GE Aviation
PSD Permit Application
Test Cell 2 and 5 Modification

Prepared for

GE Aviation

Lynn, MA

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CH2MHILL

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1.0 Introduction

GE Aviation (GE) recently was awarded a major, multi-year contract by Sikorsky Inc. to provide engines for the new CH53K, the U.S. Marine Corps Heavy Lift Replacement Helicopter. The GE38-1B engine is the 8000 shaft horsepower ("shp") turbo-shaft/turboprop (TS/TP) engine slated to power the CH53K. To accommodate the testing requirements for this contract, GE is proposing to modify Test Cells 2 and 5, both of which are located in Building 29 at the Lynn, Massachusetts facility. These two test cells originally were constructed in the mid 1950s, but have seen minimal use in the last 10 years. The modifications to Cells 2 and 5 and the intended future use of these cells principally for the GE38-1B engine development and testing program will constitute a significant net emission increase in nitrogen oxides (NO_x) over past actual emissions. These increased emissions trigger both Prevention of Significant Deterioration (PSD) and Non-attainment New Source Review (NNSR) permitting. Emissions of all other PSD pollutants will be below their respective PSD thresholds. The U.S. Environmental Protection Agency (EPA) Region I administers the PSD program in Massachusetts, while the Massachusetts Department of Environmental Protection (MassDEP) administers the NNSR program. This document represents the permit application for the PSD permit.

The CH53K is scheduled to achieve its Initial Operating Capability (IOC) in 2015. GE Aviation has reviewed its assembly and test capabilities worldwide and determined that the highly trained workforce and world-class facilities at the GE Aviation facility are best suited for the GE38-1B engine development program. The GE Aviation facility is a world leader in the design, development and production of TS/TP engines and currently produces the T700/CT7 engine for the Blackhawk and Apache helicopters in the 3000 shp range. Moreover, the GE38-1B is a derivative of the GE738 engine that previously was designed and developed at the GE Aviation facility.

This document addresses the requirements of a PSD permit application in the following sections. The NNSR permit application is included as a separate document for ease of review by the regulatory agencies.

- Facility and Project Description — Section 2
- Emission Estimates — Section 3
- Regulatory Analysis — Section 4
- Best Available Control Technology (BACT) Evaluation — Section 5
- Dispersion Modeling — Section 6
- Additional Impact Analysis — Section 7
- Major Comprehensive Plan Approval (CPA) Permit Application Forms — Section 8

- Drawings, Back-up Calculations, Modeling Protocol, and Additional Backup Information — Appendices

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2.0 Facility and Project Description

2.1 Site Description

The GE Aviation Facility is an industrial complex located in the city of Lynn, Massachusetts, at 1000 Western Avenue. The complex consists of 3.4 million square feet of buildings on 221 acres, as depicted in Figure 2-1 on the Lynn, Massachusetts (USGS MAP) quadrangle, 1985. The site houses auxiliary support facilities including a 56.8 MW power plant employing four boilers and one combustion turbine to generate electricity and steam for onsite uses, in addition to a variety of other small heaters and emergency/stand-by generators to provide heat or back-up power.

GE Aviation is a world leader in the production of turbine engines for commercial and military use, and the Lynn, MA facility has been the site of turbine engine manufacturing and testing since the 1940s. Currently at this site, aircraft engines and engine parts are manufactured, assembled, tested, and shipped offsite to customers. Testing of engines in both the research and development (R&D) stage and the production stage occurs onsite. In addition, Navy gears are manufactured and tested onsite.

The GE Aviation facility is an existing major stationary source for nitrogen oxide (NO_x) emissions, sulfur dioxide (SO_2), volatile organic compounds (VOCs), carbon monoxide (CO) and particulate matter (PM). Lynn, Massachusetts is currently within a designated moderate non-attainment area for 8-hour ozone concentrations, but is in attainment or unclassifiable for all other criteria pollutants, including nitrogen dioxide (NO_2).

The facility currently has a total of 17 permitted test cells (including Test Cells 2 and 5) available for various modes of operation for engine and engine component development, as well as for production testing. Engine test cells are essentially a structural enclosure including a frame or cartridge into which an engine or engine component is mounted and connected to an array of test equipment including instrumentation and controls. In the cell, the engine is run under a range of operating conditions simulating the engine's flight mission while engineers and operators observe and control the test from a nearby control room.

Both of the proposed test cells to be modified are located within Building 29, which is near the northwest corner of the property, adjacent to the Saugus River and Rt. 107. The locations of these test cells, along with the property boundary, are shown in Figure 2-2 (the solid bar across the GE property indicates an easement held by the Massachusetts Bay Transportation Authority). The test cell modifications largely will be internal to Building 29, with the exception of a replacement stack for Test Cell 5, replacement air inlet ductwork for Test Cell 2, and installation of a hush house for both cells to control noise.

FIGURE 2-1
Site Location
GE Aviation, Lynn, MA

FIGURE 2-2
Aerial Photograph of GE Aviation Lynn Site

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2.2 Permitting History and Historical Emissions

Seventeen (17) test cells at the GE Aviation facility currently are permitted to operate under a 310 CMR 7.02 Major Comprehensive Plan Approval (CPA), MBR-93-COM-021, dated June 24, 1998. The two cells proposed to be modified are included under this existing federally-enforceable air permit. Under the CPA, the combined NO_x emissions from all seventeen (17) test cells are capped at 637 tons per 365-day rolling calendar period.

In addition, two of the 17 test cells, Test Cells 114 and 115, are permitted under a PSD approval, also issued as a major CPA (when the PSD program was delegated to MassDEP): MBR-98-COM-017/MBR-92-COM-019 dated May 26, 1998, and most recently revised on October 31, 2002. Under this permit, NO_x and VOC emissions from Test Cells 114 and 115 are capped at 532 tons and 43 tons, respectively, per 365-day rolling calendar period.

The facility has been issued a draft Title V Operating Permit (Permit no. MBR-95-OPP-083 dated May 15, 2007), which is expected to be finalized in early September 2007. There are no restrictions on the types of engines tested in any of the existing or proposed test cell permits.

To estimate air emissions, each test cell employs a parametric emission monitoring system, which continuously measures fuel flow and multiplies the fuel flow rate by emissions factors representative of the pollutants emitted from each type of engine being tested in the test cell.

Since the test cells proposed to be modified have not been used in recent years, the proposed modification is triggering PSD review due to the expected increase in actual emissions in Test Cell 2 and 5. The existing facility-wide test cell permitted annual NO_x cap will be unchanged and remain in effect. The new permitted NO_x limit for Test Cells 2 and 5 resulting from this modification will be a separate restriction overlapping the 17-test cell permit cap, similar to the limit for Test Cells 114 and 115.

2.3 Engine Test Cell Description and Proposed Modifications

Engine test cells have two main designs: 1) open-air design and 2) enclosed design with intake and exhaust stacks. All of the test cells that are operated at the GE Aviation Lynn facility are of the enclosed design-type. The main advantage of the enclosed test cell design is the ability to reduce noise and provide safety to the test cell operators.

Each test cell enclosure will house the actual test cell and will include air inlet and exhaust stacks, air flow turning and splitting devices, test operations and control facilities, sound suppression material, and support equipment. Engine emissions initially will be directed through a horizontal augmenter tunnel that turns upwards to exhaust through a stack.

The purpose of any test cell is to perform various tests on engines under simulated conditions of pre-flight and flight for the purpose of development, new parts qualification, performance optimization, and production testing (prior to shipment to customers). During this testing, the engine is operated at various power levels to simulate conditions and to test the engine over the full test cycle. The test cycle defines the primary engine power settings, or load conditions, at which the engine is operated during a test. A "test profile" further defines the relative percentage of time within a test that an engine is operated at each of the various test cycle power settings.

In most test cells, the engine is not mounted to an aircraft, but to a thrust frame or stand. A dynamometer is used to simulate the various loads at which to test the engine. At this point in the design, GE Aviation has not determined whether the proposed dynamometer for both Cells 2 and 5 will employ an air brake or water brake. If an air brake is used, the clean air used in the dynamometer will be separately exhausted through a new hush house to be installed on the roof of each test cell. The purpose of the hush house is to control noise emissions from the test cell. If a water brake is utilized, there will be no hush house and no clean air exhaust from the dynamometer. Instead, municipal water will be used and recirculated through a cooling tower dedicated to each test cell. Blowdown from the cooling tower will be directed to the POTW sewer. The volume of this blowdown will be minimal. Test Cell 5 already has an existing cooling tower, which can be used or expanded, if needed, to accommodate the new GE38-1B engine testing. A new cooling tower will have to be sited and constructed for Test Cell 2.

The inlet air to the test cells will be heated using a direct natural gas-fired air heater. All emissions from the natural gas combustion in the air heater will be contained in the heater air supply to the test cell and exhausted through the test cell stack. Each test cell will have its own dedicated heater.

Two design concepts of Test Cell 5, which is also typical of Test Cell 2, are shown in Figures 2-3 and 2-4. Figure 2-3 shows the outside of Test Cell 5 as modified to accommodate testing of the new GE38-1B engine. Figure 2-4 shows the inside of the test cell, including the augmenter tube, which augments the flow of air through the test cell and is mounted immediately behind the engine, and the dynamometer, which is mounted immediately in front of the engine.

The augmenter is simply an ejector that serves several purposes: (1) powered by the high energy engine exhaust stream, the augmenter reduces the test cell pressures to a level equivalent to the pressure at the engine compressor inlet; (2) the air drawn over the engine provides some of the cooling normally obtained by the motion of the aircraft in flight; and (3) the air entrained by the augmenter cools the engine exhaust. The cooling protects the integrity of the exhaust stack and protects the noise control equipment.

After the exhaust gases move out of the perforated basket (or colander) section of the augmenter tube, they leave the cell through a vertical stack. In the existing stack for Test Cell 2, there are perforated tubes made from metal sheeting, steel mesh, and a woven fiberglass mesh. Between each tube is a sound insulating material identified as "rock wool" to control noise. Instead of using tubes, the proposed new stack for Test Cell 5 will be designed with an acoustic silencer and acoustic treatment for noise control.

Both Test Cells 2 and 5 are existing cells that are located in the northwest corner of Building 29. However, since they are both mid-1950 vintage cells, many components of the cells, including the controls, are outdated. The modifications required for each cell are discussed below.

In order to accommodate the GE38-1B testing, Test Cell 2, which formerly was used to test J85 Thrust engines, will require the following modifications:

- Alter Interior Building - Minor (widen cell doorway; floors)
- New Inlet Natural-Gas fired Heater
- Replace Engine Mount
- Replace Analog Data System & Facility Control with Digital
- New Air Dynamometer, or Water Brake
- If water brake option selected, new cooling tower
- Add Air Ducting & Noise Control for new, separate exhaust from air dynamometer

In addition, Test Cell 5, which formerly was used to test T64 Turboshaft engines, will require the following modifications:

- Alter Interior Building - Minor (enlarge control room; refurbish floors)
- Replace Stack & Augmenter Tube
- Replace Steam Inlet Heater with natural gas-fired and/or new steam inlet heater
- Replace Engine Mount & Power Absorption System
- Replace Analog Data System & Facility Control with Digital
- Replace Eddy Current Dynamometer with Air Dynamometer, or Water Brake
- If Water Brake Option is Selected, the Existing Cell 5 Cooling Tower will be used
- Add Air Ducting & Noise Control for new, separate exhaust from air dynamometer

In order to accommodate the GE38-1B development and manufacturing schedule, Test Cells 2 and 5 will need to be retrofitted and ready for use by February 2009 and December 2009, respectively.

FIGURE 2-3
Northwest Section of Building 29 (29U) After Project Completed: Stacks, Heated Inlet, and "Hush House" on Cell 5

FIGURE 2-4
Test Cell 5 with GE38 after Project Completed
(Typical for Both Cells 2 and 5)

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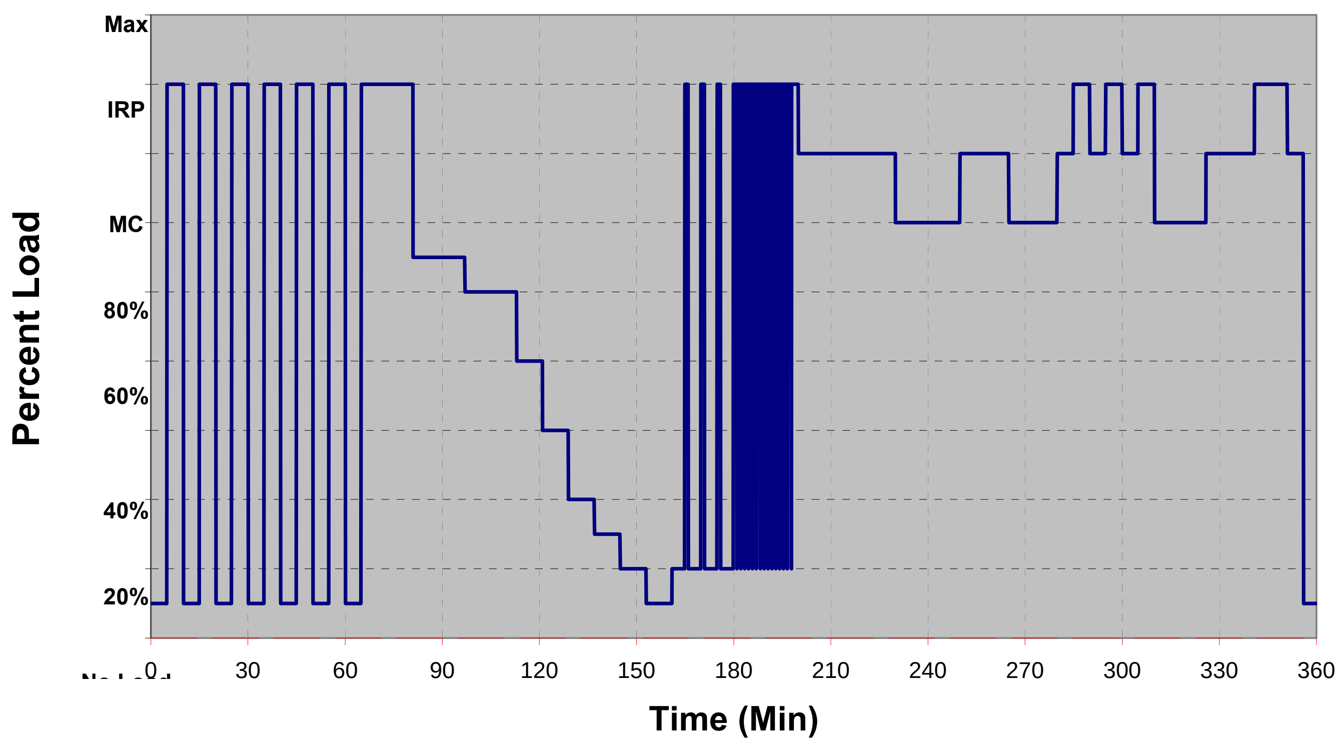
2.4 Test Cell Planned Operation

Currently, both R&D and production testing of a variety of aircraft engines are conducted at the GE Aviation facility. Since the GE38-1B engine will be a new engine model, it first will be manufactured at the GE Aviation facility, then R&D tested (engine qualification testing) before being commercially manufactured, and finally, after commercial production begins, production tested prior to delivery to customers.

During engine qualification testing, the new GE38-1B engine will burn JP5 or other jet fuel under a range of operating conditions simulating the extremes of the engine's flight mission. A graph of the testing profile to be used during GE38-1B engine qualification testing is shown in Figure 2-5. This worst case testing profile was used to estimate the emissions included in Section 3.0. Although GE38-1B development and production provides the basis for the emission limits for the modification of Cells 2 and 5, the future use of these cells will not be restricted to testing only this engine line. Any future engine testing performed in these cells will be subject to any applicable limits resulting from both this PSD and the state NNSR permits regardless of the engine being tested.

FIGURE 2-5
Profile to be used during GE38-1B Engine Qualification Testing



3.0 Emission Estimates

This section explains the assumptions made and procedures used for calculation of emissions of air pollutants from the operation of the GE38-1B helicopter engines in Test Cells 2 and 5. These emission calculations include both emissions generated from the GE38-1B engine and emissions from the natural gas-fired inlet air heater associated with each test cell. For this permit application, one 9.75 MMBtu/hr heat input natural gas-fired air heater was assumed for each test cell. However, this may change as the test cell design proceeds, if these heaters are replaced by smaller units or by steam-driven heaters (with no air emissions). Emissions also were calculated for the cooling towers, which will become necessary if the water brake dynamometer option is selected. Therefore, emissions estimates presented here are conservative, and emissions associated with the final design will be the same as or less than the emissions defined here.

3.1 Historical Emissions

Test Cells 2 and 5 were constructed at the GE Aviation facility in the mid-1950s but have seen minimal use since 1997. Actual emissions from the last ten years, considered as a part of the emissions increase criteria under PSD, averaged less than one ton of NO_x per year.

3.2 Existing Permitted Emission Limits

As discussed previously, Test Cells 2 and 5 are included in the existing CPA (MBR-93-COM-021) for all 17 of the test cells onsite. This permit has a federally enforceable NO_x limit of 637 tons per 365-day rolling calendar period for all of the 17 test cells combined. In addition, Test Cells 114 and 115 have federally enforceable PSD permit limits of 532 tons of NO_x and 43 tons of VOC per 365-day rolling calendar period. There are no test cell-specific limits except for the PSD limits on Test Cells 114 and 115. Operation of any of the test cells, except 114 and 115, can collectively generate up to the allowable 637 tons of NO_x per 365-day rolling calendar period. Thus, the applicable existing emission limit for Test Cells 2 and 5 is 637 tons of NO_x per 365-day rolling calendar period.

3.3 Emission Estimates for Permitting

The emission estimates and development of proposed permit limits are based on the following information:

- Representative weighted average test profile for the GE38-1B engine
- Projection of the number of engines to be tested per year
- Projection of the annual number of testing hours per year

As part of the engine development and qualification, only a few prototype GE38-1B engines will be built and rigorously endurance tested. After endurance testing is completed and design development is complete, the engine will be produced commercially and tested prior to shipment to customers. Since the endurance testing is by far the most rigorous testing the engine will undergo in these test cells, it was used as the basis for the emission estimates. It is anticipated that annual emissions during production testing will be considerably less than those annual emissions generated during endurance testing.

The typical test profile for this engine indicating the total test time and proportion of hours within a test cycle that the engine would be run at each of the specified test loads and the associated emission factors for each criteria pollutant at each load is shown in Table 3-1. This profile was developed based on testing of similar engines and engine components. The hours run at each power level are not meant to be run time limitations, but are used to develop a representative means of estimating emissions from the test cells. The bottom portion of the table lists the overall weighted-average (i.e., weighted by time) emission factors for each criteria pollutant calculated from the individual power level emission factors and run time data.

TABLE 3-1
Development of Emission Factors

Power Level	Test Profile Hours (%)	Fuel Consumption (lbs/hour)	Fuel Profile (%)	Emission Factors (lbs pollutant/1,000 lb fuel)				
				PM	CO	SO_2	NO_x	VOC
Idle	13	338	0.022	0.006	44	2.2	5	7.5
No Load	7	550	0.021	0.007	15	2.2	6	1
50%	7	1,313	0.047	0.006	2	2.2	14	0.5
75%	2	1,800	0.022	0.01	1	2.2	18	0.1
M/C	24	2,234	0.278	0.027	1	2.2	24	0
IRP	19	2,313	0.225	0.038	1	2.2	26	0
MAX	27	2,822	0.385	0.068	1	2.2	32	0

Time-Weighted Average Emission Factors & Fuel Flow

PM:	0.043	lb/1,000 lbs fuel
CO:	2.273	lb/1,000 lbs fuel
SO_2:	2.200	lb/1,000 lbs fuel
NO_x:	26.145	lb/1,000 lbs fuel
VOC:	0.299	lb/1,000 lbs fuel
Fuel Flow	1,967	Lb/hr

NOTE: M/C – maximum continuous power, IRP – intermediate rated power, MAX – maximum power

While the engine will cycle through a full range of load conditions during testing as explained in Section 2.4, the primary test conditions are represented by the following power levels: idle, no load, 50 percent power, 75 percent power, maximum continuous (M/C), intermediate rated power (IRP), and maximum (MAX).

The annual potential emission calculations have assumed operation for a total of 3,000 hours per year in each test cell. Due to the "batch" nature of testing and the long periods of downtime to accommodate engine changeovers, test cells are normally used far less than

3,000 hours per year. For the worst case endurance tests proposed, it is projected that Test Cell 2 and Test Cell 5 will run 1,650 and 2,225 hours per year, respectively; therefore the 3,000 hour per year estimate to develop potential emission estimates is conservatively high. The emission factors for each pollutant at each load shown in Table 3-1 are multiplied by the fuel usage rate at each load, then multiplied by the average percent time at that load and summed to calculate the time-weighted average emission factors in lb pollutant/1000 lb fuel for the engine. These weighted average emission factors are then multiplied by the amount of fuel burned at the same testing profile for 3,000 hours to calculate annual emission rates for permitting.

Table 3-2 summarizes the proposed short-term permit emissions limits for Test Cells 2 and 5. The monthly emissions limits were calculated using the worse case hourly emission rate for each pollutant and summing that for 24 hr/day and 31 days/month.

Table 3-3 summarizes the annual limits for each test cell which were calculated based on limiting both tests cells to a total of 6,000 hours of operation per year (3,000 hours per year per test cell).

TABLE 3-2
Test Cell 2 and Test Cell 5 Proposed Short term Emission Limits[(1)]

	-------Estimated Emissions (Pounds/Month)----------				
	NO_x	VOC	CO	SO_2	PM_{10}
Test Cell 2:					
Test Cell	67,186.18	1,886.04	11,064.77	4,619.05	142.77
Heater	0.96	0.05	0.81	0.01	0.07
Cooling Tower	0.00	0.00	0.00	0.00	848.16
Total Test Cell 2:	67,187.14	1,886.09	11,065.58	4,619.06	991.00
Test Cell 5:					
Test Cell	67,186.18	1,886.04	11,064.77	4,619.05	142.77
Heater	0.96	0.05	0.81	0.01	0.07
Cooling Tower	0.00	0.00	0.00	0.00	848.16
Total Test Cell 5:	67,187.14	1,886.09	11,065.58	4,619.06	991.00
Total Test Cells 2 & 5 (lb/month):	134,374	3,772	22,131	9,238	1,982
Total Test Cells 2 & 5 (ton/month):	67	2	11	5	1

*NOTE: (1) based on highest hourly emission factor in test profile * 24 hr/day * 31 days/month.*

TABLE 3-3
Test Cell 2 and Test Cell 5 Proposed Long-Term Emission Limits (1)

	-------Estimated Emissions (Tons/Year)----------				
	NO_x	VOC	CO	SO_2	PM_{10}
Test Cell 2:					
Test Cell	77.14	0.88	6.71	6.49	0.13
Heater	1.44	0.08	1.21	0.01	0.11
Cooling Tower	0.00	0.00	0.00	0.00	1.71
Total Test Cell 2:	78.58	0.96	7.92	6.50	1.95
Test Cell 5:					
Test Cell	77.14	0.88	6.71	6.49	0.13
Heater	1.44	0.08	1.21	0.01	0.11
Cooling Tower	0.00	0.00	0.00	0.00	1.71
Total Test Cell 5:	78.58	0.96	7.92	6.50	1.95
Total Test Cells 2 & 5:	157	2	16	13	4

NOTE:

(1) Based on time weighted average emission factors in Table 3-1 * 1967 lb/hr (time weighted fuel flow) * 3,000 hr/yr

The combined proposed short term and long-term emission limits for both test cells, including the heaters and cooling towers are summarized in Table 3-4.

TABLE 3-4
Test Cells 2 and 5 Proposed Short-Term and Long-Term Permit Limits(1)

Pollutant	Proposed Short-Term Emission Limits (ton/month)	Proposed Long-Term Emission Limits (tpy)
NO_x	67.2	157
CO	11.1	16
SO_2	4.6	13
PM_{10}	1.0	4
VOC	1.9	2
HAPs	-	0.4

NOTE: (1) Includes emissions from heaters and cooling towers

4.0 Federal Regulations

4.1 Prevention of Significant Deterioration

The Prevention of Significant Deterioration (PSD) regulations promulgated under 40 CFR 52.21, as amended by U.S. EPA in 2003, specify that major new stationary sources or major modifications to an existing major source within an air quality attainment area must undergo a PSD review and obtain all applicable federal and state preconstruction permits prior to commencement of construction.

Massachusetts was delegated the PSD program on behalf of U.S. EPA until 2003. In 2003, Massachusetts returned the management of the PSD program back over to EPA.

A major source under PSD regulations is defined as any source type in any of 28 designated industrial source categories having potential emissions of 100 tons per year or more, or any other source having potential emissions of 250 tons per year or more of any regulated pollutant. The GE Aviation facility is not one of the 28 source categories but is a major PSD source due to its potential emissions of more than 250 tons annually of NO_x, SO_2, VOC, PM, and CO. While the ambient air quality standard is for the pollutant nitrogen dioxide (NO_2), oxides of nitrogen (generally NO and NO_2) are considered in determining applicability under PSD. The conversion of NO_x to NO_2 in the atmosphere is discussed in Section 6.

A major modification is defined as "any physical change in or change in method of operation of a major stationary source that would result in: a significant emissions increase of a regulated New Source Review (NSR) pollutant; and a significant net emissions increase of that pollutant from the major stationary source." A "significant emissions increase" refers to numerical emissions thresholds specified for each regulated NSR pollutant. The proposed engine test cell modifications are considered a major modification due to the potential emissions increase of more than 40 TPY NO_x (significant emission increase threshold for NO_x).

A significant emissions increase is projected to occur if the difference between the *projected actual emissions* and the *baseline actual emissions* exceed the significant emission rate thresholds. *Projected Actual Emissions* are defined as the maximum annual rate, in tons per year, at which an existing emissions unit is projected to emit a regulated NSR pollutant in any one of the 5 years (12-month period) following the date the unit resumes regular operation after the project. *Baseline Actual Emissions* means the average rate, in tons per year, at which the unit actually emitted the pollutant during a consecutive 24-month period within the 10-year period immediately preceding the date a complete permit application is received by the permitting authority.

A PSD regulatory review generally consists of:

- A case-by-case Best Available Control Technology (BACT) demonstration, taking into account technical feasibility, energy, environmental and economic impacts for the pollutant(s) triggering the significant net emission increase;

- An ambient air quality analysis to determine whether the allowable emissions from the proposed source, in conjunction with all other applicable emission increases or reductions, would cause or contribute to a violation of the applicable PSD increments or NAAQS;
- An assessment of the direct and indirect effects of the proposed source on industrial growth in the area, soil, vegetation and visibility; and
- Public comment, including an opportunity for a public hearing.

Table 4-1 illustrates the net increase in emissions associated with this modification, compared to PSD thresholds for each criteria pollutant. The emission rates in the table constitute projected actual emissions as defined in the PSD regulations. As mentioned in Section 3, project actual emissions are based on the worse case endurance testing. For the worst case endurance tests proposed, it is projected that Test Cell 2 and Test Cell 5 will run 1,650 and 2,225 hours per year, respectively. Based on these emissions estimates, the proposed project is subject to PSD for NO_x emissions only. Though projected actual emissions are used in the analysis to determine if PSD permitting is triggered, PTE emissions from Section 3 are used in the modeling and discussed further in Section 6.

TABLE 4-1
PSD Threshold Determination

	-------Estimated Emissions (Tons/Year)----------				
	NO_x	**VOC**	**CO**	**SO_2**	**PM_{10}**
Test Cell 2, Baseline Actual[1]	0.20	0.03	0.23	0.01	0.00
Test Cell 5, Baseline Actual[1]	1.00	0.01	0.06	0.02	0.00
Baseline Actual Total	1.20	0.04	0.28	0.03	0.00
Test Cell 2, Projected Actual Cell 2	42.42	0.48	3.69	3.57	0.07
Test Cell 2, Projected Actual Heater	0.79	0.04	0.67	0.00	0.06
Test Cell 2, Projected Actual Cooling Tower	0.00	0.00	0.00	0.00	0.94
Test Cell 5, Projected Actual Cell 5	57.21	0.65	4.97	4.81	0.09
Test Cell 5, Projected Actual Heater	1.07	0.06	0.90	0.01	0.01
Test Cell 5, Projected Actual Cooling Tower	0.00	0.00	0.00	0.00	1.27
Projected Actual Total	100.30	1.21	9.95	8.37	2.44
Emission Increase	**99.10**	**1.17**	**9.67**	**8.34**	**2.44**
Federal PSD Permit Threshold	**40**	**40**	**100**	**100**	**100**

Notes[1] Baseline actual emissions, highest 24-month period over last 10 years

4.2 Non-attainment New Source Review (obtain offsets & LAER)

The State of Massachusetts retains the authority to implement the Non-attainment New Source Review (NNSR) program for the U.S. EPA. The NNSR program requires the application of lowest achievable emission rate (LAER) technology, rather than a BACT analysis. Before construction can begin, the source must obtain emission reductions (offsets) of the non-attainment pollutant from other sources that impact the same area as the proposed source. In addition, the applicant must certify that all other sources owned by the applicant in the State are complying with all applicable requirements of the Clean Air Act (CAA), including all applicable requirements of the State Implementation Plan (SIP). The significant net increase threshold for NO_x emissions under NNSR regulations is 25 TPY. The required information is provided in a separate NNSR application for submittal to MassDEP.

4.3 National Emission Standards for Hazardous Air Pollutants (NESHAPs) for Engine Test Cells/Stands (40 CFR Part 63, Subpart PPPPP)

The GE Aviation facility is subject to the National Emission Standards for Hazardous Air Pollutants (NESHAPs) for Engine Test Cells/Stands (40 CFR Part 63, Subpart PPPPP). However, the proposed modifications to the two test cells are exempt from the requirements of this subpart and NESHAP General Provisions (Subpart A) per 40 CFR 63.9290(d)(1) which exempts "any portion of a new or reconstructed affected source located at a major source" used exclusively for testing combustion turbine engines. Therefore, the test cell modifications automatically comply with the NESHAP without any other specific requirements under the rules.

4.4 Other Federal Regulations (40 CFR Part 87)

Another federal regulation that applies to jet engines is 40 CFR Part 87 – Control of Air Pollution from Aircraft and Aircraft Engines. This mobile source regulation stipulates testing and emissions standards for jet engines after they are fitted to the aircraft. This regulation applies only to the engines and not to the actual test cells.

5.0 Best Available Control Technology

PSD review applies on a pollutant-specific basis in areas designated as unclassified or attainment for the various ambient standards. The City of Lynn is presently designated as attainment for nitrogen dioxide (NO_2).

Under Federal PSD requirements, BACT is required for each regulated pollutant emitted in excess of the significant emission rates as presented in Section 4. Based on the comparison of the proposed GE Aviation emissions increase relative to significant rates, BACT is limited to only NO_x.

Applicants preparing PSD permit applications and permitting agencies reviewing these applications rely on U.S. EPA to provide guidance for consistent assumptions, approaches and detailed procedures for each component of the PSD permit application. The U.S. EPA guidance document used to prepare this BACT analysis is the October 1990 draft New Source Review Workshop Manual (NSRWM).

The "top-down" methodology was followed for NO_x BACT analysis in accordance with the NSRWM. The top-down approach outlined in the NSRWM consists of the following five steps:

- **Identify all control technologies**, including inherently lower emitting processes and practices, add-on control equipment, or combination of inherently lower emitting processes and practices and add-on control equipment.
- **Eliminate technically infeasible options**. Eliminate technically infeasible or technically difficult options based on physical, chemical, and engineering principles.
- **Rank remaining control technologies by control effectiveness**. Rank the remaining control options by control effectiveness, expected emission reduction, energy impacts, environmental impacts, and economic impacts.
- **Evaluate most effective controls and document results**. Determine the economic, energy, and environmental impacts of the control technology on a case-by-case basis.
- **Select the BACT**. Select the most effective option not rejected as the BACT.

5.1 BACT for NO_x Control

5.1.1 Step 1: Identify Control Technologies for Engine Test Cells

The following resources were reviewed to identify potential control technologies for engine test cells:

- Review of the most stringent BACT-PSD control measures for testing of aircraft engines in an engine test cell approved in the past 37 years by various states, as listed in EPA's Reasonably Available Control Technology (RACT)/BACT/LAER Clearinghouse (RBLC)

- Nitrogen Oxide Emissions and Their Control from Uninstalled Aircraft Engines in Enclosed Test Cell, Joint EPA - U.S. Department of Transportation (DOT) Report, Report No. EPA 453/R-94-068, October 1994
- Regulatory Support Document, Control of Air Pollution from Aircraft and Aircraft Engines, for the Direct Final Rule for Aircraft Emission Standards, U.S. EPA, February 1997
- Best Available Control Technology Analysis for Modification of Engine Test Cells at Tinker Air Force Base, Oklahoma, Air Force Center for Environmental Excellence (AFCEE), July 2006
- PSD Permit Application for General Electric Aircraft Engines River Works, Lynn, MA, Wehran Engineering Corporation, January 1993
- PSD Permit Application for Proposed New Engine Test Site 5C, GE Aviation, Peebles, Ohio, Parsons, June 2006
- NO_x Removal in Jet Engine Test Cell Exhaust, Los Alamos National Laboratory, LA-UR-99-3072

The following potential control technologies were identified:

- Low NO_x Engines
- Combustion Controls
- Selective Catalytic Reduction (SCR) with Ammonia Injection
- Selective Non-Catalytic Reduction (SNCR)
- Reburn NO_x Control Technology
- NO_x Sorbent Technology
- Water or Steam Injection
- Non-thermal Plasma Systems
- Direct Atmospheric Exhaust (No Control)

5.1.2 Step 2: Evaluate Technological Feasibility of Potential Control Options

5.1.2.1 Identification of Available NO_x Control Technologies

Inherently lower emitting processes are not considered further because Test Cells 2 and 5 will only test engines in the DoD inventory; therefore, it can neither alter the combustor in the engine nor the combustion characteristics of the engine.

The joint report submitted to the U.S. Congress in October 1994 by the EPA and the DOT entitled "Nitrogen Oxide Emissions and Their Control from Uninstalled Aircraft Engines in Enclosed Test Cell," Report No. EPA-453/R-94-068, October 1994, concludes that there are no existing technologies for control of NO_x that have been applied (full scale) to aircraft engine test cells in the United States. The differences in engines, engine tests, engine test cell sizes, and engine types complicate the application of NO_x control systems to engine test cells. The preparation and submittal of this study was mandated under Section 233(a) of the Clean Air Act Amendments of 1990.

Potential NO_x control technologies for jet engine test cells were obtained from the EPA Report, 453/R-94-068, October 1994, and the Los Alamos National Laboratory presentation, LA-UR-99-3072, titled "NO_x Removal in Jet Engine Test Cell Exhaust." These technologies are considered post-combustion control methods. Post-combustion control methods address NO_x emissions after formation.

Combustion control methods that prevent or reduce NO_x formation during the combustion process were not evaluated. This is due to the fact that changing the combustion process during testing will directly adversely impact the design, safety, operation and performance of the engine. Post-combustion control technologies are discussed further below.

5.1.2.2 Selective Catalytic Reduction (SCR) with Ammonia Injection

Using SCR, ammonia is injected to react with NO to form nitrogen and water. The required catalyst temperature is approximately 700°F, though some recent catalysts operate near 500°F. Several catalysts, including platinum and titanium oxide, are available. Proper operation depends on many factors including correct stoichiometric ratio of ammonia to NO, reaction temperature, and condition of catalyst, in addition to the "space velocity," which is expressed as exhaust gas volumetric flow rate per unit catalyst volume. The NO_x reduction efficiency for SCR with ammonia injection has been demonstrated at 80 to 90 percent.

This technology is available in the United States, and is used with stationary gas turbine applications for power plants. However, there are significant differences between exhaust gas characteristics of power plants and those from test cells. The test cell stack gas temperatures are below those required by SCR systems. Also, the stack gas temperature and the NO_x emission rates will vary with engine thrust and the augmentation air. The stack gas flow rate and the stack gas temperature vary significantly as the augmentation ratio increases as occurs with turbojet and turbofan engines. The NH_3 injection system must track NO_x emission rates, and maintain the proper NO_x to NH_3 ratio. The rapid and frequent changes in engine output will place demands on the SCR controller not found in current (non test-cell) installations where SCR technology is used. Improper NO_x to NH_3 ratio will result in excess release of either NO_x or NH_3. Due to the variance in operation and performance of the engine testing, SCR is not considered a technically feasible control option.

5.1.2.3 Selective Non-Catalytic Reduction (SNCR)

SNCR uses injection of chemicals such as ammonia or urea to the exhaust gases, for non-catalytic reactions that result in formation of nitrogen and water. Without proper process control, a competing reaction can actually generate NO. The desired reaction for NO_x reduction occurs in the temperature range of 1800°F to 2000°F. This technology has been demonstrated on utility boilers and other fossil-fuel systems to achieve up to 50 percent NO_x removal. During non-afterburner operations, the exhaust temperature at the engine, as measured approximately two feet from the flame, can be as high as 1558°F.

However, test cell stack gas temperatures are significantly below the 1800°F to 2000°F range where SNCR is viable. In addition, a uniform NO_x control distribution and an ammonia or urea injection system are required to ensure maximum NO_x reduction, and to prevent release of excess NH_3. There is actually a potential for greater NO_x production associated with the heating of exhaust gases to raise the temperature to that required by SNCR. The reheat requirements are a function of test cell operating characteristics, which are highly transient and differ depending on the type of engine tested. Due to the variance in operation and performance of the engine testing, SNCR is not considered a technically feasible control option.

5.1.2.4 Reburn NO_x Control Technology

Natural gas is injected at a region just above the main combustion zone, followed by downstream injection of additional combustion air. The injection of the gas lowers NO_x formation in the main combustion zone, where the NO_x is reduced by reaction with hydrocarbon fragments formed by the natural gas combustion in fuel-rich conditions.

Bench-scale studies of reburning in an oxygen-rich gas such as that from a test cell exhaust have been performed. The respective removal efficiencies for 1,000 parts per million (ppm) and 500 ppm NO_x inlet concentrations were reported at 60 and 30 percent. No studies have been conducted at NO_x concentration of 100 ppm that is typical of test cell operation. Until more research and evaluations are performed, the safety and performance issues of this technology cannot be addressed. Thus, reburn NO_x control technology was not considered a technically feasible control option.

5.1.2.5 NO_x Sorbent Technology

The exhaust gas passes through a bed of vermiculite impregnated with magnesium oxide. The NO_x is adsorbed on the bed and forms magnesium nitrate. When used with a bed of virgin vermiculite upstream of the one containing magnesium oxide, the removal efficiency of 50 to 70 percent has been reported. This technology has not been demonstrated on a full scale in a working test cell. Until more research and evaluations are performed, the safety and performance issues of this technology cannot be addressed, and thus this was not considered a technically feasible control option.

5.1.2.6 Water or Steam Injection

Water/steam injection is an established NO_x control technology for stationary gas turbines. The water or steam injected into the primary combustion zone of a gas turbine engine provides a heat sink, which lowers the flame temperature and thereby reduces thermal NO_x formation.

The use of water/steam injection would require temporary engine modifications and would alter the performance characteristics of the engine being tested. Since the engines are tested in a cell to evaluate their performance characteristics, any modifications affecting performance would run counter to the actual reason for testing the engines. In addition, it would result in generating significant quantities of wastewater contaminated with hydrocarbons, requiring treatment. Therefore, water/steam injection is not considered a technically feasible control option.

5.1.2.7 Non-thermal Plasma (NTP) Systems

NTP systems are a type of advanced oxidation and reduction process making use of "cold combustion" via free-radical reactions. Exhaust gases are contacted with electrical energy to create free radicals, which in turn decompose pollutants such as NO_x, SO_2, and VOC in the gas phase. The removal efficiency depends on plasma chemistry (free radical yield), reaction chemistry, and applied plasma specific energy. The process is carried out on the exhaust gases without any preheating and has demonstrated removal efficiencies greater than 50 percent in bench-scale and field-pilot demonstration studies. The study describes five candidate NTP systems: pulsed corona, dielectric barrier, hybrid NTP reactor-adsorber, plasma-catalytic hybrid, and corona radical shower. In pulsed corona, dielectric barrier, and corona radical shower systems, ammonia or methane can be added to generate radicals that drive reactions, leading to the formation of particulates that can be removed using an electrostatic precipitator.

This is an emerging technology, and has only been demonstrated on a field-pilot scale in one test cell in practice. Until more research and evaluations are performed, the safety, operation and performance issues of this technology cannot be addressed, so this was not considered a technically feasible control option.

5.1.2.8 Direct Atmospheric Exhaust

In the absence of any feasible NO_x control technologies currently available, the direct atmospheric exhaust or "no control" is determined to be BACT.

5.2 BACT Cost Evaluation

Since no control technology is technically feasible, it is unnecessary to evaluate cost effectiveness for this application.

5.3 RACT/BACT/LAER Clearinghouse

A RBLC search was completed using the following key words: "test cell," "test stand," "engine test" "engine stand," "jet engine" and "aircraft engine." All of the determinations found using this search method are summarized in Table 5-1. A comprehensive report of the determinations is included in the appendices.

As shown in the table, the search resulted in determinations for aircraft, automotive, marine and locomotive engines. All the aircraft engine determinations indicate that the BACT was no control. Only test cells testing automotive engines installed any physical controls for BACT. These are different types of test cells and engines, and these control determinations would not be applicable to aircraft engine test cells. Where available, BACT listed for other types of test cells, including aircraft engine cells, consisted of restrictions of hours of operation or fuel usage. In January 1993, GE Aviation submitted a PSD permit application to modify existing test cells at the GE Aviation facility. This application included a BACT analysis, which concluded that BACT was installation of no controls, i.e., there were no technically feasible control options for test cells.

TABLE 5-1
Results of RBLC Review

Date	Determination Number	Facility Name	Facility Description	BACT Determination
2/15/2007	OH-0306	G.E. AIRCRAFT ENGINES-PEEBLES TEST	GE Aircraft Engines is installing a single new jet engine test stand. Potential emissions from the proposed addition exceed 40 tons per year NO_x and 100 tons per year CO, PSD pollutants.	Modeling used to meet PSD requirements. Designed emission levels used to determine "no control."
2/19/1993	MA-0030	GE AIRCRAFT ENGINES	Jet engine testing	Minimize use of afterburner mode, restriction on the number of hours an engine may operate.
9/27/2005	OH-0299	G. E. AIRCRAFT ENGINES PEEBLES	Build and testing of aircraft engines	It was determined that BACT was no control, per RBLC search and other control analysis.
11/19/2002	MI-0360	Daimler Chrysler Corporation Tech Center	Car engine dynamometer test cells (controlled and uncontrolled)	Thermal oxidizers to reduce NO_x and VOC.
3/23/2005	IA-0076*	John Deere Product Engineering Center	R&D facility that develops specifications for off-road vehicles and components using 53 engine test cells.	Good combustion practices
5/19/2004	MI-0367	GM Powertrain Division	Engine test cells/dynamometers	Regenerative thermal oxidizers fired by natural gas. Limits on fuel usage.
12/18/2003	PA-0233	Naval Surface Warfare Center	Installation of marine gas turbine test cell	No controls identified.
4/28/2000	TN-0103	Arnold Engineering Development Center	Jet engine test cells at an air force base	No controls
12/30/2003	TX-0462	Perkinelmer Automotive Research	Automotive engine test facility	Limited operations
4/15/1998	MI-0306	Schenck Pegasus	Engine test cells/dynamometers	Limits on daily fuel usage
3/24/1997	IL-0065	GM Electromotive Division	Locomotive engine test cells	Engines to be tested must be equipped with turbo-charging and aftercooling, or comparable technology.

TABLE 5-1
Results of RBLC Review

Date	Determination Number	Facility Name	Facility Description	BACT Determination
8/21/1996	PA-0154	GE Transportation Systems	Diesel engine test cells for locomotives	Engine retard, split cooling, electronic fuel injection, depending on engine.

*Draft determination

5.4 BACT Selection

The joint report submitted to the U.S. Congress in October 1994 by U.S. EPA and DOT concludes that there are no existing technologies for control of NO_x that have been applied (full scale) to aircraft engine test cells in the United States. The differences in engines, engine tests, engine test cell sizes, and engine types complicate the application of NO_x control system to engine test cells.

Based on the discussion above, BACT is considered to be no add-on control for NO_x and the BACT emission limits are those that are supported through currently available emission factors.

6.0 Dispersion Modeling

6.1 Modeling Framework and Background

The air dispersion modeling techniques used to assess the impacts from the proposed modification to Test Cells 2 and 5 were submitted in a modeling protocol to EPA and MassDEP on July 18, 2007. Dialogue/comments based on review of the protocol were received from Brian Hennesey of U.S. EPA and Steve Dennis of MassDEP, and a revised modeling protocol was submitted to U.S. EPA and MassDEP on August 22, 2007. The final modeling protocol is included in Appendix E.

The modeling methodology used to demonstrate compliance with the National Ambient Air Quality Standards (NAAQS) and PSD Increment for NO_2 is described in this section. Based on U.S. EPA modeling guidance, the PSD air quality analysis is conducted in two stages: the significance analysis and the full impact analysis. If impacts from the proposed emission increase are less than significant impact levels, a full impact analysis is not required.

6.1.1 Significance Analysis (Stage One)

The significance analysis determines whether GE Aviation needs to conduct a full impact analysis, and defines the radius of impact (ROI) within which a full impact analysis (if required) should be conducted. First, the annual NO_x emission increases from the proposed sources are modeled. The maximum modeled ground-level concentrations of NO_2 are then compared to the corresponding modeling significance levels. The U.S. EPA requires that a full impact analysis be conducted if the project emissions result in maximum predicted concentrations exceeding modeling significance levels (MSLs) (*i.e.*, significant impacts).

A significance analysis for NO_2 was completed to determine if the project emission increase would have a significant impact upon the area surrounding the GE Aviation facility. As shown in Section 6.4.1, NO_2 impacts from the proposed modification to Test Cells 2 and 5 exceed the MSL in a small area, and a full impact analysis was completed for this proposed emissions increase.

6.1.2 Background Concentrations

Background concentrations used for the near-field dispersion modeling represent all current air pollution sources other than those that are explicitly modeled. Commonly, the impacts of distant background sources are accounted for by using appropriate, monitored air quality data (i.e., a background concentration). In order to demonstrate compliance with NAAQS, suitable background concentration data were used consistent with the modeling protocol.

To demonstrate compliance with the ambient air quality standards, the predicted air quality impacts were added to the existing background concentrations for the NAAQS analysis. The U.S. EPA maintains the AIRS database (http://www.epa.gov/air/data/geosel.html) that includes air monitoring site information for various regions throughout the United States. Station 250092006 in Lynn, located 2.6 kilometers from the site, was used as the background station. A summary of the three most recent years (2004 through 2006) of representative ambient NO_2 concentrations used in this study is presented in Table 6-1.

TABLE 6-1
NO_2 Background Air Concentrations in Study Area 2004-2006

Pollutant	Averaging Time	NAAQS[a]	2004 Conc. (ppm)	2005 Conc. (ppm)	2006 Conc. (ppm)	Background Conc. ($\mu g/m^3$)	Station ID
NO_2 [b]	Annual	**0.053 ppm**	0.0087	**0.0099**	0.0096	**18.7**	250092006

[a] Source of data: http://epa.gov/air/criteria.html
[b] Arithmetic average of 1-hour NO_2 concentration values for the year in ppm.

6.2 Dispersion Modeling Methodology

The dispersion modeling analysis for this project was conducted using the latest version of the **A**MS/**E**PA **R**egulatory **Mod**el (AERMOD – Version 07026) to estimate maximum ground-level concentrations. AERMOD is a steady-state plume model that incorporates planetary boundary layer (PBL) theory to define ambient turbulence parameters. AERMOD is the recommended model for use in regulatory industrial source modeling as defined in the Guideline on Air Quality Modeling (40 CFR 51, Appendix W).

The analysis includes an evaluation of the possible effects of elevated terrain, and aerodynamic effects (downwash) due to nearby building(s) and structures on plume dispersion and ground-level concentrations. The model combines simple and complex terrain algorithms, and includes the Plume Rise Model Enhancement (PRIME) algorithms to account for building downwash and cavity zone impacts.

The required emission source data inputs to AERMOD include source location, source elevation, stack height, stack diameter, stack exit temperature, stack exit velocity, and pollutant emission rates. The source locations are specified for a Cartesian (x, y) coordinate system where x and y are distances east and north in meters, respectively. The Cartesian coordinate system used for these analyses is the Universal Transverse Mercator Projection (UTM), 1927 North American Datum (NAD 27).

The AERMOD models were used with regulatory default options as recommended in the EPA Guideline on Air Quality Models as listed below:

- Accept terrain elevations and hill height input
- Use stack-tip downwash
- Perform meteorological data checking

The complete AERMOD modeling system is comprised of three parts: the AERMET pre-processor, the AERMAP pre-processor, and the AERMOD model. The AERMET pre-processor compiles the surface and upper-air meteorological data and formats the data for AERMOD input. The AERMAP pre-processor is used to obtain elevation and controlling hill heights for AERMOD input.

6.2.1 Meteorological Data

The air dispersion modeling was performed using January 1, 2001, through December 31, 2005, meteorological data based on surface observations taken from Boston Logan International Airport, Massachusetts [National Weather Service Station (NWS) number 14739] with upper air measurements from the Portland International Jetport [NWS number 54762]. The meteorological data were processed using the AERMET (Version 06341) preprocessor routine. A windrose from the meteorological station is presented in the modeling protocol in Appendix E. Preprocessing of the raw observations was done using the surface parameters presented in Table 6-2.

6.2.2 Surrounding Land Use

The land use surrounding the Airport meteorological station is similar to that of the GE Aviation site: namely, it is an urban area with the Atlantic Ocean being in close proximity to the east. The land surrounding the site is predominantly urban/industrial, along with grassland/marshes to the south and areas of residential developments. The Saugus River Marshes are 2 km to the northwest of the site. The site is set back approximately 1.5 km from Black Rock Channel to the east and is on the north shore of the Saugus River.

Lynn is located about 10 km to the northeast of downtown Boston. Therefore, since the Boston Logan Airport meteorological station is in close proximity to the Lynn site, and both have similar land use surrounding, these data from this station were believed to be the most applicable for the analysis.

The surface parameters used for the AERMET preprocessing were consistent with the Boston Logan airport site. The area around the Boston Logan airport site was divided into 3 sectors based on predominant surface characteristics: open water, urban and mixed-urban and inner harbor. For the mixed land use sector(s), the parameters were estimated as a weighted average of each of the base land use classifications (i.e. approximate percent coverage of water and urban within 3 km of the airport). Seasonal variations in albedo, surface roughness, and Bowen ratio consistent with these land use classification were included into the AERMET. Table 6-2 lists the seasonal AERMET land-use parameters used in the input files.

The land-use analysis was conducted using a combination of recent aerial and satellite photographs of the area. All sources within the AERMOD simulations were run using the urban dispersion coefficient option, with an area population of 690,000 and a surface roughness of 1.0 m.

TABLE 6-2
Seasonal AERMET Surface Parameters for Boston Logan Airport Meteorological Station

Sector†/Land Use		Albedo				Bowen Ratio (average moisture)				Surface Roughness			
		Season				Season				Season			
		1	2	3	4	1	2	3	4	1	2	3	4
1	All Urban	0.35	0.14	0.16	0.18	1.5	1.0	2.0	2.0	1.0	1.0	1.0	1.0
2	75% Water – 25% Urban	0.30	0.14	0.12	0.16	1.5	0.18	0.28	0.33	0.00033	0.013	0.025	0.0026
3	50% Urban-50% Water	0.275	0.13	0.13	0.16	1.5	0.55	1.05	1.05	0.50	0.50	0.50	0.50

1 – Winter
2 – Spring
3 – Summer
4 – Fall
† Sector: 1 270˚-70˚; Sector 2: 70˚-190˚; and Sector 3: 190˚-270˚

6.2.3 Receptor Grids

The base modeling receptor grid for AERMOD modeling consisted of receptors that were placed at the ambient air boundary and Cartesian-grid receptors that were placed beyond the boundary at spacing that increases with distance from the origin. The GE Aviation property boundary was used as the ambient air boundary.

A 6 km by 6 km grid centered on the site was sufficient to capture the contaminant maxima as well as have the estimated concentrations near the grid border be less than the Significant Impact Levels (SILs). Screening runs confirmed that maximum predicted concentrations were in close proximity to the locations of test cells 2 and 5. The site boundary receptors were spaced at 25-meter intervals. Beyond the property boundary, receptor spacing was as follows:

- 100-meter spacing out to a distance of 2 km from the facility
- 250-meter spacing a distance 2 to 3 km from the origin

Figure 6-1 shows the receptor grid used in the significance modeling analysis. For the full impact analysis only receptors within the significance impact radius were used.

6.2.4 Terrain

Terrain in the vicinity of the project was accounted for by assigning base elevations to each receptor. Data at 7.5-minute intervals from the U.S. Geological Survey (USGS) Digital Elevation Model (DEM) were used in conjunction with the AERMAP pre-processor (version 06341) to determine receptor elevations. The NAD27 Universal Transverse Mercator (UTM) Zone 19 coordinate datum was used for all the modeling. USGS 1-degree data were used only for the receptors 45-km from the site.

FIGURE 6-1
Receptor Grid Used in the Modeling Analysis

Source and building elevations were determined from site maps and other survey data, not from the DEM data. Elevations for the interactive sources in the full impact analysis were determined by using USGS 1-degree data.

6.2.5 Building Downwash Effects

Buildings or other solid structures may affect the flow of air in the vicinity of a source and cause building downwash (*e.g.*, eddies on the downwind side), which have potential to reduce plume rise and increase dispersion.

For dispersion modeling purposes, building downwash effects were considered for sources at the GE Aviation facility. A total of 12 buildings in the vicinity of the modeled sources were used in the analysis and include all buildings that could influence the dispersion of source emissions. For the full impact analysis, building downwash was not included for the off-property sources because of the tall stacks and long transport distances. The BPIP input file is included in the electronic files included in Appendix F.

6.3 Modeled Emission Sources

6.3.1 Proposed Test Cells

Emissions from the test cell modification project were summarized in Table 3-4. The physical parameters for these emission sources were identical to those presented in the modeling protocol in Appendix E.

During engine qualification testing, the new GE38 will burn jet fuel under a range of operating conditions simulating the extremes of the engine's mission. Source characteristics for the proposed Test Cells 2 and 5 that were used in the modeling are presented in Table 6-3. Since the modeling results were compared against annual average concentration thresholds and standards, exhaust flow rate and temperature conditions corresponding to the maximum continuous operating condition were modeled. Since this engine has not yet been operated, emission and exhaust characteristics were estimated for project sources using generally acceptable methods for the source type and design, for example, emission factors, stack test data, source activity levels, process modeling, and manufacturer's specifications, as applicable from similar engine models and combustors.

During the one year of initial engine qualification that represents the highest annual emissions expected in the foreseeable future, the engine will be undergoing endurance testing more than 70 percent of the time, resulting in longer operating times at higher fuel feed rates than the engine will experience in other development or production testing. The maximum continuous (M/C or max/con) operating condition accounts for 24 percent of the testing and represents the level at which the engine can operate on a continuous basis without causing undue stress on the engine.

TABLE 6-3
Exhaust Characteristics for Test Cells 2 and 5 Modeling

Test Cell	Exit Temperature (ºF)	Exhaust Flow Rate (ACFM)	Exhaust Area (ft^2)	Stack Diameter[a] (ft)	Exit Velocity (ft/sec)	Stack Height (ft)
Test Cell 2	494.1	90,763.8	46.1	7.66	32.81	36
Test Cell 5	494.1	90,763.8	30.0	6.18	50.42	50

[a]Effective Diameter

The project will result in a combined emission increase of 157 tpy of NO_x, as well as small amounts of fine particulate matter, CO, and SO_2 from Test Cells 2 and 5.

The MSL, NAAQS, and PSD Increments for nitrogen oxides are all expressed in terms of NO_2. Although PSD applicability is based on emissions of total oxides of nitrogen, the air quality analysis is limited to NO_2. Since the only standard for NO_2 is an annual one, the test cells were assumed to operate continuously, with the 157 tpy of NO_x averaged over the entire 8760 hours. A technique referred to as the Ambient Ratio Method (ARM) is typically used to assess ground-level NO_2 concentrations for a given NO_x emission increase. For the significance analysis the national default NO_2/NO_x ratio of 0.75 was used to scale and estimate the resulting NO_2 impacts from the modeled NO_x emission rates used in the model. Modeling information in units expected by the model, including the "annual average" grams/second (g/s) emission rate corresponding to 157 tpy is presented in Table 6-4.

TABLE 6-4
Source Parameters for the Significance Analysis

Source	X-UTM (m)	Y-UTM (m)	Elevation (m)	Stack Height (m)	Exhaust Temp. (K)	Exit Velocity (m/s)	Stack Diameter (m)	NO_x Emission (g/s)
Test Cell 2	337357	4701554	3.24	10.97	529.9	10.0	2.33	2.26
Test Cell 5	337302	4701567	3.42	15.24	529.9	15.37	1.88	2.26

6.3.2 GE Aviation Air Emission Sources

The NAAQS and increment emission inventories must be established for all pollutants with predicted impacts equaling or exceeding the PSD modeling significance levels. GE Aviation sources that consume PSD increment were Test Cells 114 and 115, which were permitted in 1992. The allowable emissions from these sources along with the proposed emissions from Test Cells 2 and 5 were used to determine the current increment.

The location, source parameters and allowable annual NO_x emission rates for Test Cells 114 and 115 along with the other permitted air emission sources are presented in Table 6-5. The other air emission sources were included in the NAAQS compliance demonstration. The sources include the Power Plant that consists of 4 boilers and a combined cycle turbine and heat recovery steam generator. Emissions rates for these units were based on the operating history over a 5-year period, as each unit operates for varying periods of time and uses different fuels over the course of a year.

The test cells operate under a dual NO_x emissions cap. Test Cells 114 and 115 have a cap tied to the emission limits established during their permit review. The plant has an overall cap that applies to the all 17 test cells. The operation of Test Cells 2 and 5 will not affect the overall NO_x emissions cap, as it will remain the same.

TABLE 6-5
GE Aviation Source Parameters for the Full Impacts Analysis

Source ID	Source Description	UTM Easting (m)	UTM Northing (m)	Base Elev. (m)	Stack Height (m)	Temp. (ºK)	Exit Velocity (m/s)	Stack Diam. (m)	NO_x Emis. Rate (g/s)
PH1	Power house building 99 Boiler No. 1	337609	4701367	3.3	33.5	472	11.40	1.83	0.75
PH2	Power house building 99 Boiler No. 2	337597	4701349	3.3	41.3	466	10.00	1.83	4.02
PH3	Power house building 99 Boiler No. 3	337587	4701359	3.3	41.7	422	9.90	2.44	4.85
PH4	Power house building 99 Turbine 8	337578	4701331	3.3	31.7	505	36.40	2.44	8.17
PH5	Power house building 99 Boiler No. 5	337581	4701386	3.3	53.3	422	17.98	1.53	1.41
TC114	Building 29 Test Cell 114	337524	4701363	2.93	13.7	478	32.20	4.12	6.88
TC115	Building 29 Test Cell 115	337511	4701371	2.93	13.7	478	32.20	4.12	6.88

6.3.3 Other Interactive Sources

Based on the preliminary significance modeling, the significant impact area for NO_2 has a radius of about 1 km from Test Cells 2 and 5. Based on guidance from MassDEP, external sources were identified from the 2005 reported annual emissions inventory (Source Registration); sources within 10 km of the GE Aviation site and actual NO_2 emissions greater than 100 tpy and sources between 10 and 20 km from the site. The sources identified using this approach are:

- Wheelabrator-Saugus facility in Saugus
- Eastman Gelatine facility in Peabody
- Dominion Energy – Salem Harbor in Salem
- Boston Generating Station – Mystic River in Everett
- Medical Area Total Energy Plant in Boston

Potential emissions and exhaust characteristics from the emission sources at these facilities were obtained from the MassDEP's Northeast Regional Office and are presented below in Table 6-6.

TABLE 6-6
Interactive Source Parameters for the Full Impacts Analysis

Source ID	Source Description	UTM Easting (m)	UTM Northing (m)	Base Elev. (m)	Stack Height (m)	Temp. (ºK)	Exit Velocity (m/s)	Stack Diam. (m)	NO_x Emis. Rate (g/s)
DE_EU 1	Dominion Energy-Salem Harbor LLC, EU-1	345787	4709612	2	131.1	430	29.26	2.74	39.67
DE_EU 2	Dominion Energy-Salem Harbor LLC, EU-2	345787	4709612	2	131.1	430	29.72	2.74	40.16
DE_EU 3	Dominion Energy-Salem Harbor LLC, EU-3	345787	4709612	2	131.1	430	26.97	3.81	70.51
DE_EU 4	Dominion Energy-Salem Harbor LLC, EU-4	345849	4709771	3	152.4	469	33.53	5.64	169.3 5
MATE_ ALL	Medical Area Total Energy Plant, All Units	326256	4689076	7	96.0	463	16.00	2.44	107.1 0
BG_U7	Boston Generating Mystic I LLC, Unit 7	329815	4695054	4	152.4	444	25.91	3.66	173.4 1
BG_U8 1	Boston Generating Mystic I LLC, Unit 81	329778	4694993	3	93.0	365	22.04	6.25	2.73
BG_U8 2	Boston Generating Mystic I LLC, Unit 82	329748	4694955	3	93.0	365	22.04	6.25	2.73
BG_U9 3	Boston Generating Mystic I LLC, Unit 93	329737	4694929	3	93.0	365	22.04	6.25	2.73
BG_U9 4	Boston Generating Mystic I LLC, Unit 94	329740	4694966	3	93.0	365	22.04	6.25	2.73
WS_EU 1	Wheelabrator Saugus JV, EU1	337108	4701149	4	87.2	425	17.98	2.16	14.43
WS_EU 2	Wheelabrator Saugus JV, EU2	337108	4701149	3	87.2	425	17.98	2.16	14.43
EG_E12 3	Eastman Gelatine Corp., EU01, 02 & 03	340666	4709266	10	49.4	505	5.18	2.13	10.10
EG_E4	Eastman Gelatine Corp., EU04	340712	4709276	10	41.8	500	6.10	1.52	3.50
EG_E5	Eastman Gelatine Corp., EU05	340677	4709247	10	41.8	500	6.10	1.52	3.50

6.4 Modeling Results

The following sections detail the results of the air quality modeling analyses.

6.4.1 Significance Analysis

In the significance analysis, the proposed emissions increases are modeled and the resulting maximum concentrations are compared to the MSL to determine if a full impact analysis is required. The results of the significance analysis are summarized in Table 6-7.

TABLE 6-7
Maximum Concentrations Calculated in the Significance Analysis

Pollutant	Averaging Period	Receptor Grid	UTM East (m)	UTM North (m)	Max. Modeled Concentration ($\mu g/m^3$)	MSL ($\mu g/m^3$)
NO_2	**Annual**	**Fence Line**	**337370**	**4701690**	**19.9**	**1**

The maximum modeled concentration is greater than the MSL, and therefore a full impact analysis is required. Although the predicted new source impact appears to be much greater than the MSL, the radius of impact within which predicted impacts exceed the MSL is only 1,100 meters. A summary of the PSD increment and NAAQS analysis are presented below.

6.4.2 PSD Increment Consumption

The Prevention of Significant Deterioration (PSD) program was established to allow emission increases (increments of consumption) that do not result in significant deterioration of ambient air quality in areas where criteria pollutants have not exceeded the National Ambient Air Quality Standards (NAAQS). For the purposes of determining applicability of the PSD program requirements, the following regulatory procedure is used. Increments are the maximum increases in concentration that are allowed to occur above the baseline concentration.

All increment-affecting sources that are located within the significant impact area of a proposed new major source are modeled as part of the increment analysis. EPA guidance states that increment-affecting stationary sources are those with actual emissions changes occurring since the minor source baseline date. Increment-affecting sources located within 50 km of the significant impact area may be modeled if they affect the amount of PSD increment consumed (EPA, 1990).

When GE Aviation submitted its PSD application for Test Cells 114 and 115 in 1992, it was the first PSD application in Lynn and set the baseline date for the area. No other PSD sources have been permitted in Lynn since the baseline date. Thus, Test Cells 114 and 115 were included in the emission inventory for calculating PSD Class II increment consumption. Class II areas are regions that allow for economic growth in a manner consistent with the preservation of existing clean air resources and include all areas not other wise designated as Class I areas

Because of advancements in mobile source emissions reductions, mobile source emissions are assumed to have been reduced since the baseline date. No mobile source emissions were included in the increment analysis.

Table 6-8 compares the maximum modeling impact to the Class II PSD increment. This comparison shows that the modeled impacts are below the Class II PSD increment consumption level. .

TABLE 6-8
PSD Increment Consumption Results

Pollutant	Averaging Time	Class II PSD Increment ($\mu g/m^3$)	Maximum Project Impact ($\mu g/m^3$)
NO_2	**Annual**	**25**	**20.0**

6.4.3 NAAQS Impact Analysis

Table 6-9 compares the maximum modeled NO_2 impacts for all onsite and off-site interactive sources presented in Tables 6-5 and 6-6. The representative background concentration presented in Table 6-1 was also added to the maximum impact shown in Table 6-9. This comparison shows that the modeled impacts are well below the NAAQS. .

TABLE 6-9

NAAQS Impact Analysis Results

Pollutant	Averaging Time	National Ambient Air Quality Standards ($\mu g/m^3$)	Impact from Interactive Sources ($\mu g/m^3$)	Monitored Background Concentration ($\mu g/m^3$)	Maximum Combined Project Impact ($\mu g/m^3$)
NO_2	Annual	100 [a]	21.9	18.7	40.6

[a] Highest annual arithmetic average of hourly concentrations over a calendar year.

The location of the maximum impact for the significance, PSD increment and NAAQS analyses all occur approximately 140 meters north of Test Cells 2 and 5 along the property line adjacent to Route 107, which is a four-lane state highway.

6.4.4 Class I Area Impact Analysis

A series of twenty-one discrete receptors were placed 45 km downwind of the project site along a vector headed toward each of the Class I areas. Class I areas are national parks, wilderness areas, or fish and wildlife parks and are afforded protection under the PSD program. These receptors were spaced at 250 m intervals. The width of each of the three receptor segments spans approximately 5 km. Table 6-10 below lists the three closest Class I areas, which are located within 200 km of the GE Aviation site.

TABLE 6-10
Class I Areas within 200 km of GE Aviation Site

Class I Area Name	Distance to the Site (km)	County	State	Area (acre)
Lye Brook Wilderness	184	Bennington	Vermont	17,841
Great Gulf Wilderness	185	Grafton	New Hampshire	5,552
Presidential Range Wilderness	192	Coos	New Hampshire	27,380

The high-first-high impacts at the 45 km receptor locations were compared to the EPA proposed Class I modeling significance levels. The results for this comparison were taken from the modeling simulation that included all NO_x sources located at the Lynn site including the Powerhouse, Test Cells 114, 115, 2 and 5 all running at their respective maximum emission rates. The results are shown below in Table 6-11. It shows that the maximum estimated concentration at 45-km downwind of the site is much less than the Class I significance level for annual-average NO_2. Compared to results determined in close proximity to the facility, the maximum concentrations have decreased approximately 800-fold at a 45 km distance. Therefore, it is concluded that both visibility and concentration impacts in the Class I areas, an additional 140 km or more downwind, will be negligible.

TABLE 6-11
Maximum Concentrations Calculated in the Significance Analysis for Class I Areas

Pollutant	Averaging Period	UTM East (m)	UTM North (m)	Max. Modeled Concentration ($\mu g/m^3$)	Class I Significance Level ($\mu g/m^3$)
NO_2	**Annual**	**334,384**	**4,746,453**	**0.025**	**0.1**

Included on the CD-ROM in with this air quality analysis are the input and output files (Appendix F) from the dispersion modeling analyses.

7.0 Additional Impact Analysis

PSD regulations specify that qualitative analyses be provided to address the potential impacts on growth, visibility and vegetation. This section addresses the expected impacts from the test cell modifications on each of these subject areas.

7.1 Growth Analysis

The proposed modifications to the existing Test Cells 2 and 5 will allow these two test cells to accept the new GE38 helicopter engine. There is not expected to be any appreciable industrial, commercial, or residential growth that would occur due to the renovation or operation of these modified test cells. There has historically been activity at the GE Aviation River Works facility associated with engine testing in existing Test Cells 2 and 5, and future activity is not expected to be different from past activities, other than increased development testing in the short-term and potentially more longer-term utilization of these specific cells once they have been modernized. Overall, engine testing will remain well within applicable limitations established by the existing permits. Construction and operation support and services will be available from the existing GE Aviation River Works facility. In conclusion, no impacts related to local growth due to the proposed project are expected.

7.2 Impact on Soils and Vegetation

PSD regulations require analysis of air quality impacts on sensitive vegetation and soil types located in the area surrounding the facility. Primary and secondary NAAQS are established for each criteria pollutant to protect human health and public welfare. The secondary NAAQS are designed to prevent damage to the environment (vegetation, wildlife, buildings, etc.) due to the known effects of the criteria pollutants. The primary and secondary NAAQS values for NO_2 are the same. Test Cells 2 and 5, along with the 15 other test cells at the facility have been in operation for many years. The operation of the two proposed modified test cells is not expected to change the impact of pollutants on the surrounding area significantly.

7.3 Impact on Visibility

PSD regulations require analysis of potential visibility impairment in Federal Class I areas within 100 to 200 km of a new source. The closest Class I area is the Lye Brook Wilderness Area in Vermont, approximately 184 kilometers northwest of the facility.

As the nearest Federal Class I area is more than 100 km from the facility, visibility impacts were not analyzed. Due to the Class I areas being more than 150 km to the northwest of the facility (prevailing winds in the area of the facility are generally to the east), there is expected to be no significant impact on the Lye Brook Wilderness Area due to the proposed modification of the test cells, as the predicted impact at 45km from the facility was less than half of the Class I significant impact level.

The project is not expected to produce any perceptible changes to the visibility in the immediate vicinity of the plant. Particulate emissions are expected to be minimal.

8.0 Major Comprehensive Plan Approval (CPA) Permit Application Forms

The following MassDEP permit application forms are included in this PSD permit application for informational purposes to provide detailed information on the proposed new and modified emission units. The final certified-versions of these forms will be included in the NNSR permit application.

- Transmittal Form
- BWP AQ 03 – Major Comprehensive Plan Approval
- BWP AQ CPA-1 – Fuel Utilization Facilities (for inlet air heaters)
- BWP AQ CPA-3 – Non-fuel Emissions (for test cells)

Since the proposed two new natural gas-fired inlet air heaters are very close to the permitting threshold of 10 MMBtu/hr and since it was recommended by MassDEP, a BWP AQ CPA-1 permit application form is also included.

Since the cooling tower proposed only for the water brake option would be exempt from permitting based on 310 CMR 7.02(2)(b)6 and per consultation with MassDEP, a CPA form has not been completed for the cooling tower. For the water brake option, a new cooling tower is proposed for Test Cell 2 with the following specifications:

- Maximum Water Recirculation Rate: 1000 gpm
- Total Dissolved Solids in Blowdown: < 1800 mg/l
- Non-chromium inhibitor
- Drift Eliminator

For Test Cell 5, the existing cooling tower will be used if the water brake option is chosen.

MassDEP also has advised that a BWP AQ SFC-7 form – Determination of Best Available Control Technology is not required for this permit application. Instead the BACT analysis is included in the permit application text.

Drawings and back-up calculations required as a part of the application as outlined in BWP AQ CPA-1 and CPA-3 are included in the body or appendices of this application.

Appendix A
Drawings

Appendix B
Existing Test Cell Permits

Appendix C
Backup Calculations

Appendix D
Results of RACT/BACT/LAER Clearinghouse Search

Appendix E
Modeling Protocol

Appendix F
Modeling Results Backup