Commonwealth of Massachusetts

Central Artery (I-93)/ Tunnel (I-90) Project

Operating Certification of the Project Ventilation System

Technical Support Document

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Prepared For
Massachusetts Department of Transportation

by
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LIST OF ABBREVIATIONS AND ACRONYMS

AIS	Air Intake Structure
CA/T	Central Artery/Tunnel
CEM	Continuous Emissions Monitoring
CFM	Cubic Feet Per Minute
CFR	Code of Federal Regulations
CMR	Code of Massachusetts Regulations
CO	Carbon Monoxide
CTPS	Central Transportation Planning Staff
DAHS	Data Acquisition Handling System
DST	Dewey Square Tunnel
ELA	Emission Limit Assessment
EPA	US Environmental Protection Agency
FHWA	Federal Highway Administration
FSEIS/R	Final Supplemental Environmental Impact Statement/Report
g/s	Grams per Second
hp	Horsepower
HOC	Highway Operations Center
MassDEP	Massachusetts Department of Environmental Protection
MBTA	Massachusetts Bay Transportation Authority
MassDOT	Massachusetts Department of Transportation
MMIS	Maintenance Management Information System
MPH	Miles Per Hour
MPO	Metropolitan Planning Organization
NAAQS	National Ambient Air Quality Standard
NEMA	National Electric Manufacturers Association
NIST	National Institute of Standards and Technology
NMHC	Non-Methane Hydrocarbon
NO	Nitric Oxide
NO_2	Nitrogen Dioxide
NO_x	Nitrogen Oxide
NPC	Notice of Project Change
OLM	Ozone Limiting Method
PM	Particulate Matter
PM_{10}	Particulate Matter - 10 micron
$PM_{2.5}$	Particulate Matter – 2.5 micron
PPM	Parts Per Million
PPB	Parts Per Billion
QA/QC	Quality Assurance/Quality Control
Ramps	LC-S (Leverett Circle to Central Artery SB); SA-CN (Surface Artery to Central Artery NB); CN-S (Central Artery NB to Storrow Drive); ST-CN (Sumner Tunnel to Central Artery NB); ST-SA (Sumner Tunnel to Surface Artery); CS-SA (Central Artery SB to Surface Artery); CS-P (Central Artery to Purchase Street); F (I-90 WB to Congress Street)
SIP	State Implementation Plan
SOPs	Standard Operating Procedures
TEOM® monitor	Tapered-element oscillating microbalance sensing technology monitor
THC	Total Hydrocarbons
TSD	Technical Support Document
TWT	Ted Williams Tunnel
VB	Ventilation Building
VMT	Vehicle Miles Traveled
VOC	Volatile Organic Compound
VPH	Vehicles Per Hour
$\mu g/m^3$	Micrograms Per Cubic Meter

Executive Summary

The Central Artery/Tunnel (CA/T) Project depressed and widened I-93 through downtown Boston to Charlestown and constructed (as an extension of I-90) a Seaport Access Highway through South Boston connecting to the Ted Williams Tunnel (TWT) under Boston Harbor to Logan Airport. The Project includes approximately 80 lane-miles of new tunnels within a 7.5-mile urban corridor. Commercial traffic started flowing through the TWT in 1996, and the remainder of the Project opened to general traffic in March 2005.

The CA/T's ventilation system utilizes a mixture of full-transverse and longitudinal ventilation. Most of the tunnels operate with the full-transverse ventilation system in which fresh air enters the tunnels under the roadway and the exhaust air exits through openings in the tunnel ceilings to plenums located above the ceiling. The ventilation fans and auxiliary equipment that provide fresh air and exhaust air are located in six ventilation buildings (VB) designated as VB1, VB3, VB4, VB5, VB6, and VB7. The portion of I-93 called the Dewey Square Tunnel (DST) and eight exit ramps are longitudinally ventilated. In the longitudinally ventilated tunnels, exhaust air moves in the direction of the traffic flow. In doing so, tunnel exhaust air is pushed through - and out - the exit portals of the tunnel by the piston action effect created by moving vehicles. Some longitudinally ventilated tunnels include supply air and/or jet fans mounted in the tunnel ceilings or walls. In addition, there are two VB which provide fresh air to two longitudinally ventilated tunnel sections (VB8, and the DST Air Intake Structure (AIS)).

The CA/T Project's tunnel ventilation system is subject to the regulations set forth by the Massachusetts Department of Environmental Protection (MassDEP) in the Code of Massachusetts Regulations (CMR) at 310 CMR 7.38 entitled "Certification of Tunnel Ventilation Systems in the Metropolitan Boston Air Pollution Control District." Pursuant to 310 CMR 7.38(2), no person shall construct a tunnel ventilation system and project roadway subject to 310 CMR 7.00 without first certifying to MassDEP (and receiving MassDEP written acceptance of that certification) that the operation of any tunnel ventilation system, project roadway, and roadway networks will not cause or exacerbate a violation of certain specified ambient air quality standards, guidelines, and other criteria specified in 310 CMR 7.38.

In compliance with MassDEP Regulation 310 CMR 7.38, the CA/T Project submitted to MassDEP in 2006 an Operating Certification Application for the CA/T Tunnel Ventilation System, which established emission limits for all VBs, the DST, and each longitudinally ventilated exit ramp. The 2006 Operating Certification Application established tunnel emission limits for carbon monoxide (CO), nitrogen oxides (NO_x) and particulate matter equal to or smaller than 10 microns in diameter (PM_{10}). It demonstrated that these emission limits would ensure compliance with National Ambient Air Quality Standards and Massachusetts Ambient Air Quality Standards (MAAQS) for CO, nitrogen dioxide (NO_2), and PM_{10} and state guideline values for NO_2. It also established a regional emissions budget for volatile organic compounds (VOC) based on the 2005 CA/T build predictions, which included highway and transit components. MassDEP gave final acceptance to the 2006 CA/T Operating Certification on December 22, 2006 (hereafter referred to as the 2006 CA/T Operating Certification).

The 2006 CA/T Operating Certification included a Technical Support Document (TSD) divided into four parts:

- Part I – Ventilation System – Operation and Emission Limits
- Part II – Compliance Monitoring Program
- Part III – Record Keeping and Reporting
- Part IV – Corrective Actions

The TSD also included several appendices and attachments:

- Appendix A: DEP Pre-Construction Certification Acceptance
- Appendix B: Air Quality Analysis Protocol for Determination of Emission Limits as Part of the Operating Certification of the Project Ventilation Systems
- Appendix C: Air Quality Impact Analysis Input Data
- Appendix D: CEM Certification Test Data
- Appendix E: Initial CEM Data in Support of Operating Certification
- Appendix F: MassDEP Correspondence
- Appendix G: Monitoring Equipment Standard Operating Procedures
- Attachment 1: CEM Air Emissions Monitoring Protocol

MassDEP Regulation 310 CMR 7.38 requires a renewal of the Operating Certification every five years. This TSD forms part of the July 2011 renewal application, which will cover the period from December 22, 2011 to December 22, 2016.

In November 2009, the Massachusetts Turnpike Authority (MTA) merged with the Massachusetts Highway Department to form the Massachusetts Department of Transportation (MassDOT). The Highway Division of MassDOT currently manages the 310 CMR 7.38 certification requirements for the CA/T ventilation system. A technical working group representing MassDOT and MassDEP has been meeting on a frequent basis to discuss issues and requirements associated with the renewal of the Operating Certification.

Changes to National and State Ambient Air Quality Standards (NAAQS): Implications for the Renewal Application Process

For the 2006 Operating Certification Application, the CA/T Project was required to develop emission limits for PM_{10}. Although the US Environmental Protection Agency (EPA) promulgated the NAAQS for $PM_{2.5}$ by 2006, MassDEP had not completed development of a State Implementation Plan (SIP) for $PM_{2.5}$. The EPA subsequently revised the NAAQS for $PM_{2.5}$ in September 2006. For the 2011 Renewal Application MassDEP requires emission limits for $PM_{2.5}$ that will ensure compliance with the revised NAAQS for $PM_{2.5}$. These emission limits for $PM_{2.5}$ will replace the emission limits currently in effect for PM_{10}.

In January 2010, the EPA announced the implementation schedule for the new 1-hour NAAQS for NO_2. This NAAQS has a value of 100 parts per billion (ppb), equivalent to 188 micrograms per cubic meter ($\mu g/m^3$). During the spring of 2010, MassDEP made a determination that the 2011 application for renewal of the Operating Certification must include a demonstration of compliance with the new NO_2 NAAQS. The 2006 NO_x tunnel emission limits currently in effect comply with the MassDEP 1-hour NO_2 policy guideline of 320 $\mu g/m^3$, equivalent to approximately 170 ppb.

Analyses conducted by MassDOT demonstrated that modeling techniques that had been used to show compliance with the MassDEP 1-hour NO_2 policy guideline, specifically use of the Ozone Limiting Method (OLM), would not be suitable for demonstrating compliance with the new 1-hour NAAQS for NO_2. The OLM technique assumes the instantaneous conversion of emitted nitric oxide (NO) to NO_2 and, in addition, allows this conversion process to continue as long as ambient ozone (O_3) is available in the atmosphere. Given the very short distance between source and receptor, in particular for the DST and longitudinally ventilated exit ramps; this instant conversion, which needs the presence of sunlight and Ozone, might not occur in the short period of time that takes a tunnel exit plume to reach sidewalk receptors.

Because of the limitations of the OLM technique for the CAT project, Mass DOT proposed to implement a monitoring program to collect hourly concentration data for CO, NO_x, NO, and NO_2 inside the DST exit portal and hourly concentrations of NO_x, NO, and NO_2 at three locations adjacent to the DST exit portal along Albany Street sidewalk. The collected data will be used to develop a more representative modeling approach for MassDOT to propose new emission limits that will ensure compliance with the new 1-hour NAAQS for NO_2. This new monitoring program began in early April 2011 and will run through March 2012, or beyond if necessary. The data will derive more accurate NO to NO_2 conversion factors to establish new NO_x emission limits for CA/T ventilation buildings and for each of the longitudinally ventilated ramps. MassDOT submitted the monitoring program to MassDEP on January 10, 2010, and MassDEP accepted the proposed monitoring program.

On March 18, 2011, MassDOT proposed to MassDEP that the July 2011 application for renewal of the operating certification include new emission limits for $PM_{2.5}$ and address compliance with the established emission budget for VOC. In addition, MassDOT proposed to defer setting revised emission limits for NO_x and CO for all Project ventilation buildings and longitudinally ventilated ramps until July 2012. The one-year postponement will allow MassDOT to develop new CO and NO_x emission limits based on the monitoring data being collected at the DST and Albany Street monitors. On May 12, 2011, MassDEP accepted MassDOT proposed approach indicating that the July 2012 submittal will be presented as a "supplemental application" to the 2011operating certification renewal application.

The 2006 Operating Certification established tunnel emission limits for CO, NOx and PM_{10} to demonstrate compliance with ambient air quality standards for CO, NO_2, and PM_{10} and state guideline values for NO_2. It also established a regional emission budget for volatile organic compounds (VOCs) based on the 2005 CA/T build predictions, which included highway and transit components.

The 2011 Recertification Application includes changes associated with establishing new limits for $PM_{2.5}$ that replaced the PM_{10} current limits; compliance demonstration for the new $PM_{2.5}$ limits; regional emission analysis for VOC to demonstrate compliance with the 2005 VOC emission budget; and description of the process to re-evaluate and update the CO and NOx emission limits as part of a "Supplemental Application" to be submitted in July 2012. The current CO and NOx limits are retained until the results of the ongoing NO_2-NO-NOx one-year monitoring program can be analyzed to establish new emission limits for submission in July 2012.

For consistency, this application follows the format of the 2006 TSD, retaining the aspects that remain unchanged and replacing or adding information, as needed, to incorporate new requirements and to update summaries of data collected during the term of the current operating certification.

TSD Part I describes in detail the CA/T's ventilation system and air quality emission limits that were established for the exhaust from the ventilation buildings and the longitudinally ventilated tunnel sections (DST and exit ramps). The emission limits established for the 2006-2011 operating certification apply to day-to-day tunnel operation except for emergency situations during a tunnel fire. The limits for CO, NO_x and PM_{10} were determined as concentration-based emission limits (i.e., measured levels in parts per million [ppm] or micrograms per cubic meter [$\mu g/m^3$] inside the tunnels). Note: The PM_{10} monitor located immediately outside the portal of Ramp CSSA measures representative ambient conditions.

Section 1 of TSD Part I covers the description of the CA/T Ventilation System, its physical properties, feasible emission control technologies, and expected operating conditions. Ventilation building emissions control technology reviews were performed in 1991, 1995 and 2004. They were subsequently revisited and updated in 2011. An extensive investigation, conducted as part of these reviews revealed that ventilation was the predominant method of tunnel (inside and outside) air quality control employed in the United States and around the world. All reviews concluded that there were no feasible and effective control techniques available that would result in a net reduction of the tunnel exhaust emissions.

Section 2 of TSD Part I – Determination of Emission Limits – includes the established emission limits for CO, NO_x, and VOC in the 2006 permit application with reference to the 2006 documentation, and the MassDEP acceptance of such limits.

Section 2 also explains the 2006 dispersion modeling process (using EPA approved air quality models and wind tunnel modeling techniques), the compliance demonstrations performed to meet the applicable NAAQS for CO and NO_2 and state guideline values for NO_2; and the process used to demonstrate compliance of regional transportation related emissions with the established emissions budget for VOC. MassDEP regulation 310 CMR 7.38 requires that the CA/T not increase emissions over the No-Build scenario at a regional level. This process includes a regional emission inventory for the transportation sources within the CA/T Project study area for 2005 including both the CA/T Build and No-Build scenarios. The inventory included the CA/T Project and transit projects completed by the Commonwealth as of the year 2005, and an analysis, which demonstrated a reduction of emissions relative to the No-Build scenario.

Section 2 provides a summary of the need for the monitoring program to collect CO, NO_x, NO, and NO_2 inside the DST exit portal and concentrations of NO_x, NO, and NO_2 along the Albany Street sidewalk and the limitations of using the OLM for demonstrating compliance with the new 1-hour NO_2 NAAQS. It describes how data gathered from the Albany Street monitoring program will be used to derive more accurate NO to NO_2 conversion factors that will be used to establish new NO_x emission limits to ensure compliance with the new 1-hour NO_2 NAAQS.

Section 2 also provides a summary of the modeling methodology used to establish $PM_{2.5}$ emission limits and the results of the compliance demonstration. The modeling performed used the most current version of the EPA AERMOD dispersion model, five years of meteorological data, and included daily background air quality data used to obtain a total daily (24-hour) $PM_{2.5}$ concentration at each ambient location potentially affected by emissions from the ventilation buildings. The results of the analysis indicate that a $PM_{2.5}$ emission limit of 900 $\mu g/m^3$ demonstrates compliance with the $PM_{2.5}$ annual and 24-hour NAAQS. The details of the $PM_{2.5}$ modeling methodology are described in Appendix B2 ("Air Quality Analysis Protocol for the Determination of $PM_{2.5}$ Emission Limits and Verification of VOC Emissions Budget for the Renewal of the Operation Certification for the Project Ventilation System).

Lastly, Section 2 provides a summary of the new VOC regional analysis performed by the Central Planning Transportation Staff (CTPS) using the most recent 2010 vehicular traffic and transit operating conditions. The analysis demonstrates that the 2010 total estimates for the CA/T area resulted in a reduction of 2,189 kilograms per day (kg/day) of VOC with respect to the VOC budget of 6,095.9 kg/day established in the 2006 operating certification. This VOC reduction is approximately 36% relative to the emissions budget and occurred despite an increase of approximately 1% in vehicle miles traveled (VMT) for the five-year period. The reduction is attributable to fleet turnover and cleaner vehicles and fuels mandated by Federal and State regulations over the past decade.

TSD Part II describes the CA/T's compliance monitoring program, including the Continuous Emissions Monitoring (CEM) system designed, constructed, and installed to demonstrate compliance with established emission limits and used to aid the operators to maintain safe air quality and visibility within the tunnels under normal operations.

The CEM system is a hybrid type of monitoring system. The CEM system incorporates appropriate elements of federal regulations 40 CFR Part 58, 60, and 75 for the ambient air quality monitoring systems and the continuous emission monitoring at power plants. Equipment certification and operations are, specifically tailored for use in the CA/T's emission monitoring program. MassDOT (then MTA) performed the initial Certification of the CA/T CEM system in 2005. Attachment 1 (CEM Air Emissions Monitoring Protocol) provides specific information regarding CEM equipment that has been installed and/or revised for the 2011-2016 operating certification at each VB and longitudinally ventilated exit ramp as well as the operational protocol for the CEM equipment.

MassDOT monitors vehicular emissions of CO in the exhaust plenum of each ventilation zone prior to discharge up, and out the building stacks and at the exit portal of each longitudinally ventilated exit ramp. MassDOT monitors PM_{10} emissions at four representative in-tunnel locations with the highest PM_{10} levels and Ramp CSSA. MassDOT is converting these PM_{10} monitors to measure $PM_{2.5}$ levels at the same locations.

TSD Part III describes the record keeping and reporting aspects of the CA/T's Operating Certification. MassDOT continuously recorded all CO and PM_{10} data at each CEM location, and the data are downloaded via a modem to a central computer. MassDOT reviewed the data and generated daily data summaries for each month. Using the daily summaries, MassDOT developed NO_x emission concentrations using a Project-specific CO to NO_x conversion ratio based on the statistical analysis of several thousand hours of monitored data for both pollutants at the TWT.

In 2010, peak-hour-traffic volumes using the mainline tunnels were generally in the range of 6,800 to 8,000 vehicles per hour (VPH) in each direction of I-93 and in the range of 2,900 to 3,600 VPH in each direction of the TWT. The average daily volumes were in the range of 80,000 to 107,000 vehicles per day (VPD) in each direction of I-93 and in the range of 32,000 to 50,000 VPD in each direction of the TWT. These traffic levels are still below the 2010 project design projections. The tunnel full transverse ventilation system currently operates at Step 1 (13% of exhaust capacity) for off-peak and normal peak traffic conditions. The longitudinal DST ventilation system operates between Step 1 and Step 3 for off peak and normal peak traffic conditions, respectively.

The 2006-2011 data presented in Section 5 of TSD Part III indicate that measured hourly CO concentrations for the ventilation buildings range from 1.0 to 3.0 ppm on average and as high as 34 ppm during peak periods for the ventilation buildings. For the DST and ramps, hourly CO concentrations were in the range of 1.0 to 4.0 ppm on average with maximum levels in the range of 4.0 to 68.7 ppm.

Measured hourly NO_x levels from the ventilation buildings ranged from 0.3 to 0.6 ppm on average with peak values ranging from 1.0 to 2.2 ppm. Measured hourly NO_x levels for the DST and Ramps ranged from 0.3 to 0.75 ppm on average with peaks ranging from 1 to 8.8 ppm.

Measured average daily PM_{10} concentrations in each year were between 31 and 121 $\mu g/m^3$, Maximum daily PM_{10} values were in the range of 100 to 577 $\mu g/m^3$. The PM_{10} monitor outside Ramp CS-SA, which measures ambient levels, recorded annual averages from 19 to 21 $\mu g/m^3$, and a maximum daily level of 116 $\mu g/m^3$.

MassDOT submitted the traffic, CO, NO_x and PM_{10} data to MassDEP on a monthly basis from October 2006 to October 2007 and on a quarterly basis thereafter.

At the start of the $PM_{2.5}$ monitoring, the reports will be submitted to MassDEP on a monthly basis from January through June 2012, and at a quarterly intervals thereafter.

TSD Part IV describes the procedures and actions that MassDOT implemented in the event of an exceedance of the established emissions limits due to non-emergency traffic conditions. Part IV also describes the notification process; including MassDOT written notification to MassDEP for emission limits exceedances and actions undertaken by MassDOT to restore compliance with limits.

To help ensure compliance with the emission limits at any location, MassDOT established CEM emission action levels generally in the range of 75% to 80% of the emission limit for each of the monitoring locations. Based on operating experience, MassDOT can effectively maintain acceptable in-tunnel CO concentrations by small, step-wise increases in the ventilation rate.

Based on the Project's abundant ventilation capacity and well-established procedures, the operation of the system has worked well within the established emission limits. Therefore, specific information regarding a long-term mitigation plan was not included as part of the 2006 Operating Certification and will not be provided for the 2011-2016 Operating Certification period.

It should be noted that there were eleven episodes during the period beginning in 2006 and running through the end of the first quarter of 2011 when emission limits were exceeded. These episodes resulted in a total of 10 hours when CO measured levels were above the emission limits set for specific locations and 8 days when the measured PM_{10} levels were above the emission limits set for a ventilation building. The main reasons for the CO emission limit exceedance were the result of emissions from maintenance equipment working during nighttime tunnel closings and a lack of adequate ventilation air due to the closure of the tunnels.

CO concentrations were measured every hour at 24 VB exhaust locations and at eight locations in the longitudinally ventilated ramps and DST over the last five calendar years (2006-2010) and during the first quarter of 2011, yielding approximately 1.47 million hourly observations. The 10 hours of the CO emission limit exceedance represent an exceedingly infrequent occurrence and shows that the ventilation system nearly always in compliance with its CO emission limits. The 10 hours of the CO emission limits exceedance represent only about 0.02% of the hours during this period.

The reason for the PM_{10} emission limits exceedances was due to the pulverization of road salt applied during winter snowstorm events by the wheels of moving traffic inside the tunnels. This salt on the roadway surface created a large source of salt crust available for vehicle pulverization and re-entrainment into the ventilation system.

Appropriate corrective measures were taken in these instances, and response procedures were modified when necessary as part of the contingency plan. As a result, the periods of CO emission limit exceedances never lasted longer than two hours, and the periods for daily PM_{10} emission limit exceedance never lasted for longer than one day.

The results of the Emission Limit Assessment (ELA) performed for each of these episodes demonstrated that none of these events resulted in a violation of the applicable NAAQS or MassDEP NO_2 policy guideline. Moreover, the maximum predicted ambient values resulting from these peak measurements were 50% or less of the applicable NAAQS or MassDEP NO_2 policy guideline. This provides a good indication that the emission limits established provide a considerable margin of safety with regard to ensuring compliance with NAAQS and protection of the health of abutters and surrounding communities.

Introduction

In compliance with MassDEP Regulation 310 CMR 7.38, the CA/T Project filed an Operating Certification for the Project's Tunnel Ventilation System during 2006 in which it established emission limits for the exhaust of each Ventilation Building, Dewey Square tunnel (DST), and longitudinally ventilated exit ramps. MassDEP gave final acceptance to the 2006 CA/T Operating Certification in December 22, 2006.

The 2006 Operating Certification demonstrated that the operation of the CA/T Tunnel Ventilation System will not cause a violation of applicable NAAQS and MassDEP One Hour NO2 Guidelines as specified in 310 CMR 7.38.

The 2006 Operating Certification established tunnel emission limits for carbon monoxide (CO), nitrogen oxides (NO_x) and particulate matter equal to or smaller than 10 microns in diameter (PM_{10}) that allowed the tunnel ventilation system to demonstrate compliance with ambient air quality standards for CO, NO_2, and PM_{10} and state policy guidelines for NO_2. It also established that the CA/T Project was within the regional emissions budget for volatile organic compounds (VOC) based on the 2005 CA/T build predictions, which included highway and transit components. The 2006 Operating Certification also included: a Compliance Monitoring Program for CO and PM_{10}; Record Keeping and Reporting requirements and procedures; and Corrective Actions that would be required if any of the established emission limits were exceeded.

MassDEP Regulation 310 CMR 7.38 requires MassDOT to renew the Operating Certification every five years. This Technical Support Document is part of the July 2011 renewal application, which will cover the period from 2011 to 2016. This TSD includes:

- An update of the procedures and findings of the 2006 TSD;
- Summaries of the traffic and air quality monitoring data collected since 2006;
- Changes or additions to the current emission limits, specifically limits for $PM_{2.5}$ that will replace the current PM_{10} emission limits;
- The compliance demonstration for the new $PM_{2.5}$ limits;
- A regional emission analysis for VOC to demonstrate compliance with the established VOC emissions budget;
- The current emission limits for CO and NO_x which are retained in this TSD; and
- The process for the re-evaluation and update of the CO and NO_x emission limits which will be a part of a "supplemental application" to be submitted July 2012. These emission limits will be determined using the results of the ongoing NO_2-NO-NOx one-year monitoring program that will collect near road NO_2 concentrations from the tunnel and allow for a more accurate treatment of the conversion of NO to NO_2.

Following the same format as the 2006 TSD application, this document is divided into four parts and several appendices:

- Part I – Ventilation System – Operation and Emission Limits
- Part II – Compliance Monitoring Program
- Part III – Record Keeping and Reporting of 2006-2010 operating levels
- Part IV – Corrective Actions – Procedures implemented during 2006-2010 operations

Part I – Ventilation System – Operation and Emission Limits

1 DESCRIPTION OF CENTRAL ARTERY/TUNNEL PROJECT VENTILATION SYSTEMS

The Central Artery/Tunnel (CA/T) Project was designed and built to reduce traffic congestion, accidents, and air pollution in the Boston area by replacing the old elevated Central Artery with new aboveground and underground roadways. Figure 1-1 provides the physical limits indicating the above and underground portions of the Project

Approximately 80 lane miles of these new roadways are underground tunnels, including the 7,900-foot-long, four-lane Ted Williams Tunnel (TWT) under the Boston Harbor that connects East Boston to South Boston, the eight to ten lane underground Southeast Expressway (I-93), and the underground portions of the Massachusetts Turnpike (I-90). The TWT opened to commercial and other authorized vehicles on December 15, 1995, and the entire Project was fully operational in March 2005.

As described in the 2006 TSD of the Operating Certification, in the 1991 Project-wide Final Supplemental Environmental Impact Statement/Report (FSEIS/R), and in the Preferred Alternative in the 1994 FSEIS/R for the Charles River Crossing, the CA/T Project utilizes a full-transverse ventilation system to maintain acceptable in-tunnel air quality set forth by the Federal Highway Administration (FHWA) for motorists traveling in the tunnels.

In response to authorization from the FHWA in November 1995 regarding the use of the longitudinal ventilation system, the Massachusetts Department of Transportation (MassDOT) implemented design refinements to the Project's tunnel ventilation system by using jet fans as a potentially viable alternative for maintaining adequate ventilation. Specifically, the refinements included the replacement of the full-transverse ventilation systems with longitudinal ventilation at the Dewey Square Tunnel (DST) section of I-93 Southbound, and at eight tunnel exit ramps.

1.1 VENTILATION SYSTEM DESIGN CRITERIA

Tunnel ventilation systems servicing the CA/T Project have been designed to provide adequate ventilation capacity during both normal traffic operation and emergency/fire conditions. The urban setting of the Project also imposed significant demands on the tunnel ventilation system design and its allowable impact to the surrounding community. Sensitivity to land use and ambient environmental issues such as noise and air quality weighed heavily in determining the allowable size and locations of the necessary ventilation facilities. Full transverse and longitudinal type ventilation systems were therefore utilized to meet the functional demand of the various road tunnel configurations and the local environmental challenges in the most cost effective and efficient manner.

The design followed the FHWA-Environmental Protection Agency (EPA) in-tunnel air quality criteria, which were established based on time exposure of the motorists traveling inside the tunnel. Based on these criteria the tunnel operator is required to maintain CO levels below 120 part per million, when the time exposure does not exceed 15 minutes during peak rush hour traffic, 65 ppm for the exposure between 15 and 30 minutes; below 45 ppm for exposure between 30 and 45 minutes; and below 35 ppm when motorists remain inside the tunnels for 60 minutes. The estimated average time for a vehicle traveling inside the tunnel is less than 9 minutes during PM peak hour conditions and is shorter for AM peak hour conditions.

FIGURE 1-1: PHYSICAL LIMITS OF CA/T PROJECT

From a tunnel ventilation perspective, the Project is defined as three distinct and separate road tunnel "systems": the Ted Williams Tunnel, the I-90 Tunnel Extension, and the I-93 Central Artery Tunnel. Each of these tunnel systems was divided into multiple "ventilation zones". Each ventilation zone is served by a dedicated and independently controlled set of fans. This concept allows for significant operational flexibility throughout the Project and provides the means for establishing the most efficient system operation under normal conditions and the most effective system operation in the case of a traffic incident or fire emergency.

The tunnel ventilation system was designed with a supply air capacity of 65 cubic feet per minute (cfm) per lane-foot of tunnel, and an exhaust capacity of 100 cfm per lane-foot of tunnel. The total supply capacity for the full transverse ventilation system (including all six ventilation buildings [VBs]) is approximately 11.4 million cfm serving the 22 ventilation zones. This ventilation system was designed to maintain in-tunnel CO levels between 20 and 60 ppm, and NO_x levels between 1 and 5 ppm, during normal peak hour traffic conditions. Due to advances in motor-vehicle emission control technology and the public's demand for cleaner air, new car emissions are progressively decreasing. Therefore, the CA/T Project ventilation system is expected to provide ample ventilation to accommodate the anticipated traffic growth.

1.1.1 Full-Transverse Ventilation

In the full-transverse ventilation system, fresh air supply is introduced to the tunnels from under the roadway, and the mixture of vehicle exhaust is extracted through openings in the tunnel ceilings to plenums located above the ceiling before being diverted up through the VB's exhaust stacks. Figure 1-2 provides a schematic of the full transverse ventilation system.

1.1.1.1 System Description

The full transverse ventilation system includes six ventilation buildings (VB1, VB3, VB4, VB5, VB6, and VB7) serving 22 ventilation zones with their supply and exhaust fans. The system includes a total of 73 exhaust stacks, each of which is connected to an exhaust fan. The system also includes VB8, which provides only supply air to Ramp CN-S. Figure 1-3 provides a typical cross section for VB4. Figure 1-4 provides the locations of the ventilation buildings.

The sections of the Project served by each VB are as follows:

- VB 1 serves a section of I-90 Westbound / Eastbound, and Ramps D & L. It has four ventilation zones, 11 exhaust stacks, and a supply capacity of 1.66 million cfm.
- VB 3 serves a section of I-93 Northbound / Southbound. It has three ventilation zones, 14 exhaust stacks, and a supply capacity of 2.44 million cfm.
- VB 4 serves a section of I-93 Northbound / Southbound. It has four ventilation zones, 16 exhaust stacks, and a supply capacity of 2.48 million cfm.
- VB 5 serves a section of I-90 Westbound / Eastbound. It has four ventilation zones, 12 exhaust stacks, and a supply capacity of 1.98 million cfm.
- VB 6 serves a section of the TWT Westbound / Eastbound. It has two ventilation zones, 6 exhaust stacks, and a supply capacity of 1.16 million cfm.
- VB 7 serves a section of the TWT Westbound / Eastbound, and Ramp T-AD. It has five ventilation zones, 14 exhaust stacks, and a supply capacity of 1.68 million cfm.

Figures 1-5 to 1-10 provide the location of each VB.

FIGURE 1-2: SCHEMATIC OF FULL-TRANSVERSE VENTILATION SYSTEM

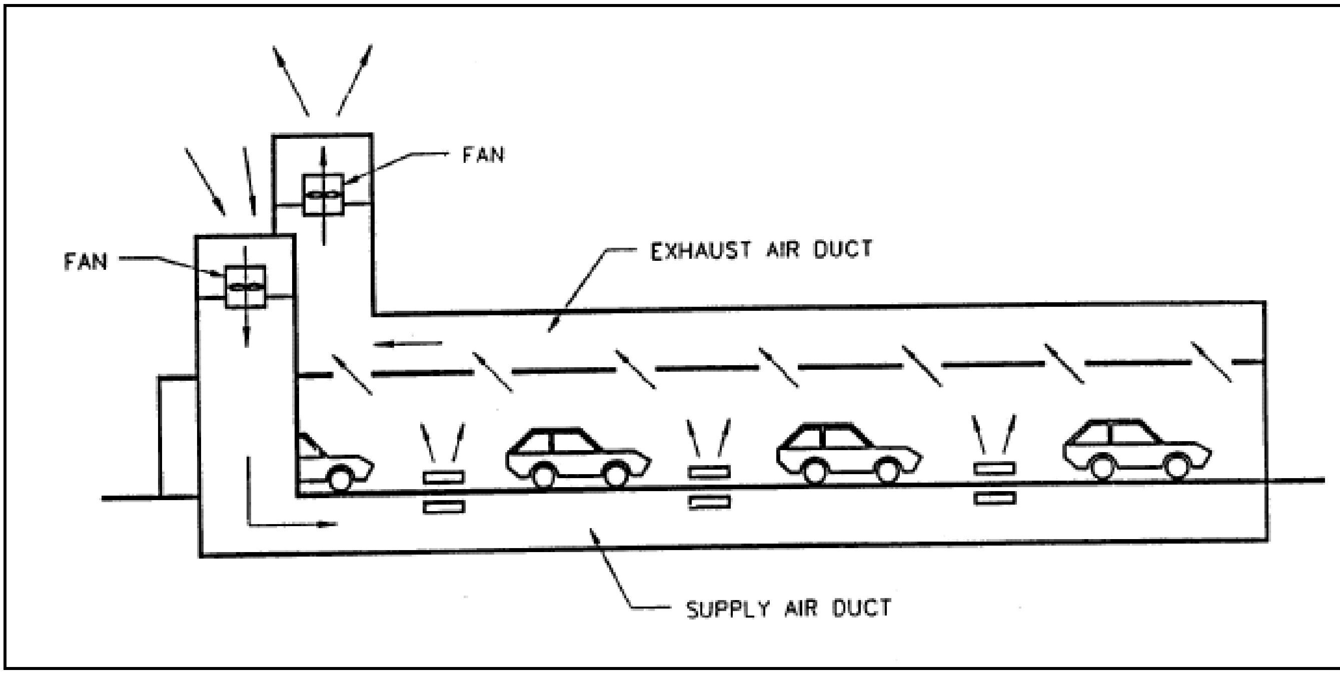


FIGURE 1-3: VENTILATION BUILDING 4 VENTILATION SCHEMATIC DIAGRAM

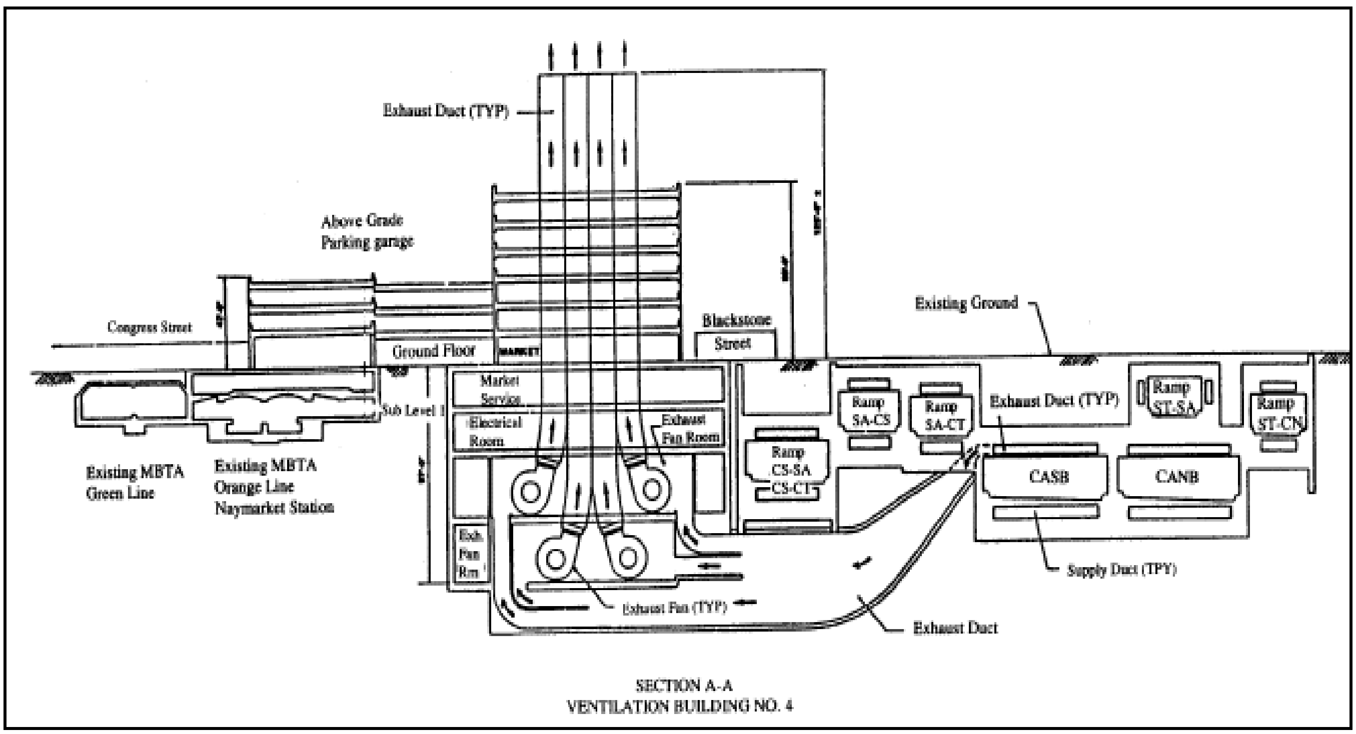


FIGURE 1-4: LOCATION OF VENTILATION BUILDINGS

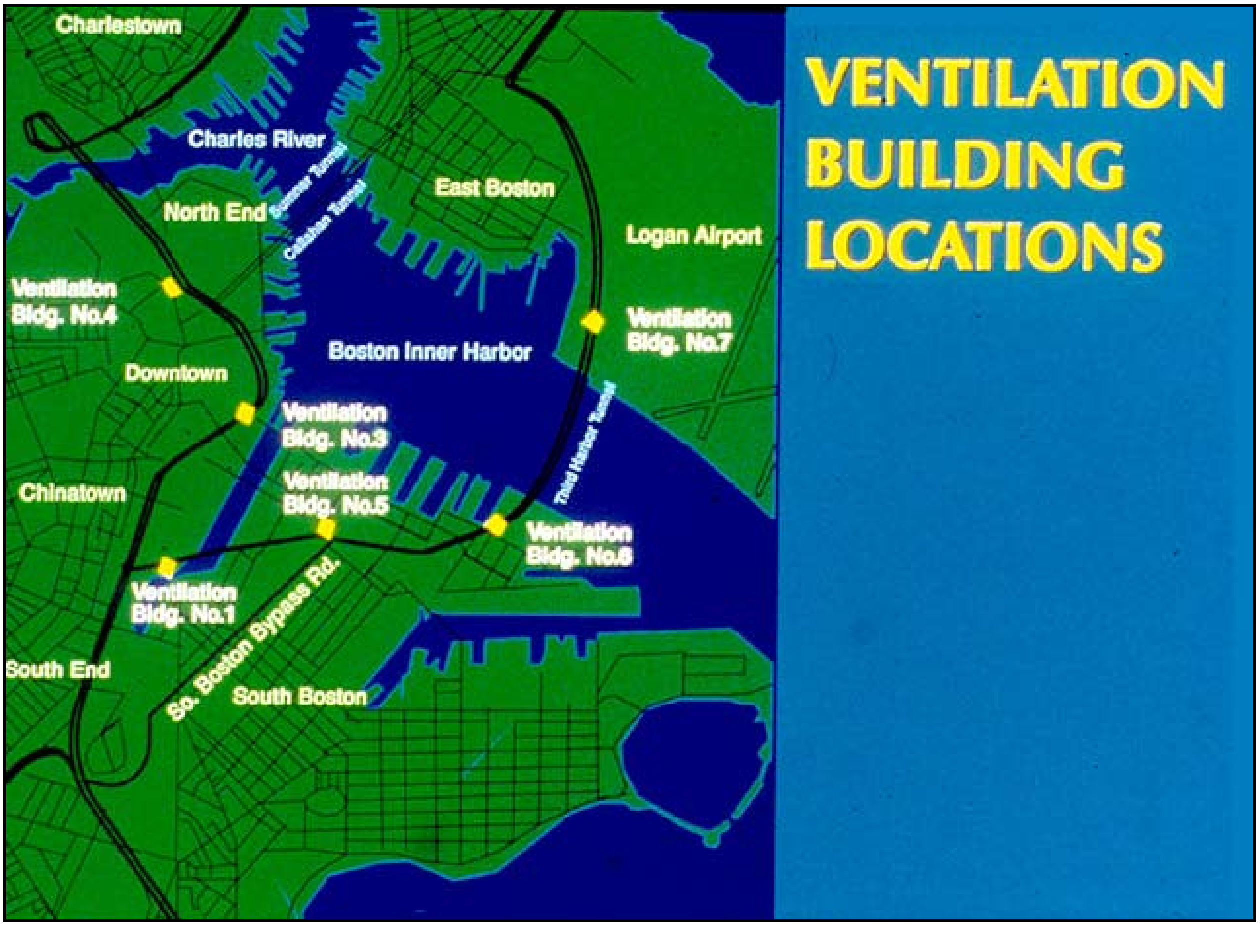


FIGURE 1-5: LOCATION OF VENTILATION BUILDING 1

FIGURE 1-6: LOCATION OF VENTILATION BUILDING 3

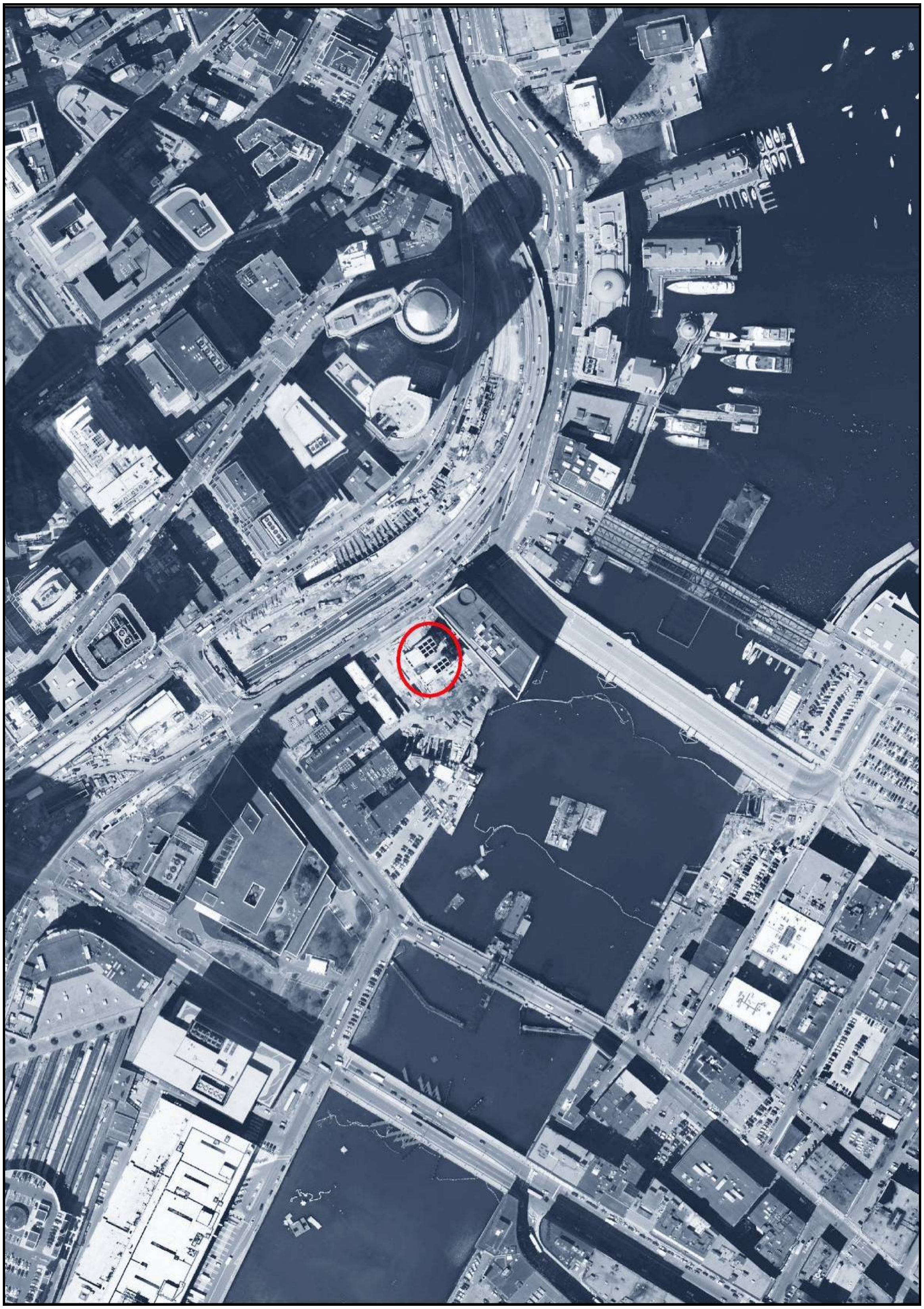


FIGURE 1-7: LOCATION OF VENTILATION BUILDING 4

FIGURE 1-8: LOCATION OF VENTILATION BUILDING 5

FIGURE 1-9: LOCATION OF VENTILATION BUILDING 6

FIGURE 1-10: LOCATION OF VENTILATION BUILDING 7

The airflows for the full-transverse system are controlled by the many supply and exhaust fans. Airflows are set from the ventilation control system located in the CA/T Project's Highway Operations Center (HOC) – formerly Operations Control Center (OCC) - in South Boston and are determined by the CO levels monitored inside each ventilation zone.

1.1.2 Longitudinal Ventilation

In the longitudinally ventilated tunnels the exhaust air moves in the direction of the traffic flow, and it is pushed through the exit portals by the piston action effect created by the moving vehicles. Longitudinal ventilation applies to the DST section of I-93 Southbound, and at eight tunnel exit ramps.

Some of these tunnel exit ramps are connected to the supply air from the ventilation buildings, and others have supply air in the form of jet fans mounted inside the tunnel ceilings and walls. In all cases, these tunnels are self-ventilated when the traffic flow moves at a speed that ranges from 20 to 45 miles per hour (MPH) (i.e., the traffic movement provides the majority or totality of the ventilation air). In the cases of traffic congestion, stalled conditions or other incidents, the mechanical ventilation (supply air and/or jet fans) supplements and/or replaces the natural self-ventilation system.

The fans that assist the longitudinal ventilation airflows are also controlled from the CA/T Project's HOC in South Boston and they are manually operated according to the CO levels monitored inside each section of these tunnels.

1.1.2.1 Dewey Square Tunnel

The original DST was designed and operated for approximately 50 years as a longitudinally ventilated tunnel. Under normal traffic conditions, the tunnel is ventilated by the piston effect of the vehicles traveling through the tunnel.

The reconstructed tunnel (which is connected at its northern end to the new CA/T I-93 southbound tunnel) includes an Air Intake Structure (AIS) housing two centrifugal fans (300 horsepower (hp) and 300,000 cfm each). The AIS located above the DST alignment slightly south of Congress Street is designed to provide supply air in cases of roadway accidents or stalled traffic conditions.

In addition, to provide operator flexibility with respect to air flow management for normal and emergency operations, three of the four existing DST fan chambers and shafts were retained and rehabilitated with reversible axial fans which typically operate in the supply mode. In the instance of a fire condition, these eight reversible fans (100 hp and 100,000 cfm each) will be operated in exhaust mode to prevent "back layering" (movement of the hot air and combustion gases counter to the desired direction of flow) of the smoke, protecting vehicles and passengers stopped behind the incident location.

The current DST exit portal is located 100 feet south of Kneeland Street (Figure 1-11). The future location of the portal under the full commercial development scenario will be an additional 300 feet further south, on the South side of the South Station Connector (also identified in Figure 1-11).

1.1.2.2 Exit Ramps with Fresh-Air Supply and/or Jet Fan Ventilation

There are eight longitudinally ventilated ramps. Three of these ramps include supply air and jet fan ventilation, while the other five (which are not connected to the mainline tunnels) only include jet fans.

The longitudinally ventilated ramps are as follows:

- Ramp LC-S (Leverett Circle to Central Artery southbound (SB))
- Ramp SA-CN (Surface Artery to Central Artery northbound (NB))
- Ramp CN-S (Central Artery NB to Storrow Drive)
- Ramp ST-CN (Sumner Tunnel to Central Artery NB)

- Ramp ST-SA (Sumner Tunnel to Surface Artery)
- Ramp CS-SA (Central Artery SB to Surface Artery)
- Ramp CS-P (Central Artery to Purchase Street)
- Ramp F (I-90 westbound (WB) to Congress Street)

The three ramps connected to supply air include:

- Ramp CN-S which has supply air provided by two fans (280,000 cfm) located inside VB 8.
- Ramp CS-SA which is connected to I-93 SB and has supply air from VB 4.
- Ramp CS-P which is also connected to I-93 SB, and has supply air from VB 3.

Figures 1-12 to 1-17 identify the location of each ramp.

FIGURE 1-11: LOCATION OF EXISTING AND FUTURE DST EXIT PORTAL

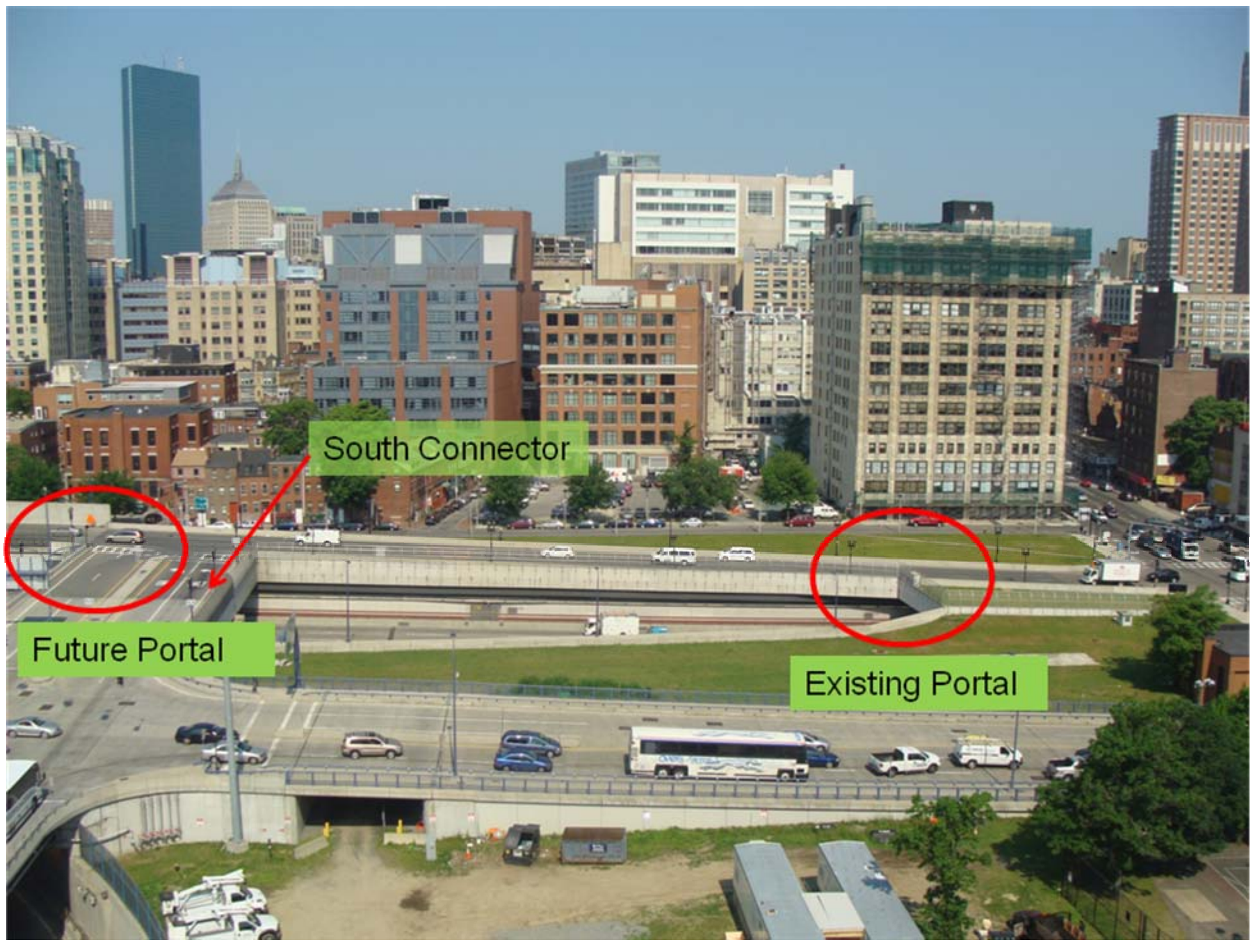


FIGURE 1-12: LOCATION OF RAMP PORTALS 1(L-CS) AND 3 (SA-CN)

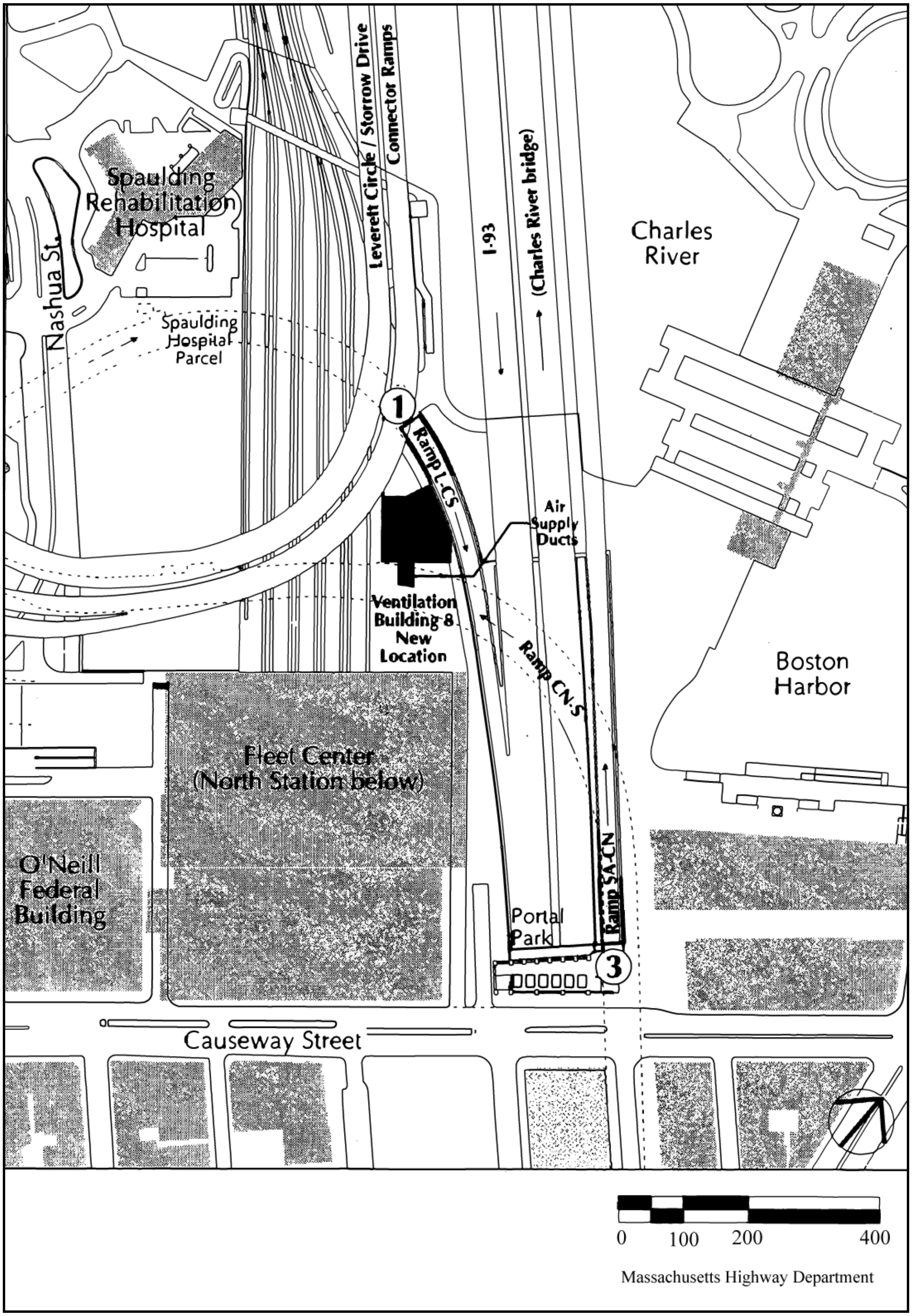


FIGURE 1-13: LOCATIONS OF RAMP PORTAL 2 (CN-S)

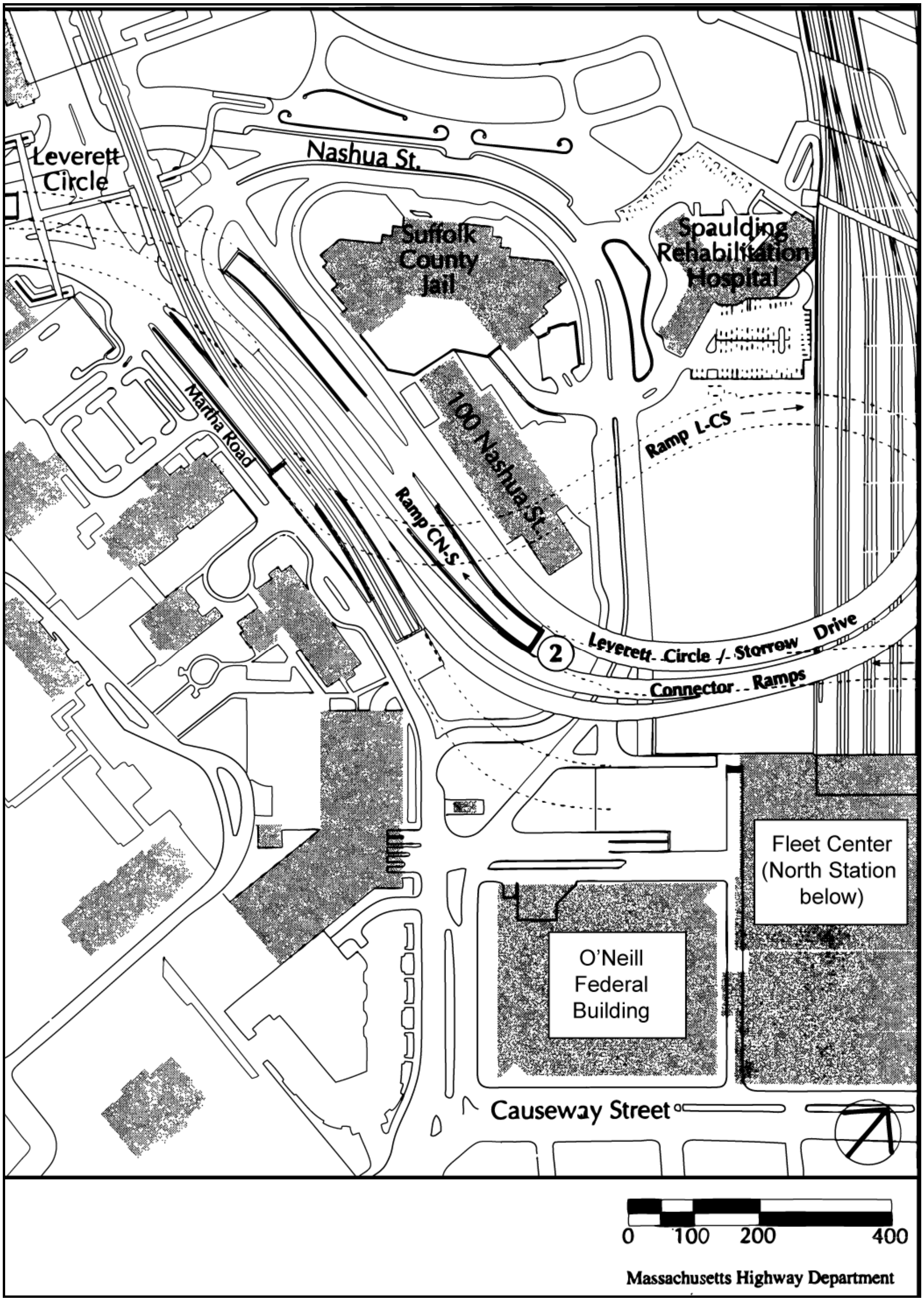


FIGURE 1-14: LOCATIONS OF RAMP PORTALS 4 (ST-CN) AND 5 (ST-SA)

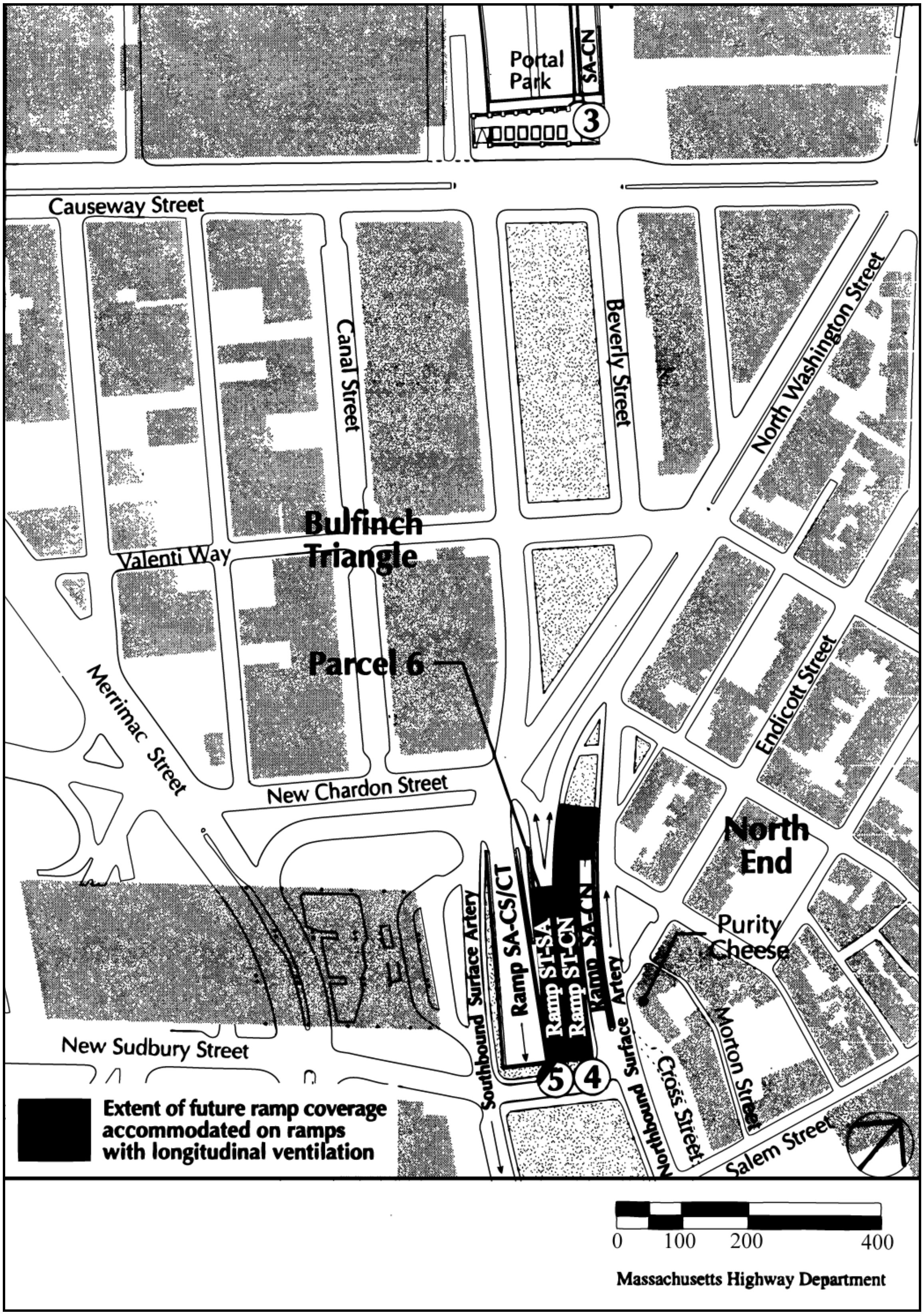


FIGURE 1-15: LOCATIONS OF RAMP PORTAL 6 (CS-SA)

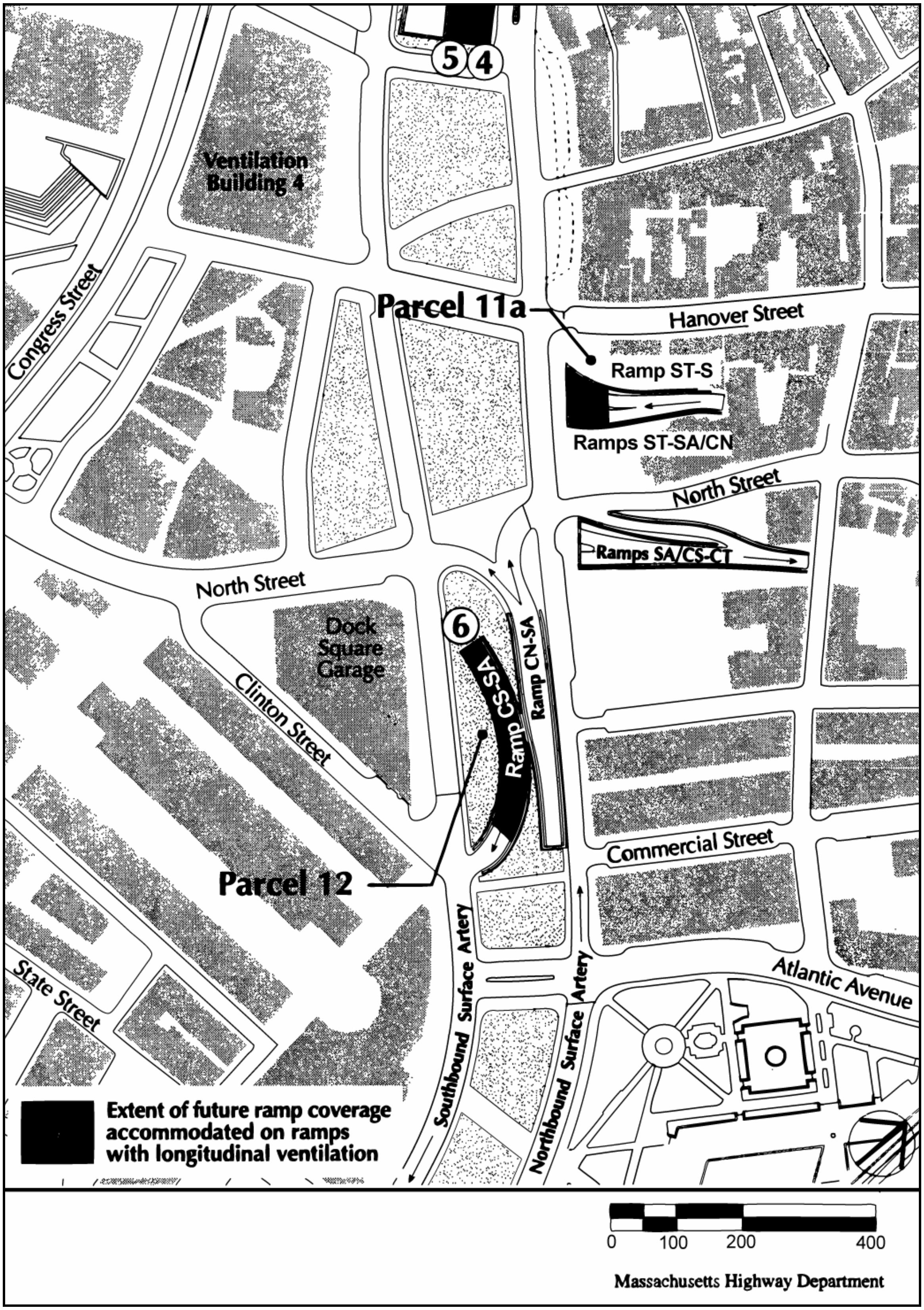


FIGURE 1-16: LOCATION OF RAMP PORTAL 7 (CS-P)

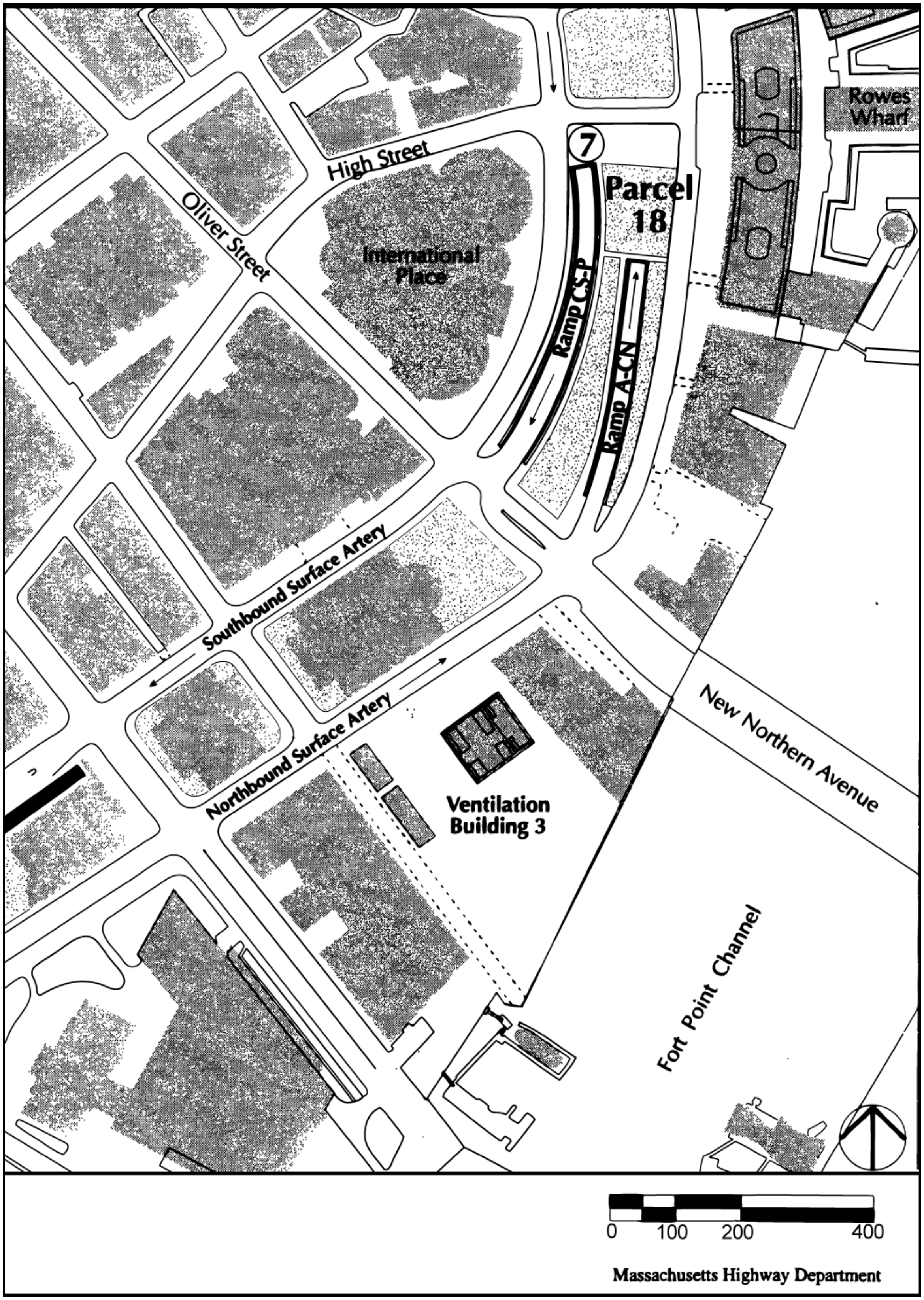
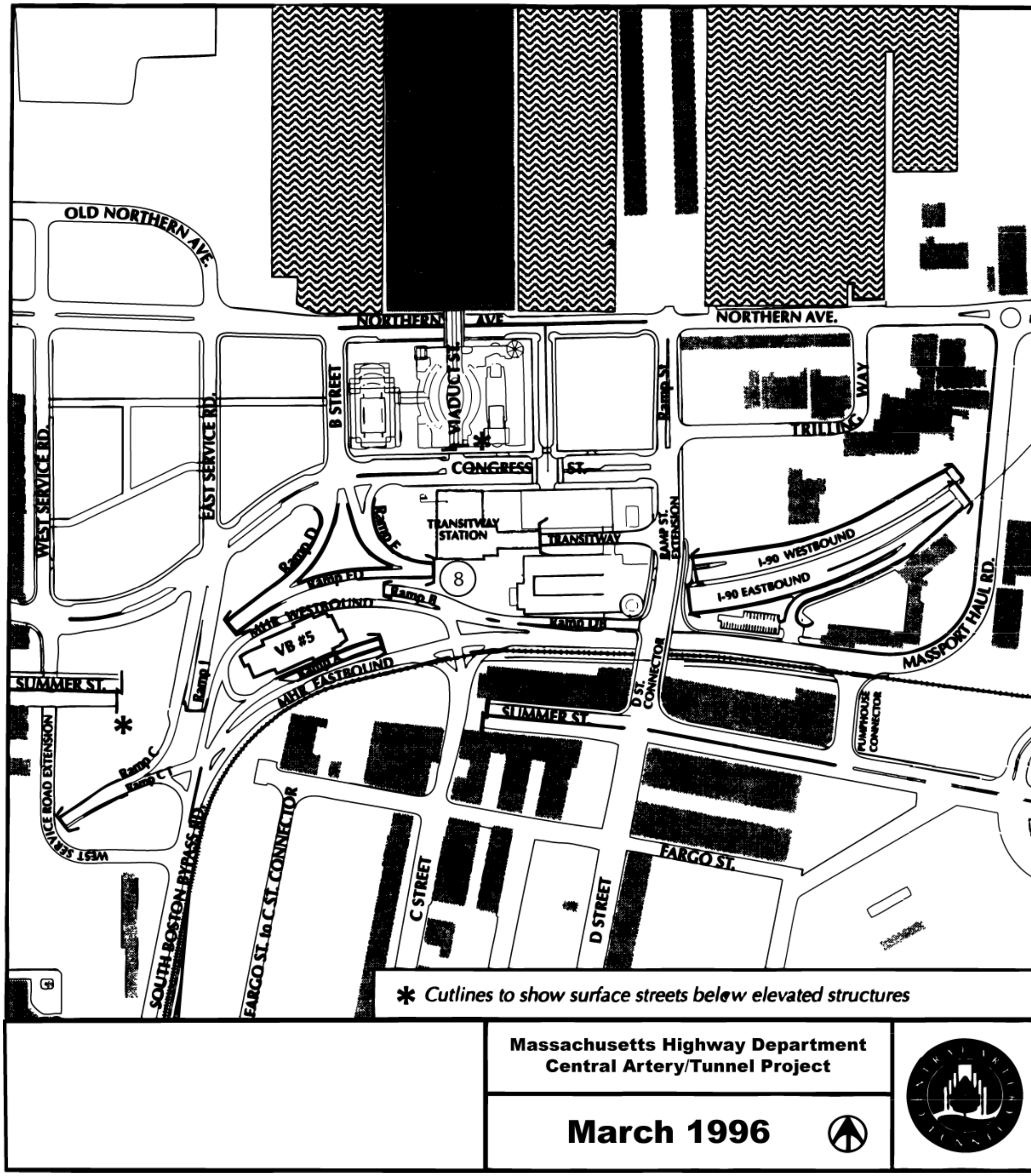


FIGURE 1-17: LOCATION OF RAMP PORTAL 8 (F)



1.2 FEASIBLE EMISSION CONTROL TECHNOLOGIES

The tunnel exhaust air contains pollutants from motor vehicles including carbon monoxide (CO), nitrogen oxides (NO_x), non-methane hydrocarbons (NMHC) and particulate matter (PM).

NMHC refers to any hydrocarbon species other than methane and is used interchangeably with volatile organic compounds (VOC) and non-methane organic gases (NMOG). The term VOC is used in this document.

The tunnel ventilation systems introduce and circulate fresh ambient air into the tunnels, and remove the mixture of vehicular exhaust and intake air from the tunnels through the exhaust stacks.

Ventilation building emissions control technology reviews were performed in 1991, 1995, 2004 and subsequently revisited and updated in 2011. An extensive investigation, conducted as part of these reviews revealed that ventilation was the predominant method of tunnel (inside and outside) air quality control employed in the United States and around the world. All reviews concluded that there were no feasible control techniques available that would result in a net reduction of the tunnel exhaust emissions.

The use of electrostatic precipitator (ESPs) systems has been an effective method for controlling particulate emissions for long tunnels that have relatively high in-tunnel particulate concentrations. Roadway tunnels equipped with ESPs systems in Europe and Japan are mostly those that are much longer than the CA/T, and have poor in-tunnel visibility caused by heavy-duty diesel truck traffic (i.e., large PM emission sources). In addition, over the last decade there has been an increased use of ESPs in tunnels for external environmental purposes in Japan. By comparison, the CA/T tunnels are relatively short and have a lower volume of diesel truck traffic. Therefore, the installation of ESPs systems for the CA/T Project would not result in any significant decreases in PM concentrations in the tunnel exhaust air.

Several methods of controlling gaseous emissions from tunnel exhausts are in various stages of development. However, these methods have not yet been tested or applied to situations with very low concentration levels such as those in the exhaust air of the CA/T tunnels. The extremely high flow and the very low concentration levels of pollutants in the exhaust air have been the greatest impediments to the practical application of these control techniques. Low concentrations and large flow rates would have necessitated unreasonably large control equipment sizes, long treatment times, and the use of large quantities of reagents and catalysts with the consequent generation of large amounts of waste and the need for their disposal. More importantly, the energy (heat and power) requirements of the control techniques would have resulted in fuel combustion and additional emissions of criteria pollutants (e.g., CO, NO_x, PM, SO_2) and non-criteria pollutants (e.g., SO_3 and greenhouse gases such as CO_2) that far exceed the original uncontrolled emission rates due to vehicle exhausts alone.

Technology for the removal of NOx from the airstream has been developed and deployed in several tunnels in Japan in recent years. However, it seems that in Japan, the decision to employ air purification for ambient purposes are determined by the politics surrounding the project, and not the technical effectiveness of the systems.

In addition, the emissions data collected inside the CA/T tunnel (and summarized in this report) indicate that safe in-tunnel air quality levels were maintained during the past five years. The results of the monitoring program and corrective actions indicated that despite a very few instances between 2006 and 2011 when abnormal conditions resulted in measured concentrations exceeding the established emission limits, ambient pollutant levels outside the tunnels never exceeded the applicable NAAQS and MassDEP One Hour NO_2 Policy Guideline.

1.3 TUNNEL OPERATING CONDITIONS

The CA/T Project's tunnel ventilation systems are controlled and monitored at the MassDOT HOC in South Boston. From this facility, tunnel operators are assigned geographical areas of responsibility for oversight of all traffic management and support systems operation. Ventilation system control from this location may be either manual—allowing the operator to make specific adjustments—or automatic via a central computer-based tunnel air quality algorithm or time-of-day histogram. In addition, each of the tunnel ventilation systems is controlled from the local ventilation facility.

The system at each ventilation zone is normally operated in what is called a balanced mode; in which equal amount of supply and exhaust air are used to keep the system in a neutral pressure state. Only in the case of emergencies will the system be operated in an unbalanced condition (i.e., over exhaust mode).

1.3.1 During Non emergency Operations

During normal daily traffic operating conditions, the tunnel ventilation system is operated to maintain safe air quality and visibility within the tunnels. CO levels resulting from vehicle emissions are continuously monitored throughout all Project tunnels.

Real time values from each CO monitor are averaged by the HOC central computer system and reported on a per ventilation zone basis. Any exceedance of preset alert levels within a ventilation zone triggers an audible alarm to the operator. A banner display on the monitoring console provides specific data regarding actual concentrations, trends and location. The operator is then able to make any necessary adjustments to the ventilation zones in that particular tunnel area in order to restore safe air quality to the tunnel.

1.3.2 During Emergencies

The tunnel ventilation system was pre-programmed to operate in the most effective mode for controlling smoke and heat in the case of a vehicle fire. The programming is based on system simulation modeling of severe fire conditions to determine the most effective way to achieve critical air velocity for smoke dissipation at all locations. If a fire occurs within any of the CA/T tunnels, the HOC operator would bring up the ventilation system emergency operating matrix on his monitor and simply "click" on the column titled "fire location." The central computer will then operate all necessary ventilation systems in their proper modes for securing as safe an environment as possible at the site of the fire.

Based on discussions with MassDEP, MassDOT understands that the criteria specified at 310CMR 7.38(2)(a) and (b) do not apply during fire emergency situations. The protection of public safety would be the priority during emergencies.

1.4 VENTILATION SYSTEM PHYSICAL PROPERTIES

The Central Artery tunnel ventilation system includes:

- A very large and complex network of supply air ducts located underneath the roadway pavement (or on the side walls in some downtown tunnel sections) to deliver supply air from the supply fans to each segment of the tunnel network.
- Exhaust plenums located over the tunnel ceiling (or on the side walls in the some downtown tunnel sections) to extract the exhaust air to exhaust fans located in the VBs.
- The supply and exhaust fans of each VB, the DST air intake structure and two reversible fan chambers.
- The jets fans on each longitudinally ventilated ramp.

- The HOC building, and extensive ancillary equipment, which provides power and controls to the entire ventilation system.
- The backup power system.

1.4.1 Ventilation Building Dimensions and Ventilation Capacities

The locations of the VBs are provided in Figures 1-5 through 1-10. Each VB is a large structure with its largest part located underground. It includes a group of stacks at a uniform height. Table 1-1 provides the VB and exhaust stack heights above grade.

TABLE 1-1: VENTILATION BUILDING AND EXHAUST STACK HEIGHTS

VB	Heights of Ventilation Buildings and Stacks Above Grade (feet)	
	Building Roof	Stacks
VB1	82	121
VB3	239	278
VB4	80	131
VB5	117	178
VB6	60	91
VB7	72	108

As stated in Section 1.2, the tunnel ventilation system was designed with a supply air capacity of 65 cfm per lane-foot of tunnel and an exhaust capacity of 100 cfm per lane-foot of tunnel. The variable speed fans can be operated at different steps (depending on the level of air flow delivered). The supply fans vary from step 1 to 6, and the exhaust fans vary from step 1 to 8. Only steps 1 to 6 are required to operate the system in a balanced mode (supply equals exhaust), while steps 7 and 8 are used in cases of emergency and fire conditions. Table 1-2 provides the total exhaust capacity of each ventilation zone and the corresponding capacity at each operating step. Figure 1-18 provides a view of a supply fan at VB7 with the CO and PM_{10} monitoring unit.

FIGURE 1-18: SUPPLY FAN AT VB 7 AIR INTAKE FLOOR

TABLE 1-2: VENTILATION BUILDINGS EXHAUST CAPACITY FOR VARYING STEPS

Ventilation Building	Ventilation Zone	Total Exhaust Capacity (CFM)	Exhaust Capacity Step 1 (CFM)	Exhaust Capacity Step 2 (CFM)	Exhaust Capacity Step 3 (CFM)	Exhaust Capacity Step 4 (CFM)	Exhaust Capacity Step 5 (CFM)	Exhaust Capacity Step 6 (CFM)
3	SB-1	1,070,000	139,100	246,100	342,400	449,400	556,400	695,500
3	NB-1	1,258,150	163,560	289,375	402,608	528,423	654,238	817,798
3	NB-2	1,139,000	148,070	261,970	364,480	478,380	592,280	740,350
4	SB-2	949,000	123,370	218,270	303,680	398,580	493,480	616,850
4	SB-3	1,130,500	146,965	260,015	361,760	474,810	587,860	734,825
4	NB-3	885,000	115,050	203,550	283,200	371,700	460,200	575,250
4	NB-4	809,000	105,170	186,070	258,880	339,780	420,680	525,850
1	SAT-Ramp D-E1	343,000	44,590	78,890	109,760	144,060	178,360	222,950
1	SAT-WB-E1	691,200	89,856	158,976	221,184	290,304	359,424	449,280
1	SAT-EB-E1	563,640	73,273	129,637	180,365	236,729	293,093	366,366
1	SAT-Ramp L/HOV-E1	941,000	122,330	216,430	301,120	395,220	489,320	611,650
5	SAT-WB-E2	1,040,000	135,200	239,200	332,800	436,800	540,800	676,000
5	SAT-WB-E3	393,000	51,090	90,390	125,760	165,060	204,360	255,450
5	SAT-EB-E2	1,112,000	144,560	255,760	355,840	467,040	578,240	722,800
5	SAT-EB-E3	558,000	72,540	128,340	178,560	234,360	290,160	362,700
6	Eastbound Zone 1	900,000	117,000	207,000	288,000	378,000	468,000	585,000
6	Westbound Zone 1	900,000	117,000	207,000	288,000	378,000	468,000	585,000
7	Eastbound Zone 2	822,000	106,860	189,060	263,040	345,240	427,440	534,300
7	Westbound Zone 2	693,000	90,090	159,390	221,760	291,060	360,360	450,450
7	Eastbound Zone 3	452,000	58,760	103,960	144,640	189,840	235,040	293,800
7	Westbound Zone 3	609,000	79,170	140,070	194,880	255,780	316,680	395,850
7	T-A/D	583,000	75,790	134,090	186,560	244,860	303,160	378,950

Notes:
Step 1 = 13% of Exhaust Capacity
Step 2 = 23% of Exhaust Capacity
Step 3 = 32% of Exhaust Capacity
Step 4 = 42% of Exhaust Capacity
Step 5 = 52% of Exhaust Capacity
Step 6 = 65% of Exhaust Capacity
Step 6 is the highest level for supply-exhaust in a balanced mode.
T-A/D - I-90 to Logon International Airport (Terminal -Arrival/Departure)

1.4.2 Longitudinally Ventilated Tunnels Dimensions and Ventilation Capacities

The plume of exhaust air that comes out of an exit portal in the wake of exiting vehicles maintains its integrity for a distance downstream of the exit portal due to the momentum created by the moving cars. This distance depends on the geometry of the roadway after the tunnel exit, the traffic flow characteristics, such as speed and density, meteorological conditions (wind direction), and other factors affecting the turbulence of the plume.

The dimensions, number of lanes and mechanical ventilation capacities of the DST and the eight longitudinally ventilated ramps exit portals are provided in Table 1-3. Figure 1-19 provides a view of a side-mounted jet fan.

TABLE 1-3: LONGITUDINAL VENTILATION TUNNEL SECTION DIMENSIONS AND MECHANICAL VENTILATION CAPACITIES

Portal No	Ramps/Scenario	Ramp Length (ft)	Number of Lanes	Total Length (lane-ft)	Mechanical Airflow Rates (KCFM) Supply Air	Min Jet Fan	Max Jet Fan
DST I-93a	DST Existing Portal	2400	4	9600	400	NA	NA
DST I-93b	DST Relocated Portal	2700	4	10800	400	NA	NA
DST I-90	I-90 Collector	2700	2	5400	200	NA	NA
1	LC-S	1020	2/1	1950	NA	197	393
2	CN-S	2000	2	4000	260	NA	NA
3a	SA-CN	1130	2	2260	NA	225	318
3b	SA-CN (with parcel 6)	2000	2/1	3000	NA	359	508
4	ST-CN	600	1	600	NA	232	328
5a	ST-SA	600	1	600	NA	232	328
5b	ST-SA (with parcel 6)	1000	1	1000	NA	130	260
6a	CS-SA	480	1	480	31	NA	NA
6b	CS-SA (with parcel 12)	780	1	780	51	NA	NA
7	CS-P	740	2	1480	96	NA	NA
8	F	700	1	700	NA	130	260

Notes: The relocated DST portal extends the DST tunnel approximately 300 feet south when development of parcel 25 is built. The DST supply capacity does not include the installed ventilation capacity of the three reversible fan chambers, which operate in exhaust mode for emergency conditions.
KCFM – thousands cfm

FIGURE 1-19: JET FAN AT LONGITUDINALLY VENTILATION RAMP

The air flows at the exit portals are very dependent on the traffic characteristics such as vehicle classification, density and speed at any given time.

Table 1-4 summarizes the air flows at each portal in order to provide an indication of the airflows generated by the traffic flows and the available mechanical ventilation that can be delivered by the air supply and jet fans. The air flows at each portal have been estimated in the *Notice of Project Change (NPC)/Environmental Reevaluation (ER) for the Implementation of Longitudinal Ventilation in the Area North of Causeway Street and Central Area, October 1996* (1996 Longitudinal Ventilation NPC/ER), and in the DST final report *Air Quality Study Dewey Square Portal Boston, Massachusetts*, prepared by RWDI, January 2006.

TABLE 1-4: TRAFFIC VOLUMES, SPEEDS AND AIR FLOW RATES FOR DST AND EIGHT LONGITUDINALLY VENTILATED RAMPS

Portal No	Ramps/Scenario	Peak Hour			Eight Hour		
		Flow Rate	Traffic Volume	Traffic Speed	Flow Rate	Traffic Volume	Traffic Speed
		cfm	veh/hr	mph	cfm	veh/hr	mph
DST I-93a	**DST Existing Portal**	746,000	4,580	20	1,140,000	3,800	44
DST I-93b	**DST Relocated Portal**	772,000	4,580	20	1,220,000	3,800	44
DST I-90	**I-90 Collector**	592,000	3,140	27	585,000	2,650	28
1	**LC-S**	183,420	2,068	8	248,460	1,839	13
2	**CN-S**	549,440	2,997	20	610,900	2,015	26
3a	**SA-CN**	345,060	2,204	27	339,400	1,756	29
3b	**SA-CN (with parcel 6)**	382,880	2,204	27	402,500	1,756	29
4	**ST-CN**	130,380	166	30	160,920	350	29
5a	**ST-SA**	169,740	1489	20	180,150	1187	26
5b	**ST-SA (with parcel 6)**	208,730	1489	20	208,070	1187	26
6a	**CS-SA**	265,000	1,904	12	273,300	875	16
6b	**CS-SA (with parcel 12)**	241,320	1,904	12	275,700	875	16
7	**CS-P**	136,150	1,559	11	81,400	1,099	15
8	**F**	308,450	1,929	29	281,300	1,440	30

The conditions analyzed in the wind tunnel tests include the partial and full development conditions. The DST airflows provided represent a combination of traffic induced piston effect and the AIS operating at 50% capacity. The airflows for the ramps represent only the result of piston action. It is worth noting the differences in the airflows between the peak and eight-hour scenarios and the effect of the traffic speeds on such airflows.

The traffic levels monitored during the last five years indicate that these assumptions remain valid.

2 DETERMINATION OF EMISSION LIMITS

In compliance with MDEP Regulation 310 CMR 7.38, during 2006 the CA/T Project filed an Operating Certification for the Project's Tunnel Ventilation System in which it established emission limits for the exhaust of each Ventilation Building, Dewey Square tunnel (DST), and longitudinal ventilated exit ramps. MassDEP gave final acceptance to the 2006 CA/T Operating Certification in December 22, 2006.

The 2006 Operating Certification established tunnel emission limits for carbon monoxide (CO), nitrogen oxides (NOx) and particulate matter equal to or smaller than 10 microns in diameter (PM_{10}) to demonstrate compliance with ambient air quality standards for CO, NO_2, and PM_{10} and state guideline values for NO_2. It also established a regional emission budget for volatile organic compounds (VOCs) based on the 2005 CA/T build predictions, which included highway and transit components.

This section includes changes associated with establishing new limits for $PM_{2.5}$ that replaced the PM_{10} limits; compliance demonstration for the new $PM_{2.5}$ limits; regional emission analysis for VOC; and description of the process to re-evaluate and update the CO and NOx emission limits as part of a "Supplemental Application" to be submitted in July 2012. The current CO and NOx limits are retained until the results of the ongoing NO_2-NO-NOx one-year monitoring program can be analyzed to establish new emission limits for submission in July 2012.

2.1 PROJECT PRECONSTRUCTION CERTIFICATION ACCEPTANCE RECORD

310 CMR 7.38(2) "Pre-Construction Certification" states that no person shall construct a tunnel ventilation system and project roadway subject to 310 CMR 7.00 without first certifying to MassDEP (and receiving MassDEP's written acceptance of that certification) that the operation of any tunnel ventilation system, project roadway, and roadway networks will not cause a violation of certain air quality standards, guidelines, and criteria specified in MassDEP Regulation 7.38.

On February 20, 1991, to comply with the provisions of 310 CMR 7.38, the Massachusetts Department of Public Works, now the MassDOT, submitted to MassDEP a Pre-Construction Certification of the Tunnel Ventilation System for the CA/T Project (Pre-Construction Certification). The Pre-Construction Certification was found to be administratively complete by MassDEP on March 27, 1991. On May 7, 1991, MassDEP conducted a public hearing on the Pre-Construction Certification to receive comments pursuant to 310 CMR 7.38(11). After review of the Pre-Construction Certification and consideration of information presented at the public hearing and during the public comment process, MassDEP accepted the Pre-Construction Certification subject to conditions set forth in the decision document dated July 8, 1991 entitled *Conditional Acceptance of Pre-Construction Certification of the Central Artery/Third Harbor Tunnel Project* (Conditional Acceptance). MassDEP determined that the mitigation measures presented in the Conditional Acceptance were necessary to mitigate potential adverse air quality impacts from the CA/T Project and to meet the criteria for project certification in 310 CMR 7.38. The mitigation measures set forth in the Conditional Acceptance included Public Transportation Measures, Measures to Increase Commuter Rail Ridership, Water Transportation Measures, Transportation Management Measures, and a High Occupancy Vehicle (HOV) Program.

On September 10, 1992, MassDOT submitted an amendment to the Pre-Construction Certification to update technical information based on design refinements to the CA/T Project and to provide a basis for MassDEP to clarify the requirements of Section VI of the 1991 Technical Support Document (that was submitted with and in support of the Pre-Construction Certification) to provide consistency with the 1991 Transit Regulations, 310 CMR 7.36, and HOV Regulations, 310 CMR 7.37, that were adopted by MassDEP in December 1991.

On January 7, 1999, the MTA, on behalf of MassDOT, submitted to MassDEP for its review and acceptance pursuant to the 310 CMR 7.38 an amendment to the Pre-Construction Certification. The 1999 Amendment to the Pre-Construction (Amended Pre-Construction Certification) superseded the 1992 amendment. Submitted with and in support of the Amended Pre-Construction Certification was a 1999 Technical Support Document that updated, but did not replace, the 1991 Technical Support Document to reflect analyses performed in connection with design changes to the CA/T Project since 1991 that had been reviewed through the Massachusetts Environmental Policy Act (MEPA) and that had then been incorporated as part of the CA/T Project design. In addition, the 1999 Technical Support Document updated Section VI, of the 1991 Technical Support Document on "Methods to Minimize Miles Traveled" to reflect the current status of the demand reduction strategies and transportation control measures included in the planning and implementation programs of the Executive Office of Transportation and Construction (EOTC), now the Executive Office of Transportation (EOT).

The Amended Pre-Construction Certification was found to be administratively complete by MassDEP on February 26, 1999. On March 30, 1999 MassDEP conducted a public hearing on the Amended Pre-Construction Certification to receive comments pursuant to 310 CMR 7.38(11). MassDEP issued proposed decision documents on the Amended Pre-Construction Certification on April 29, 1999 and conducted a public hearing on those proposed decisions on May 20, 1999. After review of the information submitted by MTA, MassDOT and EOTC and the information presented at the public hearings and during the public comment period, MassDEP accepted the Amended Pre-Construction Certification subject to certain conditions in a document dated September 1, 2000 entitled "DEP Determination on the Amended Pre-Construction Certification of the CA/T Project under 310 CMR 7.38" (MassDEP Determination). Among those conditions was an Administrative Consent Order (ACO) by and between MassDEP and EOTC, also dated September 1, 2000 that was incorporated by reference into and thereby made part of the MassDEP Determination. The ACO has been twice amended; Amendment #1 on May 23, 2002 and Amendment #2 on January 26, 2005.

The Pre-Construction Certification and the Amended Pre-Construction Certification required a number of mitigation measures designed to " ... mitigate potential adverse air quality impacts from the CA/T Project and to meet the criteria for project certification." To address delays in certain mitigation measures, the ACO and amendments to the ACO required additional measures to be implemented to provide reductions in VMT and emissions during the delay of the required mitigation measure.

2.2 MassDEP Regulatory Requirements for Operating Certifications

As discussed in Section 2.1, 310 CMR 7.38 required the issuance by the constructor, MassDOT, of a Pre-Construction Certification; and subsequently by the operator, MassDOT, of an Operating Certification. As part of the Operating Certification requirements, MassDOT must demonstrate that the tunnel ventilation system when operated in accordance with its design standard operation and maintenance procedures would not:

- Cause or exacerbate a violation of any National Ambient Air Quality Standard (NAAQS), or a Massachusetts Ambient Air Quality Standard (MAAQS);
- Cause or exacerbate a violation of the MassDEP's one hour ambient nitrogen dioxide (NO_2) guideline of 320 $\mu g/m^3$; or
- Result in an actual or projected increase in the total amount of non-methane hydrocarbons (referred as VOC in this document) measured within the Project area when compared with the No-Build alternative.

During the past five years, the 24 Hour NAAQS for particulate matter equal to or smaller than 2.5 microns in diameter ($PM_{2.5}$) was modified, and MassDEP required that the 2011 renewal include emission limits for $PM_{2.5}$. These limits for $PM_{2.5}$ will replace the limits currently in effect for PM_{10}.

During the spring of 2010, MassDEP determined that the recertification should include a demonstration of compliance with the new NO_2 NAAQS. The 2006 NO_x emission limits currently in effect were established to comply with the MassDEP 1-hour NO_2 policy guideline of 320 µg/m^3, equivalent to approximately 170 ppb.

MassDOT is required to demonstrate that the operation of the tunnel ventilation system is in accordance with the criteria set forth in the Pre-Construction Certification accepted by MassDEP. The MassDEP Regulation 310 CMR 7.38 provides that this demonstration shall be based on actual measured emissions and traffic data. [It is worth noting that that the 310 CMR 7.38(2) requirements regarding compliance with the applicable ambient air quality standards and the One-hour NO_2 Policy guideline for nitrogen dioxide do not apply during emergency conditions (i.e., tunnel fires).]

An air quality compliance demonstration was performed in support of the Operating Certification,. However, MassDOT is required to establish emission limits for the tunnel ventilation system such that operation of the CA/T ventilation system below these limits would not cause or exacerbate a violation of any applicable ambient standards. Actual CA/T operating experience and measured in-tunnel pollutant concentration levels thus far are taken into consideration in determining these emission limits.

The Project Compliance Monitoring Program approved in 2006 included CO continuous emission monitoring (CEM) at the plenum of each ventilation zone, and PM_{10} CEM at four ventilation zones that presented the highest potential PM_{10} levels at the mainline tunnel exhaust points. Due to the limited space available and other technical impediments inside the ramps, instead of in-tunnel monitoring, a permanent PM_{10} monitor was installed in 2006 at outside exit Ramp CS-SA to determine if the emissions from the longitudinally ventilated ramps could cause high PM_{10} levels in the adjacent areas. NO_x levels at each CEM monitoring location were determined as a function of the hourly monitored CO levels. The monitoring results and the calculated NO_x levels were compared to their predetermined emission limits for compliance assessment.

For VOC emissions, MassDOT is required to demonstrate that the tunnel ventilation system when operated in accordance with its design, standard operation and maintenance procedures would not result in an actual or projected increase in the total amount of VOC measured within the Project area compared to the No-Build alternative. The 2005 regional VOC emissions for the area affected by the CA/T Project Build scenario was used as a budget limit, not to be exceeded in future years for compliance demonstration purposes.

2.3 ACCEPTANCE OF CONCENTRATION–BASED EMISSION LIMITS

The MassDOT-MassDEP technical working group proposed and received concurrence from MassDEP (see MassDEP letter dated April 16, 2002) that the CA/T emission limits for CO, NO_x and PM_{10} (and now, by extension, for $PM_{2.5}$) should be determined as concentration-based levels (i.e., ppm or µg/m^3) in lieu of the mass-based (e.g., grams per second (g/s) or pounds per hour (lb/hr)) limits that are usually imposed on stationary sources. The rationale for the concentration-based emission limits, which meet the requirements of 310 CMR 7.38, is briefly discussed as follows.

Vehicular emissions depend on the number, type and conditions of the vehicles and their traveling speeds. Although the MassDOT is the Owner and Operator of the CA/T tunnel ventilation system, the Project tunnels are open for general public use under normal operation conditions without exception. Therefore, the MassDOT has no control regarding the type and conditions of vehicles entering the tunnel and can only manipulate the ventilation rates of the tunnel ventilation system based on traffic conditions to provide acceptable in-tunnel air for the motorists traveling the tunnels. Thus, the emission limits to be set for all applicable pollutants will be the maximum allowable concentrations that will ensure that the applicable ambient standards are not violated.

Since there is no NAAQS for VOC, emission limits for VOC cannot be established based on concentrations measured at a specific receptor location. As such, direct measurement or monitoring of VOC without a benchmark level to guide the operation of the ventilation system may or may not contribute to the protection of the health and welfare of the affected population. A different procedure that is based on the study area VOC budget was developed by the MassDOT-MassDEP air quality working group and accepted by MassDEP on July 30, 2002. The established VOC budget for the CA/T Build condition was then be used as the emission limit, which is not to be exceeded in the future years for compliance demonstration purposes.

2.4 ACCEPTANCE OF EMISSION LIMITS ESTABLISHED IN 2006 APPLICATION

The 2006 Operating Certification established tunnel emission limits for CO, NOx and PM_{10} to demonstrate compliance with ambient air quality standards for CO, NO_2, and PM_{10} and state guideline values for NO_2.

The final acceptance letter by MassDEP dated December 22, 2006 states that MassDEP issued the final acceptance of the Operation Certification (Final Acceptance) provided that: “Emission Limits shown in the Table 2-1 will ensure that all NAAQS and MassDEP guidelines will not be exceeded in the CA/T Project area”.

TABLE 2-1: SUMMARY OF 2006 EMISSION LIMITS

Location*	1-Hour CO Emission Limit (ppm)	8-Hour CO Emission Limit (ppm)	1-Hour NO_X Emission Limit (ppm)	24-Hour PM_{10} Emission Limit ($\mu g/m^3$)
VB 1	70	70	8.88	500
VB 3	70	70	8.88	500
VB 4	70	70	8.88	500
VB 5	70	70	8.88	500
VB 6	70	70	8.88	500
VB 7	70	70	8.88	500
Ramp L-CS	52	39	6.64	NA
Ramp CN-S	66	58	8.38	NA
Ramp ST-CN	70	70	8.88	NA
Ramp SA-CN	70	70	8.88	NA
Ramp CS-SA	56	46	7.14	150**
Ramp ST-SA	70	51	8.88	NA
Ramp CS-P	70	70	8.88	NA
Ramp F	70	70	8.88	NA
Dewey Sq. Tunnel	25	23	3.30	NA

* For VBs, location includes all ventilation zones of this VB.
** The ambient PM_{10} monitor is located outside ramp CS-SA.

It also established a regional emission budget for volatile organic compounds (VOCs) based on the 2005 CA/T build predictions, which included highway and transit components setting a limit of 6,095.9 kg/day for the CA/T Project area.

2.5 2011 RE-CERTIFICATION PROCESS

$PM_{2.5}$ Limits:

In lieu of the PM_{10} emission limits that were part of the 2006 Operating Certification, MassDOT will establish the $PM_{2.5}$ limits based on the current Air Quality Modeling Protocol for $PM_{2.5}$ that includes current recommended EPA models, modeling guidance, the form of the NAAQS, and the most recent monitoring and meteorological data.

CO and NO_2 Limits:

After a review of the Ozone Limiting Method (OLM) used in the previous CA/T analyses, MassDOT found that the OLM procedure had significant limitations for the one-hour NO_2 NAAQS compliance, as described in detail below.

The 2006 approach assumed that the NO component in the Project emissions constitutes approximately 95 % of NOx, and that NO converts to NO_2 in the presence of atmospheric ozone (O_3) and sunlight. To approximate this oxidation process and determine the ambient NO_2 levels, the CA/T Project used the OLM procedure assuming that NO will instantly convert to NO_2 to the extent that O_3 is available.

This approach resulted in ambient NO_2 concentrations as the sum of three components for each hour: (1) the direct NO_2 emissions reduced by a dilution factor to account for mixing that would occur between the source and the receptor; (2) the concurrent background level for O_3; and (3) the concurrent background level for NO_2. As discussed at the January 19, 2011 meeting between MassDOT and MassDEP, the concurrent background levels of NO_2 and O_3 by themselves nearly exceed the new 1-hour NO_2 NAAQS. Therefore, the previously used OLM methodology leaves almost no margin to include emissions associated with the Project. Although the OLM procedure was adequate to demonstrate compliance with the DEP 1-hour policy guideline, the inherent conservativeness of the procedure precludes its use in demonstrating compliance with the new 1-hour NO_2 NAAQS.

Compliance with the new NO_2 NAAQS requires a more refined analysis and a better understanding of how much NO produced by motor vehicle exhaust is actually converted to NO_2 in the vicinity of the tunnel exhaust points (portals and VBs). MassDOT presented a proposal for an NO_2-NO-NO_x monitoring program at the Albany Street sidewalk and DST portal in the fall of 2010. MassDOT designed the program to collect data to allow for a better understanding of how emissions of NO_x from the DST and other ramps affect ambient levels of NO_2 at nearby sensitive land uses. The information gained by analyzing the monitoring data will allow for a more accurate treatment of the NO to NO_2 conversion process in the vicinity of the tunnel exhaust points and will support the determination of revised NO_x emission limits that will ensure compliance with the new 1-hour NAAQS for NO_2. MassDEP accepted the twelve-month monitoring program and the data collection began during April 2011.

The 2006 Operating Certification determined that in-tunnel NOx levels can be estimated as a function of in-tunnel CO levels. MassDOT based this assumption on CO and NOx data collected in the Ted Williams tunnel (TWT) monitoring program. This program measured in-tunnel CO and NOx levels on a quarterly basis during 1997-1998 when only commercial traffic was permitted inside the TWT. MassDOT repeated the program in 2004 when the tunnel was open to general traffic use. An analysis of the measured levels and the derived relationship between the two pollutants (based on more than 20,000 hours of collected data) proved that there was a good correlation between the two pollutants and that data can predict NOx levels as a function of CO levels within the TWT.

The results of new TWT monitoring data collected during the summer of 2010 indicated that levels of both CO and NO_X were lower in 2010 than in 2004. This was most likely due to cleaner vehicles. As a result, the new 2010 data aggregated at levels closer to background (below 5 ppm for CO and 1 ppm for NOx). The extrapolation of these low monitored levels to determine emission limits near the 25 ppm CO level for DST and in the 50ppm to 70 ppm range for CO for all other ramps and ventilation buildings increases the uncertainty when using the OLM procedure. The use of data from the proposed NO_2-NO-NOx monitoring program could significantly reduce this uncertainty.

MassDOT believes that the previously used concept that NO converts completely to NO_2 due to the presence of O_3 is unrealistic at a short distance from the source. MassDOT anticipates that a more accurate conversion factor using the 2011 DST monitoring program will result in a different compliance modeling approach developed in consultation with MassDEP.

Therefore, MassDOT proposes to retain the 2006 CO and NOx emission limits for all exhaust points (VBs, DST, and longitudinally ventilated ramps) until the collection of data under the NO_2-NO-NOx monitoring program are analyzed. This analysis will help: 1) determine a more appropriate correlation between CO and NO_X at the DST; 2) improve the conversion of NO to NO_2 at the DST sidewalk receptors; and 3) determine the NOx dilution ratios from the portal to the same receptors.

VOC Limit:

The 2006 Operating Certificate established a regional emission budget for VOC based on the 2005 CA/T build predictions which included highway and transit projects completed by the Commonwealth as of the year 2005.

The results of the 2006 regional modeling analysis demonstrated that the CA/T Project resulted in a reduction of VOC within the Project affected area when compared to the No-Build condition for all regional scales analyzed. The regional analyses were conducted for three different scales: Eastern Massachusetts Regional Planning Area (EMRPA) 164 community boundary, the Metropolitan Planning Organization (MPO) 101 community boundary, and the CA/T Project area. The highest percentage reduction (13.6%) was for the CA/T Project area, and the lowest (10%) was for the EMRP area. The 2006 analysis established a VOC emission limit for the CA/T Build condition of 6,095.9 kg/day not to be exceeded in future years.

The new compliance demonstration calculated the 2010 VOC emissions for each area using the CTPS model area for Eastern Massachusetts including the highway, transit, and commuter rail components. The results are compared to the established 2005 VOC emissions budget to demonstrate compliance.

2.6 TECHNICAL APPROACH

The technical approach to determine emission limits follows the procedures established in the 2006 Operating Certification as provided in Appendices B1 and B2, which contain updated models, parameters, and procedures for the determination of $PM_{2.5}$ emission limits and for the VOC budget compliance analysis. The following sections briefly summarize the methodology employed.

2.6.1 Relevant Pollutants

The relevant vehicular pollutants for which emission limits are developed are those established in 310 CMR 7.38(2) along with the current updates recommended by MassDEP, namely CO, NO_x, $PM_{2.5}$, and VOC. This application proposes emission limits for $PM_{2.5}$ that will replace existing emission limits for PM_{10}.

2.6.2 Averaging Times for Emission Limits for CO, NO_x, and $PM_{2.5}$

The averaging times associated with the emission limits for CO, $PM_{2.5}$, and NO_x are determined by their respective NAAQS, and MassDEP NO_2 Policy Guideline Value as follows:

Duration	Pollutant	Emission Locations
1-hour and 8-hour	CO	VB exhaust plenum and longitudinally ventilated ramps
1-hour	NO_x	VB exhaust plenum and longitudinally ventilated ramps
24-hour	$PM_{2.5}$	VB exhaust plenum and ambient next to Ramp CS-SA

2.6.3 Predictive Model for NO_x Emission Estimates

The current emission limits for NO_x are retained in this application until the results of the ongoing NO_2-NO-NO_x one-year monitoring program can be analyzed. The results of this program will be used to develop a new methodology that reflects the actual conversion from NO to NO_2 over short distances. The approach used for the 2006 Operating Certification is retained in this document and is described below.

NO_x emission levels were estimated based on the monitored CO emission levels using the Project-specific regression model formulation, which correlates the monitored measurements of CO and NO_x. The statistical analysis performed as part of the 1997/98 and 2004 monitoring programs at the TWT indicated that there is a good correlation between the measured CO and NO_x data.

The 1997/98 TWT Emissions Monitoring Program measured CO, NO, NO_x, total hydrocarbons (THC), and PM_{10} for a two week period every quarter from December 1996 through December 1998 at four ventilation zones for VB7 and two ventilation zones for VB6. The results of more than 20,000 hourly values recorded indicated that there was a good correlation between measured levels of NO, NO_x, and CO. Correlation coefficients were between 0.5 and 0.82, and linear regression models were developed to predict in-tunnel NO and NO_x levels based on measured CO levels.

At the request of MassDEP, these regression models were refined by collecting additional data when I-90 opened for general public use to account for the difference in vehicle classification from the Early Opening Phase, and to represent the Full Opening traffic conditions.

During 2003, the MassDOT and MassDEP technical working group agreed that the CO/NO_x relationship (or regression model) was to be used for the prediction of NO_x levels for emission limit determination and for demonstration of compliance with the MassDEP one-hour NO_2 policy guideline (320 $\mu g/m^3$) as it relates to 310 CMR 7.38. The 2004 TWT monitoring program collected an additional two weeks of CO, NO_x and NO hourly data at all four ventilation zones of VB 7 every quarter (approximately 6,000 hours of measurements).

Since the 2004 monitoring data reflect that time TWT operating conditions (general traffic use and recent vehicle technology), the regression models based on the 2004 data were chosen to represent current full traffic conditions. Also, since the ambient O_3 levels are higher during the summer, the regression formula based on the 2004 summer data for NO_x predictions was chosen for the compliance demonstration.

The CO and NO_x data collected during August 9-25, 2004 are plotted in Figure 2-1. The equation developed from this data that was used in the modeling analysis and to estimate the hourly NO_x levels is:

$$NO_x = 0.196 + 0.124\ CO \qquad (1)$$

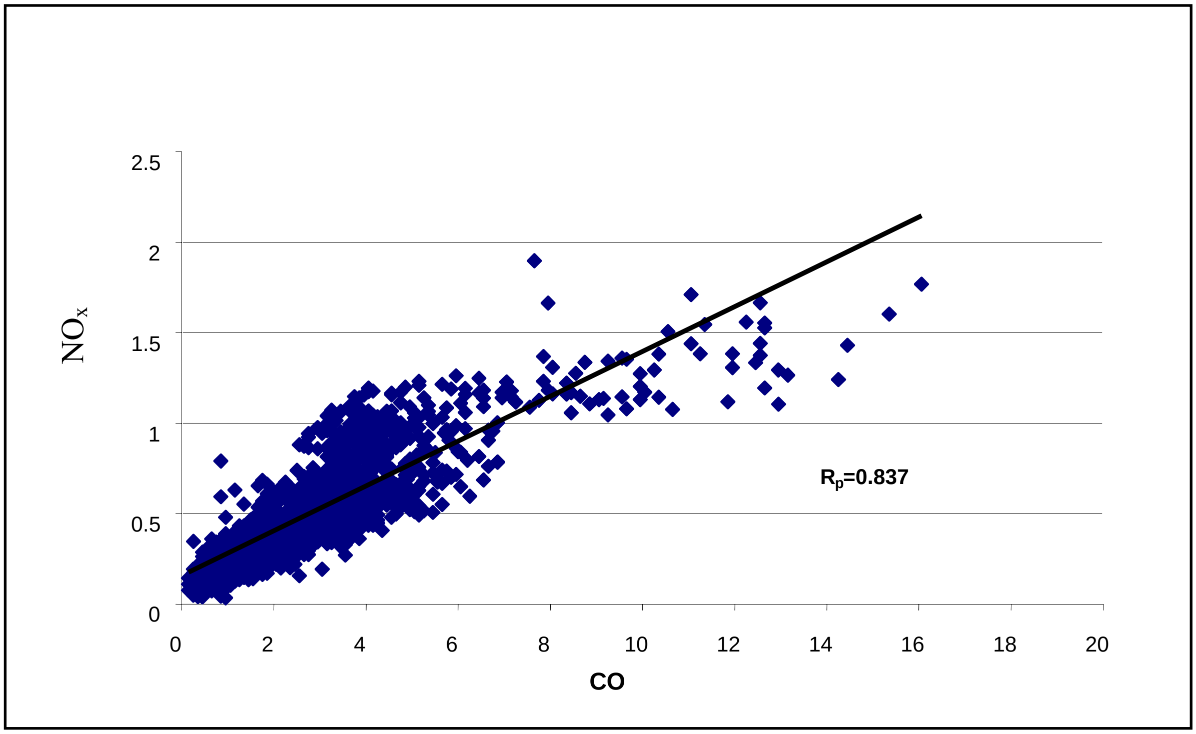
Table 2-2 presents the CO/NO_x relationship based on August 2004 measured data which were chosen to represent current conditions

TABLE 2-2: CO/NO_X RELATIONSHIP BASED ON AUGUST 2004 MEASURED DATA

CO	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	50.0	55.0	60.0	65.0	70.0
NO_x	1.44	2.06	2.68	3.30	3.92	4.54	5.16	5.78	6.40	7.02	7.64	8.26	8.88

The December 2004 report titled *CA/T Ted Williams Tunnel 2004 Carbon Monoxide – Nitrogen Oxides Monitoring Program* includes a full description of the data collection process and statistical analysis. The report was submitted to MassDEP on January 13, 2005; and MassDEP agreed to the use of the above equation for the compliance demonstration (MassDEP letter March 24, 2005).

FIGURE 2-1: CO/NO_X RELATIONSHIP BASED ON MONITORED LEVELS AT THE TED WILLIAMS TUNNEL (AUGUST 2004)



2.6.4 NO_x to NO_2 Conversion

Most of the NO_x emitted by vehicles is in the form of NO. Based on the TWT's monitoring results, the average NO component ranged from 83 to 93% of emitted NO_x. NO can convert to NO_2 through chemical reactions with oxidants, namely O_3, present in the atmosphere.

The amount of NO_2 present in the atmosphere within the areas impacted by the CA/T Project is a combination of three different sources of NO_2:

- NO_2 directly emitted from the vehicles and released into the atmosphere through the VB and the exit portals.
- NO_2 formed from the oxidation of NO that is emitted from the vehicles and released into the atmosphere through the VBs and the exit portals.
- NO_2 present as background in the atmosphere.

The OLM that was used assumes that the reaction of NO with O_3 is the predominant pathway for conversion of NO to NO_2. For the CA/T Project, an upper limit of 76% conversion of NO to NO_2 was established in the 1990 FSEIS/R analysis and has been subsequently used for all CA/T air quality modeling analyses for NO_2. In addition to the maximum 76% conversion of NO to NO_2, 5% of the vehicular NO_x is emitted directly as NO_2. Therefore, up to 81% of emitted NO_x for the CA/T may result in the form of NO_2.

The total amount of NO_2 estimated at each receptor location was calculated as follows:

For 0.81 $[NO_x] > [O_3]$, $[NO_2] = 0.05\ [NO_x] + [O_3] + [NO_2]$ background (2)

For 0.81 $[NO_x] < [O_3]$, $[NO_2] = 0.05\ [NO_x] + 0.76\ [NO_x] + [NO_2]$ background (3)

2.6.5 Representative Surface and Upper Air Meteorological Data

The 2006 demonstration used the then most recent available 5 years of surface observations collected at the Logan International Airport, Boston, Massachusetts. Data for the period 2000–2004 were used in the 2006 analysis along with concurrent upper air data collected at the National Weather Station in Portland, Maine. Due to proximity of these weather stations to the Project area, meteorological data collected at these locations offer the most regionally representative and readily available data base for the compliance demonstration study. These data were used for the CO and NO_x analyses.

The 2011 demonstration used the most recently available five years (2006–2010) of Automated Surface Observing System (ASOS) meteorological data collected at Boston Logan International Airport (BOS/KBOS) along with concurrent upper air data collected at the National Weather Station in Gray, Maine. These are the closest and most representative sources of meteorological data for the Project. These data were used for $PM_{2.5}$ analysis.

2.6.6 Attainment Status of Project Area

At the time of the 2006 application, the Boston area, inclusive of the CA/T Project, was designated as moderate nonattainment for the 8-hour NAAQS for O_3 and as attainment for PM_{10} and NO_2. In addition, since the Boston area had previously been classified as attainment for CO, it was considered a maintenance area for that pollutant.

The 8-hour O_3 standard was revised in 2008 to 0.075 ppm. In March 2009, Massachusetts recommended to EPA that the entire state be designated as nonattainment with the 2008 standard. The 2008 standard was challenged in Court and remanded to EPA. In January 2010, EPA proposed to revise the primary 8-hour O_3 standard to a level within the range of 0.060 to 0.070 ppm. EPA is now soliciting advice from the Clean Air Scientific Advisory Committee (CASAC) to finalize the new ozone standards.

The last violation in the state of the CO NAAQS occurred in 1986. In 2000, MassDEP formally requested that the EPA re-designate the cities of Lowell, Springfield, Waltham, and Worcester as attainment for CO since the CO monitoring data for those cities had been below the standard for many years. With the re-designation of these cities to CO attainment in April 2002, the entire state has remained in attainment ever since.

In December 2008, EPA designated Massachusetts as “Attainment/Unclassifiable” statewide for the 2006 24-hour $PM_{2.5}$ standards statewide based on monitoring data.

2.6.7 Background Concentration Levels

Background pollutant concentrations used in the 2006 application were obtained from several MassDEP air quality monitoring stations in the Boston area. Hourly measurements, or the highest recorded levels were used depending on the types of analyses.

For the longitudinal ventilation analysis, CO background levels were determined from the hourly measurements during the years 2000 to 2004 at the Mass DEP Roxbury monitor on Harrison Avenue. For the full transverse ventilation analysis, highest second-highest one-hour and eight-hour average concentrations from the latest three years were selected as shown in Table 2-3. CO background levels of

[4.0 ppm] and 2.4 ppm for one-hour and eight-hour averaging periods, respectively, were used in the modeling.

TABLE 2-3: CO LEVELS AT ROXBURY MONITORING STATION

Year	One Hour Concentration (ppm)	Eight Hour Concentration (ppm)
2002	2.6	1.8
2003	4.0	2.4
2004	2.8	1.5
Selected	4.0	2.4

The NO_2 background concentrations for compliance with the Mass DEP Guidance level were comprised of hourly data collected in 2000 at the Mass DEP Bremen Street monitor in East Boston and hourly data collected in 2001 to 2004 at the Mass DEP Roxbury monitor on Harrison Avenue. Monitoring of NO_2 at Bremen Street was discontinued by Mass DEP in 2001. The required concurrent five years of hourly O_3 data were collected at the Harrison Avenue Mass DEP monitoring station. The annual NO_2 background concentration was the highest of the latest three year annual averages as presented in Table 2-4.

TABLE 2-4: NO_2 ANNUAL LEVELS AT ROXBURY MONITORING STATION

Year	Annual Average Concentration
2002	0.0241
2003	0.0230
2004	0.0170
Summary	0.0241

The background $PM_{2.5}$ data from the two collocated $PM_{2.5}$ monitors at the North Street monitoring site served as the primary source of data for determining background air quality. The $PM_{2.5}$ data from North Street are relatively complete in recent years. There were only a small number of days (5 or less) in any year in the period (2006 – 2010) for which no valid data from North Street were available (see Table 2-5).

TABLE 2-5: DAYS WITH VALID PM2.5 CONCENTRATIONS AT NORTH STREET MONITORING SITE

Year	POC-1	POC-2	POC-1 or POC-2
2010	361	349	361
2009	360	342	360
2008	366	353	366
2007	365	343	365
2006	359	294	361
Notes: 1. POC = Parameter Occurrence Code 2. POC-1 refers to the designated primary PM2.5 monitor. 3. POC-2 refers to the collocated PM2.5 monitor.			

An annual monitoring design value for $PM_{2.5}$ was determined based on monitoring data from the North Street monitoring site for the most recent three calendar years (2008 through 2010) as follows:

- If valid data were available from both North Street monitors on a given day, then the daily averages at each monitor were averaged to obtain a background value for the day.
- If valid data were available from only one of the North Street monitors on a given day, then the valid data from that monitor were used to define a background value for the day.
- The annual average concentration was calculated for each year based on days with valid data.
- The annual average concentrations in each of the three years in the period were averaged to define the annual monitoring design value.

The annual background concentrations are summarized in Table 2-6. The average of the annual average concentrations over the last three years (10.5 µg/m3) was selected as the annual monitoring design value and incorporated in the compliance demonstration for the annual NAAQS for $PM_{2.5}$.

TABLE 2-6: ANNUAL $PM_{2.5}$ LEVELS AT NORTH END MONITORING STATION (MG/M^3)

Year	Annual Average $PM_{2.5}$ (µg/m^3)
2010	10.1
2009	10.3
2008	11.1
(2008 – 2010) Design Value	10.5

Daily background concentrations for $PM_{2.5}$ were defined for each day in the five-year period (2006 – 2010) that was used for the compliance demonstration with the 24-hour NAAQS for $PM_{2.5}$. The following procedure was used to define background air quality for each day in the five year period:

- If valid data were available from both North Street monitors on a given day, then the daily averages at each monitor were averaged to obtain a background value for the day.
- If valid data were available from only one of the North Street monitors on a given day, then the valid data from that monitor were used to define a background value for the day.
- If no valid data were available from North Street monitors on a given day, the 24-hour average from the Harrison Avenue monitor was used if available.
- If no valid data were available from North Street or Harrison Avenue monitors for a given day, then the higher of the two background values already selected for the prior and following days was selected.

2.6.8 Volatile Organic Compounds (VOC)

Since there are no NAAQS for VOC, concentration-based emission limits for VOC cannot be, and were not established for comparison with measurements at specific receptor locations. As such, direct measurement of VOC without a benchmark level to guide the operation of the ventilation system will not contribute to the protection of the health and welfare of the affected population. Monitoring VOC also will not resolve the aspect of how the total amount of VOC generated within the Project area can be compared to the no-build alternative.

Therefore, the following procedure to address the VOC requirements of 310 CMR 7.38 (4) and (2)(c) was developed by the MassDOT-MassDEP air quality working group and accepted by MassDEP on July 30, 2002.

- Prepare an updated emission estimate, which compares the total amount of VOC generated by motor vehicle activity within the Project area for two scenarios including the full operation of the CA/T Project (post opening – year 2005) and a No-Build condition for the same year 2005.
- Establish an emission budget for the Project study area based on the results of the VOC evaluation for year 2005.
- Verify that 2010 total VOC emissions for the study area are below the established emission budget. (2005 Build)

This process was established in the 2006 TSD application. This 2011 application compares regional VOC emissions from current 2010 traffic and vehicle emission factors (instead of future projections) to the 2005 VOC emission budget determined in the 2006 application. Therefore, this process provides a more realistic estimate of the area wide effects of the CA/T Project, including all the transit commitments that form part of the Operating Certification process.

2.7 EMISSION LIMIT DETERMINATION

In 2010, peak hour traffic volumes in vehicles per hour (VPH) using the mainline tunnels were generally in the range of 6,800 to 8,000 VPH in each direction of I-93 and in the range of 2,900 to 3,600 VPH in each direction of the TWT. The average daily volumes were in the range of 80,000 to 107,000 vehicles per day (VPD) in each direction of I-93 and in the range of 32,000 to 50,000 VPD in each direction of the TWT. The tunnel full transverse ventilation system was operating at Step 1 (13% of exhaust capacity) for normal peak and off-peak traffic conditions.

The 2006-2011 data presented in a summary form (Tables 5-1 to 5-14) indicate the following:

- Measured CO concentrations for the Ventilation Buildings range from 1.0 to 3.0 ppm on average, with maximum 1-hour values as high as 34 ppm;
- Measured concentrations for the DST and Ramps range from 1.0 to 4.0 ppm on average, with maximum 1-hour average concentrations ranging from 4.0 to 68.7 ppm;
- Measured NO_x levels for the Ventilation Buildings range from 0.3 to 0.6 ppm on average, with maximum 1-hour values ranging from 1.0 to 2.2 ppm;
- Measured NO_x levels for the DST and Ramps range from 0.3 to 0.75 ppm on average, with maximum 1-hour values ranging from 1 to 8.8 ppm;
- Measured PM_{10} concentrations were between 31 and 121 $\mu g/m^3$ on average, with maximum daily values ranging from 100 to 577 $\mu g/m^3$.
- The PM_{10} monitor outside Ramp CS-SA, which measures ambient levels, recorded annual averages from 19 to 21 $\mu g/m^3$, and a maximum daily level of 116 $\mu g/m^3$.

The maximum hourly allowable emission limits (in ppm) for the VBs, DST and the specified exit ramps were determined using an iterative modeling process by increasing or decreasing the exhaust concentration in a prescribed interval.

2.7.1 For Full Transverse Ventilation—Ventilation Buildings

2.7.1.1 Determination of Ventilation Building Emission Impacts

The VB emission impacts were evaluated using analytical models. The maximum predicted emission impacts, when added to the appropriate background pollutant concentrations were compared to the applicable ambient air quality standards or policy guideline value for compliance assessment. The entire modeling process was repeated until the maximum allowable emission limits at which ambient standards can still be attained were found. The detailed modeling procedures to determine VB emission impacts and emission limits can be found in Appendices B1 and B2 of this document.

2.7.1.2 Modeling Methodology

The modeling approach to the CO and NO_x limit determination was retained from the 2006 CA/T Project Operating Certification. The modeling approach to the $PM_{2.5}$ limit determination was updated to incorporate current models, modeling guidance, treatment of terrain, and more recent meteorological and background data. The 2006 VB emission impact analysis was performed using the EPA's Industrial Source Complex–Prime Model (ISC-Prime, 2004) in conjunction with the then most recent background air quality data collected in the area and five years of representative hourly meteorological data (see Section 2.6.7). Sensitive receptors such as building air intakes, operable windows, pedestrian walkways and potential receptors on proposed redevelopment projects within 2000 feet of each VB were updated to reflect the existing environment and future commercial development projection.

As discussed in Section 1, there are 22 ventilation zones in the CA/T ventilation system. In general each of these ventilation zones is equipped with more than one exhaust stack and each stack is dedicated to serving one exhaust fan. Fan speeds are controlled by 8 set point steps.

In the modeling, all stacks serving one ventilation zone are grouped together and treated as an individual emission point. The physical center of the stacks serving the same ventilation zone is treated as the center of the source in the modeling runs. The total stack exit area is used in calculation of the equivalent stack diameter. The total flow rate is divided by the total stack exit area to obtain the equivalent stack exit velocity. A spectrum of four ventilation scenarios (based on fan steps 2, 3, 4 and 5) were selected to be modeled.

The highest predicted pollutant concentration was added to the appropriate background level to estimate their combined impact and to compare to the applicable short or long-term air quality standard.

The 2011 $PM_{2.5}$ ventilation building analysis was performed using AERMOD, the currently recommended EPA air quality model. AERMOD is recommended for analyses where building downwash may be an important consideration. AERMET, AERMAP and the Building Profile Input Program for PRIME (BPIPPRM) were used to process meteorological and terrain information and information relating to building dimensions. A new meteorological preprocessor (AERMINUTE) that provides some supplemental information for AERMET, was also applied. These associated preprocessors are discussed in Appendix B2. AERMOD was run in the urban mode using recommended regulatory default options.

The 2006 analysis initially considered four ventilation scenarios (based on fan steps listed in Table 2-7). Since emission rates increase linearly with the increase in the exhaust flow rate and ventilation rates at step 5 or above would only occur in cases of emergency (fire or smoke dissipation), the VB analysis for the 2011 Operating Certification was based on step 4 fan speeds, the highest ventilation rate under the normal operations, which corresponds to 42% of ventilation capacity. Step 1 of the tunnel ventilation system, corresponding to the 13% of exhaust capacity, was also selected for modeling in order to analyze the low ventilation flows under the normal peak and off-peak traffic conditions.

At each receptor location, an average of the 8^{th} highest 24-hour concentrations including the corresponding background concentration for that day for the five modeled years was compared to the 24-hour NAAQS for $PM_{2.5}$. The annual average project impact at each receptor over five modeled years with addition of the annual background concentration based on the most recent three years of monitoring data was compared to the annual NAAQS for $PM_{2.5}$.

TABLE 2-7: VENTILATION BUILDING OPERATING SCENARIOS

Scenario	Zone Step 1	Zone Step 2	Zone Step 3	Zone Step 4	Zone Step 5
Ventilation Rate (% of total exhaust capacity)	13	23	32	42	52

2.7.1.3 Emission Limits Determination Methodology

The maximum hourly allowable emission limits (in ppm) for all VBs are identified using an iterative modeling process by increasing or decreasing the exhaust concentration in a specified interval.

To facilitate the selection of an initial exhaust concentration level to begin the iterative process, computer test runs were made to compare the resulting impacts of different ventilation scenarios (i.e., at fan steps 1, 2, 3 and 4). Modeling results indicate that for a given exhaust concentration level the higher the exhaust rate becomes, the worst the impact gets. Therefore, the worse impact would be associated with the highest ventilation scenario.

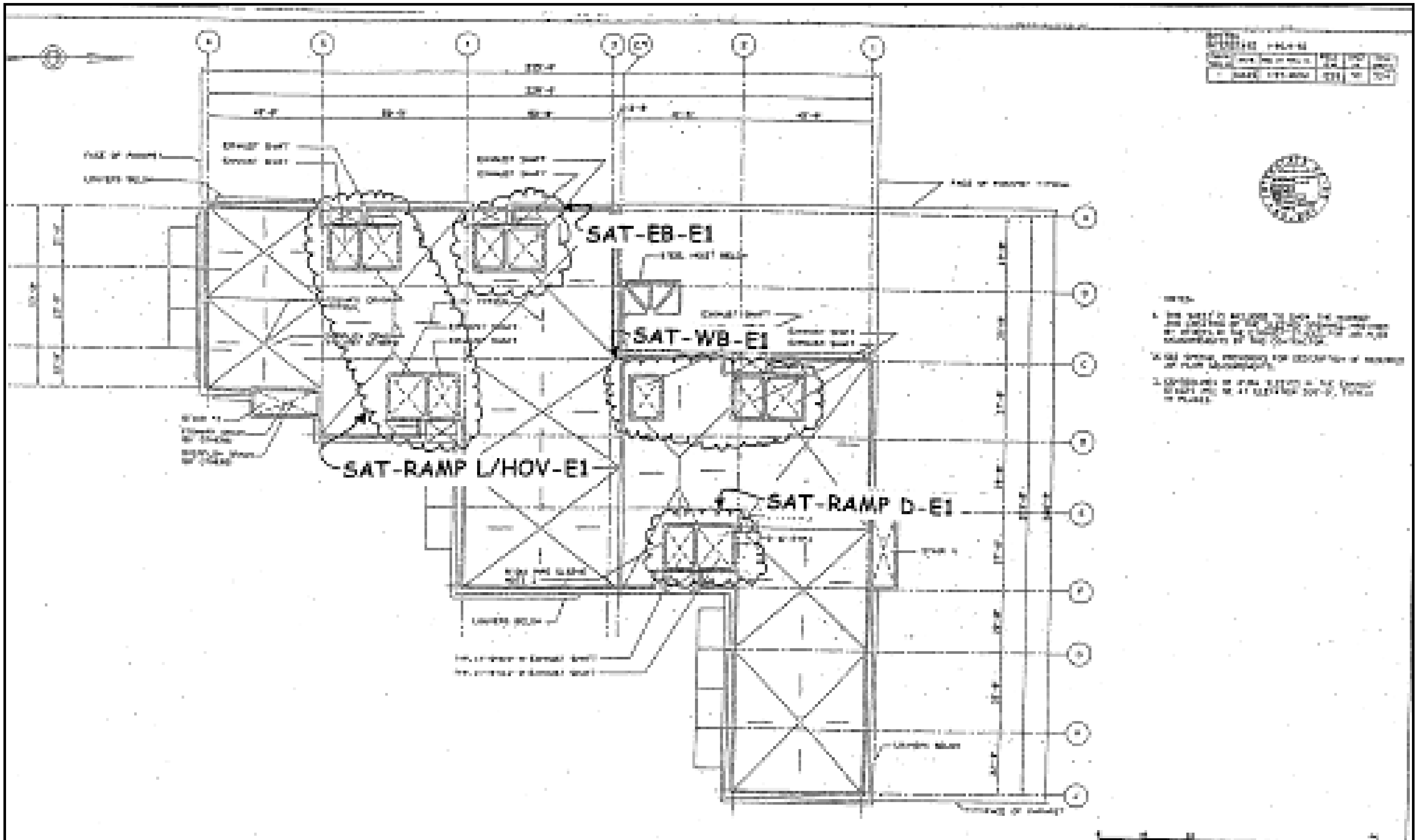
Initially a spectrum of four ventilation scenarios (based on fan steps 2, 3, 4 and 5) were selected to be modeled. Based on past CA/T Project-specific operating experience, operating the tunnel at in-tunnel CO level of 70 ppm in combination with fan speed at Step 5 is a very unlikely event. Therefore, a detailed impact assessment associated with such an operating scenario was not considered.

The 2006 model input data, including emission rates, exhaust flow rates, exhaust temperature, and number of fans by ventilation zone are presented in Table 2-8. The 2011 model input data are in Tables 2-13 and 2-14. The stack locations and configurations for all VBs are shown on Figures 2-2 through 2-7. Representative stack locations and sensitive receptors used in the 2006 modeling analysis are presented in Appendix C1, "Air Quality Impact Analysis Input Data" (Tables C-3 through C-8) for each VB. The 2011 modeling analysis input and output data are in Appendix C2. Background levels used in this analysis are described in Section 2.6.7.

2006 CO Analysis

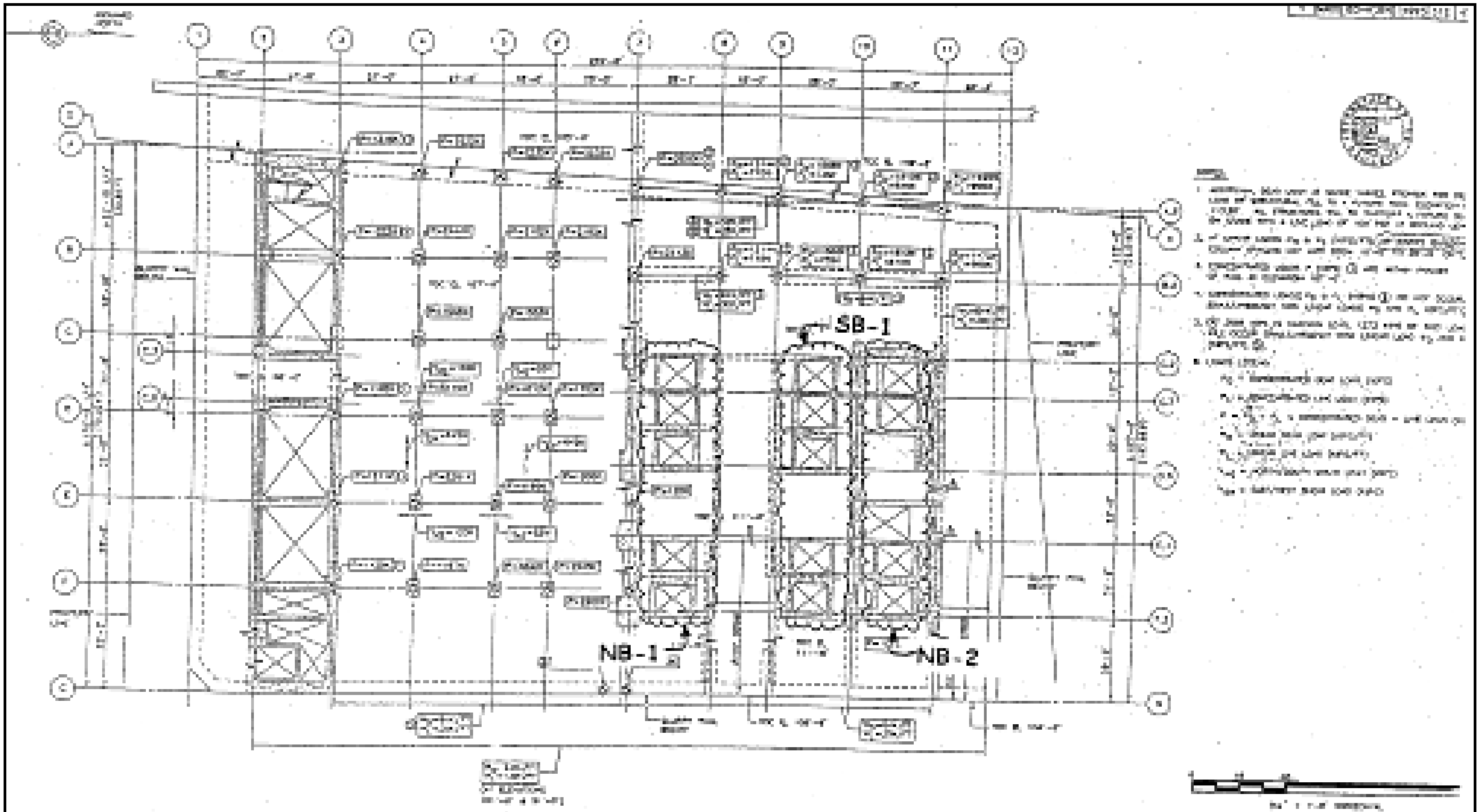
The exhaust CO concentration at each emission point was set at a much higher level (70 ppm) than the current tunnel operating conditions (20–30 ppm) to facilitate the identification of the maximum hourly allowable emission limits. This hypothetical high in-tunnel CO concentration in combination with the proposed Fan Step 4, formed the basis for the initial compliance test case. Results of the analysis for all VBs, as reported in Tables 2-9 and 2-10, indicate that the maximum combined impacts at receptor locations resulting from operation of each of the VBs are less than 60% of the NAAQS for CO. It is worth noting that the predictions for both the 1-hour and 8-hour averaged CO levels at all receptors were based on the selected hourly emission level of 70 ppm.

FIGURE 2-2: STACK CONFIGURATION VENTILATION BUILDING 1



VB #1 Roof Plan

FIGURE 2-3: STACK CONFIGURATION VENTILATION BUILDING 3



VB #3 Roof Plan

FIGURE 2-4: STACK CONFIGURATION VENTILATION BUILDING 4

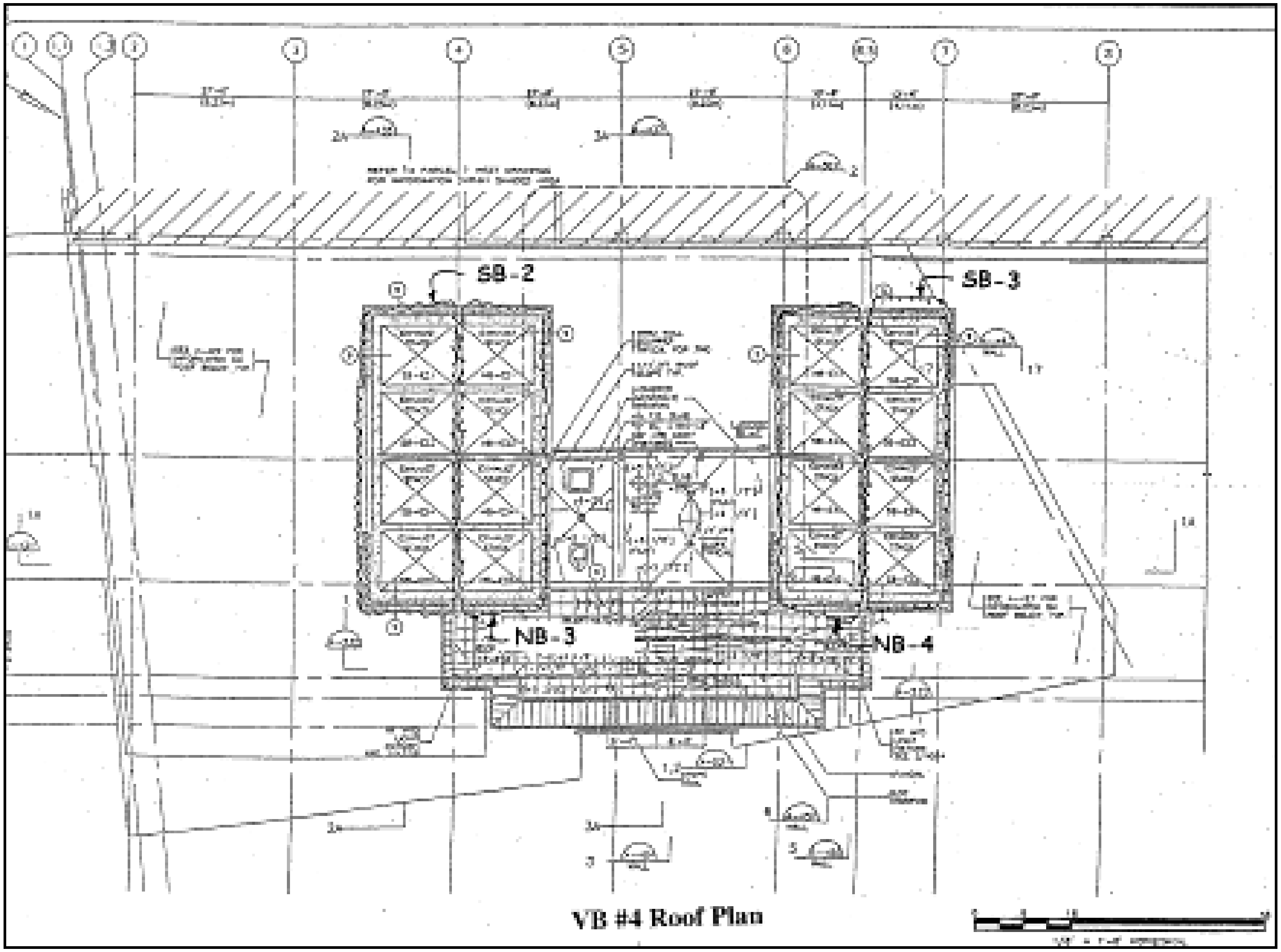
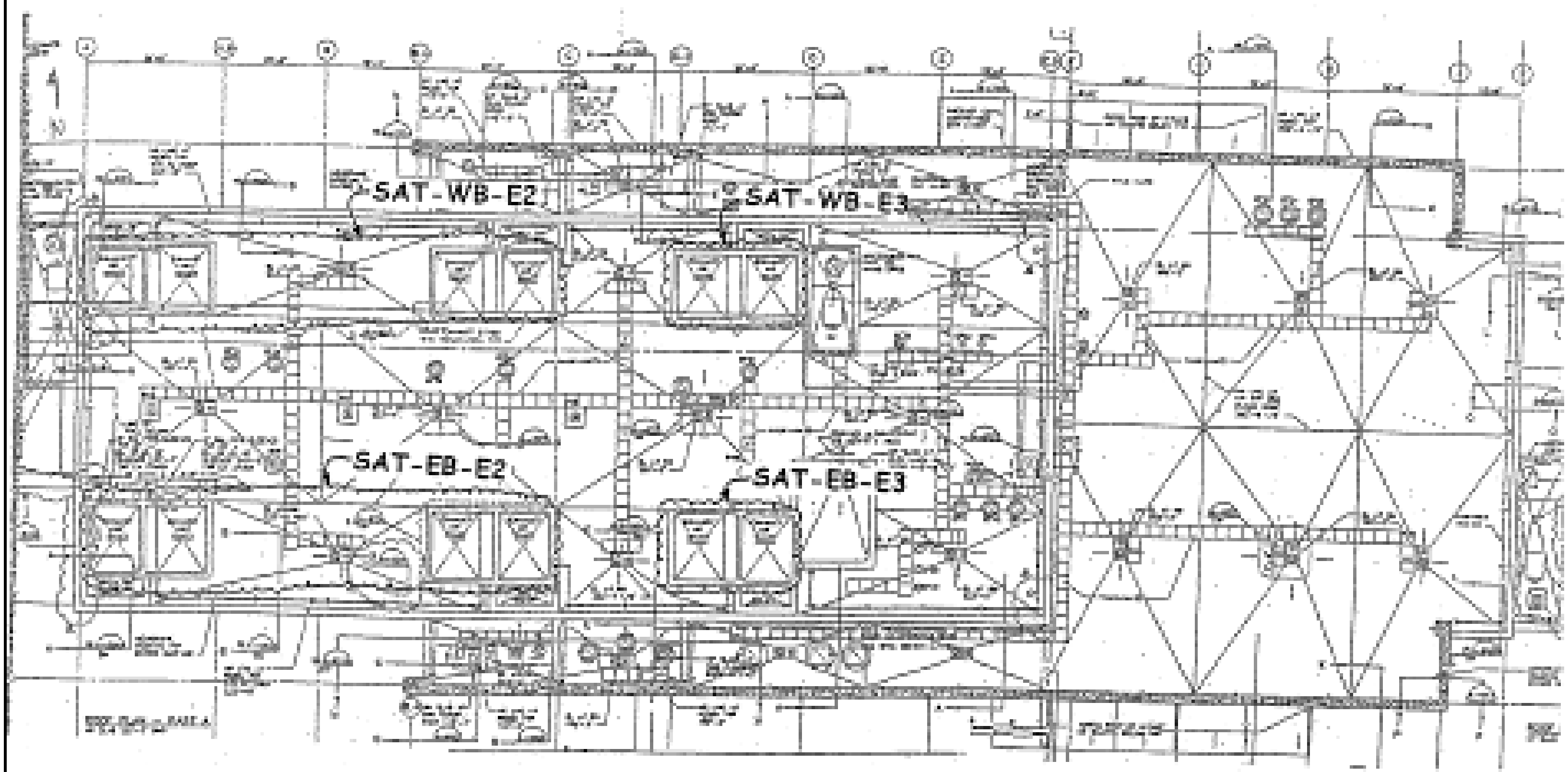
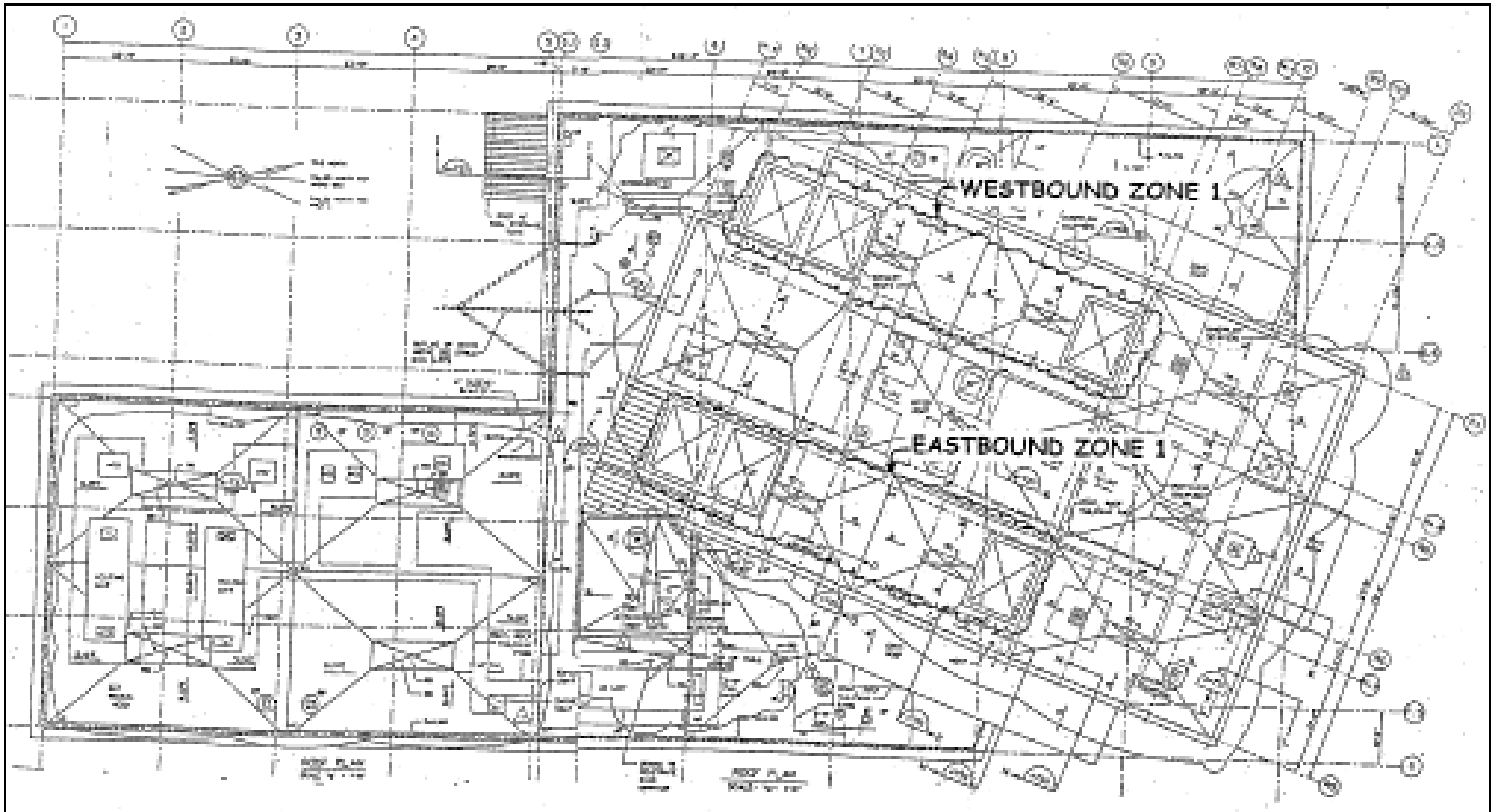


FIGURE 2-5: STACK CONFIGURATION VENTILATION BUILDING 5



VB #5 Roof Plan

FIGURE 2-6: STACK CONFIGURATION VENTILATION BUILDING 6



VB #6 Roof Plan

FIGURE 2-7: STACK CONFIGURATION VENTILATION BUILDING 7

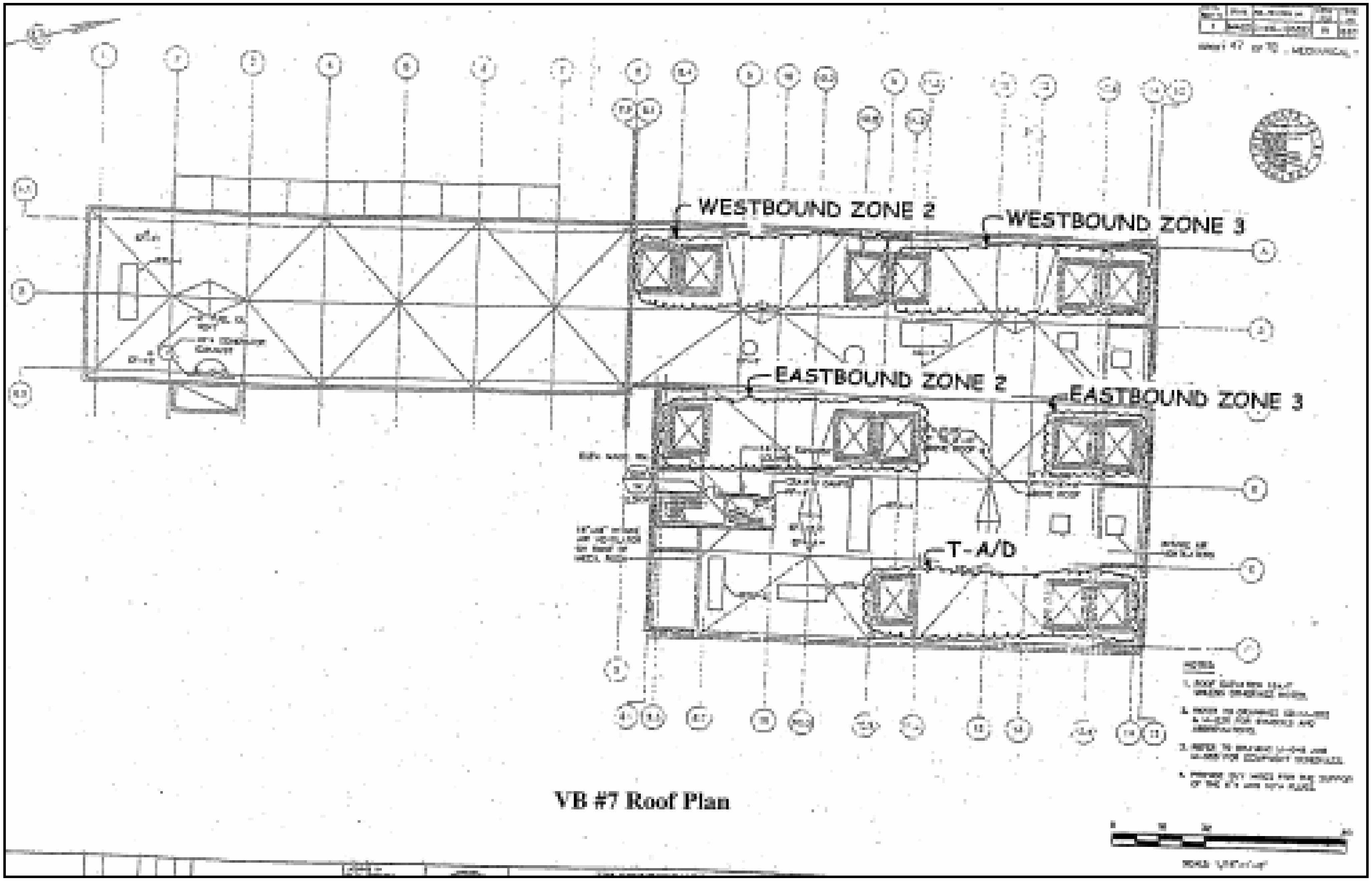


TABLE 2-8: MODEL INPUT PARAMETERS FOR VENTILATION BUILDINGS

Vent Building 3 (I-93 Tunnel) Temperature 70 °F Assumed ISC Input 1 ppm of NOx = 1259.72 ug/m3

Vent Bldg	Zone	# of Fans	Capacity/ Fan (CFM)	Exhaust Capacity (CFM)	Step Used	% Capacity Used	Flow Rate (CFM)	PPM CO	Molecular Weigt CO	CO Density (lb/ft^3)	CFM CO	Total Mass Flow CO (g/sec)	Mass Flow CO/Stack (g/sec)	Area of a single cell (ft²)	Total Exit Area (ft²)	Exit Vel. (m/s)	Equ. Dia. (m)	NOx Conc. (ppm)*	NOx Molecular Wt**	NOx Conc. (ug/m3)	NOx Emis. (g/s)
3	SB-1	5	214000	1070000	4	0.42	449400	70	28	0.07238	31.46	17.21	3.44	106.6	533	4.28	7.94	8.876	30.8	11181.3	2.37
3	NB-1	5	251630	1258150	4	0.42	528423	70	28	0.07238	36.99	20.24	4.05	106.6	533	5.04	7.94	8.876	30.8	11181.3	2.79
3	NB-2	4	284750	1139000	4	0.42	478380	70	28	0.07238	33.49	18.32	4.58	106.6	426.4	5.70	7.10	8.876	30.8	11181.3	2.52

Vent Building 4

Vent Bldg	Zone	# of Fans	Capacity/ Fan (CFM)	Exhaust Capacity (CFM)	Step Used	% Capacity Used	Flow Rate (CFM)	PPM CO	Molecular Weigt CO	CO Density (lb/ft^3)	CFM CO	Total Mass Flow CO (g/sec)	Mass Flow CO/Stack (g/sec)	Area of a single cell (ft²)	Total Exit Area (ft²)	Exit Vel. (m/s)	Equ. Dia. (m)	NOx Conc. (ppm)*	NOx Molecular Wt**	NOx Conc. (ug/m3)	NOx Emis. (g/s)
4	SB-2	4	237250	949000	4	0.42	398580	70	28	0.07238	27.90	15.27	3.82	106.6	426.4	4.75	7.10	8.876	30.8	11181.3	2.10
4	SB-3	4	282625	1130500	4	0.42	474810	70	28	0.07238	33.24	18.19	4.55	106.6	426.4	5.66	7.10	8.876	30.8	11181.3	2.50
4	NB-3	4	221250	885000	4	0.42	371700	70	28	0.07238	26.02	14.24	3.56	106.6	426.4	4.43	7.10	8.876	30.8	11181.3	1.96
4	NB-4	4	202250	809000	4	0.42	339780	70	28	0.07238	23.78	13.01	3.25	106.6	426.4	4.05	7.10	8.876	30.8	11181.3	1.79

Vent Building 1 (I-90 Tunnel)

Vent Bldg	Zone	# of Fans	Capacity/ Fan (CFM)	Exhaust Capacity (CFM)	Step Used	% Capacity Used	Flow Rate (CFM)	PPM CO	Molecular Weigt CO	CO Density (lb/ft^3)	CFM CO	Total Mass Flow CO (g/sec)	Mass Flow CO/Stack (g/sec)	Area of a single cell (ft²)	Total Exit Area (ft²)	Exit Vel. (m/s)	Equ. Dia. (m)	NOx Conc. (ppm)*	NOx Molecular Wt**	NOx Conc. (ug/m3)	NOx Emis. (g/s)
1	SAT-Ramp D-E1	2	171500	343000	4	0.42	144060	70	28	0.07238	10.08	5.52	2.76	106.6	213.2	3.43	5.02	8.876	30.8	11181.3	0.76
1	SAT-WB-E1	3	230400	691200	4	0.42	290304	70	28	0.07238	20.32	11.12	3.71	106.6	319.8	4.61	6.15	8.876	30.8	11181.3	1.53
1	SAT-EB-E1	2	281820	563640	4	0.42	236729	70	28	0.07238	16.57	9.07	4.53	106.6	213.2	5.64	5.02	8.876	30.8	11181.3	1.25
1	SAT-Ramp L/HOV-E1	4	235250	941000	4	0.42	395220	70	28	0.07238	27.67	15.14	3.78	106.6	426.4	4.71	7.10	8.876	30.8	11181.3	2.08

Vent Building 5

Vent Bldg	Zone	# of Fans	Capacity/ Fan (CFM)	Exhaust Capacity (CFM)	Step Used	% Capacity Used	Flow Rate (CFM)	PPM CO	Molecular Weigt CO	CO Density (lb/ft^3)	CFM CO	Total Mass Flow CO (g/sec)	Mass Flow CO/Stack (g/sec)	Area of a single cell (ft²)	Total Exit Area (ft²)	Exit Vel. (m/s)	Equ. Dia. (m)	NOx Conc. (ppm)*	NOx Molecular Wt**	NOx Conc. (ug/m3)	NOx Emis. (g/s)
5	SAT-WB-E2	4	260000	1040000	4	0.42	436800	70	28	0.07238	30.58	16.73	4.18	106.6	426.4	5.20	7.10	8.876	30.8	11181.3	2.30
5	SAT-WB-E3	2	196500	393000	4	0.42	165060	70	28	0.07238	11.55	6.32	3.16	106.6	213.2	3.93	5.02	8.876	30.8	11181.3	0.87
5	SAT-EB-E2	4	278000	1112000	4	0.42	467040	70	28	0.07238	32.69	17.89	4.47	106.6	426.4	5.56	7.10	8.876	30.8	11181.3	2.46
5	SAT-EB-E3	2	279000	558000	4	0.42	234360	70	28	0.07238	16.41	8.98	4.49	106.6	213.2	5.58	5.02	8.876	30.8	11181.3	1.24

Vent Building 6 (Ted Wiliam Tunnel)

Vent Bldg	Zone	# of Fans	Capacity/ Fan (CFM)	Exhaust Capacity (CFM)	Step Used	% Capacity Used	Flow Rate (CFM)	PPM CO	Molecular Weigt CO	CO Density (lb/ft^3)	CFM CO	Total Mass Flow CO (g/sec)	Mass Flow CO/Stack (g/sec)	Area of a single cell (ft²)	Total Exit Area (ft²)	Exit Vel. (m/s)	Equ. Dia. (m)	NOx Conc. (ppm)*	NOx Molecular Wt**	NOx Conc. (ug/m3)	NOx Emis. (g/s)
6	Eastbound Zone 1	3	300000	900000	4	0.42	378000	70	28	0.07238	26.46	14.48	4.83	106.6	319.8	6.00	6.15	8.876	30.8	11181.3	1.99
6	Westbound Zone 1	3	300000	900000	4	0.42	378000	70	28	0.07238	26.46	14.48	4.83	106.6	319.8	6.00	6.15	8.876	30.8	11181.3	1.99

Vent Building 7

Vent Bldg	Zone	# of Fans	Capacity/ Fan (CFM)	Exhaust Capacity (CFM)	Step Used	% Capacity Used	Flow Rate (CFM)	PPM CO	Molecular Weigt CO	CO Density (lb/ft^3)	CFM CO	Total Mass Flow CO (g/sec)	Mass Flow CO/Stack (g/sec)	Area of a single cell (ft²)	Total Exit Area (ft²)	Exit Vel. (m/s)	Equ. Dia. (m)	NOx Conc. (ppm)*	NOx Molecular Wt**	NOx Conc. (ug/m3)	NOx Emis. (g/s)
7	Eastbound Zone 2	3	274000	822000	4	0.42	345240	70	28	0.07238	24.17	13.22	4.41	106.6	319.8	5.48	6.15	8.876	30.8	11181.3	1.82
7	Westbound Zone 2	3	231000	693000	4	0.42	291060	70	28	0.07238	20.37	11.15	3.72	106.6	319.8	4.62	6.15	8.876	30.8	11181.3	1.54
7	Eastbound Zone 3	2	226000	452000	4	0.42	189840	70	28	0.07238	13.29	7.27	3.64	106.6	213.2	4.52	5.02	8.876	30.8	11181.3	1.00
7	Westbound Zone 3	3	203000	609000	4	0.42	255780	70	28	0.07238	17.90	9.80	3.27	106.6	319.8	4.06	6.15	8.876	30.8	11181.3	1.35
7	T-A/D	3	194333	583000	4	0.42	244860	70	28	0.07238	17.14	9.38	3.13	106.6	319.8	3.89	6.15	8.876	30.8	11181.3	1.29

Notes:

1. Assumes all fans in a given zone are operating simultaneously.
2. Higher bound assumed conditions represent 70 ppm CO and Step 4 (a high ventilation rate for modeling purpose).

* NOx (ppm) = 0.196 + 0.124CO (ppm)

** NO_x molecular weight assumed for 95% NO and 5% NO_2

TABLE 2-9: MAXIMUM 1-HOUR CO CONCENTRATIONS FROM VENTILATION BUILDINGS AT AMBIENT RECEPTORS FOR COMPLIANCE DEMONSTRATION (PPM)

VB	Year					Highest Concentration
	2000	2001	2002	2003	2004	
VB 1	8.9	9.6	9.8	9.4	8.6	9.8
VB 3	11.6	14.5	9.9	13.6	13.9	14.5
VB 4	8.0	7.8	7.7	8.3	7.4	8.3
VB 5	6.5	6.7	6.4	6.5	6.6	6.7
VB 6	5.1	5.1	5.1	5.1	5.1	5.1
VB 7	7.6	7.6	7.6	7.8	7.6	7.8

Note: One hour CO NAAQS is 35 ppm; source strength is 70 ppm.

TABLE 2-10: MAXIMUM 8-HOUR CO CONCENTRATIONS FROM VENTILATION BUILDINGS AT AMBIENT RECEPTORS FOR COMPLIANCE DEMONSTRATION (PPM)

VB	Year					Highest Concentration
	2000	2001	2002	2003	2004	
VB 1	4.3	4.8	4.0	4.4	4.1	4.8
VB 3	4.0	5.1	3.6	4.8	4.0	5.1
VB 4	4..0	3.9	3.7	4.1	3.9	4.1
VB 5	3.9	3.9	4.0	4.0	3.9	4.0
VB 6	3.3	3.3	3.3	3.3	3.4	3.4
VB 7	4.7	4.5	4.5	4.8	4.5	4.8

Note: Eight hour CO NAAQS is 9 ppm; source strength is 70 ppm.

Based on these modeling results, no further CO impact analysis iterations were performed.

2006 NO_2 Analysis

The NO_2 in-tunnel concentration was estimated using the Project-specific regression model as follows:

$$NO_x = 0.196 + 0.124\ CO$$

For CO at 70 ppm, the equivalent in-tunnel NO_x concentration would be 8.88 ppm.

By following the similar modeling process used in the CO analysis, the NO_x concentration levels contributed by the VBs at all receptors were calculated using the ISC model. To demonstrate air quality compliance, these NO_x concentration levels were converted into NO_2 because the applicable ambient air quality standard and the MassDEP Policy Guideline Value are set for NO_2, not NO_x.

Since most of the NO_x emitted by vehicles is mostly in the form of NO and the reaction of NO with O_3 is the predominant pathway for conversion of NO to NO_2, the final calculation of NO_2 was carried out by applying the Ozone Limiting Method (OLM). The resultant hourly NO_2 concentrations derived from the OLM are summarized in Table 2-11. As shown in the table, the maximum hourly NO_2 concentration of 0.16 ppm (296.6 $\mu g/m^3$), which is the highest among all VBs was predicted for VB7. This maximum concentration is below the MassDEP Policy Guideline value of 320 $\mu g/m^3$ (or 0.17ppm) for NO_2.

TABLE 2-11: MAXIMUM 1-HOUR NO_2 CONCENTRATIONS FROM VENTILATION BUILDINGS AT AMBIENT RECEPTORS FOR COMPLIANCE DEMONSTRATION (PPM)

VB	Parameter	Year					Highest Concentration
		2000	2001	2002	2003	2004	
VB 1	NO_2 (Bckgr)	0.017	0.022	0.036	0.025	0.021	
	NO_2 (Receptor)	0.115	0.122	0.094	0.127	0.114	0.127
VB 3	NO_2 (Bckgr)	0.076	0.037	0.025	0.036	0.032	
	NO_2 (Receptor)	0.106	0.125	0.122	0.099	0.095	0.125
VB 4	NO_2 (Bckgr)	0.052	0.029	0.014	0.025	0.021	
	NO_2 (Receptor)	0.102	0.110	0.120	0.127	0.109	0.127
VB 5	NO_2 (Bckgr)	0.031	0.039	0.027	0.028	0.017	
	NO_2 (Receptor)	0.106	0.129	0.131	0.119	0.109	0.131
VB 6	NO_2 (Bckgr)	---	0.032	0.037	0.023	0.016	
	NO_2 (Receptor)	0.093	0.127	0.141	0.132	0.110	0.141
VB 7	NO_2 (Bckgr)	0.017	0.039	0.037	0.024	0.015	
	NO_2 (Receptor)	0.117	0.130	0.158	0.133	0.128	0.158

Notes: MassDEP NO_2 one hour Guideline is 320 µg/m^3 or 0.17 ppm.
All receptor concentrations include background levels.

For compliance demonstration with the NO_2 annual NAAQS, a realistic annual average NO_x emission rate was used instead of the maximum hourly NO_x emission rate to determine the air quality impacts. The reduction factor for adjusting the maximum hourly emission rate to an annual average value was derived from five months of CO measurements made inside the DST along the I-93 Mainline and the I-90 Collector during 2005 in conjunction with the use of the Project-specific regression formulation that calculates NO_x based on the CO measurements. Analysis of the CO monitoring data indicated that the ratio of the 5-month average hourly value to the highest recorded hourly CO value is 0.23. The corresponding reduction factor for NO_x was calculated to be 0.25. Finally, a conservative conversion factor of 75% on an annual basis was further applied to the annual NO_x results for converting NO_x to NO_2 as suggested by the EPA (EPA-450/2-78-027R).

Results of the maximum annual NO_2 impacts for all VBs are summarized in Table 2-12. The maximum predicted annual NO_2 concentration, including the appropriate background, is 0.03 ppm (59 µg/m^3), which is well below the annual NO_2 NAAQS of 0.05 ppm.

TABLE 2-12: MAXIMUM ANNUAL NO_2 CONCENTRATIONS FROM VENTILATION BUILDINGS AT AMBIENT RECEPTORS FOR COMPLIANCE DEMONSTRATION (PPM)

VB	Year					Highest Concentration
	2000	2001	2002	2003	2004	
VB 1	0.026	0.026	0.026	0.026	0.025	0.026
VB 3	0.024	0.025	0.024	0.025	0.025	0.025
VB 4	0.024	0.024	0.024	0.024	0.025	0.025
VB 5	0.028	0.028	0.028	0.028	0.028	0.028
VB 6	0.025	0.025	0.025	0.025	0.024	0.025
VB 7	0.031	0.030	0.030	0.029	0.030	0.031

Notes: Annual NO_2 NAAQS is 0.05 ppm. Background NO_2 is 0.023 ppm.

Based on these modeling results, no further NO_2 impact analysis iterations were performed.

2011 $PM_{2.5}$ Analysis

The $PM_{2.5}$ emission limits for the VBs were identified by starting the modeling process at an assumed concentration of 1,000 µg/m^3 for each stack in each VB. The modeling was performed using the most recent five years of meteorological data (described in section 2.6.5) and included daily background air quality data to obtain a total daily (24-hour) $PM_{2.5}$ concentration at each receptor. The 98th percentile daily value (i.e., the 8th highest 24-hour concentration) was determined for each year and at each receptor and these five levels at each receptor were averaged to obtain the 24-hour design value to be compared to the 24-hour NAAQS for $PM_{2.5}$. The annual design value was determined by averaging the annual modeled concentrations at each receptor over five modeled years and adding the annual monitoring design value based on the most recent three years of monitoring. The annual design value was then compared to the annual NAAQS for $PM_{2.5}$. If results showed that an NAAQS was exceeded, the prospective $PM_{2.5}$ emission limit was decreased in intervals of 100 µg/m^3 and the modeling was repeated until both the 24-hour and annual NAAQS for $PM_{2.5}$ were met.

This process was conducted for Step 4 (Table 2-13) operating conditions and then repeated to verify that the same emission limit showed compliance with the NAAQS for Step 1 (Table 2-14) operating conditions.

TABLE 2-13: VENTILATION BUILDING EXHAUST AND STACK PARAMETERS – STEP 4 OPERATIONS

Ventilation Building	Number of Fans	Zone	Flow Rate (cfm)	Total Exit Area (ft^2)	Exit Velocity (m/s)	Equivalent Diameter (m)
1	2	SAT-Ramp D-E1	144,060	213.2	3.43	5.02
1	3	SAT-WB-E1	290,304	319.8	4.61	6.15
1	2	SAT-EB-E1	236,729	213.2	5.64	5.02
1	4	SAT-Ramp L/HOV-E1	395,220	426.4	4.71	7.10
3	5	SB-1	449,400	533	4.28	7.94
3	5	NB-1	528,423	533	5.04	7.94
3	4	NB-2	478,380	426.4	5.70	7.10
4	4	SB-2	398,580	426.4	4.75	7.10
4	4	SB-3	474,810	426.4	5.66	7.10
4	4	NB-3	371,700	426.4	4.43	7.10
4	4	NB-4	339,780	426.4	4.05	7.10
5	4	SAT-WB-E2	436,800	426.4	5.20	7.10
5	2	SAT-WB-E3	165,060	213.2	3.93	5.02
5	4	SAT-EB-E2	467,040	426.4	5.56	7.10
5	2	SAT-EB-E3	234,360	213.2	5.58	5.02
6	3	EB Zone 1	378,000	319.8	6.00	6.15
6	3	WB Zone 1	378,000	319.8	6.00	6.15
7	3	EB Zone 2	345,240	319.8	5.48	6.15
7	3	WB Zone 2	291,060	319.8	4.62	6.15
7	2	EB Zone 3	189,840	213.2	4.52	5.02
7	3	WB Zone 3	255,780	319.8	4.06	6.15
7	3	T-A/D	244,860	319.8	3.89	6.15

TABLE 2-14: VENTILATION BUILDING EXHAUST AND STACK PARAMETERS – STEP 1 OPERATIONS

Ventilation Building	Number of Fans	Zone	Flow Rate (cfm)	Total Exit Area (ft^2)	Exit Velocity (m/s)	Equivalent Diameter (m)
1	2	SAT-Ramp D-E1	44,590	213.2	1.06	5.02
1	3	SAT-WB-E1	89,856	319.8	1.43	6.15
1	2	SAT-EB-E1	73,273	213.2	1.75	5.02
1	4	SAT-Ramp L/HOV-E1	122,330	426.4	1.46	7.10
3	5	SB-1	139,100	533	1.33	7.94
3	5	NB-1	163,560	533	1.56	7.94
3	4	NB-2	148,070	426.4	1.76	7.10
4	4	SB-2	123,370	426.4	1.47	7.10
4	4	SB-3	146,965	426.4	1.75	7.10
4	4	NB-3	115,050	426.4	1.37	7.10
4	4	NB-4	105,170	426.4	1.25	7.10
5	4	SAT-WB-E2	135,200	426.4	1.61	7.10
5	2	SAT-WB-E3	51,090	213.2	1.22	5.02
5	4	SAT-EB-E2	144,560	426.4	1.72	7.10
5	2	SAT-EB-E3	72,540	213.2	1.73	5.02
6	3	EB Zone 1	117,000	319.8	1.86	6.15
6	3	WB Zone 1	117,000	319.8	1.86	6.15
7	3	EB Zone 2	106,860	319.8	1.70	6.15
7	3	WB Zone 2	90,090	319.8	1.43	6.15
7	2	EB Zone 3	58,760	213.2	1.40	5.02
7	3	WB Zone 3	79,170	319.8	1.26	6.15
7	3	T-A/D	75,790	319.8	1.20	6.15

The 24-hour and annual modeling results for each VB and for the cumulative impact from all are presented in Tables 2-15 and 2-16, respectively. In the cumulative analysis the receptor with the maximum 8th highest 24-hour concentration averaged over five years for Step 4 was located on the U. S. Post Office Building near VB1 at a height of 33 meters above ground level. The controlling concentration (33.6 µg/m^3) was due entirely to impacts from VB1 and background. The impacts from Step 4 were higher than those for Step 1, the level at which the Project ventilation system normally operates. The receptor with the maximum annual Project impact averaged over five years for Step 4 (4.3 µg/m^3) in the cumulative analysis was a rectangular grid receptor located at ground level immediately adjacent to VB7. Most (approximately 96%) of the controlling impact predicted at this receptor was attributable to emissions from VB7.

TABLE 2-15: MAXIMUM 24-HOUR AND ANNUAL $PM_{2.5}$ CONCENTRATIONS FROM INDIVIDUAL VENTILATION BUILDINGS AT AMBIENT RECEPTORS FOR COMPLIANCE DEMONSTRATION (µG/M^3) BASED ON A SOURCE LEVEL OF 900 (µG/M^3)

VB	Predicted 24 hour Design Value	Predicted Annual Design Value
VB 1	33.5	13.1
VB 3	29.2	11.8
VB 4	29.3	11.5
VB 5	30.9	13.1
VB 6	27.2	11.2
VB 7	32.6	14.6

Notes: $PM_{2.5}$ NAAQS: 24-Hour - 35 µg/m^3; Annual - 15 µg/m^3
Annual $PM_{2.5}$ background level - 10.5 µg/m^3

TABLE 2-16: MAXIMUM CUMULATIVE 24-HOUR AND ANNUAL $PM_{2.5}$ CONCENTRATIONS FROM ALL VENTILATION BUILDINGS FOR COMPLIANCE DEMONSTRATION (μG/M^3) BASED ON A SOURCE LEVEL OF 900 (μG/M^3)

All VB	Predicted 24 hour Design Value	Predicted Annual Design Value
	33.6	14.8

Notes: $PM_{2.5}$ NAAQS: 24-Hour - 35 μg/m^3; Annual - 15 μg/m^3
Annual $PM_{2.5}$ background level - 10.5 μg/m^3

2.7.2 2006 Analysis For Longitudinal Ventilation – Exit Ramps and DST

2.7.2.1 Modeling Procedures to Determine the Impact of Exit Portal Emissions

The plume of exhaust air that comes out of an exit portal in the wake of exiting vehicles has high pollutant concentrations because of the limited dispersion of pollutants within the tunnel. This plume maintains its integrity for a distance downstream of the exit portal due to the momentum created by the moving cars. This distance depends on the geometry of the roadway after the tunnel exit, the traffic flow characteristics, such as speed and density, meteorological conditions (wind direction), and other factors affecting the turbulence and dispersion of the plume. Given the complexity of the air flow patterns and geometries of tunnel portals, physical models were used to analyze the effect of the tunnel emissions.

1996 CA/T Physical Simulation Studies

Physical simulation studies (i.e., wind tunnel tests) were performed in support of the air quality evaluation for the *Notice of Project Change (NPC)/Environmental Reevaluation (ER) for the Implementation of Longitudinal Ventilation in the Area North of Causeway Street and Central Area, October 1996* (1996 Longitudinal Ventilation NPC/ER).

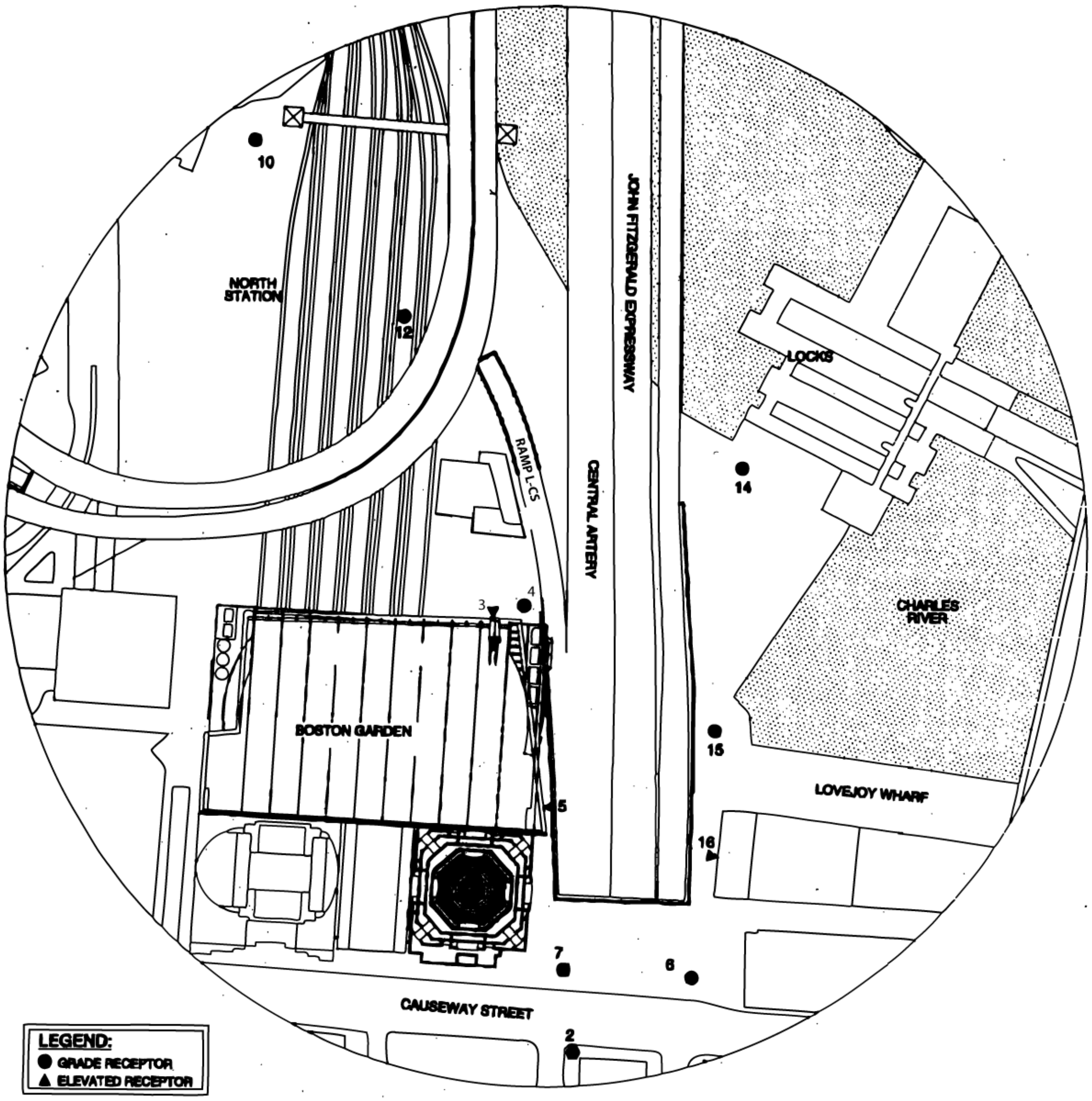
The changes analyzed in the 1996 Longitudinal Ventilation NPC/ER were the direct results of the emissions that previously were vented through the exhaust stacks of VB 8 (eliminated with longitudinal ventilation), and that now are exhausted through the exit portals of ramps CN-S and L-CS. Another change included a small portion of emissions that previously were vented through VB3 and VB4, and which now is vented through the exit portals of the ramps SA-CN, ST-CN, ST-SA, CS-SA and CS-P.

Another physical simulation study was performed for Ramp F as part of the air quality evaluation for the Notice of Project Change (NPC)/Environmental Reevaluation (ER) for the South Bay/South Boston Areas. In order to simplify the ducting system for VB5, the ventilation of exit ramp F was removed from VB5. Exit ramp F now is longitudinally ventilated by the piston action of the vehicles with the addition of jet fans exhausting the air through its exit portal during emergency conditions.

Figures 2-8 to 2-14 identify the location of each ramp analyzed.

In order to replicate the effects of the air flows created by the moving traffic at these exit ramps, six 1:100 and 1:200 scale models were built at the RWDI wind tunnel testing facility in Guelph, Ontario.

FIGURE 2-8: RAMP L-CS



Site Plan - Ramp L-CS (Above Ground Intake Structure)	True North	Drawing No. 7	RWDI
		Scale: 1"=225'	
Central Artery Air Quality Assessment - Boston, Mass.	Job No. 96-131	Date: Oct. 21,1996	

FIGURE 2-9: RAMP SA-CN

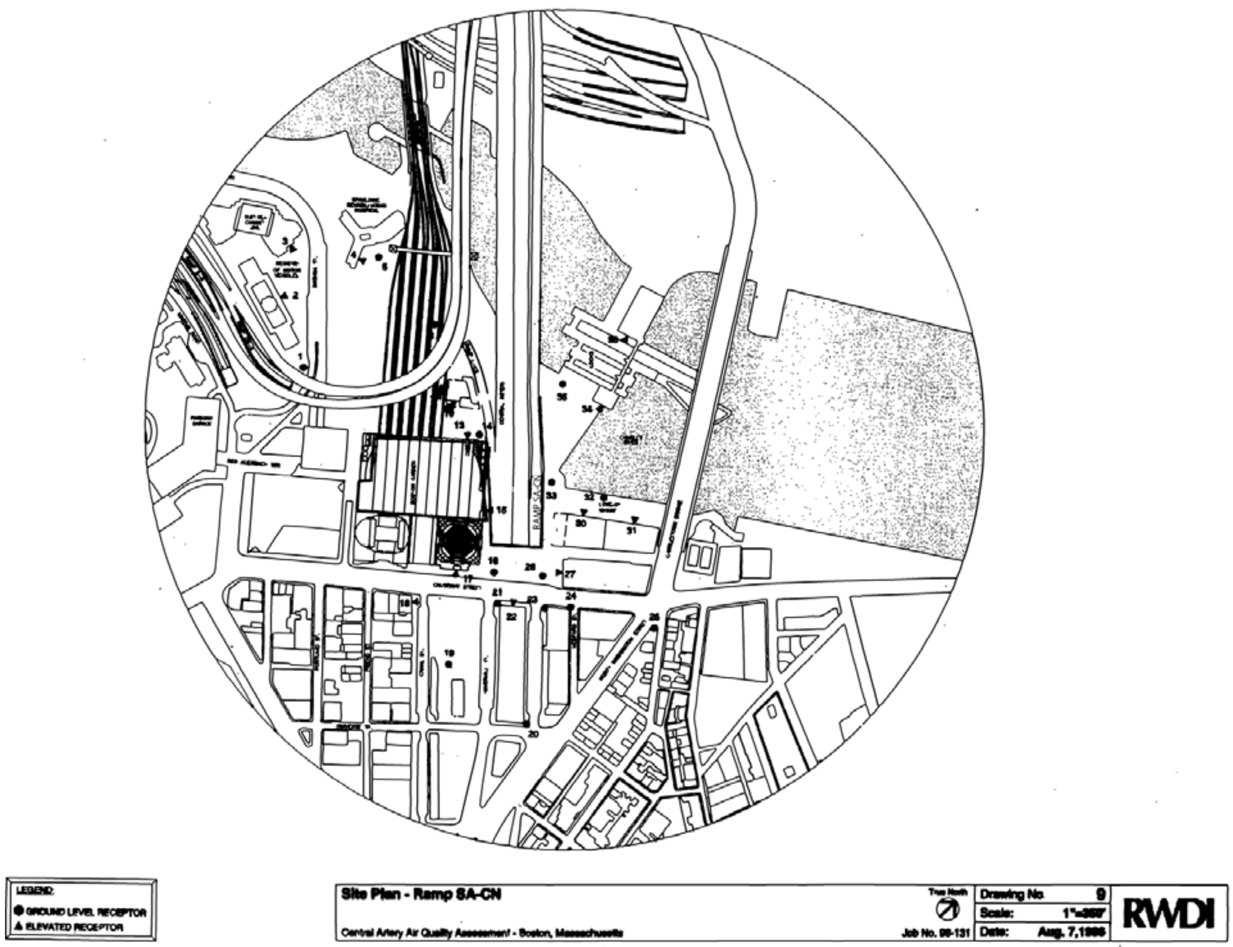
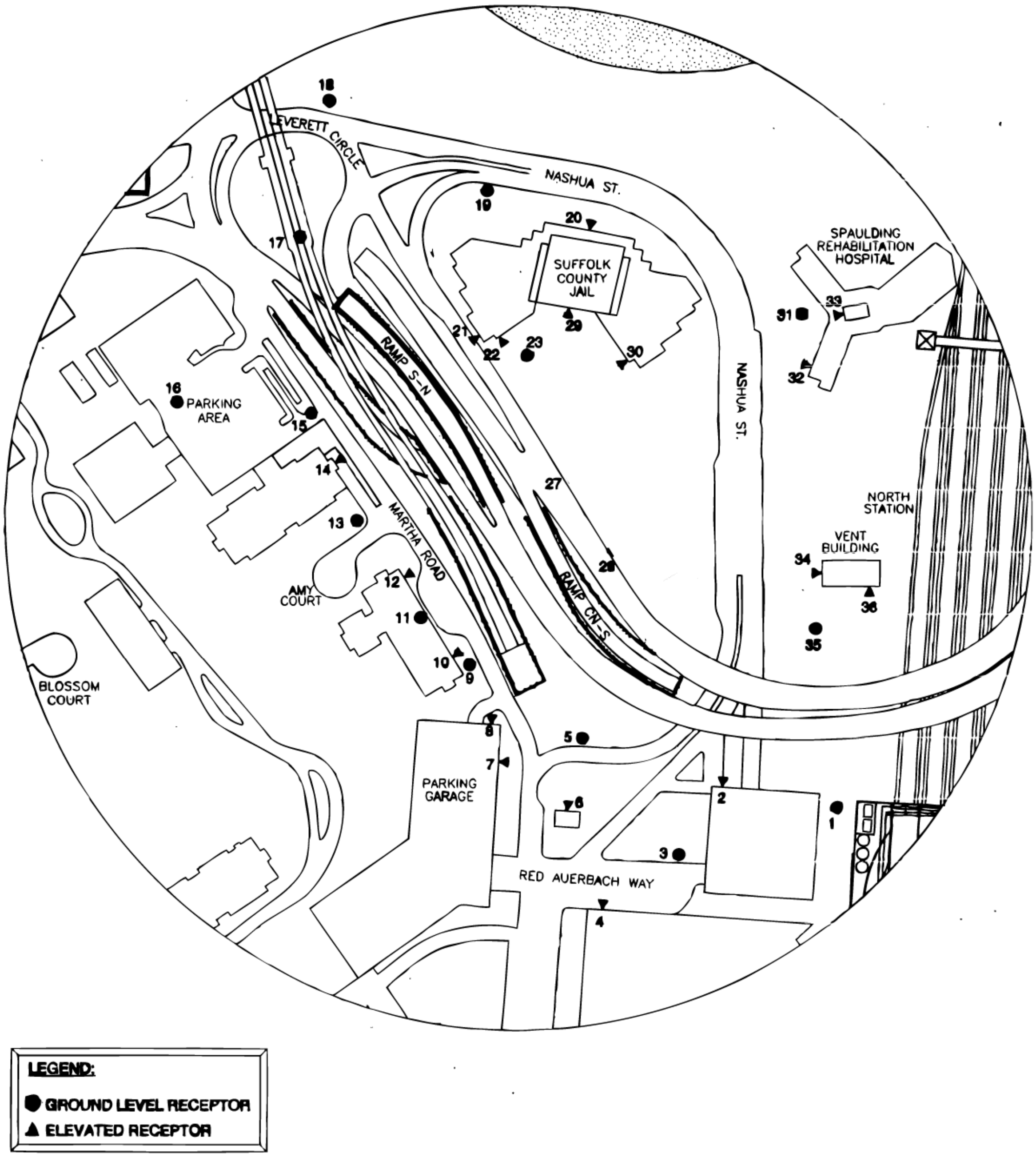


FIGURE 2-10: RAMP CN-S



Site Plan - Ramp CN-S	True North	Drawing No. 10	RWDI
		Scale: 1"=225'	
Central Artery Air Quality Assessment - Boston, Massachusetts	Job No. 96-131	Date: Oct. 21,1996	

FIGURE 2-11: RAMP ST-SA AND ST-CN

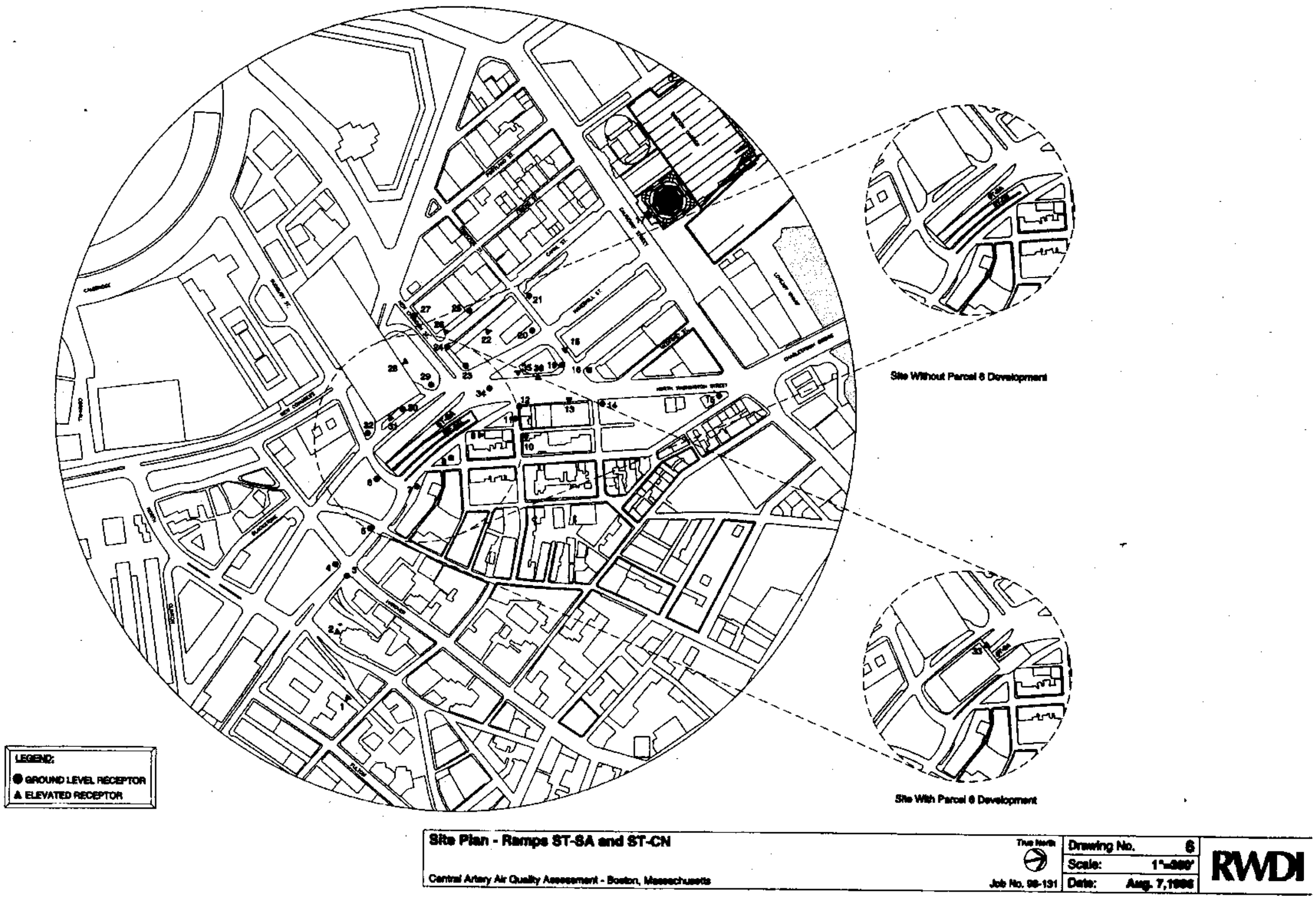


FIGURE 2-12: RAMP CS-SA

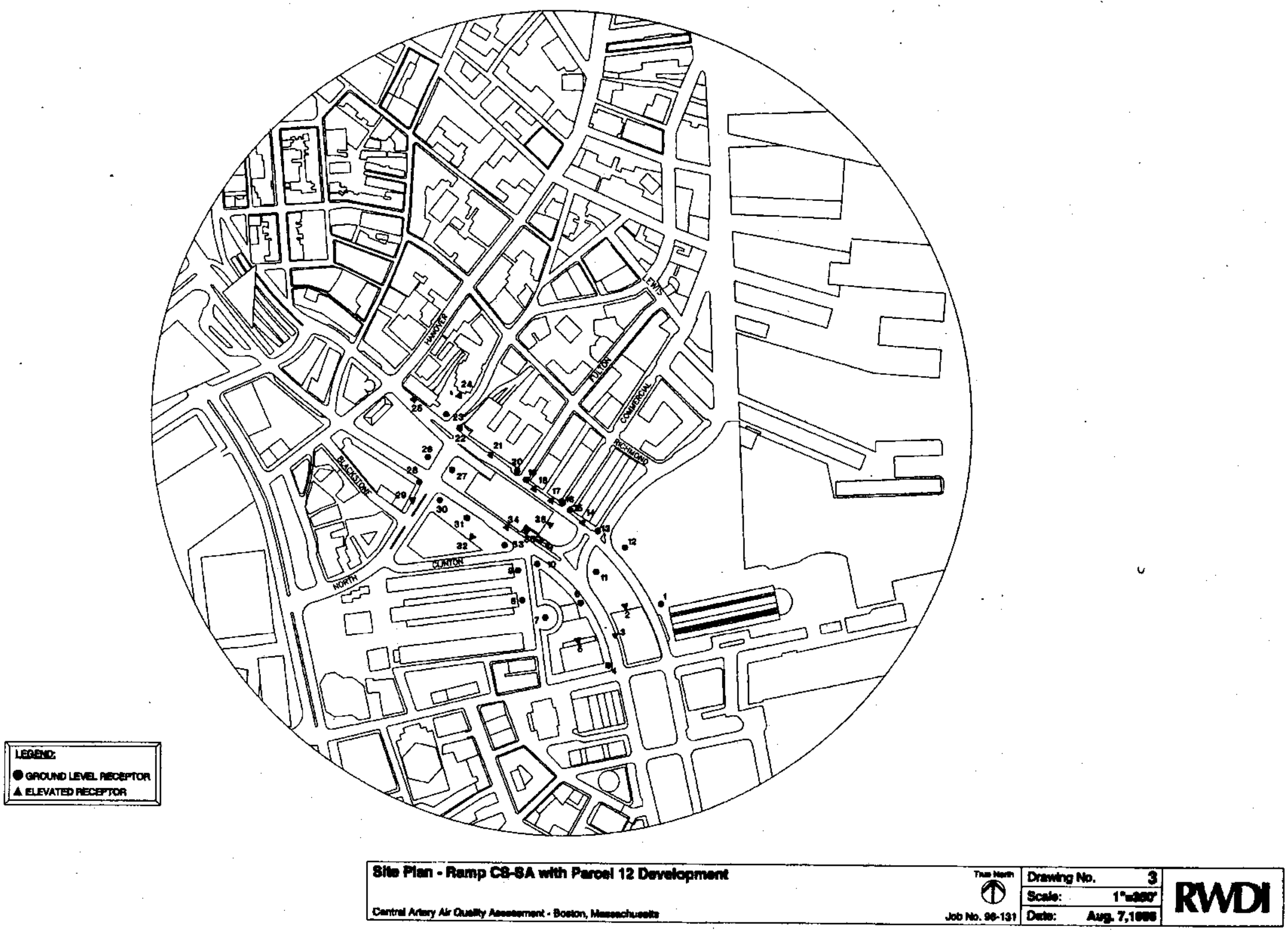


FIGURE 2-13: RAMP CS-P

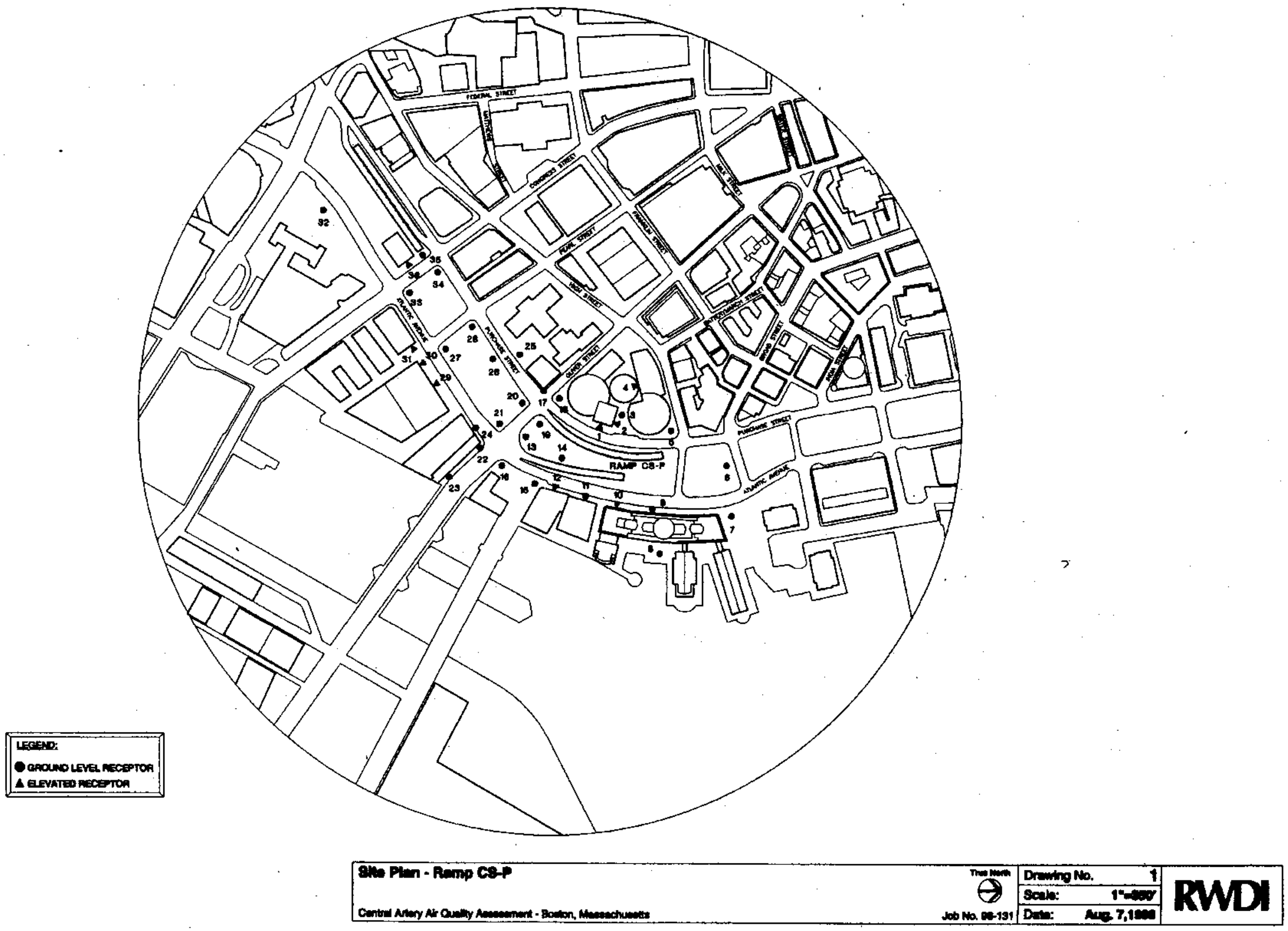
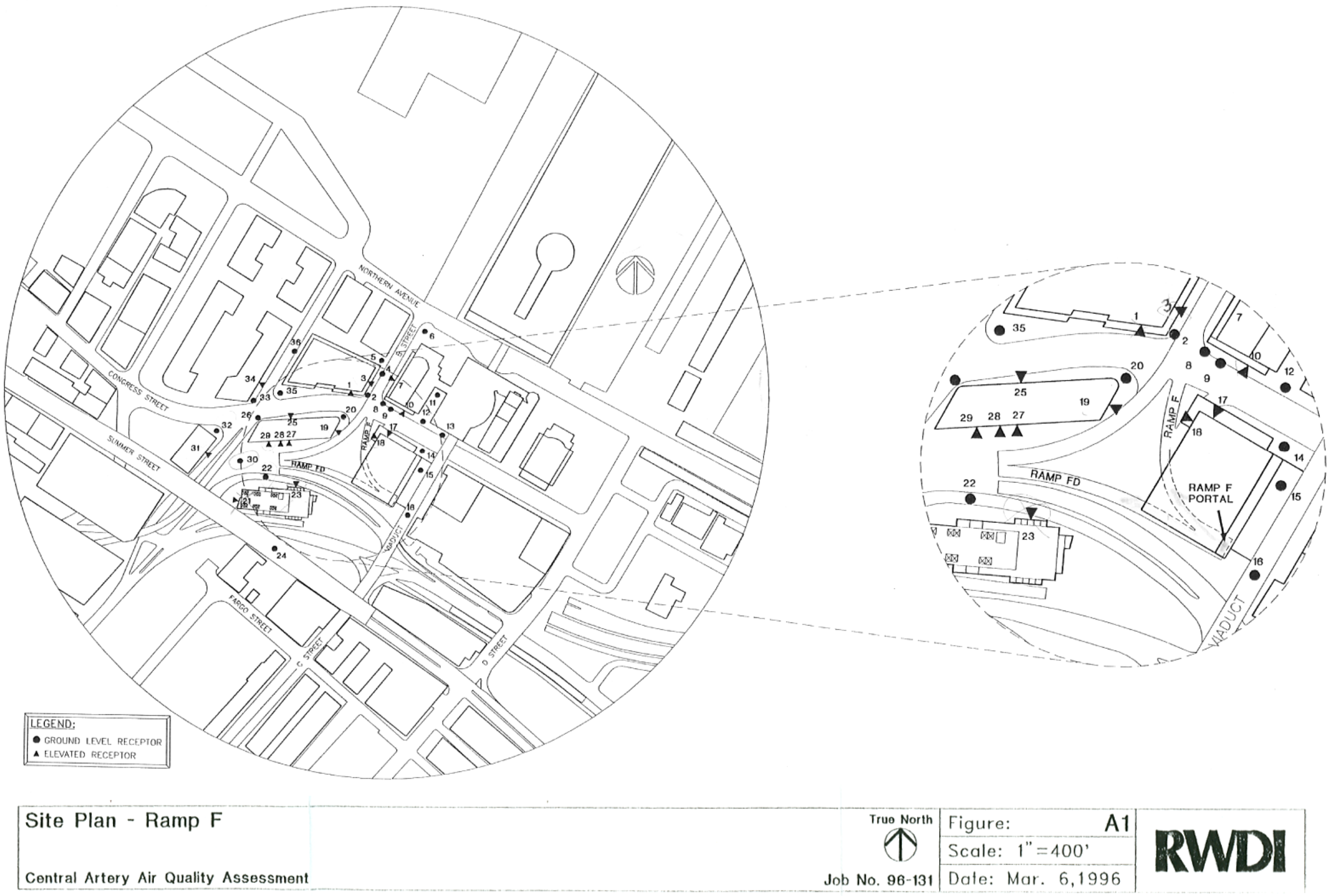


FIGURE 2-14: RAMP F



Each model included the individual ramps, and its surrounding buildings within 800 to 1,600 feet from each portal. The scenarios with and without the development of parcels 6 and 12 were also studied. The effects of the moving vehicles were simulated using moving belts, with attached semi spheres representing the aerodynamic characteristics of the predicted traffic speed and density. The model scale vehicle drag took into account the modeled vehicles and the conveyor belt itself.

Flow visualization tests were initially performed to determine the most likely location of the highest impacts, and detailed tracer gas tests were performed at the identified high impact locations, including sensitive public areas, and air intakes of the surrounding buildings. Tracer gas tests were performed at the wind tunnel facility for each ramp, at each specified traffic and parcel development scenario. The tracer gas concentration measured at each receptor location was recorded as a percentage of the gas concentration measured at the exit portal (this data provides what can be described as a dilution ratio for each location).

A full description of the study methodology and results was prepared in the report *Physical Simulation Study for the Implementation of Longitudinal Ventilation Systems in the Area North of Causeway and Central Area*, by RWDI, October 1996. The report was submitted to MassDEP as part of the 1996 Longitudinal Ventilation NPC/ER.

The detailed modeling procedures used for determination of the longitudinal ventilation emission impacts and emission limits can be found in Appendix B1, "Air Quality Analysis Protocol for Determination of Emission Limits as Part of the Operating Certification of the Project Ventilation Systems" of this document.

2005 DST Physical Simulation Study

Due to the proposed commercial building development immediately downstream and adjacent to the tunnel portal, a physical simulation study was performed to evaluate the effects of tunnel motor vehicle emissions on the existing environment, the proposed building configurations and the associated sidewalks.

The objective of the 2005 exhaust dispersion study was to evaluate different Build scenarios (from No-Build to fully developed Parcels 24, 25 and 26a), and how these scenarios would affect the dispersion of exhaust from the two vehicle tunnel portals located south of Kneeland Street. These two portals carry the I-93 south-bound mainline traffic (CASB), and the I-90 collector traffic (Ramp H/Slip Ramp). The sources included in this assessment were the exhausts from the CASB and Ramp H/Slip Ramp exit portals. Three physical configurations evaluated included:

- Configuration 1 – the relocated CASB portal (400 feet south of Kneeland Street) with development at Parcels 24, 25 and 26a (Figure 2-15)
- Configuration 2 – the existing CASB portal location with development at Parcels 24 and 26a and low existing retaining wall (Figure 2-16)
- Configuration 3A – the existing "No-Build" condition without any development on Parcels 24, 25 and 26a (Figure 2-17)

The exhaust flow from the two portals was simulated using a fan system exhausting through the modeled vehicle tunnels. The pollutants of concern for this assessment were CO, NO_2 and PM_{10}.

FIGURE 2-15: DEWEY SQUARE TUNNEL – CONFIGURATION 1

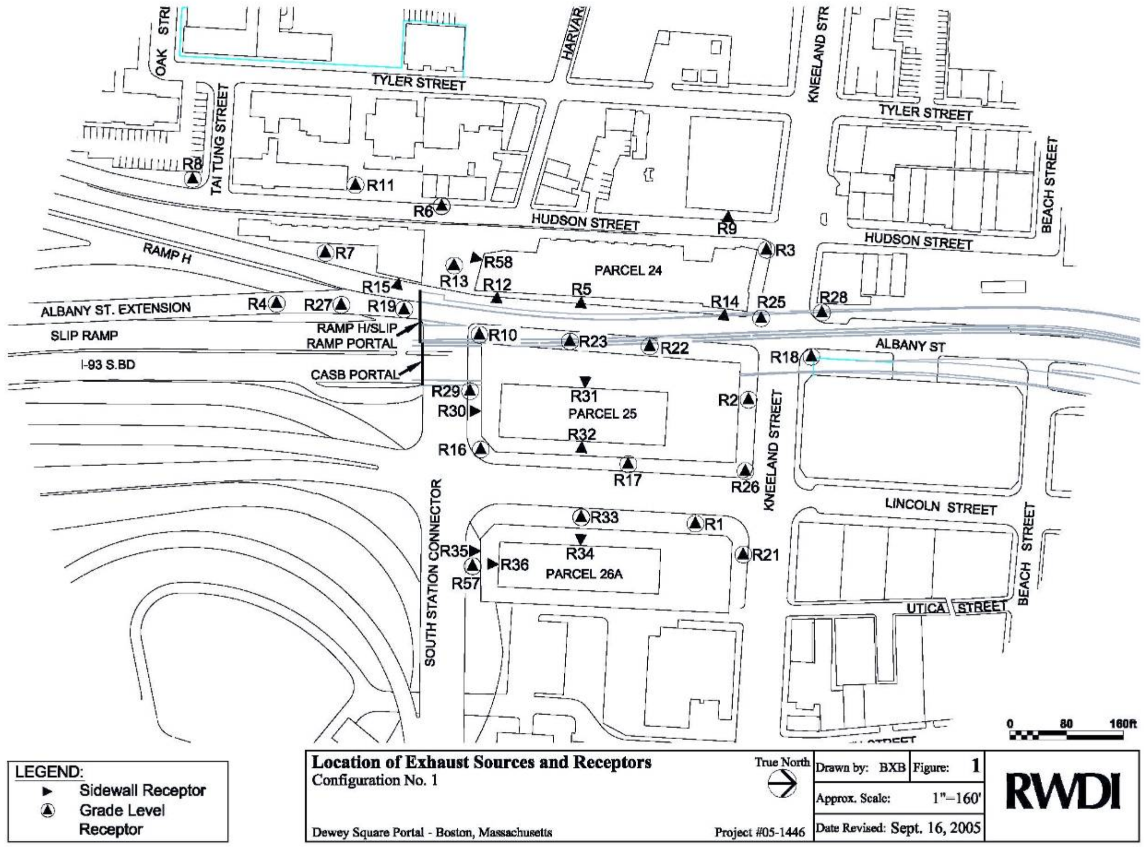


FIGURE 2-16: DEWEY SQUARE TUNNEL – CONFIGURATION 2

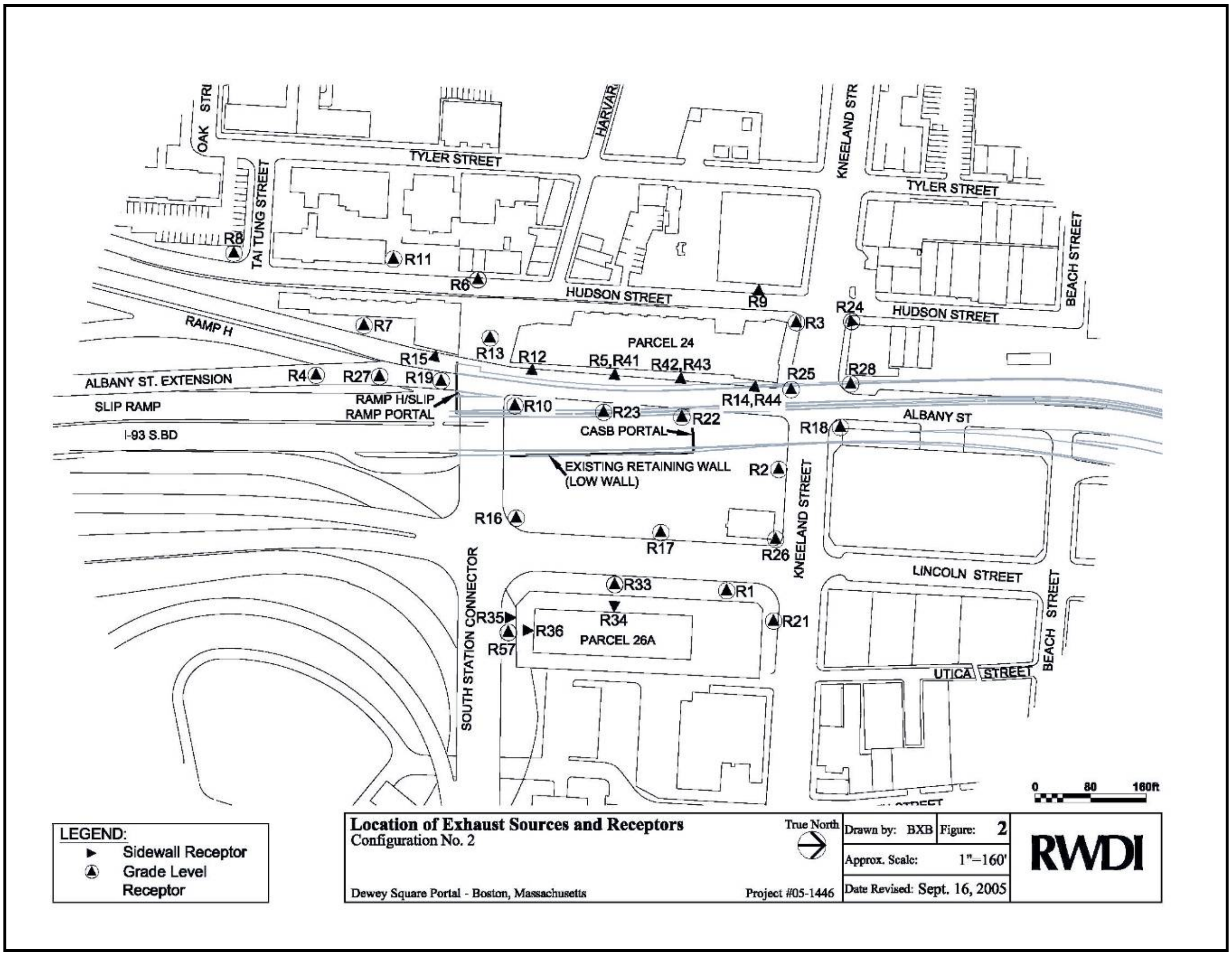
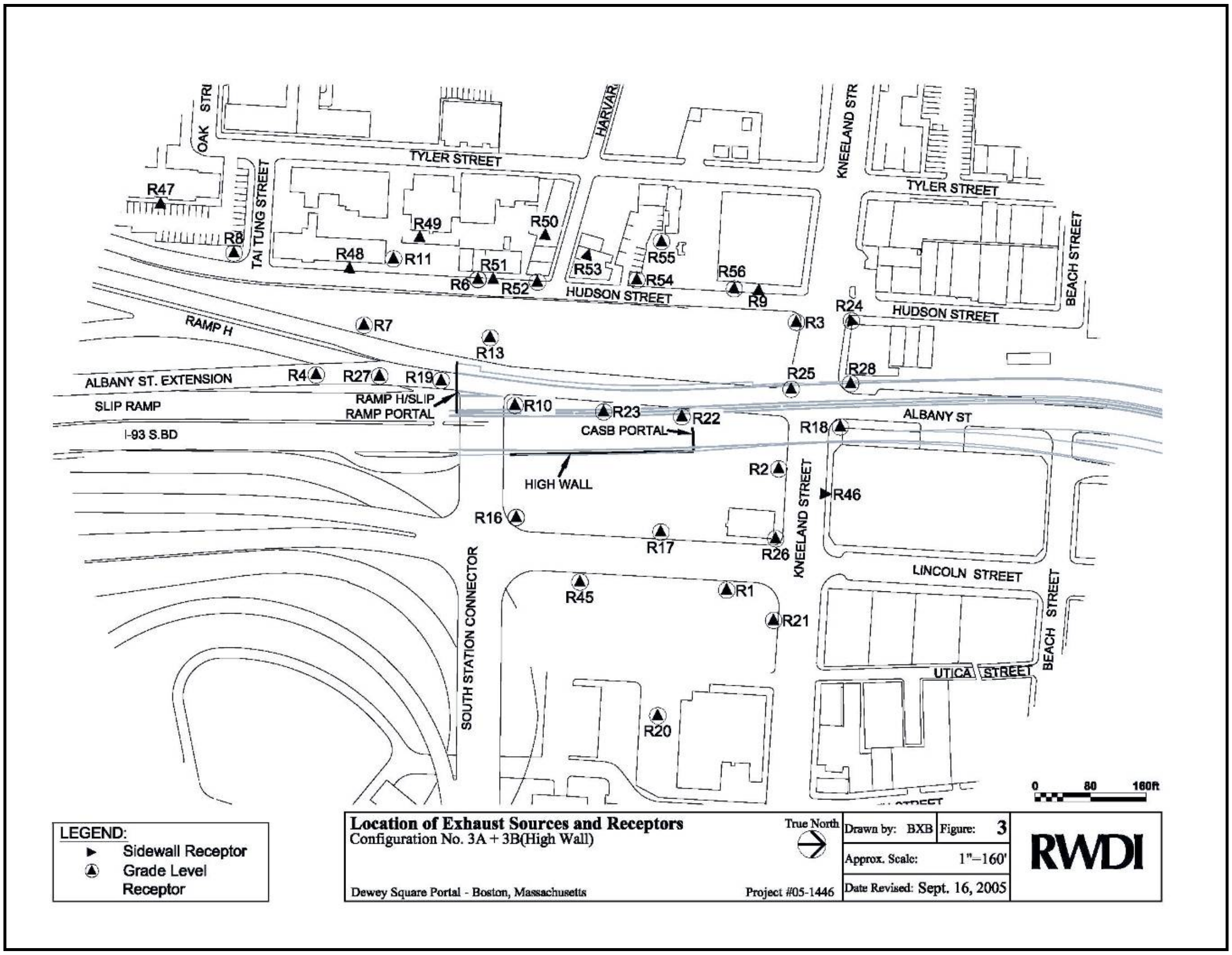


FIGURE 2-17: DEWEY SQUARE TUNNEL – CONFIGURATION 3A



Flow visualization tests were initially performed to determine the most likely location of the highest impacts, and detailed tracer gas tests were performed at the identified high impact locations, including sensitive public areas, and air intakes of the surrounding buildings.

A full description of the study methodology and results was included in the final report *Air Quality Study Dewey Square Portal Boston, Massachusetts*, prepared by RWDI, January 2006.

The detailed modeling procedures used for determination of the DST emission impacts and emission limits can be found in Appendix B ("Air Quality Analysis Protocol for Determination of Emission Limits as Part of the Operating Certification of the Project Ventilation Systems") of this document.

2.7.2.2 Use of Physical Simulation Data

The air quality dispersion modeling analysis to determine the emission limits for the longitudinally ventilated ramps and the DST is based on the dilution coefficients obtained through the 1996 physical simulation study for the longitudinally ventilated ramps and through the 2005 DST physical simulation study.

The dilution factors obtained for the three wind speeds and 24 wind angles for each scenario at each receptor location for the longitudinally ventilated ramps were used to create a series of matrices. These matrices provide the tracer gas concentration measured at each receptor location as a percentage of the full concentration measured at the exit portal (this is the dilution ratio).

This dilution ratio was applied to the full scale source concentration for each pollutant analyzed, and interpolated using the five years (2000–2004) of meteorological data in order to obtain the highest and second highest pollutant levels at each receptor location.

The receptor locations were the ambient locations (public access and buildings windows and/or air intake locations) used in the 1996 and 2005 physical simulation studies. The site plans and receptor locations for each ramp are provided in Figures 2-8 to 2-17.

2.7.2.3 CO Analysis

The CO emission source level for the exit ramps was analyzed in the range from 5 to 70 ppm for each portal. Peak-hour flow conditions (and associated dilution factors) were used for the one-hour analysis, and 8-hour flow conditions (and associated dilution factors) were used for the 8-hour analysis. Five years of actual meteorological observations were used to determine the critical source level at which both 1-hour and 8-hour NAAQS would be potentially violated. The critical source level was identified to the nearest ppm. The one and eight-hour emission limit is established as source level 1 ppm lower than the critical level or as the highest level at which both NAAQS would not be potentially violated.

An in-house program was created to multiply the emission source level by the dilution factor (from the physical simulation study matrix). This program also applies bilinear interpolation to the ratios from the dilution matrix to account for the actual wind speed and wind direction at each hour of the year from the meteorological data set of 5 years. In addition, the program adds the hourly CO background concentration for the respective hour.

The form of the equation is:

$CO_{(at\ receptor)} = CO_{(at\ source\text{-}portal)} \times \text{Dilution Factor}_{(N\ hour)} + CO_{(background\ N\text{-}hour)}$

$CO_{(at\ source\text{-}portal)}$ = from 10 to 70 ppm

Dilution Factor $_{(N\ hour)}$ = f(Wind Speed, Wind Direction)

N-hour = each hour for the full calendar year

EPA modeling procedures described in Section 9.3.4.2 of the *USEPA Guideline on Air Quality Models (EPA-450/2-78-027R)* were used for calm winds and missing meteorological data. In the case of missing background CO concentration, the program sets the level for that specific hour to zero. This also follows the procedures provided in the reference cited above.

The program output prints the 1st and 2nd highest levels for each source strength for the year indicating the date and hour of occurrence.

The eight-hour analysis procedure is based on the average of eight sequential one-hour results printing the 1st and 2nd non-overlapping highest levels for the year indicating date and the ending hour of the eight-hour period.

Tables 2-17 through 2-29 summarize the compliance demonstrations for the 1-hour and 8-hour NAAQS for CO for each ramp. The tables list 2nd high concentrations, consistent with the form of the CO NAAQS which allow for each short-term standard to be exceeded once per year. Concentrations are listed in units of ppm. The corresponding NAAQS for CO are 9 ppm for the 8-hour standard and 35 ppm for the 1-hour standard.

TABLE 2-17: 1- AND 8-HOUR CO LEVELS FOR COMPLIANCE DEMONSTRATION: RAMP LC-S

Ramp LC-S									
	One Hour CO				Eight Hour CO				
Year	Receptor	Source CO	2nd Highest Level	Date Hour	Receptor	Source CO	2nd Highest Level	Date	Ending Hour
2000	4	70	19.9	11/03/00 19	4	40	8.9	02/18/00	10
2001	4	70	18.9	03/18/01 03	4	41	8.9	08/19/01	8
2002	4	70	19.6	02/10/02 03	4	39	8.8	08/13/02	10
2003	4	70	19.1	05/03/03 22	4	40	8.8	08/29/03	8
2004	4	70	19.0	06/30/04 21	4	41	8.8	11/21/04	18

TABLE 2-18: 1- AND 8-HOUR CO LEVELS FOR COMPLIANCE DEMONSTRATION: RAMP SA-CN

Ramp SA-CN									
	One Hour CO				Eight Hour CO				
Year	Receptor	Source CO	2nd Highest Level	Date Hour	Receptor	Source CO	2nd Highest Level	Date	Ending Hour
2000	33	70	8.1	11/09/00 18	33	70	4.7	03/23/00	17
2001	33	70	8.1	07/20/01 11	33	70	4.0	04/25/01	22
2002	33	70	8.1	09/07/02 18	33	70	3.7	02/24/02	20
2003	33	70	8.4	09/08/03 20	33	70	4.7	03/24/03	21
2004	33	70	8.2	03/05/04 18	33	70	3.8	02/20/04	23

TABLE 2-19: 1- AND 8-HOUR CO LEVELS FOR COMPLIANCE DEMONSTRATION: RAMP CN-S

Ramp CN-S									
	One Hour CO				Eight Hour CO				
Year	Receptor	Source CO	2nd Highest Level	Date Hour	Receptor	Source CO	2nd Highest Level	Date	Ending Hour
2000	23	70	15.2	09/05/00 22	23	64	8.9	12/16/00	13
2001	23	70	15.0	03/02/01 08	23	59	8.9	12/13/01	10
2002	23	70	14.9	03/13/02 06	23	65	8.970	10/30/02	22
2003	23	70	15.2	12/19/03 20	23	65	8.9	11/27/03	14
2004	23	70	15.0	04/26/04 21	23	58	8.9	11/17/04	10

TABLE 2-20: 1- AND 8-HOUR CO LEVELS FOR COMPLIANCE DEMONSTRATION: RAMP ST-CN NO PARCEL 6

Ramp ST-CN no Parcel 6									
	One Hour CO				Eight Hour CO				
Year	Receptor	Source CO	2nd Highest Level	Date Hour	Receptor	Source CO	2nd Highest Level	Date	Ending Hour
2000	12	70	7.9	11/04/00 01	9	70	6.4	12/04/00	24
2001	12	70	7.4	12/17/01 12	9	70	6.4	12/10/01	10
2002	12	70	7.1	01/26/02 24	9	70	5.6	07/07/02	23
2003	34	70	7.8	12/09/03 17	9	70	5.8	10/30/03	24
2004	12	70	7.0	12/03/04 07	9	70	5.9	01/12/04	24

TABLE 2-21: 1- AND 8-HOUR CO LEVELS FOR COMPLIANCE DEMONSTRATION: RAMP ST-SA NO PARCEL 6

Ramp ST-SA no Parcel 6									
	One Hour CO				Eight Hour CO				
Year	Receptor	Source CO	2nd Highest Level	Date Hour	Receptor	Source CO	2nd Highest Level	Date	Ending Hour
2000	34	70	14.7	11/03/00 19	34	51	8.9	01/02/00	9
2001	34	70	14.3	04/27/01 22	34	56	8.962	10/03/01	9
2002	34	70	13.2	1/27/02 02	34	54	8.975	01/27/02	8
2003	34	70	13.4	07/07/03 22	34	57	8.9	08/29/03	8
2004	34	70	13.5	12/31/04 01	34	60	8.997	11/18/04	8

TABLE 2-22: 1- AND 8-HOUR CO LEVELS FOR COMPLIANCE DEMONSTRATION: RAMP ST-SA + PARCEL 6

Ramp ST-SA + Parcel 6									
	One Hour CO				Eight Hour CO				
Year	Receptor	Source CO	2nd Highest Level	Date Hour	Receptor	Source CO	2nd Highest Level	Date	Ending Hour
2000	34	70	17.3	12/11/00 10	34	48	8.9	01/02/00	9
2001	34	70	17.7	12/05/01 21	34	52	8.963	09/18/01	24
2002	34	70	16.6	10/22/02 24	34	54	8.970	07/27/02	8
2003	34	70	16.3	05/26/03 01	34	51	8.961	12/10/03	9
2004	34	70	16.8	10/13/04 18	34	54	8.975	12/03/04	9

TABLE 2-23: 1- AND 8-HOUR CO LEVELS FOR COMPLIANCE DEMONSTRATION: RAMP CS-SA + PARCEL 12

Ramp CS-SA + Parcel 12									
	One Hour CO				Eight Hour CO				
Year	Receptor	Source CO	2nd Highest Level	Date Hour	Receptor	Source CO	2nd Highest Level	Date	Ending Hour
2000	11	70	23.9	03/23/00 03	11	37	8.998	11/20/00	14
2001	11	70	23.1	01/08/01 10	11	33	8.8	01/14/01	22
2002	11	70	24.2	00/17/02 02	11	38	8.9	07/30/02	8
2003	11	70	23.3	09/16/03 20	11	38	8.8	11/27/03	9
2004	11	70	23.9	01/27/04 17	11	37	8.9	11/18/04	8

TABLE 2-24: 1- AND 8-HOUR CO LEVELS FOR COMPLIANCE DEMONSTRATION: RAMP CS-SA NO PARCEL 12

Ramp CS-SA no Parcel 12									
	One Hour CO				Eight Hour CO				
Year	Receptor	Source CO	2nd Highest Level	Date Hour	Receptor	Source CO	2nd Highest Level	Date	Ending Hour
2000	3	70	18.5	11/04/00 01	3	51	8.9	12/04/00	24
2001	3	70	18.4	04/27/01 22	3	46	8.9	12/17/01	13
2002	3	70	17.5	01/26/02 24	3	51	8.967	07/30/02	8
2003	3	70	17.6	06/07/03 16	3	53	8.9	10/01/03	12
2004	3	70	17.4	01/21/04 15	3	53	8.999	11/18/04	13

TABLE 2-25: 1- AND 8-HOUR CO LEVELS FOR COMPLIANCE DEMONSTRATION: RAMP CS-P

Ramp CS-P									
	One Hour CO				Eight Hour CO				
Year	Receptor	Source CO	2nd Highest Level	Date Hour	Receptor	Source CO	2nd Highest Level	Date	Ending Hour
2000	20	70	15.0	11/19/00 23	20	70	3.5	01/30/00	8
2001	20	70	14.8	05/07/01 07	20	70	3.9	12/10/01	10
2002	20	70	14.8	07/04/02 04	1	70	3.4	07/15/02	18
2003	20	70	14.5	10/01/03 10	19	70	3.4	11/24/03	8
2004	20	70	13.6	04/18/04 02	1	70	3.3	01/04/04	10

TABLE 2-26: 1- AND 8-HOUR CO LEVELS FOR COMPLIANCE DEMONSTRATION: RAMP F

Ramp F									
	One Hour CO				Eight Hour CO				
Year	Receptor	Source CO	2nd Highest Level	Date Hour	Receptor	Source CO	2nd Highest Level	Date	Ending Hour
2000	29	70	11.1	02/26/00 24	22	70	4.7	01/02/00	9
2001	29	70	11.4	01/08/01 13	29	70	7.4	01/08/01	14
2002	29	70	10.8	11/04/02 01	29	70	6.4	11/03/02	22
2003	29	70	10.7	11/18/03 06	29	70	7.3	02/16/03	22
2004	29	70	10.4	03/05/04 01	29	70	7.7	11/16/04	12

TABLE 2-27: 1- AND 8-HOUR CO LEVELS FOR COMPLIANCE DEMONSTRATION – DEWEY SQUARE TUNNEL: CONFIGURATION 1

CONFIG 1									
	One Hour CO				Eight Hour CO				
Year	Receptor	Source CO	2nd Highest Level	Date Hour	Receptor	Source CO	2nd Highest Level	Date	Ending Hour
2000	27	70	29.8	12/19/00 10	4	22	8.8	02/22/00	8
2001	27	70	29.5	07/05/01 01	4	24	8.7	12/10/01	23
2002	27	70	29.7	01/29/02 19	4	24	8.9	11/04/02	24
2003	27	70	29.2	05/25/03 12	4	25	8.9	03/01/01	10
2004	27	70	30.6	08/13/04 03	4	24	8.95	07/01/04	8

TABLE 2-28: 1- AND 8-HOUR CO LEVELS FOR COMPLIANCE DEMONSTRATION – DEWEY SQUARE TUNNEL: CONFIGURATION 2

CONFIG 2									
	One Hour CO				Eight Hour CO				
Year	Receptor	Source CO	2nd Highest Level	Date Hour	Receptor	Source CO	2nd Highest Level	Date	Ending Hour
2000	23	70	27.9	11/03/00 11	4	23	8.8	04/27/00	24
2001	23	70	28.0	1/23/2001 11	4	22	8.7	01/23/01	11
2002	23	70	27.7	01/27/02 02	4	24	8.9	08/22/02	8
2003	23	70	27.9	12/03/03 21	4	24	8.95	06/07/03	8
2004	23	70	27.7	11/17/04 21	4	23	8.8	07/01/04	8

TABLE 2-29: 1- AND 8-HOUR CO LEVELS FOR COMPLIANCE DEMONSTRATION – DEWEY SQUARE TUNNEL: CONFIGURATION 3A

CONFIG 3A									
	One Hour CO				Eight Hour CO				
Year	Receptor	Source CO	2nd Highest Level	Date Hour	Receptor	Source CO	2nd Highest Level	Date	Ending Hour
2000	4	70	28.4	03/23/00 21	4	24	8.98	02/18/00	10
2001	4	70	26.9	02/14/01 04	4	23	8.7	01/23/01	11
2002	4	70	27.5	09/06/02 22	4	24	8.8	06/17/02	8
2003	4	70	26.9	12/09/03 21	4	24	8.8	12/09/03	24
2004	4	70	26.9	11/18/04 19	4	24	8.8	10/08/04	9

2.7.2.4 NO_2 Analysis

The NO_x levels at the ramp exit portals were estimated using equations 1 through 3 from Sections 2.6.3 and 2.6.4. The estimated NO_x source levels varied from 0.82 to 8.88 ppm as the source CO levels varied from 5 to 70 ppm.

The Ozone Limiting Method was utilized to determine the critical concentrations. Peak-hour flow conditions (and associated dilution factors) were used to estimate one-hour impacts. Five years of actual background measurements of NO_2 and O_3 concentrations at Roxbury and East Boston were used in the analysis. Five years of actual meteorological observations at Logan International Airport were also used in the analysis. The critical source level for CO was identified to the nearest ppm. The one-hour emission limit is established as a CO source level 1 ppm lower than the critical level. The critical level is the highest level CO concentration at which the MassDEP Guideline Value for NO_2 is not violated.

A program was developed to perform the OLM analysis. This program determines the NO_2 level that is exhausted from the tunnel and multiplies it by the dilution factor (from the physical simulation study matrix) to estimate concentrations at the sensitive receptors. It applies bilinear interpolation to the ratios from the dilution factor matrix to account for the actual wind speed and direction at each hour of the year from the meteorological data set of 5 years. Calm conditions and missing data are treated in the same fashion as described in CO analysis procedures.

The program outputs the 1st and 2nd highest levels for the year and for each emission source strength analyzed and indicates the date and hour of occurrence. If the level for a specific hour exceeds the MassDEP Guideline level for NO_2, the background ozone and NO_2 concentrations for this hour are also printed.

The one-hour MassDEP NO_2 Guideline level of 0.17 ppm was not violated at the portals of the longitudinally ventilated ramps and the DSTs at the source concentrations shown in Tables 2-30 through 2-42:

TABLE 2-30: 1-HOUR NO_2 LEVELS FOR COMPLIANCE DEMONSTRATION: RAMP LC-S

Ramp LC-S						
Year	Receptor	Source CO	Source NO_x	2nd Highest NO_2	Date	Hour
2000	4	70	8.88	0.167	09/20/00	15
2001	4	70	8.88	0.160	03/18/01	3
2002	4	69	8.75	0.169	08/13/02	6
2003	4	52	6.64	0.169	06/25/03	18
2004	4	70	8.88	0.156	05/06/04	18

TABLE 2-31: 1-HOUR NO_2 LEVELS FOR COMPLIANCE DEMONSTRATION: RAMP SA-CN

Ramp SA-CN						
Year	Receptor	Source CO	Source NO_x	2nd Highest NO_2	Date	Hour
2000	33	70	8.88	0.115	06/20/00	19
2001	33	70	8.88	0.130	08/09/01	22
2002	33	70	8.88	0.142	08/13/02	10
2003	33	70	8.88	0.136	06/26/03	16
2004	33	70	8.88	0.120	06/08/04	13

TABLE 2-32: 1-HOUR NO_2 LEVELS FOR COMPLIANCE DEMONSTRATION: RAMP CN-S

Ramp CN-S						
Year	Receptor	Source CO	Source NO_x	2nd Highest NO_2	Date	Hour
2000	23	70	8.88	0.153	06/01/00	18
2001	23	70	8.88	0.154	11/23/01	7
2002	23	70	8.88	0.158	08/13/02	17
2003	23	66	8.38	0.169	06/26/03	19
2004	23	70	8.88	0.134	04/18/04	5

TABLE 2-33: 1-HOUR NO_2 LEVELS FOR COMPLIANCE DEMONSTRATION: RAMP ST-CN NO PARCEL 6

Ramp ST-CN no Parcel 6						
Year	Receptor	Source CO	Source NO_x	2nd Highest NO_2	Date	Hour
2000	9	70	8.88	0.118	06/10/00	15
2001	9	70	8.88	0.138	08/09/01	21
2002	9	70	8.88	0.142	08/13/02	18
2003	9	70	8.88	0.134	06/27/03	14
2004	9	70	8.88	0.123	06/08/04	22

TABLE 2-34: 1-HOUR NO_2 LEVELS FOR COMPLIANCE DEMONSTRATION: RAMP ST-SA NO PARCEL 6

Ramp ST-SA no Parcel 6						
Year	Receptor	Source CO	Source NO_x	2nd Highest NO_2	Date	Hour
2000	34	70	8.88	0.157	06/20/00	24
2001	34	70	8.88	0.139	08/09/01	21
2002	34	70	8.88	0.154	08/13/02	17
2003	34	70	8.88	0.160	06/25/03	17
2004	34	70	8.88	0.127	03/26/04	6

TABLE 2-35: 1-HOUR NO_2 LEVELS FOR COMPLIANCE DEMONSTRATION: RAMP ST-SA + PARCEL 6

Ramp ST-SA + Parcel 6						
Year	Receptor	Source CO	Source NO_x	2nd Highest NO_2	Date	Hour
2000	34	70	8.88	0.168	06/09/00	24
2001	34	70	8.88	0.162	12/05/01	18
2002	34	70	8.88	0.167	08/13/02	3
2003	34	70	8.88	0.167	06/27/03	2
2004	34	70	8.88	0.143	07/21/04	23

TABLE 2-36: 1-HOUR NO_2 LEVELS FOR COMPLIANCE DEMONSTRATION: RAMP CS-SA + PARCEL 12

Ramp CS-SA + Parcel 12						
Year	Receptor	Source CO	Source NO_x	2nd Highest NO_2	Date	Hour
2000	11	50	6.4	0.168	06/21/00	1
2001	11	44	5.65	0.169	05/02/01	13
2002	11	51	6.52	0.168	03/31/02	1
2003	11	51	6.52	0.169	06/25/03	18
2004	11	62	7.88	0.169	01/27/04	17

TABLE 2-37: 1-HOUR NO_2 LEVELS FOR COMPLIANCE DEMONSTRATION: RAMP CS-SA NO PARCEL 12

Ramp CS-SA no Parcel 12						
Year	Receptor	Source CO	Source NO_x	2nd Highest NO_2	Date	Hour
2000	3	60	7.64	0.169	06/20/00	24
2001	3	56	7.14	0.169	05/02/01	13
2002	3	66	8.38	0.169	08/13/02	9
2003	34	63	8.01	0.169	06/26/03	18
2004	33	70	8.88	0.156	06/08/04	22

TABLE 2-38: 1-HOUR NO_2 LEVELS FOR COMPLIANCE DEMONSTRATION: RAMP CS-P

Ramp CS-P						
Year	Receptor	Source CO	Source NO_x	2nd Highest NO_2	Date	Hour
2000	20	70	8.88	0.134	02/15/00	24
2001	1	70	8.88	0.140	06/20/01	11
2002	1	70	8.88	0.150	08/13/02	17
2003	1	70	8.88	0.139	01/01/00	1
2004	1	70	8.88	0.123	06/08/04	22

TABLE 2-39: 1-HOUR NO_2 LEVELS FOR COMPLIANCE DEMONSTRATION: RAMP F

Ramp F						
Year	Receptor	Source CO	Source NO_x	2nd Highest NO_2	Date	Hour
2000	29	70	8.88	0.114	09/09/00	11
2001	15	70	8.88	0.132	08/09/01	22
2002	22	70	8.88	0.141	08/13/02	18
2003	22	70	8.88	0.134	06/26/03	17
2004	29	70	8.88	0.12	05/12/04	21

TABLE 2-40: 1-HOUR NO_2 LEVELS FOR COMPLIANCE DEMONSTRATION: DEWEY SQUARE TUNNEL – CONFIGURATION 1

Dewey Square Tunnel CONFIG 1						
Year	Receptor	Source NO_x	Source CO	2nd Highest NO_2	Date	Hour
2000	27	4.54	35	0.162	07/02/00	16
2001	27	3.3	25	0.165	06/20/01	13
2002	27	2.92	22	0.169	08/13/02	16
2003	27	3.3	25	0.169	06/27/03	12
2004	27	4.54	35	0.162	07/30/04	15

TABLE 2-41: 1-HOUR NO_2 LEVELS FOR COMPLIANCE DEMONSTRATION : DEWEY SQUARE TUNNEL – CONFIGURATION 2

Dewey Square Tunnel CONFIG 2						
Year	Receptor	Source NO_x	Source CO	2nd Highest NO_2	Date	Hour
2000	23	4.54	35	0.166	07/03/00	4
2001	23	2.92	22	0.168	08/03/01	17
2002	19	2.8	21	0.168	08/13/02	16
2003	23	3.3	25	0.169	07/04/03	23
2004	23	3.92	30	0.169	06/08/04	22

TABLE 2-42: 1-HOUR NO_2 LEVELS FOR COMPLIANCE DEMONSTRATION : DEWEY SQUARE TUNNEL – CONFIGURATION 3A

Dewey Square Tunnel CONFIG 3A						
Year	Receptor	Source NO_x	Source CO	2nd Highest NO_2	Date	Hour
2000	4	4.54	35	0.168	06/20/00	23
2001	19	4.54	35	0.168	06/20/01	13
2002	19	3.3	25	0.169	08/13/02	16
2003	4	4.54	35	0.169	06/27/03	2
2004	19	5.16	40	0.163	07/30/04	15

2.7.3 VOC Emission Limit Determination

In order to assess the effects of the CA/T Project on VOC regional levels, transportation related (highway, transit, commuter rail and ferries) VOC emissions for 2010 were estimated for the area affected by the CA/T Project. The analysis includes a demonstration that projected VOC emissions for 2010 will not exceed the 2005 VOC emissions budget of 6,095.9 kg/day that was established as part of the 2006 Operating Certification.

2.7.3.1 Travel Demand Model

The travel model used for the CA/T Project VOC Analysis is based on procedures and data that have evolved over many years. The model set is the same type as those used in most large urban areas in North America. It is based on the traditional four-step urban transportation planning process of trip generation, trip distribution, mode choice, and trip assignment.

A description of the modeling process can be found in Appendix B2 ("Air Quality Analysis Protocol for the Determination of $PM_{2.5}$ Emission Limits and Verification of VOC Emissions Budget for the Renewal of the Operating Certification of the Project Ventilation System") of this document.

The CTPS model area encompasses 164 cities and towns in Eastern Massachusetts, as shown in Figure 2-18. The CA/T Project area is shown in Figure 2-19. The modeled area is divided into 986 internal Traffic Analysis Zones (TAZ). There are 101 external stations around the periphery of the modeled area that allow for travel between the modeled area and adjacent areas of Massachusetts, New Hampshire and Rhode Island.

Population, employment, number of households, auto ownership, highway and transit levels of service, downtown parking costs, auto operating costs, and transit fares are some of the important inputs that are used in applying the model to a real world situation. These inputs are constantly updated, so that the model set simulates current travel patterns with reasonable accuracy. The model set simulates travel on the entire Eastern Massachusetts transit and highway system. It contains all MBTA rail and bus lines and all private express bus carriers. The model contains service frequency (i.e., how often trains and buses arrive at any given transit stop), routing, travel time, and fares for all these lines. In the highway system, all express highways and principal arterial roadways and many minor arterial and local roadways are included. Results from the computer model provide detailed information relating to transit ridership demand and highway utilization.

FIGURE 2-18: CTPS MODELED AREA

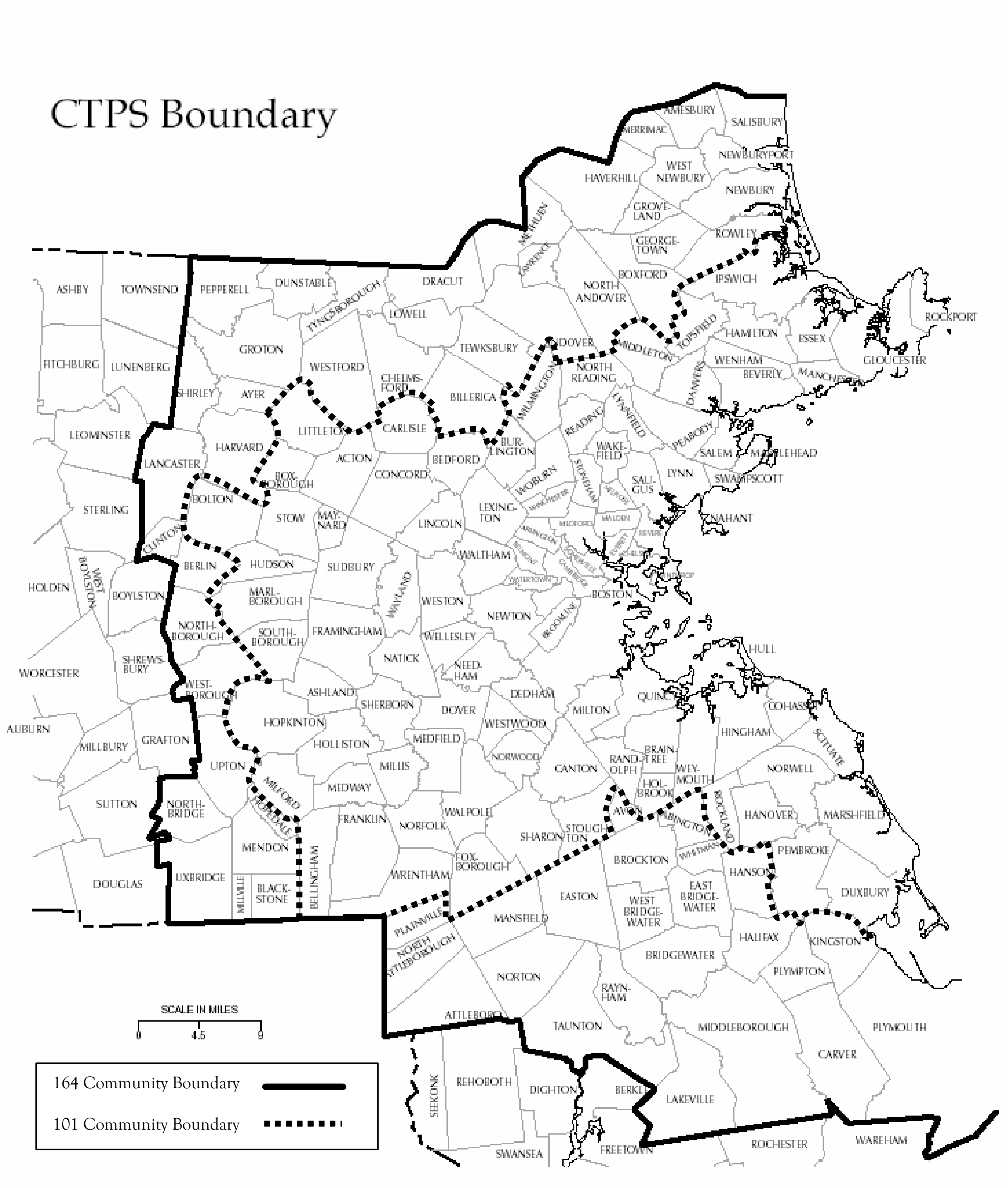


FIGURE 2-19: CA/T PROJECT STUDY AREA

2.7.3.2 Procedures for Highway Network VOC Analysis

The air quality effects of regional VOC levels of the two transportation scenarios (2005 CA/T Project Build and 2010 CA/T Project Build) were analyzed using the travel demand model previously described. From the highway assignment component of the model, traffic volumes, average highway speeds, vehicle miles, and vehicle hours traveled were estimated. The amount of VOC emitted by the highway traffic depends on the prevailing highway speeds and vehicle miles traveled on the network. The CTPS model uses MOBILE 6.2 emission factors to calculate VOC on a link-by-link basis based on the congested speed and vehicle miles of travel.

The 2010 Build network was defined by CTPS to include additional projects that were constructed between 2005 and 2010. The resulting 2010 Build network was then used to estimate VOC emissions associated with the 2010 Build scenario. VOC emissions associated with the 2010 Build network are compared to the 2005 VOC emissions budget in order to demonstrate that the Project is in compliance with the budget.

Table 2-43 provides a list of projects included in the 2005 Build and 2010 Build networks for the CA/T Project.

TABLE 2-43: PROJECTS INCLUDED IN THE 2005 AND 2010 C/A PROJECT BUILD NETWORK

Highway	Reason for inclusion
Projects Built Before 2005	
Route 53, Phase I (Hanover)	X
Blue Hill Avenue Signal Coordination	X
Brighton Avenue Signal Coordination	X
Marrett Road Signal Coordination	X
Beverly Salem Bridge	X
Route 20, Segment 1 (Marlborough)	X
Route 20, Segments 2 & 3 (Marlborough)	X
I-495 Interchange (Marlborough/Southborough)	X
I-93/Industriplex Interchange (Woburn)	X
Quincy Center Concourse, Phase I (Quincy)	X
Route 62 and Middlesex Turnpike (Burlington)	X
Route 9 (Wellesley)	X
Route 138 (Canton)	X
Bridge Street – Boston to Flint (Salem)	X
Massachusetts Avenue/Lafayette Square (Cambridge)	X
Cambridgeport Roadways	X
I-95(SB)/Dedham Street Onramp (Canton)	X
Route 140 (Franklin)	X
Route 139 (Marshfield)	X
Route 38 (Wilmington)	X
Route 1 and Associated Improvements	X
Route 3 North	X
Central Artery	X
Ted Williams Tunnel	X
South Boston Bypass Road (aka Haul Road)	X
Leverett Circle Bridge (Charlestown)	X
HOV Lane on I-93 (Mystic Avenue)	SIP
HOV Lane on Southeast Expressway	SIP

TABLE 2-43: PROJECTS INCLUDED IN THE 2005 AND 2010 C/A PROJECT BUILD NETWORK (CONTINUED)

Highway	Reason for inclusion
Projects Built Between 2005 and 2010	
Bridge Street Bypass (Salem)	X
Route 53 (Hanover)	X
Burgin Parkway (Quincy)	X
Route 53/228 (Hingham & Norwell)	X
Crosby Drive (Bedford)	X
I-93/Ballardvale Street (Wilmington) partial interchange	X
Transit	
Projects Built Before 2005	
Amtrak Northeast Corridor Electrification	X
Route 128 Amtrak Station	X
Amtrak Service to Portland, Maine	X
Mattapan Refurbishment	X
Industriplex Intermodal Center (Woburn)	X
Airport Intermodal Transmit Connector	X
Urban Ring bus service (CT1, CT2, CT3)	CAT/SIP study
Additional Park and Ride Spaces	SIP/CAT/ACO
South Station Transportation Center	SIP/CAT
Commuter Boat Service in the Inner Harbor	CAT
Newburyport Commuter Rail Service	SIP/CAT
Old Colony Commuter Rail (two lines)	SIP/CAT
Worcester Commuter Rail, full service	SIP/CAT
Worcester Commuter Rail, new stations	ACO
Silver Line – Transitway, Phase 1	SIP/CAT/ACO
Silver Line – Washington Street, Phase 2	CAT/ACO
Low Emission Buses	ACO
North Station Improvements	SIP/CAT
Bus Service Improvements to the North Shore	Substitute
Hingham Ferry	Substitute
Improved service on the Haverhill Commuter Rail Line	Substitute
New Commuter Rail Station at JFK/UMASS Station	Substitute
Projects Built Between 2005 and 2010	
Blue Line Platform Lengthening	X
Greenbush Commuter Rail Service	X
Peabody Express to Logan and Logan Express from Anderson	X
Fairmount Phase I - ACO requirements	X

Notes:
X = Also included in No Build Network
SIP = Projected included in the Transit System Improvements Regulation of the SIP
CAT = Project included in the Certification of Tunnel Ventilation System Regulation
ACO = Project included in the Administrative Consent Order
Substitute = Project approved as a substitute to the Old Colony Greenbush project
Delayed transit projects including Blue Line Platform Lengthening, Green Line extension to Medford Hillside and Union Square, Old Colony Commuter Rail extension to Greenbush, and additional Orange Line vehicles were not included in the No Build or 2005 Build Networks.

There are other transportation related components contributing to VOC emissions, which cannot be handled directly within the model. These are:

- The pollutants emitted by the Diesel Locomotives of the commuter rail system
- The pollutants emitted by the MBTA bus system
- The pollutants emitted by the commuter ferries

The pollutants from the categories above can be estimated outside of the model and included with the vehicular emissions calculated within the model. The following paragraphs describe the general off-model procedure that was used to handle these categories.

2.7.3.3 Procedure for Off-Model VOC Analysis

Commuter Rail Diesel Locomotives

The CTPS approach involved the following steps:

- Obtaining the current train-miles run by the MBTA per day.
- Estimating the number of train-miles to be run per day for 2005 on all the existing rail lines as well as on all future extensions and new services such as the Old Colony lines based on the MBTA's future service plan.

Using the emission factors developed by the EPA, and the number of train-miles, the amount of VOC emitted by the commuter rail system were estimated for 2010. The emission factors developed by EPA are based on the total diesel fuel consumption by the entire MBTA's commuter rail system. Therefore, the pollutants emitted during the long idling periods have also been figured into the calculations.

MBTA'S Diesel & CNG Buses

The bus emissions were calculated in the same way as the commuter trains but with an emission factor specific to the bus fuel type. The bus emission factors for 2010 were calculated from the MBTA's most current schedule information.

Commuter Ferries

The daily VOC emissions for the year 2005 were estimated based on fuel consumption supplied by the ferry operators, and the EPA pollutant emission factors for marine gas and diesel engines. Since there have been no significant changes in ferry operations within the CTPS modeled area; and there are no current data available on ferry fuel consumption to provide a 2010 emission estimates for actual ferry operations, the emissions reported in 2005 are reported for 2010 operations.

2.7.4 VOC Analysis Results

The results of the VOC regional analyses are presented for three different scales: Eastern Massachusetts Regional Planning Area (EMRPA) 164 community boundary, the MPO 101 community boundary, and the CA/T Project area.

Tables 2-44 to 2-47 provide the daily VMT and VOCs for the vehicular network and the off-network MBTA buses, commuter railroad, and ferries.

TABLE 2-44: NETWORK-BASED DAILY VMT (VEHICLES MILES TRAVELED) AND VOCS (KG/DAY)

Region	2005 CA/T Build		2010		Changes	
	VMT	VOC	VMT	VOC	VMT	VOC
EMRPA	121,016,208	81,734	122,226,370	50,990	1,210,162	-30,744
MPO	86,877,467	59,499	87,746,242	37,460	868,775	-22,039
CA/T	7,767,266	5,909	7,844,939	3,720	77,673	-2,189

TABLE 2-45: MBTA BUSES DAILY VMT AND VOCS (KG/DAY)

Region	2005 CA/T Build		2010		Changes	
	VMT	VOC	VMT	VOC	VMT	VOC
EMRPA	88,628	52.1	91,102	53.6	2,474	1.5
MPO	88,588	52.1	91,062	53.6	2,474	1.5
CA/T	10,001	8.2	10,280	8.4	279	0.2

TABLE 2-46: COMMUTER RAILROAD DAILY VMT AND VOCS (KG/DAY)

Region	2005 CA/T Build		2010		Changes	
	VMT	VOC	VMT	VOC	VMT	VOC
EMRPA	15,509	597	15,457	595	-52.0	-2.0
MPO	11,560	445	11,521	443	-39.0	-1.5
CA/T	1,258	48	1,254	47.8	-4.0	-0.2

TABLE 2-47: FERRY DAILY FUEL CONSUMPTION AND VOCS (KG/DAY)

Region	2005 CA/T Build		2010*		Changes	
	Fuel (gallons)	VOC	Fuel (gallons)	VOC	Fuel (gallons)	VOC
EMRPA	4,793	392.2	4,793	392.2	0	0
MPO	4,793	392.2	4,793	392.2	0	0
CA/T	1,598	130.7	1,598	130.7	0	0

* 2010 emission data unavailable; 2005 data reported.

Table 2-48 provides the total cumulative (motor vehicle and transit) VMT and VOC which results in a net reduction of VOC with the CA/T Project and transit commitments.

TABLE 2-48: TOTAL DAILY VOC EMISSIONS (KG/DAY)

Region	2005 CA/T Build	2010	Changes
EMRPA	82,775.3	52,030.8	-30,744.5
MPO	60,388.3	38,349.3	-22,039.0
CA/T	6,095.9	3,906.9	-2,189.0

The results (provided in Table 2-48) demonstrate that the 2010 total estimates for the CA/T area result in a reduction 2,189 kg/day of VOC with respect of the 2006 established VOC budget of 6,095.9 kg/day.

This reduction of approximate 36 % remains very similar for all three regional scales evaluated, despite an increase of approximately 1% in VMT for the five year period.

The emission reductions are the result of cleaner vehicles and fuels mandated by Federal and state regulations over the past decade. As older vehicles are retired and become a smaller contributor to the overall driving and VMT, newer and cleaner vehicles with better emissions control technologies account for a larger share of the VMT and result in reduced regional VOC emissions.

2.8 PROPOSED OPERATING EMISSION LIMITS

The proposed operating emission limits are based on the compliance modeling and demonstration of compliance with the applicable standards at the emission limits as described above.

2.8.1 Full-Transverse Ventilation

In summary, the VB modeling results presented in this document are based on a set of hypothetical tunnel operating conditions. Although this hypothetical operating scenario was intentionally set at the highest pollution levels, the emission impact modeling results indicated that operation of the CA/T ventilation buildings will not cause or exacerbate a violation of the applicable NAAQS for CO, NO_2 or $PM_{2.5}$ or the MassDEP Policy Guideline Value for NO_2.

In order to allow for traffic growth in the tunnels and also to provide flexibility in operating the tunnel ventilation system, the following hypothetical tunnel operating conditions analyzed are proposed to be adopted as the VB operating emission limits:

TABLE 2-49: OPERATING LIMITS FOR VENTILATION BUILDINGS

Regulated Pollutant	Time Period	Emission Limits (for All VBs)
CO	1-hour and 8-hour*	70.00 ppm
NO_x	1-hour*	8.88 ppm
$PM_{2.5}$	24-hour	900 µg/m^3

* CO and NO_x limits remain unchanged from the 2006 Application

2.8.2 Longitudinally-Ventilated Exit Ramps and DST

TABLE 2-50: OPERATING LIMITS FOR LONGITUDINALLY –VENTILATED RAMPS*

Longitudinally Ventilated	One-Hour		Eight-Hour
Ramps	Source Level CO	Source Level NO_x	Source Level CO
	ppm	ppm	ppm
LC-S	52	6.64	39
SA-CN	70	8.88	70
CN-S	66	8.38	58
ST-CN no Parcel 6	70	8.88	70
ST-SA + Parcel 6	70	8.88	48
ST-SA no Parcel 6	70	8.88	51
CS-SA + Parcel 12	44	5.65	33
CS-SA no Parcel 12	56	7.14	46
CS-P	70	8.88	70
F	70	8.88	70
DST Configuration 1 (Full Build)	22	2.92	22
DST Configuration 2 (Partial Build)	22	2.92	23
DST Configuration 3A (Existing)	25	3.30	23

* CO and NO_x limits remain unchanged from the 2006 Application

2.8.3 VOC

The results of the regional modeling demonstrate that the 2010 CA/T Project emissions of 3,906.9 kg/day are well below the VOC Budget for the 2005 CA/T Build condition of 6,095.9 kg/day.

2.9 OPERATING CERTIFICATION CRITERIA

In summary, the data collected for the Operating Certification to date demonstrates that the operation of the CA/T Project, as currently constructed and operated, complies with 310 CMR 7.38(2) (a)-(c) in that the CA/T project does not cause or exacerbate a violation of the applicable NAAQS for CO, NO_2 or $PM_{2.5}$ or the MassDEP Policy Guideline Value for NO_2 and does not result in an actual or projected increase in the total amount of non-methane hydrocarbons estimated within the project area when compared with the 2005 emission budget.

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Part II – Compliance Monitoring Program

3 PROJECT COMPLIANCE MONITORING SYSTEM

3.1 MASSDEP 310 CMR 7.38(8) REGULATORY REQUIREMENTS

MassDEP Regulation 310 CMR 7.38(8) states the following requirements for vehicle emissions and vehicle traffic monitoring.

Emissions Monitoring

(a) "Any person who constructs and operates a tunnel ventilation system which is subject to the requirements of 310 CMR 7.38 shall, prior to commencing operation of the tunnel ventilation system or opening the project roadway for public use, develop and submit to the Department for review and approval an "Air Emissions Monitoring Protocol" and shall install and operate emissions monitoring and recording equipment in accordance with the approved protocol. Monitoring as approved by the Department shall be required at the exhaust stacks or exhaust plenums of VBs as well as at exit portals that utilize longitudinal ventilation. The Department will consider for approval hybrid monitoring systems that incorporate elements of the federal regulations for monitoring ambient air pollution, for monitoring stationary source emissions, and for pollutant emission trading (i.e., 40 CFR Parts 58, 60, and 75) as practicable, as well as statistical analysis, computer modeling, and innovative technologies. The "Air Emissions Monitoring Protocol" may also be modified with prior written approval of the Department."

Traffic Monitoring

(b) "Any person who constructs and operates a tunnel ventilation system which is subject to the requirements of 310 CMR 7.38 shall install, operate and maintain traffic monitoring equipment within the project area, the numbers and locations of which shall be determined in consultation with the Department."

3.2 EMISSIONS MEASUREMENT METHODOLOGIES

3.2.1 Applicability of 40 CFR Parts 58, 60 and 75

Unlike emissions from stacks at a power plant, the emissions from the CA/T's ventilation system is unique in that the system contains multiple exhaust stacks and portal emission sources that operate at multiple exhaust flow rates that move extremely large volumes of air. In addition, unlike the emissions from a power plant which emit much higher (i.e., greater) levels of pollutants, pollutant emission levels from any CA/T VB or longitudinally ventilated exit ramp, are much lower. The CEM system described in this section, is considered a hybrid type of system, which uses elements of both ambient air quality monitoring systems and continuous emission monitoring equipment required at power plants. As such, the CA/T's CEM system incorporates various elements of the federal regulations 40 CFR Parts 58, 60, and 75 as well as statistical analysis, computer modeling, and innovative technologies.

3.3 CONTINUOUS EMISSIONS MONITORING SYSTEMS DESCRIPTION

3.3.1 Monitoring Locations for Ventilation Buildings

The pollutant levels are measured at the discharge points for each ventilation zone. Since each exhaust fan has its own exhaust stack, there are more stacks than ventilation zones for each VB. In general each ventilation zone feeds two or three exhaust fans (depending on air flow to be delivered). As examples: there are six exhaust stacks at VB 6 serving two ventilation zones; and 14 stacks at VB 7 serving five ventilation zones. This duplication provides redundancy and sufficient ventilation capacity during the times when fans have to be taken out of service due to maintenance or repairs.

The number of exhaust fans in operation at a given time depends on the control of airflow to and from various section of the tunnel. This is accomplished by the ventilation control system. The amount of ventilation depends on the in-tunnel CO measurements, which are dependent on the traffic characteristics. As such, the amount of the airflow exhausted through each stack could vary from zero to full exhaust capacity depending on the number of operating fans.

In general, there are always some fans in stand-by mode. Therefore, it was not considered cost effective to install equipment to continuously monitor emission levels at each stack, when only some are in simultaneous operation. Instead, vehicular emissions in the tunnel are monitored in the exhaust plenums of each ventilation zone prior to being diverted up and out of the building stacks. This captures the totality of exhaust emissions before they are diverted into a particular stack.

The CO monitoring system employs a "rake probe" to gather the samples. The probe consists of a length of one half inch Teflon or stainless steel tubing. Each of the probes had 8 equal distant holes drilled so that they allowed for sample collection along the entire width of the ventilation plenum. The probe is oriented so that the 8 holes are directed into the direction of flow of the source stream.

The $PM_{2.5}$ (PM_{10} for years 2006-2011) monitoring system also is deployed at the exhaust plenums, but has a single inlet probe at the center of each exhaust plenum. The flow in the plenum is very turbulent (high Reynolds number) and the exhaust stream is expected to be well mixed. This was demonstrated by the results of tests performed during 2003/04 with multiple portable MiniVOL samplers.

There are possible mechanisms that could lead to particle size stratification, but these mechanisms are not significant in the turbulent environment of the ventilation system. PM is affected by gravity, interception (e.g. filtration), inertial separation/ impaction, electrophoresis, thermophoresis and diffusion. Each of these mechanisms could affect different sizes of PM, but as discussed below, it is very unlikely that the turbulent environment of the plenums will change the outcome of the 2003/04 test results.

- Gravitational settling will act more strongly on the heavier PM_{10} particles than on $PM_{2.5}$. if PM_{10} is uniform and well mixed across the plenum, then $PM_{2.5}$ is expected to be likewise uniform.
- Interception is more likely to deplete PM_{10} than $PM_{2.5}$, however there are no filters or other structures in the plenum that are significant sites for interception, so this mechanism is expected to be insignificant.
- Differential inertial separation/impaction of $PM_{2.5}$ and PM_{10} could occur when there is a sharp bend in the ductwork and the heavier PM_{10} particles are preferentially carried to the outside of the bend by inertia. Since PM_{10} is uniform in the plenum, inertial separation is not occurring for particles of PM_{10} size and smaller.
- Electrophoresis and thermophoresis would affect the smaller $PM_{2.5}$ particles more than PM_{10}, but there are no strong electric fields or temperature gradients across the well mixed plenum to cause these effects.
- Diffusion in the plenum is dominated by turbulence caused by the forced movement of air. The turbulence has resulted in well mixed, uniform distribution of PM_{10} and will also result in a uniform distribution of smaller particles ($PM_{2.5}$) and gases.

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3.3.2 Monitoring Locations for Longitudinal Ventilation

The plume of air that escapes from these tunnels in the wake of exiting traffic maintains its integrity for a distance downstream of the exit portal due to the momentum created by the moving cars. Due to the well mixed turbulence of this plume, the pollutant concentrations inside a cross section of these ramps are fairly uniform.

The CO monitoring system employs a similar "rake probe" with eight equal distant holes to gather the samples. Such probe is located across the roadway at the tunnel ceiling level approximately 100 feet inside each exit portal (Figure 3-1). These measurements provide an average of the in-tunnel CO levels before exiting to the atmosphere.

FIGURE 3-1: CO CEILING MONITORING PROBE AT DST

A CEM PM_{10} monitoring system is also deployed just outside the east portal of longitudinally ventilated exit ramp CS-SA. This monitor measured ambient PM_{10} concentrations in the vicinity of ramp CS-SA, and $PM_{2.5}$ levels as a pilot program during several months of 2009-2010 It is being deployed as a permanent monitor to measure $PM_{2.5}$ ambient levels.

3.3.3 CO Monitoring System

The CEM equipment used to measure and/or record CO levels is described below. The tunnel ventilation CO monitoring system is independent of the CEM monitoring system. The tunnel ventilation monitoring system is used to maintain safe air quality and visibility within the tunnels and to control smoke and heat in emergencies.

3.3.3.1 Ventilation Buildings and Longitudinally Ventilated Exit Ramps

The CO CEM systems located at VBs 1, 3, 4, 5, 6 and 7 and longitudinal ventilated exit Ramps L-CS, CN-S, SA-CN, CS-SA, ST-SA/ST-CN, CS-P, DST-I93, DST-I-90 and F, consists of the following equipment:

- Non-Dispersive Infrared Continuous CO Gas Analyzer with a detection range of 0 parts per million to 150 parts per million,
- Multi-Gas Calibration System,
- Zero Air Generator,
- System Controller/Data Logger,
- CO Calibration Gas - RATA Class.

3.3.3.2 CEM Equipment Housing

All CEM equipment located at the CA/T VBs are rack mounted in NEMA certified 12 enclosures (Figure 3-2). CEM equipment located in applicable roadway utility rooms for longitudinally ventilated exit ramps are rack mounted in NEMA certified 4x enclosures (Figure 3-3).

FIGURE 3-2: CO AND $PM_{2.5}$ MONITORING UNITS AT VB 7 EXHAUST

FIGURE 3-3: CO MONITORS LONGITUDINALLY FOR VENTILATED TUNNELS

3.3.3.3 Sample Probe / Sample Transport / Sample Conditioning

The sample probe for the CO emissions monitoring system for both VBs and longitudinally ventilated exit ramps are constructed of stainless steel tubing. The sample probe is installed across each applicable VB's exhaust plenum and in the ceiling of longitudinally ventilated exit ramps in a location so that it is positioned in the stream of air being exhausted through the plenum prior to being diverted up each vent building exhaust stack or out the exit portal of a longitudinally ventilated exit ramp. The probe has eight 1/8-inch diameter holes drilled into it at equal distances along the entire length of the probe. There are no sampling holes located within 3 feet of any exhaust plenum or exit ramp wall. Each sample line is positioned in the exhaust plenum perpendicular to the direction of airflow in the plenum, which ensures that the full cross-sectional airflow within an exhaust plenum is being sampled.

The calibration system that is used to calibrate each CO analyzer uses cylinders of CO gas and a "zero" air source. The CO calibration gas used has been certified according to the EPA RATA procedures. The "zero" air source uses a zero air generator. Zero air and CO gas is diluted using a multi-gas calibration system. The calibration system is capable of controlling and mixing the CO calibration gas stream with the zero air stream to produce concentrations over the entire range of the analyzer. The calibration system supplies calibration gas through the calibration line to the sample probe at the calibration flow rates that range between 10 and 15 standard liters per minute (slpm). Calibration gases are injected through the entire sample line so that the sample line pump is constantly drawing an adequate calibration sample to the CO analyzer.

The sample/calibration bundle is comprised of two Teflon lines. The sample lines are connected to each sample probe, through a particulate filter (at the probe end of the line). The sample is drawn from the probe by a positive displacement pump that discharges to a tee. One leg of the tee is connected to an atmospheric vent and the other leg of the tee is connected to a fine particulate filter just prior to entering a CO analyzer. The sample line pump is set to operate so that the velocity in the sample line is sufficient so that sample residence time in the sample line is always less than 20 seconds. The second line in the sample/calibration bundle is a Teflon line that is connected from the calibration system to the sample probe.

3.3.4 $PM_{2.5}$ Monitoring System

$PM_{2.5}$ levels in the full-transverse ventilated section of the CA/T roadway are monitored continuously in key locations in the exhaust plenums before the exhaust air is diverted up through the VB exhaust stacks to the outside atmosphere. There are no continuous $PM_{2.5}$ CEM monitors located inside longitudinally ventilated exit ramps. At longitudinally ventilated exit ramp CS-SA, a CEM $PM_{2.5}$ monitor is located just outside the exit portal to the top of the ramps boat-wall section. This location is representative of the ambient $PM_{2.5}$ conditions close to the traffic emerging from the I-93 southbound and local traffic data in the CA/T surface corridor.

3.3.4.1 VBs and Longitudinally Ventilated Exit Ramp

The PM_{10} CEM monitoring system located at VBs 3, 5 and 7 and longitudinally ventilated exit Ramp CS-SA, consists of the following equipment:

- A continuous $PM_{2.5}$ sampler with a detection range of 0 micrograms per cubic meter to 5,000 micrograms per cubic meter,
- System Controller/Data Logger.

$PM_{2.5}$ CEM equipment located at VB 3 is continuously monitoring particulate emissions from vehicles traveling on north and southbound I-93 tunnel sections. $PM_{2.5}$ equipment located at VB 5 and VB 7, continuously monitor $PM_{2.5}$ emissions from vehicles traveling on east and westbound I-90 tunnel sections.

3.3.4.2 Monitoring Locations and Housing

The PM_{10} sensor units at VBs 3, 5 and 7 are housed in a NEMA certified 4x enclosure located in the exhaust plenums of each VB. The $PM_{2.5}$ sensor unit located at longitudinally ventilated exit ramp CS-SA samples air outside of the exit portal of the ramp itself. The intent of this monitor was to measure ambient $PM_{2.5}$ levels in the vicinity of the longitudinally ventilated exit ramp. This ramp was selected because of its close proximity to a residential community and because of the highest potential impacts predicted at the sensitive receptors in the wind-tunnel study.

3.3.5 Data Acquisition and Handling System

Data from the CO and $PM_{2.5}$ CEM systems located at VBs 1, 3, 4, 5, 6 and 7 and longitudinal ventilated exit Ramps L-CS, CN-S, SA-CN, CS-SA, ST-SA/ST-CN, CS-P, DST-I93, DST-I-90 and F, is recorded using a System Controller/Data Logger (data logger) at each location. The data loggers constitute the Data Acquisition Handling System (DAHS) for each CEM location. The data loggers control the calibration routines for the CO analyzers and records of all CO and $PM_{2.5}$ concentrations on a hourly/daily basis.

3.4 CONTINUOUS EMISSIONS MONITORING SYSTEMS INITIAL CERTIFICATION

The CA/T's ventilation system is unique in many ways. As such, the certification process performed for monitoring the emissions from the ventilation system is also unique in its application to the Project's ventilation system. Equipment certification and operations were specifically tailored for use in the Project's emissions monitoring program and reflect the unique application for which the equipment is being used.

3.4.1 CO Monitoring System

3.4.1.1 CO Analyzer Multi-Point Calibration Test

The CO analyzers that are used to monitor CO concentration in the exhaust plenum and at the longitudinally ventilated exit ramps, were calibrated using the system dilution calibration device at zero (0) concentration and at four (4) calibration points over the range of the instrument. Calibration concentrations were: a high value 100-135 ppm, a mid-range 45–75 ppm, a low-range 20–30 ppm, and a low-low-range 5-10 ppm. Calibration gas was injected directly into each CO analyzer. The instruments were adjusted first at the zero level and then at the high value. After each instrument was adjusted at the high value, the zero level was injected again. If the zero level required re-adjustment, then the high level concentration was injected again. If necessary, several iterations between the zero and high level concentrations were performed to ensure that an analyzer was calibrated. The calibration specification for acceptability was ±1.0 ppm for zero and ±5% of the input concentration for the high level point. All remaining concentrations levels were injected without any further analyzer adjustments. The average Δ% for calibration points were not allowed to exceed ±5% where:

$$\Delta\% = \frac{(\text{Analyzer Response} - \text{Input Concentration})}{\text{Input Concentration}} \, x \, 100$$

Where :

Analyzer Response = Concentration recorded by an analyzer

Input Concentration = Input calibration gas concentration

3.4.1.2 Cycle Time and Linearity Test

For this test, all monitoring systems were operated in their normal sampling mode, including the time sharing mode for the equipment located at VB 7.

Low-level calibration gas with a value of 40 to 50 ppm were input through the entire monitoring system for 30 minutes, or until a stable response was achieved. At the end of the period, a high-level calibration gas with a value of 80 to 90 ppm was input through the entire monitoring system for 30 minutes or until a stable response occurred.

The amount of time it took for 95% of the step change to be achieved between a stable low level and high-level calibration gas response was determined. The cycle time test was successful was the response time achieved was less than 15 minutes.

The linearity of the monitoring system to the low and high scale calibration gases was also tested during the cycle time test. To pass the linearity test, the monitoring system response had to be within ±5% of the low and high-level calibration gas input values using the formula:

$$\text{Linearity } \Delta\% = \frac{(\text{System Response} - \text{Input Concentration})}{\text{Input Concentration}} \, x \, 100$$

Where:

System Response = Concentration recorded by the analyzer when the calibration gas is injected through the entire system

Input Concentration = Input calibration gas concentration

3.4.1.3 Seven-Day Calibration Drift Test

The calibration drift of each monitoring system was measured once a day (approximately 24 hours apart) for seven consecutive days using zero and span gases. No manual or automatic adjustments were made to any analyzer until after recording all responses.

To pass the seven-day drift test for the zero point, each analyzer's zero drift could not be greater than $\pm$1% (1.5 ppm) of the analyzer full-scale range (150 ppm) per day. Drift for the span gas was calculated as follows:

$$\text{Calibration drift} = \frac{(\text{Analyzer Response} - \text{Input Concentration})}{\text{Input Concentration}}\, x\, 100$$

Where :

Analyzer Response = Concentration recorded by the analyzer

Input Concentration = Input span gas concentration

To pass the seven-day drift test for the span gas, each analyzer's span drift could not be greater than $\pm$5% of the span value per day.

3.4.1.4 System Bias Test

After each CO analyzer was calibrated, a system bias check was performed. The high-level calibration concentration was injected through the entire emission monitoring system. The acceptable system bias was ±5% according to the equation:

$$\text{System Bias} = \frac{\text{System Response} - \text{Direct Analyzer Response}}{\text{Direct Analyzer Response}} \quad x \quad 100$$

Where:

System Response = Concentration recorded by the analyzer when the calibration gas was injected through the entire system

Direct Analyzer Response = Concentration recorded by the analyzer when the calibration gas was injected directly into the analyzer

3.4.2 $PM_{2.5}$ Monitoring System

Tests will be performed on each $PM_{2.5}$ unit located at VBs and outside longitudinally ventilated exit Ramp CS-SA and will consist of calibration/certification of each particulate monitoring system, including the calibration of the main and auxiliary flow rate, the on-board temperature sensor, and the barometric pressure sensor by its referenced standard. In addition, verification of the Ko constant of each $PM_{2.5}$ unit mass transducer taper element will be conducted by using five pre-weighed filters. [The $PM_{2.5}$ monitoring units will become operational after December 22, 2011 when the Operating Certification is renewed.]

In all cases, the manufacturer recommended procedures specified in the $PM_{2.5}$ unit's operating manuals were applied for all certifications tests. Reference standards used were either primary standards or working standards traceable to National Institutes of Standards and Technology (NIST).

3.4.2.1 K Factors

% Error of Ko = 100 x (Average Ko – Actual Ko) /Designated Flow

The allowable Ko error ± 2.5%.

3.4.2.2 Flow

% Error of Flow = 100 x (Average Flow – Designated Ko)/Designated Flow

The allowable flow error is ± 7%.

3.4.2.3 Temperature and Barometric Pressure

Error = Display Value – Audit Value

The allowable temperature error is ± 2^{o}C. The allowable barometric pressure error is ± 10 mm Hg.

3.4.3 Continuous Emissions Monitoring Certification Data Submittal

Results for certification tests performed on CO CEM equipment (i.e., multi-point calibration, cycle time/linearity, seven-day drift and system bias) and $PM_{2.5}$ CEM equipment (i.e., K-factor, system flow and temperature/barometric pressure), are presented in Appendix D, "CEM Certification Test Data".

3.5 TRAFFIC MONITORING

The CA/T Project has an extensive array of video cameras to monitor traffic conditions through the entire project. The main function of this centralized system, which is operated by the HOC, is to monitor real time traffic conditions to assist the HOC operations in conducting safe tunnel operation.

There are four locations where hourly traffic volumes are recorded, as follows:
- I-93 southbound in the vicinity of Causeway Street
- I-93 northbound in the vicinity of South Station
- I-90 westbound in East Boston
- I-90 eastbound in the vicinity of Fort Point Channel

These locations represent the tunnel sections that account for the vast majority of the Project's traffic volumes, and as such, they provide MassDEP with a very good indication of the peak hourly and daily traffic volumes passing thru the CA/T tunnels.

4 CONTINUOUS EMISSIONS MONITORING PLAN

4.1 PROJECT-WIDE QUALITY ASSURANCE/QUALITY CONTROL PROGRAM

This section describes the overall quality assurance (QA) and quality control (QC) program for the continuous air emissions monitoring portion of the long-term Compliance Monitoring Program for the CA/T Project. CEM equipment currently in-place for CA/T's Operating Certification, along with specific information regarding the CEM QA/QC program, are described in Attachment 1, "CEM Air Emissions Monitoring Protocol" to this document.

The QA/QC program sets forth, among other things, the procedures to be followed and the criteria to be met, where applicable, for:
- Operating, maintaining and calibrating the CEMS equipment and related components,
- Determining the quality of the measured data, and
- Developing emissions-related parameters or directly reporting the measurement results to the MassDEP in order to demonstrate project compliance status with respect to the ambient concentration limits in 310 CMR 7.38(2)(a).

The QA/QC program has been developed through extensive technical consultation with the MassDEP taking into consideration Federal Regulations 40 CFR Parts 58, 60 and 75. The procedures to be followed also take into account equipment manufacturer's recommendations as well as good engineering practice.

4.1.1 Quality Assurance/Quality Control – Definition and Function

QA, as it relates to the continuous air emissions monitoring program for the CA/T Project, represents those planned or systematic activities, independently performed, that are required to ensure that the measurements made and the data reported to regulatory authorities are representative, acceptably accurate, and supported by defendable documentation.

QC, as it is to be implemented for this monitoring program, represents the series of routine and periodic operational activities (based on regulatory requirements, good engineering practice, and the agreed-upon approach for this hybrid monitoring system) that are necessary for maintaining and improving data quality and the instruments and systems that produce that information.

QA checks also serve to ensure that the QC function is not only being implemented properly, but that it is adequate to the task, such that when (or even before) data accuracy or documentation becomes unacceptable, actions are taken to identify and resolve the issues or procedural steps affecting data quality until acceptable performance is once again achieved. Periodic review of implementation and documentation are typically referred to as "Systems Audits".

Corrective action encompasses both internal policies and regulatory requirements. This QA/QC program focuses primarily on the corrective actions required to return an out-of-control system or component back to a status of compliance, but, it also acknowledges the need for periodic review of the CEM Air Emissions Monitoring Protocol and related standard operating procedures (SOPs) based on accumulated operating experience and opportunities for improvement identified as a result of Systems Audits.

4.1.2 QA/QC Goals and Objectives

The goals of this QA/QC program are to collect measurement data of known and acceptable quality and quantity, and to generate and maintain the records required to demonstrate that the continued operation of the tunnel and exit ramp ventilation systems results in compliance with the air quality criteria set forth in 310 CMR 7.38(2)(a).

In order to do so, MassDOT is committed to installing, certifying, operating, maintaining and calibrating continuous emissions monitoring and related systems in accordance with applicable Commonwealth of Massachusetts regulations at 310 CMR 7.38(8) and 7.38(9), agreed-upon requirements adapted from Federal regulations conditions in the CA/T Project's Operating Certification, the QA/QC program laid out in Attachment 1, and good engineering practice.

4.1.3 Organization and Responsibilities

This section summarizes key personnel, responsibilities and organizational structure for the continuous air emissions monitoring portion of the long-term Compliance Monitoring Program for the CA/T Project which is established pursuant to 310 CMR 7.38 and implemented in accordance with the requirements of the CA/T's Operating Certification.

4.1.3.1 Director of Environmental Engineering

The director of Environmental Engineering is responsible for the overall implementation of the CEM Program described within.

4.1.3.2 Senior Environmental Engineer

The Senior Environmental Engineer is responsible for technical oversight of the continuous air emissions monitoring program and its execution. The Senior Environmental Engineer interfaces with the Director of Environmental Engineering in carrying out the planning and administrative responsibilities of that position and with QA Management to ensure that all program activities affecting data quality are performed and documented in accordance with the CEM Air Emissions Monitoring Protocol and the applicable SOPs. The Senior Environmental Engineer also serves as technical liaison between the MassDOT and representatives of the MassDEP and other regulatory agencies in regards to the monitoring program and the reported results.

Regarding implementation of the monitoring program, the duties of the Senior Environmental Engineer encompass:

- Procurement of equipment, related components and materials;
- Training and supervision of air quality staff, participating in the operation, maintenance and calibration of the CEMS equipment and related components, and interpreting CEMS output by the DAHS;
- Ensuring that routine and periodic QC inspections, instrument response checks, calibrations and adjustments are performed and documented as required;
- Verifying that measurement and QC check data are recorded and reviewed on a regular basis, and that measurement data are reduced and validated properly;
- Review, approval and timely submittal of monthly (first year of full operations only) and quarterly (thereafter) reports of CEMS data and QC check results;
- Supporting periodic independent and third-party QA Performance and Systems Audits in coordination with QA Management, regulatory agencies (as applicable), and any subcontractor(s) that may conduct such work;
- Review and timely submittal of semi-annual QA Performance Audit and annual Systems Audit reports;
- Resolution of any issues resulting from routine operations, maintenance, QC checks or QA audits, evaluating the need for Monitoring Plan revision in coordination with QA Management and, when required, revising the CAEMP or the accompanying SOPs;
- Daily review of CO and $PM_{2.5}$ measurement data and periodic review of calculated NO_x concentrations for each monitoring location in relation to the corresponding Operating Certification limits, traffic volumes and tunnel operating conditions;
- Regular review of QC check results (i.e., daily CO analyzer response checks) versus applicable acceptance criteria and action limits;
- Routine processing and summarization of measured hourly average CO concentrations, calculated hourly average NO_x concentrations, daily (24-hour) average $PM_{2.5}$ measurements, and daily and periodic QC check results;
- Validation of CO and $PM_{2.5}$ measurement data based on operating status of analyzers and related instrumentation, and the results of daily QC response checks (CO only), other periodic QC checks (e.g., multi-point calibrations, flow rate verifications), and periodic QA Performance Audits;
- Preparation of monthly (first year of full operations only) or quarterly (thereafter) reports of CEMS data, QC check results, and excess emissions (if any) in accordance with 310 CMR 7.38(9)(a)(2);
- Supporting preparation of semi-annual QA Performance Audit reports and annual QA Systems Audit reports;

- Retaining all measurement data, results of periodic QC checks and QA Performance and Systems Audits, and other related documentation (e.g., records of routine and periodic inspections and preventive maintenance) for a period of at least five years in accordance with 310 CMR 7.38(9)(a)(1);
- The conduct of periodic independent QA Performance Audits - for example, semi-annual multi-point calibration response and bias checks of the CO analyzers, and semi-annual verification of PM_{10} mass transducer calibration and flow audit response;
- The performance of annual independent QA Systems Audits of monitoring program implementation and related documentation;
- The scheduling and conduct of any third-party (i.e., regulatory agency) QA Performance or Systems Audits; and
- The preparation and review of the corresponding QA Performance and Systems Audit reports.

If necessary, Data Management responsibilities may be integrated with the responsibilities of the Senior Environmental Engineer and/or his designee (e.g., Environmental Engineer, Environmental Technicians).

4.1.3.3 Environmental Engineer and Environmental Technicians

The Environmental Engineer with the assistance of the Environmental Technicians, working with direction from the Senior Environmental Engineer, is responsible for routine operation, maintenance and calibration of the CEMS and all related components. In this regard, the duties of the Environmental Engineer and Environmental Technicians include:

- Inspection of the CEMS equipment and shelters on a regular basis (e.g., analyzer and equipment settings and readouts, alarms appearing on instrumentation or generated by the DAHS, calibration gas bottle pressures and inventory, general housekeeping);
- Completing periodic (e.g., weekly, monthly, semi-annual, annual) preventive maintenance items on the CEMS and related equipment;
- Maintaining an adequate inventory of spare parts and consumable items such that instrument downtime is minimized to the extent practicable;
- Conducting and/or evaluating periodic QC checks – for example, daily, quarterly, annual checks of CO analyzer response and calibration gas dilution system flow meter accuracy, and quarterly, semi-annual and annual verifications and/or calibrations of $PM_{2.5}$ monitor flow rate and related flow or measurement system components; and
- Supporting independent semi-annual QA Performance Audits and annual QA Systems Audits, or other third-party (e.g., MassDEP) audits.

As indicated at the end of the preceding subsection, the Environmental Engineer and/or Environmental Technicians may undertake some of the Data Management responsibilities if so assigned by the Senior Environmental Engineer.

4.1.4 Document Distribution and Control

As a matter of practicality, copies of the Continuous Air Emissions Monitoring Plan will not be placed at each continuous emissions monitoring location simply because of the number of sites in the monitoring network. Rather, distribution of the CEM Air Emissions Monitoring Protocol will be via Controlled Copy for those individuals and organizations with a need-to-know function that directly affects the successful implementation, management and/or oversight of the continuous air emissions monitoring program. Each Controlled Copy shall be sequentially numbered.

At a minimum, recipients of Controlled Copies of the CEM Air Emissions Monitoring Protocol (Attachment 1) will include:

- Director of Environmental Engineering
- Senior Environmental Engineer
- Environmental Engineer
- Environmental Technicians

Uncontrolled copies will also be distributed to individuals or organizations on an as-needed basis for informational purposes where casual familiarity with the monitoring program may be beneficial but is not essential. The Senior Environmental Engineer in coordination with the Director of Environmental Engineering shall approve such recipients.

Distribution of Controlled Copies of the CEM Air Emissions Monitoring Protocol, and revisions to it, will be documented on form MTA-ENV-FORM01. Recipients shall sign the distribution form, return the original to the Senior Environmental Engineer or designee, and retain a copy of the signed form. The signed original shall be retained by the Director of Environmental Engineering.

Distribution of Uncontrolled Copies of the CEM Air Emissions Monitoring Protocol shall be by formal transmittal letter or e-mail, as appropriate. Documentation of all such transmittals shall also be retained by the Director of Environmental Engineering.

The CEM Air Emissions Monitoring Protocol may be updated periodically as operational experience with the CEM system is gained, as the effectiveness of the SOPs and the staff's execution of them is demonstrated (as evidenced by the quality of the data and related documentation produced), and as evaluated through the results of periodic QA Performance and Systems Audits.

At a minimum, the CEM Air Emissions Monitoring Protocol will be reviewed annually by the Senior Environmental Engineer in coordination with QA Management; more frequently, if required (e.g., due to failure of multi-point calibrations or an intervening semi-annual QA Performance Audit during two consecutive calendar quarters, frequently occurring out-of-control periods).

Revisions to any requirement of the CEM Air Emissions Monitoring Protocol (e.g., the frequency of equipment and data inspections, instrument response checks, calibration checks and adjustments) or to SOPs shall be agreed upon by the Senior Environmental Engineer and QA Management before incorporation. All changes to the CEM Air Emissions Monitoring Protocol shall be clearly marked on each affected page with the Revision Number, Date and Page Number updated accordingly. Controlled Copies of the affected sections (or subsections), or an individual SOP shall be re-issued by the Senior Environmental Engineer with distribution and receipt to be documented as described above. The Senior Environmental Engineer or designee shall keep a chronological log that summarizes all such revisions.

The Senior Environmental Engineer will identify all parties directly affected by such revisions and will coordinate the necessary training to implement those changes in a timely manner. The appropriate mode of training shall be at the discretion of the Senior Environmental Engineer.

4.2 TRAINING

Training represents an essential element of a successful QA/QC program by identifying the objectives to be accomplished and by providing the basic knowledge required to successfully complete a procedure or task. In this QA/QC program, training takes the form of:

- General training,
- Specialized vendor training,
- Monitoring plan review, and
- Periodic refresher and specialized training

Training and subsequent implementation can also provide a more thorough understanding (over time) of a given task or procedure that enables the individual involved to make more timely and effective decisions while executing the process or improving on the process itself. Therefore, training is the cornerstone of the framework within which activities were performed in a consistent manner regardless of who completes them.

4.2.1 General Training

General training was not intended as much to deliver detailed and specific knowledge, as it is to provide an overall understanding of the goals and objectives of the CA/T Project's continuous air emissions monitoring program within the framework of the CEM Air Emissions Monitoring Protocol. General training is provided to all individuals directly involved with the CEM program.

4.2.2 Specialized Vendor Training

Specialized training in the installation, operation, maintenance and calibration of the various monitoring systems and related components will be provided to the Senior Environmental Engineer, and to the Environmental Engineer, Environmental Technicians, or other support staff, as appropriate, by the respective system vendors either at the time of or soon after initial installation of the equipment.

4.2.3 Monitoring Plan Review

All personnel involved in the routine operation, maintenance and calibration of the CEMS, related components, and related systems (e.g., the DAHS), or in the review, processing, validation and reporting of the data produced by those pollutant measurement systems will be required to review:

- The appropriate sections and/or Parts of this document (including the applicable requirements adapted from the regulations under 40 CFR Parts 58, 60 and 75), and
- The CEM Air Emissions Monitoring Protocol, SOPs and corresponding System Manuals.

4.2.4 Periodic Refresher and Specialized Training

Refresher training occurs periodically (e.g., following review of the effectiveness of the CEM Air Emissions Monitoring Protocol and accompanying SOPs).

When changes in personnel or assigned responsibilities take place, the degree of specialized training is tailored to the level of previous experience with the CA/T Project's continuous air emissions monitoring program, specific systems, and tasks to be performed. Specialized training in the operation, maintenance and calibration of the various monitoring systems and components may be conducted by the vendor or by previously trained in-house staff.

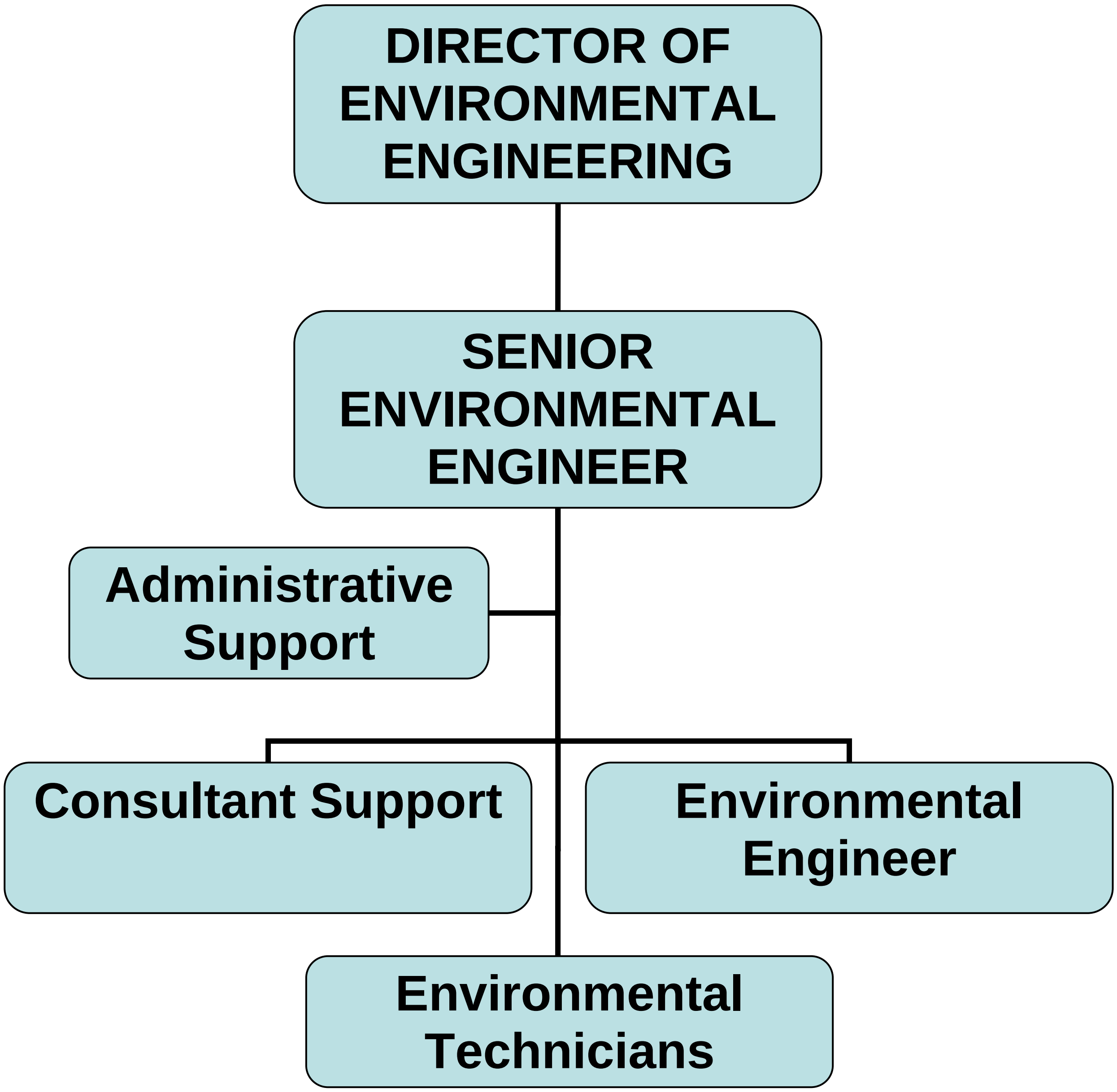
Finally, when system components change (e.g., the replacement of a pollutant monitor with an instrument that bases its measurements on a different analytical method – as opposed to the repair or replacement of a failed part) or software upgrades to the DAHS are made, specialized vendor training takes place for those personnel whose responsibilities or procedures are affected.

TABLE 4-1: KEY PERSONNEL AND RESPONSIBILITIES

Title	Responsibilities
Director of Environmental Engineering	• Overall implementation of the program
Senior Environmental Engineer	• Technical oversight of CEM program • Procure CEMS-related equipment/materials • Determine training needs of AQ staff and, as required, other program participants • Supervise Environmental Engineer and Environmental Technicians and support those responsibilities as needed • CEMS data and QC check report review/submittal • QA Performance Audit report review/submittal • QA Systems Audit report review/submittal • Revise CAEMP and SOPs (as necessary) and coordinate/conduct associated refresher training • Daily[1] data review • Data processing and validation • Prepare CEMS data and QC check reports • Support preparation of QA Performance and Systems Audit reports • Coordinate conduct of semi-annual/annual QA Performance Audits and annual QA Systems Audits • Coordinate preparation/review of Performance and Systems Audits reports
Environmental Engineer and/or Environmental Technicians	• CEMS operation, maintenance and calibration • Regular CEMS inspections[2] • Conduct quarterly, semi-annual and annual QC checks • Support independent QA Performance/Systems Audits

Notes:
1 – Data to be reviewed on a daily basis, nominally, during regular work week (Mon-Fri).
2 -- Each site to be visited 2 times, nominally, per regular work week (Mon-Fri).

FIGURE 4-1: ORGANIZATIONAL STRUCTURE FOR THE MASSDOT-CA/T PROJECT CONTINUOUS AIR EMISSIONS MONITORING PROGRAM



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Part III - Record Keeping and Reporting

5 DATA RECORDING AND REPORTING

5.1 MASSDEP 310 CMR 7.38(9) REGULATORY REQUIREMENTS

Massachusetts DEP Regulation 310 CMR 7.38(9) states the following requirements for record keeping and reporting:

"(a) Any person who constructs and operates a tunnel ventilation system on or after January 1, 1991 shall comply with the following record keeping and reporting requirements:

1. *All records and data from the continuous emissions monitors, recorders and traffic monitors shall be maintained for a period of five years. The most recent two years of data shall be readily available for Department inspection.*
2. *Emissions Reporting. For the first year of operations monthly reports shall be filed with the Department no later than 30 days following the end of the preceding calendar month. Said monthly reports shall contain a summary of continuous monitoring data showing any excursions from allowable emission limitations contained in the Department's acceptance of the certification. In the event any of the reported data shows an excursion of the emission limitations set forth in the acceptance of certification, a written explanation of any excursion shall be included. Evidence of each calibration event on the monitoring devices shall be included in such monthly reports.*
3. *Traffic Reporting. For the first year of operation monthly reports shall be filed with the Department no later than 30 days following the end of the preceding calendar month. Said monthly reports shall contain a summary of average daily and peak hour counts of vehicle miles traveled as well as average daily and peak hour vehicle speeds and vehicle hours traveled as identified through the traffic monitoring network established pursuant to 310 CMR 7.38(8).*
4. *Tunnel Ventilation System Maintenance. For the first year of operations monthly reports shall be filed with the Department no later than 30 days following the end of the preceding calendar month. Said monthly reports shall contain a summary of routine maintenance checks performed, repairs of ventilation equipment, amount of time during which ventilation equipment was not operating in accordance with standard operating procedures and measures taken to remedy this situation.*

(b) After the first year of operation, the reports required by 310 CMR 7.38(9) shall be submitted to the Department on a quarterly basis, with the first such quarterly report being due no later than 30 days after the end of the quarter and every three months thereafter."

5.2 CONTINUOUS EMISSIONS MONITORING MEASUREMENT DATA PROCESSING

As described in Sections 3.3.3 and 3.3.4, all CO and $PM_{2.5}$ CEM data are recorded using data loggers located at each CEM location. Data from each data logger are downloaded via a modem to a central computer. All CO and $PM_{2.5}$ data are reviewed edited as necessary and daily data summaries for each month are generated. Using the edited daily summaries, NO_2 emission concentrations are developed using the CO to NO_2 conversion ratio described in Section 2.4.5. At the start of the $PM_{2.5}$ monitoring, the reports will be submitted to MassDEP on a monthly basis from January through June 2012 and at a quarterly intervals thereafter.

5.3 TRAFFIC DATA PROCESSING

The HOC will record hourly volumes at the following locations:

- I-93 southbound in the vicinity of Causeway Street
- I-93 northbound in the vicinity of South Station
- I-90 westbound in East Boston
- I-90 eastbound in the vicinity of Fort Point Channel

Peak hourly and average daily traffic volumes at each of the four locations are reported to MassDEP on a quarterly basis. The data will also provide the monthly average daily volumes for each location. Figure 5-1 presents the peak and average daily traffic volumes for I-93 and I-90 in both directions from July 2006 to December 2010. Figure 5-2 presents the peak hourly volumes for the same locations and time periods.

5.4 TUNNEL VENTILATION SYSTEM MAINTENANCE RECORDS

Tunnel ventilation records for both routine and non-routine maintenance activities are logged and tracked through the Project's Maintenance Management Information System (MMIS). As described in section 1.2.1 each ventilation zone has multiple exhaust fans that serve that zone. Each zone can operate with one functioning fan. If however, multiple exhaust fans within a ventilation zone are to undergo repair that results in only one operating exhaust fan, MassDOT will notify MassDEP via monthly report as to the extent of the maintenance that will be performed and the duration of the repairs. The reports, if any, will be provided on a monthly basis for the first year of Operating Certification and on a quarterly basis thereafter.

5.5 CONTINUOUS EMISSIONS MONITORING DATA SUMMARY REPORTS

Starting in June 2006, the data were compiled and submitted to the MassDEP on a monthly basis for the period May 2006 through October 2007, and on a quarterly basis thereafter.

Annual summaries of the CO, NO_x and PM_{10} average and peak levels for each VB (Tables 5-1 to 5-6) and longitudinally ventilated section collected between 2006 and first quarter of 2011 are provided in Tables 5-7 to 5-16. The applicable emission limits for CO, NO_x and PM_{10} are also set forth in these tables.

The collected data presented in a summary form (Tables 5-1 to 5-16) indicates:

- Measured CO concentrations for the Ventilation Buildings range from 1.0 to 3.0 ppm on average, with maximum 1-hour values as high as 34 ppm;
- Measured concentrations for the DST and Ramps range from 1.0 to 4.0 ppm on average, with maximum 1-hour average concentrations ranging from 4.0 to 68.7 ppm;
- Measured NOx levels for the Ventilation Buildings range from 0.3 to 0.6 ppm on average, with maximum 1-hour values ranging from 1.0 to 2.2 ppm;

- Measured NOx levels for the DST and Ramps range from 0.3 to 0.75 ppm on average, with maximum 1-hour values ranging from 1 to 8.8 ppm;
- Measured PM_{10} concentrations were between 31 and 121 μg/m^3 on average, with maximum daily values ranging from 100 to 577 μg/m^3.

The PM_{10} monitor outside Ramp CS-SA, which measures ambient levels, recorded annual averages from 19 to 21 μg/m^3, and a maximum daily level of 116 μg/m^3.

The data indicate that the pollutant levels inside the tunnels are generally much lower than anticipated, with CO levels decreasing in the latter years. However, as described in detail in Section 6, there were a very few episodes for which the emission limits for CO or PM_{10} were exceeded.

These episodes when emission limits were exceeded were the result of abnormal conditions related to night-time tunnel closures due to maintenance, system malfunctions, and the effects of road salt application during snowstorms.

Based on the very low levels recorded during these past five years at Ramps ST-SA and F (maximum below 13 ppm CO versus an emission limit of 70 ppm), MassDOT will propose to reduce the quarterly reporting to annual reporting for these Ramps in the July 2012 Supplemental Application, assuming that the revised CO and NO_x emission limits will not include any major changes for these locations.

In accordance with condition to the MassDEP acceptance of the Operating Certification, $PM_{2.5}$ pilot monitoring program started in June of 2009 at two locations: at the I-93 exhaust plenum of the SB-1 served by VB3 and at the ambient monitor located adjacent to ramp CS-SA. The results of this monitoring are included in the Tables 5-2 and 5-10. The measured concentrations in the tunnel did not exceed 90 μg/m^3 and the concentrations outside Ramp CS-SA averaged approximately to 11 μg/m^3.

FIGURE 5-1: PEAK AND AVERAGE DAILY TRAFFIC VOLUMES FOR PERIOD 2006-2011

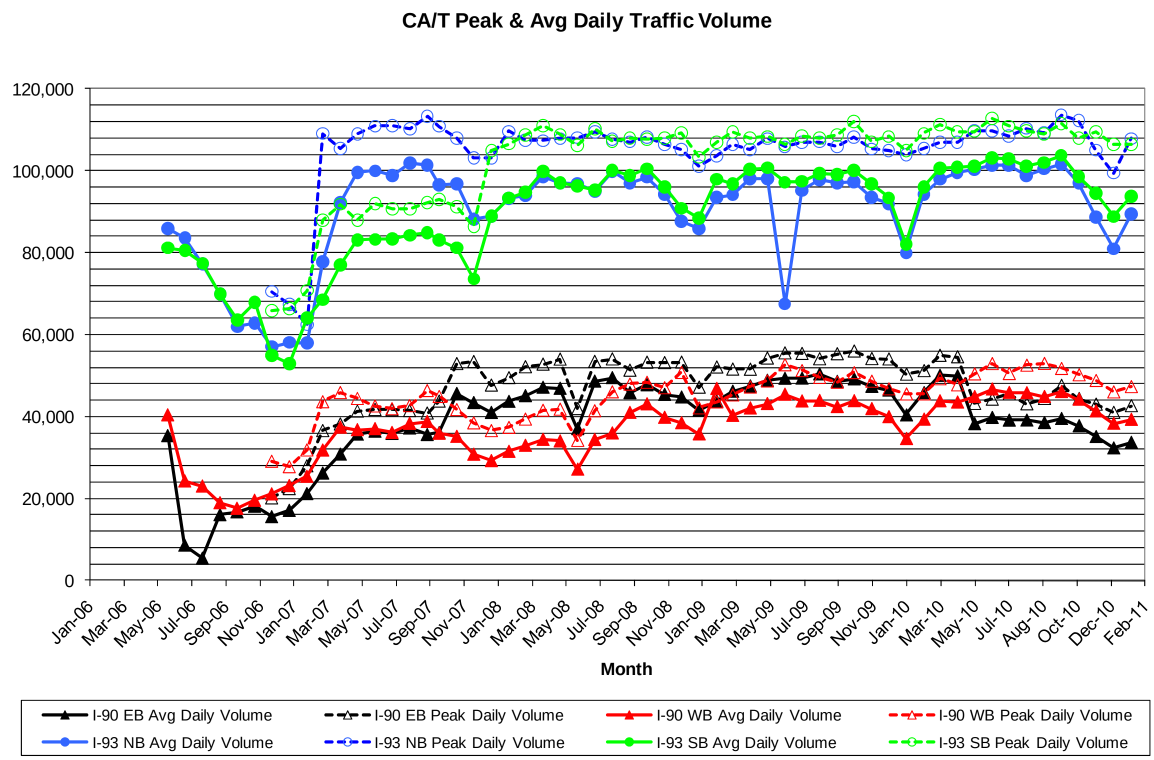

FIGURE 5-2: PEAK HOURLY TRAFFIC VOLUMES FOR PERIOD 2006-2011

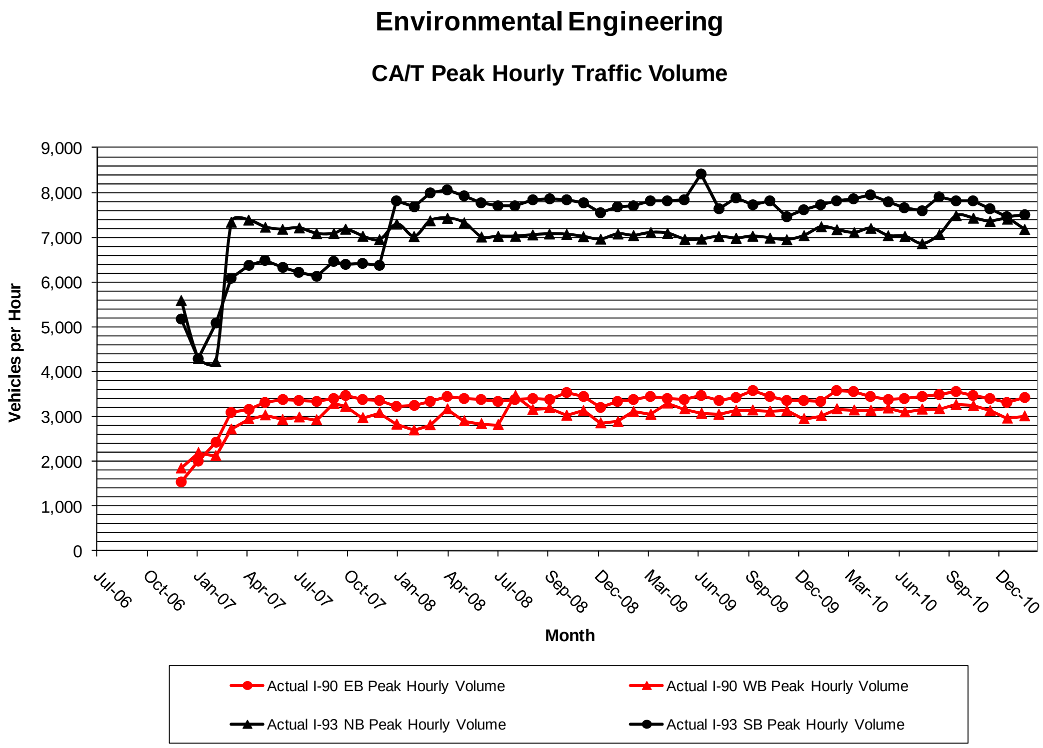

TABLE 5-1: SUMMARY OF CO, NO_X AND PM_{10} AVERAGE AND PEAK LEVELS: VENTILATION BUILDING 1

Monitor Location: *VB1 Exhuast Ducts 1 & 2 (Ramp L/HOV for I-90 EB)*

Pollutant	Time Period	Emission Limits	Parameter	Unit	2006	2007	2008	2009	2010	2011-1st Q
CO	1 Hour	70 ppm	Maximum	ppm	8.70	27.80	8.8	7.2	7.5	4.2
			Average	ppm	1.19	1.28	1.25	1.15	1.08	.73
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL							
	8 Hour	70 ppm	Maximum	ppm	5.1	5.1	3.5	3.2	3.5	2.2
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL							
NO_x	1 Hour	8.88 ppm	Maximum	ppm	1.6	3.6	1.3	1.1	1.1	.7
			Average	ppm	.33	.37	.33	.37	.32	.3
			Hours exceed EL		0	0	0	0	0	0
PM_{10}	24 Hour	500 ug/m^3	Maximum	ug/m^3	N/A	N/A	N/A	N/A	N/A	N/A
			Average	ug/m^3	N/A	N/A	N/A	N/A	N/A	N/A
			Days exceed EL		N/A	N/A	N/A	N/A	N/A	N/A
			Days exceed 80% EL		N/A	N/A	N/A	N/A	N/A	N/A

Monitor Location: *VB1 Exhaust Ducts 8 & 9 (Ramp L/HOV for I-90 EB)*

Pollutant	Time Period	Emission Limits	Parameter	Unit	2006	2007	2008	2009	2010	2011-1st Q
CO	1 Hour	70 ppm	Maximum	ppm	12.2	28.6	7.8	7.2	6.6	3.6
			Average	ppm	1.1	1.29	1.13	1.09	1.01	.9
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL							
	8 Hour	70 ppm	Maximum	ppm	5.6	6.5	3.5	3.2	3.2	3.4
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL							
NO_x	1 Hour	8.88 ppm	Maximum	ppm	1.7	3.7	1.2	1.1	1	.6
			Average	ppm	.31	.36	.33	.33	.32	.3
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL		0.00	0.00	0.00	0.00	0.00	0.00
PM_{10}	24 Hour	500 ug/m^3	Maximum	ug/m^3	N/A	N/A	N/A	N/A	N/A	N/A
			Average	ug/m^3	N/A	N/A	N/A	N/A	N/A	N/A
			Days exceed EL		N/A	N/A	N/A	N/A	N/A	N/A
			Days exceed 80% EL		N/A	N/A	N/A	N/A	N/A	N/A

Monitor Location: *VB1 Exhaust Ducts 3 & 4 (I-90 EB)*

Pollutant	Time Period	Emission Limits	Parameter	Unit	2006	2007	2008	2009	2010	2011-1st Q
CO	1 Hour	70 ppm	Maximum	ppm	12.8	26.6	12.1	3.7	3.2	2.4
			Average	ppm	1.14	.97	.91	.86	.83	.6
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL							
	8 Hour	70 ppm	Maximum	ppm	5.4	4.6	5.6	2	2.1	1.6
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL							
NO_x	1 Hour	8.88 ppm	Maximum	ppm	1.8	3.5	1.7	.8	.6	.5
			Average	ppm	.36	.33	.31	.31	.3	.3
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL		0.00	0.00	0.00	0.00	0.00	0.00
PM_{10}	24 Hour	500 ug/m^3	Maximum	ug/m^3	N/A	N/A	N/A	N/A	N/A	N/A
			Average	ug/m^3	N/A	N/A	N/A	N/A	N/A	N/A
			Days exceed EL		N/A	N/A	N/A	N/A	N/A	N/A
			Days exceed 80% EL							

Note: EL = Emission Limit

Table 5-1: Summary of CO, NOx and PM10 Average and Peak Levels: Ventilation Building 1 (continued)

Monitor Location: *VB1 Exhaust Ducts 7 (I-90 WB)*

Pollutant	Time Period	Emission Limits	Parameter	Unit	2006	2007	2008	2009	2010	2011-1st Q
CO	1 Hour	70 ppm	Maximum	ppm	9.2	34.4	5.9	4.5	2.6	3.1
			Average	ppm	1.03	1.14	.76	.96	.9	.57
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL							
	8 Hour	70 ppm	Maximum	ppm	7.9	5.3	2.7	2.2	2.2	1.6
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL							
NO_x	1 Hour	8.88 ppm	Maximum	ppm	1.3	4.5	.9	.8	.5	.6
			Average	ppm	.31	.33	.33	.32	.31	.3
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL							
PM_{10}	24 Hour	500 ug/m^3	Maximum	ug/m^3	N/A	N/A	N/A	N/A	N/A	N/A
			Average	ug/m^3	N/A	N/A	N/A	N/A	N/A	N/A
			Days exceed EL		N/A	N/A	N/A	N/A	N/A	N/A
			Days exceed 80% EL							

Monitor Location: *VB1 Exhaust Ducts 5 & 6 (I-90 WB)*

Pollutant	Time Period	Limits	Parameter	Unit	2006	2007	2008	2009	2010	2011-1st Q
CO	1 Hour	70 ppm	Maximum	ppm	8.6	21.1	9.5	4.9	2.9	2.3
			Average	ppm	1.2	1.23	1.09	1.02	1.03	.8
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL							
	8 Hour	70 ppm	Maximum	ppm	7.4	3.8	2.6	2.9	2.5	1.7
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL							
NO_x	1 Hour	8.88 ppm	Maximum	ppm	1.3	2.8	.9	.8	.8	.5
			Average	ppm	.34	.35	.33	.33	.32	.3
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL							
PM_{10}	24 Hour	500 ug/m^3	Maximum	ug/m^3	N/A	N/A	N/A	N/A	N/A	N/A
			Average	ug/m^3	N/A	N/A	N/A	N/A	N/A	N/A
			Days exceed EL		N/A	N/A	N/A	N/A	N/A	N/A
			Days exceed 80% EL							

Monitor Location: *VB1 Exhaust Ducts 10 & 11 (Ramp D I-90 WB to I-93 NB)*

Pollutant	Time Period	Limits	Parameter	Unit	2006	2007	2008	2009	2010	2011-1st Q
CO	1 Hour	70 ppm	Maximum	ppm	29.9	23.2	11.1	6	7.4	4.4
			Average	ppm	1.56	1.69	1.51	1.41	1.44	1.2
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL							
	8 Hour	70 ppm	Maximum	ppm	10.1	5.6	3.7	3.2	3.5	2.3
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL							
NO_x	1 Hour	8.88 ppm	Maximum	ppm	3.9	3.1	1.6	.9	1.1	.7
			Average	ppm	.4	.4	.4	.38	.37	.3
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL							
PM_{10}	24 Hour	500 ug/m^3	Maximum	ug/m^3	N/A	N/A	N/A	N/A	N/A	N/A
			Average	ug/m^3	N/A	N/A	N/A	N/A	N/A	N/A
			Days exceed EL		N/A	N/A	N/A	N/A	N/A	N/A
			Days exceed 80% EL							

Note: EL = Emission Limit

TABLE 5-2: SUMMARY OF CO, NO_X, PM_{10} AND $PM_{2.5}$ AVERAGE AND PEAK LEVELS: VENTILATION BUILDING 3

Monitor Location: VB3 NB-1

Pollutant	Time Period	Limits	Parameter	Unit	2006	2007	2008	2009	2010	2001-1st Q
CO	1 Hour	70 ppm	Maximum	ppm	8.1	9	5.4	9.9	5.7	4.9
			Average	ppm	1.89	1.6	1.44	1.16	1.37	1
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL							
	8 Hour	70 ppm	Maximum	ppm	5.4	6.8	4.2	4.6	4.5	2.6
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL							
NO_x	1 Hour	8.88 ppm	Maximum	ppm	1.2	1.3	.9	1.4	1.3	.8
			Average	ppm	.43	.4	0	.59	.38	.3
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL							
PM_{10}	24 Hour	500) g/m^3	Maximum	ug/m^3	176.4	328.3	270.6	375.10	312.5	302.4
			Average	ug/m^3	63.34	70.7	71.12	108.22	73.72	108.27
			Days exceed EL							
			Days exceed 80% EL		0.00	0.00	0.00	0.00	0.00	0.00

Monitor Location: VB3 NB-2

Pollutant	Time Period	Limits	Parameter	Unit	2006	2007	2008	2009	2010	2001-1st Q
CO	1 Hour	70 ppm	Maximum	ppm	9.6	25..3	10.5	11.8	9.3	8.2
			Average	ppm	1.67	1.63	1.51	1.16	1.77	1.63
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL							
	8 Hour	70 ppm	Maximum	ppm	6.9	7.6	4.1	4.4	4.7	6.6
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL							
NO_x	1 Hour	8.88 ppm	Maximum	ppm	1.9	3.3	1.5	1.7	1.3	1.2
			Average	ppm	.4	.4	.4	.41	.42	.43
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL							
PM_{10}	24 Hour	500) g/m3	Maximum	ug/m^3	N/A	N/A	N/A	N/A	N/A	N/A
			Average	ug/m^3	N/A	N/A	N/A	N/A	N/A	N/A
			Days exceed EL		N/A	N/A	N/A	N/A	N/A	N/A
			Days exceed 80% EL							

Monitor Location: VB3 SB-1

Pollutant	Time Period	Limits	Parameter	Unit	2006	2007	2008	2009	2010	2001-1st Q
CO	1 Hour	70 ppm	Maximum	ppm	13.7	13.2	10.7	16.1	12.5	7.8
			Average	ppm	3.91	3.64	3.11	3.14	3.04	2.37
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL							
	8 Hour	70 ppm	Maximum	ppm	9.1	9	8.3	7.6	8.2	5.8
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL							
NO_x	1 Hour	8.88 ppm	Maximum	ppm	1.9	1.8	1.5	2.2	1.7	1.2
			Average	ppm	.67	.63	.59	.58	.57	.5
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL							
PM_{10}	24 Hour	500 ug/m3	Maximum	ug/m^3	166.1	541.6	304.2	545.8	411.9	542
			Average	ug/m^3	77.8	109	82.88	107.8	92.57	166
			Days exceed EL				0	3	0	1
$PM_{2.5}$	24 Hour	n/a	Maximum	ug/m^3				88.1	87.5	
			Average	ug/m^3				40.7	40.9	
			Pilot program							

Notes:

1. EL = Emission Limit
2. . An Emission Limit Assessment (ELA) was performed following an EL exceedance. The results of the ELA enabled MassDOT and MassDEP to determine that the EL exceedances did not violate a National Ambient Air Quality Standard (NAAQS). Appendix F provides the results of the ELAs.

TABLE 5-3: SUMMARY OF CO, NOX AND PM10 AVERAGE AND PEAK LEVELS: VENTILATION BUILDING 4

Monitor Location: VB4 NB3

Pollutant	Time Period	Limits	Parameter	Unit	2006	2007	2008	2009	2010	2001-1st Q
CO	1 Hour	70 ppm	Maximum	ppm	11.3	15.6	10.9	13.1	10.4	7.8
			Average	ppm	3.37	2.66	2.51	2.34	2.38	1.9
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL							
	8 Hour	70 ppm	Maximum	ppm	9.3	9.4	6.5	6.3	6.5	5.2
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL							
NO_x	1 Hour	8.88 ppm	Maximum	ppm	1.6	2.1	1.5	1.8	1.5	1.1
			Average	ppm	.63	.54	.53	.48	.48	.4
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL		0.00	0.00	0.00	0.00	0.00	0.00
PM_{10}	24 Hour	500)g/m^3	Maximum	ug/m^3	N/A	N/A	N/A	N/A	N/A	N/A
			Average	ug/m^3	N/A	N/A	N/A	N/A	N/A	N/A
			Days exceed EL		N/A	N/A	N/A	N/A	N/A	N/A
			Days exceed 80% EL							

Monitor Location: VB4 NB4

Pollutant	Time Period	Limits	Parameter	Unit	2006	2007	2008	2009	2010	2001-1st Q
CO	1 Hour	70 ppm	Maximum	ppm	14.9	14.2	11.5	12.4	11.6	8
			Average	ppm	3.87	3.18	3.03	2.8	2.88	2.3
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL							
	8 Hour	70 ppm	Maximum	ppm	13.6	9.6	6.4	6.5	6.9	5
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL							
NO_x	1 Hour	8.88 ppm	Maximum	ppm	2	2	1.6	1.7	1.6	1.2
			Average	ppm	.69	.58	.57	.54	.54	.5
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL		0.00	0.00	0.00	0.00	0.00	0.00
PM_{10}	24 Hour	500)g/m^3	Maximum	ug/m^3	N/A	N/A	N/A	N/A	N/A	N/A
			Average	ug/m^3	N/A	N/A	N/A	N/A	N/A	N/A
			Days exceed EL		N/A	N/A	N/A	N/A	N/A	N/A
			Days exceed 80% EL							

Monitor Location: VB4 SB2

Pollutant	Time Period	Limits	Parameter	Unit	2006	2007	2008	2009	2010	2001-1st Q
CO	1 Hour	70 ppm	Maximum	ppm	17.9	11.2	6.8	6.8	8.7	5
			Average	ppm	2.5	1.88	1.9	1.48	1.45	1.1
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL							
	8 Hour	70 ppm	Maximum	ppm	6.2	6.7	4.7	4.8	5.3	3.1
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL							
NO_x	1 Hour	8.88 ppm	Maximum	ppm	2.4	1.6	1	1	1.3	.8
			Average	ppm	.46	.44	.43	.39	.39	.3
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL							
PM_{10}	24 Hour	500 ug/m^3	Maximum	ug/m^3	N/A	N/A	N/A	N/A	N/A	N/A
			Average	ug/m^3	N/A	N/A	N/A	N/A	N/A	N/A
			Days exceed EL		N/A	N/A	N/A	N/A	N/A	N/A
			Days exceed 80% EL							

Note: EL = Emission Limit

TABLE 5-4: SUMMARY OF CO, NOX AND PM10 AVERAGE AND PEAK LEVELS: VENTILATION BUILDING 5

Monitor Location: VB5 EB2

Pollutant	Time Period	Limits	Parameter	Unit	2006	2007	2008	2009	2010	2001-1st Q
CO	1 Hour	70 ppm	Maximum	ppm	18.4	11.1	7.3	5.9	6.6	3.2
			Average	ppm	1.49	1.5	1.43	1.31	1.45	1.1
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL							
	8 Hour	70 ppm	Maximum	ppm	7.8	5.8	3.2	3.8	3.5	2.3
			Hours exceed EL							
			Hours exceed 80% EL							
NO_x	1 Hour	8.88 ppm	Maximum	ppm	2.5	1.6	1.1	.9	1	.6
			Average	ppm	.37	.38	.39	.34	.37	.3
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL		0.00	0.00	0.00	0.00	0.00	0.00
PM_{10}	24 Hour	500 ug/m^3	Maximum	ug/m^3	N/A	N/A	N/A	N/A	N/A	N/A
			Average	ug/m^3	N/A	N/A	N/A	N/A	N/A	N/A
			Days exceed EL		N/A	N/A	N/A	N/A	N/A	N/A
			Days exceed 80% EL							

Monitor Location: VB5 EB3

Pollutant	Time Period	Limits	Parameter	Unit	2006	2007	2008	2009	2010	2001-1st Q
CO	1 Hour	70 ppm	Maximum	ppm	20.7	8.7	7.9	5	4.1	3.5
			Average	ppm	1.44	1.16	.98	.94	1.69	.97
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL							
	8 Hour	70 ppm	Maximum	ppm	9.2	7.4	3.2	2.9	3.3	2.2
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL							
NO_x	1 Hour	8.88 ppm	Maximum	ppm	2.8	1.7	1.2	.8	.7	.6
			Average	ppm	.37	.31	.31	.31	.34	.3
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL		0.00	0.00	0.00	0.00	0.00	0.00
PM_{10}	24 Hour	500 □g/m^3	Maximum	ug/m^3	N/A	N/A	N/A	N/A	N/A	N/A
			Average	ug/m^3	N/A	N/A	N/A	N/A	N/A	N/A
			Days exceed EL		N/A	N/A	N/A	N/A	N/A	N/A
			Days exceed 80% EL							

Monitor Location: VB5 WB2

Pollutant	Time Period	Limits	Parameter	Unit	2006	2007	2008	2009	2010	2001-1st Q
CO	1 Hour	70 ppm	Maximum	ppm	16.5	10	8.5	3.5	2.9	2.4
			Average	ppm	1.39	1.23	1.21	1.11	1.13	.9
			Hours exceed EL		0	0	0	0	0	0
	8 Hour	70 ppm	Maximum	ppm	7.6	3.6	7.1	2.7	2.6	1.8
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL							
NO_x	1 Hour	8.88 ppm	Maximum	ppm	2.2	1.4	1.3	.6	.6	.5
			Average	ppm	.37	.35	.34	.33	.33	.3
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL							
PM_{10}	24 Hour	500 □g/m^3	Maximum	ug/m^3	139.7	128.8	103.3	248.2	159.7	279.8
			Average	ug/m^3	46.76	38.8	36.89	44.83	31.95	74.8
			Days exceed EL		0	0	0	0	0	0
			Days exceed 80% EL		0.00	0.00	0.00	0.00	0.00	0.00

Note: EL = Emission Limit

TABLE 5-5 SUMMARY OF CO, NOX AND PM10 AVERAGE AND PEAK LEVELS: VENTILATION BUILDING 6

Monitor Location: VB6EB

Pollutant	*Time Period*	*Limits*	*Parameter*	*Unit*	*2006*	*2007*	*2008*	*2009*	*2010*	*2001-1st Q*
CO	**1 Hour**	**70 ppm**	**Maximum**	**ppm**	11.1	8.4	4.4	4.2	3	2.4
			Average	**ppm**	10.09	1.17	1.12	1.07	.86	.86
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL							
	8 Hour	**70 ppm**	**Maximum**	**ppm**	4.2	3.4	2.6	2.2	1.9	1.8
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL							
NO_x	**1 Hour**	**8.88 ppm**	**Maximum**	**ppm**	1.6	1.2	.7	.7	.6	.5
			Average	**ppm**	.33	.33	.33	.31	.31	.3
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL		0.00	0.00	0.00	0.00	0.00	0.00
PM_{10}	**24 Hour**	**500 –g/m^3**	**Maximum**	**ug/m^3**	N/A	N/A	N/A	N/A	N/A	N/A
			Average	**ug/m^3**	N/A	N/A	N/A	N/A	N/A	N/A
			Days exceed EL		N/A	N/A	N/A	N/A	N/A	N/A
			Days exceed 80% EL							

Monitor Location: VB6WB

Pollutant	*Time Period*	*Limits*	*Parameter*	*Unit*	*2006*	*2007*	*2008*	*2009*	*2010*	*2001-1st Q*
CO	**1 Hour**	**70 ppm**	**Maximum**	**ppm**	17.4	15	13.9	10.1	7.2	8.5
			Average	**ppm**	1.97	2.03	1.86	1.78	1.6	1.8
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL							
	8 Hour	**70 ppm**	**Maximum**	**ppm**	7.2	5.3	5	3.4	3.2	4.2
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL							
NO_x	**1 Hour**	**8.88 ppm**	**Maximum**	**ppm**	2.4	2.1	1.9	1.4	1.1	1.3
			Average	**ppm**	.44	.45	.42	.41	.39	.43
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL		0.00	0.00	0.00	0.00	0.00	0.00
PM_{10}	**24 Hour**	**500 ug/m^3**	**Maximum**	**ug/m^3**	N/A	N/A	N/A	N/A	N/A	N/A
			Average	**ug/m^3**	N/A	N/A	N/A	N/A	N/A	N/A
			Days exceed EL		N/A	N/A	N/A	N/A	N/A	N/A
			Days exceed 80% EL							

Note: EL = Emission Limit

TABLE 5-6: SUMMARY OF CO, NO_X AND PM_{10} AVERAGE AND PEAK LEVELS: VENTILATION BUILDING 7

Monitor Location: VB7 TA/D

Pollutant	Time Period	Limits	Parameter	Unit	2006	2007	2008	2009	2010	2001-1st Q
CO	1 Hour	70 ppm	Maximum	ppm	30.2	12.9	13.8	13.1	14	6.8
			Average	ppm	2.19	2.93	2.66	2.68	2.64	2.37
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL							
	8 Hour	70 ppm	Maximum	ppm	4.8	8.4	7.6	7.1	6.8	4.5
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL							
NO_x	1 Hour	8.88 ppm	Maximum	ppm	3.9	1.8	1.9	1.8	1.9	1
			Average	ppm	.47	.58	.42	.56	.53	.5
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL		0.00	0.00	0.00	0.00	0.00	0.00
PM_{10}	24 Hour	500 ug/m^3	Maximum	ug/m^3	N/A	N/A	N/A	N/A	N/A	N/A
			Average	ug/m^3	N/A	N/A	N/A	N/A	N/A	N/A
			Days exceed EL		N/A	N/A	N/A	N/A	N/A	N/A
			Days exceed 80% EL							

Monitor Location: VB7 Intake

Pollutant	Time Period	Limits	Parameter	Unit	2006	2007	2008	2009	2010	2001-1st Q
CO	1 Hour	70 ppm	Maximum	ppm	6.1	2.3	2.1	2.2	6.9	2.4
			Average	ppm	.99	.58	.63	.58	.58	.46
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL							
	8 Hour	70 ppm	Maximum	ppm	5.1	1.8	1.8	1.6	2.3	.8
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL							
NO_x	1 Hour	8.88 ppm	Maximum	ppm	0	0	0	0	0	0
			Average	ppm	0	0	0	0	0	0
			Hours exceed EL							
			Hours exceed 80% EL		0	0	0	0	0	0
PM_{10}	24 Hour	500 □g/m^3	Maximum	ug/m^3	52.1	54.7	41.8	36	40.8	26.4
			Average	ug/m^3	17.4	14.66	13.58	13.1	12.86	12.17
			Days exceed EL		0	0	0	0	0	0
			Days exceed 80% EL		0.00	0.00	0.00	0.00	0.00	0.00

Monitor Location: VB7 WB2

Pollutant	Time Period	Limits	Parameter	Unit	2006	2007	2008	2009	2010	2001-1st Q
CO	1 Hour	70 ppm	Maximum	ppm	10.3	9.7	10.9	11.6	6.4	6.8
			Average	ppm	1.7	1.81	1.58	1.48	1.67	1.47
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL							
	8 Hour	70 ppm	Maximum	ppm	7.2	5.2	3.6	3.5	3.4	3.9
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL							
NO_x	1 Hour	8.88 ppm	Maximum	ppm	1.6	1.4	1.5	1.6	1	1
			Average	ppm	.4	.43	.4	.39	.4	.4
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL		0.00	0.00	0.00	0.00	0.00	0.00
PM_{10}	24 Hour	500 ug/m^3	Maximum	ug/m^3	N/A	N/A	N/A	N/A	N/A	N/A
			Average	ug/m^3	N/A	N/A	N/A	N/A	N/A	N/A
			Days exceed EL		N/A	N/A	N/A	N/A	N/A	N/A
			Days exceed 80% EL							

Note: EL = Emission Limit

TABLE 5-6: SUMMARY OF CO, NOx AND PM10 AVERAGE AND PEAK LEVELS: VENTILATION BUILDING 7 (CONTINUED)

Monitor Location: VB7 EB2

Pollutant	Time Period	Limits	Parameter	Unit	2006	2007	2008	2009	2010	2001-1st Q
CO	1 Hour	70 ppm	Maximum	ppm	10.1	22.8	9.8	10.4	8.9	6.7
			Average	ppm	1.73	2.38	2.37	2.01	2.08	1.93
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL							
	8 Hour	70 ppm	Maximum	ppm	5.9	7.9	5.8	5.5	5.6	4.1
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL							
NO_x	1 Hour	8.88 ppm	Maximum	ppm	1.4	2.5	1.4	1.5	1.3	1
			Average	ppm	.4	.49	.5	.43	.46	.43
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL							
PM_{10}	24 Hour	500 ug/m^3	Maximum	ug/m^3	120.4	537.4	331.7	577.8	487.3	490
			Average	ug/m^3	46.4	72.05	80.41	123.7	76.55	138.67
			Days exceed EL			0	0	1	0	0
			Days exceed 80% EL		0.00	0.00	0.00	0.00	0.00	0.00

Monitor Location: VB7 WB3

Pollutant	Time Period	Limits	Parameter	Unit	2006	2007	2008	2009	2010	2001-1st Q
CO	1 Hour	70 ppm	Maximum	ppm	10.6	7.1	7.7	8.5	4.7	4.9
			Average	ppm	1.3	1.31	1.12	1.05	1.27	1.07
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL							
	8 Hour	70 ppm	Maximum	ppm	7.3	3.6	2.6	2.7	2.7	2.8
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL							
NO_x	1 Hour	8.88 ppm	Maximum	ppm	1.5	1.1	1.2	1.3	.8	.8
			Average	ppm	.38	.37	.31	.36	.36	.33
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL		0.00	0.00	0.00	0.00	0.00	0.00
PM_{10}	24 Hour	500 ug/m^3	Maximum	ug/m^3	N/A	N/A	N/A	N/A	N/A	N/A
			Average	ug/m^3	N/A	N/A	N/A	N/A	N/A	N/A
			Days exceed EL		N/A	N/A	N/A	N/A	N/A	N/A
			Days exceed 80% EL							

Monitor Location: VB7 EB3

Pollutant	Time Period	Limits	Parameter	Unit	2006	2007	2008	2009	2010	2001-1st Q
CO	1 Hour	70 ppm	Maximum	ppm	10.9	21.8	12	11.5	10.6	6.9
			Average	ppm	1.9	2.74	2.72	2.42	2.46	2.23
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL							
	8 Hour	70 ppm	Maximum	ppm	6.7	8.9	6.5	6.4	6.7	4.6
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL							
NO_x	1 Hour	8.88 ppm	Maximum	ppm	1.5	2.9	1.7	1.6	1.5	1.1
			Average	ppm	.47	.55	.56	.51	.52	.5
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL		0.00	0.00	0.00	0.00	0.00	0.00
PM_{10}	24 Hour	500 ug/m^3	Maximum	ug/m^3	N/A	N/A	N/A	N/A	N/A	N/A
			Average	ug/m^3	N/A	N/A	N/A	N/A	N/A	N/A
			Days exceed EL		N/A	N/A	N/A	N/A	N/A	N/A

Notes:

1. EL = Emission Limit
2. An Emission Limit Assessment (ELA) was performed following an EL exceedance. The results of the ELA enabled MassDOT and MassDEP to determine that the EL exceedances did not violate a National Ambient Air Quality Standard (NAAQS). Appendix F provides the results of the ELAs.

Table 5-7: Summary of CO, NOx and PM10 Average and Peak Levels: Ramp LC-S

Monitor Location:	Ramp LC-S									
Pollutant	*Time Period*	*Limits*	*Parameter*	*Unit*	*2006*	*2007*	*2008*	*2009*	*2010*	*2001-1st Q*
CO	1 Hour	52 ppm	Maximum	ppm	21.8	67.5	33.9	15.3	68.7	28.2
			Average	ppm	2.3	1.83	1.8	1.79	1.81	1.37
			Hours exceed EL		0	2	0	0	1	0
			Hours exceed 80% EL							
	8 Hour	39 ppm	Maximum	ppm	7.1	16.6	9.9	5.8	18.4	6.1
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL							
NO_x	1 Hour	6.64 ppm	Maximum	ppm	2.9	8.6	4.4	2.1	8.7	3.7
			Average	ppm	.49	.43	.43	.42	.43	.4
			Hours exceed EL		0	2	0	0	1	0
			Hours exceed 80% EL		0.00	0.00	0.00	0.00	0.00	0.00
PM_{10}	24 Hour		Maximum	ug/m^3	N/A	N/A	N/A	N/A	N/A	N/A
			Average	ug/m^3	N/A	N/A	N/A	N/A	N/A	N/A
			Days exceed NAAQS		N/A	N/A	N/A	N/A	N/A	N/A
			ays exceed 80% NAAQS		N/A	N/A	N/A	N/A	N/A	N/A

Notes:
1. EL = Emission Limit
2. An Emission Limit Assessment (ELA) was performed following an EL exceedance. The results of the ELA enabled MassDOT and MassDEP to determine that the EL exceedances did not violate a National Ambient Air Quality Standard (NAAQS). Appendix F provides the results of the ELAs

Table 5-8: Summary of CO, NO_X and PM_{10} Average and Peak Levels: Ramp SA-CN

Monitor Location:	Ramp SA-CN									
Pollutant	*Time Period*	*Limits*	*Parameter*	*Unit*	*2006*	*2007*	*2008*	*2009*	*2010*	*2001-1st Q*
CO	1 Hour	70 ppm	Maximum	ppm	12.7	50.3	28.7	11.2	14.4	5.3
			Average	ppm	2	1.63	1.54	1.53	1.5	1.3
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL							
	8 Hour	70 ppm	Maximum	ppm	4.6	9.3	7.5	3.8	3.8	2.3
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL							
NO_x	1 Hour	8.88 ppm	Maximum	ppm	1.8	6.4	3.8	1.6	2	.9
			Average	ppm	.44	.41	0.41	.39	.4	.4
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL		0.00	0.00	0.00	0.00	0.00	0.00
PM_{10}	24 Hour		Maximum	ug/m^3	N/A	N/A	N/A	N/A	N/A	N/A
			Average	ug/m^3	N/A	N/A	N/A	N/A	N/A	N/A
			Days exceed NAAQS		N/A	N/A	N/A	N/A	N/A	N/A

Note: EL = Emission Limit

TABLE 5-9: SUMMARY OF CO, NO_X AND PM_{10} AVERAGE AND PEAK LEVELS: RAMP CN-S

Monitor Location:	Ramp CN-S									
Pollutant	*Time Period*	*Limits*	*Parameter*	*Unit*	*2006*	*2007*	*2008*	*2009*	*2010*	*2011-1st Q*
CO	**1 Hour**	**67 ppm**	**Maximum**	**ppm**	45.8	14.5	16.3	10.4	16.5	6.6
			Average	**ppm**	4.5	3.65	3.33	3.01	3.07	2.6
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL							
	8 Hour	**58 ppm**	**Maximum**	**ppm**	15.8	8.2	9.2	6.3	7.7	4.7
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL							
NO_x	**1 Hour**	**8.5 ppm**	**Maximum**	**ppm**	4.4	1.9	2.2	1.5	2.2	1
			Average	**ppm**	.77	.64	.63	.56	.57	.5
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL		0.00	0.00	0.00	0.00	0.00	0.00
PM_{10}	**24 Hour**		**Maximum**	**ug/m^3**	N/A	N/A	N/A	N/A	N/A	N/A
			Average	**ug/m^3**	N/A	N/A	N/A	N/A	N/A	N/A
			Days exceed NAAQS		N/A	N/A	N/A	N/A	N/A	N/A
			ays exceed 80% NAAQS		N/A	N/A	N/A	N/A	N/A	N/A

Note: EL = Emission Limit

TABLE 5-10: SUMMARY OF CO, NO_X, PM_{10} AND $PM_{2.5}$ AVERAGE AND PEAK LEVELS: RAMP CS-SA

Monitor Location:	Ramp CS-SA no Parcel 12									
Pollutant	*Time Period*	*Limits*	*Parameter*	*Unit*	*2006*	*2007*	*2008*	*2009*	*2010*	*2001-1st Q*
CO	**1 Hour**	**57 ppm**	**Maximum**	**ppm**	11.2	34.4	27	10.4	22.1	5.7
			Average	**ppm**	2.57	2.33	2	1.88	1.89	1.57
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL							
	8 Hour	**46 ppm**	**Maximum**	**ppm**	6.8	9.8	10.5	5.5	6.3	3.3
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL							
NO_x	**1 Hour**	**7.26 ppm**	**Maximum**	**ppm**	1.6	4.5	3.5	1.5	2.9	.9
			Average	**ppm**	.54	.49	.43	.43	.43	.4
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL							
PM_{10}	**24 Hour**	**150 ug/m^3**	**Maximum**	**ug/m^3**	137.6	60.3	87.9	99.4	115.8	78.3
			Average	**ug/m^3**	31.24	21.29	20.38	20.78	18.79	21.7
			Days exceed NAAQS		0	0	0	0	0	0
			ays exceed 80% NAAQS		0.00	0.00	11.00	1.00	2.00	0.00
$PM_{2.5}$	**24 Hour**	**n/a**	**Maximum**	**ug/m^3**				32.9	37.1	
			Average	**ug/m^3**				11.2	10.1	
			Pilot program							

Notes: EL = Emission Limit

TABLE 5-11: SUMMARY OF CO, NO_X AND PM_{10} AVERAGE AND PEAK LEVELS: RAMP CS-P

Monitor Location:	Ramp CS-P									
Pollutant	*Time Period*	*Limits*	*Parameter*	*Unit*	*2006*	*2007*	*2008*	*2009*	*2010*	*2001-1st Q*
CO	1 Hour	70 ppm	Maximum	ppm	17	13.3	34.9	10	22.7	6.1
			Average	ppm	2.67	2.51	2.08	2.02	2.01	1.5
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL							
	8 Hour	70 ppm	Maximum	ppm	8.3	7	13.9	5.3	9.7	3.9
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL							
NO_x	1 Hour	8.88 ppm	Maximum	ppm	2.3	1.8	4.5	1.4	3	1
			Average	ppm	.54	.51	.43	.44	.45	.4
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL		0.00	0.00	0.00	0.00	0.00	0.00
PM_{10}	24 Hour		Maximum	ug/m^3	N/A	N/A	N/A	N/A	N/A	N/A
			Average	ug/m^3	N/A	N/A	N/A	N/A	N/A	N/A
			Days exceed NAAQS		N/A	N/A	N/A	N/A	N/A	N/A
			Days exceed 80% NAAQS		N/A	N/A	N/A	N/A	N/A	N/A

Note: EL = Emission Limit

TABLE 5-12: SUMMARY OF CO, NO_X AND PM_{10} AVERAGE AND PEAK LEVELS: RAMP F

Monitor Location:	Ramp F									
Pollutant	*Time Period*	*Limits*	*Parameter*	*Unit*	*2006*	*2007*	*2008*	*2009*	*2010*	*2001-1st Q*
CO	1 Hour	70 ppm	Maximum	ppm	12.6	7.3	12.3	4.3	5	1.9
			Average	ppm	1.52	1.3	1.11	1.05	.94	.4
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL							
	8 Hour	70 ppm	Maximum	ppm	5.2	4.8	4.3	2.7	2.7	1.3
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL							
NO_x	1 Hour	8.88 ppm	Maximum	ppm	1.8	1.8	1.7	.7	.8	.4
			Average	ppm	.38	.36	.32	.32	.31	.26
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0
PM_{10}	24 Hour		Maximum	ug/m^3	N/A	N/A	N/A	N/A	N/A	N/A
			Average	ug/m^3	N/A	N/A	N/A	N/A	N/A	N/A
			Days exceed NAAQS		N/A	N/A	N/A	N/A	N/A	N/A
			Days exceed 80% NAAQS		N/A	N/A	N/A	N/A	N/A	N/A

Note: EL = Emission Limit

TABLE 5-13: SUMMARY OF CO, NO_X AND PM_{10} AVERAGE AND PEAK LEVELS: DST I-93

Monitor Location:		Ramp DST-I-93 Existing								
Pollutant	*Time Period*	*Limits*	*Parameter*	*Unit*	*2006*	*2007*	*2008*	*2009*	*2010*	*2001-1st Q*
CO	1 Hour	25 ppm	Maximum	ppm	19.1	38.2	20.3	20.8	18.4	11.4
			Average	ppm	5.84	5.23	4.63	4.59	4.44	3.56
			Hours exceed EL		0	2	0	0	0	0
			Hours exceed 80% EL							
	8 Hour	23 ppm	Maximum	ppm	12.3	15.9	10.7	11.5	12.5	7.2
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL							
NO_x	1 Hour	3.3 ppm	Maximum	ppm	2.6	4.9	2.7	2.8	4.4	1.6
			Average	ppm	.91	.93	.78	.77	.76	.6
			Hours exceed EL		0	2	0	0	0	0
			Hours exceed 80% EL		10.00	2.00	12.00	2.00	2.00	2.00
PM_{10}	24 Hour		Maximum	ug/m^3	N/A	N/A	N/A	N/A	N/A	N/A
			Average	ug/m^3	N/A	N/A	N/A	N/A	N/A	N/A
			Days exceed NAAQS		N/A	N/A	N/A	N/A	N/A	N/A
			ays exceed 80% NAAQS		N/A	N/A	N/A	N/A	N/A	N/A

Notes:
1. EL = Emission Limit
2. An Emission Limit Assessment (ELA) was performed following an EL exceedance. The results of the ELA enabled MassDOT and MassDEP to determine that the EL exceedances did not violate a National Ambient Air Quality Standard (NAAQS). Appendix F provides the results of the ELAs.

TABLE 5-14: SUMMARY OF CO, NO_X AND PM_{10} AVERAGE AND PEAK LEVELS: DST I-90

Monitor Location:		Ramp DST-I-90 Existing								
Pollutant	*Time Period*	*Limits*	*Parameter*	*Unit*	*2006*	*2007*	*2008*	*2009*	*2010*	*2011-1st Q*
CO	1 Hour	25 ppm	Maximum	ppm	22.8	21	17.3	14.4	33.6	9.9
			Average	ppm	4.9	4.62	3.56	3.35	3.66	2.8
			Hours exceed EL		0	0	0	0	1	0
			Hours exceed 80% EL							
	8 Hour	23 ppm	Maximum	ppm	11.7	11.5	9.4	8.7	10.6	6.4
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL							
NO_x	1 Hour	3.3 ppm	Maximum	ppm	2.6	2.8	2.3	2	4.3	1.4
			Average	ppm	.79	.78	.63	.63	.66	.56
			Hours exceed EL		0	0	0	0	1	0
			Hours exceed 80% EL		3.00	2.00	8.00	0.00	1.00	0.00
PM_{10}	24 Hour		Maximum	ug/m^3	N/A	N/A	N/A	N/A	N/A	N/A
			Average	ug/m^3	N/A	N/A	N/A	N/A	N/A	N/A
			Days exceed NAAQS		N/A	N/A	N/A	N/A	N/A	N/A
			ays exceed 80% NAAQS		N/A	N/A	N/A	N/A	N/A	N/A

Notes:
1. EL = Emission Limit
2. An Emission Limit Assessment (ELA) was performed following an EL exceedance. The results of the ELA enabled MassDOT and MassDEP to determine that the EL exceedances did not violate a National Ambient Air Quality Standard (NAAQS). Appendix F provides the results of the ELAs.

TABLE 5-15: SUMMARY OF CO, NO_X AND PM_{10} AVERAGE AND PEAK LEVELS: RAMP ST-CN

Monitor Location:	ST-CN									
Pollutant	*Time Period*	*mission Limit*	*Parameter*	*Unit*	*2006 **	*2007*	*2008*	*2009*	*2010*	*2001-1st Q*
CO	1 Hour	70	Maximum	ppm	4.6	6.3	26.6	5.3	7.6	3.2
			Average	ppm	1.5	1.53	1.4	1.41	1.22	1.16
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0
	8 Hour	70	Maximum	ppm	3.5	3.8	7.8	3.2	3.4	2.7
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0
NO_x	1 Hour	8.88	Maximum	ppm	.8	1	3.5	.9	1.1	.6
			Average	ppm	.4	.39	.37	.39	.38	.3
			Hours exceed EL		0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0
PM_{10}	24 Hour		Maximum	ug/m^3	N/A	N/A	N/A	N/A	N/A	N/A
			Average	ug/m^3	N/A	N/A	N/A	N/A	N/A	N/A
			Days exceed EL		N/A	N/A	N/A	N/A	N/A	N/A
			Days exceed 80% EL		N/A	N/A	N/A	N/A	N/A	N/A
* 2006 is only 1 months worth of data										

Note: EL = Emission Limit

TABLE 5-16: SUMMARY OF CO, NO_X AND PM_{10} AVERAGE AND PEAK LEVELS: RAMP ST-SA

Monitor Location:	Ramp ST-SA NO PARCEL 6									
Pollutant	*Time Period*	*Limits*	*Parameter*	*Unit*	*2006*	*2007*	*2008*	*2009*	*2010*	*2001-1st Q*
CO	1 Hour	70 ppm	Maximum	ppm	No Data	12.9	5.7	8.9	4	2.9
			Average	ppm		1	.93	.84	.86	.57
			Hours exceed EL			0	0	0	0	0
			Hours exceed 80% EL							
	8 Hour	70 ppm	Maximum	ppm		4.6	2.5	2.5	2.5	1.9
			Hours exceed EL			0	0	0	0	0
			Hours exceed 80% EL							
NO_x	1 Hour	8.88 ppm	Maximum	ppm		1.8	.9	1.3	.7	.6
			Average	ppm		.33	.32	.32	.32	.3
			Hours exceed EL			0	0	0	0	0
			Hours exceed 80% EL							
PM_{10}	24 Hour		Maximum	ug/m^3	N/A	N/A	N/A	N/A	N/A	N/A
			Average	ug/m^3	N/A	N/A	N/A	N/A	N/A	N/A
			Days exceed NAAQS		N/A	N/A	N/A	N/A	N/A	N/A
			ays exceed 80% NAAQS							

Note: EL = Emission Limit

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Part IV - Corrective Actions

6 CONTINGENCY PLAN

6.1 GENERAL REQUIREMENTS (310 CMR 7.38(4))

"… the operating certificate submittal shall include a contingency plan consisting of measures which could be implemented in cases of exceedance of the emission limitations in the certificate. Said contingency plan shall identify available contingency measures including, but not limited to, alternative tunnel ventilation system operations and maintenance, and transportation control measures; a commitment for implementing said measures; a schedule for implementing measures on a days-to-full effectiveness basis; and an analysis of the daily air quality impact of the measures on the emissions from the tunnel ventilation system and within the project area."

6.2 COMPLIANCE STATUS DETERMINATION FOR DAY-TO-DAY OPERATIONS

Concentration based emission limits for CO, NO_x and $PM_{2.5}$ were established as discussed in Section 2 of this document for tunnel emission exhaust locations. The limit levels that were established ensure that applicable NAAQS for CO, NO_2 and $PM_{2.5}$ and the Mass DEP 1-hour NO_2 Policy Guideline Value for NO_2 will not be exceeded at any ambient (i.e., outside) receptor location.

Mass DOT proposed and Mass DEP agreed to retain CO and NO_x emission limits for another year until the end of the ongoing NO_x monitoring program that will help to derive new emission limits for these pollutants. The July 2012 submittal of the CO and NO_x limits will be a supplemental application of the operating certification.

In order to determine the compliance status of the tunnel emissions, the Project has installed a separate CO and $PM_{2.5}$ CEM (continuous emission monitoring) system as described in Section 3 and Attachment 1 of this document. Data collected from the CO and $PM_{2.5}$ CEM systems are compared to the emission limits for every emission location.

Based on discussion with MassDEP, MassDOT understands that the 310 CMR 7.38(2) requirements regarding compliance with the applicable ambient air quality standards and the State Policy guideline for nitrogen dioxide do not apply during emergency conditions (i.e., tunnel fires).

The established emission limits for each location are listed in the Table 6-1, as follows:

As described in Section 2.4.3 of this document, emission limits for NO_x were established using a statistical analysis of actual CO and NO_x emission data collected from the TWT. The 1-hour CO emission limits listed above were established taking into account 1-hour NO_2 impacts. As a result, if the 1-hour CO emission levels remain below the listed emission limit, then no exceedances of the Massachusetts 1-hour NO_2 Policy Guideline Limit should occur.

TABLE 6-1: SUMMARY OF EMISSION LIMITS

Location*	1-Hour CO Emission Limit (ppm)	8-Hour CO Emission Limit (ppm)	1-Hour NO_X Emission Limit (ppm)	24-Hour $PM_{2.5}$ Emission Limit ($\mu g/m^3$)
VB1	70	70	8.88	900
VB3	70	70	8.88	900
VB4	70	70	8.88	900
VB5	70	70	8.88	900
VB6	70	70	8.88	900
VB7	70	70	8.88	900
Ramp L-CS	52	39	6.64	NA
Ramp CN-S	66	58	8.38	NA
Ramp ST-CN	70	70	8.88	NA
Ramp SA-CN	70	70	8.88	NA
Ramp CS-SA	56	46	7.14	35**
Ramp ST-SA	70	51	8.88	NA
Ramp CS-P	70	70	8.88	NA
Ramp F	70	70	8.88	NA
Dewey Square Tunnel	25	23	3.30	NA

* For each ventilation building, location includes all associated ventilation zones.

** The ambient $PM_{2.5}$ monitor is located outside ramp CS-SA. See section 3.3.4.2 for details. Compliance with the 24-hour $PM_{2.5}$ NAAQS is based on the monitoring design value, which is given by the 3-year average of the annual 98th percentile value of daily average concentrations. The form of the standard allows, on average, for the numerical value of the standard (35 $\mu g/m^3$) to be exceeded on seven calendar days per calendar year without triggering a violation of the NAAQS.

6.3 PRE-EMPTIVE ACTIONS

In order to avoid exceedances of the emission limits and ensure compliance with the applicable air quality standards, two tiers of pre-emptive measures are applied.

First, the in-tunnel CO monitoring system that is used to control tunnel ventilation and maintain in-tunnel air quality is set to alarm at a 25 ppm CO level on an hourly basis. In response to an alarm, an HOC operator will lower the in-tunnel CO level to below 25 ppm by increasing the ventilation rate at the affected ventilation zone.

The second tier of pre-emptive measures involves the CEM system. The 1-hour CO and 8-hour $PM_{2.5}$ CEM emission action levels have been established for each emission location, and actions will be taken (i.e., ventilation of the affected zone or zones increased) to lower the pollutant levels inside the tunnel when these action levels are exceeded. The action level established for each emission location falls within a range between 75% and 85% of its respective emission limit as listed below.

Real-time CO concentrations for all CO CEM monitoring locations are provided in the HOC for operator use. Using CO action levels presented in Table 6-2, procedures have been established for the HOC that will trigger an HOC operator response in the event that a CEM action level is reached.

In order to comply with the lowest emission action level (i.e., 20 ppm for DST), the ventilation fans for the Dewey Square Air Intake Structure along with ventilation zone SB-1 from VB 3 are set to step 3 from 6 AM to 10AM each morning and from 2 p.m. to 8 p.m. each weekday afternoon. The increase in the ventilation zone settings should prevent hourly CO emission levels from going above 20 ppm for DST. If the emission action level for DST is exceeded because of a non-emergency situation, the ventilation will be stepped up to a higher setting to ensure emission level remains below the emission action level.

Because of the high CO emission action levels for VB6 and VB7 and low monitored CO levels at these locations, the CEM monitors from VB6 and VB7 are not displayed in the HOC. $PM_{2.5}$ CEM emission levels are also not displayed in the HOC. However, CEM $PM_{2.5}$ emission levels from VB3, VB5, VB7, and ramp CS-SA will be tracked. If $PM_{2.5}$ concentrations at a VB CEM monitor approach action level of 900 $\mu g/m^3$ for eight consecutive hours then $PM_{2.5}$ concentrations will be displayed in the HOC. However, because of the high 8-hour emission action level of 900 $\mu g/m^3$, it is very unlikely that this level will ever be reached.

TABLE 6-2: EMISSION ACTION LEVELS

Location*	CO Emission Action Levels (ppm)	Rolling 8-Hour $PM_{2.5}$ Emission Action Levels ($\mu g/m^3$)
VB1	60	NA**
VB3	60	900
VB4	60	NA**
VB5	60	900
VB6	60	NA**
VB7	60	900
Ramp L-CS	42	NA
Ramp CN-S	53	NA
Ramp ST_CN	60	NA
Ramp SA-CN	60	NA
Ramp CS-SA	47	35***
Ramp ST-SA	60	NA
Ramp CS-P	60	NA
Dewey Square Tunnel	20	NA
Ramp F	60	NA

* For each ventilation building, location includes all associated ventilation zones.

** VB1, VB4, and VB6 do not have $PM_{2.5}$ monitors. Action levels at VB3, VB5, and VB7 will be used as surrogates for these locations.

*** Action level for ramp CS-SA is for 24 hours and is set to 100% of the 24-hour $PM_{2.5}$ NAAQS. Compliance with the 24-hour $PM_{2.5}$ NAAQS is based on the monitoring design value, which is given by the 3-year average of the annual 98th percentile value of daily average concentrations. The form of the standard allows, on average, for the numerical value of the standard (35 $\mu g/m^3$) to be exceeded on seven calendar days per calendar year without triggering a violation of the NAAQS.

6.4 CORRECTIVE (CONTINGENCY) ACTIONS

6.4.1 Emission Limit Exceedance Notification

As part of the renewal of the operating certification, MassDOT proposes to change the notification requirements associated with episodes for which an emissions limit is exceeded at any location. The proposed changes are based on the results of five years of operating the system and the need for more flexibility and time to meaningfully investigate the cause of such episodes. MassDOT proposes to change the current verbal notification requirement from 4 hours to 12 hours. In addition, Mass DOT proposes to change the written notification requirement from 24 hours to 48 hours.

Provided that the necessary background concentrations of ozone, NO_2, CO, or $PM_{2.5}$, as applicable, are supplied to MassDOT by MassDEP in a timely manner, results of the emission limit assessment analysis report will be submitted to the Mass DEP along with a description of the actions that have been taken to eliminate the emission limit excursion within three business days from the time when the background data are received.

6.4.2 Emission Limit Assessment (ELA)

When an exceedance of an emission limit occurs at any of the emission locations, an Emission Limit Assessment of the causes and nature of the exceedance will continue to be prepared and sent to MassDEP.

The analysis will examine air quality impacts for each designated receptor around the VB or longitudinally ventilated exit ramp where the emission limit was exceeded. Meteorological conditions and pollutant background concentration during the exceedance time period will be used in the analysis. The results of the analysis will be reported to the MassDEP on a schedule as described in 6.4.1following the notification that the emission limit was exceeded.

6.4.3 Additional Contingency Measures

If the ELA determines that the exceedance of an emission limit resulted in an exceedance of an NAAQS for CO, $PM_{2.5}$ or the Massachusetts 1-hour NO_2 Policy Guideline Limit; actions related to a long term mitigation plan will be discussed with MassDEP for possible implementation.

6.5 MITIGATION PLAN

Pursuant to 310 CMR 7.38(4), the initial operating certificate submittal is not required to include a mitigation plan. Requirements related to the preparation, review, and acceptance of a mitigation plan is instead governed by 310 CMR 7.38(6).

310 CMR 7.38(6) states that if Mass DEP finds—based on a review of information submitted by the operator in support of the operating certification, and such information as Mass DEP has available to it—that one or more of the air quality limits specified in the regulation are being violated or are likely to be violated, then the operator of the tunnel ventilation system shall take certain identified actions. The trigger to taking those actions is a finding of a violation of air quality standards based on Mass DEP review of the operating certification submittal itself.

Sections 6.2 and 6.3 already described the process in place to reduce the possibilities of exceeding emission limits. In summary: First, the tunnel ventilation system is operated to maintain CO levels at or below 25 ppm inside the tunnel which is below all hourly limits. Secondly, the CEM monitoring system warns operators if the action level (typically set in the range of 75% to 85% of the emission limit) is reached. Finally, operators will be notified by an alarm if an emission limit is exceeded. In each case, HOC operators will increase ventilation rates in order to bring emissions in the tunnel below the indicated criteria. If an emission limit is still exceeded at any location, procedures described in section 6.4 above will be followed and an assessment will be performed to analyze air quality impacts for the particular hour/day of when an emission limit was exceeded and to determine whether this caused an NAAQS or a Mass DEP Policy Guideline to be exceeded or violated.

The corrective actions regarding the development of a CA/T mitigation plan are required only in the event that Mass DEP finds that one or more of the 7.38 criteria are being violated. Unless and until Mass DEP makes such a finding, including but not limited to an identification of the nature and severity of the violation, appropriate mitigation measures do not need to be developed.

6.6 COMPLIANCE OF THE VENTILATION SYSTEM FROM 2006 TO 1ST QUARTER OF 2011

The collected data presented in a summary form (Tables 5-1 to 5-16) indicate:

- Measured hourly CO concentrations for the ventilation buildings range from 1.0 to 3.0 ppm on average and as high as 34 ppm during peak periods for the ventilation buildings. For the DST and ramps, hourly CO concentrations were in the range of 1.0 to 4.0 ppm on average with maximum levels in the range of 4.0 to 68.7 ppm.

- Measured hourly NO_x levels from the ventilation buildings ranged from 0.3 to 0.6 ppm on average with peak values ranging from 1.0 to 2.2 ppm. Measured hourly NO_x levels for the DST and Ramps ranged from 0.3 to 0.75 ppm on average with peaks ranging from 1 to 8.8 ppm.
- Measured average daily PM_{10} concentrations in each year were between 31 and 121 $\mu g/m^3$, Maximum daily PM_{10} values were in the range ,of 100 to 577 $\mu g/m^3$. The PM_{10} monitor outside Ramp CS-SA, which measures ambient levels, recorded annual averages from 19 to 21 $\mu g/m^3$, and a maximum daily level of 116 $\mu g/m^3$.

The data indicate that the pollutant levels inside the tunnels are generally much lower than anticipated, with CO levels decreasing in the latter years.

There were eleven episodes recorded over the five-year period when an emission limit was exceeded. These were the result of abnormal conditions related to nighttime tunnel closures due to maintenance, system malfunctions and the effects of road salt application during severe snowstorms. They were corrected as soon as the cause was identified, and the associated ELA indicated that none of them resulted in a violation of an NAAQS or a Mass DEP Policy Guideline.

6.7.1 Exceedances of Emission Limits

During the period from the beginning of 2006 through the end of the first quarter of 2011, there were eleven episodes when an emission limit was exceeded. Table 6-3 provides a summary of these events in chronological order and identifies the location, the emission limit that was exceeded, the maximum level measured, and the associated conditions.

TABLE 6-3: CEM EMISSION LIMIT EXCEEDANCES

No. of Incidents	Date(s)	Time	Location(s)	Pollutant(s)	No. of Hours	Highest Measured Level*	Main Reason
1	28-Jun-07	1:00 AM	DST (I-93)	CO	2	38.2	Tunnel closed for maintenance
2	12-Sep-07	midnight	DST (I-93)	CO	2	29.8	Tunnel closed for maintenance
3	2-Oct-07	11:00 PM	Ramp L-CS	CO	1	55.0	Tunnel closed for maintenance
	3-Oct-07	midnight			1	67.5	Tunnel closed for maintenance
4	11-Oct-07	3:00 PM	DST (I-93)	CO	1	33.5	Computer system malfunction
5	17-Dec-07	Daily	VB7	PM_{10}	1	537.4	Re-suspended road salt
	18-Dec-07	Daily	VB3 & VB7		2	541.6	Re-suspended road salt
6	20-Feb-09	Daily	VB3		1	545.8	Re-suspended road salt
7	4-Mar-09	Daily	VB3		1	501.4	Re-suspended road salt
8	21-Dec-09	Daily	VB7		1	521.3	Re-suspended road salt
	22-Dec-09	Daily			1	577.7	Re-suspended road salt
9	10-Aug-10	Midnight	Ramp L-CS	CO	1	68.7	Tunnel closed for maintenance
10	7-Oct-10	Midnight	DST (I-90)	CO	1	33.6	Tunnel closed for maintenance - CO monitoring equipment failure
11	4-Feb-11	Daily	VB3	PM_{10}	1	542.0	Re-suspended road salt

*Concentrations are in ppm for CO and in $\mu g/m^3$ for PM_{10}.

An explanation of the circumstances of each episode and the actions taken to reduce concentration levels is provided below.

The June 28, 2007 exceedance of the CO emission limit occurred at approximately 1 AM , while the I-93 DST was closed to general traffic due to maintenance activities within the tunnel. Recorded levels exceeded the CO limit for two hours. As the MassDOT correspondence to DEP (July 11, 2007) indicates, that night there were multiple crews with construction equipment performing maintenance and construction activities. The HOC operators acknowledged the alarm indicating levels above the 25 ppm limit, but, since the DST was closed to traffic, the ventilation rate was not increased as expected during normal heavy traffic conditions. The high levels measured were the combined result of emissions from idling and working construction equipment and the absence of the piston action effect normally created by moving traffic which self-ventilates the DST pushing the tunnel emissions downstream of the exit portal. MassDEP acknowledged the notification, concurred with the MassDOT that the emission limit exceedance would not result in an ambient air violation of the NAAQS, and agreed that there was no need for an ELA to be prepared.

The September 12, 2007 exceedance of the CO emission limit occurred after midnight while the I-93 DST was closed to general traffic due to maintenance activities within the tunnel. As the MassDOT correspondence to DEP (September 13, 2007) indicates, the high measured levels were the result of idling equipment in the vicinity of the CO monitor and minimum ventilation rate due to the closing of the DST to general traffic. During this instance the MassDOT implemented corrective actions including a directive to turn off equipment while not in operation (limit idling) and to adjust the DST ventilation rate following the HOC Response Procedure 509 if the CO level approaches 25 ppm.

The exceedances of the CO emission limit on October 2, 2007 and October 3, 2007 occurred at 11 PM and midnight at Ramp-L-CS. The limit was exceeded for two consecutive hours. During this time, the Ramp was closed to general traffic due to maintenance activities within the tunnel. As the Mass DOT correspondence to DEP (October 10, 2007) indicates, the high measured levels were the result of idling equipment in the tunnel and the lack of ventilation since the jet fans which ventilate the ramp were shut down due to the tunnel closure. Since there was no air movement inside the tunnel at the time of occurrence, Mass DEP concurred with the Mass DOT in the October 10, 2007 correspondence that no ambient violation of standards could occur outside the tunnel and that an ELA was not warranted.

The October 11, 2007 exceedance of the CO emission limit occurred at 3 PM at the I-93 DST. It was due to a malfunction of the computer equipment that controls the automatic ventilation system for the DST Air Intake Structure. As a result of the malfunction the DST ventilation system was not increased to step 3 as it is programmed to do between 2:00 PM and 7:00 PM. Until the problem was corrected, a manual override by the operator was implemented. The emission limit was exceeded for only one hour before the situation was corrected. An ELA was performed, and the results indicated no violation of the CO NAAQS or the NO_2 DEP Policy Guideline.

On January 9, 2008, MassDEP issues a NOTICE OF NONCOMPLIANCE with reference to the October 11, 2011 exceedance of the CO limit at the DST. MassDEP accepted that the ELA submitted by MassDOT on October 23, 2007 concluded that the exceedance did not result in any violation of the CO NAAQS or DEP Policy guideline for NO_2. However MassDEP NONCOMPLIANCE letter indicated that the OCC staff failed to properly respond to the high CO level alarms, and during the incident attempted to operate the fans a Summer, Essex and Beach streets in an exhaust mode, which were to be operated only during emergency situations. The MassDEP letter required that MassDOT respond within 21 days with a plan to correct this operational deficiency.

On January 25, 2008, MassDOT responded to the NONCOMLPIANCE letter explaining the results of the investigation, and including the proposed revisions to internal procedures RP-504 "High and HI-high Carbon Monoxide" and RP-509 "CEM Stack Zone Status"; to avoid a repetition of this type of incident.

The 24-hour PM_{10} emission limit was exceeded at VB3 on December 18, 2007 and at VB3 and VB7 on December 18, 2007, yielding three daily average concentrations above the emission limit. The cause was the pulverization of road salt applied to the tunnel and its approaches during winter snow conditions followed by a very cold and dry spell after the snowstorm. These conditions created a large source of salt crust available for vehicle pulverization and re-entrainment by the movement of vehicle tires. The results of an ELA performed for the highest levels recorded at VB3 and VB7 indicated that no violation of the PM_{10} NAAQS occurred. Furthermore, the highest predicted ambient values from the ELA, including background levels from other sources, were less than 1/3 of the NAAQS. This demonstrated that the emission limit could have been set at a much higher level (over 2,000 $\mu g/m^3$) without causing concentrations above the PM_{10} NAAQS at locations corresponding to the adjacent abutters and public. After this event, MassDEP required the MassDOT to evaluate the implementation of Best Management Practices, including street sweepers and other deicing products. The analysis concluded that these possible practices were unnecessarily costly and disruptive. Also, an increase in ventilation rate was implemented, but it exacerbated the problem by increasing the suction of road salt into the ventilation system. The conclusion of the analysis was that if PM_{10} exceedances were to re-occur due to road salting, an ELA would be performed for each instance to verify compliance with the NAAQS in areas of ambient air.

Exceedances of the 24-hour PM_{10} emission limit occurred on February 20, 2009 and on March 4, 2009 at VB3 The cause was the pulverization of road salt applied to the tunnel entrances and exits during winter snow conditions. The results of an ELA performed for the highest levels indicated that no violation of the PM_{10} NAAQS occurred. The highest ambient values, including background from other sources, predicted in the ELA were less than 1/2 of the NAAQS.

Exceedances of the 24-hour PM_{10} emission limit occurred on December 21, 2009 and December 22, 2009 at VB7. The cause was also the pulverization of road salt applied to the tunnel entrances and exits during winter snow conditions. The results of an ELA performed for the highest levels indicated that no violation of the PM_{10} NAAQS occurred. The highest ambient values, including background from other sources, predicted in the ELA were less than 1/4 of the NAAQS.

The August 10, 2010 exceedance of the CO emission limit occurred at midnight at Ramp-L-CS. The limit was exceeded for one hour. That night the Ramp was closed to general traffic due to maintenance activities within the tunnel from 10:30 PM to 4:37 AM. The high measured level was the result of idling equipment in the tunnel and no ventilation, since the jet fans, which ventilate the ramp, were shut down due to the tunnel closure. Although operating procedure RP-509 requires the operator to turn on the jet fans during this type of event, the time of occurrence (midnight) coincided with the equipment auto calibration which also produces high values. Therefore, the exceedance was not recognized as such by the operator. MassDOT subsequently modified the language for RP-509 to prevent a reoccurrence. Unfortunately, the exceedance was not discovered by the environmental engineer until the monthly data review was performed, since the technician had failed to report the incident. As a result, DEP was not notified until September 29, 2010.

The October 7, 2010 exceedance of the CO emission limit occurred at midnight (12:00 to 12:59 AM) while the I-90 DST Collector was closed to general traffic due to maintenance activities within the tunnel. Even though the operator followed the RP-509 procedures and increased ventilation to steps 3, 4, and then 5, the 1-hour CO concentration exceeded the emission limit. The technician failed to immediately report this event to the Environmental Engineer. Upon notification an ELA was prepared, and the results indicated that there was no violation of the CO NAAQS or the NO_2 DEP Policy guideline. The ELA results indicated that ambient values were 50% below the NAAQS and DEP Guideline.

On January 25, 2011 DEP issue a NOTICE OF NON COMPLIANCE to Mass DOT for the exceedances measured on August 10, 2010 and October 7, 2010. This notice states that the MassDOT was in NON COMPLIANCE with the Contingency Plan provisions due to failure of the operator to act and notify MassDEP within 24 hours. The actions required by DEP included a revision of procedures, a plan to train HOC operators on RP-509, and a directive to contractors to limit equipment idling.

The February 25, 2011 MassDOT correspondence acknowledged the reasons for non Compliance and implemented the actions described above. It also stated that the October 7, 2010 exceedance was due to instrument failure resulting from the presence of VOC during the maintenance activities. The CO monitor used at DST I-90 displays 33.6 ppm of CO in the presence of propane gas regardless of the real CO level in the inlet.

The last recorded exceedance of the PM_{10} limit occurred on February 4, 2011 at VB3. The cause was the pulverization of road salt applied to the tunnel entrances and exits during winter snow conditions. The ELA performed for the highest levels indicated that no violation of the PM_{10} NAAQS occurred. The highest ambient values including background levels from other sources predicted in the ELA were less than 1/4 of the NAAQS.

6.7.2 Summary of Exceedances, Reasons and Lessons Learned

As described in the previous section, there were eleven episodes during the period from the beginning of 2006 through the end of the first quarter of 2011 when emission limits were exceeded. These episodes resulted in a total of 10 hours when CO measured levels exceeded a corresponding emission limit and 8 days when the measured PM_{10} levels exceeded an emission limit.

CO concentrations were measured every hour at 24 VB exhaust locations and at eight locations in the DST over the last five calendar years (2006-2010) and during the first quarter of 2011, yielding approximately 1.47 million observations. The 10 hours for which a CO emission limit was exceeded represent an exceedingly infrequent occurrence and shows that the ventilation system nearly always was in compliance with its CO emission limits. Over 99.99% of the hourly CO concentration measurements showed compliance with CO emission limits, and the 10 hours when CO emission limits were exceeded represent only about 0.022% of the hours during this period.

For the six cases (totaling 10 hours) when CO limits were exceeded, the main reasons were the idling emissions of the operating maintenance equipment during tunnel closing and the lack of adequate ventilation air due to the closure of the tunnels. There was one case when equipment malfunction prevented the proper ventilation at the DST and another when the VOC fumes during maintenance caused a malfunction at the CO monitor.

For the five cases (8 days) when PM_{10} limits were exceeded, the reason was the pulverization of road salt applied during winter snowstorms, which created a large source of salt crust available for vehicle pulverization and re-entrainment.

It is important to point that corrective measures were taken and response procedures were modified when necessary as part of the contingency plan.

It is also important to note that none of the episodes when an emission limit was exceeded resulted in a violation of the applicable NAAQS or DEP NO_2 Policy guideline. The results of each ELA indicated that the maximum predicted ambient values were almost always 50% or less of the applicable NAAQS or DEP NO_2 Policy Guideline. This shows that the emission limits were established with a considerable margin of safety with regard to the health related NAAQS, due to the very conservative worst-case assumptions that went into the analysis, which supported the 2006 Operating Certification process.

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