process for highways (FHWA, 2006a). The following discussion is in accordance with the interim guidance.

Background

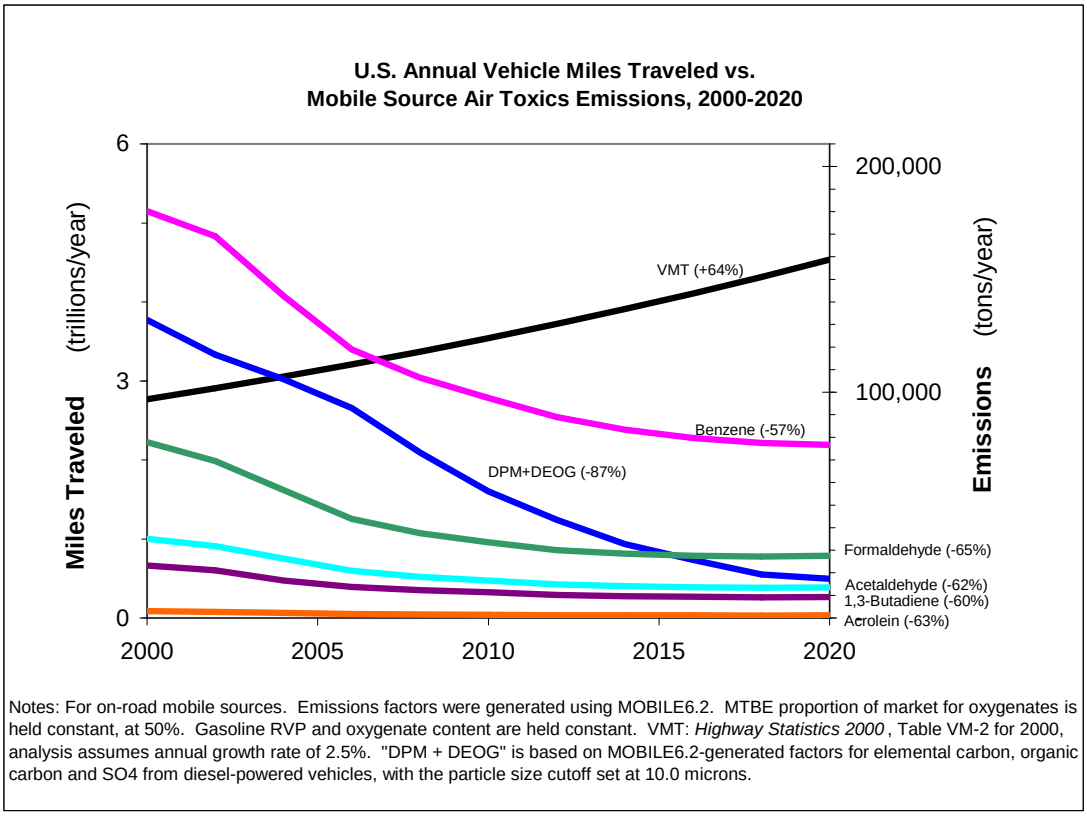
In addition to the criteria air pollutants for which there are NAAQS, EPA also regulates air toxics. Most air toxics originate from human-made sources, including on-road mobile sources, non-road mobile sources (e.g., airplanes), area sources (e.g., dry cleaners) and stationary sources (e.g., factories or refineries).

The group of 21 MSATs that has been identified by EPA is a subset of the 188 air toxics defined by the Clean Air Act. MSATs are compounds emitted from highway vehicles and non-road equipment. Some toxic compounds are present in fuel and are emitted to the air when the fuel evaporates or passes through the engine unburned. Other toxics are emitted from the incomplete combustion of fuels or as secondary combustion products. Metal air toxics also result from engine wear or from impurities in oil or gasoline (EPA, 2000b).

EPA is the lead Federal Agency for administering the Clean Air Act and has certain responsibilities regarding the health effects of MSATs. EPA issued a Final Rule on Controlling Emissions of Hazardous Air Pollutants from Mobile Sources (EPA, 2001). This rule was issued under the authority in Section 202 of the Clean Air Act. Through the rule, EPA examined the impacts of existing and newly promulgated mobile source control programs, including the reformulated gasoline program, the national low emission vehicle standards, the Tier 2 motor vehicle emissions standards and gasoline sulfur control requirements, and the proposed heavy duty engine and vehicle standards and on-highway diesel fuel sulfur control requirements. Through this rule, EPA identified a reduced list of six priority MSATs: acetaldehyde, benzene, formaldehyde, diesel exhaust, acrolein, and 1,3-butadiene (EPA, 2001).

Between 2000 and 2020, FHWA projects that even with a 64 percent increase in VMT, these programs will reduce on-highway emissions of benzene, formaldehyde, 1,3-butadiene, and acetaldehyde by 57 percent to 65 percent, and will reduce on-highway diesel particulate emissions by 87 percent (**Figure 2**). EPA is preparing another rule under authority of Section 202(l) of the Clean Air Act that will address these issues and could make adjustments to the full 21 and the six primary MSATs.

**Figure 3 Predicted National MSAT Emissions**




Notes: For on-road mobile sources. Emissions factors were generated using MOBILE6.2. MTBE proportion of market for oxygenates is held constant, at 50%. Gasoline RVP and oxygenate content are held constant. VMT: *Highway Statistics 2000*, Table VM-2 for 2000, analysis assumes annual growth rate of 2.5%. "DPM + DEOG" is based on MOBILE6.2-generated factors for elemental carbon, organic carbon and SO4 from diesel-powered vehicles, with the particle size cutoff set at 10.0 microns.

Source: FHWA, 2006a.

Benzene is unique among the primary six MSATs in that it is present both in fuel and in tailpipe emissions, while the other priority MSATs are generally only in tailpipe emissions. Therefore, benzene emissions can come from more sources than the other priority MSATs and are directly affected by more regulatory controls such as Tier 2 and reformulated gasolines.

Summary of Existing Credible Scientific Evidence Relevant to Evaluating the Impacts of MSATS

Research into the health impacts of MSATs is ongoing. For different emission types, there are a variety of studies that show that some emissions either are statistically associated with adverse health outcomes through epidemiological studies (frequently based on emissions levels found in occupational settings) or that animals demonstrate adverse health outcomes when exposed to large doses.

Exposure to toxics has been a focus of a number of EPA efforts. Most notably, EPA conducted the National Air Toxics Assessment (EPA, 1996; EPA, 2006b) to evaluate modeled estimates of human exposure applicable to the county level. While not intended for use as a measure of or benchmark for local exposure, the modeled estimates best illustrate the levels of various toxics when aggregated to a national or State level.

EPA is in the process of assessing the risks of various kinds of exposures to these pollutants. The EPA Integrated Risk Information System (IRIS) is a database of human health effects that may result from exposure to various substances found in the environment. The IRIS database is located online at http://www.epa.gov/iris. The following toxicity information for the six prioritized MSATs and two other substances of potential concern (naphthalene and polycyclic organic matter) was taken from the IRIS database Weight of Evidence Characterization summaries. This information is taken verbatim from EPA's IRIS database and represents the Agency's most current evaluations of the potential hazards and toxicology of these chemicals or mixtures.

- Benzene is characterized as a known human carcinogen.
- The potential carcinogenicity of acrolein cannot be determined because the existing data are inadequate for an assessment of human carcinogenic potential for either the oral or inhalation route of exposure.
- Formaldehyde is a probable human carcinogen, based on limited evidence in humans, and sufficient evidence in animals.
- 1,3-butadiene is characterized as carcinogenic to humans by inhalation.
- Acetaldehyde is a probable human carcinogen based on increased incidence of nasal tumors in male and female rats and laryngeal tumors in male and female hamsters after inhalation exposure.
- Diesel exhaust is likely to be carcinogenic to humans by inhalation from environmental exposures. Diesel exhaust as reviewed in this document is the combination of diesel particulate matter and diesel exhaust organic gases.
- Diesel exhaust also represents chronic respiratory effects, possibly the primary non-cancer hazard from MSATs. Prolonged exposures may impair pulmonary function and could produce symptoms, such as cough, phlegm, and chronic bronchitis. Exposure relationships have not been developed from these studies.
- Naphthalene is a possible human carcinogen. Acute exposure may cause cataracts or hemolytic anemia in children and infants after oral or inhalation exposure or after maternal exposure during pregnancy.
- Polycyclic organic matter includes several compounds common in combustion which are considered to be human carcinogens.

There have been other studies that address MSAT health impacts in proximity to roadways. The Health Effects Institute, a non-profit organization funded by EPA, FHWA, and industry, has undertaken a major series of studies to research near-roadway MSAT hot spots, the health implications of the entire mix of mobile source pollutants, and other topics. The final summary of the series is not expected for several years.

Some recent studies have reported that proximity to roadways is related to adverse health outcomes, particularly respiratory problems (South Coast Air Quality Management District, 2000; Sierra Club, 2004; and Environmental Law Institute, 2005). Much of this research is not specific to MSATs, but instead surveys the full spectrum of both NAAQS and other pollutants. The FHWA cannot evaluate the validity of these studies, but more importantly, the studies do not provide information that would be useful to alleviate the uncertainties listed above and enable a more comprehensive evaluation of the health impacts specific to this project.

### Construction

Finally, air quality impacts from construction can be a concern. Long-term construction projects near sensitive receptors can represent health concerns. As with MSATs, there are no ambient air standards specifically for construction or direct mechanisms for assessing such impacts.

# 3.0 ENVIRONMENTAL CONSEQUENCES

Because of the past and present regional air quality challenges in the Denver metropolitan area (including the study area), infrastructure projects that might exacerbate the air quality problems must meet certain requirements before they can proceed. In general, projects of the type considered in the EA must be analyzed with respect to the potential impact on air quality at both the regional and local levels. The region of influence examined for air quality in this project is around the highways and streets described in **Section 2.4**.

## *3.1 Transportation and Circulation System*

The EA is examining possible future changes to the highway and street network in the study area. The future transportation and circulation system will be similar in many ways to the existing system. Some roads may be widened and some intersections may be improved. The proposed changes to area roads were previously described in **Section 1.1**.

## *3.2 Sensitive Receptors*

The receptors most likely to be directly affected by pollutants from project roads are those receptors closest to the roads (**Figure 1**). The Action Alternative could bring traffic closer to some receptors. There are approximately 31 developed properties within about 100 feet of the study area roads that were examined. This includes a portion of the Walnut Hills neighborhood.

## *3.3 Carbon Monoxide Results*

Three study area intersections predicted to function at LOS D or worse in 2035 (**Table 2**) were selected for CO hot spot analysis—the Arapahoe Road intersections with Greenwood Plaza Boulevard, Yosemite Street and Boston Street (**Figure 1**), respectively. A “worst case” situation was modeled and reviewed for each intersection to ensure that the year of maximum CO emissions was considered. For this “worst case” model, the highest CO emissions factors (2011) were combined with the highest traffic volumes (2035). These artificial conditions were purposely devised to maximize CO concentrations associated with the project to ensure that the maximum potential CO concentrations were adequately considered. The afternoon peak hour traffic volumes were used because they were predicted to be higher. The model results were compared to the NAAQS.

The CO model results are summarized in **Table 3**. The model output data (**Appendix A**) have been corrected for altitude within CAL3QHC. The CAL3QHC model provides 1-hour average CO concentrations which must then be added to background CO concentrations. To calculate 8-hour CO results, the 1-hour model results were multiplied by a persistence factor of 0.32 (from APCD) and added to the 8-hour background CO concentrations, following APCD and CDOT guidance. This correction is needed because the average hourly traffic over eight consecutive hours will be less than the peak hour traffic that is modeled, and the meteorological conditions including wind speed and direction may vary during that time.

Year 2011 CO background concentrations were also used for the 2011/2035 “worst case” results because they were higher than 2035 (per APCD). A 1-hour CO background concentration of 6.8 and an 8-hour CO background of 2.2 ppm were used. The maximum 1-hour CO concentration predicted for any intersection was 12.8 ppm, which is below the NAAQS of 35 ppm (**Table 3**). The maximum 8-hour CO concentration predicted was 4.1 ppm, which is below the NAAQS of 9 ppm (**Table 3**). Therefore, no CO hot spots in violation of the NAAQS are predicted and no mitigation for CO is required.

**Table 3 Maximum Modeled Carbon Monoxide Concentrations**

| Intersection | 1-Hour CO Result (ppm) | 8-Hour CO Result (ppm) |
|---|---|---|
| Arapahoe Rd. & Greenwood Plaza Blvd. | 11.0 | 3.5 |
| Arapahoe Rd. & Yosemite St. | 12.8 | 4.1 |
| Arapahoe Rd. & Boston St. | 12.0 | 3.9 |
| *NAAQS* | *35* | *9* |

Source: FHU Modeling Results.

CO concentrations are expected to decrease at the target intersections in the future. This is primarily because vehicles will be emitting less CO. This benefit will be from vehicle emission regulation and will be realized regardless of whether the proposed improvements are made.

## *3.4 Particulate Matter Results*

A qualitative evaluation of $PM_{10}$ emissions was performed for the project.

### Description of Project

This information has been summarized in **Section 1.0**.

### Description of Existing Conditions and Changes Resulting from Project

This information is presented in **Section 2.0**. In evaluating the $PM_{10}$ hot spot potential of the project, the worst-case location in the study area was identified based on the highest daily traffic volumes. Re-entrained road dust is a major source of vehicular $PM_{10}$ and road dust is most prevalent where the largest traffic volume travels at the highest speed. In the study area, this is the I-25 corridor, so the Arapahoe Road interchange was selected. Estimated 2035 traffic volumes on I-25 from DRCOG data would be approximately 278,000 vehicles per day.

### Contributing Factors

This information is provided in **Section 2.0** above (air quality, meteorology, climate data, built and natural environment) and in the EA. Emissions control measures for $PM_{10}$ in the Denver metropolitan area include a diesel vehicle inspection and maintenance program, and various state and local programs to reduce road dust emissions, including street sweeping and use of alternative deicers. These programs will be in place in the study area to reduce $PM_{10}$ emissions regardless.

The $PM_{10}$ monitor nearest the study area at 678 S. Jason Street in Denver has been active since 2005. There has been one calculated exceedence of the $PM_{10}$ standard anywhere in the Denver region in the past decade in Commerce City. The most relevant $PM_{10}$ components from mobile sources are re-entrained fugitive dust and tailpipe emissions, which account for about half the $PM_{10}$ emissions in the Denver area.

APCD is responsible for studying and improving the air quality in Colorado. In addition to the air quality monitoring mentioned above, APCD also performs regional air quality modeling. $PM_{10}$ concentrations are modeled in support of the SIP and the model includes the emissions from local sources of $PM_{10}$. The model provides predicted $PM_{10}$ concentrations for a modeling grid covering most of the Denver metropolitan area (CAQCC, 2005b). The APCD model nodes nearest the study area (#236 and #237) were reviewed. The model results show that $PM_{10}$ concentrations are predicted to increase at these locations over the next 25 years, due mainly to

higher traffic volumes. The highest predicted sixth-maximum $PM_{10}$ concentration modeled by APCD (132.20 µg/$m^3$ at #237 in 2030) is below the NAAQS of 150 µg/$m^3$.

As was previously mentioned, the Final Rule redesignating the Denver area from nonattainment to maintenance status for $PM_{10}$ became effective on October 16, 2002. This redesignation also included approval of a Maintenance Plan for $PM_{10}$ for the Denver area (CAQCC, 2001b) that was updated in 2005 (CAQCC, 2005b). These types of plans are required to ensure maintenance of the relevant NAAQS for at least 10 years. The Maintenance Plan included a number of strategies to reduce future $PM_{10}$ emissions to demonstrate maintenance for 2002 and beyond. These reductions will come mostly from lower tailpipe emissions, better street sanding procedures and ongoing vehicle inspection/maintenance requirements of the AIR Program. Re-entrained road dust tends to be a larger source of $PM_{10}$ then tailpipe emissions for mobile sources. Street sanding practices are controlled by Colorado Air Quality Commission Regulation No. 16 and are expected to be the biggest contributor to $PM_{10}$ control for the Denver area. The Maintenance Plan also includes controls for emissions from road construction activities.

### Description of Analysis Method Chosen

The study area is within the "fine grid" of the $PM_{10}$ SIP modeling domain, so the analysis used the "air quality studies for the proposed project location" approach outlined in Section 4.1 of the March 2006 guidance (FHWA, 2006b). The analysis relies on the modeling for the $PM_{10}$ Maintenance Plan done by APCD that was described above.

### Description of Type of Emissions Considered in this Analysis

Because the dispersion modeling for the Maintenance Plan includes all sources (mobile and stationary) of local $PM_{10}$ emissions, the analysis method used for $PM_{10}$ includes all mobile sources of emissions. As noted above, road dust is the predominant source of mobile source emissions in the Denver area, followed by tailpipe exhaust emissions.

Construction emissions are also reflected in the Maintenance Plan modeling. These emissions include all types of construction (residential, commercial and roadway). The transportation conformity rule only requires consideration of construction emissions in cases where construction activity lasts longer than five years at any individual location, which is not expected for this project.

The dispersion modeling for the Maintenance Plan also includes mobile source precursor gases (such as NOx) that contribute to $PM_{10}$ concentrations. $PM_{10}$ hot spot analyses are not required to consider these emissions under the conformity rule, so including the dispersion modeling results is more comprehensive than required.

### Description of Analysis Years

The amended conformity rule (EPA, 2006a) and the EPA/FHWA guidance (FHWA, 2006b) require that particulate matter hot spot analyses 1) cover the entire timeframe of the area's RTP, and 2) be based on the year or years in which peak emissions are expected. The currently conforming RTP in the Denver metropolitan region is the 2035 Metro Vision Regional Transportation Plan, adopted in February 2011and most recently amended in August 2011. Therefore, the analysis must extend at least through the year 2035.

To identify the year or years of peak emissions, both mobile source trends and general trends in background emissions need to be considered. The mobile source emissions inventories from the $PM_{10}$ Maintenance Plan are presented in the SIP support document (APCD, 2005). The dispersion modeling for the Maintenance Plan includes mobile source contributions as well as background concentrations (APCD, 2005). Both of these trends show $PM_{10}$ increases throughout the maintenance period, with the highest values in 2030. While the tailpipe fraction of emissions declines due to tighter tailpipe emissions standards, road dust emissions increase

due to increased traffic volumes. These trends are likely to continue past 2030, therefore, it was concluded that 2035 represents the year of peak emissions.

### Professional Judgment of Impact

As was mentioned previously, the $PM_{10}$ Maintenance Plan extends to 2030 while the RTP is for 2035. To overcome this disconnect, the APCD-modeled $PM_{10}$ concentrations for 2030 were adjusted by an amount equivalent to the change in predicted I-25 traffic volumes between 2030 and 2035. For the Maintenance Plan, the sixth-highest 2030 $PM_{10}$ concentration at the grid node #237is predicted to be 132.20 $\mu g/m^3$ (APCD, 2005), below the $PM_{10}$ NAAQS of 150 $\mu g/m^3$. The traffic volume increase from 2030 to 2035 is estimated to be about 5 percent. Increasing the maximum APCD-modeled $PM_{10}$ concentration by 5 percent would give approximately 139 $\mu g/m^3$, which would still be below the NAAQS. Therefore, it is expected that a worst-case condition for the study area would be below the NAAQS through 2035.

Overall, No Action should have lower total $PM_{10}$ emissions because of lower traffic speeds and greater overall congestion in the study area—note that traffic volumes are expected to be equal. However, $PM_{10}$ is the subject of a comprehensive Maintenance Plan for the Denver area and impacts from traffic are major considerations within the Maintenance Plan. $PM_{10}$ concentrations around Denver have been below the NAAQS even with the past growth in traffic. The proposed improvements are not expected to cause or contribute to violations of the $PM_{10}$ NAAQS. The proposed improvements are not expected to interfere with the Maintenance Plan or its goals. Therefore, no impacts are expected and no mitigation is necessary for $PM_{10}$.

### Evaluate Both Forms of Particulate Matter Standard (24 Hour and Annual)

Effective December 18, 2006, EPA revoked the annual $PM_{10}$ standard, so it is not included in this discussion.

The Denver area has been designated nonattainment, and then maintenance, due to the 24-hour $PM_{10}$ standard. The $PM_{10}$ monitoring data for the Denver area was discussed in **Section 2.3**, and the $PM_{10}$ concentrations have been below the NAAQS for more than a decade. Both the Maintenance Plan comparison results and the worst-case extrapolation results (see previous subsection) showed that the $PM_{10}$ concentrations are predicted to be below the 24-hour $PM_{10}$ NAAQS.

### Discussion of Any Mitigation Measures

As noted above, the proposed project is not expected to cause or contribute to violations of the $PM_{10}$ standard nor is the proposed project expected to interfere with the Maintenance Plan or its goals. Therefore, no mitigation is necessary to demonstrate conformity for $PM_{10}$. However, standard particulate control measures during construction will be implemented.

### Conclusion of How Project Meets 40 CFR 93.116 and 93.123

As outlined above, the study area is within the APCD modeling domain for the $PM_{10}$ maintenance area. The projected 2035 conditions were extrapolated from the reported 2030 modeling results of APCD for the Denver $PM_{10}$ Maintenance Plan. The modeling included contributions from roadway traffic, precursor and construction emissions, and emissions from all other sources affecting urban background concentrations. The evaluation showed that the proposed project location would not be likely to cause or contribute to violations of the $PM_{10}$ NAAQS.

## *3.5 Ozone*

As was previously discussed, $O_3$ is a regional pollutant (**Section 2.2**) and as such is controlled at a regional level. Emissions of $O_3$ precursors near a particular location may not be important because the precursors need time to mix and the right weather conditions to be present before

$O_3$ is formed. In that time, the precursors can drift a considerable distance, so the pollution may not be near the emission source.

The entire Denver metropolitan area is subject to $O_3$ precursor emission reduction strategies developed for the $O_3$ Action Plan for the Denver nonattainment area. All projects in the Denver $O_3$ nonattainment area must, in the aggregate, conform to the $O_3$ SIP and must be compatible with regional $O_3$ concentration reductions to comply with the NAAQS. That analysis must occur at the regional level, i.e. with the RTP. Therefore, the inclusion of the proposed project in the conforming 2035 RTP satisfies conformity for the $O_3$ NAAQS.

## *3.6 Toxic Air Pollutants*

Detailed quantitative methods have not been established for the analysis of MSATs for transportation projects. The proposed project is expected to have a low potential for MSAT effects. Therefore, a qualitative MSAT assessment was performed.

### Unavailable or Incomplete Information for Project Specific MSAT Impact Analysis

The EA air quality analysis includes a basic assessment of the likely MSAT emission impacts from the future alternatives. However, the available technical tools do not allow prediction of the project-specific health impacts of the emission changes associated with the alternatives. Due to these limitations, the following discussion is included in accordance with Council on Environmental Quality regulations (40 CFR 1502.22(b)) regarding incomplete or unavailable information.

Evaluating the environmental and health impacts from MSATs on a proposed highway project would involve several key elements, including emissions modeling, dispersion modeling to estimate ambient concentrations resulting from the estimated emissions, exposure modeling to estimate human exposure to the estimated concentrations, and then final determination of health impacts based on the estimated exposure. Each of these steps faces technical shortcomings or uncertain science that prevents a more complete determination of the MSAT health impacts of this project.

Emissions

The EPA tools to estimate MSAT emissions from motor vehicles are not sensitive to key variables in the context of highway projects (EPA, 2002). While MOBILE 6.2 is used to predict emissions at a regional level, it has limited applicability at the project level. MOBILE 6.2 is a trip-based model—emission factors are projected based on a typical trip of 7.5 miles, and on average speeds for this typical trip. This means that MOBILE 6.2 does not have the ability to predict emission factors for a specific vehicle operating condition at a specific location at a specific time. Because of this limitation, MOBILE 6.2 can only approximate the operating speeds and levels of congestion likely to be present on the largest-scale projects, and cannot adequately capture emissions effects of smaller projects. For particulate matter, the model results are not sensitive to average trip speed, although the other MSAT emission rates do change with changes in trip speed. Lastly, in its discussions of particulate matter under the conformity rule, EPA has identified problems with MOBILE 6.2 as an obstacle to quantitative analysis.

These deficiencies compromise the use of MOBILE 6.2 to estimate MSAT emissions. MOBILE 6.2 is an adequate tool for projecting emissions trends, and performing relative analyses between alternatives for very large projects, but it is not sensitive enough to capture the effects of travel changes tied to smaller projects or to predict emissions near specific roadside locations.

Dispersion

The tools to predict how MSATs disperse are also limited. EPA's current regulatory models, CALINE3 and CAL3QHC, were developed and validated more than a decade ago for the purpose of predicting episodic concentrations of CO to determine compliance with the NAAQS. The performance of dispersion models is more accurate for predicting maximum concentrations that can occur at some time at some location within a geographic area. This limitation makes it difficult to predict accurate exposure patterns at specific times at specific highway project locations across an urban area to assess potential health risk. The NCHRP is conducting research on best practices in applying models and other technical methods in the analysis of MSATs. This work also will focus on identifying appropriate methods of documenting and communicating MSAT impacts in the NEPA process and to the general public. Along with these general limitations of dispersion models, FHWA is also faced with a lack of monitoring data in most areas for use in establishing project-specific MSAT background concentrations.

Exposure Levels and Health Effects

Finally, even if emission levels and concentrations of MSATs could be accurately predicted, shortcomings in current techniques for exposure assessment and risk analysis preclude us from reaching meaningful conclusions about project-specific health impacts. Exposure assessments are difficult because it is difficult to calculate accurately annual concentrations of MSATs near roadways, and to determine the portion of a year that people are actually exposed to those concentrations at a specific location. These difficulties are magnified for EPA's standard 70-year cancer assessments, particularly because unsupportable assumptions would have to be made regarding changes in travel patterns and vehicle technology (which affects emissions rates) over a 70-year period. There are also considerable uncertainties associated with the existing estimates of toxicity of the various MSATs, because of factors such as low-dose extrapolation and translation of occupational exposure data to the general population. Because of these shortcomings, any calculated difference in health impacts between alternatives is likely to be much smaller than the uncertainties associated with calculating the impacts. Consequently, the results of such assessments would not be useful to decision makers, who would need to weigh this information against other project impacts that are better suited for quantitative analysis.

## Relevance of Unavailable or Incomplete Information

This section discusses the relevance of unavailable or incomplete information to evaluating reasonably foreseeable significant adverse impacts on the environment, and evaluation of impacts based upon theoretical approaches or research methods generally accepted in the scientific community. Because of the uncertainties described above, FHWA believes a quantitative assessment of the effects of air toxic emissions on human health cannot be made at the transportation project level. While available tools do allow us to reasonably predict relative emissions changes between alternatives for larger projects, the amount of MSAT emissions from each of the project alternatives and MSAT concentrations or exposures created by each of the project alternatives cannot be predicted with enough accuracy to be useful in estimating health impacts. As noted above, the current emissions model is not capable of serving as a meaningful emissions analysis tool for smaller projects. Therefore, the relevance of the unavailable or incomplete information is that it is not possible to make a determination of whether any of the alternatives would have "significant adverse impacts on the human environment."

This air quality analysis provides a qualitative analysis of MSAT emissions relative to the various alternatives, and has acknowledged that all of the project alternatives may result in increased exposure to MSAT emissions in certain locations, although the concentrations and duration of exposures are uncertain. Because of this uncertainty, the health effects from these emissions cannot be estimated.

## Project Level MSAT Discussion

The proposed improvements do not meet the thresholds requiring a quantitative MSAT analysis (FHWA, 2006a), so a qualitative discussion has been prepared. As described previously (**Section 2.6**), FHWA believes the technical shortcomings of emissions and dispersion models and the uncertain science with respect to health effects prevent meaningful or reliable estimates of MSAT emissions and effects from the alternatives. However, even though reliable methods do not exist to accurately estimate the health impacts of MSATs at the project level, it is possible to assess qualitatively the levels of future MSAT emissions under the alternative. Although a qualitative analysis cannot identify and measure health impacts from MSATs, such an analysis can give a basis for identifying and comparing the potential differences among MSAT emissions—if any—between the various alternatives. The qualitative assessment presented below is derived in part from a study conducted by FHWA entitled *A Methodology for Evaluating Mobile Source Air Toxic Emissions Among Transportation Project Alternatives*, found online at: www.fhwa.dot.gov/environment/airtoxic/msatcompare/msatemissions.htm. The following analysis is consistent with the FHWA guidance (FHWA, 2006a).

For each alternative, the amount of MSATs emitted would be proportional to the VMT, assuming that other variables such as fleet mix are the same for each alternative. The project traffic analysis has indicated that traffic volumes in the project area would be the same for the two alternatives, so daily VMT would be the same as well. Because the daily VMT estimated for No Action and the Action Alternative is expected to be the same, there would be no difference between the two alternatives in terms of regional MSATs. Regardless of the alternative chosen, emissions will likely be lower in 2035 than present levels as a result of EPA's national control programs that are projected to reduce MSAT emissions by 57 to 87 percent from 2000 to 2020. Local conditions may differ from these national projections in terms of fleet mix and turnover, VMT growth rates, and local control measures. However, the magnitude of the EPA-projected reductions is so great (even after accounting for VMT growth) that MSAT emissions in the study area are likely to be lower in the future in virtually all locations.

Because of the specific characteristics of each alternative, there may be localized areas where VMT would increase and other areas where VMT would decrease. Therefore, corresponding localized increases and decreases in MSAT emissions may also occur. The localized increases in MSAT emissions would likely be most pronounced along the widened Arapahoe Road where traffic would be closer to adjacent receptors. Localized decreases in MSAT emissions would likely be most pronounced where traffic has moved farther away from receptors.

Approximately 19 developed residential properties are within approximately 100 feet of the affected roads in the study area. These properties are in the Walnut Hills neighborhood. Regardless of the alternative, overall future emissions will be substantially reduced from current levels due to implementation of EPA's vehicle and fuel regulations.

In sum, the proposed improvements in the design year are expected to have reduced MSAT emissions in the immediate area of the project, relative to current conditions, due to EPA's MSAT reduction programs. Overall MSAT emissions are expected to be equivalent between No Action and the Action Alternative. In comparing the project alternatives, MSAT levels could be higher in some locations than others, but current tools and science are not adequate to quantify them. However, on a regional basis, EPA's vehicle and fuel regulations, coupled with fleet turnover, will over time cause substantial reductions that, in almost all cases, will cause region-wide MSAT levels to be significantly lower than today.

## 3.7 Construction Impacts

The overall construction project has the potential to last many months. Construction activities may be sources of temporary air quality impacts from fugitive dust or equipment emissions. Adjoining properties in the study area would be near construction activities when the proposed project is built. Construction emissions differ from regular traffic emissions in several ways:

- construction emissions last only for the duration of the construction period
- construction activities generally are short-term, and depending on the nature of the construction operations, could last from seconds (e.g., a truck passing) to months (e.g., constructing a bridge)
- construction can involve other emission sources, such as fugitive dust from ground disturbance
- construction emissions tend to be intermittent and depend on the type of operation, location, and function of the equipment, and the equipment usage cycle; traffic emissions are present in a more continuous fashion after construction activities are completed
- construction emissions tend to be from mobile sources with diesel engines

Construction emission impacts will be minimized somewhat because most, but not all, of the project improvements do not abut sensitive areas such as residences. Even so, people in neighboring areas could be exposed to construction-related emissions. The Action Alternative would be similar in nature to other highway projects and the construction emissions should be representative of projects of this type and magnitude. These types of projects generally do not cause meaningful air quality impacts.

## 3.8 Mitigation

Given that air pollutants are not predicted to exceed the NAAQS in the future as a result of implementing the build alternative, mitigation measures for air quality are not necessary for the project. Future emissions from on-road mobile sources will be minimized globally through several federal regulations. The Denver area SIPs for CO, $O_3$ and $PM_{10}$ will serve to avoid and minimize pollutant emissions from project roads.

Standard emission minimization measures for construction activities are recommended (**Section 3.7**). Construction emission impacts will be minimized somewhat because much of the alternative alignments are located away from sensitive areas such as residences. Even so, neighboring areas could be exposed to construction-related emissions and particular attention will be given to minimizing total emissions near sensitive areas such as homes. To address the temporary elevated air emissions that may be experienced during construction, standard construction mitigation measures shall be incorporated into construction contracts where feasible. These include following best management practices and relevant CDOT construction specifications. These will include:

- Engines and exhaust systems on equipment in good working order. Equipment maintained on a regular basis, and equipment subject to inspection by the project manager to ensure maintenance.
- Fugitive dust systematically controlled through diligent implementation of CDOT's Standard Specifications for Road and Bridge Construction, particularly Sections 107.24, 209 and 250, and APCD's Air Pollutant Emission Notification requirements.
- No excessive idling of inactive equipment or vehicles.

- Construction equipment and vehicles using low-sulfur fuel to reduce pollutant emissions.

Other emission reduction actions may include:

- Stationary equipment located as far from sensitive receivers as possible (when conditions allow).
- Stricter dust control measures near schools during school hours.
- Retrofit older construction vehicles to reduce emissions.

## 3.9 Summary

Project-related air pollutants were evaluated through air quality analysis. Regional conformity for the proposed improvements has been demonstrated by inclusion in the 2035 RTP. Relevant NAAQS air quality standards were reviewed for the future years. Future emissions from vehicles will be minimized through several federal regulations (such as emission standards) and regional controls (such as street sanding regulations). The Denver area maintenance plans that are already in place for CO and $PM_{10}$ will serve to avoid and minimize pollutant emissions from vehicles. Due to cleaner vehicles, future daily air pollutant levels for most pollutants are predicted to be lower than current levels, even with more vehicles on the roads. Total particulate matter levels may increase in the future because of more vehicles, but the preliminary analysis indicates the concentrations would meet the NAAQS. Standard emission minimization measures for construction activities, as previously described, are recommended.

The proposed improvements were found not to cause violations of health-based air quality standards or other relevant evaluation criteria through the air quality analysis.

# 4.0 CUMULATIVE IMPACTS

A description of the potential effects that could occur as a result of the improvements being considered by the EA is presented in **Section 3.0**. NEPA requires assessment of the proposed action in combination with other actions that could result in cumulative environmental impacts. Cumulative impacts are defined in the Council on Environmental Quality regulations as "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency or person undertakes such other actions." The Council on Environmental Quality notes that "cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time." Cumulative impacts were evaluated by comparing the potential impacts from the three build alternatives and other past, current, or proposed actions in the area to establish whether, in the aggregate, the actions could result in substantive environmental impacts (**Section 3.0**).

## *4.1 NAAQS Pollutants*

The study area is part of the Denver metropolitan area that has been growing and developing steadily for more than 100 years. This historical growth and development has been a major contributor to air quality problems that have been observed in the metropolitan area, culminating in the designation by EPA of local nonattainment areas in the 1970s (**Section 2.2**). However, several air quality improvement actions over the past few decades have resulted in better air quality and the redesignation of the metropolitan area by EPA from nonattainment to maintenance for all NAAQS pollutants by 2002. Denver was subsequently designated nonattainment for the 8-hour $O_3$ NAAQS when that standard was revised.

For much of the past century, the study area was a rural, mostly undeveloped area. Since approximately the 1960s, the study area has seen growing development and is now a highly developed area. Road improvements such as the Action Alternative may be necessary just to accommodate the future local traffic. Such growth would be expected to result in more vehicle traffic in the area and may lead to more vehicle emissions. These changes would be regional in nature and not really specific to a particular location.

There are maintenance plans in place for the Denver metropolitan area. One of the main purposes of these plans is to ensure compliance with the NAAQS for at least 10 years into the future. These plans consider air quality impacts from probable growth in the maintenance areas from both vehicles and other pollutant sources, so by their very nature the plans are cumulative.

DRCOG is responsible for monitoring regional growth and regularly examines regional impacts of this kind through their regional conformity evaluations. These conformity evaluations are regularly updated, particularly for the RTP, to reflect recent changes including expanded roads. These evaluations are cumulative for the jurisdiction and are necessary to demonstrate ongoing conformity to the SIPs. If the evaluation results were ever to indicate that NAAQS violations may occur either from a specific project or from general growth, preventative actions would be then be necessary to ensure that the NAAQS are met. Therefore, there are mechanisms in place to ensure that cumulative changes in air quality in the study area, regardless of pollutant source, do not lead to violations of the NAAQS.

The proposed Action Alternative is intended to benefit regional transportation, as it would enhance the function of surrounding infrastructure features. The potential improvements may help to alleviate some traffic congestion on adjacent roads. Improved traffic flow generally leads to fewer emissions from mobile sources, and this may lead to reduced emissions over the long term even with more vehicles in the area. Construction of the Action Alternative may generate

additional vehicle trips during construction and require some traffic rerouting, but these should be temporary and not create substantial adverse effects.

There are potentially mixed outcomes from the Action Alternative. Whereas more efficient roads may sustain higher intersection LOS and higher average vehicle speeds that should reduce most emissions, the improvements could also attract more traffic that could increase the number of emission sources. Most vehicle emissions per mile are expected to decrease in the future because of cleaner vehicles, regardless of the alternative chosen. On the whole, traffic and emission sources may increase on a local scale; however, traffic and overall emissions should improve on the larger regional scale from the Action Alternative.

The net cumulative effect on regional air quality with a proposed alternative is taken into account in the regional conformity analysis performed by DRCOG for the RTP and TIP (**Section 1.2.1**). As well, many of the project-specific air quality analyses were also cumulative in nature (**Section 3.0**), and no violations of the NAAQS were predicted so the build alternative is not expected to cause cumulative impacts. Finally, there are federal air quality regulations that future cumulative growth within the Denver metropolitan area must continue to meet. Therefore, there are also regulatory controls in place to ensure that there are not cumulative air quality impacts from the combination of air pollutant sources in the Denver metropolitan area.

## *4.2 Global Climate Change Cumulative Effects Discussion*

The issue of global climate change is an important national and global concern that is being addressed in several ways by the Federal government. The transportation sector is the second largest source of total greenhouse gases (GHGs) in the U.S., and the greatest source of carbon dioxide ($CO_2$) emissions – the predominant GHG. In 2004, the transportation sector was responsible for 31 percent of all U.S. $CO_2$ emissions. The principal anthropogenic (human-made) source of carbon emissions is the combustion of fossil fuels, which account for approximately 80 percent of anthropogenic emissions of carbon worldwide. Almost all of the transportation-sector emissions (98 percent) result from the consumption of petroleum products, such as gasoline, diesel fuel, and aviation fuel.

Recognizing this concern, FHWA is working nationally with other modal administrations through the DOT Center for Climate Change and Environmental Forecasting to develop strategies to reduce transportation's contribution to greenhouse gases - particularly $CO_2$ emissions - and to assess the risks to transportation systems and services from climate changes.

At the state level, there are also several programs underway in Colorado to address transportation GHGs. The Governor's Climate Action Plan, adopted in November 2007, includes measures to adopt vehicle $CO_2$ emissions standards and to reduce vehicle travel through transit, flex time, telecommuting, ridesharing, and broadband communications. CDOT issued a policy Directive on Air Quality in May 2009. This Policy Directive was developed with input from a number of agencies, including the State of Colorado's Department of Public Health and Environment, EPA, FHWA, the Federal Transit Administration, the Denver Regional Transportation District and the Denver Regional Air Quality Council. This Policy Directive addresses unregulated MSATs and GHGs produced from Colorado's state highways, interstates, and construction activities.

As a part of CDOT's commitment to addressing MSATs and GHGs, some of CDOT's program-wide activities include:

- Developing truck routes/restrictions with the goal of limiting truck traffic in proximity to facilities, including schools, with sensitive receptor populations.

- Continue researching pavement durability opportunities with the goal of reducing the frequency of resurfacing and/or reconstruction projects.
- Developing air quality educational materials, specific to transportation issues, for citizens, elected officials, and schools.
- Offering outreach to communities to integrate land use and transportation decisions to reduce growth in VMT, such as smart growth techniques, buffer zones, transit-oriented development, walkable communities, access management plans, etc.
- Committing to research additional concrete additives that would reduce the demand for cement.
- Expanding Transportation Demand Management efforts statewide to better utilize the existing transportation mobility network.
- Continuing to diversify the CDOT fleet by retrofitting diesel vehicles, specifying the types of vehicles and equipment contractors may use, purchasing low-emission vehicles, such as hybrids, and purchasing cleaner burning fuels through bidding incentives where feasible. Incentivizing is the likely vehicle for this.
- Exploring congestion and/or right-lane only restrictions for motor carriers.
- Funding truck parking electrification (note: mostly via exploring external grant opportunities)
- Researching additional ways to improve freight movement and efficiency statewide.
- Committing to incorporating ultra-low sulfur diesel for non-road equipment statewide before June 2010 – likely using incentives during bidding.
- Developing a low-VOC emitting tree landscaping specification.

Because climate change is a global issue, and the emissions changes due to project alternatives are very small compared to global totals, the GHG emissions associated with the alternatives were not calculated. Because GHGs are directly related to energy use, the changes in GHG emissions would be similar to the changes in energy consumption presented in the EA. The relationship of current and projected Colorado highway emissions to total global $CO_2$ emissions is presented in **Table 4**. Colorado highway emissions are expected to increase by 4.7% between now and 2035. The benefits of the fuel economy and renewable fuels programs in the 2007 Energy Bill are offset by growth in VMT; the draft 2035 statewide transportation plan predicts that Colorado VMT will double between 2000 and 2035. This table also illustrates the relatively small size of the project corridor relative to total Colorado travel activity.

**Table 4 Carbon Dioxide Emissions Data**

| Global $CO_2$ emissions, 2005, million metric tons (MMT)[1] | Colorado highway $CO_2$ emissions, 2005, MMT[2] | Projected Colorado 2035 highway $CO_2$ emissions, MMT[2] | Colorado highway emissions, % of global total (2005)[2] | Project corridor VMT, % of statewide VMT (2005) |
|---|---|---|---|---|
| 27,700 | 29.9 | 31.3 | 0.108 | <0.01 |

[1] US Department of Energy, 2007
[2] Calculated by FHWA Resource Center

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# APPENDIX A CAL3QHC Model Output Files

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1                        CAL3QHC: LINE SOURCE DISPERSION MODEL - VERSION 2.0, JANUARY 1992                  PAGE  1
                             (Modified by Balloffet & Associates, April, 1994)
                                      POLLUTANT MODELLED: CARBON MONOXIDE
      JOB: I-25 Arapahoe Road                                        RUN: Worst Case Combo 2011/2035
      DATE: 10/06/2011   TIME: 23:46
       SITE & METEOROLOGICAL VARIABLES
       ------------------------------
       VS =    .0 cm/s       VD =    .0 cm/s       Z0 = 175. cm          TMPC = -6.0Deg C     ALT =1768.0 m
        U =  1.0 m/s         CLAS =   4  (D)     ATIM =  60. Minutes     MIXH =  1000. m   AMB =   .0 ppm
       LINK VARIABLES
       --------------
         LINK DESCRIPTION     *         LINK COORDINATES (FT)          *    LENGTH  BRG TYPE   VPH    EF      H   W    V/C QUEUE
                              *   X1        Y1        X2        Y2      *     (FT)  (DEG)             (G/MI)  (FT) (FT)       (VEH)
      ------------------------*----------------------------------------*-----------------------------------------------------------
       1. EB Arap LT1 Que     * 174410.0  642211.0  174334.6  642208.4 *      75.   268. AG    186. 100.0    .0 12.0  .55   3.8
       2. EB Arap LT2 Que     * 174410.0  642200.0  174334.6  642197.9 *      75.   269. AG    186. 100.0    .0 12.0  .55   3.8
       3. EB ARAP THRU 3 Que  * 174432.0  642166.0  174139.3  642153.2 *     293.   268. AG    112. 100.0    .0 12.0  .92  14.9
       4. EB ARAP THRU1 Que   * 174421.0  642189.0  174128.3  642176.4 *     293.   268. AG    112. 100.0    .0 12.0  .92  14.9
       5. EB ARAP THRU2 Que   * 174426.0  642177.0  174133.3  642164.5 *     293.   268. AG    112. 100.0    .0 12.0  .92  14.9
       6. NB CLINTON LT1 Que  * 174468.0  642132.0  174468.7  642005.1 *     127.   180. AG    160. 100.0    .0 12.0  .60   6.5
       7. NB CLINTON LT2 Que  * 174480.0  642132.0  174480.7  642005.1 *     127.   180. AG    160. 100.0    .0 12.0  .60   6.5
       8. NB CLINTON THRU1 Que* 174495.0  642134.0  174496.5  642061.1 *      73.   179. AG    160. 100.0    .0 12.0  .35   3.7
       9. NB CLINTON THRU2 Que* 174507.0  642133.0  174508.5  642060.1 *      73.   179. AG    160. 100.0    .0 12.0  .35   3.7
      10. SB CLINTON LT1 Que  * 174478.0  642285.0  174477.1  642334.3 *      49.   359. AG    180. 100.0    .0 12.0  .32   2.5
      11. SB CLINTON LT2 Que  * 174466.0  642284.0  174465.1  642333.3 *      49.   359. AG    180. 100.0    .0 12.0  .32   2.5
      12. SB CLINTON THRU1 Que* 174456.0  642283.0  174455.1  642321.7 *      39.   359. AG    180. 100.0    .0 12.0  .25   2.0
      13. SB CLINTON THRU2 Que* 174444.0  642282.0  174443.1  642320.7 *      39.   359. AG    180. 100.0    .0 12.0  .25   2.0
      14. WB ARAP LT1 Que     * 174523.0  642206.0  174532.3  642206.4 *       9.    87. AG    113. 100.0    .0 12.0  .03    .5
      15. WB ARAP LT2 Que     * 174523.0  642218.0  174538.4  642218.7 *      15.    87. AG    188. 100.0    .0 12.0  .12    .8
      16. WB ARAP RT1 Que     * 174527.0  642278.0  174548.7  642279.0 *      22.    87. AG    113. 100.0    .0 12.0  .08   1.1
      17. WB ARAP THRU1 Que   * 174510.0  642229.0  174726.2  642238.5 *     216.    87. AG    113. 100.0    .0 12.0  .81  11.0
      18. WB ARAP THRU2 Que   * 174509.0  642241.0  174725.2  642250.5 *     216.    87. AG    113. 100.0    .0 12.0  .81  11.0
      19. WB ARAP THRU3 Que   * 174509.0  642253.0  174725.2  642262.5 *     216.    87. AG    113. 100.0    .0 12.0  .81  11.0
      20. WB ARAP THRU4 Que   * 174508.0  642265.0  174724.2  642274.5 *     216.    87. AG    113. 100.0    .0 12.0  .81  11.0
      21. EB ARAP THRU 3 Apr  * 174483.0  642168.0  173816.0  642139.0 *     668.   268. AG    980.  16.1    .0 32.0
      22. EB ARAP THRU1 Apr   * 174475.0  642191.0  173815.0  642163.0 *     661.   268. AG    980.  16.1    .0 32.0
      23. EB ARAP THRU2 Apr   * 174480.0  642180.0  173816.0  642151.0 *     665.   267. AG    980.  16.1    .0 32.0
      24. NB CLINTON THRU1 Apr* 174493.0  642207.0  174502.0  641798.0 *     409.   179. AG    453.  16.1    .0 32.0
      25. NB CLINTON THRU2 Apr* 174505.0  642210.0  174514.0  641799.0 *     411.   179. AG    452.  16.1    .0 32.0
      26. SB CLINTON THRU1 Apr* 174457.0  642208.0  174444.0  642786.0 *     578.   359. AG    323.  16.1    .0 32.0
      27. SB CLINTON THRU2 Apr* 174445.0  642207.0  174432.0  642786.0 *     579.   359. AG    323.  16.1    .0 32.0
      28. WB ARAP THRU1 Apr   * 174465.0  642227.0  175125.0  642256.0 *     661.    87. AG    675.  16.1    .0 32.0
      29. WB ARAP THRU2 Apr   * 174465.0  642239.0  175124.0  642268.0 *     660.    87. AG    675.  16.1    .0 32.0
      30. WB ARAP THRU3 Apr   * 174464.0  642251.0  175124.0  642280.0 *     661.    87. AG    675.  16.1    .0 32.0
      31. WB ARAP THRU4 Apr   * 174464.0  642263.0  175123.0  642292.0 *     660.    87. AG    675.  16.1    .0 32.0
      32. EB ARAP THRU 3 Dprt * 175127.0  642196.0  174483.0  642168.0 *     645.   268. AG    829.  16.1    .0 32.0
      33. EB ARAP THRU1 Dprt  * 175126.0  642220.0  174475.0  642191.0 *     652.   267. AG    828.  16.1    .0 32.0
      34. EB ARAP THRU2 Dprt  * 175127.0  642208.0  174480.0  642180.0 *     648.   268. AG    828.  16.1    .0 32.0
      35. NB CLINTON THRU Dprt* 174480.0  642787.0  174493.0  642207.0 *     580.   179. AG    325.  16.1    .0 32.0
      36. NB CLINTON THRU Dprt* 174492.0  642788.0  174505.0  642210.0 *     578.   179. AG    325.  16.1    .0 32.0
      37. SB CLINTON THRU Dprt* 174454.0  641797.0  174445.0  642207.0 *     410.   359. AG    310.  16.1    .0 32.0
      38. SB CLINTON THRU Dprt* 174466.0  641798.0  174457.0  642208.0 *     410.   359. AG    310.  16.1    .0 32.0
      39. WB ARAP THRU1 Dprt  * 173814.0  642199.0  174465.0  642227.0 *     652.    88. AG    780.  16.1    .0 32.0
```

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 40. WB ARAP THRU2 Dprt | * 173813.0 | 642211.0 | 174465.0 | 642239.0 * | 653. | 88. AG | 780. | 16.1 | .0 | 32.0 | | |
| 41. WB ARAP THRU3 Dprt | * 173813.0 | 642223.0 | 174464.0 | 642251.0 * | 652. | 88. AG | 780. | 16.1 | .0 | 32.0 | | |
| 42. WB ARAP THRU4 Dprt | * 173812.0 | 642234.0 | 174464.0 | 642263.0 * | 653. | 87. AG | 780. | 16.1 | .0 | 32.0 | | |
| 43. EB ARAP RT1 | * 174429.0 | 642153.0 | 173817.0 | 642127.0 * | 613. | 268. AG | 420. | 16.1 | .0 | 32.0 | | |
| 44. NB I25 | * 172794.0 | 643429.0 | 173857.0 | 641085.0 * | 2574. | 156. FL | 9000. | 15.6 | 25.0 | 80.0 | | |

1



JOB: I-25 Arapahe Road RUN: Worst Case Combo 2011/2035
DATE: 10/06/2011 TIME: 23:46

LINK VARIABLES

| LINK DESCRIPTION | * LINK COORDINATES (FT) X1 | Y1 | X2 | Y2 * | LENGTH (FT) | BRG (DEG) | TYPE | VPH | EF (G/MI) | H (FT) | W (FT) | V/C QUEUE (VEH) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 45. SB Clinton RT1 | * 173811.0 | 642246.0 | 174414.0 | 642273.0 * | 604. | 87. | AG | 315. | 16.1 | .0 | 32.0 | |
| 46. SB I25 | * 173776.0 | 641070.0 | 172707.0 | 643434.0 * | 2594. | 336. | FL | 9000. | 14.3 | 25.0 | 80.0 | |

1



JOB: I-25 Arapahe Road RUN: Worst Case Combo 2011/2035
DATE: 10/06/2011 TIME: 23:46

ADDITIONAL QUEUE LINK PARAMETERS

| LINK DESCRIPTION | * CYCLE LENGTH (SEC) | RED TIME (SEC) | CLEARANCE LOST TIME (SEC) | APPROACH VOL (VPH) | SATURATION FLOW RATE (VPH) | IDLE EM FAC (gm/hr) | SIGNAL TYPE | ARRIVAL RATE |
|---|---|---|---|---|---|---|---|---|
| 1. EB Arap LT1 Que | * 120 | 100 | .4 | 138 | 1700 | 83.20 | 1 | 3 |
| 2. EB Arap LT2 Que | * 120 | 100 | .4 | 138 | 1700 | 83.20 | 1 | 3 |
| 3. EB ARAP THRU 3 Que | * 120 | 60 | .4 | 748 | 1700 | 83.20 | 1 | 3 |
| 4. EB ARAP THRU1 Que | * 120 | 60 | .4 | 748 | 1700 | 83.20 | 1 | 3 |
| 5. EB ARAP THRU2 Que | * 120 | 60 | .4 | 748 | 1700 | 83.20 | 1 | 3 |
| 6. NB CLINTON LT1 Que | * 120 | 86 | .4 | 270 | 1700 | 83.20 | 1 | 3 |
| 7. NB CLINTON LT2 Que | * 120 | 86 | .4 | 270 | 1700 | 83.20 | 1 | 3 |
| 8. NB CLINTON THRU1 Que | * 120 | 86 | .4 | 155 | 1700 | 83.20 | 1 | 3 |
| 9. NB CLINTON THRU2 Que | * 120 | 86 | .4 | 155 | 1700 | 83.20 | 1 | 3 |
| 10. SB CLINTON LT1 Que | * 120 | 97 | .4 | 93 | 1700 | 83.20 | 1 | 3 |
| 11. SB CLINTON LT2 Que | * 120 | 97 | .4 | 93 | 1700 | 83.20 | 1 | 3 |
| 12. SB CLINTON THRU1 Que | * 120 | 97 | .4 | 73 | 1700 | 83.20 | 1 | 3 |
| 13. SB CLINTON THRU2 Que | * 120 | 97 | .4 | 73 | 1700 | 83.20 | 1 | 3 |
| 14. WB ARAP LT1 Que | * 120 | 61 | .4 | 28 | 1700 | 83.20 | 1 | 3 |
| 15. WB ARAP LT2 Que | * 120 | 101 | .4 | 28 | 1700 | 83.20 | 1 | 3 |
| 16. WB ARAP RT1 Que | * 120 | 61 | .4 | 65 | 1700 | 83.20 | 1 | 3 |
| 17. WB ARAP THRU1 Que | * 120 | 61 | .4 | 645 | 1700 | 83.20 | 1 | 3 |
| 18. WB ARAP THRU2 Que | * 120 | 61 | .4 | 645 | 1700 | 83.20 | 1 | 3 |
| 19. WB ARAP THRU3 Que | * 120 | 61 | .4 | 645 | 1700 | 83.20 | 1 | 3 |
| 20. WB ARAP THRU4 Que | * 120 | 61 | .4 | 645 | 1700 | 83.20 | 1 | 3 |

RECEPTOR LOCATIONS

| RECEPTOR | * COORDINATES (FT) X | Y | Z * |
|---|---|---|---|
| 1. R-01 | * 174533.0 | 642294.0 | 6.0 * |
| 2. R-02 | * 174574.0 | 642296.0 | 6.0 * |

| | | | | | |
|---|---|---|---|---|---|
| 3. | R-03 | * | 174624.0 | 642299.0 | 6.0 * |
| 4. | R-04 | * | 174518.0 | 642344.0 | 6.0 * |
| 5. | R-05 | * | 174517.0 | 642393.0 | 6.0 * |
| 6. | R-06 | * | 174523.0 | 642124.0 | 6.0 * |
| 7. | R-07 | * | 174525.0 | 642035.0 | 6.0 * |
| 8. | R-08 | * | 174524.0 | 642085.0 | 6.0 * |
| 9. | R-09 | * | 174622.0 | 642157.0 | 6.0 * |
| 10. | R-10 | * | 174570.0 | 642155.0 | 6.0 * |
| 11. | R-11 | * | 174417.0 | 642137.0 | 6.0 * |
| 12. | R-12 | * | 174326.0 | 642132.0 | 6.0 * |
| 13. | R-13 | * | 174380.0 | 642135.0 | 6.0 * |
| 14. | R-14 | * | 174430.0 | 642090.0 | 6.0 * |
| 15. | R-15 | * | 174432.0 | 642036.0 | 6.0 * |
| 16. | R-16 | * | 174425.0 | 642384.0 | 6.0 * |
| 17. | R-17 | * | 174427.0 | 642336.0 | 6.0 * |
| 18. | R-18 | * | 174427.0 | 642296.0 | 6.0 * |
| 19. | R-19 | * | 174375.0 | 642287.0 | 6.0 * |
| 20. | R-20 | * | 174325.0 | 642285.0 | 6.0 * |

1



JOB: I-25 Arapahoe Road RUN: Worst Case Combo 2011/2035

MODEL RESULTS

REMARKS : In search of the angle corresponding to the maximum concentration, only the first angle, of the angles with same maximum concentrations, is indicated as maximum.

WIND ANGLE RANGE: 0.-355.

| WIND ANGLE (DEGR) | * CONCENTRATION (PPM) * REC1 | REC2 | REC3 | REC4 | REC5 | REC6 | REC7 | REC8 | REC9 | REC10 | REC11 | REC12 | REC13 | REC14 | REC15 | REC16 | REC17 | REC18 | REC19 | REC20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0. | * .2 | .0 | .0 | .4 | .4 | 2.2 | 1.7 | 2.2 | 2.3 | 2.4 | 3.2 | 3.2 | 3.5 | 2.1 | 1.6 | .4 | .6 | .6 | .1 | .0 |
| 5. | * .2 | .0 | .0 | .3 | .3 | 2.0 | 1.9 | 2.0 | 2.3 | 2.3 | 3.2 | 3.2 | 3.5 | 1.9 | 1.7 | .7 | .8 | .8 | .2 | .0 |
| 10. | * .1 | .0 | .0 | .3 | .3 | 1.9 | 1.4 | 1.7 | 2.3 | 2.3 | 3.2 | 3.1 | 3.4 | 1.8 | 1.8 | .8 | .8 | .9 | .2 | .0 |
| 15. | * .0 | .0 | .0 | .1 | .1 | 1.7 | 1.4 | 1.5 | 2.2 | 2.2 | 2.9 | 3.4 | 3.4 | 2.2 | 2.3 | .7 | .8 | .9 | .4 | .1 |
| 20. | * .0 | .0 | .0 | .1 | .1 | 1.8 | 1.3 | 1.5 | 2.3 | 2.3 | 3.3 | 3.5 | 3.2 | 2.2 | 2.3 | .7 | .7 | .9 | .4 | .2 |
| 25. | * .0 | .0 | .0 | .0 | .0 | 1.8 | 1.3 | 1.5 | 2.3 | 2.3 | 3.0 | 3.7 | 3.3 | 2.1 | 2.0 | .7 | .7 | .9 | .4 | .3 |
| 30. | * .0 | .0 | .0 | .0 | .0 | 1.7 | 1.3 | 1.4 | 2.3 | 2.4 | 2.8 | 3.6 | 3.2 | 2.3 | 2.6 | .7 | .7 | 1.2 | .4 | .4 |
| 35. | * .0 | .0 | .0 | .0 | .0 | 1.8 | 1.2 | 1.4 | 2.6 | 2.6 | 2.8 | 3.6 | 3.3 | 2.2 | 2.4 | .7 | .7 | 1.2 | .4 | .4 |
| 40. | * .0 | .0 | .0 | .0 | .0 | 1.9 | 1.1 | 1.4 | 2.7 | 2.7 | 3.0 | 3.7 | 3.1 | 2.4 | 2.8 | .7 | .7 | 1.4 | .4 | .4 |
| 45. | * .0 | .0 | .0 | .0 | .0 | 2.0 | 1.0 | 1.3 | 2.6 | 2.7 | 3.2 | 3.9 | 3.3 | 2.5 | 2.9 | .6 | .6 | 1.5 | .4 | .4 |
| 50. | * .0 | .0 | .0 | .0 | .0 | 2.0 | 1.0 | 1.2 | 2.6 | 2.8 | 3.2 | 3.3 | 3.2 | 2.4 | 2.8 | .6 | .6 | 1.6 | .4 | .4 |
| 55. | * .0 | .0 | .0 | .0 | .0 | 2.1 | 1.0 | 1.1 | 2.5 | 2.8 | 3.2 | 3.4 | 3.5 | 2.6 | 2.6 | .6 | .6 | 1.8 | .6 | .4 |
| 60. | * .0 | .0 | .0 | .0 | .0 | 1.9 | 1.0 | 1.1 | 2.6 | 2.9 | 3.3 | 3.5 | 3.5 | 2.7 | 2.4 | .6 | .6 | 1.9 | .8 | .4 |
| 65. | * .0 | .0 | .0 | .0 | .0 | 1.7 | .9 | 1.1 | 2.6 | 2.8 | 3.3 | 3.7 | 3.6 | 2.7 | 2.4 | .6 | .6 | 1.9 | .8 | .4 |
| 70. | * .1 | .1 | .1 | .0 | .0 | 1.5 | .6 | 1.0 | 2.6 | 2.8 | 3.2 | 3.6 | 3.4 | 2.4 | 2.2 | .6 | .6 | 2.0 | .9 | .8 |
| 75. | * .2 | .2 | .2 | .0 | .0 | 1.4 | .3 | 1.0 | 2.4 | 2.5 | 2.7 | 3.5 | 3.2 | 2.5 | 1.8 | .6 | .6 | 2.2 | 1.2 | 1.1 |
| 80. | * .6 | .5 | .4 | .0 | .0 | 1.2 | .3 | .5 | 2.2 | 2.3 | 2.3 | 2.6 | 2.4 | 2.3 | 1.6 | .6 | .8 | 2.6 | 1.7 | 1.4 |
| 85. | * 1.0 | .8 | .7 | .2 | .0 | .9 | .0 | .3 | 1.8 | 1.9 | 2.4 | 2.3 | 2.4 | 1.8 | 1.3 | .6 | 1.1 | 2.9 | 2.1 | 2.1 |
| 90. | * 1.6 | 1.4 | 1.1 | .4 | .0 | .4 | .0 | .2 | 1.3 | 1.4 | 1.9 | 2.1 | 2.0 | 1.7 | 1.1 | .7 | 1.2 | 3.4 | 2.6 | 2.7 |
| 95. | * 1.8 | 1.8 | 1.5 | .7 | .3 | .3 | .0 | .0 | .8 | .8 | 1.3 | 1.4 | 1.4 | 1.5 | 1.1 | 1.0 | 1.9 | 3.7 | 3.0 | 2.6 |
| 100. | * 2.5 | 2.1 | 1.9 | .9 | .5 | .1 | .0 | .0 | .6 | .6 | 1.1 | 1.3 | 1.2 | 1.3 | 1.1 | 1.3 | 2.4 | 4.1 | 3.4 | 3.0 |

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 105. | * | 2.8 | 2.7 | 2.3 | 1.2 | .7 | .0 | .0 | .0 | .3 | .3 | 1.1 | .9 | 1.0 | 1.2 | 1.1 | 1.3 | 2.6 | 4.1 | 3.1 | 3.2 |
| 110. | * | 3.0 | 2.8 | 2.5 | 1.4 | .7 | .0 | .0 | .0 | .1 | .2 | 1.1 | .9 | .9 | 1.2 | 1.1 | 1.6 | 2.9 | 3.6 | 3.1 | 2.8 |
| 115. | * | 3.0 | 2.9 | 2.6 | 1.6 | .8 | .0 | .0 | .0 | .1 | .1 | 1.2 | .6 | 1.0 | 1.3 | 1.0 | 1.8 | 3.1 | 3.6 | 2.9 | 2.7 |
| 120. | * | 2.8 | 2.6 | 2.5 | 1.7 | .9 | .0 | .0 | .0 | .1 | .1 | 1.2 | .6 | 1.0 | 1.3 | .9 | 1.9 | 3.2 | 3.4 | 2.5 | 2.6 |
| 125. | * | 2.8 | 2.7 | 2.5 | 1.7 | 1.1 | .0 | .0 | .0 | .1 | .1 | 1.1 | .6 | 1.0 | 1.2 | .9 | 2.0 | 3.4 | 3.1 | 2.7 | 2.7 |
| 130. | * | 2.9 | 2.7 | 2.6 | 1.7 | 1.1 | .0 | .0 | .0 | .0 | .0 | 1.2 | .6 | .7 | 1.1 | .9 | 2.0 | 3.4 | 2.9 | 2.5 | 2.8 |
| 135. | * | 2.9 | 2.7 | 2.6 | 1.6 | 1.1 | .0 | .0 | .0 | .0 | .0 | 1.2 | .5 | .7 | 1.2 | .9 | 1.9 | 3.3 | 2.8 | 2.4 | 3.1 |
| 140. | * | 2.8 | 2.6 | 2.5 | 1.5 | 1.1 | .0 | .0 | .0 | .0 | .0 | 1.1 | .4 | .6 | 1.2 | .8 | 2.1 | 2.7 | 2.6 | 2.7 | 3.2 |
| 145. | * | 2.9 | 2.6 | 2.4 | 1.4 | 1.1 | .0 | .0 | .0 | .0 | .0 | .9 | .4 | .6 | 1.3 | .9 | 2.3 | 2.6 | 2.4 | 2.9 | 3.3 |
| 150. | * | 2.8 | 2.5 | 2.3 | 1.4 | 1.1 | .1 | .1 | .1 | .0 | .0 | 1.0 | .3 | .6 | 1.1 | .7 | 2.0 | 2.8 | 2.5 | 2.9 | 3.4 |
| 155. | * | 2.7 | 2.4 | 2.4 | 1.6 | 1.2 | .1 | .1 | .1 | .0 | .0 | .9 | .1 | .5 | 1.0 | .7 | 2.1 | 2.9 | 3.0 | 3.1 | 3.4 |
| 160. | * | 2.7 | 2.3 | 2.3 | 1.5 | 1.2 | .1 | .1 | .1 | .0 | .0 | .9 | .0 | .4 | 1.0 | .7 | 2.2 | 3.2 | 2.9 | 3.1 | 3.0 |
| 165. | * | 2.6 | 2.3 | 2.3 | 1.6 | 1.2 | .3 | .2 | .2 | .0 | .0 | .7 | .0 | .2 | .8 | .7 | 2.9 | 2.7 | 2.6 | 3.3 | 2.6 |
| 170. | * | 2.9 | 2.3 | 2.3 | 1.8 | 1.5 | .5 | .3 | .3 | .0 | .0 | .6 | .0 | .1 | .8 | .6 | 2.0 | 2.3 | 2.5 | 3.2 | 2.6 |
| 175. | * | 2.9 | 2.4 | 2.3 | 1.9 | 1.6 | .5 | .4 | .4 | .0 | .0 | .2 | .0 | .0 | .5 | .4 | 2.0 | 2.2 | 2.5 | 2.9 | 2.6 |
| 180. | * | 3.2 | 2.5 | 2.3 | 2.1 | 1.6 | .8 | .6 | .6 | .0 | .1 | .2 | .0 | .0 | .3 | .3 | 1.5 | 2.2 | 2.4 | 2.8 | 2.6 |
| 185. | * | 3.6 | 2.5 | 2.3 | 2.2 | 1.9 | 1.3 | .6 | .7 | .0 | .2 | .1 | .0 | .0 | .3 | .3 | 1.4 | 2.3 | 2.5 | 2.8 | 2.4 |
| 190. | * | 3.4 | 2.7 | 2.4 | 2.3 | 2.3 | 1.6 | .9 | 1.0 | .0 | .2 | .0 | .1 | .0 | .1 | .1 | 1.3 | 2.1 | 2.5 | 2.9 | 2.5 |
| 195. | * | 3.6 | 3.0 | 2.5 | 2.2 | 2.3 | 1.8 | 1.0 | 1.2 | .1 | .2 | .1 | .2 | .1 | .1 | .1 | 1.5 | 2.3 | 2.6 | 3.0 | 2.7 |
| 200. | * | 3.3 | 3.1 | 2.6 | 2.6 | 2.3 | 2.0 | .9 | 1.2 | .2 | .5 | .2 | .3 | .3 | .3 | .2 | 1.9 | 2.5 | 2.9 | 3.0 | 2.9 |
| 205. | * | 3.3 | 3.3 | 3.0 | 2.4 | 2.2 | 2.3 | 1.0 | 1.5 | .3 | 1.0 | .3 | .5 | .5 | .3 | .3 | 2.0 | 2.6 | 3.1 | 3.1 | 3.1 |

1

PAGE 5

JOB: I-25 Arapahe Road RUN: Worst Case Combo 2011/2035

| WIND ANGLE (DEGR) | * | CONCENTRATION (PPM) REC1 | REC2 | REC3 | REC4 | REC5 | REC6 | REC7 | REC8 | REC9 | REC10 | REC11 | REC12 | REC13 | REC14 | REC15 | REC16 | REC17 | REC18 | REC19 | REC20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 210. | * | 3.4 | 3.6 | 3.4 | 2.7 | 2.7 | 2.5 | 1.2 | 1.9 | .4 | 1.2 | .5 | .7 | .7 | .5 | .5 | 2.2 | 2.8 | 3.4 | 3.3 | 3.2 |
| 215. | * | 3.5 | 3.6 | 3.6 | 3.6 | 3.0 | 2.7 | 1.4 | 2.1 | .6 | 1.4 | .7 | .9 | .7 | .7 | .7 | 2.3 | 2.8 | 3.3 | 3.6 | 3.4 |
| 220. | * | 3.6 | 3.7 | 3.8 | 3.8 | 3.3 | 2.8 | 1.5 | 2.4 | .9 | 1.7 | .9 | .9 | .9 | .9 | .7 | 2.6 | 3.0 | 3.4 | 3.5 | 3.5 |
| 225. | * | 3.8 | 3.8 | 3.7 | 4.1 | 3.4 | 3.0 | 1.6 | 2.6 | 1.4 | 1.8 | .9 | 1.1 | .9 | .9 | .9 | 2.6 | 2.8 | 3.5 | 3.7 | 3.8 |
| 230. | * | 4.0 | 4.0 | 3.5 | 4.2 | 3.6 | 3.0 | 1.8 | 2.7 | 1.7 | 2.0 | .9 | 1.1 | 1.0 | .9 | .9 | 2.5 | 2.9 | 3.6 | 3.8 | 3.9 |
| 235. | * | 4.2 | 4.0 | 3.8 | 4.3 | 3.2 | 3.0 | 1.8 | 2.8 | 1.6 | 2.1 | .9 | 1.1 | 1.0 | .9 | 1.0 | 2.2 | 2.9 | 3.7 | 3.8 | 3.9 |
| 240. | * | 4.2 | 4.2 | 4.2 | 4.2 | 2.9 | 3.0 | 1.9 | 2.9 | 1.7 | 2.1 | 1.0 | 1.2 | 1.1 | 1.0 | 1.0 | 2.1 | 2.8 | 3.7 | 3.8 | 3.8 |
| 245. | * | 4.3 | 4.4 | 4.0 | 4.0 | 2.5 | 2.9 | 1.9 | 2.9 | 1.7 | 1.9 | 1.0 | 1.2 | 1.1 | 1.0 | 1.0 | 1.9 | 2.6 | 3.6 | 3.8 | 3.8 |
| 250. | * | 4.5 | 4.4 | 4.1 | 3.7 | 2.4 | 2.9 | 2.0 | 2.9 | 1.9 | 2.1 | 1.2 | 1.3 | 1.2 | 1.0 | 1.0 | 1.8 | 2.3 | 3.6 | 3.6 | 3.6 |
| 255. | * | 4.6 | 4.4 | 3.9 | 3.2 | 2.3 | 3.1 | 2.0 | 2.9 | 2.2 | 2.5 | 1.6 | 1.5 | 1.6 | 1.0 | 1.0 | 1.7 | 2.0 | 3.2 | 3.5 | 3.4 |
| 260. | * | 3.8 | 4.0 | 3.3 | 2.9 | 1.8 | 3.3 | 2.0 | 3.0 | 3.0 | 3.2 | 1.9 | 2.1 | 2.0 | 1.1 | 1.0 | 1.3 | 1.9 | 2.6 | 3.1 | 3.1 |
| 265. | * | 3.4 | 3.2 | 3.0 | 2.2 | 1.6 | 3.7 | 2.1 | 3.3 | 3.3 | 3.6 | 2.6 | 2.6 | 2.6 | 1.3 | .9 | 1.0 | 1.4 | 2.4 | 2.6 | 2.6 |
| 270. | * | 3.2 | 2.9 | 2.6 | 2.0 | 1.5 | 4.4 | 2.3 | 3.4 | 3.7 | 4.1 | 3.5 | 3.0 | 3.4 | 1.5 | 1.2 | .9 | 1.2 | 1.9 | 2.0 | 2.0 |
| 275. | * | 2.6 | 2.4 | 1.9 | 1.5 | 1.5 | 4.5 | 2.5 | 4.1 | 4.3 | 4.6 | 4.0 | 3.7 | 3.7 | 2.1 | 1.4 | .9 | .9 | 1.5 | 1.6 | 1.7 |
| 280. | * | 2.4 | 2.0 | 1.6 | 1.5 | 1.5 | 4.7 | 2.9 | 4.4 | 4.8 | 4.9 | 4.4 | 4.2 | 4.3 | 2.5 | 1.5 | .9 | .9 | 1.2 | 1.4 | 1.4 |
| 285. | * | 2.1 | 1.7 | 1.3 | 1.5 | 1.5 | 5.2 | 3.4 | 4.6 | 4.6 | 4.7 | 4.7 | 4.5 | 4.7 | 2.7 | 2.1 | .9 | .9 | .9 | 1.2 | 1.2 |
| 290. | * | 2.0 | 1.4 | 1.2 | 1.4 | 1.4 | 5.1 | 3.6 | 4.7 | 4.0 | 4.5 | 4.6 | 4.7 | 4.7 | 3.0 | 2.3 | .9 | .9 | .9 | 1.0 | 1.2 |
| 295. | * | 1.7 | 1.3 | 1.1 | 1.3 | 1.3 | 4.7 | 3.6 | 5.0 | 3.4 | 4.2 | 4.7 | 4.7 | 4.7 | 3.1 | 2.5 | .8 | .8 | .9 | .9 | .9 |
| 300. | * | 1.5 | 1.1 | .9 | 1.2 | 1.1 | 4.5 | 3.6 | 5.0 | 3.3 | 3.6 | 4.6 | 4.6 | 4.4 | 3.1 | 2.3 | .6 | .7 | .7 | .8 | .9 |
| 305. | * | 1.1 | .8 | .7 | 1.0 | .9 | 4.0 | 3.5 | 4.7 | 3.3 | 3.1 | 4.3 | 4.3 | 4.1 | 2.9 | 2.3 | .4 | .5 | .5 | .6 | .7 |
| 310. | * | .9 | .6 | .6 | .8 | .8 | 3.7 | 3.6 | 4.2 | 3.3 | 3.1 | 4.2 | 4.1 | 3.9 | 2.7 | 2.0 | .2 | .3 | .3 | .4 | .4 |
| 315. | * | .7 | .4 | .4 | .6 | .6 | 2.8 | 3.6 | 3.6 | 3.1 | 3.2 | 4.0 | 3.6 | 3.7 | 2.4 | 1.8 | .1 | .1 | .2 | .2 | .2 |
| 320. | * | .7 | .4 | .4 | .7 | .7 | 2.3 | 3.4 | 3.2 | 2.9 | 2.7 | 3.7 | 3.4 | 3.6 | 2.2 | 1.6 | .0 | .0 | .0 | .0 | .1 |
| 325. | * | .6 | .4 | .4 | .7 | .7 | 2.2 | 3.1 | 3.0 | 2.7 | 2.7 | 3.6 | 3.0 | 3.3 | 1.9 | 1.5 | .0 | .0 | .0 | .0 | .0 |
| 330. | * | .6 | .4 | .3 | .7 | .7 | 2.5 | 2.6 | 2.9 | 2.7 | 2.9 | 3.4 | 3.0 | 3.3 | 1.7 | 1.6 | .0 | .0 | .0 | .0 | .0 |

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 335. | * | .6 | .4 | .2 | .7 | .7 | 2.8 | 2.6 | 2.7 | 2.7 | 2.8 | 3.4 | 2.9 | 3.3 | 1.7 | 1.6 | .1 | .1 | .1 | .0 | .0 |
| 340. | * | .6 | .4 | .2 | .7 | .7 | 2.5 | 2.9 | 2.8 | 2.4 | 2.7 | 3.3 | 2.8 | 3.2 | 1.7 | 1.7 | .1 | .1 | .1 | .0 | .0 |
| 345. | * | .6 | .2 | .0 | .8 | .8 | 2.4 | 2.8 | 2.5 | 2.5 | 2.7 | 3.2 | 2.8 | 3.3 | 1.8 | 1.7 | .1 | .2 | .1 | .0 | .0 |
| 350. | * | .5 | .2 | .0 | .8 | .8 | 2.1 | 2.5 | 2.3 | 2.3 | 2.5 | 3.1 | 3.0 | 3.4 | 2.0 | 1.8 | .3 | .3 | .3 | .0 | .0 |
| 355. | * | .3 | .1 | .0 | .6 | .6 | 2.3 | 2.1 | 2.0 | 2.3 | 2.5 | 3.1 | 3.2 | 3.4 | 2.0 | 2.0 | .4 | .4 | .4 | .0 | .0 |
| MAX | * | 4.6 | 4.4 | 4.2 | 4.3 | 3.6 | 5.2 | 3.6 | 5.0 | 4.8 | 4.9 | 4.7 | 4.7 | 4.7 | 3.1 | 2.9 | 2.9 | 3.4 | 4.1 | 3.8 | 3.9 |
| DEGR. | * | 255 | 245 | 240 | 235 | 230 | 285 | 295 | 295 | 280 | 280 | 285 | 290 | 290 | 295 | 45 | 165 | 125 | 100 | 230 | 230 |

THE HIGHEST CONCENTRATION IS 5.20 AT 285 DEGREES FROM REC6 .

1



JOB: I-25 Arapahoe Road RUN: Worst Case Combo 2011/2035
DATE: 10/06/2011 TIME: 23:46
RECEPTOR - LINK MATRIX FOR THE ANGLE PRODUCING
THE MAXIMUM CONCENTRATION FOR EACH RECEPTOR
* CO/LINK (PPM)
* ANGLE (DEGREES)

| LINK # | * | REC1 255 | REC2 245 | REC3 240 | REC4 235 | REC5 230 | REC6 285 | REC7 295 | REC8 295 | REC9 280 | REC10 280 | REC11 285 | REC12 290 | REC13 290 | REC14 295 | REC15 45 | REC16 165 | REC17 125 | REC18 100 | REC19 230 | REC20 230 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | * | .1 | .1 | .0 | .1 | .0 | .1 | .0 | .0 | .1 | .1 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 2 | * | .0 | .1 | .0 | .1 | .0 | .1 | .0 | .1 | .1 | .1 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 3 | * | .1 | .1 | .1 | .1 | .1 | .2 | .1 | .1 | .1 | .1 | .3 | .3 | .3 | .1 | .0 | .0 | .0 | .0 | .1 | .1 |
| 4 | * | .1 | .1 | .1 | .1 | .1 | .1 | .1 | .1 | .1 | .1 | .2 | .2 | .2 | .1 | .0 | .0 | .0 | .0 | .1 | .1 |
| 5 | * | .1 | .1 | .1 | .1 | .1 | .1 | .1 | .1 | .1 | .1 | .2 | .2 | .2 | .1 | .0 | .0 | .0 | .0 | .1 | .1 |
| 6 | * | .0 | .0 | .0 | .0 | .0 | .1 | .2 | .2 | .0 | .0 | .0 | .0 | .0 | .0 | .3 | .1 | .0 | .0 | .0 | .0 |
| 7 | * | .0 | .0 | .0 | .0 | .0 | .1 | .3 | .3 | .0 | .0 | .0 | .0 | .0 | .0 | .3 | .1 | .0 | .0 | .0 | .0 |
| 8 | * | .0 | .0 | .0 | .0 | .0 | .2 | .1 | .3 | .0 | .0 | .0 | .0 | .0 | .0 | .2 | .0 | .0 | .0 | .0 | .0 |
| 9 | * | .0 | .0 | .0 | .0 | .0 | .4 | .0 | .5 | .0 | .0 | .0 | .0 | .0 | .0 | .1 | .0 | .0 | .0 | .0 | .0 |
| 10 | * | .1 | .0 | .0 | .3 | .1 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .1 | .2 | .2 | .0 | .0 |
| 11 | * | .1 | .0 | .0 | .2 | .1 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .1 | .3 | .2 | .0 | .0 |
| 12 | * | .1 | .0 | .0 | .1 | .1 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .1 | .3 | .3 | .0 | .0 |
| 13 | * | .1 | .0 | .0 | .1 | .1 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .1 | .2 | .5 | .0 | .0 |
| 14 | * | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 15 | * | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 16 | * | .0 | .1 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 17 | * | .0 | .0 | .1 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .1 | .0 | .1 | .1 | .0 | .0 |
| 18 | * | .0 | .0 | .1 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .1 | .0 | .1 | .1 | .0 | .0 |
| 19 | * | .0 | .1 | .2 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .1 | .0 | .1 | .2 | .0 | .0 |
| 20 | * | .0 | .2 | .3 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .1 | .0 | .1 | .2 | .0 | .0 |
| 21 | * | .2 | .2 | .2 | .2 | .1 | .5 | .2 | .3 | .3 | .4 | .7 | .7 | .7 | .3 | .0 | .1 | .0 | .0 | .2 | .2 |
| 22 | * | .2 | .3 | .2 | .2 | .2 | .4 | .2 | .3 | .3 | .4 | .4 | .4 | .4 | .3 | .0 | .1 | .0 | .0 | .3 | .3 |
| 23 | * | .2 | .2 | .2 | .2 | .2 | .4 | .2 | .3 | .3 | .4 | .5 | .5 | .5 | .3 | .0 | .1 | .0 | .0 | .2 | .2 |
| 24 | * | .0 | .0 | .0 | .0 | .0 | .2 | .2 | .2 | .1 | .1 | .0 | .0 | .0 | .0 | .1 | .1 | .0 | .0 | .0 | .0 |
| 25 | * | .0 | .0 | .0 | .0 | .0 | .3 | .3 | .3 | .1 | .1 | .0 | .0 | .0 | .0 | .1 | .1 | .0 | .0 | .0 | .0 |
| 26 | * | .1 | .1 | .0 | .1 | .1 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .2 | .2 | .2 | .0 | .0 |
| 27 | * | .1 | .0 | .0 | .1 | .1 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .3 | .2 | .2 | .0 | .0 |
| 28 | * | .0 | .1 | .2 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .1 | .1 | .2 | .2 | .0 | .0 |
| 29 | * | .0 | .1 | .2 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .1 | .1 | .2 | .3 | .0 | .0 |
| 30 | * | .1 | .2 | .3 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .1 | .1 | .2 | .3 | .0 | .0 |
| 31 | * | .2 | .4 | .4 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .1 | .1 | .2 | .4 | .0 | .0 |
| 32 | * | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .7 | .6 | .0 | .0 | .0 | .0 | .2 | .1 | .2 | .1 | .0 | .0 |
| 33 | * | .0 | .0 | .1 | .0 | .0 | .0 | .0 | .0 | .2 | .1 | .0 | .0 | .0 | .0 | .2 | .1 | .2 | .2 | .0 | .0 |

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 34 | * | .0 | .0 | .1 | .0 | .0 | .0 | .0 | .0 | .4 | .3 | .0 | .0 | .0 | .0 | .2 | .1 | .2 | .2 | .0 | .0 |
| 35 | * | .1 | .1 | .0 | .2 | .2 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .1 | .1 | .0 | .0 |
| 36 | * | .2 | .1 | .0 | .2 | .2 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .1 | .1 | .0 | .0 |
| 37 | * | .0 | .0 | .0 | .0 | .0 | .1 | .1 | .1 | .0 | .0 | .0 | .0 | .0 | .0 | .2 | .1 | .0 | .0 | .0 | .0 |
| 38 | * | .0 | .0 | .0 | .0 | .0 | .1 | .1 | .1 | .0 | .1 | .0 | .0 | .0 | .0 | .2 | .1 | .0 | .0 | .0 | .0 |
| 39 | * | .3 | .2 | .1 | .2 | .1 | .2 | .1 | .2 | .2 | .2 | .2 | .2 | .2 | .2 | .0 | .1 | .0 | .0 | .3 | .3 |
| 40 | * | .3 | .2 | .1 | .2 | .2 | .2 | .1 | .2 | .2 | .2 | .2 | .2 | .2 | .2 | .0 | .1 | .0 | .0 | .3 | .3 |
| 41 | * | .3 | .2 | .1 | .2 | .2 | .2 | .1 | .1 | .2 | .2 | .2 | .2 | .2 | .1 | .0 | .1 | .0 | .0 | .4 | .4 |
| 42 | * | .4 | .2 | .1 | .2 | .2 | .1 | .1 | .1 | .2 | .2 | .2 | .2 | .2 | .1 | .0 | .1 | .0 | .0 | .5 | .5 |
| 43 | * | .1 | .1 | .1 | .1 | .1 | .1 | .1 | .1 | .1 | .1 | .5 | .4 | .4 | .2 | .0 | .0 | .0 | .0 | .1 | .1 |
| 44 | * | .5 | .4 | .4 | .5 | .5 | .5 | .5 | .5 | .5 | .5 | .5 | .6 | .6 | .5 | .0 | .0 | .0 | .0 | .5 | .5 |
| 45 | * | .1 | .0 | .0 | .1 | .1 | .1 | .0 | .1 | .1 | .1 | .1 | .1 | .1 | .1 | .0 | .0 | .0 | .0 | .3 | .3 |

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PAGE 7

JOB: I-25 Arapahoe Road RUN: Worst Case Combo 2011/2035

* CO/LINK (PPM)

* ANGLE (DEGREES)

| LINK # | * | REC1 | REC2 | REC3 | REC4 | REC5 | REC6 | REC7 | REC8 | REC9 | REC10 | REC11 | REC12 | REC13 | REC14 | REC15 | REC16 | REC17 | REC18 | REC19 | REC20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | * | 255 | 245 | 240 | 235 | 230 | 285 | 295 | 295 | 280 | 280 | 285 | 290 | 290 | 295 | 45 | 165 | 125 | 100 | 230 | 230 |
| 46 | * | .4 | .4 | .4 | .4 | .4 | .4 | .4 | .4 | .4 | .4 | .5 | .5 | .5 | .5 | .0 | .0 | .0 | .0 | .4 | .5 |

1 CAL3QHC: LINE SOURCE DISPERSION MODEL - VERSION 2.0, JANUARY 1992 PAGE 1
(Modified by Balloffet & Associates, April, 1994)
POLLUTANT MODELLED: CARBON MONOXIDE

JOB: Arapahoe @ Greenwood RUN: Worst Case Combo 2011/2035
DATE: 10/06/2011 TIME: 23:45

SITE & METEOROLOGICAL VARIABLES

VS = .0 cm/s VD = .0 cm/s Z0 = 175. cm TMPC = -6.0Deg C ALT =1768.0 m
U = 1.0 m/s CLAS = 4 (D) ATIM = 60. Minutes MIXH = 1000. m AMB = .0 ppm

LINK VARIABLES

| LINK DESCRIPTION | LINK COORDINATES (FT) X1 | Y1 | X2 | Y2 | LENGTH (FT) | BRG (DEG) | TYPE | VPH | EF (G/MI) | H (FT) | W (FT) | V/C | QUEUE (VEH) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. EB ARAP THRU 1 Que | 170889.0 | 642179.0 | 170724.1 | 642177.6 | 165. | 270. | AG | 125. | 100.0 | .0 | 12.0 | .63 | 8.4 |
| 2. EB ARAP THRU2 Que | 170889.0 | 642167.0 | 170724.1 | 642165.6 | 165. | 270. | AG | 125. | 100.0 | .0 | 12.0 | .63 | 8.4 |
| 3. EB ARAP THRU3 Que | 170889.0 | 642155.0 | 170724.1 | 642153.6 | 165. | 270. | AG | 125. | 100.0 | .0 | 12.0 | .63 | 8.4 |
| 4. NB GRNWD LT1 Que | 170925.0 | 642140.0 | 170924.6 | 642112.7 | 27. | 181. | AG | 186. | 100.0 | .0 | 12.0 | .20 | 1.4 |
| 5. NB GRNWD THRU1 Que | 170936.0 | 642138.0 | 170936.4 | 642086.1 | 52. | 180. | AG | 186. | 100.0 | .0 | 12.0 | .38 | 2.6 |
| 6. SB GRNWD LT1 Que | 170921.0 | 642257.0 | 170913.3 | 643474.3 | 1217. | 360. | AG | 143. | 100.0 | .0 | 12.0 | 1.14 | 61.8 |
| 7. SB GRNWD LT2 Que | 170909.0 | 642257.0 | 170901.3 | 643474.3 | 1217. | 360. | AG | 143. | 100.0 | .0 | 12.0 | 1.14 | 61.8 |
| 8. SB GRNWD THRU1 Que | 170900.0 | 642254.0 | 170898.4 | 642321.8 | 68. | 359. | AG | 136. | 100.0 | .0 | 12.0 | .27 | 3.4 |
| 9. WB ARAP LT1 Que | 170971.0 | 642194.0 | 171092.6 | 642194.0 | 122. | 90. | AG | 190. | 100.0 | .0 | 12.0 | .83 | 6.2 |
| 10. WB ARAP THRU1 Que | 170974.0 | 642206.0 | 171322.7 | 642207.8 | 349. | 90. | AG | 126. | 100.0 | .0 | 12.0 | .97 | 17.7 |
| 11. WB ARAP THRU2 Que | 170974.0 | 642218.0 | 171322.7 | 642219.8 | 349. | 90. | AG | 126. | 100.0 | .0 | 12.0 | .97 | 17.7 |
| 12. WB ARAP THRU3 Que | 170974.0 | 642230.0 | 171322.7 | 642231.8 | 349. | 90. | AG | 126. | 100.0 | .0 | 12.0 | .97 | 17.7 |
| 13. EB ARAP THRU 1 Apr | 170926.0 | 642179.0 | 170407.0 | 642175.0 | 519. | 270. | AG | 555. | 16.1 | .0 | 32.0 | | |
| 14. EB ARAP THRU2 Apr | 170930.0 | 642167.0 | 170407.0 | 642163.0 | 523. | 270. | AG | 555. | 16.1 | .0 | 32.0 | | |
| 15. EB ARAP THRU3 Apr | 170929.0 | 642155.0 | 170407.0 | 642151.0 | 522. | 270. | AG | 555. | 16.1 | .0 | 32.0 | | |
| 16. NB GRNWD THRU1 Apr | 170936.0 | 642191.0 | 170939.0 | 641718.0 | 473. | 180. | AG | 235. | 16.1 | .0 | 32.0 | | |
| 17. SB GRNWD THRU1 Apr | 170902.0 | 642192.0 | 170890.0 | 642666.0 | 474. | 359. | AG | 1840. | 16.1 | .0 | 32.0 | | |
| 18. WB ARAP THRU1 Apr | 170930.0 | 642206.0 | 171563.0 | 642209.0 | 633. | 90. | AG | 745. | 16.1 | .0 | 32.0 | | |
| 19. WB ARAP THRU2 Apr | 170919.0 | 642218.0 | 171563.0 | 642221.0 | 644. | 90. | AG | 745. | 16.1 | .0 | 32.0 | | |
| 20. WB ARAP THRU3 Apr | 170919.0 | 642230.0 | 171563.0 | 642233.0 | 644. | 90. | AG | 745. | 16.1 | .0 | 32.0 | | |
| 21. EB ARAP THRU 1 Dprt | 171563.0 | 642184.0 | 170926.0 | 642179.0 | 637. | 270. | AG | 918. | 16.1 | .0 | 32.0 | | |
| 22. EB ARAP THRU2 Dprt | 171563.0 | 642172.0 | 170930.0 | 642167.0 | 633. | 270. | AG | 918. | 16.1 | .0 | 32.0 | | |
| 23. EB ARAP THRU3 Dprt | 171563.0 | 642160.0 | 170929.0 | 642155.0 | 634. | 270. | AG | 918. | 16.1 | .0 | 32.0 | | |
| 24. NB GRNWD THRU1 Dprt | 170932.0 | 642657.0 | 170936.0 | 642191.0 | 466. | 180. | AG | 405. | 16.1 | .0 | 32.0 | | |
| 25. SB GRNWD THRU1 Dprt | 170914.0 | 641714.0 | 170902.0 | 642192.0 | 478. | 359. | AG | 425. | 16.1 | .0 | 32.0 | | |
| 26. WB ARAP THRU1 Dprt | 170393.0 | 642203.0 | 170930.0 | 642206.0 | 537. | 90. | AG | 818. | 16.1 | .0 | 32.0 | | |
| 27. WB ARAP THRU2 Dprt | 170393.0 | 642215.0 | 170919.0 | 642218.0 | 526. | 90. | AG | 818. | 16.1 | .0 | 32.0 | | |
| 28. WB ARAP THRU3 Dprt | 170393.0 | 642227.0 | 170919.0 | 642230.0 | 526. | 90. | AG | 818. | 16.1 | .0 | 32.0 | | |
| 29. NB GRNWD THRU2 | 170949.0 | 642658.0 | 170949.0 | 642254.0 | 404. | 180. | AG | 405. | 16.1 | .0 | 32.0 | | |
| 30. SB GRNWD RT1 | 170885.0 | 642256.0 | 170884.0 | 642415.0 | 159. | 360. | AG | 355. | 16.1 | .0 | 32.0 | | |
| 31. WB ARAP RT1 | 170974.0 | 642242.0 | 171563.0 | 642245.0 | 589. | 90. | AG | 470. | 16.1 | .0 | 32.0 | | |

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JOB: Arapahoe @ Greenwood RUN: Worst Case Combo 2011/2035
DATE: 10/06/2011 TIME: 23:45

ADDITIONAL QUEUE LINK PARAMETERS

| LINK DESCRIPTION | CYCLE LENGTH | RED TIME | CLEARANCE LOST TIME | APPROACH VOL | SATURATION FLOW RATE | IDLE EM FAC | SIGNAL TYPE | ARRIVAL RATE |
|---|---|---|---|---|---|---|---|---|

| | * | (SEC) | (SEC) | (SEC) | (VPH) | (VPH) | (gm/hr) | | |
|---|---|---|---|---|---|---|---|---|---|
| 1. EB ARAP THRU 1 Que | * | 120 | 67 | .4 | 450 | 1700 | 83.20 | 1 | 3 |
| 2. EB ARAP THRU2 Que | * | 120 | 67 | .4 | 450 | 1700 | 83.20 | 1 | 3 |
| 3. EB ARAP THRU3 Que | * | 120 | 67 | .4 | 450 | 1700 | 83.20 | 1 | 3 |
| 4. NB GRNWD LT1 Que | * | 120 | 100 | .4 | 50 | 1700 | 83.20 | 1 | 3 |
| 5. NB GRNWD THRU1 Que | * | 120 | 100 | .4 | 95 | 1700 | 83.20 | 1 | 3 |
| 6. SB GRNWD LT1 Que | * | 120 | 77 | .3 | 658 | 1700 | 83.20 | 1 | 3 |
| 7. SB GRNWD LT2 Que | * | 120 | 77 | .3 | 658 | 1700 | 83.20 | 1 | 3 |
| 8. SB GRNWD THRU1 Que | * | 120 | 73 | .4 | 170 | 1700 | 83.20 | 1 | 3 |
| 9. WB ARAP LT1 Que | * | 120 | 102 | .3 | 185 | 1700 | 83.20 | 1 | 3 |
| 10. WB ARAP THRU1 Que | * | 120 | 68 | .4 | 683 | 1700 | 83.20 | 1 | 3 |
| 11. WB ARAP THRU2 Que | * | 120 | 68 | .4 | 683 | 1700 | 83.20 | 1 | 3 |
| 12. WB ARAP THRU3 Que | * | 120 | 68 | .4 | 683 | 1700 | 83.20 | 1 | 3 |

RECEPTOR LOCATIONS

| | * | COORDINATES (FT) | | | * |
|---|---|---|---|---|---|
| RECEPTOR | * | X | Y | Z | * |
| 1. R-01 | * | 170868.0 | 642264.0 | 6.0 | * |
| 2. R-02 | * | 170869.0 | 642303.0 | 6.0 | * |
| 3. R-03 | * | 170868.0 | 642353.0 | 6.0 | * |
| 4. R-04 | * | 170818.0 | 642246.0 | 6.0 | * |
| 5. R-05 | * | 170768.0 | 642245.0 | 6.0 | * |
| 6. R-06 | * | 170994.0 | 642258.0 | 6.0 | * |
| 7. R-07 | * | 171033.0 | 642258.0 | 6.0 | * |
| 8. R-08 | * | 171084.0 | 642259.0 | 6.0 | * |
| 9. R-09 | * | 170882.0 | 642138.0 | 6.0 | * |
| 10. R-10 | * | 170842.0 | 642138.0 | 6.0 | * |
| 11. R-11 | * | 170792.0 | 642138.0 | 6.0 | * |
| 12. R-12 | * | 170889.0 | 642088.0 | 6.0 | * |
| 13. R-13 | * | 170890.0 | 642038.0 | 6.0 | * |
| 14. R-14 | * | 170953.0 | 642122.0 | 6.0 | * |
| 15. R-15 | * | 170952.0 | 642082.0 | 6.0 | * |
| 16. R-16 | * | 170953.0 | 642031.0 | 6.0 | * |
| 17. R-17 | * | 171002.0 | 642139.0 | 6.0 | * |
| 18. R-18 | * | 171053.0 | 642140.0 | 6.0 | * |
| 19. R-19 | * | 170965.0 | 642309.0 | 6.0 | * |
| 20. R-20 | * | 170964.0 | 642360.0 | 6.0 | * |

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JOB: Arapahoe @ Greenwood RUN: Worst Case Combo 2011/2035

MODEL RESULTS

REMARKS : In search of the angle corresponding to
the maximum concentration, only the first
angle, of the angles with same maximum
concentrations, is indicated as maximum.

WIND ANGLE RANGE: 0.-355.

| WIND ANGLE (DEGR) | * CONCENTRATION (PPM) | REC1 | REC2 | REC3 | REC4 | REC5 | REC6 | REC7 | REC8 | REC9 | REC10 | REC11 | REC12 | REC13 | REC14 | REC15 | REC16 | REC17 | REC18 | REC19 | REC20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | * | | | | | | | | | | | | | | | | | | | | |

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0. | * | 1.4 | 1.5 | 1.4 | .4 | .2 | .5 | .2 | .0 | 4.1 | 3.1 | 2.7 | 2.9 | 2.3 | 2.7 | 2.3 | 1.9 | 3.4 | 3.1 | 1.1 | 1.0 |
| 5. | * | 2.0 | 1.9 | 1.8 | .6 | .3 | .3 | .0 | .0 | 4.1 | 3.4 | 2.7 | 2.7 | 2.1 | 2.6 | 2.0 | 1.6 | 3.2 | 2.9 | .8 | .8 |
| 10. | * | 2.4 | 2.3 | 2.2 | .8 | .4 | .0 | .0 | .0 | 4.2 | 3.7 | 2.9 | 2.5 | 2.7 | 2.6 | 2.0 | 1.9 | 2.7 | 2.8 | .5 | .5 |
| 15. | * | 2.4 | 2.4 | 2.3 | 1.0 | .5 | .0 | .0 | .0 | 3.8 | 3.8 | 3.2 | 2.5 | 2.3 | 2.6 | 1.9 | 1.5 | 2.7 | 2.8 | .1 | .2 |
| 20. | * | 2.4 | 2.4 | 2.4 | 1.2 | .6 | .0 | .0 | .0 | 3.4 | 3.8 | 3.4 | 2.2 | 2.0 | 2.3 | 1.5 | 1.4 | 2.7 | 2.8 | .1 | .1 |
| 25. | * | 2.4 | 2.3 | 2.3 | 1.2 | .7 | .0 | .0 | .0 | 3.1 | 3.8 | 3.4 | 2.1 | 1.7 | 2.3 | 1.7 | 1.4 | 2.9 | 2.9 | .1 | .1 |
| 30. | * | 2.4 | 2.2 | 2.2 | 1.3 | .8 | .0 | .0 | .0 | 2.8 | 3.4 | 3.5 | 2.0 | 2.0 | 2.3 | 1.7 | 1.4 | 3.0 | 2.9 | .0 | .1 |
| 35. | * | 2.3 | 2.2 | 2.2 | 1.3 | .8 | .0 | .0 | .0 | 2.6 | 3.4 | 3.3 | 2.4 | 2.1 | 2.3 | 1.7 | 1.4 | 3.0 | 2.9 | .0 | .0 |
| 40. | * | 2.3 | 2.3 | 2.2 | 1.3 | .9 | .0 | .0 | .0 | 2.6 | 3.3 | 3.4 | 2.4 | 2.0 | 2.5 | 1.9 | 1.4 | 3.0 | 2.8 | .0 | .0 |
| 45. | * | 2.3 | 2.1 | 2.0 | 1.3 | 1.0 | .0 | .0 | .0 | 3.0 | 3.0 | 3.4 | 2.4 | 1.9 | 2.5 | 1.8 | 1.4 | 3.2 | 3.0 | .0 | .0 |
| 50. | * | 2.1 | 2.0 | 1.9 | 1.4 | 1.0 | .0 | .0 | .0 | 2.9 | 3.2 | 3.2 | 2.7 | 1.9 | 2.6 | 1.8 | 1.3 | 3.3 | 3.2 | .0 | .0 |
| 55. | * | 2.1 | 1.9 | 1.8 | 1.3 | 1.0 | .0 | .0 | .0 | 2.8 | 3.5 | 3.2 | 2.8 | 1.9 | 2.7 | 2.0 | 1.3 | 3.5 | 3.2 | .0 | .0 |
| 60. | * | 2.1 | 2.0 | 1.8 | 1.3 | 1.1 | .1 | .1 | .1 | 3.2 | 3.4 | 3.5 | 2.8 | 1.7 | 2.7 | 1.9 | 1.3 | 3.5 | 3.2 | .0 | .0 |
| 65. | * | 2.1 | 2.0 | 1.8 | 1.2 | 1.1 | .1 | .1 | .1 | 3.5 | 3.2 | 3.7 | 2.8 | 1.7 | 2.7 | 1.8 | 1.1 | 3.4 | 3.2 | .0 | .0 |
| 70. | * | 2.0 | 1.9 | 1.7 | 1.3 | 1.1 | .1 | .1 | .1 | 3.6 | 3.3 | 3.7 | 2.6 | 1.5 | 2.6 | 1.6 | .9 | 3.5 | 3.4 | .0 | .0 |
| 75. | * | 2.1 | 1.9 | 1.7 | 1.8 | 1.4 | .4 | .3 | .3 | 3.7 | 3.4 | 3.8 | 2.1 | 1.1 | 2.6 | 1.3 | .7 | 3.3 | 3.2 | .0 | .0 |
| 80. | * | 2.4 | 2.0 | 1.7 | 2.3 | 1.9 | .8 | .8 | .8 | 3.5 | 3.5 | 3.5 | 1.7 | .9 | 2.0 | 1.0 | .4 | 2.9 | 2.9 | .0 | .0 |
| 85. | * | 2.9 | 2.4 | 1.7 | 2.7 | 2.6 | 1.5 | 1.3 | 1.2 | 3.2 | 3.1 | 3.1 | 1.5 | .7 | 1.5 | .7 | .3 | 2.6 | 2.5 | .1 | .0 |
| 90. | * | 3.2 | 2.7 | 1.7 | 3.1 | 2.8 | 2.0 | 2.0 | 1.8 | 2.6 | 2.5 | 2.5 | 1.0 | .5 | 1.2 | .3 | .0 | 1.9 | 1.9 | .4 | .0 |
| 95. | * | 3.8 | 3.2 | 2.1 | 3.5 | 3.3 | 2.5 | 2.5 | 2.2 | 2.0 | 1.6 | 1.6 | .8 | .4 | .6 | .2 | .0 | 1.3 | 1.3 | .9 | .2 |
| 100. | * | 4.1 | 3.3 | 2.5 | 3.6 | 3.4 | 3.0 | 3.0 | 2.8 | 1.4 | 1.1 | .9 | .5 | .4 | .4 | .0 | .0 | .8 | .8 | 1.2 | .6 |
| 105. | * | 4.0 | 3.8 | 2.7 | 3.6 | 3.4 | 3.4 | 3.3 | 3.1 | 1.2 | .8 | .7 | .5 | .3 | .1 | .0 | .0 | .5 | .5 | 1.5 | .8 |
| 110. | * | 3.7 | 3.9 | 3.0 | 3.6 | 3.3 | 3.5 | 3.4 | 3.2 | 1.0 | .6 | .4 | .4 | .3 | .0 | .0 | .0 | .3 | .3 | 1.8 | 1.0 |
| 115. | * | 3.7 | 3.8 | 3.2 | 2.9 | 3.0 | 3.5 | 3.4 | 3.2 | .8 | .5 | .2 | .4 | .4 | .0 | .0 | .0 | .1 | .2 | 1.8 | 1.1 |
| 120. | * | 3.5 | 3.7 | 3.5 | 3.1 | 2.6 | 3.4 | 3.3 | 3.2 | .8 | .4 | .2 | .4 | .4 | .0 | .0 | .0 | .1 | .1 | 1.9 | 1.3 |
| 125. | * | 3.1 | 3.6 | 3.6 | 2.6 | 2.8 | 3.4 | 3.3 | 3.2 | .7 | .3 | .1 | .4 | .4 | .0 | .0 | .0 | .1 | .1 | 2.0 | 1.4 |
| 130. | * | 2.9 | 3.5 | 3.5 | 2.6 | 2.4 | 3.4 | 3.3 | 3.1 | .7 | .2 | .1 | .4 | .4 | .0 | .0 | .0 | .1 | .1 | 2.0 | 1.4 |
| 135. | * | 2.8 | 3.5 | 3.4 | 2.7 | 2.5 | 3.0 | 2.9 | 2.8 | .6 | .3 | .1 | .4 | .4 | .0 | .0 | .0 | .1 | .1 | 2.0 | 1.2 |
| 140. | * | 2.8 | 3.1 | 3.3 | 2.5 | 2.4 | 2.9 | 2.9 | 2.7 | .5 | .3 | .1 | .4 | .4 | .0 | .0 | .0 | .0 | .0 | 1.8 | 1.3 |
| 145. | * | 2.8 | 2.7 | 3.0 | 2.2 | 2.2 | 2.9 | 2.9 | 2.7 | .5 | .3 | .1 | .5 | .5 | .0 | .0 | .0 | .0 | .0 | 1.9 | 1.1 |
| 150. | * | 2.6 | 2.5 | 2.8 | 2.1 | 2.1 | 3.0 | 2.9 | 2.7 | .4 | .3 | .1 | .5 | .5 | .0 | .0 | .0 | .0 | .0 | 1.8 | 1.1 |
| 155. | * | 2.5 | 2.8 | 2.9 | 2.2 | 2.1 | 2.9 | 2.8 | 2.6 | .5 | .3 | .1 | .5 | .5 | .0 | .0 | .0 | .0 | .0 | 1.8 | 1.2 |
| 160. | * | 2.3 | 2.6 | 2.8 | 2.1 | 2.1 | 2.8 | 2.8 | 2.7 | .5 | .3 | .1 | .6 | .5 | .1 | .1 | .1 | .0 | .0 | 1.9 | 1.2 |
| 165. | * | 2.3 | 2.3 | 2.6 | 2.1 | 2.1 | 2.8 | 2.8 | 2.7 | .5 | .1 | .1 | .6 | .6 | .1 | .1 | .1 | .0 | .0 | 1.8 | 1.2 |
| 170. | * | 2.2 | 1.9 | 2.0 | 2.1 | 2.0 | 2.8 | 2.8 | 2.7 | .5 | .1 | .0 | .6 | .6 | .1 | .1 | .1 | .0 | .0 | 1.7 | 1.3 |
| 175. | * | 2.1 | 2.0 | 1.5 | 2.1 | 2.0 | 2.8 | 2.8 | 2.7 | .4 | .1 | .0 | .5 | .5 | .3 | .3 | .3 | .0 | .0 | 1.9 | 1.3 |
| 180. | * | 1.8 | 1.7 | 1.8 | 2.0 | 2.0 | 2.8 | 2.9 | 2.8 | .3 | .1 | .0 | .4 | .4 | .4 | .3 | .3 | .0 | .0 | 1.6 | 1.4 |
| 185. | * | 1.8 | 1.6 | 1.5 | 2.0 | 2.0 | 3.0 | 2.8 | 2.8 | .2 | .0 | .0 | .3 | .3 | .4 | .4 | .3 | .0 | .0 | 1.4 | 1.3 |
| 190. | * | 1.7 | 1.5 | 1.2 | 2.0 | 2.0 | 3.0 | 2.9 | 2.8 | .1 | .0 | .0 | .2 | .2 | .7 | .5 | .4 | .2 | .0 | 1.5 | 1.7 |
| 195. | * | 1.6 | 1.3 | 1.2 | 2.0 | 1.9 | 2.9 | 3.0 | 2.8 | .1 | .0 | .0 | .1 | .1 | .7 | .5 | .4 | .2 | .0 | 1.8 | 2.1 |
| 200. | * | 1.6 | 1.2 | 1.2 | 2.0 | 1.9 | 2.7 | 3.0 | 2.9 | .0 | .0 | .0 | .1 | .1 | .7 | .4 | .4 | .2 | .1 | 2.0 | 2.2 |
| 205. | * | 1.6 | 1.2 | 1.1 | 2.0 | 1.9 | 2.6 | 3.1 | 2.9 | .0 | .0 | .0 | .1 | .1 | .8 | .4 | .4 | .2 | .1 | 1.9 | 2.4 |

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JOB: Arapahe @ Greenwood RUN: Worst Case Combo 2011/2035

| WIND ANGLE (DEGR) | * CONCENTRATION (PPM) * REC1 | REC2 | REC3 | REC4 | REC5 | REC6 | REC7 | REC8 | REC9 | REC10 | REC11 | REC12 | REC13 | REC14 | REC15 | REC16 | REC17 | REC18 | REC19 | REC20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 210. | * 1.6 | 1.2 | 1.1 | 2.1 | 2.0 | 2.6 | 3.1 | 3.0 | .0 | .0 | .0 | .0 | .0 | .8 | .4 | .4 | .2 | .2 | 2.2 | 2.3 |
| 215. | * 1.6 | 1.2 | 1.1 | 2.1 | 2.0 | 2.5 | 3.1 | 3.1 | .0 | .0 | .0 | .0 | .0 | .9 | .4 | .4 | .2 | .2 | 2.3 | 2.6 |
| 220. | * 1.7 | 1.2 | .9 | 2.3 | 2.1 | 2.3 | 2.9 | 3.1 | .0 | .0 | .0 | .0 | .0 | .9 | .4 | .4 | .3 | .3 | 2.6 | 2.8 |
| 225. | * 1.7 | 1.3 | .9 | 2.3 | 2.0 | 2.4 | 2.8 | 2.9 | .0 | .0 | .0 | .0 | .0 | .9 | .4 | .4 | .4 | .3 | 2.6 | 3.0 |

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 230. | * | 1.8 | 1.1 | .9 | 2.4 | 2.1 | 2.7 | 2.9 | 3.0 | .0 | .0 | .0 | .0 | .0 | .9 | .4 | .4 | .4 | .3 | 2.6 | 2.8 |
| 235. | * | 1.9 | 1.0 | .9 | 2.4 | 2.2 | 2.5 | 3.1 | 3.2 | .0 | .0 | .0 | .0 | .0 | 1.0 | .4 | .4 | .5 | .3 | 2.7 | 2.6 |
| 240. | * | 1.8 | 1.0 | .9 | 2.3 | 2.2 | 2.6 | 3.0 | 3.5 | .1 | .1 | .1 | .0 | .0 | .9 | .3 | .3 | .5 | .3 | 2.8 | 2.6 |
| 245. | * | 1.7 | 1.0 | .8 | 2.3 | 2.3 | 2.7 | 3.0 | 3.4 | .1 | .1 | .1 | .0 | .0 | .9 | .3 | .3 | .6 | .3 | 2.7 | 2.3 |
| 250. | * | 1.6 | 1.0 | .4 | 2.4 | 2.3 | 2.8 | 2.8 | 3.1 | .1 | .1 | .1 | .0 | .0 | 1.0 | .3 | .3 | .7 | .4 | 2.6 | 2.1 |
| 255. | * | 1.5 | .9 | .3 | 2.3 | 2.3 | 2.5 | 2.9 | 3.1 | .4 | .4 | .3 | .0 | .0 | 1.1 | .3 | .3 | .9 | .7 | 2.6 | 1.8 |
| 260. | * | 1.3 | .6 | .3 | 2.1 | 2.1 | 2.4 | 2.7 | 2.7 | .6 | .6 | .6 | .0 | .0 | 1.3 | .4 | .3 | 1.3 | 1.2 | 2.4 | 1.8 |
| 265. | * | 1.1 | .3 | .1 | 1.8 | 1.7 | 2.4 | 2.2 | 2.1 | 1.1 | 1.0 | .9 | .0 | .0 | 1.7 | .4 | .3 | 1.9 | 1.8 | 1.9 | 1.6 |
| 270. | * | .6 | .3 | .0 | 1.3 | 1.3 | 2.0 | 2.1 | 2.1 | 1.8 | 1.5 | 1.3 | .2 | .0 | 2.1 | .6 | .4 | 2.3 | 2.2 | 1.9 | 1.5 |
| 275. | * | .4 | .1 | .0 | .9 | .9 | 1.6 | 1.6 | 1.6 | 2.1 | 2.0 | 1.8 | .5 | .0 | 2.5 | 1.0 | .3 | 2.6 | 2.8 | 1.8 | 1.6 |
| 280. | * | .2 | .0 | .0 | .7 | .7 | 1.5 | 1.3 | 1.4 | 2.6 | 2.5 | 2.1 | .7 | .2 | 2.7 | 1.2 | .6 | 3.0 | 3.1 | 1.6 | 1.5 |
| 285. | * | .1 | .0 | .0 | .4 | .4 | 1.3 | 1.1 | .9 | 2.9 | 2.7 | 2.3 | .9 | .6 | 3.0 | 1.5 | .9 | 3.0 | 3.0 | 1.5 | 1.4 |
| 290. | * | .0 | .0 | .0 | .2 | .2 | 1.1 | 1.1 | .8 | 3.0 | 2.9 | 2.7 | 1.1 | .6 | 3.1 | 1.8 | .9 | 3.1 | 3.2 | 1.6 | 1.5 |
| 295. | * | .0 | .0 | .0 | .1 | .1 | 1.3 | 1.1 | .8 | 3.0 | 2.9 | 2.6 | 1.5 | .6 | 3.2 | 2.2 | 1.0 | 3.1 | 3.2 | 1.5 | 1.5 |
| 300. | * | .0 | .0 | .0 | .1 | .1 | 1.4 | .9 | .7 | 3.0 | 2.9 | 2.7 | 1.5 | .6 | 3.1 | 2.3 | 1.1 | 2.8 | 3.1 | 1.6 | 1.6 |
| 305. | * | .0 | .0 | .0 | .1 | .1 | 1.4 | .9 | .7 | 2.8 | 2.8 | 2.9 | 1.6 | .8 | 2.6 | 2.5 | 1.3 | 2.9 | 3.1 | 1.7 | 1.6 |
| 310. | * | .0 | .0 | .0 | .1 | .1 | 1.4 | .8 | .7 | 2.6 | 2.6 | 2.6 | 1.6 | .9 | 2.4 | 2.4 | 1.3 | 2.9 | 3.4 | 1.7 | 1.6 |
| 315. | * | .0 | .0 | .0 | .0 | .1 | 1.3 | .9 | .7 | 2.6 | 2.6 | 2.6 | 1.6 | .9 | 2.6 | 2.6 | 1.3 | 2.9 | 3.3 | 1.7 | 1.6 |
| 320. | * | .0 | .0 | .0 | .0 | .0 | 1.4 | .9 | .7 | 2.5 | 2.5 | 2.5 | 1.6 | .9 | 2.5 | 2.5 | 1.3 | 3.2 | 3.6 | 1.7 | 1.6 |
| 325. | * | .0 | .0 | .0 | .0 | .0 | 1.3 | 1.0 | .7 | 2.4 | 2.5 | 2.5 | 1.6 | .9 | 2.2 | 2.3 | 1.5 | 3.4 | 3.6 | 1.7 | 1.7 |
| 330. | * | .0 | .0 | .0 | .0 | .0 | 1.3 | 1.0 | .6 | 2.3 | 2.3 | 2.3 | 1.5 | 1.0 | 2.5 | 2.4 | 1.7 | 3.3 | 3.6 | 2.0 | 1.9 |
| 335. | * | .0 | .1 | .0 | .0 | .0 | 1.3 | .9 | .6 | 2.4 | 2.3 | 2.3 | 1.6 | 1.1 | 3.2 | 2.5 | 1.7 | 3.5 | 3.7 | 1.9 | 1.9 |
| 340. | * | .2 | .2 | .1 | .0 | .0 | 1.3 | .8 | .4 | 2.5 | 2.3 | 2.3 | 1.5 | 1.1 | 3.2 | 2.7 | 1.8 | 3.5 | 3.7 | 1.9 | 1.8 |
| 345. | * | .4 | .4 | .4 | .0 | .0 | 1.0 | .8 | .3 | 2.7 | 2.4 | 2.3 | 1.7 | 1.4 | 3.4 | 3.2 | 2.2 | 3.5 | 3.5 | 1.9 | 1.8 |
| 350. | * | .6 | .6 | .6 | .0 | .0 | .9 | .6 | .2 | 2.9 | 2.5 | 2.3 | 1.9 | 1.6 | 3.1 | 3.0 | 2.7 | 3.4 | 3.2 | 1.6 | 1.5 |
| 355. | * | 1.0 | 1.0 | .9 | .3 | .0 | .8 | .3 | .2 | 3.7 | 2.7 | 2.5 | 2.4 | 2.0 | 2.8 | 2.7 | 2.3 | 3.5 | 3.2 | 1.4 | 1.3 |
| MAX | * | 4.1 | 3.9 | 3.6 | 3.6 | 3.4 | 3.5 | 3.4 | 3.5 | 4.2 | 3.8 | 3.8 | 2.9 | 2.7 | 3.4 | 3.2 | 2.7 | 3.5 | 3.7 | 2.8 | 3.0 |
| DEGR. | * | 100 | 110 | 125 | 110 | 100 | 110 | 110 | 240 | 10 | 15 | 75 | 0 | 10 | 345 | 345 | 350 | 340 | 335 | 240 | 225 |

THE HIGHEST CONCENTRATION IS 4.20 AT 10 DEGREES FROM REC9 .

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PAGE 5

JOB: Arapahoe @ Greenwood RUN: Worst Case Combo 2011/2035
DATE: 10/06/2011 TIME: 23:45
RECEPTOR - LINK MATRIX FOR THE ANGLE PRODUCING
THE MAXIMUM CONCENTRATION FOR EACH RECEPTOR
* CO/LINK (PPM)
* ANGLE (DEGREES)

| LINK # | * | REC1 | REC2 | REC3 | REC4 | REC5 | REC6 | REC7 | REC8 | REC9 | REC10 | REC11 | REC12 | REC13 | REC14 | REC15 | REC16 | REC17 | REC18 | REC19 | REC20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | * | 100 | 110 | 125 | 110 | 100 | 110 | 110 | 240 | 10 | 15 | 75 | 0 | 10 | 345 | 345 | 350 | 340 | 335 | 240 | 225 |
| 1 | * | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .1 | .2 | .1 | .1 | .0 | .0 | .0 | .0 | .0 | .0 | .1 | .1 |
| 2 | * | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .2 | .3 | .2 | .1 | .0 | .0 | .0 | .0 | .0 | .0 | .1 | .1 |
| 3 | * | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .1 | .3 | .4 | .4 | .1 | .0 | .0 | .0 | .0 | .0 | .0 | .1 | .1 |
| 4 | * | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .1 | .0 | .1 | .1 | .0 | .0 | .0 | .0 |
| 5 | * | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .1 | .0 | .4 | .2 | .0 | .0 | .0 | .0 |
| 6 | * | .1 | .2 | .2 | .0 | .0 | .0 | .0 | .0 | .3 | .2 | .0 | .2 | .2 | .2 | .2 | .2 | .2 | .2 | .2 | .3 |
| 7 | * | .1 | .2 | .3 | .0 | .0 | .0 | .0 | .0 | .3 | .2 | .0 | .2 | .2 | .2 | .2 | .2 | .2 | .2 | .2 | .2 |
| 8 | * | .2 | .3 | .1 | .0 | .0 | .0 | .0 | .0 | .1 | .1 | .0 | .1 | .0 | .1 | .0 | .0 | .0 | .0 | .1 | .1 |
| 9 | * | .1 | .1 | .1 | .1 | .1 | .1 | .0 | .2 | .0 | .0 | .1 | .0 | .0 | .0 | .0 | .0 | .2 | .3 | .0 | .0 |
| 10 | * | .2 | .1 | .1 | .1 | .1 | .2 | .2 | .1 | .0 | .0 | .1 | .0 | .0 | .0 | .0 | .0 | .1 | .2 | .0 | .0 |
| 11 | * | .2 | .1 | .1 | .1 | .1 | .3 | .3 | .2 | .0 | .0 | .1 | .0 | .0 | .0 | .0 | .0 | .1 | .1 | .0 | .0 |
| 12 | * | .2 | .2 | .1 | .1 | .1 | .4 | .4 | .3 | .0 | .0 | .1 | .0 | .0 | .0 | .0 | .0 | .1 | .1 | .0 | .0 |

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 13 | * | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .1 | .2 | .2 | .2 | .1 | .1 | .0 | .1 | .0 | .0 | .0 | .1 | .1 |
| 14 | * | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .1 | .3 | .3 | .3 | .1 | .1 | .1 | .1 | .1 | .0 | .0 | .1 | .1 |
| 15 | * | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .1 | .3 | .3 | .5 | .2 | .1 | .0 | .1 | .1 | .0 | .0 | .1 | .1 |
| 16 | * | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .2 | .2 | .2 | .0 | .0 | .0 | .0 |
| 17 | * | .8 | .9 | 1.0 | .4 | .3 | .0 | .0 | .1 | 1.0 | .7 | .1 | .7 | .4 | .7 | .6 | .5 | .5 | .3 | .5 | .6 |
| 18 | * | .3 | .2 | .2 | .2 | .2 | .3 | .3 | .3 | .0 | .0 | .2 | .0 | .0 | .1 | .1 | .0 | .2 | .2 | .0 | .0 |
| 19 | * | .3 | .2 | .2 | .2 | .2 | .4 | .4 | .3 | .0 | .0 | .2 | .0 | .1 | .1 | .1 | .1 | .2 | .2 | .0 | .0 |
| 20 | * | .4 | .3 | .2 | .2 | .2 | .5 | .5 | .5 | .0 | .0 | .2 | .0 | .1 | .1 | .1 | .1 | .2 | .2 | .0 | .0 |
| 21 | * | .2 | .2 | .2 | .3 | .2 | .3 | .3 | .2 | .0 | .0 | .3 | .0 | .1 | .2 | .1 | .1 | .4 | .4 | .0 | .0 |
| 22 | * | .2 | .2 | .2 | .3 | .2 | .3 | .3 | .1 | .0 | .0 | .2 | .0 | .1 | .3 | .1 | .1 | .4 | .5 | .0 | .0 |
| 23 | * | .2 | .2 | .1 | .2 | .2 | .2 | .2 | .1 | .0 | .0 | .2 | .0 | .1 | .4 | .1 | .1 | .5 | .5 | .0 | .0 |
| 24 | * | .1 | .1 | .1 | .1 | .0 | .0 | .0 | .0 | .1 | .1 | .0 | .1 | .1 | .2 | .1 | .1 | .1 | .1 | .2 | .2 |
| 25 | * | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .1 | .2 | .0 | .1 | .3 | .4 | .0 | .1 | .1 | .0 | .0 | .0 | .0 |
| 26 | * | .0 | .0 | .0 | .2 | .2 | .0 | .0 | .1 | .2 | .2 | .1 | .2 | .1 | .1 | .1 | .1 | .0 | .0 | .2 | .2 |
| 27 | * | .0 | .0 | .0 | .4 | .4 | .0 | .0 | .1 | .2 | .2 | .0 | .1 | .1 | .1 | .1 | .1 | .0 | .0 | .2 | .2 |
| 28 | * | .1 | .0 | .0 | .7 | .8 | .0 | .0 | .0 | .2 | .2 | .0 | .1 | .1 | .1 | .1 | .1 | .0 | .0 | .3 | .2 |
| 29 | * | .0 | .1 | .1 | .0 | .0 | .0 | .0 | .0 | .1 | .1 | .0 | .1 | .1 | .1 | .1 | .1 | .1 | .1 | .2 | .3 |
| 30 | * | .2 | .2 | .2 | .0 | .0 | .0 | .0 | .0 | .1 | .1 | .0 | .1 | .0 | .1 | .0 | .0 | .0 | .0 | .1 | .1 |
| 31 | * | .2 | .1 | .1 | .0 | .1 | .5 | .5 | .4 | .0 | .0 | .1 | .0 | .0 | .0 | .0 | .0 | .0 | .1 | .0 | .0 |

1 CAL3QHC: LINE SOURCE DISPERSION MODEL - VERSION 2.0, JANUARY 1992 PAGE 1
(Modified by Balloffet & Associates, April, 1994)
POLLUTANT MODELLED: CARBON MONOXIDE

JOB: Arapahoe @ Yosemite RUN: Worst Case Combo 2011/2035
DATE: 10/06/2011 TIME: 23:46

SITE & METEOROLOGICAL VARIABLES

VS = .0 cm/s VD = .0 cm/s Z0 = 175. cm TMPC = -6.0Deg C ALT =1768.0 m
U = 1.0 m/s CLAS = 4 (D) ATIM = 60. Minutes MIXH = 1000. m AMB = .0 ppm

LINK VARIABLES

| LINK DESCRIPTION | LINK COORDINATES (FT) X1 | Y1 | X2 | Y2 | LENGTH (FT) | BRG (DEG) | TYPE | VPH | EF (G/MI) | H (FT) | W (FT) | V/C | QUEUE (VEH) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. EB ARAP LT1 Que | 172153.0 | 642159.0 | 172076.1 | 642153.7 | 77. | 266. | AG | 193. | 100.0 | .0 | 12.0 | .67 | 3.9 |
| 2. EB ARAP LT2 Que | 172154.0 | 642147.0 | 172077.1 | 642141.7 | 77. | 266. | AG | 193. | 100.0 | .0 | 12.0 | .67 | 3.9 |
| 3. EB ARAP THRU1 Que | 172154.0 | 642123.0 | 171920.7 | 642115.3 | 233. | 268. | AG | 132. | 100.0 | .0 | 12.0 | .85 | 11.9 |
| 4. EB ARAP THRU2 Que | 172155.0 | 642111.0 | 171921.7 | 642103.3 | 233. | 268. | AG | 132. | 100.0 | .0 | 12.0 | .85 | 11.9 |
| 5. EB ARAP THRU3 Que | 172155.0 | 642099.0 | 171921.7 | 642091.3 | 233. | 268. | AG | 132. | 100.0 | .0 | 12.0 | .85 | 11.9 |
| 6. EB ARAP THRU4 Que | 172155.0 | 642087.0 | 171921.7 | 642079.3 | 233. | 268. | AG | 132. | 100.0 | .0 | 12.0 | .85 | 11.9 |
| 7. NB YOS LT1 Que | 172220.0 | 642080.0 | 172219.0 | 641985.9 | 94. | 181. | AG | 186. | 100.0 | .0 | 12.0 | .67 | 4.8 |
| 8. NB YOS LT2 Que | 172232.0 | 642080.0 | 172231.0 | 641985.9 | 94. | 181. | AG | 186. | 100.0 | .0 | 12.0 | .67 | 4.8 |
| 9. NB YOS THRU1 Que | 172243.0 | 642080.0 | 172242.4 | 641809.7 | 270. | 180. | AG | 166. | 100.0 | .0 | 12.0 | .98 | 13.7 |
| 10. NB YOS THRU2 Que | 172255.0 | 642077.0 | 172254.4 | 641806.8 | 270. | 180. | AG | 166. | 100.0 | .0 | 12.0 | .98 | 13.7 |
| 11. SB YOS LT1 Que | 172221.0 | 642243.0 | 172222.7 | 642508.6 | 266. | 0. | AG | 162. | 100.0 | .0 | 12.0 | .96 | 13.5 |
| 12. SB YOS LT2 Que | 172212.0 | 642243.0 | 172208.7 | 642507.2 | 264. | 359. | AG | 162. | 100.0 | .0 | 12.0 | .96 | 13.4 |
| 13. SB YOS THRU1 Que | 172202.0 | 642158.0 | 172201.7 | 641983.5 | 175. | 180. | AG | 141. | 100.0 | .0 | 12.0 | .71 | 8.9 |
| 14. SB YOS THRU2 Que | 172189.0 | 642159.0 | 172188.7 | 641984.5 | 175. | 180. | AG | 141. | 100.0 | .0 | 12.0 | .71 | 8.9 |
| 15. WB ARAP LT1 Que | 172291.0 | 642156.0 | 172449.6 | 642160.3 | 159. | 88. | AG | 184. | 100.0 | .0 | 12.0 | .89 | 8.1 |
| 16. WB ARAP LT2 Que | 172290.0 | 642168.0 | 172448.6 | 642172.3 | 159. | 88. | AG | 184. | 100.0 | .0 | 12.0 | .89 | 8.1 |
| 17. WB ARAP THRU 3 Que | 172294.0 | 642205.0 | 172482.7 | 642207.7 | 189. | 89. | AG | 123. | 100.0 | .0 | 12.0 | .72 | 9.6 |
| 18. WB ARAP THRU 4 Que | 172292.0 | 642217.0 | 172480.7 | 642219.7 | 189. | 89. | AG | 123. | 100.0 | .0 | 12.0 | .72 | 9.6 |
| 19. WB ARAP THRU1 Que | 172295.0 | 642181.0 | 172483.7 | 642183.7 | 189. | 89. | AG | 123. | 100.0 | .0 | 12.0 | .72 | 9.6 |
| 20. WB ARAP THRU2 Que | 172295.0 | 642193.0 | 172483.7 | 642195.7 | 189. | 89. | AG | 123. | 100.0 | .0 | 12.0 | .72 | 9.6 |
| 21. EB ARAP THRU1 Apr | 172224.0 | 642126.0 | 171820.0 | 642112.0 | 404. | 268. | AG | 689. | 16.1 | .0 | 32.0 | | |
| 22. EB ARAP THRU2 Apr | 172225.0 | 642114.0 | 171821.0 | 642100.0 | 404. | 268. | AG | 689. | 16.1 | .0 | 32.0 | | |
| 23. EB ARAP THRU3 Apr | 172227.0 | 642102.0 | 171821.0 | 642088.0 | 406. | 268. | AG | 689. | 16.1 | .0 | 32.0 | | |
| 24. EB ARAP THRU4 Apr | 172227.0 | 642090.0 | 171822.0 | 642076.0 | 405. | 268. | AG | 689. | 16.1 | .0 | 32.0 | | |
| 25. NB YOS THRU1 Apr | 172243.0 | 642153.0 | 172242.0 | 641613.0 | 540. | 180. | AG | 800. | 16.1 | .0 | 32.0 | | |
| 26. NB YOS THRU2 Apr | 172255.0 | 642154.0 | 172254.0 | 641613.0 | 541. | 180. | AG | 800. | 16.1 | .0 | 32.0 | | |
| 27. SB YOS THRU1 Apr | 172202.0 | 642240.0 | 172201.0 | 641614.0 | 626. | 180. | AG | 975. | 16.1 | .0 | 32.0 | | |
| 28. SB YOS THRU2 Apr | 172189.0 | 642240.0 | 172188.0 | 641614.0 | 626. | 180. | AG | 975. | 16.1 | .0 | 32.0 | | |
| 29. WB ARAP THRU 3 Apr | 172227.0 | 642204.0 | 172857.0 | 642213.0 | 630. | 89. | AG | 733. | 16.1 | .0 | 32.0 | | |
| 30. WB ARAP THRU 4 Apr | 172228.0 | 642216.0 | 172857.0 | 642225.0 | 629. | 89. | AG | 733. | 16.1 | .0 | 32.0 | | |
| 31. WB ARAP THRU1 Apr | 172227.0 | 642180.0 | 172858.0 | 642189.0 | 631. | 89. | AG | 733. | 16.1 | .0 | 32.0 | | |
| 32. WB ARAP THRU2 Apr | 172226.0 | 642192.0 | 172857.0 | 642201.0 | 631. | 89. | AG | 733. | 16.1 | .0 | 32.0 | | |
| 33. EB ARAP THRU1 Dprt | 172853.0 | 642147.0 | 172224.0 | 642126.0 | 629. | 268. | AG | 885. | 16.1 | .0 | 32.0 | | |
| 34. EB ARAP THRU2 Dprt | 172853.0 | 642135.0 | 172225.0 | 642114.0 | 628. | 268. | AG | 885. | 16.1 | .0 | 32.0 | | |
| 35. EB ARAP THRU3 Dprt | 172854.0 | 642123.0 | 172227.0 | 642102.0 | 627. | 268. | AG | 885. | 16.1 | .0 | 32.0 | | |
| 36. EB ARAP THRU4 Dprt | 172854.0 | 642111.0 | 172227.0 | 642090.0 | 627. | 268. | AG | 885. | 16.1 | .0 | 32.0 | | |
| 37. NB YOS THRU1 Dprt | 172244.0 | 642589.0 | 172243.0 | 642153.0 | 436. | 180. | AG | 710. | 16.1 | .0 | 32.0 | | |
| 38. NB YOS THRU2 Dprt | 172256.0 | 642589.0 | 172255.0 | 642154.0 | 435. | 180. | AG | 710. | 16.1 | .0 | 32.0 | | |
| 39. SB YOS THRU1 Dprt | 172203.0 | 642590.0 | 172202.0 | 642240.0 | 350. | 180. | AG | 785. | 16.1 | .0 | 32.0 | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 40. SB YOS THRU2 Dprt | * 172190.0 | 642590.0 | 172189.0 | 642240.0 * | 350. | 180. AG | 785. | 16.1 | .0 | 32.0 | | |
| 41. WB ARAP THRU 3 Dprt | * 171773.0 | 642197.0 | 172227.0 | 642204.0 * | 454. | 89. AG | 681. | 16.1 | .0 | 32.0 | | |
| 42. WB ARAP THRU 4 Dprt | * 171773.0 | 642209.0 | 172228.0 | 642216.0 * | 455. | 89. AG | 681. | 16.1 | .0 | 32.0 | | |
| 43. WB ARAP THRU1 Dprt | * 171774.0 | 642173.0 | 172227.0 | 642180.0 * | 453. | 89. AG | 681. | 16.1 | .0 | 32.0 | | |
| 44. WB ARAP THRU2 Dprt | * 171773.0 | 642185.0 | 172226.0 | 642192.0 * | 453. | 89. AG | 681. | 16.1 | .0 | 32.0 | | |

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JOB: Arapahoe @ Yosemite RUN: Worst Case Combo 2011/2035
DATE: 10/06/2011 TIME: 23:46

LINK VARIABLES

| LINK DESCRIPTION | * LINK COORDINATES (FT) | | | | * LENGTH (FT) | BRG (DEG) | TYPE | VPH | EF (G/MI) | H (FT) | W (FT) | V/C QUEUE (VEH) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | * X1 | Y1 | X2 | Y2 * | | | | | | | | |
| 45. NB I25 | * 172794.0 | 643429.0 | 173857.0 | 641085.0 * | 2574. | 156. | FL | 9000. | 15.6 | 25.0 | 80.0 | |
| 46. NB YOS RT1 | * 172268.0 | 642080.0 | 172266.0 | 641894.0 * | 186. | 181. | AG | 475. | 16.1 | .0 | 32.0 | |
| 47. SB I25 | * 173776.0 | 641070.0 | 172707.0 | 643434.0 * | 2594. | 336. | FL | 9000. | 14.3 | 25.0 | 80.0 | |
| 48. SB YOS RT1 | * 172176.0 | 642243.0 | 172174.0 | 642400.0 * | 157. | 359. | AG | 280. | 16.1 | .0 | 32.0 | |

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JOB: Arapahoe @ Yosemite RUN: Worst Case Combo 2011/2035
DATE: 10/06/2011 TIME: 23:46

ADDITIONAL QUEUE LINK PARAMETERS

| LINK DESCRIPTION | * CYCLE LENGTH (SEC) | RED TIME (SEC) | CLEARANCE LOST TIME (SEC) | APPROACH VOL (VPH) | SATURATION FLOW RATE (VPH) | IDLE EM FAC (gm/hr) | SIGNAL TYPE | ARRIVAL RATE |
|---|---|---|---|---|---|---|---|---|
| 1. EB ARAP LT1 Que | * 120 | 104 | .3 | 130 | 1700 | 83.20 | 1 | 3 |
| 2. EB ARAP LT2 Que | * 120 | 104 | .3 | 130 | 1700 | 83.20 | 1 | 3 |
| 3. EB ARAP THRU1 Que | * 120 | 71 | .4 | 559 | 1700 | 83.20 | 1 | 3 |
| 4. EB ARAP THRU2 Que | * 120 | 71 | .4 | 559 | 1700 | 83.20 | 1 | 3 |
| 5. EB ARAP THRU3 Que | * 120 | 71 | .4 | 559 | 1700 | 83.20 | 1 | 3 |
| 6. EB ARAP THRU4 Que | * 120 | 71 | .4 | 559 | 1700 | 83.20 | 1 | 3 |
| 7. NB YOS LT1 Que | * 120 | 100 | .3 | 168 | 1700 | 83.20 | 1 | 3 |
| 8. NB YOS LT2 Que | * 120 | 100 | .3 | 168 | 1700 | 83.20 | 1 | 3 |
| 9. NB YOS THRU1 Que | * 120 | 89 | .4 | 395 | 1700 | 83.20 | 1 | 3 |
| 10. NB YOS THRU2 Que | * 120 | 89 | .4 | 395 | 1700 | 83.20 | 1 | 3 |
| 11. SB YOS LT1 Que | * 120 | 87 | .4 | 415 | 1700 | 83.20 | 1 | 3 |
| 12. SB YOS LT2 Que | * 120 | 87 | .3 | 415 | 1700 | 83.20 | 1 | 3 |
| 13. SB YOS THRU1 Que | * 120 | 76 | .1 | 420 | 1700 | 83.20 | 1 | 3 |
| 14. SB YOS THRU2 Que | * 120 | 76 | .4 | 420 | 1700 | 83.20 | 1 | 3 |
| 15. WB ARAP LT1 Que | * 120 | 99 | .3 | 235 | 1700 | 83.20 | 1 | 3 |
| 16. WB ARAP LT2 Que | * 120 | 99 | .3 | 235 | 1700 | 83.20 | 1 | 3 |
| 17. WB ARAP THRU 3 Que | * 120 | 66 | .4 | 523 | 1700 | 83.20 | 1 | 3 |
| 18. WB ARAP THRU 4 Que | * 120 | 66 | .4 | 523 | 1700 | 83.20 | 1 | 3 |
| 19. WB ARAP THRU1 Que | * 120 | 66 | .4 | 523 | 1700 | 83.20 | 1 | 3 |
| 20. WB ARAP THRU2 Que | * 120 | 66 | .4 | 523 | 1700 | 83.20 | 1 | 3 |

RECEPTOR LOCATIONS

| RECEPTOR | * COORDINATES (FT) X | Y | Z * |
|---|---|---|---|

| | | | | | |
|---|---|---|---|---|---|
| 1. | R-01 | * | 172065.0 | 642230.0 | 6.0 * |
| 2. | R-02 | * | 172115.0 | 642231.0 | 6.0 * |
| 3. | R-03 | * | 172158.0 | 642286.0 | 6.0 * |
| 4. | R-04 | * | 172157.0 | 642336.0 | 6.0 * |
| 5. | R-05 | * | 172301.0 | 642233.0 | 6.0 * |
| 6. | R-06 | * | 172342.0 | 642235.0 | 6.0 * |
| 7. | R-07 | * | 172391.0 | 642235.0 | 6.0 * |
| 8. | R-08 | * | 172271.0 | 642282.0 | 6.0 * |
| 9. | R-09 | * | 172272.0 | 642332.0 | 6.0 * |
| 10. | R-10 | * | 172161.0 | 642247.0 | 6.0 * |
| 11. | R-11 | * | 172147.0 | 642070.0 | 6.0 * |
| 12. | R-12 | * | 172104.0 | 642070.0 | 6.0 * |
| 13. | R-13 | * | 172054.0 | 642067.0 | 6.0 * |
| 14. | R-14 | * | 172173.0 | 642022.0 | 6.0 * |
| 15. | R-15 | * | 172174.0 | 641972.0 | 6.0 * |
| 16. | R-16 | * | 172284.0 | 642026.0 | 6.0 * |
| 17. | R-17 | * | 172284.0 | 642064.0 | 6.0 * |
| 18. | R-18 | * | 172284.0 | 641976.0 | 6.0 * |
| 19. | R-19 | * | 172331.0 | 642076.0 | 6.0 * |
| 20. | R-20 | * | 172381.0 | 642077.0 | 6.0 * |

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JOB: Arapahoe @ Yosemite RUN: Worst Case Combo 2011/2035

MODEL RESULTS

REMARKS : In search of the angle corresponding to the maximum concentration, only the first angle, of the angles with same maximum concentrations, is indicated as maximum.

WIND ANGLE RANGE: 0.-355.

| WIND ANGLE (DEGR) | * | CONCENTRATION (PPM) REC1 | REC2 | REC3 | REC4 | REC5 | REC6 | REC7 | REC8 | REC9 | REC10 | REC11 | REC12 | REC13 | REC14 | REC15 | REC16 | REC17 | REC18 | REC19 | REC20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0. | * | .0 | .1 | .8 | .4 | .2 | .0 | .0 | 1.1 | .9 | .9 | 3.3 | 3.3 | 2.7 | 3.2 | 3.3 | 2.8 | 3.0 | 2.6 | 3.2 | 3.0 |
| 5. | * | .0 | .2 | 1.0 | .7 | .3 | .1 | .2 | .7 | .7 | 1.4 | 3.5 | 3.4 | 2.9 | 3.6 | 3.6 | 2.2 | 3.1 | 2.0 | 3.0 | 3.1 |
| 10. | * | .1 | .4 | 1.4 | 1.1 | .3 | .3 | .3 | .6 | .5 | 1.6 | 3.8 | 3.7 | 3.1 | 4.1 | 4.1 | 2.5 | 2.8 | 2.4 | 3.2 | 3.2 |
| 15. | * | .2 | .9 | 1.6 | 1.5 | .3 | .5 | .5 | .7 | .6 | 1.9 | 3.9 | 4.0 | 3.4 | 4.8 | 4.9 | 2.5 | 3.0 | 2.2 | 3.4 | 3.5 |
| 20. | * | .4 | 1.1 | 2.0 | 1.7 | .5 | .7 | .7 | .7 | .7 | 2.4 | 4.0 | 4.2 | 3.7 | 5.1 | 5.3 | 2.6 | 3.3 | 2.5 | 3.7 | 3.8 |
| 25. | * | .9 | 1.4 | 2.4 | 2.1 | .7 | .8 | .9 | .8 | .8 | 2.6 | 4.3 | 4.4 | 4.1 | 4.7 | 5.1 | 2.8 | 3.6 | 2.7 | 3.8 | 3.9 |
| 30. | * | 1.2 | 1.8 | 2.6 | 2.6 | .9 | 1.0 | 1.0 | .9 | .9 | 2.7 | 4.8 | 4.5 | 4.5 | 5.1 | 5.6 | 2.8 | 3.6 | 2.6 | 4.2 | 4.0 |
| 35. | * | 1.4 | 1.9 | 2.8 | 2.6 | 1.0 | 1.0 | 1.2 | 1.1 | 1.1 | 2.9 | 4.5 | 5.0 | 4.8 | 5.2 | 5.5 | 3.0 | 3.8 | 2.7 | 4.2 | 4.0 |
| 40. | * | 1.6 | 1.9 | 2.7 | 2.6 | 1.0 | 1.0 | 1.2 | 1.1 | 1.0 | 2.9 | 4.4 | 5.1 | 5.0 | 6.0 | 6.0 | 3.0 | 3.9 | 2.5 | 4.3 | 4.0 |
| 45. | * | 1.7 | 1.9 | 2.8 | 2.8 | 1.0 | 1.0 | 1.2 | 1.0 | 1.0 | 3.1 | 4.6 | 5.0 | 4.9 | 5.7 | 6.0 | 2.9 | 3.9 | 2.3 | 4.3 | 3.8 |
| 50. | * | 1.7 | 2.0 | 2.8 | 2.8 | 1.1 | 1.0 | 1.2 | 1.0 | 1.0 | 2.8 | 5.4 | 4.7 | 5.0 | 5.7 | 5.6 | 2.9 | 4.0 | 2.2 | 4.3 | 3.8 |
| 55. | * | 1.7 | 2.0 | 2.8 | 2.8 | 1.1 | 1.1 | 1.2 | 1.0 | 1.0 | 2.8 | 5.4 | 5.3 | 5.2 | 5.8 | 5.2 | 2.7 | 4.0 | 2.2 | 4.3 | 3.7 |
| 60. | * | 1.7 | 2.1 | 2.7 | 2.7 | 1.1 | 1.1 | 1.2 | 1.0 | 1.0 | 2.8 | 5.5 | 5.7 | 5.2 | 5.9 | 4.8 | 2.5 | 3.9 | 2.2 | 4.3 | 3.9 |
| 65. | * | 1.6 | 2.0 | 2.7 | 2.7 | 1.1 | 1.1 | 1.2 | 1.0 | 1.0 | 2.7 | 5.7 | 5.8 | 5.9 | 5.8 | 4.7 | 2.5 | 3.6 | 2.2 | 4.1 | 3.9 |
| 70. | * | 1.5 | 2.1 | 2.7 | 2.7 | 1.2 | 1.2 | 1.3 | 1.0 | 1.0 | 2.7 | 5.8 | 5.6 | 5.6 | 5.8 | 4.5 | 2.4 | 3.5 | 1.9 | 3.9 | 3.9 |
| 75. | * | 1.8 | 2.3 | 2.7 | 2.7 | 1.6 | 1.5 | 1.5 | 1.0 | 1.0 | 2.8 | 5.7 | 5.3 | 5.2 | 5.5 | 4.0 | 2.3 | 3.2 | 1.5 | 3.8 | 3.6 |
| 80. | * | 2.4 | 2.5 | 2.7 | 2.7 | 2.1 | 1.9 | 2.1 | 1.0 | 1.0 | 2.9 | 5.3 | 4.9 | 4.7 | 5.3 | 3.5 | 1.8 | 3.0 | 1.4 | 3.5 | 3.5 |
| 85. | * | 3.1 | 3.1 | 2.9 | 2.7 | 2.5 | 2.3 | 2.4 | 1.2 | 1.0 | 3.5 | 5.1 | 4.7 | 4.5 | 4.7 | 3.4 | 1.5 | 2.5 | 1.2 | 3.1 | 2.9 |
| 90. | * | 4.0 | 4.3 | 3.1 | 2.8 | 3.2 | 2.9 | 3.0 | 1.4 | 1.0 | 3.7 | 4.6 | 3.9 | 4.0 | 4.6 | 3.0 | 1.4 | 2.0 | 1.0 | 2.5 | 2.3 |

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 95. | * | 4.2 | 4.5 | 3.7 | 3.1 | 4.0 | 3.7 | 3.5 | 1.7 | 1.3 | 4.6 | 4.1 | 3.4 | 3.1 | 4.4 | 2.8 | 1.2 | 1.7 | 1.0 | 1.9 | 1.9 |
| 100. | * | 4.6 | 4.7 | 4.1 | 3.2 | 4.5 | 4.3 | 4.0 | 2.3 | 1.4 | 4.9 | 3.8 | 2.9 | 2.9 | 4.1 | 2.8 | 1.0 | 1.4 | 1.0 | 1.6 | 1.5 |
| 105. | * | 4.8 | 5.0 | 4.6 | 3.7 | 5.0 | 4.6 | 4.5 | 2.6 | 1.7 | 5.1 | 3.5 | 2.6 | 2.5 | 4.1 | 2.8 | 1.0 | 1.1 | 1.0 | 1.3 | 1.3 |
| 110. | * | 4.5 | 4.8 | 4.6 | 4.0 | 5.2 | 5.0 | 4.6 | 2.7 | 2.0 | 5.2 | 3.4 | 2.3 | 2.2 | 4.0 | 2.8 | 1.0 | 1.0 | .8 | 1.2 | 1.1 |
| 115. | * | 4.5 | 4.6 | 4.7 | 4.3 | 5.2 | 5.0 | 4.8 | 3.1 | 2.1 | 4.9 | 3.3 | 2.1 | 2.0 | 3.8 | 2.6 | .8 | .8 | .8 | 1.1 | 1.1 |
| 120. | * | 3.7 | 4.5 | 4.6 | 4.2 | 5.4 | 4.9 | 4.6 | 3.3 | 2.4 | 4.5 | 3.0 | 2.1 | 1.7 | 3.5 | 2.4 | .6 | .7 | .6 | .9 | .9 |
| 125. | * | 3.7 | 4.0 | 4.6 | 4.0 | 5.1 | 4.7 | 4.6 | 3.2 | 2.3 | 4.2 | 2.8 | 1.9 | 1.1 | 3.3 | 2.3 | .4 | .5 | .4 | .7 | .6 |
| 130. | * | 3.8 | 3.2 | 3.8 | 3.6 | 4.6 | 4.5 | 4.3 | 2.9 | 2.3 | 3.9 | 2.5 | 1.7 | 1.0 | 3.3 | 2.3 | .2 | .2 | .2 | .3 | .4 |
| 135. | * | 3.8 | 3.5 | 3.1 | 3.2 | 4.2 | 4.1 | 4.0 | 2.6 | 2.0 | 3.5 | 2.4 | 1.4 | .8 | 3.1 | 2.2 | .1 | .1 | .0 | .2 | .2 |
| 140. | * | 3.6 | 4.0 | 3.0 | 2.9 | 4.0 | 4.0 | 3.8 | 2.6 | 1.8 | 2.8 | 2.4 | 1.3 | .8 | 3.1 | 2.3 | .0 | .0 | .0 | .0 | .0 |
| 145. | * | 3.6 | 3.9 | 2.9 | 3.0 | 3.9 | 3.8 | 3.7 | 2.2 | 1.6 | 3.5 | 2.3 | 1.2 | .8 | 3.1 | 2.3 | .0 | .0 | .0 | .0 | .0 |
| 150. | * | 3.5 | 3.6 | 3.1 | 2.7 | 3.8 | 3.7 | 3.8 | 2.2 | 1.6 | 3.8 | 2.0 | 1.1 | .6 | 2.9 | 2.4 | .0 | .0 | .0 | .0 | .0 |
| 155. | * | 3.4 | 3.5 | 3.3 | 3.2 | 3.7 | 3.7 | 3.7 | 2.1 | 1.6 | 4.1 | 1.8 | 1.0 | .6 | 2.9 | 2.5 | .1 | .1 | .0 | .0 | .0 |
| 160. | * | 3.3 | 3.6 | 3.5 | 3.2 | 3.7 | 3.7 | 3.7 | 2.0 | 1.5 | 4.2 | 1.7 | .7 | .5 | 2.9 | 2.4 | .1 | .1 | .1 | .0 | .0 |
| 165. | * | 2.9 | 3.7 | 3.2 | 3.3 | 3.7 | 3.7 | 3.7 | 2.2 | 1.8 | 3.9 | 1.5 | .6 | .2 | 2.6 | 2.4 | .2 | .2 | .2 | .0 | .0 |
| 170. | * | 2.5 | 3.4 | 3.2 | 3.0 | 3.8 | 3.6 | 3.7 | 2.7 | 2.3 | 3.8 | 1.0 | .5 | .2 | 2.4 | 2.1 | .5 | .6 | .4 | .0 | .0 |
| 175. | * | 2.4 | 3.1 | 3.0 | 2.4 | 4.1 | 3.8 | 3.8 | 2.8 | 2.2 | 3.6 | .9 | .2 | .0 | 1.9 | 1.8 | .7 | .8 | .6 | .0 | .0 |
| 180. | * | 2.3 | 2.6 | 2.6 | 2.3 | 4.2 | 3.9 | 3.8 | 3.1 | 2.4 | 2.9 | .6 | .2 | .0 | 1.6 | 1.6 | 1.3 | 1.3 | 1.1 | .2 | .0 |
| 185. | * | 2.0 | 2.6 | 2.6 | 2.0 | 4.3 | 4.2 | 3.9 | 3.6 | 3.0 | 2.9 | .3 | .0 | .0 | 1.2 | 1.1 | 1.8 | 1.8 | 1.5 | .4 | .0 |
| 190. | * | 2.0 | 2.4 | 2.1 | 1.8 | 4.7 | 4.4 | 4.1 | 3.5 | 3.4 | 2.4 | .2 | .0 | .0 | .8 | .8 | 2.0 | 2.4 | 1.9 | .8 | .2 |
| 195. | * | 2.0 | 2.4 | 1.9 | 1.6 | 4.6 | 4.6 | 4.3 | 4.0 | 3.4 | 2.3 | .0 | .0 | .0 | .5 | .5 | 2.4 | 2.5 | 2.2 | .9 | .4 |
| 200. | * | 2.1 | 2.4 | 1.8 | 1.4 | 4.4 | 4.8 | 4.5 | 4.1 | 3.4 | 2.3 | .0 | .0 | .0 | .3 | .3 | 2.6 | 2.8 | 2.5 | 1.1 | .6 |
| 205. | * | 2.1 | 2.3 | 1.8 | 1.4 | 4.1 | 5.0 | 4.6 | 3.4 | 3.2 | 2.2 | .0 | .0 | .0 | .2 | .2 | 2.6 | 2.8 | 2.5 | 1.4 | .7 |

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JOB: Arapahoe @ Yosemite RUN: Worst Case Combo 2011/2035

| WIND ANGLE (DEGR) | * | CONCENTRATION (PPM) REC1 | REC2 | REC3 | REC4 | REC5 | REC6 | REC7 | REC8 | REC9 | REC10 | REC11 | REC12 | REC13 | REC14 | REC15 | REC16 | REC17 | REC18 | REC19 | REC20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 210. | * | 2.2 | 2.4 | 1.8 | 1.2 | 4.4 | 4.9 | 4.9 | 3.1 | 2.9 | 2.1 | .0 | .0 | .0 | .1 | .1 | 2.6 | 2.9 | 2.6 | 1.4 | .9 |
| 215. | * | 2.3 | 2.4 | 1.8 | 1.2 | 3.8 | 4.7 | 5.1 | 3.4 | 3.3 | 2.1 | .0 | .0 | .0 | .1 | .1 | 2.6 | 2.9 | 2.6 | 1.5 | 1.0 |
| 220. | * | 2.4 | 2.4 | 1.7 | 1.1 | 3.4 | 4.9 | 4.9 | 3.4 | 3.4 | 2.1 | .0 | .0 | .0 | .1 | .1 | 2.7 | 3.0 | 2.6 | 1.6 | 1.1 |
| 225. | * | 2.4 | 2.4 | 1.6 | 1.0 | 3.6 | 4.3 | 4.9 | 3.5 | 3.2 | 2.2 | .0 | .0 | .0 | .1 | .1 | 2.7 | 3.1 | 2.5 | 1.6 | 1.2 |
| 230. | * | 2.1 | 2.4 | 1.5 | .9 | 3.9 | 4.1 | 4.7 | 3.4 | 3.3 | 2.1 | .0 | .1 | .0 | .1 | .1 | 2.5 | 3.0 | 2.3 | 1.6 | 1.2 |
| 235. | * | 2.1 | 2.5 | 1.3 | .6 | 4.1 | 4.3 | 4.5 | 3.6 | 3.0 | 2.0 | .1 | .1 | .1 | .0 | .1 | 2.6 | 2.9 | 2.2 | 1.9 | 1.5 |
| 240. | * | 2.0 | 2.2 | 1.2 | .4 | 4.1 | 4.0 | 4.7 | 3.3 | 2.7 | 1.9 | .1 | .1 | .1 | .0 | .0 | 2.7 | 2.9 | 2.2 | 1.9 | 1.3 |
| 245. | * | 2.0 | 2.2 | .9 | .4 | 3.9 | 4.2 | 4.6 | 3.1 | 2.5 | 1.7 | .1 | .1 | .1 | .0 | .0 | 2.8 | 2.9 | 2.2 | 1.9 | 1.5 |
| 250. | * | 1.9 | 2.1 | .6 | .4 | 3.9 | 4.2 | 4.1 | 2.8 | 2.1 | 1.5 | .3 | .3 | .2 | .0 | .0 | 2.8 | 3.0 | 2.2 | 2.1 | 1.4 |
| 255. | * | 1.6 | 1.7 | .5 | .3 | 3.8 | 3.9 | 3.9 | 2.4 | 2.0 | 1.2 | .5 | .5 | .4 | .0 | .0 | 2.7 | 3.0 | 2.0 | 2.2 | 1.6 |
| 260. | * | 1.6 | 1.6 | .4 | .1 | 3.3 | 3.2 | 3.5 | 2.2 | 1.9 | 1.1 | .9 | .9 | .6 | .0 | .0 | 2.8 | 3.5 | 2.1 | 2.7 | 2.1 |
| 265. | * | 1.2 | 1.3 | .3 | .0 | 2.4 | 2.4 | 2.6 | 2.1 | 1.7 | .7 | 1.4 | 1.4 | 1.2 | .1 | .0 | 3.1 | 3.8 | 2.1 | 3.0 | 2.9 |
| 270. | * | 1.0 | 1.2 | .1 | .0 | 2.4 | 2.3 | 2.3 | 2.1 | 1.7 | .5 | 2.0 | 2.0 | 1.5 | .2 | .0 | 3.4 | 4.1 | 2.5 | 3.5 | 3.4 |
| 275. | * | .7 | .8 | .0 | .0 | 2.0 | 1.9 | 1.8 | 1.8 | 1.6 | .4 | 2.4 | 2.3 | 1.8 | .6 | .0 | 3.7 | 4.3 | 2.6 | 3.9 | 4.0 |
| 280. | * | .4 | .5 | .0 | .0 | 1.7 | 1.4 | 1.4 | 1.7 | 1.6 | .2 | 2.9 | 2.8 | 2.3 | .8 | .1 | 4.0 | 4.7 | 3.0 | 4.4 | 3.5 |
| 285. | * | .3 | .3 | .0 | .0 | 1.4 | 1.1 | .9 | 1.7 | 1.6 | .0 | 3.4 | 3.2 | 2.8 | 1.0 | .3 | 4.2 | 4.8 | 3.3 | 4.2 | 3.7 |
| 290. | * | .1 | .1 | .0 | .0 | 1.2 | .9 | .7 | 1.7 | 1.7 | .0 | 3.6 | 3.5 | 2.9 | 1.5 | .6 | 4.4 | 4.8 | 3.6 | 4.2 | 3.3 |
| 295. | * | .1 | .1 | .0 | .0 | 1.5 | .9 | .7 | 1.8 | 1.8 | .0 | 3.5 | 3.5 | 3.2 | 1.8 | .8 | 4.7 | 4.7 | 4.2 | 4.0 | 3.2 |
| 300. | * | .1 | .1 | .0 | .0 | 1.5 | .9 | .7 | 1.8 | 1.7 | .0 | 3.5 | 3.5 | 3.2 | 1.8 | 1.3 | 4.7 | 4.5 | 4.2 | 3.5 | 3.3 |
| 305. | * | .1 | .0 | .0 | .0 | 1.5 | .9 | .7 | 1.9 | 1.8 | .0 | 3.5 | 3.4 | 3.3 | 1.9 | 1.4 | 4.8 | 4.1 | 4.3 | 3.5 | 3.4 |
| 310. | * | .0 | .0 | .0 | .0 | 1.3 | .9 | .6 | 1.9 | 1.8 | .0 | 3.6 | 3.3 | 3.2 | 2.0 | 1.4 | 4.5 | 3.9 | 4.5 | 3.1 | 3.4 |
| 315. | * | .0 | .0 | .0 | .0 | 1.4 | 1.0 | .6 | 2.0 | 1.9 | .0 | 3.4 | 3.3 | 3.2 | 2.1 | 1.4 | 4.0 | 3.4 | 4.6 | 3.3 | 3.3 |
| 320. | * | .0 | .0 | .0 | .0 | 1.4 | 1.0 | .6 | 2.1 | 2.0 | .0 | 3.3 | 3.2 | 3.0 | 2.1 | 1.3 | 4.0 | 3.6 | 4.4 | 3.6 | 3.4 |

| | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 325. | * | .0 | .0 | .0 | .0 | 1.4 | .8 | .6 | 2.2 | 2.0 | .0 | 3.2 | 2.9 | 2.9 | 2.1 | 1.3 | 3.7 | 3.7 | 4.1 | 3.6 | 3.6 |
| 330. | * | .0 | .0 | .0 | .0 | 1.4 | .8 | .6 | 2.2 | 2.0 | .0 | 3.2 | 3.0 | 2.7 | 1.9 | 1.5 | 3.9 | 3.7 | 4.1 | 3.1 | 3.7 |
| 335. | * | .0 | .0 | .0 | .0 | 1.4 | .8 | .4 | 2.2 | 2.0 | .1 | 3.1 | 3.0 | 2.7 | 2.0 | 1.6 | 3.6 | 3.7 | 4.2 | 3.1 | 3.6 |
| 340. | * | .0 | .0 | .0 | .0 | 1.2 | .7 | .2 | 2.1 | 2.0 | .1 | 3.1 | 2.9 | 2.7 | 1.9 | 1.8 | 3.6 | 3.6 | 4.1 | 3.2 | 3.5 |
| 345. | * | .0 | .0 | .2 | .0 | .9 | .4 | .1 | 2.0 | 1.7 | .2 | 3.1 | 3.0 | 2.7 | 2.4 | 2.0 | 3.3 | 3.4 | 3.0 | 3.6 | 3.4 |
| 350. | * | .0 | .0 | .3 | .2 | .9 | .2 | .0 | 1.8 | 1.5 | .3 | 3.2 | 3.1 | 2.7 | 2.7 | 2.7 | 3.1 | 3.2 | 3.2 | 3.6 | 3.1 |
| 355. | * | .0 | .0 | .4 | .3 | .5 | .2 | .0 | 1.5 | 1.3 | .6 | 3.4 | 3.1 | 2.7 | 3.1 | 2.9 | 2.6 | 3.3 | 2.9 | 3.3 | 3.0 |
| MAX | * | 4.8 | 5.0 | 4.7 | 4.3 | 5.4 | 5.0 | 5.1 | 4.1 | 3.4 | 5.2 | 5.8 | 5.8 | 5.9 | 6.0 | 6.0 | 4.8 | 4.8 | 4.6 | 4.4 | 4.0 |
| DEGR. | * | 105 | 105 | 115 | 115 | 120 | 110 | 215 | 200 | 195 | 110 | 70 | 65 | 65 | 40 | 40 | 305 | 290 | 315 | 280 | 30 |

THE HIGHEST CONCENTRATION IS 6.00 AT 40 DEGREES FROM REC14.

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JOB: Arapahoe @ Yosemite RUN: Worst Case Combo 2011/2035
DATE: 10/06/2011 TIME: 23:46
RECEPTOR - LINK MATRIX FOR THE ANGLE PRODUCING
THE MAXIMUM CONCENTRATION FOR EACH RECEPTOR
* CO/LINK (PPM)
* ANGLE (DEGREES)

| LINK # | * | REC1 105 | REC2 105 | REC3 115 | REC4 115 | REC5 120 | REC6 110 | REC7 215 | REC8 200 | REC9 195 | REC10 110 | REC11 70 | REC12 65 | REC13 65 | REC14 40 | REC15 40 | REC16 305 | REC17 290 | REC18 315 | REC19 280 | REC20 30 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | * | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .1 | .1 | .1 | .0 | .0 |
| 2 | * | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .1 | .0 | .0 | .1 | .1 | .1 | .1 | .0 |
| 3 | * | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .1 | .0 | .0 | .1 | .1 | .1 | .1 | .0 |
| 4 | * | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .1 | .2 | .0 | .0 | .1 | .1 | .1 | .1 | .0 |
| 5 | * | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .2 | .3 | .0 | .0 | .1 | .1 | .1 | .1 | .0 |
| 6 | * | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .4 | .4 | .0 | .0 | .1 | .1 | .1 | .1 | .0 |
| 7 | * | .0 | .0 | .0 | .0 | .0 | .0 | .1 | .1 | .0 | .0 | .0 | .0 | .0 | .2 | .3 | .2 | .1 | .2 | .1 | .0 |
| 8 | * | .0 | .0 | .0 | .0 | .0 | .0 | .1 | .1 | .0 | .0 | .0 | .0 | .0 | .1 | .2 | .2 | .1 | .3 | .1 | .0 |
| 9 | * | .0 | .0 | .0 | .0 | .0 | .0 | .1 | .1 | .1 | .0 | .0 | .0 | .0 | .1 | .2 | .3 | .2 | .3 | .1 | .0 |
| 10 | * | .0 | .0 | .0 | .0 | .0 | .0 | .1 | .1 | .1 | .0 | .0 | .0 | .0 | .0 | .1 | .4 | .2 | .4 | .1 | .0 |
| 11 | * | .0 | .0 | .2 | .2 | .0 | .0 | .0 | .0 | .1 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 12 | * | .0 | .0 | .2 | .2 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 13 | * | .0 | .0 | .0 | .0 | .0 | .0 | .1 | .1 | .1 | .0 | .2 | .1 | .1 | .3 | .3 | .2 | .2 | .2 | .1 | .0 |
| 14 | * | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .1 | .1 | .0 | .2 | .2 | .1 | .5 | .4 | .1 | .1 | .2 | .1 | .0 |
| 15 | * | .1 | .1 | .1 | .0 | .2 | .0 | .2 | .0 | .0 | .1 | .1 | .1 | .1 | .1 | .1 | .0 | .0 | .0 | .0 | .2 |
| 16 | * | .1 | .1 | .1 | .1 | .2 | .1 | .2 | .0 | .0 | .1 | .1 | .1 | .1 | .1 | .1 | .0 | .0 | .0 | .0 | .1 |
| 17 | * | .0 | .1 | .1 | .1 | .3 | .3 | .3 | .0 | .0 | .1 | .1 | .1 | .1 | .1 | .1 | .0 | .0 | .0 | .0 | .1 |
| 18 | * | .0 | .1 | .1 | .1 | .5 | .4 | .4 | .0 | .0 | .1 | .0 | .1 | .1 | .1 | .1 | .0 | .0 | .0 | .0 | .1 |
| 19 | * | .1 | .1 | .1 | .1 | .2 | .1 | .2 | .0 | .0 | .1 | .1 | .1 | .1 | .1 | .1 | .0 | .0 | .0 | .0 | .1 |
| 20 | * | .1 | .1 | .1 | .1 | .3 | .2 | .2 | .0 | .0 | .1 | .1 | .1 | .1 | .1 | .1 | .0 | .0 | .0 | .0 | .1 |
| 21 | * | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .1 | .1 | .0 | .1 | .2 | .2 | .0 | .0 | .2 | .2 | .1 | .2 | .0 |
| 22 | * | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .1 | .1 | .0 | .1 | .3 | .3 | .0 | .0 | .2 | .3 | .1 | .2 | .0 |
| 23 | * | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .1 | .1 | .0 | .3 | .4 | .4 | .1 | .0 | .2 | .3 | .1 | .2 | .0 |
| 24 | * | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .1 | .1 | .0 | .5 | .6 | .6 | .1 | .0 | .2 | .3 | .1 | .2 | .0 |
| 25 | * | .0 | .0 | .0 | .0 | .0 | .0 | .2 | .2 | .1 | .0 | .2 | .1 | .1 | .2 | .2 | .3 | .3 | .4 | .2 | .0 |
| 26 | * | .0 | .0 | .0 | .0 | .0 | .0 | .2 | .1 | .1 | .0 | .2 | .1 | .1 | .2 | .2 | .4 | .4 | .4 | .2 | .0 |
| 27 | * | .2 | .2 | .0 | .0 | .0 | .0 | .2 | .4 | .3 | .3 | .3 | .2 | .2 | .6 | .6 | .3 | .2 | .3 | .2 | .0 |
| 28 | * | .2 | .2 | .0 | .0 | .0 | .0 | .2 | .3 | .3 | .3 | .4 | .2 | .2 | .8 | .8 | .2 | .2 | .2 | .2 | .0 |
| 29 | * | .1 | .2 | .2 | .2 | .5 | .5 | .4 | .1 | .1 | .3 | .2 | .2 | .1 | .1 | .1 | .0 | .0 | .0 | .0 | .1 |
| 30 | * | .1 | .2 | .2 | .2 | .7 | .7 | .5 | .2 | .1 | .3 | .1 | .1 | .1 | .1 | .1 | .0 | .0 | .0 | .0 | .1 |
| 31 | * | .2 | .2 | .2 | .1 | .3 | .3 | .3 | .1 | .1 | .3 | .2 | .2 | .1 | .1 | .1 | .0 | .0 | .0 | .0 | .2 |

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 32 | * | .2 | .2 | .2 | .2 | .4 | .4 | .3 | .1 | .1 | .3 | .2 | .2 | .1 | .1 | .1 | .0 | .0 | .0 | .0 | .2 |
| 33 | * | .2 | .2 | .2 | .1 | .2 | .2 | .2 | .1 | .1 | .2 | .3 | .2 | .1 | .2 | .2 | .0 | .0 | .0 | .1 | .3 |
| 34 | * | .2 | .2 | .2 | .1 | .2 | .2 | .2 | .1 | .0 | .2 | .3 | .2 | .1 | .2 | .2 | .0 | .0 | .0 | .1 | .4 |
| 35 | * | .2 | .2 | .1 | .1 | .2 | .2 | .2 | .0 | .0 | .2 | .3 | .1 | .1 | .2 | .2 | .0 | .1 | .0 | .3 | .4 |
| 36 | * | .2 | .2 | .1 | .1 | .2 | .2 | .1 | .0 | .0 | .2 | .3 | .1 | .1 | .2 | .2 | .1 | .3 | .0 | .7 | .6 |
| 37 | * | .1 | .1 | .2 | .2 | .0 | .0 | .0 | .4 | .4 | .2 | .0 | .0 | .1 | .1 | .0 | .0 | .0 | .0 | .0 | .0 |
| 38 | * | .1 | .1 | .2 | .2 | .0 | .0 | .0 | .7 | .7 | .2 | .0 | .0 | .1 | .1 | .0 | .0 | .0 | .0 | .0 | .0 |
| 39 | * | .0 | .0 | .3 | .3 | .0 | .0 | .0 | .0 | .0 | .1 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 40 | * | .0 | .0 | .4 | .4 | .0 | .0 | .0 | .0 | .0 | .1 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 41 | * | .4 | .3 | .0 | .0 | .0 | .0 | .0 | .1 | .0 | .1 | .0 | .0 | .0 | .0 | .0 | .1 | .1 | .1 | .1 | .0 |
| 42 | * | .6 | .6 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .2 | .0 | .0 | .0 | .0 | .0 | .1 | .1 | .1 | .1 | .0 |
| 43 | * | .2 | .1 | .0 | .0 | .0 | .0 | .0 | .1 | .1 | .0 | .0 | .0 | .1 | .0 | .0 | .1 | .1 | .1 | .1 | .0 |
| 44 | * | .2 | .2 | .0 | .0 | .0 | .0 | .0 | .1 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .1 | .1 | .1 | .1 | .0 |
| 45 | * | .5 | .5 | .5 | .5 | .5 | .6 | .0 | .0 | .0 | .5 | .5 | .4 | .4 | .4 | .4 | .0 | .0 | .0 | .0 | .5 |

1

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JOB: Arapahoe @ Yosemite RUN: Worst Case Combo 2011/2035

* CO/LINK (PPM)

* ANGLE (DEGREES)

| LINK # | * | REC1 | REC2 | REC3 | REC4 | REC5 | REC6 | REC7 | REC8 | REC9 | REC10 | REC11 | REC12 | REC13 | REC14 | REC15 | REC16 | REC17 | REC18 | REC19 | REC20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | * | 105 | 105 | 115 | 115 | 120 | 110 | 215 | 200 | 195 | 110 | 70 | 65 | 65 | 40 | 40 | 305 | 290 | 315 | 280 | 30 |
| 46 | * | .0 | .0 | .0 | .0 | .0 | .0 | .1 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .1 | .3 | .3 | .3 | .1 | .0 |
| 47 | * | .5 | .5 | .5 | .5 | .5 | .6 | .0 | .0 | .0 | .5 | .4 | .4 | .4 | .4 | .4 | .0 | .0 | .0 | .0 | .5 |
| 48 | * | .0 | .0 | .2 | .2 | .0 | .0 | .0 | .0 | .0 | .1 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |

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I-25/Arapahoe Interchange

Environmental Assessment

# Traffic Noise and Vibration Impact Assessment Technical Report for I-25 / Arapahoe Road Interchange Environmental Assessment

**April, 2012**

**Prepared for:**

Colorado Department of Transportation
Federal Highway Administration
Arapahoe County
City of Centennial
City of Greenwood Village

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Arapahoe County Project C07-010
FHU Project No. 10-025

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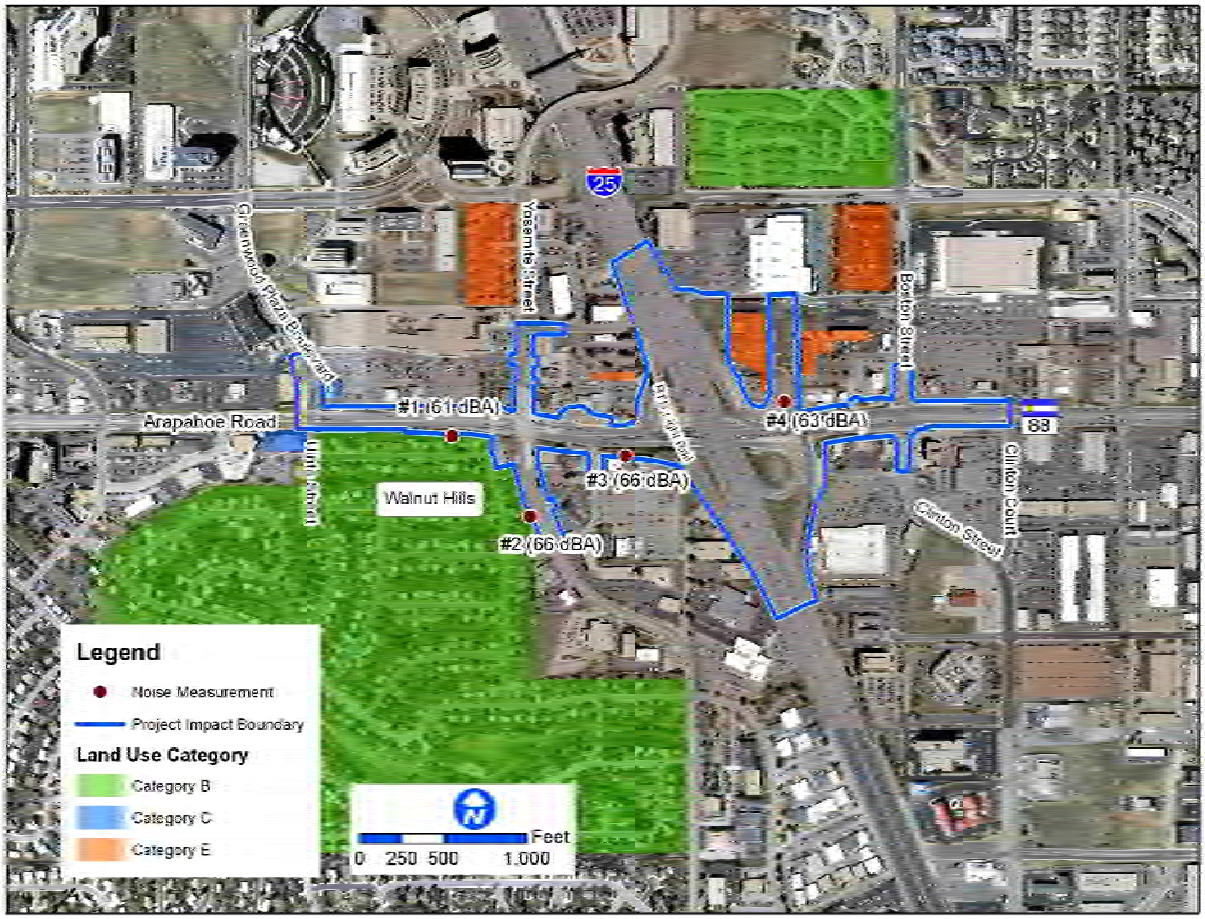
# APPENDICES

# 1.0 INTRODUCTION

The National Environmental Policy Act (NEPA) of 1969 established a mandate for federal agencies to consider the potential environmental consequences of their proposed actions, to document the analysis, and to make the information available to the public for comment prior to implementation. In accordance with NEPA and related regulations, the Federal Highway Administration (FHWA), as the Lead Agency, in cooperation with the Colorado Department of Transportation (CDOT) as a Joint Lead Agency, has prepared this Environmental Assessment (EA) for proposed improvements to the Interstate 25 (I-25) interchange with Arapahoe Road/State Highway (SH) 88 in Arapahoe County, Colorado (**Figure 1**). The project is sponsored by Arapahoe County in cooperation with the City of Centennial and the City of Greenwood Village.

The purpose of the analyses presented in this report is to conclude whether noise or vibration levels at properties (i.e., receptors) near the potential road improvements from the project alternatives may exceed applicable thresholds, according to CDOT or FHWA guidelines. This report presents an overall analysis that was performed as part of the EA to evaluate existing and future traffic noise levels as well as assess potential impacts to properties near the road improvements from noise and vibration from road traffic.

**Figure 1 Project Study Area, Land Uses and Noise Measurement Results**



## 1.1 Project Description

The purpose of the I-25/Arapahoe Road interchange project is to reduce congestion and to improve functional deficiencies and operational and safety elements for the traveling public. The existing design and capacity of the interchange no longer accommodate traffic demands, and this will worsen in the future without action.

The study area straddles I-25 near Milepost 197 and is in both Centennial and Greenwood Village. The study area includes residences, motels and businesses abutting the streets and roads of interest for the project (**Figure 1**). The study area is nearly fully developed at present, with few vacant parcels remaining.

Two future alternatives are being considered in the analysis: the No Action Alternative (No Action) and the Action Alternative. No Action would have no new road improvements as part of this project, though some changes to the current road network may be made by other projects.

The Action Alternative was selected through a robust alternatives-evaluation process conducted earlier for the study area. The design consists of an Improved Partial Cloverleaf Interchange and includes:

- **I-25 Mainline:** The I-25 mainline roadway configuration would be generally unchanged under the Action Alternative. To accommodate the Arapahoe Road lanes beneath I-25, a longer bridge structure would replace the existing structure. The new bridge structure height would be approximately 7 feet higher than the existing structure to accommodate the additional through lanes on Arapahoe Road beneath the structure. The raised structure height would require reconstruction of approximately 1,000 feet of I-25 to the north and south to meet with the existing I-25 mainline lanes. In addition, the I-25 bridge structure would be wider than the existing structure to provide adequate room for temporary lane-alignment shifts during construction. The location of the merge/diverge points along I-25, where on-ramp lanes meet with and off-ramp lanes separate from the mainline lanes, would remain unchanged.
- **I-25 Ramps:** The interchange ramps would be designed to accommodate the 2035 traffic volume projections. Lane configurations along the ramps would generally remain unchanged from existing conditions. The ramps would shift slightly to accommodate the wider I-25 mainline bridge structure. The ramps' heights would increase approximately 1 foot at Arapahoe Road to accommodate a change in height of Arapahoe Road. Ramps would gradually taper to meet with mainline I-25 at the existing merge/diverge points. Both the northbound and southbound off-ramps would be restriped to provide triple left turns onto Arapahoe Road.
- **Arapahoe Road:** Improvements to Arapahoe Road would be designed to meet the requirements of CDOT and local agency design standards. The Action Alternative would include the addition of one eastbound and one westbound through lane between the Yosemite Street and Boston/Clinton Street intersections. Arapahoe Road would also be raised approximately 1 foot within the interchange complex. The Action Alternative would include the following auxiliary lane (turn lane and acceleration/deceleration lane) improvements along Arapahoe Road:
    - An additional westbound lane on Arapahoe Road extending from Dayton Street to the northbound I-25 on-ramp. The additional lane would separate right turning traffic bound for the northbound on-ramp from the lanes leading to the southbound on-ramp loop.
    - An additional westbound lane on Arapahoe Road extending from Yosemite Street to Greenwood Plaza Boulevard.

- Conversion of the eastbound right turn lane on Arapahoe Road at Yosemite Street to a shared through/right lane and extension of the lane to the west approximately 300 feet.
- An eastbound auxiliary acceleration/deceleration lane extending from the northbound off-ramp to Clinton Street.

- **Yosemite Street:** Improvements to Yosemite Street would be designed to meet the requirements of local agency design standards. The Action Alternative would include the following auxiliary lane improvements along Yosemite Street:
  - A second northbound left turn lane on Yosemite Street at Arapahoe Road with complimentary widening of the north leg of Yosemite Street for lane alignment.
  - A northbound right turn lane at Yosemite Court to better accommodate truck access into the northwest quadrant of the interchange.
- **Frontage Road:** The existing frontage road along the east side of I-25 north of Arapahoe Road would be relocated to help facilitate bridge construction phasing and northbound on-ramp modifications. Rather than incurring the cost of reconstruction of the frontage road adjacent to I-25, which provides poor access to businesses in the northeast quadrant, a new road extending straight north of the northbound off-ramp intersection with Arapahoe Road would be constructed. This new roadway would intersect with Southtech Drive on the north. Southtech Drive would terminate just east of I-25. This revised access configuration is consistent with City of Greenwood Village plans and was recommended as part of the Arapahoe Road Corridor Study to provide a long-term solution to access issues in the northeast quadrant of the interchange.
- **Signal Coordination and Timing:** Signal system upgrades would be implemented for the signalized intersections along Arapahoe Road from Quebec Street to Havana Street (potential early action improvement).
- **Sidewalks:** Reconstruction of existing sidewalks would be provided along both the north and south sides of Arapahoe Road from west of Yosemite Street, through the interchange, to east of Boston/Clinton Street. Sidewalk widths would vary from 5 feet to 8 feet in width based on available right-of-way.

## 1.2 *Basics of Sound*

Sound is created when an object vibrates and radiates part of that energy as acoustic pressure or waves through a medium, such as air, water or a solid. Noise is commonly defined as unwanted sound. Sound and noise have many characteristics that are important to consider for impacts, including loudness (energy intensity), frequency, and fluctuations over time.

Sound pressure levels are measured in units of decibels (dB). The dB scale is logarithmic. To illustrate this, consider that two identical noise sources, each producing 60 dB, would produce 63 dB when added together.

The human ear can sense a wide range of sound energy levels, with the maximum levels having more than a million times the sound energy of the minimum levels. The human ear is not equally receptive to all frequencies of sound-producing vibrations. Mathematical adjustments to sound levels by sound frequencies using the “A” weighting network are often used to approximate how the human ear perceives a sound. In simple terms, the weighting consists of reducing the contributions from low and extremely high sound frequencies by a specified amount. Sound levels that have been weighted this way are reported in dBA.

Research has shown that most people do not notice a difference in loudness between sound levels of less than 3 dBA, which corresponds to a two-fold change in the sound energy. Most

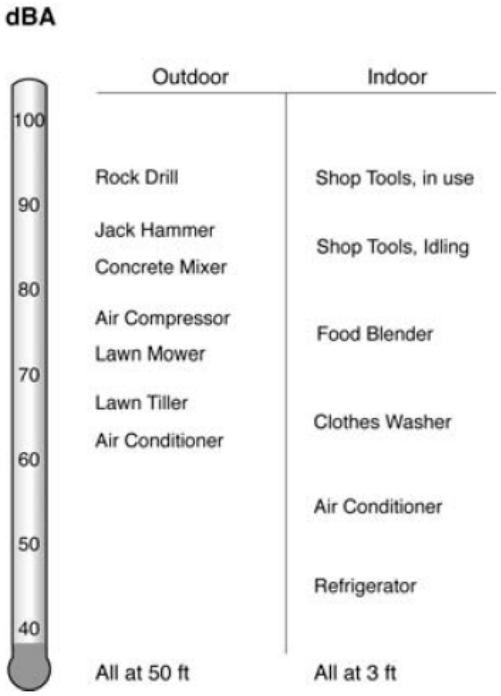
people relate a 10-dBA increase in sound levels to a doubling of sound loudness, though it represents a 10-fold increase in sound energy. Examples of sound levels are shown in **Figure 2**.

Noise often is not constant and fluctuates over time because of the characteristics of the source. For example, traffic noise will fluctuate from changes in traffic volumes, vehicle types and vehicle speeds. This fluctuation makes it difficult to describe adequately the many aspects of noise through a single value, but CDOT uses the one-hour equivalent sound level ($L_{eq}$) as the metric for assessing traffic noise impacts (CDOT, 2011). In simple terms, the $L_{eq}$ is the "average" of the fluctuating noise levels over a time period, or more precisely, it is the constant sound level that would produce the same amount of sound energy overall as the fluctuating noise levels.

Sound levels decrease with distance from the source because of spreading, atmospheric absorption, interference from objects and ground effects. "Hard" ground (such as asphalt) and "soft" ground (such as grass) affect sound transmission differently. "Hard" ground is more reflective and will lead to louder sound levels farther from the source. Using traffic noise passing over "hard" ground as an example, either doubling the traffic volume or cutting the distance from the listener to the roadway in half could cause a 3-dBA increase in noise levels, which would be barely noticeable to most people.

On busy roads and highways, the loudest traffic noise generally occurs when the largest traffic volume can travel at the highest speed, which is not necessarily rush hour because the traffic volume can be so high that roads become congested and speeds slow. This noisiest traffic condition generally corresponds to Level of Service (LOS) C or D for a highway (CDOT, 2011).

**Figure 2 Typical Sound Levels**




Source: FTA, 2006

## 1.3 Basics of Vibration

Ground-borne vibration is the oscillatory motion of the ground about some equilibrium position, and can be described in terms either of displacement, velocity or acceleration. Because human sensitivity to vibration typically corresponds best to the amplitude of vibration velocity within the low frequency range of most concern (approximately 5-100 Hertz), vibration velocity is the preferred measure for evaluating ground-borne vibration from transportation projects.

There are no federal or state requirements directed specifically to traffic-induced vibration. Studies that have been done to assess the impact of traffic vibrations have shown that both measured and predicted traffic vibration levels are less than any known criteria for causing structural damage to buildings (FHWA, 1995). Often, normal indoor activities like closing doors have been shown to create greater levels of vibration in homes than nearby highway traffic. Because of these findings, vibration from road traffic has been concluded not to be a concern within the EA and will not be examined further in this analysis.

Vibration from road construction could be a concern, if high-vibration construction techniques such as pile driving or blasting are used. Issues with construction-generated vibrations would depend on high-vibration activities occurring close to vibration-sensitive locations (**Section 1.1**). It is not known if these types of construction techniques would be used by a contractor near sensitive properties. If such construction techniques are necessary at a specific location, the vibration concerns will be addressed during construction planning on a case-by-case basis and appropriate abatement action taken for the specific situation. Therefore, vibration from road construction will not be examined further in this analysis.

## 1.4 Noise Analysis Approach

The overall purpose of the following noise analysis is to conclude whether noise levels at any sensitive receptors within approximately 500 feet of potential project improvements may exceed applicable impact thresholds because of a project alternative. If so, abatement actions for the impacted receptors are considered for the project design. The analysis examined roads that would be changed or newly built by the project or would have substantially different traffic volumes because of an alternative.

The overall analysis was based on measurements of existing conditions (2011) and on modeling of both existing (2011) conditions and future design year (2035) conditions (**Section 2.0**). Current conditions and two future alternative conditions being considered in the analysis were examined. Currently, there are primarily residences and businesses (including motels) near project roads. Homes are the most sensitive of these receptors to noise.

Several measurements of existing noise were performed in the project area in 2011 (**Section 3.0**). Computer modeling was used to examine existing and expected future conditions for numerous locations in the project area, focusing on potential impacts to the most sensitive receptors (**Sections 3.0** and **4.0**). The resulting noise levels were compared to applicable criteria to assess for and identify impacted areas (**Section 4.0**). The efficacy of various abatement measures for the impacted areas were evaluated and select abatement measures were recommended, if appropriate according to CDOT feasibility and reasonableness guidelines (**Section 5.0**).

# 2.0 ANALYSIS METHODS

Noise impacts from automobile traffic were evaluated through a combination of measurements and computer modeling. The specific methods used for each part of the analysis are described below. For comparisons, typical noise levels are shown in **Figure 2**.

The roads of interest for the proposed project and the study area include state and federal highways. The state and federal transportation departments have developed traffic noise evaluation criteria specifically for their environmental impact analyses, so the appropriate impact criteria are these state and federal highway noise guidelines. CDOT has the most restrictive noise limits of this group (**Table 1**). Therefore, traffic noise impacts for the proposed project have been assessed following CDOT's guidelines.

To summarize the noise analysis process, traffic noise impacts occur when properties near the project roads will have future design year noise levels at or above the relevant CDOT Noise Abatement Criteria (NAC) (**Table 1**) or future noise levels that increase by 10 dBA or more over current conditions. Typically, the most crucial NAC on highway projects is for homes (Land Use Category B), which is an hourly average noise level of 66 dBA. The future noise levels are evaluated through computer modeling. Properties that are found to be impacted by noise (**Sections 3.0 and 4.0**) are then considered for abatement actions (**Section 5.0**). Noise abatement actions that are found to be both feasible and reasonable according to the guidelines are recommended for construction under the proposed improvements.

**Table 1 CDOT Noise Abatement Criteria**

| Land Use Category | CDOT NAC ($L_{eq}$) | Description of Land Use Category |
|---|---|---|
| A | 56 dBA (Exterior) | Tracts of land in which serenity and quiet are of extraordinary significance and serve an important public need and where the preservation of those qualities is to continue to serve its intended purpose. |
| B | 66 dBA (Exterior) | Residential |
| C | 66 dBA (Exterior) | Active sport areas, amphitheaters, auditoriums, campgrounds, cemeteries, day care centers, hospitals, libraries, medical facilities, places of worship, public meeting rooms, public or non-profit institutional structures, radio studios, recording studios, schools, Section 4(f) sites, trails, trail crossings, and television studios |
| D | 51 (Interior) | Auditoriums, day care centers, hospitals, libraries, medical facilities, places of worship, public meeting rooms, public or non-profit institutional structures, radio studios, recording studios, schools and television studios |
| E | 71 dBA (Exterior) | Hotels, motels, offices, restaurants, bars and other developed lands, properties or activities not included in A-D or F. |
| F | NA | Agriculture, airports, bus yards, emergency services, industrial, logging, maintenance facilities, manufacturing, mining, rail yards, retail facilities, ship yards, utilities (water resources, water treatment, electrical), and warehousing |
| G | NA | Undeveloped lands that are not permitted for development |

Source: CDOT, 2011

Most of the NAC target exterior areas of frequent human use on properties (**Table 1**). These areas include uses such as yards for Category B, playgrounds at parks for Category C or exterior dining areas at restaurants for Category E. For a noise impact to occur, the noise levels

must meet one of the thresholds described above and an applicable exterior area of frequent human use must be present on the property.

For the noise impact discussion, the “peak hour” refers to the highest traffic noise hour, which may or may not correspond to the hour of largest traffic volume. Note that traffic noise can decrease during rush hour due to lower vehicle speeds from overloaded and congested roads.

## 2.1 Traffic Noise Measurements

The traffic noise measurements were taken with an NTI XL2 Type 1 sound level meter calibrated at the site with a Larson-Davis CAL200 calibrator. This equipment conforms to American National Standards Institute Standard S1.4 for Type 1 sound level meters. Calibrations traceable to the U.S. National Institute of Standards and Technology were performed in the field before and after each set of measurements using the acoustical calibrator. The measurement microphone was protected by a windscreen and located on a tripod approximately 5 feet above the ground. The microphone was positioned at each site to characterize the exposure to the dominant noise sources in the area.

Noise measurements were made during weather conditions, including wind speed, that were acceptable according to FHWA guidance (FHWA, 1996) and weather conditions were monitored during the measurements. The traffic noise measurements were spread over a variety of locations in the study area (**Figure 1**). Short-term (10-minute) traffic noise measurements were performed in duplicate back to back in the afternoon (**Section 3.2**) to document existing ambient conditions in the study area. Traffic counts, including the number of large trucks, were collected during the noise measurement periods for model verification. The measurement results were used to document ambient conditions and to evaluate the performance of the computer models.

## 2.2 Traffic Noise Modeling Methods

Two future alternatives are being evaluated through this analysis—No Action and the Action Alternative. The Action Alternative would include a new I-25 bridge over Arapahoe Road and realigned/widened roads and ramps. Other changes, such as increased traffic speeds, may lead to noise impacts from traffic. The Action Alternative includes modifications to the interchange at I-25, so it is important to consider I-25 traffic. The other important noise sources that are the focus of the traffic noise modeling include Arapahoe Road and streets such as Yosemite Street and Boston Street.

Computer modeling was performed for both current conditions and the two project alternatives for Year 2035. The traffic noise modeling software is FHWA’s Traffic Noise Model (TNM) Version 2.5. The ultimate purpose of the models is to examine whether traffic noise levels would be high enough to impact neighboring properties, and subsequently whether noise abatement should be provided for any such impacts within the study area.

Modeling is used because day-to-day variations in traffic or weather conditions that affect noise levels cannot be captured or quantified by brief noise measurements alone, and because the future noise levels can not be measured now. In addition, the modeling can evaluate many more locations than can reasonably be field measured. The modeling results represent predicted typical average traffic conditions during peak noise periods.

The existing traffic conditions model included the 2011 road configurations and traffic volumes. The two alternatives were modeled for their respective 2035 conditions (**Section 1.1**). The 2035 peak traffic volumes for I-25 are often predicted to exceed LOS C capacities, so the I-25 volumes included in the noise models followed CDOT’s guidelines (CDOT, 2011). The conditions examined for the other highways and arterial roads used the predicted afternoon peak traffic volumes.

TNM was used to calculate noise levels at 96 points up to 500 feet from a modeled roadway. This distance follows CDOT guidance (CDOT, 2011) and was chosen as the project study zone for noise to identify the receptors that could be impacted by the alternatives. In some cases, a single model point represents several nearby receptors/properties where traffic and geography were similar (e.g., one point for a multi-unit apartment building), so the number of model "points" is not always the same as the number of individual "receptors." The modeled roadways are the roads that would be built or changed by the build alternatives or are important local noise sources. The same model points are used in each model for consistency (**Appendix A**), unless a specific alternative removes a specific receptor.

The TNM models require a considerable amount of input data regarding the geometry of the roadways as well as traffic volumes, vehicle mix and vehicle speeds. Detailed traffic studies were completed for the project (FHU, 2011) to provide traffic volumes. The current positions of roads and streets were mapped and used in both the existing and No Action Alternative models, though individual road parameters differed between the two models. The Action Alternative (**Section 1.1**) was modeled to assess the possible noise impacts from the proposed roadway additions and changes. In general, the following data were used in the models:

- Units–feet and miles per hour
- Current Roadway Alignments–XY coordinates from CAD files and aerial photographs
- Future Roadway Alignments–XY coordinates from CAD files
- Vehicle Speeds–ranged from 25-75 miles per hour (MPH), depending on road
- Traffic Volumes–from traffic study or CDOT-recommended volumes (CDOT, 2011)
- Vehicle Mix–from published CDOT traffic count data
- Elevations–from ground surface contours of the study area and preliminary road designs; field measurement locations and model receptors were 5 feet above ground
- Structural and terrain barriers were used as needed to emulate the existing area; abatement barriers were added to models where appropriate for the abatement evaluations.

# 3.0 AFFECTED ENVIRONMENT

The current traffic noise conditions in the study area were assessed through a combination of measurements and modeling. There are several residential and business areas within the study area that are of interest to the project. The existing conditions for traffic noise for these areas are presented below.

## *3.1 Traffic Noise Measurements*

The short-term noise measurements described below were intended to be representative of daily peak traffic noise periods. Short-term traffic noise measurements were performed in the afternoon in the project area to document existing ambient conditions (**Table 2**). These locations (**Figure 1**) include residential and commercial areas along the project corridors that are under consideration for the EA. Each location is also representative of other nearby properties that may have the same or different land uses.

**Table 2 Existing Traffic Noise Measurement Results**

| Location Number | Location Description | Land Use Category* | CDOT NAC (dBA)* | Measured $L_{eq}$ (dBA) |
|---|---|---|---|---|
| 1 | 8449 E. Briarwood Ave. | B | 66 | 61 |
| 2 | 6795 S. Yosemite St | B | 66 | 66 |
| 3 | 8770 E. Arapahoe Road | E | 71 | 66 |
| 4 | 9069 E. Arapahoe Road | E | 71 | 63 |

* See Table 1.
Source: FHU field data, 2011.

One of the measurement results reached the applicable CDOT NAC for the locations in the project area (**Table 2**). This location represented residential receptors in the Walnut Hills neighborhood (**Section 3.4**).

## *3.2 Traffic Noise Verification Model*

As a check on noise model parameters, the traffic conditions observed during the noise measurements were used to construct a verification model in TNM. The intent is to check the accuracy of the noise levels calculated through a model that reflects the road alignment, traffic volumes and model receptors at the time of field measurement. A close match between model results and field measurements ensures that the models are providing accurate noise results (CDOT, 2011).

The verification model covers the areas where noise level measurements were made (**Figure 1**). The model was constructed in TNM using the same approach as the alternatives models (**Section 2.2**). Note that Location 1 was in a residential backyard that has a wooden privacy fence along Arapahoe Road. This fence was not constructed as a noise barrier but it does provide substantive noise reduction. A noise barrier needed to be included in the verification model for this property but a barrier was not included in the other TNM models, as directed by CDOT guidance (CDOT, 2011).

The verification results are in close agreement (**Table 3**), as the measured and modeled results differ by less than 3 dBA. The results are acceptable according to the CDOT guidelines (CDOT, 2011) which require the variation in results to be no more than 3 dBA.

**Table 3 Verification Noise Model Results**

| Location Number | Location | Measurement $L_{eq}$ (dBA) | Verification Model Result (dBA) | Difference (dBA) |
|---|---|---|---|---|
| 1 | 8449 E. Briarwood Ave. | 61 | 61 | 0 |
| 2 | 6795 S. Yosemite St | 66 | 66 | 0 |
| 3 | 8770 E. Arapahoe Road | 66 | 68 | 2 |
| 4 | 9069 E. Arapahoe Road | 63 | This point was not modeled because the traffic was too complex to count during the measurement (I-25, Arapahoe Road, two ramps, frontage road) | |

Source: FHU modeling results, 2011

## *3.3 Existing Conditions Traffic Noise Model Results*

A noise model was developed (**Section 2.2**) to evaluate existing conditions on a broader basis than allowed by the field measurements alone. The existing conditions model included the major existing roads that may be affected by the project, with existing (2011) traffic volumes and road layouts. Approximately 96 points were modeled for traffic noise (**Figure 3** and **Appendix A**).

The calculated result for each model point is presented in **Appendix A**. Overall, the calculated noise level range for the model points was 53-78 dBA. Modeled points that represent 17 individual receptors are calculated to be impacted through existing traffic noise levels being above the respective NAC during the peak hour (**Figure 4**). The impacted Category B receptors are in Walnut Hills. Arapahoe Road and Yosemite Street traffic are the predominant noise source for Walnut Hills, but I-25 traffic noise is noticeable throughout the study area.

## Figure 3 Traffic Noise Model Receptor Locations

## Figure 4 Impacted Receptors from Existing Conditions Noise Model

# 4.0 ENVIRONMENTAL CONSEQUENCES

The alternatives being considered for the project were described in **Section 1.1**. The traffic noise modeling effort was conducted as described in **Section 2.0** to assess whether future noise levels near the project alternatives would exceed relevant CDOT thresholds. If so, abatement measures to alleviate the predicted impacts were considered and evaluated for the build alternative following CDOT guidelines (**Section 5.0**).

Traffic noise models were developed as described in **Section 2.1** for each alternative. The models included the major project roads using predicted future (2035) traffic volumes and road layouts. The model noise results are tabulated in **Appendix A**.

## *4.1 No Action Alternative 2035 Results*

As described in **Section 2.2**, traffic vibration is not a concern. Therefore, only projected traffic noise impacts are relevant for No Action and are discussed below.

The results for this alternative (**Figure 5**) follow the existing conditions results. The areas impacted under existing conditions are also impacted under No Action. The traffic noise patterns are similar to existing conditions with the noise levels a bit higher due to increased traffic volumes.

For No Action, it has been calculated that 16 Category B receptors in Walnut Hills would be at or above the NAC and impacted by traffic noise (**Table 4**) and two Category E receptors would be impacted. Overall, the calculated noise level range at the model points is 53-78 dBA. No receptors are expected to experience a 10-dBA increase; the largest increase is predicted to be 1.6 dBA.

**Table 4 Summary of Receptors Impacted by Traffic Noise**

| Land Use Category | Existing Conditions (2011) | No Action (2035) | Action Alternative (2035) |
|---|---|---|---|
| Category B | 15 | 16 | 16 |
| Category E | 2 | 2 | 2 |
| **Total** | **17** | **18** | **18** |

Source: FHU modeling results, 2011.

**Figure 5 Noise Impacts for No Action Alternative—Year 2035**


## 4.2 *Action Alternative 2035 Results*

As described in **Section 2.2**, traffic vibration is not a concern. Therefore, only potential traffic noise impacts are relevant for the Action Alternative and are discussed below.

The results for the Action Alternative are the same as for No Action: 16 Category B receptors and two Category E receptors in the study area would be impacted by traffic noise (**Figure 6; Table 4**). Of the 18 impacted receptors, 18 are predicted to equal or exceed the NAC and none are predicted to increase by 10 dBA or more over existing conditions without reaching the relevant NAC. Overall, the calculated noise level range at the model points is 54-78 dBA.

The Action Alternative would impact the same number of receptors as No Action, and both are nearly identical to Existing Conditions.

**Figure 6 Noise Impacts for Action Alternative—Year 2035**


## 4.3 Summary of Traffic Noise Impacts

Several traffic noise impacts were predicted for each of the alternatives for 2035. The predicted impacts (without abatement) are summarized in **Table 4**. There is little that separates the two alternatives in terms of noise; the noise results are essentially identical. The predicted noise contour lines for the Action Alternative in 2035 are illustrated in **Figure 7** and are provided to support land use planning decisions in the area.

## 4.4 Construction Noise

Adjoining properties in the study area could be exposed to noise from construction activities from the build alternatives. Construction noise differs from traffic noise in several ways:

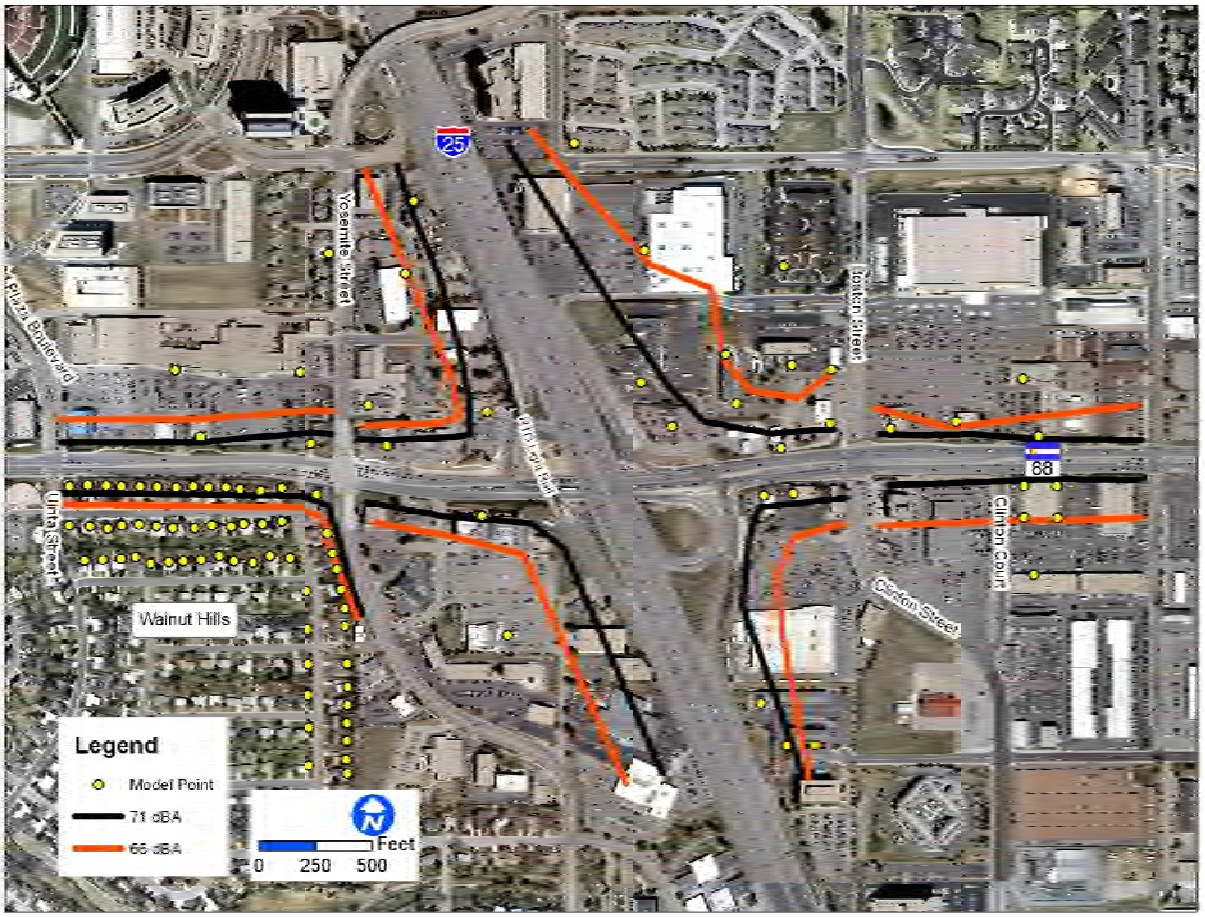
- Construction noise lasts only for the duration of the construction event, with most construction activities in noise-sensitive areas being conducted during hours that are least disturbing to adjacent and nearby residents.
- Construction activities generally are short term and, depending on the nature of the construction operations, could last from seconds (e.g., a truck passing a receptor) to months (e.g., constructing a bridge).
- Construction noise is intermittent and depends on the type of operation, location, and function of the equipment, and the equipment usage cycle.

Construction noise is not assessed like operational traffic noise; there are no CDOT NACs for construction noise. Construction noise would be subject to relevant local regulations and ordinances, and any construction activities would be expected to comply with them.

The project corridor abuts a residential area. To address the temporary elevated noise levels that may be experienced during construction, standard abatement measures shall be incorporated into construction contracts, where it is feasible to do so. These would include:

- Exhaust systems on equipment would be in good working order. Equipment would be maintained on a regular basis, and equipment may be subject to inspection by the project manager to ensure maintenance.
- Properly designed engine enclosures and intake silencers would be used where appropriate.
- New equipment would be subject to new product noise emission standards.
- Stationary equipment would be located as far from sensitive receptors as possible.
- Most construction activities in noise sensitive areas would be conducted during hours that are least disturbing to adjacent and nearby residents.

**Figure 7 Noise Contour Lines—Action Alternative Year 2035**



## 4.5 Local Ordinances

The City of Centennial local noise ordinance 2007-O-16 prohibits "any person to make, continue or cause to be made or continued, any excessive or unusually loud noise which (a) disturbs, annoys or endangers the peace, repose, comfort, safety or health of others; or (b) endangers or injures personal or real property." (City of Centennial, 2007). Specific noise levels are not established in this ordinance.

For projects such as this one which involve arterial highways, interchanges and collector highways, City of Centennial Regulation 1041 states the following:

> Noise levels caused by the new or modified arterial highway or interchange or collector highway will not exceed 55 decibels as measured by a 24-hour Equivalent Sound Level metric at any residence, school, church, or other noise-sensitive location, unless the City Council determines that meeting such sound level is infeasible, that all feasible avoidance or abatement measures will be incorporated, and the public benefit of any new or modified arterial highway or interchange or collector highway necessitates the proposed construction, expansion or modification of the arterial highway or interchange or collector highway.

This regulation does not match the requirements under the CDOT and FHWA regulations (**Section 2.0**).

It is a conclusion of this analysis that the project area will not meet the requirements of Regulation 1041 with or without the proposed improvements. For example, Walnut Hills residences facing Arapahoe Road are calculated to have peak noise hour $L_{eq}$s of at least 70 dBA for both existing conditions and the No Action Alternative (**Appendix A**). Even if each of the remaining 23 hours in a day at these locations had an $L_{eq}$ of 0 dBA (which cannot happen—traffic noise will be louder than 0 dBA), the corresponding 24-hour $L_{eq}$ (stipulated by Regulation 1041) would be 56 dBA—higher than the 55 dBA allowed. Therefore, the residences along Arapahoe Road will not meet the Regulation 1041 limit even if no improvements are made.

Regarding the Action Alternative, the noise abatement actions under the CDOT guidelines must achieve a "substantial" noise reduction (i.e., at least 7 dBA), but are not required to reach a specific noise level (CDOT, 2011). An 8-feet-tall barrier along Arapahoe Road and 10-feet-tall barrier along Yosemite Street were calculated to be sufficient to meet this requirement (**Section 5.2**). Attempting to increase the noise abatement from these barriers to reach 55 dBA (24-hour $L_{eq}$) would be a significant enhancement and likely not eligible for federal funding. As a check on the noise abatement, a 20-feet-tall barrier (20 feet is the tallest permitted under CDOT guidelines) along Arapahoe Road was evaluated through TNM simulation modeling and found to result in 24-hour $L_{eq}$s at the affected properties in Walnut Hills of greater than 55 dBA (i.e., approximately 56 dBA). This is due to traffic noise that would not be blocked by the barrier. Therefore, this analysis has concluded that 20-feet-tall barriers would be insufficient to bring traffic noise into compliance with the Regulation 1041 limit.

Finally, the City of Greenwood Village Municipal Code 8.24 states "No person shall make, continue, or cause to be made or continued, any noise disturbance, including, but not limited to, the specific noise disturbances prohibited in subsection (B) of this section." (City of Greenwood Village, 2006). The only noise limit specified applies to amphitheaters, which is not relevant to this project. Greenwood Village does not have a "1041" ordinance. There is not a City of Greenwood Village ordinance relevant for general traffic noise.

# 5.0 NOISE ABATEMENT EVALUATION

The results from the traffic noise analysis indicate that receptors would be impacted by noise from each of the alternatives. Therefore, potential abatement actions for the impacted receptors under the Action Alternative were investigated in accordance with relevant guidelines (CDOT, 2011; FHWA, 1995). Impacted areas are not guaranteed abatement measures under these guidelines, but abatement measures for the areas must be evaluated for feasibility and reasonableness. Reasonableness includes assessment of abatement benefits and costs.

Noise impacts from the alternatives were previously described (**Section 4.0**)**.** Several types of noise abatement for the impacts were considered. Barriers are a common abatement action and were evaluated, but other kinds of abatement were also considered. The overall feasibility and reasonableness of noise abatement actions that provide a substantive benefit for the impacted receptors were evaluated. Those actions found to be feasible and reasonable were then recommended for inclusion in the project.

For reasons described below, barriers appear to be the only viable abatement action and are the only abatement evaluated through modeling. CDOT has several criteria to evaluate noise barriers (CDOT, 2011). CDOT's required minimum noise reduction is 5 dBA for a barrier to be feasible, with a 7 dBA noise reduction goal.

## *5.1 Evaluation of Abatement Other than Barriers*

CDOT guidelines require the evaluation of several non-barrier abatement options. For a variety of reasons that are described below, none of these options appear to be viable for the project.

Traffic management measures such as lane closures or reduced speeds could reduce noise but broad application of these concepts is not reasonable for the roads of primary interest to the project or compatible with the purpose of the project. One of the reasons for the proposed improvements in the study area is to improve access and traffic flow. Traffic management concepts were applied during development of the Action Alternative to minimize impacts, but additional actions just to reduce noise would not meet the project purpose and need.

Changes in horizontal alignments of the roads near the impacted receptors could reduce noise but have limited possibilities as a separate abatement. The area is already fully developed, so there is not vacant space available to shift the roads and would therefore be prohibitively expensive to do so.

Changes in vertical alignments (cuts or fills) could reduce noise. However, wholesale changes in road elevations, such as along Arapahoe Road, could have secondary impacts to connecting or adjoining roads that would not be reasonable or desirable. Other undesirable impacts, such as to drainage or utilities, could be created. In summary, vertical elevation changes were evaluated, but vertical realignments just to reduce traffic noise are not practical.

Noise buffer zones could reduce noise levels, but there are limited opportunities in the study area due to prior zoning and platting of local land use. Often, prior development has been purposely built near the roads for access, which leaves little or no space for a buffer. In the few places where there may be space, there generally are no nearby impacted receptors.

Pavement types and surfaces can affect traffic noise. Research efforts to learn more about the long-term noise benefits of different pavement types and surface treatments are ongoing. Quieter pavement types can be preferred for the project when minimum requirements for safety, durability and other materials requirements are also met. However, this cannot be counted as an abatement action under the noise reduction evaluation because it is not a "permanent" solution.

## 5.2 Traffic Noise Barrier Evaluations

To permit the evaluation of new noise barriers, computer models with barriers protecting the impacted areas were developed in TNM. Each potential barrier was assessed for effectiveness and feasibility. If the minimum parameters for an effective barrier were met and the barrier was feasible, the barrier was checked for reasonability according to CDOT guidance (CDOT, 2011). The feasibility and reasonableness of each barrier determined whether the barrier was recommended for the project (**Appendix C**).

Briefly, for an abatement action to be feasible it must:

- Provide at least 5 dBA of noise reduction
- Not have any "fatal flaw" issues (safety, maintenance, access, drainage, etc.)
- Not exceed 20 feet in height

For an abatement action to be reasonable it must:

- Meet the minimum design goal of at least 7 dBA of noise reduction
- Meet the cost/benefit index of not more than $6,800/dBA of benefit
- Have support from more than 50 percent of the potentially benefitting receptors

The locations evaluated for new noise barriers are shown in **Figure 8**. Each of these barriers was assessed for feasibility and reasonableness (CDOT, 2011), and barrier recommendations were made based on the findings.

The typical locations for the abatement barriers are at the edge of road right-of-way. It is important to note that the noise barriers can be earth berms or constructed walls and that many materials can be effective barriers. Berms can be very effective but occupy considerably more space than comparable walls. Throughout the project area, the impacted receptors tend to be close to the project roads. This usually makes earth berms impractical or impossible choices for the noise barriers.

Barrier cost-effectiveness was based on an assumed cost of $45/square foot of barrier and compared to the CDOT upper threshold of $6,800/decibel of benefit. The barriers evaluated (**Appendix B**) are summarized in **Table 5** and described in the following sections.

**Table 5 Summary of Noise Abatement Barriers Evaluated**

| Noise Impacted Area | Approximate Barrier Segment Dimensions (feet) | Total Barrier Size (square feet) | Approximate Barrier Cost |
|---|---|---|---|
| Walnut Hills (2 wall segments) | 8 x 1060<br>8 x 70<br>9 x 250<br>11 x 180 | 13,270 | $597,000 |
| NE Quadrant of I-25 and Arapahoe Road | 20 x 475 | 9,430 | $424,000 |

Source: FHU modeling results, 2012.

**Figure 8 Locations of Traffic Noise Abatement Barriers Evaluated**


## Walnut Hills

Homes in the Walnut Hills neighborhood are predicted to be impacted by traffic noise under the Action Alternative**.** The impacts are along both Arapahoe Road and Yosemite Street. The homes are even with to slightly above Arapahoe Road, and even with to slightly below Yosemite Street in elevation. Two abatement barriers, extending along Arapahoe Road and Yosemite Street (**Figure 8**), were evaluated to mitigate the predicted noise impacts. The two barriers were evaluated as a single abatement action for feasibility and reasonableness. The wall dimensions are presented in **Table 5**.

A continuous barrier along the entire length of the neighborhood facing Arapahoe Road was evaluated. Along Yosemite Street, the barrier length was intended to protect the three impacted properties and terminate at a logical end point in terms of protecting the neighborhood. Therefore, the Yosemite Street barrier selected ran approximately 500 feet between the commercial properties at 8586 E. Arapahoe Road and 6789 S. Yosemite Street (**Figure 8**). This southern endpoint was selected because the commercial buildings along Yosemite Street to the south are acting as noise barriers for the homes in Walnut Hills behind them, and these homes were calculated to be well below the NAC and not impacted (**Attachment A**).

A combined length of approximately 1,560 feet of barrier was calculated to provide a noise reduction benefit to 18 homes (i.e., all of the impacted Category B receptors). The barrier

performance results are presented in **Table 6** and **Appendix B**. Based on these results, this abatement action for the Walnut Hills neighborhood (**Figure 8**) was found to be feasible and passed the design goal and cost/benefit criteria for reasonableness. The desires of the benefitted receptors will be gauged in coordination with the public meeting for the EA (**Section 5.5**). Therefore, the abatement walls are preliminarily recommended for the Action Alternative (**Table 6**), pending the outcome of the benefitted receptors desires from the public meeting.

No new right-of-way is expected to be needed for either of the Walnut Hills barriers. One important caveat with these barriers is they would have to replace some existing privacy fences and would need the agreement of the affected property owners for construction and long-term maintenance.

### Category E Receptors

Two Category E receptors were calculated to be impacted by the Action Alternative. One receptor was chosen for abatement analysis (**Figure 8**) to be representative of both properties. A barrier was located along the current I-25 frontage road along the east side of I-25 (which will be relocated under the Action Alternative), adjacent to the northbound on-ramps (**Figure 8**). The need to maintain property access and parking areas limits where this barrier can be placed. Within these constraints, the best-performing barrier was found to be 425 feet long and 20 feet tall (the maximum height allowed by CDOT guidance) and provided this one receptor with a 6 dB reduction **(Table 6** and **Appendix B)**. That was not enough of a reduction to meet the 7 dBA reduction design goal required for reasonableness. In addition, the cost/benefit for this barrier was too high to be reasonable. This barrier is not recommended for the Action Alternative (**Table 6**).

**Table 6 Summary of Barrier Performance and Abatement Conclusions**

| Noise Impacted Area | Number of Benefitting Receptors | Total Benefit Provided (dBA) | Cost Analysis ($/ total dBA) | Is Barrier Feasible? | Is Barrier Reasonable? | Is Barrier Recommended? | Comment |
|---|---|---|---|---|---|---|---|
| Walnut Hills (2 wall segments) | 18 | 126 | 4,700 | Yes | Yes | Yes | Preliminarily recommended for Action Alternative. |
| NE Quadrant of I-25 and Arapahoe Road | 1 | 6 | 75,000 | Yes | No | No | Not recommended for Action Alternative. |

Source: FHU modeling results, 2012.

## *5.3 Summary of Recommended Abatement*

The recommendations provided above and summarized here were based on specific project design conditions. If the final designs in the future differ from the designs examined here, corresponding adjustments to the abatement evaluations may be required.

The overall traffic noise barrier findings are summarized in **Table 6**. The overall traffic noise reductions for each abatement action have been estimated. The project recommendations are for select noise barriers to be included, generally along the road right of way and private

property lines, pending the concurrence of affected property owners as documented during the upcoming EA public comment period (**Section 5.5**). The two traffic noise barriers for the Walnut Hills neighborhood as illustrated in **Figure 8** are preliminarily recommended from the feasibility and reasonableness evaluations.

## 5.4 Impacted Receptors After Recommended Abatement

For a noise abatement action to be recommended, it must be both feasible and reasonable according to the evaluation guidelines. In some of the areas identified with traffic noise impacts (**Section 4.0**), noise barriers were determined to be not appropriate (**Section 5.2**). Therefore, not all areas identified with impacts have been recommended for noise abatement.

The recommended abatement actions would serve to reduce noise impacts for the Action Alternative (**Section 5.2**). The recommended abatement actions would not eliminate all of the calculated noise impacts; some noise impacts would remain. These remnant noise impacts are described below for each of the alternatives.

### No Action Alternative

The No Action Alternative does not include any noise abatement actions, so there would be no change in the traffic noise impacts (**Section 4.1**). The same 16 Category B receptors and two Category E receptors would still be impacted by traffic noise (**Figure 5**).

### Action Alternative

The Action Alternative would include one abatement action that consists of two barrier segments (**Section 5.2**). The recommended abatement measure would give the benefit of eliminating the traffic noise impacts from 14 of the 16 Category B receptors within Walnut Hills. Two Category B receptors and two Category E receptors would still be impacted by traffic noise **(Figure 9)**, which is 14 receptors fewer than No Action.

## 5.5 Statement of Likelihood

The analysis described above concluded that one noise abatement action consisting of two barrier segments would be both feasible and reasonable (for the design goal and cost/benefit criteria). The barriers would be located on the south side of Arapahoe Road between Yosemite Street and Uinta Street, and the west side of Yosemite Street south of Arapahoe Road. The barrier sizes from the preliminary analysis are presented in **Table 5** and **Appendix B**. The final noise abatement decision will be made during the final design and public involvement phases of the project.

Based on the noise abatement evaluation outcome (**Section 5.3**), targeted outreach with the Walnut Hills neighborhood will be performed during the EA. Specific invitations to participate in the EA public meetings will be provided to owners and residents for the affected properties along Arapahoe Road and Yosemite Street. Input from the potentially benefiting receptors will be solicited regarding their opinion on the potential abatement actions. This information will be used to gauge the desires of the benefitting receptors and whether the abatement action will be formally recommended for construction—this must be completed before the Finding of No Significant Impact can be signed. Additional coordination on the noise abatement decisions will occur during final design for the project, as necessary.

## Figure 9 Action Alternative Impacts After Recommended Abatement Action

# 6.0 REFERENCES

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City of Greenwood Village. 2006. Municipal Code Chapter 8.

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Felsburg Holt & Ullevig. 2011. Traffic data for the I-25/Arapahoe Road Project, October.

# APPENDIX A
# TNM Noise Impacts Modeling Results

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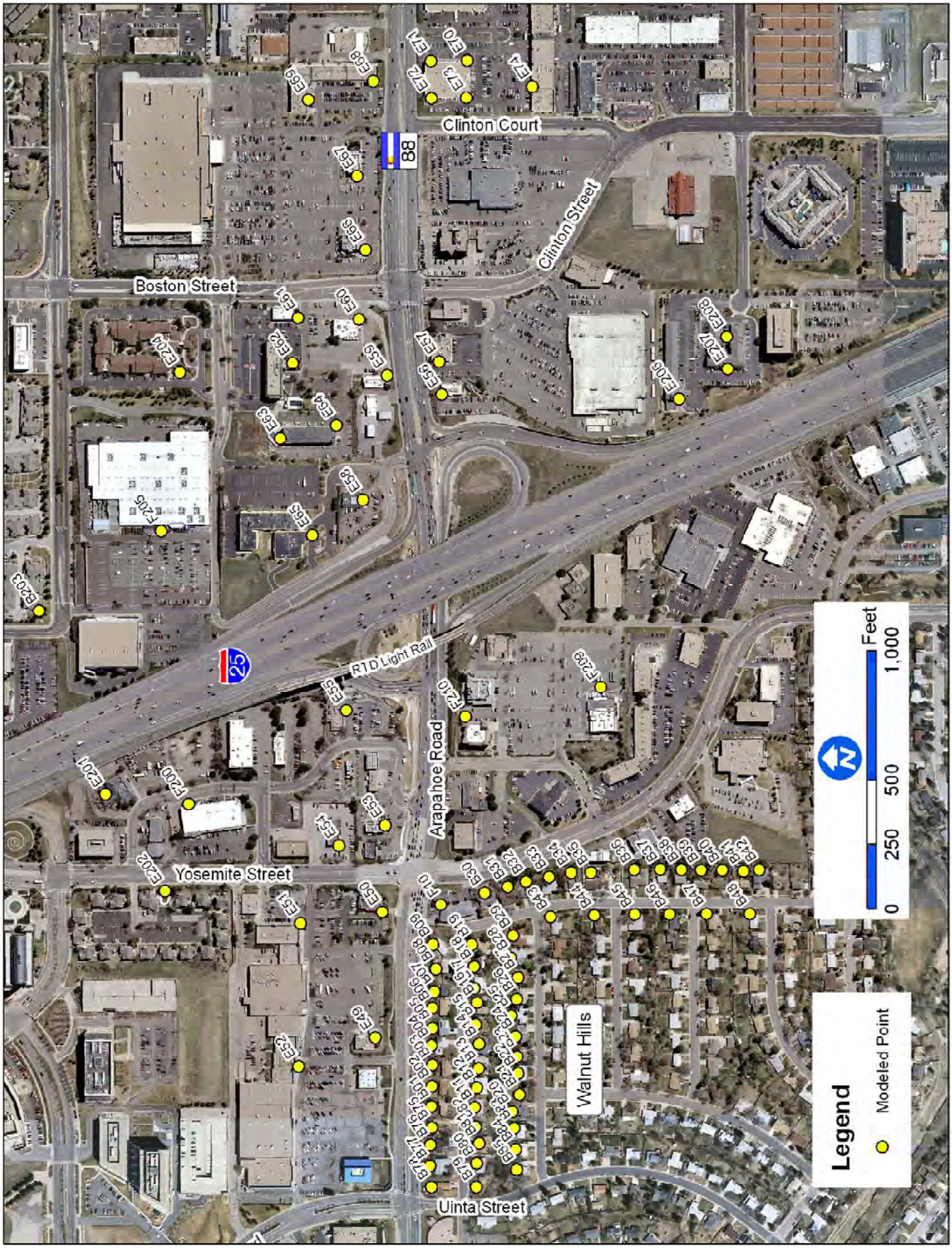
Clinton Court
Clinton Street
Boston Street
RTD Light Rail
Arapahoe Road
Yosemite Street
Walnut Hills
Uinta Street
88
25
Legend
Modeled Point
Feet
0
250
500
1,000
N

| Model Point | CDOT NAC (dBA) | Existing (2011) $L_{eq}$ (dBA) | Existing Result | No Action (2035) $L_{eq}$ (dBA) | No Action Result | Action Alternative (2035) $L_{eq}$ (dBA) | Action Alternative Result | Noise Abatement Recommended? |
|---|---|---|---|---|---|---|---|---|
| B01 | 66 | 70.1 | Impacted | 71.4 | Impacted | 71.4 | Impacted | Yes |
| B02 | 66 | 70.0 | Impacted | 71.3 | Impacted | 71.3 | Impacted | Yes |
| B03 | 66 | 69.8 | Impacted | 71.2 | Impacted | 71.1 | Impacted | Yes |
| B04 | 66 | 70.3 | Impacted | 71.6 | Impacted | 71.5 | Impacted | Yes |
| B05 | 66 | 69.9 | Impacted | 71.2 | Impacted | 71.1 | Impacted | Yes |
| B06 | 66 | 69.9 | Impacted | 71.2 | Impacted | 71.2 | Impacted | Yes |
| B07 | 66 | 69.5 | Impacted | 70.8 | Impacted | 70.8 | Impacted | Yes |
| B08 | 66 | 69.5 | Impacted | 70.8 | Impacted | 70.7 | Impacted | Yes |
| B09 | 66 | 70.2 | Impacted | 71.5 | Impacted | 71.5 | Impacted | Yes |
| F10 | 99 | 71.1 | ---- | 72.3 | ---- | 72.5 | ---- | No |
| B11 | 66 | 61.1 | ---- | 62.5 | ---- | 63.1 | ---- | No |
| B12 | 66 | 60.9 | ---- | 62.3 | ---- | 62.9 | ---- | No |
| B13 | 66 | 60.6 | ---- | 61.9 | ---- | 62.5 | ---- | No |
| B14 | 66 | 60.6 | ---- | 61.9 | ---- | 62.5 | ---- | No |
| B15 | 66 | 61.2 | ---- | 62.5 | ---- | 63.0 | ---- | No |
| B16 | 66 | 61.7 | ---- | 62.9 | ---- | 63.2 | ---- | No |
| B17 | 66 | 62.3 | ---- | 63.5 | ---- | 63.7 | ---- | No |
| B18 | 66 | 62.5 | ---- | 63.7 | ---- | 64.0 | ---- | No |
| B19 | 66 | 63.3 | ---- | 64.5 | ---- | 64.9 | ---- | No |
| B20 | 66 | 58.4 | ---- | 59.6 | ---- | 59.8 | ---- | No |
| B21 | 66 | 58.3 | ---- | 59.5 | ---- | 59.4 | ---- | No |
| B22 | 66 | 58.3 | ---- | 59.5 | ---- | 59.4 | ---- | No |
| B23 | 66 | 57.9 | ---- | 59.0 | ---- | 59.2 | ---- | No |
| B24 | 66 | 58.3 | ---- | 59.4 | ---- | 59.5 | ---- | No |
| B25 | 66 | 58.7 | ---- | 59.7 | ---- | 59.8 | ---- | No |
| B26 | 66 | 58.7 | ---- | 59.7 | ---- | 60.1 | ---- | No |
| B27 | 66 | 59.3 | ---- | 60.3 | ---- | 60.7 | ---- | No |
| B28 | 66 | 60.2 | ---- | 61.1 | ---- | 61.5 | ---- | No |
| B29 | 66 | 61.0 | ---- | 62.0 | ---- | 62.2 | ---- | No |
| B30 | 66 | 68.1 | Impacted | 69.2 | Impacted | 69.2 | Impacted | Yes |
| B31 | 66 | 66.2 | Impacted | 67.3 | Impacted | 67.0 | Impacted | Yes |
| B32 | 66 | 64.8 | ---- | 66.0 | Impacted | 66.3 | Impacted | Yes |
| B33 | 66 | 63.2 | ---- | 64.3 | ---- | 63.8 | ---- | No |
| B34 | 66 | 61.4 | ---- | 62.5 | ---- | 62.1 | ---- | No |
| B35 | 66 | 59.4 | ---- | 60.5 | ---- | 60.0 | ---- | No |
| B36 | 66 | 56.5 | ---- | 57.4 | ---- | 57.8 | ---- | No |
| B37 | 66 | 54.6 | ---- | 55.5 | ---- | 55.6 | ---- | No |
| B38 | 66 | 54.2 | ---- | 55.0 | ---- | 55.1 | ---- | No |
| B39 | 66 | 54.4 | ---- | 55.2 | ---- | 55.4 | ---- | No |
| B40 | 66 | 53.9 | ---- | 54.6 | ---- | 54.8 | ---- | No |
| B41 | 66 | 53.5 | ---- | 54.1 | ---- | 54.2 | ---- | No |
| B42 | 66 | 53.3 | ---- | 53.8 | ---- | 54.0 | ---- | No |
| B43 | 66 | 60.9 | ---- | 61.8 | ---- | 62.0 | ---- | No |
| B44 | 66 | 57.8 | ---- | 58.8 | ---- | 58.3 | ---- | No |
| B45 | 66 | 55.1 | ---- | 56.1 | ---- | 56.2 | ---- | No |
| B46 | 66 | 54.1 | ---- | 54.9 | ---- | 55.0 | ---- | No |
| B47 | 66 | 53.3 | ---- | 54.1 | ---- | 54.4 | ---- | No |
| B48 | 66 | 52.8 | ---- | 53.4 | ---- | 53.6 | ---- | No |

| Model Point | CDOT NAC (dBA) | Existing (2011) $L_{eq}$ (dBA) | Existing Result | No Action (2035) $L_{eq}$ (dBA) | No Action Result | Action Alternative (2035) $L_{eq}$ (dBA) | Action Alternative Result | Noise Abatement Recommended? |
|---|---|---|---|---|---|---|---|---|
| E49 | 71 | 67.8 | ---- | 69.2 | ---- | 69.4 | ---- | No |
| E50* | 71 | 70.2 | ---- | 71.7 | ---- | 72.0 | ---- | No |
| E51 | 71 | 61.5 | ---- | 62.6 | ---- | 62.9 | ---- | No |
| E52 | 71 | 58.2 | ---- | 59.3 | ---- | 59.8 | ---- | No |
| E53* | 71 | 70.1 | ---- | 71.2 | ---- | 71.4 | ---- | No |
| E54 | 71 | 67.7 | ---- | 69.1 | ---- | 69.4 | ---- | No |
| E55 | 71 | 74.0 | Impacted | 74.2 | Impacted | 73.2 | Impacted | No |
| E56* | 71 | 74.2 | ---- | 74.7 | ---- | 75.1 | ---- | No |
| E57* | 71 | 73.3 | ---- | 73.8 | ---- | 73.9 | ---- | No |
| E58 | 71 | 73.4 | Impacted | 73.6 | Impacted | 73.4 | Impacted | No |
| E59* | 71 | 73.2 | ---- | 74.3 | ---- | 75.4 | ---- | No |
| E60 | 71 | 69.1 | ---- | 70.0 | ---- | 70.8 | ---- | No |
| E61 | 71 | 66.0 | ---- | 66.3 | ---- | 66.5 | ---- | No |
| E62 | 71 | 64.0 | ---- | 64.3 | ---- | 64.6 | ---- | No |
| E63 | 71 | 65.7 | ---- | 65.8 | ---- | 65.8 | ---- | No |
| E64 | 71 | 65.2 | ---- | 65.6 | ---- | 66.4 | ---- | No |
| E65* | 71 | 74.4 | ---- | 74.5 | ---- | 74.2 | ---- | No |
| E66 | 71 | 67.7 | ---- | 68.4 | ---- | 68.8 | ---- | No |
| E67 | 71 | 64.2 | ---- | 64.8 | ---- | 64.8 | ---- | No |
| E68 | 71 | 69.2 | ---- | 70.1 | ---- | 70.5 | ---- | No |
| E69 | 71 | 58.9 | ---- | 59.5 | ---- | 59.6 | ---- | No |
| E70 | 71 | 64.1 | ---- | 64.8 | ---- | 65.4 | ---- | No |
| E71 | 71 | 69.3 | ---- | 69.9 | ---- | 70.1 | ---- | No |
| E72 | 71 | 69.8 | ---- | 70.4 | ---- | 70.6 | ---- | No |
| E73 | 71 | 65.2 | ---- | 65.7 | ---- | 66.5 | ---- | No |
| E74 | 71 | 61.3 | ---- | 61.6 | ---- | 61.6 | ---- | No |
| B75 | 66 | 70.2 | Impacted | 71.5 | Impacted | 71.5 | Impacted | Yes |
| B76 | 66 | 70.7 | Impacted | 72.0 | Impacted | 71.9 | Impacted | Yes |
| B77 | 66 | 71.1 | Impacted | 72.4 | Impacted | 72.4 | Impacted | Yes |
| B78 | 66 | 71.3 | Impacted | 72.6 | Impacted | 72.5 | Impacted | Yes |
| B79 | 66 | 63.8 | ---- | 65.4 | ---- | 65.2 | ---- | No |
| B80 | 66 | 62.0 | ---- | 63.3 | ---- | 63.5 | ---- | No |
| B81 | 66 | 61.4 | ---- | 62.7 | ---- | 62.7 | ---- | No |
| B82 | 66 | 61.4 | ---- | 62.7 | ---- | 63.2 | ---- | No |
| B83 | 66 | 58.5 | ---- | 59.8 | ---- | 59.9 | ---- | No |
| B84 | 66 | 59.1 | ---- | 60.4 | ---- | 60.3 | ---- | No |
| B85 | 66 | 60.0 | ---- | 61.6 | ---- | 61.6 | ---- | No |
| F200 | 99 | 65.9 | ---- | 66.2 | ---- | 66.5 | ---- | No |
| E201* | 71 | 73.2 | ---- | 73.2 | ---- | 73.2 | ---- | No |
| E202 | 71 | 68.3 | ---- | 69.7 | ---- | 69.8 | ---- | No |
| B203 | 66 | 64.8 | ---- | 64.9 | ---- | 64.6 | ---- | No |
| E204 | 71 | 62.2 | ---- | 62.3 | ---- | 62.1 | ---- | No |
| F205 | 99 | 66.6 | ---- | 66.7 | ---- | 65.9 | ---- | No |
| E206* | 71 | 77.7 | ---- | 77.8 | ---- | 77.7 | ---- | No |
| E207* | 71 | 76.9 | ---- | 76.9 | ---- | 76.9 | ---- | No |
| E208 | 71 | 56.5 | ---- | 56.5 | ---- | 56.5 | ---- | No |
| F209 | 99 | 65.0 | ---- | 65.2 | ---- | 65.0 | ---- | No |
| F210 | 99 | 72.4 | ---- | 73.0 | ---- | 74.5 | ---- | No |

* These model points did not have identified exterior areas of frequent human use that would be impacted; the results are provided for informational and disclosure purposes.
NA = not applicable

# APPENDIX B
# TNM Noise Abatement Barrier Modeling Results

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# Walnut Hills Walls


Approximate dimensions of the traffic noise abatement walls.

| Barrier | Barrier Height & Width (feet) | Overall Barrier Size (sq. ft.) | Overall Cost |
|---|---|---|---|
| Arapahoe Road | 8 x 1,060 | 8,480 | $381,600 |
| Yosemite Street | 8 x 70<br>9 x 250<br>11 x 180 | 4,790 | $215,600 |

Noise abatement results from TNM for the above walls.

| TNM Model Receptor | Units | NAC (dBA) | Noise Level w/o Abatement (dBA) | Result from Modeling | Noise reduction w/ Abatement (dBA) | Noise Level w/ Abatement (dBA) | Does Receptor Benefit? |
|---|---|---|---|---|---|---|---|
| B01 | 1 | 66 | 71.4 | Impact | 8.3 | 63.1 | Yes |
| B02 | 1 | 66 | 71.3 | Impact | 8.7 | 62.6 | Yes |
| B03 | 1 | 66 | 71.1 | Impact | 8.5 | 62.6 | Yes |
| B04 | 1 | 66 | 71.5 | Impact | 6.6 | 64.9 | Yes |
| B05 | 1 | 66 | 71.1 | Impact | 8.7 | 62.4 | Yes |
| B06 | 1 | 66 | 71.2 | Impact | 8.9 | 62.3 | Yes |
| B07 | 1 | 66 | 70.8 | Impact | 7.9 | 62.9 | Yes |

| TNM Model Receptor | Units | NAC (dBA) | Noise Level w/o Abatement (dBA) | Result from Modeling | Noise reduction w/ Abatement (dBA) | Noise Level w/ Abatement (dBA) | Does Receptor Benefit? |
|---|---|---|---|---|---|---|---|
| B08 | 1 | 66 | 70.7 | Impact | 6.4 | 64.3 | Yes |
| B09 | 1 | 66 | 71.5 | Impact | 5.4 | 66.1 | Yes |
| B11 | 1 | 66 | 63.1 | ---- | 3.9 | 59.2 | No |
| B12 | 1 | 66 | 62.9 | ---- | 4.0 | 58.9 | No |
| B13 | 1 | 66 | 62.5 | ---- | 3.9 | 58.6 | No |
| B14 | 1 | 66 | 62.5 | ---- | 3.9 | 58.6 | No |
| B15 | 1 | 66 | 63.0 | ---- | 4.1 | 58.9 | No |
| B16 | 1 | 66 | 63.2 | ---- | 3.8 | 59.4 | No |
| B17 | 1 | 66 | 63.7 | ---- | 3.7 | 60.0 | No |
| B18 | 1 | 66 | 64.0 | ---- | 3.2 | 60.8 | No |
| B19 | 1 | 66 | 64.9 | ---- | 2.3 | 62.6 | No |
| B29 | 1 | 66 | 62.2 | ---- | 1.3 | 60.8 | No |
| B30 | 1 | 66 | 69.2 | Impact | 5.8 | 63.4 | Yes |
| B31 | 1 | 66 | 67.0 | Impact | 7.1 | 59.9 | Yes |
| B32 | 1 | 66 | 66.3 | Impact | 6.2 | 60.1 | Yes |
| B33 | 1 | 66 | 63.8 | ---- | 6.0 | 57.8 | Yes |
| B34 | 1 | 66 | 62.1 | ---- | 5.0 | 57.1 | Yes |
| B35 | 1 | 66 | 60.0 | ---- | 2.9 | 57.1 | No |
| B43 | 1 | 66 | 62.0 | ---- | 1.9 | 60.1 | No |
| B44 | 1 | 66 | 58.3 | ---- | 1.1 | 57.2 | No |
| B75 | 1 | 66 | 71.5 | Impact | 6.8 | 64.7 | Yes |
| B76 | 1 | 66 | 71.9 | Impact | 7.5 | 64.4 | Yes |
| B77 | 1 | 66 | 72.4 | Impact | 7.1 | 65.3 | Yes |
| B78 | 1 | 66 | 72.5 | Impact | 5.4 | 67.1 | Yes |
| B79 | 1 | 66 | 65.2 | ---- | 0.7 | 64.5 | No |
| B80 | 1 | 66 | 63.5 | ---- | 2.0 | 61.5 | No |
| B81 | 1 | 66 | 62.7 | ---- | 2.7 | 60.0 | No |
| B82 | 1 | 66 | 63.2 | ---- | 3.6 | 59.6 | No |

**Total Barrier Benefit = 126.3 dBA**

**Cost Benefit Index = $597,000 / 126.3 = $4,700/receptor▪decibel**

# Brothers Barbeque Wall


Approximate dimensions of the optimized traffic noise abatement wall.

| Barrier | Barrier Height & Width (feet) | Overall Barrier Size (sq. ft.) | Overall Cost |
|---|---|---|---|
| Brothers BBQ | 20 x 475 | 9,500 | $427,500 |

Noise abatement results from TNM for the above wall.

| TNM Model Receptor | Units | NAC (dBA) | Noise Level w/o Abatement (dBA) | Result from Modeling | Noise reduction w/ Abatement (dBA) | Noise Level w/ Abatement (dBA) | Does Receptor Benefit? |
|---|---|---|---|---|---|---|---|
| E58 | 1 | 71 | 72.9 | Impact | 5.7 | 67.2 | Yes, but does not meet design goal |

**Total Barrier Benefit = 5.7 dBA**

**Cost Benefit Index = $427,500 / 5.7 = $75,000/receptor▪decibel**

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# APPENDIX C
# Noise Abatement Evaluation Worksheets

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# COLORADO DEPARTMENT OF TRANSPORTATION
# NOISE ABATEMENT DETERMINATION WORKSHEET

**Instructions: To complete this form refer to CDOT Noise Analysis Guidelines**

STIP # _____ Date of Analysis: 3/30/2012

Project Name & Location: I-25/Arapahoe Road EA---Walnut Hills

A. FEASIBILITY:
1. Can a 5dBA noise reduction be achieved by constructing a noise barrier or berm?
   ☒ YES ☐ NO
2. Are there any fatal flaw drainage, terrain, safety, or maintenance issues involving the proposed noise barrier or berm?
   ☐ YES ☒ NO
3. Can a noise barrier or berm less than 20 feet tall be constructed?
   ☒ YES ☐ NO

B. REASONABLENESS:
1. Has the Design goal of 7 dBA noise reduction for abatement measure been met for at least one impacted receptor?
   ☒ YES ☐ NO
2. Is the Cost Benefit Index below $6800 per receptor per dBA?
   ☒ YES ☐ NO
3. Are more than 50% of benefited resident/owners in favor of the recommended noise abatement measure?
   ☐ YES ☐ NO This will be assessed during public comment period. Early indications from previous meetings are "Yes".

C. INSULATION CONSIDERATION:
1. Are normal noise abatement measures physically infeasible or economically unreasonable?
   ☐ YES ☒ NO
   If the answer to 1 is YES, then:
2. a. Does this project have noise impacts to NAC Activity Category D?
      ☐ YES ☐ NO
   b. If yes, is it reasonable and feasible to provide insulation for these buildings?
      ☐ YES ☐ NO

D. ADDITIONAL CONSIDERATIONS: Two barrier segments are needed for these impacts: one along Arapahoe and one along Yosemite. The two barriers were evaluated as a single abatement action. The barriers were: 8 ft x 1060 ft along Arapahoe; 8 ft x 70 ft plus 9 ft x 250 ft plus 11 ft x 180 ft along Yosemite. They would provide 126 dB of benefit and the cost index would be $4700/dB. The ends of the barriers would need to be wrapped to be most effective. The barriers would have to replace existing privacy fences and be built ON the property lines due to limited space.

E. STATEMENT OF LIKELIHOOD:
1. Are noise mitigation measures feasible?
   ☒ YES ☐ NO
2. Are noise mitigation measures reasonable?
   ☒ YES ☐ NO
3. Is insulation of buildings both feasible and reasonable?
   ☐ YES ☒ NO
4. Shall noise abatement measures be provided?
   ☒ YES ☐ NO

F. ABATEMENT DECISION DESCRIPTION AND JUSTIFICATION:
Property owner opinions will be gathered at the upcoming EA public meeting but have been supportive so far. The abatement action was preliminarily found to be both feasible and reasonable and is therefore recommended for construction by the project, pending the outcome of the opinions of the affected receptors. For this evaluation, it has been assumed that there are no fatal flaws with locating the barriers on the private property lines (due to lack of right of way space).

Completed by: Dale Tischmak Date: 3/30/12

# COLORADO DEPARTMENT OF TRANSPORTATION
# NOISE ABATEMENT DETERMINATION WORKSHEET

**Instructions: To complete this form refer to CDOT Noise Analysis Guidelines**

STIP # _____ Date of Analysis: 3/9/2012

Project Name & Location: I-25/Arapahoe Road EA---Category E (Brothers BBQ)

A. FEASIBILITY:
1. Can a 5dBA noise reduction be achieved by constructing a noise barrier or berm?
   ☒ YES ☐ NO
2. Are there any fatal flaw drainage, terrain, safety, or maintenance issues involving the proposed noise barrier or berm?
   ☐ YES ☒ NO
3. Can a noise barrier or berm less than 20 feet tall be constructed?
   ☒ YES ☐ NO

B. REASONABLENESS:
1. Has the Design goal of 7 dBA noise reduction for abatement measure been met for at least one impacted receptor?
   ☐ YES ☒ NO
2. Is the Cost Benefit Index below $6800 per receptor per dBA?
   ☐ YES ☒ NO
3. Are more than 50% of benefited resident/owners in favor of the recommended noise abatement measure?
   ☐ YES ☐ NO

C. INSULATION CONSIDERATION:
1. Are normal noise abatement measures physically infeasible or economically unreasonable?
   ☒ YES ☐ NO
   If the answer to 1 is YES, then:
2. a. Does this project have noise impacts to NAC Activity Category D?
      ☐ YES ☒ NO
   b. If yes, is it reasonable and feasible to provide insulation for these buildings?
      ☐ YES ☐ NO

D. ADDITIONAL CONSIDERATIONS: One barrier segment was modeled for this impact. The barrier would be for a Category E property--an outdoor dining area for a restaurant. Generally, barriers are not favored by commercial property owners. The barrier evaluated was 20 ft x 475 ft along the old frontage road. It would provide approximately 6 dB of benefit for one receptor and the cost index would be $75,000/dB.

E. STATEMENT OF LIKELIHOOD:
1. Are noise mitigation measures feasible?
   ☒ YES ☐ NO
2. Are noise mitigation measures reasonable?
   ☐ YES ☒ NO
3. Is insulation of buildings both feasible and reasonable?
   ☐ YES ☒ NO
4. Shall noise abatement measures be provided?
   ☐ YES ☒ NO

F. ABATEMENT DECISION DESCRIPTION AND JUSTIFICATION:
The abatement action was found not to be reasonable and is not recommended for construction by the project.

Completed by: Dale Tischmak Date: 3/9/2012

I-25/Arapahoe Interchange

Environmental Assessment

# Visual Resources Technical Memorandum

*April 2012*

# I-25/Arapahoe Road Visual Resources Technical Memorandum

Visual quality analyses for the alternatives were conducted in accordance with the U.S. Department of Transportation, Federal Highway Administration (FHWA) *Visual Impact Assessment for Highway Projects* (FHWA 1988). The FHWA methodology uses a qualitative and quantitative approach to analyze existing and proposed views of the project area. Visual quality is assessed under FHWA guidance through three elements: vividness, intactness, and unity, none of which alone is equivalent to total visual quality. All three must be high to indicate high visual quality (FHWA 1998).

- **Vividness:** Vividness is the memorability of the visual impression received from the contrasting landscape elements as they combine to form a striking and distinctive visual pattern.
- **Intactness:** Intactness is the integrity of visual order in the natural and built landscape, and the extent to which the landscape is free from visual encroachment.
- **Unity:** Unity is the degree to which the visual resources of the landscape join together to form a coherent, harmonious, visual pattern. Unity refers to the compositional harmony or the inter-compatibility between landscape elements.

The characteristics of these elements ranging from very high to very low are described in Table 1.

### Table 1: Visual Quality Rating Descriptions

| Component | Very High | Average | Very Low |
|---|---|---|---|
| Vividness | ✦ Highly memorable; contrasting landscape elements combine to form distinctive visual patterns.<br>✦ Strongly defined landscape or landforms, i.e., mountains, large bodies of water.<br>✦ Distinctive patterns, colors, and textures of vegetation or memorable built structures. | ✦ Moderately memorable, some distinctive patterns.<br>✦ Moderately defined landscape or landforms, i.e., low rolling hills and smaller water bodies.<br>✦ Vegetation patterns, colors, and textures are less visible. Some memorable built structures. | ✦ Low memorability. Little visual pattern; landscape elements do not form striking and distinctive pattern.<br>✦ Homogeneous landforms or landscapes and small bodies of water.<br>✦ Unnoticeable vegetation patterns, colors, textures; built structures are not memorable. |
| Intactness | ✦ High visual integrity between natural and built landscape, free from visual encroachment.<br>✦ Natural areas and built landscapes blend into surrounding | ✦ Average visual integrity between natural and built landscape.<br>✦ Some visual encroachment present and lacks visual order.<br>✦ Some disruption of | ✦ Low visual integrity between natural and built landscape.<br>✦ Visual encroachment very apparent.<br>✦ Disrupted patterns; integrity of natural visual order is lost. |

| Component | Very High | Average | Very Low |
|---|---|---|---|
| | character and create no visual discontinuity.<br>✦ Natural and built patterns are not disturbed and maintain visual order. | natural and built patterns. | |
| Unity | ✦ Landscape elements join to form highly coherent, harmonious visual pattern.<br>✦ Built and natural elements blend together. | ✦ Landscape elements join to form a moderately coherent, harmonious visual pattern.<br>✦ Built elements blend with natural elements, but visual order is disrupted. | ✦ Landscape elements do not join to form a coherent, harmonious visual pattern.<br>✦ Built elements have no visual relationship to natural landforms or patterns; no visual order. |

Source: FHWA 1988.

Evaluations based on the three criteria have proven to be good predictors of the visual quality using the following equation (FHWA 1988):

$$\text{Visual Quality} = \frac{\text{Vividness} + \text{Intactness} + \text{Unity}}{3}$$

The table below provides the numeric ranges for total visual quality ratings based on FHWA guidance (FHWA 1988).

### Table 2: Visual Quality Rating Numeric Range

| Vividness, Unity, Intactness | Developed Land Uses | Encroachments, Undesirable Elements |
|---|---|---|
| Very High: 5.7-7 | None | None |
| High: 4.7-5.6 | Little | Few |
| Moderately High: 3.7-4.6 | Some | Some |
| Average: 2.7-3.6 | Average | Average |
| Moderately Low: 1.9-2.6 | Moderately High | Several |
| Low: 1.0-1.8 | High | Many |
| Very Low: 0.0-0.9 | Very High | Very Many |

Source: FHWA 1988.

The existing and post-construction conditions within the study area are described and evaluated below based on the anticipated changes in vividness, intactness, and unity. The following images demonstrate the study area's existing visual quality for viewers looking *from* the road (i.e., drivers) and viewers looking *toward* the road (e.g., pedestrians, shoppers, etc.).

1. Approaching Arapahoe Road on Yosemite Street from the south. Restaurants and office buildings are near the intersection.

2. Farther north on Yosemite Street approaching Arapahoe Road; some street-side landscaping to the right.

3. Looking north toward Papa Johns and Taco Bell from intersection of Yosemite Street and Arapahoe Road.

4. Looking northwest from Arapahoe Road and Yosemite Street toward Red Robin, shopping center, and office buildings.

5. Looking west along Arapahoe Road toward I-25; gas station in foreground with fast food restaurants and office high-rise in background.

6. Looking north on Clinton Street toward Arapahoe Road with Wells Fargo to the east (right) and Key Bank to the west (left).

The images below indicate the visual setting where most of the proposed changes would occur for both viewers looking *from* the road and *toward* the road.

7. Looking southeast from the southbound I-25 off-ramp and Arapahoe Road.


8. Looking east along Arapahoe Road toward the I-25 interchange; fence and landscaping buffer a residential area to the right.

9. Looking west along Arapahoe Road toward the light rail overpass.

10. Looking west from the intersection of the northbound I-25 off-ramp and Arapahoe Road.

11. Looking north along Yosemite Street toward Arapahoe Road; fence and landscaping buffer a residential area to the left.

12. Looking north along northbound I-25 on-ramp at left; frontage road at right.

The study area is highly developed. I-25 is currently an important transportation arterial that serves local communities, the metropolitan region, and the western U.S. The City of Greenwood Village believes that I-25 is "an important public image and landscape element of the community" and notes that "the I-25 corridor warrants special attention to design and landscaping detail because it is both a major transportation and image element" (Greenwood Village 2011). As shown in Figure X in the "Land Use" section and validated with site visits, several commercial enterprises of various size occur along Arapahoe Road, with a large residential area southwest of Yosemite Street. Banks, fast-food establishments, shopping centers, service providers, and gas stations border much of Arapahoe Road within the study area. Large structures that occupy substantial amounts of space, such as motels and big box stores like Lowes and Target, are also visible. Considerable amounts of land are occupied by sizeable parking lots on both sides of I-25. No parks and few undeveloped areas exist in the study area. The visual quality of this setting is described below.

**Vividness:** The photos above indicate some memorable built structures, particularly the high-rise building shown in photos 1, 5, 11, and 12. Few distinctive or memorable patterns exist. The mountains can be seen in the distance from views looking west, as indicated in photos 9 and 10. Some man-made landscaping exists, primarily where residential areas front the roadways, as shown in photos 8 and 11. However, vegetation patterns are not particularly noticeable in the majority of the study area. Trees typically exist in isolation (photos 2, 4, and 5). The result is low overall memorability. Therefore, vividness is moderately low, with a rating of 1.9.

**Intactness:** Developed land use is very high, resulting in a high degree of visual encroachment. The natural landscape consists of some landscaped trees and low vegetation; no naturally occurring vegetation exists. Visual order between the natural and built landscape is mostly lacking. Building heights and store front designs vary considerably as shown in photos 1-6 and 12, resulting in disrupted visual patterns. Disruption is minimized on the south side of Arapahoe Road between S. Uinta and Yosemite Streets, and on the west side of Yosemite Street where a residential area exists. This area is buffered from both roads by a tall fence and landscaped vegetation, which provides some level of intactness along these roadway sections (photos 8 and 11). The level of traffic varies, with high peak rush hour periods, resulting in inconsistent traffic flow and encroachment. For these reasons, intactness is low, with a rating of 1.0.

**Unity:** The fence and landscape elements that buffer the residential area described above join to form a moderately coherent, harmonious visual pattern (photos 8 and 11). Elsewhere throughout the study area, the varying building heights and store front designs lack visual order and have no visual relationship to natural landforms or patterns, which are absent throughout most of the area (photos 1-6). There is little inter-compatibility between the visual elements. At some locations, the linear nature of the roadways creates a minimal degree of unity, such as shown in photo 10, where strong horizontal lines provide some compositional harmony. However, unity is generally low, with a rating of 1.0.

Using the evaluation formula for vividness, intactness, and unity described above, overall existing visual quality in the study area is 1.3, low.

## Environmental Consequences of the No Action Alternative

Under the No Action Alternative, no further improvements would be made to the I-25/ Arapahoe Road interchange. Further increases in congestion would result in additional

encroachment into the visual setting. However, this change would be minimal in the overall setting. The existing built environment would continue to dominate views. Therefore, impacts to viewers from the road and toward the road would be negligible.

### *Cumulative Impacts*

Past regional growth has contributed to increased travel demand and traffic volumes along Arapahoe Road. The resulting growth influenced rapid commercial development in the area, with a mix of building sizes and designs. High-density development resulting from transit-oriented development (TOD) may result in more visual cohesiveness, with standard design elements concentrated in specific areas – a slight beneficial effect. TOD is a mixed-use residential or commercial area designed to maximize access to public transport, and often incorporates features to encourage transit ridership. Small retail centers and restaurants are anticipated to develop on parcels along Arapahoe Road and adjacent thoroughfares. Such new development would likely further decrease intactness and unity, decreasing overall visual quality for viewers from the road and toward the road to a slight degree. When these actions are combined with the negligible impacts expected under the No Action alternative, cumulative impacts to visual resources would also be negligible.

## Environmental Consequences of the Action Alternative

The primary visual changes that would occur under the Action Alternative include:

- Raising the I-25 bridge an additional 7 to 8 feet.
- Widening Arapahoe Road primarily by creating additional lanes.
- Widening northbound Yosemite Street where it approaches Arapahoe Road by creating additional lanes.
- Modifying the intersections of Arapahoe Road with Yosemite Street and Clinton Street, and the I-25 on/off ramps to accommodate additional lanes.
- Realigning the frontage road in the northeast quadrant of the study area to accommodate construction and improve access.

Although additional improvements are called for under the Action Alternative, they are not expected to measurably affect visual resources.

One Key Observation Point (KOP) was selected to represent the most substantial changes proposed in the study area for views both *from* and *toward* the interchange. The photo for this KOP was taken looking east on Arapahoe Road from Xanthia Street, shown below. A simulation that follows shows the proposed changes that would occur under the Action Alternative.

Figure 1: Existing Conditions Looking East on Arapahoe Road from Xanthia Street

### Figure 2: Simulated Conditions Looking East on Arapahoe Road from Xanthia Street

As shown in the simulation, raising the I-25 bridge seven to eight feet would not be visually noticeable. Widening Arapahoe Road to provide an additional eastbound through lane would result in removal of some landscaping on the south side of the road and the addition of a short retaining wall. The bridge supports for the new interstate bridge over Arapahoe Road would be moved to the center of Arapahoe Road (which would be widened), and the relocated median may be vegetated and more prominent.

The highway signs that overhang Arapahoe Road would be relocated behind the viewer position, and may be sized differently (which would be determined during final design). The simulation shows a small sign for the interstate beside the sidewalk in conjunction with interstate emblems potentially painted on the eastbound lanes, which are visually unobtrusive.

The telephone lines may be buried underground (as shown in the simulation) or replaced aboveground (also to be determined during final design). In general, removal of the vertical elements as shown in the simulation would add a slight degree of unity by decreasing visual clutter. However, vertical elements such as telephone lines may be introduced later during final design. The additional lanes and reconfigured striping would help create a visual convergence point from the foreground toward the bridges, creating slightly more visual order and enhancing unity.

Vividness and intactness would not noticeably change. Slight increases in unity would change the unity rating at this KOP from 1.0 to 1.2, as developed land use would remain moderately high and several visual encroachments would remain. Overall visual quality would change from 1.3 to 1.37 at this location for viewers *from* the interchange and *toward* the interchange — a negligible impact.

Visual quality is not expected to measurably change throughout the study area at other locations. Widening Arapahoe Road and Yosemite Street to provide additional lanes would not create a perceptible visual change in the context of the setting, which is primarily defined by existing built elements.

The existing frontage road in the northeast quadrant of the study area would be closed and a new road constructed to the north of the intersection of the northbound I-25 exit ramp with Arapahoe Road. The new road would pass between the La Quinta Inn and Motel 6, and would terminate at East Southtech Drive behind Lowes. The road would provide access to two large existing parking lots that serve the motels on either side. The area that would be occupied by the new road is already disturbed and paved, although some landscaped vegetation associated with the parking lots would be removed. The City of Greenwood Village may add landscaping along this new city street. The new road would not measurably alter visual quality given the highly developed visual setting. Closing the existing frontage road, shown to the right of photo 12, would slightly improve visual quality for viewers from the road as they enter northbound I-25, but the change would be slight and unnoticeable as drivers would be concentrating on merging with highway traffic.

There would be no perceptible change in the number of parking lots and variety of building heights and store front designs throughout the study area as a result of the Action Alternative. Changes to vegetation would be minimal. Overall visual quality is not expected to fall below 1.0 or above 1.5 and would therefore remain low for viewers both *from* the road and *toward* the road.

### *Cumulative Impacts*

The same past, present, and reasonably foreseeable actions described for the No Action Alternative would apply to this alternative as well. High-density development resulting from future TOD may result in more visual cohesiveness — a slight beneficial effect. Development of small retail centers and restaurants along Arapahoe Road and adjacent thoroughfares would likely further decrease intactness and unity, decreasing overall visual quality for viewers *from* the road and *toward* the road to a slight degree. When these actions are combined with the negligible impacts expected under the Action alternative, cumulative impacts to visual resources would also be negligible.

## Mitigation

No mitigation is anticipated given the negligible effects of the alternative.

References

Federal Highway Administration (FHWA). 1998. *Visual Impact Assessment for Highway Projects*. Office of Environmental Policy. Publication No. FHWA-HI-88-054.

Greenwood Village. 2011. *Greenwood Village Comprehensive Plan*. http://www.greenwoodvillage.com/DocumentView.aspx?DID=1645.

I-25/Arapahoe Interchange

Environmental Assessment

# HAZARDOUS MATERIALS ASSESSMENT
# INTERSTATE 25 (I-25)/ARAPAHOE ROAD
# ENVIRONMENTAL ASSESSMENT

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FHU Reference No. 10-025
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# 1.0 INTRODUCTION

Felsburg, Holt & Ullevig (FHU), acting on behalf of Arapahoe County, conducted a hazardous materials assessment in support of the National Environmental Policy Act (NEPA) documentation for the Interstate 25 (I-25)/Arapahoe Road Interchange Environmental Assessment (EA).

The purpose of the hazardous materials assessment is to evaluate properties adjacent to or within the vicinity of the I-25/Arapahoe Road Interchange project footprint (i.e., study area) for the presence of contamination from hazardous materials and to identify if these sites have potential or recognized (known) existing or past soil and groundwater contamination. Contaminated soils and groundwater and the presence of hazardous materials require special consideration for worker health and safety, right-of-way acquisition processes, and materials management practices. Encountering soil and groundwater contamination during the construction process without prior knowledge of contamination has the potential to affect the project in terms of mitigation, cost, schedule, and project worker health and safety. Therefore, the identification of potential or recognized soil and groundwater contamination within the study area is necessary during the planning process so that avoidance or mitigation measures can be implemented when reasonably possible.

This hazardous materials assessment has been prepared with a level of detail appropriate for the development of an Action Alternative for the I-25/Arapahoe Road Interchange EA project. Full and partial property acquisitions for right-of-way are expected based on preliminary project engineering design. It is anticipated that additional assessment and/or field investigations could be needed to assist in the right-of-way acquisition process and the development of specific materials management or institutional controls that may be required during construction. Recommendations are provided in **Section 6.0**.

## *1.1 Project Description*

The purpose of the I-25/Arapahoe Road Interchange project is to reduce congestion and to improve functional deficiencies and operational and safety elements for the traveling public. The existing design and capacity of the interchange no longer accommodates traffic demands, and this will worsen in the future without action. The study area straddles I-25 near Milepost 197 and is in both Centennial and Greenwood Village. The area includes residences, businesses and undeveloped areas abutting the streets and roads of interest for the project. The study area is currently almost fully developed. Two alternatives are being considered in the EA analysis: the No-Build Alternative and the Action Alternative. The No-Build Alternative (No-Build) has no new road improvements as part of this project, though some changes to the current road network may be made by other projects. The Action Alternative was selected through a robust alternatives evaluation process. To summarize, the Action Alternative consists of replacing the I-25 bridge over Arapahoe Road and making numerous improvements to Arapahoe Road and the interchange ramps that would result in an improved partial cloverleaf interchange configuration. For additional details on the alternatives and improvements, refer to the EA document.

## 1.2 Guidance Modifications and Limitations

This hazardous materials assessment was prepared for Arapahoe County for their sole use and reliance. Reliance on this report by any other person(s) or entity (ies) is strictly at their own risk, and FHU makes no warranties to person(s) or entity (ies) other than Arapahoe County who use the information provided in this report. If any other person(s) or entity (ies) wish to rely on this report, FHU will require that such parties agree to our contract terms in writing.

FHU performed this work for the sole purpose of assisting in the identification of potential and recognized environmental conditions associated with properties within the study area. The scope of work commissioned for this project does not represent an exhaustive study, but rather a reasonable inquiry generally consistent with the Colorado Department of Transportation (CDOT) hazardous materials guidance (*CDOT, 2010*), as modified from the American Society for Testing and Materials (ASTM) Designation E 1527-05, "Standard Practice for Environmental Site Assessments: Phase I Environmental Site Assessment Process" (ASTM, 2005) and U.S. Environmental Protection Agency (EPA) Standards and Practices for All Appropriate Inquiries [40 Code of Federal Regulations (CFR) Part 312] (EPA, 2005*).*

Any findings and recommendations presented in this report are geared specifically to address the issues regarding hazardous materials that would affect the planning and design of this construction project. This hazardous materials assessment has been prepared with a level of detail appropriate for the I-25/Arapahoe Road Interchange project NEPA documentation and identifies sites with potential and recognized environmental conditions associated with the study area. Potential and recognized environmental conditions are defined in **Section 1.3.**

FHU's assessment and findings presented herein are based upon observation of current conditions within the study area and a review of readily available standard historical sources and environmental agency databases. Modifications to the standard Phase I Environmental Site Assessment (ESA) process include:

- FHU's assessment did not include interviews of current and/or past owners and occupants of properties located within the study area.
- FHU's assessment did not include a review of historical aerial photographs, topographic maps or city directories.
- FHU's assessment did not include a search for environmental cleanup liens.
- FHU's assessment did not attempt to detect the presence of types of equipment that have been historically associated with the use of polychlorinated biphenyls (PCBs) as a dielectric fluid coolant and stabilizer.
- FHU's visual site assessment was limited to areas visible from public right-of-way and did not include access to fenced-in areas, interiors of buildings, rear lots (alley side portion of adjacent sites), or areas not visible from public right-of-way.
- This assessment did not attempt to detect the presence of potential environmental contamination that may exist in areas that could not be visually inspected.

This hazardous materials assessment was non-intrusive. Sampling of soils, groundwater, and/or surface waters was beyond the scope of this hazardous materials assessment. Other environmental liabilities to a property owner, such as identifying the presence of asbestos-containing materials, radon, or lead-based paint were also beyond the scope of investigation for this hazardous materials assessment. The presence or absence of such conditions can not be confirmed without additional investigation.

This hazardous materials assessment report does not guarantee that no contamination exists on sites within the study area beyond that described at the time of writing this report. Therefore, conclusions presented herein are not necessarily indicative of future conditions or operating practices surrounding the study area. No warranties, expressed or implied, are made. All conclusions and recommendations represent the professional opinions of the FHU personnel involved with the hazardous materials assessment and the results should not be considered a legal interpretation of existing environmental conditions.

## *1.3 Terminology*

This section provides a brief explanation of some of the common terminology utilized within the hazardous materials assessment report.

- **Hazardous Materials** - The term hazardous materials is an all-inclusive term for materials that are regulated as solid waste, hazardous waste, and other wastes contaminated with hazardous substances, radioactive materials, petroleum fuels, toxic substances, and pollutants.
- **Recognized Environmental Conditions** - For this hazardous materials assessment report, sites within the study area were identified as having known (current and historic) soil or groundwater contamination and are distinguished in this report as sites with recognized environmental conditions. Recognized environmental conditions, as defined by ASTM, include sites *with "the presence or likely presence of any hazardous substances or petroleum products on a property under conditions that indicate an existing release, a past release, or a material threat of a release of any hazardous substances or petroleum products into structures on the property or into the ground, groundwater, or surface water of the property"*.
- **Potential Environmental Conditions** - Sites identified within the study area as having potential environmental conditions (e.g. evidence of storage, handling, or disposal of hazardous materials) during site reconnaissance activities that could not be confirmed without additional inspection or investigation are distinguished in this report as sites with potential environmental conditions.

## 2.0 METHODOLOGY

The methodology utilized to identify the presence of sites with recognized and potential environmental conditions within the study area included the following steps:

- Review of previous studies relevant to the study area;
- Review of readily available local, state, tribal, and federal environmental agency databases as dictated by ASTM Standard E1527-05 (ASTM, 2005);
- Performance of a limited site reconnaissance ("windshield survey") of properties within the study area from public right-of-way to identify site activities and potential contamination sources adjacent to the study area;
- Screening of sites identified in the regulatory databases based on distance from the proposed right-of-way and type of environmental conditions.
- Review of previous Arapahoe County, Colorado Department of Labor and Employment Division of Oil and Public Safety (OPS) records, and other available records from local, state, and federal agencies regarding properties with recognized environmental conditions within the study area; and
- Identification of properties within the study area requiring additional evaluation or investigation to assist in project design, specific-materials management/institutional controls that may be required during construction, or the right-of-way acquisition process, if full acquisition is necessary.

# 3.0 REVIEW OF PREVIOUS REPORTS

As part of the hazardous materials assessment, the Arapahoe Road Corridor Study Environmental Overview (Arapahoe County, 2007) was reviewed to determine if any sites were previously identified with potential or known contamination issues that are relevant to the project. The hazardous materials assessment for this project included a limited site reconnaissance along the project corridor, review of federal, state, and local regulatory databases, and identification of sites with potential or recognized environmental conditions within 100 feet of the study area right-of-way. Based on the review of the Arapahoe Road Corridor Study Environmental Overview report, 72 sites with recognized or potential environmental conditions were identified within the Study Area. Of these sites, eight are adjacent to the I-25/Arapahoe Road EA study area (**Table 2**).

# 4.0 SITE RECONNAISSANCE

A limited site reconnaissance was conducted on October 12, 2011 by Laura Haas, an Environmental Scientist with FHU. The purpose of the site reconnaissance was to assess the study area for potential hazardous materials concerns associated with current land use and observable site activities. The visual inspection assessed the properties for evidence of potential or recognized environmental conditions, such as:

- Presence of above ground storage tanks (ASTs) and secondary containment for spill prevention;
- Evidence of underground storage tanks (USTs), including fill ports, vent pipes, and fueling facilities;
- Disposal of solid waste, waste management practices, and general good housekeeping of waste storage/disposal areas;
- Evidence of on-site dumping and landfilling;
- Handling and storage of hazardous materials, such as the presence of 55-gallon drums, tote containers, etc.; and
- Presence of drains, sumps, septic systems, wastewater discharges, pits, ponds, or lagoons.

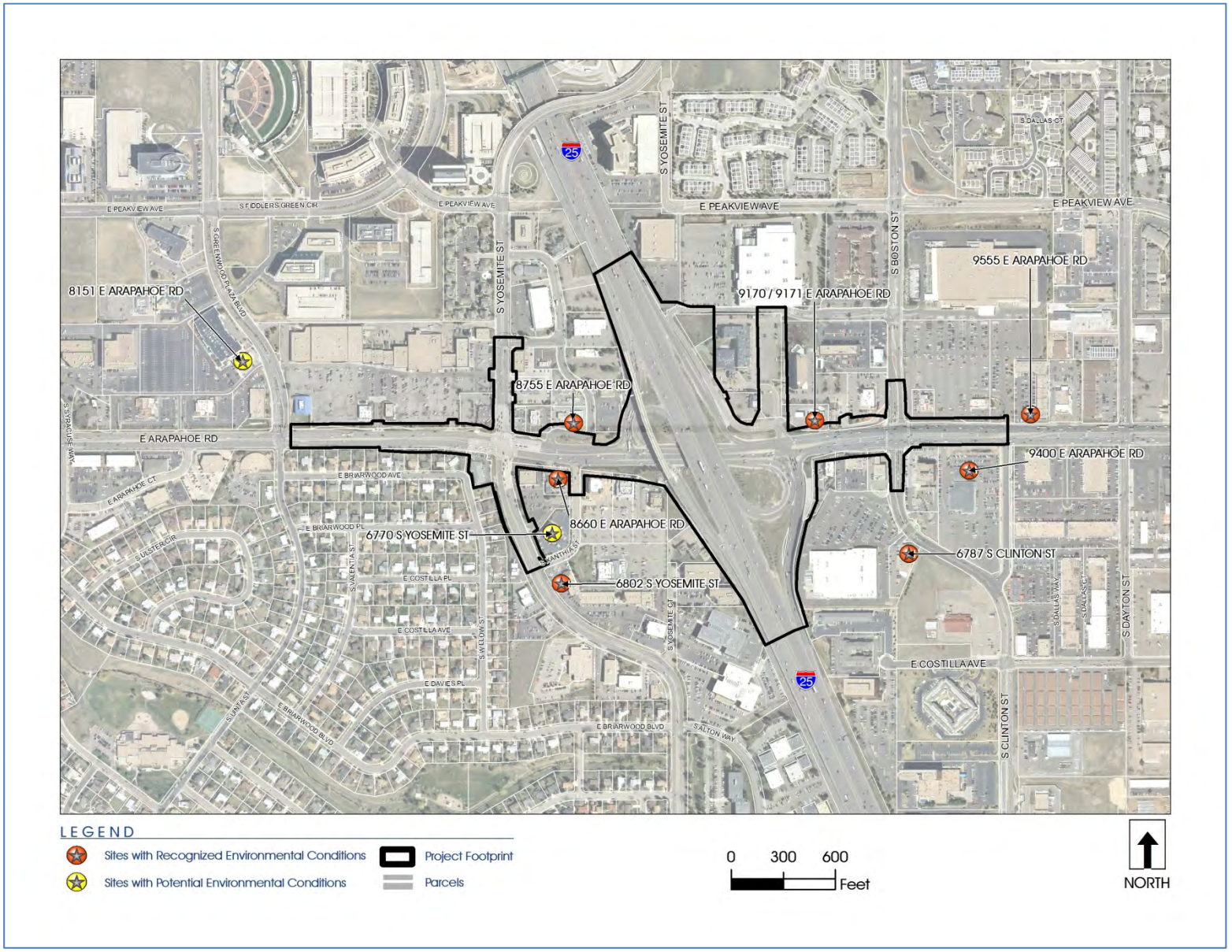
The objective of the site reconnaissance was to obtain information indicating the likelihood of identifying potential environmental conditions in connection with sites within the study area. Modifications to the guidance on site reconnaissance and project limitations are discussed in **Section 1.2**. Photographs taken during the site reconnaissance are included in **Appendix A**.

Current land use adjacent to the study area consists mainly of commercial and retail operations. Information concerning sites with potential environmental conditions identified during the site reconnaissance is included in **Table 1** and **Figure 1**. Sites that were identified with potential environmental conditions during the site reconnaissance that were also identified with recognized environmental conditions during the database screening are included in **Table 2** in **Section 5.0**.

### Table 1. Sites with Potential Environmental Conditions Identified during the Site Reconnaissance

| Site Address/Name | Description of Property |
|---|---|
| 6770 S. Yosemite St. (Brakes Plus/Fast Traxx Fast Lube) | There are two automotive service/repair/maintenance facilities with vehicle maintenance bays at this address. Unknown material handling, storage, and disposal practices. Potential materials include: fuel, motor oils, hydraulic fluids, degreasers, paints and solvents. 55-gallon drums and miscellaneous storage were observed in the parking lot. |
| 8151 E. Arapahoe Rd. (Big O Tires) | Automotive service/repair/maintenance facility. Vehicle maintenance bays. Unknown material handling, storage, and disposal practices. Potential materials include: fuel, motor oils, hydraulic fluids, degreasers, paints and solvents. |

**Figure 1. Sites with Potential and Recognized Environmental Conditions**



# 5.0 AGENCY RECORDS REVIEW AND SITE SCREENING

FHU contracted Environmental Data Resources (EDR) to conduct a database search of local, state, and federal environmental database records for known or potential environmental concerns within one mile of the study area, as dictated by the ASTM standard E 1527-05. The entire EDR Radius Map Report (EDR, 2011) is included in this report as **Appendix B**.

## *5.1 Site Screening*

Sites identified in the EDR database record search were screened to determine which sites would potentially have the presence of contamination (existing or residual) from hazardous materials and could have an adverse impact on the Action Alternative identified in the EA. The screening process consisted of identifying sites listed in the EDR database report that lie within 1,000 feet of the project footprint for the Action Alternative. Sites were categorized as adjacent to the project footprint, within 500 feet, or 500 to 1,000 feet from the project footprint (**Table 2**).

The EDR sites were then ranked with a high, medium, or low designation based on the type of site. The site ranking categories are defined as:

**Low:** Sites with minimal indications of an existing release, past release, or material threat of a release of any hazardous substances or petroleum products into the ground (soil), groundwater, or surface water. Examples include residential sites or commercial sites with activities that do not require the use of hazardous substances or petroleum products (>55 gallons/year), Resource Conservation and Recovery Information System (RCRIS) database hazardous waste generators with no reported violations, facilities with ASTs/USTs with no reported leaks or spills, and sites reported on the Facility Index System (FINDS).

**Medium:** Sites with moderate indications of an existing release, past release, or material threat of a release of any hazardous substances or petroleum products into the ground (soil), groundwater, or surface water. Examples include, RCRA hazardous waste generators with reported violations, sites reported on the Emergency Response Notification System (ERNS) list, and facilities with leaking underground storage tanks (LUSTs).

**High:** Sites with indications of a known existing or past release of any hazardous substances or petroleum products into the ground (soil), groundwater, or surface water and the possibility for large-scale migration from the contaminant source. Examples include sites listed on the National Priority List (NPL) or Superfund, sites included on the Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS), RCRA permitted treatment, storage, or disposal (TSD) facilities, RCRA Corrective Action Sites (CORRACTS), sites in the Colorado Voluntary Cleanup program (VCUP), and State active and historical solid waste landfills.

**Table 2. Sites Identified in the Regulatory Database Search**

| Parcel ID Number | Distance from Project Area | Site Address/Name | Site Description/Ranking | Selected for Detailed Review? | Identified in Previous Study? |
|---|---|---|---|---|---|
| 2075-21-4-05-047 | Adjacent | 6578 S Yosemite Cir. (A B Dick Company) | RCRA-Non-Gen[1] Low Ranking | No | No |
| 2075-27-2-12-013 | Adjacent | 6767 S. Clinton St. (Target Store #147) | RCRA-CESQG[2], ASBESTOS[3] Low Ranking | No | Yes |
| 2075-28-1-21-020 | Adjacent | 6802 S. Yosemite St. (7-Eleven #39214/Silco Oil Co., Barn Store) | UST[4], Closed LUST[5] Medium Ranking | Yes | Yes |
| 2075-27-2-02-053 | Adjacent | 6900 S. Yosemite St. (Safeway, Inc.) | RCRA-CESQG[2] Low Ranking | No | Yes |
| 2075-21-4-18-001 | Adjacent | 8525 E. Arapahoe Rd. (Longs Drug Store #420) | RCRA-CESQG[2] Low Ranking | No | No |
| 2075-21-4-08-001 | Adjacent | 8575 E. Arapahoe Rd., Unit A (High Country Suede & Leather DBA CO Lace) | DRYCLEANERS[6], RCRA-Non-Gen[1] No reported violations. Low Ranking | No | No |
| 2075-28-1-21-001 | Adjacent | 8660 E. Arapahoe Rd. (Firestone Store No. 2843) | RCRA-CESQG[2], UST[4], Closed LUST[5] Medium Ranking | Yes | No |
| 2075-21-4-05-042 | Adjacent | 8695 E. Arapahoe Rd. (Former Walnut Hills Conoco) | UST[4] (Closed) Low Ranking | No | No |
| 2075-21-4-05-043 | Adjacent | 8755 E. Arapahoe Rd. (Phillips 66 #23880) | RCRA-CESQG[2], UST[4], Closed LUST[5], CO ERNS[7], Open LUST[5] Trust (Implementing CAP) Medium Ranking | Yes | No |
| 2075-22-3-42-001 | Adjacent | 9100 E PEAKVIEW AVE (Lowe's) | RCRA-CESQG[2], CO ERNS[7] Medium Ranking | No* | No |
| 2075-27-2-12-007 | Adjacent | 9138 E. Arapahoe Rd. (Arapahoe Exxon) | AST[8] Low Ranking | No | Yes |
| 2075-27-2-12-007/2075-22-3-02-002 | Adjacent | 9170/9171 E. Arapahoe Rd. (Amoco Oil #8606, BP Facility #24545, K & G Store #518) | Open LUST[5] (Implementing CAP), RCRA-Non-Gen[1],AST[8], UST[4], Open LUST[5] Trust Medium Ranking | Yes | Yes |
| 2075-27-2-12-007 | Adjacent | 9200 E. Arapahoe Rd. (Unknown) | CO ERNS[7] Low Ranking - Spill of sewage reported 8/2/2006 due to equipment failure at Bennigan's Restaurant | No* | No |

| Parcel ID Number | Distance from Project Area | Site Address/Name | Site Description/Ranking | Selected for Detailed Review? | Identified in Previous Study? |
|---|---|---|---|---|---|
| 2075-22-3-23-008 | Adjacent | 9201 E. Arapahoe Rd. (Unknown) | ERNS[7] Low Ranking - Spill of sewage reported 4/17/1989 due to equipment failure at former Days Inn. | No* | No |
| 2075-22-3-38-006 | Adjacent | 9301 E. Arapahoe Rd. (Mike Flannery Chevrolet) | RCRA-Non-Gen[1] Low Ranking | No | Yes |
| 2075-27-2-05-003 | Adjacent | 9400 E. Arapahoe Rd. (Arapahoe Mitsubishi, Global Collision Arapahoe, Inc) | Closed LUST[5], UST[4], RCRA-CESQG[2] Medium Ranking | Yes | Yes |
| 2075-27-2-11-003 | Adjacent | Arapahoe and Clinton | CO ERNS[7], ERNS[7] Spill of oil and diesel reported 6/30/1992 Medium Ranking | No* | No |
| 2075-22-3-02-025 | Within 500 feet | 9555 E. Arapahoe Rd. (Meke Cleaners Inc., Star Cleaners) | DRYCLEANERS[6], RCRA-Non-Gen[1] Reported Violations. Medium Ranking | No | Yes |
| 2075-28-1-21-007 | Within 500 feet | 6841 S. Yosemite St. (Unknown) | Closed LUST[5], UST[4] Medium Ranking | No | No |
| 2075-27-2-12-013 | Within 500 feet | 6787 S. Clinton St. (Continental Cleaners) | CORRACTS, RCRA-Non-Gen[1], DRYCLEANERS[6], CO ERNS[7] High Ranking | No | No |
| 2075-27-2-19-001 | 500 – 1,000 feet | 9248 E. Costilla Ave. (Unknown) | CO ERNS[7] Low Ranking - Spill of sewage reported 6/5/2007 due to equipment failure at Castlewood Sanitation. | No* | No |
| 2075-21-4-13-005 | 500 – 1,000 feet | 6455 S. Yosemite St. (Banner Building East Parking Lot) | Closed LUST[5], ERNS[7] Medium Ranking | No | No |
| 2075-27-2-10-001 | 500 – 1,000 feet | 9678 E. Arapahoe Rd. (Continental Cleaners) | DRYCLEANERS[6], RCRA-Non-Gen[1] Medium Ranking | No | Yes |
| 2075-21-4-29-001 | 500 – 1,000 feet | 6430 S. Fiddlers Green Circle (High Pointe) | AST[8] Low Ranking | No | No |
| 2075-27-1-01-075 | 500 – 1,000 feet | 9700 E. Arapahoe Rd. (Fay Myers Motorcycle World) | RCRA-CESQG[2] Low Ranking | No | Yes |
| 2075-22-4-19-001 | 500 – 1,000 feet | 9701 E. Arapahoe Rd. (Kuni Lexus/Burt Lincoln Mercury) | UST[4], RCRA-Non-Gen[1] Low Ranking | No | Yes |
| 2075-21-3-27-003 | 500 – 1,000 feet | 7939 E. Arapahoe Rd. (Autotek, Robert Waxman) | RCRA-CESQG[2] Low Ranking | No | No |

| Parcel ID Number | Distance from Project Area | Site Address/Name | Site Description/Ranking | Selected for Detailed Review? | Identified in Previous Study? |
|---|---|---|---|---|---|
| 2075-21-3-27-003 | 500 – 1,000 feet | 7919 E. Arapahoe Rd. (Autowash One) | Closed LUST[5] Medium Ranking | No | No |

1 Resource Conservation and Recovery Act Non – Generator (May include facilities that transport, store, treat and/or dispose of hazardous waste)
2 Resource Conservation and Recovery Act Small Quantity Generator – Conditionally Exempt (generate less than 100 kg of hazardous waste, or less than 1 kg of acutely hazardous waste per month)
3 Asbestos
4 Underground Storage Tank
5 Leaking Underground Storage Tank
6 Past or current drycleaner operations
7 Reported spills
8 Aboveground storage tank
* No additional information available concerning sites with hazardous materials spills

The sites in **Table 2** were evaluated based on the type of site or release and the proximity of the site or release to the study area. A detailed records review was conducted for open and closed LUST sites that are located adjacent to the study area. All other sites located within 500 feet of the study area and sites located greater than 500 feet from the study area were judged relatively unlikely to have impacts on project activities. However, further investigation of these sites could be needed during later stages of the project in the event that shifts in design occur.

A detailed records review was conducted for a total of five sites with recognized environmental conditions located adjacent to the study area. When a detailed review was deemed necessary, individual records for sites were reviewed to assess the extent of current on-site environmental conditions and the potential presence of soil and groundwater contamination due to an existing or past release of a hazardous substance or petroleum product. The following section summarizes the findings of the detailed review for sites with recognized environmental conditions identified within the study area (**Figure 1**).

## *5.2 Detailed Review of Selected Sites*

### 5.2.1 6802 South Yosemite Street

The site located at 6802 South Yosemite Street is an open LUST located adjacent to the study area. A petroleum release was discovered at this site in October 2000 during a Phase I investigation conducted as part of a prospective property transaction (Silco, 2000).Further site assessments indicated minimal contamination of soils on the site (OPS, 2001). A no further action/closure letter was issued by OPS in March 2001 for this release. However, in August 2011, another release was detected at this site (OPS website, 2011). OPS requested that a site summary form be completed for the release on August 23, 2011 (OPS website, 2011). The due date for the site summary form is October 24, 2011 (OPS website, 2011). No further information concerning this release is available at the time of writing this report (October 2011).

This is an open LUST site that lies adjacent to the study area. Due to the recent timing of the release, it is unknown if soil and groundwater contamination is present on the site. Construction activities that entail ground disturbance in the vicinity of this site could encounter soil and groundwater contamination and present a materials management and worker health and safety concern. As an open LUST site, acquisition of this property also presents a liability concern.

### 5.2.2 8660 East Arapahoe Road

The site located at 8660 East Arapahoe Road is a closed LUST located adjacent to the study area. One 550-gallon used oil UST was removed from this site in July 1996. During removal of the UST, approximately 15 cubic yards of soil was removed and disposed of off-site. Oil and

grease were detected in soil samples at the time of the tank removal. A Phase II investigation was performed on the property in February 1998 to determine the extent of contamination. Three groundwater monitoring wells were installed as part of this investigation.

Results of the investigation indicated that soils from borings placed in the vicinity of the former used oil UST did not exceed remedial action category (RAC) I guidelines of 20 mg/kg. However, stained soils and odors were detected near two of the monitoring wells (down-gradient/cross-gradient of former used oil UST), which were attributed to groundwater contamination. Also, at the time of the Phase II investigation, evidence of additional USTs was observed. Results of groundwater sampling indicated that benzene exceeded the Colorado Basic Groundwater Standards (CBGS) in the down-gradient and cross-gradient wells. It was determined that the source of petroleum contamination was due to the USTs that were observed on the property and/or nearby off-site sources, rather than the used oil UST (ERM, 1998).

A no further action/closure letter was issued by OPS in October 1998 for this site. OPS defines a LUST site as closed/clean up complete when "*the owner and/or operator has not necessarily removed all contamination, but instead actions taken have met the criteria that the State uses for determining adequate clean up*."

Although this site is closed, this property presents a liability for any potential right-of-way acquisition, notably full acquisition, related to the project because residual soil and groundwater contamination may be present. In addition, if construction activities entail ground disturbance on the property at 8660 East Arapahoe Road or cross/downgradent (i.e., west-northwest) of the property, the potential exists for residual soil and groundwater contamination to be present and could present a materials management and worker health and safety concern.

### 5.2.3 8755 East Arapahoe Road

The site located at 8755 East Arapahoe Road is an open LUST located adjacent to the study area. One 560-gallon used oil UST was removed from the northern portion of the site in March 1996. Four 10,000-gallon USTs that were installed in 1978 are still in use at this site. The USTs are located along the eastern portion of the site. Multiple releases have occurred at this site.

- In May 1995, petroleum impacted soils were discovered. The impacts were attributed to spills and overfills associated with the USTs.
- In March 2003, approximately ten gallons of gasoline were released from a product line that ruptured during drilling activities for one of the monitoring wells.
- In June 2003, approximately 30-40 gallons of gasoline were released as the result of a UST overfill incident.

Multiple site assessments have been performed at this site since the mid- 1990's. Remediation activities at the site have included enhanced fluid recovery (EFR) events, quarterly groundwater monitoring, and dual phase extraction (DPE). The DPE system began operating in July 2007, but has operated intermittently due to several different operations issues. The system was restarted on June 17, 2010 (Delta, 2010).

Remediation activities for this site are on-going and the projected closure date is December 31, 2013.

This is an open LUST site that lies adjacent to the study area. Groundwater flow direction in this area it to the west-northwest. Known soil and groundwater contamination is present on the site. Construction activities that entail ground disturbance in the vicinity of this site could encounter soil and groundwater contamination and present a materials management and worker health and safety concern. As an open LUST site, acquisition of this property, notably full acquisition, also presents a liability concern.

### 5.2.4 9170/9171 East Arapahoe Road

The site located at 9170/9171 East Arapahoe Road is an open LUST located adjacent to the study area. Five USTs are currently in use at this site (two 6,000-gallon tanks, two 8,000-gallon tanks, and one 10,000-gallon tank). Also, one LPG tank is in use at this site. The site has historically operated as a gasoline station since 1956. In December 1990, a petroleum release was reported at this site. Site assessments and remediation activities have been on-going since the discovery of the petroleum release (E-21, 2011). Remediation activities have included:

- Removal of USTs, including one 500-gallon waste oil tank in August 1994. At the time of the tank removal, soils were also excavated.
- Installation of groundwater monitoring wells and quarterly groundwater monitoring.
- Installation of a soil vapor extraction (SVE) system in 1992.
- Installation of a second SVE system in 1995.
- SVE pilot testing activities in 2003.
- Multi-phase extraction (MPE) pilot testing activities in 2002.
- Excavation of additional soils in 2004.
- EFR events conducted in 2008 (E-21, 2011)

According to the most recent CAP modification, groundwater contamination is still in excess of the Tier 1 Risk Based Screening Levels (RBSLs) for benzene in several wells. Residual soil contamination may also be present on-site. Remediation activities are on-going (E-21, 2011). A CAP modification was completed on September 26, 2011 which proposed the following remediation activities:

- Installation of a new monitoring well approximately 25 feet southeast of MW-3 and 20 feet north of MW-1.
- Conducting a project file review at OPS to determine if confirmation soil sampling is needed.
- Slug testing and fate and transport modeling.
- Oxygen diffusion pilot testing near MW-3 (E-21, 2011).

At the time of writing this report (October 2011), OPS has not approved the most recent CAP modification.

This is an open LUST site that lies adjacent to the study area. Groundwater flow direction in this area it to the west-northwest. Known soil and groundwater contamination is present on the site. Construction activities that entail ground disturbance in the vicinity of this site could encounter soil and groundwater contamination and present a materials management and worker health and safety concern. As an open LUST site, acquisition of this property, notably full acquisition, also presents a liability concern.

### 5.2.5 9400 East Arapahoe Road

The site located at 9400 East Arapahoe Road is a closed LUST located adjacent to the study area. In July 2008, one 1,000-gallon waste oil tank was removed from this site. The excavation area was approximately 14 feet x 7 feet x 9 feet. Groundwater was not encountered during excavation activities. Sampling of soils detected low levels of total petroleum hydrocarbons (TPH) (Corn & Associates, 2008). Groundwater flow direction in this area it to the west-northwest. A no further action/closure letter was issued by OPS in September 2008 for this site. OPS defines a LUST site as closed/clean up complete when "*the owner and/or operator has not necessarily removed all contamination, but instead actions taken have met the criteria that the State uses for determining adequate clean up*."

Although this site is closed, this property presents a liability for any potential right-of-way acquisition, notably full acquisition, related to the project because residual soil and groundwater contamination may be present. In addition, if construction activities entail ground disturbance on the property at 9400 East Arapahoe Road or cross/downgradent of the property, the potential exists for residual soil and groundwater contamination to be present and could present a materials management and worker health and safety concern.

# 6.0 FINDINGS AND RECOMMENDATIONS

## *6.1 Findings*

Historical and current land use in the study area consists primarily of retail and commercial uses. The primary businesses adjacent to the study area include gasoline stations, automotive repair and maintenance shops, and restaurants. General environmental concerns within the study area include residual contamination from LUSTs and spilled chemicals due to a long history of chemical storage and handling practices. As such, several areas of known and potential soil and groundwater contamination are located in the study area.

A total of nine sites with potential and recognized environmental conditions were identified within the study area (**Figure 1**). A total of two sites were identified as having potential environmental conditions during the site reconnaissance, and seven were identified with recognized environmental conditions as a result of the EDR database search. **Section 5.0** includes specific details on sites recognized environmental conditions.

## *6.2 Property Specific Recommendations*

Based on the findings of the hazardous materials assessment, **Table 3** includes specific recommendations for each property with potential or recognized conditions located adjacent to the study area.

## *6.3 Additional Corridor-Wide Issues of Concern*

Based on the findings of the hazardous materials assessment, FHU makes the following general recommendations.

### 6.3.1 More Detailed Assessment - Right-of-way Acquisition

For properties that are to be acquired by CDOT, further investigation and/or coordination may be necessary to confirm the presence or absence of contamination and to determine the extent and severity, appropriate methodology and preliminary costs of corrective or preventive action. Further investigation may include performing an Initial Site Assessment (ISA) or Phase I Environmental Site Assessment (Phase I) per the *CDOT Hazardous Material Document Guidance Table* (CDOT, 2011a).

**Initial Site Assessment** – The ISA is performed for properties that are to be acquired by, dedicated to, or disposed by CDOT and have minimal hazardous materials concerns. The ISA would be performed per the guidance provided in the *CDOT Hazardous Material Document Guidance Table* (CDOT, 2011a). An ISA checklist (CDOT Form 881) would be necessary on properties that are to be acquired by CDOT. For individual projects, it is recommended that one ISA checklist be completed to cover all partial acquisitions when Field Inspection Review (FIR) plans become available.

**Phase I Environmental Site Assessment** – A Phase I is performed for properties that are to be acquired by or dedicated to CDOT and have known or are suspected of storing hazardous materials. The Phase I would be performed per the guidance provided in the *CDOT Hazardous Material Document Guidance Table* (CDOT, 2011a).

**Table 3. Property Specific Recommendations**

| Site Address | Description of Property | Recommendations |
|---|---|---|
| | | |
| 6770 S. Yosemite St. (Brakes Plus/Fast Traxx Fast Lube) | Potential Environmental Conditions.<br><br>*Partial right-of-way acquisition expected.* Currently there are two automotive repair/maintenance shops located at this address. Unknown material handling, storage, and disposal practices. Potential materials include: fuel, motor oils, hydraulic fluids, degreasers, paints and solvents. | An ISA is recommended for acquisition of right-of-way. |
| 8151 E. Arapahoe Rd. (Big O Tires) | Potential Environmental Conditions.<br><br>Currently this site is an automotive repair/maintenance shop. Unknown material handling, storage, and disposal practices. Potential materials include: fuel, motor oils, hydraulic fluids, degreasers, paints and solvents. | No further assessment is required for this project; however, if acquisition is necessary, an ISA is recommended. |
| 6787 S. Clinton St. (Former Continental Cleaners) | Recognized Environmental Conditions.<br><br>Former dry cleaner facility. Corrective Action site. Former use, handling, and storage of solvents (e.g., perchloroethylene). Unknown disposal practices. | No further assessment is required for this project; however, if acquisition is necessary, an ISA is recommended. |
| 9555 E. Arapahoe Rd. (Former Dry Cleaners) | Recognized Environmental Conditions.<br><br>Former dry cleaner facility. Former use, handling, and storage of solvents (e.g., perchloroethylene). Unknown disposal practices. | No further assessment is required for this project; however, if acquisition is necessary, a Phase I is recommended. |
| 6802 S. Yosemite St. (7-Eleven #39214/Silco Oil Co., Barn Store) | Recognized Environmental Conditions.<br><br>Currently the site is an operating gasoline station. **Open LUST.** | No further assessment is required for this project; however, if acquisition is necessary, a Phase I is recommended. |
| 8660 E. Arapahoe Rd. (Firestone Store No. 2843) | Recognized Environmental Conditions.<br><br>*Partial right-of-way acquisition expected.* **Closed LUST.** Currently the site is an automotive repair/maintenance shop.<br><br>Unknown material handling, storage, and disposal practices. Potential materials include: fuel, motor oils, hydraulic fluids, degreasers, paints and solvents. | A Phase I is recommended for acquisition of right-of-way. |
| 8755 E. Arapahoe Rd. (Phillips 66 #23880) | Recognized Environmental Conditions.<br><br>Currently the site is an operating gasoline station. **Open LUST.** | No further assessment is required for this project; however, if acquisition is necessary, a Phase I is recommended. |

| Site Address | Description of Property | Recommendations |
|---|---|---|
| 9170/9171 E. Arapahoe Rd. (Amoco Oil #8606, BP Facility #24545, K & G Store #518) | Recognized Environmental Conditions.<br><br>*Full right-of-way acquisition is expected.* Currently the site is an operating gasoline station. **Open LUST.** | A Phase I would be required for full acquisition. |
| 9400 E. Arapahoe Rd. (Arapahoe Mitsubishi, Global Collision Arapahoe, Inc) | Recognized Environmental Conditions.<br><br>Currently this site is an automotive sales and repair/maintenance facility. Unknown material handling, storage, and disposal practices. Potential materials include: fuel, motor oils, hydraulic fluids, degreasers, paints and solvents. | No further assessment is required for this project; however, if acquisition is necessary, a Phase I is recommended. |

### 6.3.2 Removal of Structures

FHU's assessment did not attempt to detect the presence of types of equipment that have been historically associated with the use of PCBs as a dielectric fluid coolant and stabilizer, such as older electrical transformers. However, if identified, any electrical equipment with no label or unknown concentration is assumed to be "PCB contaminated equipment" per EPA regulation and should be managed accordingly. In general, legal and financial responsibility for PCB-containing equipment lies with the equipment owner; however, if another party causes the equipment to fail, financial and legal responsibility may be transferred to the responsible party.

Wells must be abandoned and plugged according to CDOT Section 202.02 Standard Specifications for Road and Bridge Construction (CDOT, 2011b) and in conformance with the Colorado Department of Natural Resources Division of Water Resources State Engineer Water Well Construction Rules, specifically Rule 16 Standards for Plugging, Sealing, and Abandoning Wells and Boreholes, in the event that they are encountered (Colorado Division of Water Resources, 2006).

### 6.3.3 Contaminated Soil and Groundwater Management and Health and Safety Plans

Encountering soil and groundwater contamination during the construction process without prior knowledge of contamination has the potential to affect the project in terms of mitigation, cost, schedule, and project worker health and safety. Contaminated soils and groundwater and the presence of hazardous materials require special consideration for worker health and safety and materials management practices.

Because known contamination sources are present within the study area, preparation of a Materials Management Plan may be required for individual projects, per Section 250.03 of the CDOT Standard Specifications for Road and Bridge Construction (CDOT, 2011b). The CDOT Standard Specifications for Road and Bridge Construction states that a Materials Management Plan will be required when stated as such in the contract with the Engineer's approval.

If groundwater is to be encountered during activities associated with excavations for caisson/retaining walls, a Clean Water Act Section 402 Construction Dewatering Permit or Individual Construction Dewatering Permit will be required to be obtained from the Colorado Department of Public Health and Environment Water Quality Control Division. In addition, if dewatering is necessary, groundwater brought to the surface will be managed according to

Section 107.25 of the CDOT Standard Specifications for Road and Bridge Construction (CDOT, 2011b).

Prior to construction activities preparation of a Health and Safety Plan, may be required for individual projects, per Section 250.03 of the CDOT Standard Specifications for Road and Bridge Construction (CDOT, 2011b). The CDOT Standard Specifications for Road and Bridge Construction states that a Health and Safety Plan will be required when stated as such in the contract with the Engineer's approval.

### 6.3.4 Regulated Materials Clearance

Regulated materials may be present in buildings and structures that could be demolished as part of the project. Prior to demolition of any structures, an asbestos, lead-based paint, and miscellaneous hazardous materials survey will be conducted at each parcel, where applicable. Regulated materials abatement will be conducted in accordance with Section 250, Environmental, Health, and Safety Management, of the CDOT Standard Specifications for Road and Bridge Construction (CDOT, 2011b) and relevant Occupational Health and Safety Administration (OSHA) regulatory details.

### 6.3.5 Asbestos and Materials Containing Lead-Based Paint

By law, all friable asbestos-containing materials (ACM) must be removed from structures, including bridges, prior to demolition, and soils if encountered in excavated landfill or building debris, buried utilities, or other ACM. Asbestos-contaminated soils (friable and non-friable asbestos-contaminated soils that have been rendered friable) must be managed in accordance with Section 5 of the CDPHE Hazardous Materials and Waste Management Division, Regulations Pertaining to Solid Waste Sites and Facilities. These regulations only apply to projects involving excavations that are greater than one $yd^3$ of soil. The contractor performing the asbestos abatement is required to be licensed to perform such work and obtain permits from the CDPHE. Improper abatement can lead to release of asbestos in soils and the need for soil remediation. ACM management will be conducted in accordance with Section 250.07 of the CDOT Standard Specifications for Road and Bridge Construction (CDOT, 2011b).

Third party certification is required to document that the abatement was completed in accordance with regulatory requirements. The certification is needed to obtain the demolition permits for the structures. All ACM must be bagged and labeled for transport and disposal at a facility permitted to accept ACM.

Lead-based paint may need to be removed prior to demolition if the lead is leachable at concentrations greater than regulatory levels. Where lead-based painted surfaces would be removed via torching, additional health and safety monitoring requirements are applicable.

### 6.3.6 Other Regulated Materials

Prior to demolition, other regulated materials must be removed from any structures and appropriately recycled or disposed. Other hazardous materials that could be present include items such as: mercury-containing equipment (e.g., switches, meters), electrical equipment, containerized regulated liquids such as paints, solvents, oil, grease, hazardous materials, PCB-containing ballasts, thermostats, and refrigeration units, equipment containing chlorofluorocarbons (CFCs) (equipment must be emptied before equipment is removed), and propane tanks.

# 7.0 REFERENCES

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# APPENDIX A
# PHOTOGRAPH LOG

| | |
|---|---|
|  | 9400 E. Arapahoe Rd.; Closed LUST. |
|  | 9170/9171 E. Arapahoe Rd.; Open LUST. |
|  | 8660 E. Arapahoe Rd.; Closed LUST. |

| | |
|---|---|
|  | 6802 S. Yosemite St.; Open LUST. |
|  | 8755 E. Arapahoe Rd.; Open LUST. |
|  | 8151 E. Arapahoe Rd.; Automotive repair/maintenance. |

| | |
|---|---|
|  | 6770 S. Yosemite St.; Automotive repair/maintenance. |
|   | 6787 S. Clinton St.; Former Dry Cleaners. |

# APPENDIX B
# EDR RADIUS MAP REPORT
**(see attached CD)**

DAVID EVANS
AND ASSOCIATES INC.

# MEMORANDUM

| | |
|---|---|
| **DATE:** | December 12, 2011 Revised May 15, 2012 and July 2, 2012 |
| **TO:** | Jon Chesser, CDOT |
| **FROM:** | Wendy Wallach |
| **SUBJECT:** | **Biological Resources** |
| **PROJECT:** | I-25/Arapahoe Road Interchange EA |
| **COPIES:** | Bryan Weimer; Nicolle Kord; John Hall; Joe Hart |

**Introduction:** This memorandum summarizes the 2011 findings of vegetation, noxious weeds, wetlands, and wildlife (including Threatened and Endangered species, special status species, migratory birds). The information presented in this memorandum is based upon literature review, field reconnaissance, map and photo interpretation, desktop analysis, and professional judgment by David Evans and Associates (DEA) biologist, Licia A. Stragis. Ms. Stragis conducted a site visit on September 30, 2011. Because the field reconnaissance was conducted late in the growing season, it is understood that the vegetation and wildlife observed represents those present at that time and should not be considered comprehensive.

**Updates from Arapahoe Road Corridor Study:** In 2007, an Environmental Overview for the Arapahoe Road Corridor Study was completed for the segment of Arapahoe Road between I-25 and Parker Road. The findings of that report concerning biological resources are still applicable and valid. Within the project area for the I-25/Arapahoe Road Interchange EA (Attachment A), the following species that were documented in the Environmental Overview are not known to occur and do not have suitable habitat.

- Black-tailed prairie dog
- Preble's meadow jumping mouse
- Burrowing Owl

Best management practices for weed management in the Environmental Overview are still applicable and valid. Mitigation measures regarding the Migratory Bird Act are further discussed in this technical memorandum.

**Vegetation**: The project is located in the Flat to Rolling Plains area of the High Plains ecosystem, however current land use is urban and fully developed. Vegetation within the project area is predominantly landscaped lawns and well-maintained ornamental plantings.

**Noxious Weeds:** No infestations of noxious weeds were identified within the project area. All transportation right- of-way contained well-maintained and mowed vegetation.

**Water Resources and Wetlands:** No waters, wetlands, or riparian areas were identified within the project area. A landscaped stormwater facility is located within the southeast quarter of the I-25/ Arapahoe interchange to infiltrate and convey stormwater.

**Wildlife:** The U.S. Fish and Wildlife Service, July 2010 list includes nine Threatened, Endangered, Candidate, and Proposed species in Arapahoe County. Table 1 documents the species, status, habitat/range, and likelihood of the project to affect the species.

Table 1. USFWS listed Threatened, Endangered, Candidate, and Proposed species in Arapahoe County.

| Common Name | Scientific Name | USFWS Status | Habitat/Range | Likelihood to Affect |
|---|---|---|---|---|
| Least Tern (Interior) | *Sterna antillarum athalassos* | Endangered | Bare, sandy, shoreline habitat/ Arkansas River Valley | None[1] |
| Mexican Spotted Owl | *Strix occidentalis lucida* | Threatened | Forest lands- riparian, wetland or upland | None |
| Pallid sturgeon | *Scaphirhynchus albus* | Endangered | Platte River in Nebraska | None[1] |
| Piping Plover | *Charadrius melodus* | Threatened | Platte River in Nebraska | None[1] |
| Preble's meadow jumping mouse | *Zapus hudsonius preblei* | Threatened | Shrubby or forested riparian areas | None |
| Ute ladies'-tresses orchid | *Spiranthes diluvialis* | Threatened | Old stream channels, alluvial terraces, subirrigated meadows | None |
| Western prairie fringed orchid | *Platanthera praeclara* | Threatened | Tallgrass prairie, meadows, old fields, ditches | None[1] |
| Whooping Crane | *Grus americana* | Endangered | Agricultural fields and mudflats/ San Luis Valley , rare migrant | None[1] |

[1]Programatic Biological Assessment (PBA)

This project has elements that will cause a depletion to the South Platte River basin. In order to address the effects this depletion will have on federally listed species downstream that depend on the river for their survival, CDOT, as a state agency, is participating in the South Platte Water Related Activities Program (SPWRAP). CDOT is cooperating with the Federal Highway Administration (FHWA) which provides a federal nexus for the project. In response to the need for formal consultation for the water used from the South Platte basin, FHWA has prepared a Programmatic Biological Assessment (PBA) dated 02/22/2012 that estimates total water usage until 2019. The PBA addresses the following species: Least Tern (interior population) (*Sternula antillarum),* pallid sturgeon (*Scaphirhynchus albus),* Piping Plover (*Charadrius melodus),* western prairie fringed orchid (*Platanthera praeclara),* and the Whooping Crane (*Grus americana).* On 04/04/2012, the USFWS signed a Biological Opinion which concurs with this approach and requires a yearly reporting of water usage. The water used for this project will be reported to the USFWS at the year's end after the completion of the project as per the aforementioned consultation. Effects to species not addressed in the PBA or affected by causes other than water depletions to the South Platte, will be analyzed separately.

None of these federally protected species are known to occur within the project area and none are expected to occur in the project area due to a lack of suitable native habitat. Migrating or long-ranging species may occur incidentally. None of these species area anticipated to be affected by this project.

Colorado Division of Wildlife lists over 70 state endangered, threatened, and species of concern. None are known to occur within the project area and, with one possible exception, none are expected to occur in the project study area due to lack of suitable native habitat. There may be habitat suitable for the common garter snake (*Thamnophis sirtalis*).This species of concern is found in various habitats including urban settings, often near water. Because there is potentially suitable habitat at roadside ditches, the common garter snake has the potential to occur incidentally in the project area. However, there are no documented occurrences of common garter snake in the project study area. Furthermore, the nature and the scale of potential habitat in the study area habitat would not significantly change as a result of the project. Therefore, although there is incidental potential for common garter snake to occur, the proposed action is not likely to significantly affect populations or suitable habitat of common garter snake. Migrating or long-ranging species also may occur incidentally. None of the state protected species are anticipated to be affected by this project.

A number of migratory bird species that are adapted to urban landscapes are likely to use the landscaped vegetation as habitat within the project study area. These would include Yellow Warbler (*Dendroica petechia*), American Crow (*Corvus brachyrhynchos*), Black-billed Magpie (*Pica hudsonia*), Killdeer (*Charadrius vociferous*), Mourning Dove (*Zenaida macroura*), Rock Dove (*Columba livia*), American Robin *(Turdus migratorius),* House Sparrow *(Passer domesticus),* House Finch *(Carpodacus mexicanus),* European Starling (*Sturnus vulgaris*), Swallows (family *Hirundinidae*) and California Gull (*Larus californicus*). House Finches, House Sparrows, and American Robins were observed during the field reconnaissance.

Disturbance of most migratory bird nests, if active, are prohibited under the Migratory Bird Treaty Act (MBTA). Removal of active bird nests requires a MBTA permit from the USFWS. Typically, unless a nest is endangering human life or could cause injury, the permit to take an active nest is denied. More often, seasonal restrictions are used to ensure that active nests are not harmed during the breeding season. Generally, CDOT considers the

breeding season (and thus, seasonal restriction) is from April 1st through August 31st. If activities, which could disrupt nests, take place outside of those dates, then no impact is expected. No active or inactive bird nests of any species were found in the project study area at the time of the site visit.

If construction is to occur during the breeding season, an additional nest survey will be conducted no more than 7 days prior to construction. To avoid impacts to nesting birds, any existing nests will be removed prior to the nesting season, (April 1st) before birds reuse them. No construction work can occur within 50 feet of an active nest.

Attachments/Enclosures: Project Area Map

Initials: waw

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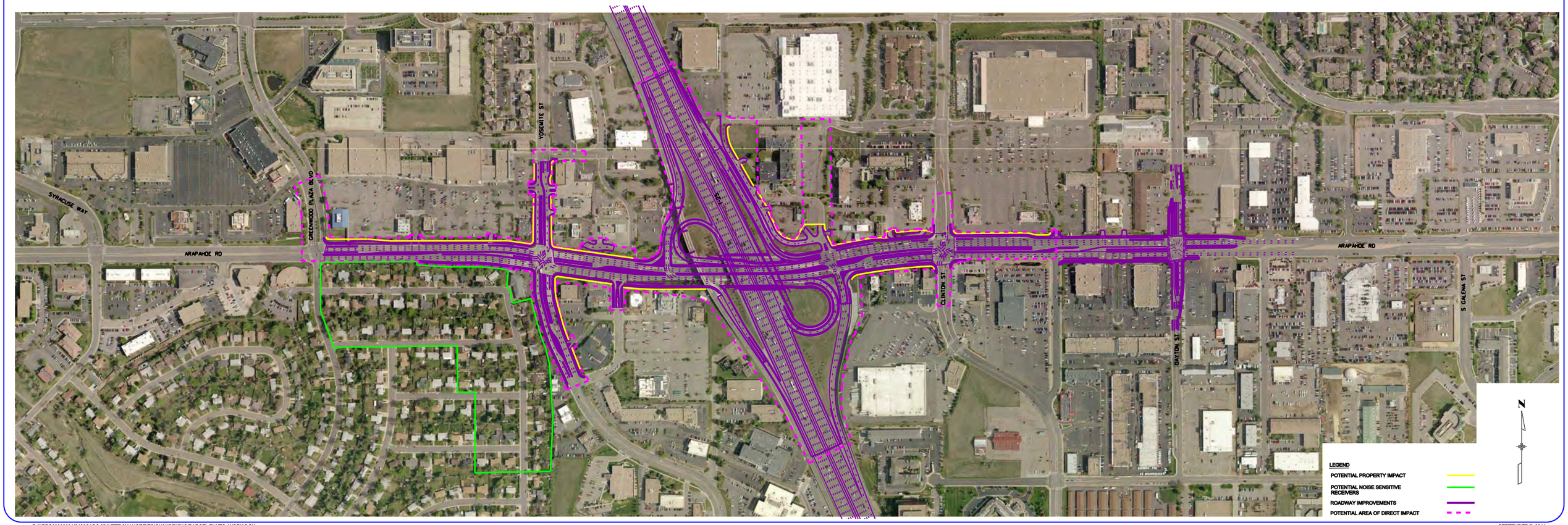
**Biological Resources Technical Memorandum**

**Attachment A**

I-25/Arapahoe Interchange
*Environmental Assessment*

## Improved Partial Cloverleaf without Costilla Crossing

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SEPTEMBER 7, 2011