Appendix V4-2I

Madrid-Boston Project:
Air Quality Modeling Study

Air Quality Modeling Study

Madrid-Boston Project

Final Report

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Executive Summary

An air quality modeling study (AQMS) was conducted to inform the assessment of air quality for the Madrid-Boston Project of the Hope Bay Project Final Environmental Impact Statement (TMAC 2017).

The AQMS used the CALPUFF air dispersion model (version 7.1.2) to predict ambient air quality due to: the existing permitted Hope Bay project activities, the Madrid-Boston Project activities, and the cumulative existing permitted activities along with Madrid-Boston Project activities (the Hope Bay Project). The CALPUFF model used appropriate terrain elevation and land use data for the Hope Bay Project area. The meteorological data inputs were from the on-site Doris and Boston meteorological stations along with an appropriate Weather Research and Forecasting model dataset. Model parameters were chosen using BC regulatory guidance, professional judgement and experience.

The air contaminants modeled were nitrogen oxides (NO_X), nitrogen dioxide (NO_2), sulphur dioxide (SO_2), carbon monoxide (CO), total suspended particulate (TSP), particulate matter with diameter less than 10 micrometers (PM_{10}), particulate matter with diameter less than 2.5 micrometers ($PM_{2.5}$), and dust deposition. Predicted contaminant concentrations were compared against relevant ambient air quality standards, objectives and guidelines for Nunavut, other provinces, or Canada.

Baseline ambient air quality conditions were characterized from historical data collected from the Doris North Project Air Quality Monitoring Program from 2009 to 2014.

The AQMS used two spatial domains, one for the Roberts Bay, Doris and Madrid area (Northern Domain), and the other for the Boston area (Southern Domain). Both construction and operation periods were modeled for each domain. For each modeling domain and period, ambient air quality was predicted for the existing permitted activities alone, Madrid-Boston Project activities alone, and the cumulative existing permitted activities along with the Madrid-Boston Project activities. The AQMS spatial domains were established based on a “zone of influence” beyond which potential air contaminant concentrations from the Madrid-Boston Project are expected to reduce to near existing levels.

The emissions inventory for the AQMS was built using a number of information sources, calculations and assumptions. Some information sources and assumptions were informed by descriptions about proposed components and activities of the Madrid-Boston Project as well as existing information about the existing permitted activities. At the time of preparing the emissions inventory, the most up-to-date information from the Project Description (July 31, 2017) was used. There may be changes to the Madrid-Boston Project design before construction as additional planning and detailed engineering design develops. Any changes to Madrid-Boston Project components and activities made after the emissions inventory was completed were not incorporated into the emissions inventory and therefore were not represented in the predicted ambient air quality results.

Where input data uncertainties existed, conservative assumptions were used following regulatory guidance, professional judgement and experience. Emissions from the Project employed a conservative approach based on maximum production rates which is expected to over-estimate emissions. The use of conservative assumptions can lead to conservative model predictions and therefore the model results are interpreted with the understanding that the predicted effects are likely overestimated.

The predicted ambient air quality results are compared against relevant guidelines, objectives and standards for each ambient air quality contaminant at or outside a modelling property boundary that was chosen to represent the potential for public exposure and compliance with air quality criteria. The hunting exclusion zone around the TMAC facilities was used as a reasonable extent to define the property boundary. The hunting exclusion zone is a requirement of the Consolidation of the Mine Health and Safety Regulations, which prohibits discharge of a firearm within 2-km of any mine infrastructure. Local populations have been notified of the exclusion zone - any occurrences of members of the public being located within the hunting exclusion zone are expected to be infrequent and brief in duration.

The following conclusions were made from the AQMS predictions:

- maximum predicted ground level concentrations of SO_2, CO, TSP, $PM_{2.5}$ and dust deposition are predicted to be below their relevant criteria outside the property boundary for construction and operations.
- Maximum 24-hour average PM_{10} concentrations are predicted to exceed the relevant criteria in a limited area to the south-east of Madrid South for Project Operations. The maximum predicted 24-hour average concentration at the property boundary was predicted to be 19% above the criteria and exceedances were predicted to occur infrequently (1 day in 365). Maximum annual average PM_{10} concentrations in the Northern Domain for operations are predicted to be below the applicable criterion.
- Maximum ground level PM_{10} concentrations are predicted to be below their applicable criterion in the Southern Domain for both construction and operations.
- Canadian Ambient Air Quality Standards (CAAQS) for nitrogen dioxide (NO_2) were released on November 3, 2017 and come into effect in 2020 and 2025. These new criteria were incorporated into the assessment for the FEIS as these criteria are more stringent than the current Nunavut criteria. The following were noted from the air quality predictions for NO_2:
    - The Madrid-Boston Project and the Hope Bay Development ambient 24-hour average NO_2 concentrations are predicted to be below the relevant 24-hour (Nunavut) guideline outside the PB.
    - The Madrid-Boston Project and the Hope Bay Development annual average NO_2 concentrations are predicted to be below the newly introduced annual CAAQS outside of the PB.
    - The maximum hourly average NO_2 concentrations are predicted to intermittently (up to 53% of the days annually) exceeded the criteria by up to 382% of the CAAQS. Exceedances were predicted to occur within the LSA but not extend into the RSA. No exceedances are predicted to occur with respect to the currently applicable Nunavut hourly NO_2 criteria.
        - In the Southern domain, exceedances are predicted to occur within 0.5 - 5-km of the PB (depending on direction), but infrequently (less than 20% of the time) outside of 1-km from the PB.
        - In the Northern Domain exceedances are predicted to occur within 2-10 km of the PB (depending on direction), but infrequently (less than 20% of the time) outside of 3.5 km from the PB.

- Exceedances of the health-based hourly average NO_2 CAAQS are predicted to occur in areas where there is expected to be infrequent human occupancy and therefore adverse health effects are unlikely. TMAC will consider additional NOx mitigation measures to address the new NO_2 CAAQS as the Project design progresses.

Ambient air quality modeling predictions were not completed for the reclamation and closure, post closure, and temporary closure periods. Based on the Project Description (July 31, 2017), the air emissions during these three periods were identified as being much lower than the air emissions during the construction and operation periods. Therefore, use of the construction and operation period predictions for these phases is expected to be conservative.

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Abbreviations

µg	Microgram
ANFO	Ammonium nitrate-fuel oil
AQMS	Air quality modeling study
ASTM	ASTM International
AWR	All-weather road
BC	British Columbia
BTU	British thermal units
CAAQS	Canadian Ambient Air Quality Standards
CALMET	The meteorological model component of the California Puff (CALPUFF) air dispersion model
CALPUFF	The California Puff air dispersion model
CCME	Canadian Council of Ministers of the Environment
CDED	Canadian Digital Elevation Data
cm	Centimetre
CO	Carbon monoxide
DEIS	Draft Environmental Impact Statement
dm^2	Square decimetre (equal to 100 square centimetres)
ECCC	Environment and Climate Change Canada
EIS	Environmental Impact Statement
ERM	ERM Consultants Canada Ltd.
FEIS	Final Environmental Impact Statement
GLCC	Global Land Cover Characterization
hr	Hour
km	Kilometre
LTO	Landing and take-off
m	Metre
m^2	Square metre
m^3	Cubic metre

mg	Milligram
MOE	Ministry of Environment
NIRB	Nunavut Impact Review Board
NO_2	Nitrogen dioxide
NO_X	Nitrogen oxides
NSA	Nunavut Settlement Area
Nunami Stantec	Nunami Stantec Ltd.
O_3	Ground level ozone
PDA	Project development area
PM	Particulate matter
PM_{10}	Particulate matter less than 10 µm in diameter
$PM_{2.5}$	Particulate matter less than 2.5 µm in diameter
ppb	Parts per billion
ppm	Parts per million
Rescan	Rescan Environmental Services Ltd.
SO_2	Sulphur dioxide
SOGs	Standards, Objectives and Guidelines
TIA	Tailings Impoundment Area (Doris)
TMA	Tailings Management Area (Boston)
TMAC	TMAC Resources Inc.
TSP	Total suspended particulate
US	United States
US EPA	United States Environmental Protection Agency
US FAA	United States Federal Aviation Administration
VOC	Volatile organic compounds
WRF	Weather Research and Forecasting (a mesoscale meteorological model)

1 INTRODUCTION

The Hope Bay Project is located on the Hope Bay Belt, an 80 by 20 km property located along the south shore of Melville Sound in Nunavut. The property consists of a greenstone belt (the Hope Bay Belt) that contains three main gold deposits. The Doris and Madrid deposits are located in the northern portion of the belt and the Boston deposit is at the southern end. The Project is located approximately 125 km southwest of Cambridge Bay (Iqaluktuttiaq) on the southern shore of Melville Sound.

TMAC Resources Inc. (TMAC) acquired the Hope Bay Belt property from Newmont Corporation in March 2013. The acquisition included exploration and mineral rights over the Hope Bay Belt, including the Doris North Project and its permits, licenses and authorizations for development received by previous owners.

The Doris Project of the Hope Bay Project involved the development of the Doris deposit and the proposed Madrid-Boston Project will involve the development of the Madrid and Boston deposits. High-level activities of the Madrid-Boston Project will involve the construction, operation, closure and post-closure of the following components:

- expansion of the Doris Tailings Impoundment Area (TIA);
- expansion of the Roberts Bay Laydown and Dock;
- development of Madrid North, Madrid South and Boston sites; and
- development of an all-weather road (AWR) between Madrid and Boston.

1.1 Study Objectives

This Report entitled “Madrid–Boston Project Air Quality Modelling Study” (AQMS) describes the existing air quality conditions related to the Madrid-Boston Project followed by an analysis of potential effects and mitigation measures for the Project. The key components of the AQMS are as follows:

- study methodology;
- review of applicable regulatory requirements;
- review of baseline ambient air quality;
- emission inventory for the Project;
- dispersion modeling; and,
- comparison of model predictions to applicable air quality criteria.

Based on past experience, it is anticipated that a primary pathway for air contaminants to reach human and ecological receptors is via airborne dispersion and deposition of contaminants during the operation of the Project. As a result, the key objectives of the air quality modelling study are:

- to provide the data required to conduct the assessment of the potential environmental effects, of the Madrid – Boston Project in conjunction with the current Doris Project on air quality; and,
- to provide concentration and deposition data to the following assessments:
  - Terrestrial Environment: Landform and Soils;
  - Vegetation and Special Landscape Features;
  - Terrestrial Wildlife and Wildlife Habitat;
  - Marine Sediment Quality;
  - Freshwater Sediment Quality; and
  - Human Health and Environmental Risk Assessment.

This AQMS will form part of the supporting documentation for the FEIS completed for the Project.

1.2 Changes from the Draft Air Quality Assessment

The draft air quality assessment for the Draft Environmental Impact Study (DEIS) was conducted by ERM Consultants (ERM 2016). This AQMS, developed for the Final Environmental Impact Study (FEIS) addresses comments from agencies and other stakeholders, and addresses advances in the Madrid-Boston Project design. Nunami Stantec Limited (Nunami Stantec) was retained by TMAC to update and refine the Draft Environmental Impact Study (DEIS) air quality assessment, including refining conservative emissions estimates and dispersion model assumptions and re-modelling the Project. The resulting refined predictions are expected to be more representative of air quality levels when the Project is in operation. The following provides a summary of the main updates that have been incorporated into the air quality assessment since publication of the DEIS in December 2016:

- Updates in the site plan resulting in changes in source locations.
- Inclusion of assessment scenarios that address the potential for the Madrid North facility to be moved approximately 400-m north of the location assessed in the DEIS (referred to as the reference and alternative locations). The Madrid North facility was assessed in both locations in the FEIS.
- Updates to the mining rate and operating life of the Boston site. The mining rate in the FEIS has increased relative to the DEIS (1600 TDP in the DEIS to 2400 TPD in the FEIS) and the operating life has decreased.
- Utilization of the appropriate Canadian emissions standards in effect at the time new or existing equipment is or was purchased.
- The number of surface vehicles in the emission inventory will be revised based on the updated mining rate at Boston and required vehicle trips between camps.

- Boston Power Plant – in the DEIS 8 - 1.2 MW units were assumed operating. For the FEIS, only 6 - 1.2 MW units will be operating at any given time, with 2 on stand-by.
- Boston Processing Plant – in the DEIS the processing plant included crushing, milling and concentration. For the FEIS, the processing plant will be identical in design and capacity to the Doris processing plant and also include flotation, cyanide leach and gold recovery.
- Madrid and Boston Power Plant Stacks – in the DEIS, stack heights equal to Doris (30-m) were used. Stack heights in the FEIS are expected to be lower, and were assessed using a 15-m stack height.
- Inclusion of two wind turbines near the Doris site, two wind turbines near the Madrid North site and two wind turbines near the Boston site. These turbines will supply the power necessary to operate the Doris mill and camp, Madrid concentrator, and, Boston mill and camp, and will be located approximately 2.5 km and 3.0 km south of the sites. The power plants were conservatively assumed to operate at maximum capacity without any reduction in capacity due to the wind energy generation.
- In the DEIS the facility “property boundary” was assumed to be the PDA. In the FEIS a refined dispersion modelling "property boundary" was used to better represent the potential for public exposure and compliance with air quality criteria. The hunting exclusion zone around the TMAC facilities was used as a reasonable extent to define the property boundary. The hunting exclusion zone is a requirement of the Consolidation of the Mine Health and Safety Regulations, which prohibits discharge of a firearm within 2-km of any mine infrastructure. Local populations have been notified of the exclusion zone - any occurrences of members of the public being located within the hunting exclusion zone are expected to be infrequent and brief in duration.
- Various dispersion model input parameters for area and road sources were refined (following US EPA protocols) to reduce conservatisms in the modelling methodology.

The Nunami Stantec scope of work included updating the emissions inventory based on updated Project information, refining the emissions calculation methodology and inputs, updating and refining the dispersion model inputs, running the models and updating the dispersion model results. Analysis and interpretation of the following aspects of the air quality assessment presented in this report were outside the scope of the Nunami Stantec updates, and the original assessments were relied upon by Nunami Stantec:

- Incorporation of Traditional Knowledge (Section 2.2 of Volume 4, Chapter 2 of the FEIS)
- Substances of Concern
- Existing and Baseline Air Quality monitoring (Section 3 of this report)
- Study Area development
- Characterization of Baseline Conditions and Existing Conditions

1.3 Assessment Approach

Standard air dispersion modeling techniques were applied to predict the potential air quality effects associated with the Madrid-Boston Project. Air dispersion modeling is commonly used to assess air quality effects of a proposed source with respect to federal, territorial and provincial ambient air quality SOGs. The dispersion model allows an understanding of the interaction of existing and future emission sources and takes into account meteorological conditions, terrain elevation, land use and the existing ambient air quality.

This air dispersion modeling approach followed the Nunavut Impact Review Board (NIRB)'s EIS Guidelines for the Hope Bay Phase 2 Project (NIRB 2012).

1.4 Project Overview

The Madrid-Boston Project consists of proposed mine operations at the Madrid North, Madrid South and Boston deposits. The Madrid-Boston Project is part of a staged approach to continuous development of the Hope Bay Greenstone Belt, comprised of existing operations at Doris, a bulk sample followed by commercial mining at Madrid North and Madrid South, and commercial mining of the Boston deposit. The Madrid-Boston Project would utilize and expand upon the existing Doris Project infrastructure.

The Madrid-Boston Project is the focus of this application. Because the infrastructure of existing and approved projects will be utilized by the Madrid-Boston Project, and because the existing and approved projects have the potential to interact cumulatively with the Madrid-Boston Project, existing and approved project are described below.

1.4.1 The Approved Projects

Existing and approved projects include:

- the Doris Project (NIRB Project Certificate 003, NWB Type A Water License 2AM-DOH1323);
- the Hope Bay Regional Exploration Project (NWB Type B Water License 2BE-HOP1222);
- the Madrid Advanced Exploration Program (NWB Type B Water License 2BB-MAE1727); and
- the Boston Advanced Exploration Project (NWB Type B Water License 2BB-BOS1727).

1.4.1.1 The Doris Project

The Doris Project was approved by NIRB in 2006 (NIRB Project Certificate 003) and licensed by NWB in 2007 (Type A Water License 2AM-DOH0713). The Type A Water License was amended in 2010, 2011 and 2012 and received modifications in 2009, 2010, and 2011.

Construction of the Doris Project began in early 2010. In early 2012, the Doris Project was placed into care and maintenance, suspending further Project-related construction as well as exploration activity along the Hope Bay Greenstone Belt. Following TMAC's acquisition of the Hope Bay Project in March of 2013, NWB renewed the Doris Project Type A Water License (Type A Water License 2AM-DOH1323), and TMAC advanced planning, permitting, exploration and construction activities. In 2016, NIRB approved an amendment to Project Certificate 003 and NWB granted Amendment No. 1 to Type A Water License 2AM-DOH1323, extending operations from two to six years through mining two additional mineralized zones (Doris Connector and Doris Central zones) to be accessed via the existing Doris North portal. Amendment No. 1 to Type A Water License 2AM-DOH1323 authorizes a mining rate of up to 2,000 tonnes per day of ore and a milling throughput of 2,000 tonnes per day of ore. The Doris Project began production early in 2017.

The Doris Project includes the following components and facilities:

- The Roberts Bay offloading facility: marine jetty, barge landing area, beach laydown area, access roads, weather havens, fuel tank farm/transfer station, waste storage facilities and incinerator, and quarry;
- The Doris site: 280-person camp, laydown areas, service complex (e.g., workshop, wash bay, administration buildings, mine dry), two quarries (mill site platform and solid waste landfill), core storage areas, batch plant, brine mixing facilities, vent raise (3), air heating units, reagent storage, fuel tank farm/transfer station, potable water treatment, waste water treatment, incinerator, land farm and handling/temporary hazardous waste storage, explosives magazine, and diesel power plant;
- Doris Mine works and processing: underground portal, overburden stockpile, temporary waste rock pile, ore stockpile, and processing mill;
- Tailings Impoundment Area (TIA): Schedule 2 designation for Tail Lake with two dams (North and South dams), sub-aerial deposition of flotation tailings, emergency tailings dump catch basins, pump house, and quarry;
- All-season main road with transport trucks: Roberts Bay to Doris site (4.8 km, 150 to 200 tractors and 300 fuel tanker trucks/year);
- Access roads from Doris site used predominantly by light-duty trucks to: Tail Lake (5.9 km), the explosives magazine (0.5 km), Doris Lake float plane dock (0.5 km), solid waste disposal site (0.2 km), and to the tailings decant pipe (0.4 km), from the Roberts Bay offloading facility to the location where the discharge pipe enters the ocean (0.6 km); and
- All-weather airstrip (914 m), winter airstrip (1,524 m), helicopter landing site and building, and Doris Lake float plane and boat dock.

Water is managed at the Doris Project through:

- freshwater input from Doris Lake for mining, milling and associated activities and domestic purposes;
- freshwater input from Windy Lake for domestic purposes;
- process water input primarily from Tail Lake;

- saline water from mining, porewater from waste rock and ore discharged to Tail Lake;
- sewage and greywater treated in a waste water treatment plant and discharged to Tail Lake; and
- water from Tail Lake treated and discharged to Roberts Bay via a discharge pipeline, with use of a marine outfall mixing box (MOMB).

1.4.1.2 Hope Bay Regional Exploration Project

The Hope Bay Regional Exploration Project has been renewed several times since 1995. The current extension expires in June 2022. Much of the previous work for the program was based out of Windy Lake and Boston camps. These camps were closed in October 2008 with infrastructure either decommissioned or moved to the Doris site. All exploration activities are now based from the Doris site and in the future from the Boston site. Components and activities for the Hope Bay Regional Exploration Project include:

- operation of helicopters from Doris (4 hours per day in the summer months); and
- the use of exploration drills, which are periodically moved by helicopter.

1.4.1.3 Madrid Advanced Exploration

In 2017, the NWB approved a Type B Water License (2BB-MAE1727) for the Madrid Advanced Exploration Program to support continued exploration and a bulk sample program at the Madrid North and Madrid South sites, located approximately 4 km south of the Doris site. The program includes extraction of a bulk sample totaling 50 to 60 tonnes, which will be trucked to the mill at the Doris site for processing and placement of tailings in the tailings impoundment area (TIA). All personnel will be housed in the Doris camp.

The Madrid Advanced Exploration Program includes the following components and activities.

- Utilization of existing infrastructure associated with the Doris Project:
  - camp facilities to support up to 70 personnel as required to undertake the advanced exploration activities;
  - mill to process ore;
  - TIA;
  - landfill and hazardous waste areas, particularly if closure and remediation becomes required for the Madrid Advanced Exploration Program infrastructure;
  - fuel tank farms; and
  - Doris airstrip and Roberts Bay facility for transport of personnel and supplies.
- Utilization of existing infrastructure at the Madrid and Boston areas:
  - borrow and rock quarry facilities: existing Quarries A, B, and D along the Doris-Windy AWR;
  - AWR between Doris and Windy Lake for transportation of personnel, ore, waste, fuel, and supplies; and

- future mobilization of existing exploration site infrastructure, should it become necessary.
- Construction of additional facilities at Madrid North and South:
    - access portals and ramps for underground operations at Madrid North and at Madrid South;
    - 4.7 km extension of the existing AWR originating from the Doris to the Windy exploration area (Madrid North) to the Madrid South deposit, with branches to Madrid North, Madrid North vent raise, and the Madrid South portal;
    - development of a WRR from Madrid North to access Madrid South until AWR has been constructed;
    - all weather access road and tailings line from Madrid North to the south end of the TIA;
    - borrow and rock quarry facilities; two quarries referenced as Quarries G and H;
    - waste rock and ore stockpiles;
    - water and waste management structures; and
    - additional site infrastructure, including compressor building, brine mixing facility, saline storage tank, air heating facility, four vent raises, workshop and office, laydown area, diesel generator, emergency shelter, fuel storage facility/transfer station.
- Undertaking of advanced exploration access to the deposits through:
    - continue field mapping and sampling, as well as airborne/ground/downhole geophysics;
    - diamond drilling from the surface and underground; and
    - bulk sampling through underground mining methods and mine development.

1.4.1.4 Boston Advanced Exploration

The Boston Advanced Exploration Project Type B Water License No. 2BB-BOS1217 was renewed as Water License No. 2BB-BOS1727 in July 2017 and includes:

- the Boston camp (120 person), maintenance shops, workshops, laydown areas, water pumphouse, vent raise, warehouse, site service roads, sewage and greywater treatment plant, fuel storage and transfer station, land farm, solid waste landfill and a heli-pad;
- mine works, consisting of underground development for exploration drilling and bulk sampling, temporary waste rock pile, and ore stockpile;
- potable water and industrial water from Aimokatalok Lake; and
- treated sewage and greywater discharged to the tundra.

1.4.2 The Madrid-Boston Project

The Madrid-Boston Project includes: Construction and Operation of commercial mining at the Madrid North, Madrid South and Boston sites; the continued operation of Roberts Bay and the Doris site to support mining at Madrid and Boston; and the Reclamation and Closure and Post-Closure phases of all sites. Excluded from the Madrid-Boston Project for the purposes of the assessment are the Reclamation and Closure and Post-closure components of the Doris Project as currently permitted and approved.

1.4.2.1 Construction

Madrid-Boston construction will utilize the infrastructure associated with Existing and Approved Projects. This may include:

- an all-weather airstrip at the Boston exploration area and helicopter pad;
- seasonal construction and/or operation of a winter ice strip on Aimaokatalok Lake;
- Boston camp with capacity for up to 65 people during construction
- Quarry D Camp with capacity for up to 100 people;
- seasonal construction/operation of Doris to Boston winter road route (WRR);
- three existing quarry sites along the Doris to Windy all-weather road (AWR);
- Doris camp with capacity for up to 280 people;
- Doris airstrip, winter ice strip, and helicopter pad;
- Roberts Bay offloading facility and road to Doris; and
- Madrid North and Madrid South sites and access roads.

Additional infrastructure to be constructed for the proposed Madrid-Boston Project includes:

- expansion of the Doris TIA (raising of the South Dam, construction of the West Dam, development of a west road to facilitate access, and quarrying, crushing, and screening of aggregate for the construction);
- construction of an off-loading cargo dock at Roberts Bay (including a fuel pipeline, upland mooring points, beach landing and gravel pad, shore manifold);
- construction of an additional tank farm at Robert's Bay (consisting of two 5 ML tanks);
- expansion of accommodation facility (from 280 to 400 person), mine dry and administrative building, water treatment at Doris site;
- complete development of the Madrid North and Madrid South underground workings;
- incremental expansion of infrastructure at Madrid North and Madrid South to accommodate production mining, including vent raise, access road, process plant buildings.;
- construction of a 1,200 tpd concentrator, fuel storage, power plant, mill maintenance shop, warehouse/reagent storage at Madrid North;

- all weather access road and tailings line from Madrid North to the south end of the TIA;
- AWR linking Madrid to Boston (approximately 53 km in length, nine quarries for permitting purposes, four of which will likely be used);
- all-weather airstrip, airstrip building, helipad and heliport building at Boston;
- construction of a 2400 tpd process plant at Boston;
- all infrastructure necessary to support mining and processing activities at Boston including construction of a new 300-person accommodation facility, mine office and dry and administration building s, additional fuel storage, laydown area, ore pad, waste rock pad, diesel power plant and dry-stack tailings management area (TMA);
- infrastructure necessary to support ongoing exploration activities at both Madrid and Boston; and
- wind turbines near the Doris site (2), Madrid (2) and Boston (2).

1.4.2.2 Operation

Madrid-Boston Project is intended to cover the proposed incremental development of the Hope Bay Greenstone Belt. The operation phase includes:

- mining of the Madrid North, Madrid South, and Boston deposits;
- operation of a concentrator at Madrid North;
- transportation of ore from Madrid North, Madrid South and Boston to the Doris process plant, and transportation of concentrate from the Madrid North concentrator to the Doris process plant;
- extending the operation at Roberts Bay and Doris;
- processing the ore and/or concentrate from Madrid North, Madrid South and Boston at the Doris process plant with disposal of the detoxified tailings underground at Madrid North, flotation tailings from the Doris process plant pumped to the expanded Doris TIA, and discharge of the TIA effluent to the marine environment;
- operation of a concentrator at Madrid North and disposal of tailings at the Doris TIA;
- operation of a process plant and wastewater treatment plant at Boston with disposal of flotation tailings to the Boston TMA and the detoxified leached tailings in the underground mine at Boston;
- operation of two wind turbines for power generation; and
- on-going maintenance of transportation infrastructure at all sites (cargo dock, jetty, roads, and quarries).

The location of the Madrid North facilities was assessed for a second location since at the time of the DEIS, the location was not finalized. The second location for Madrid North was for the entire facility to be shifted approximately 400-m to the north of the location presented in Figure 1-1. The location presented in Figure 1-1 is referred to as the Madrid North Reference Location while the location of Madrid North shifted 400-m to the north is referred to as the Madrid North Alternative Location.

1.4.2.3 Reclamation and Closure

At Reclamation and Closure, all sites will be deactivated and reclaimed in the following manner (see Volume 3, Section 5.5):

- Camps and associated infrastructure, laydown areas and quarries, buildings and physical structures will be decommissioned. All foundations will be re-graded to ensure physical and geotechnical stability and promote free-drainage, and any obstructed drainage patterns will be re-established.
- Using non-hazardous landfill, facilities will receive a final quarry rock cover which will ensure physical and geotechnical stability.
- Mine waste rock will be used as structural mine backfill.
- The Doris TIA surface will be covered rock. Once the water quality in the reclaim pond has reached the required discharge criteria, the North Dam will be breached and the flow returned to Doris Creek.
- The Madrid to Boston All-Weather Road and Boston Airstrip will remain in place after Reclamation and Closure. Peripheral equipment will be removed. Where rock drains, culverts, or bridges have been installed, the roadway or airstrip will be breached and the element removed. The breached opening will be sloped and armored with rock to ensure that natural drainage can pass without the need for long-term maintenance.
- A low permeability cover, including a geomembrane, will be placed over the Boston TMA. The contact water containment berms will be breached and the liner will be cut to prevent collecting any water. The balance of the berms will be left in place to prevent localized permafrost degradation.

1.5 Substances of Concern

The AQMS predicted results for the following substances:

- nitrogen oxides (NO_X);
- nitrogen dioxide (NO_2) resulting from emissions of NOx;
- sulphur dioxide (SO_2);
- carbon monoxide (CO);
- total suspended particulate matter (TSP);
- particulate matter with diameter less than 10 micrometers (PM_{10}; inhalable particulate);
- particulate matter with diameter less than 2.5 micrometers ($PM_{2.5}$; respirable particulate); and
- dust deposition (dustfall).

Ambient air quality contaminants are described in Table 1-1.

Volatile organic compounds (VOC) and ground level ozone (O_3) were not included in the AQMS as Madrid-Boston Project VOC and O_3 emissions were determined to be negligible based on the Project Description (as of July 31, 2017). O_3 is primarily produced from photochemically active nitrogen oxides (NO_X) and VOCs in the atmosphere. O_3 is primarily created downwind and away from NO_X and VOC emission sources as the chemical reaction takes place over time.

Ambient airborne metal concentrations and depositions are not included in the air quality effects assessment. Metal concentrations and depositions are estimated using the TSP and dust deposition predictions and metals composition data from the Air Quality Monitoring Program. The metal results, along with other air contaminant species predicted in the air quality model study, are used to inform the following EIS chapters:

- Terrestrial Environment: Landforms and Soils;
- Vegetation and Special Landscape Features;
- Terrestrial Wildlife and Wildlife Habitat;
- Marine Sediment Quality;
- Freshwater Sediment Quality; and
- Human Health and Environmental Risk Assessment.

Table 1-1 Description of Substances Used as Ambient Air Quality Indicators

Substance	Description
SO_2	Fossil fuels contain a small amount of organic sulphur compounds. During fuel combustion, the sulphur is oxidized and emitted as SO_2 gas with the combustion exhaust. In the atmosphere, SO_2 can further oxidize to sulphate particles, which contribute to acid deposition. SO_2 can be harmful to humans at high concentrations.
NO_2	Nitrogen oxides (NO_X) gas is a product of fuel combustion and primarily consists of NO and NO_2. The gases are emitted with exhaust from combustion engines, power generation, and products from blasting operations. NO can be converted to NO_2 in the atmosphere. NO_X emissions can also be converted to nitric acid in the atmosphere, which contributes to acid deposition. NO_2 can be harmful to humans at high concentrations.
O_3	Ozone (O_3) exists naturally in the upper atmosphere (the Ozone Layer), and is also formed in the lower atmosphere and ground level due to photochemical reactions that result in ozone formation from precursor emissions (primarily NOx and VOCs). Ground level ozone is harmful to humans and vegetation at high concentrations.
CO	CO is formed as a result of incomplete combustion of fossil fuels and can be harmful to humans at high concentrations.
VOC	Volatile organic compounds (VOCs) are organic chemicals that have high vapor pressure resulting in high evaporation of the chemicals. There are a variety of common emission sources of VOCs such as some household product chemicals (e.g., paint) and the burning of some substances. VOCs are primary precursors to the formation of ground level ozone and particulate matter which leads to smog. VOCs, ground level ozone and particulate matter are harmful to humans at high concentrations.

Table 1-1 Description of Substances Used as Ambient Air Quality Indicators

Substance	Description
TSP	TSP are airborne particulate matter that have diameters of approximately 44 µm or less. Sources of TSP include combustion processes (e.g., combustion engines) and fugitive dust. Particles less than 10 µm are small enough to be inhaled and may be harmful to humans at high concentrations. Depending on the source of TSP, other constituents such as metals may also be transported as part of the airborne particulates.
PM_{10}	PM_{10} is particulate matter with a diameter of less than 10 µm. It is a subset of TSP. PM_{10} particles are small enough to be inhaled by humans into the upper respiratory tract and may be harmful at high concentrations.
$PM_{2.5}$	$PM_{2.5}$ is particulate matter with a diameter of less than 2.5 µm. It is a subset of TSP and PM_{10}. $PM_{2.5}$ particles are small enough to be inhaled deep into the respiratory system by humans and may be harmful at high concentrations.
Dust deposition (dustfall)	Dust deposition is airborne dust (TSP) that is deposited onto a surface (i.e., on top of soil, vegetation, etc.) by gravity, precipitation or wind. Depending on the source of dust, other harmful chemicals such as heavy metals may also be transported as part of the airborne particulates and deposited onto a surface.

1.6 Spatial Boundaries

Spatial boundaries of the AQMS for the FEIS were taken to be consistent with those chosen in the DEIS. To maximize air quality modeling efficiency, two smaller spatial boundaries were used rather than one larger boundary. The AQMS spatial domains (study areas) were established based on the “zone of influence” beyond which potential air contaminant concentrations from the Madrid-Boston Project are expected to reduce to near existing levels.

The two AQMS spatial domains were selected for the modelling were:

- Northern Domain: The northern domain includes the area around Roberts Bay, Doris, Madrid North, Madrid South and approximately 20 km of the AWR extending out to potential quarry M. This domain is a square area extending 30 km north to south, by 30 km east to west, and is centred approximately half way between Doris and Madrid North. This domain is shown in Figure 5.3-1.
- Southern Domain: The southern domain includes the area around Boston and approximately 20 km of the AWR extending from Boston to potential quarry T. This domain is a square area extending 30 km north to south, by 30 km east to west, and is centred approximately on the proposed Boston Mill. This domain is shown in Figure 5.3-2.

To increase air quality modeling efficiency, the middle section of the AWR (spanning a length of approximately 20 km) and potential quarries along this road section were not included in the modeling study (Figure 1-1), i.e., emissions from these sources are not included. It is expected that the AWR’s impact on ambient air quality will be approximately uniform along the entire length of the AWR because:

- air contaminant emissions along the AWR (primarily vehicle tailpipe and fugitive unpaved road dust emissions) are expected to be uniform;

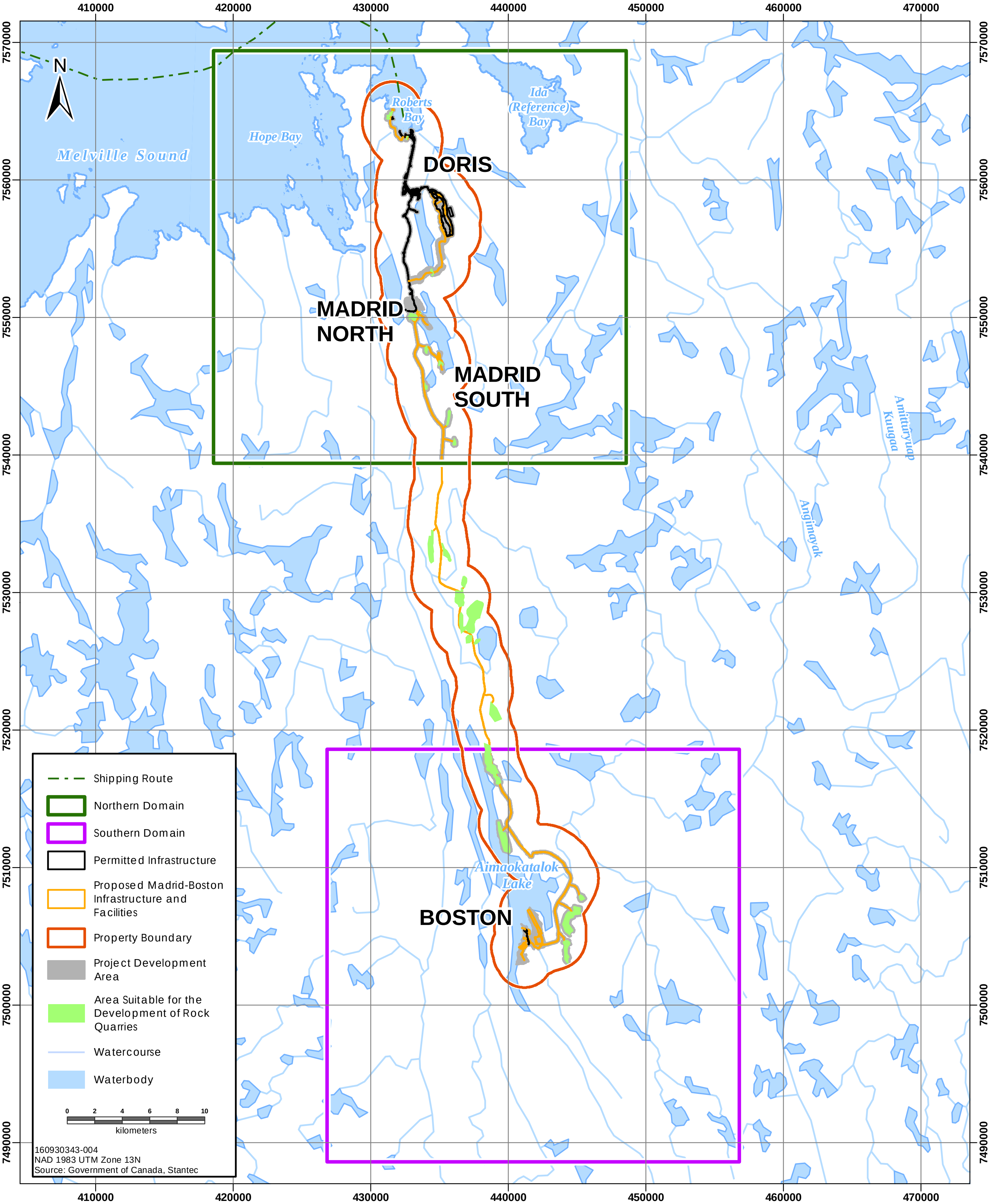
- the AWR alignment is generally a straight path; and
- regional topography, land use and meteorological conditions are generally uniform along the whole AWR length.

The ambient air quality impacts of the AWR sections modeled within the northern and southern domains can be extrapolated and assessed over the entire AWR.

The ocean shipping route within the Nunavut Settlement Area (NSA) is partially included in the northern domain, with a shipping route length of approximately 4 km within Roberts Bay. It is expected that the air emissions over the entire shipping route (including the entire route within the NSA) will be relatively uniform and the resulting ambient air quality impact from a moving ship will be generally consistent along the full shipping route. The ambient air quality impacts of the shipping route modelled within the northern domain can be extrapolated and assessed over the entire shipping route.

The northern and southern spatial boundaries are shown in Figure 1-1. Additional information about the spatial boundaries is included in Section 6.4.

Figure 1-1
Spatial Boundaries for the Air Quality Modeling Study



1.7 Temporal Boundaries

Temporal boundaries of the AQMS were chosen to model the highest air emission sources during the Project Schedule, as described in the FEIS Project Description (as of July 31, 2017). Based on the Project Schedule, the Madrid-Boston Project construction and operation periods were determined to have the highest emissions compared to the closure, post-closure and care and maintenance periods.

Because some of the different components of the Madrid-Boston Project would be under construction and operation at different times, two temporal domains for each of the two spatial domains were needed to model the maximum emissions. For the northern domain, construction period (Project Year 1; calendar year 2019) and operation period (Project Year 12; calendar year 2030) components and activities were modeled. For the southern domain, construction period (Project Year 4; calendar year 2022) and operation period (Project Year 10; calendar year 2028) components and activities were modeled.

The Madrid-Boston Project DEIS air quality assessment assesses the resulting ambient air quality conditions due to Madrid-Boston Project components and activities against the existing air quality conditions before the Madrid-Boston Project. In addition, it also assesses the cumulative air quality effects of the Madrid-Boston Project combined with the existing conditions (the Hope Bay Development cumulatively). Air emissions from the Doris Project existing permitted components and activities are used to represent the existing air quality conditions before the Madrid-Boston Project. Therefore, the AQMS also models the ambient air quality resulting from the Hope Bay Project existing permitted components and activities during The Madrid-Boston Project Year 1 (calendar year 2019) and Project Year 12 (calendar year 2030). Existing air quality conditions are further discussed in Section 3.

For each spatial and temporal domain, ambient air quality was modeled for a full year in order to account for seasonal meteorological conditions and air emissions, and compute the required averaging periods needed to compare against relevant ambient air quality SOGs.

The temporal boundaries used for the Madrid-Boston Project: Air Quality Modelling Study (Nunami Stantec 2017) include modeling air emissions and the resulting ambient air quality during Project Years 1, 4, 10 and 12 for the following reasons:

- Project Year 1 was chosen for modeling because it was determined to have the highest amount of construction air emissions in the northern domain due to the highest amount of overlapping construction activities in the proposed Project Schedule (see Project Description, Volume 3). Areas with Project Year 1 construction activities in the northern domain include Roberts Bay, Doris, Madrid North, Madrid South and the AWR.

- Project Year 4 was chosen for modeling because it was determined to have the highest amount of construction air emissions in the southern LSA due to the highest amount of overlapping construction activities in the proposed Project Schedule (see Project Description, Volume 3). Areas with Project Year 4 construction activities in the southern domain include Boston and it was assumed that AWR construction would also be included. The proposed Project Schedule has AWR construction taking place in Project Years 1 to 3. The modeling study conservatively assumes that Boston and AWR construction activities overlap in Year 4 in the southern domain. This is a conservative assumption used to account for any delays in AWR construction that may cause AWR construction overlap into Year 4 with Boston construction. This assumption also helps to improve modeling efficiency.
- Project Year 10 was chosen for modeling because it was determined to have the highest amount of operational air emissions in the southern domain due to the highest amount of operational activity in the proposed Project Schedule (see Project Description, Volume 3).
- Project Year 12 was chosen for modeling because it was determined to have the highest amount of operational air emissions in the northern domain due to the highest amount of operational activity in the proposed Project Schedule (see Project Description, Volume 3).

Air quality modeling was not conducted for the reclamation and closure, post-closure, and temporary closure periods. Based on the Project Description (as of July 31, 2017), air emissions during these three phases were identified to be much lower than the air emissions during the Construction and Operation phases. The resulting ambient air quality concentrations are therefore expected to be lower during the Reclamation and Closure, Post-Closure, and Temporary Closure phases compared to the Construction and Operation phases.

2 AIR QUALITY STANDARDS, OBJECTIVES AND GUIDELINES

Ambient air quality Standards, Objectives and Guidelines (SOGs) have been developed by the Canadian federal government and individual provinces and territories to assist or mandate the management of common air contaminants.

The AQMS incorporates the Nunavut Environmental Guideline for Ambient Air Quality (Government of Nunavut 2011). Nunavut does not have guidelines or standards for some of the air contaminants required to be included in the air quality assessment by the EIS guidelines (NIRB 2012). In these cases, guidelines, objectives or standards from the federal government (CCME 2016b, 2016a), British Columbia (BC) government (BC MOE 2016) and Alberta government (Alberta Environment and Parks 2016) have been used to inform the AQMS.

The ambient air quality SOGs that are used in the AQMS are summarized in Table 2-1. Canadian Ambient Air Quality Standards (CAAQS) for sulphur dioxide (SO_2), ground-level ozone (O_3) and particulate matter with diameter less than 2.5 µm ($PM_{2.5}$) have recently been revised and will come into effect in the years 2020 (for SO_2, O_3 and $PM_{2.5}$) and 2025 (for SO_2) (CCME 2016b, 2016a).

CAAQS for nitrogen dioxide (NO_2) was released on November 3, 2017 and come into effect in 2020 and 2025 (CCME 2017). Development of the NO_2 CAAQS was informed by a risk assessment conducted by Health Canada (Health Canada 2016) that reported that the evidence supported the establishment of both short-term and long-term air quality standards to protect against health effects associated with ambient NO_2.

For simplicity, the proposed activity timelines in the Project Schedule (as of July 31, 2017) are compared against the most stringent SO_2 and $PM_{2.5}$ standards.

There are no Nunavut or federal ambient air quality guidelines or standards for airborne concentrations of total or specific volatile organic compounds (VOCs) for the mining sector.

Table 2-1 Ambient Air Quality Standards, Objectives and Guidelines

Contaminant	Units	Averaging Period	Nunavut Ambient Air Quality Guideline[a]	Guidelines or Standards from Other Government Agencies	
				Value	Agency
Sulphur dioxide (SO_2)	µg/m³	1-hour	450	183 (70 ppb; Effective in 2020)[b] **170 (65 ppb; Effective in 2025)[b]**	CAAQS[g]
		24-hour	**150**	-	-
		Annual	30	13 (5 ppb; Effective in 2020)[c] **10 (4 ppb; Effective in 2025)[c]**	CAAQS[g]
Nitrogen dioxide (NO_2)	µg/m³	1-hour	400	113 (60 ppb; Effective in 2020)[j] **79 (42 ppb; Effective 2025)[j]**	CAAQS[g]
		24-hour	**200**	-	
		Annual	60	32 (17 ppb; Effective 2020)[k] **23 (12 ppb; Effective 2025)[k]**	CAAQS[g]
Ozone (O_3)	µg/m³	8-hour	126 (65 ppb)	123 (63 ppb)[d] **121 (62 ppb; Effective in 2020)[d]**	CAAQS[g]
Carbon monoxide (CO)	µg/m³	1-hour	-	**14,300**	BC Ambient Air Quality Objective[h]
		8-hour	-	**5,500**	BC Ambient Air Quality Objective[h]

Table 2-1 Ambient Air Quality Standards, Objectives and Guidelines

Contaminant	Units	Averaging Period	Nunavut Ambient Air Quality Guideline[a]	Guidelines or Standards from Other Government Agencies	
				Value	Agency
Total suspended particulates (TSP)	µg/m³	24-hour	**<u>120</u>**	-	
		Annual (geometric mean)	**<u>60</u>**	-	
Particulate matter < 10 µm diameter (PM_{10})	µg/m³	24-hour	-	**<u>50</u>**	BC Ambient Air Quality Objective[h]
Particulate matter <2.5 µm diameter ($PM_{2.5}$)	µg/m³	24-hour	30	28[e] **<u>27 (Effective in 2020)[e]</u>**	CAAQS[g]
	µg/m³	Annual	-	10[f] **<u>8.8 (Effective in 2020)[f]</u>**	CAAQS[g]
Dust deposition	mg/dm²/30 days	30-day	-	**53 (residential and recreation areas)** **158 (commercial and industrial areas)**	Alberta Ambient Air Quality Objectives and Guidelines[i]

NOTES:
Bold underlined values indicate values that are used as reference values in the model study.
Dash (-) = not applicable
ppb = parts per billion
a: (Government of Nunavut 2011)
b: The 1-hour SO_2 value is calculated from the 3-year average of the 99th percentile of the daily maximum 1-hour average concentrations.
c: The annual SO_2 value is calculated from the arithmetic average over a single calendar year of all 1-hour average concentrations.
d: The 8-hour O_3 value is calculated from the 3-year average of the annual 4th highest daily maximum 8-hour average concentration.
e: The 24-hour $PM_{2.5}$ value is calculated from the 3-year average of the annual 98th percentile of the daily 24-hour average concentration.
f: The annual $PM_{2.5}$ value is calculated from the 3-year average of the annual average concentrations.
g: Canadian Ambient Air Quality Standards for SO_2: (CCME 2016b). Canadian Ambient Air Quality Standards for O_3 and $PM_{2.5}$: (CCME 2016a)
h: (BC MOE 2016)
i: (Alberta Environment and Parks 2016)

3 EXISTING AND BASELINE AMBIENT AIR QUALITY

The AQMS uses distinct definitions when describing either baseline ambient air quality conditions or existing ambient air quality conditions for the Madrid-Boston Project.

- Baseline ambient air quality represents the ambient air quality conditions within the Hope Bay Project property area before any significant air emissions were released by any Hope Bay Project activity, i.e., before the Doris Project, the Madrid-Boston Project or Madrid Permitted activities. It is also used to describe the ambient air quality conditions within the Hope Bay Project property area when significant Doris Project or Madrid Permitted construction or operation activities were temporarily stopped (e.g., during the winter in some years) or put under care and maintenance (e.g., in 2013 and 2014).
- Existing ambient air quality represents the ambient air quality conditions within the Hope Bay Project property area during Doris Project operations and Madrid Permitted activities, but before the Madrid-Boston Project construction or operation activities.

The distinct difference between baseline and existing ambient air quality is consistently and clearly used throughout this report.

3.1 Data Sources and Application

For characterizing the Madrid-Boston Project baseline ambient air quality conditions, 2009 to 2014 (inclusive) data from the Doris North Project Air Quality Monitoring Program are used (Rescan 2009, 2010, 2011b, 2011a, 2012c, 2012a; ERM Rescan 2014a, 2014b, ERM 2016). Emphasis is placed on the data collected during 2013 and 2014 as the Doris North Project was in care and maintenance at the time. The 2013 and 2014 data is therefore thought to be more representative of baseline ambient air quality conditions as there were less project air emissions in these years compared to years 2009 to 2012 when Doris North Project construction activities were taking place.

On-site ambient air quality monitoring data exists prior to 2009, but they are not incorporated into this ambient air quality setting section as these six years of monitoring data are sufficient to inform the baseline conditions for The Madrid-Boston Project.

3.2 Characterization of Baseline Conditions

Table 3-1 summarizes the on-site 2009 to 2014 air quality monitoring results (ERM, 2016). The values that are bold and underlined are the baseline ambient air quality values used in the AQMS. These baseline values are assumed to be constant and applicable to the entire modeling spatial and temporal domains.

Detailed air quality baseline data can be found in the 2009 to 2014 air quality baseline and compliance reports (Rescan 2009, 2010, 2011b, 2011a, 2012c, 2012a; ERM Rescan 2014a, 2014b).

There are no Hope Bay Project site-specific background concentrations available for CO, therefore the 2015 annual average CO concentrations at monitoring stations in Yellowknife, Norman Wells and Fort Smith were used to represent baseline conditions (GNWT 2016). The median of these three annual values is 261 $\mu g/m^3$.

Existing and baseline ambient air quality data were incorporated into the model results during post-processing so that results could be compared with and without the existing or baseline ambient air quality levels.

Baseline ambient air quality data were applied to model results by adding the baseline values to the entire domain. Baseline values were assumed to be constant over the entire spatial and temporal domain.

Table 3-1 Air Quality Baseline Results Summary

Contaminant	Units	Normalized Sampling Period for Each Sample	2009-2014 Monitoring Data			2013-2014 Monitoring Data (During Care and Maintenance)		
			Median	Mean	Range	Median	Mean	Range
Sulphur dioxide (SO_2)	µg/m³	30 days	0.1	0.4	0.1-5.0	**<u>0.3</u>**	0.6	0.1-3.7
Nitrogen dioxide (NO_2)	µg/m³	30 days	1.2	1.9	0.1-9.6	**<u>1.1</u>**	1.9	0.1-7.0
Ground level ozone (O_3)	µg/m³	30 days	53.0	53.9	1.4-92.5	**<u>52.6</u>**	58.4	44.3-86.1
Total suspended particulate (TSP)	µg/m³	24 hours	4.4	5.4	0.1-45.0	**<u>5.8</u>**	6.7	1.1-17.5
Particulate matter < 10 µm diameter (PM_{10})	µg/m³	24 hours	4.7	6.3	0.5-46.0	**<u>5.4</u>**	6.1	1.2 -17.1
Particulate matter <2.5 µm diameter ($PM_{2.5}$)	µg/m³	24 hours	2.6	3.0	0.1-20.0	**<u>3.1</u>**	3.5	1.2 -13.3
Dust deposition (ASTM method)	mg/dm²/ 30 days	30 days	**<u>6.3</u>**	19.0	1.5-98.1	-	-	-
Dust deposition (Alberta Environment method)	mg/dm²/ 30 days	30 days	5.7	8.7	0.6-32.7			

NOTES:

Bold underlined values indicate values that are used as the baseline values in the assessment.

Dash (-) = not available

Data have been summarized from the 2009 – 2014 air quality compliance monitoring reports (Rescan 2009, 2010, 2011b, 2011a, 2012c, 2012a; ERM Rescan 2014a, 2014b).

There are no Hope Bay Project site-specific background concentrations available for CO, therefore the 2015 annual average CO concentrations at monitoring stations in Yellowknife, Norman Wells and Fort Smith were used to represent baseline conditions (GNWT 2016). The median of these three annual values is 261 µg/m³.

4 EMISSIONS INVENTORY

An emissions inventory was prepared for the AQMS that was then used as an input to the air dispersion model. The objective of the emissions inventory was to estimate maximum emissions of air contaminants from the Madrid-Boston Project components and activities during both construction and operation.

The emissions inventory for the AQMS was built using a number of information sources, calculations and assumptions. Some information sources and assumptions were informed by descriptions about proposed components and activities of the Madrid-Boston Project as well as existing information about the existing permitted activities. At the time of preparing the emissions inventory, the most up-to-date information from the Project Description as of July 31, 2017 was used. Actual production rates and therefore emissions, vary from year to year. Emissions from the Project employed a conservative approach based on maximum production rates which is expected to over-estimate emissions.

The emission sources associated with the Madrid-Boston Project include:

- Drilling and blasting
- Diesel combustion exhaust emissions from off-road surface and underground mining equipment and haul trucks
- Diesel combustion exhaust emissions from trucks travelling on the AWR
- Diesel combustion exhaust emissions from the power generation plants at Madrid North and Boston, and generators at Madrid South.
- Combustion exhaust emissions from aircraft landing and takeoff at the Doris and Boston airstrips
- Combustion exhaust emissions from ship cruising, maneuvering and docking at Roberts Bay
- Fugitive dust emissions from bulldozing and grading
- Fugitive dust emissions from truck loading and unloading
- Fugitive dust emissions generated by haul trucks along surface haul roads
- Fugitive dust emissions generated by trucks travelling on the AWR
- Fugitive dust emissions from wind erosion of stockpiles
- Fugitive dust emissions from wind erosion at Doris tailings impoundment area (TIA) and Boston tailings management areas (TMA)
- Emissions from processing plant stacks, non-hazardous waste incinerators and underground air heating facility stacks

Crown pillar recovery will be utilized at the Madrid North and Boston sites at locations within the PDA where ore is at or near surface. The process entails removing overburden by way of an excavated trench at surface, and collapsing the ore into the underground workings with underground blasting methods. The ore is then mucked out from the underground void and the trench is backfilled with waste rock and overburden. Crown pillar recovery at both sites will occur in localized areas of the PDA and is anticipated to be of short duration (several months) after which the area is backfilled and reclaimed at surface. The air quality effects due to this process are expected to be less than that associated with underground or quarry blasting and are not expected to occur concurrently. Therefore, crown pillar recovery was not explicitly included in the air quality assessment.

The detailed emissions inventory is tabulated in Appendix A.

4.1 General Assumptions

Where input data uncertainties existed, conservative assumptions were used following regulatory guidance, professional judgement and experience. At the time of preparing the emissions inventory, the most up-to-date information was used as of July 31, 2017.

General assumptions used to prepare the emissions inventory are listed below:

- A sulphur content of 15 ppm (0.0015%) in diesel was used for off-road mining equipment, and a sulphur content of 1,000 ppm (0.1%) was used for marine shipping vessels. These sulphur contents conform to the Canadian Sulphur in Diesel Fuel Regulations (ECCC 2016b). A sulphur content of 680 ppm (0.068%; US FAA 2013) in jet fuel was used for aircraft.
- Running load factors from the US EPA NONROAD model (US EPA 2008) were used for each type of off-road diesel equipment. A running load factor of 70% was assumed for highway trucks.
- The US EPA Motor Vehicle Emission Simulator version 2014a (MOVES2014a; US EPA 2014) was used to generated emission factors for all off-road mobile equipment. MOVES2014a was used with the assumption that mining equipment at Doris complies with Tier 3 emission standards for off-road diesel engines (equipment manufactured in or after 2010) and mining equipment at Madrid and Boston complies with Tier 4 emission standards (equipment manufactured in or after 2014).
- Power ratings (hp) for off-road mining equipment were based on manufacturer specifications using the equipment manufacturer and model.
- The moisture content of waste rock, ore, overburden, exposed tailings, road surfaces and pad surfaces was assumed to be 7.9%, the same as overburden moisture content (US EPA 1995) before any additional mitigation measures are applied.
- The silt content of waste rock, ore, overburden, road surfaces and pad surfaces was assumed to be 6.9%, the same as overburden silt content (US EPA 1995, § 11.9). The silt content of tailings for both the Doris TIA and Boston TMA was assumed to be 51.2% (ERM 2016).
- Dust control efficiency of 75% was assumed on haul roads and the AWR during summer, corresponding to application of water twice daily (US EPA 2006). Summer is assumed to be 4 months – June to September.
- Natural mitigation efficiency of 90% for fugitive dust emissions was assumed on haul roads and the AWR during winter (Golder Associates 2012). Winter is assumed to be 8 months – October to May.

- A dust control efficiency of 85% was assumed for wind erosion emissions from the Doris TIA, corresponding to application of chemical dust suppressant or watering at high wind conditions in the summer months - June to September (US EPA 2006). Natural mitigation efficiency of 85% was assumed during winter due to snow cover and frozen ground. Winter is assumed to be 8 months – October to May.
- Fugitive dust control was not applied to emissions from bulldozing and grading, and truck loading and unloading.
- For any emissions resulting from diesel fuel combustion that did not have specific TSP emission factors, it was assumed TSP emission factors were equal to PM_{10} emission factors.
- For any emissions resulting from diesel fuel combustion that did not have specific PM_{10} emission factors, it was assumed PM_{10} emission factors were equal to TSP emission factors multiplied by 0.976 (California Air Resource Board 2016).

Sources were categorized and modeled as point, area, volume or road sources in CALPUFF depending on their dispersion parameters.

Additional assumptions specific to each emission source are described in Section 4.3 and included in Appendix A.

4.2 Emission Scaling Factors

Most mining activities and associated emissions are continuous (24 hour per day, 365 days per year) such as the operation of the surface and underground mining equipment. However, there are operations that are intermittent during the day (e.g. drilling and blasting) or during the year (aircraft landing and takeoff), and operations with shorter duration per day (e.g. trucks transporting fuel and supplies to the mine sites) or per year (docking of marine vessels at Roberts Bay).

Emissions are estimated for each project activity based on the maximum production rate and expressed as maximum 1-hour emission rates. While the 1-hour emission rates are appropriate to estimate short-term (less than 24 hour) average concentrations, they will overstate daily and annual average emission rates and associated daily and annual average concentrations and deposition. Therefore, the 1-hour average emission rates are reduced by scaling the 1-hour emission rates with emission scaling factors which represent the ratio of operating hours per day to total hours in a day (i.e. a daily scaling factor) and the ratio of operating hours in a year to total hours in a year (i.e. an annual scaling factor). An hourly emission scaling factor is introduced for completeness; however, the hourly scaling factor is always equal to 1.0 since the shortest period modeled is 1 hour. (i.e. no sub-hourly emissions). The scaled daily and annual average emission rates are applied uniformly in the model to all hours and days of the modeled year.

Emissions presented in Appendix A are the maximum hourly emission rates together with the hourly, daily and annual emission scaling factors. Continuous emissions have all the hourly, daily and annual emission scaling factors equal to 1.0.

Ambient concentration predictions associated with maximum hourly emission rates are compared to short-term ambient criteria based on averaging periods shorter than a day (e.g., 1-hour, 8-hour). Ambient concentration predictions associated with daily average emission rates are compared to ambient criteria based on averaging periods shorter than a year (e.g., 24-hour, 30-day). Ambient concentration predictions associated with annual emission rates are compared to annual ambient criteria.

The daily emission scaling factor for each emission source is calculated as the ratio of the operating hours per day to the total hours per day modeled for the source. For example, underground blasting occurs 7 times a day. The daily emission scaling factor is calculated as the ratio of 7 hours blasting per day to 24 hour per day (7/24 = 0.292). The daily emission rate is scaled from the hourly emission rate by the factor of 0.292 and applied as a continuous emission over all hours and days of the modeled year.

Similarly, the annual emission scaling factor for each source is calculated as the ratio of operating hours per year to total hours per year modeled for the source. For example, 1 aircraft landing and takeoff per hour is assumed at Boston airstrip, occurring 4 times a week throughout the year, equivalent to 208 hours per year (1 hour x 4 times per week x 52 weeks per year). The annual scaling factor is calculated as the ratio of 208 hours of landing and takeoffs to 8760 total hours per year (24 hours per day x 365 days per year), equal to 0.024 (208/8760).

In addition to intermittent emission sources and emission sources operating for shorter periods of time, there are sources with a fixed (known) schedule, for example shipping occurs only in the open water season between August and October and the underground air heating facilities operate only in the winter season between October and May. For these sources, emissions are applied in the dispersion model only during the operating hours and days for the source by “turning on” emissions only during the periods of operation and “turning off” emissions during not operating periods. This is implemented in CALPUFF by using time varying switches by time of day, day of month and month of year. For emission sources with a fixed schedule all the hourly, daily and annual emission scaling factors are equal to 1.0.

4.3 Emission Sources

The air emissions associated with the Madrid-Boston Project within the modeling domains are outlined below. Sources were categorized and modeled as point, volume, area or road sources in CALPUFF depending on their dispersion parameters. The CALPUFF road source type was first introduced in CALPUFF version 7.

For CALPUFF volume, area and road sources, the emission effective release height and initial sigma-z (vertical dispersion) for each source were estimated based on the dimensions of the predominant off-road equipment (e.g. haul truck, bulldozer) operating on site and following US EPA guidance for defining dispersion parameters for haul roads (US EPA 2012). An initial vertical dispersion of 1 m was assumed for wind erosion area sources.

4.3.1 Point Sources

Emissions that come out of a fixed stack were modeled as CALPUFF point sources.

4.3.1.1 Genset Stacks

Emissions from the existing power plant gensets located at Doris were calculated using the selected model (CAT 3516B-2250) and manufacturer specifications. The Doris power plant configuration includes 8 x1,600 kW gensets with 6 continuous, 1 stand by and 1 maintenance unit. The Doris power plant has 3 stacks with 30 m height. The same genset configuration and but a stack height of 15-m was assumed for the Boston power plant. The power plant at Madrid North consists of 3 x 1,600 kW gensets as described in the Project Description (as of July 31, 2017), and the same genset model as Doris was assumed. It was assumed that 2 x 725 kW gensets operate at Madrid South, 1 x 725 kW genset operates at Quarry D construction camp and 1 x 750 kW genset operates at Boston construction camp. Emissions for the 750 kW gensets were estimated based on emission standards Tier 2 (gensets manufactured between 2006 and 2010) for diesel generators (DieselNet 2016).

Assumptions used for the inventory include:

- the same generator model (CAT 3516B-2250), power output (1,600 kW) as at Doris power plant will be used for the Boston and Madrid North power plants.
- the gensets at Madrid South, Quarry D construction camp and Boston construction camp comply with Tier 2 emission standards for diesel generators (generators manufactured between 2006 and 2010).
- stack internal diameter, exit velocity, exit temperature and emission rates for the power plants at Doris, Madrid North and Boston are based on manufacturer specifications for generator model CAT 3516B-2250.
- stack location, height, internal diameter, exit velocity and exit temperature for the gensets at Madrid South, Quarry D construction camp and the Boston construction camp were assumed based on similar equipment because of a lack of information for a specific manufacturer and model.

4.3.1.2 Processing Plant Stacks

Emissions from the Doris, Madrid North and Boston processing plants were calculated using the processing rate of each facility as described in the Project Description (as of July 31, 2017), and published emission factors for crushing and conveyor transfer points (US EPA 1995, § 11.24). The Doris processing plant emissions also incorporated emission factors for sludge drying (US EPA 1995, § 1.3) and smelting (Golder 2005).

Assumptions used for the inventory include:

- the sludge drying kiln is electric and has 15 kW rating (Golder 2005); and
- stack locations, height, internal diameter, exit velocity and exit temperature were all assumed for each stack using professional judgement and based on similar equipment.

4.3.1.3 Incinerator Stacks

Emissions from the Roberts Bay Laydown and Boston incinerators were calculated using the number of people in each camp as described in the Project Description (as of July 31, 2017), and published emission factors for multi-chamber industrial incinerators (US EPA 1995, § 2.1).

Assumptions used for the inventory include:

- the amount of waste burned is 2.5 kg/person/day; and
- stack locations, height, internal diameter, exit velocity and exit temperature were all assumed for each stack due to limited available information about the existing incinerators operating at Roberts Bay Laydown.

4.3.1.4 Underground Air Heating Facility Stacks

Emissions from the Doris, Madrid North, Madrid South and Boston underground air heating facilities were calculated using the 30 million British thermal unit per hour (BTU/hr) heating requirements described in the Project Description (as of July 31, 2017), and published emission factors for diesel fuel oil combustion (US EPA 1995, § 1.3).

Assumptions used for the inventory include:

- the heating facilities are used only between October and May (inclusive); and
- stack locations, height, internal diameter, exit velocity and exit temperature were all assumed for each stack based on limited available information about the existing mine air heating facility operated at Doris.

4.3.1.5 Docked Ship Stack

Emissions from marine shipping vessels docked at Roberts Bay Dock were calculated using the shipping volumes and number of annual vessels described in the Project Description (as of July 31, 2017). Shipping emissions for a stationary docked ship were calculated using published emission factors and calculation methodology for marine vessels (US EPA 2000).

Assumptions used for the inventory include:

- each shipping vessel would stay docked at the Roberts Bay Dock for a period of seven days.
- shipping vessels will be docked only during the open water season August to October.
- only one shipping vessel would be docked at a time; and
- stack location, height, internal diameter, exit velocity and exit temperature were assumed based on professional judgement and similar equipment.

4.3.2 Volume Sources

Fugitive air emissions from the mine portals such as diesel exhaust emissions from the underground mining equipment and blasting emissions were modeled as CALPUFF volume sources.

4.3.2.1 Mine Portals Air Ventilation Exhaust

Ventilation of the underground mines will be provided by downcast ventilation raises that will push air into the mine workings and exhaust fans that will pull air through the mine portals. Diesel exhaust emissions from the underground mining equipment and blasting emissions at the Doris, Madrid North, Madrid South and Boston underground mines were calculated using the mobile underground mine fleet inventory and underground blasting rates described in the Project Description (as of July 31, 2017). Emissions from the mobile underground mine fleet were calculated using emission factors from MOVES2014a (US EPA 2014). Year 2010 was modeled to represent Tier 3 emission standards for off-road diesel engines at the existing Doris mine and year 2016 was modeled to represent Tier 4 emission standards for off-road diesel engines at Madrid North, Madrid South and Boston mines. Emissions from underground blasting activities were calculated using published emission factors for ammonium nitrate-fuel oil (ANFO) detonation (US EPA 1995, § 13.3) and blasting particulate (US EPA 1995, § 11.9). It was conservatively assumed that emissions from the underground mines are released from the mine portals as passive releases, i.e. without exit and buoyancy momentum.

Assumptions used for the inventory include:

- all mine ventilation raises are downcast (i.e. draw air inside the underground mine) and ventilation exhaust is through the mine portals.
- release height, sigma-y (initial horizontal dispersion) and sigma-z (initial vertical dispersion) were estimated using professional judgement and based on the dimensions of the portals and vertical infrastructure near the portals.

4.3.3 Area Sources

Emissions that occur over a geographic area were modeled as CALPUFF area sources. A limitation in CALPUFF is that area sources can only be described with 4 vertices. The shape of each source was therefore approximated by using a number of 4-sided polygons. The resulting shapes were evaluated to ensure that the source was appropriately characterized, while keeping the number of polygons at a reasonable level given model run time considerations.

4.3.3.1 General Areas with Surface Mobile Equipment

Emissions from mobile equipment operating in common general areas were calculated using the mobile surface equipment fleet operating at each area and emission factors from MOVES2014a (US EPA 2014). Year 2010 was modeled to represent Tier 3 emission standards for off-road diesel engines at the existing Doris and Roberts Bay areas, and year 2016 was modelled to represent Tier 4 emission standards for off-road diesel engines at Madrid North, Madrid South and Boston sites. The common general areas that were modeled were:

- Roberts Bay Dock;
- Roberts Bay Laydown;
- Doris site including mine portal, stockpiles and camp;
- Madrid North site including mine portal and stockpiles;
- Madrid South site including mine portal and stockpiles;
- Boston site including mine portal, stockpiles and camp;
- Quarry D construction camp;
- Quarry H (during construction);
- Quarry AH (during construction);
- Quarry U (during construction)
- Quarry AJ (during construction)
- Doris TIA west and south dams (during construction).

Assumptions used for the inventory include:

- all mobile equipment is operating continuously throughout the year except for equipment at Roberts Bay Dock which operates only during the August to October shipping season, and equipment at the Quarry D construction camp which operates 12 hours a day;
- mining equipment at Doris complies with Tier 3 emission standards for off-road diesel engines (equipment manufactured in or after 2010) and mining equipment at Madrid and Boston complies with Tier 4 emission standards (equipment manufactured in or after 2014).
- power ratings (hp) for off-road mining equipment were based on manufacturer specifications using the equipment manufacturer and model.
- running load factors from the US EPA NONROAD model (US EPA 2008) were used for each type of off-road diesel equipment. A running load factor of 70% was assumed for highway trucks.
- mobile crushers used at the quarries use a dust suppression system to reduce fugitive dust emissions from rock crushing.

4.3.3.2 Aircraft

Aircraft landing and takeoff (LTO) emissions from aircraft activities were calculated for the Doris and Boston airstrips and helipad areas using the aircraft descriptions and flight schedule described in the Project Description (as of July 31, 2017), and emission factors from the US Federal Aviation Administration (FAA) Emissions and Dispersion Modeling System (EDMS) Version 5.1.4.1 (US FAA 2013).

Assumptions used for the inventory include:

- each aircraft would perform 1 LTO cycle per hour, 1 LTO per day and 208 LTOs per year (4 times per week) for modeling the maximum 1-hour, 24-hour and annual average emissions, respectively.

4.3.3.3 Marine Shipping Vessels

Emissions from marine shipping vessels travelling to and from Roberts Bay Dock were calculated using the shipping volumes and number of vessels on an annual basis described in the Project Description (as of July 31, 2017). Shipping emissions for a maneuvering and slow cruise speed ship were calculated using published emission factors and calculation methodology for marine vessels (US EPA 2000). The modeled shipping route extended approximately 4 km long within Roberts Bay.

Assumptions used for the inventory include:

- shipping vessels will be docked at Roberts Bay Dock only during the open water season August to October;
- approximately seven shipping vessels will enter Roberts Bay per year, based on the Project Description (as of July 31, 2017);
- each shipping vessel would stay docked at the Roberts Bay Dock for a period of seven days;
- a shipping vessel would take 1 hour to manoeuver into or out of the Roberts Bay Dock and take 1 hour to travel at slow cruise speed out of Roberts Bay; and
- only one shipping vessel would be within the Roberts Bay area at a time.

4.3.3.4 Material Handling and Transport

Fugitive dust emissions from bulldozing, grading and material transfer activities for each stockpile, the Boston TMA and the AWR (during construction) were calculated using the area of each location, the material transfer rates described in the Project Description (as of July 31, 2017) and the published fugitive dust emission factors and calculation methods for bulldozing and grading (US EPA 1995, § 11.9), and material transfer (US EPA 1995, § 13.2.4).

Assumptions used for the inventory include:

- only one bulldozer would be operating at each stockpile area, the Boston TMA and the quarries (during construction) at a time and it would operate continuously, except for the Boston TMA where bulldozing is assumed to operate 8 hours a day;

- only one grader would be operating at each stockpile area and the quarries (during construction) at a time and it would operate for 8 hours a day, except for the quarries where grading is assumed to operate 3 hours a day;
- graders would operate along the AWR during construction for 12 hours a day;
- a utilization factor of 70% was assumed for bulldozing and grading; and
- material transfer to stockpiles would be continuous;

4.3.3.5 Drilling

Fugitive dust emissions from drilling in each underground mine and at the L and U quarries were calculated using the drilling frequency described in the Project Description (as of July 31, 2017) and published fugitive dust emission factors for drilling (ECCC 2016a).

Assumptions used for the inventory include:

- drilling activity is wet drilling; and
- blasting occurs 7 times a day in the underground mines and 3 times a day at the quarries (during construction), and each blast uses 5 holes at each drilling location.

4.3.3.6 Blasting

Emissions from blasting (including fugitive dust) in each underground mine and at the quarries (during construction) were calculated using the blasting activities and explosive consumption rates described in the Project Description (as of July 31, 2017) and published ANFO emission factors (US EPA 1995, § 13.3) and blasting particulate emission factors (US EPA 1995, § 11.9).

Assumptions used for the inventory include:

- blasting occurs 7 times a day in the underground mines and 3 times a day at the quarries (during construction),
- the explosive used would be ANFO; and
- the area disturbed by each blast is 200 m^2 for underground blasting and 2,460 m^2 for blasting at the quarries.

4.3.3.7 Wind Erosion

Fugitive dust emissions resulting from wind erosion at each overburden, ore and waste rock stockpile, and the TIA and TMA were calculated using the surface area and material transfer rates at each stockpile from the Project Description (as of July 31, 2017), and published wind erosion emission factors and calculation methodology (US EPA 1995, § 13.2.5). Emission factors were calculated for the upper wind speed limit of each of the 6 wind speed categories in CALPUFF. This approach allowed wind erosion emissions to be modelled in CALPUFF as variable emissions by wind speed category.

The wind erosion approach described in Section 13.2.5 of US EPA (1995, § 13.2.5) calculates emissions for a wind erosion event (referred to as "disturbance"), which occurs when the wind exceeds a threshold that is defined based on the characteristics of the material subject to erosion. During each event, emissions calculations are based on the assumption that all erodible material is removed and that no emissions will occur until the area is disturbed (i.e. material is added to the storage area or material is removed to expose more erodible material). The number of disturbances per hour were calculated from the material transfer rates at each stockpile and the disturbed area was calculated assuming that each truck unloading will disturb approximately 100 m^2 area. For Doris TIA and Boston TMA it was assumed that there would be one disturbance per hour and during that event, 10% of the surface area would be dry enough to be subject to wind erosion. In the calculation of emission factors for each of the wind speed categories, the hourly average wind speeds were corrected to "fastest mile wind" using a correction factor of 1.26 based on Durst curves (Durst 1960).

Assumptions used for the inventory include:

- the threshold friction velocity for all stockpiles was assumed to be 1.02 m/s corresponding to overburden as per Section 13.2.5 of US EPA (1995, § 13.2.5);
- a threshold friction velocity of 0.40 m/s was used for the Doris TIA and Boston TMA based on particle size distribution analysis of the Doris North tailings;
- the roughness height for all stockpile was assumed to be 0.30 cm corresponding to overburden as per Section 13.2.5 of US EPA (1995, § 13.2.5);
- the roughness height for the Doris TIA and Boston TMA was assumed to be 0.05 cm corresponding to sand from US EPA AERSURFACE User's Guide (US EPA 2013);
- Dust control efficiency of 85% was assumed for wind erosion emissions from the Doris TIA, corresponding to application of chemical dust suppressant or watering at high wind conditions in the summer months - June to September (US EPA 2006). Natural mitigation efficiency of 85% was assumed in winter due to snow cover and frozen ground. Winter was assumed to be 8 months – October to May.

4.3.4 Road Sources

Tailpipe and fugitive dust emissions from haul trucks travelling on mine haul roads and vehicles travelling on the AWR were calculated using the traffic volumes and road dust mitigation measures described in the Project Description (as of July 31, 2017), tailpipe emission factors from MOVES2014a (US EPA 2014) and published fugitive dust emission factors from (US EPA 1995, § 13.2.2). Year 2010 was modeled in MOVES2014a to represent Tier 3 emission standards for haul trucks at the existing Doris mine site, and year 2016 was modelled to represent Tier 4 emission standards for haul trucks at Madrid North, Madrid South and Boston sites and trucks travelling along the AWR. The haul trucks traffic volume was estimated from the hauled material volumes per day and the haul truck payload capacity.

Tailpipe emissions were calculated for the actual number of trucks operating per day rather than the number of truck trips per day. The actual number of trucks operating per day was estimated based on the number of round trips per day and the maximum travel speed assumed for the road. The actual number of truck per day was multiplied with the tailpipe emission factor on hourly basis.

Tailpipe and fugitive dust emissions for the roads were calculated per meter of road length because this is the required input for road sources in CALPUFF.

Assumptions used for the inventory include:

- haul trucks within the mine sites operate continuously throughout the year;
- supply trucks and service vehicles travelling along the AWR operate 12 hours a day;
- running load factor of 59% from the US EPA NONROAD model (US EPA 2008) was used for haul trucks. A running load factor of 70% was assumed for highway trucks travelling on the AWR;
- maximum travelling speed was assumed to be 50 km/h along the AWR and 25 km/h on the haul roads;
- dust control efficiency of 75% was assumed on haul roads and the AWR during summer, corresponding to application of water twice daily (US EPA 2006). Summer is assumed to be 4 months – June to September.
- Natural mitigation efficiency of 90% for fugitive dust emissions was assumed on haul roads and the AWR during winter (Golder Associates 2012). Winter is assumed to be 8 months – October to May.

5 MODELING SCENARIOS AND EMISSION SUMMARY

The Madrid-Boston Project spatial and temporal boundaries were chosen to represent the maximum air emissions for predicting changes to ambient air quality. Based on the Project Description (as of July 31, 2017), the construction and operation periods were determined to have the highest emissions compared to the closure, post closure and care and maintenance periods. Because some of the different components of the Madrid-Boston Project would be under construction and operation at different times, multiple spatial and temporal domains were needed to model the maximum scenarios.

The modelling scenarios for the Northern Domain and Southern Domain during construction and operation are summarized in Table 5-1. The modeling scenarios for the Northern Domain include existing permitted activities at Doris, Roberts Bay and Madrid North in addition to activities associated with the Madrid-Boston Project. An additional scenario is presented for the Northern Domain to address the potential for the Madrid North facility to be moved approximately 400-m north of the location assessed in the DEIS (referred to as the reference and alternative locations). The Madrid North facility is assessed in both locations.

There are no existing activities at Boston and air quality effects due to existing activities in the Northern Domain are expected to be near baseline conditions at the Southern Domain because of the distance between the two domains. Therefore, the modeling scenarios for the Southern Domain include only activities associated with the Madrid-Boston Project.

The emission summary for the identified modeling scenarios is presented in Table 5-2. The Madrid-Boston Project emission summary indicates that:

- Total gaseous emissions (NO_X, SO_2 and CO) during operation combined for both northern and southern domains are about the same as total gaseous emissions during construction; and total particulate emissions (TSP, PM_{10}, $PM_{2.5}$) during operation are up to 78% higher than total particulate emissions during construction. These comparisons are based on daily emission rates.
- During construction, the Madrid-Boston Project contribution to cumulative emissions is 60% to 68% for gaseous emissions (NO_X, SO_2 and CO) and 50% to 59% for particulate emissions (TSP, PM_{10}, $PM_{2.5}$). During operation, the Madrid-Boston Project contribution to cumulative emissions is 60% to 76% for gaseous emissions (NO_X, SO_2 and CO) and 92% to 97% for particulate emissions (TSP, PM_{10}, $PM_{2.5}$). These comparisons are based on daily emission rates.
- The daily equivalent emission rates are about 58% to 92% the maximum hourly emission rates; and the annual equivalent emission rates are about 80% to 100% the daily emission rates.

Table 5-1 Modeling Scenarios, and Spatial and Temporal Domains

Model Scenario Description	Spatial Domain	Construction		Operation	
		Project Year[a]	Calendar Year	Project Year[a]	Calendar Year
Northern Domain (Madrid North in Reference Location), Existing Conditions	Northern Domain (Roberts Bay, Doris and Madrid)	1	2019	12	2030
Northern Domain (Madrid North in Reference Location), the Madrid-Boston Project Only	Northern Domain (Roberts Bay, Doris and Madrid)	1	2019	12	2030
Northern Domain (Madrid North in Reference Location), the Madrid-Boston Project + Existing Conditions	Northern Domain (Roberts Bay, Doris and Madrid)	1	2019	12	2030
Northern Domain (Madrid North in Alternative Location), Existing Conditions	Northern Domain (Roberts Bay, Doris and Madrid)	1	2019	12	2030
Northern Domain (Madrid North in Alternative Location), the Madrid-Boston Project Only	Northern Domain (Roberts Bay, Doris and Madrid)	1	2019	12	2030
Northern Domain (Madrid North in Alternative Location), the Madrid-Boston Project + Existing Conditions	Northern Domain (Roberts Bay, Doris and Madrid)	1	2019	12	2030
Southern Domain, the Madrid-Boston Project Only	Southern Domain (Boston)	4	2022	10	2028

NOTES:

[a] This is the same as the “Operating Year” label used in the Madrid-Boston Project Schedule in the Project Description (as of July 31, 2017). “Project Year” is used instead to avoid potential confusion between years with construction and operation activities.

Table 5-2 Emission Summary for the Modeling Scenarios

Project Phase	Model Domain	Modeling Scenario	Hourly Average Emission Rate (t/d)						Daily Average Emission Rate (t/d)						Annual Average Emission Rate (t/d)					
			NO_X	SO_2	CO	TSP	PM_{10}	$PM_{2.5}$	NO_X	SO_2	CO	TSP	PM_{10}	$PM_{2.5}$	NO_X	SO_2	CO	TSP	PM_{10}	$PM_{2.5}$
Construction	**Northern Domain**	Existing Conditions	5.29	0.13	1.86	5.23	2.52	0.62	3.32	0.02	1.18	4.61	2.29	0.53	3.18	0.02	1.16	4.60	2.28	0.52
		The Madrid-Boston Project Only	4.76	0.07	3.12	8.32	3.04	0.65	3.57	0.02	1.82	4.41	1.57	0.41	3.45	0.02	1.79	4.13	1.49	0.39
		The Madrid-Boston Project + Existing Conditions	**10.05**	**0.20**	**4.98**	**13.55**	**5.56**	**1.27**	**6.89**	**0.04**	**3.00**	**9.02**	**3.86**	**0.94**	**6.63**	**0.04**	**2.95**	**8.73**	**3.77**	**0.91**
	Southern Domain	The Madrid-Boston Project	1.61	0.02	1.20	5.62	2.00	0.35	1.37	0.01	0.68	2.15	0.70	0.18	1.35	0.01	0.67	2.05	0.67	0.17
	Total Emissions during Construction (t/d):		**11.66**	**0.22**	**6.18**	**19.17**	**7.56**	**1.62**	**8.26**	**0.05**	**3.68**	**11.17**	**4.56**	**1.12**	**7.98**	**0.05**	**3.62**	**10.78**	**4.44**	**1.08**
	The Madrid-Boston Project Contribution to the Cumulative Case (%):		55%	41%	70%	73%	67%	62%	60%	60%	68%	59%	50%	53%	60%	60%	68%	57%	49%	52%
Operation	**Northern Domain**	Existing Conditions	4.54	0.12	1.18	1.05	0.47	0.24	2.64	0.02	0.76	0.68	0.33	0.18	2.49	0.01	0.74	0.67	0.33	0.18
		The Madrid-Boston Project Only	4.70	0.07	2.70	26.11	12.07	2.03	3.67	0.02	1.65	24.13	11.45	1.88	3.55	0.02	1.61	23.88	11.37	1.87
		The Madrid-Boston Project + Existing Conditions	**9.24**	**0.19**	**3.88**	**27.16**	**12.54**	**2.27**	**6.31**	**0.04**	**2.41**	**24.81**	**11.78**	**2.06**	**6.04**	**0.03**	**2.35**	**24.55**	**11.70**	**2.05**
	Southern Domain	The Madrid-Boston Project	2.60	0.03	1.26	3.30	1.22	0.33	2.27	0.01	0.77	2.23	0.88	0.25	2.25	0.01	0.76	2.18	0.86	0.25
	Total Emissions during Operation (t/d):		**11.84**	**0.22**	**5.14**	**30.46**	**13.76**	**2.60**	**8.58**	**0.05**	**3.18**	**27.04**	**12.66**	**2.31**	**8.29**	**0.04**	**3.11**	**26.73**	**12.56**	**2.30**
	The Madrid-Boston Project Contribution to the Cumulative Case (%):		62%	45%	77%	97%	97%	91%	69%	60%	76%	97%	97%	92%	70%	75%	76%	97%	97%	92%

6 MODELING METHODOLOGY

6.1 Model Selection

The AQMS was completed using the California Puff (CALPUFF) air dispersion model (version 7) to simulate the effects on ambient air quality from emission sources associated with the Madrid-Boston Project.

The CALPUFF model is a multi-layer, multi-species, non-steady state puff dispersion model that can simulate the effects of time and space-varying meteorological conditions on substance transport, transformation, and removal. CALPUFF contains algorithms for near-source effects such as building downwash, transitional plume rise, partial plume penetration, as well as longer-range effects such as chemical transformation, and pollutant removal (wet scavenging and dry deposition). It can accommodate arbitrarily varying point source and area source emissions. CALPUFF includes options to parameterize chemical transformation effects of nitrogen oxides and sulphur dioxide into nitrates and sulphates that contribute to acid deposition. CALPUFF utilizes a three-dimensional meteorological data field that is prepared with the meteorological pre-processor for CALPUFF - CALMET.

The CALPUFF model was previously used to complete the air quality assessment for the 2005 Doris North Project Environmental Impact Statement (EIS) study (Golder 2005). CALPUFF has been used to model other mining projects in Nunavut including the Back River Project, Mary River Project, Meadowbank Project, and Jericho Diamond Mine Project.

There are many modular components that make up the CALPUFF modeling system (e.g., pre-processors, core models, post-processors, utilities, etc.), each with their own name and version number. For simplicity in this report, the overall CALPUFF modeling system will simply be referred to as “CALPUFF”, rather than referring to specific individual modules. The exception is the CALMET processor which is explicitly referenced.

The latest version of the CALPUFF modeling system (version 7.2.1, Level 150618) was used as it aligns with the recommendations from the BC Ministry of Environment (BC MOE 2015) and Alberta Environment and Parks, formerly Alberta Environment and Sustainable Resource Development (Alberta ESRD 2013). The Nunavut government does not have any published guidelines or regulations regarding air dispersion modeling and therefore guidelines from the BC and Alberta governments have been used instead.

The CALPUFF model uses a variety of input data and parameters, including emission source characteristics and emission rates, terrain elevations and surface characteristics to account for terrain influences on air flow and turbulence, and meteorological data on an hourly basis to characterize airflow and turbulence in the region.

The list of options (or "switches") used to run the CALPUFF model are included in Appendix C. Parameters were chosen based on guidance from the BC Air Quality Dispersion Modeling Guideline (BC MOE 2015) and Alberta Air Quality Model Guideline (Alberta ESRD 2013), and professional judgement and experience.

6.2 Model Limitations and Uncertainty

The effects of Project releases of air contaminants are based on calculated emission rates and the CALPUFF dispersion model.

The emissions inventory was built using a number of information sources, calculations and assumptions. Some information sources and assumptions were informed by existing information about the Doris project. Where input data uncertainties existed, conservative assumptions were used following regulatory guidance, professional judgement and experience. At the time of preparing the emissions inventory, the most up-to-date information was used as of July 31, 2017. Emissions from the Project employed a conservative approach based on maximum production rates which is expected to over-estimate emissions. Actual production rates and therefore emissions, vary from year to year. Because of the nature of this approach, there is a high degree of confidence that emissions are over estimated.

Air quality dispersion models such as CALPUFF also employ assumptions to simplify the random behaviour of the atmosphere into short periods of average behaviour. These assumptions limit the capability of the model to replicate every individual meteorological event. To compensate for these simplifications, a full year of meteorological data are applied to evaluate a wide range of possible conditions. Regulatory models, such as CALPUFF, are also designed to have a bias toward over estimation of contaminant concentrations (e.g., to be conservative under most conditions).

Prediction confidence is therefore high because emission rates used in the modeling were conservatively estimated based on a combination of emission factors, engineering estimates and maximum production levels and the dispersion modeling is expected to be conservative.

Therefore, the model results of the model study are interpreted with the understanding that the predicted effects are likely conservative.

6.3 Meteorological Data

The CALMET meteorological pre-processor (Version 6.5.0 Level 150223) was used to generate site specific, hourly three-dimensional meteorological fields (i.e. winds, temperatures and turbulence) with spatial resolution of 1 km for input to the CALPUFF model.

Meteorological data from the Weather Research and Forecasting mesoscale model (WRF) for year 2012 was used to provide spatially and temporally varying wind and temperature fields for the CALMET model. The CALMET model also incorporated on-site surface observational data for year 2012 from the Doris and Boston meteorological stations (Rescan 2012b). A CALMET model domain 100 km by 100 km was created for the air quality assessment. The CALMET domain contains the Northern and Southern LAAs with a buffer on each side to minimize potential grid cell boundary effects around the perimeter of the

LSAs. Specifically, the larger CALMET domain allows air emissions to exit and re-enter the LSAs if the wind directions are shifting.

The meteorological model followed the guidance from the BC Air Quality Dispersion Modeling Guideline (BC MOE 2015) and Alberta Air Quality Model Guideline (Alberta ESRD 2013).

The details of the CALMET modeling approach and results are provided in Appendix B. The list of options (or "switches") used to run CALMET are included in Appendix B. Key findings include:

- The wind roses derived for Doris and Boston sites from the CALMET model indicates dominant winds from west and northwest at Doris and dominant winds from west at Boston;
- The CALMET generated wind fields near the Madrid and Boston meteorological stations are in good agreement with the measured winds;
- Wind speed increases with increasing height above ground.

The meteorological data that are used to evaluate air quality changes associated with Project emissions account for the seasonal and diurnal variations over a one-year period, and for the spatial terrain and land-cover variations across the CALMET domain. The one-year data is viewed as being representative of the wide range of weather conditions that could occur in the region.

6.4 Model Receptors and Terrain Elevations

The air quality model used both grid receptors and discrete sensitive receptors. Terrain elevations were applied to all receptors using the Canadian Digital Elevation Model (CDEM; (NRCan 2017)) with spatial resolution of 0.75 arc seconds in south-north direction and 1.5 arc seconds in west-east direction, specific for the latitude of the Madrid-Boston Project.

6.4.1 Grid Receptors

Grid receptor spacing in each domain was based on the BC and Alberta air quality model guidelines (BC MOE 2015; Alberta ESRD 2013), as follows:

- 20 m spacing along the Project Development Area (PDA)
- 200 m spacing outside the PDA and within the Property Boundary
- 20 m spacing along the Property Boundary
- 50 m spacing within 500 m of the Property Boundary
- 250 m spacing within 2,000 m of the Property Boundary
- 500 m spacing within 5,000 m of the Property Boundary
- 1,000 m spacing beyond 5,000 m of the Property Boundary

Receptors inside the Property Boundary were used to provide information to other discipline assessments. Only receptors along and outside the Property Boundary were used to compare with ambient air quality criteria. The receptor grids for the Northern Domain and Southern Domain are shown in Figure 6-1 and Figure 6-2, respectively.

6.4.2 Discrete Sensitive Receptors

Discrete sensitive receptors were used to predict air quality changes at specific locations inside and outside of the northern and southern modeling domains. These sensitive receptor locations were informed by human health, soil and vegetation locations of interest. The results at these discrete sensitive receptors are specifically used for informing the FEIS assessment chapters: Human Health and Environmental Risk Assessment, Terrestrial Environment: Soils and Special Landforms, and Vegetation and Special Landscape Features.

Discrete sensitive receptor locations are shown in in Figure 6-1 and Figure 6-2. The discrete receptor coordinates together with their maximum predicted ground-level concentrations and depositions are tabulated in Appendix D. The locations of the special receptors were taken from the air quality assessment for the DEIS (ERM, 2016).

6.4.3 Building Downwash

Buildings or other solid structures can affect the flow of air near a source and cause building downwash effects (e.g. eddies on the downwind side), which have the potential to reduce plume rise and affect dispersion. Generally, building downwash problems may occur if the height of the stack is less than 2.5 times the height of an adjacent building. Adjacent buildings may also affect the stack plume dispersion if the stack is located in the building's region of influence defined as a distance of 5 times the lesser of the width or height of the cross-wind face of the building.

For dispersion modelling purposes, building downwash effects were considered for all stacks at Doris, Madrid North, Madrid South and Boston sites using the U.S. EPA Building Profile Input Program (BPIP, (U.S. EPA, 1995)) for use with the Plume Rise Model Enhancement (PRIME) downwash algorithms in CALPUFF. The locations and dimensions of the buildings are based on the latest engineering design for the mine sites. All buildings located within the mine sites that have potential to cause building downwash effects were included in the BPIP PRIME model. Storage piles were considered structures that could influence the air flow and were conservatively included in the building downwash model.

Figure 6-1
CALPUFF Northern Domain and Receptor Locations

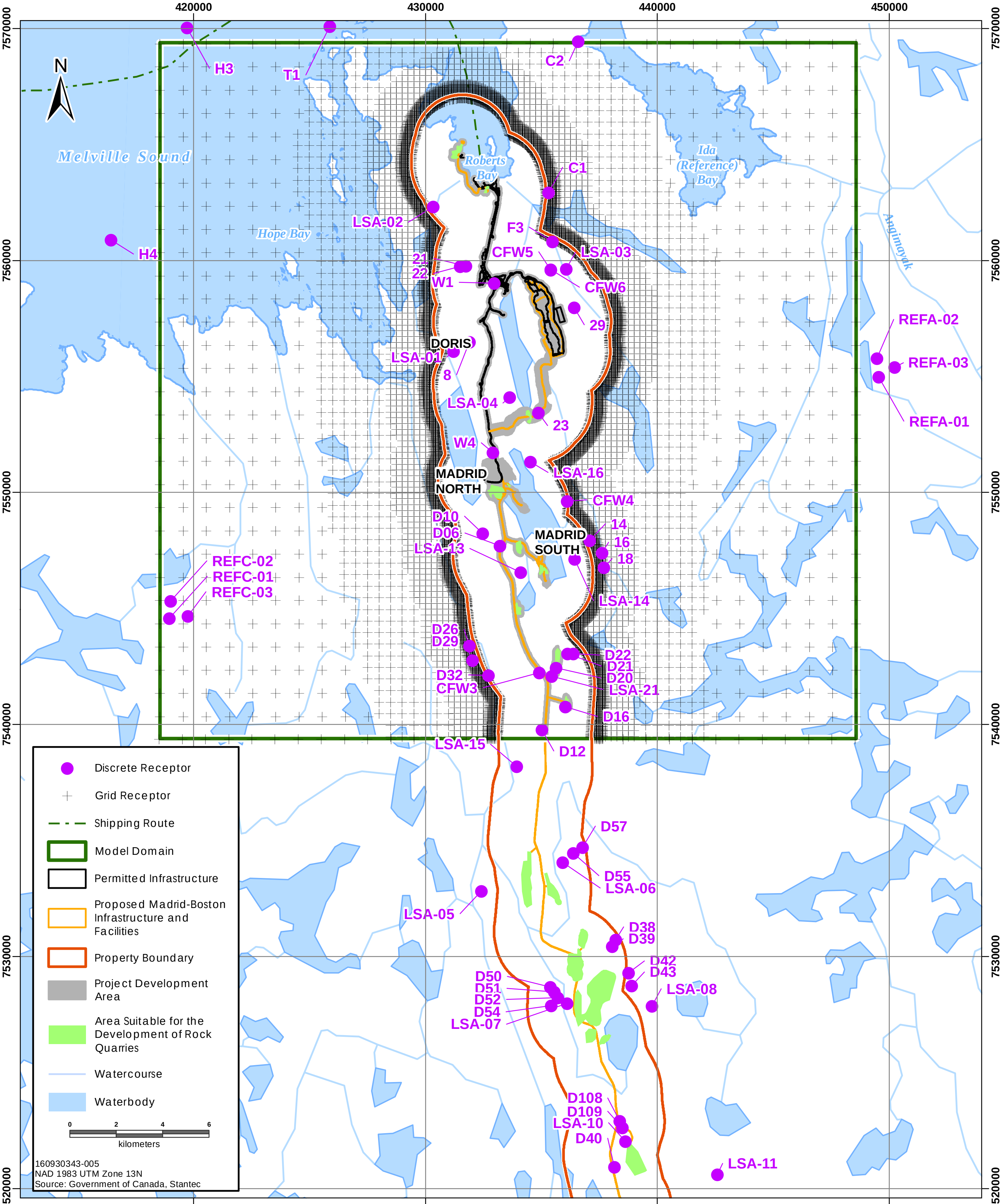
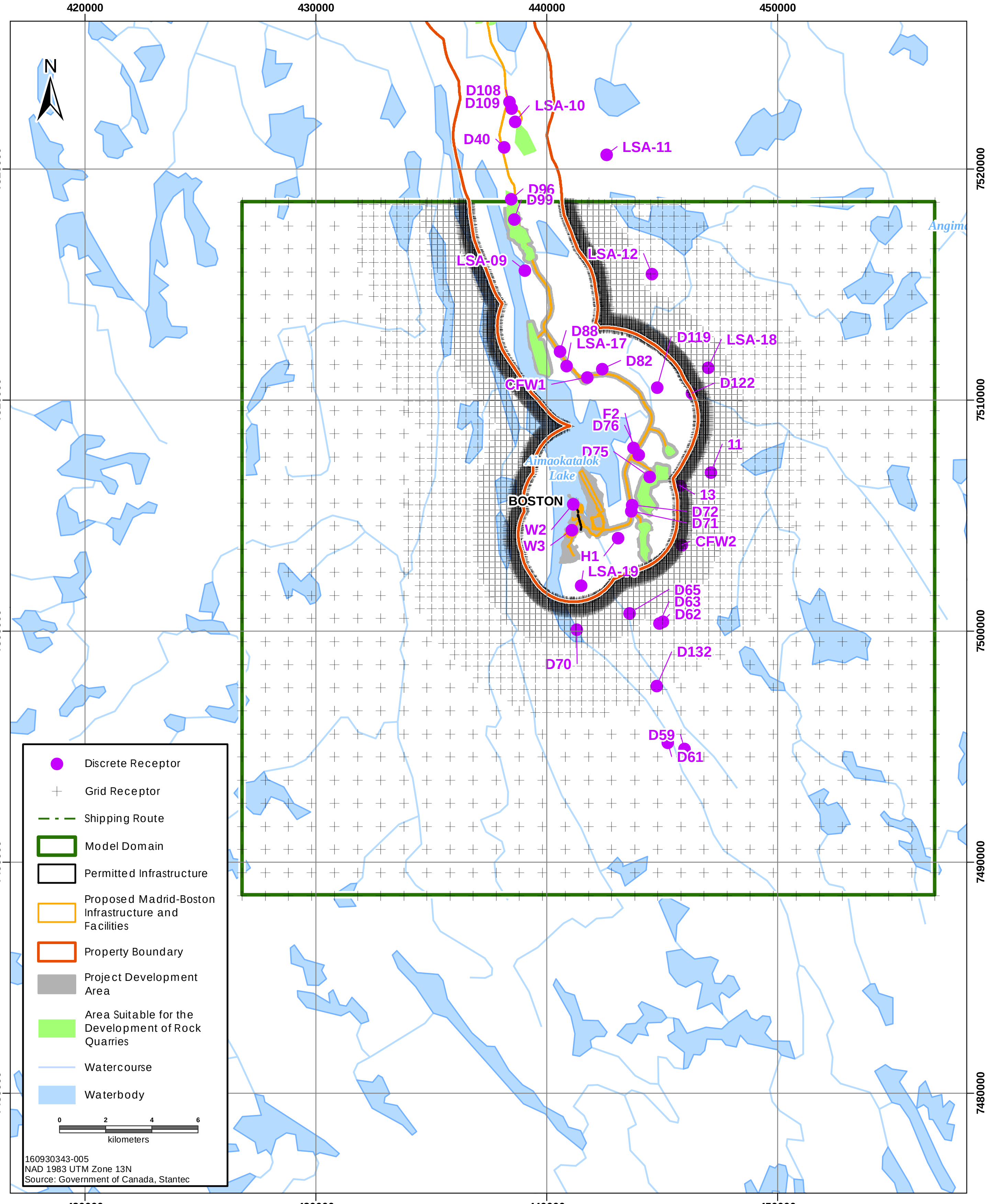


Figure 6-2
CALPUFF Southern Domain and Receptor Locations



6.5 NO TO NO_2 Conversion

NO_X are comprised of nitrous oxide (NO) and nitrogen dioxide (NO_2). Only NO_2 concentrations have ambient air quality criteria. In this assessment, the Ozone Limiting Method (OLM) method was implemented to approximate the amount of NO_2 that is contained in the plume.

The OLM method accounts for the oxidation of NO to NO_2 due to photochemical reactions in the atmosphere in the presence of ozone. According to the OLM method, the conversion of NO to NO_2 is limited by the ambient concentration of ozone (O_3) in the atmosphere. It is assumed that 10% (by volume) of the NO_X emission release from the source is in the form of NO_2 and the remaining 90% is converted to NO_2 as follows:

- If 90% of NO_X concentration is less than the ambient O_3 concentration, then

  $[NO_2] = [NO_X]$ (complete conversion);

- If 90% of NO_X concentration is greater than the ambient O_3 concentration, then

  $[NO_2] = 10\% [NO_X] + [O_3]$ (limited conversion).

In the application of the OLM, the above relationships assume that all concentrations are expressed in parts per million (ppm).

BC Air Quality Dispersion Modeling Guideline (BC MOE 2015) recommends the use of onsite hourly O_3 concentrations for the above conversion that match with the meteorological data used for the assessment. As no onsite O_3 data were available, data from Fort Smith station in NWT was used as being the most representative of the site. Hourly ozone data from Fort Smith was downloaded for the period January 2015 to June 2017. The maximum hourly measured ozone concentration (71.0 ppb) was used in the OLM conversion.

7 MODELING RESULTS

Summaries of the maximum predicted contaminant results for ambient SO_2, NO_2, CO, TSP, PM_{10} and $PM_{2.5}$ concentrations and dust deposition rates for the Madrid-Boston Project construction and operation phases are presented in the following tables:

- Construction: Table 7-1; and
- Operations: Table 7-2.

The results in Table 7-1 and Table 7-2 present the maximum predicted air contaminant concentrations and dust deposition rates for each relevant averaging period and each model domain (i.e., the Northern LSA and Southern LSA). The tables include predicted results due to existing permitted activities (the Existing Conditions column), the Madrid-Boston Project activities (the Madrid-Boston Project Only column), and the cumulative Madrid-Boston Project activities with existing permitted activities (the Madrid-Boston Project + Existing Conditions column). The tables also present predicted results for both the Madrid North Reference Location and the Madrid North Alternative Location (the entire Madrid North Facility shifted 400-m to the north). All presented results include baseline contaminant concentrations or deposition rates (Section 3.2).

The tabulated maximum values represent the maximum air contaminant concentration or deposition rate from any model receptor location between the PB perimeter and the LSA boundaries. Similarly, the tabulated number of exceedances per year represents the maximum number of exceedances at any model receptor location between the PB perimeter and the LSA boundaries. The receptor that experienced the highest contaminant concentration or deposition rate was not necessarily the same receptor that experienced the highest number of exceedances. The general location of the maximum air contaminant concentration or deposition rate is also included in the table by categorizing receptor locations into those that were along the PB perimeter, or those that were outside of the PB and within the LSA.

VOC and O_3 were not included in the modeling study as the Madrid-Boston Project VOC emissions and O_3 formation were determined to be negligible based on the Project Description.

Results along and outside the PB perimeter are compared against relevant guidelines, objectives or standards (Section 2) for each relevant averaging period. The model results for Madrid-Boston Project construction indicate that:

- The maximum predicted concentrations of SO_2, NO_2, CO, TSP, PM_{10} and $PM_{2.5}$ and the maximum predicted dust deposition rates for both the northern and southern domain are less than the ambient criteria for all averaging periods, except for the 98^{th} percentile daily NO_2 concentrations.

- The 98th percentile daily maximum hourly average NO_2 concentrations are greater than the CAAQS for existing permitted activities (Existing Conditions), the Madrid-Boston Project Only and the cumulative case (Madrid-Boston Project + Existing Conditions), for both northern and southern domain. The cumulative NO_2 concentrations are predicted to be above the CAAQS for 191 days a year (194 days a year for Madrid North in Alternative Location) in the northern domain and 96 days a year in the southern domain.

The model results for the Madrid-Boston Project operation indicate that:

- The maximum predicted concentrations of SO_2, NO_2, CO, TSP, PM_{10} and $PM_{2.5}$ and the maximum predicted dust deposition rates for both the northern and southern domain are less than the ambient criteria for all averaging periods, except for the 98th percentile of the daily maximum hourly average NO_2 concentrations and 24-hour average PM_{10} concentrations.
- The 98th percentile daily maximum NO_2 concentrations are greater than the CAAQS for existing permitted activities (Existing Conditions), the Madrid-Boston Project Only and the cumulative case (Madrid-Boston Project + Existing Conditions), for both northern and southern domain. The cumulative NO_2 concentrations are predicted to be above the CAAQS for 188 days a year (190 days a year for Madrid North in Alternative Location) in the northern domain and 93 days a year in the southern domain.
- The maximum predicted 24-hour average PM_{10} concentrations are greater than the BC ambient air quality objective (BC AAQO) for the Madrid-Boston Project Only and the cumulative case (Madrid-Boston Project + Existing Conditions), for both the northern and southern domains. The cumulative PM_{10} concentrations are predicted to be above the BC AAQO for 1 day a year (1 day a year for Madrid North in Alternative Location) in the northern domain and 1 day a year in the southern domain.

Tabulated results at discrete sensitive receptors for use in the human health, vegetation and soil assessments are included in Appendix D.

Contour maps for all predicted air contaminants, averaging periods, domains and model scenarios (construction and operation) are included in Appendix E to Appendix J, as follows:

- Appendix E: Construction, Northern Domain (Madrid North in Reference Location), the Madrid-Boston Project + Existing Conditions (includes Baseline Conditions)
- Appendix F: Construction, Northern Domain (Madrid North in Alternative Location), the Madrid-Boston Project + Existing Conditions (includes Baseline Conditions)
- Appendix G: Construction, Southern Domain, the Madrid-Boston Project Only (includes Baseline Conditions)
- Appendix H: Operation, Northern Domain (Madrid North in Reference Location), the Madrid-Boston Project + Existing Conditions (includes Baseline Conditions)

- Appendix I: Operation, Northern Domain (Madrid North in Alternative Location), the Madrid-Boston Project + Existing Conditions (includes Baseline Conditions)
- Appendix J: Operation, Southern Domain, the Madrid-Boston Project Only (includes Baseline Conditions)

These contour maps show the geographic extent and magnitude of contaminants emitted from the Madrid-Boston Project with existing permitted activities. To limit the number of contour maps included in the report, only the Hope Bay Project (Madrid-Boston Project + Existing Conditions) results are included for the northern domain.

7.1 Construction

7.1.1 Northern Domain Results

The predicted maximum ambient air contaminant concentrations and deposition rates for Madrid-Boston Project construction in the Northern Domain are summarized in Table 7-1. The maximum predicted values are based on areas along and outside the Property Boundary. The presented model results include baseline conditions. Concentration contour plots for the cumulative case (the Madrid-Boston Project + Existing Conditions) for Madrid North in the Reference Location and Madrid North in the Alternative Location are included in Appendix E and Appendix F, respectively.

7.1.1.1 Existing Conditions

The maximum predicted concentrations and dust deposition rates for existing permitted activities in the Northern Domain during Madrid-Boston Project construction are summarized in Table 7-1 ("Existing Conditions" column). The Existing Conditions case includes existing permitted activities at Doris, Roberts Bay and Madrid North.

The maximum predicted concentrations of SO_2, NO_2, CO, TSP, PM_{10} and $PM_{2.5}$ and the maximum predicted dust deposition rates for the Existing Conditions case in the Northern Domain are less than the ambient criteria for all averaging periods, except for the 98th percentile of the daily hourly maximum NO_2 concentrations. The maximum predicted concentrations for all contaminants except the 99th percentile daily maximum 1-hour SO_2 concentration occur along the Property Boundary. The maximum predicted 99th percentile daily maximum 1-hour SO_2 concentration occurs in the LSA along the shipping route at Roberts Bay.

The predicted 98th percentile of the daily maximum hourly NO_2 concentrations are greater than the CAAQS. The NO_2 concentrations are predicted to be above the CAAQS for 90 days a year.

7.1.1.2 The Madrid-Boston Project (Madrid North in Reference Location)

The maximum predicted concentrations and dust deposition rates for the Madrid-Boston Project construction in the Northern Domain (Madrid North in Reference Location) are summarized in Table 7-1 ("The Madrid-Boston Project Only" column). The Madrid-Boston Project Only (Northern Domain) includes construction activities at Madrid North (in the Reference Location), Madrid South, and construction of the AWR.

The maximum predicted concentrations of SO_2, NO_2, CO, TSP, PM_{10} and $PM_{2.5}$ and the maximum predicted dust deposition rates for the Madrid-Boston Project Only (Madrid North in the Reference Location) case in the Northern Domain are less than the ambient criteria for all averaging periods, except for the 98th percentile daily maximum hourly NO_2 concentrations. The maximum predicted concentrations for all contaminants except the 99th percentile daily maximum 1-hour SO_2 concentration occur along the Property Boundary. The maximum predicted 99th percentile daily maximum 1-hour SO_2 concentration occurs along the shipping route at Roberts Bay.

The predicted 98th percentile daily maximum hourly NO_2 concentrations are greater than the CAAQS. The NO_2 concentrations are predicted to be above the CAAQS for up to 184 days a year.

7.1.1.3 The Madrid-Boston Project + Existing Conditions (Madrid North in Reference Location)

The maximum predicted concentrations and dust deposition rates for the cumulative Madrid-Boston Project activities with existing permitted activities during construction in the Northern Domain (Madrid North in the Reference Location) are summarized in Table 7-1 ("the Madrid-Boston Project + Existing Conditions" column). The cumulative case (Northern Domain) includes construction activities at Madrid North (in reference location), Madrid South, and construction of the AWR together with existing permitted activities at Doris, Roberts Bay and Madrid North.

The maximum predicted concentrations of SO_2, NO_2, CO, TSP, PM_{10} and $PM_{2.5}$ and the maximum predicted dust deposition rates for the cumulative case in the Northern Domain are less than the ambient criteria for all averaging periods, except for the 98th percentile daily maximum hourly NO_2 concentrations. The maximum predicted concentrations for all contaminants except the 99th percentile daily maximum 1-hour SO_2 concentration occur along the Property Boundary. The maximum predicted 99th percentile daily maximum 1-hour SO_2 concentration occurs along the shipping route at Roberts Bay.

The predicted 98th percentile daily maximum hourly NO_2 concentrations are greater than the CAAQS. The NO_2 concentrations are predicted to be above the CAAQS for up to 191 days a year (52% of the days). NO_2 exceedances are predicted to occur in a region extending 2 to 10-km from the PB (depending on direction), however the area in which exceedances are predicted to occur greater than 20% of the days extends between 0 to 3-km from the PB.

7.1.1.4 The Madrid-Boston Project (Madrid North in Alternative Location)

The maximum predicted concentrations and dust deposition rates for Madrid-Boston Project construction in the Northern Domain (Madrid North in Alternative Location) are summarized in Table 7-1 ("The Madrid-Boston Project Only" column). The Madrid-Boston Project Only (Northern Domain) includes construction activities at Madrid North (in alternative location), Madrid South, and construction of the AWR.

The maximum predicted concentrations of SO_2, NO_2, CO, TSP, PM_{10} and $PM_{2.5}$ and the maximum predicted dust deposition rates for the Madrid-Boston Project Only (Madrid North in the Alternative Location) case in the Northern Domain are less than the ambient criteria for all averaging periods, except for the 98^{th} percentile daily maximum hourly NO_2 concentrations. The maximum predicted concentrations for all contaminants except the 99^{th} percentile daily maximum 1-hour SO_2 concentration occur along the Property Boundary. The maximum predicted 99^{th} percentile daily maximum 1-hour SO_2 concentration occurs along the shipping route at Roberts Bay.

The predicted 98^{th} percentile daily maximum hourly NO_2 concentrations are greater than the CAAQS. The NO_2 concentrations are predicted to be above the CAAQS for up to 181 days a year.

7.1.1.5 The Madrid-Boston Project + Existing Conditions (Madrid North in Alternative Location)

The maximum predicted concentrations and dust deposition rates for the cumulative Madrid-Boston Project activities with existing permitted activities during construction in the Northern Domain (Madrid North in the Alternative Location) are summarized in Table 7-1 ("the Madrid-Boston Project + Existing Conditions" column). The cumulative case (Northern Domain) includes construction activities at Madrid North (in alternative location) and Madrid South, and construction of the AWR together with existing permitted activities at Doris, Roberts Bay and Madrid North.

The maximum predicted concentrations of SO_2, NO_2, CO, TSP, PM_{10} and $PM_{2.5}$ and the maximum predicted dust deposition rates for the cumulative case in the Northern Domain are less than the ambient criteria for all averaging periods, except for the 98^{th} percentile daily maximum hourly NO_2 concentrations. The maximum predicted concentrations for all contaminants except the 99^{th} percentile daily maximum 1-hour SO_2 concentration occur along the Property Boundary. The maximum predicted 99^{th} percentile daily maximum 1-hour SO_2 concentration occurs along the shipping route at Roberts Bay.

The predicted 98^{th} percentile daily maximum hourly NO_2 concentrations are greater than the CAAQS for up to 194 days a year in an area around the Property Boundary (53% of the days). NO_2 exceedances are predicted to occur in a region extending 2 to 10-km from the PB (depending on direction), however the area in which exceedances are predicted to occur greater than 20% of the days extends between 0 to 3-km from the PB.

7.1.2 Southern Domain Results

The predicted maximum ambient air contaminant concentrations and deposition rates for the Madrid-Boston Project construction in the Southern Domain are summarized in Table 7-1. The maximum predicted values are based on areas along and outside the Property Boundary. The presented model results include baseline conditions. Concentration contour plots for the Madrid-Boston Project, Southern Domain are included in Appendix G.

7.1.2.1 The Madrid-Boston Project

The maximum predicted concentrations and dust deposition rates for Madrid-Boston Project construction in the Southern Domain are summarized in Table 7-1 ("The Madrid-Boston Project" column). The Madrid-Boston Project (Southern Domain) includes construction activities at Boston and construction of the AWR.

The maximum predicted concentrations of SO_2, NO_2, CO, TSP, PM_{10} and $PM_{2.5}$ and the maximum predicted dust deposition rates for the Madrid-Boston Project case in the Southern Domain are less than the ambient criteria for all averaging periods, except for the 98^{th} percentile daily maximum hourly NO_2 concentrations. The maximum predicted concentrations for all contaminants occur along the Property Boundary.

The predicted 98^{th} percentile daily maximum NO_2 concentrations are greater than the CAAQS. The NO_2 concentrations are predicted to be above the CAAQS for up to 96 days a year (26% of the days). NO_2 exceedances are predicted to occur in a region extending 0 to 3.5-km from the PB (depending on direction), however the area in which exceedances are predicted to occur greater than 20% of the days extends less than 0.5-km from the PB.

Table 7-1 Maximum Predicted Air Contaminant Concentrations Resulting from Madrid-Boston Project Construction

Contaminant (Ambient Air Quality Indicator)	Averaging Period	Units	Relevant Guideline, Objective or Standard[b]	Baseline Conditions	Northern Domain Construction (Operating Year 1; 2019)															Southern Domain Construction (Operating Year 4; 2022)		
					Existing Conditions (includes Baseline Conditions)			Madrid North in Reference Location						Madrid North in Alternative Location								
								The Madrid-Boston Project Only (includes Baseline Conditions)			The Madrid-Boston Project + Existing Conditions			The Madrid-Boston Project Only (includes Baseline Conditions)			The Madrid-Boston Project + Existing Conditions			The Madrid-Boston Project (includes Baseline Conditions)[a]		
					Max. Value	Max. No. of Exceedances per Year	Location of Max. Value[c]	Max. Value	Max. No. of Exceedances per Year	Location of Max. Value[c]	Max. Value	Max. No. of Exceedances per Year	Location of Max. Value[c]	Max. Value	Max. No. of Exceedances per Year	Location of Max. Value[c]	Max. Value	Max. No. of Exceedances per Year	Location of Max. Value[c]	Max. Value	Max. No. of Exceedances per Year	Location of Max. Value[c]
SO_2	1-hour	µg/m^3	170[d]	0.3	89.1	0	LSA	22.7	0	LSA	111	0	LSA	22.7	0	LSA	111	0	LSA	6.5	0	PB
	24-hour (daily)	µg/m^3	150	0.3	1.1	0	PB	1.6	0	PB	1.7	0	PB	1.6	0	PB	1.6	0	PB	1.0	0	PB
	Annual	µg/m^3	10	0.3	0.3	0	PB	0.4	0	PB	0.4	0	PB	0.4	0	PB	0.4	0	PB	0.3	0	PB
NO_2	1-hour	µg/m^3	79[h]	1.1	262	90 (of 365 days)	PB	196	184 (of 365 days)	PB	302	191 (of 365 days)	PB	198	181 (of 365 days)	PB	302	194 (of 365 days)	PB	165	96 (of 365 days)	PB
	24-hour (daily)	µg/m^3	200	1.1	111	0	PB	158	0	PB	163	0	PB	156	0	PB	161	0	PB	139	0)	PB
	Annual	µg/m^3	23[i]	1.1	10.4	0	PB	18.5	0	PB	19.7	0	PB	19.6	0	PB	21.0	0	PB	9.6	0	PB
CO	1-hour	µg/m^3	14,300	261	732	0	PB	992	0	PB	995	0	PB	921	0	PB	921	0	PB	674	0	PB
TSP	24-hour (daily)	µg/m^3	120	5.8	29.3	0	PB	66.8	0	PB	69.9	0	PB	73.5	0	PB	73.5	0	PB	54.1	0	PB
	Annual (geometric mean)	µg/m^3	60	5.8	7.1	0	PB	13.1	0	PB	13.3	0	PB	14.3	0	PB	14.5	0	PB	9.0	0	PB
PM_{10}	24-hour (daily)	µg/m^3	50[e]	5.4	21.0	0	PB	47.2	0	PB	49.6	0	PB	44.5	0	PB	47.0	0	PB	37.0	0	PB
$PM_{2.5}$	24-hour (daily; 98th percentile)	µg/m^3	27[f]	3.1	8.2	0	PB	11.7	0	PB	12.1	0	PB	13.3	0	PB	13.4	0	PB	9.4	0	PB
	Annual	µg/m^3	8.8[g]	3.1	3.9	0	PB	4.8	0	PB	5.0	0	PB	5.0	0	PB	5.1	0	PB	3.9	0	PB
Dust Deposition	30-day	mg/dm2/30 days	53 (residential and recreation areas); 158 (commercial and industrial areas)[e]	6.3	7.2	0	PB	9.8	0	PB	9.8	0	PB	10.3	0	PB	10.4	0	PB	7.8	0	PB

NOTES:

[a] Air contaminants from existing permitted activities (the Existing Conditions) are assumed to dilute to baseline levels before reaching the southern model domain and therefore it is assumed that the southern domain ambient air quality from the Madrid-Boston Project activities is the same as the ambient air quality from the Madrid-Boston Project + Existing Conditions.

[b] See Section 2.2.1 for a description of the relevant guidelines, objectives and standards.

[c] PB = The maximum value is from a receptor located on the PB perimeter; LSA = The maximum value is from a receptor located outside of the PB and inside of the LSA.

[d] The 1-hour SO_2 value is calculated from the 3-year average of the 99th percentile of the daily maximum 1-hour average concentrations.

[e] There are no Nunavut or Canadian guidelines, objectives or standards for this contaminant. The contaminant is included in the assessment to satisfy the EIS Guidelines (NIRB 2012a). An appropriate provincial objective threshold for this contaminant was included for comparison.

[f] The 24-hour $PM_{2.5}$ value is calculated from the 3-year average of the annual 98th percentile of the daily 24-hour average concentration.

[g] The annual $PM_{2.5}$ value is calculated from the 3-year average of the annual average concentrations.

[h] The 3-year average of the annual 98th percentile of the daily maximum 1-hour average concentrations

[i] The average over a single calendar year of all 1-hour average concentrations

7.2 Operation

7.2.1 Northern Domain Results

The predicted maximum ambient air contaminant concentrations and deposition rates for the Madrid-Boston Project operation in the Northern Domain are summarized in Table 7-2 and include baseline conditions. Concentration contour plots for the cumulative case (the Madrid-Boston Project + Existing Conditions) for Madrid North in the Reference Location and Madrid North in the Alternative Location are included in Appendix H and Appendix I, respectively.

7.2.1.1 Existing Conditions

The maximum predicted concentrations and dust deposition rates for existing permitted activities in the Northern Domain during Madrid-Boston Project operation are summarized in Table 7-2 ("Existing Conditions" column). The Existing Conditions case includes existing permitted activities at Doris, Roberts Bay and Madrid North.

The maximum predicted concentrations of SO_2, NO_2, CO, TSP, PM_{10} and $PM_{2.5}$ and the maximum predicted dust deposition rates for the Existing Conditions case in the Northern Domain are less than the ambient criteria for all averaging periods, except for the 98th percentile daily maximum hourly NO_2 concentration. The maximum predicted concentrations for all contaminants occur along the Property Boundary except the 99th percentile daily maximum 1-hour SO_2 concentration, which occurs along the shipping route at Roberts Bay.

The 98th percentile daily maximum hourly NO_2 concentration is predicted to be greater than the CAAQS for 61 days a year.

7.2.1.2 The Madrid-Boston Project (Madrid North in Reference Location)

The maximum predicted concentrations and dust deposition rates for Madrid-Boston Project operation in the Northern Domain (Madrid North in Reference Location) are summarized in Table 7-2 ("The Madrid-Boston Project Only" column). The Madrid-Boston Project Only (Northern Domain) includes operation activities at Madrid North (in the reference location) and Madrid South.

The maximum predicted concentrations of SO_2, NO_2, CO, TSP and $PM_{2.5}$ and the maximum predicted dust deposition rates for the Madrid-Boston Project Only (Madrid North in the Reference Location) case in the Northern Domain are less than their ambient criteria for all averaging periods, except for the 98th percentile daily maximum 1-hour NO_2 concentration. The maximum predicted concentrations for all contaminants occur along the Property Boundary except for the 99th percentile daily maximum 1-hour SO_2 concentration, which occurs along the shipping route at Roberts Bay.

The predicted 98th percentile daily maximum 1-hour NO_2 concentration is greater than the CAAQS and is predicted to be above the criteria for up to 186 days a year.

The maximum 24-hour average PM_{10} concentration is predicted to greater than the BC AAQO, but only exceed the criteria for 1 day a year.

7.2.1.3 The Madrid-Boston Project + Existing Conditions (Madrid North in Reference Location)

The maximum predicted concentrations and dust deposition rates for the cumulative Madrid-Boston Project activities with existing permitted activities during operation in the Northern Domain (Madrid North in Reference Location) are summarized in Table 7-2 (“the Madrid-Boston Project + Existing Conditions” column). The cumulative case (Northern Domain) includes operations at Madrid North (in reference location) and Madrid South together with existing permitted activities at Doris, Roberts Bay and Madrid North.

The maximum predicted concentrations of SO_2, NO_2, CO, TSP and $PM_{2.5}$ and the maximum predicted dust deposition rates for the cumulative case in the Northern Domain are less than the ambient criteria for all averaging periods, except for the 98th percentile daily maximum NO_2 concentrations. The maximum predicted concentrations for all contaminants along the Property Boundary except for hourly average SO_2 which occurs along the shipping route at Roberts Bay.

The 98th percentile daily maximum 1-hour NO_2 concentrations are predicted to be greater than the CAAQS. The NO_2 concentrations are predicted to be above the CAAQS for up to 191 days a year (52% of the days). NO_2 exceedances are predicted to occur in a region extending 1 to 9-km from the PB (depending on direction), however the area in which exceedances are predicted to occur greater than 20% of the days extends between 0 to 3.5-km from the PB.

The maximum predicted 24-hour average PM_{10} concentration is greater than the BC AAQO. The 24-hour average PM_{10} concentrations are predicted to be above the BC AAQO for up to 1 day a year in a small area located southeast of Madrid South and extending up to 400 m from the Property Boundary.

7.2.1.4 The Madrid-Boston Project (Madrid North in Alternative Location)

The maximum predicted concentrations and dust deposition rates for Madrid-Boston Project operation in the Northern Domain (Madrid North in Alternative Location) are summarized in Table 7-2 (“The Madrid-Boston Project Only” column). The Madrid-Boston Project Only (Northern Domain) includes operations at Madrid North (in the alternative location) and Madrid South.

The maximum predicted concentrations of SO_2, NO_2, CO, TSP and $PM_{2.5}$ and the maximum predicted dust deposition rates for the Madrid-Boston Project Only (Madrid North in the Alternative Location) case in the Northern Domain are less than their respective ambient criteria for all averaging periods, except for the 98th percentile daily maximum 1-hour NO_2 concentrations. The maximum predicted concentrations occur along the Property Boundary except for hourly SO_2 which occurs in the shipping channel.

The predicted 98th percentile daily maximum NO_2 concentrations are greater than the CAAQS. The NO_2 concentrations are predicted to be above the CAAQS for up to 186 days a year.

The maximum predicted 24-hour average PM_{10} concentration is greater than the BC AAQO, but occurs infrequently (up to 1 day a year).

7.2.1.5 The Madrid-Boston Project + Existing Conditions (Madrid North in Alternative Location)

The maximum predicted concentrations and dust deposition rates for the cumulative Madrid-Boston Project activities with existing permitted activities during operation in the Northern Domain (Madrid North in the Alternative Location) are summarized in Table 7-2 ("the Madrid-Boston Project + Existing Conditions" column). The cumulative case (Northern Domain) includes operations at Madrid North (in the alternative location) and Madrid South, together with existing permitted activities at Doris, Roberts Bay and Madrid North.

The maximum predicted concentrations of SO_2, NO_2, CO, TSP and $PM_{2.5}$ and the maximum predicted dust deposition rates for the cumulative case in the Northern Domain are less than the ambient criteria for all averaging periods, except for the 98th percentile daily maximum NO_2 concentrations. The maximum predicted concentrations for all contaminants except the 99th percentile daily maximum 1-hour SO_2 concentration occur along the Property Boundary. The maximum predicted 99th percentile daily maximum 1-hour SO_2 concentration occurs along the shipping route at Roberts Bay.

The 98th percentile daily maximum NO_2 concentration is predicted to be greater than the relevant criteria. The NO_2 concentrations are predicted to be above the CAAQS for up to 194 days a year (53% of the days). NO_2 exceedances are predicted to occur in a region extending 1 to 9-km from the PB (depending on direction), however the area in which exceedances are predicted to occur greater than 20% of the days extends between 0 to 3.5-km from the PB.

The maximum predicted 24-hour average PM_{10} concentrations are greater than the BC AAQO. The 24-hour average PM_{10} concentrations are predicted to be above the BC AAQO for up to 1 day a year in a small area located approximately 2.5 km southeast of Madrid South and extends up to 400 m from the Property Boundary.

7.2.2 Southern Domain Results

The predicted maximum ambient air contaminant concentrations and deposition rates for the Madrid-Boston Project operation in the Southern Domain are summarized in Table 7-2. The presented model results include baseline conditions. Concentration contour plots for the Madrid-Boston Project operation in the Southern Domain are included in Appendix J.

7.2.2.1 The Madrid-Boston Project

The maximum predicted concentrations and dust deposition rates for the Madrid-Boston Project operation in the Southern Domain are summarized in Table 7-2 ("The Madrid-Boston Project" column). The Madrid-Boston Project (Southern Domain) includes operations at Boston.

The maximum predicted concentrations of SO_2, NO_2, CO, TSP and $PM_{2.5}$ and the maximum predicted dust deposition rates for the Madrid-Boston Project case in the Southern Domain are less than the ambient criteria for all averaging periods, except for the 98^{th} percentile daily maximum 1-hour NO_2 concentration. The maximum predicted concentrations for all contaminants occur along the Property Boundary.

The predicted 98^{th} percentile daily maximum 1-hour NO_2 concentration is greater than the CAAQS. The NO_2 concentrations are predicted to be above the CAAQS for up to 93 days a year (25% of the days). NO_2 exceedances are predicted to occur in a region extending 0.5 to 5-km from the PB (depending on direction), however the area in which exceedances are predicted to occur greater than 20% of the days extends between 0 to 1-km from the PB.

The maximum predicted 24-hour average PM_{10} concentrations are greater than the BC AAQO. The 24-hour average PM_{10} concentrations are predicted to be above the BC AAQO for up to 1 day a year in a small area along the Property Boundary southeast of Boston.

7.3 Closure, Post-Closure, and Care and Maintenance

Ambient air quality modeling predictions were not completed for the Reclamation and Closure, Post-Closure, and Temporary Closure phases. Based on the Project Description (as of July 31, 2017), the air emissions during these three phases were identified to be much lower than the air emissions during Construction and Operation phases. The resulting ambient air quality concentrations are therefore expected to be lower during the Reclamation and Closure, Post-Closure, and Temporary Closure phases compared to the Construction and Operation phases.

Therefore, if the effects assessment determines that the Madrid-Boston Project does not have a significant impact on ambient air quality during Construction and Operations, then the same can be said about the Reclamation and Closure, Post-Closure, and Temporary Closure phases.

Table 7-2 Maximum Predicted Air Contaminants Concentrations Resulting from Madrid-Boston Project Operation

Contaminant (Ambient Air Quality Indicator)	Averaging Period	Units	Relevant Guideline, Objective or Standard[b]	Baseline Conditions	Northern Domain Operation (Operating Year 12; 2030)																	Southern Domain Operation (Operating Year 10; 2028)		
					Existing Conditions (includes Baseline Conditions)			Madrid North in Reference Location						Madrid North in Alternative Location						The Madrid-Boston Project (includes Baseline Conditions)[a]		
								The Madrid-Boston Project Only (includes Baseline Conditions)			The Madrid-Boston Project + Existing Conditions			The Madrid-Boston Project Only (includes Baseline Conditions)			The Madrid-Boston Project + Existing Conditions					
					Max. Value	No. of Exceedances per Year	Location of Max. Value[c]	Max. Value	No. of Exceedances per Year	Location of Max. Value[c]	Max. Value	No. of Exceedances per Year	Location of Max. Value[c]	Max. Value	No. of Exceedances per Year	Location of Max. Value[c]	Max. Value	No. of Exceedances per Year	Location of Max. Value[c]	Max. Value	No. of Exceedances per Year	Location of Max. Value[c]
SO_2	1-hour	µg/m^3	170[d]	0.3	89.1	0	LSA	22.6	0	LSA	111	0	LSA	22.6	0	LSA	111	0	LSA	8.9	0	PB
	24-hour (daily)	µg/m^3	150	0.3	1.1	0	PB	2.1	0	PB	2.2	0	PB	2.0	0	PB	2.1	0	PB	1.6	0	PB
	Annual	µg/m^3	10	0.3	0.3	0	PB	0.4	1	PB	0.4	0	PB	0.4	0	PB	0.4	0	PB	0.4	0	PB
NO_2	1-hour	µg/m^3	79[h]	1.1	262	61 (of 365 days)	PB	201	186 (of 365 days)	PB	296	188 (of 365 days)	PB	217	186 (of 365 days)	PB	296	190 (of 365 days)	PB	178	93 (of 365 days)	PB
	24-hour (daily)	µg/m^3	200	1.1	71	0	PB	159	0	PB	162	0	PB	156	0	PB	159	0	PB	147	0	PB
	Annual	µg/m^3	23[i]	1.1	7.7	0	PB	18.9	0	PB	19.7	0	PB	19.8	0	PB	20.9	0	PB	9.5	0	PB
CO	1-hour	µg/m^3	14,300	261	732	0	PB	919	0	PB	921	0	LSA	992	0	PB	992	0	PB	727	0	LSA
TSP	24-hour (daily)	µg/m^3	120	5.8	16	0	PB	99	0	PB	101	0	PB	94	0	PB	96	0	PB	81.7	0	PB
	Annual (geometric mean)	µg/m^3	60	5.8	6.6	0	PB	14.1	0	PB	14.2	0	PB	14.9	0	PB	15.0	0	PB	9.5	0	PB
PM_{10}	24-hour (daily)	µg/m^3	50[e]	5.4	13.7	0	PB	59.4	1 (of 365 days)	PB	60.9	1 (of 365 days)	PB	56.0	1 (of 365 days)	PB	57.9	1 (of 365 days)	PB	50.6	1 (of 365 days)	PB
$PM_{2.5}$	24-hour (daily; 98th percentile)	µg/m^3	27[f]	3.1	6.2	0	PB	13.1	0	PB	13.1	0	PB	14.9	0	PB	15.0	0	PB	9.9	0	PB
	Annual	µg/m^3	8.8[g]	3.1	3.6	0	PB	5.0	0	PB	5.1	0	PB	5.2	0	PB	5.3	0	PB	4.1	0	PB
Dust Deposition	30-day	mg/dm^2/30 days	53 (residential and recreation areas); 158 (commercial and industrial areas)[e]	6.3	6.7	0	PB	10.2	0	PB	10.2	0	PB	10.7	0	PB	10.7	0	PB	8.2	0	PB

NOTES:

[a] Air contaminants from existing permitted activities (the Existing Conditions) are assumed to dilute to baseline levels before reaching the southern model domain and therefore it is assumed that the southern domain ambient air quality from the Madrid-Boston Project activities is the same as the ambient air quality from the Madrid-Boston Project + Existing Conditions.

[b] See Section 2.2.1 for a description of the relevant guidelines, objectives and standards.

[c] PDA = The maximum value is from a receptor located on the PDA perimeter; LSA = The maximum value is from a receptor located outside of the PDA and inside of the LSA

[d] The 1-hour SO_2 value is calculated from the 3-year average of the 99th percentile of the daily maximum 1-hour average concentrations.

[e] There are no Nunavut or Canadian guidelines, objectives or standards for this contaminant. The contaminant is included in the assessment to satisfy the EIS Guidelines (NIRB 2012a). An appropriate provincial objective threshold for this contaminant was included for comparison.

[f] The 24-hour $PM_{2.5}$ value is calculated from the 3-year average of the annual 98th percentile of the daily 24-hour average concentration.

[g] The annual $PM_{2.5}$ value is calculated from the 3-year average of the annual average concentrations.

[h] The 3-year average of the annual 98th percentile of the daily maximum 1-hour average concentrations

[i] The average over a single calendar year of all 1-hour average concentrations

8 SUMMARY

An air quality modeling study (AQMS) was conducted to inform the assessment of air quality for the Madrid-Boston Project of the Hope Bay Project Final Environmental Impact Statement (TMAC 2017).

The AQMS used the CALPUFF air dispersion model (version 7.1.2) to predict ambient air quality due to: the existing permitted Hope Bay project activities, the Madrid-Boston Project activities, and the Hope Bay Project. The CALPUFF model used appropriate terrain elevation and land use data for the Hope Bay Project area. The meteorological data inputs were from the on-site Doris and Boston meteorological stations along with an appropriate Weather Research and Forecasting model dataset. Model parameters were chosen using BC regulatory guidance, professional judgement and experience.

The air contaminants modeled were nitrogen oxides (NO_X), nitrogen dioxide (NO_2), sulphur dioxide (SO_2), carbon monoxide (CO), total suspended particulate (TSP), particulate matter with diameter less than 10 micrometers (PM_{10}), particulate matter with diameter less than 2.5 micrometers ($PM_{2.5}$), and dust deposition. Predicted contaminant concentrations were compared against relevant ambient air quality standards, objectives and guidelines for Nunavut, other provinces, or Canada.

Baseline ambient air quality conditions were characterized from historical data collected from the Doris North Project Air Quality Monitoring Program from 2009 to 2014.

The AQMS used two spatial domains, one for the Roberts Bay, Doris and Madrid area (Northern Domain), and the other for the Boston area (Southern Domain). Both construction and operation periods were modeled for each domain. For each modeling domain and period, ambient air quality was predicted for the existing permitted activities alone, Madrid-Boston Project activities alone, and the cumulative existing permitted activities along with the Madrid-Boston Project activities (the Hope Bay Project cumulatively). The AQMS spatial domains were established based on a “zone of influence” beyond which potential air contaminant concentrations from the Madrid-Boston Project are expected to reduce to near existing levels.

The emissions inventory for the AQMS was built using a number of information sources, calculations and assumptions. Some information sources and assumptions were informed by descriptions about proposed components and activities of the Madrid-Boston Project as well as existing information about the existing permitted activities. At the time of preparing the emissions inventory, the most up-to-date information from the Project Description (July 31, 2017) was used. There may be changes to the Madrid-Boston Project design before construction as additional planning and detailed engineering design develops. Any changes to Madrid-Boston Project components and activities made after the emissions inventory was completed were not incorporated into the emissions inventory and therefore were not represented in the predicted ambient air quality results.

Where input data uncertainties existed, conservative assumptions were used following regulatory guidance, professional judgement and experience. Emissions from the Project employed a conservative approach based on maximum production rates which is expected to over-estimate emissions. The use of conservative assumptions can lead to conservative model predictions and therefore the model results are interpreted with the understanding that the predicted effects are likely overestimated.

The predicted ambient air quality results are compared against relevant guidelines, objectives and standards for each ambient air quality contaminant at or outside a modelling property boundary that was chosen to represent the potential for public exposure and compliance with air quality criteria. The hunting exclusion zone around the TMAC facilities was used as a reasonable extent to define the property boundary. The hunting exclusion zone is a requirement of the Consolidation of the Mine Health and Safety Regulations, which prohibits discharge of a firearm within 2-km of any mine infrastructure. Local populations have been notified of the exclusion zone - any occurrences of members of the public being located within the hunting exclusion zone are expected to be infrequent and brief in duration.

The following conclusions were made from the AQMS predictions:

- maximum predicted ground level concentrations of SO_2, CO, TSP, $PM_{2.5}$ and dust deposition are predicted to be below their relevant criteria outside the property boundary for construction and operations.
- Maximum 24-hour average PM_{10} concentrations are predicted to exceed the relevant criteria in a limited area to the south-east of Madrid South for Project Operations. The maximum predicted 24-hour average concentration at the property boundary was predicted to be 19% above the criteria and exceedances were predicted to occur infrequently (1 day in 365). Maximum annual average PM_{10} concentrations in the Northern Domain for operations are predicted to be below the applicable criterion.
- Maximum ground level PM_{10} concentrations are predicted to be below their applicable criterion in the Southern Domain for both construction and operations.
- CAAQS for nitrogen dioxide (NO_2) were released on November 3, 2017 and come into effect in 2020 and 2025. These new criteria were incorporated into the assessment for the FEIS as these criteria are more stringent than the current Nunavut criteria. The following were noted from the air quality predictions for NO_2:
    - The Madrid-Boston Project and the Hope Bay Project ambient NO_2 concentrations are predicted to be below the relevant 24-hour (Nunavut) guideline outside the PB.
    - The Madrid-Boston Project and the Hope Bay Project annual average NO_2 concentrations are predicted to be below the newly introduced annual CAAQS outside of the PB.
    - The maximum hourly average NO_2 concentrations are predicted to intermittently (up to 53% of the days annually) exceeded the criteria by up to 382% of the CAAQS. Exceedances were predicted to occur within the LSA but not extend into the RSA. No exceedances are predicted to occur with respect to the currently applicable Nunavut hourly NO_2 criteria.

    - In the Southern domain, exceedances are predicted to occur within 0.5 - 5-km of the PB (depending on direction), but infrequently (less than 20% of the time) outside of 1-km from the PB.
    - In the Northern Domain exceedances are predicted to occur within 2-10 km of the PB (depending on direction), but infrequently (less than 20% of the time) outside of 3.5 km from the PB.
- Exceedances of the health-based hourly average NO_2 CAAQS are predicted to occur in areas where there is expected to be infrequent human occupancy and therefore adverse health effects are unlikely. TMAC will consider additional NOx mitigation measures to address the new NO_2 CAAQS as the Project design progresses.

Ambient air quality modeling predictions were not completed for the reclamation and closure, post closure, and temporary closure periods. Based on the Project Description (as of July 31, 2017), the air emissions during these three periods were identified as being much lower than the air emissions during the construction and operation periods. Therefore, use of the construction and operation period predictions for these phases is expected to be conservative.

9 CLOSURE

This document entitled Madrid-Boston Project – Air Quality Modeling Study was prepared by Nunami Stantec Ltd. for the account of TMAC Resources Ltd. The material in it reflects Nunami Stantec's best judgment in light of the information available to it at the time of preparation. Any use which a third party makes of this report, or any reliance on or decisions made based on it, are the responsibilities of such third parties. Nunami Stantec Ltd. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

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10 REFERENCES

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APPENDIX A Emission Inventory

Table A-1 Generator Stack Parameters and Emission Rates

Emission Source	Source Description	Emission Standard	Total Power Output	Stack ID	Power Output per Stack	Fuel Consumpt.	Stack Location (UTM zone 13, NAD 83)		Stack Parameters							Emission Factors											
									Stack Height	Stack Internal Diameter	Stack Exit Flow Rate		Stack Exit Velocity	Stack Exit Temperature		NO_X		SO_2		CO		TSP		PM_{10}		$PM_{2.5}$	
			(kW)		(kW)	(L/h)	Easting (m)	Northing (m)	(m)	(m)	(Am³/s)	(Nm³/s)	(m/s)	(° C)	(K)	(g/kWh)	(mg/Nm³)	(g/kWh)	(g/L)	(g/kWh)	(mg/Nm³)	(g/kWh)	(mg/Nm³)	(g/kWh)	(mg/Nm³)	(g/kWh)	(mg/Nm³)
Doris Power Plant	8 x 1,600 kW generators: 6 continuous and 2 standby. 3 stacks	Manufacturer specifications	9600	P6	3200	412.2	433016	7559168	15	0.356	5.66	1.95	56.96	517	790	—	2000	—	0.0254	—	125	—	18	—	18	—	17.46
Doris Power Plant				P7	3200	412.2	433025	7559167	15	0.356	5.66	1.95	56.96	517	790	—	2000	—	0.0254	—	125	—	18	—	18	—	17.46
Doris Power Plant				P8	3200	412.2	433034	7559167	15	0.356	5.66	1.95	56.96	517	790	—	2000	—	0.0254	—	125	—	18	—	18	—	17.46
Madrid North Power Plant	3 x 1,600 kW generators. Assume 2 stacks	Manufacturer specifications	4800	P10	2400	413.2	433155	7550027	15	0.356	5.66	1.95	56.96	517	790	—	2000	—	0.0254	—	125	—	18	—	18	—	17.46
Madrid North Power Plant				P11	2400	414.2	433155	7550003	15	0.356	5.66	1.95	56.96	517	790	—	2000	—	0.0254	—	125	—	18	—	18	—	17.46
Madrid South	2 x 725 kW generators, N+1 configuration	Assumed Tier 2 (2006-2010)	725	P12	725	—	434968	7546916	6	0.356	—	—	56.96	—	790	6.03	—	0.007	—	3.50	—	0.20	—	0.20	—	0.19	—
Quarry D construction Camp	Assume 1 x 725 kW	Assumed Tier 2 (2006-2010)	725	P13	725	—	432874	7551687	6	0.356	—	—	56.96	—	790	6.03	—	0.007	—	3.50	—	0.20	—	0.20	—	0.19	—
Boston Power Plant	8 x 1,600 kW generators: 6 continuous and 2 standby. 3 stacks	Manufacturer specifications	9600	P14	3200	412.2	441026	7504145	15	0.356	5.66	1.95	56.96	517	790	—	2000	—	0.0254	—	125	—	18	—	18	—	17.46
Boston Power Plant				P15	3200	412.2	441039	7504144	15	0.356	5.66	1.95	56.96	517	790	—	2000	—	0.0254	—	125	—	18	—	18	—	17.46
Boston Power Plant				P16	3200	412.2	441053	7504143	15	0.356	5.66	1.95	56.96	517	790	—	2000	—	0.0254	—	125	—	18	—	18	—	17.46
Boston Construction Camp	Assume 1 x 725 kW	Assumed Tier 2 (2006-2010)	725	P18	725	—	441193	7505544	6	0.356	—	—	56.96	—	790	6.03	—	0.007	—	3.50	—	0.20	—	0.20	—	0.19	—

Table A-1 Generator Stack Parameters and Emission Rates (continued)

Emission Source	Stack ID	Emission Rates									Emission Scaling Factors			Modelling Domain and Scenario to Apply Emission					
		NO_X	SO_2	CO	ETSP	EPM_{10}	$EPM_{2.5}$	FTSP	FPM_{10}	$FPM_{2.5}$	Hourly	Daily	Annual	Existing North Con.	Existing North Ops.	Project North Con.	Project North Ops.	Project South Con.	Project South Ops.
		(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	—	—	—	(1=yes; " "=no)					
Doris Power Plant	P6	3.91	0.0029	0.24	0.035	0.035	0.034	0	0	0	1.00	1.00	1.00	1	1				
Doris Power Plant	P7	3.91	0.0029	0.24	0.035	0.035	0.034	0	0	0	1.00	1.00	1.00	1	1				
Doris Power Plant	P8	3.91	0.0029	0.24	0.035	0.035	0.034	0	0	0	1.00	1.00	1.00	1	1				
Madrid North Power Plant	P10	3.91	0.0029	0.24	0.035	0.035	0.034	0	0	0	1.00	1.00	1.00				1		
Madrid North Power Plant	P11	3.91	0.0029	0.24	0.035	0.035	0.034	0	0	0	1.00	1.00	1.00				1		
Madrid South	P12	1.21	0.0015	0.70	0.040	0.040	0.039	0	0	0	1.00	1.00	1.00				1		
Quarry D construction Camp	P13	1.21	0.0015	0.70	0.040	0.040	0.039	0	0	0	1.00	1.00	1.00			1			
Boston Power Plant	P14	3.91	0.0029	0.24	0.035	0.035	0.034	0	0	0	1.00	1.00	1.00						1
Boston Power Plant	P15	3.91	0.0029	0.24	0.035	0.035	0.034	0	0	0	1.00	1.00	1.00						1
Boston Power Plant	P16	3.91	0.0029	0.24	0.035	0.035	0.034	0	0	0	1.00	1.00	1.00						1
Boston Construction Camp	P18	1.21	0.0015	0.70	0.040	0.040	0.039	0	0	0	1.00	1.00	1.00					1	

NOTES:

ETSP, EPM_{10}, $EPM_{2.5}$ - particulate matter resulting from combustion

FTSP, FPM_{10}, $FPM_{2.5}$ - fugitive particulate matter

"—" Not applicable

" " - equal to 0

Table A-2 Processing Plant Stack Parameters and Emission Rates

Emission Source	Source Description	Stack ID	Material Crushing Rate	Sludge Drying Rate	Diesel Use for Sludge Drying	Smelting Rate	Stack Location (UTM zone 13, NAD 83)		Stack Parameters				
									Stack Height	Stack Internal Diameter	Stack Exit Velocity	Stack Exit Temperature	
			(t/d)	(t/d)	(L/h)	(t/d)	Easting (m)	Northing (m)	(m)	(m)	(m/s)	(° C)	(K)
Doris Processing Plant	Assumed that all emissions from the processing plant building exhaust through 1 stack	P55	2400	0.0471	1.41	0.157	433155	7559187	20	0.5	10	100	373.15
Boston Processing Plant		P56	2400	0.0471	1.41	0.157	441042	7504181	20	0.5	10	100	373.15
Madrid North Processing Plant		P57	1200	0	0	0	433185	7550013	20	0.5	10	100	373.15

Table A-2 Processing Plant Stack Parameters and Emission Rates (continued)

Emission Source	Stack ID	Emission Rates									Emission Scaling Factors			Modelling Domain and Scenario to Apply Emission					
		NO_x	SO_2	CO	ETSP	EPM_{10}	$EPM_{2.5}$	FTSP	FPM_{10}	$FPM_{2.5}$	Hourly	Daily	Annual	Existing North Con.	Existing North Ops.	Project North Con.	Project North Ops.	Project South Con.	Project South Ops.
		(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	—	—	—	(1=yes; " "=no)					
Doris Processing Plant	P55	9.43E-04	1.00E-05	2.36E-04	3.98E-03	3.93E-03	3.75E-03	1.255	0.503	0.503	1.00	1.00	1.00	1	1				
Boston Processing Plant	P56	9.43E-04	1.00E-05	2.36E-04	3.98E-03	3.93E-03	3.75E-03	1.255	0.503	0.503	1.00	1.00	1.00						1
Madrid North Processing Plant	P57	0	0	0	0	0	0	0.625	0.250	0.250	1.00	1.00	1.00				1		

NOTES:

ETSP, EPM_{10}, $EPM_{2.5}$ - particulate matter resulting from combustion

FTSP, FPM_{10}, $FPM_{2.5}$ - fugitive particulate matter

" " - equal to 0

Table A-3 Incinerator Stack Parameters and Emission Rates

Emission Source	Source Description	Stack ID	Stack Location (UTM zone 13, NAD 83)		Amount of waste per person per day	Number of people per incinerator	Total amount of waste per year	Stack Parameters						Emission Factors					
								Stack Height	Stack Internal Diameter	Actual Flow Rate	Stack Exit Velocity	Stack Exit Temperature		NO_X	SO_2	CO	TSP	PM_{10}	$PM_{2.5}$
			Easting (m)	Northing (m)	(kg/person/ day)	population	(t/y)	(m)	(m)	(Am³/s)	(m/s)	(° C)	(K)	(kg/tonne)					
Roberts Bay Incinerator	Incinerator taking waste from Doris and Quarry D camps	P1	432876	7563172	2.5	166.67	152.08	8	0.4572	1.67	10.15	1049	1322.15	1.50	1.25	5.00	3.50	3.42	3.38
Roberts Bay Incinerator		P2	432870	7563172	2.5	166.67	152.08	7	0.381	1.67	14.62	1049	1322.15	1.50	1.25	5.00	3.50	3.42	3.38
Roberts Bay Incinerator		P3	432873	7563172	2.5	166.67	152.08	7	0.381	1.67	14.62	1049	1322.15	1.50	1.25	5.00	3.50	3.42	3.38
Boston Incinerator	Incinerator taking waste from Boston camp	P4	441198	7504262	2.5	100	91.25	7	0.381	1.67	14.62	1049	1322.15	1.50	1.25	5.00	3.50	3.42	3.38
Boston Incinerator		P5	441198	7504269	2.5	100	91.25	7	0.381	1.67	14.62	1049	1322.15	1.50	1.25	5.00	3.50	3.42	3.38

Table A-3 Incinerator Stack Parameters and Emission Rates (continued)

Emission Source	Stack ID	Emission Rates									Emission Scaling Factors			Modelling Domain and Scenario to Apply Emission					
		NO_X	SO_2	CO	ETSP	EPM_{10}	$EPM_{2.5}$	FTSP	FPM_{10}	$FPM_{2.5}$	Hourly	Daily	Annual	Existing North Con.	Existing North Ops.	Project North Con.	Project North Ops.	Project South Con.	Project South Ops.
		(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	—	—	—	(1=yes; " "=no)					
Roberts Bay Incinerator	P1	7.23E-03	6.03E-03	2.41E-02	1.69E-02	1.65E-02	1.63E-02	0	0	0	1.00	1.00	1.00	1	1				
Roberts Bay Incinerator	P2	7.23E-03	6.03E-03	2.41E-02	1.69E-02	1.65E-02	1.63E-02	0	0	0	1.00	1.00	1.00	1	1				
Roberts Bay Incinerator	P3	7.23E-03	6.03E-03	2.41E-02	1.69E-02	1.65E-02	1.63E-02	0	0	0	1.00	1.00	1.00	1	1				
Boston Incinerator	P4	4.34E-03	3.62E-03	1.45E-02	1.01E-02	9.88E-03	9.79E-03	0	0	0	1.00	1.00	1.00					1	1
Boston Incinerator	P5	4.34E-03	3.62E-03	1.45E-02	1.01E-02	9.88E-03	9.79E-03	0	0	0	1.00	1.00	1.00					1	1

NOTES:

ETSP, EPM_{10}, $EPM_{2.5}$ - particulate matter resulting from combustion

FTSP, FPM_{10}, $FPM_{2.5}$ - fugitive particulate matter

"   " - equal to 0

Table A-4 Underground Mine Air Heating Facility Stacks Parameters and Emission Rates

Emission Source	Source Description	Stack ID	Diesel Fuel Usage			Stack Location (UTM zone 13, NAD 83)		Stack Parameters					Emission Factors						Emission Factors					
								Stack Height	Stack Internal Diameter	Stack Exit Velocity	Stack Exit Temperature		NO_X	SO_2	CO	TSP	PM_{10}	$PM_{2.5}$	NO_X	SO_2	CO	TSP	PM_{10}	$PM_{2.5}$
			(L/y)	(L/s)	(L/s/stack)	Easting	Northing (m)	(m)	(m)	(m/s)	(° C)	(K)	(lb/1000 gallons)						(g/L)					
Doris	Underground mine air heater; 30 MMBTU/hr diesel heater, air heated to -8 ° C.	P19	500,000	0.024	0.006	433687	7559416	6	0.5	10	200	473.15	20	0.213	5	3.3	2.30	1.55	2.40	0.03	0.60	0.40	0.28	0.19
Doris		P20			0.006	433693	7559419	6	0.5	10	200	473.15	20	0.213	5	3.3	2.30	1.55	2.40	0.03	0.60	0.40	0.28	0.19
Doris		P21			0.006	433699	7559408	6	0.5	10	200	473.15	20	0.213	5	3.3	2.30	1.55	2.40	0.03	0.60	0.40	0.28	0.19
Doris		P22			0.006	433694	7559406	6	0.5	10	200	473.15	20	0.213	5	3.3	2.30	1.55	2.40	0.03	0.60	0.40	0.28	0.19
Madrid North	Underground mine air heater; 30 MMBTU/hr diesel heater, air heated to -8 ° C.	P23	500,000	0.024	0.006	433560	7550340	6	0.5	10	200	473.15	20	0.213	5	3.3	2.30	1.55	2.40	0.03	0.60	0.40	0.28	0.19
Madrid North		P24			0.006	433565	7550339	6	0.5	10	200	473.15	20	0.213	5	3.3	2.30	1.55	2.40	0.03	0.60	0.40	0.28	0.19
Madrid North		P25			0.006	433557	7550328	6	0.5	10	200	473.15	20	0.213	5	3.3	2.30	1.55	2.40	0.03	0.60	0.40	0.28	0.19
Madrid North		P26			0.006	433563	7550327	6	0.5	10	200	473.15	20	0.213	5	3.3	2.30	1.55	2.40	0.03	0.60	0.40	0.28	0.19
Madrid South	Underground mine air heater; 30 MMBTU/hr diesel heater, air heated to -8 ° C.	P27	500,000	0.024	0.006	435157	7546646	6	0.5	10	200	473.15	20	0.213	5	3.3	2.30	1.55	2.40	0.03	0.60	0.40	0.28	0.19
Madrid South		P28			0.006	435166	7546640	6	0.5	10	200	473.15	20	0.213	5	3.3	2.30	1.55	2.40	0.03	0.60	0.40	0.28	0.19
Madrid South		P29			0.006	435160	7546631	6	0.5	10	200	473.15	20	0.213	5	3.3	2.30	1.55	2.40	0.03	0.60	0.40	0.28	0.19
Madrid South		P30			0.006	435151	7546637	6	0.5	10	200	473.15	20	0.213	5	3.3	2.30	1.55	2.40	0.03	0.60	0.40	0.28	0.19
Boston	Underground mine air heater; 30 MMBTU/hr diesel heater, air heated to -8 ° C.	P31	500,000	0.024	0.006	441179	7505092	6	0.5	10	200	473.15	20	0.213	5	3.3	2.30	1.55	2.40	0.03	0.60	0.40	0.28	0.19
Boston		P32			0.006	441189	7505092	6	0.5	10	200	473.15	20	0.213	5	3.3	2.30	1.55	2.40	0.03	0.60	0.40	0.28	0.19
Boston		P33			0.006	441189	7505082	6	0.5	10	200	473.15	20	0.213	5	3.3	2.30	1.55	2.40	0.03	0.60	0.40	0.28	0.19
Boston		P34			0.006	441179	7505082	6	0.5	10	200	473.15	20	0.213	5	3.3	2.30	1.55	2.40	0.03	0.60	0.40	0.28	0.19

Table A-4 Underground Mine Air Heating Facility Stacks Parameters and Emission Rates (continued)

Emission Source	Stack ID	Emission Rates									Emission Scaling Factors			Modelling Domain and Scenario to Apply Emission					
		NO_X	SO_2	CO	ETSP	EPM_{10}	$EPM_{2.5}$	FTSP	FPM_{10}	$FPM_{2.5}$	Hourly	Daily	Annual	Existing North Con.	Existing North Ops.	Project North Con.	Project North Ops.	Project South Con.	Project South Ops.
		(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	—	—	—	(1=yes; " "=no)					
Doris	P19	1.42E-02	1.52E-04	3.56E-03	2.35E-03	1.64E-03	1.10E-03	0	0	0	1.00	1.00	1.00	1					
Doris	P20	1.42E-02	1.52E-04	3.56E-03	2.35E-03	1.64E-03	1.10E-03	0	0	0	1.00	1.00	1.00	1					
Doris	P21	1.42E-02	1.52E-04	3.56E-03	2.35E-03	1.64E-03	1.10E-03	0	0	0	1.00	1.00	1.00	1					
Doris	P22	1.42E-02	1.52E-04	3.56E-03	2.35E-03	1.64E-03	1.10E-03	0	0	0	1.00	1.00	1.00	1					
Madrid North	P23	1.42E-02	1.52E-04	3.56E-03	2.35E-03	1.64E-03	1.10E-03	0	0	0	1.00	1.00	1.00			1	1		
Madrid North	P24	1.42E-02	1.52E-04	3.56E-03	2.35E-03	1.64E-03	1.10E-03	0	0	0	1.00	1.00	1.00			1	1		
Madrid North	P25	1.42E-02	1.52E-04	3.56E-03	2.35E-03	1.64E-03	1.10E-03	0	0	0	1.00	1.00	1.00			1	1		
Madrid North	P26	1.42E-02	1.52E-04	3.56E-03	2.35E-03	1.64E-03	1.10E-03	0	0	0	1.00	1.00	1.00			1	1		
Madrid South	P27	1.42E-02	1.52E-04	3.56E-03	2.35E-03	1.64E-03	1.10E-03	0	0	0	1.00	1.00	1.00				1		
Madrid South	P28	1.42E-02	1.52E-04	3.56E-03	2.35E-03	1.64E-03	1.10E-03	0	0	0	1.00	1.00	1.00				1		
Madrid South	P29	1.42E-02	1.52E-04	3.56E-03	2.35E-03	1.64E-03	1.10E-03	0	0	0	1.00	1.00	1.00				1		
Madrid South	P30	1.42E-02	1.52E-04	3.56E-03	2.35E-03	1.64E-03	1.10E-03	0	0	0	1.00	1.00	1.00				1		
Boston	P31	1.42E-02	1.52E-04	3.56E-03	2.35E-03	1.64E-03	1.10E-03	0	0	0	1.00	1.00	1.00						1
Boston	P32	1.42E-02	1.52E-04	3.56E-03	2.35E-03	1.64E-03	1.10E-03	0	0	0	1.00	1.00	1.00						1
Boston	P33	1.42E-02	1.52E-04	3.56E-03	2.35E-03	1.64E-03	1.10E-03	0	0	0	1.00	1.00	1.00						1
Boston	P34	1.42E-02	1.52E-04	3.56E-03	2.35E-03	1.64E-03	1.10E-03	0	0	0	1.00	1.00	1.00						1

NOTES:

ETSP, EPM_{10}, $EPM_{2.5}$ - particulate matter resulting from combustion

FTSP, FPM_{10}, $FPM_{2.5}$ - fugitive particulate matter

"   " - equal to 0

Table A-5 Marine Shipping Vessels Parameters and Emission Rates

Emission Source	Source Description	Stack ID	Ship DWT	Maximum Main Engine Power	Main Engine Power during Activity	Auxiliary Engine Power during Activity	Stack Location (UTM zone 13, NAD 83)		Stack Parameters: Emission Release Height/ Stack Height	Stack Parameters: Stack Internal Diameter	Stack Parameters: Stack Exit Velocity	Stack Parameters: Stack Exit Temperature		Main Engine (Maneuvering) Emission Factors: NO_X	SO_2	CO	TSP	PM_{10}	$PM_{2.5}$	Auxiliary Engine (Hoteling) Emission Factors: NO_X	SO_2	CO	TSP	PM_{10}	$PM_{2.5}$
			(tonne)	(kW)	(kW)	(kW)	Easting (m)	Northing (m)	(m)	(m)	(m/s)	(° C)	(K)	(g/kW-hr)						(g/kW-hr)					
Roberts Bay Dock	Docked ship, hoteling, stack source	P58	16640	10846	0	1000	431626	7565136	15	1	10	300	573.15	0	0	0	0	0	0	10.58	0.522	0.838	0.261	0.251	0.245
Roberts Bay	Maneuvering ship, area source	—	16640	10846	2169	1250	—	—	7	—	—	—	—	11.85	0.656	4.189	0.321	0.308	0.301	10.58	0.522	0.838	0.261	0.251	0.245
Roberts Bay	Slow cruise ship, road source	—	16640	10846	4339	750	—	—	3.5	—	—	—	—	10.95	0.572	2.095	0.278	0.267	0.261	10.58	0.522	0.838	0.261	0.251	0.245

Table A-5 Marine Shipping Vessels Parameters and Emission Rates (continued)

Emission Source	Source Description	Stack ID	Emission Rates: NO_X	SO_2	CO	ETSP	EPM_{10}	$EPM_{2.5}$	FTSP	FPM_{10}	$FPM_{2.5}$	Emission Scaling Factors: Hourly	Daily	Annual	Modelling Domain and Scenario to Apply Emission: Existing North Con.	Existing North Ops.	Project North Con.	Project North Ops.	Project South Con.	Project South Ops.
			(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	—	—	—	(1=yes; " "=no)					
Roberts Bay Dock	Docked ship, hoteling, stack source	P58	2.94	0.145	0.233	0.073	0.070	0.068	—	—	—	1.00	1.000	0.533	0.8	0.8	0.2	0.2		
Roberts Bay	Maneuvering ship, area source	—	10.81	0.576	2.815	0.284	0.273	0.266	—	—	—	1.00	0.042	0.022	0.8	0.8	0.2	0.2		
Roberts Bay	Slow cruise ship, road source	—	15.39	0.798	2.699	0.390	0.374	0.365	—	—	—	1.00	0.042	0.022	0.8	0.8	0.2	0.2		

NOTES:

ETSP, EPM_{10}, $EPM_{2.5}$ - particulate matter resulting from combustion

FTSP, FPM_{10}, $FPM_{2.5}$ - fugitive particulate matter

"—" Not applicable

" " - equal to 0

Table A-6 Mine Portals Air Ventilation Exhaust (Tailpipe Emissions) Parameters and Emission Rates

Emission Source	Source Description	Emission Standard	Stack Location (UTM zone 13, NAD 83)		Emission Rates									Emission Scaling Factors			Modelling Domain and Scenario to Apply Emission					
					NO_X	SO_2	CO	ETSP	EPM_{10}	$EPM_{2.5}$	FTSP	FPM_{10}	$FPM_{2.5}$	Hourly	Daily	Annual	Existing North Con.	Existing North Ops.	Project North Con.	Project North Ops.	Project South Con.	Project South Ops.
			Easting (m)	Northing (m)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	—	—	—	(1=yes; " "=no)					
Doris Portal	Total tailpipe emissions from underground mining equipment	Tier 3 (2010-2014)	433351	7559130	3.78	0.0045	1.94	0.325	0.325	0.316	—	—	—	1.00	1.00	1.00	1					
Madrid North Portal		Assumed Tier 4 (after 2014)	433171	7550089	3.71	0.0069	1.94	0.336	0.336	0.326	—	—	—	1.00	1.00	1.00			0.5	1		
Madrid South Portal			435066	7546783	1.70	0.0031	0.90	0.155	0.155	0.150	—	—	—	1.00	1.00	1.00				1		
Boston Portal			441226	7505288	2.84	0.0053	1.50	0.259	0.259	0.251	—	—	—	1.00	1.00	1.00						1

NOTES:

ETSP, EPM_{10}, $EPM_{2.5}$ - particulate matter resulting from combustion

FTSP, FPM_{10}, $FPM_{2.5}$ - fugitive particulate matter

"—" Not applicable

"   " - equal to 0

Table A-7 General Areas with Surface Mobile Equipment (Tailpipe Emissions) Parameters and Emission Rates

Emission Source	Source Description	Emission Rates									Emission Scaling Factors			Modelling Domain and Scenario to Apply Emission					
		NO_X	SO_2	CO	ETSP	EPM_{10}	$EPM_{2.5}$	FTSP	FPM_{10}	$FPM_{2.5}$	Hourly	Daily	Annual	Existing North Con.	Existing North Ops.	Project North Con.	Project North Ops.	Project South Con.	Project South Ops.
		(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	—	—	—	(1=yes; " "=no)					
Doris General Area (Year 2019)	General operation equipment	14.32	0.020	6.827	1.009	1.009	0.979	—	—	—	1.00	1.00	1.00	1					
Doris General Area (Year 2030)	General operation equipment	11.66	0.017	5.610	0.823	0.823	0.798	—	—	—	1.00	1.00	1.00		1				
Roberts Bay New Dock, Construction	General construction equipment	2.25	0.005	1.077	0.170	0.170	0.165	—	—	—	1.00	1.00	1.00			1			
Roberts Bay New Dock, Operation	Operation equipment at Roberts Bay dock	0.60	0.001	0.202	0.035	0.035	0.034	—	—	—	1.00	1.00	1.00				1		
Roberts Bay General Area (Year 2019)	General operation equipment	3.03	0.004	1.626	0.245	0.245	0.238	—	—	—	1.00	1.00	1.00	1	1				
Roberts Bay General Area, Construction	General construction equipment for construction of a new fuel storage facility	2.25	0.005	1.077	0.170	0.170	0.165	—	—	—	1.00	1.00	1.00			1			
Madrid North General Area, Construction	General construction equipment	7.35	0.019	3.269	0.506	0.506	0.490	—	—	—	1.00	1.00	1.00			1			
Madrid North General Area, Operation	General operation equipment	11.02	0.027	4.994	0.773	0.773	0.750	—	—	—	1.00	1.00	1.00				1		
Madrid South General Area, Construction	General construction equipment	4.12	0.010	1.855	0.289	0.289	0.281	—	—	—	1.00	1.00	1.00			1			
Madrid South General Area, Operation	General operation equipment	4.92	0.012	2.259	0.350	0.350	0.339	—	—	—	1.00	1.00	1.00				1		
Quarry AH, Construction	General quarry equipment and crusher	3.08	0.006	1.357	0.202	0.202	0.196	—	—	—	1.00	1.00	1.00			1			
Quarry H, Construction	General quarry equipment and crusher	3.08	0.006	1.357	0.202	0.202	0.196	—	—	—	1.00	1.00	1.00			1			
Quarry AJ, Construction	General quarry equipment and crusher	3.08	0.006	1.357	0.202	0.202	0.196	—	—	—	1.00	1.00	1.00					1	
Quarry U, Construction	General quarry equipment and crusher	3.08	0.006	1.357	0.202	0.202	0.196	—	—	—	1.00	1.00	1.00					1	
Boston General Area, Construction	General construction equipment	5.93	0.015	2.701	0.418	0.418	0.405	—	—	—	1.00	1.00	1.00					1	
Boston General Area, Operation	General operation equipment	7.47	0.019	3.385	0.522	0.522	0.506	—	—	—	1.00	1.00	1.00						1
Quarry D Construction Camp Construction	General construction equipment for construction of camp	2.25	0.005	1.077	0.170	0.170	0.165	—	—	—	1.00	0.50	0.50			1			
Doris TIA, West Dam Construction	General construction equipment	2.25	0.005	1.077	0.170	0.170	0.165	—	—	—	1.00	1.00	1.00			1			
Doris TIA, South Dam Construction	General construction equipment	2.25	0.005	1.077	0.170	0.170	0.165	—	—	—	1.00	1.00	1.00			1			

NOTES:

ETSP, EPM_{10}, $EPM_{2.5}$ - particulate matter resulting from combustion

FTSP, FPM_{10}, $FPM_{2.5}$ - fugitive particulate matter

"—" Not applicable

" " - equal to 0

Table A-8 Aircraft Parameters and Emission Rates

Emission Source	Aircraft type	# Aircraft Units	# LTO Events per Hour	Emission Rates									Emission Scaling Factors			Modelling Domain and Scenario to Apply Emission					
				NO_X	SO_2	CO	ETSP	EPM_{10}	$EPM_{2.5}$	FTSP	FPM_{10}	$FPM_{2.5}$	Hourly	Daily	Annual	Existing North Con.	Existing North Ops.	Project North Con.	Project North Ops.	Project South Con.	Project South Ops.
		(Units/h)	(LTO/h)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	—	—	—	(1=yes; " "=no)					
Doris Runway	737-200 Aircraft	1	1	1.120	0.0895	0.20	0.027	0.027	0.027	—	—	—	1.00	0.042	0.024	1	1				
Doris Runway	Dash 8 aircraft	1	1	0.047	0.0092	0.09	0.002	0.002	0.002	—	—	—	1.00	0.042	0.024	1	1				
Doris Helicopter Pad	Bell 206 Long Ranger Helicopter	1	1	0.001	0.0006	0.04	0.001	0.001	0.001	—	—	—	1.00	0.042	0.024	1	1				
Boston Runway	737-200 Aircraft	1	1	1.120	0.0895	0.20	0.027	0.027	0.027	—	—	—	1.00	0.042	0.024						1
Boston Runway	Dash 8 aircraft	1	1	0.047	0.0092	0.09	0.002	0.002	0.002	—	—	—	1.00	0.042	0.024						1
Boston Runway	Hercules C130	1	1	0.216	0.0300	0.20	0.005	0.005	0.005	—	—	—	1.00	0.042	0.024						1
Boston Helicopter Pad	Bell 206 Long Ranger Helicopter	1	1	0.001	0.0006	0.04	0.001	0.001	0.001	—	—	—	1.00	0.042	0.024						1

NOTES:

ETSP, EPM_{10}, $EPM_{2.5}$ - particulate matter resulting from combustion

FTSP, FPM_{10}, $FPM_{2.5}$ - fugitive particulate matter

"—" Not applicable

" " - equal to 0

Table A-9 Roads (Tailpipe + Fugitive Dust) Parameters and Emission Rates

Road Segment	Equipment Description	Equipment Model	Equipment Parameters						Total Number of Units per day	Average Speed	Number of Round Trips			Activity Schedule	
			Horse-power	Load Factor	Total Equipment Weight (i.e. GVW)		Payload Capacity				per hour	per day	per year	Hours per Day	Days per Year
			hp	%	tonne	ton	tonne	ton	# units	(km/h)	# trips/h	# trips/d	# trips/y	h/d	d/y
Roberts Bay New Port to Roberts Bay Laydown	Service Pickup Truck	Ford F350	385	70%	5.13	5.65	—	—	2	50	1.0	12	1104	12	92
Roberts Bay New Port to Roberts Bay Laydown	Transport of supplies	Kenworth T800 with Paccar MX-13 engine	500	70%	49.60	54.67	40.00	44.09	4	50	3.0	36	1764	12	49
Roberts Bay Laydown to Doris	Service Pickup Truck	Ford F350	385	70%	5.13	5.65	—	—	2	50	1.7	20	7000	12	350
Roberts Bay Laydown to Doris	Flatbed for supplies	Kenworth T800 with Paccar MX-13 engine	500	70%	49.60	54.67	40.00	44.09	1	50	0.2	2	700	12	350
Roberts Bay Laydown to Doris	Flatbed for supplies	Kenworth T800 with Paccar MX-13 engine	500	70%	49.60	54.67	40.00	44.09	1	50	0.1	1	350	12	350
Roberts Bay Laydown to Doris	Flatbed for supplies	Kenworth T800 with Paccar MX-13 engine	500	70%	49.60	54.67	40.00	44.09	1	50	0.2	2	700	12	350
Roberts Bay Laydown to Doris	Flatbed for supplies	Kenworth T800 with Paccar MX-13 engine	500	70%	49.60	54.67	40.00	44.09	1	50	0.2	2	700	12	350
Roberts Bay Laydown to Doris	Fuel Tanker 60 m³	Kenworth T800 with Paccar MX-13 engine	500	70%	57.50	63.38	48.00	52.91	1	50	0.1	1	175	12	175
Roberts Bay Laydown to Doris	Fuel Tanker 60 m³	Kenworth T800 with Paccar MX-13 engine	500	70%	57.50	63.38	48.00	52.91	1	50	0.1	1	175	12	175
Roberts Bay Laydown to Doris	Fuel Tanker 60 m³	Kenworth T800 with Paccar MX-13 engine	500	70%	57.50	63.38	48.00	52.91	1	50	0.1	1	117	12	117
Roberts Bay Laydown to Doris	Fuel Tanker 60 m³	Kenworth T800 with Paccar MX-13 engine	500	70%	57.50	63.38	48.00	52.91	1	50	0.1	1	117	12	117
Roberts Bay Laydown to Doris	Passenger Bus	International Bus CE Series	260	70%	14.97	16.50	—	—	1	50	0.2	2	20	12	10
Doris to Doris TIA, access road	Service Pickup Truck	Ford F350	385	70%	5.13	5.65	—	—	2	50	0.8	10	3500	12	350
AWR to Doris TIA South Dam, access road	Service Pickup Truck	Ford F350	385	70%	5.13	5.65	—	—	1	50	0.8	10	3500	12	350
Doris Portal to Ore Stockpile	Underground Mining Truck	CAT AD30	409	59%	60.00	66.14	30.00	33.07	4	25	2.7	66	24000	24	365
Doris Portal to Waste Rock Pile	Underground Mining Truck	CAT AD30	409	59%	60.00	66.14	30.00	33.07	1	25	1.1	28	10063	24	365
Doris to Madrid North	Flatbed for supplies	Kenworth T800 with Paccar MX-13 engine	500	70%	49.60	54.67	40.00	44.09	1	50	0.2	2	700	12	350
Doris to Madrid North	Fuel Tanker 60 m³	Kenworth T800 with Paccar MX-13 engine	500	70%	57.50	63.38	48.00	52.91	1	50	0.1	1	175	12	175
Doris to Madrid North	Crew Busses 16+ passenger	Ford E450	350	70%	6.35	7.00	—	—	1	50	0.5	12	4200	24	350
Doris to Madrid North	Service Pickup Truck	Ford F350	385	70%	5.13	5.65	—	—	3	50	1.7	20	7000	12	350
Doris to Madrid North	Super B Train Haul Truck	Kenworth T800 with Paccar MX-13 engine	500	70%	48.60	53.57	40.00	44.09	4	50	2.5	60	21000	24	350
Madrid North Portal to middle of Ore Stockpile	Underground Mining Truck	CAT AD30	409	59%	60.00	66.14	30.00	33.07	6	25	4.4	107	38933	24	365
Madrid North Portal to middle of Waste Rock Pile	Underground Mining Truck	CAT AD30	409	59%	60.00	66.14	30.00	33.07	3	25	2.5	60	21803	24	365
Doris to Madrid South	Flatbed for supplies	Kenworth T800 with Paccar MX-13 engine	500	70%	49.60	54.67	40.00	44.09	1	50	0.1	1	350	12	350
Doris to Madrid South	Fuel Tanker 60 m³	Kenworth T800 with Paccar MX-13 engine	500	70%	57.50	63.38	48.00	52.91	1	50	0.1	1	175	12	175
Doris to Madrid South	Crew Busses 16+ passenger	Ford E450	350	70%	6.35	7.00	—	—	1	50	0.5	12	4200	24	350
Doris to Madrid South	Service Pickup Truck	Ford F350	385	70%	5.13	5.65	—	—	3	50	1.7	20	7000	12	350
Doris to Madrid South	Super B Train Haul Truck	Kenworth T800 with Paccar MX-13 engine	500	70%	49.60	54.67	40.00	44.09	3	50	1.5	36	12600	24	350
Madrid South Portal to middle of Ore Stockpile	Underground Mining Truck	CAT AD30	409	59%	60.00	66.14	30.00	33.07	2	25	2.0	47	17200	24	365
Madrid South Portal to middle of Waste Rock Pile	Underground Mining Truck	CAT AD30	409	59%	60.00	66.14	30.00	33.07	2	25	2.5	59	21669	24	365
Doris to Boston	Flatbed for supplies	Kenworth T800 with Paccar MX-13 engine	500	70%	49.60	54.67	40.00	44.09	1	50	0.2	2	700	12	350
Doris to Boston	Fuel Tanker 60 m³	Kenworth T800 with Paccar MX-13 engine	500	70%	57.50	63.38	48.00	52.91	1	50	0.1	1	117	12	117
Doris to Boston	Passenger Bus	International Bus CE Series	260	70%	14.97	16.50	—	—	1	50	0.2	2	20	12	10

Table A-9 Roads (Tailpipe + Fugitive Dust) Parameters and Emission Rates

Road Segment	Equipment Description	Equipment Model	Equipment Parameters						Total Number of Units per day	Average Speed	Number of Round Trips			Activity Schedule	
			Horse-power	Load Factor	Total Equipment Weight (i.e. GVW)		Payload Capacity				per hour	per day	per year	Hours per Day	Days per Year
			hp	%	tonne	ton	tonne	ton	# units	(km/h)	# trips/h	# trips/d	# trips/y	h/d	d/y
Doris to Boston	Service Pickup Truck	Ford F350	385	70%	5.13	5.65	—	—	6	50	1.7	20	7000	12	350
Doris to Boston	Super B Train Haul Truck	Kenworth T800 with Paccar MX-13 engine	500	70%	49.60	54.67	40.00	44.09	2	50	0.4	10	3500	24	350
Doris to Boston	Super B Train Haul Truck	Kenworth T800 with Paccar MX-13 engine	500	70%	49.60	54.67	40.00	44.09	0	50	0.0	0	0	24	350
Doris to Boston	Flatbed for supplies	Kenworth T800 with Paccar MX-13 engine	500	70%	49.60	54.67	40.00	44.09	1	50	0.2	2	700	12	350
Doris to Boston	Fuel Tanker 60 m³	Kenworth T800 with Paccar MX-13 engine	500	70%	57.50	63.38	48.00	52.91	1	50	0.1	1	117	12	117
Doris to Boston	Passenger Bus	International Bus CE Series	260	70%	14.97	16.50	—	—	1	50	0.2	2	20	12	10
Doris to Boston	Service Pickup Truck	Ford F350	385	70%	5.13	5.65	—	—	6	50	1.7	20	7000	12	350
Doris to Boston	Super B Train Haul Truck	Kenworth T800 with Paccar MX-13 engine	500	70%	49.60	54.67	40.00	44.09	2	50	0.4	10	3500	24	350
Doris to Boston	Super B Train Haul Truck	Kenworth T800 with Paccar MX-13 engine	500	70%	49.60	54.67	40.00	44.09	0	50	0.0	0	0	24	350
Boston Portal to middle of Ore Stockpile	Underground Mining Truck	CAT AD30	409	59%	60.00	66.14	30.00	33.07	5	25	3.3	80	29200	24	365
Boston Portal to middle of Waste Rock pile	Underground Mining Truck	CAT AD30	409	59%	60.00	66.14	30.00	33.07	2	25	1.5	37	13383	24	365
Boston Mill to middle of Drystack Tailings	Haul Truck	CAT 740B	489	59%	73.98	81.54	39.50	43.54	3	25	2.1	51	18481	24	365
Boston camp to portal	Crew Busses 16+ passenger	Ford E450	350	70%	6.35	7.00	—	—	1	25	0.5	12	4200	24	350
Boston airstrip to camp	Passenger Bus	International Bus CE Series	260	70%	14.97	16.50	—	—	1	25	0.2	2	20	12	10
Boston airstrip to camp	Service Pickup Truck	Ford F350	385	70%	5.13	5.65	—	—	1	25	0.2	2	700	12	350

NOTES:

ETSP, EPM_{10}, $EPM_{2.5}$ - particulate matter resulting from combustion

FTSP, FPM_{10}, $FPM_{2.5}$ - fugitive particulate matter

"—" Not applicable

"   " - equal to 0

Table A-9 Roads (Tailpipe + Fugitive Dust) Parameters and Emission Rates (continued)

Road Segment	Equipment Description	Tailpipe Emissions: Emission Factors (g/hp-hr)						Tailpipe Emission Rates (g/s)						Fugitive Dust Emissions: Emissions Factors (g/VKT) without Dust Control			Emissions Factors (g/VKT) with 75% Watering Control Efficiency			Hourly Fugitive Dust Emission Rates (g/s/m) with 75% Control Efficiency			Emission Scaling Factors			Modelling Domain and Scenario to Apply Emission					
		NO_X	SO_2	CO	ETSP	EPM_{10}	$EPM_{2.5}$	NO_X	SO_2	CO	ETSP	EPM_{10}	$EPM_{2.5}$	FTSP	FPM_{10}	$FPM_{2.5}$	FTSP	FPM_{10}	$FPM_{2.5}$	FTSP	FPM_{10}	$FPM_{2.5}$	Hourly	Daily	Annual	Existing North Con.	Existing North Ops.	Project North Con.	Project North Ops.	Project South Con.	Project South Ops.
		(g/hp-hr)	(g/hp-hr)	(g/hp-hr)	(g/hp-hr)	(g/hp-hr)	(g/hp-hr)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/VKT)	(g/VKT)	(g/VKT)	(g/VKT)	(g/VKT)	(g/VKT)	(g/m/s)	(g/m/s)	(g/m/s)	—	—	—	(1=yes; " "=no)					
Roberts Bay New Port to Roberts Bay Laydown	Service Pickup Truck	1.330	0.004	0.499	0.078	0.078	0.075	0.199	0.001	0.075	0.012	0.012	0.011	1430.79	407.84	40.78	357.70	101.96	10.20	1.99E-04	5.66E-05	5.66E-06	1.00	0.50	0.50			1	1		
Roberts Bay New Port to Roberts Bay Laydown	Transport of supplies	1.330	0.004	0.499	0.078	0.078	0.075	0.517	0.002	0.194	0.030	0.030	0.029	3149.73	897.82	89.78	787.43	224.45	22.45	1.31E-03	3.74E-04	3.74E-05	1.00	0.50	0.27			1	1		
Roberts Bay Laydown to Doris	Service Pickup Truck	3.347	0.005	1.453	0.209	0.209	0.203	0.501	0.001	0.217	0.031	0.031	0.030	1430.79	407.84	40.78	357.70	101.96	10.20	3.31E-04	9.44E-05	9.44E-06	1.00	0.50	0.48	1	1				
Roberts Bay Laydown to Doris	Flatbed for supplies	1.330	0.004	0.499	0.078	0.078	0.075	0.129	0.000	0.049	0.008	0.008	0.007	3149.73	897.82	89.78	787.43	224.45	22.45	7.29E-05	2.08E-05	2.08E-06	1.00	0.50	0.48			1	1		
Roberts Bay Laydown to Doris	Flatbed for supplies	1.330	0.004	0.499	0.078	0.078	0.075	0.129	0.000	0.049	0.008	0.008	0.007	3149.73	897.82	89.78	787.43	224.45	22.45	3.65E-05	1.04E-05	1.04E-06	1.00	0.50	0.48			1	1		
Roberts Bay Laydown to Doris	Flatbed for supplies	1.330	0.004	0.499	0.078	0.078	0.075	0.129	0.000	0.049	0.008	0.008	0.007	3149.73	897.82	89.78	787.43	224.45	22.45	7.29E-05	2.08E-05	2.08E-06	1.00	0.50	0.48			1	1		
Roberts Bay Laydown to Doris	Flatbed for supplies	3.347	0.005	1.453	0.209	0.209	0.203	0.325	0.000	0.141	0.020	0.020	0.020	3149.73	897.82	89.78	787.43	224.45	22.45	7.29E-05	2.08E-05	2.08E-06	1.00	0.50	0.48	1	1				
Roberts Bay Laydown to Doris	Fuel Tanker 60 m³	1.330	0.004	0.499	0.078	0.078	0.075	0.129	0.000	0.049	0.008	0.008	0.007	3330.14	949.24	94.92	832.53	237.31	23.73	3.85E-05	1.10E-05	1.10E-06	1.00	0.50	0.24			1	1		
Roberts Bay Laydown to Doris	Fuel Tanker 60 m³	1.330	0.004	0.499	0.078	0.078	0.075	0.129	0.000	0.049	0.008	0.008	0.007	3330.14	949.24	94.92	832.53	237.31	23.73	3.85E-05	1.10E-05	1.10E-06	1.00	0.50	0.24			1	1		
Roberts Bay Laydown to Doris	Fuel Tanker 60 m³	1.330	0.004	0.499	0.078	0.078	0.075	0.129	0.000	0.049	0.008	0.008	0.007	3330.14	949.24	94.92	832.53	237.31	23.73	3.85E-05	1.10E-05	1.10E-06	1.00	0.50	0.16			1	1		
Roberts Bay Laydown to Doris	Fuel Tanker 60 m³	3.347	0.005	1.453	0.209	0.209	0.203	0.325	0.000	0.141	0.020	0.020	0.020	3330.14	949.24	94.92	832.53	237.31	23.73	3.85E-05	1.10E-05	1.10E-06	1.00	0.50	0.16	1	1				
Roberts Bay Laydown to Doris	Passenger Bus	0.859	0.004	0.203	0.029	0.029	0.028	0.043	0.000	0.010	0.001	0.001	0.001	2317.62	660.63	66.06	579.40	165.16	16.52	5.36E-05	1.53E-05	1.53E-06	1.00	0.50	0.01			1	1		
Doris to Doris TIA, access road	Service Pickup Truck	3.347	0.005	1.453	0.209	0.209	0.203	0.501	0.001	0.217	0.031	0.031	0.030	1430.79	407.84	40.78	357.70	101.96	10.20	1.66E-04	4.72E-05	4.72E-06	1.00	0.50	0.48	1	1	1	1		
AWR to Doris TIA South Dam, access road	Service Pickup Truck	1.330	0.004	0.499	0.078	0.078	0.075	0.100	0.000	0.037	0.006	0.006	0.006	1430.79	407.84	40.78	357.70	101.96	10.20	1.66E-04	4.72E-05	4.72E-06	1.00	0.50	0.48			1	1		
Doris Portal to Ore Stockpile	Underground Mining Truck	3.347	0.005	1.453	0.209	0.209	0.203	0.898	0.001	0.389	0.056	0.056	0.054	3803.10	1084.06	108.41	950.77	271.01	27.10	1.45E-03	4.13E-04	4.13E-05	1.00	1.00	1.00	1					
Doris Portal to Waste Rock Pile	Underground Mining Truck	3.347	0.005	1.453	0.209	0.209	0.203	0.224	0.000	0.097	0.014	0.014	0.014	3803.10	1084.06	108.41	950.77	271.01	27.10	6.07E-04	1.73E-04	1.73E-05	1.00	1.00	1.00	1					
Doris to Madrid North	Flatbed for supplies	1.330	0.004	0.499	0.078	0.078	0.075	0.129	0.000	0.049	0.008	0.008	0.007	3149.73	897.82	89.78	787.43	224.45	22.45	7.29E-05	2.08E-05	2.08E-06	1.00	0.50	0.48			1	1		
Doris to Madrid North	Fuel Tanker 60 m³	1.330	0.004	0.499	0.078	0.078	0.075	0.129	0.000	0.049	0.008	0.008	0.007	3330.14	949.24	94.92	832.53	237.31	23.73	3.85E-05	1.10E-05	1.10E-06	1.00	0.50	0.24			1	1		
Doris to Madrid North	Crew Busses 16+ passenger	1.330	0.004	0.499	0.078	0.078	0.075	0.091	0.000	0.034	0.005	0.005	0.005	1575.61	449.12	44.91	393.90	112.28	11.23	1.09E-04	3.12E-05	3.12E-06	1.00	1.00	0.96			1	1		
Doris to Madrid North	Service Pickup Truck	1.330	0.004	0.499	0.078	0.078	0.075	0.299	0.001	0.112	0.017	0.017	0.017	1430.79	407.84	40.78	357.70	101.96	10.20	3.31E-04	9.44E-05	9.44E-06	1.00	0.50	0.48			1	1		
Doris to Madrid North	Super B Train Haul Truck	1.330	0.004	0.499	0.078	0.078	0.075	0.517	0.002	0.194	0.030	0.030	0.029	3101.39	884.04	88.40	775.35	221.01	22.10	1.08E-03	3.07E-04	3.07E-05	1.00	1.00	0.96			1	1		
Madrid North Portal to middle of Ore Stockpile	Underground Mining Truck	1.330	0.004	0.499	0.078	0.078	0.075	0.535	0.002	0.201	0.031	0.031	0.030	3803.10	1084.06	108.41	950.77	271.01	27.10	2.35E-03	6.69E-04	6.69E-05	1.00	1.00	1.00			1	1		
Madrid North Portal to middle of Waste Rock Pile	Underground Mining Truck	1.330	0.004	0.499	0.078	0.078	0.075	0.268	0.001	0.100	0.016	0.016	0.015	3803.10	1084.06	108.41	950.77	271.01	27.10	1.31E-03	3.75E-04	3.75E-05	1.00	1.00	1.00			1	1		
Doris to Madrid South	Flatbed for supplies	1.330	0.004	0.499	0.078	0.078	0.075	0.129	0.000	0.049	0.008	0.008	0.007	3149.73	897.82	89.78	787.43	224.45	22.45	3.65E-05	1.04E-05	1.04E-06	1.00	0.50	0.48			1	1		
Doris to Madrid South	Fuel Tanker 60 m³	1.330	0.004	0.499	0.078	0.078	0.075	0.129	0.000	0.049	0.008	0.008	0.007	3330.14	949.24	94.92	832.53	237.31	23.73	3.85E-05	1.10E-05	1.10E-06	1.00	0.50	0.24			1	1		
Doris to Madrid South	Crew Busses 16+ passenger	1.330	0.004	0.499	0.078	0.078	0.075	0.091	0.000	0.034	0.005	0.005	0.005	1575.61	449.12	44.91	393.90	112.28	11.23	1.09E-04	3.12E-05	3.12E-06	1.00	1.00	0.96			1	1		
Doris to Madrid South	Service Pickup Truck	1.330	0.004	0.499	0.078	0.078	0.075	0.299	0.001	0.112	0.017	0.017	0.017	1430.79	407.84	40.78	357.70	101.96	10.20	3.31E-04	9.44E-05	9.44E-06	1.00	0.50	0.48			1	1		
Doris to Madrid South	Super B Train Haul Truck	1.330	0.004	0.499	0.078	0.078	0.075	0.388	0.001	0.146	0.023	0.023	0.022	3149.73	897.82	89.78	787.43	224.45	22.45	6.56E-04	1.87E-04	1.87E-05	1.00	1.00	0.96				1		
Madrid South Portal to middle of Ore Stockpile	Underground Mining Truck	1.330	0.004	0.499	0.078	0.078	0.075	0.178	0.001	0.067	0.010	0.010	0.010	3803.10	1084.06	108.41	950.77	271.01	27.10	1.04E-03	2.96E-04	2.96E-05	1.00	1.00	1.00				1		
Madrid South Portal to middle of Waste Rock Pile	Underground Mining Truck	1.330	0.004	0.499	0.078	0.078	0.075	0.178	0.001	0.067	0.010	0.010	0.010	3803.10	1084.06	108.41	950.77	271.01	27.10	1.31E-03	3.72E-04	3.72E-05	1.00	1.00	1.00				1		
Doris to Boston	Flatbed for supplies	1.330	0.004	0.499	0.078	0.078	0.075	0.129	0.000	0.049	0.008	0.008	0.007	3149.73	897.82	89.78	787.43	224.45	22.45	7.29E-05	2.08E-05	2.08E-06	1.00	0.50	0.48			1	1		
Doris to Boston	Fuel Tanker 60 m³	1.330	0.004	0.499	0.078	0.078	0.075	0.129	0.000	0.049	0.008	0.008	0.007	3330.14	949.24	94.92	832.53	237.31	23.73	3.85E-05	1.10E-05	1.10E-06	1.00	0.50	0.16			1	1		
Doris to Boston	Passenger Bus	0.859	0.004	0.203	0.029	0.029	0.028	0.043	0.000	0.010	0.001	0.001	0.001	2317.62	660.63	66.06	579.40	165.16	16.52	5.36E-05	1.53E-05	1.53E-06	1.00	0.50	0.01			1			
Doris to Boston	Service Pickup Truck	1.330	0.004	0.499	0.078	0.078	0.075	0.598	0.002	0.224	0.035	0.035	0.034	1430.79	407.84	40.78	357.70	101.96	10.20	3.31E-04	9.44E-05	9.44E-06	1.00	0.50	0.48			1	1		
Doris to Boston	Super B Train Haul Truck	1.330	0.004	0.499	0.078	0.078	0.075	0.259	0.001	0.097	0.015	0.015	0.015	3149.73	897.82	89.78	787.43	224.45	22.45	1.82E-04	5.20E-05	5.20E-06	1.00	1.00	0.96			1			
Doris to Boston	Super B Train Haul Truck	1.330	0.004	0.499	0.078	0.078	0.075	0.000	0.000	0.000	0.000	0.000	0.000	3149.73	897.82	89.78	787.43	224.45	22.45	0.00E+00	0.00E+00	0.00E+00	1.00	1.00	0.96				1		
Doris to Boston	Flatbed for supplies	1.330	0.004	0.499	0.078	0.078	0.075	0.129	0.000	0.049	0.008	0.008	0.007	3149.73	897.82	89.78	787.43	224.45	22.45	7.29E-05	2.08E-05	2.08E-06	1.00	0.50	0.48					1	1
Doris to Boston	Fuel Tanker 60 m³	1.330	0.004	0.499	0.078	0.078	0.075	0.129	0.000	0.049	0.008	0.008	0.007	3330.14	949.24	94.92	832.53	237.31	23.73	3.85E-05	1.10E-05	1.10E-06	1.00	0.50	0.16					1	1
Doris to Boston	Passenger Bus	0.859	0.004	0.203	0.029	0.029	0.028	0.043	0.000	0.010	0.001	0.001	0.001	2317.62	660.63	66.06	579.40	165.16	16.52	5.36E-05	1.53E-05	1.53E-06	1.00	0.50	0.01					1	
Doris to Boston	Service Pickup Truck	1.330	0.004	0.499	0.078	0.078	0.075	0.598	0.002	0.224	0.035	0.035	0.034	1430.79	407.84	40.78	357.70	101.96	10.20	3.31E-04	9.44E-05	9.44E-06	1.00	0.50	0.48					1	1
Doris to Boston	Super B Train Haul Truck	1.330	0.004	0.499	0.078	0.078	0.075	0.259	0.001	0.097	0.015	0.015	0.015	3149.73	897.82	89.78	787.43	224.45	22.45	1.82E-04	5.20E-05	5.20E-06	1.00	1.00	0.96					1	
Doris to Boston	Super B Train Haul Truck	1.330	0.004	0.499	0.078	0.078	0.075	0.000	0.000	0.000	0.000	0.000	0.000	3149.73	897.82	89.78	787.43	224.45	22.45	0.00E+00	0.00E+00	0.00E+00	1.00	1.00	0.96						1
Boston Portal to middle of Ore Stockpile	Underground Mining Truck	1.330	0.004	0.499	0.078	0.078	0.075	0.446	0.001	0.167	0.026	0.026	0.025	3803.10	1084.06	108.41	950.77	271.01	27.10	1.76E-03	5.02E-04	5.02E-05	1.00	1.00	1.00						1
Boston Portal to middle of Waste Rock pile	Underground Mining Truck	1.330	0.004	0.499	0.078	0.078	0.075	0.178	0.001	0.067	0.010	0.010	0.010	3803.10	1084.06	108.41	950.77	271.01	27.10	8.07E-04	2.30E-04	2.30E-05	1.00	1.00	1.00						1
Boston Mill to middle of Drystack Tailings	Haul Truck	1.330	0.004	0.499	0.078	0.078	0.075	0.320	0.001	0.120	0.019	0.019	0.018	4136.01	1178.95	117.90	1034.00	294.74	29.47	1.21E-03	3.45E-04	3.45E-05	1.00	1.00	1.00						1
Boston camp to portal	Crew Busses 16+ passenger	1.330	0.004	0.499	0.078	0.078	0.075	0.091	0.000	0.034	0.005	0.005	0.005	1575.61	449.12	44.91	393.90	112.28	11.23	1.09E-04	3.12E-05	3.12E-06	1.00	1.00	0.96					1	1
Boston airstrip to camp	Passenger Bus	0.859	0.004	0.203	0.029	0.029	0.028	0.043	0.000	0.010	0.001	0.001	0.001	2317.62	660.63	66.06	579.40	165.16	16.52	5.36E-05	1.53E-05	1.53E-06	1.00	0.50	0.01						1
Boston airstrip to camp	Service Pickup Truck	1.330	0.004	0.499	0.078	0.078	0.075	0.100	0.000	0.037	0.006	0.006	0.006	1430.79	407.84	40.78	357.70	101.96	10.20	3.31E-05	9.44E-06	9.44E-07	1.00	0.50	0.48					1	1

NOTES:

ETSP, EPM_{10}, $EPM_{2.5}$ - particulate matter resulting from combustion

FTSP, FPM_{10}, $FPM_{2.5}$ - fugitive particulate matter

"—" Not applicable

" " - equal to 0

Table A-10 Grading Parameters and Fugitive Emission Rates

Grading Emission Source	Grader Speed	Utilization	Activity Schedule		Emission Factors			Emission Rates									Emission Scaling Factors			Modelling Domain and Scenario to Apply Emission					
			Hours per Day	Days per Year	TSP	PM_{10}	$PM_{2.5}$	NO_X	SO_2	CO	ETSP	EPM_{10}	$EPM_{2.5}$	FTSP	FPM_{10}	$FPM_{2.5}$	Hourly	Daily	Annual	Existing North Con.	Existing North Ops.	Project North Con.	Project North Ops.	Project South Con.	Project South Ops.
	(km/h)	(%)	h/d	d/y	(kg/VKT)	(kg/VKT)	(kg/VKT)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	—	—	—	(1=yes; " "=no)					
AWR, Roberts Bay New Dock to Roberts Bay Laydown	11.4	70%	12	365	1.492	0.437	0.046	—	—	—	—	—	—	3.307	0.968	0.103	1.00	0.50	0.50			1			
AWR, Madrid North to Madrid South road section	11.4	70%	12	365	1.492	0.437	0.046	—	—	—	—	—	—	3.307	0.968	0.103	1.00	0.50	0.50			1			
AWR, Madrid South to Boston road section	11.4	70%	12	365	1.492	0.437	0.046	—	—	—	—	—	—	3.307	0.968	0.103	1.00	0.50	0.50			1			
AWR, Madrid South to Boston road section	11.4	70%	12	365	1.492	0.437	0.046	—	—	—	—	—	—	3.307	0.968	0.103	1.00	0.50	0.50					1	
Doris Waste Rock Pile	11.4	70%	8	365	1.492	0.437	0.046	—	—	—	—	—	—	3.307	0.968	0.103	1.00	0.33	0.33	1					
Doris Ore Pile	11.4	70%	8	365	1.492	0.437	0.046	—	—	—	—	—	—	3.307	0.968	0.103	1.00	0.33	0.33	1	1				
Madrid North Waste Rock Pile	11.4	70%	8	365	1.492	0.437	0.046	—	—	—	—	—	—	3.307	0.968	0.103	1.00	0.33	0.33			1	1		
Madrid North Ore Pile	11.4	70%	8	365	1.492	0.437	0.046	—	—	—	—	—	—	3.307	0.968	0.103	1.00	0.33	0.33			1	1		
Madrid South Waste Rock Pile	11.4	70%	8	365	1.492	0.437	0.046	—	—	—	—	—	—	3.307	0.968	0.103	1.00	0.33	0.33				1		
Madrid South Ore Pile	11.4	70%	8	365	1.492	0.437	0.046	—	—	—	—	—	—	3.307	0.968	0.103	1.00	0.33	0.33				1		
Boston Waste Rock Pile	11.4	70%	8	365	1.492	0.437	0.046	—	—	—	—	—	—	3.307	0.968	0.103	1.00	0.33	0.33						1
Boston Ore Pile	11.4	70%	8	365	1.492	0.437	0.046	—	—	—	—	—	—	3.307	0.968	0.103	1.00	0.33	0.33						1
Boston Overburden	11.4	70%	8	365	1.492	0.437	0.046	—	—	—	—	—	—	3.307	0.968	0.103	1.00	0.33	0.33					1	
Boston airstrip, construction	11.4	70%	3	365	1.492	0.437	0.046	—	—	—	—	—	—	3.307	0.968	0.103	1.00	0.13	0.13					1	
Boston general camp area, construction	11.4	70%	3	365	1.492	0.437	0.046	—	—	—	—	—	—	3.307	0.968	0.103	1.00	0.13	0.13					1	
Quarry AH, construction	11.4	70%	3	365	1.492	0.437	0.046	—	—	—	—	—	—	3.307	0.968	0.103	1.00	0.13	0.13			1			
Quarry H, construction	11.4	70%	3	365	1.492	0.437	0.046	—	—	—	—	—	—	3.307	0.968	0.103	1.00	0.13	0.13			1			
Quarry AJ, construction	11.4	70%	3	365	1.492	0.437	0.046	—	—	—	—	—	—	3.307	0.968	0.103	1.00	0.13	0.13					1	
Quarry U, construction	11.4	70%	3	365	1.492	0.437	0.046	—	—	—	—	—	—	3.307	0.968	0.103	1.00	0.13	0.13					1	

NOTES:

ETSP, EPM_{10}, $EPM_{2.5}$ - particulate matter resulting from combustion

FTSP, FPM_{10}, $FPM_{2.5}$ - fugitive particulate matter

"—" Not applicable

" " - equal to 0

Table A-11 Bulldozing Parameters and Fugitive Emission Rates

Bulldozing Emission Source	Utilization	Activity Schedule		Silt Content	Moisture Content	Emission Factors			Emission Rates									Emission Scaling Factors			Modelling Domain and Scenario to Apply Emission					
		Hours per Day	Days per Year			TSP	PM_{10}	$PM_{2.5}$	NO_X	SO_2	CO	ETSP	EPM_{10}	$EPM_{2.5}$	FTSP	FPM_{10}	$FPM_{2.5}$	Hourly	Daily	Annual	Existing North Con.	Existing North Ops.	Project North Con.	Project North Ops.	Project South Con.	Project South Ops.
	(%)	h/d	d/y	(%)	(%)	(kg/hr)	(kg/hr)	(kg/hr)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	—	—	—	(1=yes; " "=no)					
Doris Waste Rock Pile	70%	24	365	6.9	7.9	1.798	0.339	0.189	—	—	—	—	—	—	0.350	0.066	0.037	1.00	1.00	1.00	1					
Doris Ore Pile	70%	24	365	6.9	7.9	1.798	0.339	0.189	—	—	—	—	—	—	0.350	0.066	0.037	1.00	1.00	1.00	1	1				
Madrid North Waste Rock Pile	70%	24	365	6.9	7.9	1.798	0.339	0.189	—	—	—	—	—	—	0.350	0.066	0.037	1.00	1.00	1.00			1	1		
Madrid North Ore Pile	70%	24	365	6.9	7.9	1.798	0.339	0.189	—	—	—	—	—	—	0.350	0.066	0.037	1.00	1.00	1.00			1	1		
Madrid South Waste Rock Pile	70%	24	365	6.9	7.9	1.798	0.339	0.189	—	—	—	—	—	—	0.350	0.066	0.037	1.00	1.00	1.00				1		
Madrid South Ore Pile	70%	24	365	6.9	7.9	1.798	0.339	0.189	—	—	—	—	—	—	0.350	0.066	0.037	1.00	1.00	1.00				1		
Boston Waste Rock Pile	70%	24	365	6.9	7.9	1.798	0.339	0.189	—	—	—	—	—	—	0.350	0.066	0.037	1.00	1.00	1.00						1
Boston Ore Pile	70%	24	365	6.9	7.9	1.798	0.339	0.189	—	—	—	—	—	—	0.350	0.066	0.037	1.00	1.00	1.00						1
Boston Overburden	70%	24	365	6.9	7.9	1.798	0.339	0.189	—	—	—	—	—	—	0.350	0.066	0.037	1.00	1.00	1.00					1	
Boston Tailings	70%	8	365	51.2	7.9	19.915	6.847	2.091	—	—	—	—	—	—	3.872	1.331	0.407	1.00	0.33	0.33						1
Boston airstrip, construction	70%	24	365	6.9	7.9	1.798	0.339	0.189	—	—	—	—	—	—	0.350	0.066	0.037	1.00	1.00	1.00					1	
Boston general camp area, construction	70%	24	365	6.9	7.9	1.798	0.339	0.189	—	—	—	—	—	—	0.350	0.066	0.037	1.00	1.00	1.00					1	
Madrid North to Madrid South Road, construction	70%	24	365	6.9	7.9	1.798	0.339	0.189	—	—	—	—	—	—	0.350	0.066	0.037	1.00	1.00	1.00			1			
Madrid South to Boston road section	70%	24	365	6.9	7.9	1.798	0.339	0.189	—	—	—	—	—	—	0.350	0.066	0.037	1.00	1.00	1.00			1			
Madrid South to Boston road section	70%	24	365	6.9	7.9	1.798	0.339	0.189	—	—	—	—	—	—	0.350	0.066	0.037	1.00	1.00	1.00					1	
Quarry AH, construction	70%	24	365	6.9	7.9	1.798	0.339	0.189	—	—	—	—	—	—	0.350	0.066	0.037	1.00	1.00	1.00			1			
Quarry H, construction	70%	24	365	6.9	7.9	1.798	0.339	0.189	—	—	—	—	—	—	0.350	0.066	0.037	1.00	1.00	1.00			1			
Quarry AJ, construction	70%	24	365	6.9	7.9	1.798	0.339	0.189	—	—	—	—	—	—	0.350	0.066	0.037	1.00	1.00	1.00					1	
Quarry U, construction	70%	24	365	6.9	7.9	1.798	0.339	0.189	—	—	—	—	—	—	0.350	0.066	0.037	1.00	1.00	1.00					1	

NOTES:

ETSP, EPM_{10}, $EPM_{2.5}$ - particulate matter resulting from combustion

FTSP, FPM_{10}, $FPM_{2.5}$ - fugitive particulate matter

"—" Not applicable

"   " - equal to 0

Table A-12 Material Transfer Parameters and Fugitive Emission Rates

Material Transfer Emission Source	Material Transfer Rate	Silt Content	Moisture Content	Max Pile Height	Annual Average Wind Speed	Estimated Wind Speed at 2/3 Pile Height	Emission Factors			Emission Rates									Emission Scaling Factors			Modelling Domain and Scenario to Apply Emission					
							TSP	PM_{10}	$PM_{2.5}$	NO_X	SO_2	CO	ETSP	EPM_{10}	$EPM_{2.5}$	FTSP	FPM_{10}	$FPM_{2.5}$	Hourly	Daily	Annual	Existing North Con.	Existing North Ops.	Project North Con.	Project North Ops.	Project South Con.	Project South Ops.
	(tonne/ day)	(%)	(%)	(m)	(m/s)	(m/s)	(kg/Mg)	(kg/Mg)	(kg/Mg)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	—	—	—	(1=yes; " "=no)					
Doris Waste Rock Pile	827	6.9	7.9	23	4.37	4.91	4.91E-04	2.32E-04	3.51E-05	—	—	—	—	—	—	4.70E-03	2.22E-03	3.36E-04	1.00	1.00	1.00	1					
Doris Ore Pile	1973	6.9	7.9	4	4.37	2.72	2.28E-04	1.08E-04	1.64E-05	—	—	—	—	—	—	5.22E-03	2.47E-03	3.74E-04	1.00	1.00	1.00	1	1				
Madrid North Waste Rock Pile	1792	6.9	7.9	20	2.97	3.22	2.83E-04	1.34E-04	2.03E-05	—	—	—	—	—	—	5.88E-03	2.78E-03	4.21E-04	1.00	1.00	1.00			1	1		
Madrid North Ore Pile	3200	6.9	7.9	7	2.97	2.33	1.86E-04	8.80E-05	1.33E-05	—	—	—	—	—	—	6.89E-03	3.26E-03	4.93E-04	1.00	1.00	1.00			1	1		
Madrid South Waste Rock Pile	1781	6.9	7.9	20	2.82	3.05	2.65E-04	1.25E-04	1.90E-05	—	—	—	—	—	—	5.45E-03	2.58E-03	3.91E-04	1.00	1.00	1.00				1		
Madrid South Ore Pile	1414	6.9	7.9	4	2.82	1.76	1.29E-04	6.11E-05	9.25E-06	—	—	—	—	—	—	2.11E-03	9.99E-04	1.51E-04	1.00	1.00	1.00				1		
Boston Waste Rock Pile	1100	6.9	7.9	23	3.90	4.38	4.24E-04	2.00E-04	3.03E-05	—	—	—	—	—	—	5.39E-03	2.55E-03	3.86E-04	1.00	1.00	1.00						1
Boston Ore Pile	2400	6.9	7.9	5	3.90	2.68	2.24E-04	1.06E-04	1.60E-05	—	—	—	—	—	—	6.21E-03	2.94E-03	4.45E-04	1.00	1.00	1.00						1
Boston Overburden	1000	6.9	7.9	5	3.90	2.68	2.24E-04	1.06E-04	1.60E-05	—	—	—	—	—	—	2.59E-03	1.22E-03	1.85E-04	1.00	1.00	1.00					1	
Boston Tailings	2000	51.2	7.9	26	3.90	4.31	4.15E-04	1.96E-04	2.97E-05	—	—	—	—	—	—	9.60E-03	4.54E-03	6.87E-04	1.00	1.00	1.00						1

NOTES:

ETSP, EPM_{10}, $EPM_{2.5}$ - particulate matter resulting from combustion

FTSP, FPM_{10}, $FPM_{2.5}$ - fugitive particulate matter

"—" Not applicable

" " - equal to 0

Table A-13 Drilling Parameters and Fugitive Emission Rates

Drilling Emission Source	# Holes per Blast	# Blasts per Day	Emission Factors			Emission Rates									Emission Scaling Factors			Modelling Domain and Scenario to Apply Emission					
			TSP	PM_{10}	$PM_{2.5}$	NO_X	SO_2	CO	ETSP	EPM_{10}	$EPM_{2.5}$	FTSP	FPM_{10}	$FPM_{2.5}$	Hourly	Daily	Annual	Existing North Con.	Existing North Ops.	Project North Con.	Project North Ops.	Project South Con.	Project South Ops.
			(kg/hole)	(kg/hole)	(kg/hole)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	—	—	—	(1=yes; " "=no)					
Doris, underground mine. Emission release through mine portal.	5	7	0.59	0.31	0.31	—	—	—	—	—	—	0.819	0.431	0.431	1.00	0.29	0.29	1					
Madrid North, underground mine. Emission release through mine portal.	5	7	0.59	0.31	0.31	—	—	—	—	—	—	0.819	0.431	0.431	1.00	0.29	0.29			1	1		
Madrid South, underground mine. Emission release through mine portal.	5	7	0.59	0.31	0.31	—	—	—	—	—	—	0.819	0.431	0.431	1.00	0.29	0.29				1		
Boston, underground mine. Emission release through mine portal.	5	7	0.59	0.31	0.31	—	—	—	—	—	—	0.819	0.431	0.431	1.00	0.29	0.29						1
Quarry AH, construction	5	3	0.59	0.31	0.31	—	—	—	—	—	—	0.819	0.431	0.431	1.00	0.13	0.13			1			
Quarry H, construction	5	3	0.59	0.31	0.31	—	—	—	—	—	—	0.819	0.431	0.431	1.00	0.13	0.13			1			
Quarry AJ, construction	5	3	0.59	0.31	0.31	—	—	—	—	—	—	0.819	0.431	0.431	1.00	0.13	0.13					1	
Quarry U, construction	5	3	0.59	0.31	0.31	—	—	—	—	—	—	0.819	0.431	0.431	1.00	0.13	0.13					1	

NOTES:

ETSP, EPM_{10}, $EPM_{2.5}$ - particulate matter resulting from combustion

FTSP, FPM_{10}, $FPM_{2.5}$ - fugitive particulate matter

"—" Not applicable

"   " - equal to 0

Table A-14 Blasting Parameters and Emission Rates

Blasting Emission Source	Explosive Type	# Blasts per Day	ANFO Usage		Blasting Area	Explosives Emission Factors			Dust Emission Factors			Emission Rates									Emission Scaling Factors			Modelling Domain and Scenario to Apply Emission					
			per Day	per Blast		NO_X	SO_2	CO	TSP	PM_{10}	$PM_{2.5}$	NO_X	SO_2	CO	ETSP	EPM_{10}	$EPM_{2.5}$	FTSP	FPM_{10}	$FPM_{2.5}$	Hourly	Daily	Annual	Existing North Con.	Existing North Ops.	Project North Con.	Project North Ops.	Project South Con.	Project South Ops.
			(kg/d)	(kg/blast)	(m²)	(kg/tonne)	(kg/tonne)	(kg/tonne)	(kg/blast)	(kg/blast)	(kg/blast)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	—	—	—	(1=yes; " "=no)					
Doris, underground mine. Emission release through mine portal.	ANFO	7	3,070	439	200	1	8	34	0.62	0.32	0.02	0.975	0.122	4.142	—	—	—	0.173	0.090	0.005	1.00	0.29	0.29	1					
Madrid North, underground mine. Emission release through mine portal.	ANFO	7	6,420	917	200	1	8	34	0.62	0.32	0.02	2.038	0.255	8.662	—	—	—	0.173	0.090	0.005	1.00	0.29	0.29			1	1		
Madrid South, underground mine. Emission release through mine portal.	ANFO	7	3,370	481	200	1	8	34	0.62	0.32	0.02	1.070	0.134	4.547	—	—	—	0.173	0.090	0.005	1.00	0.29	0.29				1		
Boston, underground mine. Emission release through mine portal.	ANFO	7	4,815	688	200	1	8	34	0.62	0.32	0.02	1.529	0.191	6.496	—	—	—	0.173	0.090	0.005	1.00	0.29	0.29						1
Quarry AH, construction	ANFO	3	1,000	333	2,460	1	8	34	26.88	13.98	0.81	0.741	0.093	3.148	—	—	—	7.465	3.882	0.224	1.00	0.13	0.13			1			
Quarry H, construction	ANFO	3	1,000	333	2,460	1	8	34	26.89	13.98	0.81	0.741	0.093	3.148	—	—	—	7.470	3.884	0.224	1.00	0.13	0.13			1			
Quarry AJ, construction	ANFO	3	1,000	333	2,460	1	8	34	26.91	13.99	0.81	0.741	0.093	3.148	—	—	—	7.474	3.887	0.224	1.00	0.13	0.13					1	
Quarry U, construction	ANFO	3	1,000	333	2,460	1	8	34	26.86	13.97	0.81	0.741	0.093	3.148	—	—	—	7.461	3.880	0.224	1.00	0.13	0.13					1	

NOTES:

ETSP, EPM_{10}, $EPM_{2.5}$ - particulate matter resulting from combustion

FTSP, FPM_{10}, $FPM_{2.5}$ - fugitive particulate matter

"—" Not applicable

" " - equal to 0

Table A-15 Wind Erosion Parameters and Fugitive Emission Rates

Location	Emission Source	Footprint Area	Material Transfer Rate	Truck Payload Capacity	Number of Material Loadings			Disturbed Area per Hour	CALPUFF Wind Speed Category	Evaluated Wind Speed	Emission Factors			Control Efficiency (Chemical Application)	Controlled Emission Factors			Emission Rates									Emission Scaling Factors			Modelling Domain and Scenario to Apply Emission					
					per hour	per day	per year				TSP	PM_{10}	$PM_{2.5}$		TSP	PM10	PM2.5	NO_X	SO_2	CO	ETSP	EPM_{10}	$EPM_{2.5}$	FTSP	FPM_{10}	$FPM_{2.5}$	Hourly	Daily	Annual	Existing North Con.	Existing North Ops.	Project North Con.	Project North Ops.	Project South Con.	Project South Ops.
		m²	(tonne/d)	(tonne)	—	—	—	(m²/h)	(1-6)	(m/s)	(g/m²/disturbance)			(%)	(g/m²/disturbance)			(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	—	—	—	(1=yes; " "=no)					
Doris	Doris Waste Rock Pile	21,400	827	30	1.15	28	10,063	115	1	1.54	0	0	0	—	0	0	0	—	—	—	—	—	—	0	0	0	1.00	1.00	1.00	1	1				
									2	3.09	0	0	0	—	0	0	0	—	—	—	—	—	—	0	0	0	1.00	1.00	1.00	1	1				
									3	5.14	0	0	0	—	0	0	0	—	—	—	—	—	—	0	0	0	1.00	1.00	1.00	1	1				
									4	8.23	0	0	0	—	0	0	0	—	—	—	—	—	—	0	0	0	1.00	1.00	1.00	1	1				
									5	10.8	0	0	0	—	0	0	0	—	—	—	—	—	—	0	0	0	1.00	1.00	1.00	1	1				
									6	20	8.44	4.22	0.633	—	8.44	4.22	0.633	—	—	—	—	—	—	0.309	0.155	0.023	1.00	1.00	1.00	1	1				
Doris	Doris Ore stockpile	5,000	1,973	30	2.74	66	24,000	274	1	1.54	0	0	0	—	0	0	0	—	—	—	—	—	—	0	0	0	1.00	1.00	1.00	1	1				
									2	3.09	0	0	0	—	0	0	0	—	—	—	—	—	—	0	0	0	1.00	1.00	1.00	1	1				
									3	5.14	0	0	0	—	0	0	0	—	—	—	—	—	—	0	0	0	1.00	1.00	1.00	1	1				
									4	8.23	0	0	0	—	0	0	0	—	—	—	—	—	—	0	0	0	1.00	1.00	1.00	1	1				
									5	10.8	0	0	0	—	0	0	0	—	—	—	—	—	—	0	0	0	1.00	1.00	1.00	1	1				
									6	20	8.44	4.22	0.633	—	8.44	4.22	0.633	—	—	—	—	—	—	1.76	0.880	0.132	1.00	1.00	1.00	1	1				
Doris	Doris Overburden	67,855	1,000	40	1.05	25	9,241	105	1	1.54	0	0	0	—	0	0	0	—	—	—	—	—	—	0	0	0	1.00	1.00	1.00	1	1				
									2	3.09	0	0	0	—	0	0	0	—	—	—	—	—	—	0	0	0	1.00	1.00	1.00	1	1				
									3	5.14	0	0	0	—	0	0	0	—	—	—	—	—	—	0	0	0	1.00	1.00	1.00	1	1				
									4	8.23	0	0	0	—	0	0	0	—	—	—	—	—	—	0	0	0	1.00	1.00	1.00	1	1				
									5	10.8	0	0	0	—	0	0	0	—	—	—	—	—	—	0	0	0	1.00	1.00	1.00	1	1				
									6	20	8.44	4.22	0.633	—	8.44	4.22	0.633	—	—	—	—	—	—	0.261	0.130	0.020	1.00	1.00	1.00	1	1				
Doris	Doris TIA (Existing)	273,715	2,000	—	1.00	24	8,760	27,372	1	1.54	0	0	0	85%	0	0	0	—	—	—	—	—	—	0	0	0	1.00	1.00	1.00	1					
									2	3.09	0	0	0	85%	0	0	0	—	—	—	—	—	—	0	0	0	1.00	1.00	1.00	1					
									3	5.14	0	0	0	85%	0	0	0	—	—	—	—	—	—	0	0	0	1.00	1.00	1.00	1					
									4	8.23	0.49	0.25	0.037	85%	0.07	0.04	0.006	—	—	—	—	—	—	0.560	0.280	0.042	1.00	1.00	1.00	1					
									5	10.8	5.04	2.52	0.378	85%	0.76	0.38	0.057	—	—	—	—	—	—	5.75	2.873	0.431	1.00	1.00	1.00	1					
									6	20	37.58	18.79	2.819	85%	5.64	2.82	0.423	—	—	—	—	—	—	42.9	21.4	3.21	1.00	1.00	1.00	1					
Doris	Doris TIA (Madrid-Boston Project)	1,463,416	3,600	—	1.00	24	8,760	146,342	1	1.54	0	0	0	85%	0	0	0	—	—	—	—	—	—	0	0	0	1.00	1.00	1.00				1		
									2	3.09	0	0	0	85%	0	0	0	—	—	—	—	—	—	0	0	0	1.00	1.00	1.00				1		
									3	5.14	0	0	0	85%	0	0	0	—	—	—	—	—	—	0	0	0	1.00	1.00	1.00				1		
									4	8.23	0.49	0.25	0.037	85%	0.07	0.04	0.006	—	—	—	—	—	—	3.00	1.50	0.225	1.00	1.00	1.00				1		
									5	10.8	5.04	2.52	0.378	85%	0.76	0.38	0.057	—	—	—	—	—	—	30.7	15.4	2.3	1.00	1.00	1.00				1		
									6	20	37.58	18.79	2.819	85%	5.64	2.82	0.423	—	—	—	—	—	—	229	115	17.2	1.00	1.00	1.00				1		
Madrid North	Madrid North Waste Rock Pile	32,888	1,792	30	2.49	60	21,803	249	1	1.54	0	0	0	—	0	0	0	—	—	—	—	—	—	0	0	0	1.00	1.00	1.00			1	1		
									2	3.09	0	0	0	—	0	0	0	—	—	—	—	—	—	0	0	0	1.00	1.00	1.00			1	1		
									3	5.14	0	0	0	—	0	0	0	—	—	—	—	—	—	0	0	0	1.00	1.00	1.00			1	1		
									4	8.23	0	0	0	—	0	0	0	—	—	—	—	—	—	0	0	0	1.00	1.00	1.00			1	1		
									5	10.8	0	0	0	—	0	0	0	—	—	—	—	—	—	0	0	0	1.00	1.00	1.00			1	1		
									6	20	8.44	4.22	0.633	—	8.44	4.22	0.633	—	—	—	—	—	—	1.45	0.726	0.109	1.00	1.00	1.00			1	1		
Madrid North	Madrid North Ore stockpile	2,000	3,200	30	4.44	107	38,933	444	1	1.54	0	0	0	—	0	0	0	—	—	—	—	—	—	0	0	0	1.00	1.00	1.00			1	1		
									2	3.09	0	0	0	—	0	0	0	—	—	—	—	—	—	0	0	0	1.00	1.00	1.00			1	1		
									3	5.14	0	0	0	—	0	0	0	—	—	—	—	—	—	0	0	0	1.00	1.00	1.00			1	1		
									4	8.23	0	0	0	—	0	0	0	—	—	—	—	—	—	0	0	0	1.00	1.00	1.00			1	1		
									5	10.8	0	0	0	—	0	0	0	—	—	—	—	—	—	0	0	0	1.00	1.00	1.00			1	1		
									6	20	8.44	4.22	0.633	—	8.44	4.22	0.633	—	—	—	—	—	—	4.63	2.316	0.347	1.00	1.00	1.00			1	1		
Madrid South	Madrid South Waste Rock Pile	45,150	1,781	30	2.47	59	21,669	247	1	1.54	0	0	0	—	0	0	0	—	—	—	—	—	—	0	0	0	1.00	1.00	1.00				1		
									2	3.09	0	0	0	—	0	0	0	—	—	—	—	—	—	0	0	0	1.00	1.00	1.00				1		
									3	5.14	0	0	0	—	0	0	0	—	—	—	—	—	—	0	0	0	1.00	1.00	1.00				1		
									4	8.23	0	0	0	—	0	0	0	—	—	—	—	—	—	0	0	0	1.00	1.00	1.00				1		
									5	10.8	0	0	0	—	0	0	0	—	—	—	—	—	—	0	0	0	1.00	1.00	1.00				1		
									6	20	8.44	4.22	0.633	—	8.44	4.22	0.633	—	—	—	—	—	—	1.435	0.717	0.108	1.00	1.00	1.00				1		
Madrid South	Madrid South Ore stockpile	1,162	1,414	30	1.96	47	17,200	196	1	1.54	0	0	0	—	0	0	0	—	—	—	—	—	—	0	0	0	1.00	1.00	1.00				1		
									2	3.09	0	0	0	—	0	0	0	—	—	—	—	—	—	0	0	0	1.00	1.00	1.00				1		
									3	5.14	0	0	0	—	0	0	0	—	—	—	—	—	—	0	0	0	1.00	1.00	1.00				1		
									4	8.23	0	0	0	—	0	0	0	—	—	—	—	—	—	0	0	0	1.00	1.00	1.00				1		
									5	10.8	0	0	0	—	0	0	0	—	—	—	—	—	—	0	0	0	1.00	1.00	1.00				1		
									6	20	8.44	4.22	0.633	—	8.44	4.22	0.633	—	—	—	—	—	—	0.904	0.452	0.068	1.00	1.00	1.00				1		
Boston	Boston Waste Rock Pile	37,500	1,100	30	1.53	37	13,383	153	1	1.54	0	0	0	—	0	0	0	—	—	—	—	—	—	0	0	0	1.00	1.00	1.00						1
									2	3.09	0	0	0	—	0	0	0	—	—	—	—	—	—	0	0	0	1.00	1.00	1.00						1
									3	5.14	0	0	0	—	0	0	0	—	—	—	—	—	—	0	0	0	1.00	1.00	1.00						1
									4	8.23	0	0	0	—	0	0	0	—	—	—	—	—	—	0	0	0	1.00	1.00	1.00						1
									5	10.8	0	0	0	—	0	0	0	—	—	—	—	—	—	0	0	0	1.00	1.00	1.00						1
									6	20	8.44	4.22	0.633	—	8.44	4.22	0.633	—	—	—	—	—	—	0.547	0.274	0.041	1.00	1.00	1.00						1

Table A-15 Wind Erosion Parameters and Fugitive Emission Rates

Location	Emission Source	Footprint Area	Material Transfer Rate	Truck Payload Capacity	Number of Material Loadings			Disturbed Area per Hour	CALPUFF Wind Speed Category	Evaluated Wind Speed	Emission Factors			Control Efficiency (Chemical Application)	Controlled Emission Factors			Emission Rates									Emission Scaling Factors			Modelling Domain and Scenario to Apply Emission					
					per hour	per day	per year				TSP	PM_{10}	$PM_{2.5}$		TSP	PM10	PM2.5	NO_X	SO_2	CO	ETSP	EPM_{10}	$EPM_{2.5}$	FTSP	FPM_{10}	$FPM_{2.5}$	Hourly	Daily	Annual	Existing North Con.	Existing North Ops.	Project North Con.	Project North Ops.	Project South Con.	Project South Ops.
		m²	(tonne/d)	(tonne)	—	—	—	(m²/h)	(1-6)	(m/s)	(g/m²/disturbance)			(%)	(g/m²/disturbance)			(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	—	—	—	(1=yes; " "=no)					
Boston	Boston Ore stockpile	1,600	2,400	30	3.33	80	29,200	333	1	1.54	0	0	0	—	0	0	0	—	—	—	—	—	—	0	0	0	1.00	1.00	1.00						1
									2	3.09	0	0	0	—	0	0	0	—	—	—	—	—	—	0	0	0	1.00	1.00	1.00						1
									3	5.14	0	0	0	—	0	0	0	—	—	—	—	—	—	0	0	0	1.00	1.00	1.00						1
									4	8.23	0	0	0	—	0	0	0	—	—	—	—	—	—	0	0	0	1.00	1.00	1.00						1
									5	10.8	0	0	0	—	0	0	0	—	—	—	—	—	—	0	0	0	1.00	1.00	1.00						1
									6	20	8.44	4.22	0.633	—	8.44	4.22	0.633	—	—	—	—	—	—	2.61	1.303	0.195	1.00	1.00	1.00						1
Boston	Boston Overburden	16,600	1,000	40	1.05	25	9,241	105	1	1.54	0	0	0	—	0	0	0	—	—	—	—	—	—	0	0	0	1.00	1.00	1.00					1	1
									2	3.09	0	0	0	—	0	0	0	—	—	—	—	—	—	0	0	0	1.00	1.00	1.00					1	1
									3	5.14	0	0	0	—	0	0	0	—	—	—	—	—	—	0	0	0	1.00	1.00	1.00					1	1
									4	8.23	0	0	0	—	0	0	0	—	—	—	—	—	—	0	0	0	1.00	1.00	1.00					1	1
									5	10.8	0	0	0	—	0	0	0	—	—	—	—	—	—	0	0	0	1.00	1.00	1.00					1	1
									6	20	8.44	4.22	0.633	—	8.44	4.22	0.633	—	—	—	—	—	—	0.261	0.130	0.020	1.00	1.00	1.00					1	1
Boston	Boston Tailings (dry stack)	197,609	2,000	40	2.11	51	18,481	211	1	1.54	0	0	0	—	0	0	0	—	—	—	—	—	—	0	0	0	1.00	1.00	1.00						1
									2	3.09	0	0	0	—	0	0	0	—	—	—	—	—	—	0	0	0	1.00	1.00	1.00						1
									3	5.14	0	0	0	—	0	0	0	—	—	—	—	—	—	0	0	0	1.00	1.00	1.00						1
									4	8.23	0.49	0.25	0.037	—	0.49	0.25	0.037	—	—	—	—	—	—	0.061	0.030	0.005	1.00	1.00	1.00						1
									5	10.8	5.04	2.52	0.378	—	5.04	2.52	0.378	—	—	—	—	—	—	0.623	0.312	0.047	1.00	1.00	1.00						1
									6	20	37.58	18.79	2.819	—	37.58	18.79	2.819	—	—	—	—	—	—	4.65	2.323	0.349	1.00	1.00	1.00						1

NOTES:

ETSP, EPM_{10}, $EPM_{2.5}$ - particulate matter resulting from combustion

FTSP, FPM_{10}, $FPM_{2.5}$ - fugitive particulate matter

"—" Not applicable

" " - equal to 0

Table A-16 Existing Doris Mobile Equipment and Emission Rates

Location	Equipment Type	Equipment Model	Application (SURFACE/ UNDERGROUND)	Number of Units	Horse-power	GVWR	Running Load Factor	Emission Factors						Emission Rates					
					(hp)	(tonne)	(%)	NO_X (g/hp-hr)	SO_2 (g/hp-hr)	CO (g/hp-hr)	TSP (g/hp-hr)	PM_{10} (g/hp-hr)	$PM_{2.5}$ (g/hp-hr)	NO_X (g/s)	SO_2 (g/s)	CO (g/s)	ETSP (g/s)	EPM_{10} (g/s)	$EPM_{2.5}$ (g/s)
Doris	Articulated Truck	CAT 740B	SURFACE	2	489	73.98	59%	3.347	4.93E-03	1.453	0.209	0.209	0.203	0.537	7.90E-04	0.233	0.034	0.034	0.033
Doris	Articulated Truck	CAT 725	SURFACE	1	320	47.04	59%	3.347	4.93E-03	1.453	0.209	0.209	0.203	0.176	2.59E-04	0.076	0.011	0.011	0.011
Doris	Hydraulic Excavator	CAT 349L	SURFACE	1	396	53.30	53%	3.909	4.93E-03	1.640	0.218	0.218	0.212	0.228	2.87E-04	0.096	0.013	0.013	0.012
Doris	Hydraulic Excavator	CAT 325DL	SURFACE	1	204	29.24	53%	3.377	4.93E-03	1.222	0.230	0.230	0.223	0.101	1.48E-04	0.037	0.007	0.007	0.007
Doris	Hydraulic Excavator	CAT 329	SURFACE	1	204	29.24	53%	3.377	4.93E-03	1.222	0.230	0.230	0.223	0.101	1.48E-04	0.037	0.007	0.007	0.007
Doris	Hydraulic Excavator	CAT 308C	SURFACE	1	55	8.04	53%	4.181	5.47E-03	3.387	0.397	0.397	0.386	0.034	4.43E-05	0.027	0.003	0.003	0.003
Doris	Wheel Loader	CAT 988H	SURFACE	1	555	50.14	48%	4.626	4.93E-03	2.012	0.271	0.271	0.263	0.342	3.65E-04	0.149	0.020	0.020	0.019
Doris	Wheel Loader	CAT 980H	SURFACE	1	359	29.95	48%	4.626	4.93E-03	2.012	0.271	0.271	0.263	0.221	2.36E-04	0.096	0.013	0.013	0.013
Doris	Wheel Loader	CAT 930H	SURFACE	1	149	13.03	48%	4.079	4.93E-03	1.543	0.328	0.328	0.318	0.081	9.79E-05	0.031	0.007	0.007	0.006
Doris	Backhoe Loader	CAT 420F	SURFACE	1	94	11.00	21%	6.293	6.36E-03	7.627	1.156	1.156	1.121	0.035	3.49E-05	0.042	0.006	0.006	0.006
Doris	Multi Terain Loader	CAT 257	SURFACE	1	74	3.65	23%	6.185	6.36E-03	6.993	1.066	1.066	1.034	0.029	3.02E-05	0.033	0.005	0.005	0.005
Doris	Multi Terrain Loader	CAT 287C	SURFACE	1	74	4.50	23%	6.185	6.36E-03	6.993	1.066	1.066	1.034	0.029	3.02E-05	0.033	0.005	0.005	0.005
Doris	Skid Steer Loader	CAT 272H	SURFACE	1	98	3.74	23%	6.738	6.35E-03	8.321	1.285	1.285	1.246	0.042	3.97E-05	0.052	0.008	0.008	0.008
Doris	Compact Track Loader	ASV RT-30	SURFACE	1	33	1.63	23%	5.416	6.37E-03	4.715	0.790	0.790	0.766	0.011	1.33E-05	0.010	0.002	0.002	0.002
Doris	Motor Grader	CAT 14M	SURFACE	1	259	24.38	58%	3.555	4.93E-03	1.233	0.237	0.237	0.230	0.148	2.06E-04	0.051	0.010	0.010	0.010
Doris	Motor Grader	CAT 140G	SURFACE	1	150	12.62	58%	3.728	4.93E-03	1.449	0.318	0.318	0.308	0.090	1.19E-04	0.035	0.008	0.008	0.007
Doris	Vibratory Soil Compactor	CAT CS-74B	SURFACE	1	174	16.36	59%	4.080	4.93E-03	1.542	0.328	0.328	0.318	0.116	1.40E-04	0.044	0.009	0.009	0.009
Doris	Dozer	CAT D8T	SURFACE	1	363	39.42	58%	4.190	4.93E-03	1.769	0.232	0.232	0.225	0.245	2.88E-04	0.103	0.014	0.014	0.013
Doris	Dozer	CAT D6R	SURFACE	1	179	18.14	58%	3.586	4.93E-03	1.237	0.238	0.238	0.231	0.103	1.42E-04	0.036	0.007	0.007	0.007
Doris	Snow Groomer	Prinoth BR 350	SURFACE	1	350	8.41	58%	4.190	4.93E-03	1.769	0.232	0.232	0.225	0.236	2.78E-04	0.100	0.013	0.013	0.013
Doris	Telehandler	CAT TL1255	SURFACE	1	142	16.27	59%	4.287	4.93E-03	1.633	0.336	0.336	0.326	0.100	1.15E-04	0.038	0.008	0.008	0.008
Doris	Telehandler	JLG 1055	SURFACE	1	130	11.52	59%	4.287	4.93E-03	1.633	0.336	0.336	0.326	0.091	1.05E-04	0.035	0.007	0.007	0.007
Doris	Telehandler	CAT TL943	SURFACE	1	111	12.03	59%	4.287	4.93E-03	1.633	0.336	0.336	0.326	0.078	8.98E-05	0.030	0.006	0.006	0.006
Doris	Toolcarrier	CAT IT28G	SURFACE	1	144	12.13	59%	4.287	4.93E-03	1.633	0.336	0.336	0.326	0.101	1.16E-04	0.039	0.008	0.008	0.008
Doris	Forklift	Hyster H80-120FT	SURFACE	1	74	9.65	59%	4.662	5.47E-03	3.708	0.514	0.514	0.498	0.057	6.63E-05	0.045	0.006	0.006	0.006
Doris	Rough Terrain Forklift	JCB 930	SURFACE	1	74	6.62	59%	4.662	5.47E-03	3.708	0.514	0.514	0.498	0.057	6.63E-05	0.045	0.006	0.006	0.006
Doris	Mobile Boom Lift	Geniew Z60/34	SURFACE	1	75	10.22	21%	7.125	6.35E-03	6.886	1.075	1.075	1.042	0.031	2.78E-05	0.030	0.005	0.005	0.005
Doris	Mobile Scissor Lift	Geniew GS-5390RT	SURFACE	1	75	7.52	21%	7.125	6.35E-03	6.886	1.075	1.075	1.042	0.031	2.78E-05	0.030	0.005	0.005	0.005
Doris	Mobile Telescopic Lift	Genie S-60	SURFACE	1	75	9.31	21%	7.125	6.35E-03	6.886	1.075	1.075	1.042	0.031	2.78E-05	0.030	0.005	0.005	0.005
Doris	Mobile Telescopic Lift	Genie S-65	SURFACE	3	75	10.02	21%	7.125	6.35E-03	6.886	1.075	1.075	1.042	0.094	8.34E-05	0.090	0.014	0.014	0.014
Doris	Mobile Telescopic Lift	Geniew S-80	SURFACE	1	74	16.10	21%	7.125	6.35E-03	6.886	1.075	1.075	1.042	0.031	2.74E-05	0.030	0.005	0.005	0.004
Doris	Mobile Telescopic Lift	Geniew S-85	SURFACE	1	74	17.19	21%	7.125	6.35E-03	6.886	1.075	1.075	1.042	0.031	2.74E-05	0.030	0.005	0.005	0.004
Doris	RTV	Polaris Sportsman 6x6 570	SURFACE	4	44	1.00	59%	6.396	6.33E-03	8.826	1.253	1.253	1.215	0.184	1.83E-04	0.255	0.036	0.036	0.035
Doris	RTV	Kubota RTV-X1100C	SURFACE	4	25	1.81	59%	7.302	6.33E-03	9.826	1.396	1.396	1.354	0.119	1.03E-04	0.160	0.023	0.023	0.022
Doris	Self-propelled All Terrain Fusion Machine (joining PE pipes)	TracStar 412/618	SURFACE	1	20	0.95	21%	4.557	5.46E-03	3.325	0.414	0.414	0.402	0.005	6.38E-06	0.0039	0.0005	0.0005	0.0005
Doris	Generator/Welder - Diesel	Miller 800	SURFACE	3	66	—	21%	6.317	6.35E-03	7.654	1.146	1.146	1.112	0.073	7.30E-05	0.088	0.013	0.013	0.013
Doris	Generator/Welder - Diesel	SQ-3350	SURFACE	3	38	—	21%	6.065	6.34E-03	7.505	1.118	1.118	1.084	0.040	4.17E-05	0.049	0.007	0.007	0.007
Doris	Generator/Welder - Diesel	Lincoln 300D	SURFACE	1	33	—	21%	6.065	6.34E-03	7.505	1.118	1.118	1.084	0.012	1.21E-05	0.014	0.002	0.002	0.002
Doris	Mobile Light Tower	Magnum MLT3060	SURFACE	8	13	0.82	43%	6.074	5.40E-03	3.589	0.606	0.606	0.588	0.078	6.91E-05	0.046	0.008	0.008	0.008

Table A-16 Existing Doris Mobile Equipment and Emission Rates

Location	Equipment Type	Equipment Model	Application (SURFACE/ UNDERGROUND)	Number of Units	Horse-power	GVWR	Running Load Factor	Emission Factors						Emission Rates					
								NO_X	SO_2	CO	TSP	PM_{10}	$PM_{2.5}$	NO_X	SO_2	CO	ETSP	EPM_{10}	$EPM_{2.5}$
					(hp)	(tonne)	(%)	(g/hp-hr)	(g/hp-hr)	(g/hp-hr)	(g/hp-hr)	(g/hp-hr)	(g/hp-hr)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)
Doris	Mobile Light Tower	Wacker LTC 4	SURFACE	5	13	0.82	43%	6.074	5.40E-03	3.589	0.606	0.606	0.588	0.049	4.32E-05	0.029	0.005	0.005	0.005
Doris	Heavy Duty Truck	Kenworth T800 with Paccar MX-13 engine	SURFACE	3	500	40.37	70%	3.347	4.93E-03	1.453	0.209	0.209	0.203	0.976	1.44E-03	0.424	0.061	0.061	0.059
Doris	Freightliner Truck	Freightliner 108SD	SURFACE	1	380	31.30	70%	3.347	4.93E-03	1.453	0.209	0.209	0.203	0.247	3.64E-04	0.107	0.015	0.015	0.015
Doris	Fuel/Water truck	Kenworth T370 with Paccar PX-9 engine	SURFACE	2	380	27.22	70%	3.347	4.93E-03	1.453	0.209	0.209	0.203	0.495	7.29E-04	0.215	0.031	0.031	0.030
Doris	Fuel/Water truck	Peterbilt 348 with PACCAR PX-7 Engine	SURFACE	3	360	27.22	70%	3.347	4.93E-03	1.453	0.209	0.209	0.203	0.703	1.04E-03	0.305	0.044	0.044	0.043
Doris	General Truck	Sterling Acterra Class 5-8	SURFACE	1	350	29.94	70%	3.347	4.93E-03	1.453	0.209	0.209	0.203	0.228	3.36E-04	0.099	0.014	0.014	0.014
Doris	Passenger Van	Mercedes Sprinter 2500	SURFACE	1	188	5.00	70%	2.960	4.93E-03	1.240	0.237	0.237	0.229	0.108	1.80E-04	0.045	0.009	0.009	0.008
Doris	Transporter Truck	Ford E450	SURFACE	2	350	6.35	70%	3.347	4.93E-03	1.453	0.209	0.209	0.203	0.456	6.71E-04	0.198	0.029	0.029	0.028
Doris	Pickup Truck	Ford F250	SURFACE	3	330	4.54	70%	3.347	4.93E-03	1.453	0.209	0.209	0.203	0.644	9.49E-04	0.280	0.040	0.040	0.039
Doris	Pickup truck	Ford F350	SURFACE	17	385	5.13	70%	3.347	4.93E-03	1.453	0.209	0.209	0.203	4.260	6.27E-03	1.849	0.267	0.267	0.259
Doris	Pickup truck	Ford F550	SURFACE	7	440	6.35	70%	3.347	4.93E-03	1.453	0.209	0.209	0.203	2.005	2.95E-03	0.870	0.125	0.125	0.122
Doris	Scissor Bolter	MacLean MEM-928 with Deutz BF4M-1013C diesel engine	UNDERGROUND	2	154	22.00	43%	6.106	4.87E-03	1.920	0.377	0.377	0.366	0.225	1.79E-04	0.071	0.014	0.014	0.013
Doris	Face Drilling Rig	ATLAS COPCO Boomer 104	UNDERGROUND	2	57	9.00	43%	6.060	5.41E-03	3.199	0.590	0.590	0.572	0.083	7.36E-05	0.044	0.008	0.008	0.008
Doris	Face Drilling Rig	ATLAS COPCO Boomer 282	UNDERGROUND	2	78	18.30	43%	6.060	5.41E-03	3.199	0.605	0.605	0.587	0.113	1.01E-04	0.060	0.011	0.011	0.011
Doris	Underground Mining Truck	CAT AD30	UNDERGROUND	5	409	60.00	59%	3.347	4.93E-03	1.453	0.209	0.209	0.203	1.122	1.65E-03	0.487	0.070	0.070	0.068
Doris	Underground Mining Loader	CAT R1600	UNDERGROUND	4	279	44.20	59%	3.904	4.93E-03	1.310	0.255	0.255	0.247	0.714	9.01E-04	0.240	0.047	0.047	0.045
Doris	Underground Mining Loader	CAT R1300	UNDERGROUND	4	165	27.75	59%	4.079	4.93E-03	1.543	0.328	0.328	0.318	0.441	5.33E-04	0.167	0.035	0.035	0.034
Doris	Underground Mining Loader	ATLAS COPCO ST-2G	UNDERGROUND	2	117	22.60	59%	4.079	4.93E-03	1.543	0.328	0.328	0.318	0.156	1.89E-04	0.059	0.013	0.013	0.012
Doris	Motor Grader	Getman RDG-1504C	UNDERGROUND	1	147	16.33	59%	3.728	4.93E-03	1.449	0.318	0.318	0.308	0.090	1.19E-04	0.035	0.008	0.008	0.007
Doris	Telehandler	CAT TL943	UNDERGROUND	1	111.3	12.03	59%	4.287	4.93E-03	1.633	0.336	0.336	0.326	0.078	8.98E-05	0.030	0.006	0.006	0.006
Doris	Scissor Lift	Getman A64 SL	UNDERGROUND	5	173	12.25	21%	7.272	5.73E-03	4.329	0.765	0.765	0.742	0.367	2.89E-04	0.218	0.039	0.039	0.037
Doris	RTV	JohnDeere M-Gator A1	UNDERGROUND	3	18.5	1.13	59%	7.302	6.33E-03	9.826	1.396	1.396	1.354	0.066	5.76E-05	0.089	0.013	0.013	0.012
Doris	RTV	Kubota RTV-X1100C	UNDERGROUND	11	25	1.81	59%	7.302	6.33E-03	9.826	1.396	1.396	1.354	0.326	2.83E-04	0.439	0.062	0.062	0.061
												TOTAL EMISSION:	SURFACE	g/s	**14.32**	**0.0199**	**6.83**	**1.01**	**1.01**	**0.98**
														t/d	**1.24**	**0.00172**	**0.590**	**0.087**	**0.087**	**0.085**
													UNDERGROUND	g/s	**3.78**	**0.0045**	**1.94**	**0.33**	**0.33**	**0.32**
														t/d	**0.33**	**0.00039**	**0.167**	**0.028**	**0.028**	**0.027**

NOTES:

ETSP, EPM_{10}, $EPM_{2.5}$ - particulate matter resulting from combustion

"—" Not applicable

Table A-17 Existing Roberts Bay Cargo Dock Mobile Equipment and Emission Rates

Location	Equipment Type	Equipment Model	Application (SURFACE/ UNDERGROUND)	Number of Units	Horse-power	GVWR	Running Load Factor	Emission Factors						Emission Rates					
								NO_X	SO_2	CO	TSP	PM_{10}	$PM_{2.5}$	NO_X	SO_2	CO	ETSP	EPM_{10}	$EPM_{2.5}$
					(hp)	(tonne)	(%)	(g/hp-hr)	(g/hp-hr)	(g/hp-hr)	(g/hp-hr)	(g/hp-hr)	(g/hp-hr)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)
Roberts Bay Cargo Dock	Reach stacker	Terex TFC 45	SURFACE	1	345	86.00	43%	2.888	4.34E-03	0.743	0.111	0.111	0.108	0.119	1.79E-04	0.031	0.005	0.005	0.004
Roberts Bay Cargo Dock	Rough Terrain Mobile Crane	Link-Belt RTC 80130	SURFACE	1	350	120.00	43%	2.888	4.34E-03	0.743	0.111	0.111	0.108	0.121	1.81E-04	0.031	0.005	0.005	0.005
Roberts Bay Cargo Dock	Rough Terrain Mobile Crane	Grove RT625	SURFACE	1	157	24.55	43%	2.138	4.24E-03	0.573	0.140	0.140	0.135	0.040	7.96E-05	0.011	0.003	0.003	0.003
Roberts Bay Cargo Dock	Terminal Forklift	Kalmar Ottawa T2 6x4 with Cummins ISB engine	SURFACE	2	200	36.74	59%	2.111	4.23E-03	0.705	0.134	0.134	0.130	0.138	2.77E-04	0.046	0.009	0.009	0.009
Roberts Bay Cargo Dock	Generator/Welder - Diesel	SQ-3350	SURFACE	1	38	—	43%	4.916	5.92E-03	4.086	0.645	0.645	0.626	0.022	2.65E-05	0.018	0.003	0.003	0.003
Roberts Bay Cargo Dock	Fishing boat gasoline engine	YAMAHA F115TJR	SURFACE	1	115	—	21%	4.143	4.53E-03	1.260	0.256	0.256	0.248	0.028	3.04E-05	0.008	0.002	0.002	0.002
Roberts Bay Cargo Dock	Fishing boat gasoline engine	YAMAHA F115XB	SURFACE	1	115	—	21%	4.143	4.53E-03	1.260	0.256	0.256	0.248	0.028	3.04E-05	0.008	0.002	0.002	0.002
Roberts Bay Cargo Dock	Fishing boat gasoline engine	YAMAHA F30	SURFACE	1	30	—	21%	4.383	4.95E-03	1.474	0.277	0.277	0.269	0.008	8.66E-06	0.003	0.000	0.000	0.000
Roberts Bay Cargo Dock	Fishing boat gasoline engine	YAMAHA F25 MLHF	SURFACE	1	25	—	21%	4.811	5.41E-03	2.585	0.383	0.383	0.371	0.007	7.89E-06	0.004	0.001	0.001	0.001
Roberts Bay Cargo Dock	Fishing boat gasoline engine	YAMAHA F15 LMH	SURFACE	5	15	—	21%	4.811	5.41E-03	2.585	0.383	0.383	0.371	0.021	2.37E-05	0.011	0.002	0.002	0.002
Roberts Bay Cargo Dock	Fishing boat gasoline engine	YAMAHA F15 MSH	SURFACE	1	15	—	21%	4.811	5.41E-03	2.585	0.383	0.383	0.371	0.004	4.73E-06	0.002	0.000	0.000	0.000
Roberts Bay Cargo Dock	Motor boat	STARWELD 1600 DC	SURFACE	1	90	—	21%	4.245	5.03E-03	2.355	0.426	0.426	0.413	0.022	2.64E-05	0.012	0.002	0.002	0.002
Roberts Bay Cargo Dock	Motor boat	LUND SSV-14	SURFACE	3	35	—	21%	4.383	4.95E-03	1.474	0.277	0.277	0.269	0.027	3.03E-05	0.009	0.002	0.002	0.002
Roberts Bay Cargo Dock	Motor boat	LUND A-14	SURFACE	3	15	—	21%	4.811	5.41E-03	2.585	0.383	0.383	0.371	0.013	1.42E-05	0.007	0.001	0.001	0.001
												TOTAL EMISSION: SURFACE	g/s	**0.597**	**0.0009**	**0.202**	**0.035**	**0.035**	**0.034**
													t/d	**0.052**	**0.00008**	**0.017**	**0.003**	**0.003**	**0.003**

NOTES:

ETSP, EPM_{10}, $EPM_{2.5}$ - particulate matter resulting from combustion

"—" Not applicable

Table A-18 Existing Roberts Bay Mobile Equipment (Assumed) and Emission Rates

Location	Equipment Type	Equipment Model	Application (SURFACE/ UNDERGROUND)	Number of Units	Horse-power	GVWR	Running Load Factor	Emission Factors						Emission Rates					
								NO_X	SO_2	CO	TSP	PM_{10}	$PM_{2.5}$	NO_X	SO_2	CO	ETSP	EPM_{10}	$EPM_{2.5}$
					(hp)	(tonne)	(%)	(g/hp-hr)	(g/hp-hr)	(g/hp-hr)	(g/hp-hr)	(g/hp-hr)	(g/hp-hr)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)
Roberts Bay	Snow Groomer	Prinoth BR 350	SURFACE	1	350	8.41	58%	4.190	4.93E-03	1.769	0.232	0.232	0.225	0.236	2.78E-04	0.100	0.013	0.013	0.013
Roberts Bay	Telehandler	CAT TL1255	SURFACE	1	142	16.27	59%	4.287	4.93E-03	1.633	0.336	0.336	0.326	0.100	1.15E-04	0.038	0.008	0.008	0.008
Roberts Bay	Telehandler	JLG 1055	SURFACE	1	130	11.52	59%	4.287	4.93E-03	1.633	0.336	0.336	0.326	0.091	1.05E-04	0.035	0.007	0.007	0.007
Roberts Bay	Telehandler	CAT TL943	SURFACE	1	111	12.03	59%	4.287	4.93E-03	1.633	0.336	0.336	0.326	0.078	8.98E-05	0.030	0.006	0.006	0.006
Roberts Bay	Forklift	Hyster H80-120FT	SURFACE	1	74	9.65	59%	4.662	5.47E-03	3.708	0.514	0.514	0.498	0.057	6.63E-05	0.045	0.006	0.006	0.006
Roberts Bay	Rough Terrain Forklift	JCB 930	SURFACE	1	74	6.62	59%	4.662	5.47E-03	3.708	0.514	0.514	0.498	0.057	6.63E-05	0.045	0.006	0.006	0.006
Roberts Bay	Mobile Boom Lift	Geniew Z60/34	SURFACE	1	75	10.22	21%	7.125	6.35E-03	6.886	1.075	1.075	1.042	0.031	2.78E-05	0.030	0.005	0.005	0.005
Roberts Bay	Mobile Scissor Lift	Geniew GS-5390RT	SURFACE	1	75	7.52	21%	7.125	6.35E-03	6.886	1.075	1.075	1.042	0.031	2.78E-05	0.030	0.005	0.005	0.005
Roberts Bay	Mobile Telescopic Lift	Genie S-60	SURFACE	1	75	9.31	21%	7.125	6.35E-03	6.886	1.075	1.075	1.042	0.031	2.78E-05	0.030	0.005	0.005	0.005
Roberts Bay	Mobile Telescopic Lift	Genie S-65	SURFACE	2	75	10.02	21%	7.125	6.35E-03	6.886	1.075	1.075	1.042	0.062	5.56E-05	0.060	0.009	0.009	0.009
Roberts Bay	Mobile Telescopic Lift	Geniew S-80	SURFACE	1	74	16.10	21%	7.125	6.35E-03	6.886	1.075	1.075	1.042	0.031	2.74E-05	0.030	0.005	0.005	0.004
Roberts Bay	Mobile Telescopic Lift	Geniew S-85	SURFACE	1	74	17.19	21%	7.125	6.35E-03	6.886	1.075	1.075	1.042	0.031	2.74E-05	0.030	0.005	0.005	0.004
Roberts Bay	RTV	Polaris Sportsman 6x6 570	SURFACE	2	44	1.00	59%	6.396	6.33E-03	8.826	1.253	1.253	1.215	0.092	9.13E-05	0.127	0.018	0.018	0.018
Roberts Bay	RTV	Kubota RTV-X1100C	SURFACE	2	25	1.81	59%	7.302	6.33E-03	9.826	1.396	1.396	1.354	0.059	5.15E-05	0.080	0.011	0.011	0.011
Roberts Bay	Generator/Welder - Diesel	Miller 800	SURFACE	2	66		21%	6.317	6.35E-03	7.654	1.146	1.146	1.112	0.048	4.87E-05	0.059	0.009	0.009	0.009
Roberts Bay	Generator/Welder - Diesel	SQ-3350	SURFACE	2	38		21%	6.065	6.34E-03	7.505	1.118	1.118	1.084	0.027	2.78E-05	0.033	0.005	0.005	0.005
Roberts Bay	Generator/Welder - Diesel	Lincoln 300D	SURFACE	1	33		21%	6.065	6.34E-03	7.505	1.118	1.118	1.084	0.012	1.21E-05	0.014	0.002	0.002	0.002
Roberts Bay	Mobile Light Tower	Magnum MLT3060	SURFACE		13	0.82	43%	6.074	5.40E-03	3.589	0.606	0.606	0.588	0.039	3.46E-05	0.023	0.004	0.004	0.004
Roberts Bay	Mobile Light Tower	Wacker LTC 4	SURFACE	3	13	0.82	43%	6.074	5.40E-03	3.589	0.606	0.606	0.588	0.029	2.59E-05	0.017	0.003	0.003	0.003
Roberts Bay	Fuel/Water truck	Kenworth T370 with Paccar PX-9 engine	SURFACE	1	380	27.22	70%	3.347	4.93E-03	1.453	0.209	0.209	0.203	0.247	3.64E-04	0.107	0.015	0.015	0.015
Roberts Bay	Fuel/Water truck	Peterbilt 348 with PACCAR PX-7 Engine	SURFACE	2	360	27.22	70%	3.347	4.93E-03	1.453	0.209	0.209	0.203	0.469	6.90E-04	0.203	0.029	0.029	0.028
Roberts Bay	General Truck	Sterling Acterra Class 5-8	SURFACE	1	350	29.94	70%	3.347	4.93E-03	1.453	0.209	0.209	0.203	0.228	3.36E-04	0.099	0.014	0.014	0.014
Roberts Bay	Transporter Truck	Ford E450	SURFACE	1	350	6.35	70%	3.347	4.93E-03	1.453	0.209	0.209	0.203	0.228	3.36E-04	0.099	0.014	0.014	0.014
Roberts Bay	Pickup Truck	Ford F250	SURFACE	2	330	4.54	70%	3.347	4.93E-03	1.453	0.209	0.209	0.203	0.430	6.33E-04	0.186	0.027	0.027	0.026
Roberts Bay	Reach stacker	Terex TFC 45	SURFACE	1	345	86.00	43%	4.947	4.87E-03	1.365	0.214	0.214	0.207	0.204	2.01E-04	0.056	0.009	0.009	0.009
Roberts Bay	Rough Terrain Mobile Crane	Grove RT625	SURFACE	1	157	24.55	43%	4.291	4.87E-03	1.029	0.244	0.244	0.236	0.080	9.14E-05	0.019	0.005	0.005	0.004
											TOTAL EMISSION:	SURFACE	g/s	**3.03**	**0.0039**	**1.63**	**0.24**	**0.24**	**0.24**
													t/d	**0.26**	**0.00033**	**0.140**	**0.021**	**0.021**	**0.021**

NOTES:

ETSP, EPM_{10}, $EPM_{2.5}$ - particulate matter resulting from combustion

"—" Not applicable

Table A-19 Madrid North Mobile Equipment during Operation (Based on Doris) and Emission Rates

Location	Equipment Type	Equipment Model	Application (SURFACE/ UNDERGROUND)	Number of Units	Horse-power	GVWR	Running Load Factor	Emission Factors						Emission Rates					
					(hp)	(tonne)	(%)	NO_X (g/hp-hr)	SO_2 (g/hp-hr)	CO (g/hp-hr)	TSP (g/hp-hr)	PM_{10} (g/hp-hr)	$PM_{2.5}$ (g/hp-hr)	NO_X (g/s)	SO_2 (g/s)	CO (g/s)	ETSP (g/s)	EPM_{10} (g/s)	$EPM_{2.5}$ (g/s)
Madrid North	Articulated Truck	CAT 740B	SURFACE	3	489	73.98	59%	1.330	3.90E-03	0.499	0.078	0.078	0.075	0.320	9.39E-04	0.120	0.019	0.019	0.018
Madrid North	Articulated Truck	CAT 725	SURFACE	2	320	47.04	59%	1.330	3.90E-03	0.499	0.078	0.078	0.075	0.140	4.09E-04	0.052	0.008	0.008	0.008
Madrid North	Hydraulic Excavator	CAT 349L	SURFACE	2	396	53.30	53%	1.899	4.17E-03	0.770	0.117	0.117	0.113	0.221	4.86E-04	0.090	0.014	0.014	0.013
Madrid North	Hydraulic Excavator	CAT 325DL	SURFACE	2	204	29.24	53%	1.342	3.90E-03	0.435	0.079	0.079	0.077	0.081	2.35E-04	0.026	0.005	0.005	0.005
Madrid North	Hydraulic Excavator	CAT 329	SURFACE	2	204	29.24	53%	1.342	3.90E-03	0.435	0.079	0.079	0.077	0.081	2.34E-04	0.026	0.005	0.005	0.005
Madrid North	Hydraulic Excavator	CAT 308C	SURFACE	2	55	8.04	53%	3.144	4.67E-03	1.591	0.158	0.158	0.153	0.051	7.57E-05	0.026	0.003	0.003	0.002
Madrid North	Wheel Loader	CAT 988H	SURFACE	2	555	50.14	48%	2.676	4.36E-03	1.081	0.148	0.148	0.144	0.396	6.46E-04	0.160	0.022	0.022	0.021
Madrid North	Wheel Loader	CAT 980H	SURFACE	2	359	29.95	48%	2.676	4.36E-03	1.081	0.148	0.148	0.144	0.256	4.18E-04	0.104	0.014	0.014	0.014
Madrid North	Wheel Loader	CAT 930H	SURFACE	2	149	13.03	48%	2.040	4.27E-03	0.845	0.196	0.196	0.191	0.081	1.70E-04	0.034	0.008	0.008	0.008
Madrid North	Backhoe Loader	CAT 420F	SURFACE	2	94	11.00	21%	4.285	5.85E-03	5.288	0.764	0.764	0.741	0.047	6.42E-05	0.058	0.008	0.008	0.008
Madrid North	Multi Terain Loader	CAT 257	SURFACE	2	74	3.65	23%	4.792	5.95E-03	4.631	0.662	0.662	0.642	0.045	5.65E-05	0.044	0.006	0.006	0.006
Madrid North	Multi Terrain Loader	CAT 287C	SURFACE	2	74	4.50	23%	4.792	5.95E-03	4.631	0.662	0.662	0.642	0.045	5.65E-05	0.044	0.006	0.006	0.006
Madrid North	Skid Steer Loader	CAT 272H	SURFACE	2	98	3.74	23%	4.909	5.93E-03	6.128	0.921	0.921	0.893	0.061	7.43E-05	0.077	0.012	0.012	0.011
Madrid North	Compact Track Loader	ASV RT-30	SURFACE	2	33	1.63	23%	4.240	5.69E-03	1.949	0.326	0.326	0.317	0.018	2.38E-05	0.008	0.001	0.001	0.001
Madrid North	Motor Grader	CAT 14M	SURFACE	2	259	24.38	58%	1.521	4.00E-03	0.511	0.096	0.096	0.093	0.127	3.34E-04	0.043	0.008	0.008	0.008
Madrid North	Motor Grader	CAT 140G	SURFACE	2	150	12.62	58%	1.669	4.13E-03	0.726	0.173	0.173	0.168	0.081	2.00E-04	0.035	0.008	0.008	0.008
Madrid North	Vibratory Soil Compactor	CAT CS-74B	SURFACE	2	174	16.36	59%	2.041	4.27E-03	0.845	0.196	0.196	0.191	0.116	2.43E-04	0.048	0.011	0.011	0.011
Madrid North	Dozer	CAT D8T	SURFACE	2	363	39.42	58%	2.221	4.26E-03	0.890	0.128	0.128	0.124	0.260	4.98E-04	0.104	0.015	0.015	0.015
Madrid North	Dozer	CAT D6R	SURFACE	2	179	18.14	58%	1.554	4.01E-03	0.523	0.098	0.098	0.095	0.090	2.31E-04	0.030	0.006	0.006	0.005
Madrid North	Snow Groomer	Prinoth BR 350	SURFACE	2	350	8.41	58%	2.221	4.26E-03	0.890	0.128	0.128	0.124	0.250	4.80E-04	0.100	0.014	0.014	0.014
Madrid North	Telehandler	CAT TL1255	SURFACE	2	142	16.27	59%	2.297	4.33E-03	0.927	0.207	0.207	0.201	0.107	2.02E-04	0.043	0.010	0.010	0.009
Madrid North	Telehandler	JLG 1055	SURFACE	2	130	11.52	59%	2.297	4.33E-03	0.927	0.207	0.207	0.201	0.098	1.85E-04	0.040	0.009	0.009	0.009
Madrid North	Telehandler	CAT TL943	SURFACE	2	111	12.03	59%	2.297	4.33E-03	0.927	0.207	0.207	0.201	0.084	1.58E-04	0.034	0.008	0.008	0.007
Madrid North	Toolcarrier	CAT IT28G	SURFACE	2	144	12.13	59%	2.297	4.33E-03	0.927	0.207	0.207	0.201	0.108	2.04E-04	0.044	0.010	0.010	0.009
Madrid North	Forklift	Hyster H80-120FT	SURFACE	2	74	9.65	59%	3.595	4.93E-03	2.265	0.256	0.256	0.249	0.087	1.20E-04	0.055	0.006	0.006	0.006
Madrid North	Rough Terrain Forklift	JCB 930	SURFACE	2	74	6.62	59%	3.595	4.93E-03	2.265	0.256	0.256	0.249	0.087	1.20E-04	0.055	0.006	0.006	0.006
Madrid North	Mobile Boom Lift	Geniew Z60/34	SURFACE	2	75	10.22	21%	5.470	6.01E-03	5.073	0.722	0.722	0.700	0.048	5.26E-05	0.044	0.006	0.006	0.006
Madrid North	Mobile Scissor Lift	Geniew GS-5390RT	SURFACE	2	75	7.52	21%	5.470	6.01E-03	5.073	0.722	0.722	0.700	0.048	5.26E-05	0.044	0.006	0.006	0.006
Madrid North	Mobile Telescopic Lift	Genie S-60	SURFACE	2	75	9.31	21%	5.470	6.01E-03	5.073	0.722	0.722	0.700	0.048	5.26E-05	0.044	0.006	0.006	0.006
Madrid North	Mobile Telescopic Lift	Genie S-65	SURFACE	5	75	10.02	21%	5.470	6.01E-03	5.073	0.722	0.722	0.700	0.120	1.32E-04	0.111	0.016	0.016	0.015
Madrid North	Mobile Telescopic Lift	Geniew S-80	SURFACE	2	74	16.10	21%	5.470	6.01E-03	5.073	0.722	0.722	0.700	0.047	5.19E-05	0.044	0.006	0.006	0.006
Madrid North	Mobile Telescopic Lift	Geniew S-85	SURFACE	2	74	17.19	21%	5.470	6.01E-03	5.073	0.722	0.722	0.700	0.047	5.19E-05	0.044	0.006	0.006	0.006
Madrid North	RTV	Polaris Sportsman 6x6 570	SURFACE	6	44	1.00	59%	5.446	6.01E-03	6.001	0.881	0.881	0.854	0.236	2.60E-04	0.260	0.038	0.038	0.037
Madrid North	RTV	Kubota RTV-X1100C	SURFACE	6	25	1.81	59%	6.245	6.38E-03	7.258	1.033	1.033	1.002	0.152	1.56E-04	0.177	0.025	0.025	0.024
Madrid North	Self-propelled All Terrain Fusion Machine (joining PE pipes)	TracStar 412/618	SURFACE	2	20	0.95	21%	4.457	5.47E-03	2.429	0.352	0.352	0.341	0.010	1.28E-05	0.0057	0.0008	0.0008	0.0008
Madrid North	Generator/Welder - Diesel	Miller 800	SURFACE	5	66	—	21%	5.146	6.00E-03	5.394	0.776	0.776	0.753	0.099	1.15E-04	0.103	0.015	0.015	0.014
Madrid North	Generator/Welder - Diesel	SQ-3350	SURFACE	5	38	—	21%	4.916	5.92E-03	4.086	0.645	0.645	0.626	0.054	6.48E-05	0.045	0.007	0.007	0.007
Madrid North	Generator/Welder - Diesel	Lincoln 300D	SURFACE	2	33	—	21%	4.916	5.92E-03	4.086	0.645	0.645	0.626	0.019	2.26E-05	0.016	0.002	0.002	0.002
Madrid North	Mobile Light Tower	Magnum MLT3060	SURFACE	13	13	0.82	43%	5.059	5.41E-03	2.783	0.427	0.427	0.414	0.105	1.13E-04	0.058	0.009	0.009	0.009
Madrid North	Mobile Light Tower	Wacker LTC 4	SURFACE	8	13	0.82	43%	5.059	5.41E-03	2.783	0.427	0.427	0.414	0.065	6.93E-05	0.036	0.005	0.005	0.005

Table A-19 Madrid North Mobile Equipment during Operation (Based on Doris) and Emission Rates

Location	Equipment Type	Equipment Model	Application (SURFACE/ UNDERGROUND)	Number of Units	Horse-power	GVWR	Running Load Factor	Emission Factors						Emission Rates					
								NO_X	SO_2	CO	TSP	PM_{10}	$PM_{2.5}$	NO_X	SO_2	CO	ETSP	EPM_{10}	$EPM_{2.5}$
					(hp)	(tonne)	(%)	(g/hp-hr)	(g/hp-hr)	(g/hp-hr)	(g/hp-hr)	(g/hp-hr)	(g/hp-hr)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)
Madrid North	Heavy Duty Truck	Kenworth T800 with Paccar MX-13 engine	SURFACE	5	500	40.37	70%	1.330	3.90E-03	0.499	0.078	0.078	0.075	0.647	1.90E-03	0.243	0.038	0.038	0.037
Madrid North	Freightliner Truck	Freightliner 108SD	SURFACE	2	380	31.30	70%	1.330	3.90E-03	0.499	0.078	0.078	0.075	0.197	5.77E-04	0.074	0.011	0.011	0.011
Madrid North	Fuel/Water truck	Kenworth T370 with Paccar PX-9 engine	SURFACE	3	380	27.22	70%	1.330	3.90E-03	0.499	0.078	0.078	0.075	0.295	8.65E-04	0.111	0.017	0.017	0.017
Madrid North	Fuel/Water truck	Peterbilt 348 with PACCAR PX-7 Engine	SURFACE	5	360	27.22	70%	1.330	3.90E-03	0.499	0.078	0.078	0.075	0.466	1.37E-03	0.175	0.027	0.027	0.026
Madrid North	General Truck	Sterling Acterra Class 5-8	SURFACE	2	350	29.94	70%	1.330	3.90E-03	0.499	0.078	0.078	0.075	0.181	5.31E-04	0.068	0.011	0.011	0.010
Madrid North	Passenger Van	Mercedes Sprinter 2500	SURFACE	2	188	5.00	70%	0.859	3.63E-03	0.203	0.029	0.029	0.028	0.063	2.65E-04	0.015	0.002	0.002	0.002
Madrid North	Transporter Truck	Ford E450	SURFACE	3	350	6.35	70%	1.330	3.90E-03	0.499	0.078	0.078	0.075	0.272	7.97E-04	0.102	0.016	0.016	0.015
Madrid North	Pickup Truck	Ford F250	SURFACE	5	330	4.54	70%	1.330	3.90E-03	0.499	0.078	0.078	0.075	0.427	1.25E-03	0.160	0.025	0.025	0.024
Madrid North	Pickup truck	Ford F350	SURFACE	28	385	5.13	70%	1.330	3.90E-03	0.499	0.078	0.078	0.075	2.789	8.18E-03	1.047	0.162	0.162	0.158
Madrid North	Pickup truck	Ford F550	SURFACE	11	440	6.35	70%	1.330	3.90E-03	0.499	0.078	0.078	0.075	1.252	3.67E-03	0.470	0.073	0.073	0.071
Madrid North	Scissor Bolter	MacLean MEM-928 with Deutz BF4M-1013C diesel engine	UNDERGROUND	4	154	22.00	43%	4.183	4.52E-03	1.201	0.250	0.250	0.242	0.308	3.33E-04	0.088	0.018	0.018	0.018
Madrid North	Face Drilling Rig	ATLAS COPCO Boomer 104	UNDERGROUND	4	57	9.00	43%	4.867	5.10E-03	2.424	0.413	0.413	0.401	0.133	1.39E-04	0.066	0.011	0.011	0.011
Madrid North	Face Drilling Rig	ATLAS COPCO Boomer 282	UNDERGROUND	4	78	18.30	43%	4.316	5.03E-03	2.319	0.421	0.421	0.408	0.161	1.87E-04	0.086	0.016	0.016	0.015
Madrid North	Underground Mining Truck	CAT AD30	UNDERGROUND	9	409	60.00	59%	1.330	3.90E-03	0.499	0.078	0.078	0.075	0.803	2.36E-03	0.301	0.047	0.047	0.045
Madrid North	Underground Mining Loader	CAT R1600	UNDERGROUND	7	279	44.20	59%	1.861	4.15E-03	0.630	0.122	0.122	0.118	0.596	1.33E-03	0.202	0.039	0.039	0.038
Madrid North	Underground Mining Loader	CAT R1300	UNDERGROUND	7	165	27.75	59%	2.040	4.27E-03	0.845	0.196	0.196	0.191	0.386	8.08E-04	0.160	0.037	0.037	0.036
Madrid North	Underground Mining Loader	ATLAS COPCO ST-2G	UNDERGROUND	4	117	22.60	59%	2.040	4.27E-03	0.845	0.196	0.196	0.191	0.157	3.27E-04	0.065	0.015	0.015	0.015
Madrid North	Motor Grader	Getman RDG-1504C	UNDERGROUND	2	147	16.33	59%	1.669	4.13E-03	0.726	0.173	0.173	0.168	0.080	1.99E-04	0.035	0.008	0.008	0.008
Madrid North	Telehandler	CAT TL943	UNDERGROUND	2	111.3	12.03	59%	2.297	4.33E-03	0.927	0.207	0.207	0.201	0.084	1.58E-04	0.034	0.008	0.008	0.007
Madrid North	Scissor Lift	Getman A64 SL	UNDERGROUND	9	173	12.25	21%	4.946	5.34E-03	2.897	0.504	0.504	0.489	0.449	4.85E-04	0.263	0.046	0.046	0.044
Madrid North	RTV	JohnDeere M-Gator A1	UNDERGROUND	5	18.5	1.13	59%	6.245	6.38E-03	7.258	1.033	1.033	1.002	0.095	9.67E-05	0.110	0.016	0.016	0.015
Madrid North	RTV	Kubota RTV-X1100C	UNDERGROUND	18	25	1.81	59%	6.245	6.38E-03	7.258	1.033	1.033	1.002	0.457	4.67E-04	0.531	0.076	0.076	0.073
											TOTAL EMISSION: SURFACE		g/s	**11.02**	**0.0275**	**4.99**	**0.77**	**0.77**	**0.75**
													t/d	**0.95**	**0.00237**	**0.431**	**0.067**	**0.067**	**0.065**
											UNDERGROUND		g/s	**3.71**	**0.0069**	**1.94**	**0.34**	**0.34**	**0.33**
													t/d	**0.32**	**0.00059**	**0.168**	**0.029**	**0.029**	**0.028**

NOTES:

ETSP, EPM_{10}, $EPM_{2.5}$ - particulate matter resulting from combustion

"—" Not applicable

Table A-20 Madrid South Mobile Equipment during Operation (Based on Doris) and Emission Rates

Location	Equipment Type	Equipment Model	Application (SURFACE/ UNDERGROUND)	Number of Units	Horse-power	GVWR	Running Load Factor	Emission Factors						Emission Rates					
								NO_X	SO_2	CO	TSP	PM_{10}	$PM_{2.5}$	NO_X	SO_2	CO	ETSP	EPM_{10}	$EPM_{2.5}$
					(hp)	(tonne)	(%)	(g/hp-hr)	(g/hp-hr)	(g/hp-hr)	(g/hp-hr)	(g/hp-hr)	(g/hp-hr)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)
Madrid South	Articulated Truck	CAT 740B	SURFACE	1	489	73.98	59%	1.330	3.90E-03	0.499	0.078	0.078	0.075	0.107	3.13E-04	0.040	0.006	0.006	0.006
Madrid South	Articulated Truck	CAT 725	SURFACE	1	320	47.04	59%	1.330	3.90E-03	0.499	0.078	0.078	0.075	0.070	2.05E-04	0.026	0.004	0.004	0.004
Madrid South	Hydraulic Excavator	CAT 349L	SURFACE	1	396	53.30	53%	1.899	4.17E-03	0.770	0.117	0.117	0.113	0.111	2.43E-04	0.045	0.007	0.007	0.007
Madrid South	Hydraulic Excavator	CAT 325DL	SURFACE	1	204	29.24	53%	1.342	3.90E-03	0.435	0.079	0.079	0.077	0.040	1.17E-04	0.013	0.002	0.002	0.002
Madrid South	Hydraulic Excavator	CAT 329	SURFACE	1	204	29.24	53%	1.342	3.90E-03	0.435	0.079	0.079	0.077	0.040	1.17E-04	0.013	0.002	0.002	0.002
Madrid South	Hydraulic Excavator	CAT 308C	SURFACE	1	55	8.04	53%	3.144	4.67E-03	1.591	0.158	0.158	0.153	0.025	3.79E-05	0.013	0.001	0.001	0.001
Madrid South	Wheel Loader	CAT 988H	SURFACE	1	555	50.14	48%	2.676	4.36E-03	1.081	0.148	0.148	0.144	0.198	3.23E-04	0.080	0.011	0.011	0.011
Madrid South	Wheel Loader	CAT 980H	SURFACE	1	359	29.95	48%	2.676	4.36E-03	1.081	0.148	0.148	0.144	0.128	2.09E-04	0.052	0.007	0.007	0.007
Madrid South	Wheel Loader	CAT 930H	SURFACE	1	149	13.03	48%	2.040	4.27E-03	0.845	0.196	0.196	0.191	0.041	8.48E-05	0.017	0.004	0.004	0.004
Madrid South	Backhoe Loader	CAT 420F	SURFACE	1	94	11.00	21%	4.285	5.85E-03	5.288	0.764	0.764	0.741	0.023	3.21E-05	0.029	0.004	0.004	0.004
Madrid South	Multi Terain Loader	CAT 257	SURFACE	1	74	3.65	23%	4.792	5.95E-03	4.631	0.662	0.662	0.642	0.023	2.83E-05	0.022	0.003	0.003	0.003
Madrid South	Multi Terrain Loader	CAT 287C	SURFACE	1	74	4.50	23%	4.792	5.95E-03	4.631	0.662	0.662	0.642	0.023	2.83E-05	0.022	0.003	0.003	0.003
Madrid South	Skid Steer Loader	CAT 272H	SURFACE	1	98	3.74	23%	4.909	5.93E-03	6.128	0.921	0.921	0.893	0.031	3.71E-05	0.038	0.006	0.006	0.006
Madrid South	Compact Track Loader	ASV RT-30	SURFACE	1	33	1.63	23%	4.240	5.69E-03	1.949	0.326	0.326	0.317	0.009	1.19E-05	0.004	0.001	0.001	0.001
Madrid South	Motor Grader	CAT 14M	SURFACE	1	259	24.38	58%	1.521	4.00E-03	0.511	0.096	0.096	0.093	0.063	1.67E-04	0.021	0.004	0.004	0.004
Madrid South	Motor Grader	CAT 140G	SURFACE	1	150	12.62	58%	1.669	4.13E-03	0.726	0.173	0.173	0.168	0.040	9.99E-05	0.018	0.004	0.004	0.004
Madrid South	Vibratory Soil Compactor	CAT CS-74B	SURFACE	1	174	16.36	59%	2.041	4.27E-03	0.845	0.196	0.196	0.191	0.058	1.21E-04	0.024	0.006	0.006	0.005
Madrid South	Dozer	CAT D8T	SURFACE	1	363	39.42	58%	2.221	4.26E-03	0.890	0.128	0.128	0.124	0.130	2.49E-04	0.052	0.007	0.007	0.007
Madrid South	Dozer	CAT D6R	SURFACE	1	179	18.14	58%	1.554	4.01E-03	0.523	0.098	0.098	0.095	0.045	1.16E-04	0.015	0.003	0.003	0.003
Madrid South	Snow Groomer	Prinoth BR 350	SURFACE	1	350	8.41	58%	2.221	4.26E-03	0.890	0.128	0.128	0.124	0.125	2.40E-04	0.050	0.007	0.007	0.007
Madrid South	Telehandler	CAT TL1255	SURFACE	1	142	16.27	59%	2.297	4.33E-03	0.927	0.207	0.207	0.201	0.053	1.01E-04	0.022	0.005	0.005	0.005
Madrid South	Telehandler	JLG 1055	SURFACE	1	130	11.52	59%	2.297	4.33E-03	0.927	0.207	0.207	0.201	0.049	9.23E-05	0.020	0.004	0.004	0.004
Madrid South	Telehandler	CAT TL943	SURFACE	1	111	12.03	59%	2.297	4.33E-03	0.927	0.207	0.207	0.201	0.042	7.90E-05	0.017	0.004	0.004	0.004
Madrid South	Toolcarrier	CAT IT28G	SURFACE	1	144	12.13	59%	2.297	4.33E-03	0.927	0.207	0.207	0.201	0.054	1.02E-04	0.022	0.005	0.005	0.005
Madrid South	Forklift	Hyster H80-120FT	SURFACE	1	74	9.65	59%	3.595	4.93E-03	2.265	0.256	0.256	0.249	0.044	5.98E-05	0.027	0.003	0.003	0.003
Madrid South	Rough Terrain Forklift	JCB 930	SURFACE	1	74	6.62	59%	3.595	4.93E-03	2.265	0.256	0.256	0.249	0.044	5.98E-05	0.027	0.003	0.003	0.003
Madrid South	Mobile Boom Lift	Geniew Z60/34	SURFACE	1	75	10.22	21%	5.470	6.01E-03	5.073	0.722	0.722	0.700	0.024	2.63E-05	0.022	0.003	0.003	0.003
Madrid South	Mobile Scissor Lift	Geniew GS-5390RT	SURFACE	1	75	7.52	21%	5.470	6.01E-03	5.073	0.722	0.722	0.700	0.024	2.63E-05	0.022	0.003	0.003	0.003
Madrid South	Mobile Telescopic Lift	Genie S-60	SURFACE	1	75	9.31	21%	5.470	6.01E-03	5.073	0.722	0.722	0.700	0.024	2.63E-05	0.022	0.003	0.003	0.003
Madrid South	Mobile Telescopic Lift	Genie S-65	SURFACE	2	75	10.02	21%	5.470	6.01E-03	5.073	0.722	0.722	0.700	0.048	5.26E-05	0.044	0.006	0.006	0.006
Madrid South	Mobile Telescopic Lift	Geniew S-80	SURFACE	1	74	16.10	21%	5.470	6.01E-03	5.073	0.722	0.722	0.700	0.024	2.60E-05	0.022	0.003	0.003	0.003
Madrid South	Mobile Telescopic Lift	Geniew S-85	SURFACE	1	74	17.19	21%	5.470	6.01E-03	5.073	0.722	0.722	0.700	0.024	2.60E-05	0.022	0.003	0.003	0.003
Madrid South	RTV	Polaris Sportsman 6x6 570	SURFACE	3	44	1.00	59%	5.446	6.01E-03	6.001	0.881	0.881	0.854	0.118	1.30E-04	0.130	0.019	0.019	0.018
Madrid South	RTV	Kubota RTV-X1100C	SURFACE	3	25	1.81	59%	6.245	6.38E-03	7.258	1.033	1.033	1.002	0.076	7.78E-05	0.089	0.013	0.013	0.012
Madrid South	Self-propelled All Terrain Fusion Machine (joining PE pipes)	TracStar 412/618	SURFACE	1	20	0.95	21%	4.457	5.47E-03	2.429	0.352	0.352	0.341	0.005	6.38E-06	0.0028	0.0004	0.0004	0.0004
Madrid South	Generator/Welder - Diesel	Miller 800	SURFACE	2	66	—	21%	5.146	6.00E-03	5.394	0.776	0.776	0.753	0.039	4.60E-05	0.041	0.006	0.006	0.006
Madrid South	Generator/Welder - Diesel	SQ-3350	SURFACE	2	38	—	21%	4.916	5.92E-03	4.086	0.645	0.645	0.626	0.022	2.59E-05	0.018	0.003	0.003	0.003
Madrid South	Generator/Welder - Diesel	Lincoln 300D	SURFACE	1	33	—	21%	4.916	5.92E-03	4.086	0.645	0.645	0.626	0.009	1.13E-05	0.008	0.001	0.001	0.001
Madrid South	Mobile Light Tower	Magnum MLT3060	SURFACE	6	13	0.82	43%	5.059	5.41E-03	2.783	0.427	0.427	0.414	0.049	5.19E-05	0.027	0.004	0.004	0.004
Madrid South	Mobile Light Tower	Wacker LTC 4	SURFACE	4	13	0.82	43%	5.059	5.41E-03	2.783	0.427	0.427	0.414	0.032	3.46E-05	0.018	0.003	0.003	0.003

Table A-20 Madrid South Mobile Equipment during Operation (Based on Doris) and Emission Rates

Location	Equipment Type	Equipment Model	Application (SURFACE/ UNDERGROUND)	Number of Units	Horse-power	GVWR	Running Load Factor	Emission Factors						Emission Rates					
								NO_X	SO_2	CO	TSP	PM_{10}	$PM_{2.5}$	NO_X	SO_2	CO	ETSP	EPM_{10}	$EPM_{2.5}$
					(hp)	(tonne)	(%)	(g/hp-hr)	(g/hp-hr)	(g/hp-hr)	(g/hp-hr)	(g/hp-hr)	(g/hp-hr)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)
Madrid South	Heavy Duty Truck	Kenworth T800 with Paccar MX-13 engine	SURFACE	2	500	40.37	70%	1.330	3.90E-03	0.499	0.078	0.078	0.075	0.259	7.59E-04	0.097	0.015	0.015	0.015
Madrid South	Freightliner Truck	Freightliner 108SD	SURFACE	1	380	31.30	70%	1.330	3.90E-03	0.499	0.078	0.078	0.075	0.098	2.88E-04	0.037	0.006	0.006	0.006
Madrid South	Fuel/Water truck	Kenworth T370 with Paccar PX-9 engine	SURFACE	1	380	27.22	70%	1.330	3.90E-03	0.499	0.078	0.078	0.075	0.098	2.88E-04	0.037	0.006	0.006	0.006
Madrid South	Fuel/Water truck	Peterbilt 348 with PACCAR PX-7 Engine	SURFACE	2	360	27.22	70%	1.330	3.90E-03	0.499	0.078	0.078	0.075	0.186	5.47E-04	0.070	0.011	0.011	0.011
Madrid South	General Truck	Sterling Acterra Class 5-8	SURFACE	1	350	29.94	70%	1.330	3.90E-03	0.499	0.078	0.078	0.075	0.091	2.66E-04	0.034	0.005	0.005	0.005
Madrid South	Passenger Van	Mercedes Sprinter 2500	SURFACE	1	188	5.00	70%	0.859	3.63E-03	0.203	0.029	0.029	0.028	0.031	1.33E-04	0.007	0.001	0.001	0.001
Madrid South	Transporter Truck	Ford E450	SURFACE	1	350	6.35	70%	1.330	3.90E-03	0.499	0.078	0.078	0.075	0.091	2.66E-04	0.034	0.005	0.005	0.005
Madrid South	Pickup Truck	Ford F250	SURFACE	2	330	4.54	70%	1.330	3.90E-03	0.499	0.078	0.078	0.075	0.171	5.01E-04	0.064	0.010	0.010	0.010
Madrid South	Pickup truck	Ford F350	SURFACE	12	385	5.13	70%	1.330	3.90E-03	0.499	0.078	0.078	0.075	1.195	3.51E-03	0.449	0.070	0.070	0.068
Madrid South	Pickup truck	Ford F550	SURFACE	5	440	6.35	70%	1.330	3.90E-03	0.499	0.078	0.078	0.075	0.569	1.67E-03	0.214	0.033	0.033	0.032
Madrid South	Scissor Bolter	MacLean MEM-928 with Deutz BF4M-1013C diesel engine	UNDERGROUND	2	154	22.00	43%	4.183	4.52E-03	1.201	0.250	0.250	0.242	0.154	1.66E-04	0.044	0.009	0.009	0.009
Madrid South	Face Drilling Rig	ATLAS COPCO Boomer 104	UNDERGROUND	2	57	9.00	43%	4.867	5.10E-03	2.424	0.413	0.413	0.401	0.066	6.94E-05	0.033	0.006	0.006	0.005
Madrid South	Face Drilling Rig	ATLAS COPCO Boomer 282	UNDERGROUND	2	78	18.30	43%	4.316	5.03E-03	2.319	0.421	0.421	0.408	0.080	9.37E-05	0.043	0.008	0.008	0.008
Madrid South	Underground Mining Truck	CAT AD30	UNDERGROUND	4	409	60.00	59%	1.330	3.90E-03	0.499	0.078	0.078	0.075	0.357	1.05E-03	0.134	0.021	0.021	0.020
Madrid South	Underground Mining Loader	CAT R1600	UNDERGROUND	3	279	44.20	59%	1.861	4.15E-03	0.630	0.122	0.122	0.118	0.255	5.69E-04	0.086	0.017	0.017	0.016
Madrid South	Underground Mining Loader	CAT R1300	UNDERGROUND	3	165	27.75	59%	2.040	4.27E-03	0.845	0.196	0.196	0.191	0.166	3.46E-04	0.069	0.016	0.016	0.015
Madrid South	Underground Mining Loader	ATLAS COPCO ST-2G	UNDERGROUND	2	117	22.60	59%	2.040	4.27E-03	0.845	0.196	0.196	0.191	0.078	1.64E-04	0.032	0.008	0.008	0.007
Madrid South	Motor Grader	Getman RDG-1504C	UNDERGROUND	1	147	16.33	59%	1.669	4.13E-03	0.726	0.173	0.173	0.168	0.040	9.96E-05	0.017	0.004	0.004	0.004
Madrid South	Telehandler	CAT TL943	UNDERGROUND	1	111.3	12.03	59%	2.297	4.33E-03	0.927	0.207	0.207	0.201	0.042	7.90E-05	0.017	0.004	0.004	0.004
Madrid South	Scissor Lift	Getman A64 SL	UNDERGROUND	4	173	12.25	21%	4.946	5.34E-03	2.897	0.504	0.504	0.489	0.200	2.16E-04	0.117	0.020	0.020	0.020
Madrid South	RTV	JohnDeere M-Gator A1	UNDERGROUND	3	18.5	1.13	59%	6.245	6.38E-03	7.258	1.033	1.033	1.002	0.057	5.80E-05	0.066	0.009	0.009	0.009
Madrid South	RTV	Kubota RTV-X1100C	UNDERGROUND	8	25	1.81	59%	6.245	6.38E-03	7.258	1.033	1.033	1.002	0.203	2.07E-04	0.236	0.034	0.034	0.033
												TOTAL EMISSION: SURFACE	g/s	**4.92**	**0.0121**	**2.26**	**0.35**	**0.35**	**0.34**
													t/d	**0.43**	**0.00104**	**0.195**	**0.030**	**0.030**	**0.029**
												UNDERGROUND	g/s	**1.70**	**0.0031**	**0.90**	**0.15**	**0.15**	**0.15**
													t/d	**0.15**	**0.00027**	**0.077**	**0.013**	**0.013**	**0.013**

NOTES:

ETSP, EPM_{10}, $EPM_{2.5}$ - particulate matter resulting from combustion

"—" Not applicable

Table A-21 Boston Mobile Equipment during Operation (Based on Doris) and Emission Rates

Location	Equipment Type	Equipment Model	Application (SURFACE/ UNDERGROUND)	Number of Units	Horse-power	GVWR	Running Load Factor	Emission Factors						Emission Rates					
								NO_X	SO_2	CO	TSP	PM_{10}	$PM_{2.5}$	NO_X	SO_2	CO	ETSP	EPM_{10}	$EPM_{2.5}$
					(hp)	(tonne)	(%)	(g/hp-hr)	(g/hp-hr)	(g/hp-hr)	(g/hp-hr)	(g/hp-hr)	(g/hp-hr)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)
Boston	Articulated Truck	CAT 740B	SURFACE	2	489	73.98	59%	1.330	3.90E-03	0.499	0.078	0.078	0.075	0.213	6.26E-04	0.080	0.012	0.012	0.012
Boston	Articulated Truck	CAT 725	SURFACE	1	320	47.04	59%	1.330	3.90E-03	0.499	0.078	0.078	0.075	0.070	2.05E-04	0.026	0.004	0.004	0.004
Boston	Hydraulic Excavator	CAT 349L	SURFACE	1	396	53.30	53%	1.899	4.17E-03	0.770	0.117	0.117	0.113	0.111	2.43E-04	0.045	0.007	0.007	0.007
Boston	Hydraulic Excavator	CAT 325DL	SURFACE	1	204	29.24	53%	1.342	3.90E-03	0.435	0.079	0.079	0.077	0.040	1.17E-04	0.013	0.002	0.002	0.002
Boston	Hydraulic Excavator	CAT 329	SURFACE	1	204	29.24	53%	1.342	3.90E-03	0.435	0.079	0.079	0.077	0.040	1.17E-04	0.013	0.002	0.002	0.002
Boston	Hydraulic Excavator	CAT 308C	SURFACE	1	55	8.04	53%	3.144	4.67E-03	1.591	0.158	0.158	0.153	0.025	3.79E-05	0.013	0.001	0.001	0.001
Boston	Wheel Loader	CAT 988H	SURFACE	1	555	50.14	48%	2.676	4.36E-03	1.081	0.148	0.148	0.144	0.198	3.23E-04	0.080	0.011	0.011	0.011
Boston	Wheel Loader	CAT 980H	SURFACE	1	359	29.95	48%	2.676	4.36E-03	1.081	0.148	0.148	0.144	0.128	2.09E-04	0.052	0.007	0.007	0.007
Boston	Wheel Loader	CAT 930H	SURFACE	1	149	13.03	48%	2.040	4.27E-03	0.845	0.196	0.196	0.191	0.041	8.48E-05	0.017	0.004	0.004	0.004
Boston	Backhoe Loader	CAT 420F	SURFACE	1	94	11.00	21%	4.285	5.85E-03	5.288	0.764	0.764	0.741	0.023	3.21E-05	0.029	0.004	0.004	0.004
Boston	Multi Terain Loader	CAT 257	SURFACE	1	74	3.65	23%	4.792	5.95E-03	4.631	0.662	0.662	0.642	0.023	2.83E-05	0.022	0.003	0.003	0.003
Boston	Multi Terrain Loader	CAT 287C	SURFACE	1	74	4.50	23%	4.792	5.95E-03	4.631	0.662	0.662	0.642	0.023	2.83E-05	0.022	0.003	0.003	0.003
Boston	Skid Steer Loader	CAT 272H	SURFACE	1	98	3.74	23%	4.909	5.93E-03	6.128	0.921	0.921	0.893	0.031	3.71E-05	0.038	0.006	0.006	0.006
Boston	Compact Track Loader	ASV RT-30	SURFACE	1	33	1.63	23%	4.240	5.69E-03	1.949	0.326	0.326	0.317	0.009	1.19E-05	0.004	0.001	0.001	0.001
Boston	Motor Grader	CAT 14M	SURFACE	1	259	24.38	58%	1.521	4.00E-03	0.511	0.096	0.096	0.093	0.063	1.67E-04	0.021	0.004	0.004	0.004
Boston	Motor Grader	CAT 140G	SURFACE	1	150	12.62	58%	1.669	4.13E-03	0.726	0.173	0.173	0.168	0.040	9.99E-05	0.018	0.004	0.004	0.004
Boston	Vibratory Soil Compactor	CAT CS-74B	SURFACE	1	174	16.36	59%	2.041	4.27E-03	0.845	0.196	0.196	0.191	0.058	1.21E-04	0.024	0.006	0.006	0.005
Boston	Dozer	CAT D8T	SURFACE	1	363	39.42	58%	2.221	4.26E-03	0.890	0.128	0.128	0.124	0.130	2.49E-04	0.052	0.007	0.007	0.007
Boston	Dozer	CAT D6R	SURFACE	1	179	18.14	58%	1.554	4.01E-03	0.523	0.098	0.098	0.095	0.045	1.16E-04	0.015	0.003	0.003	0.003
Boston	Snow Groomer	Prinoth BR 350	SURFACE	1	350	8.41	58%	2.221	4.26E-03	0.890	0.128	0.128	0.124	0.125	2.40E-04	0.050	0.007	0.007	0.007
Boston	Telehandler	CAT TL1255	SURFACE	1	142	16.27	59%	2.297	4.33E-03	0.927	0.207	0.207	0.201	0.053	1.01E-04	0.022	0.005	0.005	0.005
Boston	Telehandler	JLG 1055	SURFACE	1	130	11.52	59%	2.297	4.33E-03	0.927	0.207	0.207	0.201	0.049	9.23E-05	0.020	0.004	0.004	0.004
Boston	Telehandler	CAT TL943	SURFACE	1	111	12.03	59%	2.297	4.33E-03	0.927	0.207	0.207	0.201	0.042	7.90E-05	0.017	0.004	0.004	0.004
Boston	Toolcarrier	CAT IT28G	SURFACE	1	144	12.13	59%	2.297	4.33E-03	0.927	0.207	0.207	0.201	0.054	1.02E-04	0.022	0.005	0.005	0.005
Boston	Forklift	Hyster H80-120FT	SURFACE	1	74	9.65	59%	3.595	4.93E-03	2.265	0.256	0.256	0.249	0.044	5.98E-05	0.027	0.003	0.003	0.003
Boston	Rough Terrain Forklift	JCB 930	SURFACE	1	74	6.62	59%	3.595	4.93E-03	2.265	0.256	0.256	0.249	0.044	5.98E-05	0.027	0.003	0.003	0.003
Boston	Mobile Boom Lift	Geniew Z60/34	SURFACE	1	75	10.22	21%	5.470	6.01E-03	5.073	0.722	0.722	0.700	0.024	2.63E-05	0.022	0.003	0.003	0.003
Boston	Mobile Scissor Lift	Geniew GS-5390RT	SURFACE	1	75	7.52	21%	5.470	6.01E-03	5.073	0.722	0.722	0.700	0.024	2.63E-05	0.022	0.003	0.003	0.003
Boston	Mobile Telescopic Lift	Genie S-60	SURFACE	1	75	9.31	21%	5.470	6.01E-03	5.073	0.722	0.722	0.700	0.024	2.63E-05	0.022	0.003	0.003	0.003
Boston	Mobile Telescopic Lift	Genie S-65	SURFACE	4	75	10.02	21%	5.470	6.01E-03	5.073	0.722	0.722	0.700	0.096	1.05E-04	0.089	0.013	0.013	0.012
Boston	Mobile Telescopic Lift	Geniew S-80	SURFACE	1	74	16.10	21%	5.470	6.01E-03	5.073	0.722	0.722	0.700	0.024	2.60E-05	0.022	0.003	0.003	0.003
Boston	Mobile Telescopic Lift	Geniew S-85	SURFACE	1	74	17.19	21%	5.470	6.01E-03	5.073	0.722	0.722	0.700	0.024	2.60E-05	0.022	0.003	0.003	0.003
Boston	RTV	Polaris Sportsman 6x6 570	SURFACE	5	44	1.00	59%	5.446	6.01E-03	6.001	0.881	0.881	0.854	0.196	2.17E-04	0.216	0.032	0.032	0.031
Boston	RTV	Kubota RTV-X1100C	SURFACE	5	25	1.81	59%	6.245	6.38E-03	7.258	1.033	1.033	1.002	0.127	1.30E-04	0.148	0.021	0.021	0.020
Boston	Self-propelled All Terrain Fusion Machine (joining PE pipes)	TracStar 412/618	SURFACE	1	20	0.95	21%	4.457	5.47E-03	2.429	0.352	0.352	0.341	0.005	6.38E-06	0.0028	0.0004	0.0004	0.0004
Boston	Generator/Welder - Diesel	Miller 800	SURFACE	4	66	—	21%	5.146	6.00E-03	5.394	0.776	0.776	0.753	0.079	9.20E-05	0.083	0.012	0.012	0.012
Boston	Generator/Welder - Diesel	SQ-3350	SURFACE	4	38	—	21%	4.916	5.92E-03	4.086	0.645	0.645	0.626	0.043	5.18E-05	0.036	0.006	0.006	0.005
Boston	Generator/Welder - Diesel	Lincoln 300D	SURFACE	1	33	—	21%	4.916	5.92E-03	4.086	0.645	0.645	0.626	0.009	1.13E-05	0.008	0.001	0.001	0.001
Boston	Mobile Light Tower	Magnum MLT3060	SURFACE	10	13	0.82	43%	5.059	5.41E-03	2.783	0.427	0.427	0.414	0.081	8.66E-05	0.045	0.007	0.007	0.007

Table A-21 Boston Mobile Equipment during Operation (Based on Doris) and Emission Rates

Location	Equipment Type	Equipment Model	Application (SURFACE/ UNDERGROUND)	Number of Units	Horse-power	GVWR	Running Load Factor	Emission Factors						Emission Rates					
								NO_X	SO_2	CO	TSP	PM_{10}	$PM_{2.5}$	NO_X	SO_2	CO	ETSP	EPM_{10}	$EPM_{2.5}$
					(hp)	(tonne)	(%)	(g/hp-hr)	(g/hp-hr)	(g/hp-hr)	(g/hp-hr)	(g/hp-hr)	(g/hp-hr)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)
Boston	Mobile Light Tower	Wacker LTC 4	SURFACE	6	13	0.82	43%	5.059	5.41E-03	2.783	0.427	0.427	0.414	0.049	5.19E-05	0.027	0.004	0.004	0.004
Boston	Heavy Duty Truck	Kenworth T800 with Paccar MX-13 engine	SURFACE	4	500	40.37	70%	1.330	3.90E-03	0.499	0.078	0.078	0.075	0.517	1.52E-03	0.194	0.030	0.030	0.029
Boston	Freightliner Truck	Freightliner 108SD	SURFACE	1	380	31.30	70%	1.330	3.90E-03	0.499	0.078	0.078	0.075	0.098	2.88E-04	0.037	0.006	0.006	0.006
Boston	Fuel/Water truck	Kenworth T370 with Paccar PX-9 engine	SURFACE	2	380	27.22	70%	1.330	3.90E-03	0.499	0.078	0.078	0.075	0.197	5.77E-04	0.074	0.011	0.011	0.011
Boston	Fuel/Water truck	Peterbilt 348 with PACCAR PX-7 Engine	SURFACE	4	360	27.22	70%	1.330	3.90E-03	0.499	0.078	0.078	0.075	0.373	1.09E-03	0.140	0.022	0.022	0.021
Boston	General Truck	Sterling Acterra Class 5-8	SURFACE	1	350	29.94	70%	1.330	3.90E-03	0.499	0.078	0.078	0.075	0.091	2.66E-04	0.034	0.005	0.005	0.005
Boston	Passenger Van	Mercedes Sprinter 2500	SURFACE	1	188	5.00	70%	0.859	3.63E-03	0.203	0.029	0.029	0.028	0.031	1.33E-04	0.007	0.001	0.001	0.001
Boston	Transporter Truck	Ford E450	SURFACE	2	350	6.35	70%	1.330	3.90E-03	0.499	0.078	0.078	0.075	0.181	5.31E-04	0.068	0.011	0.011	0.010
Boston	Pickup Truck	Ford F250	SURFACE	4	330	4.54	70%	1.330	3.90E-03	0.499	0.078	0.078	0.075	0.341	1.00E-03	0.128	0.020	0.020	0.019
Boston	Pickup truck	Ford F350	SURFACE	21	385	5.13	70%	1.330	3.90E-03	0.499	0.078	0.078	0.075	2.091	6.14E-03	0.785	0.122	0.122	0.118
Boston	Pickup truck	Ford F550	SURFACE	9	440	6.35	70%	1.330	3.90E-03	0.499	0.078	0.078	0.075	1.024	3.01E-03	0.385	0.060	0.060	0.058
Boston	Scissor Bolter	MacLean MEM-928 with Deutz BF4M-1013C diesel engine	UNDERGROUND	3	154	22.00	43%	4.183	4.52E-03	1.201	0.250	0.250	0.242	0.231	2.50E-04	0.066	0.014	0.014	0.013
Boston	Face Drilling Rig	ATLAS COPCO Boomer 104	UNDERGROUND	3	57	9.00	43%	4.867	5.10E-03	2.424	0.413	0.413	0.401	0.099	1.04E-04	0.050	0.008	0.008	0.008
Boston	Face Drilling Rig	ATLAS COPCO Boomer 282	UNDERGROUND	3	78	18.30	43%	4.316	5.03E-03	2.319	0.421	0.421	0.408	0.121	1.40E-04	0.065	0.012	0.012	0.011
Boston	Underground Mining Truck	CAT AD30	UNDERGROUND	7	409	60.00	59%	1.330	3.90E-03	0.499	0.078	0.078	0.075	0.624	1.83E-03	0.234	0.036	0.036	0.035
Boston	Underground Mining Loader	CAT R1600	UNDERGROUND	5	279	44.20	59%	1.861	4.15E-03	0.630	0.122	0.122	0.118	0.425	9.49E-04	0.144	0.028	0.028	0.027
Boston	Underground Mining Loader	CAT R1300	UNDERGROUND	5	165	27.75	59%	2.040	4.27E-03	0.845	0.196	0.196	0.191	0.276	5.77E-04	0.114	0.027	0.027	0.026
Boston	Underground Mining Loader	ATLAS COPCO ST-2G	UNDERGROUND	3	117	22.60	59%	2.040	4.27E-03	0.845	0.196	0.196	0.191	0.117	2.45E-04	0.049	0.011	0.011	0.011
Boston	Motor Grader	Getman RDG-1504C	UNDERGROUND	2	147	16.33	59%	1.669	4.13E-03	0.726	0.173	0.173	0.168	0.080	1.99E-04	0.035	0.008	0.008	0.008
Boston	Telehandler	CAT TL943	UNDERGROUND	2	111.3	12.03	59%	2.297	4.33E-03	0.927	0.207	0.207	0.201	0.084	1.58E-04	0.034	0.008	0.008	0.007
Boston	Scissor Lift	Getman A64 SL	UNDERGROUND	7	173	12.25	21%	4.946	5.34E-03	2.897	0.504	0.504	0.489	0.349	3.77E-04	0.205	0.036	0.036	0.035
Boston	RTV	JohnDeere M-Gator A1	UNDERGROUND	4	18.5	1.13	59%	6.245	6.38E-03	7.258	1.033	1.033	1.002	0.076	7.74E-05	0.088	0.013	0.013	0.012
Boston	RTV	Kubota RTV-X1100C	UNDERGROUND	14	25	1.81	59%	6.245	6.38E-03	7.258	1.033	1.033	1.002	0.355	3.63E-04	0.413	0.059	0.059	0.057
												TOTAL EMISSION: SURFACE	g/s	**7.47**	**0.0190**	**3.38**	**0.52**	**0.52**	**0.51**
													t/d	**0.646**	**0.00164**	**0.292**	**0.045**	**0.045**	**0.044**
												UNDERGROUND	g/s	**2.84**	**0.0053**	**1.50**	**0.26**	**0.26**	**0.25**
													t/d	**0.245**	**0.00046**	**0.129**	**0.022**	**0.022**	**0.022**

NOTES:

ETSP, EPM_{10}, $EPM_{2.5}$ - particulate matter resulting from combustion

"—" Not applicable

APPENDIX B Meteorological Data

B.1 Introduction

This appendix provides an overview of the meteorology for the Hope Bay Gold Mine Project. Also provided are the technical details and options that were used for the application of the CALMET model for the assessment.

This assessment incorporates the Nunavut Environmental Guideline for Ambient Air Quality (Government of Nunavut 2011). Nunavut does not have guidelines for some of the dispersion modeling required to be included in the air quality assessment by the EIS guidelines (NIRB 2012). In these cases, British Columbia (BC) Air Quality Dispersion Modelling Guideline (AQDMG) (BC MOE, 2015) has been used.

Meteorology determines the transport and dispersion of industrial emissions, and hence plays a significant role in determining air quality downwind of emission sources. For this air quality assessment, meteorological data for the one year period from January 1, 2012 to December 31, 2012 were used to define transport and dispersion parameters. This is consistent with BCMOE AQDMG (MOE 2015).

Meteorological characteristics vary with time (e.g., season and time of day) and location (e.g., height, terrain and land cover). Historically, meteorological data measured at one location have been used and extrapolated to reflect the conditions over the full Model Domain. For large model domains, this approach fails to recognize that meteorological conditions for any given hour can vary significantly across the domain due to terrain and geophysical differences. Curvilinear airflow can also result from mesoscale and synoptic-scale weather patterns.

Meteorological models can be used to provide spatially and temporally varying wind and temperature fields across a model domain to overcome the limitations associated with the use of single station measurements. The CALMET meteorological pre-processing program was used to provide temporally and spatially varying meteorological parameters required by the CALPUFF model.

The CALMET pre-processor is available from the web site of the model developer (i.e., Exponent Inc. - http://www.src.com/calpuff/calpuff1.htm). At the time of this updated assessment, the most recent Exponent version of CALMAET was Version 6.5.0 level 150223, released June 22, 2015. The corresponding current U.S. EPA version of CALMET is Version 5.8.5, level 151214. Consistent with the BCMOE AQDMG (MOE 2015), The Version 6.5.0 was adopted for this assessment.

B.2 Model Domain

B.2.1 Boundaries

The Model Domain adopted for this assessment extends from 67.4420 degrees latitude to 68.3604 degrees latitude (resulting in a north south extent of 100 km), and from 107.6509 degrees longitude to 105.3269 degrees longitude (resulting in an east west extent of100 km), as shown in Figure B-1. The study domain covers a 10,000 km^2 area, the extents of which are provided in Table B-1. A horizontal grid spacing of 1 km was selected for the CALMET simulation. The study area therefore corresponds to 100 rows by 100 columns. With this grid spacing, it was possible to maximize run time and file size efficiencies while still capturing large-scale terrain feature influences on wind flow patterns.

To simulate transport and dispersion processes, it is also important to simulate the representative vertical profiles of wind direction, wind speed, temperature, and turbulence intensity within the atmospheric boundary layer (i.e., the layer within about 2,000 m above the Earth's surface). To capture this vertical structure, ten vertical layers were selected. CALMET defines a vertical layer as the midpoint between two faces (i.e., eleven faces correspond to ten layers, with the lowest layer always being ground level or 10 m). The vertical faces used in this study are 0 m, 20 m, 40 m, 80 m, 160 m, 320 m, 640 m, 1,000 m, 1,500 m, 2,000 m and 3,000 m.

Table B-1 Model Domain (100 km by 100 km) Coordinates (UTM Zone 13; NAD 83)

Domain Corner	Easting (m)	Northing (m)
Southwest	386547	7483084
Northwest	386547	7583084
Northeast	486547	7583084
Southeast	486547	7483084

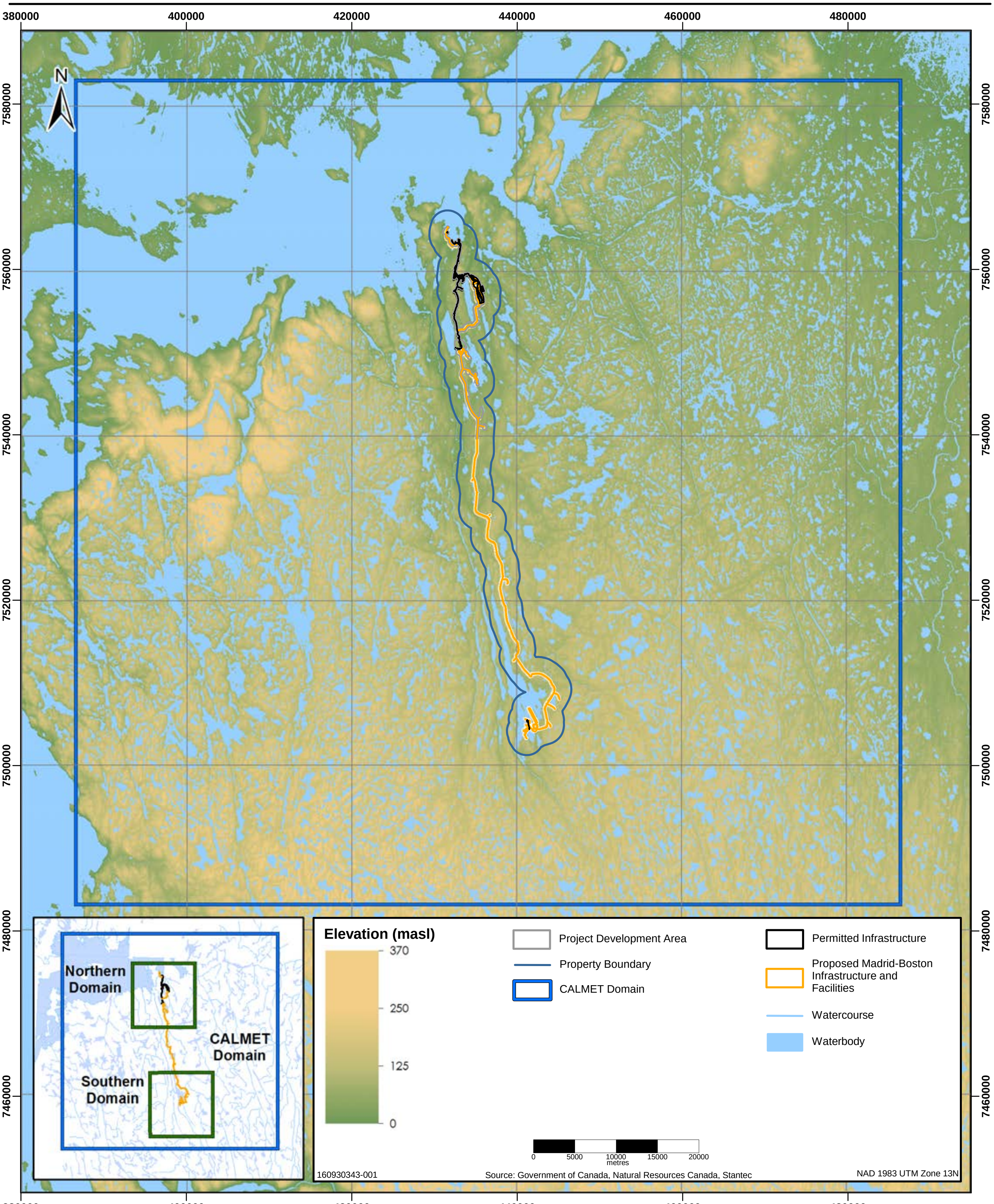
B.2.2 Topography

The valleys and elevated terrain features in the meteorological domain can affect surface wind flow patterns. The terrain data used to define these features were obtained Canadian Digital Elevation Model (CDEM 2016). The CDEM stems from the existing Canadian Digital Elevation Data (CDED). The pre-packaged GeoTif datasets are based on the National Topographic System of Canada (NTS) at the 1:250 000 scale; the NTS index file is available in the Data Resources section (Shape, KML). These data have a horizontal resolution of about 30 m, which is more than sufficient for air quality assessment purposes.

A general overview of the terrain in the domain is presented in Figure B-1. Broadly speaking, the higher elevations are towards the southwest of the domain and the lowest elevations are near the northern portion of the domain.

Figure B-1

Terrain within CALMET Model Domain



B.2.3 Land-Cover Types

For this assessment, the U.S. Geological Survey (USGS) Global Land Cover Characterization (GLCC) dataset (USGS 2016) was used to initialize land-cover categories in the CALMET model. GLCC (by continent) provides the GLCC classifications, as well as monthly NDVI composites, on a continent-by-continent basis (Africa, North America, South America, Eurasia, and Australia/Pacific). The continent GLCC data is available in the Interrupted Goode Homolosine or in the Lambert Azimuthal Equal-Area projection. Nominal spatial resolution is 1 kilometer.

For this assessment, the GLCC dataset was extracted and then converted into the fractional land-use format accepted by the CALMET MAKEGEO pre-processor. MAKEGEO creates the geophysical data file (GEO.DAT) for CALMET. Two seasonal land use datasets were applied for this assessment base on local climate data at nearest ECCC climate station at Cambridge Bay: snow covered land and season free land. The snow-covered land use dataset assumed the entire domain was categorized as perennial snow and ice. The snow free land use dataset included tundra, lake and ocean categories. Tables B-2 to B-3 describe the seasonal values for surface roughness (z_0), albedo, Bowen ratio, soil heat flux, anthropogenic heat flux and LAI defined according to the BCMOE AQDMG (MOE 2015) and the CALMET User Guide (Scire et al. 2000).

Land-cover in the CALMET domain are shown in Figures B-2 and B-2. Based on the 1 km grid resolution data, for the snow free land season, the domain is comprised of 82.9 percent tundra, 10.5 percent ocean or sea and 6.6 percent streams or canals. While for the snow-covered land season, the domain is comprised of 100 percent snow or ice.

Figure B-2

Land Use Classes within the Model Domain for the 'Snow Free Land' Season

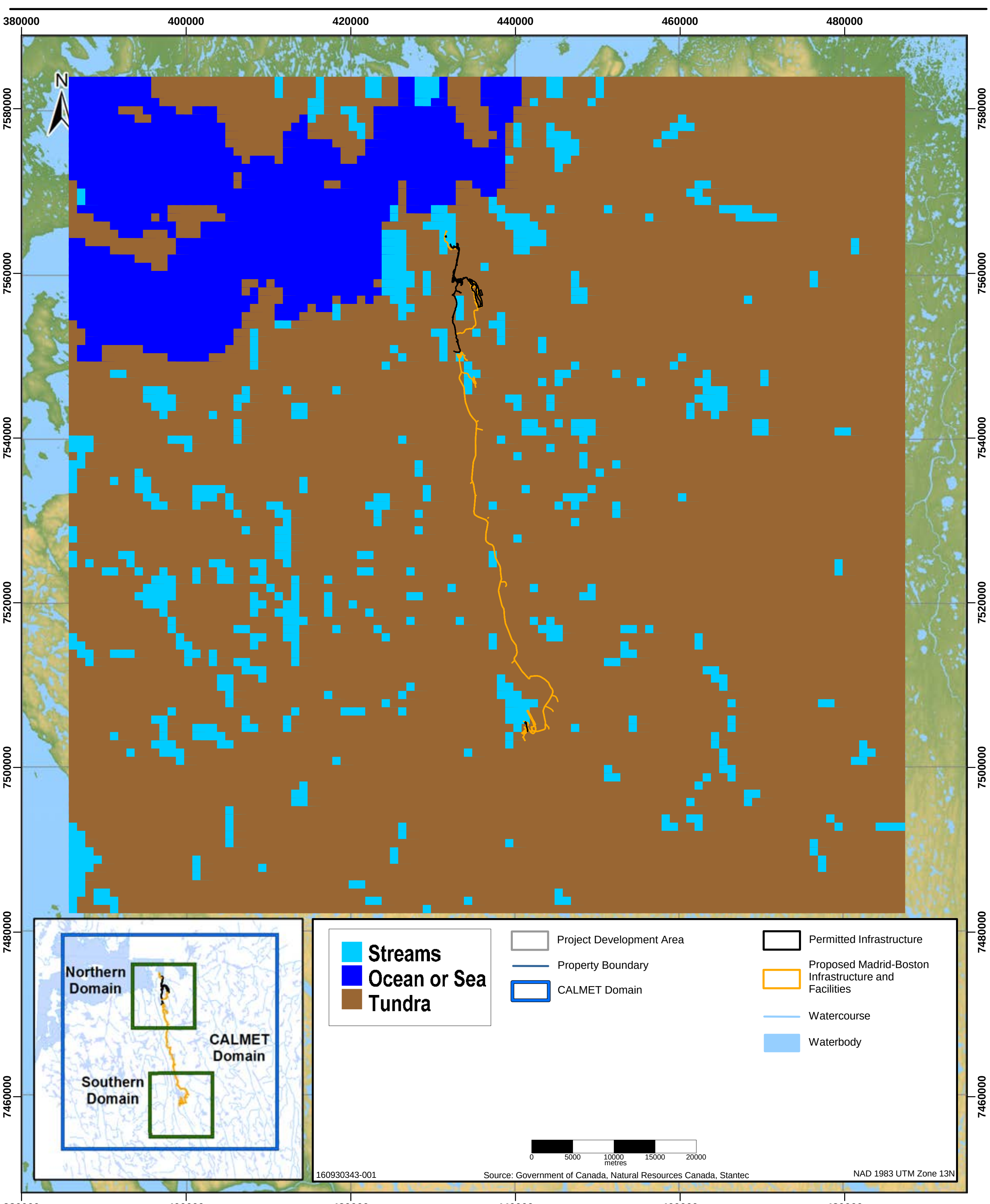


Figure B-3

Land Use Classes within the Model Domain for the 'Snow Covered Land' Season

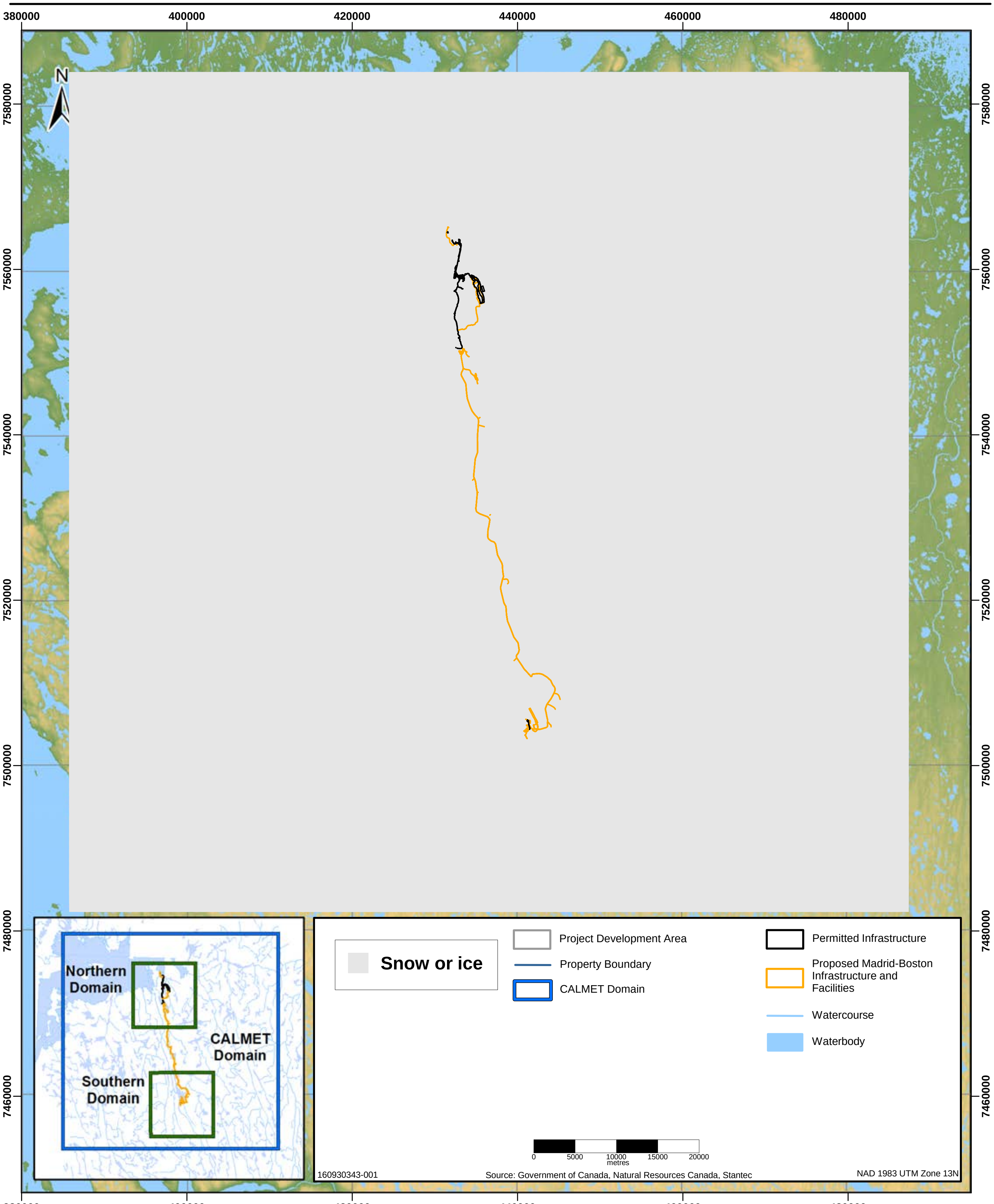


Table B-2 Land-cover Characterization and Associated Geophysical Parameters for the Snow-Covered Land Season

GLCC Code	Surface Roughness (m)	Albedo	Bowen Ratio	Soil Heat Flux (fraction)	Anthropogenic Heat Flux (W/m^2)	Leaf Area Index	CALMET Code	CALMET Land Cover Type
90	0.2	0.7	0.5	0.15	0.0	0.0	90	Snow or Ice

NOTES:
Winter = October, November, December, January, February, March, April and May
W/m^2 = watts per square metre

Table B-3 Land-cover Characterization and Associated Geophysical Parameters for the Snow Free Land Season

GLCC Code	Surface Roughness (m)	Albedo	Bowen Ratio	Soil Heat Flux (fraction)	Anthropogenic Heat Flux (W/m^2)	Leaf Area Index	CALMET Code	CALMET Land Cover Type
80	0.2	0.3	0.5	0.15	0.0	0.0	80	Tundra
51	0.001	0.1	1.0	1.0	0.0	0.0	51	Canals or streams
55	0.001	0.1	1.0	1.0	0.0	0.0	55	Ocean or Sea Water

NOTES:
Snow Free Land = June, July, August and September
W/m^2 = watts per square metre

B.2.4 Meteorological Measurements

Meteorological data parameterize a wide range of phenomena that include: ambient air temperature, precipitation, relative humidity, visibility, solar radiation, wind, severe weather, and thermal inversions. Selected parameters at nearby Environment Canada Cambridge Bay climate station were reviewed in the context of evaluating the representativeness of meteorological data of year 2012 to represent long-term means.

B.2.5 Ambient Air Temperature

Table B-4 summarizes the historical monthly and annual mean air temperatures at the Cambridge Bay climate station for the period of 1981 to 2010. Annual average ambient temperature is -13.3°C at this station.

Table B-4 Historical Monthly and Annual Mean Daily Temperatures at Cambridge Bay station (1981 to 2010)

Month	Mean Daily Temperature (°C)
January	-32.0
February	-32.5
March	-29.3
April	-20.8
May	-9.3
June	2.7
July	8.9
August	6.8
September	0.3
October	-10.4
November	-22.3
December	-28.3
ANNUAL	-13.9
SOURCE: National Climate Data and Information Archive http://climate.weather.gc.ca/climate_normals/index_e.html	

B.2.6 Precipitation

Monthly mean total precipitation, rainfall, and snowfall are summarized in Table B-5 for the Cambridge Bay climate station. The average total precipitation at the Cambridge Bay was 141.7mm/y. The driest months are during the winter, while the wettest months are during the summer.

Table B-5 Mean Monthly and Annual Total Precipitation, Rainfall and Snowfall at Cambridge Bay station (1981 to 2010)

Month	Total Precipitation (mm)	Total Rainfall (mm)	Snowfall (cm)
January	5.8	0.0	6.7
February	4.9	0.0	5.9
March	7.1	0.0	8.4
April	5.7	0.0	6.9
May	7.0	1.0	7.2
June	13.6	10.0	3.8
July	24.1	23.9	0.1
August	25.7	23.9	1.8
September	19.1	12.7	6.8
October	14.7	0.6	15.9
November	8.0	0.0	9.8
December	6.1	0.0	6.8
ANNUAL	141.7	72.1	80.2

B.3 CALMET Input Data

The CALMET model requires the input of surface and upper air meteorological fields. For this application, CALMET model was run in Hybrid mode (BC MOE, 2015) by using surface observations and Weather Research and Forecasting mesoscale model (WRF) model output (Lakes Environmental, 2016) for the period of January 1, 2012 to December 31, 2012. There are no upper air stations within or nearby the CALMET domain.

B.3.1 Lakes Environmental WRF Data

For this assessment, 4 km grid resolution WRF model data was generated by the Lakes Environmental (Lakes Environmental 2016) for the year 2012 and incorporated into the CALMET processing. Figure B-4 shows the WRF grid point locations based on 4 km grid resolution within the 100 km by 100 km CALMET model domain.

B.3.2 Surface Observations

For this assessment, there are three hourly surface observation stations within CALMET domain (shown in Table B-6 and Figure B-4). On-site meteorological data for the year 2012 from the Doris and Boston meteorological stations (Rescan 2012b) were used as surface observational data in the model. The year 2012 was chosen as it was the most recent year with meteorological data available from both stations without significant data gaps. Surface temperature, relative humidity, wind speed and wind direction are four meteorological parameters included in CALMET modeling.

QAQC (e.g., data values range and wind roses) was completed for input wind data at all three stations to ensure data should be included in CALMET modeling. Measurements at both stations have good coverage over 90%, and this is consistent with BCMOE AQDMG (MOE 2015).

Figure B-6 shows wind roses for Doris and Boston stations for the year 2012. The prevailing wind directions at the Doris station exhibit high percent of west and east winds. Winds at the Boston are mainly from west and south, likely attributable to the local topography near this station.

Table B-6 Coordinates and Meteorological Parameters of Surface Stations within Model Domain

Source	Station Name	Latitude	Longitude	Elevation (m amsl)	UTM NAD 83 (Zone 13)		Parameters included in CALMET modeling
					m East	m North	
Rescan 2012b	Doris	68.1330	-106.6053	28	433281	7558557	wind speed, wind direction, temperature, relative humidity
	Boston	67.6573	-106.3860	118	441207	7505312	wind speed, wind direction, temperature, relative humidity

Figure B-4

WRF 4km Grids within CALMET Model Domain

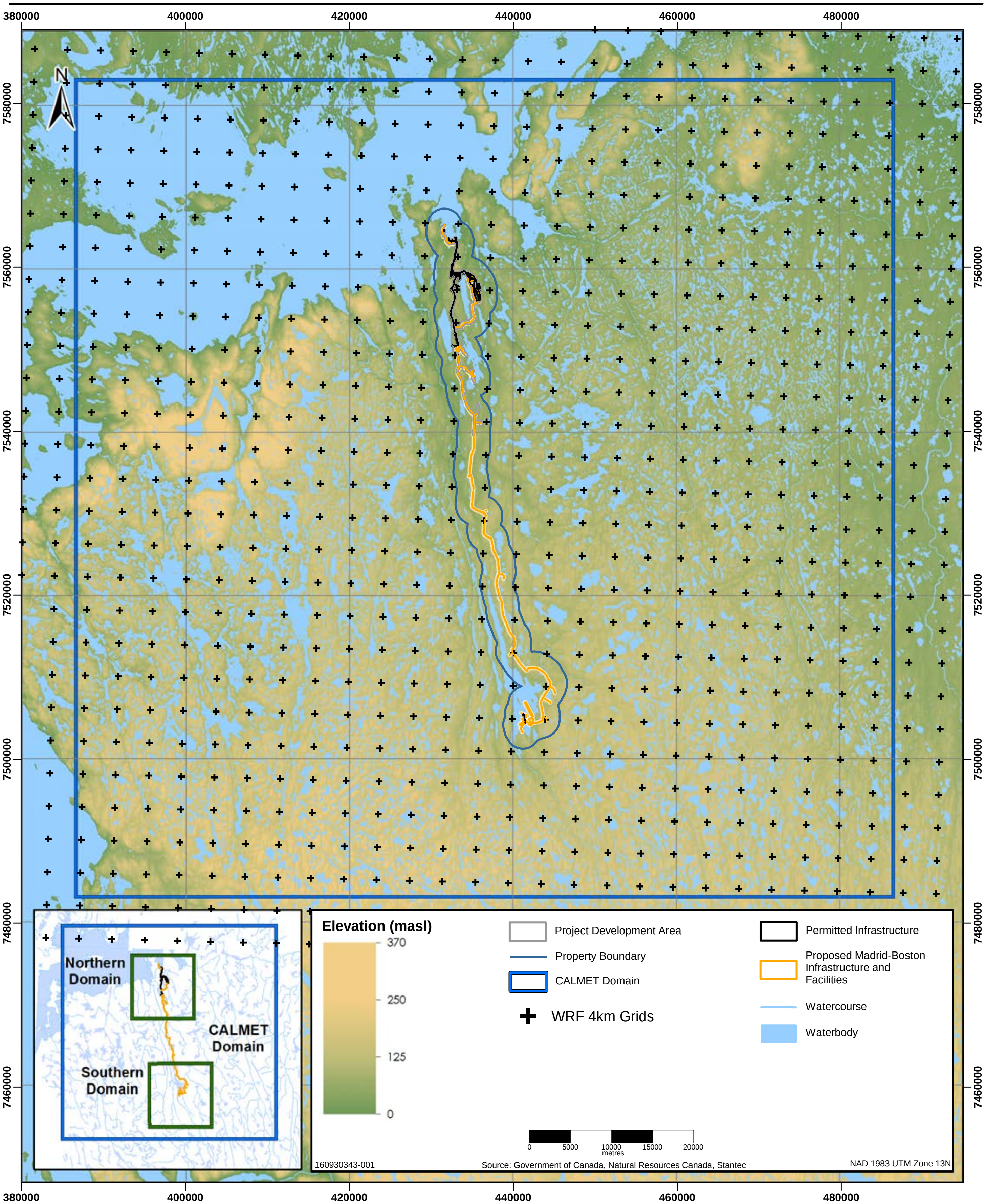
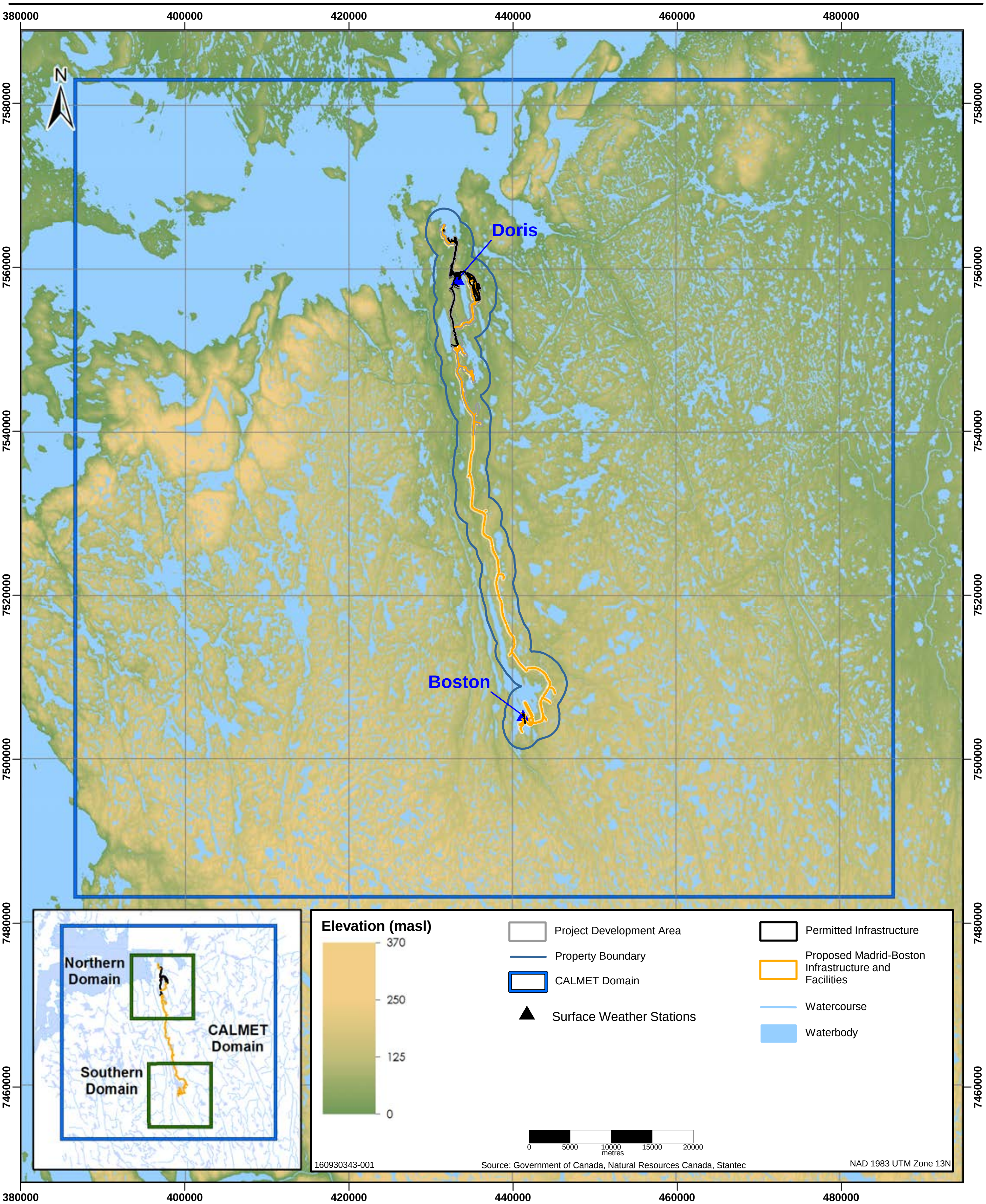


Figure B-5

Surface Weather Stations within CALMET Model Domain



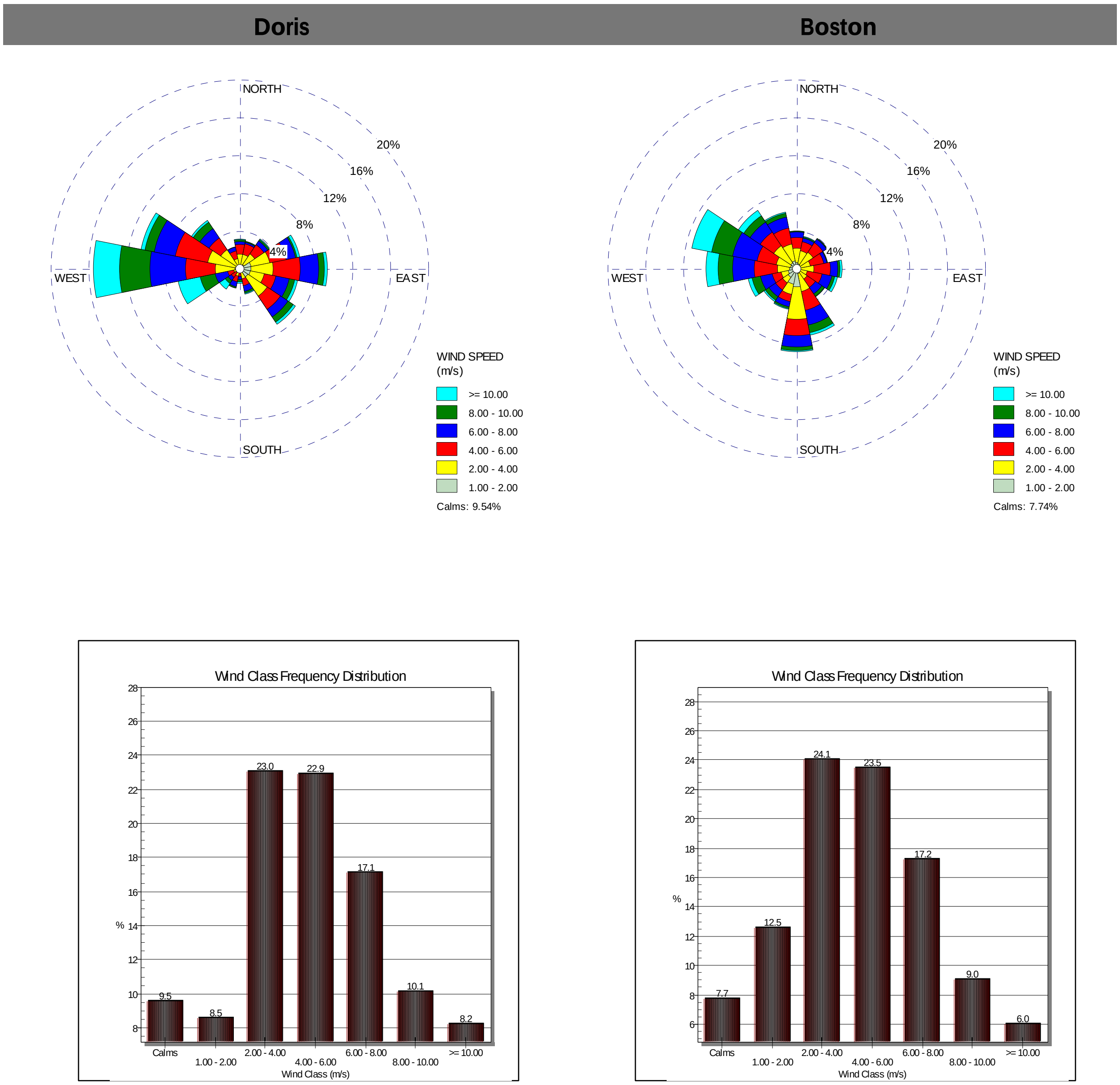


Figure B-6 Measured Wind Roses and Classes for Two Meteorological Stations in the CALMET Domain (2012)

B.3.3 CALMET Predictions

In order to assess the value of the WRF-CALMET model approach for this assessment, CALMET output surface and elevated winds, surface temperature, mixing height and PG stability class data were extracted at two projects sites (Doris and Boston) for analysis.

B.3.4 Predicted Surface Winds Field

The CALMET model can provide surface wind vector plots for all the grid points across a model domain. Three plots were generated to represent unstable, stable, and neutral conditions for the near-field model domain. The three sample wind vector plots are described below:

- Figure B-7 shows the wind field as a vector plot at 1300 LST on May 1, 2012, for convective (i.e., unstable) conditions (PG class B). Winds in the northwest portion of the domain tend to be southerly, whereas those in the other part of the domain tend to be from the west to northwest. The predicted winds at both Doris and Boston sites are mainly from the west.
- Figure B-8 shows the wind field as a vector plot at 0600 LST on January 6, 2012, for stable conditions (PG class F). Winds in the northwest portion of the domain tend to be northerly, whereas those in the other part of the domain tend to be from the west to northwest. The predicted winds at the Doris site are mainly from the northwest. The predicted winds at the Boston site are mainly from the west.
- Figure B-9 shows the wind field as a vector plot at 1400 LST on September 22, 2012, for high wind speed (i.e., neutral) conditions. Under these conditions, winds are from the west across most of the domain. The predicted winds at both Doris and Boston sites are mainly from the west.

The vector plots were not selected to represent a specific meteorological condition; they are provided to show the variability of the airflow that can occur over the 100 km by 100 km area during any given hour. Departures of the predicted vector plots from the actual wind field for a given hour are to be expected given the nature of modelling and the relatively low density of actual observations across the region. The predicted values, however, are preferable to assuming a homogeneous wind field across the domain for each hour, based on the local terrain influences that are reflected in the measured data.

Figure B-7

Predicted Surface Wind Field for Unstable Conditions (1300 LST on May 1, 2012)

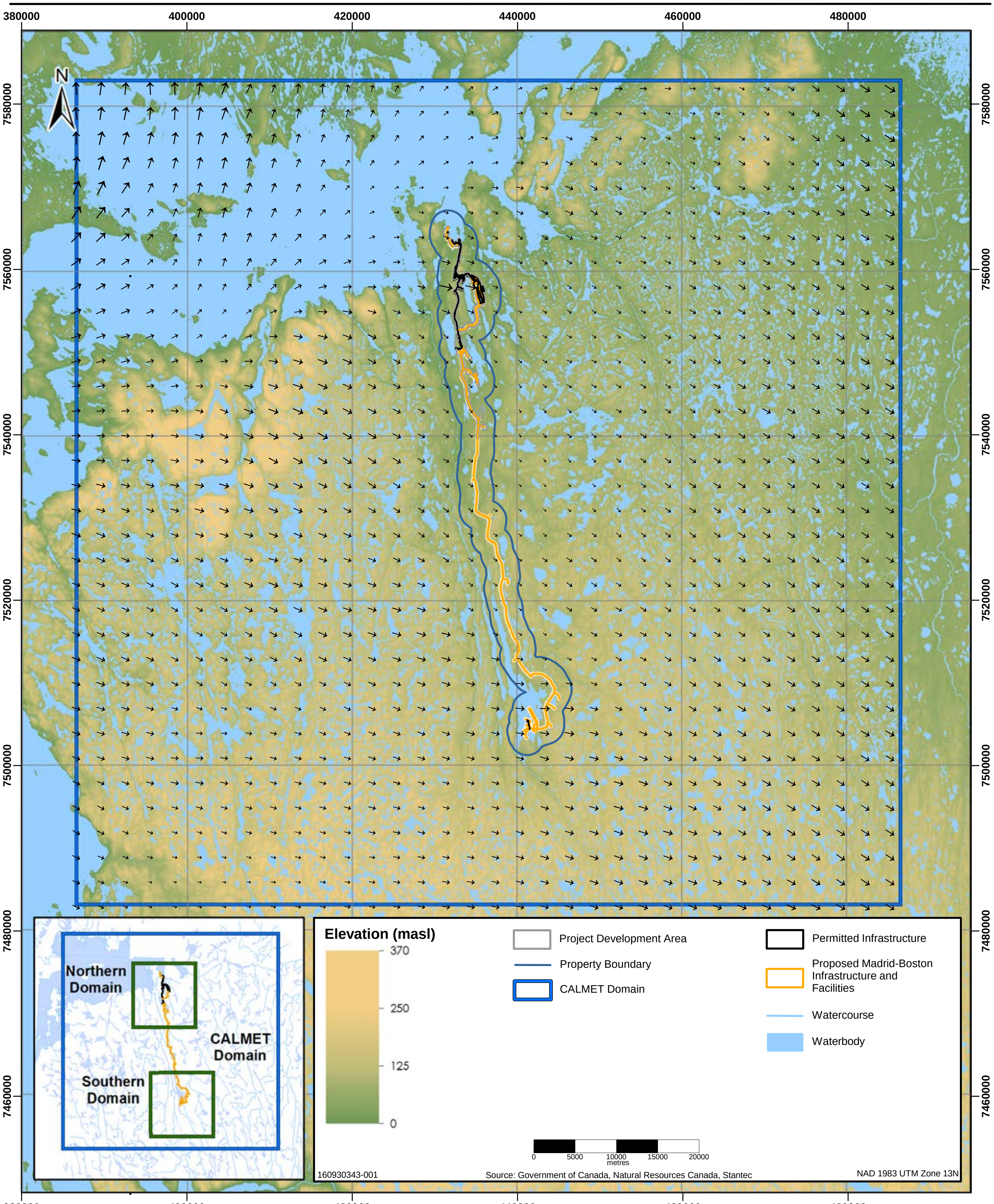


Figure B-8

Predicted Surface Wind Field for Stable Conditions (0600 LST on January 6, 2012)

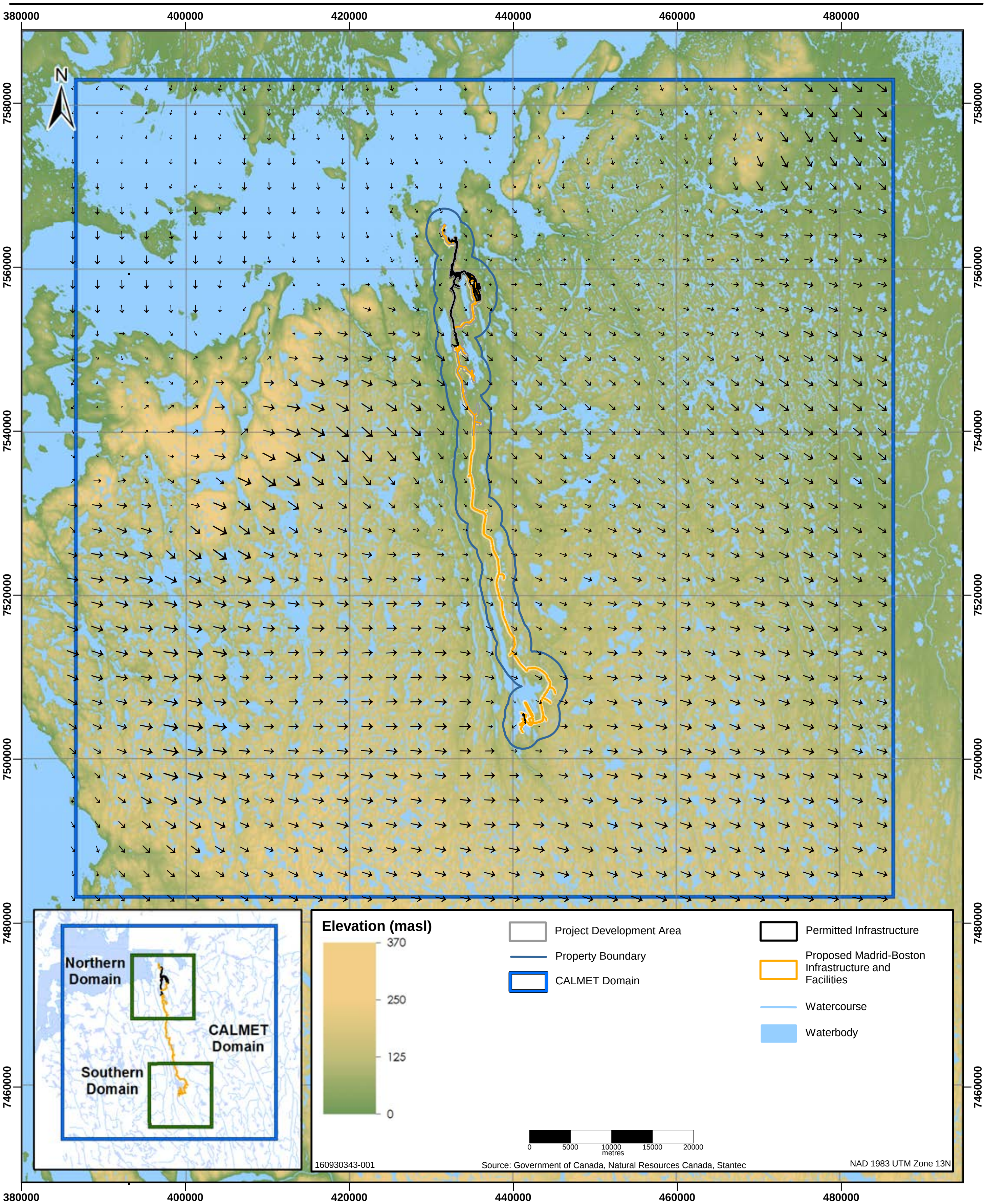
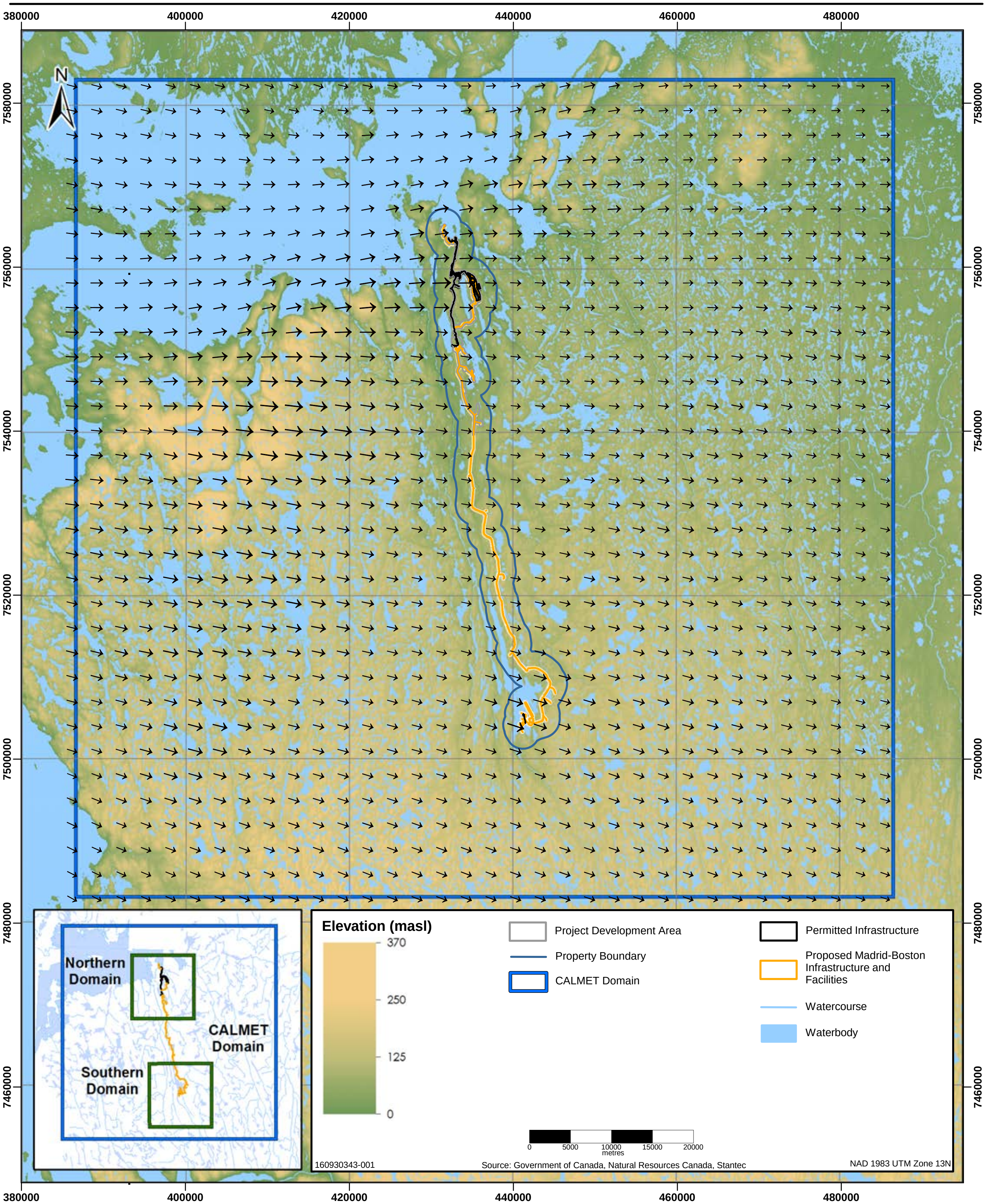


Figure B-9

Predicted Surface Wind Field for High Winds Conditions (1400 LST on September 22, 2012)



B.3.5 Predicted Elevated Winds

Figure B-10 shows the wind roses predicted by CALMET for the Doris site at various elevations above ground (10 m, 60 m, 120 m and 240 m). The results indicate:

- At all levels (10 m, 60 m, 120 m and 240 m), winds are mainly from northwest, west and east. This is due to open area of this site.
- Wind speed increases with increasing height above the ground.

Figure B-11 shows the wind roses predicted by CALMET for the Boston site at various elevations above ground (10 m, 60 m, 120 m and 240 m). The results indicate:

- At middle levels (120 m and 240 m), winds are mainly from northwest and south.
- At 10 and 60 m elevation, winds are mainly from northwest, southeast and south. This is likely due to local topography.
- Wind speed increases with increasing height above the ground.

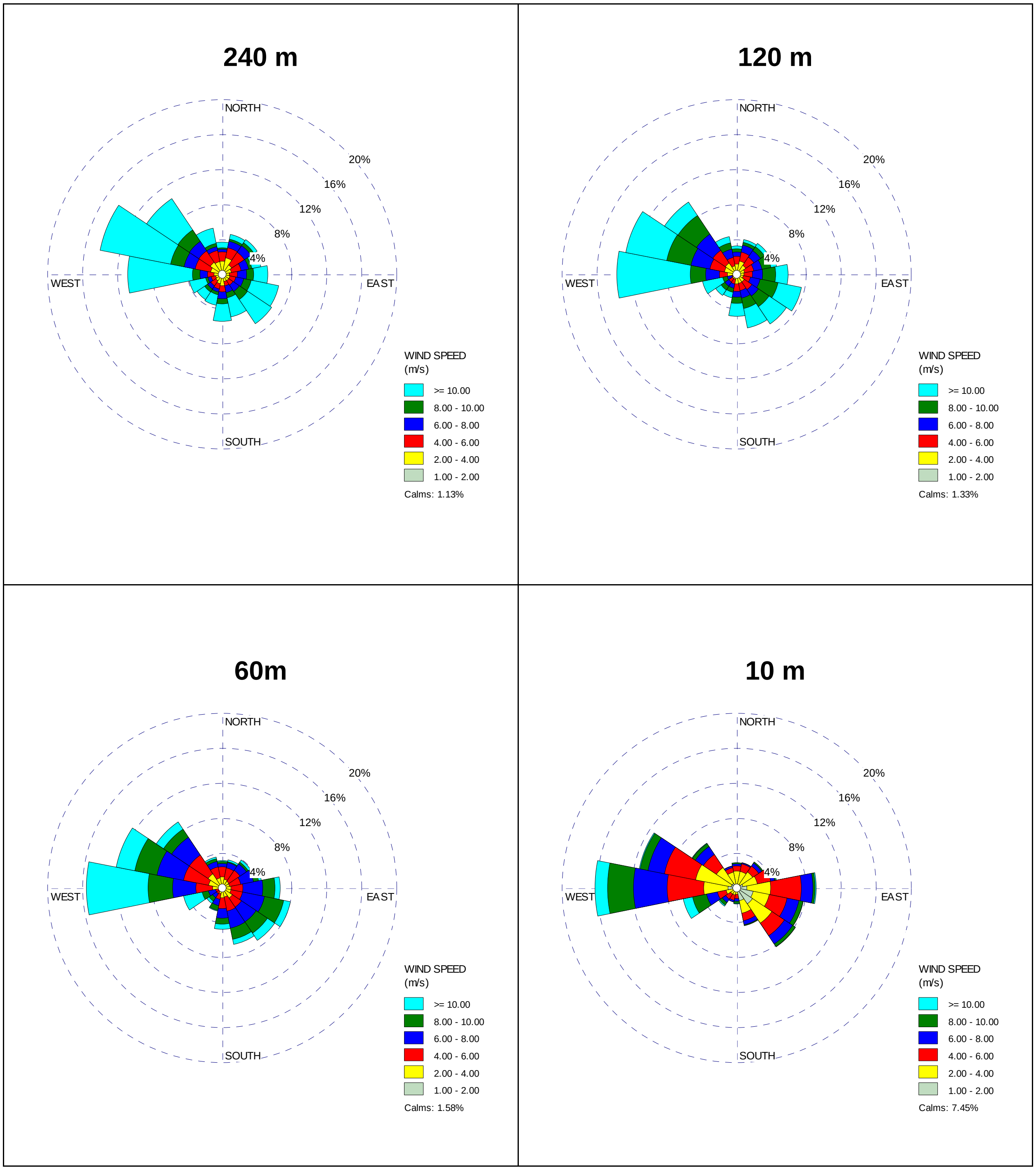


Figure B-10 CALMET Predicted Wind Roses at the Doris Site (2012)

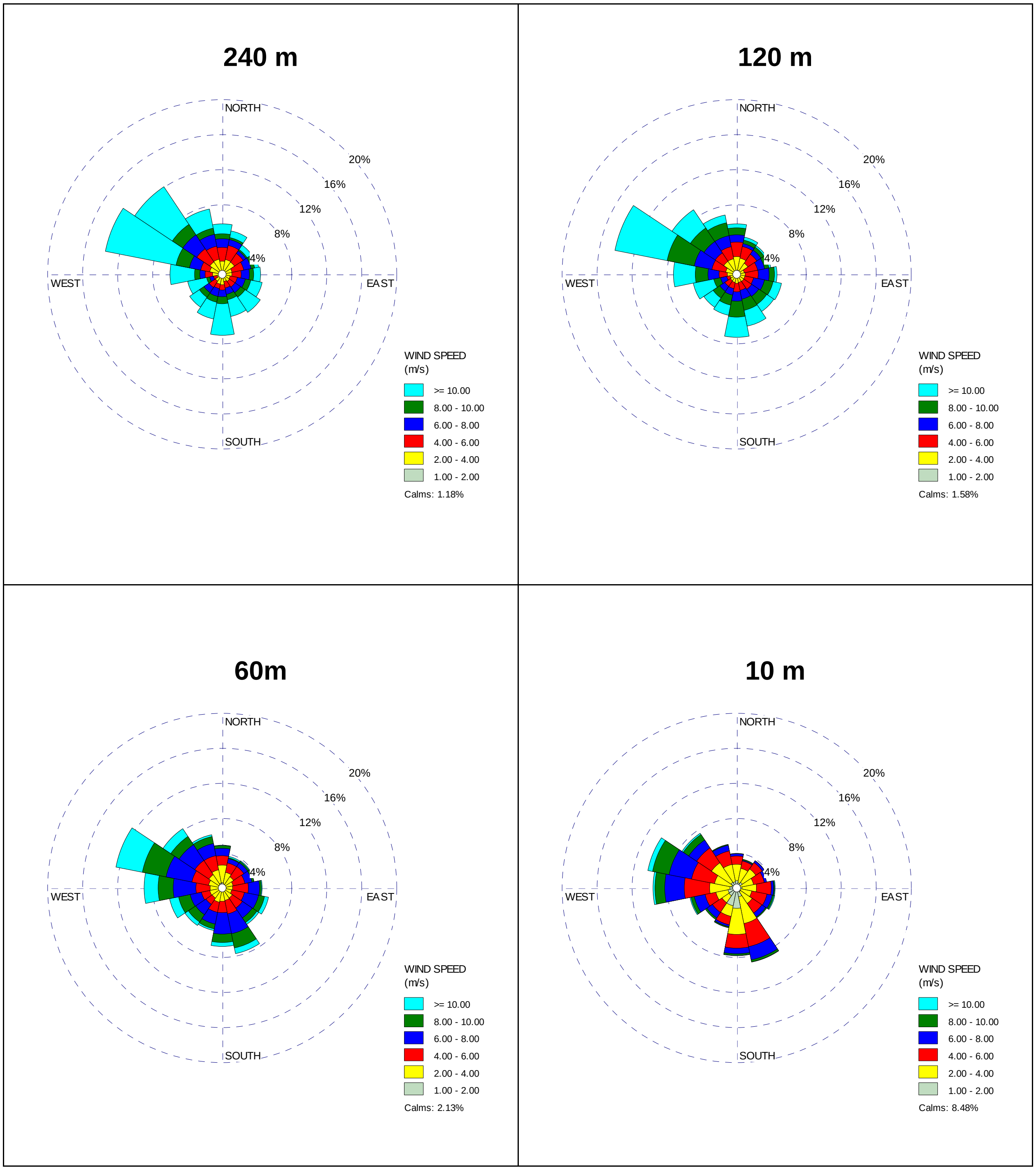


Figure B-11 CALMET Predicted Wind Roses at the Boston Site (2012)

B.3.6 Predicted Surface Temperatures

Figures B-12 and B-13 show the monthly average surface temperatures predicted by CALMET for the Doris and Boston sites, respectively. The predicted monthly temperatures indicate similar and reasonable seasonal surface temperature variations at both sites.

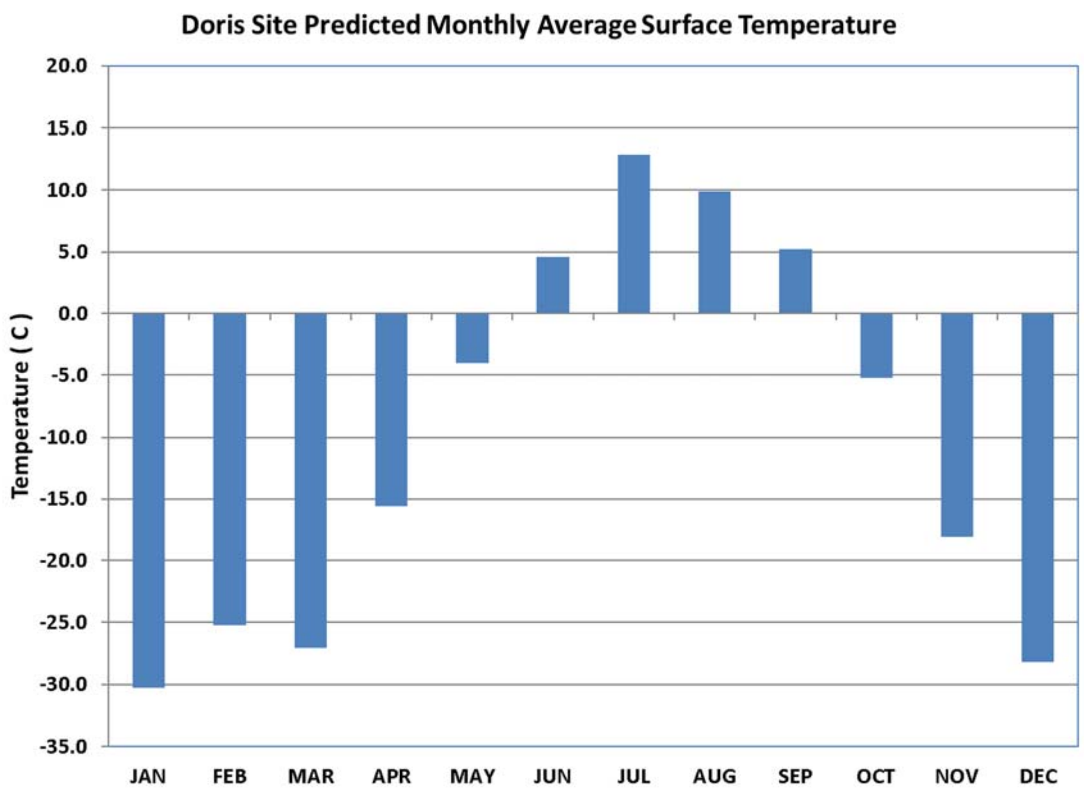


Figure B-12 CALMET Predicted Monthly Average Surface Temperatures for the Doris Site (2012)

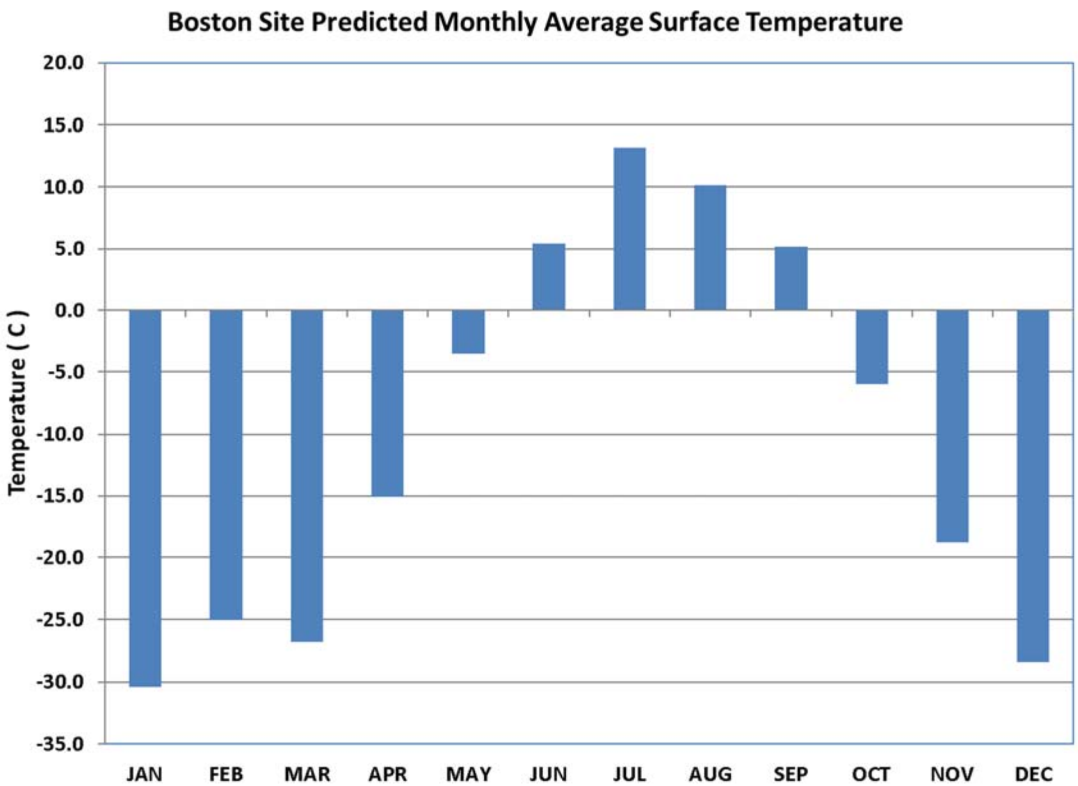


Figure B-13 CALMET Predicted Monthly Average Surface Temperatures for the Boston Site (2012)

B.3.7 Predicted Mixing Heights

The presence of an elevated inversion can trap effluents discharged into the atmosphere in the layer between the surface and the base of the inversion layer, which can increase ground-level ambient concentrations relative to the absence of an inversion layer. Mixing heights are usually the highest (i.e., in the 1,000 m to 2,000 m range) during daytime periods that are characterized by strong solar heating, and the lowest (i.e., about 100 m) during the night. High wind speeds can also produce well-mixed layers.

The minimum values for each season are predicted to occur during the night. During the night, the mixing height tends to be determined by mechanical mixing processes, with higher wind speeds resulting in a deeper mixed layer. The convective mixing process dominates during the day, leading to maximum mixed layer depths during the afternoon. The CALMET model, as applied, sets the minimum mixing height to 50 m.

For this assessment, the CALMET post-processor was used to extract the mixing heights from CALMET output files, and the mixing height predictions for the Doris and Boston sites are provided in Figures B-14 and B-15 for two seasons. The results show:

- 'Snow Free Land' Season: The maximum median values are about 845 m at Doris site, and about 710 m at Boston site.
- 'Snow Covered Land' Season: The maximum median values are about 415 m at Doris site, and about 303 m at Boston site.

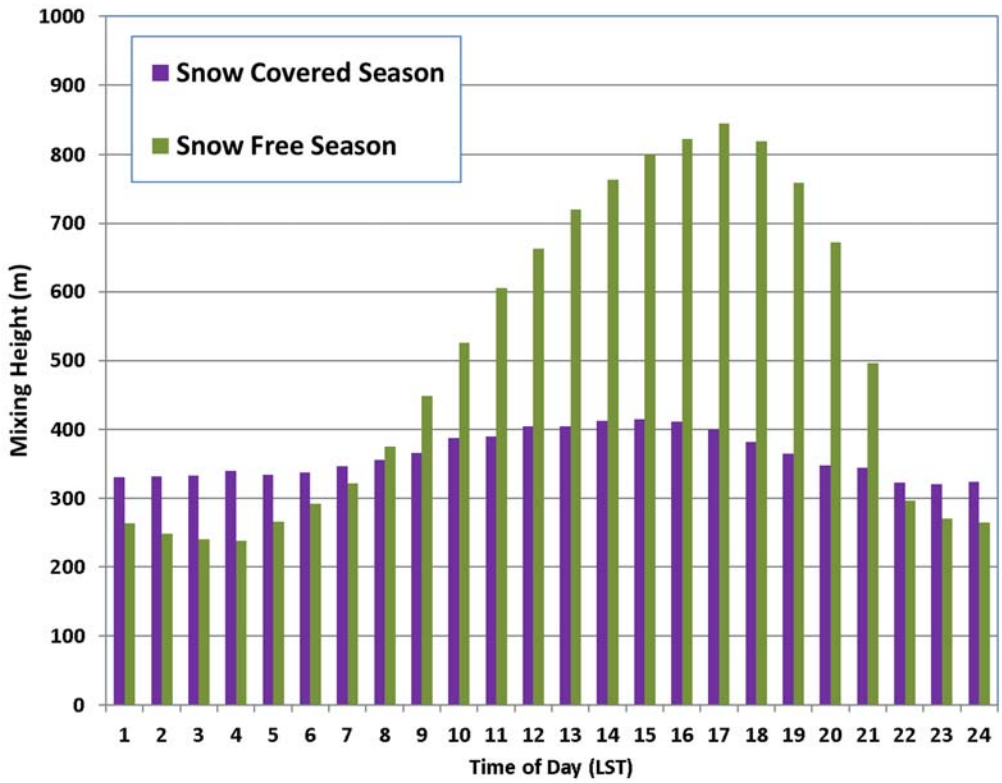


Figure B-14 CALMET Predicted Mixing Heights for Different Seasons and Times of Day for the Doris Site (2012)

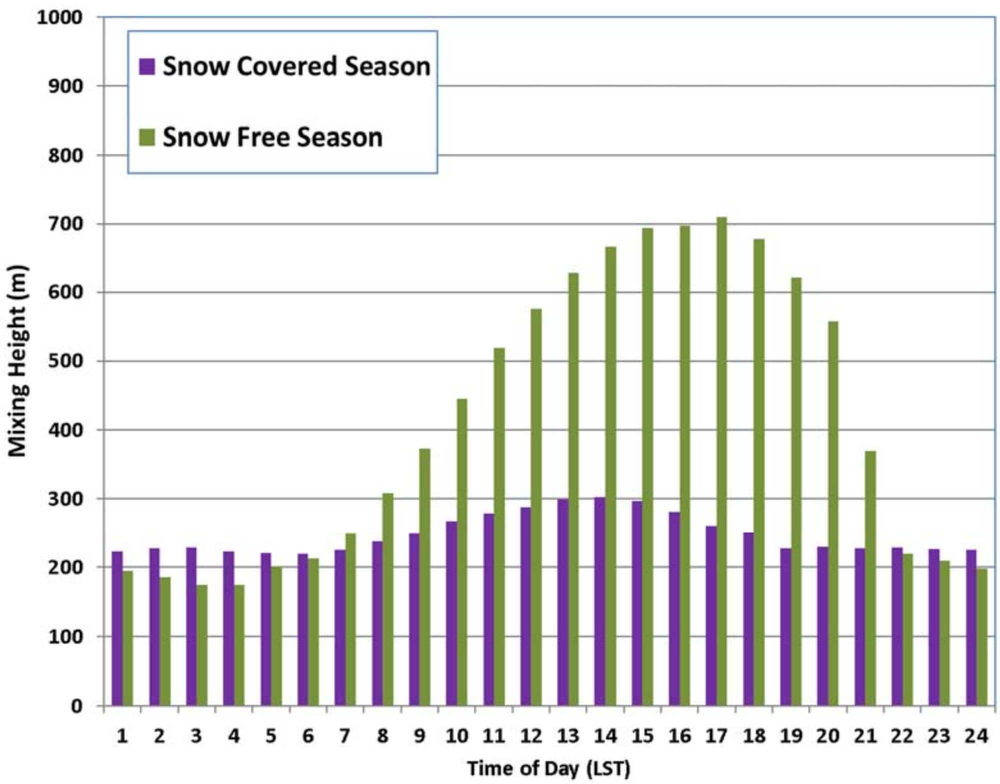


Figure B-15 CALMET Predicted Mixing Heights for Different Seasons and Times of Day for the Boston Site (2012)

B.3.8 Predicted Atmospheric Stability Class

Atmospheric dispersion results from atmospheric turbulence, which can be related to atmospheric stability. Meteorologists define six stability classes (referred to as the Pasquill Gifford [PG] classes):

- Stability classes A, B and C occurs during the day, when the earth is heated by solar radiation. The air next to the earth is heated and tends to rise, enhancing vertical motions. This is referred to as an unstable atmosphere.
- Stability classes E and F occur during the night, when the earth cools due to long-wave radiation losses. The air next to the earth cools, suppressing vertical motions. This is referred to as a stable atmosphere.
- Stability class D is associated with completely overcast conditions (day or night) when there is no net heating or cooling of the earth, transitional periods between stable and unstable conditions, or during high wind speed periods (winds greater than 6 m/s [or 22 km/h]). This is referred to as a neutral atmosphere.

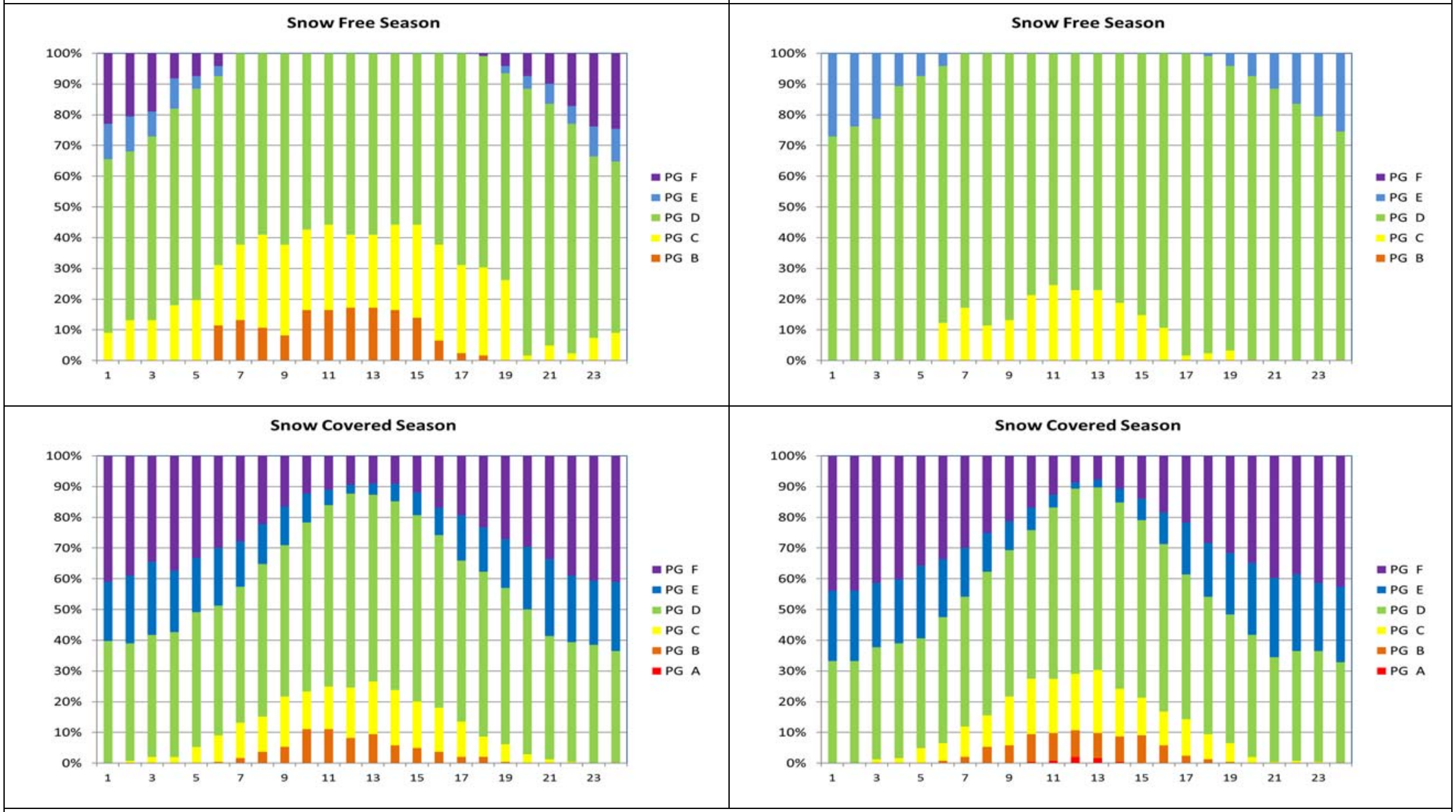
Stability classes undergo a significant daily variation, and they have a seasonal dependence. Stability classes can be determined from routine airport observations using he method devised by Turner (1963). A stability classification algorithm is also included in the CALMET model, this approach is also based on the Turner approach using wind speed and cloud cover information for each grid point in the domain.

Table B-7 compares the stability class frequency distributions based on the CALMET model predictions for the Project Site. Figure C-15 shows the frequency distributions of predicted seasonal PG stability classes on a diurnal basis for the Doris and Boston sites for two seasons. Unstable conditions are more frequent during the summer, and during daytime periods. Stable conditions are more frequent during nighttime periods.

Table B-7 CALMET Predicted Stability Class Frequency Distributions (%) at the Doris and Boston Sites (2012)

PG Class	Doris Site	Boston Site
A	0.0	0.1
B	4.1	2.1
C	12.0	8.1
D	53.4	57.7
E	11.3	13.1
F	19.5	19.0
Total	**100.0**	**100.0**
NOTE: PG – Pasquill-Gifford.		

Doris Site	**Boston Site**



NOTE: **Snow Covered Land Season**: October, November, December, January, February, March, April and May.
Snow Free Land Season: June, July, August and September.

Figure B-16 Seasonal Frequency of CALMET Predicted PG Stability Class for the Doris and Boston Sites (2012)

B.4 CALMET Model Options

The input parameters for the CALMET control file used in the modelling assessment are provided in Tables B-8 to B-15. The BC MOE Air Quality Model Guideline indicates that default assumptions and switches are to be used. Although not specified in the Model Guideline, it is assumed that the default values are defined in the CALMET user manual (Scire et al. 2000). The default values and the values adopted for this updated assessment are identified in the tables.

Table B-8 Input Groups in the CALMET Control File

Input Group	Description	Applicable to Project
0	Input and output file names	Yes
1	General run control parameters	Yes
2	Grid control parameters	Yes
3	Output Options	Yes
4	Meteorological data options	Yes
5	Wind Field Options and Parameters	Yes
6	Mixing Height, Temperature and Precipitation Parameters	Yes
7	Surface meteorological station parameters	Yes
8	Upper air meteorological station parameters	No
9	Precipitation parameters	No

Table B-9 CALMET Model Options Groups 0 and 1

Parameter	Default	Project	Comment
Input Group 0: Input and Output File Names			
NUSTA	-	0	Number of upper air stations
NOWSTA	-	0	Number of overwater meteorological stations
MM3D	-	12	Number of WRF.DAT files (one for each month)
NIGF	-	0	Number of IGF-CALMET.DAT files
Input Group 1: General Run Control Parameters			
IBYR	-	2012	Starting year
IBMO	-	1	Starting month
IBDY	-	1	Starting day
IBHR	-	0	Starting hour
IBSEC	-	0	Starting second
IEYR	-	2013	Ending year
IEMO	-	1	Ending month
IEDY	-	1	Ending day
IEHR	-	0	Ending hour

Table B-9 CALMET Model Options Groups 0 and 1

Parameter	Default	Project	Comment
IESEC	-	0	Ending second
ABTZ	-	UTC-0600	UTC time zone
NSECDT	3,600	3,600	Length of modeling time-step (seconds)
IRTYPE	1	1	Run type = 1 computes wind fields and micro-meteorological fields. Run type = 1 required for CALPUFF.
LCALGRD	T	T	LCALGRD = 1 stores the special data fields required by CALPUFF.
ITEST	2	2	Flag to stop run after SETUP phase
MREG	-	0	Test options specified to see if they conform to regulatory values 0 = NO checks are made

Table B-10 CALMET Model Options Group 2: Grid control parameters

Parameter	Default	Project	Comment
PMAP	UTM	UTM	Map projection
IUTMZN	-	13	UTM Zone
UTMHEM	N	N	Hemisphere for UTM projection
DATUM	WGS-84	WGS-84	WGS-84 Reference Ellipsoid and Geoid, Global coverage (WGS84)
NX	-	100	Number of X grid cells
NY	-	100	Number of Y grid cells
DGRIDKM	-	1.0	Horizontal grid spacing (km)
XORIGKM	-	386.547	Reference coordinate of SW corner of grid cell (1,1) -X coordinate (km)
YORIGKM	-	7483.084	Reference coordinate of SW corner of grid cell (1,1) -Y coordinate (km)
NZ	-	10	Vertical grid definition: Number of vertical layers
ZFACE	-	0, 20, 40, 80, 160, 320, 640, 1000, 1500, 2000 and 3000	Vertical grid definition: Cell face heights (m)

Table B-11 CALMET Model Options Group 3: Output Options

Parameter	Default	Project	Comment
Disk Output:			
LSAVE	T	T	Save meteorological fields in the unformatted output files
IFORMO	1	1	Unformatted output file suitable for input into CALPUFF is generated
Line Printer Output:			
LPRINT	F	F	LPRINT = F, do not print meteorological fields
IPRINF	1	1	Print intervals (h); used only if LPRINT = T.
IUVOUT (NZ)	NZ*0	10*0	Specify which layers of U,V wind component to print
IWOUT (NZ)	NZ*0	10*0	Specify which level of the w wind component to print
ITOUT (NZ)	NZ*0	10*0	Specify which levels of the 3-D temperature field to print
Meteorological fields to print:			
Variable		**0 = don't print 1 = print**	**Comment**
STABILITY		0	PGT stability; used only if LPRINT = T.
USTAR		0	Friction velocity; used only if LPRINT = T.
MONIN		0	Monin-Obukhov length; used only if LPRINT = T.
MIXHT		0	Mixing height; used only if LPRINT = T.
WSTAR		0	Convective velocity scale; used only if LPRINT = T.
PRECIP		0	Precipitation rate; used only if LPRINT = T.
SENSHEAT		0	Sensible heat flux; used only if LPRINT = T.
CONVZI		0	Convective mixing height; used only if LPRINT = T.
Testing and debug print options for micrometeorological module:			
LDB	F	F	Print input meteorological data and internal variables
NN1	1	1	First time step for which debug data are printed
NN2	1	1	Last time step for which debug data are printed
LDBCST	F	F	Print distance to land internal variables
Testing and debug print options for wind field module:			
Variable		**0 = don't write 1 = write**	**Comment**
IOUTD	0	0	Control variable for writing the test/debug wind fields to disk files
NZPRN2	1	1	Number of levels to print, starting at surface,
IPR0	0	0	Print the interpolated wind components
IPR1	0	0	Print the terrain adjusted surface wind components
IPR2	0	0	Print the smoothed wind components and the initial divergence fields
IPR3	0	0	Print the final wind speed and direction
IPR4	0	0	Print the final divergence fields

Table B-11 CALMET Model Options Group 3: Output Options

Parameter	Default	Project	Comment
IPR5	0	0	Print the winds after kinematic effects are added
IPR6	0	0	Print the winds after the Froude number adjustment is made
IPR7	0	0	Print the winds after slope flows are added
IPR8	0	0	Print the final wind field components

Table B-12 CALMET Model Options Group 4: Meteorological Data Options

Parameter	Default	Project	Comment
NOOBS	-	1	Use surface and overwater stations (no upper air observations); Use WRF/3D for upper air data
Number of Surface & Precipitation Meteorological Stations:			
NSSTA	-	2	Number of surface stations used
NPSTA	-	-1	Precipitation stations not used
Cloud Data Options:			
ICLDOUT	-	Not applicable	output a CLOUD.DAT file (yes or no) 1=yes
MCLOUD	4	4	Use WRF gridded cloud data as per BCMOE Model Guideline preference.
File Formats:			
IFORMS	2	2	Used free-formatted surface meteorological data file
IFORMP	2	Not applicable	Precipitation data file format
IFORMC	2	Not applicable	Cloud data file format

Table B-13 CALMET Model Option Group 5: Wind Field Options and Parameters

Parameter	Default	Project	Comment
Wind Field Model Options:			
IWFCOD	1	1	Model selection variables
IFRADJ	1	1	Compute Froude number adjustment
IKINE	0	0	Compute kinematic effects
IOBR	0	0	Use O'Brien procedure for adjustment of the vertical velocity
ISLOPE	1	1	Compute slope flow effects
IEXTRP	-4	-4	Extrapolate surface wind observations to upper layers (similarity theory used with layer 1 data at upper air stations ignored)
ICALM	0	0	Extrapolate surface winds even if calm
BIAS	NZ*0	10*0	Layer-dependent biases modifying the weights of surface and upper air stations Zero BIAS leaves weights unchanged
RMIN2	4	Not applicable	Minimum distance from nearest upper air station to surface station for which extrapolation of surface winds at surface station will be allowed
IPROG	14	14	Use gridded prognostic wind field model output fields as input to the diagnostic wind field model. Set to 14 as WRF gridded model data was used as the main input to CALMET model for this assessment.
ISTEPPGs	3600	3600	Time step (seconds) of the prognostic model input data
IGFMET	0	0	Use coarse CALMET fields as initial guess fields
Radius of Influence Parameters:			
LVARY	F	F	Use varying radius of influence
RMAX1	-	4	Maximum radius of influence over land in the surface layer (km)
RMAX2	-	Not Applicable	Maximum radius of influence over land aloft (km)
RMAX3	-	Not Applicable	Maximum radius of influence over water set
Other Wind Field Input Parameters:			
RMIN	0.1	0.1	Minimum radius of influence used in the wind field interpolation (km)
TERRAD	-	5	Radius of influence of terrain features (km) based on local topographic conditions near the Project Site
R1	-	1.5	Relative weighting of the first guess field and observations in the surface layer (km)
R2	-	Not Applicable	Relative weighting of the first guess field and observations in the layers aloft (km)
RPROG	-	0	Relative weighting parameter of the prognostic wind field data (km)
DIVLIM	5.0E-6	5.0E-6	Maximum acceptable divergence in the divergence minimization procedure
NITER	50	50	Maximum number of iterations in the divergence minimization procedure

Table B-13 CALMET Model Option Group 5: Wind Field Options and Parameters

Parameter	Default	Project	Comment
NSMTH (NZ)	2, (MXNZ-1) *4	2, 9*4	Number of passes in the smoothing procedure For NZ level 1, the CALMET default value 2 was used for the Project. For other levels, value 4 was used as CALMET input 4km WRF data already provided high resolution spatial wind fields
NINTR2	99	10*99	Maximum number of stations used in each layer for the interpolation of data to a grid point
CRITFN	1.0	1.0	Critical Froude number
ALPHA	0.1	0.1	Empirical factor controlling the influence of kinematic effects
FEXTR2(NZ)	NZ*0.0	10*0	Multiplicative scaling factor for extrapolation of surface observations to upper layers
Barrier Information:			
NBAR	0	0	Number of barriers to interpolation of the wind fields (The barrier option is not used)
KBAR	NZ	10	Level (1 to NZ) up to which barriers apply For this project, NZ=12
XBBAR	-	0	X coordinate of beginning of each barrier
YBBAR	-	0	Y coordinate of beginning of each barrier
XEBAR	-	0	X coordinate of ending of each barrier
YEBAR	-	0	Y coordinate of ending of each barrier
Diagnostic Module Data Input Options:			
IDIOPT1	0	0	Surface temperature (0 = compute internally from hourly surface observation)
ISURFT	-	-1	use 2-D spatially varying surface temperatures
IDIOPT2	0	0	Domain-averaged temperature lapse (0 = compute internally from hourly surface observation)
IUPT	-	Not Applicable	Upper air station to use for the domain-scale lapse rate
ZUPT	200	200	Depth through which the domain-scale lapse rate is computed (m)
IDIOPT3	0	0	Domain-averaged wind components
IUPWND	-1	Not Applicable	Not applicable since no upper air stations are used
ZUPWND	1., 1000	Not Applicable	Bottom and top of layer through which domain-scale winds are computed (m). Not applicable since it is only used if IDIOPT3 = 0, NOOBS > 0 and IUPWND > 0
IDIOPT4	0	0	Observed surface wind components for wind field module
IDIOPT5	0	Not Applicable	Observed upper air wind components for wind field module
Lake Breeze Information:			
LLBREZE	F	F	**Lake breeze module is not used**
NBOX	-	0	Number of lake breeze regions
XG1	-	0	X Grid line 1 defining the region of interest
XG2	-	0	X Grid line 2 defining the region of interest

Table B-13 CALMET Model Option Group 5: Wind Field Options and Parameters

Parameter	Default	Project	Comment
YG1	-	0	Y Grid line 1 defining the region of interest
YG2	-	0	Y Grid line 2 defining the region of interest
XBCST	-	0	X Point defining the coastline in kilometres (Straight line)
YBCST	-	0	Y Point defining the coastline in kilometres (Straight line)
XECST	-	0	X Point defining the coastline in kilometres (Straight line)
YECST	-	0	Y Point defining the coastline in kilometres (Straight line)
NLB	-	0	Number of stations in the region
METBXID	-	0	Station ID’s in the region

Table B-14 CALMET Model Option Group 6: Mixing Height, Temperature and Precipitation Parameters

Parameter	Default	Project	Comment
Empirical Mixing Height Constants:			
CONSTB	1.41	1.41	Neutral, mechanical equation
CONSTE	0.15	0.15	Convective mixing height equation
CONSTN	2400	2400	Stable mixing height equation
CONSTW	0.16	0.16	Over water mixing height equation
FCORIO	1.0E-4	1.0E-04	Absolute value of Coriolis parameter
Spatial Averaging of Mixing Heights:			
IAVEZI	1	1	Conduct spatial averaging
MNMDAV	1	1	Maximum search radius in averaging (grid cells)
HAFANG	30	30	Half-angle of upwind looking cone for averaging
ILEVZI	1	1	Layer of winds used in upwind averaging
Convective Mixing Heights Options:			
IMIXH	1	1	Method to compute the convective mixing height (Maul-Carson)
THRESHL	0.0	0.0	Threshold buoyancy flux required to sustain convective mixing height growth overland (W/m^3)
THRESHW	0.05	0.05	Threshold buoyancy flux required to sustain convective mixing height growth overwater (W/m^3)
IZICRLX	1	1	Flag to allow relaxation of convective mixing height to equilibrium value when 0<QH<THRESHL (overland) or 0<QH<THRESHW (overwater)
TZICRLX	800	800	Relaxation time of convective mixing height to equilibrium value Used only if IZICRLX = 1 and TZICRLX must be >= 1.
ITWPROG	0	0	Option for overwater lapse rates used in convective mixing height growth (1=use prognostic lapse rates)
ILUOC3D	16	16	Land use category ocean in 3D.DAT datasets

Table B-14 CALMET Model Option Group 6: Mixing Height, Temperature and Precipitation Parameters

Parameter	Default	Project	Comment
Other Mixing Height Variables:			
DPTMIN	0.001	0.001	Minimum potential temperature lapse rate in the stable layer above the current convective mixing height (K/m)
DZZI	200	200	Depth of layer above current convective mixing height through which lapse rate is computed (m)
ZIMIN	50	50	Minimum overland mixing height (m)
ZIMAX	3,000	3,000	Maximum overland mixing height (m)
ZIMINW	50	50	Minimum overwater mixing height (m)
ZIMAXW	3,000	3,000	Maximum overwater mixing height (m)
Overwater Surface Fluxes Method and Parameters:			
ICOARE	10	10	Overwater surface fluxes method Set to 10 means COARE with no wave parameterization
DSHELF	0	0	Coastal/Shallow water length scale (km)
IWARM	0	0	COARE warm layer computation
ICOOL	0	0	COARE cool skin layer computation
Relative Humidity Parameters:			
IRHPROG	0	0	Use the surface stations relative humidity data
Temperature Parameters:			
ITPROG	0	1	Use surface stations temperature data
IRAD	1	1	Interpolation type
TRADKM	500	500	Radius of influence for temperature interpolation (km)
NUMTS	5	2	Maximum number of stations to include in temperature interpolation
IAVET	1	1	Conduct spatial averaging of temperatures (1 = yes)
TGDEFB	-0.0098	-0.0098	Default temperature gradient below the mixing height over water (K/m)
TGDEFA	-0.0045	-0.0045	Default temperature gradient above the mixing height over water (K/m)
JWAT1	-	55	Beginning land use categories for temperature interpolation over water
JWAT2	-	55	Ending land use categories for temperature interpolation over water
Precipitation Interpolation Parameters:			
NFLAGP	2	2	Method of interpolation
SIGMAP	100	Not Applicable	Radius of Influence (km) Not Applicable for this project as no precipitation station data were used
CUTP	0.01	0.01	Minimum Precipitation rate cut-off (mm/h)

Table B-15 CALMET Model Option Group 7: Surface Meteorological Station Parameters

Name	ID	X coordinate (km)	Y coordinate (km)	Time zone	Anemometer Height
DORS	99991	433.281	7558.557	7	10
BOTN	99992	441.207	7505.312	7	10

NOTES:
DORS Doris Monitoring Station
BOTN Boston Monitoring Station

B.5 References

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APPENDIX C CALPUFF Model Options

C.1 CALPUFF Model Options

For the purposes of organization, the CALPUFF control file defines 20 input groups as identified in Table C-1. The input parameters for the CALPUFF control file used in this modelling assessment are provided in Tables C-2 to C-9. The default values are assumed to be those defined in the CALPUFF user manual (Scire et al. 2000). The default values and the values adopted for this assessment are identified in the tables.

Table C-1 Input Groups in the CALPUFF Control File

Input Group	Description	Applicable to Project?
0	Input and output file names	Yes
1	General run control parameters	Yes
2	Technical options	Yes
3	Species list	Yes
4	Map projection and grid control parameters	Yes
5	Output options	Yes
6	Sub grid scale complex terrain inputs	No
7	Dry deposition parameters for gases	Yes
8	Dry deposition parameters for particles	Yes
9	Miscellaneous dry deposition for parameters	Yes
10	Wet deposition parameters	Yes
11	Chemistry parameters	Yes
12	Misc. dispersion and computational parameters	Yes
13	Point source parameters	Yes
14	Area source parameters	Yes
15	Line source parameters	No
16	Volume source parameters	Yes
17	Flare source control parameters	No
18	Road emissions parameters	Yes
19	Emission rate scale-factor tables	Yes

Table C-2 CALPUFF Model Options Groups 1 and 2

Input Group 1: General Run Control Parameters

Parameter	Default	Project	Comments
METRUN	0	0	All model periods in met file(s) will be run
IBYR	-	2012	Starting year
IBMO	-	1	Starting month
IBDY	-	1	Starting day
IBHR	-	0	Starting hour
IEYR	-	2013	Ending year
IEMO	-	1	Ending month
IEDY	-	1	Ending day
IEHR	-	0	Ending hour
ABTZ		UTC-0700	Base time zone (7 = MST)
NSPEC	5	14	Number of chemical species
NSE	3	11	Number of chemical species to be emitted
ITEST	2	2	Program is executed after SETUP phase
MRESTART	0	0	Do not read or write a restart file during run
NRESPD	0	0	File written only at last period
METFM	1	1	CALMET binary file (CALMET.MET)
MPRFFM	1	1	CTDM plus tower file
AVET	60	60	Averaging time in minutes
PGTIME	60	60	PG Averaging time in minutes
IOUTU	1	1	Output units for binary concentration and flux files written in Dataset v2.2 or later formats. 1 = mass - g/m^3 (concentration) or g/m^2/s (deposition)

Input Group 2: Technical Options

Parameter	Default	Project	Comments
MGAUSS	1	1	Gaussian distribution used in near field
MCTADJ	3	3	Partial plume path terrain adjustment
MCTSG	0	0	Scale-scale complex terrain not modelled
MSLUG	0	0	Near-field puffs not modelled as elongated
MTRANS	1	1	Transitional plume rise modelled
MTIP	1	1	Stack tip downwash used
MRISE	1	1	Method used to compute plume rise for point sources not subject to building downwash 1 = Briggs plume rise
MTIP_FL	0	0	No stack-tip downwash for flare sources
MRISE_FL	2	2	Plume rise module for flare sources; 2=Numerical plume rise

Table C-2 CALPUFF Model Options Groups 1 and 2

Input Group 2: Technical Options (cont'd)

Parameter	Default	Project	Comments
MBDW	1	2	PRIME Method is used to simulate building downwash
MSHEAR	0	0	Vertical wind shear is not modelled
MSPLIT	0	0	Puff splitting not used
MCHEM	3	6	transformation rates computed internally (Updated RIVAD scheme with ISORROPIA equilibrium)
MAQCHEM	0	1	transformation rates and wet scavenging coefficients adjusted for in-cloud aqueous phase reactions (adapted from RADM cloud model implementation in CMAQ/SCICHEM)
MLWC	1	1	Liquid Water Content flag (Used only if MAQCHEM = 1)
MWET	1	1	Wet removal modelled
MDRY	1	1	Dry deposition modelled
MTILT	0	0	Gravitational settling (plume tilt) not modelled
MDISP	3	2	Dispersion coefficients from internally calculated sigma v, sigma w using micrometeorological variables (u*, w*, L, etc.)
MTURBVW	3	3	Use both σ_v and σ_w from PROFILE.DAT to compute σ_y and σ_z (n/a)
MDISP2	3	3	PG dispersion coefficients for rural areas (computed using ISCST3 approximation) and MP coefficients in urban areas when measured turbulence data is missing
MTAULY	0	0	Draxler default 617.284 (s)
MTAUADV	0	0	No turbulence advection
MCTURB	1	1	Standard CALPUFF subroutines
MROUGH	0	0	PG σ_y and σ_z is not adjusted for roughness
MPARTL	1	1	Partial plume penetration of elevated inversion
MPARTLBA	1	1	Partial plume penetration of elevated inversion modelled for the buoyant area sources
MTINV	0	0	Strength of temperature inversion computed from default gradients
MPDF	0	1	The probability density function (PDF) to be used for dispersion under convective conditions
MSGTIBL	0	0	Sub-grid TIBL module not used for shoreline
MBCON	0	0	Boundary concentration conditions not modelled
MSOURCE	0	0	Individual source contributions not saved
MFOG	0	0	Do not configure for FOG model output
MREG	1	0	Do not test options specified to see if they conform to regulatory values

Table C-3 CALPUFF Model Options Groups 3 and 4

Input Group 3: Species List-Chemistry Options

CSPEC	Modelled[1]	Emitted[2]	Dry Deposition[3]	Output Group Number
SO_2	1	1	1	0
SO_4^{2-}	1	0	2	0
NO	1	1	1	0
NO_2	1	1	1	0
HNO_3	1	0	1	0
NO_3^-	1	0	2	0
NO_X	1	1	0	0
CO	1	1	0	0
$PM_{2.5}$ (Combustion product)	1	1	2	0
$PM_{2.5}$ to PM_{10} range (Combustion product)	1	1	2	0
PM_{10} to TSP (Combustion product)	1	1	2	0
$PM_{2.5}$ (Fugitive dust)	1	1	2	0
$PM_{2.5}$ to PM_{10} range (Fugitive dust)	1	1	2	0
PM_{10} to TSP (Fugitive dust)	1	1	2	0

NOTES:
[1] 0=no, 1=yes
[2] 0=no, 1=yes
[3] 0=none, 1=computed-gas, 2=computed particle, 3=user-specified

Input Group 4: Map Projection and Grid Control Parameters

Parameter	Default	Project	Comments
PMAP	UTM	UTM	Universal Transverse Mercator
FEAST	0	0	False Easting (km) at the projection origin
FNORTH	0	0	False Northing (km) at the projection origin
IUTMZN	-	13	UTM zone
UTMHEM	N	N	Northern Hemisphere for UTM projection
DATUM	WGS-84	WGS-84	WGS-84 Reference Ellipsoid and Geoid, Global coverage
NX	-	100	Number of X grid cells in meteorological grid
NY		100	Number of Y grid cells in meteorological grid
NZ	No default	10	Vertical grid definition: Number of vertical layers as per the AEP Model Guideline.
DGRIDKM	-	0.5	Grid spacing (km) to match CALMET (see Appendix B)
ZFACE	No default	0, 20, 40, 80, 160, 320, 640, 1000, 1500, 2000 and, 3000	Vertical grid definition: Cell face heights (m)

Table C-3 CALPUFF Model Options Groups 3 and 4

Input Group 4: Map Projection and Grid Control Parameters (cont'd)

Parameter	Default	Project	Comments
XORIGKM	-	386.547	Reference X coordinate for SW corner of grid cell (1,1) of meteorological grid (km)
YORIGKM	-	7483.084	Reference Y coordinate for SW corner of grid cell (1,1) of meteorological grid (km)
IBCOMP	-	1	X index of lower left corner of the computational grid
JBCOMP	-	1	Y index of lower left corner of the computational grids
IECOMP	-	100	X index of the upper right corner of the computational grid
JECOMP	-	100	Y index of the upper right corner of the computational grid
LSAMP	T	F	Sampling grid is not used
IBSAMP	-	1	X index of lower left corner of the sampling grid
JBSAMP	-	1	Y index of lower left corner of the sampling grid
IESAMP	-	100	X index of upper right corner of the sampling grid
JESAMP	-	100	Y index of upper right corner of the sampling grid
MESHDN	1	1	Nesting factor of the sampling grid

Table C-4 CALPUFF Model Option Group 5

Input Group 5: Output Option

Parameter	Default	Project	Comments
ICON	1	1	Output file CONC.DAT containing concentrations is created
IDRY	1	1	Output file DFLX.DAT containing dry fluxes is created
IWET	1	1	Output file WFLX.DAT containing wet fluxes is created
IT2D	0	0	2D Temperature
IRHO	0	0	Density
IVIS	1	0	Output file containing relative humidity data is not created
LCOMPRS	T	T	Do not perform data compression in output file
IQAPLOT	1	1	Create a standard series of output files (e.g., locations of sources, receptors, grids ...) suitable for plotting
IMFLX	0	0	Do not calculate mass fluxes across specific boundaries
IPFTRAK	0	0	Puff locations and properties reported to PFTRAK.DAT file for postprocessing
IMBAL	0	0	Mass balances for each species are not reported hourly
ICPRT	0	1	print concentration fields to the output list file
IDPRT	0	0	Do not print dry flux fields to the output list file
IWPRT	0	0	Do not print wet flux fields to the output list file
ICFRQ	1	24	Concentration fields are printed to output list file every 24-hour
IDFRQ	1	24	Dry flux fields are printed to output list file every 24-hour
IWFRQ	1	24	Wet flux fields are printed to output list file every 24-hour
IPRTU	1	3	Units for line printer output are in $\mu g/m^3$ for concentration and $\mu g/m^2/s$ for deposition
IMESG	2	2	Messages tracking the progress of run are written on screen
LDEBUG	F	F	Logical value for debug output
IPFDEB	1	1	First puff to track
NPFDEB	1	1	Number of puffs to track
NN1	1	1	Meteorological period to start output
NN2	10	10	Meteorological period to end output

Table C-4 CALPUFF Model Option Group 5

Input Group 5: Output Option (cont'd)

Species	Concentrations Printed (0= no, 1 = yes)		Dry Fluxes Printed (0 = no, 1 = yes)		Wet Fluxes Printed (0 = no, 1 = yes)		Mass Flux	
	Printed	Saved to Disk	Printed	Saved to Disk	Printed	Saved to Disk	Printed	Saved to Disk
SO_2	0	1	0	1	0	1	0	1
SO_4^{2-}	0	1	0	1	0	1	0	1
NO	0	1	0	1	0	1	0	1
NO_2	0	1	0	1	0	1	0	1
HNO_3	0	1	0	1	0	1	0	1
NO_3^-	0	1	0	1	0	1	0	1
NO_X	0	1	0	1	0	1	0	1
CO	0	1	0	1	0	1	0	1
$PM_{2.5}$ (Combustion product)	0	1	0	1	0	1	0	1
$PM_{2.5}$ to PM_{10} range (Combustion product)	0	1	0	1	0	1	0	1
PM_{10} to TSP (Combustion product)	0	1	0	1	0	1	0	1
$PM_{2.5}$ (Fugitive dust)	0	1	0	1	0	1	0	1
$PM_{2.5}$ to PM_{10} range (Fugitive dust)	0	1	0	1	0	1	0	1
PM_{10} to TSP (Fugitive dust)	0	1	0	1	0	1	0	1

Table C-5 CALPUFF Model Option Groups 6 and 7

Input Group 6: Sub-Grid Scale Complex Terrain Inputs

Parameter	Default	Project	Comments
NHILL	0	0	Number of terrain features
NCTREC	0	0	Number of special complex terrain receptors
MHILL	-	2	Hill data created by OPTHILL & input below in Subgroup (6b); Receptor data in Subgroup (6c)
XHILL2M	1	1	Conversion factor for changing horizontal dimensions to metres
ZHILL2M	1	1	Conversion factor for changing vertical dimensions to metres
XCTDMKM	-	0	X origin of CTDM system relative to CALPUFF coordinate system (km)
YCTDMKM	-	0	Y origin of CTDM system relative to CALPUFF coordinate system (km)

Input Group 7: Dry Deposition Parameters for Gases

Species	Default	Project	Comments
SO_2	0.1509	0.1509	Diffusivity
	1000	1000	Alpha star
	8.0	8.0	Reactivity
	0.0	0.0	Mesophyll resistance
	0.4	0.4	Henry’s Law coefficient
NO	0.1345	0.1345	Diffusivity
	1.0	1.0	Alpha star
	2.0	2.0	Reactivity
	25	25	Mesophyll resistance
	18	18	Henry’s Law coefficient
NO_2	0.1656	0.1656	Diffusivity
	1.0	1.0	Alpha star
	8.0	8.0	Reactivity
	5.0	5.0	Mesophyll resistance
	3.5	3.5	Henry’s Law coefficient
HNO_3	0.1628	0.1628	Diffusivity
	1.0	1.0	Alpha star
	18.0	18.0	Reactivity
	0.0	0.0	Mesophyll resistance
	0.0000001	0.0000001	Henry’s Law coefficient

Table C-6 CALPUFF Model Option Groups 8, 9, 10, and 11

Input Group 8: Dry Deposition Parameters for Particles

Species	Default	Project	Comments
SO_4^{2-}	0.48	0.48	Geometric mass mean diameter of SO_4^{2-} [µm]
SO_4^{2-}	2.0	2.0	Geometric standard deviation of SO_4^{2-} [µm]
NO_3^-	0.48	0.48	Geometric mass mean diameter of NO_3^-[µm]
NO_3^-	2.0	2.0	Geometric standard deviation of NO_3^- [µm]
$PM_{2.5}$ (Combustion product)	-	1.6	Geometric mass mean diameter of PM [µm]
$PM_{2.5}$ (Combustion product)	-	0.0	Geometric standard deviation of PM [µm]
$PM_{2.5}$ to PM_{10} range (Combustion product)	-	6.9	Geometric mass mean diameter of PM [µm]
$PM_{2.5}$ to PM_{10} range (Combustion product)	-	0.0	Geometric standard deviation of PM [µm]
PM_{10} to TSP (Combustion product)	-	21.5	Geometric mass mean diameter of PM [µm]
PM_{10} to TSP (Combustion product)	-	0.0	Geometric standard deviation of PM [µm]
$PM_{2.5}$ (Fugitive dust)	-	1.6	Geometric mass mean diameter of PM [µm]
$PM_{2.5}$ (Fugitive dust)	-	0.0	Geometric standard deviation of PM [µm]
$PM_{2.5}$ to PM_{10} range (Fugitive dust)	-	6.9	Geometric mass mean diameter of PM [µm]
$PM_{2.5}$ to PM_{10} range (Fugitive dust)	-	0.0	Geometric standard deviation of PM [µm]
PM_{10} to TSP (Fugitive dust)	-	21.5	Geometric mass mean diameter of PM [µm]
PM_{10} to TSP (Fugitive dust)	-	0.0	Geometric standard deviation of PM [µm]
NOTES: Geometric mass mean diameter and geometric standard deviation pf different size fractions are derived from US EPA (2005)			

Input Group 9: Miscellaneous Dry Deposition Parameters

Parameters	Default	Project	Comments
RCUTR	30	30	Reference cuticle resistance (s/cm)
RGR	10	10	Reference ground resistance (s/cm)
REACTR	8	8	Reference pollutant reactivity
NINT	9	9	Number of particle size intervals for effective particle deposition velocity
IVEG	1	1	Vegetation in non-irrigated areas is active and unstressed

Table C-6 CALPUFF Model Option Groups 8, 9, 10, and 11

Input Group 10: Wet Deposition Parameters

Species	Default	Project	Comments
SO_2	3.0E-05	3.0E-05	Scavenging coefficient for liquid precipitation [s^{-1}]
	0.0	0.0	Scavenging coefficient for frozen precipitation [s^{-1}]
SO_4^{2-}	1.0E-04	1.0E-04	Scavenging coefficient for liquid precipitation [s^{-1}]
	3.0E-05	3.0E-05	Scavenging coefficient for frozen precipitation [s^{-1}]
NO	-	2.9E-05	Scavenging coefficient for liquid precipitation [s^{-1}]
	-	0.0	Scavenging coefficient for frozen precipitation [s^{-1}]
NO_2	-	5.1E-05	Scavenging coefficient for liquid precipitation [s^{-1}]
	-	0.0	Scavenging coefficient for frozen precipitation [s^{-1}]
HNO_3	6.0E-05	6.0E-05	Scavenging coefficient for liquid precipitation [s^{-1}]
	0.0	0.0	Scavenging coefficient for frozen precipitation [s^{-1}]
NO_3^-	1.0E-04	1.0E-04	Scavenging coefficient for liquid precipitation [s^{-1}]
	0.00003	0.00003	Scavenging coefficient for frozen precipitation [s^{-1}]
$PM_{2.5}$ (Combustion product)	-	6.0E-05	Scavenging coefficient for liquid precipitation [s^{-1}]
	-	2.0E-05	Scavenging coefficient for frozen precipitation [s^{-1}]
$PM_{2.5}$ to PM_{10} range (Combustion product)	-	4.2E-04	Scavenging coefficient for liquid precipitation [s^{-1}]
	-	1.4E-04	Scavenging coefficient for frozen precipitation [s^{-1}]
PM_{10} to TSP (Combustion product)	-	6.6E-04	Scavenging coefficient for liquid precipitation [s^{-1}]
	-	2.2E-04	Scavenging coefficient for frozen precipitation [s^{-1}]
$PM_{2.5}$ (Fugitive dust)	-	6.0E-05	Scavenging coefficient for liquid precipitation [s^{-1}]
	-	2.0E-05	Scavenging coefficient for frozen precipitation [s^{-1}]
$PM_{2.5}$ to PM_{10} range (Fugitive dust)	-	4.2E-04	Scavenging coefficient for liquid precipitation [s^{-1}]
	-	1.4E-04	Scavenging coefficient for frozen precipitation [s^{-1}]
PM_{10} to TSP (Fugitive dust)	-	6.6E-04	Scavenging coefficient for liquid precipitation [s^{-1}]
	-	2.2E-04	Scavenging coefficient for frozen precipitation [s^{-1}]

NOTES:
NO and NO_2 scavenging coefficients are from RWDI (2005)
PM size fractions scavenging coefficients are from US EPA (1995)

Table C-6 CALPUFF Model Option Groups 8, 9, 10, and 11

Input Group 11: Chemistry Parameters

Parameters	Default	Project	Comments
MOZ	1	1	Rural hourly ozone values based on the Fort Smith NWT
BCKO3	12*80	Not used	Background ozone concentration (ppb)
MNH3	0	0	Ammonia data option (Used only if MCHEM = 6 or 7)
MAVGNH3	1	0	Use ammonia at puff centre height (Used only if MCHEM = 6 or 7, and MNH3 = 1)
BCKNH3	12*10	1.59,1.69,1.55, 1.86, 2.16, 2.79, 3.78, 1.90, 2.15, 1.55, 1.37, 1.59	Background ammonia concentration (ppb) (Based on passive measurements in north eastern Alberta)
RNITE1	0.2	0.2	Night-time NO_2 loss rate in percent/hour
RNITE2	2	2	Night-time NO_X loss rate in percent/hour
RNITE3	2	2	Night-time HNO_3 loss rate in percent/hour
MH202	1	0	H_2O_2 data input option
BCKH202	12*1	12*1	Monthly background H_2O_2 concentrations (Aqueous phase transformations modelled)
RH_ISRP	50	50	Minimum relative humidity used in ISORRPOIA computations (Used only if MCHEM = 6 or7)
SO4_ISRP	0.4	0.4	Minimum SO_4 used in ISORRPOIA computations (Used only if MCHEM = 6 or7)
BCKPMF	-	Not used	Fine particulate concentration for Secondary Organic Aerosol Option
OFRAC	-	Not used	Organic fraction of fine particulate for SOA Option
VCNX	-	Not used	VOC/NO_X ratio for SOA Option

Table C-7 CALPUFF Model Option Group 12

Input Group 12: Diffusion/Computational Parameters

Parameters	Default	Project	Comments
SYTDEP	550	550	Horizontal size of a puff in metres beyond which the time dependent dispersion equation of Heffter (1965) is used
MHFTSZ	0	0	Do not use Heffter formulas for sigma z
JSUP	5	5	Stability class used to determine dispersion rates for puffs above boundary layer
CONK1	0.01	0.01	Vertical dispersion constant for stable conditions
CONK2	0.1	0.1	Vertical dispersion constant for neutral/stable conditions
TBD	0.5	0.5	Use ISC transition point for determining the transition point between the Schulman-Scire (Schulman et al., 1998) to Huber-Snyder Building Downwash scheme
ISIGMAV	1	1	Sigma-v is read for lateral turbulence data
IMIXCTDM	0	0	Predicted mixing heights are used
XMXLEN	1	1	Maximum length of emitted slug in meteorological grid units
XSAMLEN	1	1	Maximum travel distance of slug or puff in meteorological grid units during one sampling unit
MXNEW	99	99	Maximum number of puffs or slugs released from one source during one time step
MXSAM	99	99	Maximum number of sampling steps during one time step for a puff or slug
NCOUNT	2	2	Number of iterations used when computing the transport wind for a sampling step that includes transitional plume rise
SYMIN	1	1	Minimum sigma y in metres for a new puff or slug
SZMIN	1	1	Minimum sigma z in metres for a new puff or slug
SZCAP_M	5.0E06	5.0E06	Maximum sigma z in metres to avoid numerical problem in calculating time or distance

Stability Class	Parameter			
	SVMIN		SWMIN	
	Minimum turbulence (σ_v) (m/s)		Minimum turbulence (σ_v) (m/s)	
	Land	Water	Land	Water
A	0.5	0.37	0.2	0.2
B	0.5	0.37	0.12	0.12
C	0.5	0.37	0.08	0.08
D	0.5	0.37	0.06	0.06
E	0.5	0.37	0.03	0.03
F	0.5	0.37	0.016	0.016

Table C-7 CALPUFF Model Option Group 12

Input Group 12: Diffusion/Computational Parameters (cont'd)

Parameters	Default	Project	Comments	
CDIV	0.0, 0.0	0.0, 0.0	Divergence criteria for dw/dz in met cells	
NLUTBIL	4	4	Search radius for nearest land and water cells used in the subgrid TIBL module	
WSCALM	0.5	0.5	Minimum wind speed allowed for non-calm conditions (m/s)	
XMAXZI	3000	3000	Maximum mixing height in metres	
XMINZI	50	50	Minimum mixing height in metres	
TKCAT	265	265	Temperature class 1	Temperatures (K) used for defining upper bound of categories for emissions scale-factors; 11 upper bounds (K) are entered; the 12th class has no upper
	270	270	Temperature class 2	
	275	275	Temperature class 3	
	280	280	Temperature class 4	
	285	285	Temperature class 5	
	290	290	Temperature class 6	
	295	295	Temperature class 7	
	300	300	Temperature class 8	
	305	305	Temperature class 9	
	310	310	Temperature class 10	
	315	315	Temperature class 11	
WSCAT	1.54	1.54	wind speed category 1 [m/s]	
	3.09	3.09	wind speed category 2 [m/s]	
	5.14	5.14	wind speed category 3 [m/s]	
	8.23	8.23	wind speed category 4 [m/s]	
	10.80	10.80	wind speed category 5 [m/s]	

Stability Class	Parameter	
	PLX0	PPC (see text)
	Wind speed profile exponent	Plume path coefficient
A	0.07	0.5
B	0.07	0.5
C	0.10	0.5
D	0.15	0.5
E	0.35	0.35
F	0.55	0.35

Table C-7 CALPUFF Model Option Group 12

Input Group 12: Diffusion/Computational Parameters (cont'd)

Parameters	Default	Project	Comments
PTG0	0.020	0.020	Potential temperature gradient for E stability [K/m]
	0.035	0.035	Potential temperature gradient for F stability [K/m]
SL2PF	10	10	Slug-to-puff transition criterion factor equal to sigma y/length of slug
FCLIP	0.0	0.0	No extrapolation of receptor-specific puff/slug properties
NSPLIT	3	3	Number of puffs that result every time a puff is split
IRESPLIT	0,0,0,0,0,0,0,0,0,0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0	0,0,0,0,0,0,0,0,0,0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0	Time(s) of day when split puffs are eligible to be split once again
ZISPLIT	100	100	Minimum allowable last hour's mixing height for puff splitting
ROLDMAX	0.25	0.25	Maximum allowable ratio of last hour's mixing height and maximum mixing height experienced by the puff for puff splitting
NSPLITH	5	5	Number of puffs that result every time a puff is horizontally split
SYSPLITH	1	1	Minimum sigma-y of puff before it may be horizontally split
SHSPLITH	2	2	Minimum puff elongation rate due to wind shear before it may be horizontally split
CNSPLITH	1.0E-7	1.0E-7	Minimum concentration of each species in puff before it may be horizontally split
EPSSLUG	1.00E-04	1.00E-04	Fractional convergence criterion for numerical SLUG sampling iteration
EPSAREA	1.00E-06	1.00E-06	Fractional convergence criterion for numerical AREA sampling iteration
DRISE	1.0	1.0	Trajectory step length for numerical rise
HTMINBC	500	500	Minimum height (m) to which boundary condition puffs are mixed as they are emitted (MBCON=2 ONLY)
RSAMPBC	10	10	Search radius (km) about a receptor for sampling nearest boundary condition puff.
MDEPBC	1	1	Concentration is adjusted for depletion

Table C-8 CALPUFF Model Option Groups 13, 14, and 15

Input Group 13: Point Source Parameters

Parameters	Default	Project	Comments
NPT1	-	Varies by scenario	Number of point sources with constant stack parameters or variable emission rate scale factors
IPTU	1	1	Units for point source emission rates are g/s
NSPT1	0	0	Number of source-species combinations with variable emissions scaling factors
NPT2	-	0	Number of point sources with variable emission parameters provided in external file

Input Group 14: Area Source Parameters

Parameters	Default	Project	Comments
NAR1	-	Varies by scenario	Number of polygon area sources
IARU	1	1	Units for area source emission rates are $g/m^2/s$
NSAR1	0	Varies by scenario	Number of source species combinations with variable emissions scaling factors
NAR2	-	0	Number of buoyant polygon area sources with variable location and emission parameters

Input Group 15: Line Source Parameters

Parameters	Default	Project	Comments
NLN2	-	0	No line sources modelled
NLINES	-	0	Number of buoyant line sources
ILNU	1	1	Units for line source emission rates is g/s
NSLN1	0	0	Number of source-species combinations with variable emissions scaling factors
MXNSEG	7	7	Maximum number of segments used to model each line
NLRISE	6	6	Number of distance at which transitional rise is computed
XL	-	0.1	Average line source length (m)
HBL	-	0.1	Average height of line source height (m)
WBL	-	0.1	Average building width (m)
WML	-	25	Average line source width (m)
DXL	-	0.1	Average separation between buildings (m)
FPRIMEL	-	50	Average buoyancy parameter (m^4/s^3)

Table C-9 CALPUFF Model Option Groups 16, 17, 18, 19 and 20

Input Group 16: Volume Source Parameters

Parameter	Default	Project	Comments
NVL1	-	Varies by scenario	Number of volume sources
IVLU	1	1	Units for volume source emission rates is grams per second
NSVL1	0	Varies by scenario	Number of source-species combinations with variable emissions scaling factors
NVL2	0	0	No volume source with variable location and emissions

Input Group 17: Flare Source Parameters

Parameter	Default	Project	Comments
NFL2	-	0	Number of flare sources defined in FLEMARB.DAT

Input Group 18: Road Source Parameters

Parameter	Default	Project	Comments
NRD1	-	0	Number of road sources
NRD2	-	0	Number of road-links with arbitrarily time-varying emission parameters
NSFRDS	0	Varies by scenario	Number of road links and species combinations with variable emission-rate scale-factors

Input Group 19: Emission Rate Scale-factor Tables

Parameter	Default	Project	Comments
NSFTAB	-	Varies by scenario	Number of emission scale-factors

Input Group 20: Discrete Receptor Information

Parameter	Default	Project	Comments
NREC	-	24,551	Number of receptors in the Northern Domain
		17,262	Number of receptors in the Southern Domain

C.2 References

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APPENDIX D Ambient Air Quality Predictions at Discrete Receptor Locations

Table D-1 Maximum Predicted Concentrations and Dust Deposition Rates at Discrete Receptors during Madrid-Boston Project Construction

Receptor ID	Receptor Description	Receptor Location		SO_2, µg/m³		NO_2, µg/m³		CO, µg/m³		TSP, µg/m³		PM_{10}, µg/m³		$PM_{2.5}$, µg/m³		Dust Deposition, mg/100/cm²
		Easting, m	Northing, m	1-hour	24-hour	Annual	1-hour	24-hour	Annual	1-hour	24-hour	Annual	24-hour	24-hour	Annual	30-day
Baseline/Background Value Included in Results:				**0.3**	**0.3**	**0.3**	**1.1**	**1.1**	**1.1**	**261**	**5.8**	**5.8**	**5.4**	**3.1**	**3.1**	**6.3**
CB1	Cabin	406275	7551933	0.5	0.3	0.3	11.4	6.1	1.4	274.3	6.4	5.9	5.9	3.3	3.1	6.4
CB2	Cabin	406503	7552314	0.5	0.3	0.3	11.4	5.9	1.4	275.0	6.4	5.9	5.9	3.3	3.1	6.4
C1	Outpost Camp	435299	7562924	10.3	0.5	0.3	162.1	69.0	8.2	415.1	13.7	6.8	12.2	5.8	3.7	6.7
C2	Seasonal Camp (spring/summer)	436579	7569440	4.2	0.4	0.3	109.6	18.9	2.5	307.3	8.4	6.0	7.7	3.8	3.2	6.4
F1	Fishing Area	408133	7551357	0.5	0.3	0.3	11.3	7.1	1.5	277.2	6.5	5.9	6.0	3.3	3.1	6.4
F2	Fishing Area	443743	7507935	1.8	0.5	0.3	129.6	65.7	7.9	354.6	50.5	13.9	29.6	8.3	4.0	10.1
F3	Fishing Area	435464	7560804	5.1	0.5	0.3	157.2	69.7	9.4	465.1	16.7	7.2	14.1	6.6	3.8	6.8
H1	Hunting and Fishing	443076	7504033	5.1	0.8	0.4	174.3	120.3	16.4	586.1	97.1	18.0	47.8	12.8	5.0	14.0
H2	Hunting and Fishing	435004	7575863	2.5	0.3	0.3	58.1	17.5	2.0	308.3	7.9	5.9	7.3	3.6	3.2	6.4
H3	Hunting and Fishing	419714	7570036	1.6	0.4	0.3	45.1	17.1	2.6	297.7	8.8	6.1	7.5	3.9	3.2	6.5
H4	Hunting and Fishing	416437	7560888	0.9	0.3	0.3	26.1	9.3	2.1	293.9	7.5	6.0	6.7	3.6	3.2	6.4
T1	Travel Route	425864	7570079	3.5	0.4	0.3	81.5	30.3	3.4	320.6	9.8	6.1	9.0	4.5	3.3	6.4
E3	Queen Maude Gulf Migratory Bird Sanctuary	478687	7503125	0.4	0.3	0.3	10.6	9.1	1.4	273.8	6.8	5.9	6.4	3.3	3.1	6.3
W1	Doris Camp (active)	432965	7559020	16.1	2.0	0.6	294.4	194.4	83.2	1680.5	191.1	35.9	84.9	38.4	12.6	28.1
W2	Boston Exploration Camp	441137	7505488	2.8	1.0	0.4	204.3	152.3	21.9	594.9	168.3	23.8	73.1	22.0	6.2	16.3
W3	Boston Operation Camp	441091	7504367	8.1	5.3	1.6	410.6	337.4	181.5	1733.8	664.3	146.7	271.4	132.3	42.8	62.9
W4	Quarry D Camp	432902	7551720	23.8	5.0	1.5	577.1	268.3	169.6	2984.8	283.1	79.9	163.4	75.0	33.8	39.8
8	Soil and Vegetation Site	431889	7556491	4.0	1.1	0.4	169.4	128.8	17.0	557.9	78.2	14.6	43.0	11.4	4.7	9.7
11	Soil and Vegetation Site	447111	7506863	1.9	0.5	0.3	117.8	48.7	4.6	370.7	16.0	7.0	15.1	5.3	3.5	6.7
13	Soil and Vegetation Site	445764	7506296	3.3	0.6	0.3	152.8	78.4	6.7	470.4	24.0	7.9	21.9	7.0	3.7	7.0
14	Soil and Vegetation Site	437081	7547927	5.6	0.8	0.4	171.5	112.6	15.8	640.3	37.3	10.6	24.9	9.9	4.5	8.1
16	Soil and Vegetation Site	437606	7547393	6.1	0.8	0.4	171.3	104.9	14.9	651.4	40.8	10.3	27.1	10.0	4.4	8.1
18	Soil and Vegetation Site	437685	7546759	5.6	0.8	0.4	172.3	104.7	14.5	618.6	37.6	9.7	26.4	9.4	4.3	7.9
21	Soil and Vegetation Site	431742	7559767	4.6	1.2	0.4	198.5	165.1	28.6	743.8	54.1	12.1	41.9	18.5	6.1	8.7
22	Soil and Vegetation Site	431495	7559736	4.8	1.3	0.4	203.8	162.7	25.2	791.8	57.4	11.6	44.9	18.0	5.7	8.7
23	Soil and Vegetation Site	434866	7553440	3.7	0.7	0.3	157.1	82.1	13.3	492.0	34.1	12.2	19.8	8.0	4.2	10.2
29	Soil and Vegetation Site	436397	7557975	2.7	0.8	0.3	163.2	125.6	15.0	537.8	37.7	8.9	26.4	9.4	4.3	7.7
CFW1	Soil and Vegetation Site	441742	7510979	2.7	0.5	0.3	125.3	53.8	9.8	426.2	85.0	24.7	32.2	7.4	4.4	21.9
CFW2	Soil and Vegetation Site	445842	7503723	3.9	0.5	0.3	152.6	48.3	6.4	473.2	22.3	7.8	17.2	6.0	3.6	7.4
CFW3	Soil and Vegetation Site	434895	7542242	3.4	0.8	0.3	159.2	97.8	9.4	502.5	118.0	21.1	48.5	8.7	4.3	19.4

Table D-1 Maximum Predicted Concentrations and Dust Deposition Rates at Discrete Receptors during Madrid-Boston Project Construction

Receptor ID	Receptor Description	Receptor Location		SO_2, µg/m³		NO_2, µg/m³		CO, µg/m³		TSP, µg/m³		PM_{10}, µg/m³		$PM_{2.5}$, µg/m³		Dust Deposition, mg/100/cm²
		Easting, m	Northing, m	1-hour	24-hour	Annual	1-hour	24-hour	Annual	1-hour	24-hour	Annual	24-hour	24-hour	Annual	30-day
Baseline/Background Value Included in Results:				**0.3**	**0.3**	**0.3**	**1.1**	**1.1**	**1.1**	**261**	**5.8**	**5.8**	**5.4**	**3.1**	**3.1**	**6.3**
CFW4	Soil and Vegetation Site	436096	7549618	5.0	0.9	0.4	163.8	108.3	18.9	564.6	38.9	11.2	25.7	9.6	4.7	8.2
CFW5	Soil and Vegetation Site	435388	7559596	6.8	1.1	0.4	195.3	135.1	18.6	846.1	50.3	10.2	37.6	15.6	5.0	8.2
CFW6	Soil and Vegetation Site	435400	7559601	6.7	1.1	0.4	195.0	134.7	18.5	843.0	49.9	10.2	37.5	15.4	4.9	8.1
D06	Soil and Vegetation Site	433211	7547705	11.3	1.3	0.4	214.5	102.2	20.5	1062.7	99.4	25.3	53.5	13.8	5.6	18.5
D10	Soil and Vegetation Site	432471	7548235	9.6	1.5	0.4	192.7	115.1	15.4	1025.5	54.3	12.4	35.0	10.5	4.6	9.9
D12	Soil and Vegetation Site	435015	7539769	2.1	0.6	0.3	147.2	61.0	5.0	416.4	48.7	9.1	27.2	6.0	3.5	8.5
D16	Soil and Vegetation Site	436028	7540759	2.6	0.7	0.3	151.6	93.2	6.0	423.4	34.3	9.2	24.6	6.5	3.6	7.9
D20	Soil and Vegetation Site	435631	7542445	3.6	0.9	0.3	159.3	106.4	8.0	517.5	34.6	11.4	25.7	7.5	3.9	9.1
D21	Soil and Vegetation Site	436121	7543061	4.2	0.8	0.3	163.7	114.5	8.4	542.4	31.1	9.0	24.5	7.9	3.9	7.6
D22	Soil and Vegetation Site	436364	7543054	4.4	0.9	0.3	164.8	111.9	8.7	539.0	34.1	8.9	24.3	7.9	3.9	7.5
D26	Soil and Vegetation Site	431884	7543400	2.3	0.5	0.3	144.4	52.3	5.8	400.2	17.2	7.3	14.0	6.1	3.5	6.9
D29	Soil and Vegetation Site	432032	7542769	2.3	0.6	0.3	149.6	55.3	5.6	396.0	18.3	7.3	15.0	5.9	3.5	6.9
D32	Soil and Vegetation Site	432709	7542116	1.4	0.4	0.3	96.0	37.5	4.0	353.1	13.2	6.7	11.1	4.9	3.4	6.8
D38	Soil and Vegetation Site	438196	7530728	0.9	0.4	0.3	55.5	31.7	2.4	316.6	11.4	6.1	10.4	4.0	3.2	6.4
D39	Soil and Vegetation Site	438041	7530438	0.9	0.4	0.3	54.2	30.6	2.4	315.6	11.2	6.0	10.2	4.0	3.2	6.4
D40	Soil and Vegetation Site	438143	7520942	0.7	0.4	0.3	32.1	16.3	2.3	294.6	10.0	6.3	8.8	4.1	3.2	6.4
D42	Soil and Vegetation Site	438752	7529300	0.9	0.4	0.3	50.1	29.3	2.3	312.9	10.8	6.0	9.9	3.9	3.2	6.4
D43	Soil and Vegetation Site	438876	7528748	0.9	0.4	0.3	47.8	28.3	2.2	312.0	10.6	6.0	9.7	3.9	3.2	6.3
D50	Soil and Vegetation Site	435378	7528680	0.8	0.4	0.3	41.5	20.4	2.1	303.0	9.0	6.0	8.4	3.8	3.2	6.3
D51	Soil and Vegetation Site	435550	7528477	0.8	0.4	0.3	40.8	20.4	2.1	302.4	9.0	6.0	8.3	3.8	3.2	6.3
D52	Soil and Vegetation Site	435710	7528231	0.8	0.4	0.3	40.7	20.4	2.0	302.5	9.0	6.0	8.3	3.8	3.2	6.3
D54	Soil and Vegetation Site	435410	7527893	0.8	0.4	0.3	39.5	19.4	2.0	300.7	8.8	6.0	8.2	3.8	3.2	6.3
D55	Soil and Vegetation Site	436373	7534463	1.1	0.5	0.3	70.3	37.8	2.8	329.7	13.0	6.2	11.7	4.3	3.3	6.4
D57	Soil and Vegetation Site	436768	7534703	1.2	0.5	0.3	73.6	41.1	2.9	332.7	14.0	6.2	12.3	4.3	3.3	6.4
D59	Soil and Vegetation Site	445959	7494897	0.6	0.3	0.3	34.6	11.8	2.0	293.5	9.4	6.1	7.9	3.9	3.2	6.4
D61	Soil and Vegetation Site	445242	7495181	0.7	0.3	0.3	37.0	11.7	2.0	294.8	9.4	6.1	7.8	3.9	3.2	6.4
D62	Soil and Vegetation Site	445021	7500408	2.0	0.4	0.3	87.2	36.7	4.1	365.5	17.6	6.8	13.6	5.5	3.4	6.6
D63	Soil and Vegetation Site	444873	7500332	2.0	0.4	0.3	94.1	34.9	4.0	365.6	17.3	6.8	13.3	5.4	3.4	6.6
D65	Soil and Vegetation Site	443575	7500774	2.1	0.4	0.3	117.8	34.9	4.5	399.4	17.3	7.0	13.2	5.5	3.4	6.7
D70	Soil and Vegetation Site	441289	7500063	1.1	0.4	0.3	121.3	29.1	3.3	344.1	17.1	6.5	12.8	4.9	3.3	6.6

Table D-1 Maximum Predicted Concentrations and Dust Deposition Rates at Discrete Receptors during Madrid-Boston Project Construction

Receptor ID	Receptor Description	Receptor Location		SO_2, µg/m³		NO_2, µg/m³		CO, µg/m³		TSP, µg/m³		PM_{10}, µg/m³		$PM_{2.5}$, µg/m³		Dust Deposition, mg/100/cm²
		Easting, m	Northing, m	1-hour	24-hour	Annual	1-hour	24-hour	Annual	1-hour	24-hour	Annual	24-hour	24-hour	Annual	30-day
Baseline/Background Value Included in Results:				**0.3**	**0.3**	**0.3**	**1.1**	**1.1**	**1.1**	**261**	**5.8**	**5.8**	**5.4**	**3.1**	**3.1**	**6.3**
D71	Soil and Vegetation Site	443663	7505186	5.0	0.9	0.4	166.3	130.8	18.7	582.8	157.0	30.5	65.2	14.0	5.4	25.3
D72	Soil and Vegetation Site	443686	7505467	4.1	0.8	0.4	163.4	125.5	15.8	490.3	122.8	25.9	58.9	13.3	5.0	21.6
D75	Soil and Vegetation Site	444448	7506676	3.8	0.7	0.3	153.6	99.9	9.0	474.6	33.4	9.7	26.6	8.5	4.0	7.6
D76	Soil and Vegetation Site	443985	7507621	2.1	0.5	0.3	142.1	70.1	8.1	378.4	70.4	14.3	28.6	8.3	4.0	11.1
D82	Soil and Vegetation Site	442400	7511353	2.2	0.4	0.3	97.6	43.1	7.5	378.9	47.7	14.2	24.4	6.5	3.9	11.1
D88	Soil and Vegetation Site	440559	7512116	5.5	0.7	0.4	161.5	86.6	21.1	572.9	100.0	30.9	37.1	10.1	5.5	23.3
D96	Soil and Vegetation Site	438453	7518693	1.0	0.4	0.3	50.5	20.0	3.0	311.8	17.6	7.2	12.1	4.6	3.3	6.8
D99	Soil and Vegetation Site	438580	7517814	1.2	0.4	0.3	63.6	26.1	4.0	324.4	54.0	12.6	22.1	5.4	3.6	11.1
D108	Soil and Vegetation Site	438371	7522912	0.7	0.4	0.3	34.9	18.4	2.0	298.5	8.5	6.1	8.0	3.8	3.2	6.4
D109	Soil and Vegetation Site	438474	7522631	0.6	0.4	0.3	34.5	18.3	2.0	298.4	8.6	6.1	8.0	3.8	3.2	6.4
D119	Soil and Vegetation Site	444785	7510544	1.1	0.4	0.3	74.4	37.1	4.9	321.0	24.5	8.6	17.8	5.6	3.6	7.8
D122	Soil and Vegetation Site	446280	7510306	1.0	0.4	0.3	59.9	28.4	3.8	314.1	14.2	7.1	12.4	4.8	3.4	6.8
D132	Soil and Vegetation Site	444763	7497621	1.0	0.4	0.3	54.0	16.9	2.6	317.2	11.0	6.3	8.9	4.3	3.2	6.5
LSA-01	Soil and Vegetation Site	431198	7556075	2.4	0.6	0.3	152.9	64.3	11.1	427.2	30.0	9.5	18.6	7.2	4.0	8.0
LSA-02	Soil and Vegetation Site	430333	7562313	6.5	0.7	0.3	163.3	105.0	12.0	474.1	24.6	7.9	20.6	8.8	4.0	7.3
LSA-03	Soil and Vegetation Site	436054	7559625	3.7	0.7	0.3	165.4	105.6	13.6	559.5	27.6	8.2	22.6	9.8	4.2	7.4
LSA-04	Soil and Vegetation Site	433617	7554104	8.5	1.4	0.4	187.4	127.8	18.8	817.0	59.7	15.9	36.7	12.8	5.0	11.7
LSA-05	Soil and Vegetation Site	432400	7532829	0.9	0.4	0.3	54.9	19.9	2.4	319.3	9.7	6.1	9.0	4.1	3.2	6.4
LSA-06	Soil and Vegetation Site	435904	7534067	1.0	0.5	0.3	65.5	33.9	2.7	328.0	12.0	6.1	10.8	4.2	3.2	6.4
LSA-07	Soil and Vegetation Site	436108	7527987	0.8	0.4	0.3	41.8	21.0	2.0	303.7	9.1	6.0	8.5	3.8	3.2	6.3
LSA-08	Soil and Vegetation Site	439762	7527869	0.8	0.4	0.3	44.3	27.6	2.2	311.3	10.4	6.0	9.5	3.9	3.2	6.3
LSA-09	Soil and Vegetation Site	439040	7515620	2.4	0.5	0.3	105.4	40.4	5.0	391.3	22.0	9.3	14.4	5.4	3.6	8.2
LSA-10	Soil and Vegetation Site	438617	7522046	0.6	0.4	0.3	33.8	17.9	2.1	297.8	8.9	6.2	8.0	3.9	3.2	6.4
LSA-11	Soil and Vegetation Site	442582	7520614	0.7	0.4	0.3	28.9	19.5	2.2	295.4	8.7	6.1	8.1	3.8	3.2	6.4
LSA-12	Soil and Vegetation Site	444545	7515463	0.9	0.4	0.3	41.9	23.7	3.1	302.6	11.7	6.6	10.5	4.3	3.3	6.5
LSA-13	Soil and Vegetation Site	434097	7546555	12.7	1.6	0.4	207.5	125.7	21.4	1201.5	83.5	19.1	48.9	16.1	5.6	11.7
LSA-14	Soil and Vegetation Site	436417	7547137	6.8	1.2	0.4	182.6	138.7	20.6	716.0	45.8	12.1	34.9	12.2	5.1	8.5
LSA-15	Soil and Vegetation Site	433932	7538190	1.5	0.5	0.3	104.6	37.3	3.7	372.5	15.9	6.5	14.2	5.0	3.3	6.5
LSA-16	Soil and Vegetation Site	434510	7551315	9.0	0.9	0.4	183.1	108.3	21.8	919.2	48.2	13.7	28.3	10.9	5.0	9.8
LSA-17	Soil and Vegetation Site	440860	7511479	4.8	0.6	0.4	154.4	73.0	13.9	528.8	83.1	20.3	32.8	7.7	4.6	16.3

Table D-1 Maximum Predicted Concentrations and Dust Deposition Rates at Discrete Receptors during Madrid-Boston Project Construction

Receptor ID	Receptor Description	Receptor Location		SO_2, µg/m³		NO_2, µg/m³		CO, µg/m³		TSP, µg/m³		PM_{10}, µg/m³		$PM_{2.5}$, µg/m³		Dust Deposition, mg/100/cm²
		Easting, m	Northing, m	1-hour	24-hour	Annual	1-hour	24-hour	Annual	1-hour	24-hour	Annual	24-hour	24-hour	Annual	30-day
Baseline/Background Value Included in Results:				**0.3**	**0.3**	**0.3**	**1.1**	**1.1**	**1.1**	**261**	**5.8**	**5.8**	**5.4**	**3.1**	**3.1**	**6.3**
LSA-18	Soil and Vegetation Site	446981	7511394	0.9	0.4	0.3	53.0	26.2	3.4	306.2	13.5	6.7	12.0	4.6	3.4	6.6
LSA-19	Soil and Vegetation Site	441491	7501963	2.2	0.5	0.3	161.1	58.8	6.1	413.5	28.6	7.8	19.9	7.1	3.6	7.3
LSA-20	Soil and Vegetation Site	456292	7556062	0.9	0.4	0.3	44.3	15.9	2.6	295.0	8.3	6.1	7.7	3.9	3.2	6.4
LSA-21	Soil and Vegetation Site	435441	7542089	3.2	0.8	0.3	156.7	99.8	8.6	495.0	56.0	16.4	26.7	7.8	4.1	12.9
REFA-01	Soil and Vegetation Site	449538	7554968	1.1	0.4	0.3	57.4	21.6	3.5	308.5	9.4	6.2	8.6	4.2	3.3	6.5
REFA-02	Soil and Vegetation Site	449451	7555774	1.2	0.4	0.3	60.2	24.9	3.5	310.4	10.3	6.3	9.3	4.3	3.3	6.5
REFA-03	Soil and Vegetation Site	450209	7555395	1.1	0.4	0.3	58.0	22.9	3.4	308.3	9.9	6.2	9.0	4.3	3.3	6.5
REFB-01	Soil and Vegetation Site	421758	7530961	0.6	0.3	0.3	27.1	10.2	1.7	291.4	7.2	5.9	6.7	3.6	3.2	6.4
REFB-02	Soil and Vegetation Site	420156	7530543	0.5	0.3	0.3	23.5	9.4	1.7	286.4	7.1	5.9	6.6	3.5	3.1	6.3
REFB-03	Soil and Vegetation Site	420802	7530042	0.6	0.3	0.3	24.5	9.5	1.7	288.1	7.1	5.9	6.6	3.5	3.1	6.3
REFC-01	Soil and Vegetation Site	418953	7544574	0.7	0.4	0.3	28.1	12.2	1.9	303.0	8.0	6.0	7.2	3.6	3.2	6.4
REFC-02	Soil and Vegetation Site	419009	7545326	0.7	0.4	0.3	29.4	11.5	2.0	304.6	7.9	6.0	7.2	3.6	3.2	6.4
REFC-03	Soil and Vegetation Site	419750	7544665	0.7	0.4	0.3	30.6	14.3	2.0	307.0	8.5	6.0	7.6	3.7	3.2	6.4

Table D-2 Maximum Predicted Concentrations and Dust Deposition Rates at Discrete Receptors during Madrid-Boston Project Operation

Receptor ID	Receptor Description	Receptor Location		SO_2, µg/m³		NO_2, µg/m³		CO, µg/m³		TSP, µg/m³		PM_{10}, µg/m³		$PM_{2.5}$, µg/m³		Dust Deposition, mg/100/cm²
		Easting, m	Northing, m	1-hour	24-hour	Annual	1-hour	24-hour	Annual	1-hour	24-hour	Annual	24-hour	24-hour	Annual	30-day
Baseline/Background Value Included in Results:				**0.3**	**0.3**	**0.3**	**1.1**	**1.1**	**1.1**	**261**	**5.8**	**5.8**	**5.4**	**3.1**	**3.1**	**6.3**
CB1	Cabin	406275	7551933	0.5	0.3	0.3	10.1	4.8	1.4	271.8	6.2	5.8	5.8	3.3	3.1	6.4
CB2	Cabin	406503	7552314	0.5	0.3	0.3	10.2	4.7	1.4	272.3	6.2	5.8	5.8	3.3	3.1	6.4
C1	Outpost Camp	435299	7562924	10.3	0.5	0.3	157.3	39.5	5.6	369.5	10.8	6.6	9.6	4.9	3.5	6.7
C2	Seasonal Camp (spring/summer)	436579	7569440	4.2	0.4	0.3	100.2	15.4	2.1	294.6	8.0	6.0	7.3	3.7	3.2	6.4
F1	Fishing Area	408133	7551357	0.5	0.3	0.3	10.0	5.6	1.4	274.1	6.4	5.9	5.9	3.3	3.1	6.4
F2	Fishing Area	443743	7507935	6.4	0.8	0.3	159.9	83.7	8.9	581.3	45.0	10.7	26.5	8.8	4.0	8.5
F3	Fishing Area	435464	7560804	5.0	0.4	0.3	150.3	49.2	6.6	353.5	14.0	6.9	11.9	5.5	3.6	6.8
H1	Hunting and Fishing	443076	7504033	8.3	1.7	0.4	194.7	134.6	16.4	798.1	98.5	15.4	58.1	14.8	5.1	12.0
H2	Hunting and Fishing	435004	7575863	2.5	0.3	0.3	51.5	13.5	1.8	291.5	7.4	5.9	6.9	3.5	3.2	6.4
H3	Hunting and Fishing	419714	7570036	1.5	0.3	0.3	37.3	13.3	2.4	289.1	8.8	6.1	7.4	3.7	3.2	6.5
H4	Hunting and Fishing	416437	7560888	0.9	0.3	0.3	21.9	8.3	2.0	284.6	7.4	6.0	6.6	3.5	3.2	6.4
T1	Travel Route	425864	7570079	3.4	0.4	0.3	66.7	22.3	2.7	313.1	9.1	6.1	8.3	4.1	3.2	6.4
E3	Queen Maude Gulf Migratory Bird Sanctuary	478687	7503125	0.4	0.3	0.3	9.5	7.8	1.4	270.9	6.7	5.9	6.3	3.3	3.1	6.3
W1	Doris Camp (active)	432965	7559020	4.4	0.9	0.4	231.4	175.1	66.5	838.0	155.2	31.8	64.9	22.9	9.6	23.2
W2	Boston Exploration Camp	441137	7505488	75.6	12.5	1.6	382.8	228.5	46.1	4091.4	359.8	44.7	170.6	69.2	15.0	24.7
W3	Boston Operation Camp	441091	7504367	24.8	7.1	2.1	488.6	396.2	201.4	2431.0	702.2	154.0	298.8	160.8	53.6	58.6
W4	Quarry D Camp	432902	7551720	16.3	3.8	0.7	313.5	223.1	56.4	1648.5	266.5	64.0	132.5	42.4	12.0	46.0
8	Soil and Vegetation Site	431889	7556491	3.5	1.1	0.4	165.0	132.0	15.7	512.8	87.9	15.7	47.5	10.6	4.6	10.3
11	Soil and Vegetation Site	447111	7506863	2.2	0.5	0.3	110.6	41.4	4.6	390.6	16.4	6.9	13.7	5.8	3.5	6.7
13	Soil and Vegetation Site	445764	7506296	3.5	0.6	0.3	151.4	62.8	6.2	444.1	23.1	7.7	18.9	7.2	3.7	7.0
14	Soil and Vegetation Site	437081	7547927	6.2	0.9	0.4	170.5	105.3	15.9	651.6	39.7	11.1	26.1	10.6	4.6	8.2
16	Soil and Vegetation Site	437606	7547393	6.0	0.9	0.4	170.8	103.3	15.2	653.8	43.2	11.2	26.2	11.4	4.6	8.5
18	Soil and Vegetation Site	437685	7546759	5.6	1.0	0.4	170.9	107.3	14.6	610.9	44.2	10.6	27.8	10.6	4.5	8.2
21	Soil and Vegetation Site	431742	7559767	4.3	0.6	0.3	176.8	149.0	24.0	507.5	41.6	11.0	30.5	13.7	5.2	8.2
22	Soil and Vegetation Site	431495	7559736	3.9	0.6	0.3	180.1	144.2	21.0	530.9	43.6	10.7	32.5	13.1	5.0	8.2
23	Soil and Vegetation Site	434866	7553440	2.6	0.7	0.3	156.1	71.8	11.3	464.7	33.6	12.5	19.7	7.4	4.1	10.5
29	Soil and Vegetation Site	436397	7557975	2.2	0.5	0.3	151.0	73.8	9.8	365.7	27.1	8.7	19.0	6.7	3.9	8.9
CFW1	Soil and Vegetation Site	441742	7510979	3.6	0.7	0.3	150.7	62.1	7.2	418.3	40.6	14.3	20.6	7.6	3.9	12.6

Table D-2 Maximum Predicted Concentrations and Dust Deposition Rates at Discrete Receptors during Madrid-Boston Project Operation

Receptor ID	Receptor Description	Receptor Location		SO_2, µg/m³		NO_2, µg/m³		CO, µg/m³		TSP, µg/m³		PM_{10}, µg/m³		$PM_{2.5}$, µg/m³		Dust Deposition, mg/100/cm²
		Easting, m	Northing, m	1-hour	24-hour	Annual	1-hour	24-hour	Annual	1-hour	24-hour	Annual	24-hour	24-hour	Annual	30-day
CFW2	Soil and Vegetation Site	445842	7503723	2.8	0.6	0.3	141.2	48.9	6.5	417.4	22.9	7.7	18.8	6.1	3.7	7.2
CFW3	Soil and Vegetation Site	434895	7542242	3.3	0.8	0.3	157.4	96.2	8.1	489.1	54.2	11.8	28.3	7.2	3.8	10.9
CFW4	Soil and Vegetation Site	436096	7549618	3.7	1.0	0.4	162.9	113.0	19.1	504.8	36.8	11.7	24.6	10.2	4.8	8.3
CFW5	Soil and Vegetation Site	435388	7559596	3.1	0.6	0.3	170.1	115.1	13.7	463.3	32.6	8.9	25.8	10.1	4.2	7.6
CFW6	Soil and Vegetation Site	435400	7559601	3.1	0.6	0.3	169.8	114.7	13.6	462.6	32.4	8.9	25.6	10.0	4.2	7.6
D06	Soil and Vegetation Site	433211	7547705	8.6	1.2	0.4	216.0	105.1	20.1	946.4	75.0	18.4	43.6	14.1	5.4	13.5
D10	Soil and Vegetation Site	432471	7548235	6.5	1.3	0.4	189.1	116.9	15.7	862.5	50.5	11.7	33.1	10.6	4.7	9.4
D12	Soil and Vegetation Site	435015	7539769	2.0	0.6	0.3	135.7	62.6	4.7	403.3	26.3	7.4	17.8	5.6	3.5	7.1
D16	Soil and Vegetation Site	436028	7540759	2.5	0.8	0.3	151.3	93.6	6.0	408.4	31.5	7.7	23.4	6.5	3.6	7.0
D20	Soil and Vegetation Site	435631	7542445	3.8	1.0	0.3	158.6	110.8	7.9	526.2	39.1	8.8	27.8	7.8	3.8	7.5
D21	Soil and Vegetation Site	436121	7543061	4.3	1.0	0.3	162.9	114.3	8.4	543.2	41.5	8.3	29.0	8.4	3.8	7.1
D22	Soil and Vegetation Site	436364	7543054	4.4	1.0	0.3	162.7	109.3	8.8	542.9	39.3	8.4	27.6	8.8	3.9	7.2
D26	Soil and Vegetation Site	431884	7543400	2.1	0.6	0.3	135.1	51.7	5.6	394.6	18.9	7.1	14.2	6.1	3.5	6.7
D29	Soil and Vegetation Site	432032	7542769	2.1	0.6	0.3	142.7	58.8	5.5	390.9	20.5	7.1	15.8	6.1	3.5	6.7
D32	Soil and Vegetation Site	432709	7542116	1.2	0.5	0.3	83.5	36.3	3.8	344.0	13.1	6.5	11.1	4.9	3.3	6.6
D38	Soil and Vegetation Site	438196	7530728	0.9	0.4	0.3	54.5	31.5	2.4	310.1	11.3	6.0	10.3	4.1	3.2	6.4
D39	Soil and Vegetation Site	438041	7530438	0.9	0.4	0.3	53.9	30.7	2.4	309.2	11.1	6.0	10.1	4.0	3.2	6.4
D40	Soil and Vegetation Site	438143	7520942	0.8	0.4	0.3	33.4	16.8	2.1	291.0	8.9	6.1	8.0	3.9	3.2	6.4
D42	Soil and Vegetation Site	438752	7529300	0.8	0.4	0.3	49.4	29.0	2.3	308.0	10.7	6.0	9.8	3.9	3.2	6.3
D43	Soil and Vegetation Site	438876	7528748	0.8	0.4	0.3	47.2	27.9	2.3	307.1	10.5	6.0	9.6	3.9	3.2	6.3
D50	Soil and Vegetation Site	435378	7528680	0.7	0.4	0.3	41.6	21.3	2.1	298.0	9.0	6.0	8.3	3.8	3.2	6.3
D51	Soil and Vegetation Site	435550	7528477	0.7	0.4	0.3	41.0	21.0	2.1	297.5	8.9	6.0	8.3	3.8	3.2	6.3
D52	Soil and Vegetation Site	435710	7528231	0.7	0.4	0.3	40.4	20.9	2.0	296.9	8.9	6.0	8.3	3.8	3.2	6.3
D54	Soil and Vegetation Site	435410	7527893	0.7	0.4	0.3	39.7	20.0	2.0	295.7	8.7	6.0	8.1	3.8	3.2	6.3
D55	Soil and Vegetation Site	436373	7534463	1.0	0.5	0.3	68.6	38.0	2.8	321.9	12.9	6.1	11.5	4.3	3.3	6.4
D57	Soil and Vegetation Site	436768	7534703	1.1	0.5	0.3	70.8	40.9	2.9	325.8	13.7	6.2	12.1	4.3	3.3	6.4
D59	Soil and Vegetation Site	445959	7494897	0.9	0.4	0.3	51.9	23.8	2.6	297.5	11.4	6.1	9.3	4.2	3.2	6.5
D61	Soil and Vegetation Site	445242	7495181	1.0	0.4	0.3	51.1	25.7	2.5	300.0	11.7	6.1	9.3	4.3	3.2	6.5
D62	Soil and Vegetation Site	445021	7500408	2.0	0.6	0.3	111.2	58.9	4.8	370.3	25.4	6.9	19.6	5.5	3.5	6.7
D63	Soil and Vegetation Site	444873	7500332	2.1	0.6	0.3	108.2	54.7	4.7	366.8	23.9	6.9	18.3	5.7	3.5	6.7

Table D-2 Maximum Predicted Concentrations and Dust Deposition Rates at Discrete Receptors during Madrid-Boston Project Operation

		Receptor Location		SO_2, µg/m³		NO_2, µg/m³		CO, µg/m³		TSP, µg/m³		PM_{10}, µg/m³		$PM_{2.5}$, µg/m³		Dust Deposition, mg/100/cm²
Receptor ID	Receptor Description	Easting, m	Northing, m	1-hour	24-hour	Annual	1-hour	24-hour	Annual	1-hour	24-hour	Annual	24-hour	24-hour	Annual	30-day
D65	Soil and Vegetation Site	443575	7500774	2.8	0.6	0.3	144.1	54.4	5.5	429.1	25.3	7.3	16.7	7.0	3.6	6.9
D70	Soil and Vegetation Site	441289	7500063	2.6	0.4	0.3	154.0	41.3	4.1	447.6	22.0	6.7	15.3	5.8	3.4	6.7
D71	Soil and Vegetation Site	443663	7505186	8.4	1.4	0.4	183.7	141.2	13.9	732.9	98.6	19.2	55.1	14.9	4.8	14.7
D72	Soil and Vegetation Site	443686	7505467	8.6	1.3	0.4	181.3	134.1	13.4	714.3	84.3	17.1	48.1	14.2	4.7	13.1
D75	Soil and Vegetation Site	444448	7506676	6.1	0.8	0.3	160.8	83.0	8.8	544.7	38.7	9.2	26.6	9.3	4.0	7.8
D76	Soil and Vegetation Site	443985	7507621	6.7	0.8	0.3	160.3	81.9	8.8	582.8	37.7	11.0	25.3	9.1	4.0	8.5
D82	Soil and Vegetation Site	442400	7511353	2.9	0.6	0.3	127.0	52.7	6.0	366.3	29.9	9.9	18.0	7.1	3.7	8.4
D88	Soil and Vegetation Site	440559	7512116	2.9	0.6	0.3	137.6	49.8	6.4	445.4	43.7	15.0	19.7	7.0	3.8	12.7
D96	Soil and Vegetation Site	438453	7518693	1.0	0.4	0.3	45.9	17.4	2.5	304.1	11.9	6.5	9.5	4.3	3.3	6.5
D99	Soil and Vegetation Site	438580	7517814	1.1	0.4	0.3	56.4	20.6	3.1	310.8	26.4	8.8	13.7	4.6	3.4	8.3
D108	Soil and Vegetation Site	438371	7522912	0.7	0.4	0.3	33.7	18.8	1.9	294.3	8.5	6.0	7.9	3.8	3.2	6.4
D109	Soil and Vegetation Site	438474	7522631	0.7	0.4	0.3	33.1	18.6	1.9	294.1	8.5	6.0	7.9	3.8	3.2	6.4
D119	Soil and Vegetation Site	444785	7510544	2.9	0.6	0.3	110.3	53.5	4.9	452.6	24.8	7.6	18.1	6.0	3.5	7.0
D122	Soil and Vegetation Site	446280	7510306	2.3	0.5	0.3	86.2	32.2	3.9	351.5	16.6	6.8	13.6	5.3	3.4	6.6
D132	Soil and Vegetation Site	444763	7497621	1.4	0.4	0.3	77.8	32.3	3.4	318.3	14.7	6.4	11.2	4.9	3.3	6.6
LSA-01	Soil and Vegetation Site	431198	7556075	2.1	0.6	0.3	150.7	67.4	9.8	377.7	32.8	9.8	19.8	6.8	3.9	8.2
LSA-02	Soil and Vegetation Site	430333	7562313	6.3	0.5	0.3	155.1	83.6	9.0	384.3	20.8	7.4	16.6	7.1	3.8	7.1
LSA-03	Soil and Vegetation Site	436054	7559625	3.4	0.5	0.3	152.8	81.9	9.6	398.7	20.3	7.6	16.7	7.0	3.8	7.1
LSA-04	Soil and Vegetation Site	433617	7554104	7.3	1.4	0.4	187.4	128.5	17.5	780.3	65.9	17.1	39.2	12.1	5.0	12.6
LSA-05	Soil and Vegetation Site	432400	7532829	0.9	0.4	0.3	52.8	20.1	2.4	313.7	9.2	6.1	8.5	4.2	3.2	6.4
LSA-06	Soil and Vegetation Site	435904	7534067	1.0	0.5	0.3	62.4	34.4	2.7	320.3	11.9	6.1	10.8	4.2	3.2	6.4
LSA-07	Soil and Vegetation Site	436108	7527987	0.7	0.4	0.3	40.8	21.7	2.1	298.0	9.1	6.0	8.4	3.8	3.2	6.3
LSA-08	Soil and Vegetation Site	439762	7527869	0.8	0.4	0.3	42.8	27.0	2.2	306.0	10.3	6.0	9.5	3.9	3.2	6.3
LSA-09	Soil and Vegetation Site	439040	7515620	1.3	0.4	0.3	64.2	24.0	3.3	330.8	13.7	7.4	10.5	4.6	3.3	7.1
LSA-10	Soil and Vegetation Site	438617	7522046	0.7	0.4	0.3	32.2	18.2	2.0	293.5	8.4	6.0	7.8	3.9	3.2	6.4
LSA-11	Soil and Vegetation Site	442582	7520614	0.8	0.4	0.3	32.6	18.8	2.2	290.9	8.6	6.1	8.0	4.0	3.2	6.4
LSA-12	Soil and Vegetation Site	444545	7515463	1.2	0.4	0.3	56.7	23.3	3.0	305.9	11.8	6.3	10.2	4.7	3.3	6.4
LSA-13	Soil and Vegetation Site	434097	7546555	14.2	2.2	0.5	207.4	138.2	21.0	1347.9	119.5	17.6	58.8	17.7	5.8	12.0
LSA-14	Soil and Vegetation Site	436417	7547137	7.8	1.4	0.4	184.1	133.3	21.1	733.1	56.3	14.3	38.8	14.4	5.4	9.7
LSA-15	Soil and Vegetation Site	433932	7538190	1.4	0.5	0.3	98.0	40.4	3.6	363.4	13.7	6.4	12.4	5.0	3.3	6.5

Table D-2 Maximum Predicted Concentrations and Dust Deposition Rates at Discrete Receptors during Madrid-Boston Project Operation

Receptor ID	Receptor Description	Receptor Location		SO_2, µg/m³		NO_2, µg/m³		CO, µg/m³		TSP, µg/m³		PM_{10}, µg/m³		$PM_{2.5}$, µg/m³		Dust Deposition, mg/100/cm²
		Easting, m	Northing, m	1-hour	24-hour	Annual	1-hour	24-hour	Annual	1-hour	24-hour	Annual	24-hour	24-hour	Annual	30-day
LSA-16	Soil and Vegetation Site	434510	7551315	6.2	0.9	0.4	180.4	95.3	19.4	822.1	49.3	14.2	28.5	10.5	5.0	10.0
LSA-17	Soil and Vegetation Site	440860	7511479	3.6	0.6	0.3	136.9	50.5	6.3	506.7	35.8	11.8	16.2	6.9	3.7	10.3
LSA-18	Soil and Vegetation Site	446981	7511394	1.7	0.5	0.3	70.5	29.6	3.5	336.2	14.9	6.5	12.7	5.0	3.3	6.5
LSA-19	Soil and Vegetation Site	441491	7501963	5.1	0.7	0.3	176.7	87.1	7.6	622.1	37.3	8.5	25.5	9.7	3.9	7.6
LSA-20	Soil and Vegetation Site	456292	7556062	0.9	0.4	0.3	34.9	12.8	2.3	289.5	8.1	6.0	7.5	3.8	3.2	6.4
LSA-21	Soil and Vegetation Site	435441	7542089	3.2	0.9	0.3	156.2	103.8	7.9	503.7	35.1	10.3	25.4	6.8	3.8	8.7
REFA-01	Soil and Vegetation Site	449538	7554968	1.1	0.4	0.3	45.7	17.6	2.9	299.1	9.2	6.2	8.4	4.1	3.3	6.6
REFA-02	Soil and Vegetation Site	449451	7555774	1.1	0.4	0.3	49.7	20.2	3.0	303.1	9.8	6.2	8.9	4.1	3.3	6.5
REFA-03	Soil and Vegetation Site	450209	7555395	1.1	0.4	0.3	48.2	18.9	2.9	301.1	9.6	6.2	8.7	4.1	3.3	6.5
REFB-01	Soil and Vegetation Site	421758	7530961	0.5	0.3	0.3	26.6	10.2	1.7	287.1	7.2	5.9	6.7	3.6	3.2	6.4
REFB-02	Soil and Vegetation Site	420156	7530543	0.5	0.3	0.3	22.8	9.5	1.7	282.6	7.1	5.9	6.6	3.5	3.1	6.3
REFB-03	Soil and Vegetation Site	420802	7530042	0.5	0.3	0.3	24.1	9.7	1.7	284.2	7.1	5.9	6.6	3.5	3.1	6.3
REFC-01	Soil and Vegetation Site	418953	7544574	0.6	0.4	0.3	28.3	15.8	1.9	299.0	8.3	6.0	7.4	3.6	3.2	6.4
REFC-02	Soil and Vegetation Site	419009	7545326	0.7	0.4	0.3	29.7	13.9	1.9	299.8	8.2	6.0	7.4	3.6	3.2	6.4
REFC-03	Soil and Vegetation Site	419750	7544665	0.7	0.4	0.3	31.5	18.5	2.0	302.1	8.8	6.0	7.9	3.7	3.2	6.4

APPENDIX E

Concentration Contour Plots for the Northern Domain (Madrid North in Reference Location), the Madrid-Boston Project + Existing Conditions (includes Baseline Conditions), Construction

Figure E-1
Predicted 99th Percentile Daily Maximum SO_2 Ground-level Concentrations (µg/m³)
Construction, Northern Domain (Madrid North in Reference Location), the Madrid-Boston Project + Existing Conditions (includes Baseline Conditions)

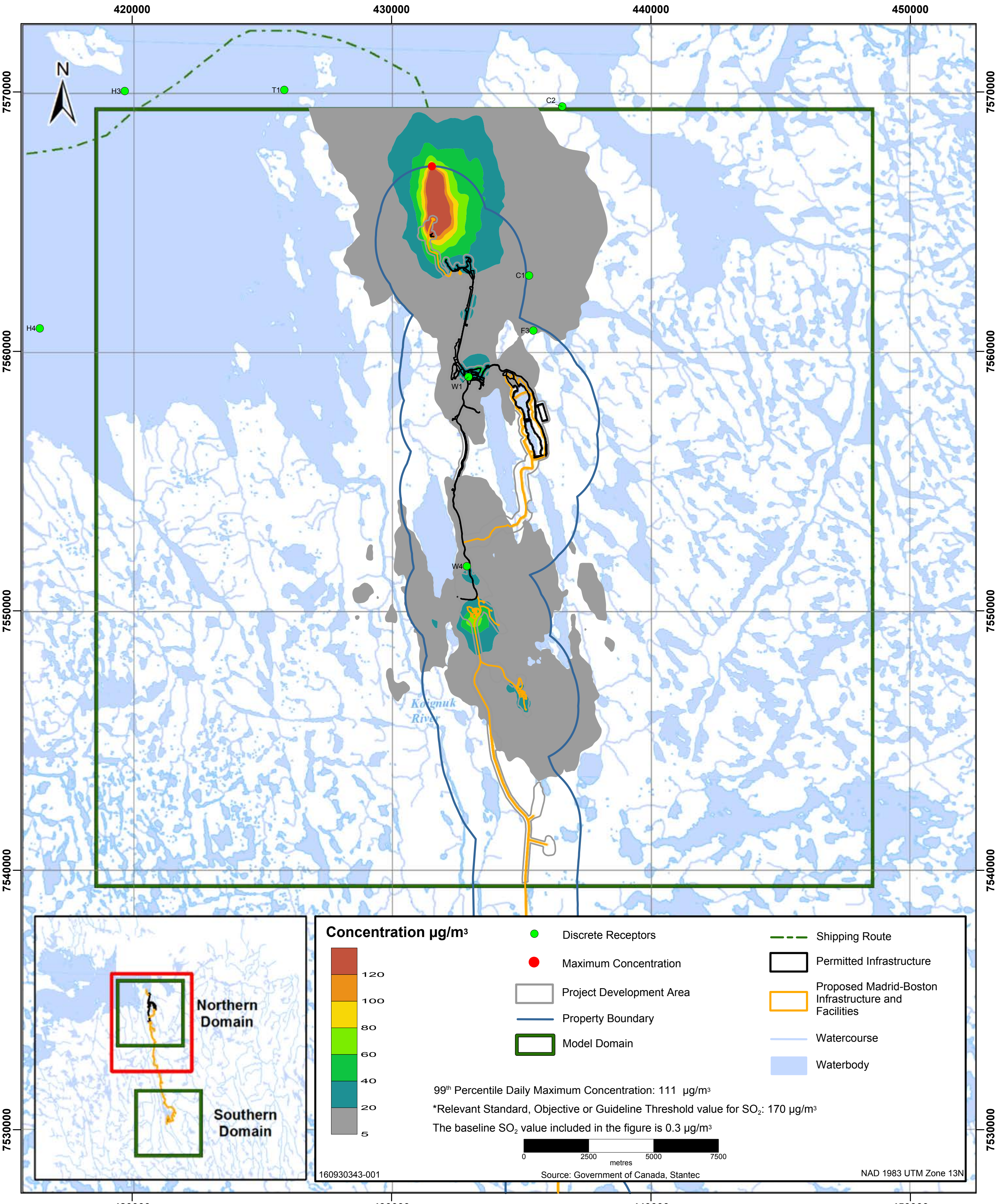


Figure E-2
Maximum Predicted 24-hour Average SO_2 Ground-level Concentrations (µg/m³)
Construction, Northern Domain (Madrid North in Reference Location), the Madrid-Boston Project + Existing Conditions (includes Baseline Conditions)

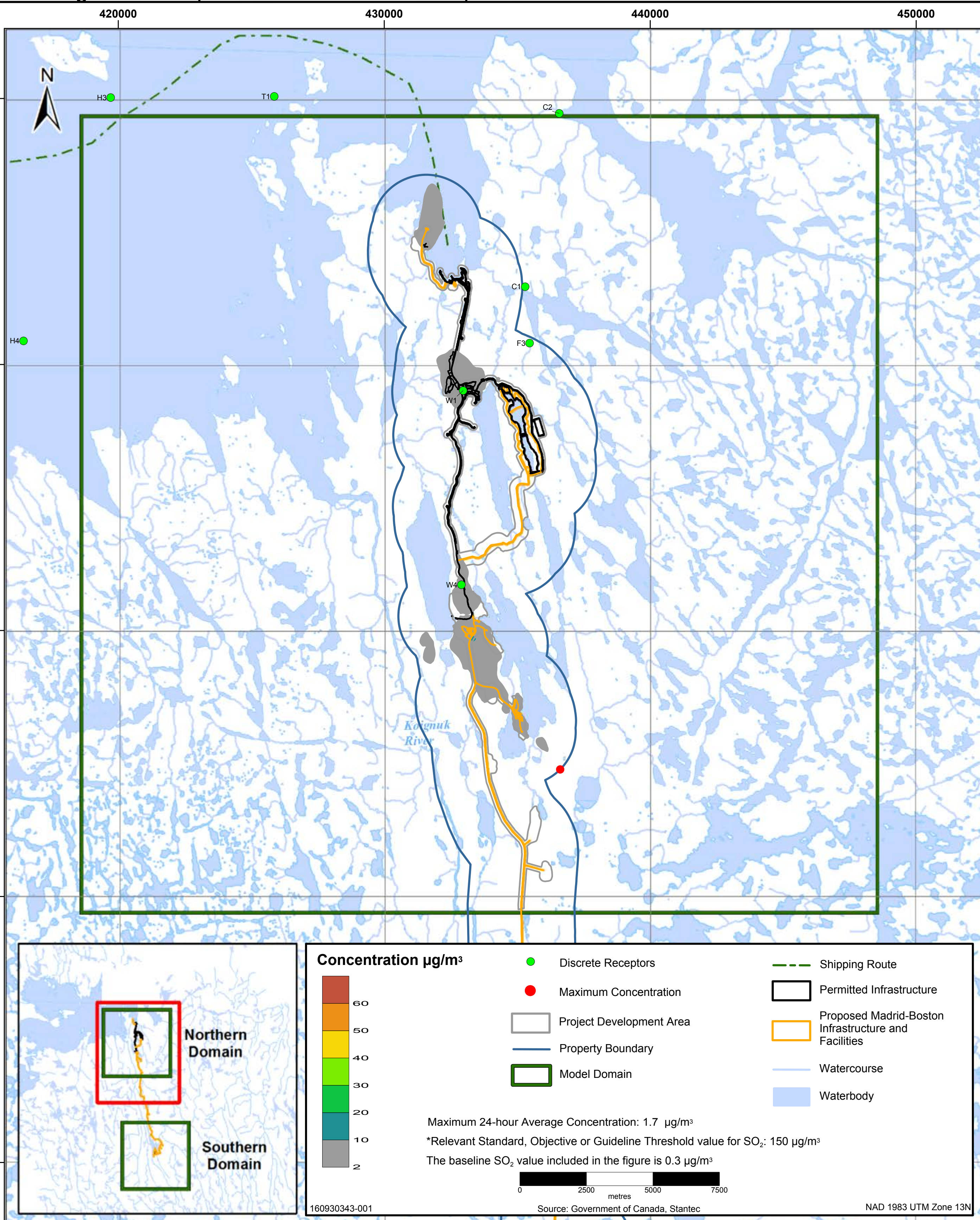


Figure E-3
Maximum Predicted Annual Average SO_2 Ground-level Concentrations (µg/m³)
Construction, Northern Domain (Madrid North in Reference Location), the Madrid-Boston Project + Existing Conditions (includes Baseline Conditions)

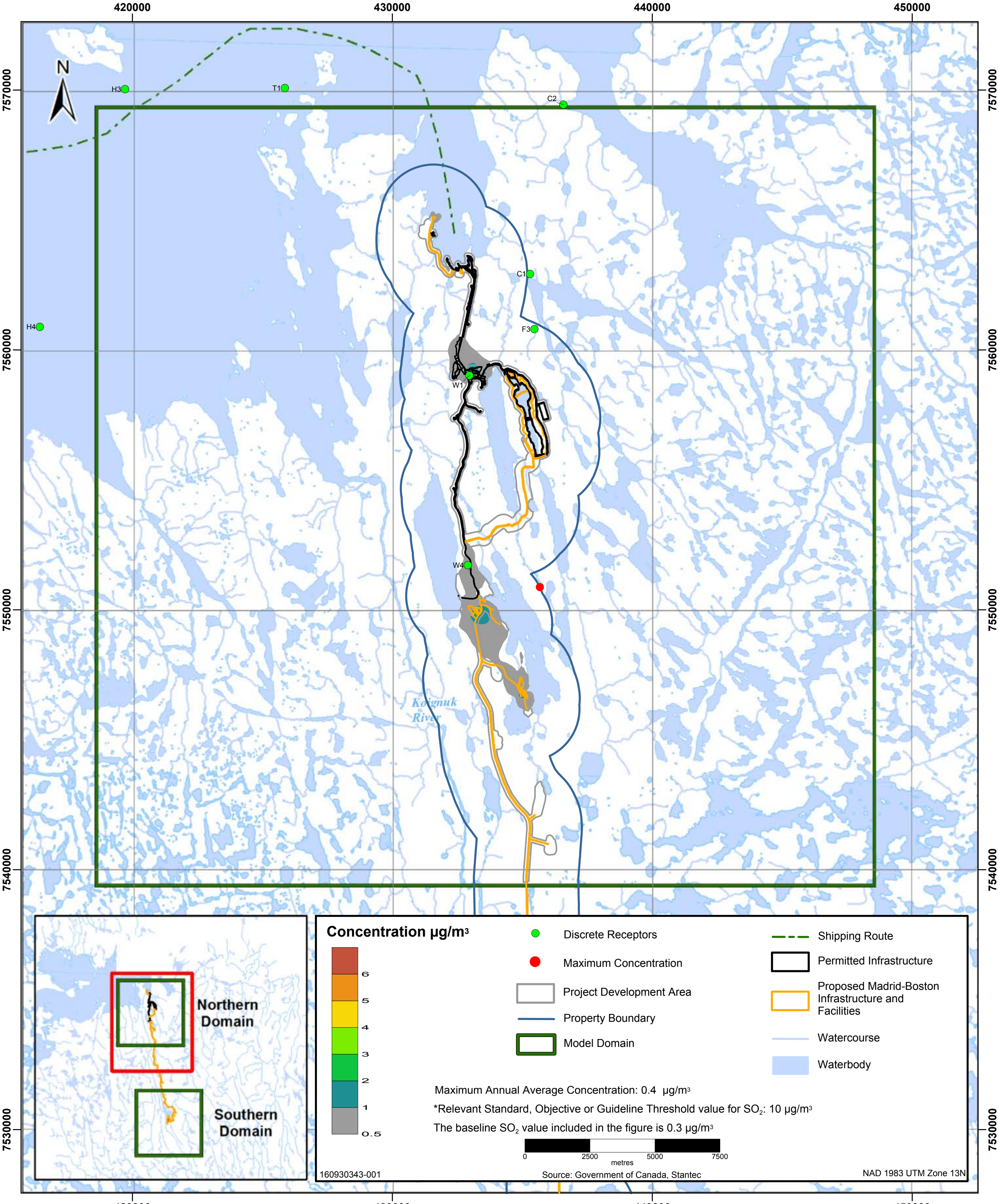


Figure E-4
Predicted 98th Percentile Daily Maximum NO_2 Ground-level Concentrations (µg/m³) Construction, Northern Domain (Madrid North in Reference Location), the Madrid-Boston Project + Existing Conditions (includes Baseline Conditions)

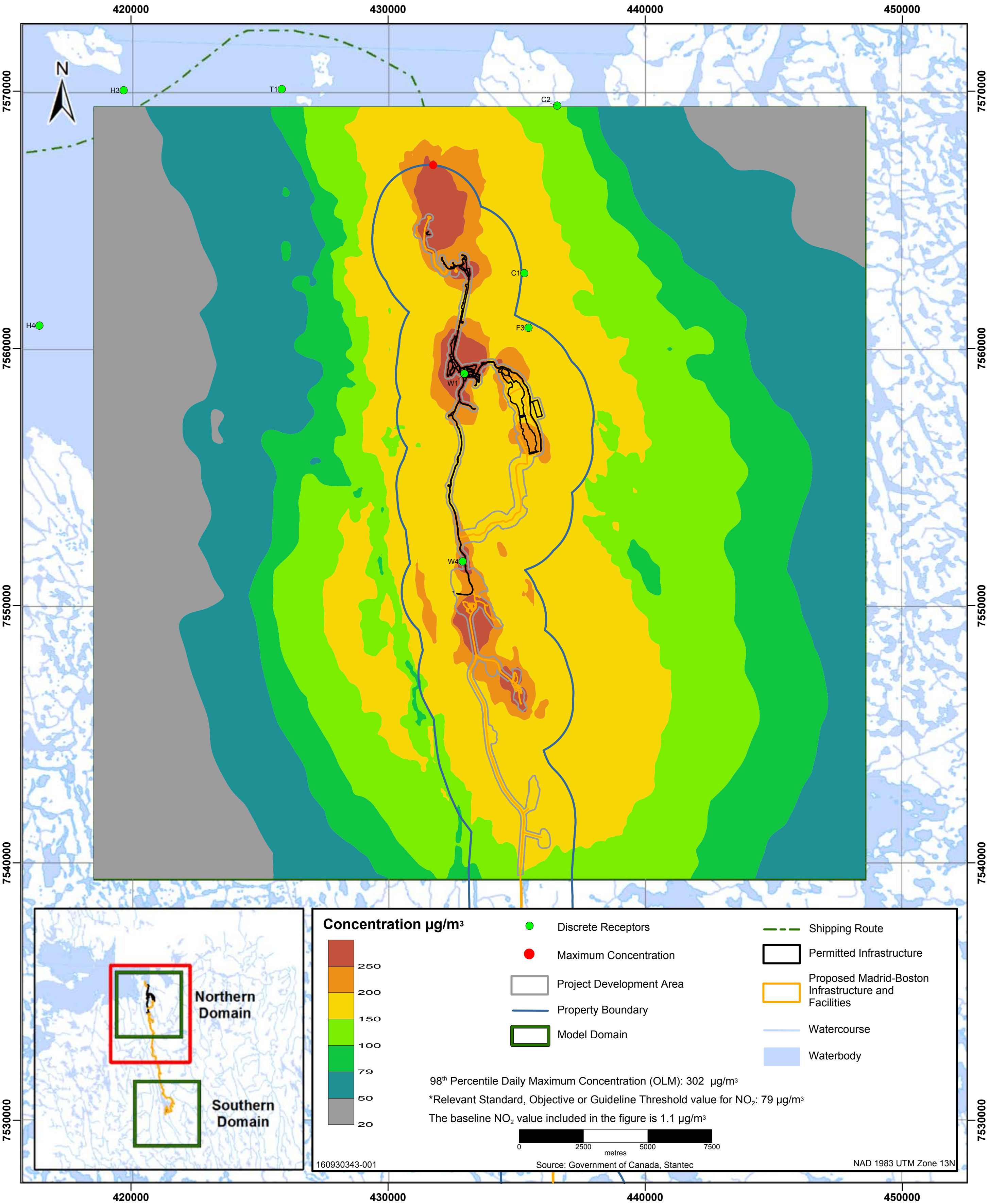


Figure E-5
Frequency of 98th Percentile Daily Maximum NO_2 Concentration Above the Ambient Criteria*
Construction, Northern Domain (Madrid North in Reference Location), the Madrid-Boston Project + Existing Conditions (includes Baseline Conditions)

TMAC RESOURCES

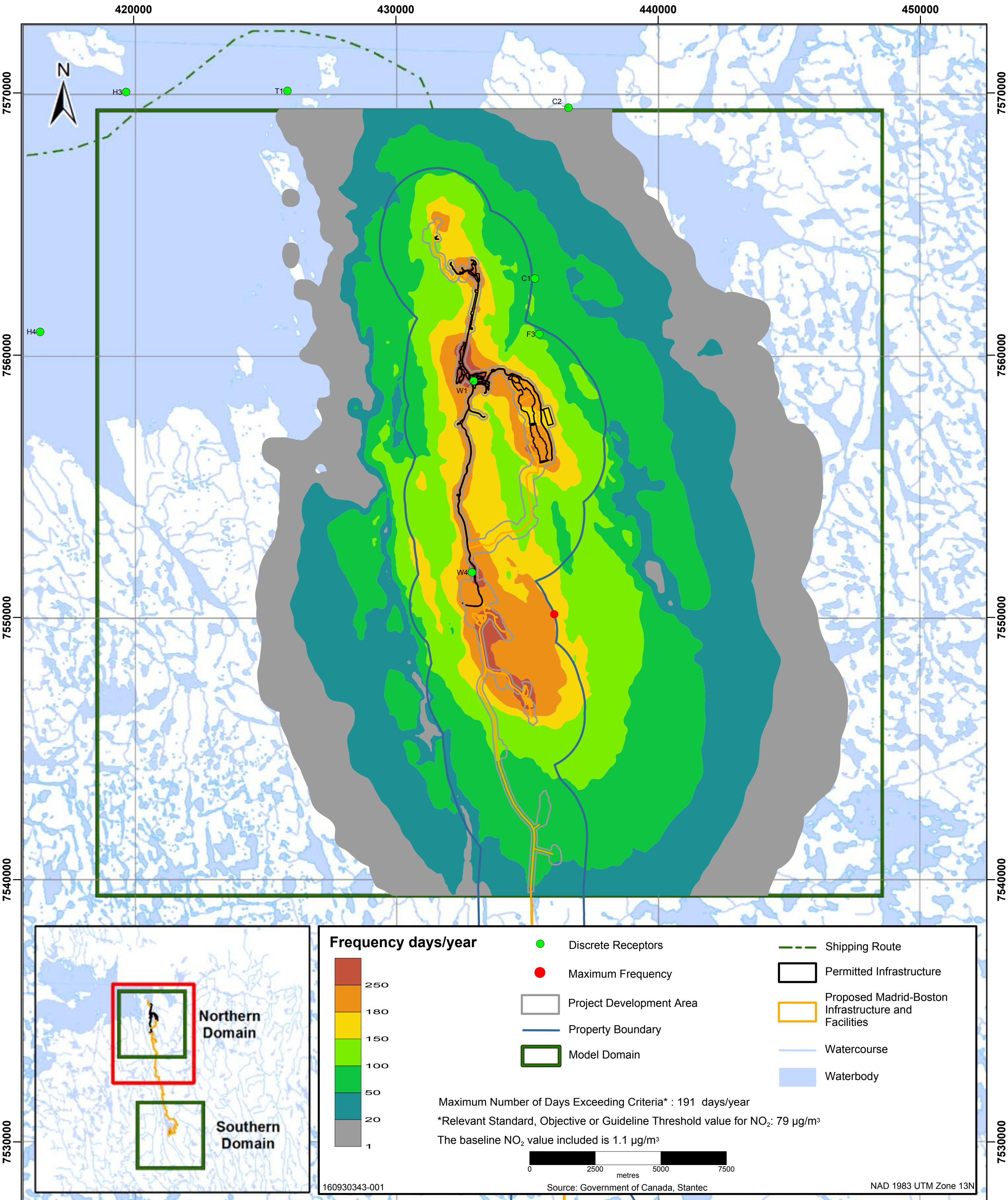


Figure E-6

Maximum Predicted 24-hour Average NO_2 Ground-level Concentrations (µg/m³) Construction, Northern Domain (Madrid North in Reference Location), the Madrid-Boston Project + Existing Conditions (includes Baseline Conditions)

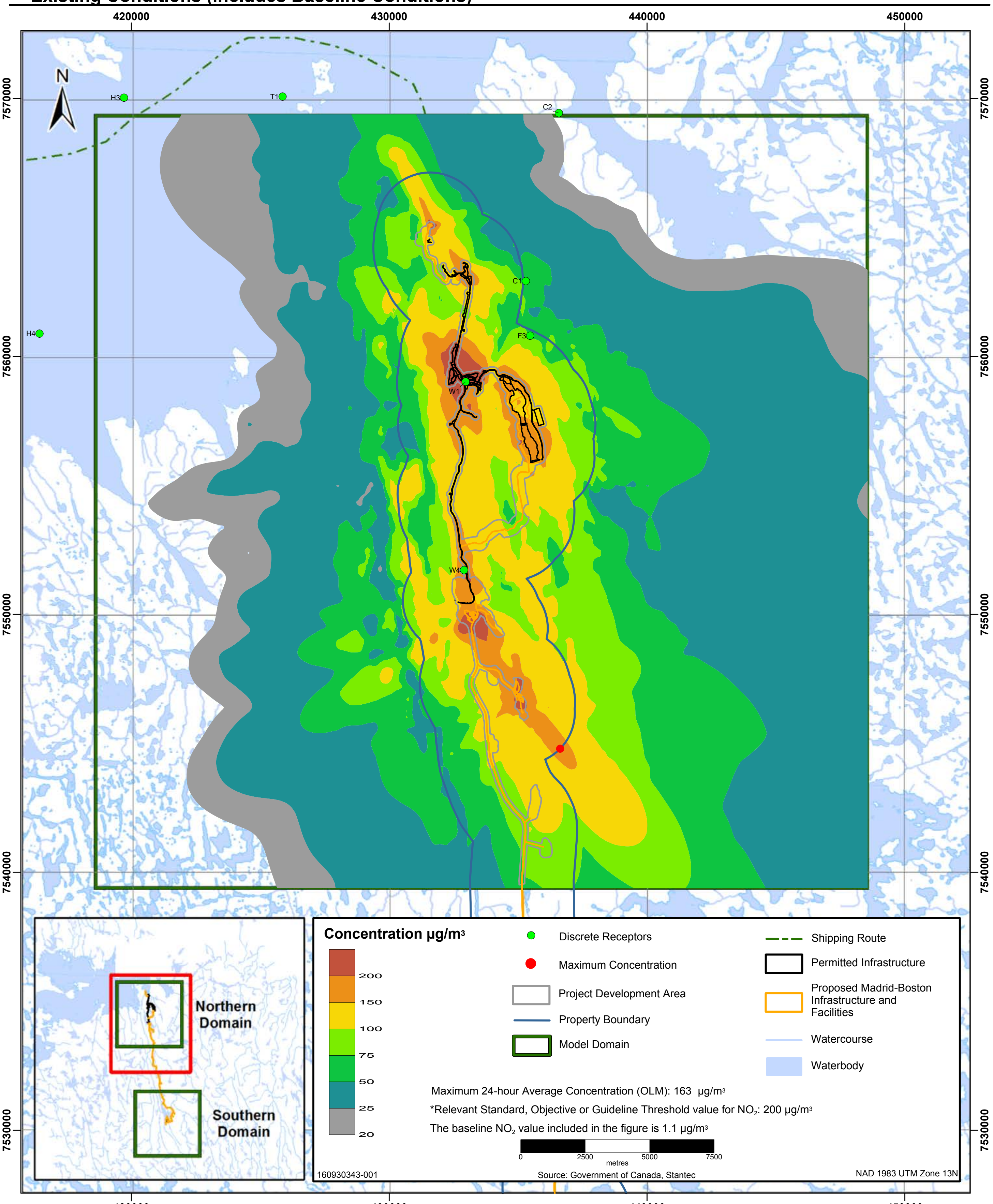


Figure E-7
Maximum Predicted Annual Average NO_2 Ground-level Concentrations (µg/m³) Construction, Northern Domain (Madrid North in Reference Location), the Madrid-Boston Project + Existing Conditions (includes Baseline Conditions)

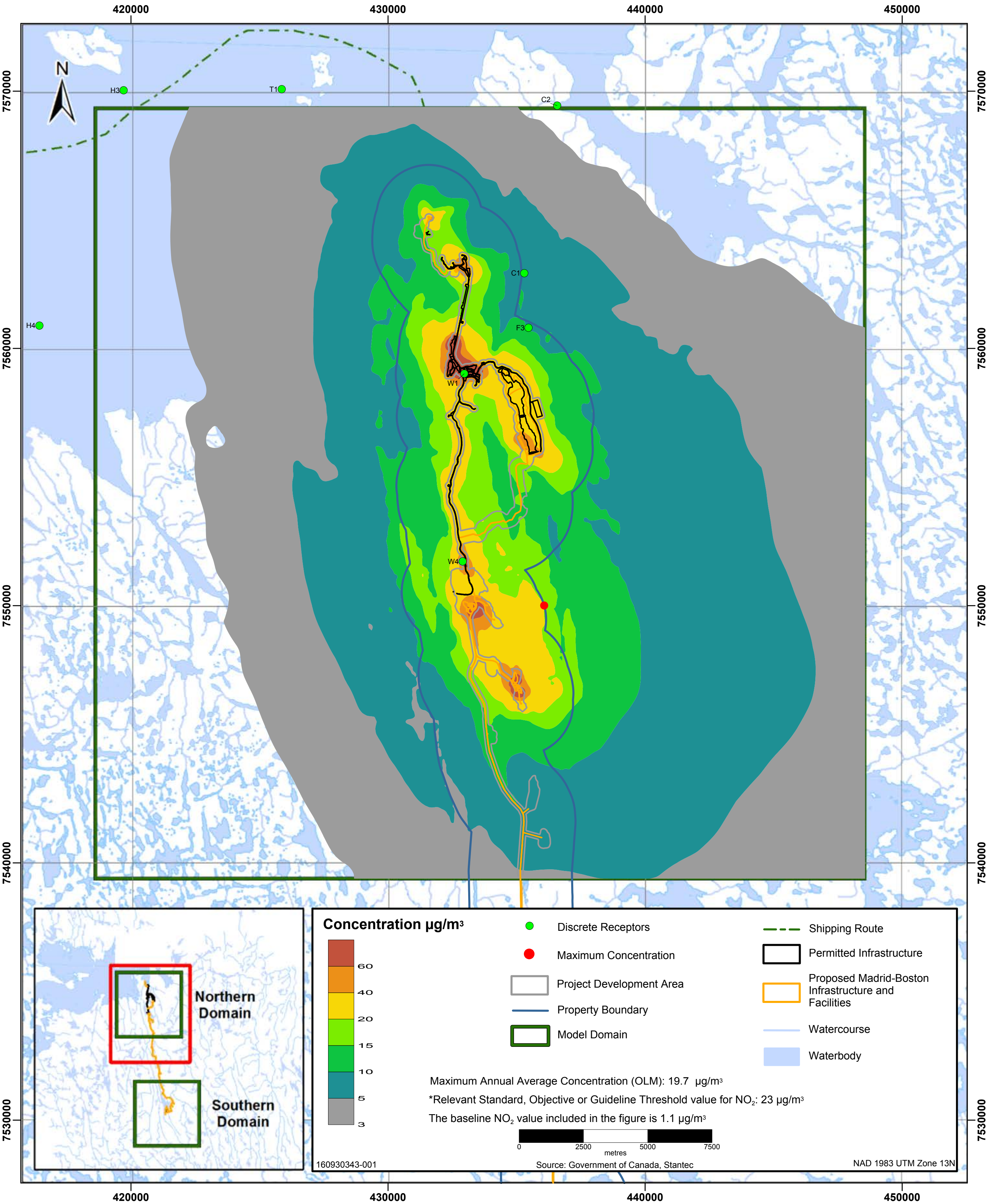


Figure E-8
Maximum Predicted One-hour Average CO Ground-level Concentrations (µg/m³) Construction, Northern Domain (Madrid North in Reference Location), the Madrid-Boston Project + Existing Conditions (includes Baseline Conditions)

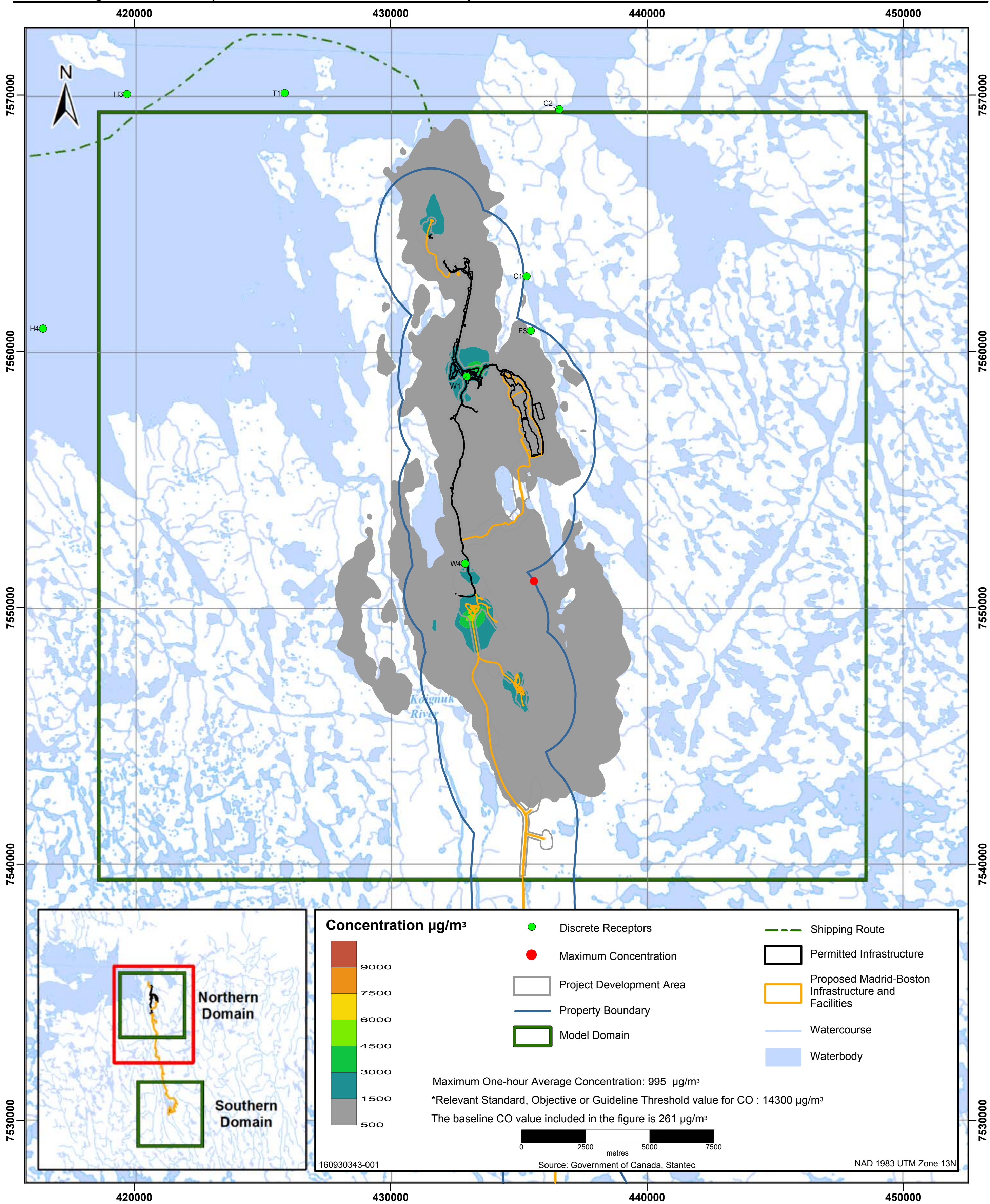


Figure E-9
Maximum Predicted 24-hour Average TSP Ground-level Concentrations (µg/m³)
Construction, Northern Domain (Madrid North in Reference Location), the Madrid-Boston Project + Existing Conditions (includes Baseline Conditions)

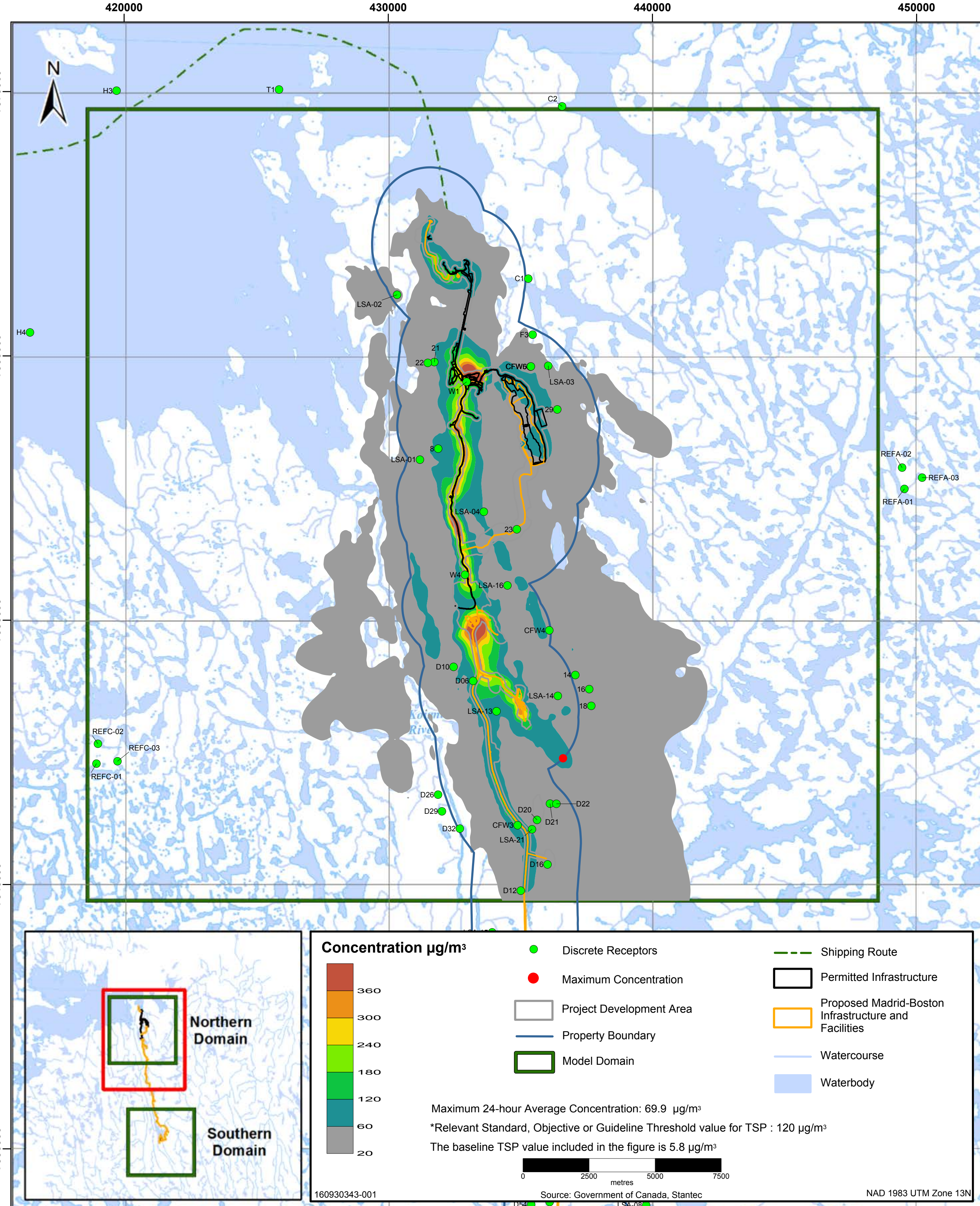


Figure E-10
Maximum Predicted Annual Average TSP Ground-level Concentrations (µg/m³)
Construction, Northern Domain (Madrid North in Reference Location), the Madrid-Boston Project + Existing Conditions (includes Baseline Conditions)

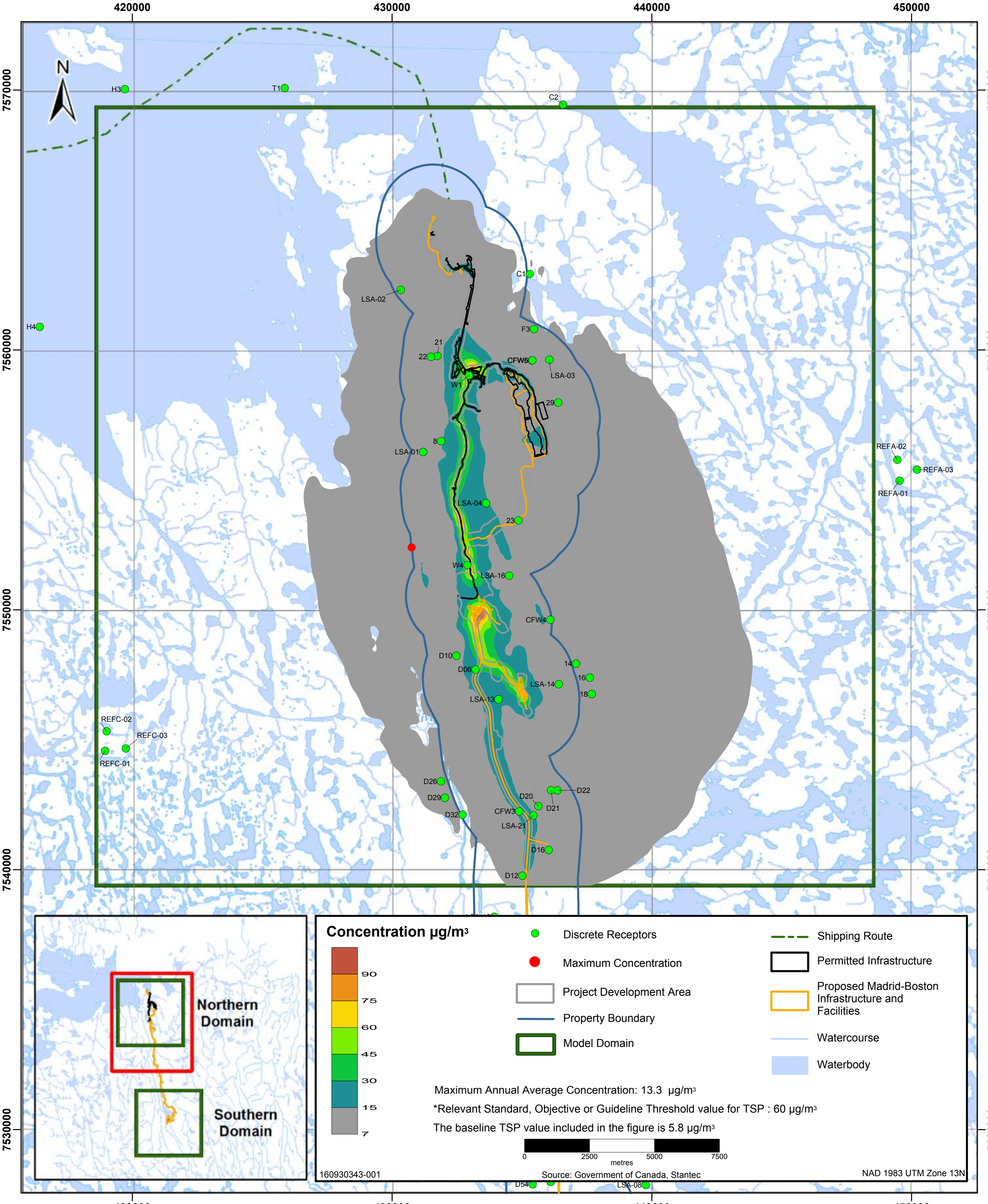


Figure E-11
Maximum Predicted 24-hour Average PM_{10} Ground-level Concentrations (µg/m³) Construction, Northern Domain (Madrid North in Reference Location), the Madrid-Boston Project + Existing Conditions (includes Baseline Conditions)

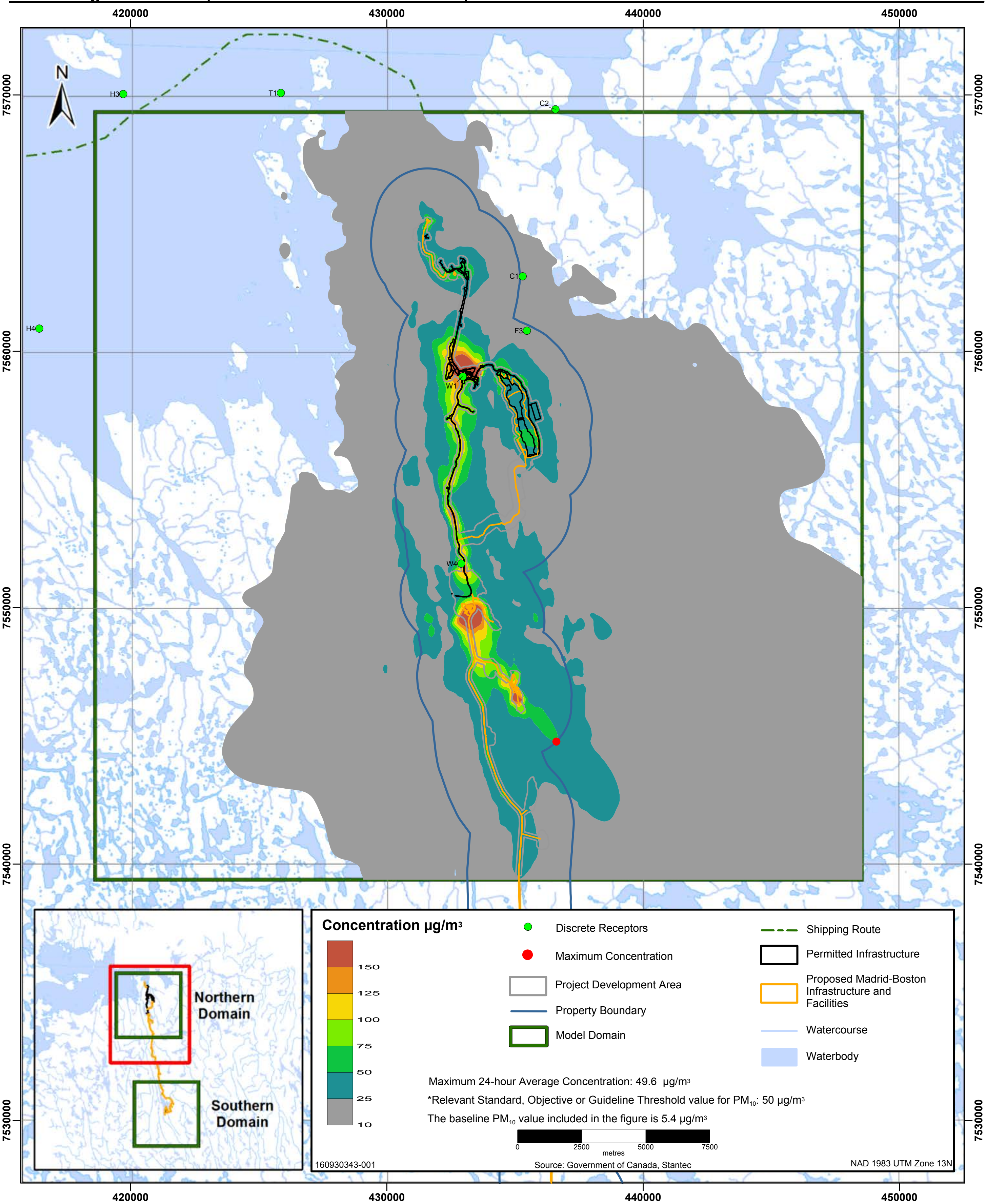


Figure E-12
Predicted 98th Percentile 24-hour Average $PM_{2.5}$ Ground-level Concentrations (µg/m³) Construction, Northern Domain (Madrid North in Reference Location), the Madrid-Boston Project + Existing Conditions (includes Baseline Conditions)

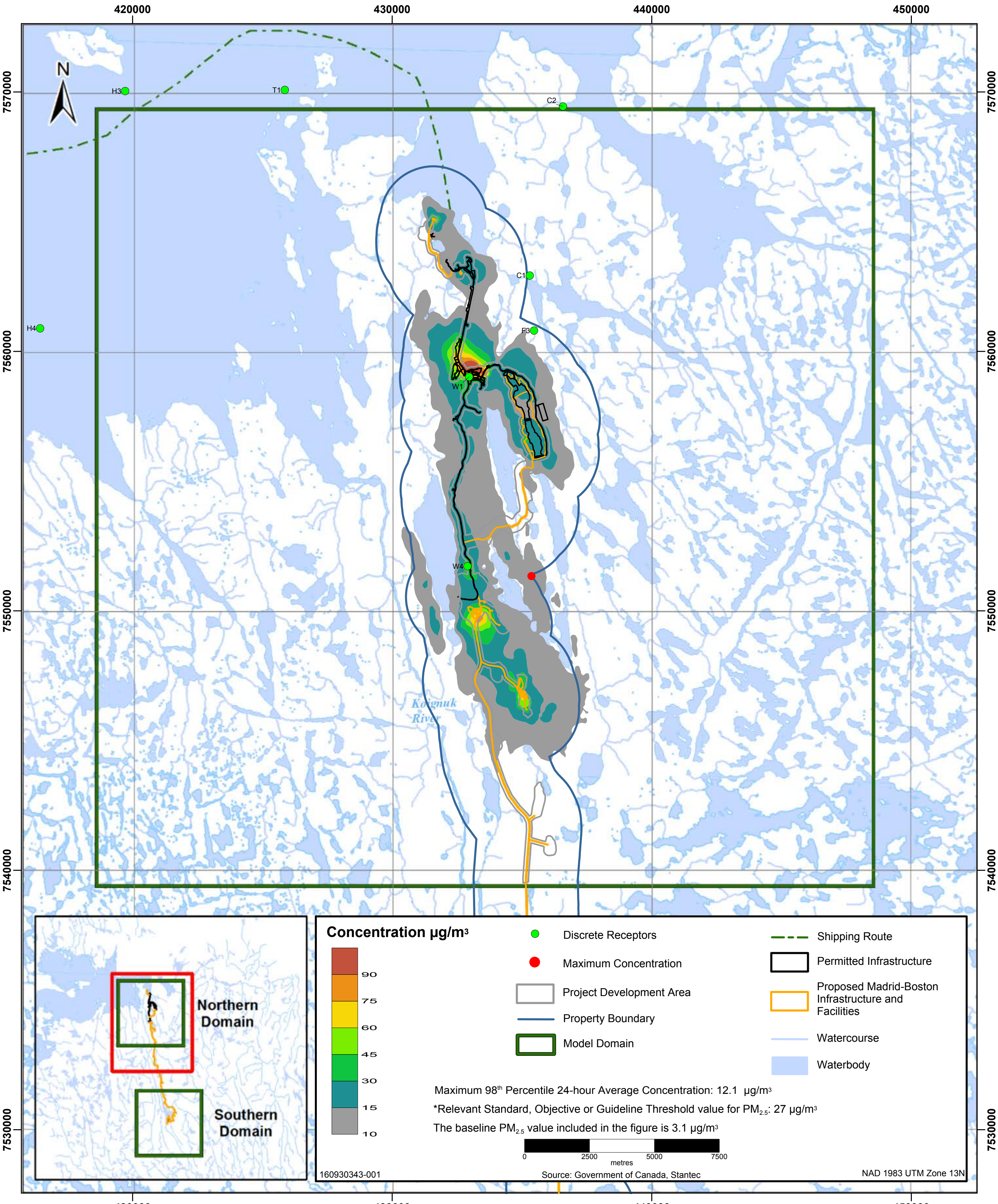


Figure E-13

Maximum Predicted Annual Average $PM_{2.5}$ Ground-level Concentrations (μg/m³) Construction, Northern Domain (Madrid North in Reference Location), the Madrid-Boston Project + Existing Conditions (includes Baseline Conditions)

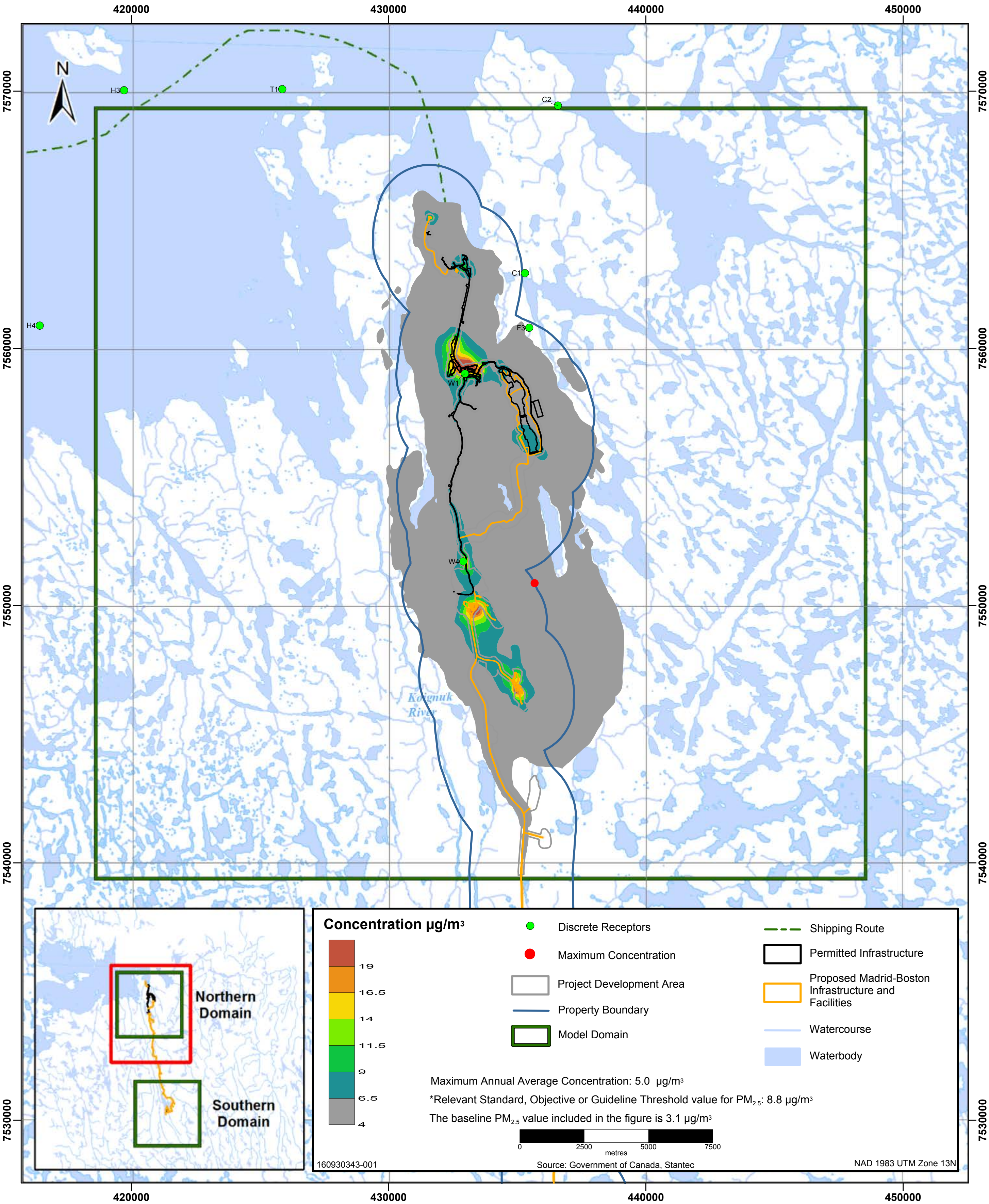
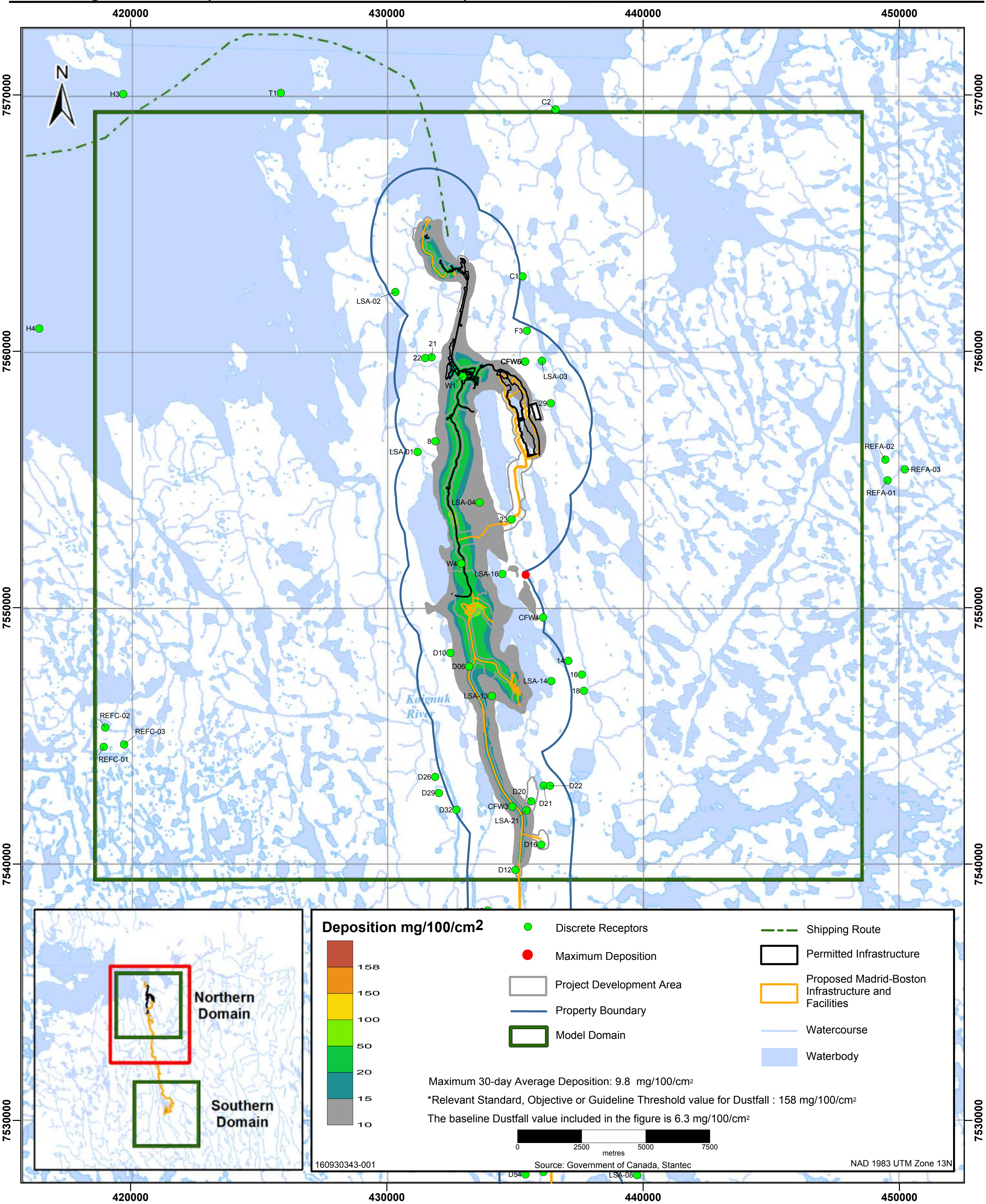


Figure E-14
Maximum Predicted 30-day Average Dustfall Ground-level Deposition (mg/100/cm2)
Construction, Northern Domain (Madrid North in Reference Location), the Madrid-Boston Project
+ Existing Conditions (includes Baseline Conditions)



APPENDIX F

Concentration Contour Plots for the Northern Domain (Madrid North in Alternative Location), the Madrid-Boston Project + Existing Conditions (includes Baseline Conditions), Construction

Figure F-1

Predicted 99th Percentile Daily Maximum SO_2 Ground-level Concentrations (µg/m³)
Construction, Northern Domain (Madrid North in Alternative Location), the Madrid-Boston Project + Existing Conditions (includes Baseline Conditions)

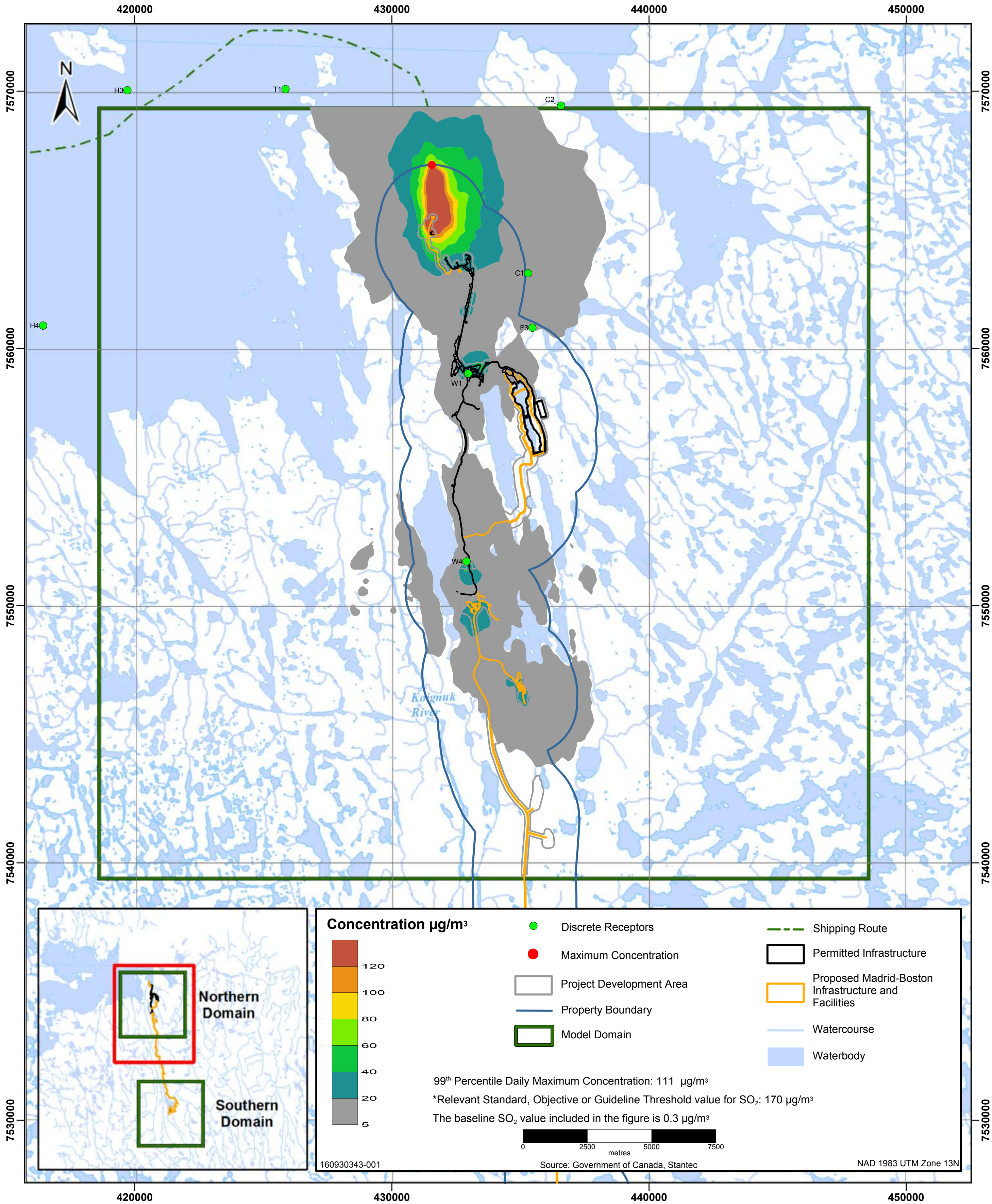


Figure F-2

Maximum Predicted 24-hour Average SO_2 Ground-level Concentrations (µg/m³)
Construction, Northern Domain (Madrid North in Alternative Location), the Madrid-Boston Project + Existing Conditions (includes Baseline Conditions)

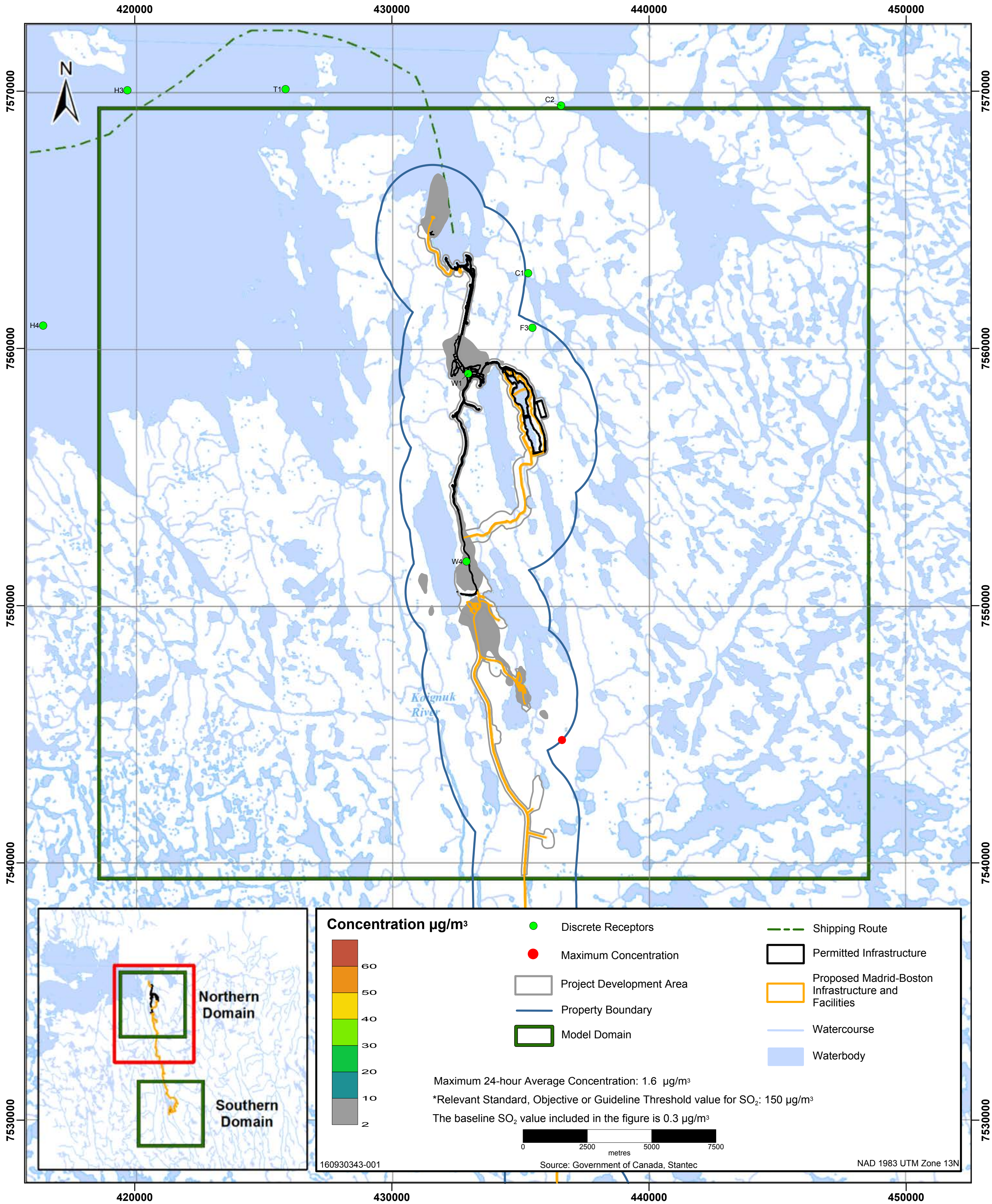


Figure F-3
Maximum Predicted Annual Average SO_2 Ground-level Concentrations (μg/m³)
Construction, Northern Domain (Madrid North in Alternative Location), the Madrid-Boston Project + Existing Conditions (includes Baseline Conditions)

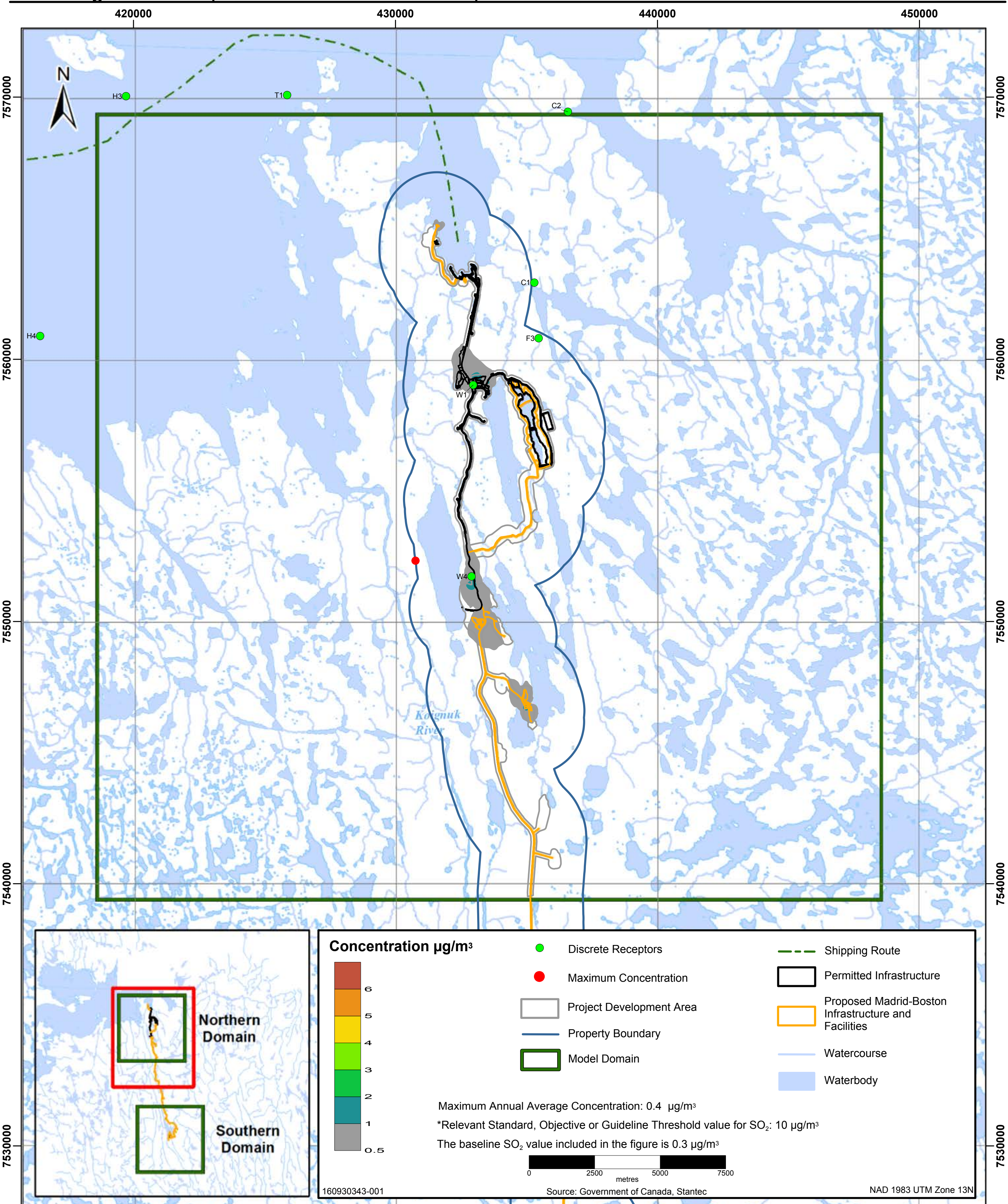


Figure F-4

Predicted 98th Percentile Daily Maximum NO_2 Ground-level Concentrations (µg/m³) Construction, Northern Domain (Madrid North in Alternative Location), the Madrid-Boston Project + Existing Conditions (includes Baseline Conditions)

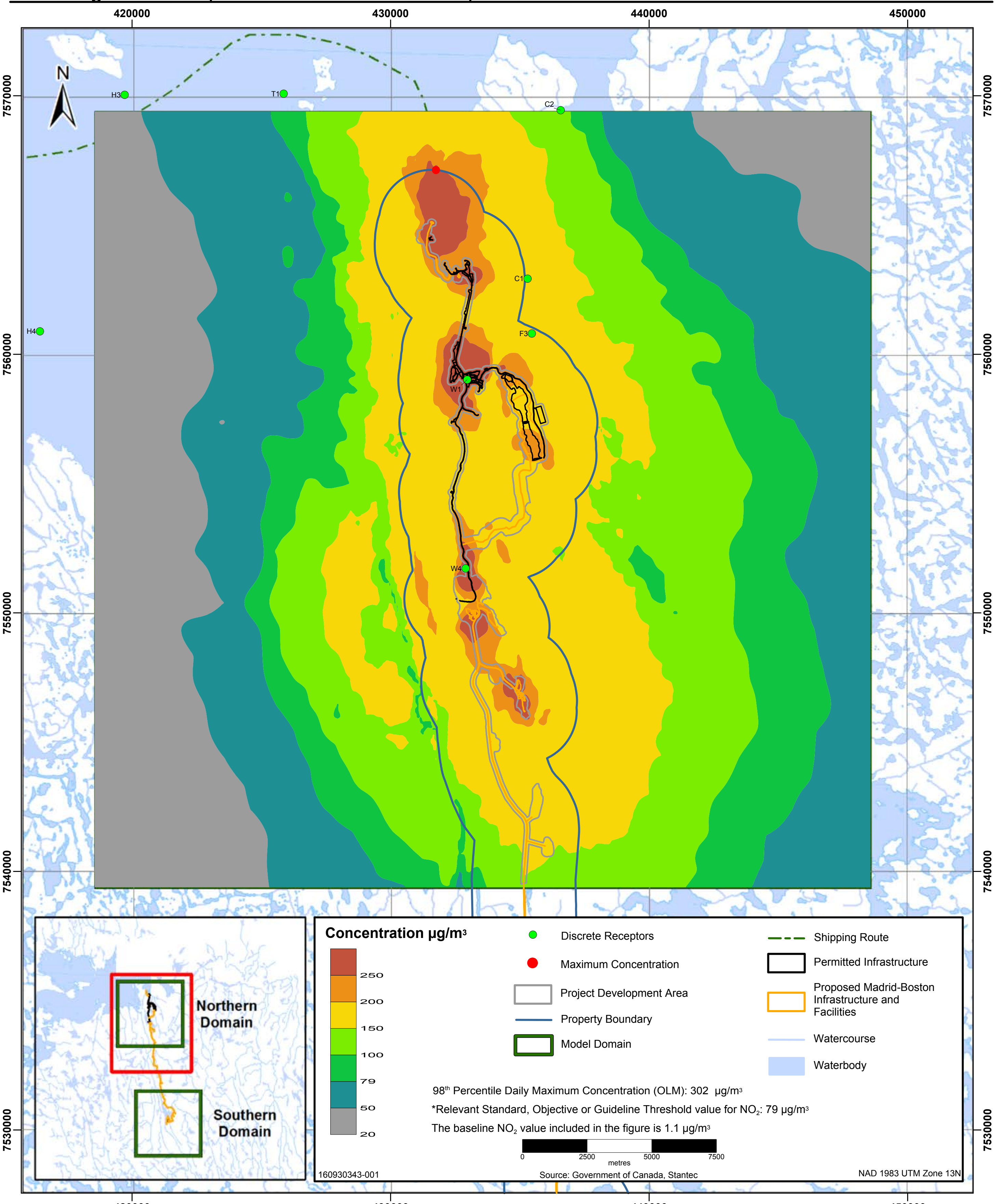


Figure F-5

Frequency of 98th Percentile Daily Maximum NO_2 Concentration Above the Ambient Criteria* Construction, Northern Domain (Madrid North in Alternative Location), the Madrid-Boston Project + Existing Conditions (includes Baseline Conditions)

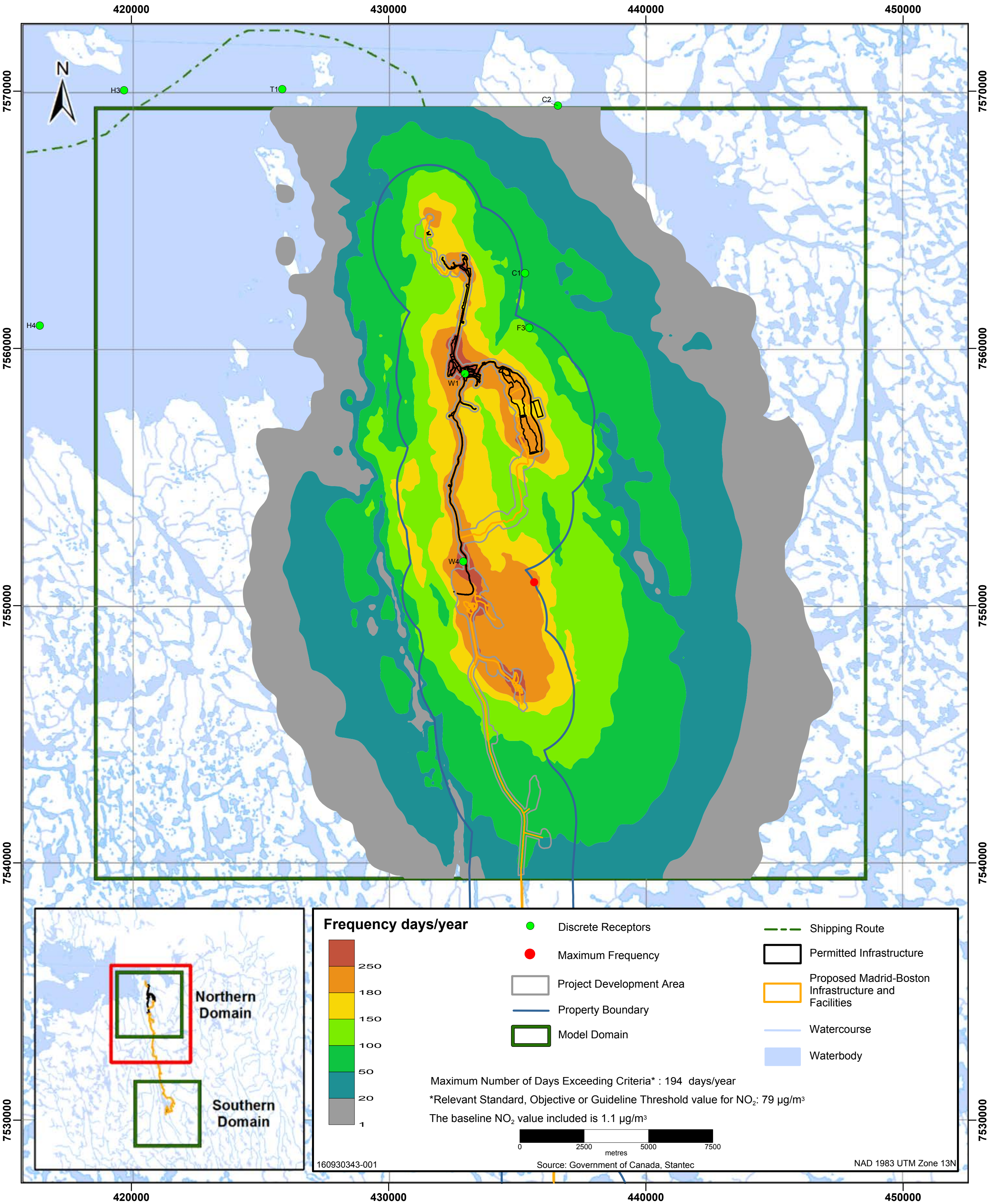


Figure F-6
Maximum Predicted 24-hour Average NO_2 Ground-level Concentrations (µg/m³)
Construction, Northern Domain (Madrid North in Alternative Location), the Madrid-Boston Project + Existing Conditions (includes Baseline Conditions)

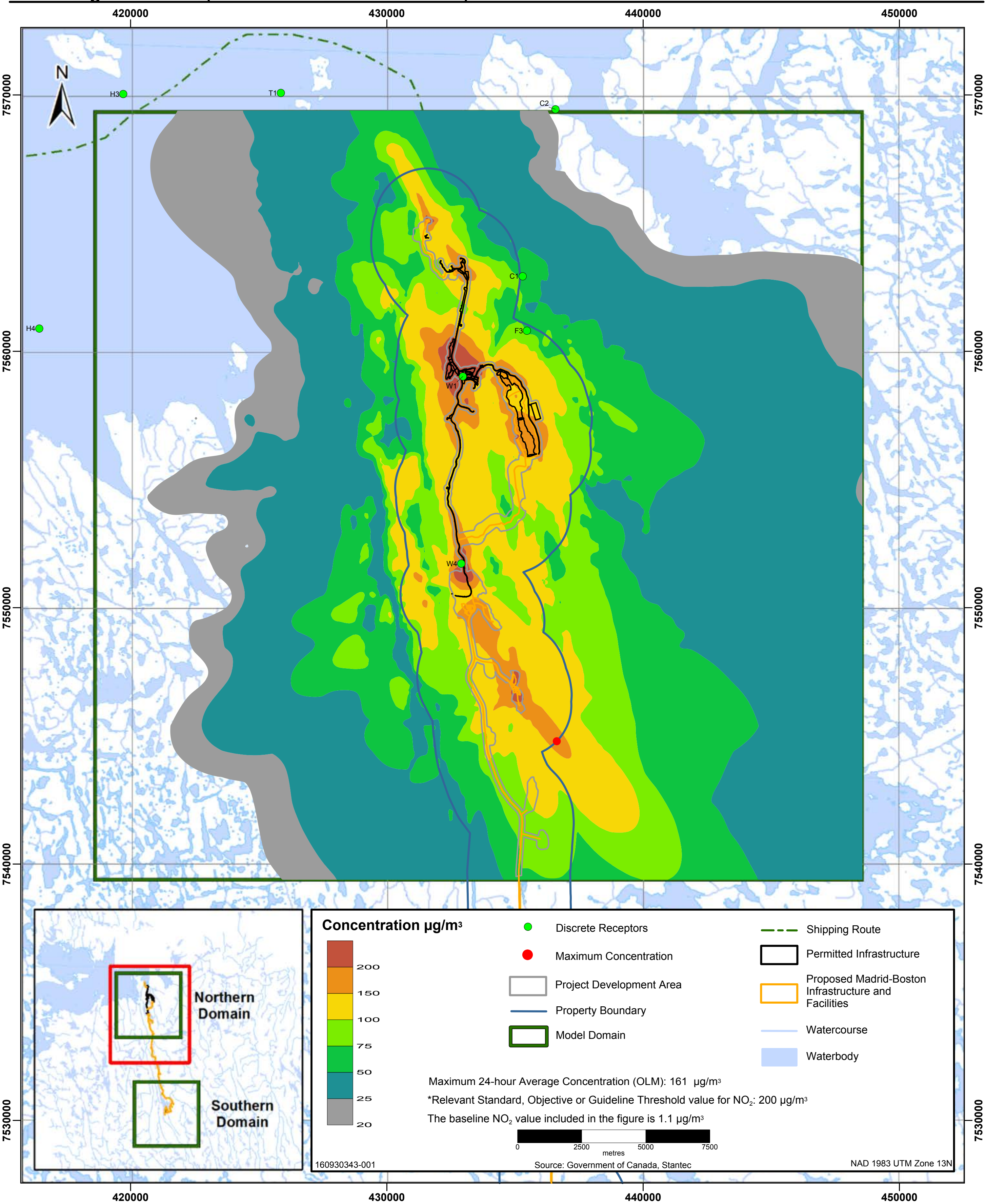


Figure F-7
Maximum Predicted Annual Average NO_2 Ground-level Concentrations (µg/m³)
Construction, Northern Domain (Madrid North in Alternative Location), the Madrid-Boston Project + Existing Conditions (includes Baseline Conditions)

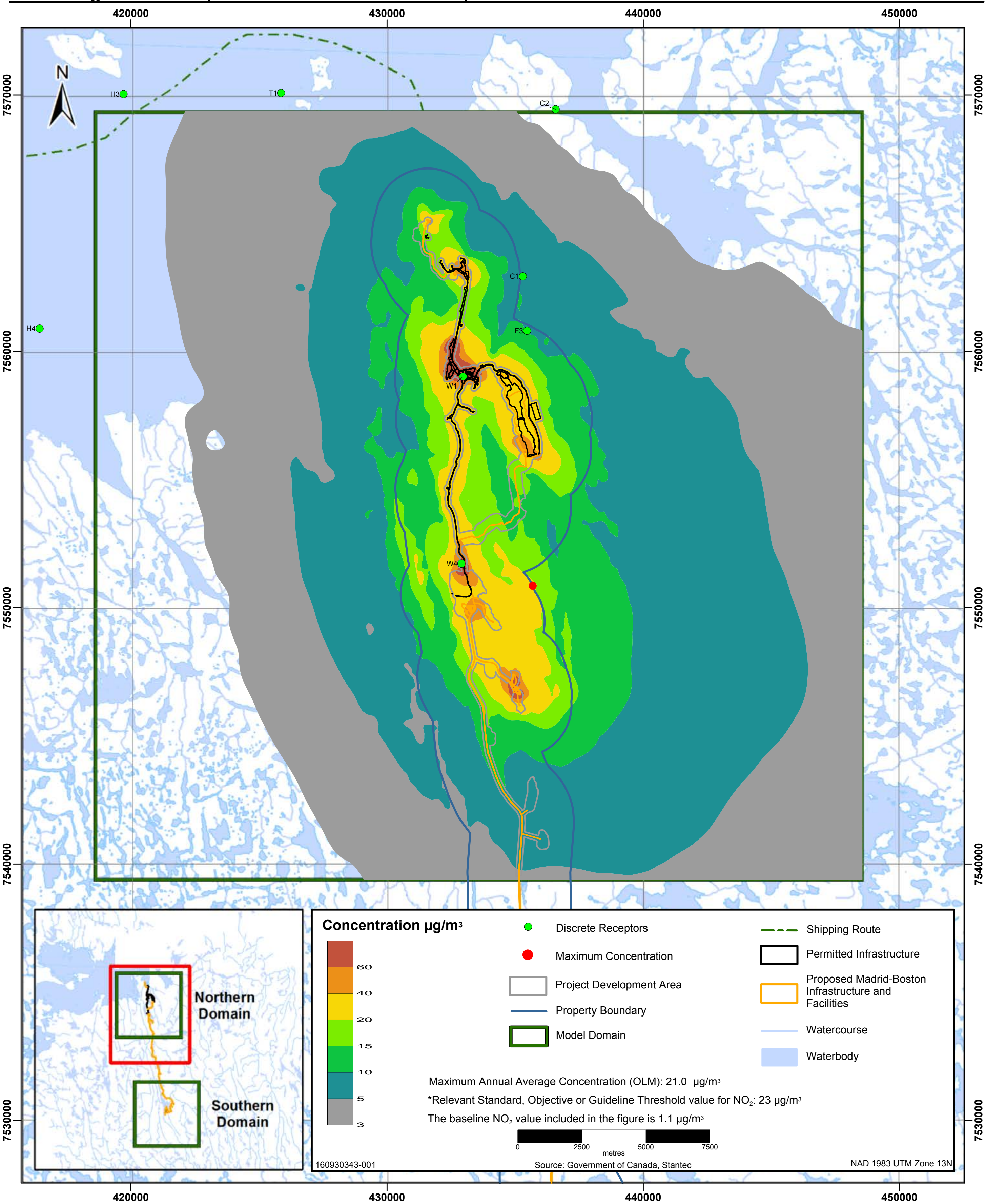


Figure F-8
Maximum Predicted One-hour Average CO Ground-level Concentrations (µg/m³)
Construction, Northern Domain (Madrid North in Alternative Location), the Madrid-Boston Project + Existing Conditions (includes Baseline Conditions)

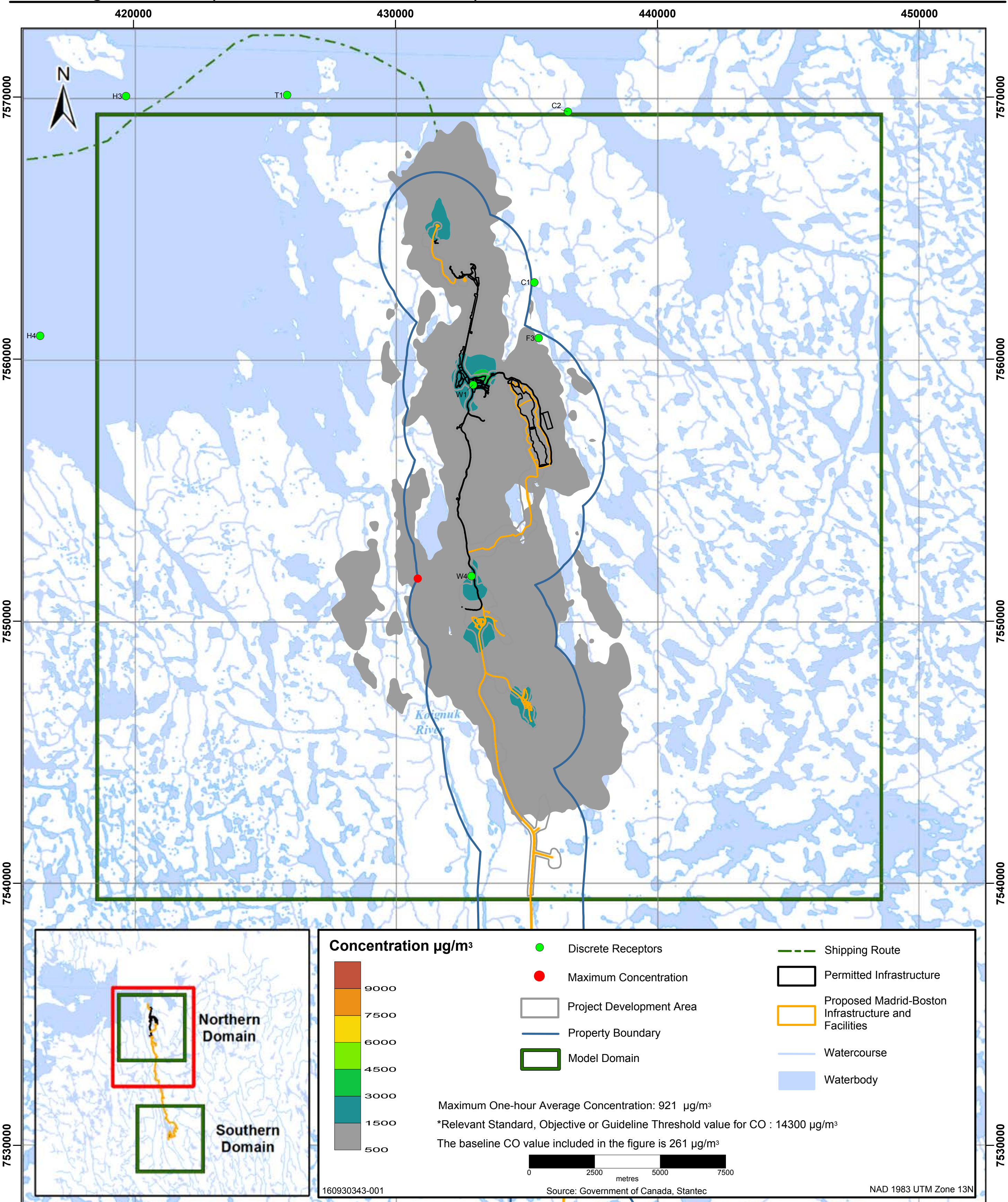


Figure F-9
Maximum Predicted 24-hour Average TSP Ground-level Concentrations (µg/m³)
Construction, Northern Domain (Madrid North in Alternative Location), the Madrid-Boston Project + Existing Conditions (includes Baseline Conditions)

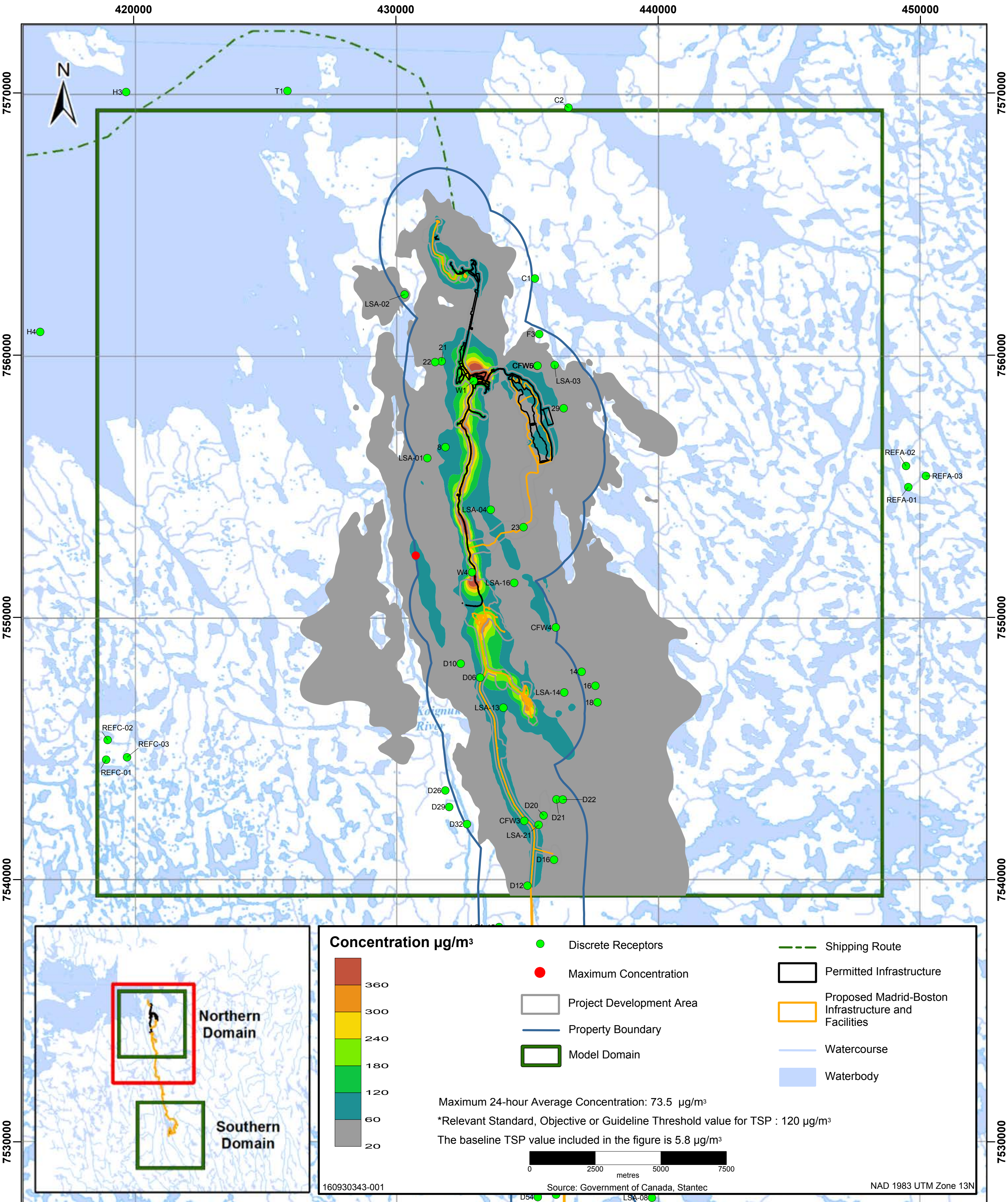


Figure F-10
Maximum Predicted Annual Average TSP Ground-level Concentrations (µg/m³) Construction, Northern Domain (Madrid North in Alternative Location), the Madrid-Boston Project + Existing Conditions (includes Baseline Conditions)

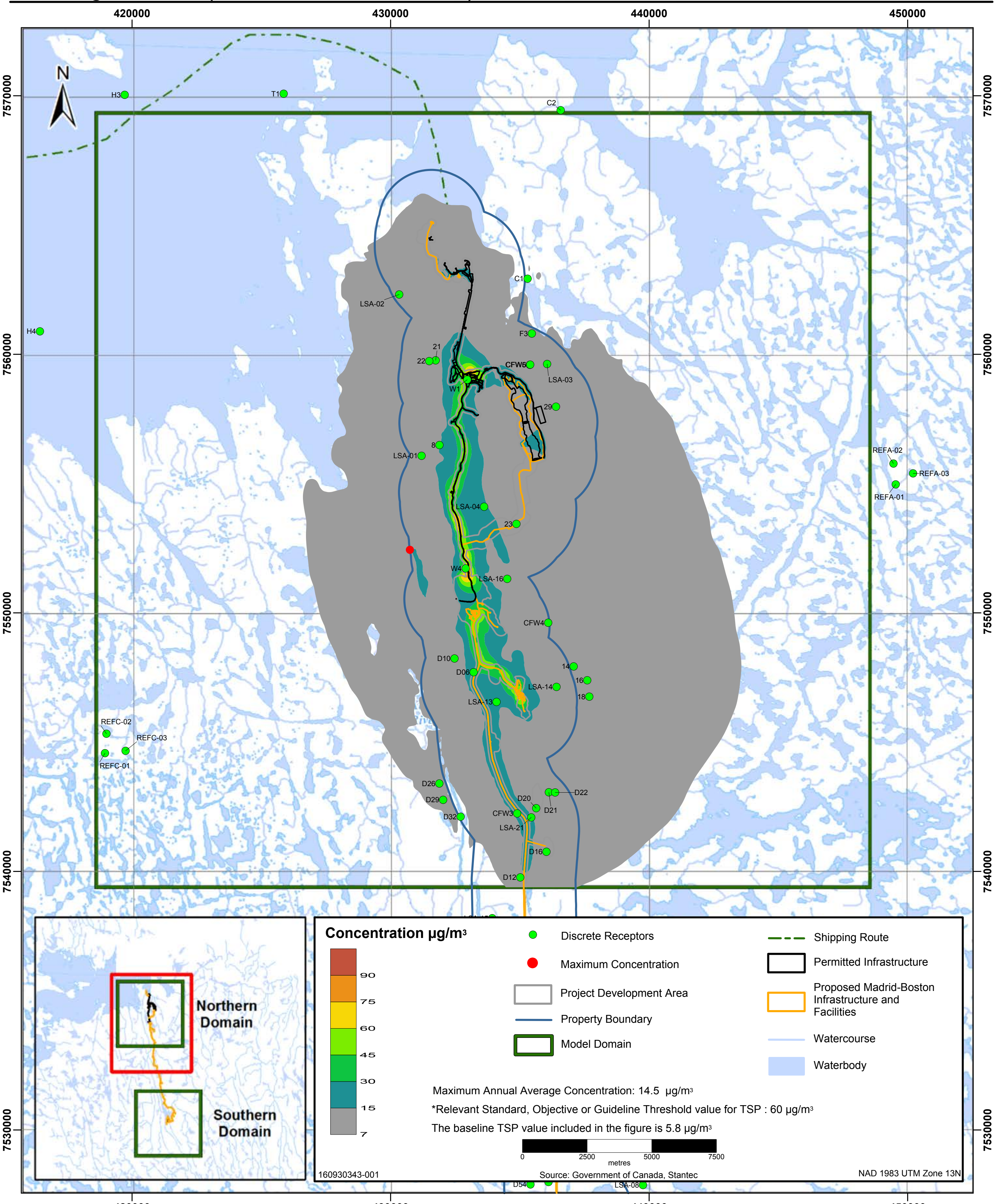


Figure F-11
Maximum Predicted 24-hour Average PM_{10} Ground-level Concentrations (µg/m³)
Construction, Northern Domain (Madrid North in Alternative Location), the Madrid-Boston Project + Existing Conditions (includes Baseline Conditions)

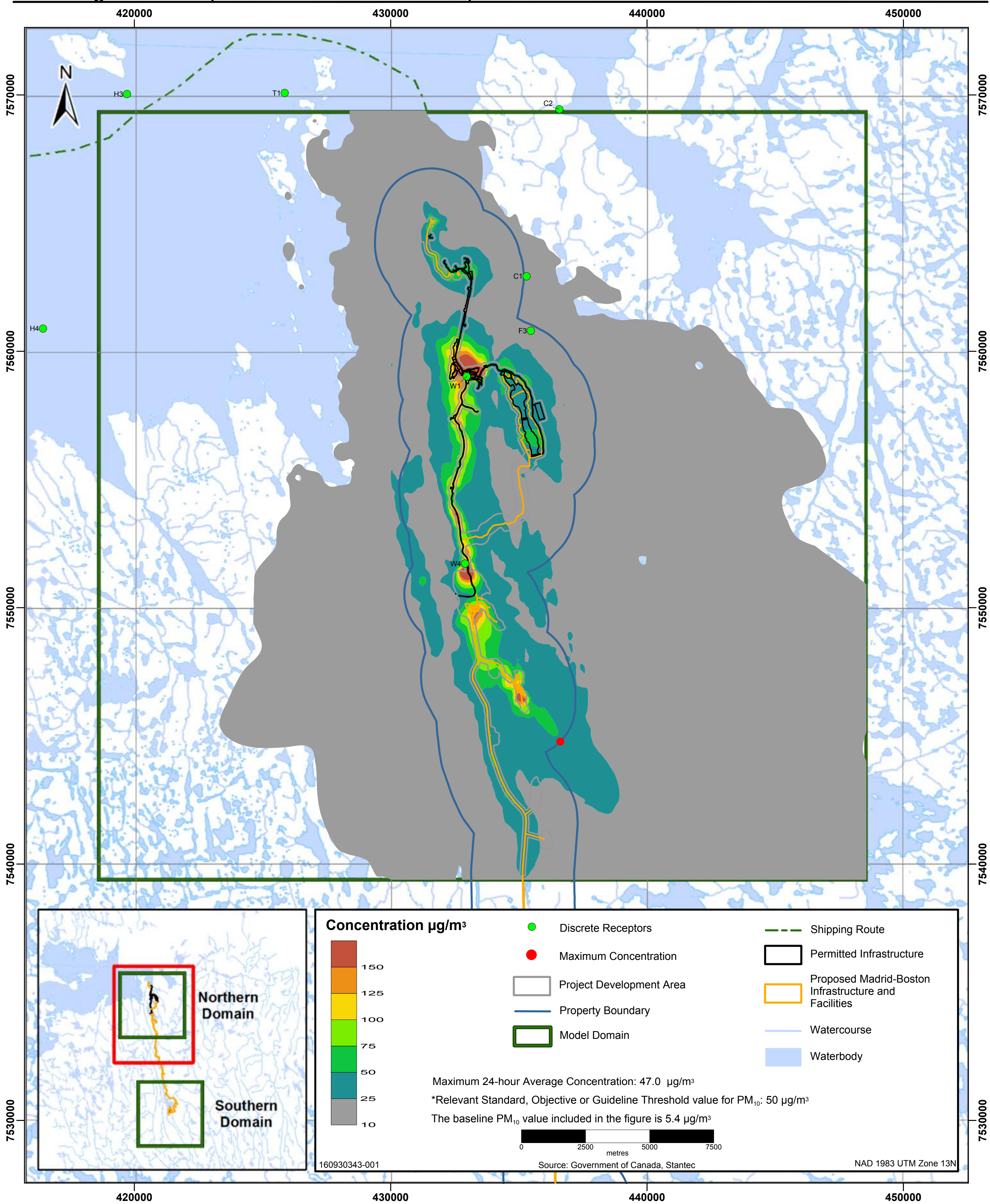


Figure F-12

Predicted 98th Percentile 24-hour Average $PM_{2.5}$ Ground-level Concentrations (µg/m³) Construction, Northern Domain (Madrid North in Alternative Location), the Madrid-Boston Project + Existing Conditions (includes Baseline Conditions)

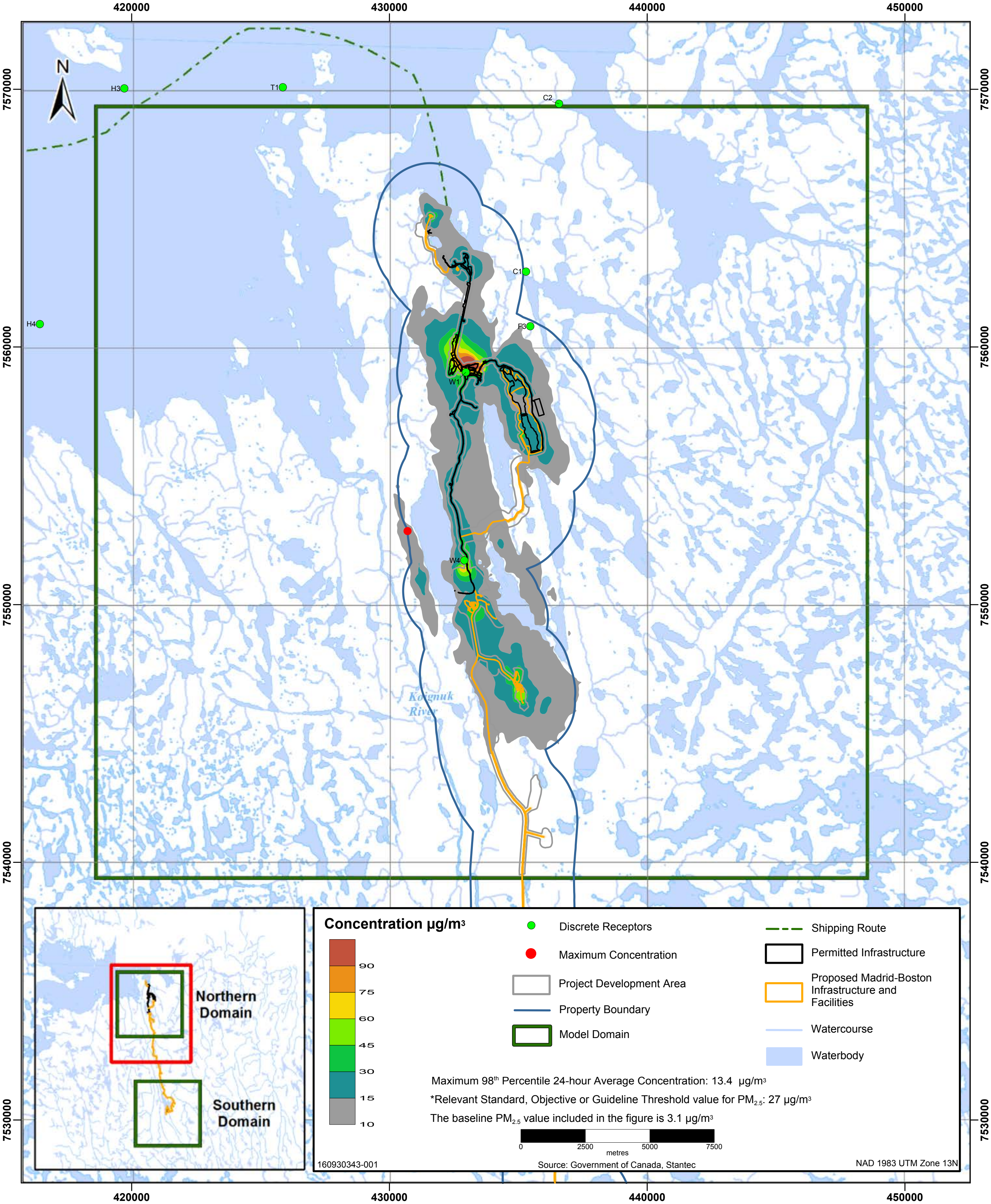


Figure F-13
Maximum Predicted Annual Average $PM_{2.5}$ Ground-level Concentrations (µg/m³) Construction, Northern Domain (Madrid North in Alternative Location), the Madrid-Boston Project + Existing Conditions (includes Baseline Conditions)

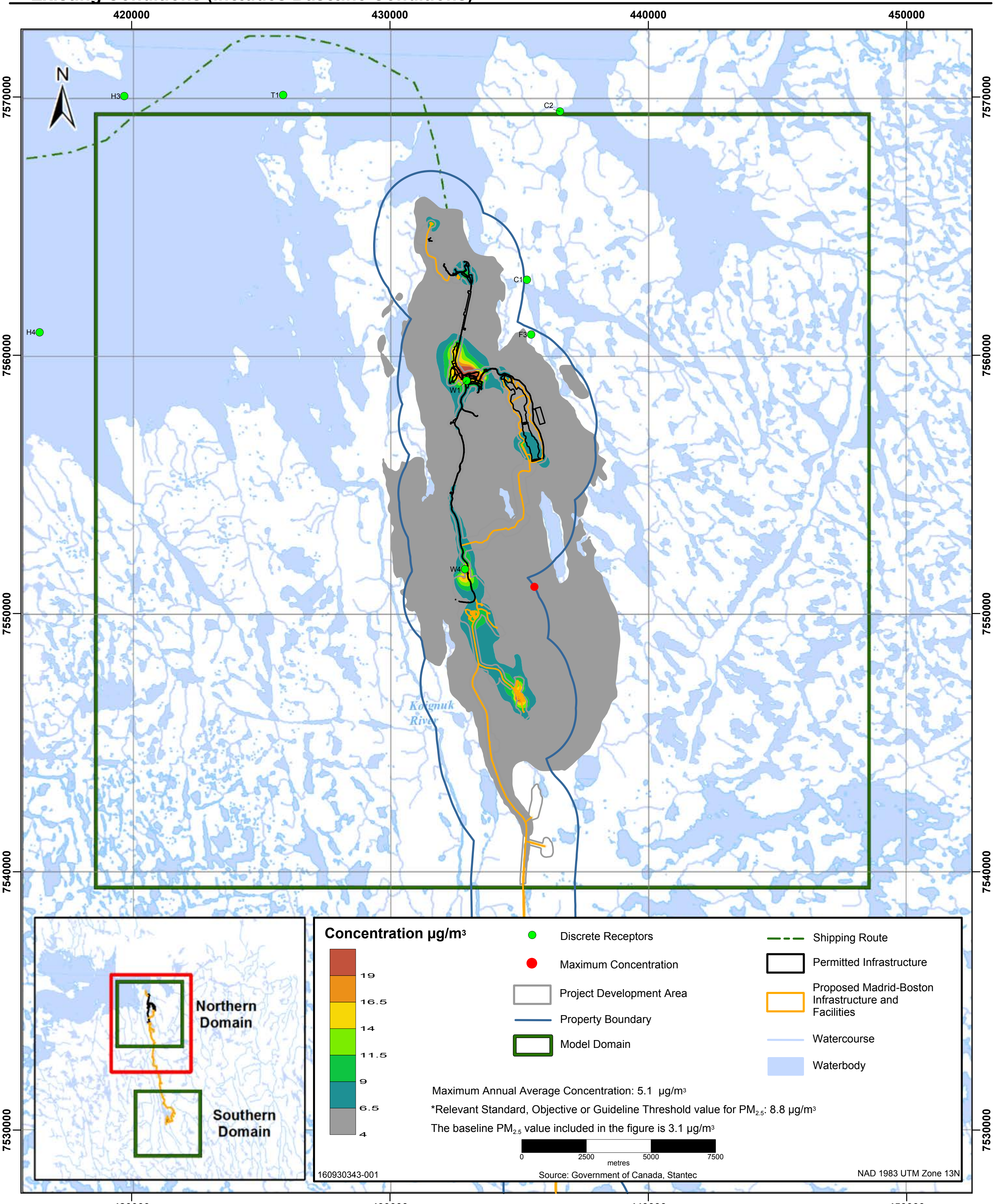
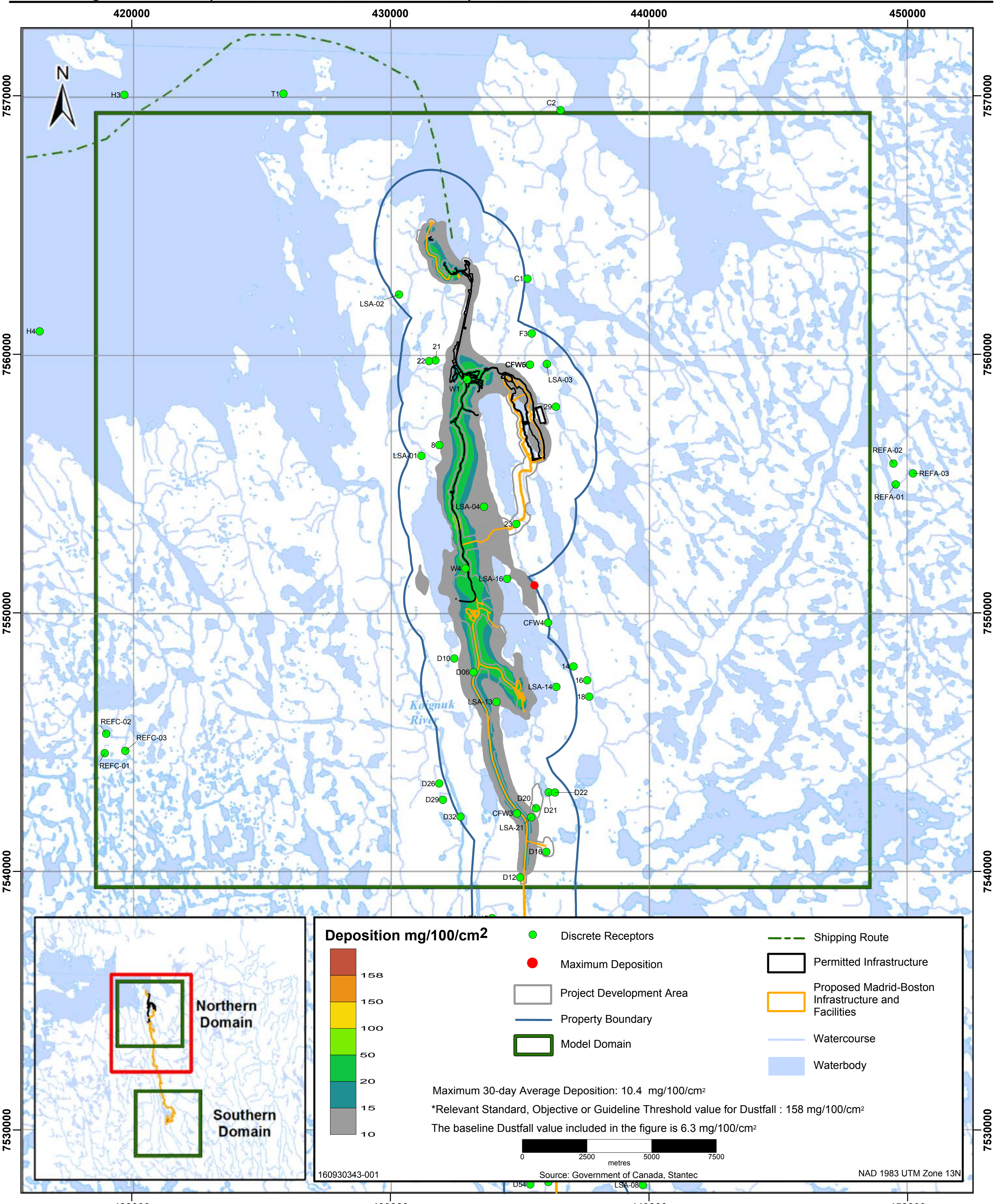


Figure F-14
Maximum Predicted 30-day Average Dustfall Ground-level Deposition (mg/100/cm²)
Construction, Northern Domain (Madrid North in Alternative Location), the Madrid-Boston Project + Existing Conditions (includes Baseline Conditions)



APPENDIX G Concentration Contour Plots for the Southern Domain, the Madrid-Boston Project (includes Baseline Conditions), Construction

Figure G-1
Predicted 99th Percentile Daily Maximum SO_2 Ground-level Concentrations (µg/m³) Construction, Southern Domain, the Madrid-Boston Project Only (includes Baseline Conditions)

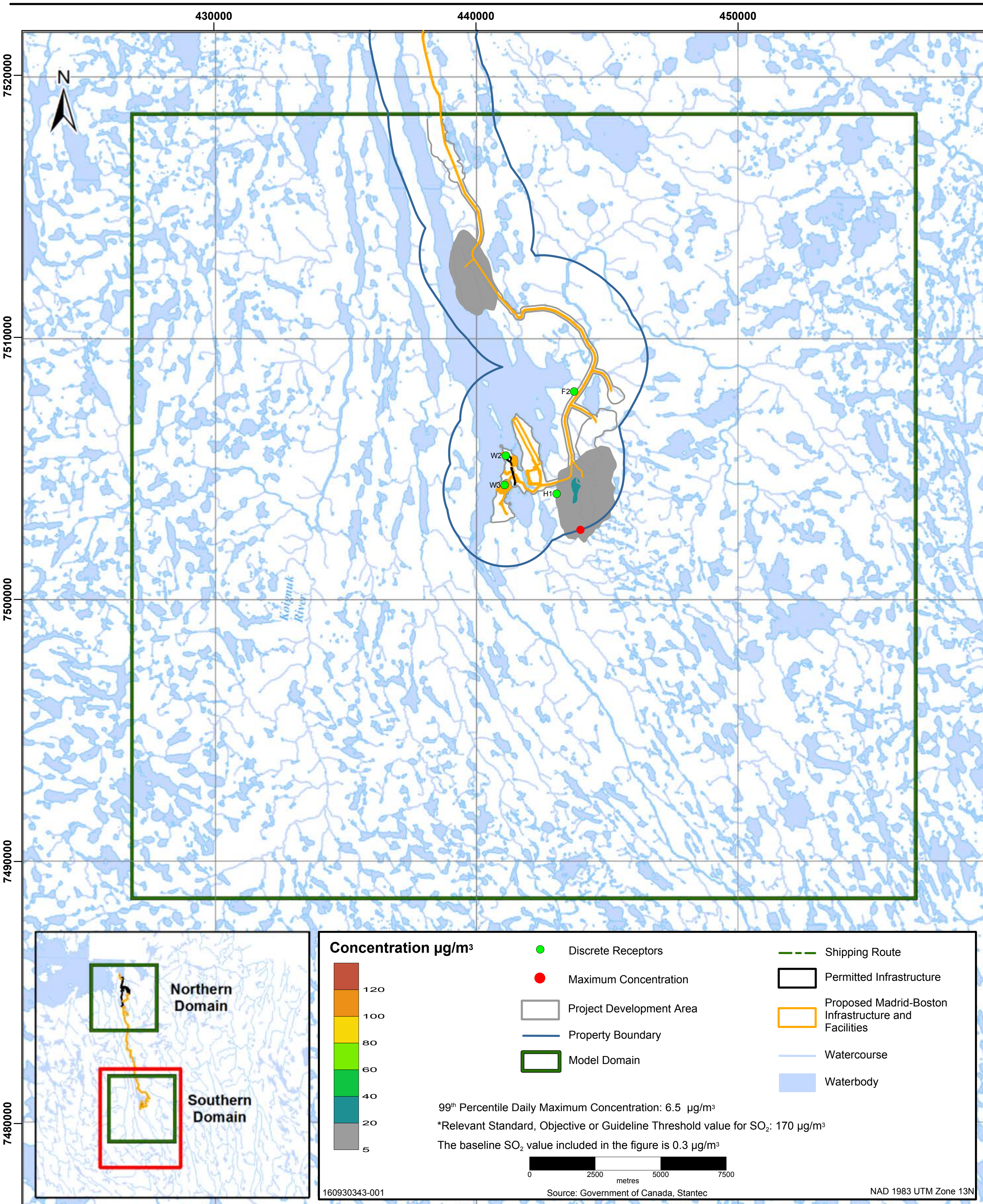


Figure G-2
Maximum Predicted 24-hour Average SO_2 Ground-level Concentrations (μg/m³)
Construction, Southern Domain, the Madrid-Boston Project Only (includes Baseline Conditions)

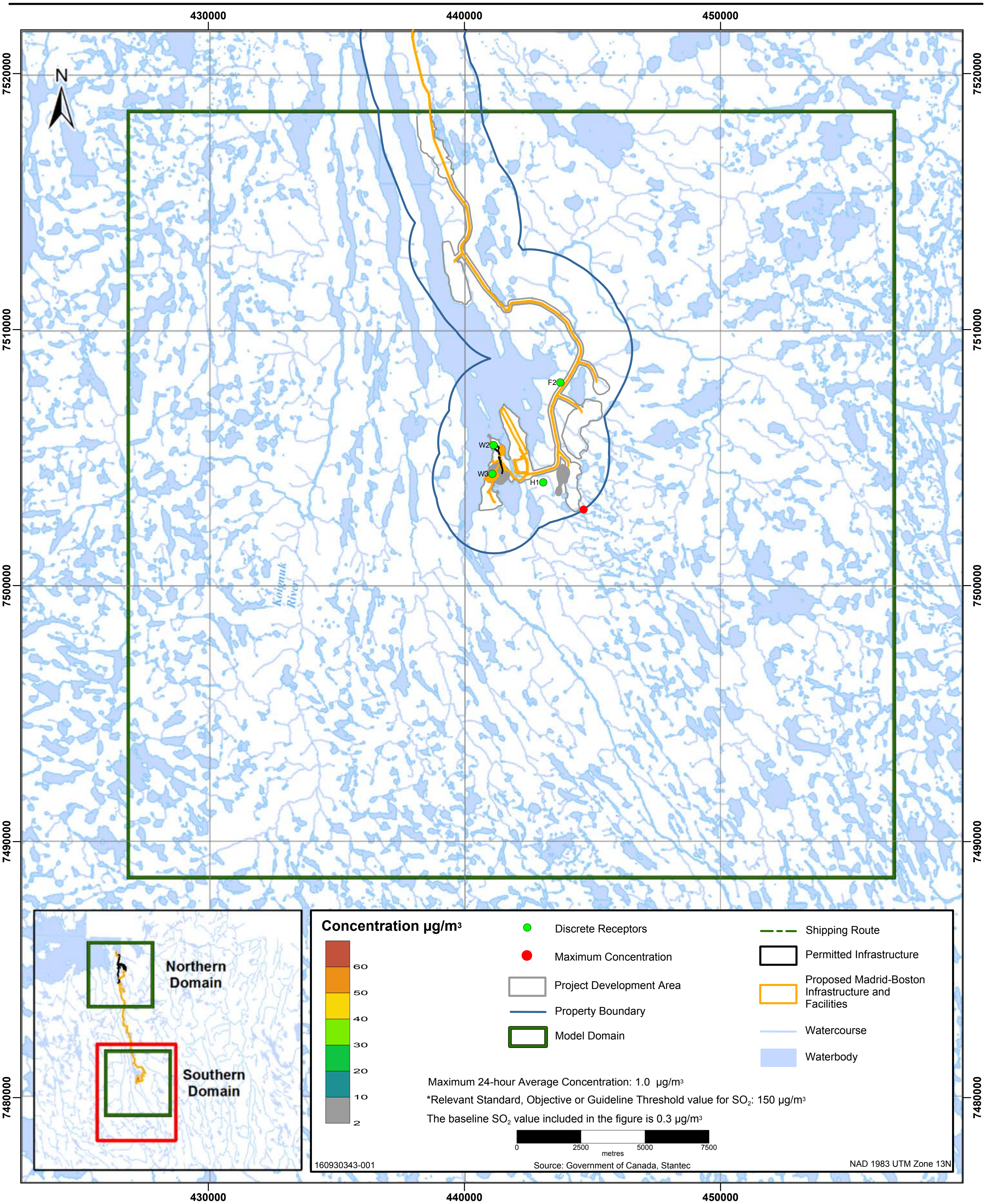


Figure G-3
Maximum Predicted Annual Average SO_2 Ground-level Concentrations (µg/m³) Construction, Southern Domain, the Madrid-Boston Project Only (includes Baseline Conditions)

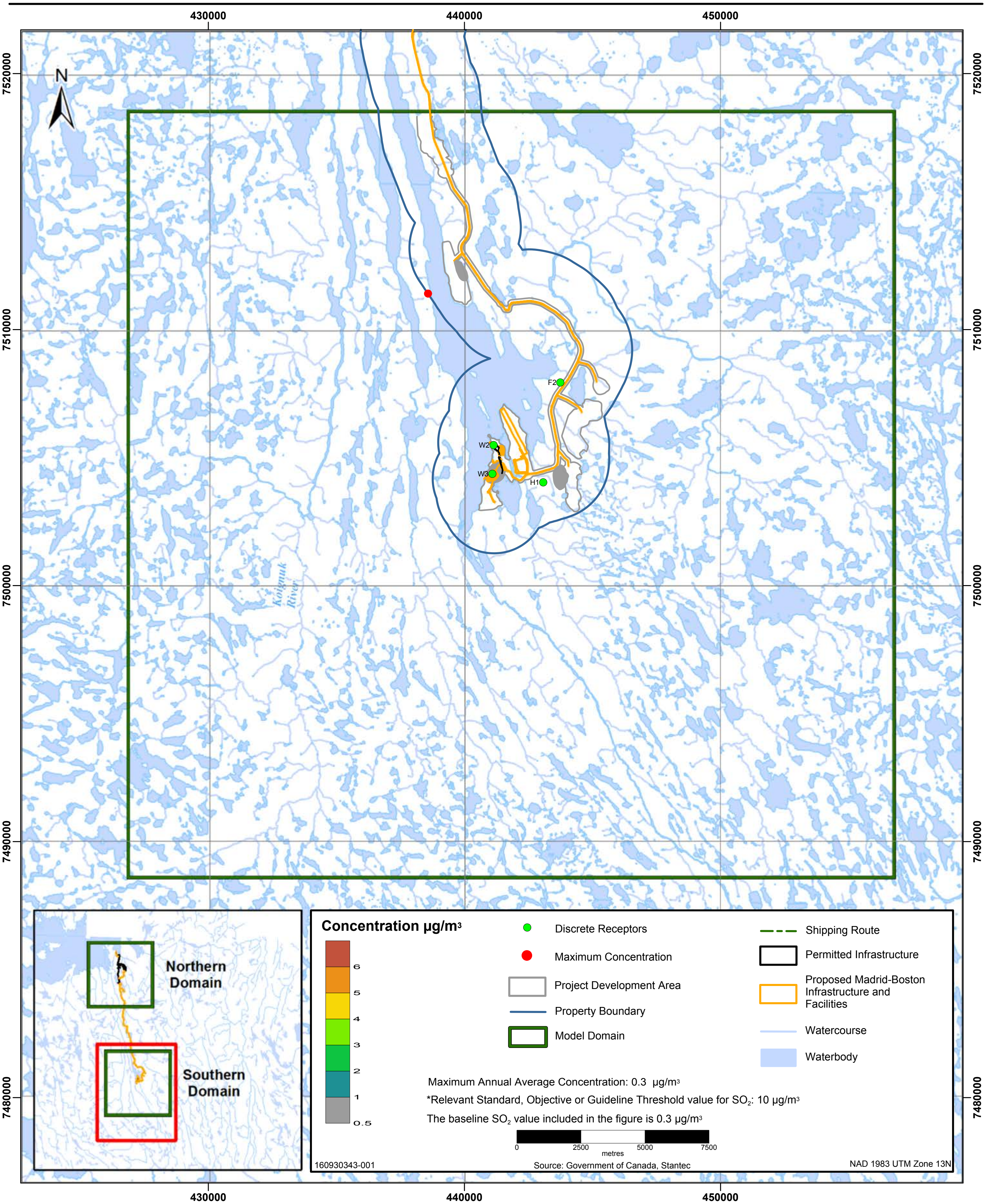


Figure G-4
Predicted 98th Percentile Daily Maximum NO_2 Ground-level Concentrations (µg/m³)
Construction, Southern Domain, the Madrid-Boston Project Only (includes Baseline Conditions)

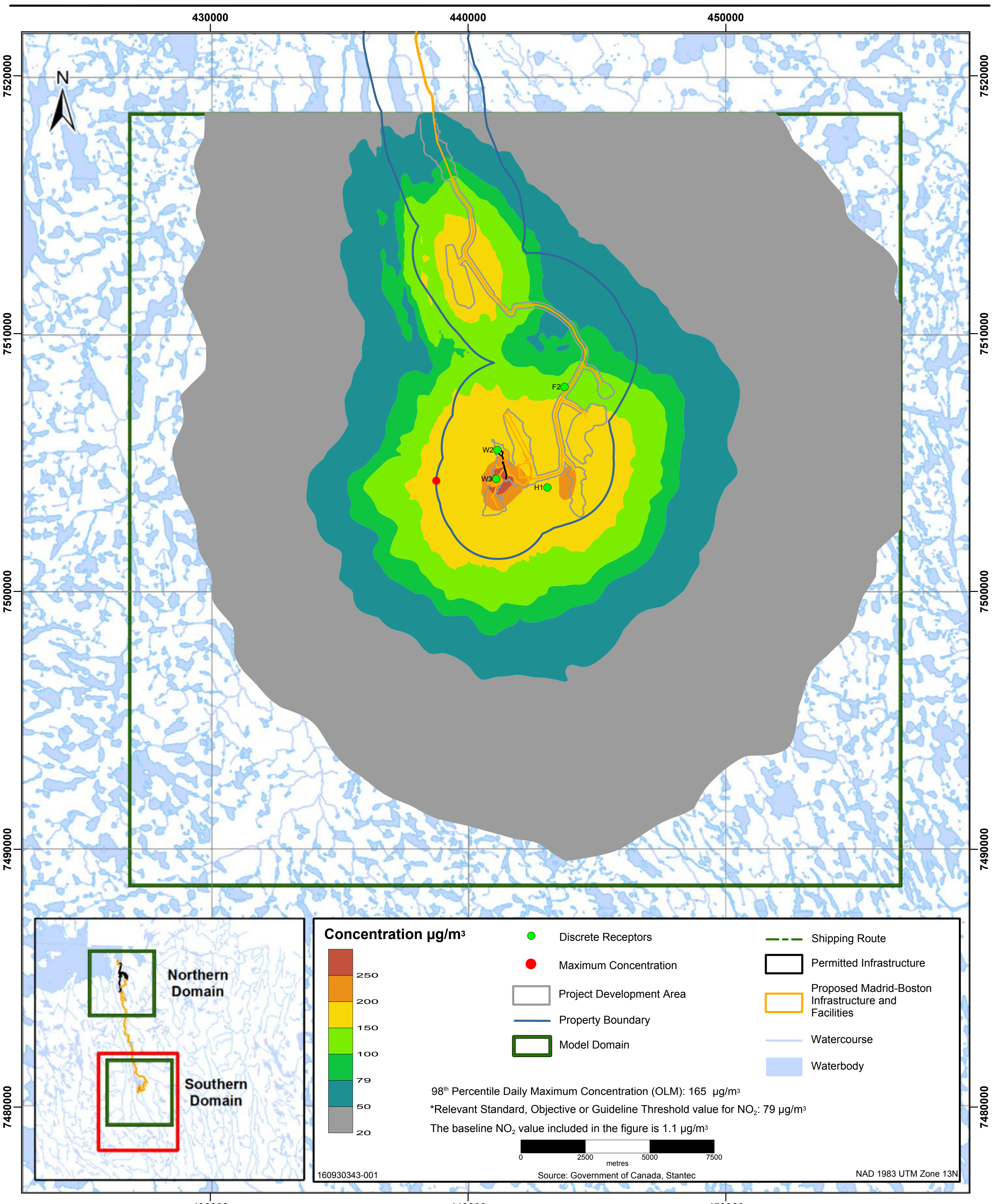


Figure G-5

Frequency of 98th Percentile Daily Maximum NO_2 Concentration Above the Ambient Criteria*
Construction, Southern Domain, the Madrid-Boston Project Only (includes Baseline Conditions)

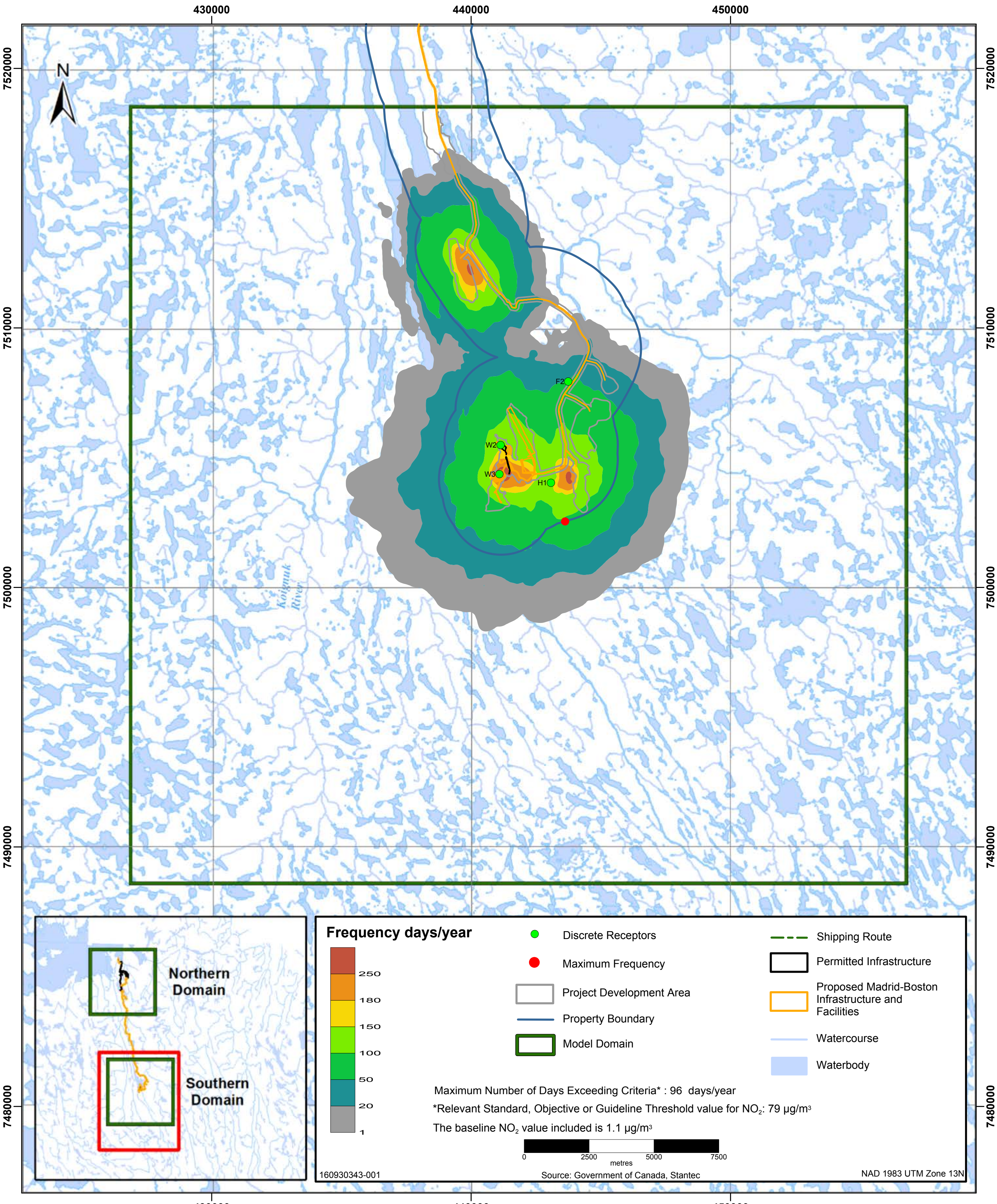


Figure G-6
Maximum Predicted 24-hour Average NO_2 Ground-level Concentrations (µg/m³)
Construction, Southern Domain, the Madrid-Boston Project Only (includes Baseline Conditions)

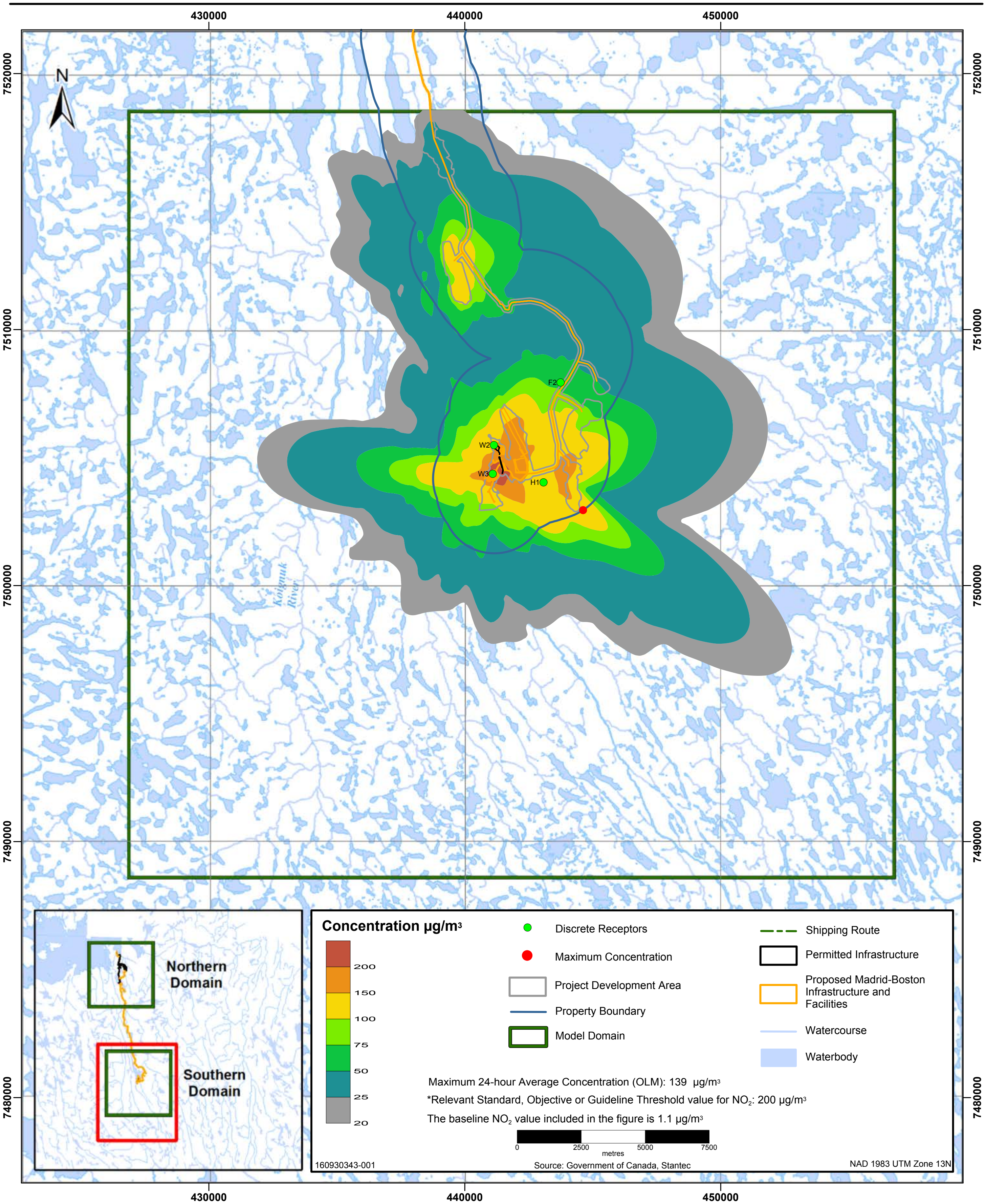


Figure G-7
Maximum Predicted Annual Average NO_2 Ground-level Concentrations (µg/m³) Construction, Southern Domain, the Madrid-Boston Project Only (includes Baseline Conditions)

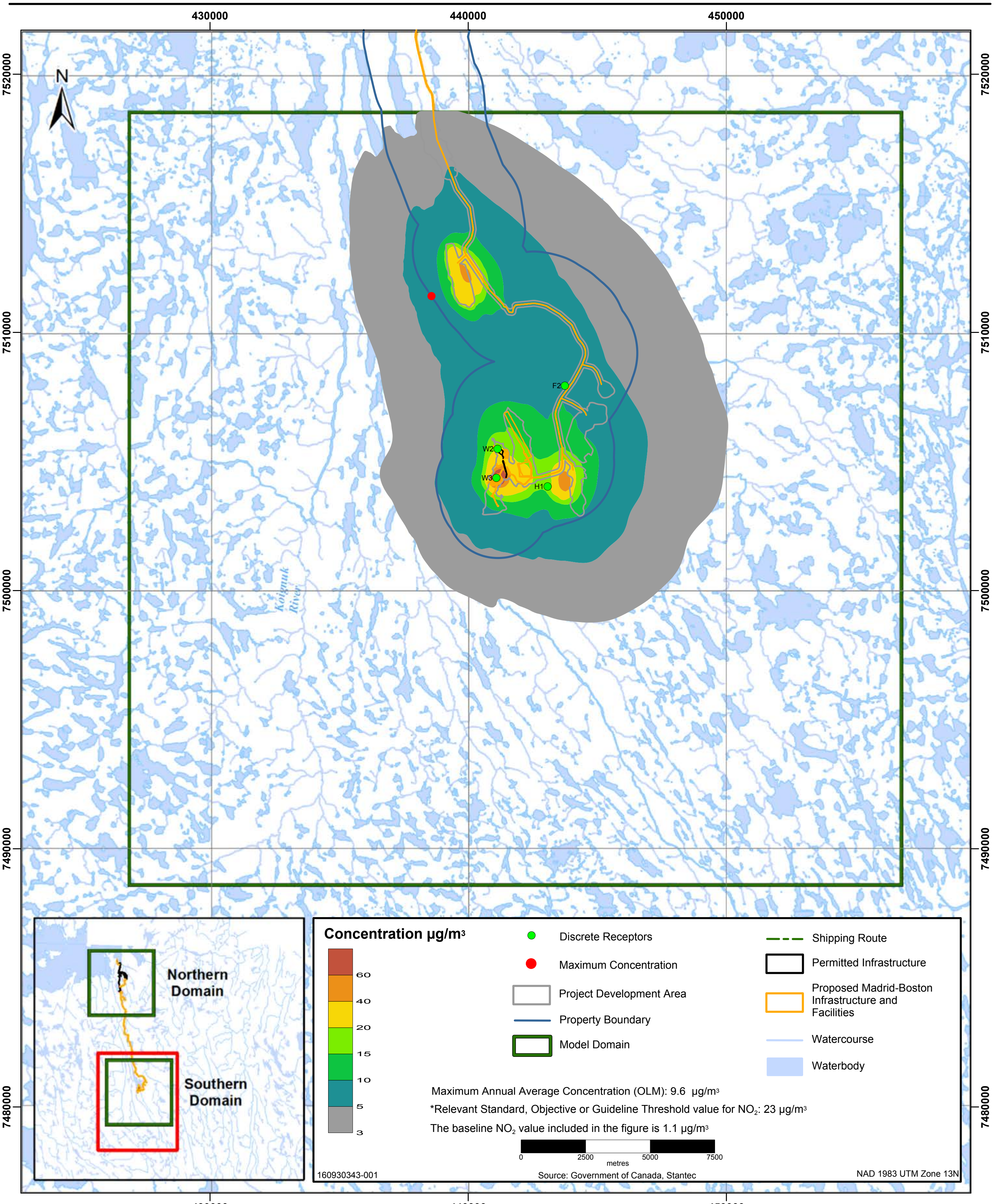


Figure G-8
Maximum Predicted One-hour Average CO Ground-level Concentrations (µg/m³)
Construction, Southern Domain, the Madrid-Boston Project Only (includes Baseline Conditions)

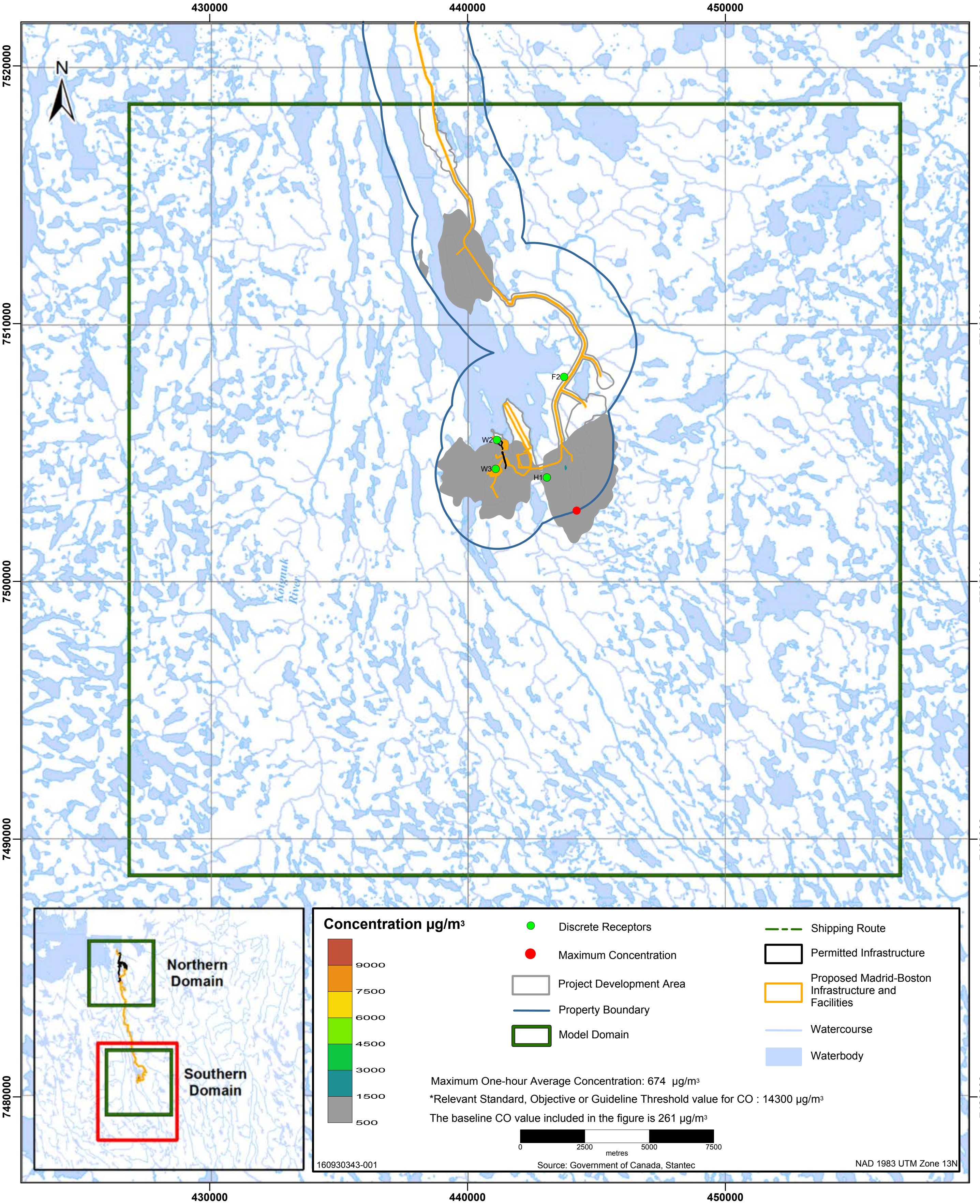


Figure G-9
Maximum Predicted 24-hour Average TSP Ground-level Concentrations (µg/m³)
Construction, Southern Domain, the Madrid-Boston Project Only (includes Baseline Conditions)

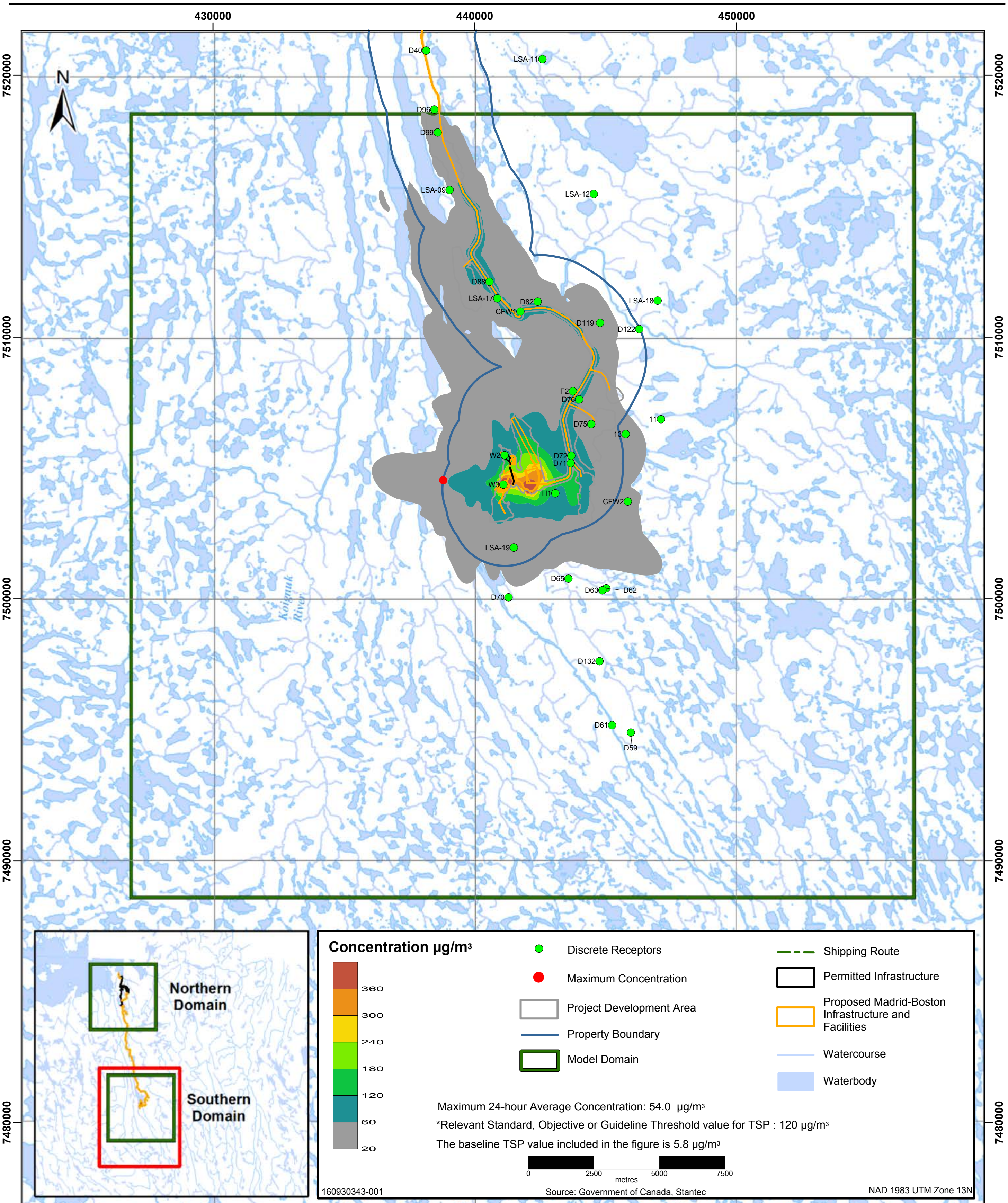


Figure G-10
Maximum Predicted Annual Average TSP Ground-level Concentrations (µg/m³) Construction, Southern Domain, the Madrid-Boston Project Only (includes Baseline Conditions)

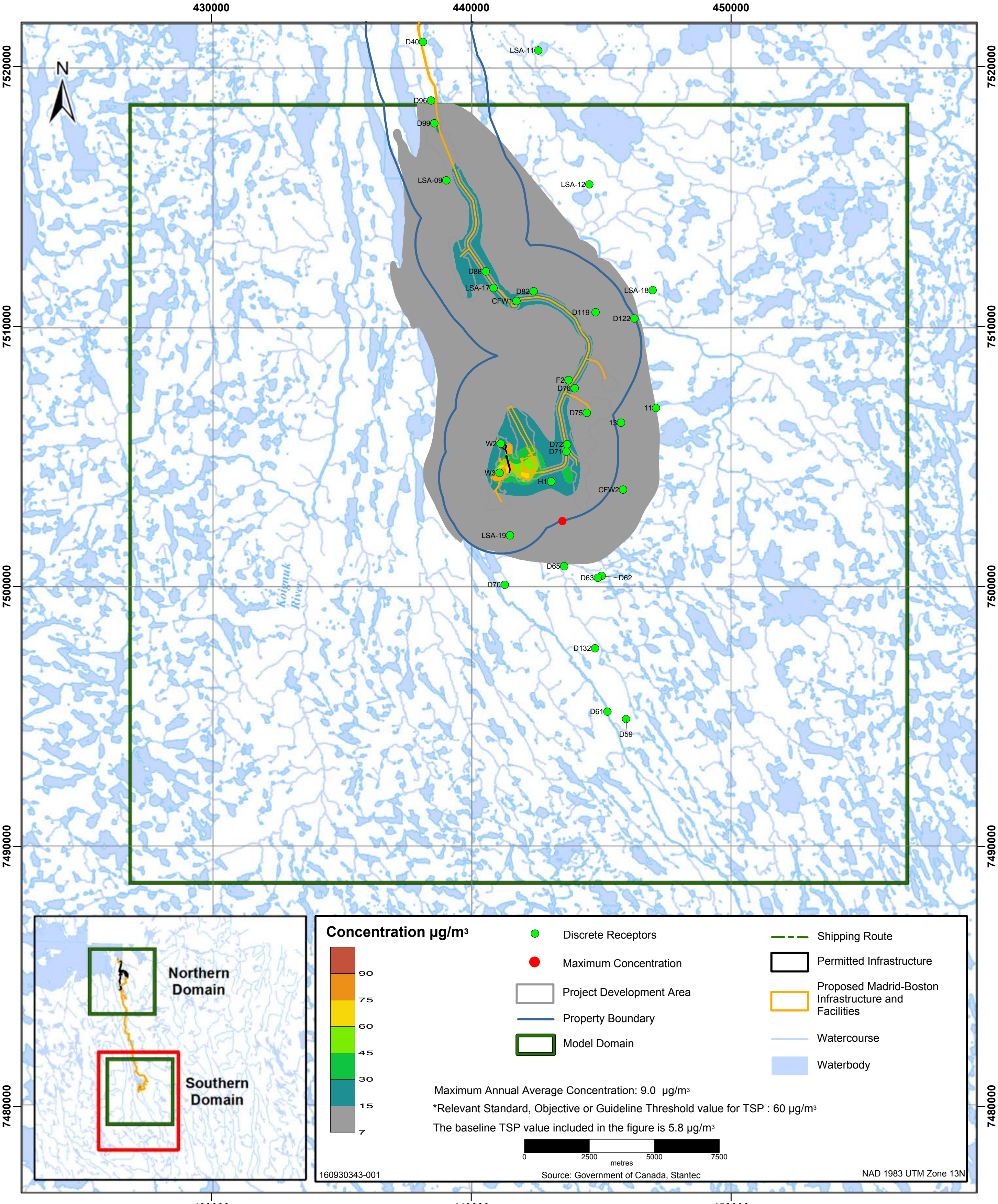


Figure G-11
Maximum Predicted 24-hour Average PM_{10} Ground-level Concentrations (µg/m³)
Construction, Southern Domain, the Madrid-Boston Project Only (includes Baseline Conditions)

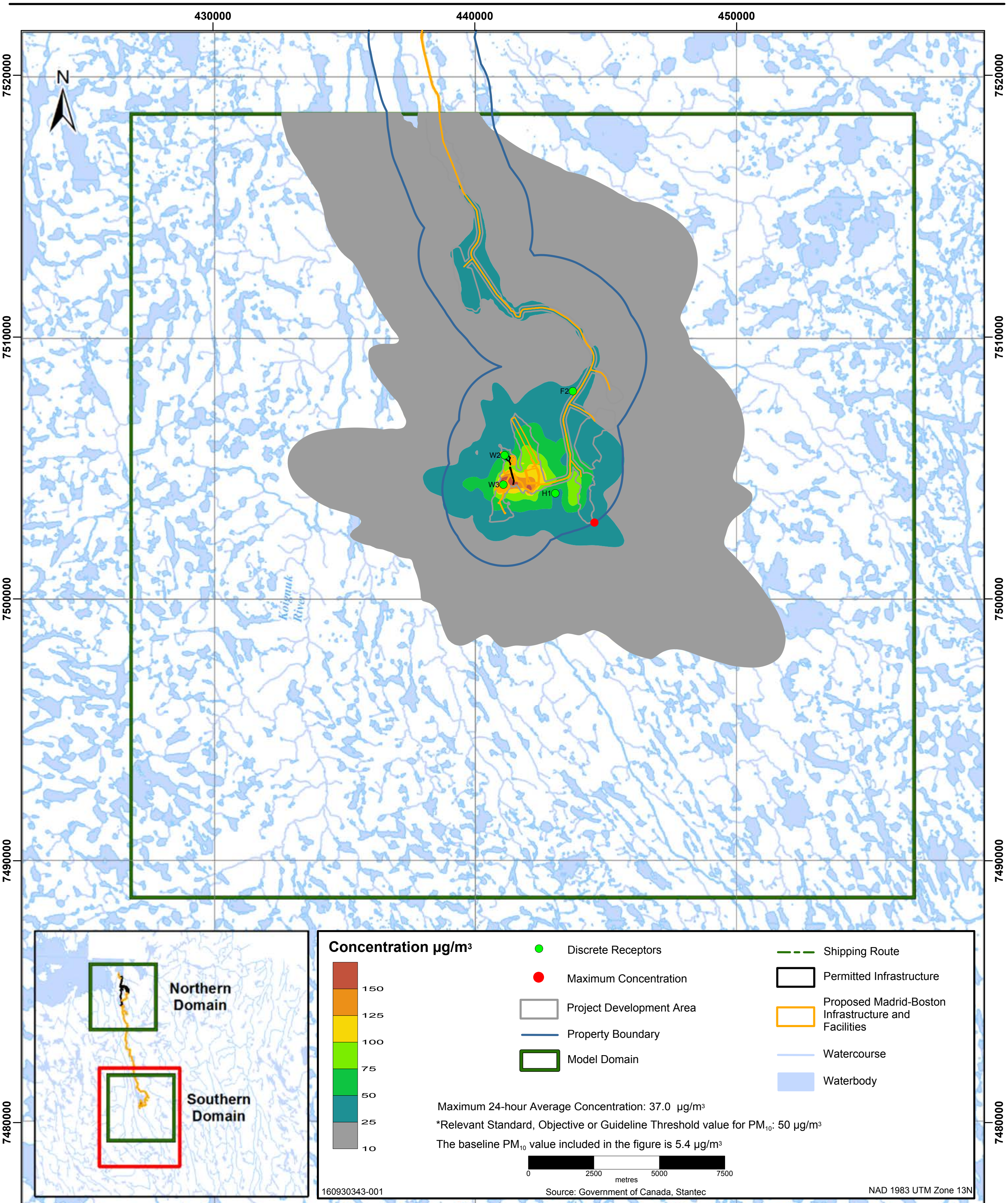


Figure G-12
Predicted 98th Percentile 24-hour Average $PM_{2.5}$ Ground-level Concentrations (µg/m³) Construction, Southern Domain, the Madrid-Boston Project Only (includes Baseline Conditions)

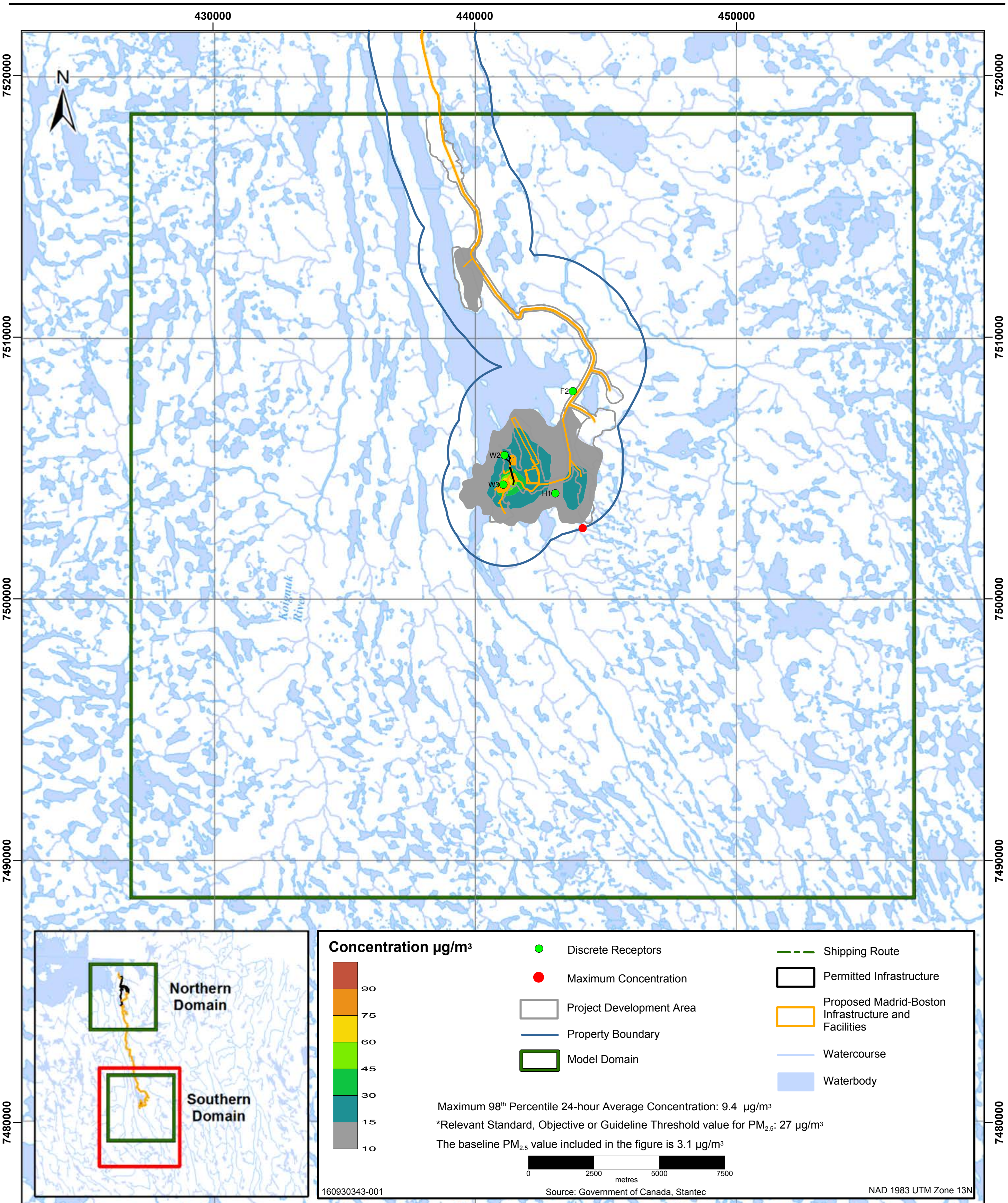


Figure G-13

Maximum Predicted Annual Average $PM_{2.5}$ Ground-level Concentrations (µg/m³)
Construction, Southern Domain, the Madrid-Boston Project Only (includes Baseline Conditions)

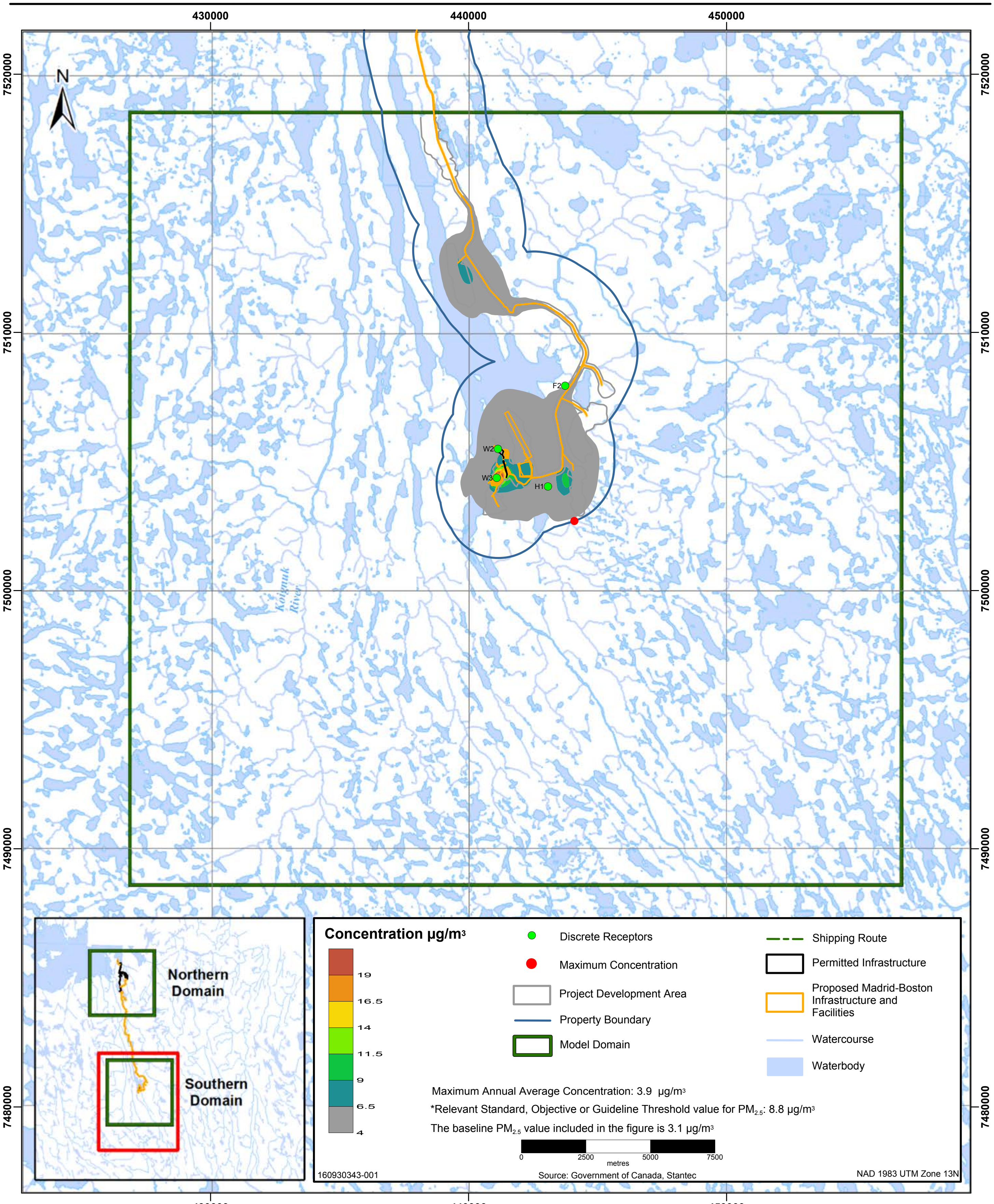
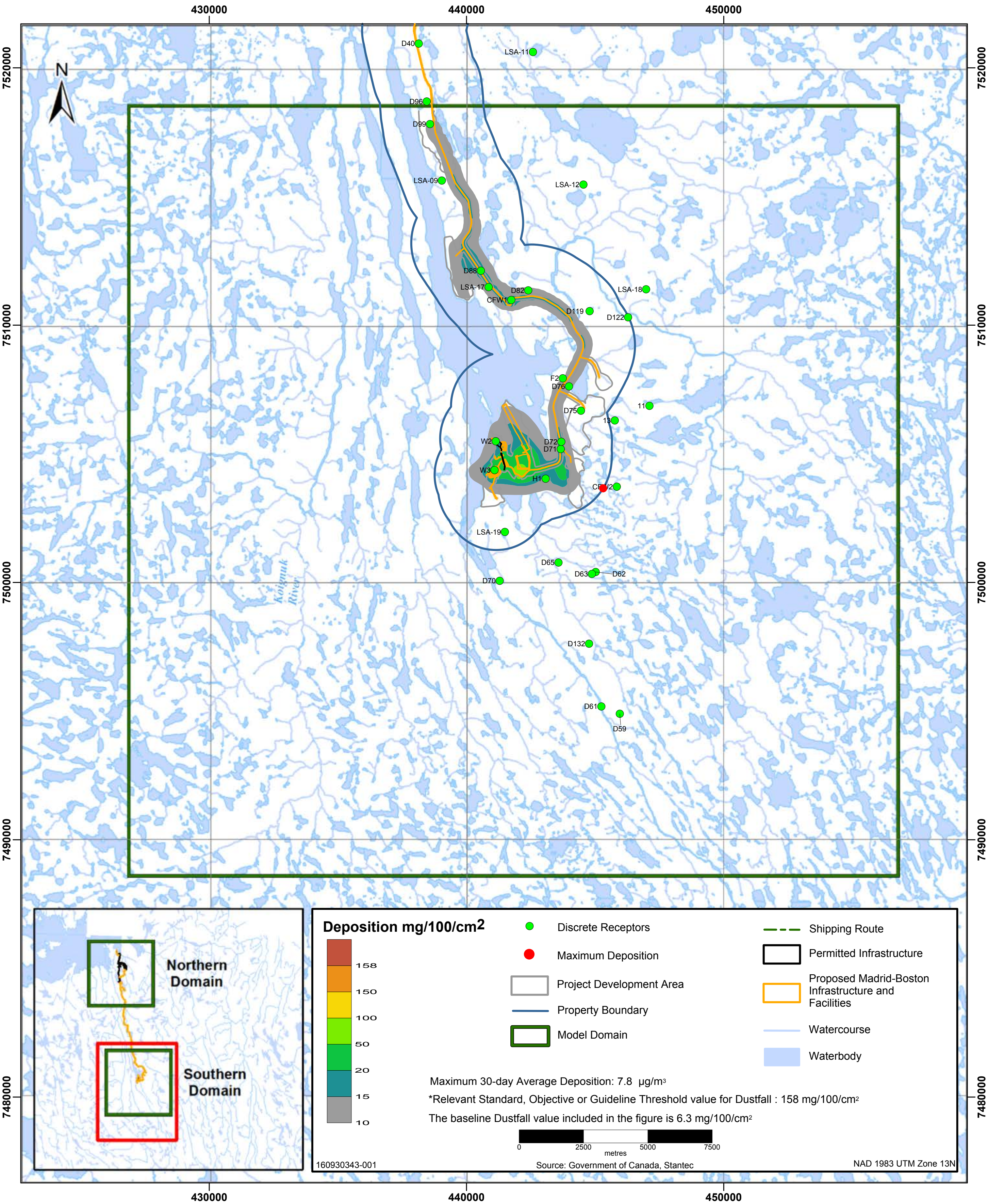


Figure G-14
Maximum Predicted 30-day Average Dustfall Ground-level Deposition (mg/100/cm²)
Construction, Southern Domain, the Madrid-Boston Project Only (includes Baseline Conditions)



APPENDIX H

Concentration Contour Plots for the Northern Domain (Madrid North in Reference Location), the Madrid-Boston Project + Existing Conditions (includes Baseline Conditions), Operation

Figure H-1
Predicted 99th Percentile Daily Maximum SO_2 Ground-level Concentrations (µg/m³) Operation, Northern Domain (Madrid North in Reference Location), the Madrid-Boston Project + Existing Conditions (includes Baseline Conditions)

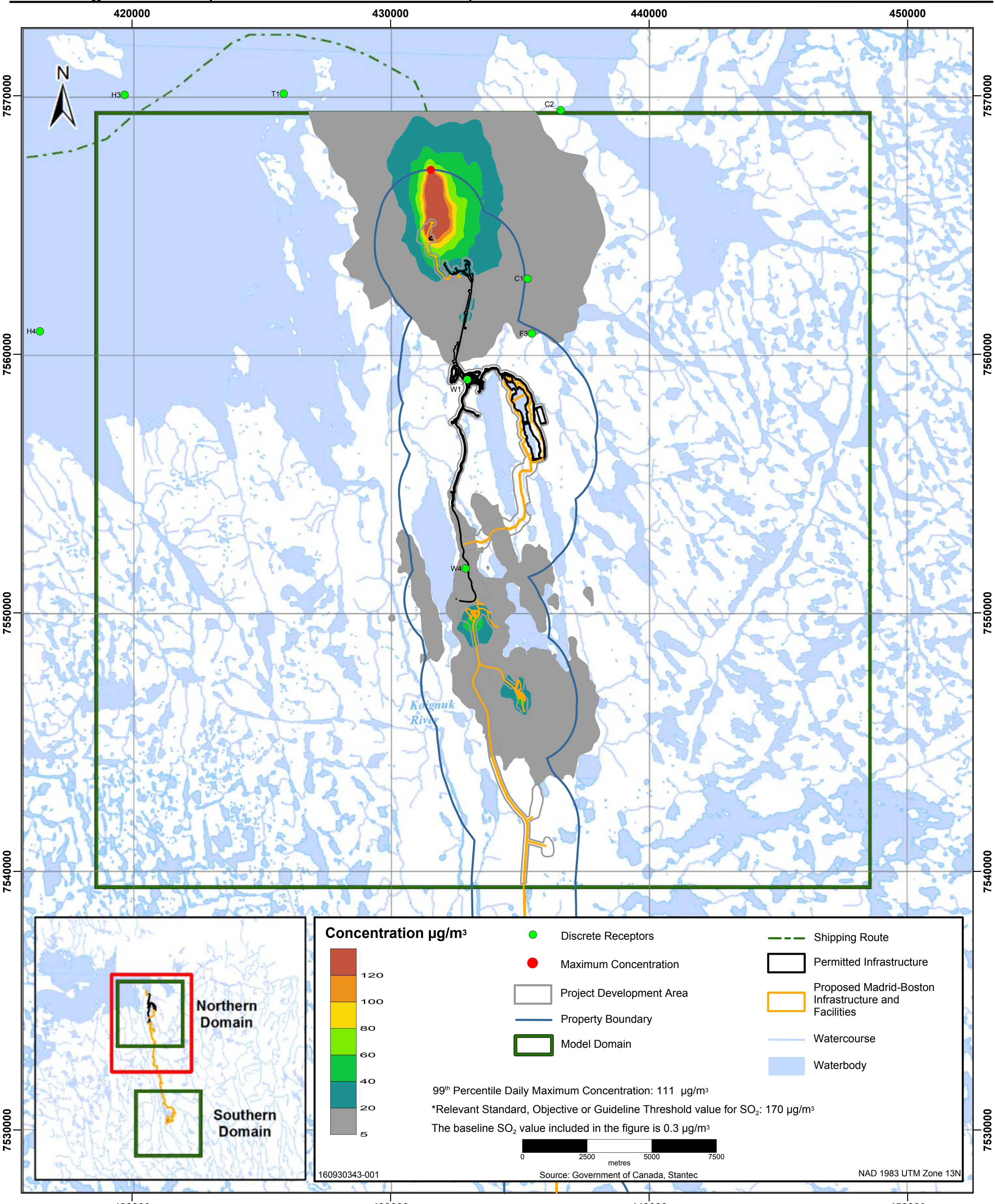


Figure H-2
Maximum Predicted 24-hour Average SO_2 Ground-level Concentrations (µg/m³)
Operation, Northern Domain (Madrid North in Reference Location), the Madrid-Boston Project + Existing Conditions (includes Baseline Conditions)

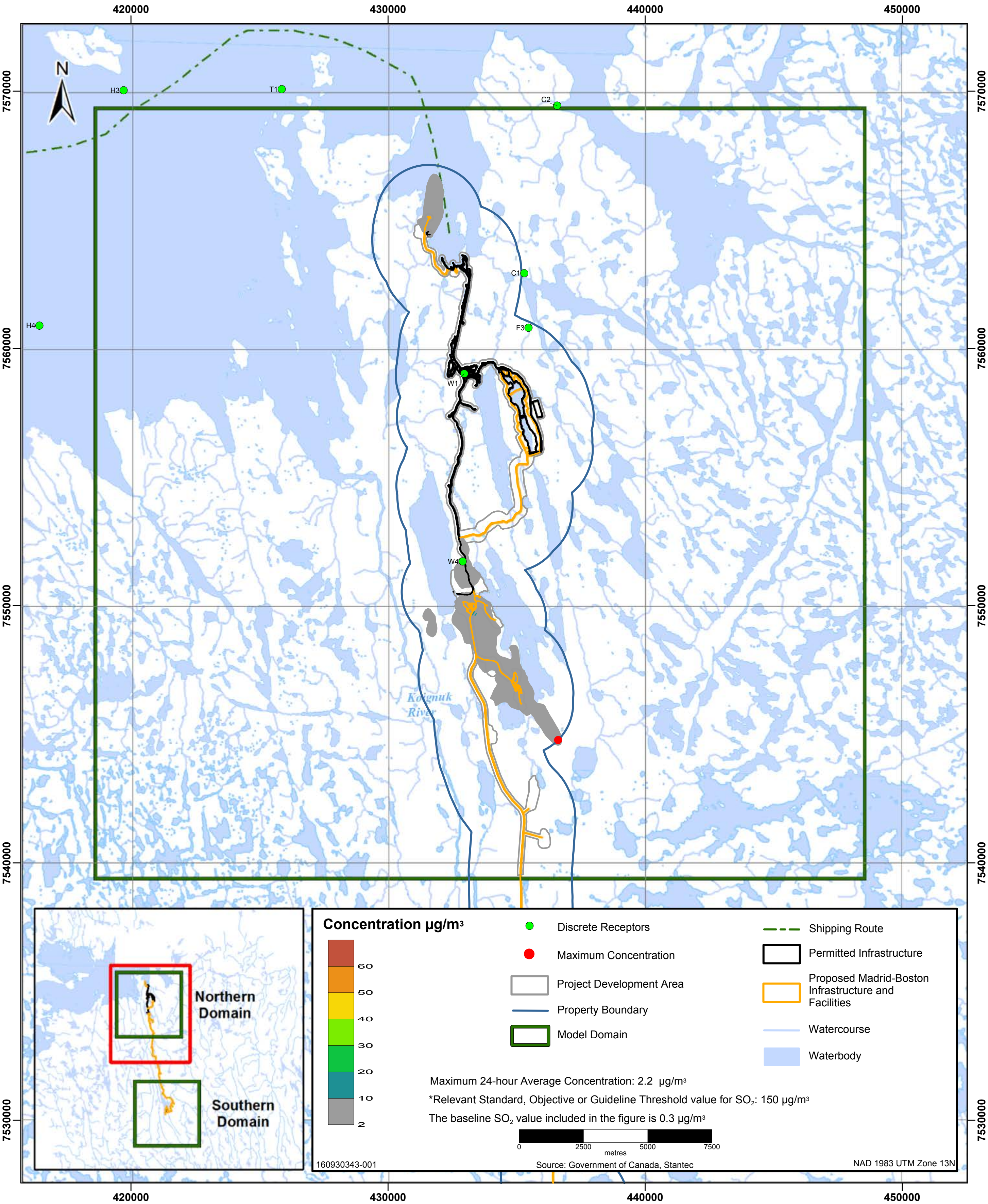


Figure H-3

Maximum Predicted Annual Average SO_2 Ground-level Concentrations (µg/m³)
Operation, Northern Domain (Madrid North in Reference Location), the Madrid-Boston Project
+ Existing Conditions (includes Baseline Conditions)

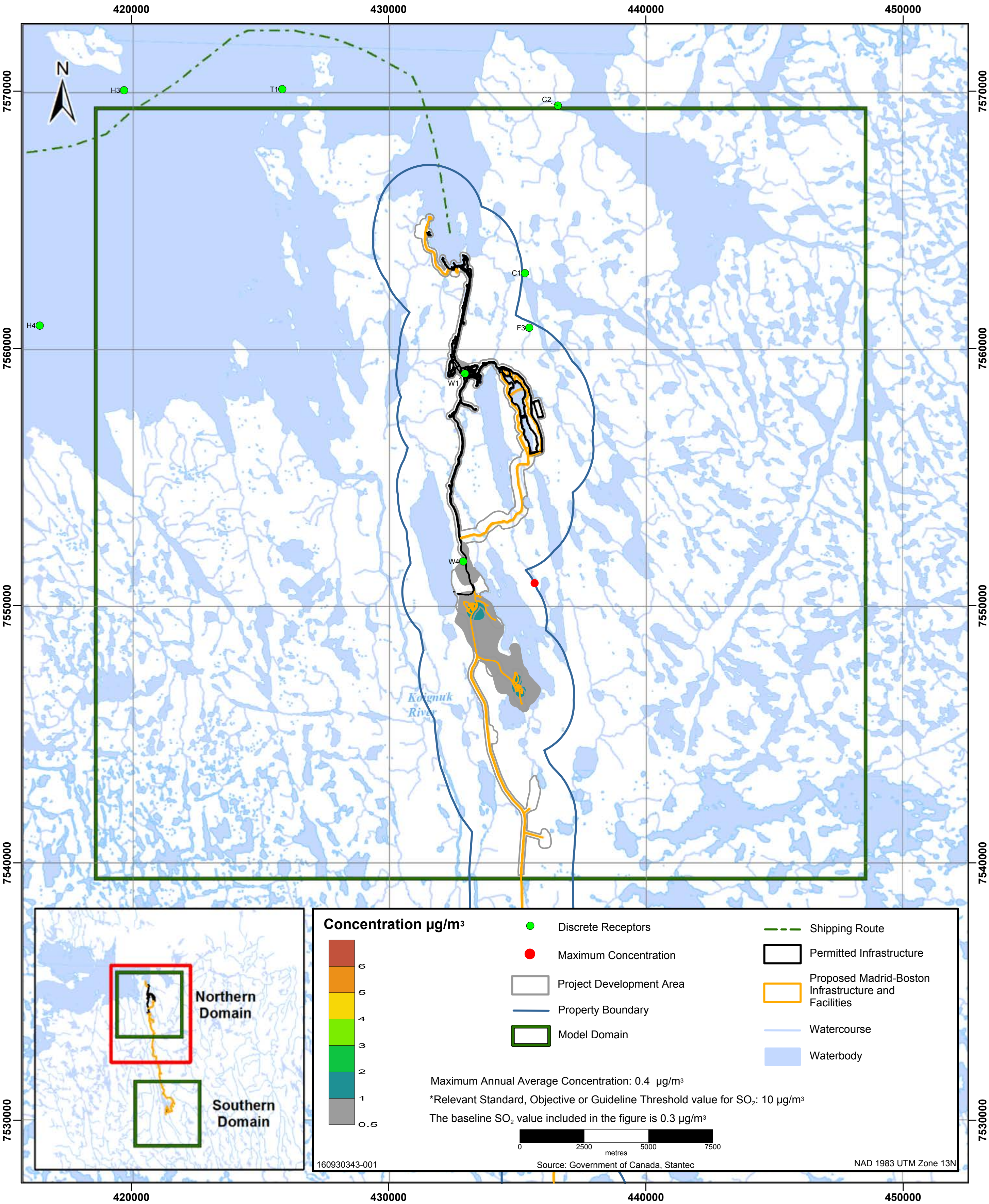


Figure H-4
Predicted 98th Percentile Daily Maximum NO_2 Ground-level Concentrations (µg/m³)
Operation, Northern Domain (Madrid North in Reference Location), the Madrid-Boston Project + Existing Conditions (includes Baseline Conditions)

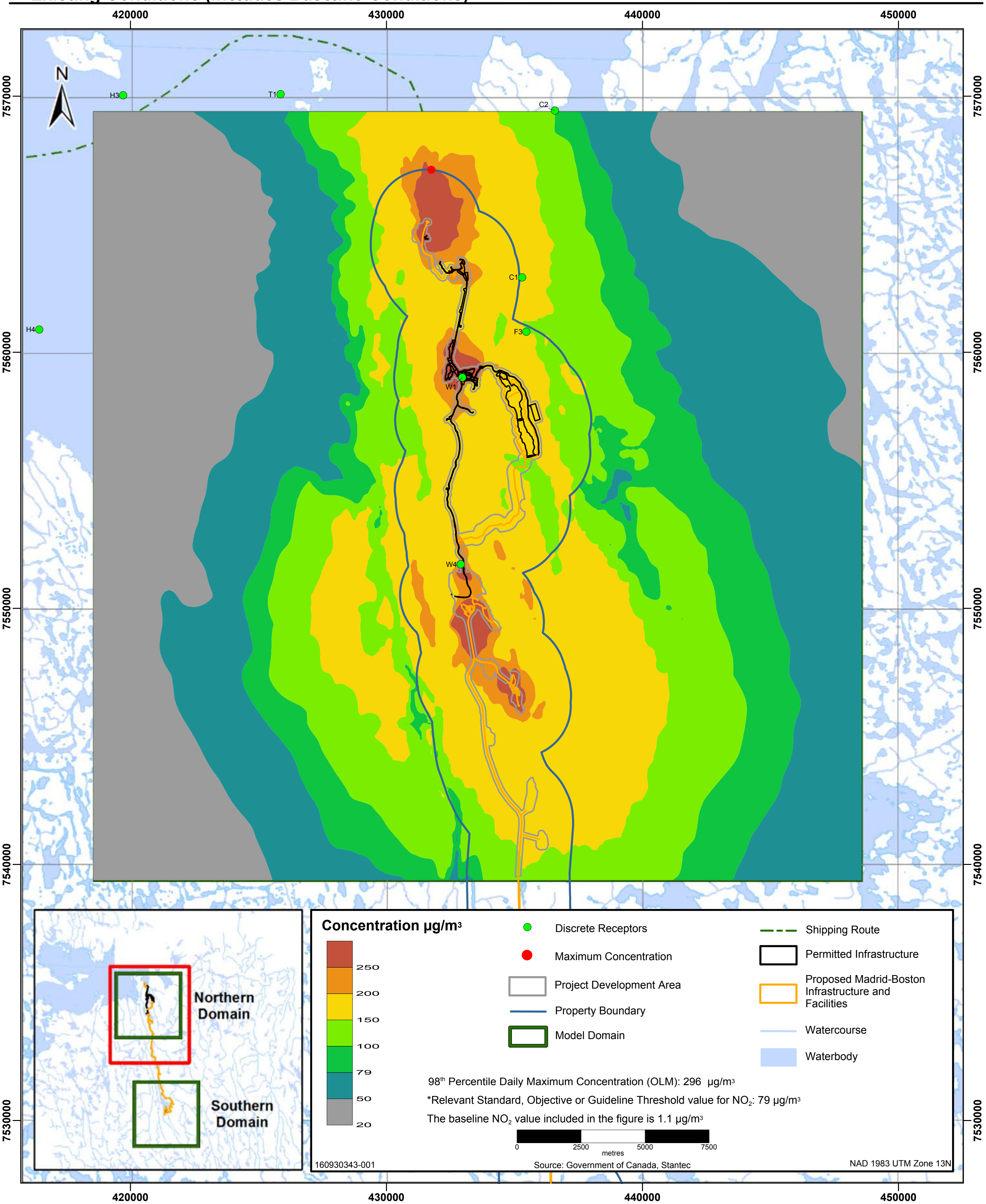


Figure H-5
Frequency of 98th Percentile Daily Maximum NO_2 Concentration Above the Ambient Criteria*
Operation, Northern Domain (Madrid North in Reference Location), the Madrid-Boston Project + Existing Conditions (includes Baseline Conditions)

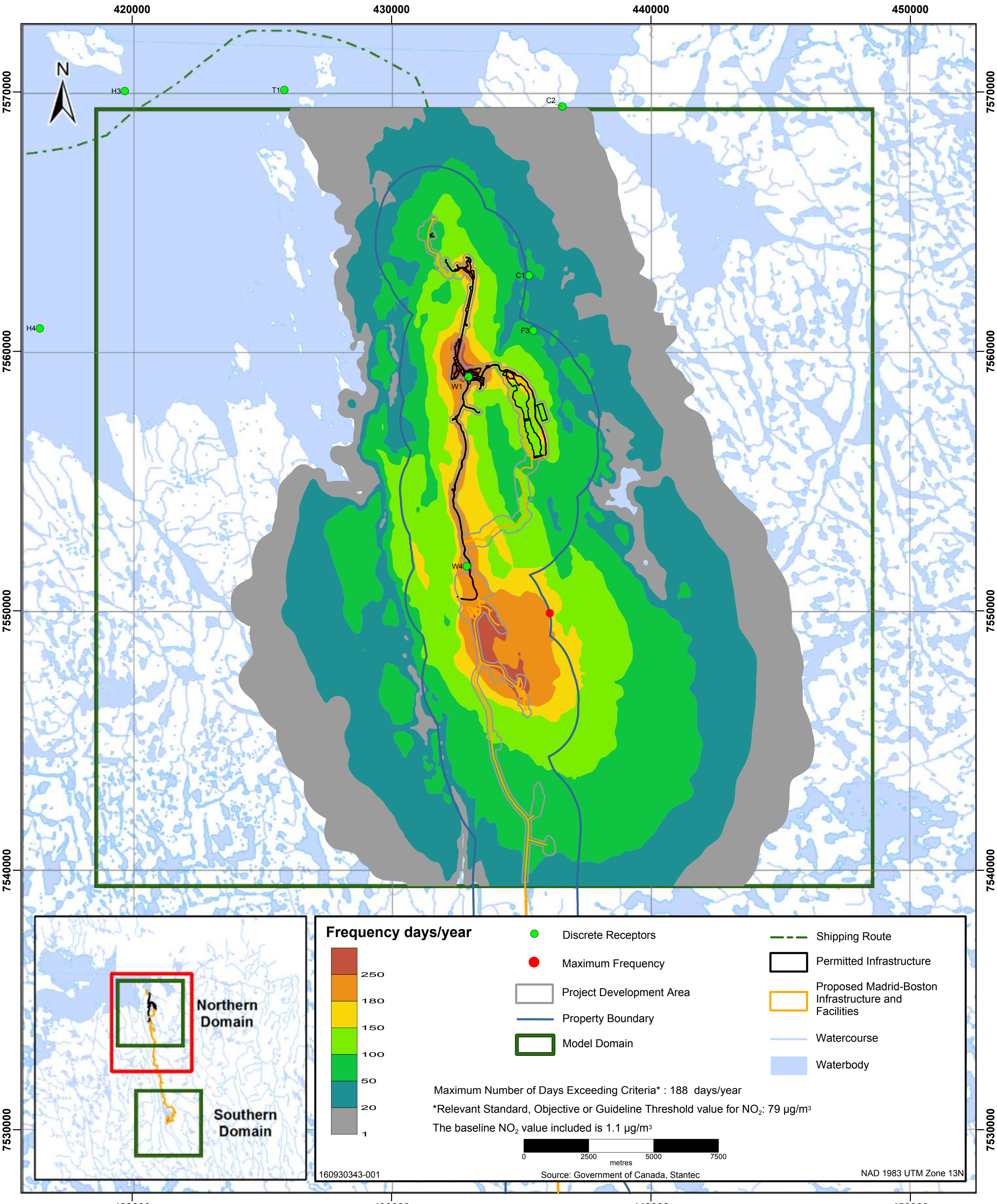


Figure H-6

Maximum Predicted 24-hour Average NO_2 Ground-level Concentrations (µg/m³) Operation, Northern Domain (Madrid North in Reference Location), the Madrid-Boston Project + Existing Conditions (includes Baseline Conditions)

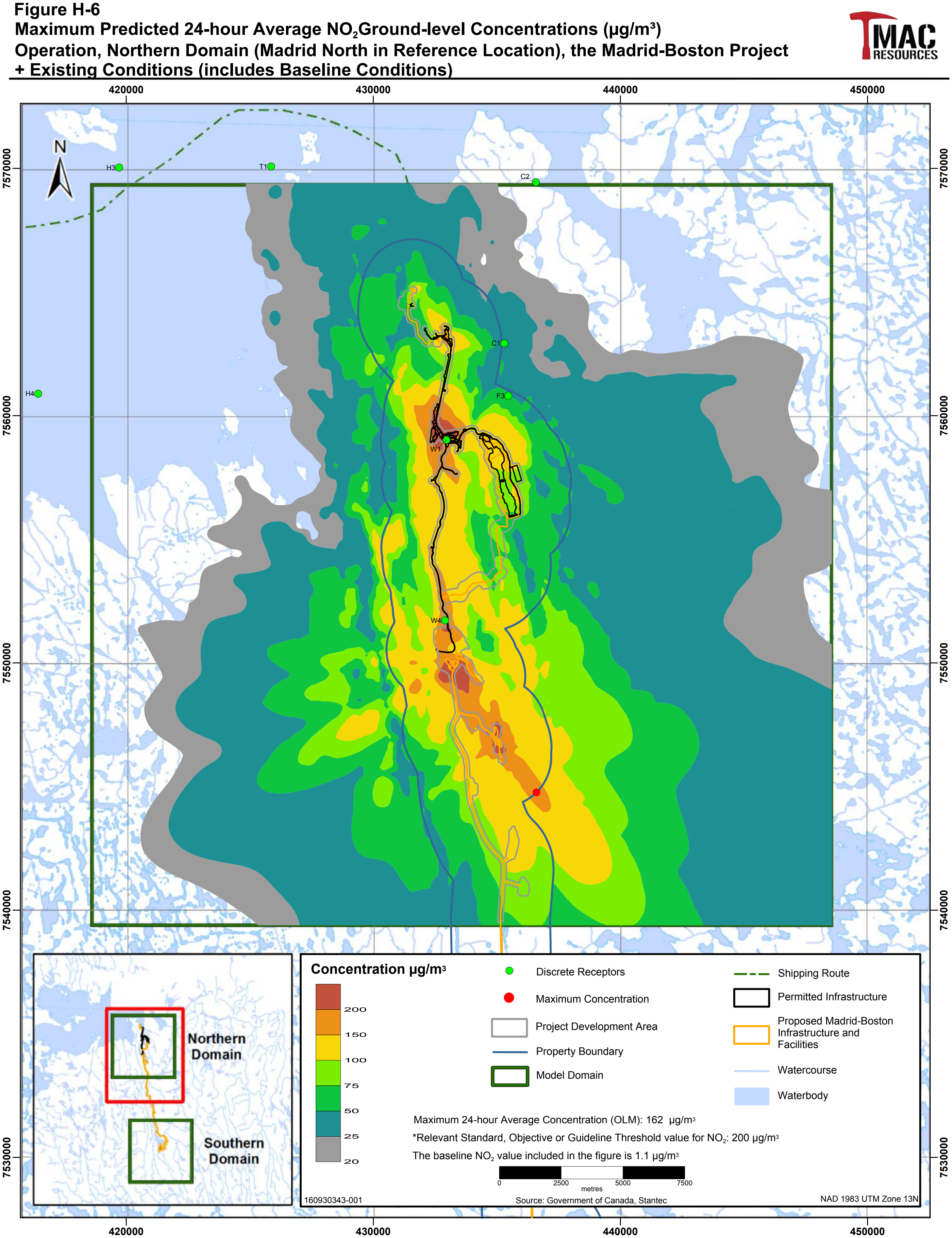


Figure H-7
Maximum Predicted Annual Average NO_2 Ground-level Concentrations (µg/m³)
Operation, Northern Domain (Madrid North in Reference Location), the Madrid-Boston Project + Existing Conditions (includes Baseline Conditions)

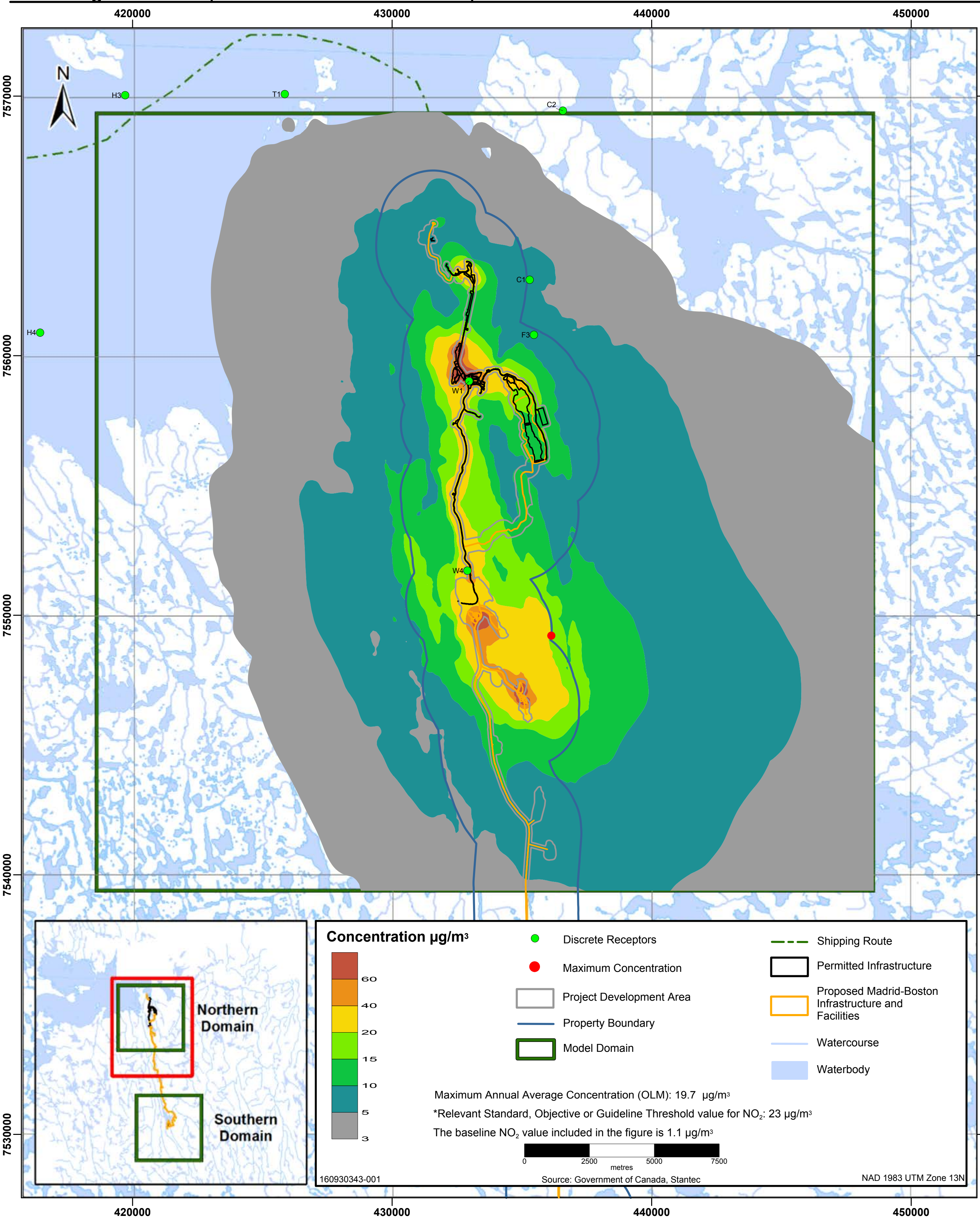


Figure H-8
Maximum Predicted One-hour Average CO Ground-level Concentrations (µg/m³) Operation, Northern Domain (Madrid North in Reference Location), the Madrid-Boston Project + Existing Conditions (includes Baseline Conditions)

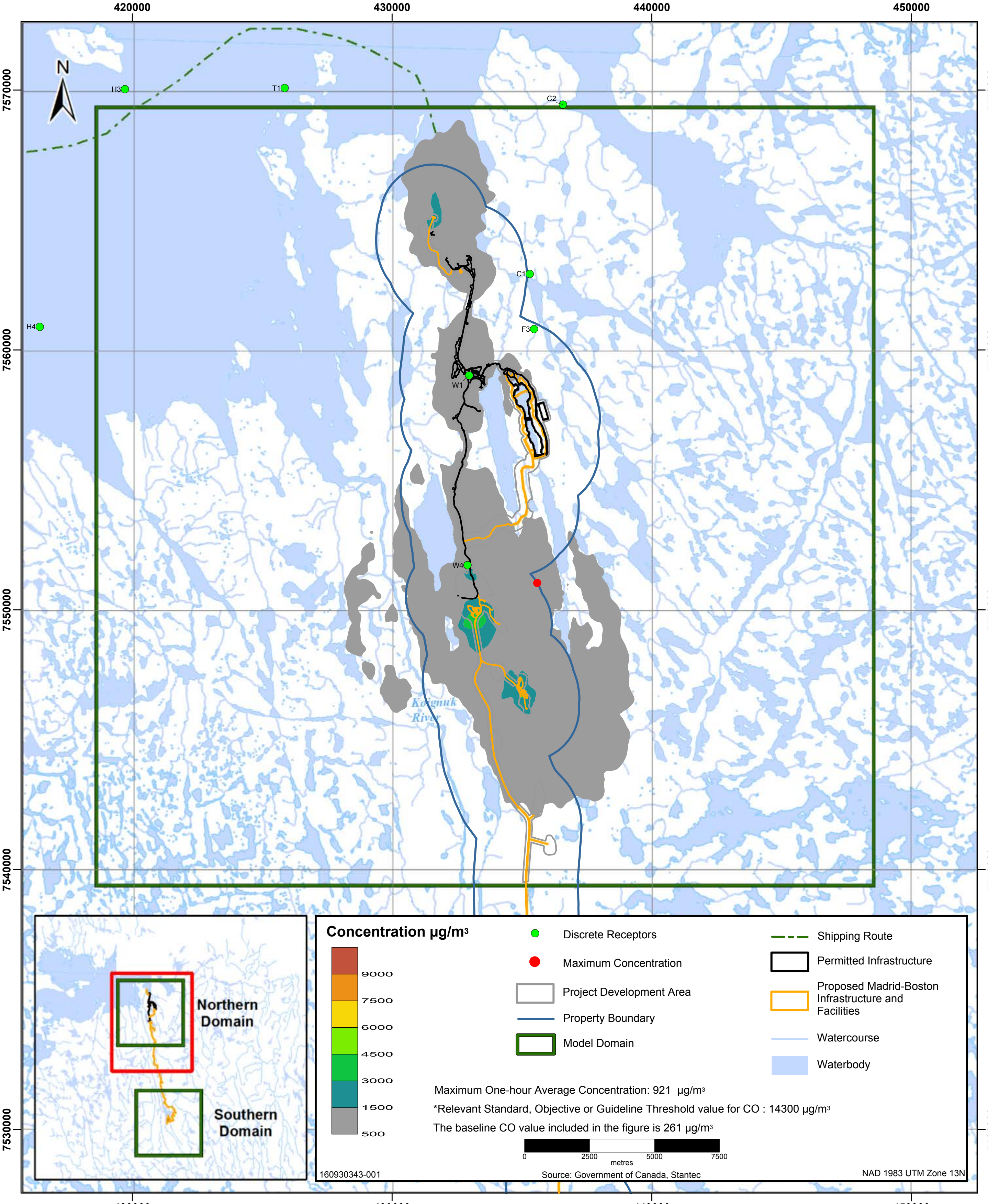


Figure H-9
Maximum Predicted 24-hour Average TSP Ground-level Concentrations (µg/m³)
Operation, Northern Domain (Madrid North in Reference Location), the Madrid-Boston Project + Existing Conditions (includes Baseline Conditions)

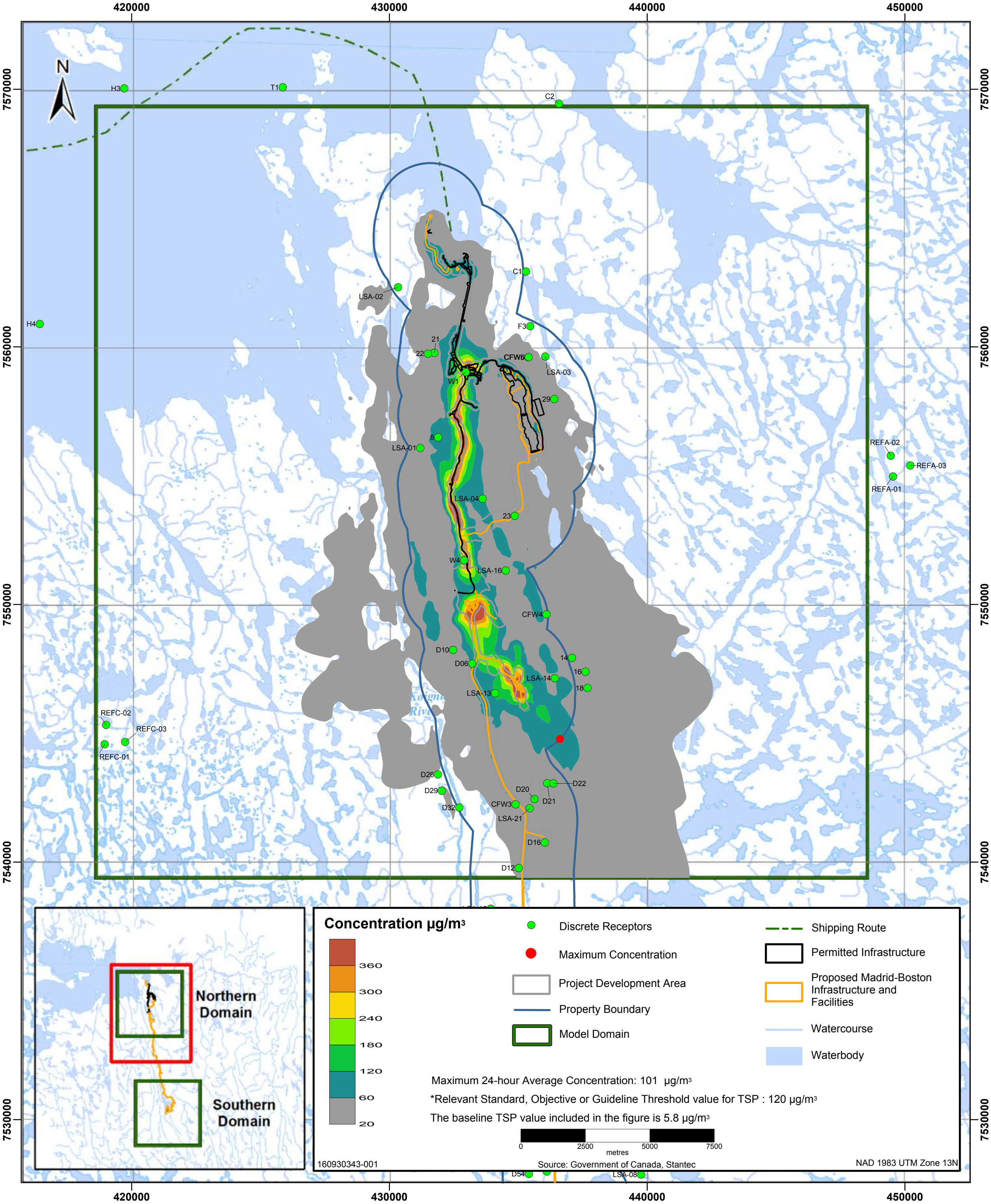


Figure H-10
Maximum Predicted Annual Average TSP Ground-level Concentrations (µg/m³)
Operation, Northern Domain (Madrid North in Reference Location), the Madrid-Boston Project + Existing Conditions (includes Baseline Conditions)

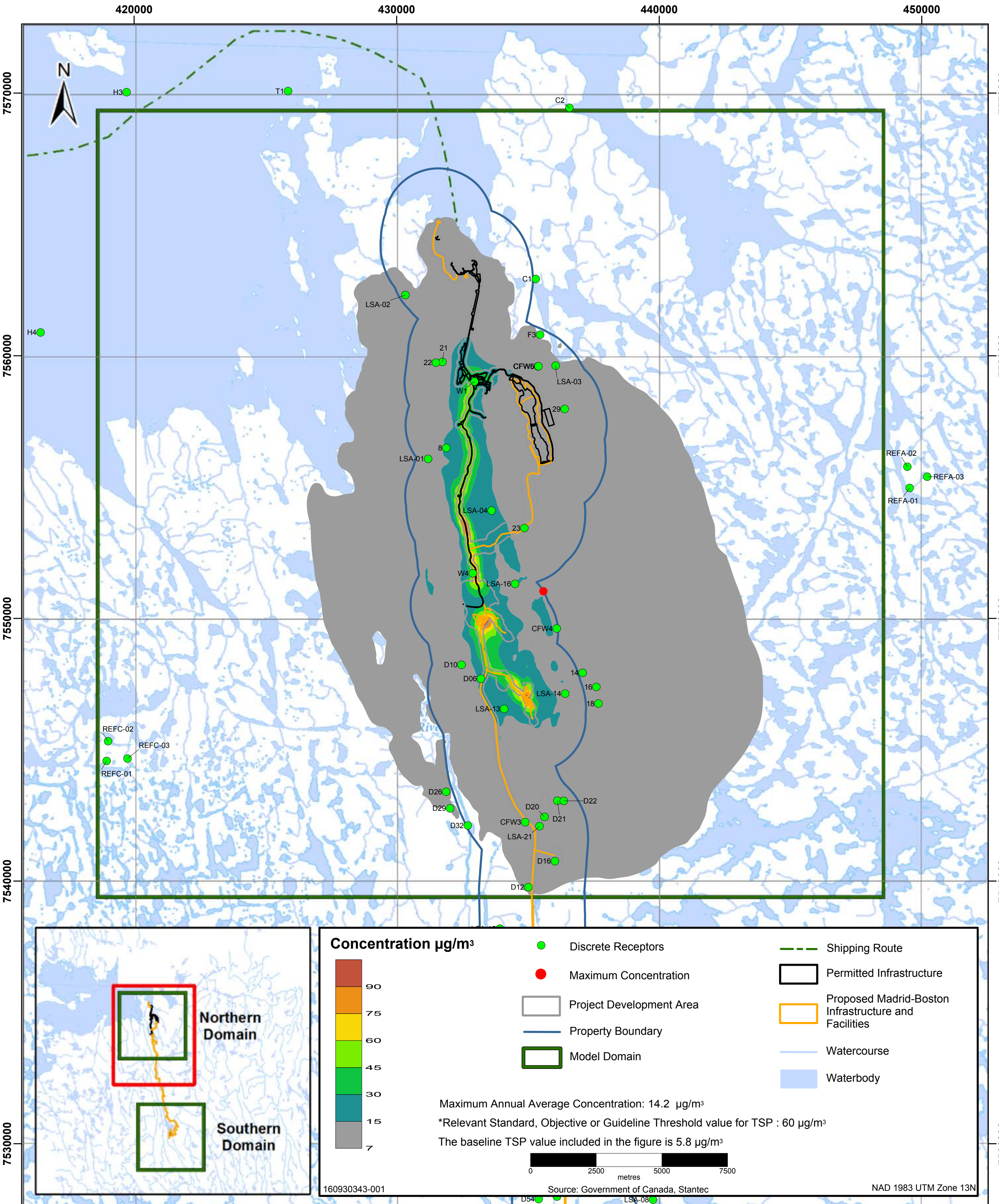


Figure H-11
Maximum Predicted 24-hour Average PM_{10} Ground-level Concentrations (µg/m³)
Operation, Northern Domain (Madrid North in Reference Location), the Madrid-Boston Project + Existing Conditions (includes Baseline Conditions)

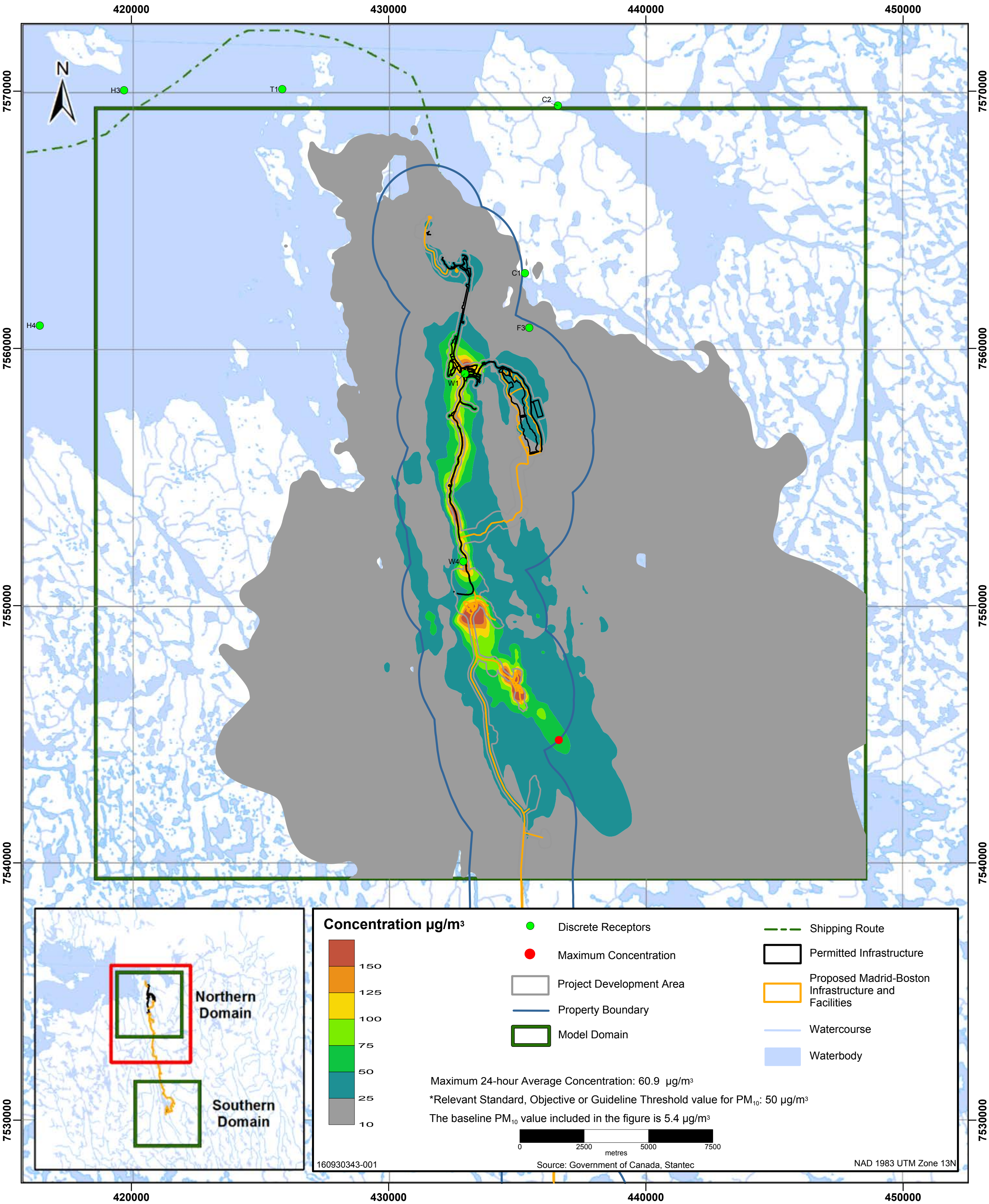


Figure H-12
Frequency of 24-hour Average PM_{10} Concentration Above the Ambient Criteria*
Operation, Northern Domain (Madrid North in Reference Location), the Madrid-Boston Project + Existing Conditions (includes Baseline Conditions)

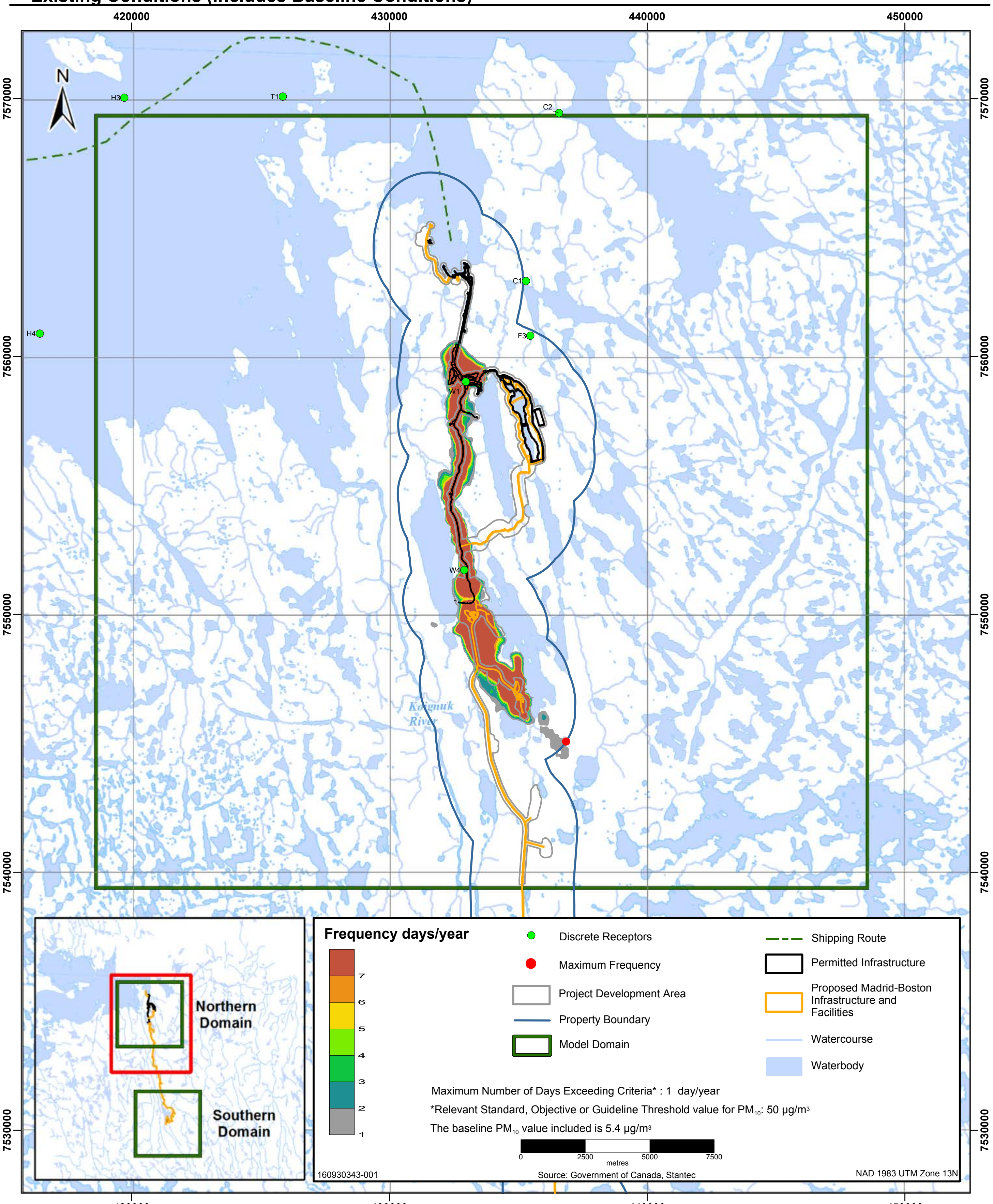


Figure H-13
Predicted 98th Percentile 24-hour Average $PM_{2.5}$ Ground-level Concentrations (µg/m³) Operation, Northern Domain (Madrid North in Reference Location), the Madrid-Boston Project + Existing Conditions (includes Baseline Conditions)

TMAC RESOURCES

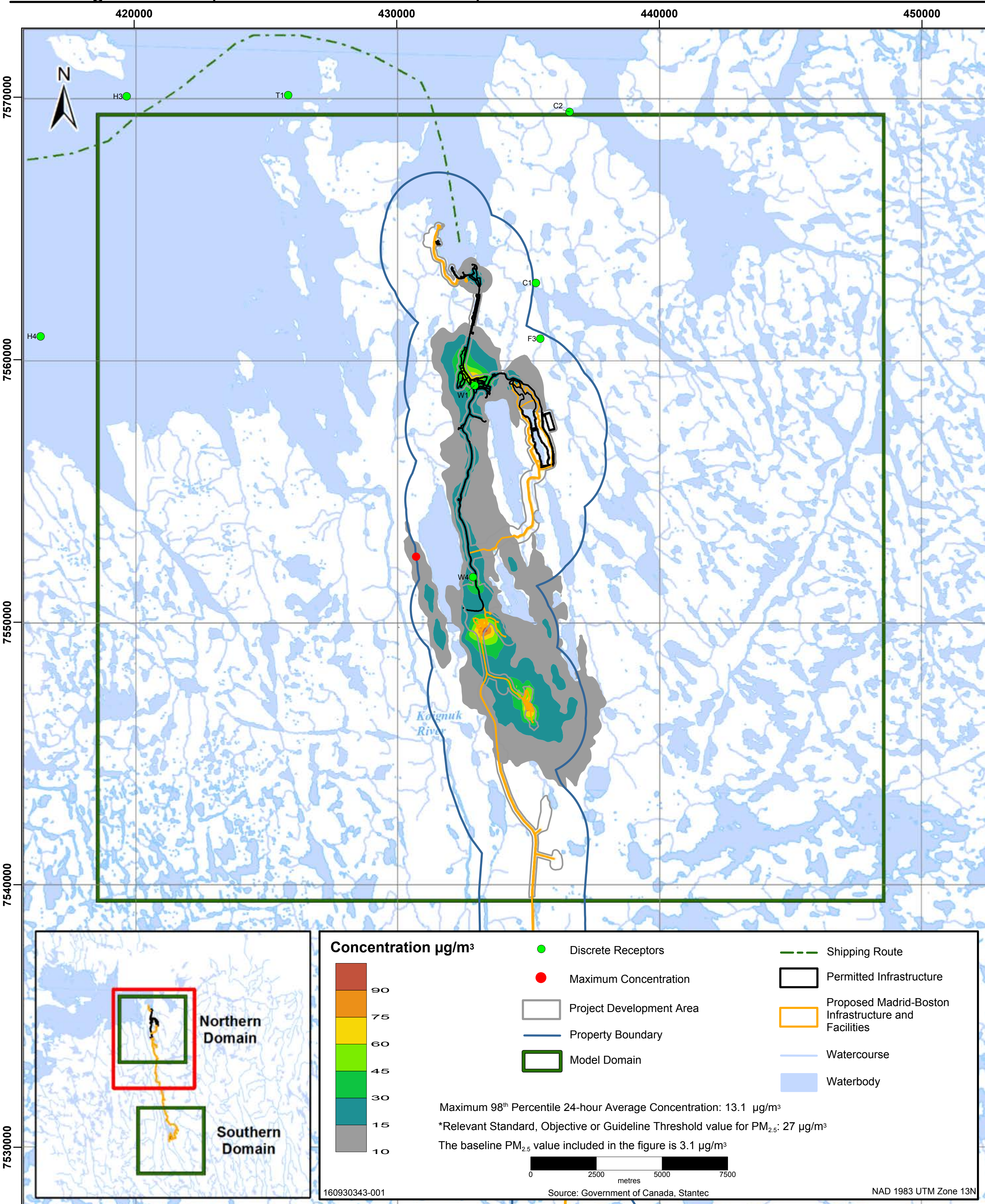


Figure H-14
Maximum Predicted Annual Average $PM_{2.5}$ Ground-level Concentrations (μg/m³)
Operation, Northern Domain (Madrid North in Reference Location), the Madrid-Boston Project
+ Existing Conditions (includes Baseline Conditions)

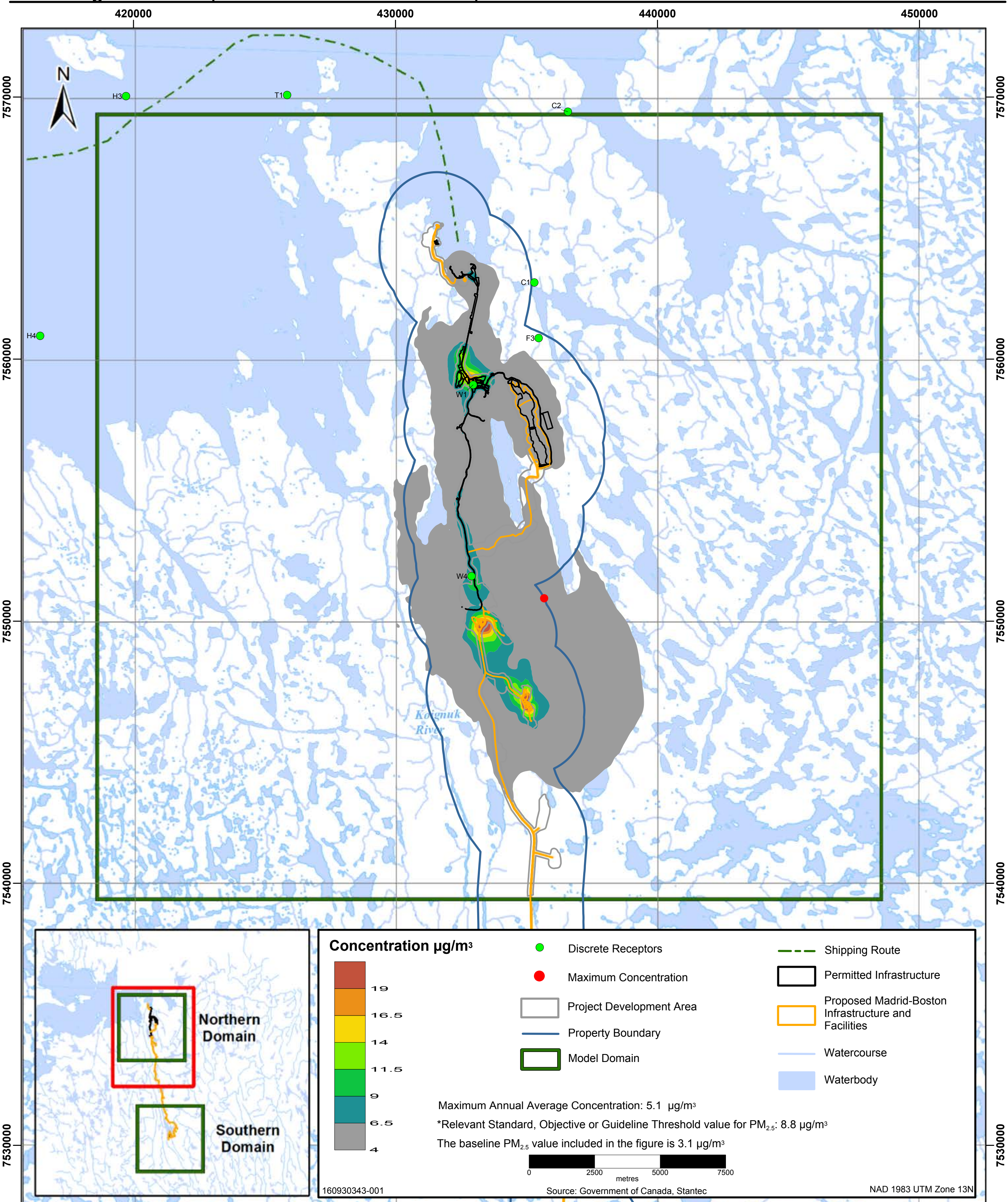
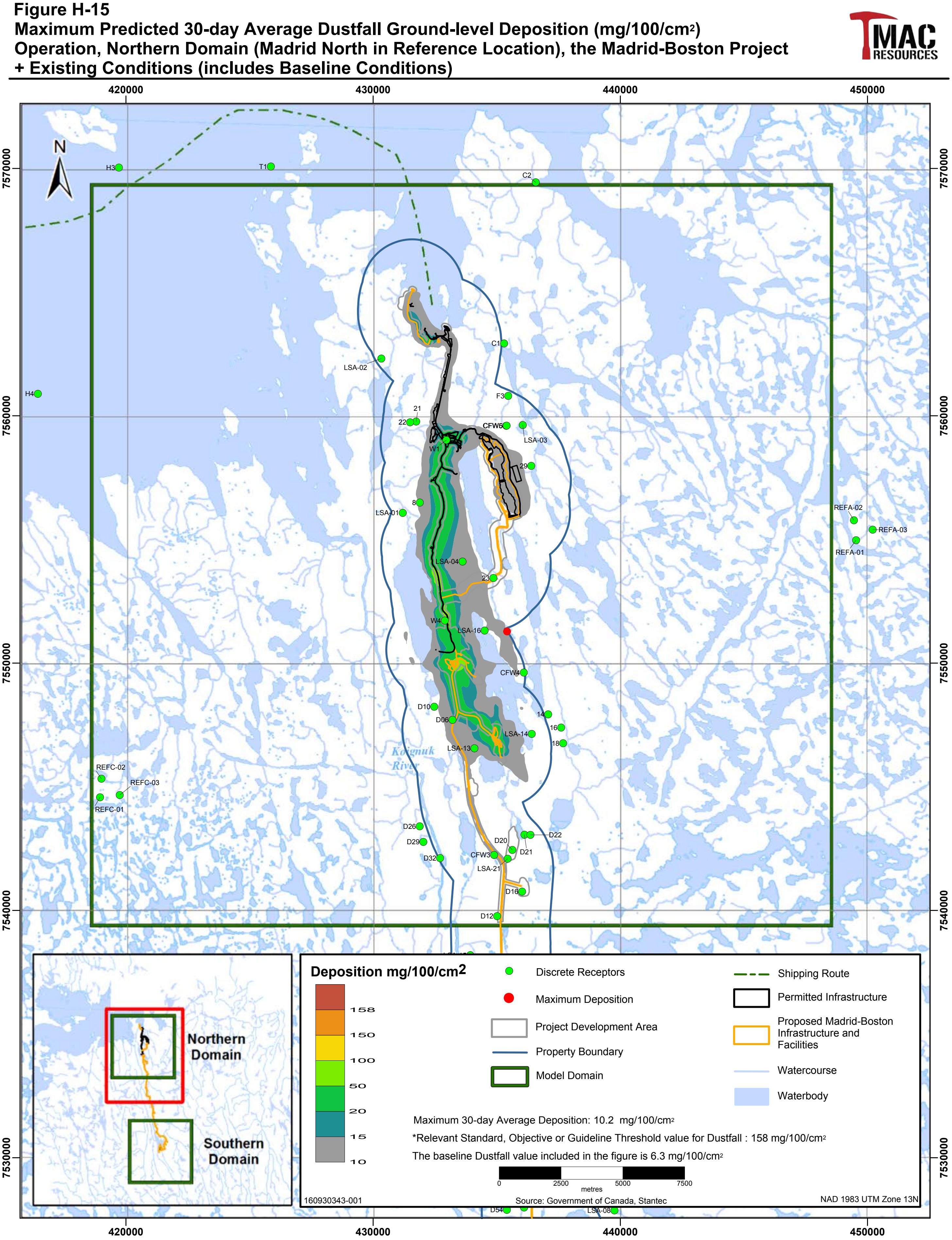


Figure H-15
Maximum Predicted 30-day Average Dustfall Ground-level Deposition (mg/100/cm²)
Operation, Northern Domain (Madrid North in Reference Location), the Madrid-Boston Project + Existing Conditions (includes Baseline Conditions)



APPENDIX I

Concentration Contour Plots for the Northern Domain (Madrid North in Alternative Location), the Madrid-Boston Project + Existing Conditions (includes Baseline Conditions), Operation

Figure I-1
Predicted 99th Percentile Daily Maximum SO_2 Ground-level Concentrations (µg/m³)
Operation, Northern Domain (Madrid North in Alternative Location), the Madrid-Boston Project + Existing Conditions (includes Baseline Conditions)

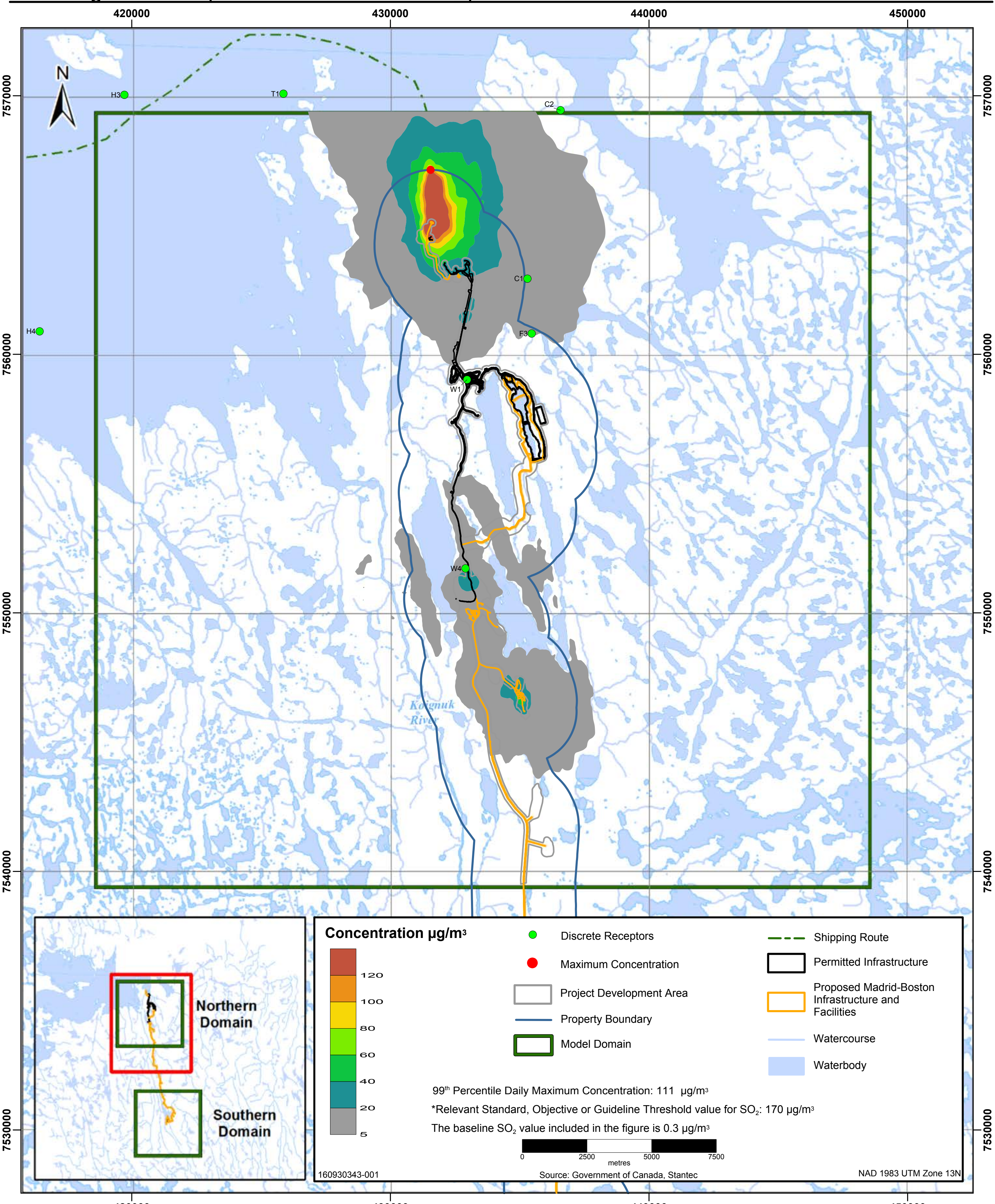


Figure I-2

Maximum Predicted 24-hour Average SO_2 Ground-level Concentrations (µg/m³) Operation, Northern Domain (Madrid North in Alternative Location), the Madrid-Boston Project + Existing Conditions (includes Baseline Conditions)

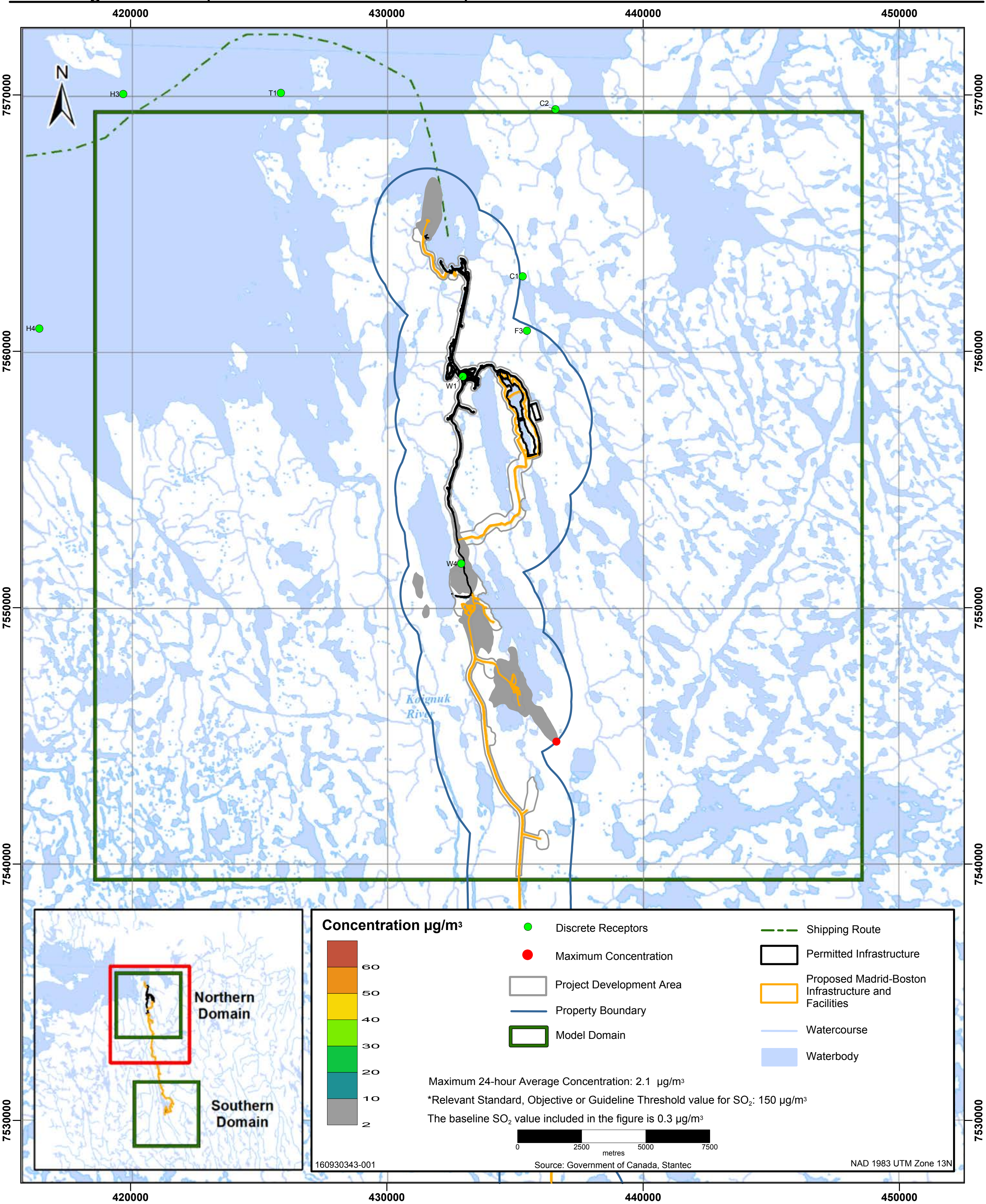


Figure I-3

Maximum Predicted Annual Average SO_2 Ground-level Concentrations (µg/m³)
Operation, Northern Domain (Madrid North in Alternative Location), the Madrid-Boston Project
+ Existing Conditions (includes Baseline Conditions)

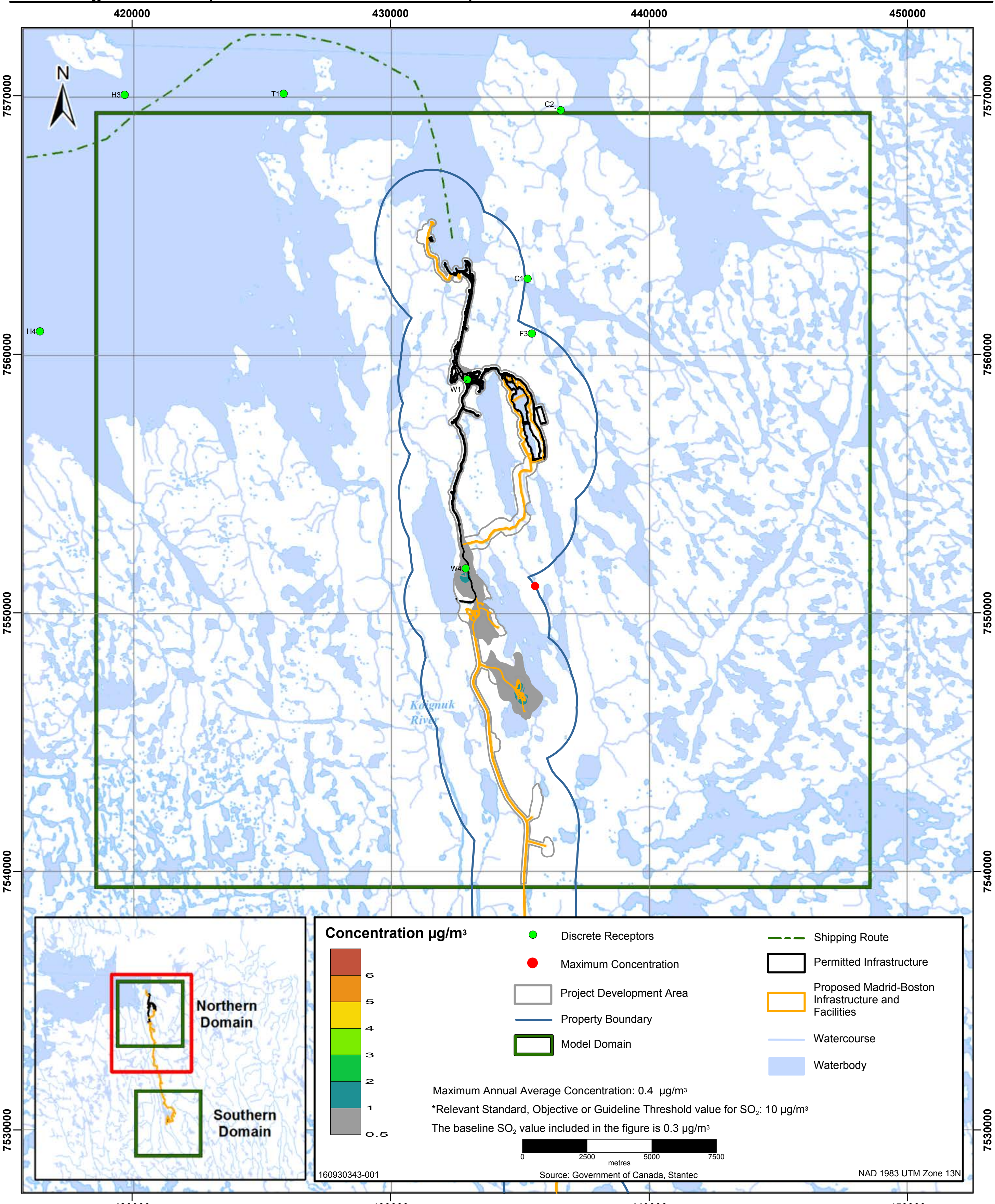


Figure I-4
Predicted 98th Percentile Daily Maximum NO_2 Ground-level Concentrations (µg/m³)
Operation, Northern Domain (Madrid North in Alternative Location), the Madrid-Boston Project + Existing Conditions (includes Baseline Conditions)

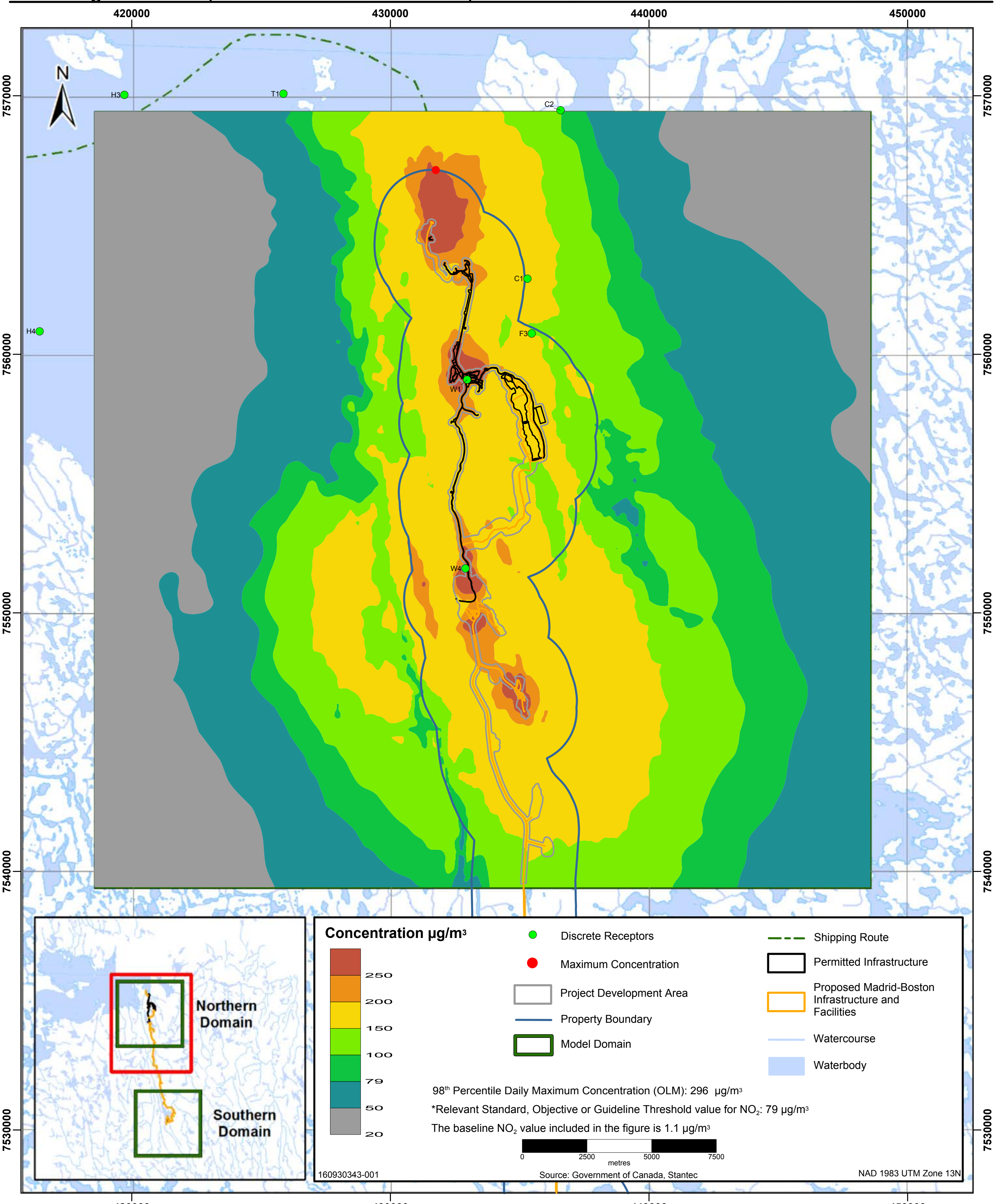


Figure I-5

Frequency of 98th Percentile Daily Maximum NO_2 Concentration Above the Ambient Criteria*
Operation, Northern Domain (Madrid North in Alternative Location), the Madrid-Boston Project + Existing Conditions (includes Baseline Conditions)

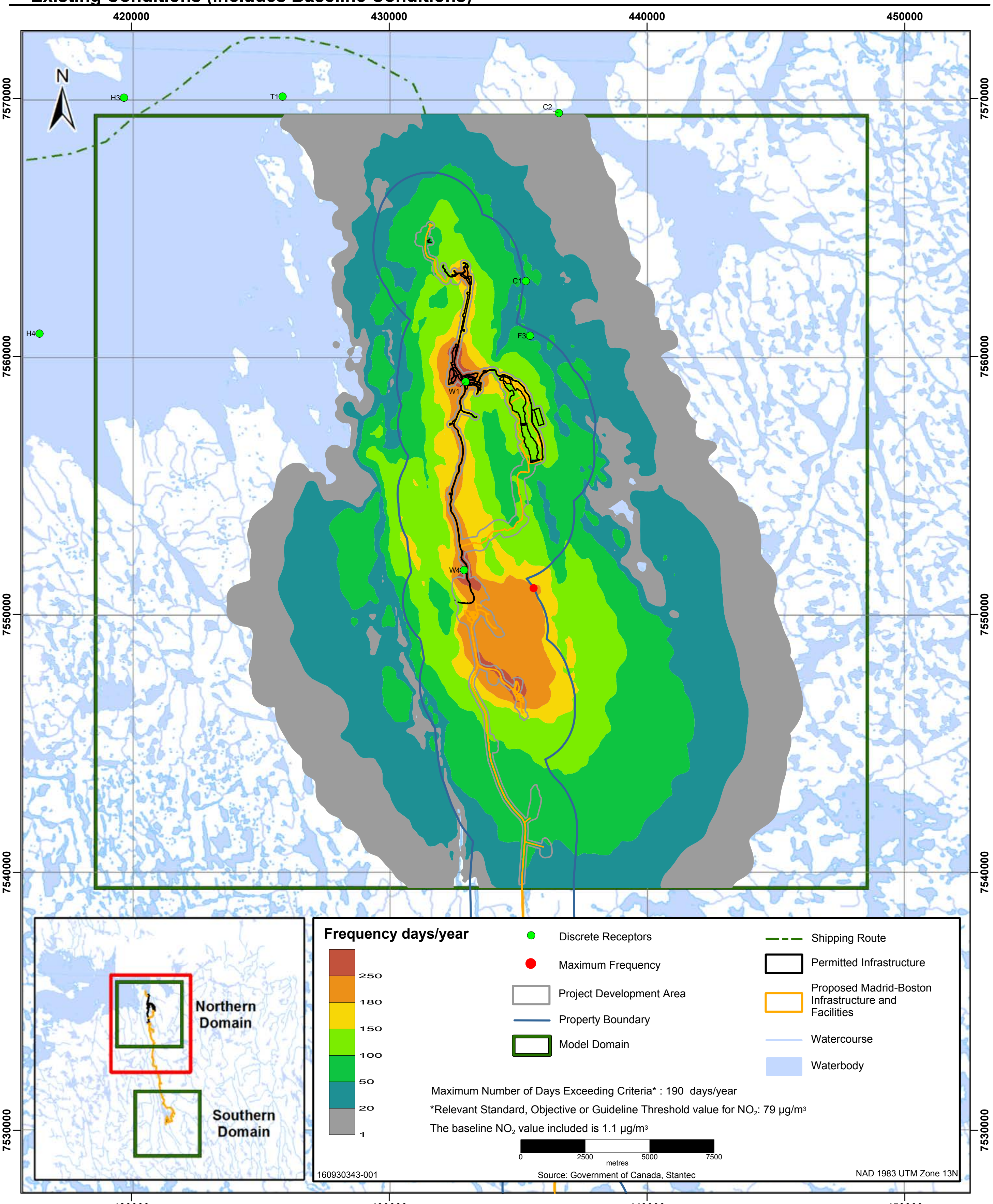


Figure I-6
Maximum Predicted 24-hour Average NO_2 Ground-level Concentrations (µg/m³) Operation, Northern Domain (Madrid North in Alternative Location), the Madrid-Boston Project + Existing Conditions (includes Baseline Conditions)

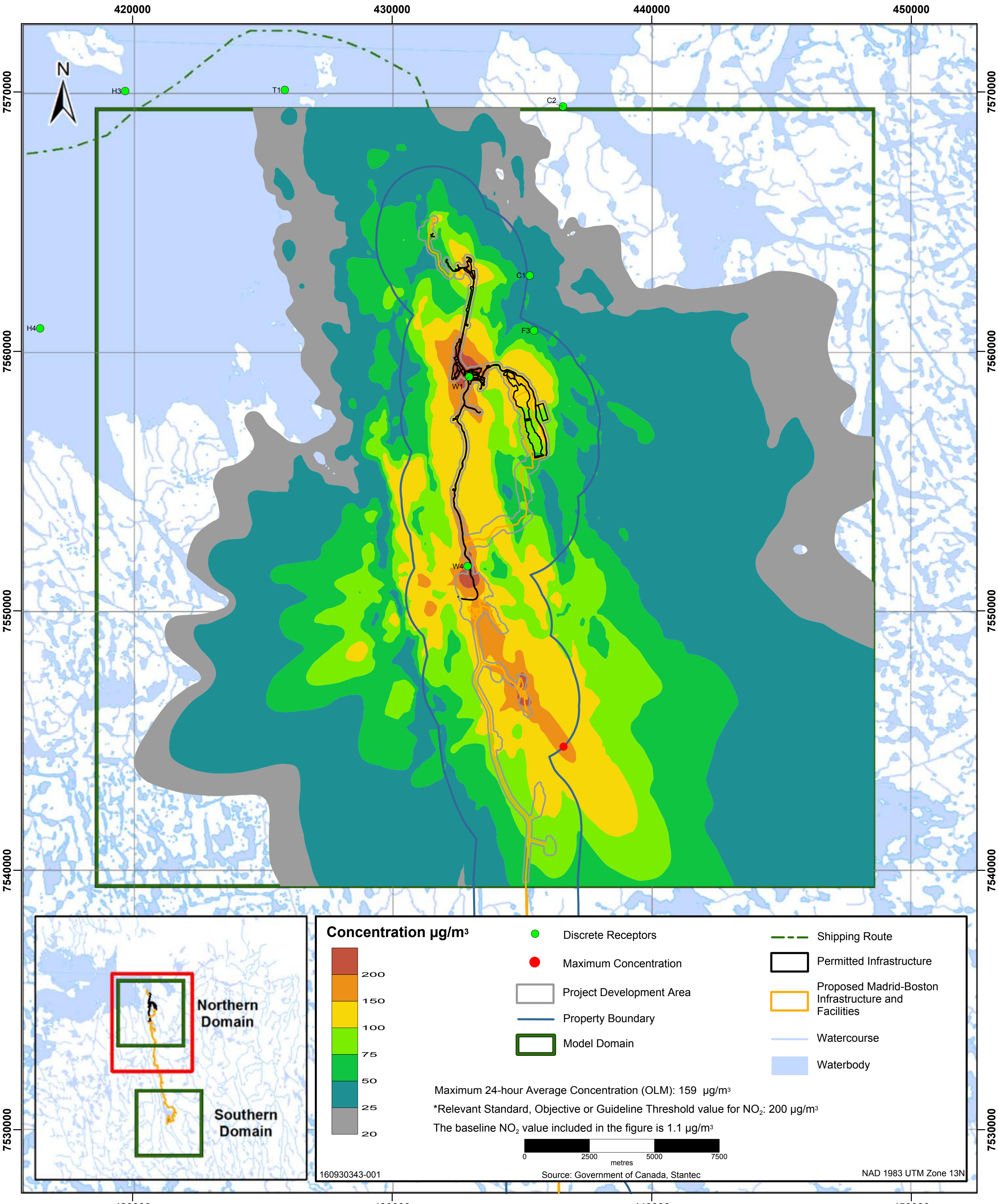


Figure I-7
Maximum Predicted Annual Average NO_2 Ground-level Concentrations (µg/m³)
Operation, Northern Domain (Madrid North in Alternative Location), the Madrid-Boston Project + Existing Conditions (includes Baseline Conditions)

TMAC RESOURCES

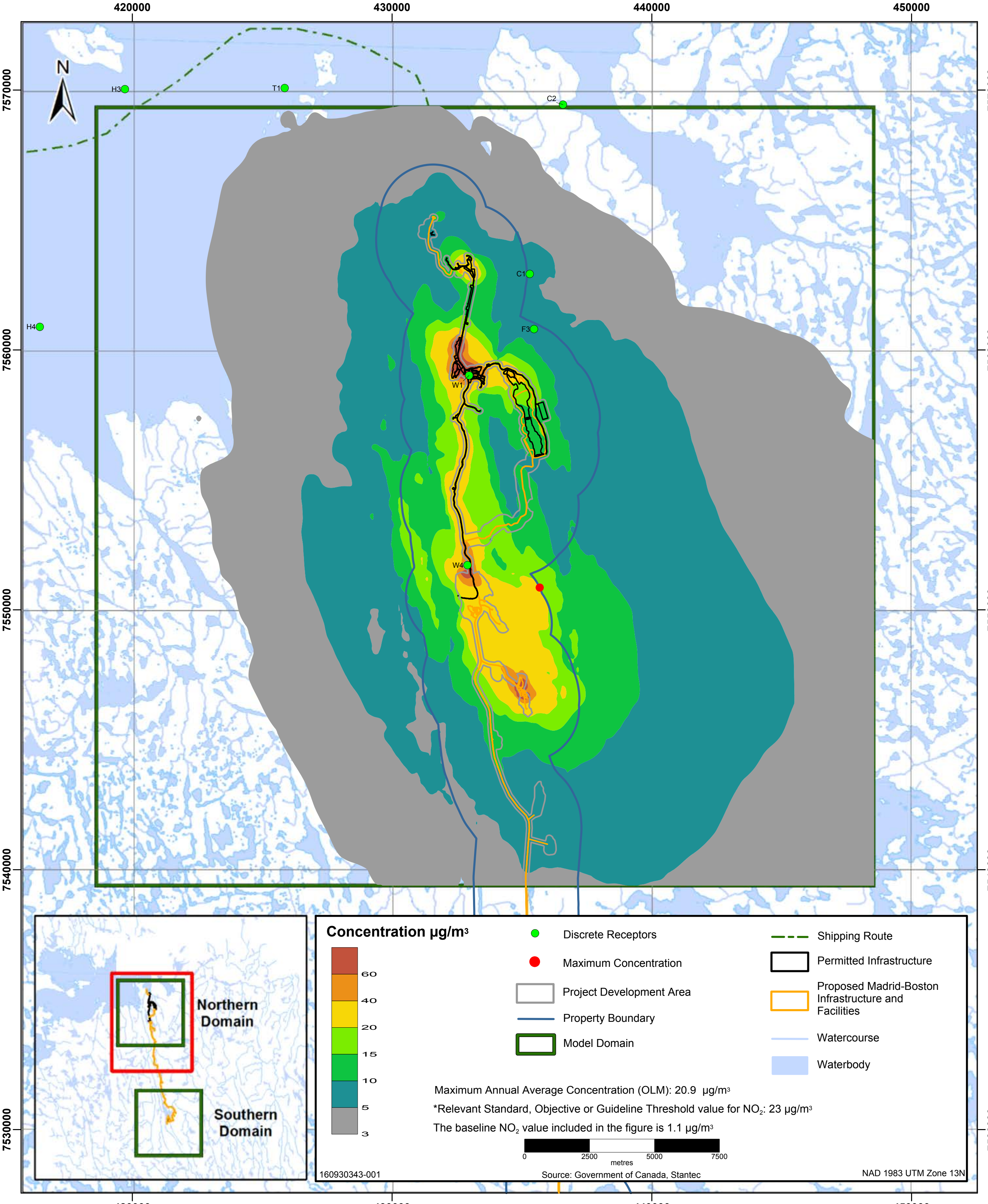


Figure I-8
Maximum Predicted One-hour Average CO Ground-level Concentrations (µg/m³)
Operation, Northern Domain (Madrid North in Alternative Location), the Madrid-Boston Project + Existing Conditions (includes Baseline Conditions)

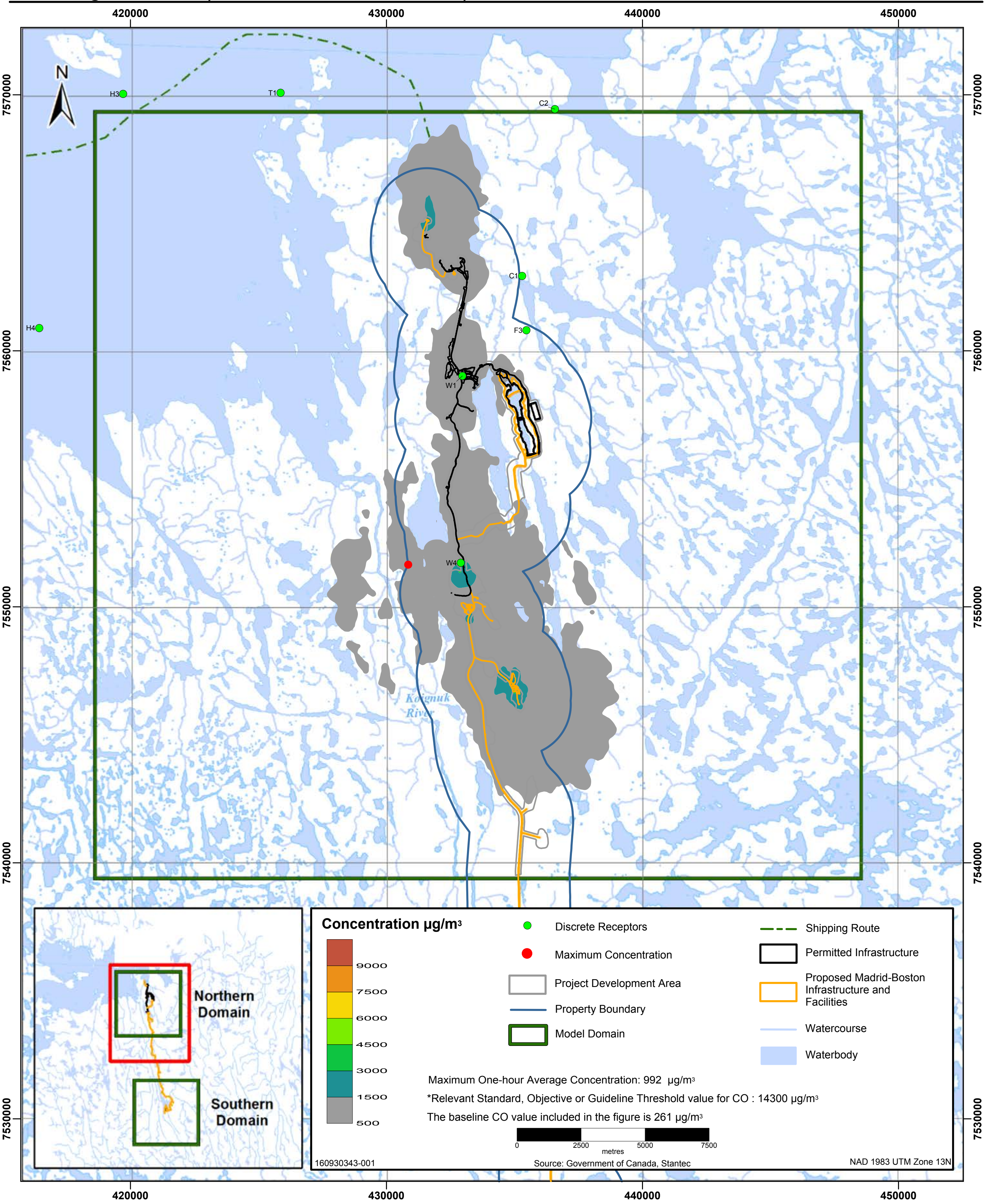


Figure I-9
Maximum Predicted 24-hour Average TSP Ground-level Concentrations (μg/m³) Operation, Northern Domain (Madrid North in Alternative Location), the Madrid-Boston Project + Existing Conditions (includes Baseline Conditions)

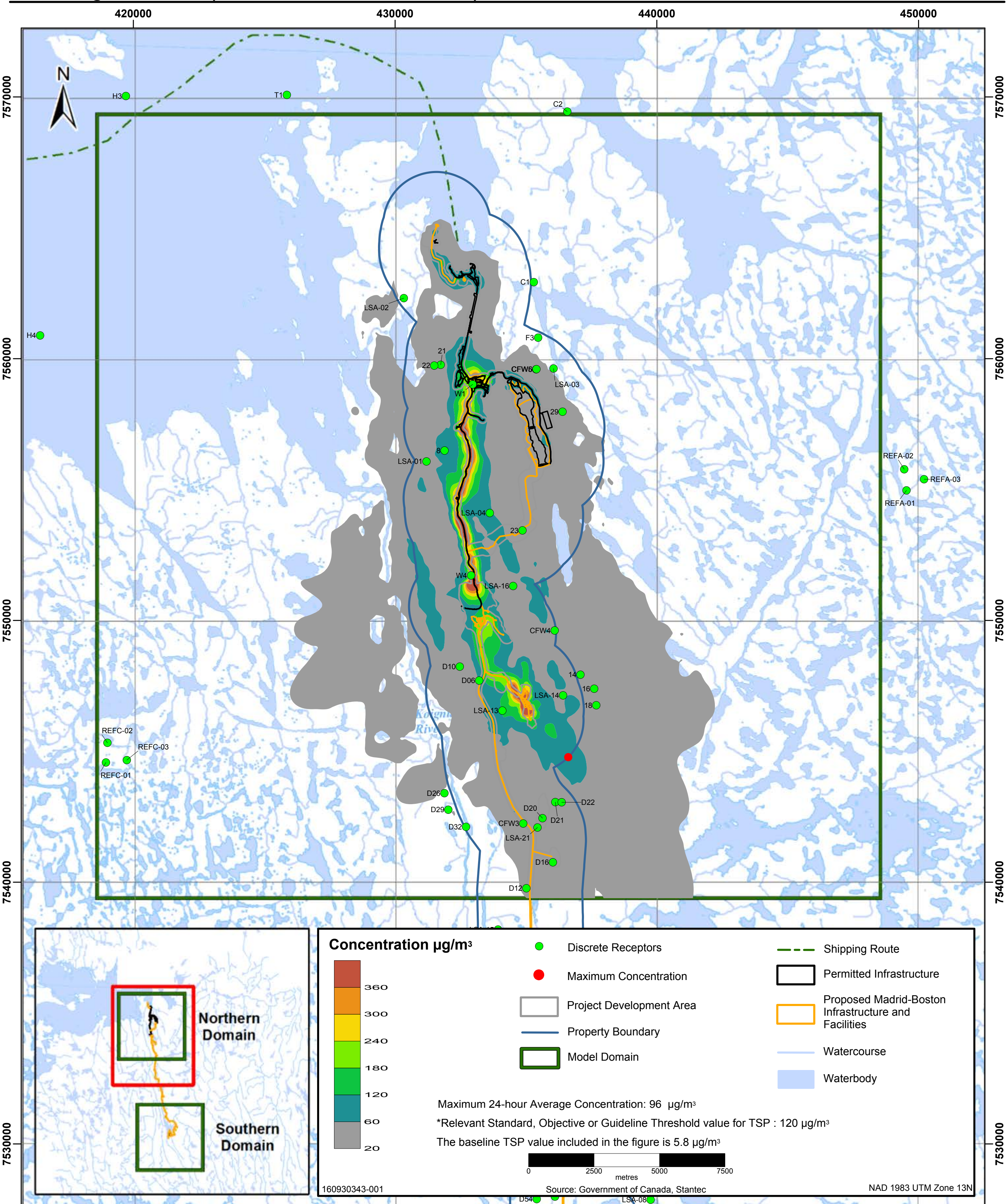


Figure I-10
Maximum Predicted Annual Average TSP Ground-level Concentrations (µg/m³)
Operation, Northern Domain (Madrid North in Alternative Location), the Madrid-Boston Project
+ Existing Conditions (includes Baseline Conditions)

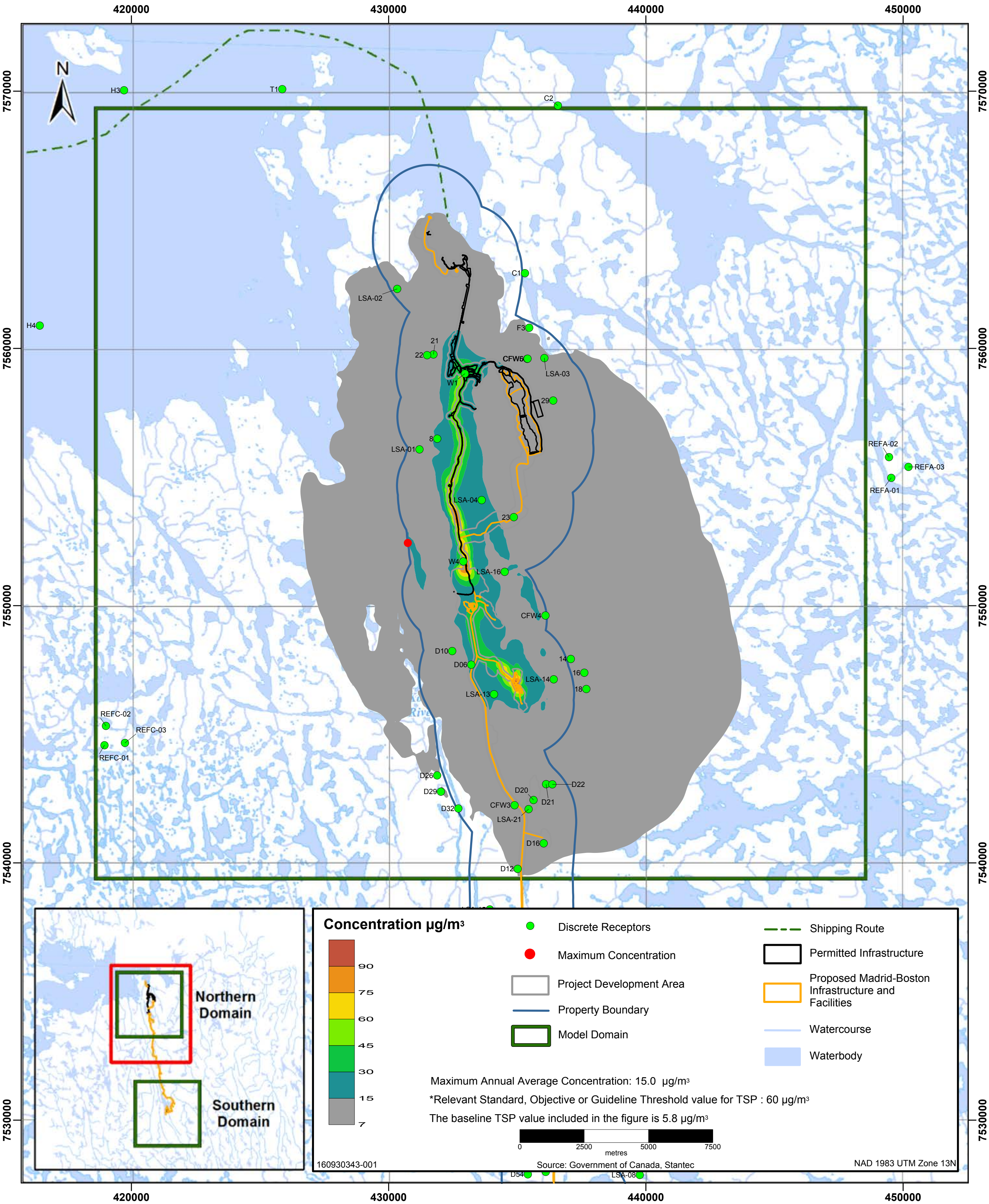


Figure I-11
Maximum Predicted 24-hour Average PM_{10} Ground-level Concentrations (µg/m³)
Operation, Northern Domain (Madrid North in Alternative Location), the Madrid-Boston Project + Existing Conditions (includes Baseline Conditions)

TMAC RESOURCES

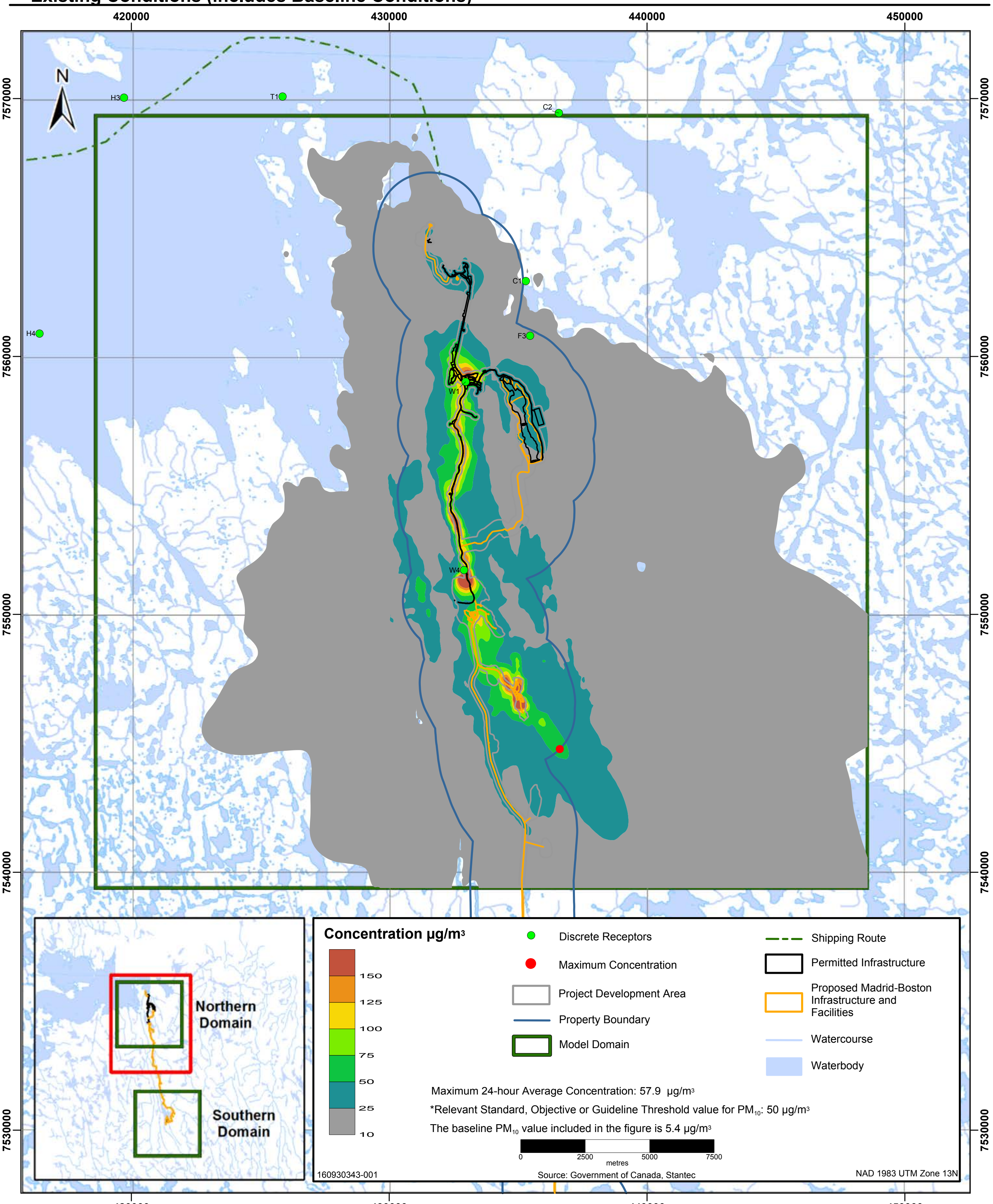


Figure I-12
Frequency of 24-hour Average PM_{10} Concentration Above the Ambient Criteria*
Operation, Northern Domain (Madrid North in Alternative Location), the Madrid-Boston Project + Existing Conditions (includes Baseline Conditions)

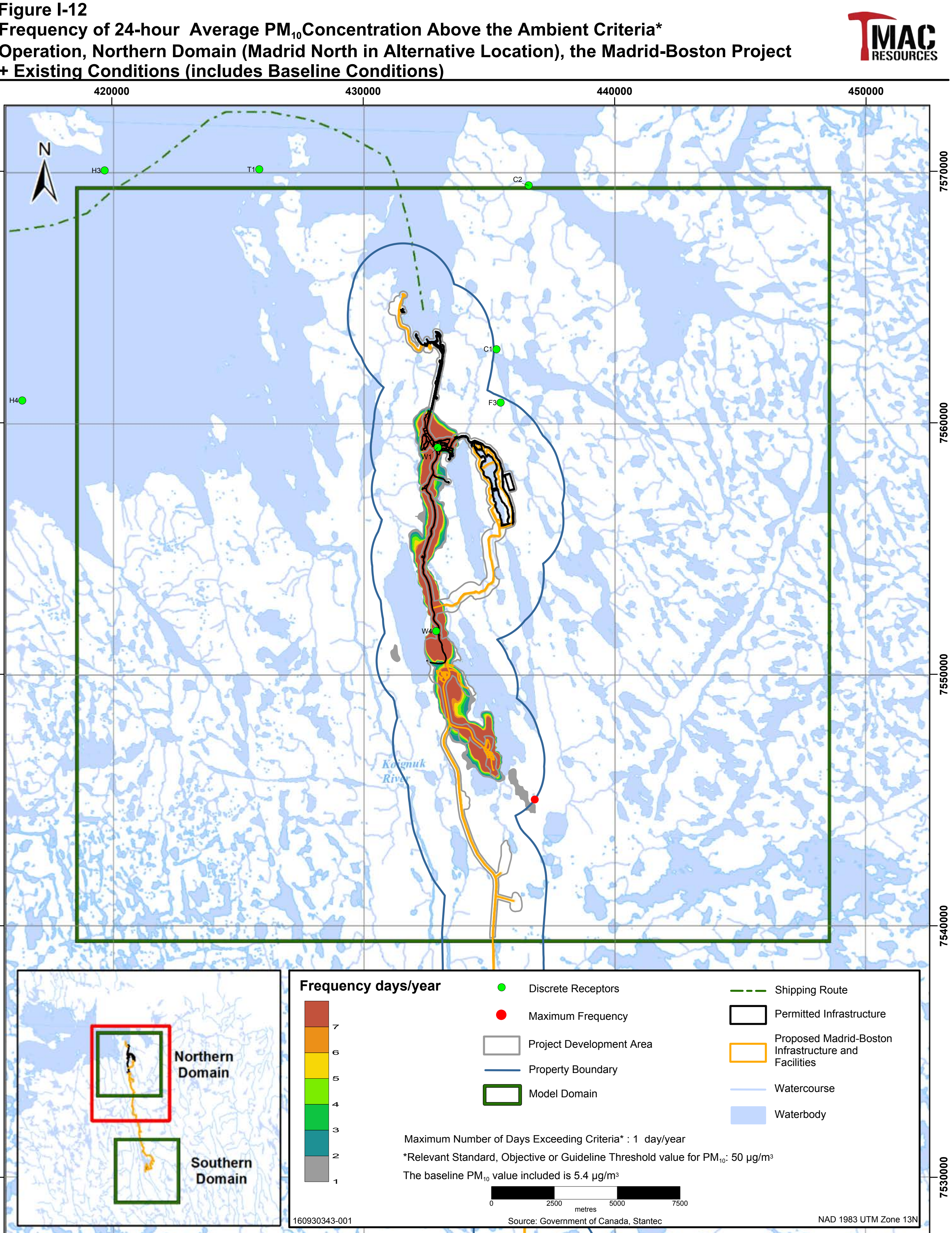


Figure I-13
Predicted 98th Percentile 24-hour Average $PM_{2.5}$ Ground-level Concentrations (µg/m³) Operation, Northern Domain (Madrid North in Alternative Location), the Madrid-Boston Project + Existing Conditions (includes Baseline Conditions)

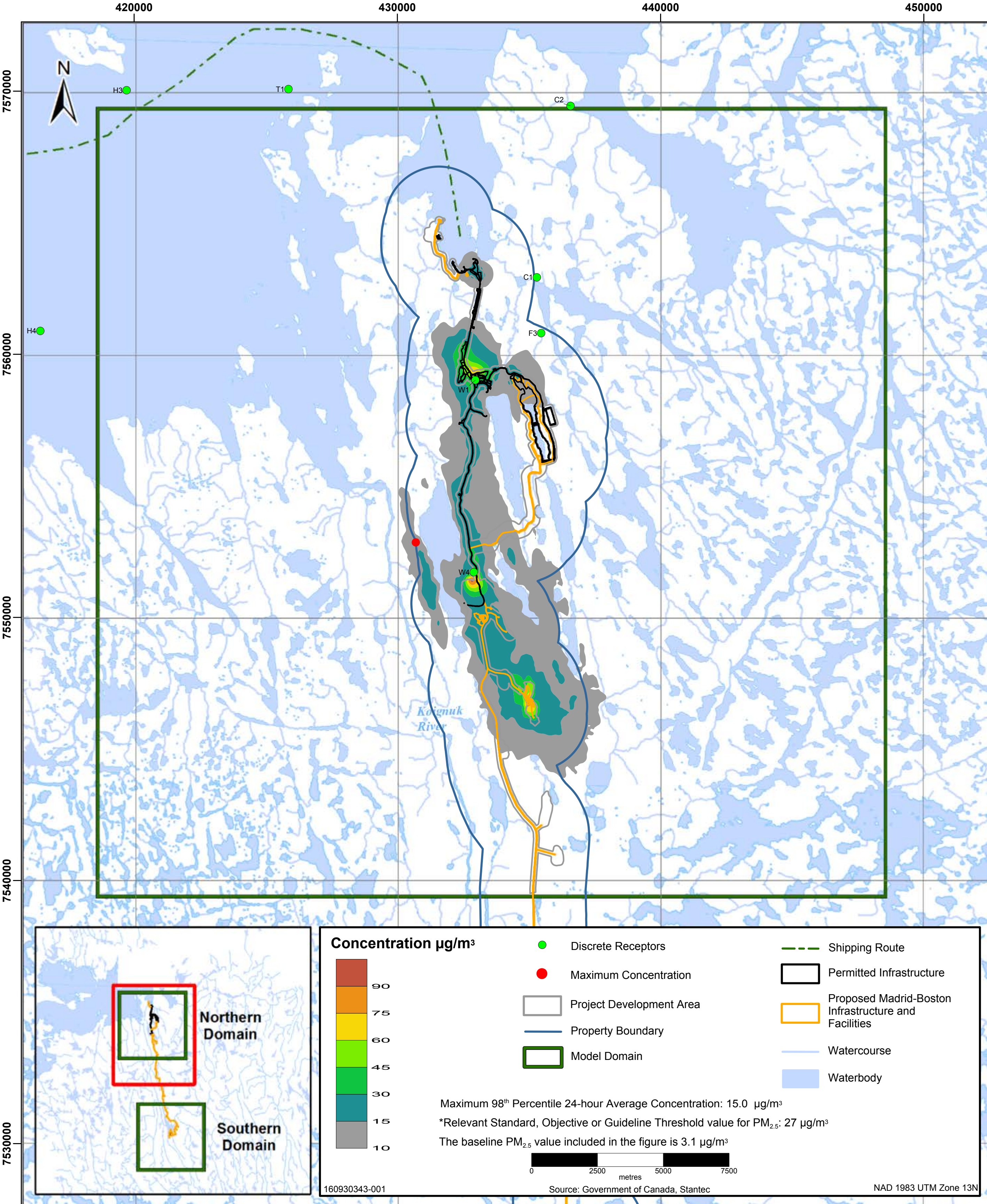


Figure I-14

Maximum Predicted Annual Average $PM_{2.5}$ Ground-level Concentrations (µg/m³)
Operation, Northern Domain (Madrid North in Alternative Location), the Madrid-Boston Project + Existing Conditions (includes Baseline Conditions)

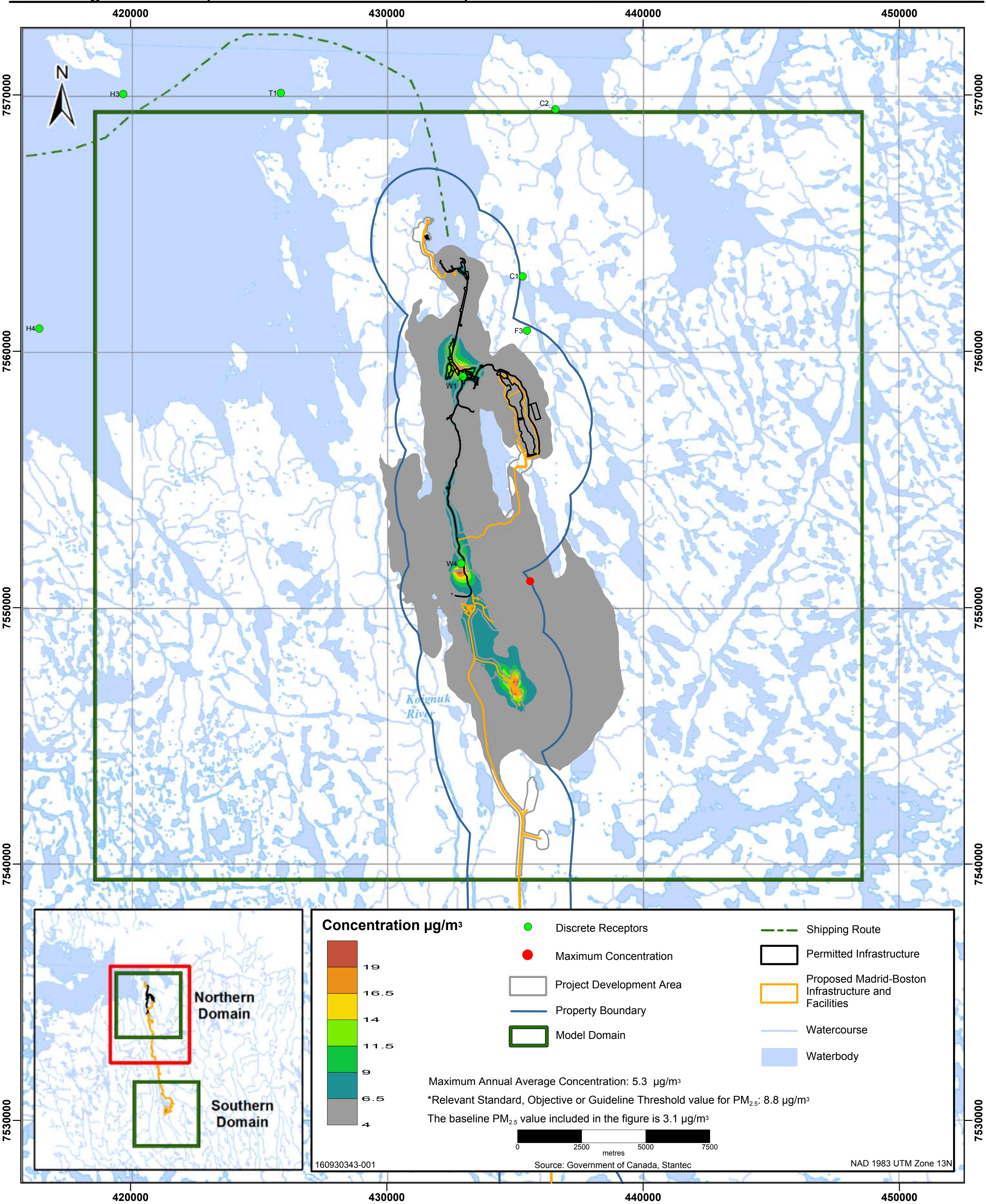
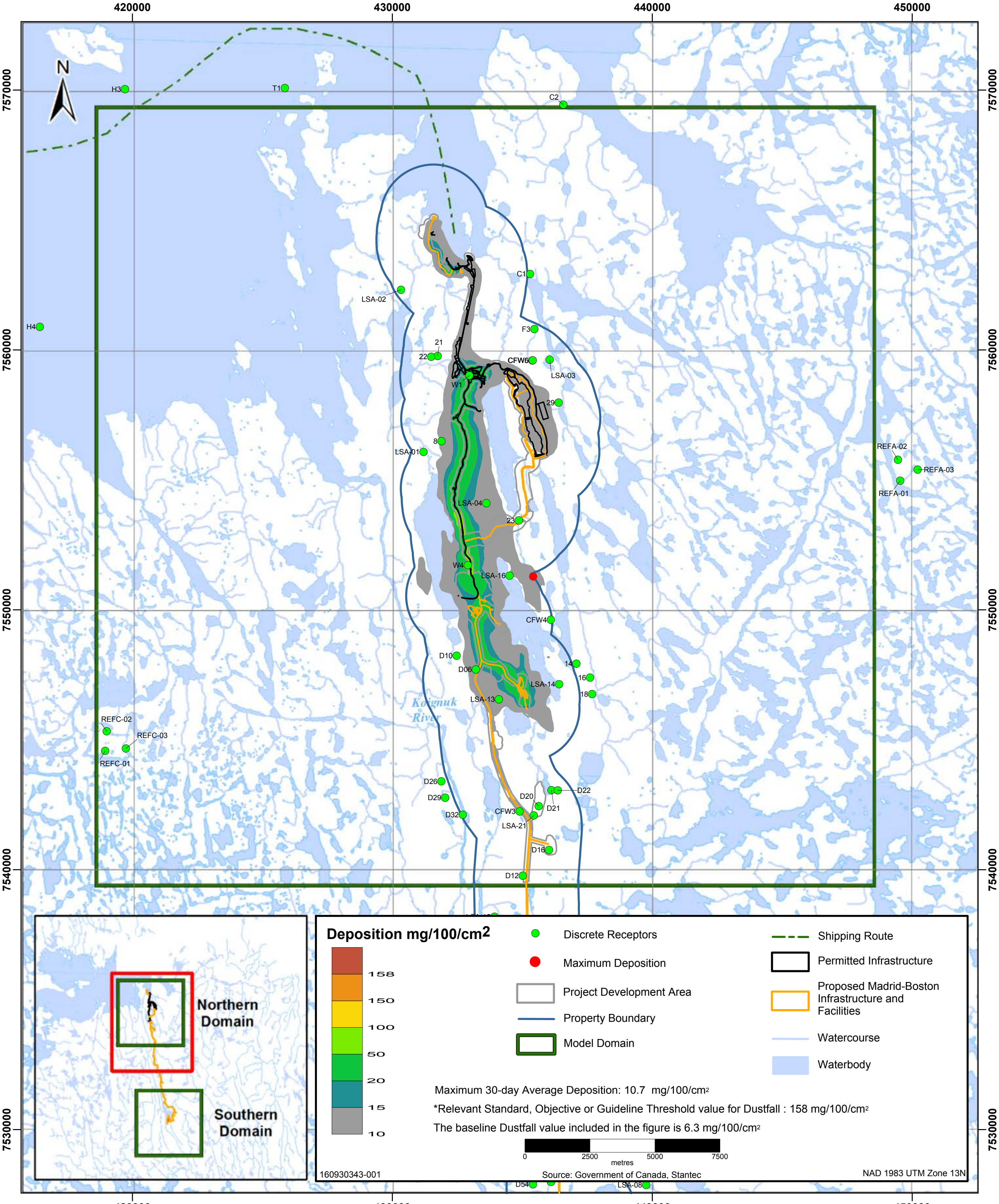


Figure I-15

Maximum Predicted 30-day Average Dustfall Ground-level Deposition (mg/100/cm²) Operation, Northern Domain (Madrid North in Alternative Location), the Madrid-Boston Project + Existing Conditions (includes Baseline Conditions)



APPENDIX J

Concentration Contour Plots for the Southern Domain, the Madrid-Boston Project (includes Baseline Conditions), Operation

Figure J-1

Predicted 99th Percentile Daily Maximum SO_2 Ground-level Concentrations (µg/m³)

Operation, Southern Domain, the Madrid-Boston Project Only (includes Baseline Conditions)

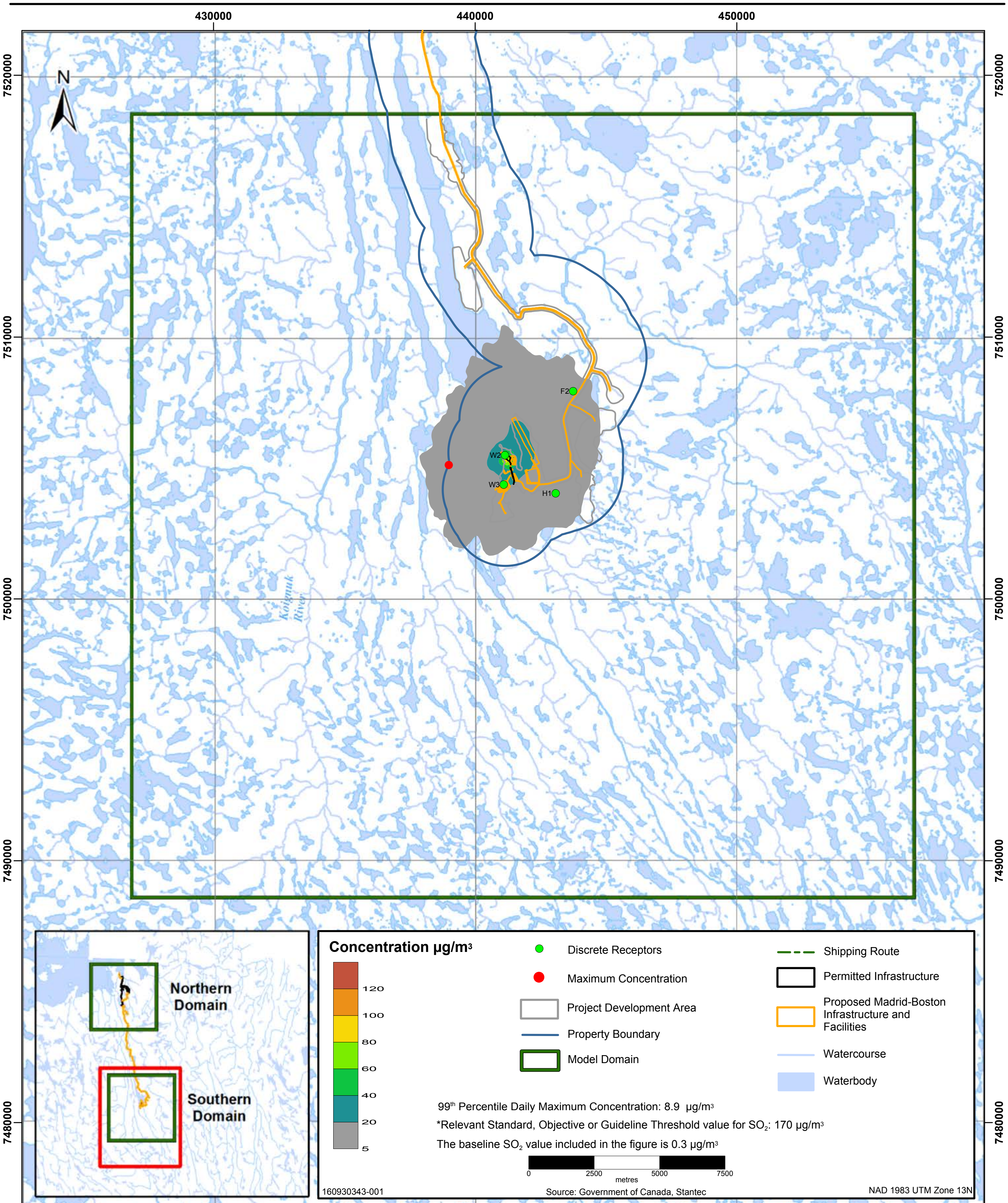


Figure J-2

Maximum Predicted 24-hour Average SO_2 Ground-level Concentrations (µg/m³)
Operation, Southern Domain, the Madrid-Boston Project Only (includes Baseline Conditions)

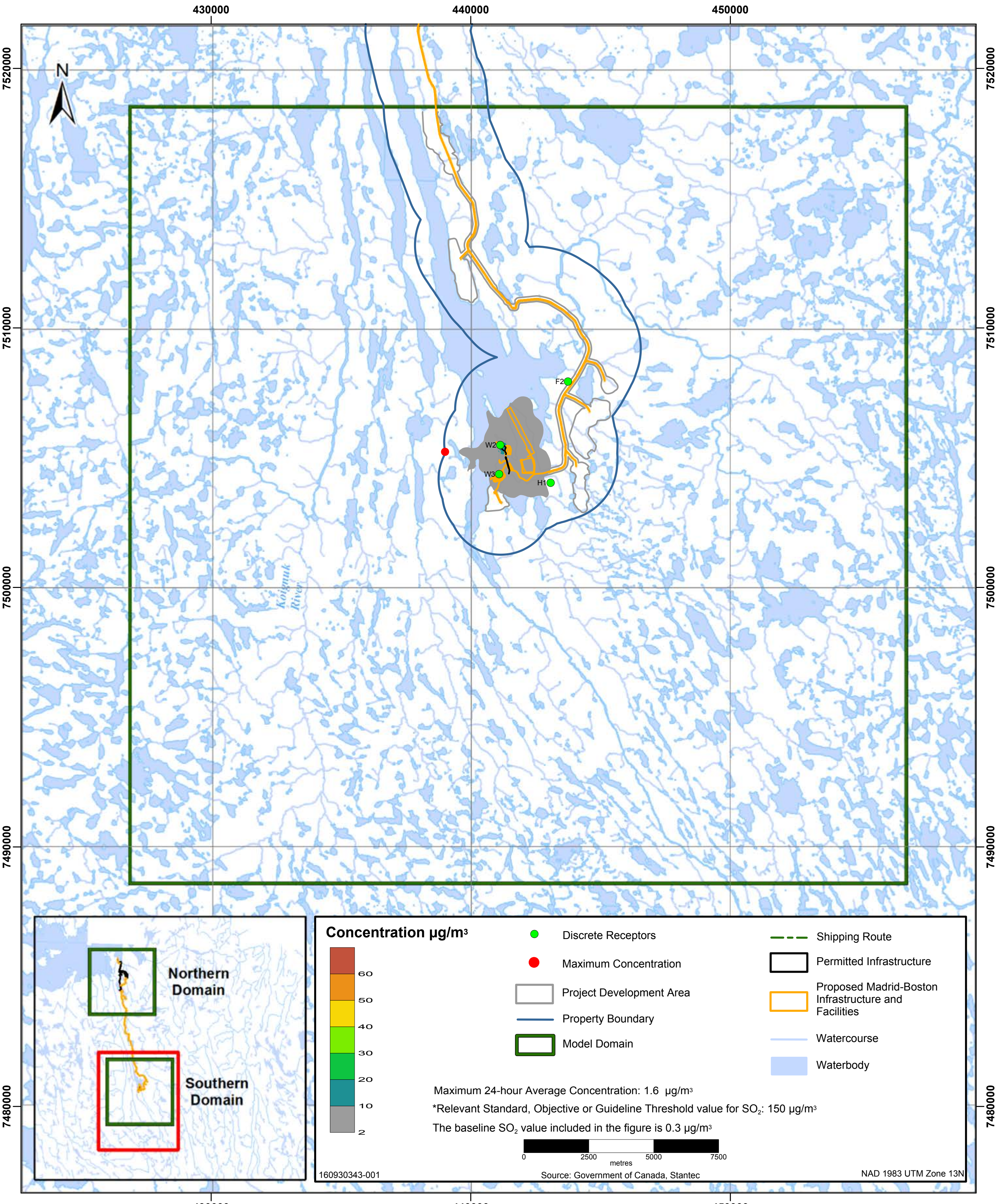


Figure J-3
Maximum Predicted Annual Average SO_2 Ground-level Concentrations (µg/m³)
Operation, Southern Domain, the Madrid-Boston Project Only (includes Baseline Conditions)

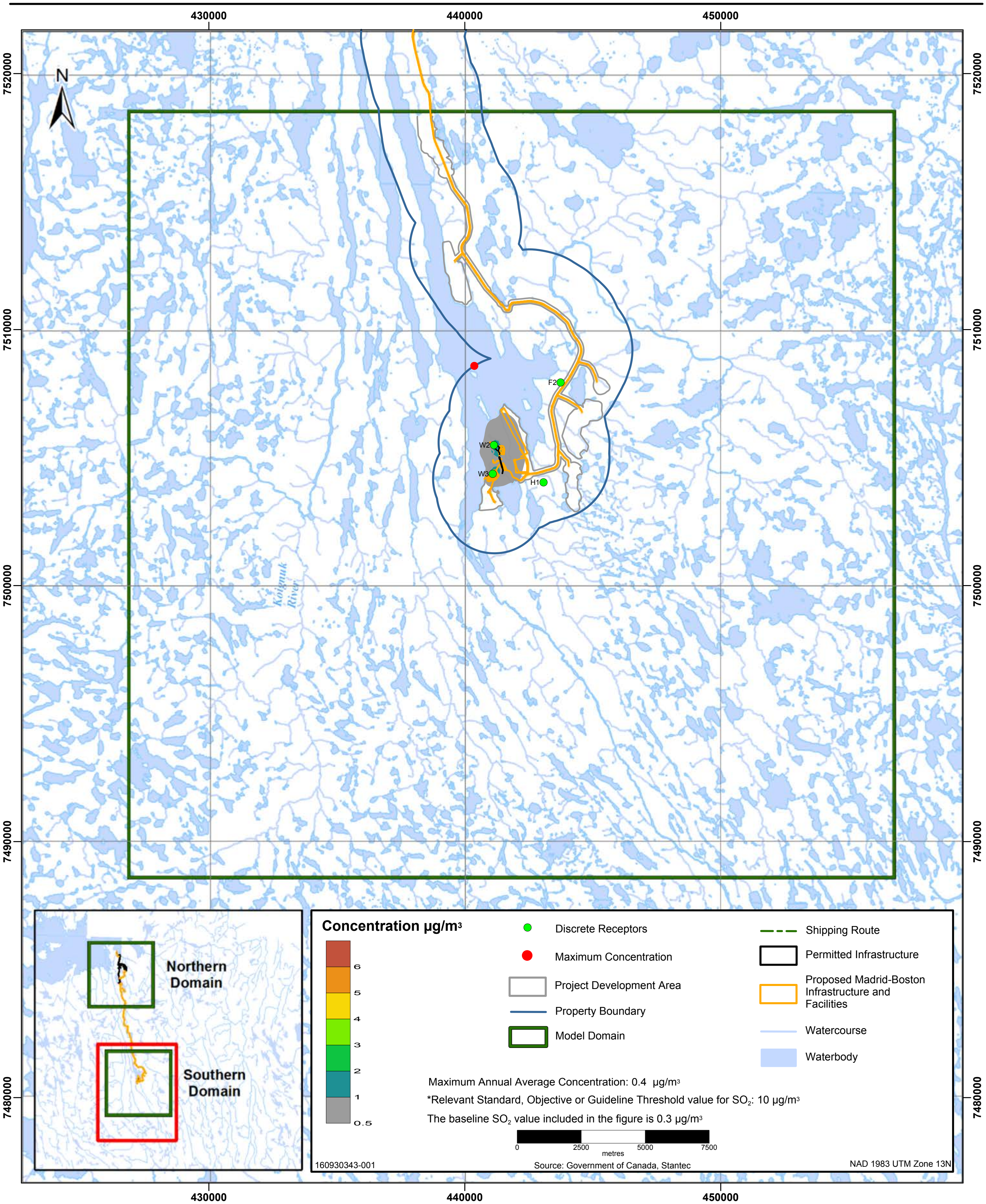


Figure J-4
Predicted 98th Percentile Daily Maximum NO_2 Ground-level Concentrations (μg/m³)
Operation, Southern Domain, the Madrid-Boston Project Only (includes Baseline Conditions)

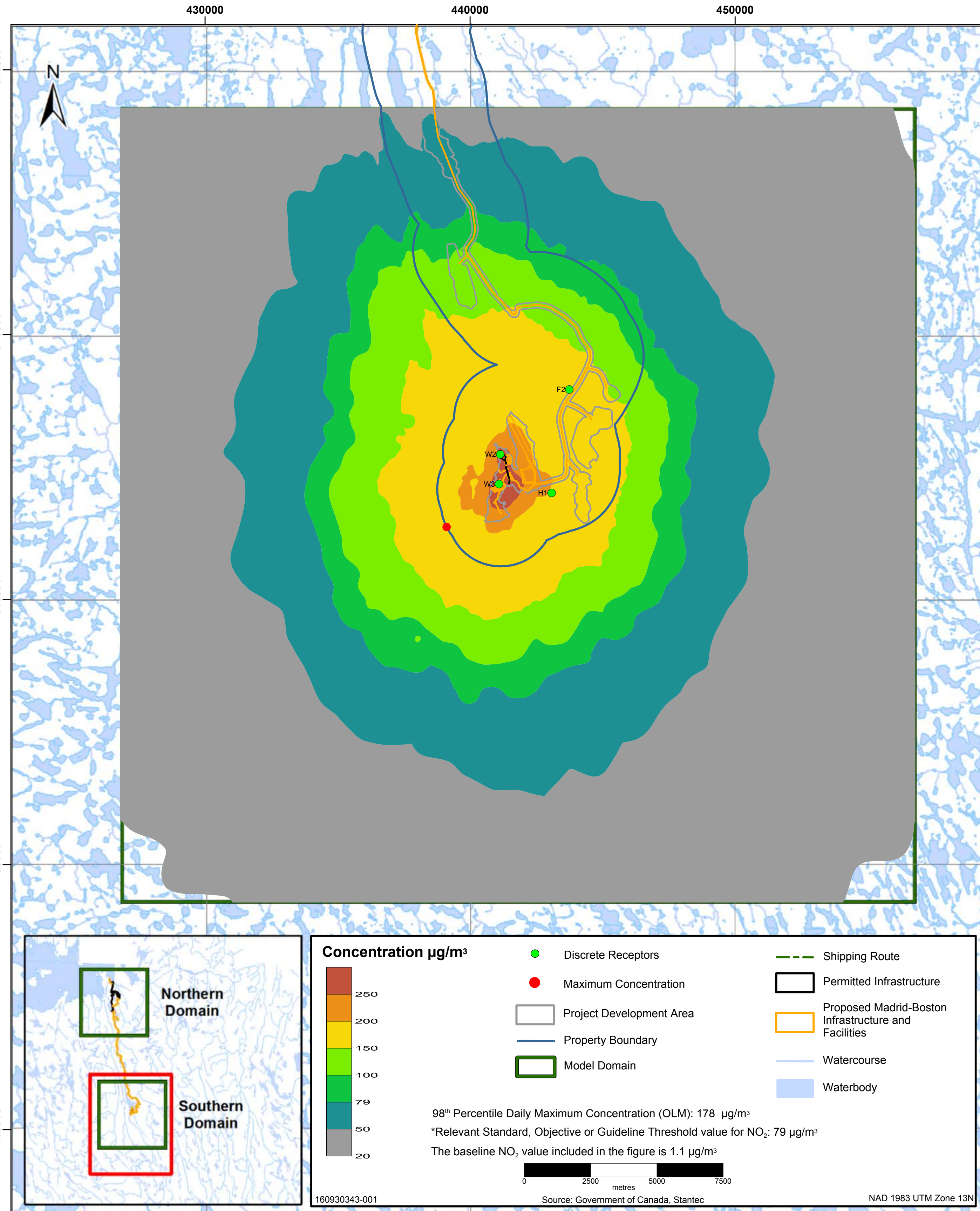


Figure J-5
Frequency of 98th Percentile Daily Maximum NO_2 Concentration Above the Ambient Criteria*
Operation, Southern Domain, the Madrid-Boston Project Only (includes Baseline Conditions)

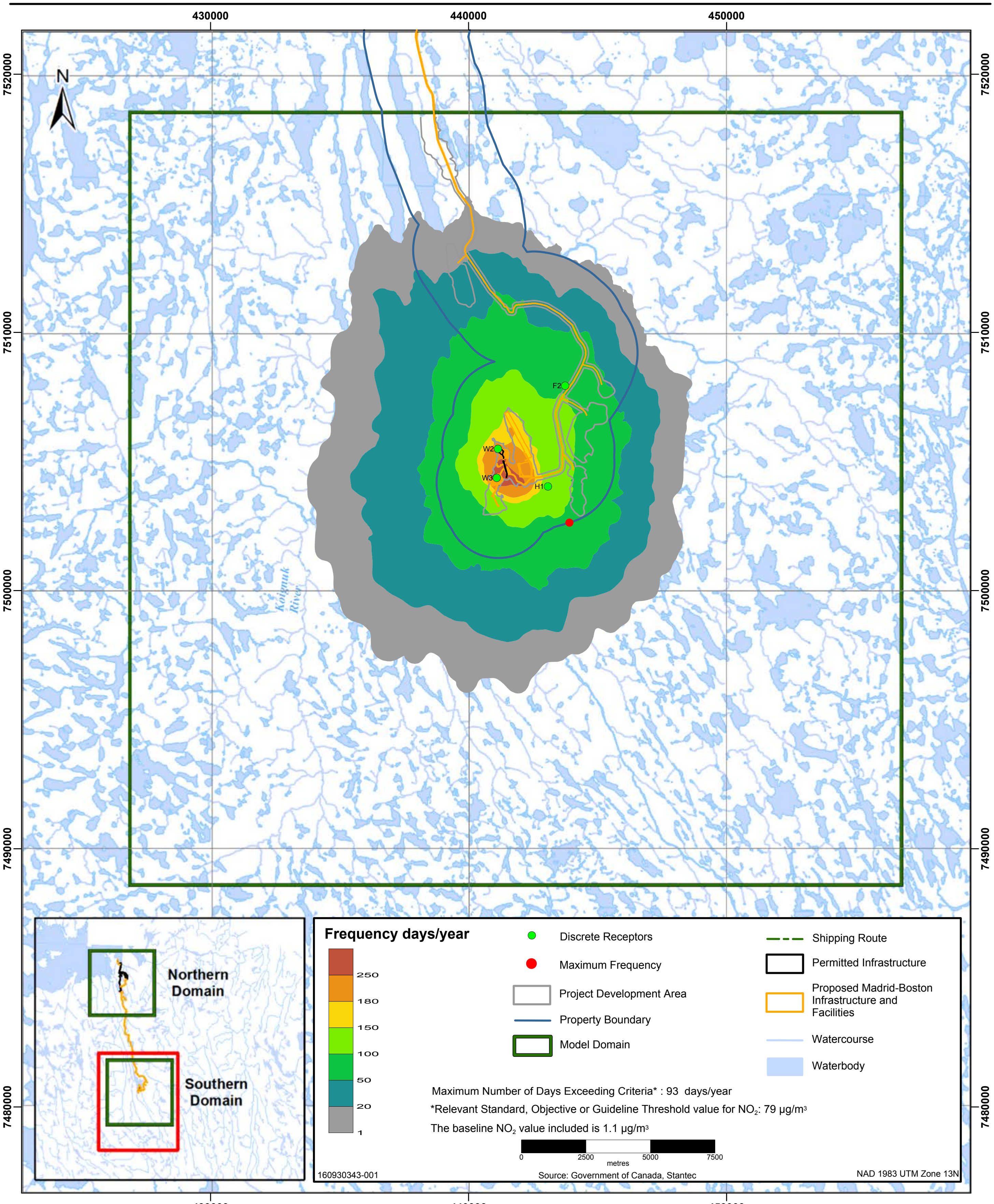


Figure J-6
Maximum Predicted 24-hour Average NO_2 Ground-level Concentrations (µg/m³)
Operation, Southern Domain, the Madrid-Boston Project Only (includes Baseline Conditions)

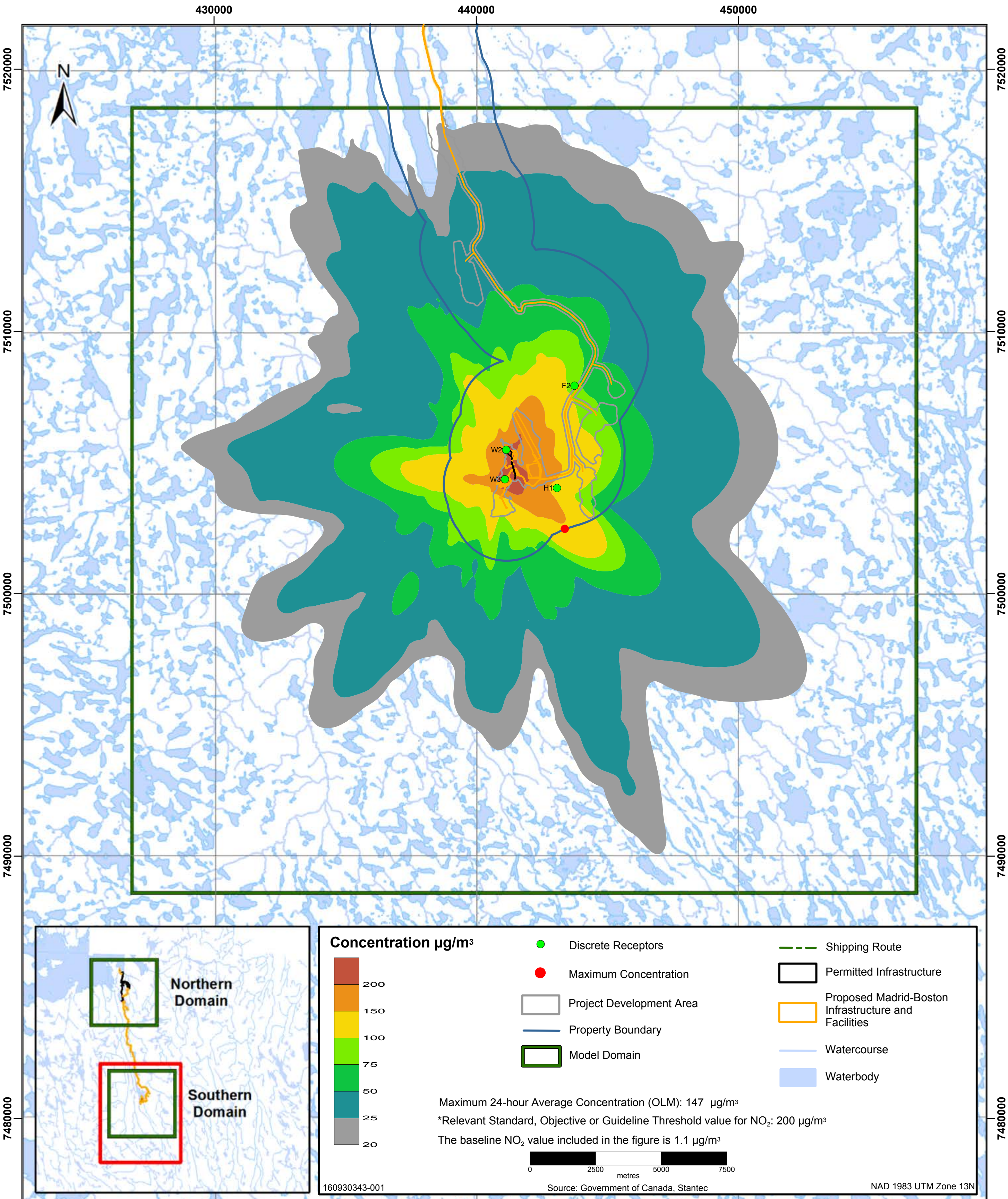


Figure J-7
Maximum Predicted Annual Average NO_2 Ground-level Concentrations (µg/m³)
Operation, Southern Domain, the Madrid-Boston Project Only (includes Baseline Conditions)

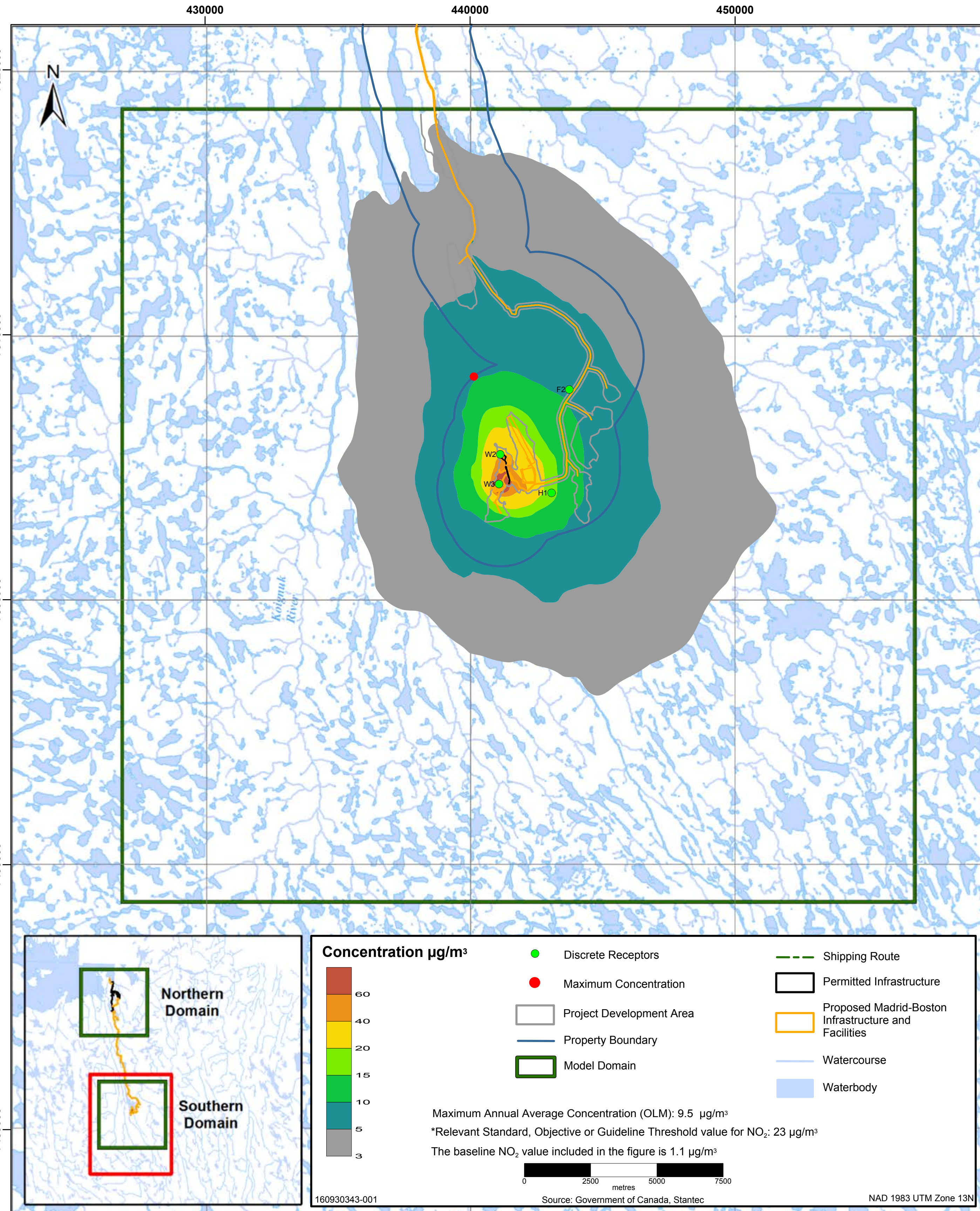


Figure J-8
Maximum Predicted One-hour Average CO Ground-level Concentrations (µg/m³) Operation, Southern Domain, the Madrid-Boston Project Only (includes Baseline Conditions)

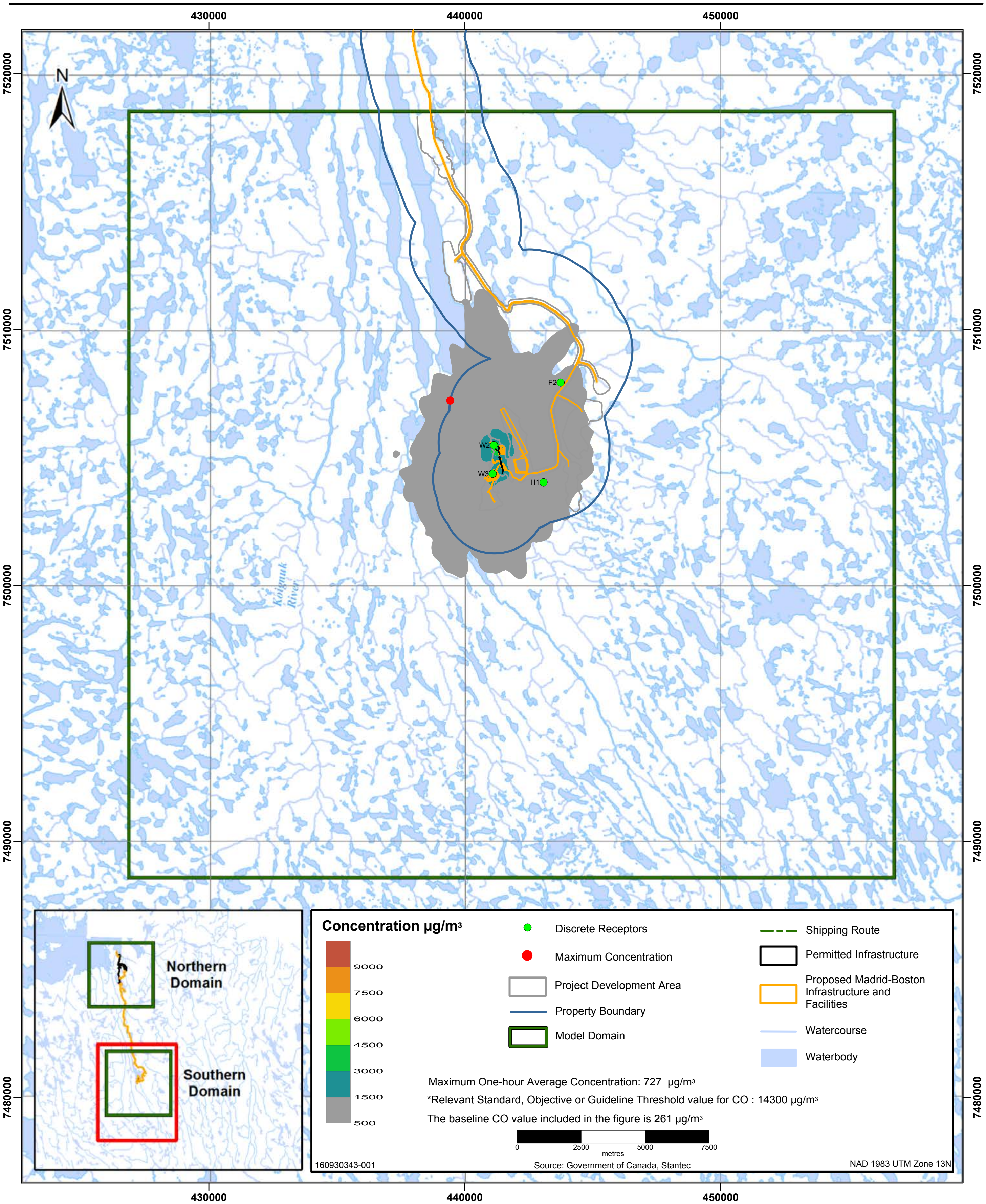


Figure J-9
Maximum Predicted 24-hour Average TSP Ground-level Concentrations (µg/m³)
Operation, Southern Domain, the Madrid-Boston Project Only (includes Baseline Conditions)

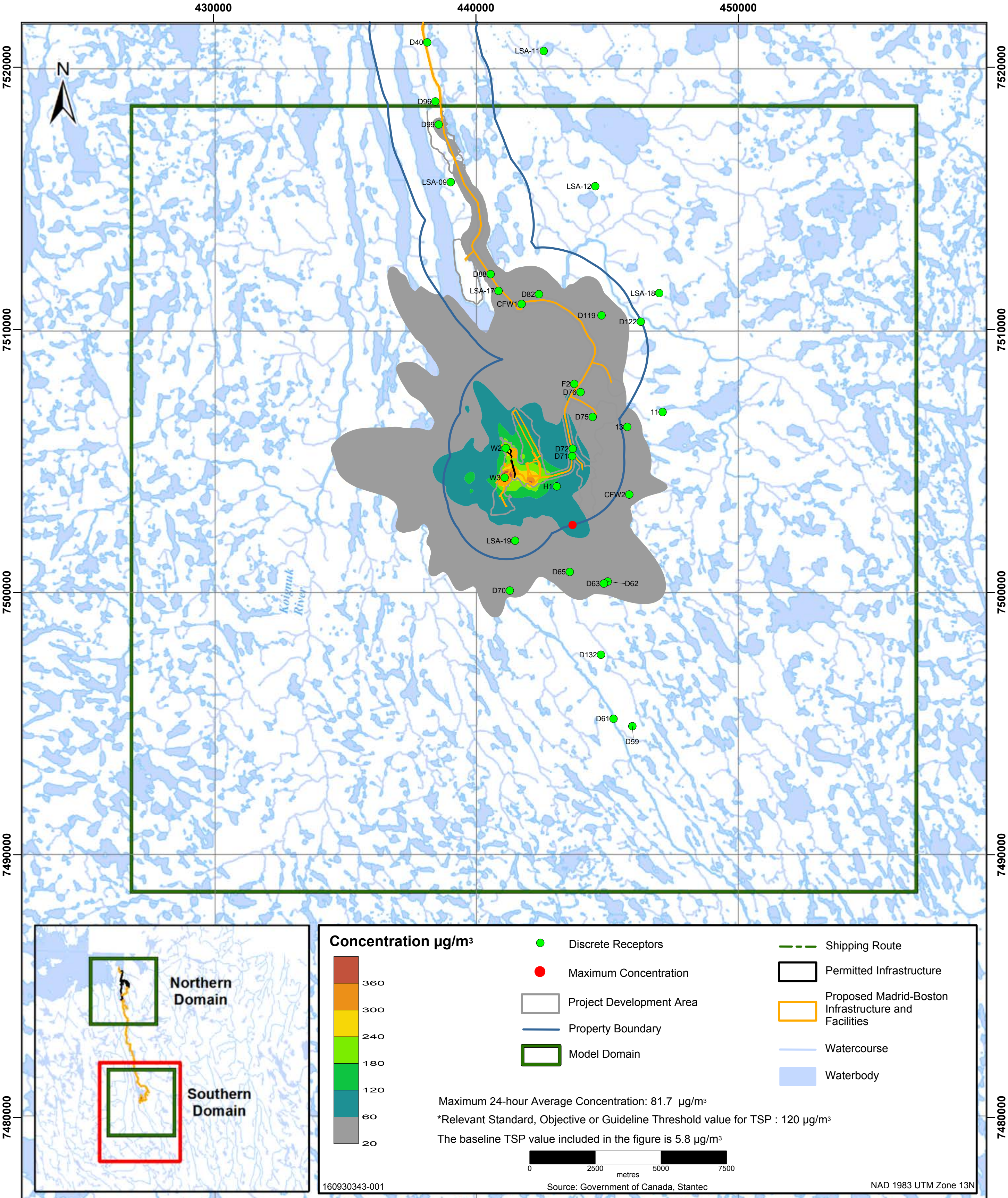


Figure J-10
Maximum Predicted Annual Average TSP Ground-level Concentrations (µg/m³)
Operation, Southern Domain, the Madrid-Boston Project Only (includes Baseline Conditions)

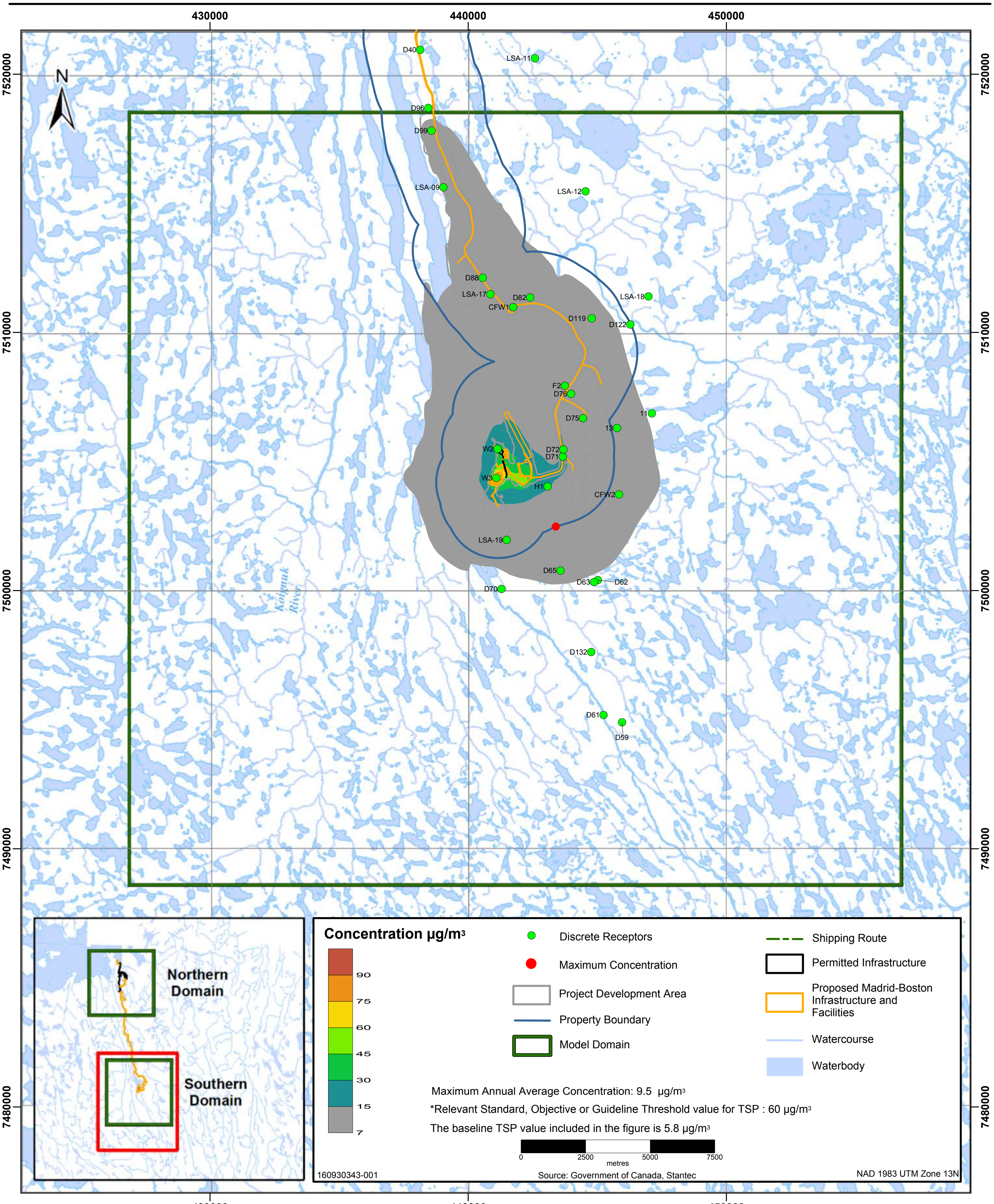


Figure J-11
Maximum Predicted 24-hour Average PM_{10} Ground-level Concentrations (µg/m³)
Operation, Southern Domain, the Madrid-Boston Project Only (includes Baseline Conditions)

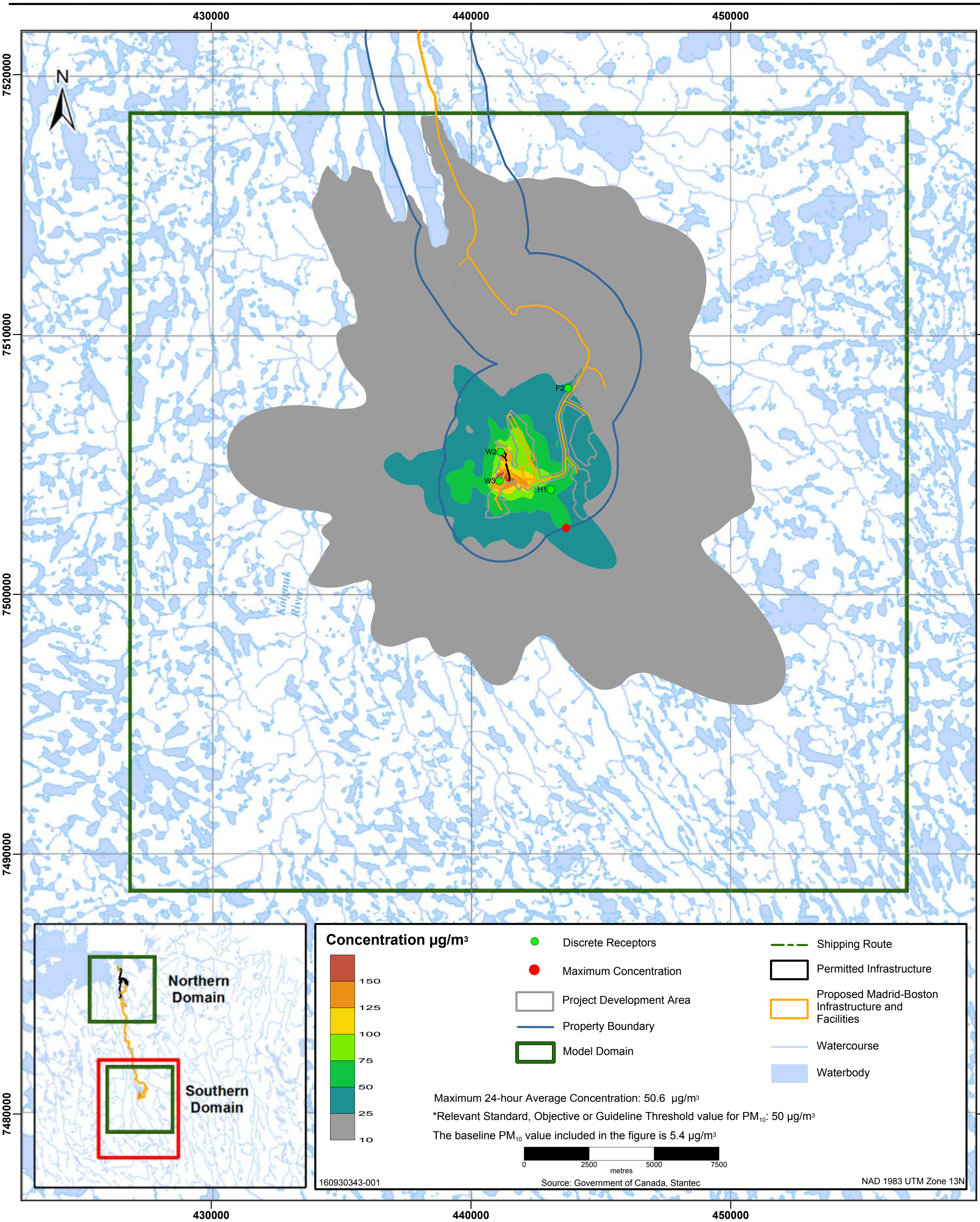


Figure J-12
Frequency of 24-hour Average PM_{10} Concentration Above the Ambient Criteria*
Operation, Southern Domain, the Madrid-Boston Project Only (includes Baseline Conditions)

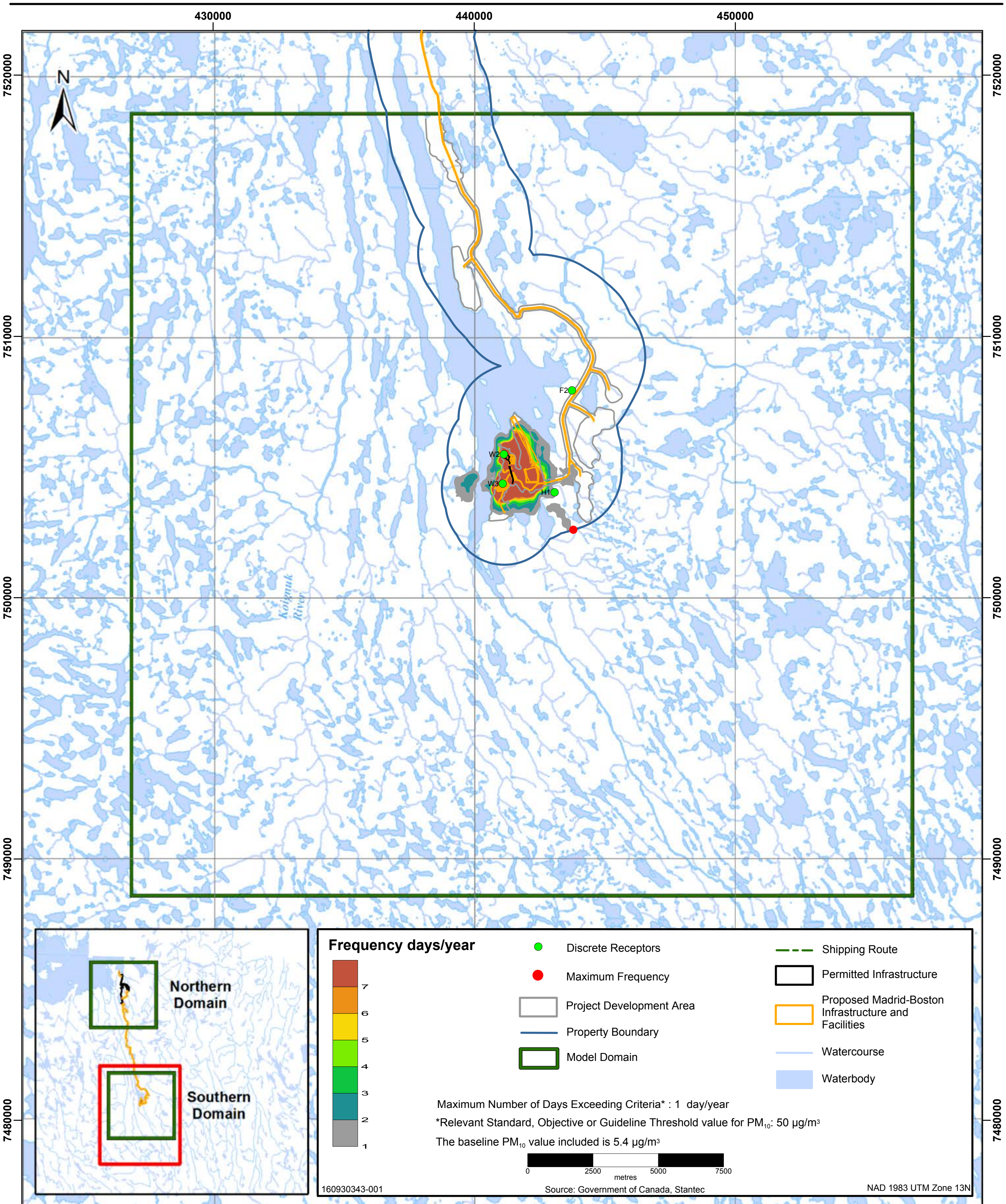


Figure J-13
Predicted 98th Percentile 24-hour Average $PM_{2.5}$ Ground-level Concentrations (µg/m³) Operation, Southern Domain, the Madrid-Boston Project Only (includes Baseline Conditions)

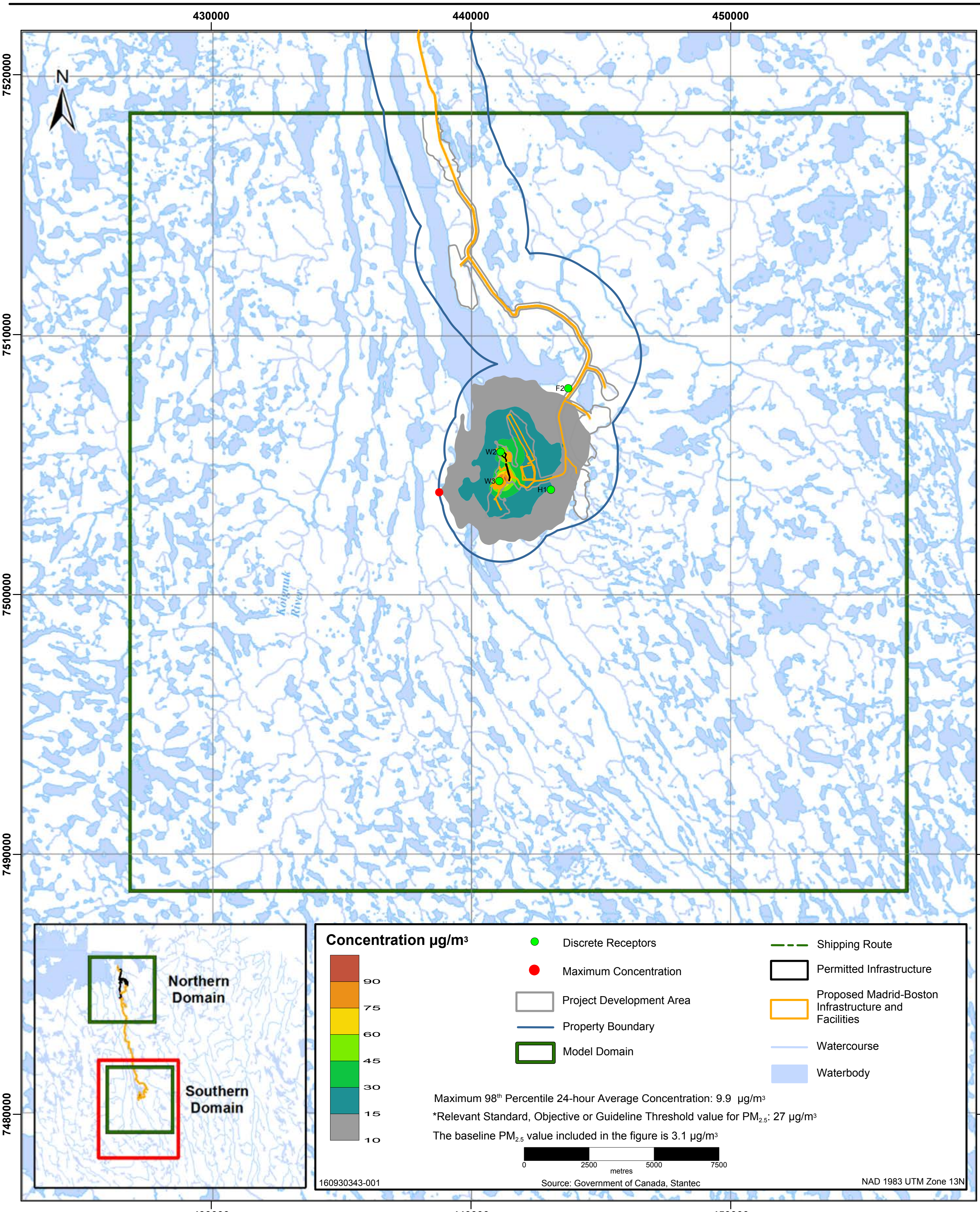


Figure J-14

Maximum Predicted Annual Average $PM_{2.5}$ Ground-level Concentrations (µg/m³)
Operation, Southern Domain, the Madrid-Boston Project Only (includes Baseline Conditions)

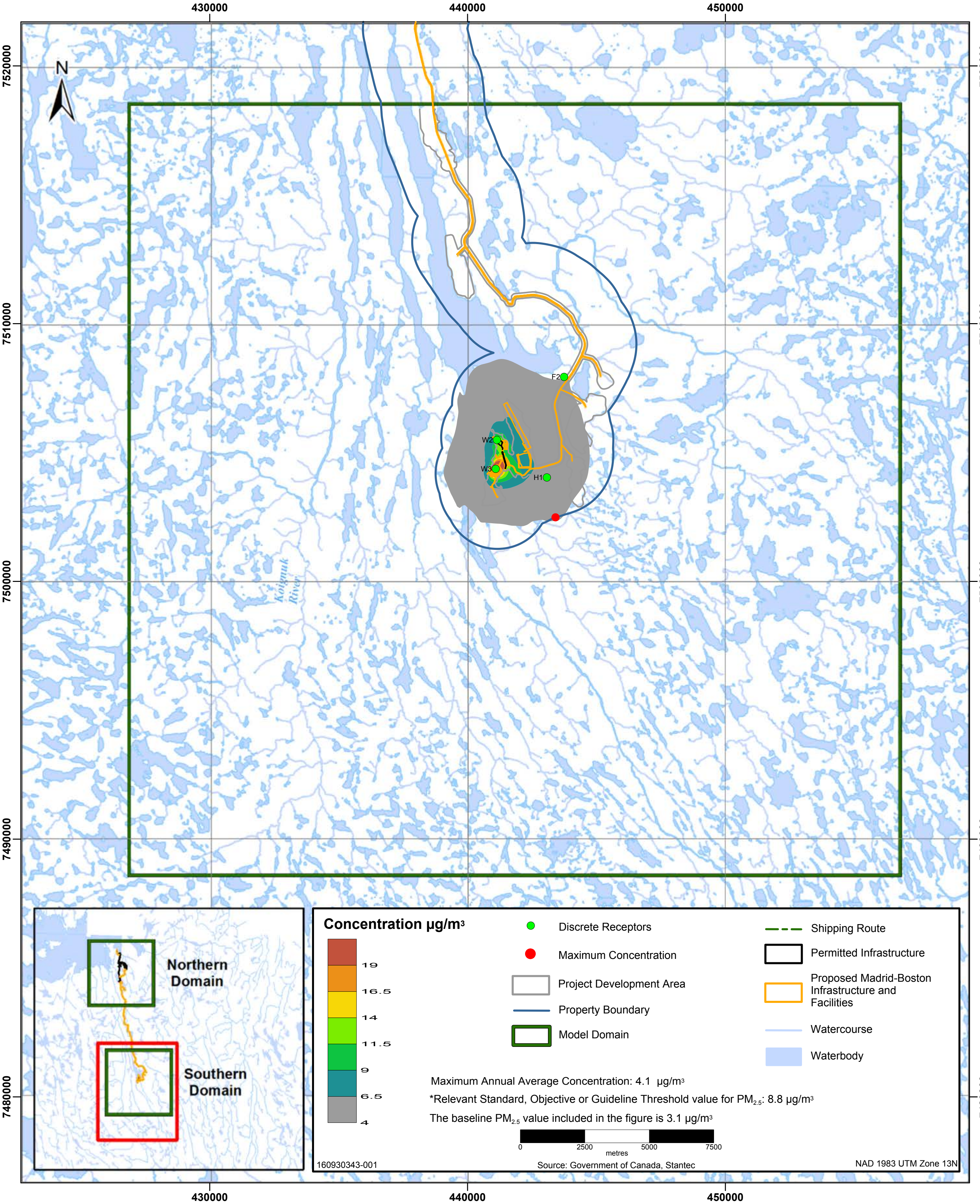


Figure J-15
Maximum Predicted 30-day Average Dustfall Ground-level Deposition (mg/100/cm2)
Operation, Southern Domain, the Madrid-Boston Project Only (includes Baseline Conditions)