Vermont Agency of Natural Resources
Departmentof Environmental Conservation:
Air Pollution Control Division

Air Quality Data and Observations Made in Vermont during the November 2006 Trial Burn of Tire Derived Fuel at the International Paper Company, Ticonderoga, New York

Final Report
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Executive Summary

In September of 2003 the International Paper Company (IP) submitted a request to the State of New York Department of Environmental Conservation (NYDEC) for approval to conduct a trial burn of tire fuel in their Power boiler. IP proposed to burn shredded tires, referred to as tire-derived-fuel (TDF), at a rate of up to 3 tons per hour; which is approximately 10% of the heat input capacity of the 855 million BTU per hour Power boiler. The Power boiler burns predominantly No.6 fuel oil but also has solid fuel burning capability. IP typically burns wood/bark at a rate of 425 tons per day which is approximately 20% of the boiler capacity. IP proposed to maintain the wood/bark firing at a constant rate and mix in increasing amounts of TDF as No.6 fuel oil was to be decreased proportionately. TDF use at the facility was intended to displace No.6 fuel oil usage and lower the mill's energy costs.

The State of Vermont formally raised concerns and objections with IP and the NYDEC with the proposal based on the belief that the Power boiler was not fitted with appropriate exhaust gas clean-up technology to properly control the effluent from burring tire-derived fuel. However, seeing that there was a likelihood that the project would be moving forward, the Vermont Agency of Natural Resources, Department of Environmental Conservation, Air Pollution Control Division (APCD) was tasked with conducting ambient air quality monitoring to determine IP's impact on Vermont in the event the trial proceeded. Identifying and isolating IP's impact on ambient air quality in Vermont from all other sources of air contaminants was expected to be difficult given the likely small impacts attributable to the plant compared to existing ambient levels. The general network design thought best to accomplish this goal was to locate two air quality monitoring sites in the vicinity of the plant; one "upwind" and one "downwind" of the plant. To this end, two nearly identical monitoring stations were established, one northeast of the plant and one southeast of the plant, both in the town of Shoreham and approximately 2.5 miles distant from the plant. The locations were selected based on modeling of the most likely and significant areas of impact. Assuming IP's emission plume would only impact one monitoring station simultaneously, the difference between the ambient levels at the two stations when IP's plume was impacting one could be inferred to be due to a local source such as IP.

The two monitoring stations began collecting samples in late 2003. The monitoring consisted of every six day sampling (24 hour samples) for particulate matter less than 10 microns in size (PM_{10}) and fine particulate matter less than 2.5 microns in size ($PM_{2.5}$). TDF combustion is most associated with an increase in fine particulate matter due to the presence of zinc oxide in the tires themselves that forms fine particles when burned and therefore was expected to be difficult to control with the existing emission control devices in place at IP. These early monitoring samples prior to the trial burn would provide a background level on which to compare readings during the trial. Differences in the readings at the two stations could also indicate an impact associated with IP's current operations without TDF. While there were several instances where the two monitors detected slight differences in ambient levels prior to the trial burn, it was not possible to definitively determine the reason or identify the source of the difference as being related to IP operations.

Two weeks prior to the trial burn that began on November 6, 2006 the APCD ramped up monitoring efforts, increasing particulate sampling to every day. To supplement and enhance the APCD air quality measurements during the trial, the APCD contracted with three external research groups to conduct additional air quality monitoring. This supplemental monitoring included: gaseous elemental, reactive gaseous and particulate mercury at the Shoreham North site; continuous hourly measurements of $PM_{2.5}$ mass by FDMS TEOM, SO_2 gas, SO_4 aerosol, organic carbon, elemental carbon, polycyclic aromatic hydrocarbons (PAH), light absorption

(aethalometer) and particle size distributions at the Shoreham North site; daily PUF sampling for organic analysis and daily filter sampling using $PM_{2.5}$ speciation samplers at both Shoreham sites, collecting 24-hour fine particle samples for subsequent lab analyses for gravimetric mass, major inorganic ions (SO_4=, NO_3-, Cl-, NH_4+), elemental and organic carbon and trace elements by X-Ray Florescence (XRF); and an 8-stage DRUM sampler (Davis Rotating Unit for Monitoring) at both Shoreham sites which collect size-fractionated particle samples in 8 size ranges: 10 to 5.0 um, 5.0 to 2.5, 2.5 to 1.15, 1.15 to 0.75, 0.75 to 0.56, 0.56 to 0.34, 0.34 to 0.26, 0.26 to 0.09 um. It was the DRUM samplers where the most likely signature of the trial burn on ambient air quality levels was expected to be found.

The trial burn began on Monday November 6, 2006 with baseline testing of the Power boiler with the normal fuel mix of bark and oil and no TDF. Baseline particulate emissions were measured at a respectable 0.043 lbs/MMBtu for this boiler. TDF was first fired in the Power boiler on Tuesday November 7, 2006 at a rate of 0.5 tons per hour and soon thereafter increased to 1.0 tons per hour. IP monitored boiler operation at this rate throughout the day but did not conduct stack testing for particulates this day. TDF feed was shut off for the night and resumed again Wednesday morning. IP again monitored boiler operations while firing TDF throughout the day and most of the evening at this rate and began particulate matter stack testing on Thursday morning. The preliminary results showed particulate emissions to be elevated at 0.08 to 0.09 lbs/MMMBtu in the first two test runs. TDF feed was shut off following these preliminary results without a third test run and resumed Friday at 0.5 tons per hour. Stack testing at this rate on Friday again showed elevated preliminary particulate matter emission rates of 0.077 and 0.083 lbs/MMBtu. On Friday evening TDF feed was shut off for the weekend. On Monday morning, TDF feed commenced at 0.25 tons per hour and three particulate matter stack test runs were completed before shutting off TDF feed for the night. This was the last time TDF was fired in the boiler. On Tuesday November 14, 2006 IP reported the result from the prior day's three stack test runs as 0.105 lbs/MMBtu, 0.105 lbs/MMBtu, and 0.070 lbs/MMBtu. Given the operational experience the trial burn of TDF provided to date, at noon on November 14, 2006, IP announced that the trial burn was being terminated immediately.

Even though the trial burn ended earlier than expected and without conducting the detailed stack testing that was scheduled to be completed the second week, significant ambient monitoring data from the Vermont sites were available to evaluate the potential impacts of the shortened trial. A detailed review of this ambient data indicated that there were slight increases in zinc and other metals detected during the trial but all impacts were still well within state and federal health standards. These increases appear to have been caused in part by a regional transport event that raised impacts at monitors all over New England during this time and which make it difficult to discern IP's contribution. Had the trial burn continued for the full expected duration or had IP burned TDF at the expected higher rates of two and three tons per hour it may have been possible to more accurately detect the impacts of the trial burn. The testing completed during the trial burn did however confirm Vermont's initial concerns that IP's existing air pollution controls were not adequate and that advanced emissions controls would be necessary to burn TDF in an environmentally sound manner at this facility.

Overview of Events Preceding the Trial Burn

In September of 1997 International Paper Company (IP) conducted a very limited trial burn of crumb rubber in the Power boiler at the Ticonderoga mill. A total of 4 tons of tire crumb rubber was burned over a period of two days. Other than the continuous emission monitors for carbon monoxide, nitrogen oxides and sulfur dioxide no actual stack emission testing was conducted. Ash samples from the bottom ash and multicyclone (prior to the wet scrubber) were collected and analyzed. The effect of tire fuel on air pollution emissions was largely left unknown.

In September of 2003 IP submitted a request to the State of New York Department of Environmental Conservation (NYDEC) for approval to once again conduct a trial burn of tire fuel in the Power boiler. This time IP proposed to burn shredded tires, referred to as tire-derived-fuel (TDF), at a rate of up to 3 tons per hour; which is approximately 10% of the heat input capacity of the boiler (although it generally operates at a rate much less than this). The Power boiler is an 855 million BTU per hour boiler that burns predominantly No.6 fuel oil. The Power boiler also has solid fuel burning capability and typically burns wood/bark at a rate of 425 tons per day. This is approximately 177 million BTU per hour of heat input or 20% of capacity. IP proposed to maintain the wood/bark firing at a constant rate and mix in increasing amounts of TDF as No.6 fuel oil was to be decreased proportionately. TDF use at the facility was intended to displace No.6 fuel oil usage and lower the mill's energy costs.

It was proposed that the trial burn would take place over a period of up to 30 days and include extensive stack emission testing. Emissions data would be collected both when the boiler burned the TDF and when it did not. This would provide comparative emission data that could be used in support of a possible future permit application for permanent approval to burn TDF.

On January 26, 2004 the NYDEC determined that a formal application to amend the existing Title V Air Permit was required. One year later on February 1, 2005 IP filed the Title V amendment application with the NYDEC. The NYDEC determined the application to be incomplete on March 10, 2005. IP subsequently addressed the deficiencies in the initial application and resubmitted it July 6, 2005. On August 18, 2005 the Vermont Agency of Natural Resources (ANR) hosted a public informational meeting to enable the public to hear from and ask question of International Paper and opposition groups regarding the tire burning issue. On October 12, 2005 the NYDEC issued a “Draft” Title V Air Permit to the International Paper Company approving the trial burn of TDF at their Ticonderoga, NY mill. The NYDEC held their official public hearings to take comments on the draft permit on November 9, 2005 and November 30, 2005 at the Ticonderoga Armory Community Center located at 123 Champlain Avenue in Ticonderoga, N.Y. In order to facilitate public input on the draft permit from Vermont citizens, Vermont ANR also held a public meeting to take comment on the draft permit from those unable to attend the NYDEC meeting or who preferred to make their comments at this meeting instead. The meeting was held on Tuesday November 15, 2005 at the Middlebury Union Middle School located at 48 Deerfield Lane in Middlebury, Vermont. Vermont ANR transcribed the proceedings of the meeting and submitted this transcript to the NYDEC as part of the public record. The State of Vermont also submitted its own comments on the “Draft” permit to the NYDEC on December 23, 2005.

On February 8, 2006, the State of Vermont, through the Office of the Attorney General, filed an action in New York state court against NYDEC and IP to block the proposed tire burn. Vermont alleged that NYDEC failed to comply with New York’s State Environmental Quality Review Act (SEQRA). The court, however, held that NYSDEC had fully complied with SEQRA.

On July 27, 2006 the NYDEC released their Response to Comments received on the “Draft” permit and sent a “Proposed” permit to the US EPA Region II for their 45 day review period. The “Proposed” permit still intended to allow the trail burn to proceed under certain conditions and requirements. On September 11, 2006, EPA’s 45-day period for reviewing the proposed permit modifications ended, and EPA did not issue any objections. On September 12, 2007, the State of Vermont submitted a petition to EPA to object to the proposed permit modifications and further requested that EPA direct NYDEC to refrain from issuing to IP a modified permit or suspend any permit issued pending resolution of Vermont’s petition.

On September 20, 2006, NYDEC issued a final permit modification to IP approving the trial burn. Under the terms of the permit issued, IP was required to provide 30 days notice before initiating the trail burn. On October 5, 2006, IP notified NYDEC that it proposed to commence a trail burn of TDF in its power boiler on November 6, 2006.

On October 10, the State of Vermont, through the Office of the Attorney General, filed a petition with the Second Circuit Court of Appeals requesting that the court enjoin IP from commencing the test burn until EPA issued a decision on Vermont’s petition objecting to the permit modifications. On November 3, 2006, the court denied Vermont’s petition. IP commenced the trial burn on November 6, 2006 with baseline testing of the Power boiler with normal fuel mix and no TDF. TDF was first fired in the Power boiler on Tuesday November 7, 2006. TDF was then fired Wednesday, Thursday and Friday of that week and shut off Friday evening for the remainder of the weekend. TDF was again fired in the boiler on Monday morning November 13 and shut off at approximately 10:00 pm that evening. The trial burn was terminated on Tuesday November 14 without firing any TDF that day.

On-Site Trial Burn Observation Summaries

The complete field reports containing the trial burn observations by the on-site Vermont ANR personnel for each day of the trial are contained in Appendix I. Below is a summary of each days' events during the trial burn.

(Day 1 - Monday November 6, 2006) In accordance with the permit, the first day of the trial was to begin with baseline emission testing for particulate matter under normal firing of fuel oil and bark before TDF could be added. As a result of unanticipated problems with the bark fuel feed system in the morning (unrelated to TDF) the baseline testing was delayed and not completed until approximately 6:00 PM. Upon completion of the baseline testing, IP decided to wait until Day 2 before beginning any burning of TDF.

The results of the baseline particulate matter testing was reported as[1]:

Run 1	0.038 lbs/MMBtu
Run 2	0.040 lbs/MMBtu
Run 3	0.051 lbs/MMBtu
Average	0.043 lbs/MMBtu

[1] Results are preliminary and subject to change based on review of final stack test report.

(Day 2 - Tuesday November 7, 2006) At approximately 8:15 AM on the second day of the trial the TDF feed system was first turned on; adding TDF to the bark fuel feed at a rate of 0.5 tons of TDF per hour. Due to delays in the delivery of fuel from the wood yard to the boiler it was estimated that TDF was not actually being burned in the boiler until approximately 8:55 AM. At approximately 10:45 AM the TDF feed rate was increased to 1.0 tons per hour. Based on our visual observations of the TDF feed where it drops into the bark fuel feed we requested to review the calibration data and to have IP conduct a one point check of the TDF feed to verify the accuracy of the feed rate. This test was scheduled for the following day (day 3). In accordance with the permit, particulate matter testing must also be completed at the 1.0 ton per hour TDF firing rate that demonstrates compliance with the Power boiler emission limit of 0.10 lbs PM/million BTU before the TDF feed rate can be increased to 2.0 tons per hour. IP continued with the 1.0 ton per hour TDF feed rate until approximately 7:00 PM when they shut off the TDF feed for the night. Again, due to delays in the fuel feed it was assumed that by 8:00 PM the boiler had burned all the TDF that had been added to the system.

(Day 3 - Wednesday November 8, 2006) The third day of the trial began with the TDF feed system being turned on at 5:15 AM at the rate of 0.5 tons per hour. This was quickly increased to 1.0 tons per hour at 6:00 AM. The boiler operators continued to monitor the boiler at the 1.0 ton per hour feed rate throughout the day. At 10:20 AM the TDF feed system was audited to verify the accuracy of the TDF feed rate. The audit yielded a rate of 1.05 tons per hour at the 1.0 ton per hour setting and was considered sufficiently accurate and representative. IP opted to continue firing TDF at the 1.0 ton per hour rate throughout the night, with an expected interruption from approximately 2:00 AM to 4:00 AM for normal maintenance, in order to allow additional boiler operators to gain experience with the fuel. No stack emission testing was conducted this day.

(Day 4 - Thursday November 9, 2006) Following the shutdown of the TDF feed for normal maintenance at 2:00 AM Thursday morning, the TDF feed was turned back on at 4:30 AM at the rate of 0.5 tons per hour. By 5:00 AM this was increased to 1.0 tons per hour. IP began the first Method 5 particulate matter test at the 1.0 tons per hour feed rate at 9:15 AM and began the

second test run at 11:10 AM. During both particulate matter test runs observations of the CEM system displays indicated NOx and SO_2 emissions were within permit limits. The preliminary particulate matter results for the two runs were reported as 0.089 lbs/MMBtu and 0.082 lbs/MMBtu. The preliminary results are based only on the filter weights, which are still subject to change as they equilibrate. The preliminary results do not include the probe wash component of the test runs which requires the samples be placed in an oven for several hours until the liquid fraction evaporates off, leaving the particulates collected by the probe wash to be weighed. Since the preliminary particulate matter emission rates were higher than expected with minimal margin of compliance, IP decided to shut off the TDF feed at 4:00 PM for the rest of the day and did not complete a third particulate matter test run.

(Day 5 - Friday November 10, 2006) On the 5th day of the trial, the refined results of the two particulate matter emission test runs completed the day before were reported as 0.109 lbs/MMBtu and 0.093 lbs/MMBtu, respectively. The permit limit is 0.10 lbs/MMBtu. The refined results include both the filter weight and probe wash component but are still subject to change slightly as the data and calculations are verified and presented in a final stack test report that typically follows within 30 days of the testing. Based on these refined results IP restarted the TDF feed at 5:00 AM at the 0.5 tons per hour feed rate with intentions of conducting particulate matter tests at this lower feed rate. The first particulate matter test run was started at approximately 11:00 AM and the second run was started at approximately 3:45 PM. The preliminary test results for these two test runs were reported as 0.077 lbs/MMBtu and 0.083 lbs/MMBtu, respectively. Based on these higher than expected preliminary results, IP ceased TDF feed at 5:30 PM for the weekend. IP intended to explore options for reducing emissions over the weekend, including ways to optimize the wet scrubber, before commencing TDF firing again on Monday morning November 13th.

(Day 6 and 7 - Saturday November 11 and Sunday November 12, 2006) Over the weekend of November 11th and 12th, IP made adjustments to the spray patterns in the wet scrubber pollution control device. These adjustment were completed with the expectation it would improve the performance of the wet scrubber and achieve greater particulate matter removal. No TDF was burned over the weekend.

(Day 8 - Monday November 13, 2006) On November 13th TDF was re-introduced to the power boiler fuel mixture mid-morning. The feed rate of the TDF was limited to 1/4 ton per hour. A particulate test was completed this day and produced a preliminary result of 0.065 lbs/MMBtu. IP planned to conduct a second test at this feed rate before deciding next steps. On Monday at approximately 10:00 AM the TDF feed was restarted at a rate of 0.25 tons per hour. Particulate matter testing at this level began in the early afternoon. The preliminary results from the first test were reported as 0.07 lbs/MMBtu. This included an estimate of the probe wash component. Two additional test runs at the 0.25 ton per hour TDF feed rate were completed that afternoon and evening (the 3rd run failed the leak test and had to be repeated). The final test run was completed around 10:00 PM and TDF feed was shut off at this point for the night. Preliminary results from the last two test runs were not provided that evening.

(Day 9 - Tuesday November 14, 2006) On Tuesday morning the refined results from the three particulate testing runs at the 0.25 tons per hour TDF feed rate were reported as 0.105 lbs/MMBtu, 0.105 lbs/MMBtu, and 0.070 lbs/MMBtu, respectively. These refined results included the probe wash component in addition to the filter weight. The initial estimate of the probe wash component for the first run the prior day was shown not to be accurate as the refined results showed the probe wash component to be more significant than with prior tests at

higher TDF levels. At approximately noon IP announced that it would cease the trial immediately. No TDF was fired this day.

As emissions measured under this trail burn program indicated that emissions while burning even the lowest amount of TDF resulted in emissions very close to the permit limit of 0.10 lbs/MMBtu. IP concluded that further testing would not be useful and that the trail program had yielded data that supported not going forward with TDF as a component of the Power boiler fuel.

Ambient Air Monitoring

Introduction

The Vermont ANR maintains a statewide network for routine monitoring of ambient air quality. Beginning in late 2003, this statewide network was supplemented with special purpose monitoring at two locations in Shoreham, Vermont. There were two monitoring sites in Shoreham for this Special Study. They were generally referred to as Shoreham North and Shoreham South. The Shoreham North site was located on Lapham Bay Road, about a quarter mile east of Lake Champlain. The Shoreham South site was located just off of Smith Street, near Route 74. The Shoreham North and Shoreham South monitoring sites were selected based on mathematical model simulation of were it was expected that the plume form the power boiler stack would have its maximum impact in Vermont.

The two Shoreham monitoring stations were fitted with instruments to collect data as to the ambient air concentrations of particulate matter in two particle size ranges; 10 microns and less (PM_{10}) and 2.5 microns and less ($PM_{2.5}$). The devices to collect these data also allow the samples to be analyzed for specific particulate compounds (chemical speciation). Samples were collected every six (6) days beginning in late 2003 until just prior to the trial burn when sampling was increased to every day.

To aid in the understanding of the air quality data, instruments to record meteorological data was located at the Shoreham North site.

Vermont ANR Intensive Sampling

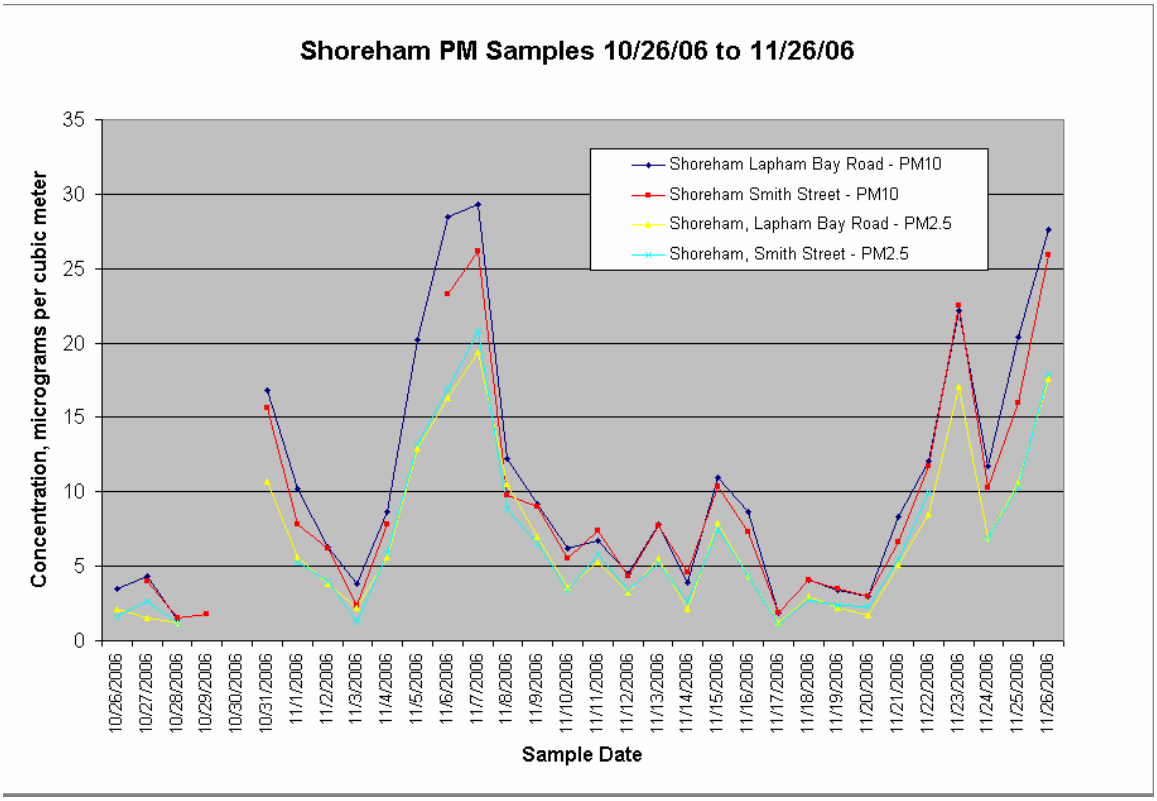
On 10/26/06, intensive daily, noon to noon sampling for particulate (both PM2.5 and PM10) began. The intent was to collect daily values before the commencement of the trial burn on November 6th. One 10/26/06 sample was missed because that sampler was reconfigured for daily, noon to noon sampling on that day (prior to this day this was the sampler used to trial the daily operating mode). On 10/29/06, three of four samples were lost because the samplers were mistakenly operated in field blank mode. On 10/30/06, all four samples were lost because of operator error. Single samples on 11/5/06 & 11/23/06 were invalidated due to instrumental and laboratory errors. There was 92% data capture for these samples, which represents excellent sampler and personnel performance.

During this intensive sampling period the Shoreham North meteorological system operated without incident. Meteorological data collection also began at Shoreham South at this time. The electronic wind speed and wind direction sensor on the Shoreham South sampler failed on or about 11/12/06. For this reason, there is only wind speed and wind direction from the Shoreham South site for 10/28/06 to 11/11/06. Both PM10 and PM2.5 ambient monitoring data for Shoreham North and Shoreham South for the intensive sampling period are presented below.

Vermont ANR Intensive Sampling Month Results

Sample Date	Shoreham North PM_{10} (24 hr ug/m^3)	Shoreham South PM_{10} (24 hr ug/m^3)	Shoreham North $PM_{2.5}$ (24 hr ug/m^3)	Shoreham South $PM_{2.5}$ (24 hr ug/m^3)
Date/NAAQS	150 ug/m^3	150 ug/m^3	35 ug/m^3	35 ug/m^3
10/26/2006	3.5	na	2.1	1.6
10/27/2006	4.3	4	1.5	2.6
10/28/2006	1.4	1.5	1.2	1.2
10/29/2006	na	1.8	na	na
10/30/2006	na	na	na	na
10/31/2006	16.8	15.6	10.7	6.2
11/1/2006	10.2	7.8	5.6	5.3
11/2/2006	6.3	6.2	3.8	4
11/3/2006	3.8	2.4	2.2	1.3
11/4/2006	8.7	7.8	5.6	5.9
11/5/2006	20.2	na	12.9	13.2
11/6/2006	28.5	23.3	16.3	16.9
11/7/2006*	29.3	26.2	19.4	20.8
11/8/2006*	12.2	9.8	10.5	8.8
11/9/2006*	9.2	9	7	6.5
11/10/2006*	6.2	5.5	3.6	3.4
11/11/2006	6.7	7.4	5.3	5.8
11/12/2006	4.5	4.3	3.2	3.4
11/13/2006*	7.8	7.7	5.5	5.2
11/14/2006	3.9	4.6	2.1	2.6
11/15/2006	11	10.4	7.9	7.5
11/16/2006	8.7	7.3	4.3	4.3
11/17/2006	1.9	1.9	1.2	1.1
11/18/2006	4.1	4.1	3	2.7
11/19/2006	3.4	3.5	2.2	2.4
11/20/2006	3	3	1.7	2.3
11/21/2006	8.3	6.6	5.1	5.4
11/22/2006	12.1	11.7	8.5	9.9
11/23/2006	22.2	22.5	17.1	na

11/24/2006	11.7	10.3	6.9	6.9
11/25/2006	20.4	16	10.6	10.4
11/26/2006	27.6	25.9	17.6	17.9
* TDF was burned at IP on these dates.				



Contracted Private Research Group Sampling

To supplement and enhance the VTANR air quality measurements, ANR contracted with three external research groups to conduct air quality monitoring activities at the Shoreham sites. These research groups included: Ecosystems Research Group (Dr. Eric Miller), Clarkson University (Dr. Phillip Hopke), and the DELTA Group at U. California, Davis (Dr. Thomas Cahill).

Ecosystems Research Group (ERG) measured gaseous elemental, reactive gaseous and particulate mercury using a Tekran semi-continuous analyzer at the Shoreham North site from 10/18/06 through 12/7/06. Dr. Miller was also making similar concurrent Hg measurements at the rural Underhill, VT site. The Tekran in Shoreham was operated to collect and analyze 2-hour average samples every 3 hours. Dr. Miller also operated a meteorological station and a web camera (image refreshed every 5 minutes) pointed at the IP stack and from which images have been archived. An example photo is displayed in Figure 1. Note the corner of the Clarkson University monitoring shelter in the foreground and the IP plume in the background (this was not a TDF test burn day).

Figure 1. WebCam Image from Shoreham North Monitoring Site (10:06 AM on 11/15/06)

Dr. Hopke's Clarkson group ran samplers at both Shoreham sites from 11/4/06 through 11/27/06. At the northern site, they made (or attempted – there were several equipment and detection limit problems) continuous hourly measurements of $PM_{2.5}$ mass by FDMS TEOM (Filter Dynamic Measurement System, Tapered Element Oscillating Microbalance), SO_2 gas, SO_4 aerosol, organic carbon, elemental carbon, polycyclic aromatic hydrocarbons (PAH), light absorption (aethalometer) and particle size distributions. With daily filter-changing assistance from VT APCD, the Clarkson group also conducted daily PUF sampling for organic analysis and daily filter sampling using $PM_{2.5}$ speciation samplers at both Shoreham sites, collecting 24-hour fine particle samples for subsequent lab analyses for gravimetric mass, major inorganic ions ($SO4^{=}$, $NO3^{-}$, Cl^{-}, $NH4^{+}$), elemental and organic carbon and trace elements by X-Ray Florescence (XRF). The Clarkson mobile sampling van that contained most of their continuous instruments at the Shoreham north site is shown in Figure 2. Also shown are the Clarkson TEOM, VT DEC Meteorology sensors and the ERG Tekran and met system, all mounted on top of the VT DEC monitoring shelter (behind the Clarkson van). The UC Davis DRUM sampler, VT DEC $PM_{2.5}$ sampler and the Clarkson PUF sampler are in the foreground.

Figure 2. Air Sampling Equipment at the Shoreham North Monitoring Site

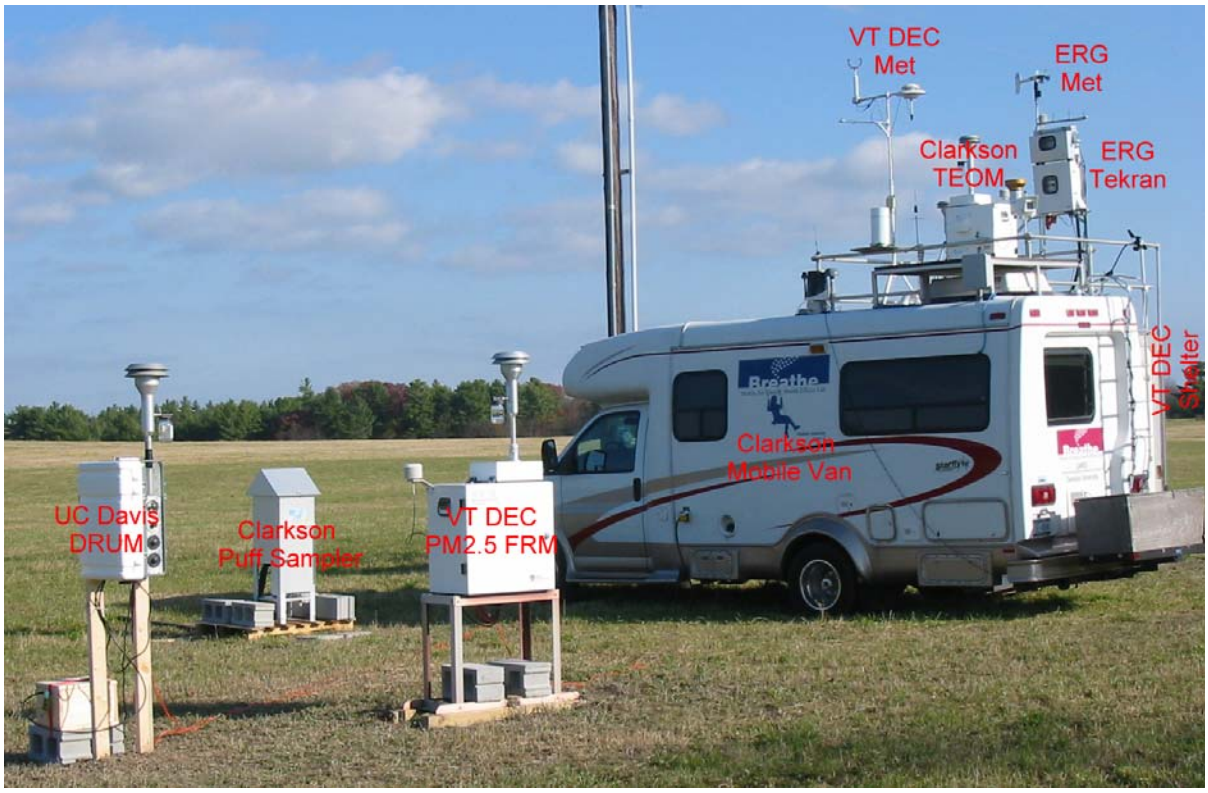


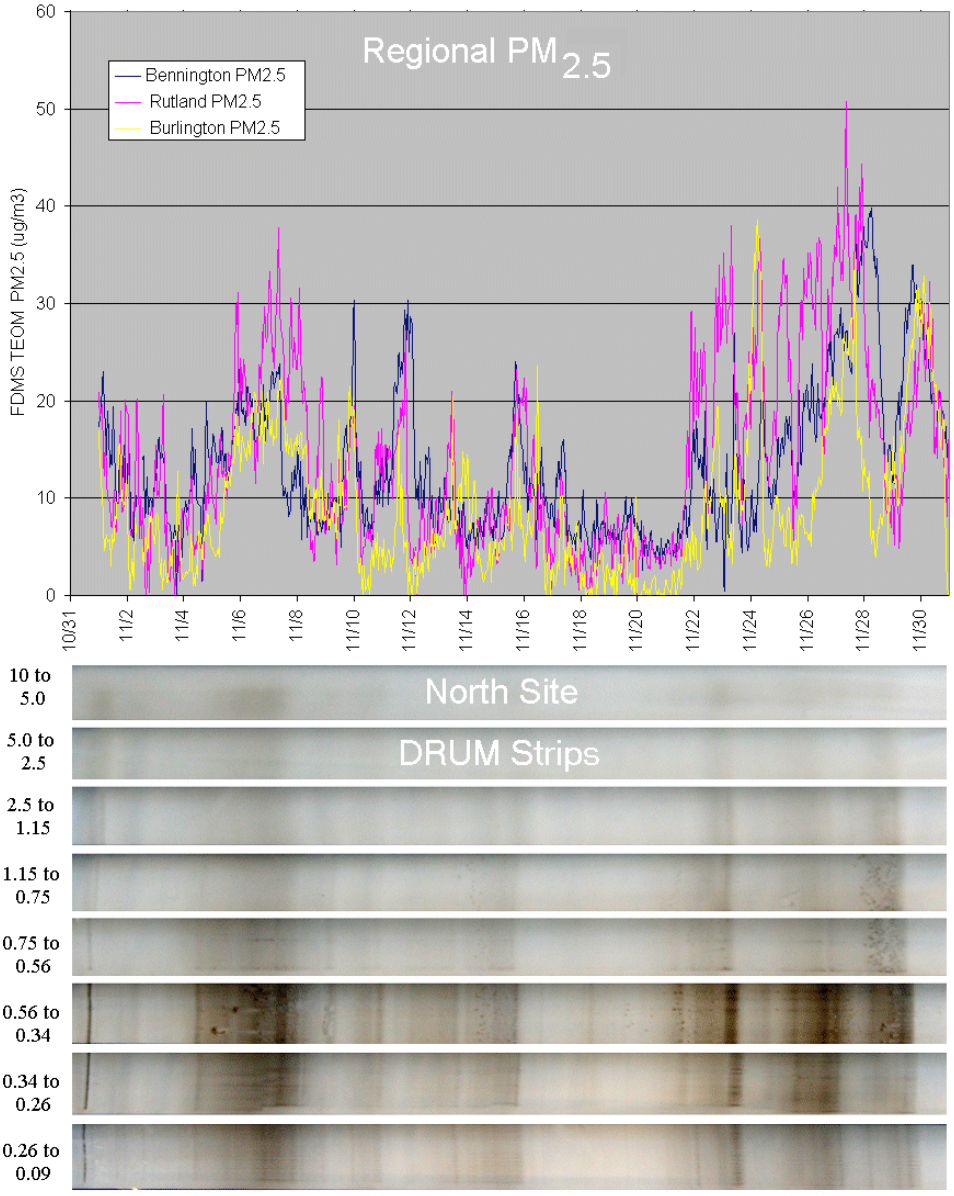
Figure 3. UC Davis DRUM

Dr. Thomas Cahill's DELTA group at UC Davis provided two 8-stage DRUM samplers (Davis Rotating Unit for Monitoring), which were run at both Shoreham sites from 11/1/06 through 11/30/06. The DRUMs collect size-fractionated particle samples in 8 size ranges: 10 to 5.0 um, 5.0 to 2.5, 2.5 to 1.15, 1.15 to 0.75, 0.75 to 0.56, 0.56 to 0.34, 0.34 to 0.26, 0.26 to 0.09 um. Samples are deposited on greased Mylar strips, affixed to the outside of slowly rotating "drums". After sampling, the individual strips can then be subject to analyses for mass (beta attenuation), optical attenuation (for multiple wavelengths), and multiple elements by Synchrotron X-Ray Florescence (S-XRF), with a temporal resolution of 1 to 3 hours. The DRUM sampler is displayed in Figure 3. A pump beneath the sampler draws air through a PM_{10} inlet and deposits the particles in progressively smaller size ranges on Mylar strips attached to the 8 slowly rotating drums, clockwise from upper right to upper left.

Other sources of supplemental monitoring data include routine monitoring data from other VT sites during the month of November 2006, which can provide a more regional context to the intensive monitoring at the Shoreham sites. These include the speciated $PM_{2.5}$ data from every 3rd day filter sampling from

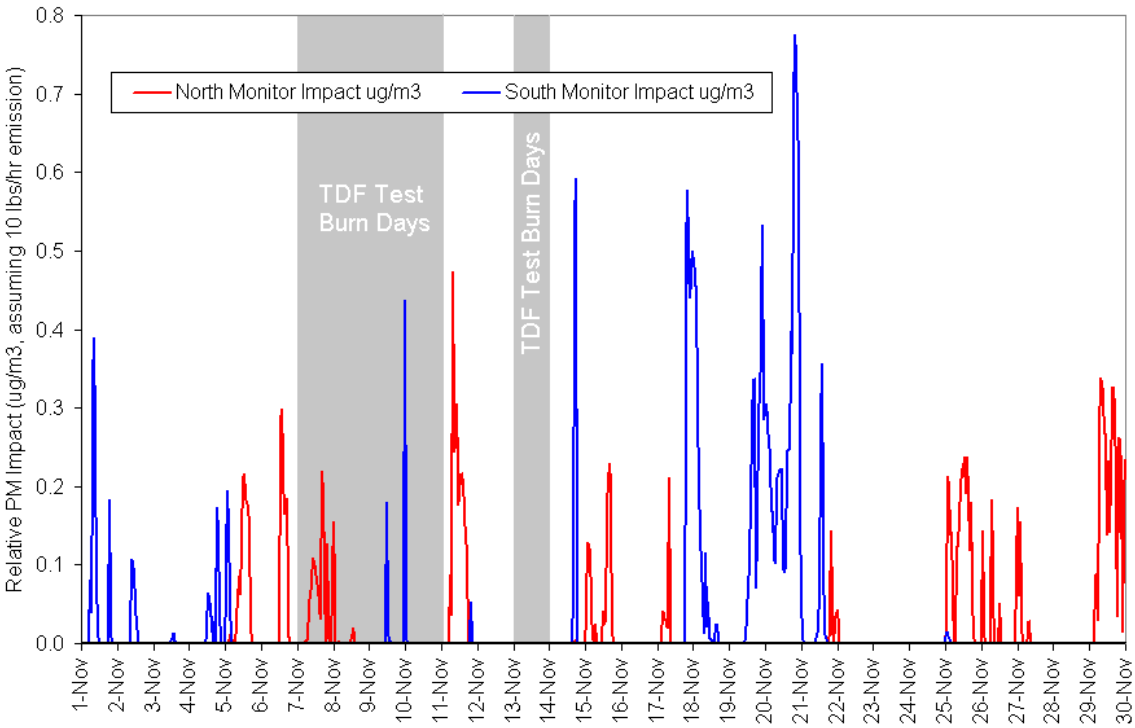
the EPA Speciation Trends Network (STN) site in Burlington, continuous $PM_{2.5}$ mass data from sites in Burlington, Rutland and Underhill, VT, and hourly SO2 from rural sites in northeastern NY. For example, the hourly $PM_{2.5}$ mass data from Burlington, Rutland and Underhill are plotted in Figure 4 along with a photo of the 8 DRUM sample strips - which cover the same 1-month period from left to right, with the largest particle sizes (10 to 5 microns on top and the smallest (0.26 to 0.29 microns on the bottom). It can be noted that the darkest sections of the DRUM strips, indicative of light absorbing carbonaceous particles and most evident in the smaller sizes (<0.56 microns), correspond to multi-day regional $PM_{2.5}$ events from roughly November 5-8 and November 25-28.

Figure 4. Hourly VT $PM_{2.5}$ data (top) and Photo of Shoreham North DRUM strips (bottom)



The CALPUFF modeling described in Appendix 3 can be considered as an additional form of augmented data related to the measurements from the Shoreham monitoring sites. The model was run with the constant generic emission rate (10 lbs./hr.) for the IP boiler stack. Detailed 3-dimensional meteorological fields were developed using the CALMET model with inputs of the VT DEC surface meteorology measurements from the Shoreham North site (no met measurements for the South site due to data logger malfunction), wind fields developed from National Weather Service meteorological models, and detailed local terrain data. Spatial depictions of the daily CALPUFF model results for the period of November 5th through 14th are presented in Appendix 3. The model results were also polled to provide hourly time series estimates of relative plume impacts at the Shoreham North and South monitoring sites, as displayed in Figure 5 below. Note that for the Shoreham North site (due north of the IP plant and where most of the ambient measurements were taken), the periods of modeled source impacts coincidentally correspond to the multi-day regional $PM_{2.5}$ events on November 5-8 and November 25-28 as indicated in Figure 4.

Figure 5. Relative CALPUFF Modeled Plume Impacts at the Shoreham Monitoring Sites



It can be noted that during the days of the TDF test burn there were estimated plume impacts at the North site (11/7 and 8) and South site (11/9 and 10) with maximum hourly relative concentrations (at a generic emission rate of 10 lbs/hr) in the range of 0.2 to 0.5 ug/m3. With an estimated heat input for the IP boiler (from all fuels combined) of about 500 to 600 MMBtu/hr and a permit-limited PM emission rate of 0.1 lbs/MMBtu (measured during parts of the TDF test), an actual PM emission rate of up to 50 or 60 lbs/hr is a reasonable estimate of maximum hourly PM emissions from the IP plant during the TDF test burn, and modeled hourly particulate matter source impacts as high as 1 to 3 ug/m3 and daily impacts of up to 0.1 to 0.6 ug/m3 might have been expected at the Shoreham monitoring sites during the TDF test burn.

Quality Assurance Comparison of Similar Measurements

The assorted Shoreham and other VT measurement data include a number of redundant or semi-redundant measurements (approximately the same thing measured more than 1 way). Comparisons of these redundant measurements provides an extra measure of confidence in (or raises questions about) the quality of the individual measurement data. Figure 6 compares the daily filter-based measurements of $PM_{2.5}$ mass from the sampling conducted by the VT DEC using Federal Reference Method (FRM) $PM_{2.5}$ samplers with the concurrent filter-based measurements conducted by the Clarkson group using $PM_{2.5}$ speciation samplers.

Figure 6. Comparison of daily Shoreham $PM_{2.5}$ filter measurements by VT DEC and Clarkson

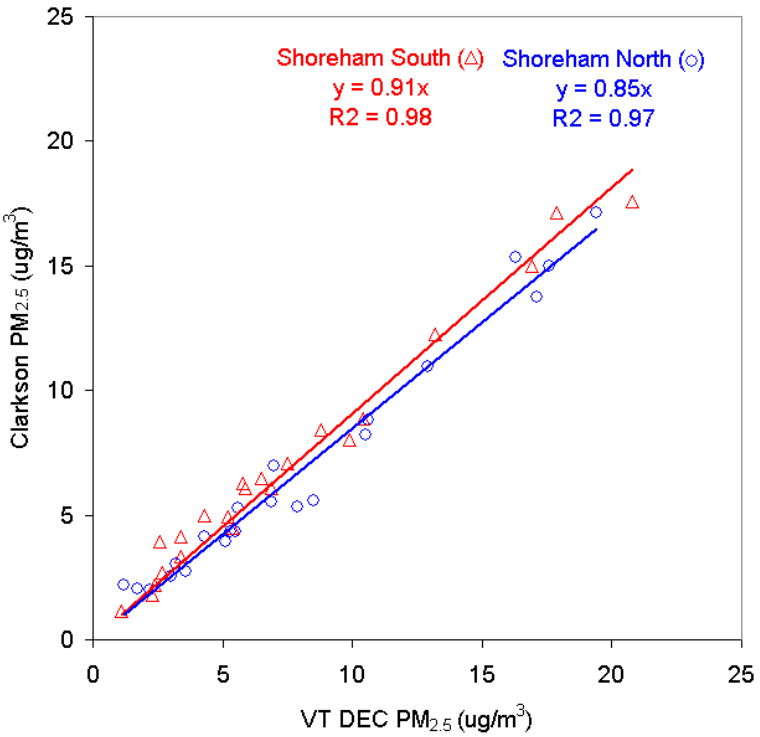
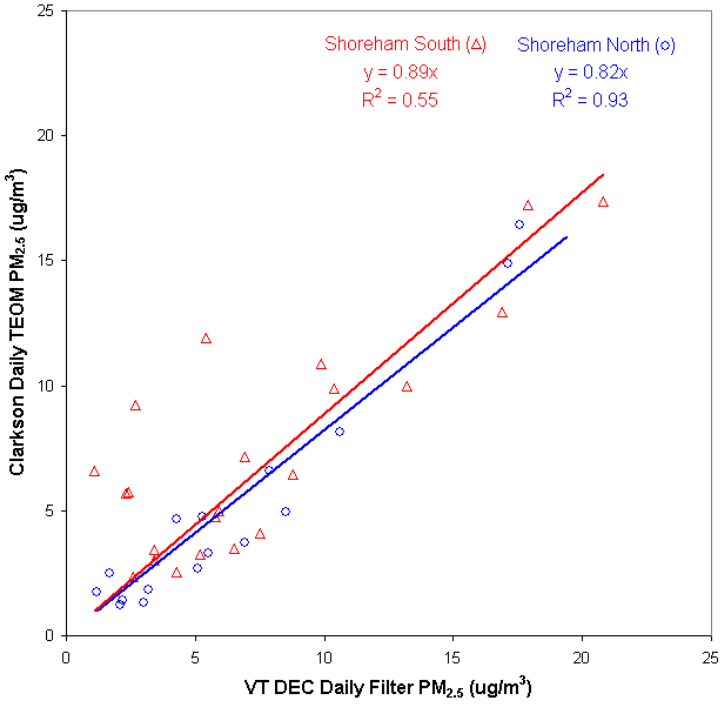


Figure 7. Comparison of daily Shoreham $PM_{2.5}$ mass by VT DEC FRM Filter and Clarkson TEOMs



While the Clarkson filter-based $PM_{2.5}$ mass measurements compare well with the collocated VT DEC FRM samples at both Shoreham sites (adding confidence to both sets of measurements), the Clarkson TEOM $PM_{2.5}$ data, aggregated to the same 24-hour periods for which the filter sampling was conducted, do not agree very well (Figure 7) with the VT FRM data, especially at the Shoreham South site. There were also operational problems with the TEOM at the Shoreham North site, resulting in invalid data prior to 11/11/06, missing all but the last day of the TDF test burn. So the Clarkson TEOM data will not be used in subsequent analyses.

Additional comparisons can be made between the elemental concentration data from the Clarkson daily speciation filter samples and the U.C.

Davis DRUM data, aggregated to a similar size range and averaging times. The Clarkson $PM_{2.5}$ speciation samplers ran for 24 hours, (approximately) noon to noon, on November 4-26, 2006. Davis DRUM Syncratron XRF data were aggregated to the same (<2.5 micron) size range (sum of 6 smallest DRUM stages) and to the same 24-hour sample periods (average of eight 3-hour samples) for direct comparison. An Average 24-hour value was calculated by averaging daily values from both laboratories and for both sites. Values from the individual labs and sites (Y axis) are compared to the 4-sample daily averages (X axis) in the following plots for sulfur, aluminum, iron, calcium, vanadium and zinc (S-ND = sulfur, north site, Davis analysis; S-SC = sulfur, south site, Clarkson analysis).

Figure 8. Daily $PM_{2.5}$ S and Al from Clarkson Filter XRF vs. DRUM Syncratron XRF

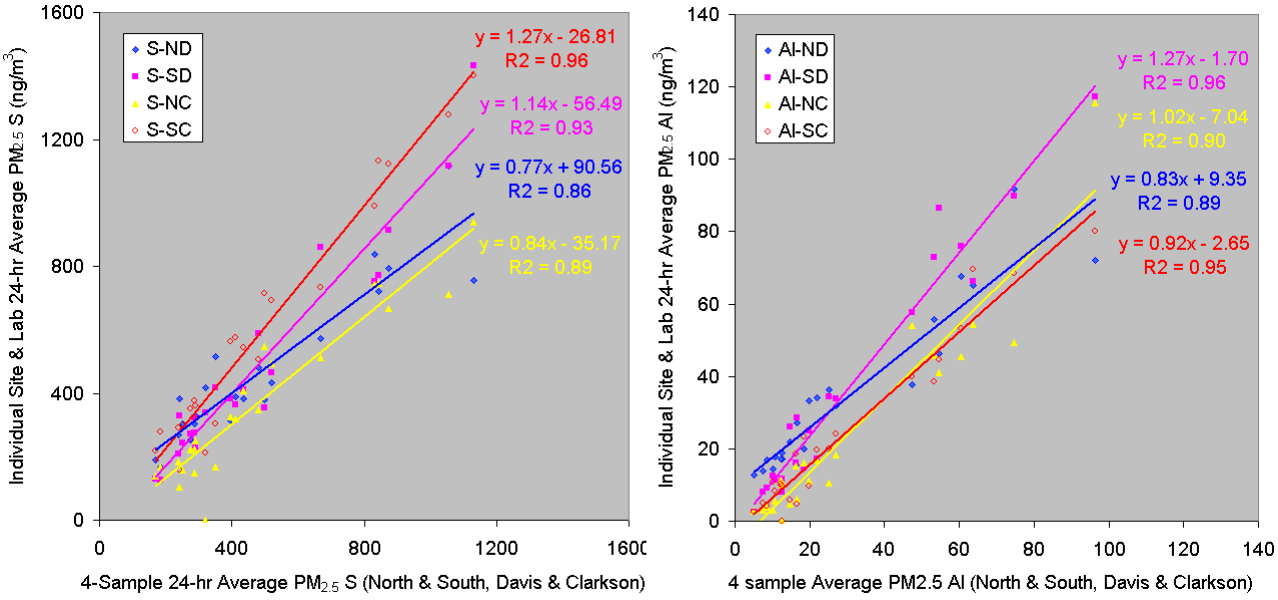


Figure 9. Daily $PM_{2.5}$ Fe and Ca from Clarkson Filter XRF vs. DRUM Syncratron XRF

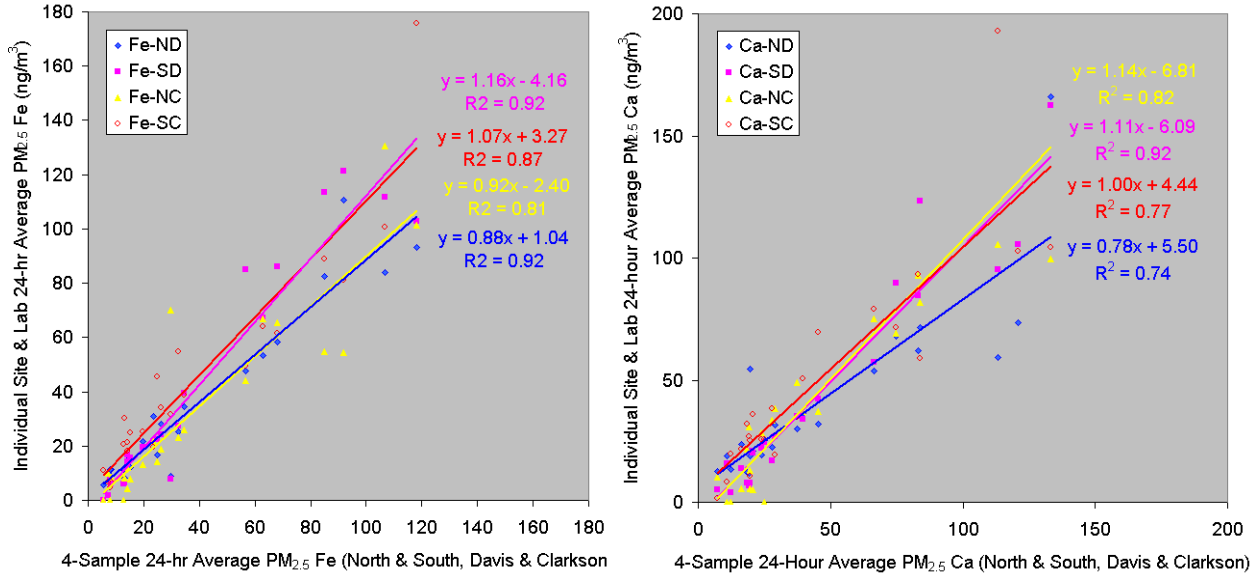
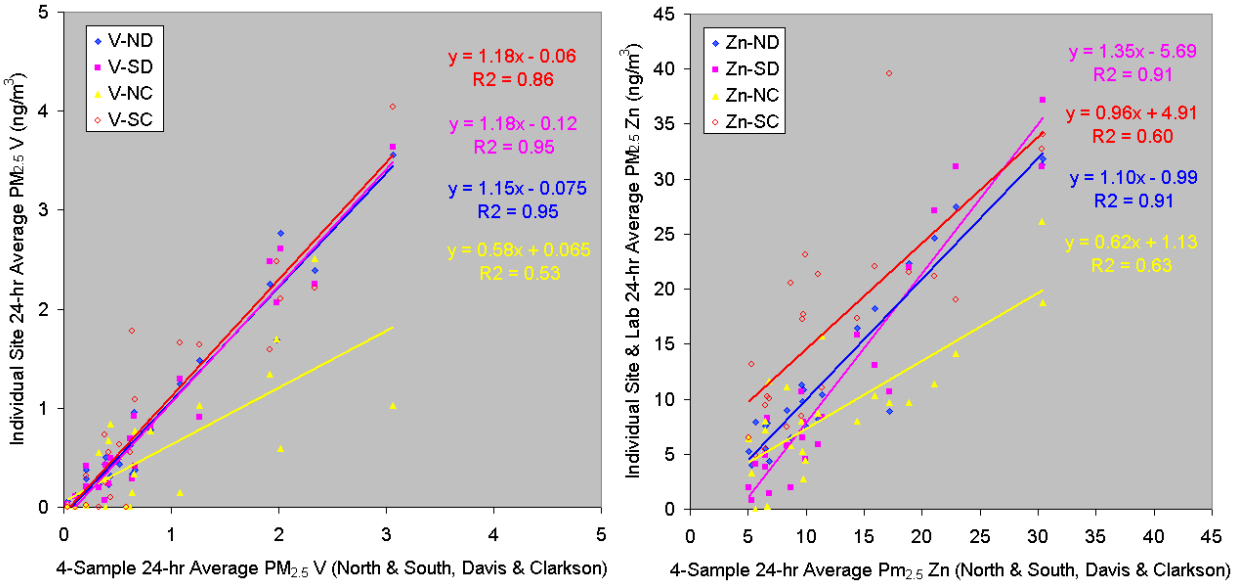


Figure 10. Daily $PM_{2.5}$ V and Zn from Clarkson Filter XRF vs. DRUM Syncratron XRF



Generally, the Clarkson 24-hour $PM_{2.5}$ filter results agree reasonably well with the time and size-aggregated UC Davis Syncratron XRF results. In most cases correlations (R^2) are > 0.85 and slopes are within 20% of 1:1. One exception is that the vanadium and zinc data from the Clarkson filters from the Shoreham South site are roughly 40% lower than the average DRUM results, with correlations (R^2) of 0.53 and 0.63 respectively.

Figure 11. DRUM Stage 7 Zn from Shoreham North & South

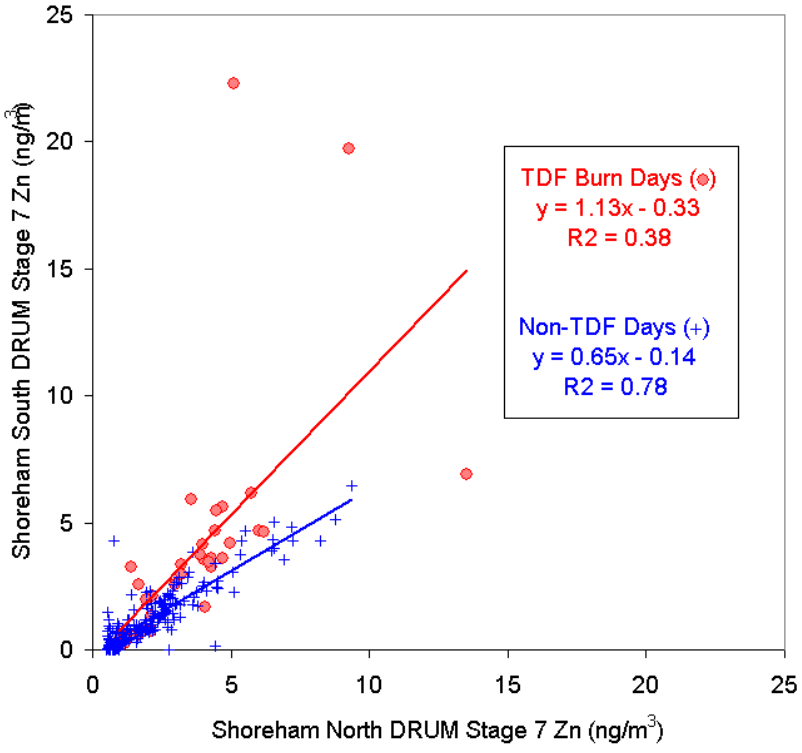
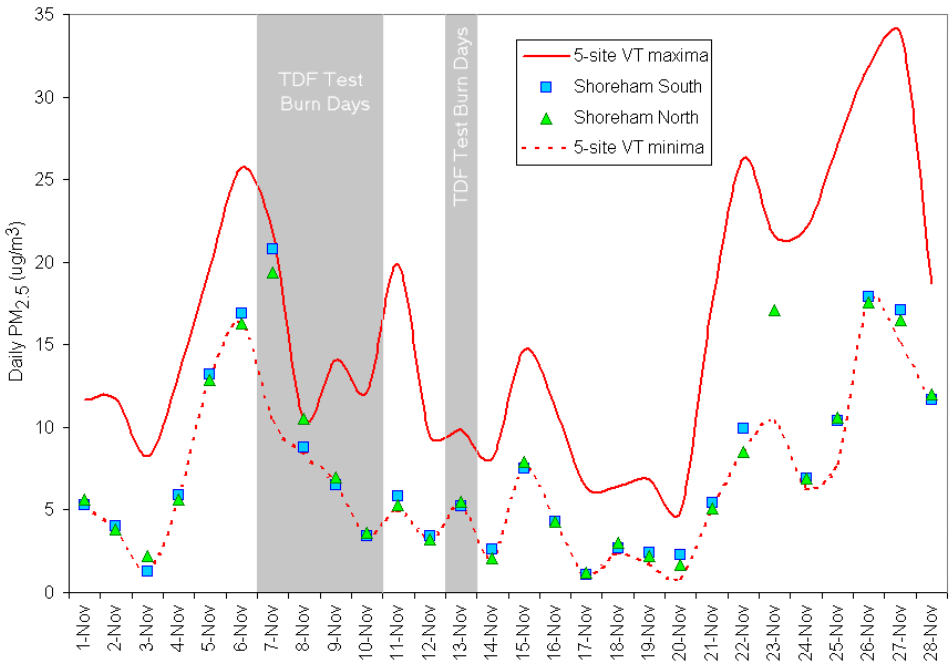


Figure 11 compares 3-hr. Zn data from stage 7 (0.24 to 0.36 µm) DRUM samples at the Shoreham North and South sites, with TDF test burn days and all other days during November 2006 displayed separately. The correlation (R^2=0.78) is much stronger on non-test burn days, suggesting influence of a regional source impacting both sites concurrently. Highest Zn concentrations at both sites were observed on TDF test burn days, and the correlation is much lower (R2=0.38), suggesting a nearby local source impacting each site at different times.

Regional Background

As indicated in Figure 4, there were several periods of heavy loading on the Shoreham DRUM samples that corresponded to multi-day regional $PM_{2.5}$ events from roughly November 5-8 and November 25-28, 2006. The hourly $PM_{2.5}$ data from the Burlington, Rutland and Bennington sites can be aggregated to daily averages (for the same noon to noon sample times for which the Shoreham filter samples were collected). These aggregated hourly data, combined with the two sets of daily Shoreham filter measurements provides 5 VT sites of daily $PM_{2.5}$ data from which statewide maxima and minima can be calculated. The Shoreham filter data and these statewide ranges are displayed in Figure 12. The minimum values at all sites can be taken as a rough indicator of statewide regional transport influences.

Figure 12. Range of Daily VT fine particle concentrations during 11/06 Shoreham Intensive



Note that no VT sites experienced concentrations as high as the new 24-hour $PM_{2.5}$ national health standard (35 ug/m^3). It can also be noted that the first few days of the TDF test burn occurred during a regional transport event. On most days, the concentrations at the rural Shoreham sites were at or near the statewide minima – such that whatever local influences there might have been affecting the Shoreham sites in November 2006, they were typically much smaller than the local influences at the other (urban) VT sites during that time period. Possible exceptions to this pattern occurred on November 7 and 8, when one or both Shoreham sites were near the statewide maxima.

Figure 13. Average Daily Shoreham Composition of Major $PM_{2.5}$ Mass-contributing Species

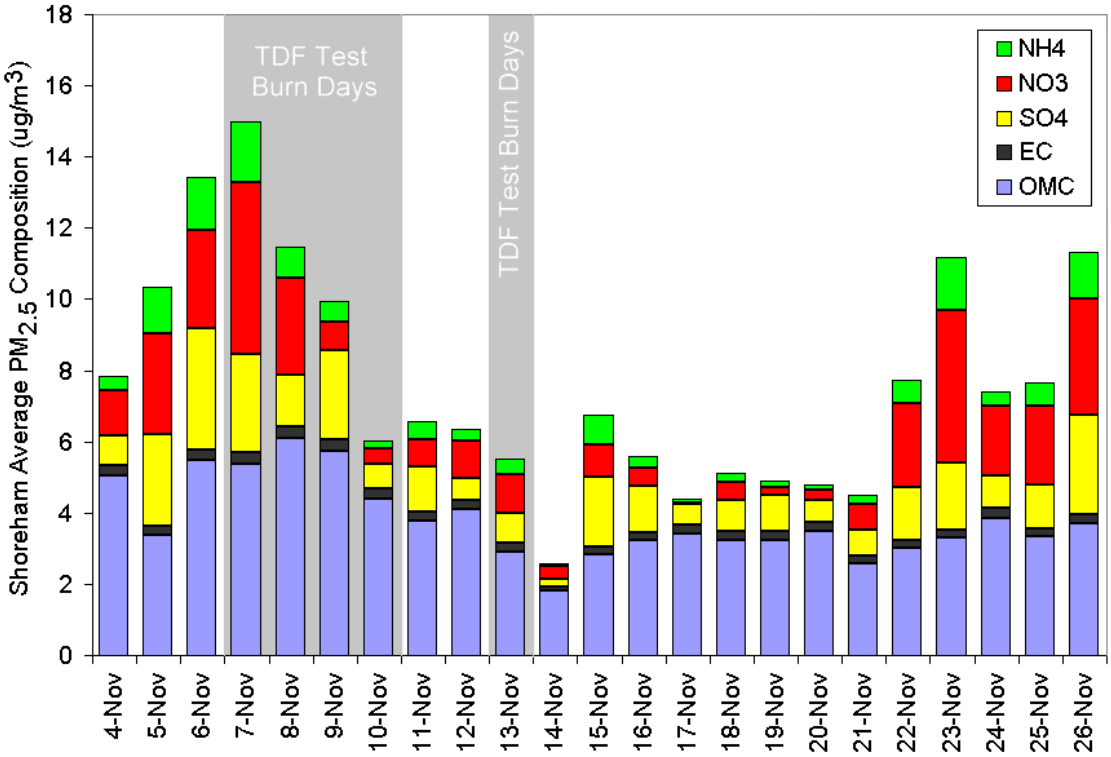


Figure 13 plots the average Shoreham daily fine particle composition of major $PM_{2.5}$ mass contributing species based on the Clarkson $PM_{2.5}$ speciation filters from both Shoreham sites. OMC in this case represents "Organic Matter by Carbon" and is calculated as 1.6 times organic carbon (to account for unmeasured oxygen and hydrogen associated with organic carbon in organic compounds). It may be noted that the highest November 2006 $PM_{2.5}$ mass concentration occurs on 11/7/06 – the first day of the TDF test burn, but with similarly high concentrations on the preceding day. It can be noted that more than half the $PM_{2.5}$ composition on 11/6 and 11/7 is composed of sulfate, nitrate and ammonium. Ammonium nitrate and ammonium sulfate are "secondary" pollutants – primarily formed in the atmosphere from reactions of precursor gases - sulfur dioxide, nitrogen oxides and ammonia. Secondary aerosol formation takes time, and sulfate and nitrate concentrations in VT are predominantly the result of regional transport from high SO_2 and NOx emitting regions to our south and west.

The Top row of Figure 14 shows NOAA HY-SPLIT model 48-hour backward air trajectory calculations arriving at a height of 500m at Shoreham every 2 hours on November 6 and 7, 2006. The trajectories indicate synoptic scale transport primarily from the Midwest on 11/6 with increasingly southerly flows on 11/7 from major source regions in both the Ohio River Valley and East Coast urban corridor. The bottom row of Figure 14 shows surface wind vectors from National Weather Service observations at 18:00 UTC (1 PM Eastern Standard Time) on 11/6 and 7 overlain on daily Satellite images from the NASA MODIS sensor (data obtained via http://datafed.net). The surface winds are south/southwesterly on 11/6, switching to strong and persistent southerly flows on 11/7. Thus we might expect transport from both the Midwest and East Coast along with high concentrations of secondary sulfate and nitrate (and coal and oil-associated trace elements like Se, As, V and Ni) on and just before the first few days of the TDF test burn, making it difficult to sort out influences of local and distant sources. The transport winds weakened and became less organized on 11/8-13, as the Shoreham ammonium sulfate and ammonium nitrate levels dropped considerably during the course of the TDF test burn.

Fig 14. HY-SPLIT 48-hr Back Trajectories from Shoreham on 11/ 6 & 7, 2006 and Surface Wind Vectors(NOAA) with MODIS Satellite images on 11/6 & 7, 2006

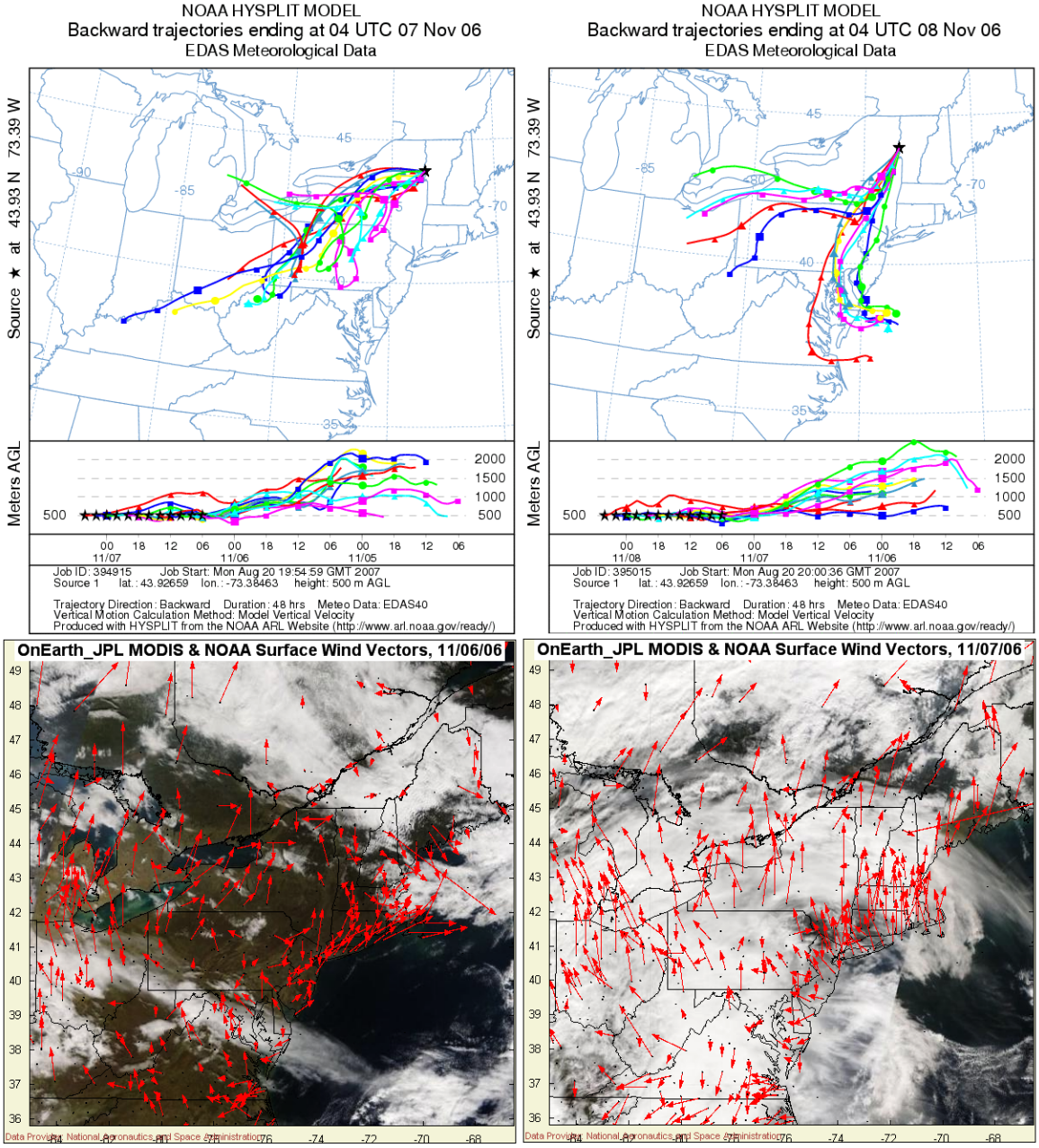
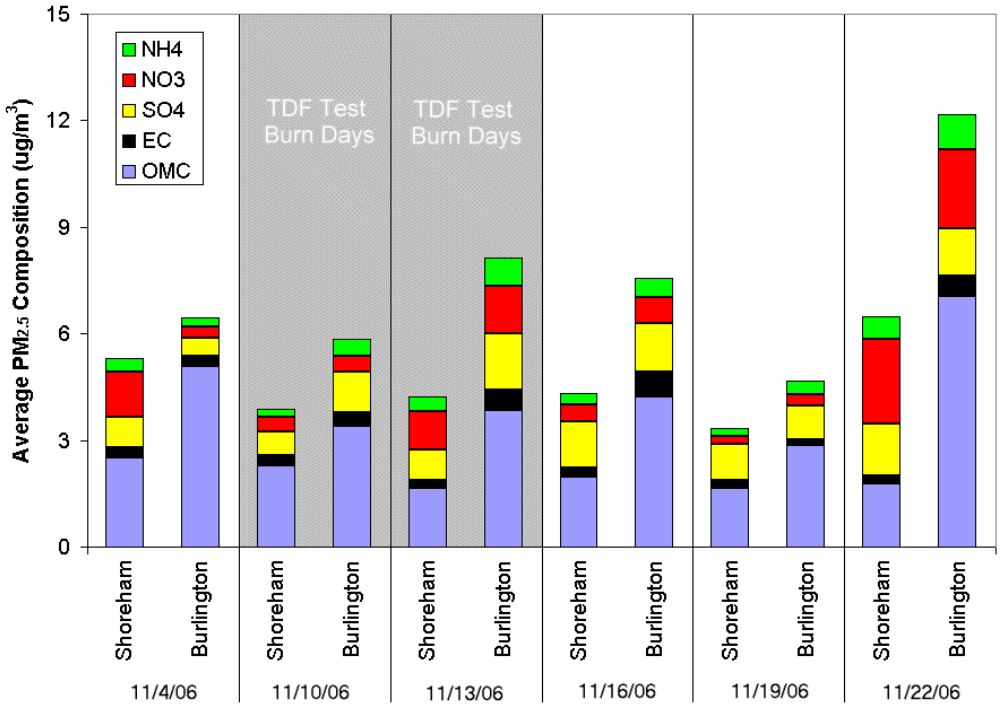


Figure 13 also shows that the levels of organic matter (OMC) in Shoreham peak slightly after the sulfate and nitrate, reaching maximum concentrations on 11/8 and 11/9 during the middle of TDF test burn. VT organic aerosol concentrations can result from both regional transport and local sources (woodstoves, automotive emissions, and some point sources) with local sources relatively more important in colder weather. If there were a perceptible $PM_{2.5}$ mass increase in VT from the TDF test burn, its likely that OC would represent a high proportion of that impact. On average, the Clarkson filter $PM_{2.5}$ concentrations on TDF test burn days were 20% higher than on non-test burn days, but OC concentrations were 40% (about 0.8 ug/m3) higher on TDF burn days.

Limited additional VT speciated fine particle data is available from 1-in-3 day samples from the EPA Speciation Trends Network (STN) site in Burlington. Major mass-contributing species from same day samples in Shoreham and Burlington are compared in Figure 15. Unfortunately, the 2 days – 11/10 and 11/13 – when TFD testing was conducted and when speciated data were available from both sites – were not days when the CALPUFF modeling indicated impacts from the IP source at either of the Shoreham sites. Nevertheless, it can be seen that PM concentrations – especially of organic matter – were typically several ug/m^3 higher in Burlington than in Shoreham. Thus the IP boiler - burning its standard mixture of residual oil and wood waste or with supplemental TDF fuel - appears to add less to the regional background concentrations in Shoreham than is contributed by local sources in (small) urban areas like Burlington.

Figure 15. Comparative PM 2.5 Speciation data from Shoreham and Burlington, Nov. 2006

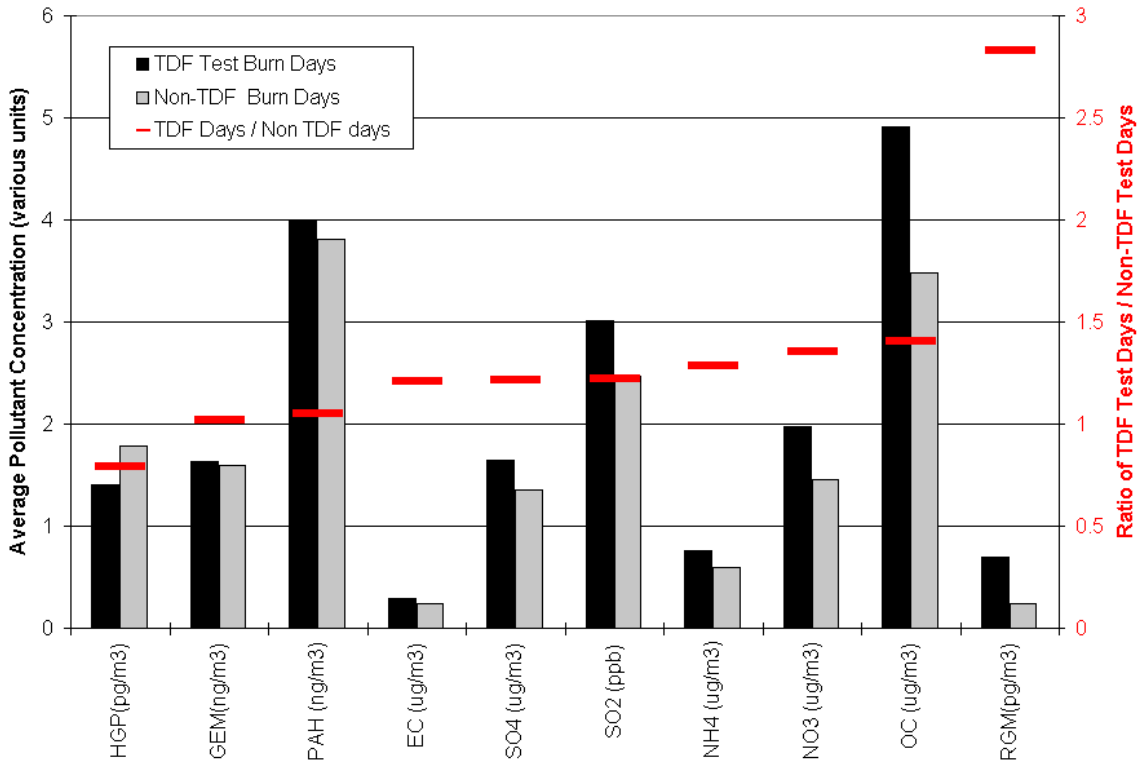


As previously indicated, the abbreviated 5-day period of the TDF test burn included only a few days when meteorological conditions were "favorable" for impacts at either of the Shoreham monitoring sites. Relatively small amounts of TDF (not exceeding 1 ton/hour) were burned during the test (in combination with the plant's usual mix of roughly 10 tons/hr of residual oil and 15 tons/hr of wood waste). The Shoreham North site, where most measurements were taken, is downwind of the IP plant when local surface winds in the Champlain Valley are from the south, conditions which are typically associated with synoptic-scale flows from the south and southwest, bringing transported pollutants from the East Coast Urban Corridor and Ohio River Valley. Several days of the test burn - including days of (small) modeled impact from IP at the Shoreham sites - coincided with regional transport from the south and southwest, making it especially difficult to discern impacts from the TDF fuel from other coincidental influences.

Figure 16 is based on Shoreham OC, EC, SO_4, NO_3 and NH_4 data from the Clarkson filter samples, SO_2 and PAH from the Clarkson continuous instruments, and gaseous

elemental Hg (GEM), particulate Hg (HGP), and reactive gaseous Hg (RGM) from the ERG Tekran. The bars display concentrations averaged for days of the TDF test burn (11/7, 8, 9, 10, 13/06) and for non-TDF test days (most other days of November, 2006). The red bars and right-hand Y scale show the ratios of the concentrations on TDF burn days vs. other days. Note that for most of these pollutants, the ratios are within 30% plus or minus of 1:1, with the minor exception of organic carbon (about 40% higher on TDF burn days) and the major exception of reactive gaseous mercury, for which Shoreham concentrations were more than twice as high during the TDF test burn than on other November 06 days.

Figure 16. Shoreham North Concentrations during TDF Test Burn and other 11/06 Days



A small influence on Shoreham reactive gaseous Hg concentrations from the IP plant burning its routine mix of residual oil and wood waste would not be surprising (both fuels contain trace levels of Hg), but an increase in mercury emissions from the addition of TDF fuel was not expected, as the Hg content of TDF is not estimated to be as high as from residual oil. It should be noted that the apparent increase in average Shoreham RGM on TDF test burn days is very small (1 pg/m3) and not statistically significant. It should also be noted that the average and peak RGM concentrations in Shoreham during November 2006 (mean = 0.33 pg/m3) were substantially lower than concurrent RGM measurements at the rural Underhill, VT site (mean = 2.89 pg/m3).

Figure 17. Gaseous Elemental, Reactive and Particulate Mercury at Shoreham North

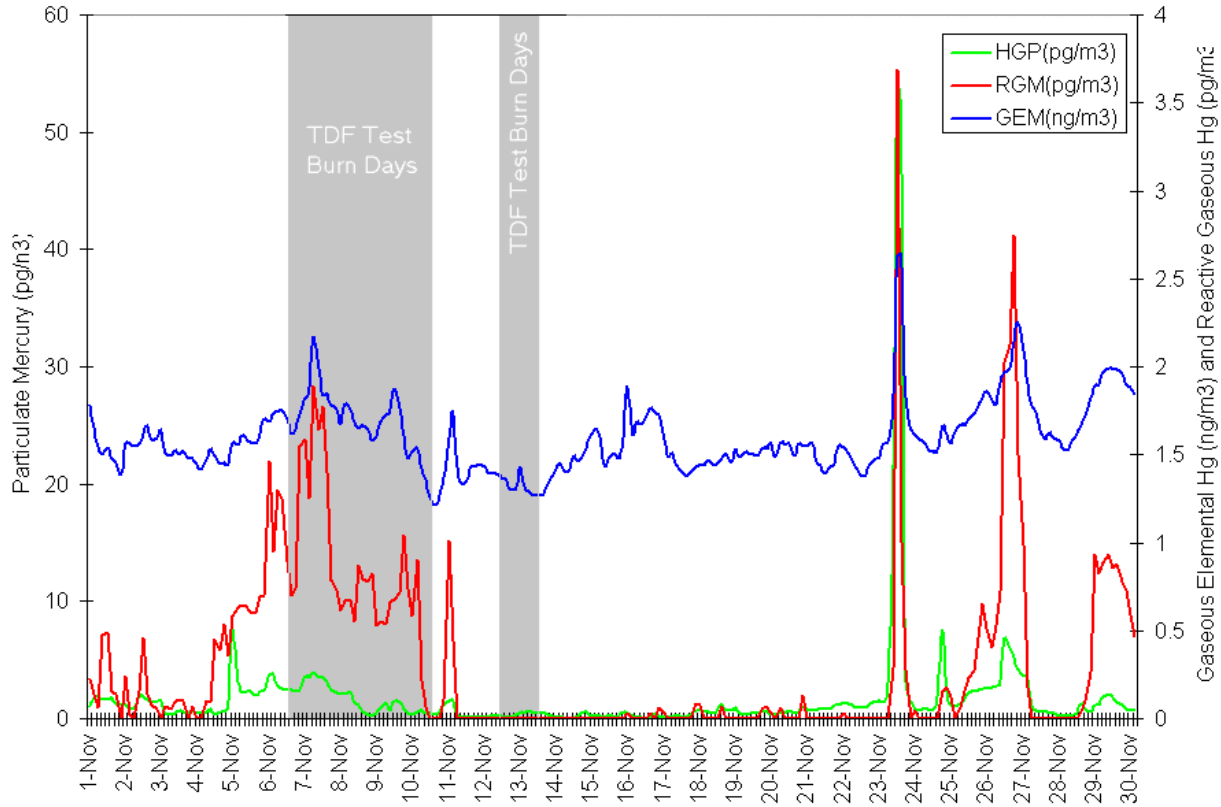
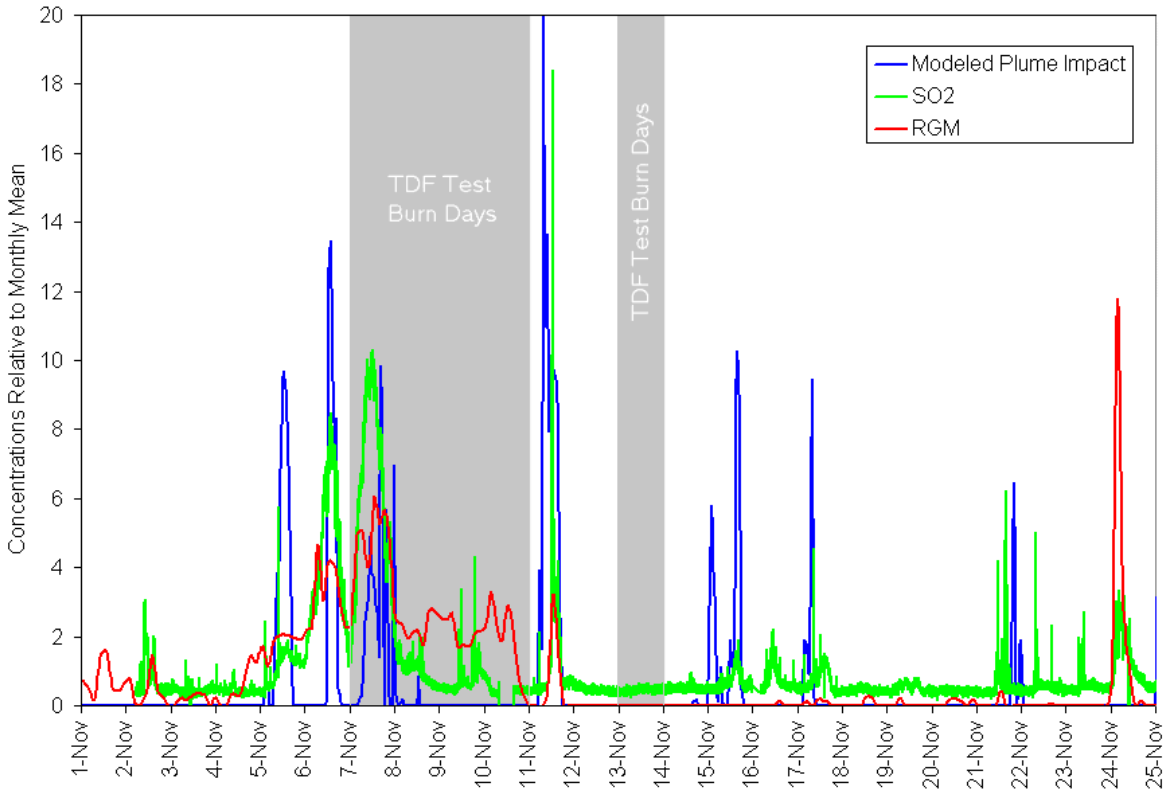


Figure 17 displays the time series of the Tekran measurements of gaseous elemental mercury (GEM), reactive gaseous mercury (RGM) and particulate mercury (HGP) at the Shoreham North site. While the RGM concentrations are clearly elevated on the first 4 days of the TDF test burn, it should be noted that this prolonged period of high RGM begins several days prior to the TDF test and also that there were several episodes of even higher RGM (and GEM and HGP) concentrations later in the month, on 11/23 and 11/26-27, long after the test burn had ended.

Figure 18 compares the time series of the relative CALPUFF modeled plume impacts, the SO2 measurements from the Clarkson Group, and the RGM measurements from the ERG group at the Shoreham North site. There are a number of coincident periods of modeled plume impact and measured SO_2 (November 5, 6, 7, 11, 15, 17, 21), most of which also show elevated concentrations of RGM. Note that many of these occur on days outside the TDF test burn period, and would be consistent with small but perceptible contributions of SO_2 and RGM from the IP plant under its standard (oil and wood waste) operating conditions. Note also that the relatively large RGM and SO_2 spike on 11/23-24, a period of strong northeasterly winds when no impact from the IP plant was predicted in Shoreham.

Figure 18. Comparison of Modeled IP Plume Impact, SO2 and RGM at Shoreham North



As noted previously, the most likely conditions for IP plume impacts at the Shoreham North site occur during persistent southerly surface winds, which tend to also coincide with synoptic-scale transport winds from the South and Southwest. Figure 19 compares the Clarkson Shoreham SO_2 data (expressed as hourly averages) with similar measurements from 4 rural sites in northeastern NY (Whiteface Mtn. Base, Paul Smith's, Piseco Lake and Grafton State Park).

The Shoreham SO_2 spikes are not locally unique, but clearly coincide with periods of high SO_2 at many surrounding rural sites indicative of regional transport, and can't be attributed to local impacts from the IP source. The correspondence between modeled IP plume impacts and measured SO_2 at the Shoreham North site, during the TDF test burn and during other periods of routine operation, appears to be coincidental rather than causal.

A similar argument can be made regarding causality of the peak Shoreham RGM concentrations, which often coincided with periods of modeled IP plume impacts and/or elevated Shoreham SO_2 concentrations, and which appeared (Figure 16) to be (illogically) higher during the TDF test burn period. As shown in Figure 20, however, RGM in Underhill, VT (50 miles north of Shoreham and not likely influenced by IP emissions) are 10 times higher than RGM in Shoreham on the (11/7/06) first day of the IP TDF test burn. The apparent Shoreham RGM increase during the TDF test burn is likely to be coincidental rather than causal.

Figure 19. 11/06 SO2 Concentrations at Rural Sites in Shoreham, VT and Upstate NY

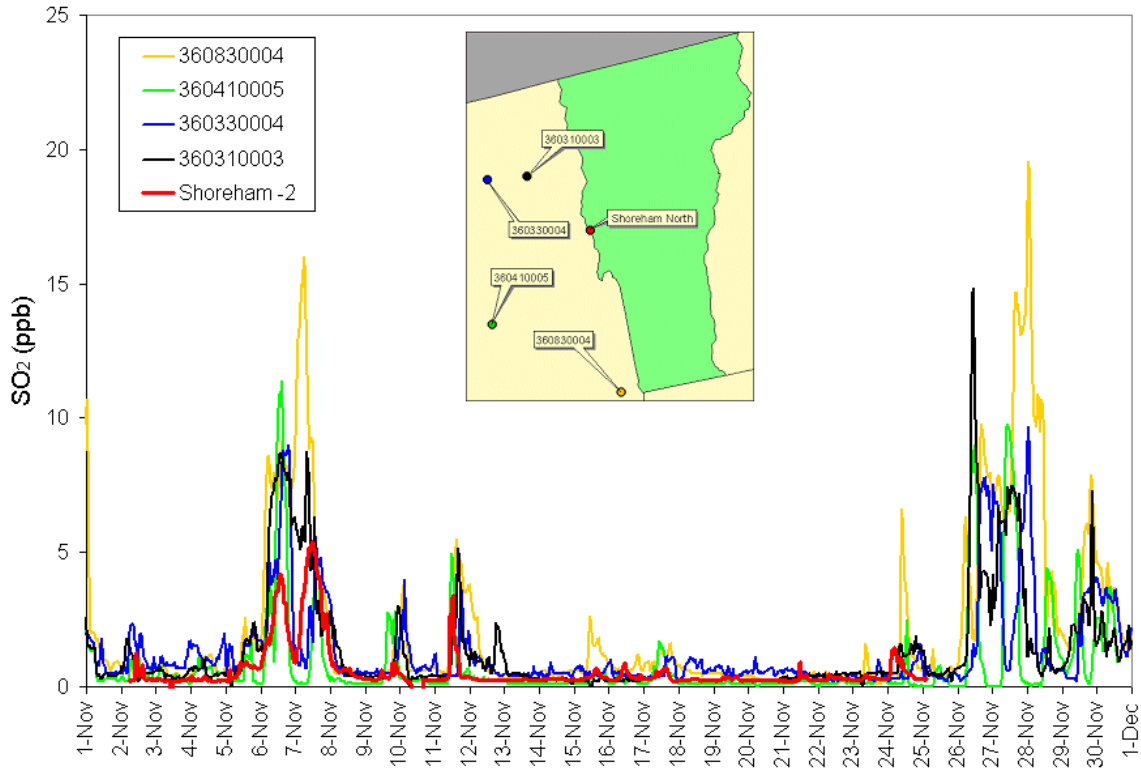
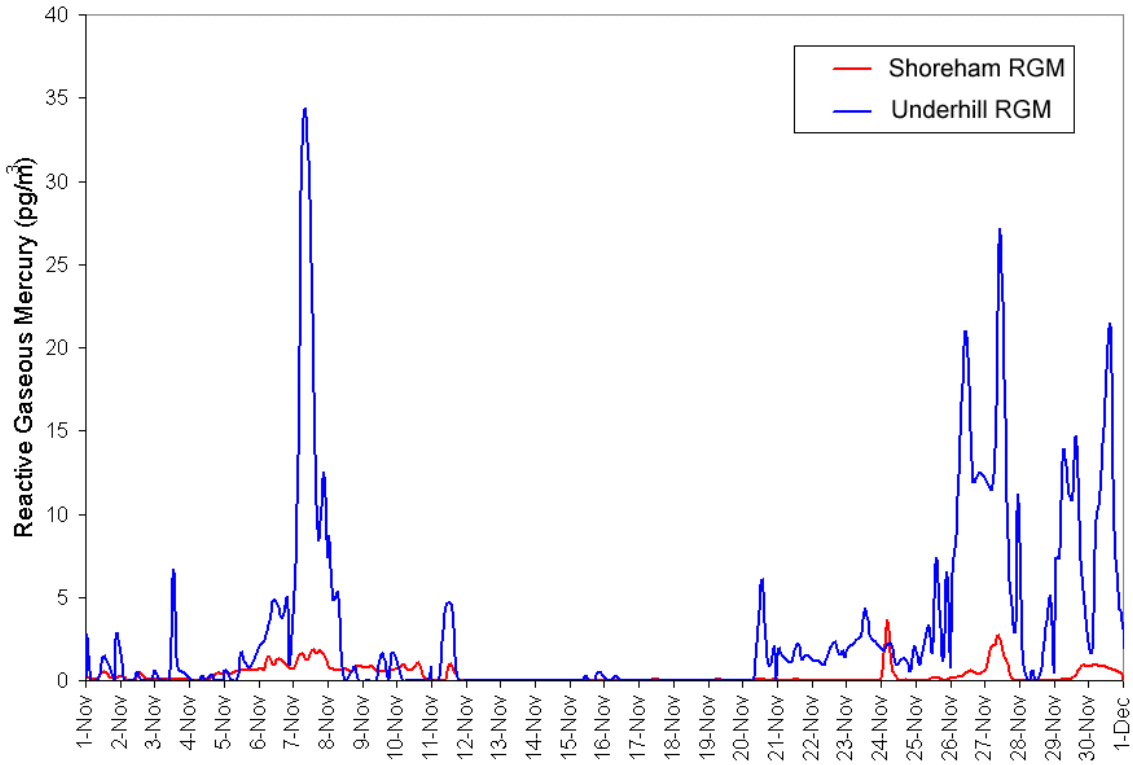
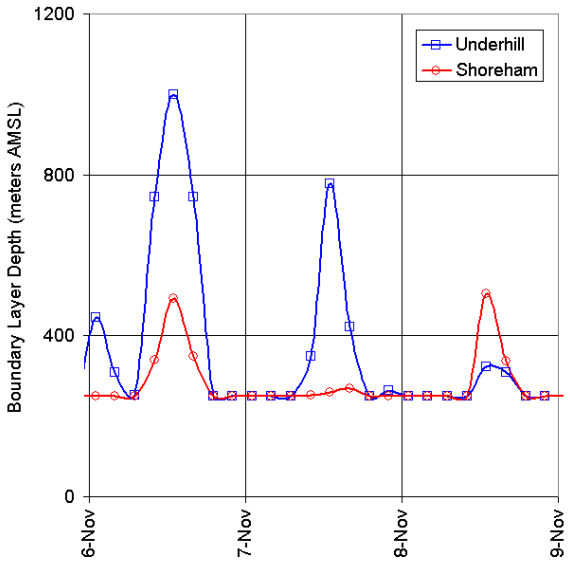


Figure 20. Reactive Gaseous Mercury Concentrations in Shoreham and Underhill, VT, 11/06



A possible explanation for the much higher RGM concentrations in Underhill than in Shoreham is that RGM, originating primarily from distant coal burning and waste incineration sources, is highly reactive and rapidly depleted within the mixed surface layer through deposition to the earth's surface. Air arriving at the low elevation Shoreham site (about 50 meters above sea level) is always within the mixed layer and has previously passed over higher surrounding terrain, where most of the RGM has been removed. Air arriving at the 400 meter Underhill site is often above the mixed layer, especially during the colder months, and so may contain RGM transported from distant sources, which has not yet been depleted through contact with the earth's surface. The estimated boundary layer depths (from NOAA EDAS 40 Km grid model) for Underhill and Shoreham on 11/6-8/06 are plotted In Figure 21. On the (11/7) day of high RGM at both sites, the 50 m Shoreham site was below the mixed layer all day, while the 400 m Underhill site was above the mixed layer for most of that day.

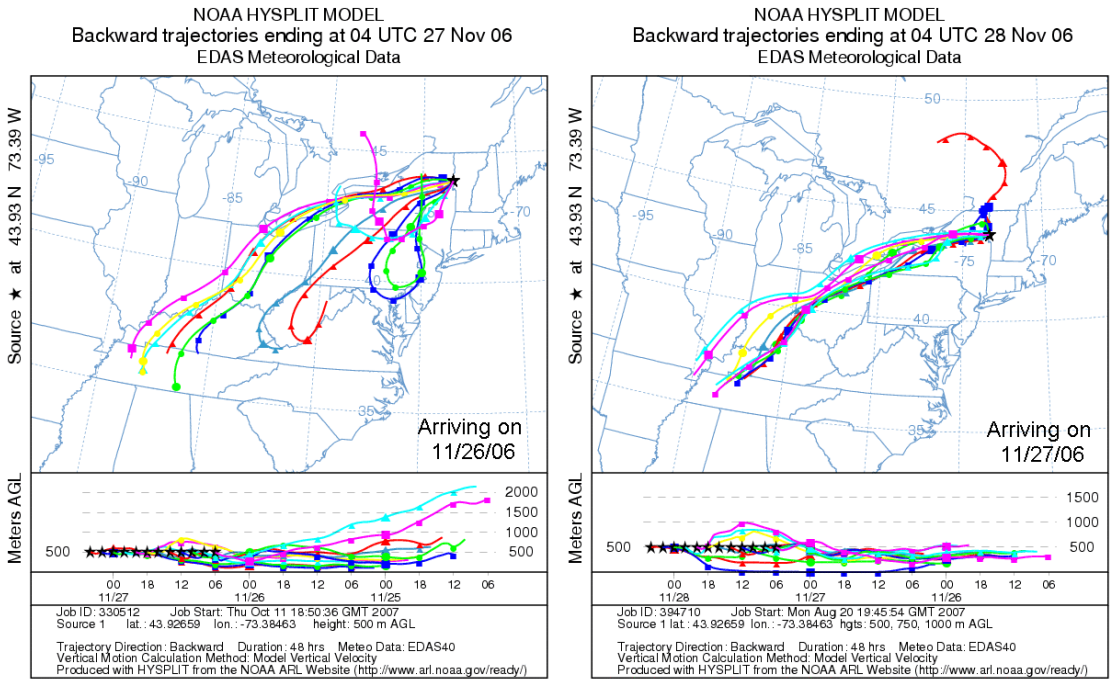
Figure 21. Estimated boundary layer depths, Shoreham & Underhill, VT, Nov. 6-8, 2006



It can also be noted from Figures 20 and 18 that on the few occasions during 11/06 when Shoreham RGM exceeded Underhill RGM (Nov. 4, 9, 10 and 24), there were no CALPUFF modeled impacts from the IP source at the Shoreham North site. So again, it seems probable that the highest Shoreham RGM concentrations are associated with regional transport rather than IP emissions during the TDF test burn or under its routine oil and wood burning operations. To the extent that some of the observed RGM at Shoreham may have resulted from IP emissions, those local impacts appear to be at least an order of magnitude lower than those resulting from long range transport impacts at higher elevations in VT.

Figures 4, 12, 19 and 20 also show higher regional levels of $PM_{2.5}$, SO_2 and RGM on 11/26 and 27, 2006. NOAA HY-SPLIT back trajectories arriving at Shoreham every 2 hours on the 26 and 27th are plotted in Figure 22. Although 11/26 and 27 were days when the CALPUFF model indicated potential impacts from the IP boiler (not burning TDF but rather its regular mix of residual oil and wood, it is likely that any perceptible local source influences may have been masked by larger coincident regional transport influences. As for the earlier 11/6-8/06 event (Figure 14), the synoptic –scale flows for the 11/26-27 event passed over high emission areas in the Midwestern US, and it is likely that VT pollutant concentrations of SO2, RGM and other coal-associated trace elements on these dates were heavily influenced by regional transport – rather than local emissions.

Figure 22. HY-SPLIT Back Trajectories Arriving at Shoreham on 11/26 & 27, 2006



Organic Compound Analysis of Clarkson PUF Samples

Daily PUF samples (quartz filter with backup polyurethane foam) collected from 11/4/06 through 11/26/06 at both Shoreham sites were analyzed by gas chromatography at the Clarkson CARES Laboratory (Center for Air Resources Engineering and Science) for selected mid-weight Alkanes (C19 through C40), PAHs (polycyclic aromatic hydrocarbons) and a few polar organic compounds. Given the relatively low expected concentrations and high cost of analysis, only the filter (particulate) portion of the samples were analyzed, and many of these were first composited into 10 multi-day samples for each site, including the November 2006 dates: 4-5, 6, 7-9, 10, 11-12, 13, 14-17, 18-19, 20-24, 25-26.

Figures 23 and 24 show the temporal patterns of the total measured Alkanes and the total measured PAH compounds for the Shoreham North and South sites during November, 2006. It can be noted that the absolute concentrations and daily variations are quite similar at the North and South sites, suggesting that the Alkanes and PAHs are not dominated by a single local source like IP that would likely not impact both sites simultaneously. Nor are concentrations higher on the TDF test burn days than on other sample days during the month.

Figures 25 and 26 show the average Alkane and PAH concentration profiles (measured compounds) for samples collected during the 5 days of the TDF test burn (11/7, 11/8, 11/9, 11/10 and 11/13) compared to the average concentrations during a the overlapping 5-day period when TDF was not burned (11/ 4, 11/5, 11/6, 11/11 and 11/12).

Figure 23. Time Series of Total Measured Alkanes at Shoreham Sites, Nov. 2006

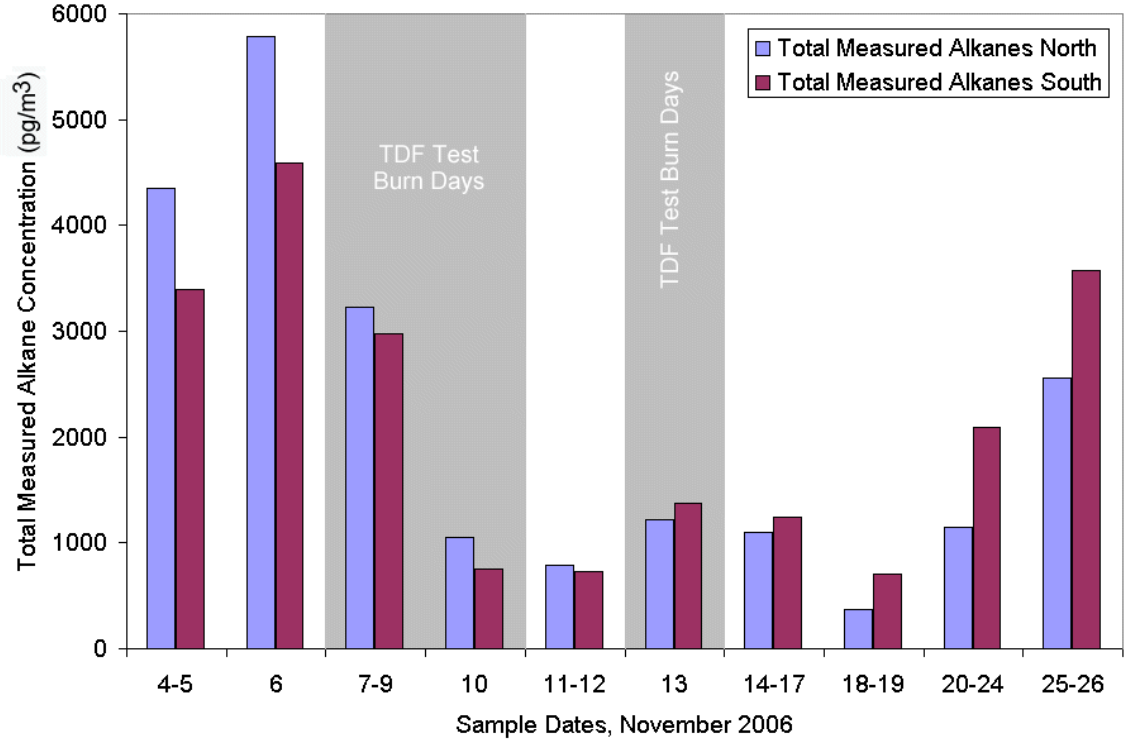
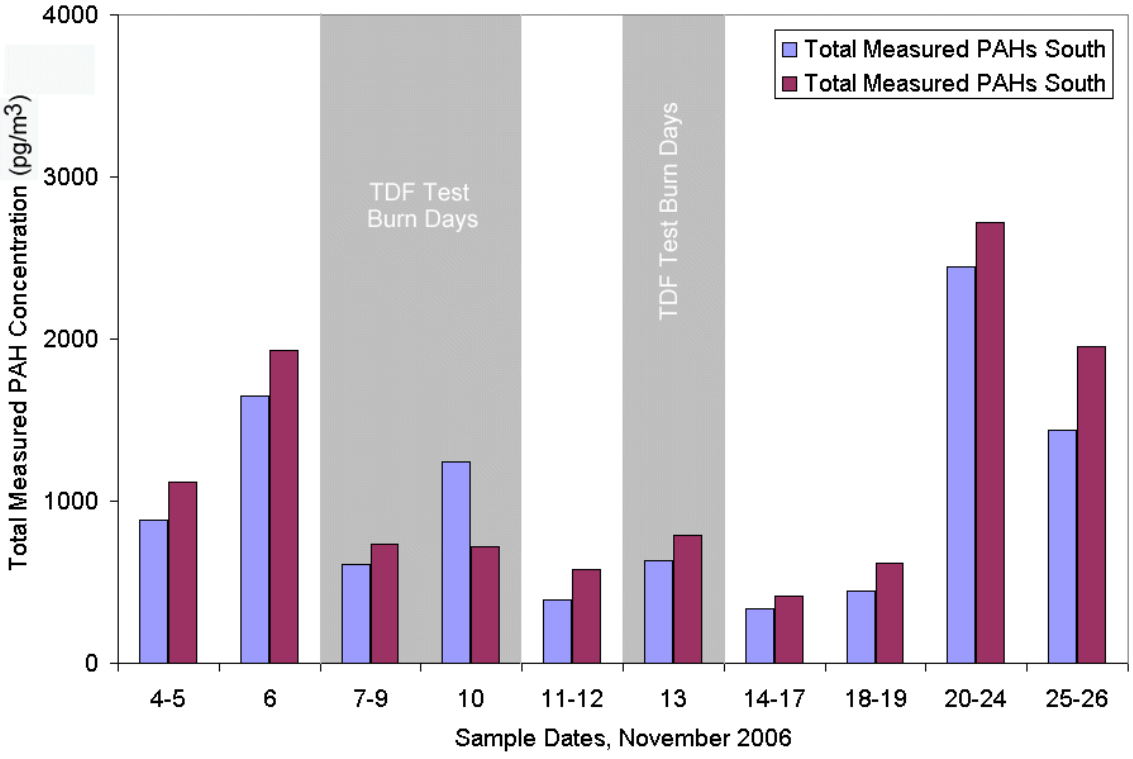


Figure 24. Time Series of Total Measured PAHs at Shoreham Sites, Nov. 2006



The Alkanes are defined by carbon number (C19 through C40) and the PAHs defined by the specific compounds identified. These data are averaged for the Shoreham North and South sites. The absolute concentrations and species profiles for both the Alkane and PAH compounds are very similar for the days of the TDF test burn compared to days when TDF was not burned, and for several species are slightly higher on days with no TDF combustion.

Figure 25. Comparison of Alkane Profiles on TDF Burn Days and Non-Burn Days.

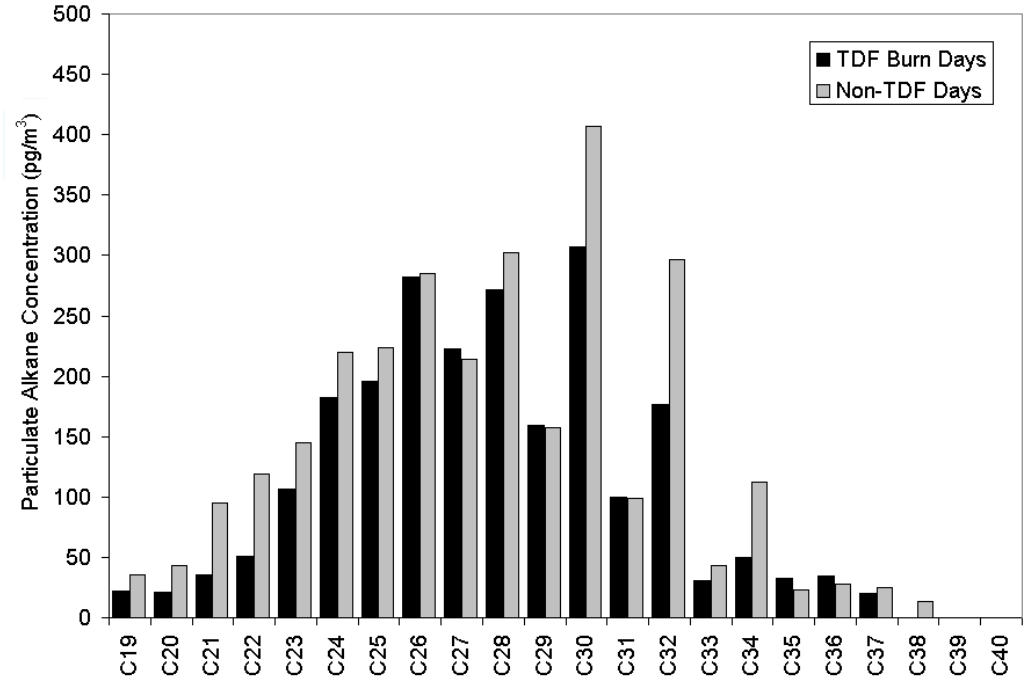
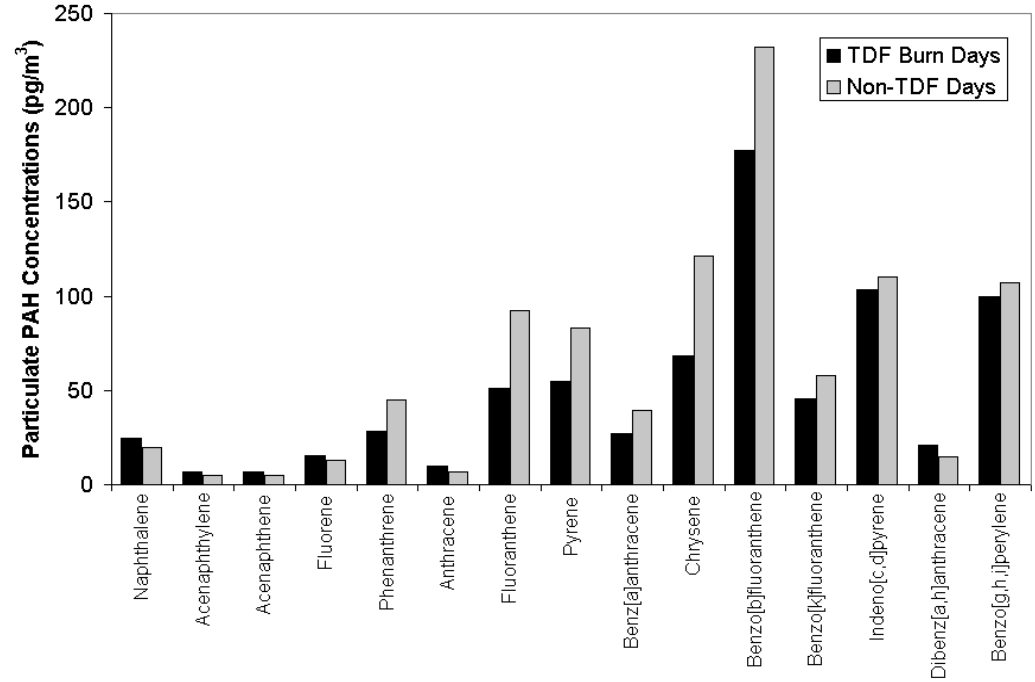


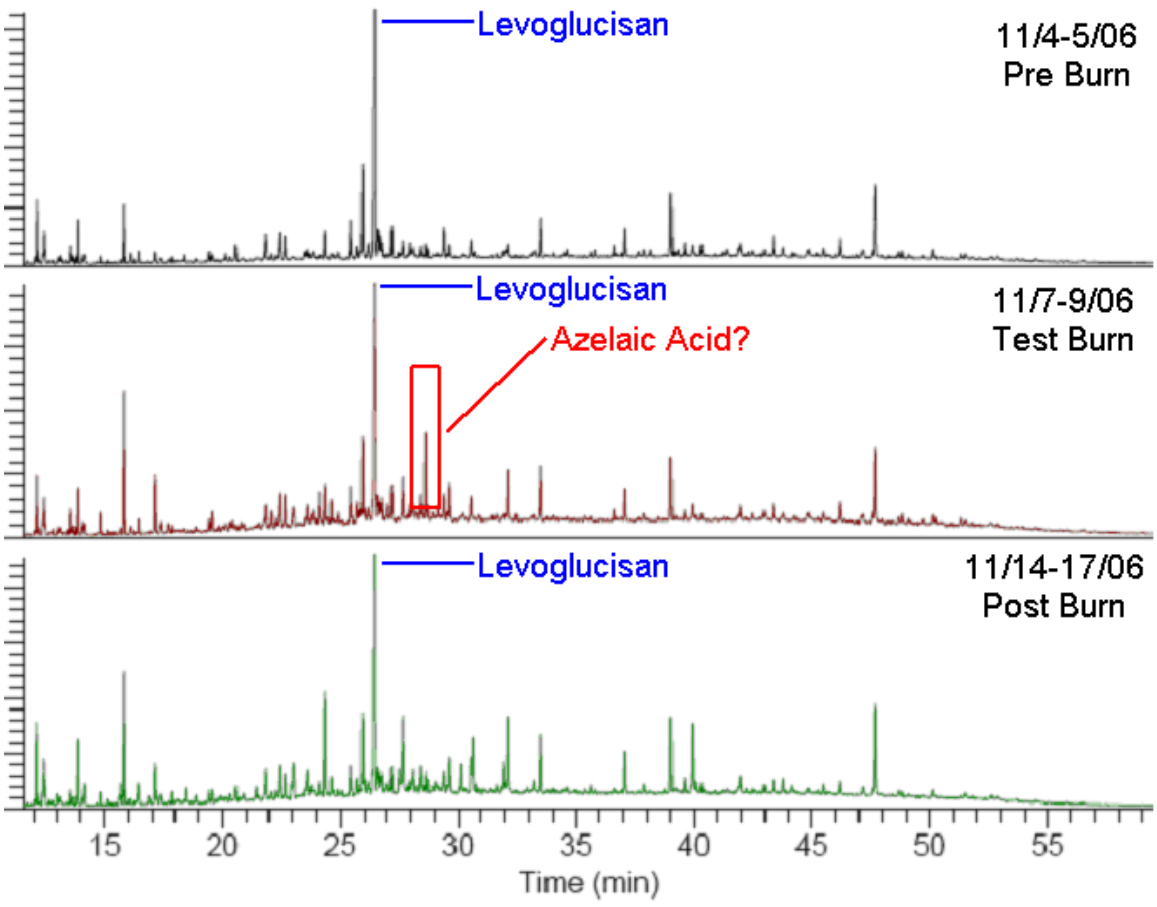
Figure 26. Comparison of PAH Profiles on TDF Burn Days and Non-Burn Days.



For the Alkanes, which are generally non-reactive and have minimal biological activity, biogenic sources like plant waxes are often associated with relatively high ratios of odd to even carbon numbers especially in the C29 to C31 range. In this case, it can be noted from Figure 25 that there was a relatively greater abundance of even numbered carbon compounds in this range, suggesting contributions from anthropogenic combustion sources. Several of the measured PAHs (naphthalene, fluorine, phenanthrene, fluoranthrene and pyrene) are on Vermont's list of "hazardous air contaminants". However, the measured concentrations were well below the level of the state's hazardous ambient air standards in all cases, nor does there appear to have been any perceptible contribution to the PAHs or Alkanes from the IP plant burning TDF fuel.

Several of the composited filter extracts used for Alkane and PAH analysis were also analyzed for polar organic compounds. These included 3 samples for each site, covering the periods 11/4-5/06 (Pre Burn), 11-7-9/06 (TDF Test Burn), and 11/14-17/06 (Post Burn). As expected, all samples exhibited a strong presence of levoglucisan, considered a direct tracer for wood combustion (including both residential wood burning and industrial sources). The levoglucisan peak is clearly evident in the Figure 27 gas chromatographs for the polar organic compound analysis for all the samples from the Shoreham North site, as was also the case for the South site.

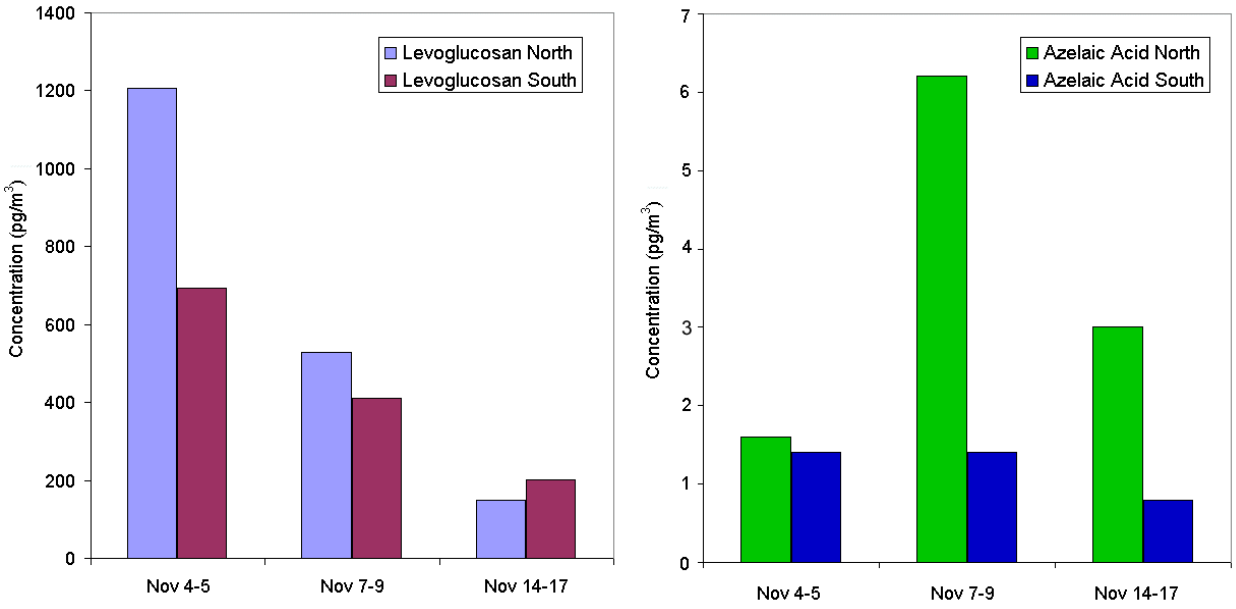
Figure 27. Chromatograms for Polar Organic Compounds at Shoreham North Site.



An additional (unexpected) peak was identified somewhat uniquely in the Shoreham North sample collected 11/7/9/06 during the TDF test burn for a compound eluting at 28.60 minutes. This peak was much less pronounced in the other (pre-burn and post-burn) composites, as well as in the 11/7-9/06 sample from the South site (where modeled IP TDF source impacts were much lower than the North site). Using the NIST mass spectral library, this peak was tentatively identified as azelaic acid (nonanedioic acid) sylyl derivative and has been subsequently confirmed as azelaic acid using a neat standard at the Clarkson Laboratory.

It can be noted in Figure 28 that while the wood smoke tracer levoglucisan is highest at both sites in the 11/4-5/06 pre-test burn sample, the Azelaic acid is uniquely highest at the North site (location of maximum modeled IP plume impact) during the TDF test burn. One of the prominent industrial applications of azelaic acid is as a plasticizer in the production of rubber used in tire manufacturing, and so its large increase in the air samples taken downwind of the TDF test burn suggests it might be useful as a direct qualitative tracer for TDF fuel combustion.

Figure 28. Levoglucisan and Azelaic Acid in Shoreham on TDF Burn and Non-Burn Days.



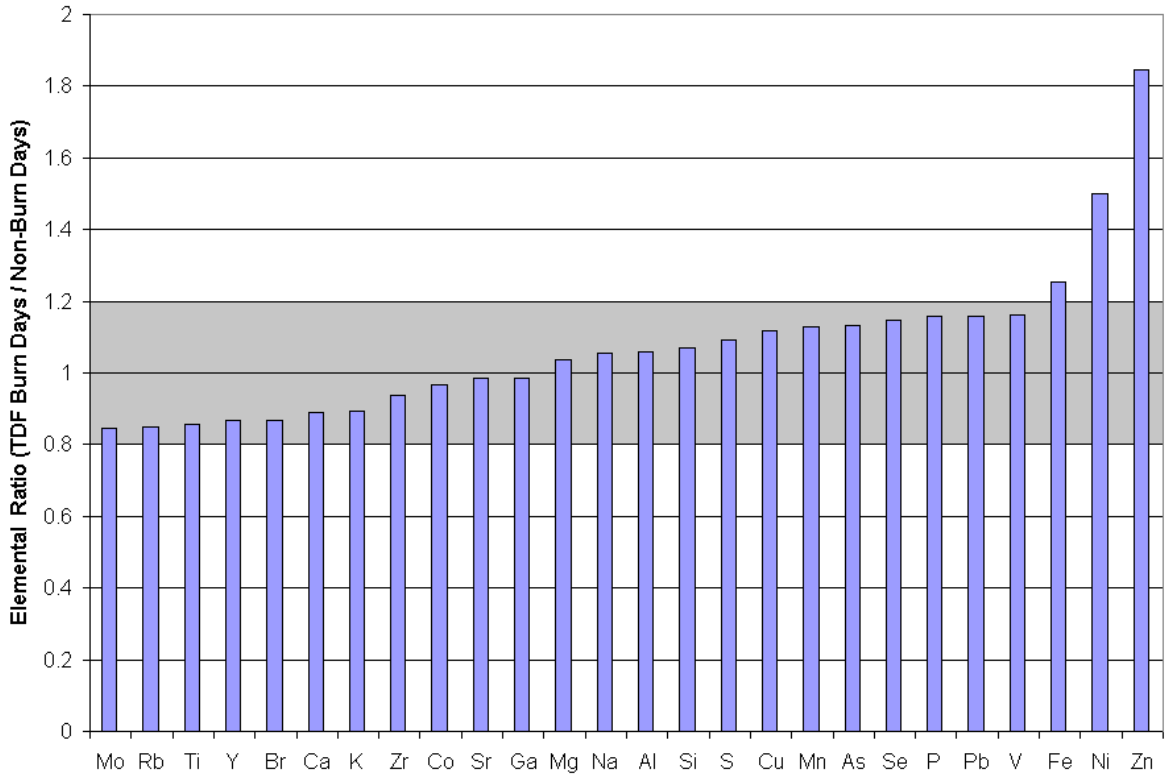
DRUM Results

The coincidental occurrence of a regional transport event during the first few days of the TDF test burn, and on several other occasions during the November 2006 intensive sampling period, makes it extremely challenging to discern the separate influence of the IP boiler in the Shoreham data. Of all the Shoreham measurements, the DRUM data may provide the best opportunity to discern some influence from IP – under standard operating conditions or during the TDF test. Reasons include:

- DRUMs ran at both Shoreham sites for nearly the entire month of Nov.2006,
- Highly resolved particle size information (8 sizes) to help distinguish coarse mode and fine mode sources and aged vs. local very fine particles,
- Highly resolved temporal information (every 3 hours) provides best opportunity for discerning short-term impacts of a nearby source plume,
- Detailed elemental composition including tracers for wood (K), oil (Ni) and TDF (Zn).

Figure 29 is based on data from the DRUM samples which have been aggregated up to daily $PM_{2.5}$ (sum of data from the 6 smallest size bins and eight 3-hr samples/day), and averaged for both Shoreham sites for the days of the TDF test burn (11/7, 8, 9, 10, 13) and for all other days during the November 2006 sample period (11/2-6, 11, 12, 14-29). The shaded gray area in Figure 29 highlights elements for which the ratios (TDF Burn days / Non-TDF days) are within +-20% of 1:1. Nearly all of the elemental ratios fall into this range, indicating relatively little increase (or decrease) on days of the TDF test burn compared to other days. Exceptions include Fe (marginally higher on TDF days), Ni (about 1.5 times higher on TDF days) and especially Zn (averaging nearly twice as high on TDF burn days).

Figure 29. Shoreham $PM_{2.5}$ Trace Elements on TDF Burn Days vs. other Sample Days



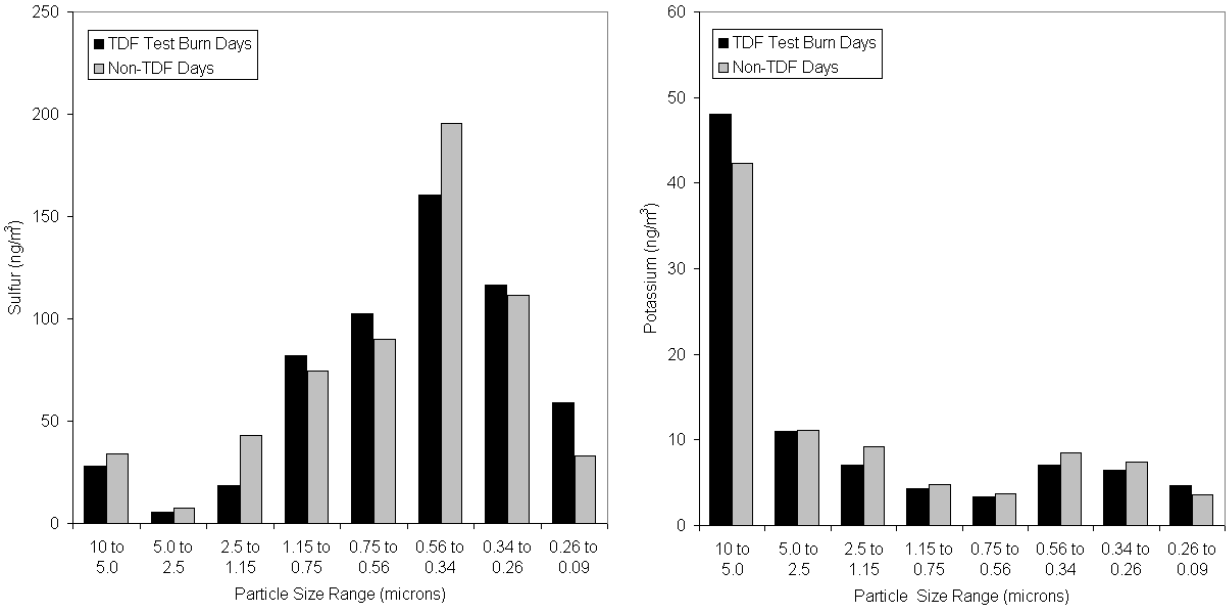
Particulate iron in the Shoreham DRUM samples occurs primarily in the larger particle sizes (90% of Fe is > 1 micron) and appears to be primarily from windblown soil, as it is highly correlated with Si, Al and Ca (in the larger size ranges). However, the largest proportionate increases in iron on TDF Burn Days occur in the smallest particle size ranges (twice as high on TDF burn days in the two smallest particle size bins). A slight increase in very fine particle Fe could potentially result from the small amounts of steal belt remnants in the TDF fuel.

It may be noted that sulfur and potassium are two elements which exhibit small differences (within +- 10%) on TDF test burn days vs. other sample days. S is emitted by fossil fuel (and TDF) combustion sources, but primarily as gaseous SO2, with a small fraction as particle-phase sulfate aerosol. Additional sulfate aerosol is formed from oxidation of SO2 in the atmosphere, but this secondary formation takes time, more so in cold weather, and so while we expect most secondary sulfate to be present in relatively small size ranges (DRUM stages 5-8), we don't expect S in any particle size range to be a good indicator of local source influence – for sources burning oil or TDF fuel.

Potassium, like levoglucisan, can be a good indicator of wood combustion, but potassium is also present in soil dust and is relatively abundant in smoke from fireworks and in sea salt aerosol. We don't expect fireworks influence in the November 06 Shoreham data, and transport of sea salt as far inland as western VT is relatively rare. Soil K will tend to occur primarily in the larger particle sizes (DRUM stages 1-4) and on that basis, can be distinguished from wood smoke K, which would tend to occur in smaller particle sizes (DRUM stages 5-8).

Figure 30 shows the particle size distributions for S (left) and K (right) from the DRUM samples, aggregated for both Shoreham sites and averaged for days during the TDF burn (black bars) and for all other sample days (grey bars). As expected, the particulate sulfur shows little difference during the TDF test days compared to other sample days, and is found primarily in the smaller size ranges (less than about 1 micron in diameter).

Figure 30. Particle Size Distributions for S (left) and K (right) averaged for both Shoreham sites on days of the TDF test burn and on other days during November 2006

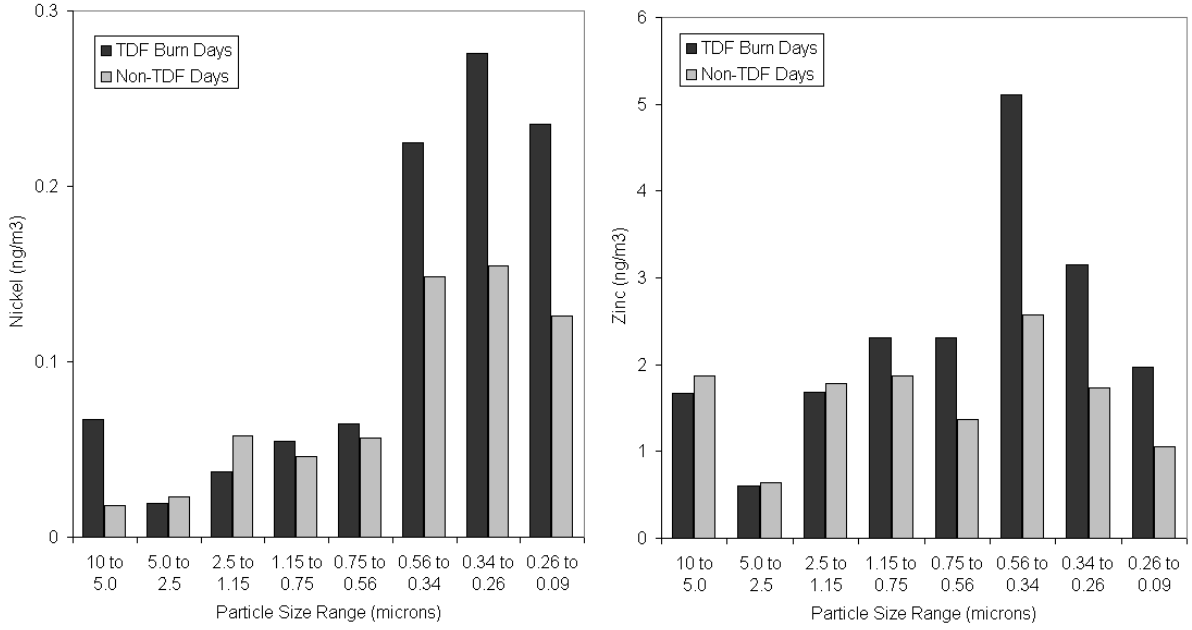


Potassium shows much higher concentrations in the largest size bin (larger than 5 microns in diameter) indicative of coarse mode particles. This coarse K is likely indicative of local soil dust emissions from sources like dirt roads or freshly plowed fields, as very large particles are typically not transported over long distances. The K data also exhibit a bimodal size distribution, with a secondary peak in the smaller (0.25 to 0.56 micron) size range. The IP source burns a substantial amount of wood waste (typically about 15 to 20 tons/hr) - both during the TDF test burn and under standard operating conditions and might be expected to contribute to wood smoke and associated K in Shoreham. However, there are also many other smaller but numerous local and regional wood burning sources contributing to wood smoke and fine particle K concentrations in Shoreham. In any event, it can be noted that there is no increase in the smaller sized K particles during the TDF test burn (nor was any increase expected).

In Figure 31, the DRUM data for Ni (left) and Zn (right) are averaged for each particle size bin for both sites for samples collected during the TDF test burn days (black bars) and for samples collected during other days during November 2006 (grey bars). It can be noted that the largest

absolute and proportionate increases in both Ni and Zn occur primarily in the 3 smallest particle size bins – 0.56 to 0.34 µm, 0.34 to 0.25 µm, and 0.25 to 0.09 µm. This fine particle increase (especially in the smallest stage 7 and 8 size bins) is consistent with contributions from a relatively nearby source, as particles from more distant sources would tend to agglomerate into a slightly larger size range.

Figure 31. Particle Size Distributions for Ni (left) and Zn (right) averaged for both Shoreham sites on days of the TDF test burn and on other days during November 2006



Nickel is often a good tracer for residual oil combustion and might be expected to increase when the IP plume is impacting the Shoreham sites. It would also be expected to increase during transport events from the East Coast Urban Corridor, which contains a high density of oil burning utility sources. However, there's no logical reason to expect Ni emissions from the IP boiler to increase when TDF fuel is added. As with the apparent increase in RGM concentrations, the cause for this is unclear. Possibly there is something about the TDF emissions that affected the efficiency of the flue gas control system, allowing increased emissions of chemical species like Ni and Hg that are not directly associated with the TDF fuel itself. Or possibly the apparent increase in fine nickel on TDF burn days is – like the increases in SO_2 and RGM – largely coincidental and due more to a concurrent regional transport event than to influence from the nearby IP plant. The large increases in the very smallest size ranges suggests that at least some of the increase is due to nearby, un-aged sources. Whatever the cause, It should be noted that the increase in $PM_{2.5}$ Ni - averaging about 0.3 ng/m^3 higher on TDF burn days - was very small.

The absolute and proportionate increases in $PM_{2.5}$ Zn on TDF burn days were larger than for any other DRUM species, averaging about 5 ng/m^3 higher on TDF burn days. The large proportionate increase in zinc in the smallest particle size ranges during the TDF test burn was definitely an expected result, given the relatively high Zn content of TDF fuel (estimated as roughly 1% by mass of TDF fuel). This increase in $PM_{2.5}$ Zn is also quite similar for the DRUM data (aggregated up to $PM_{2.5}$ size and 24-hour averaging times) and the Clarkson 24-hour $PM_{2.5}$ speciation filters (Figure 32).

Figure 33 shows the time series of $PM_{2.5}$ Zn at the Shoreham north and south sites for November 2006. The data for the two sites magnitude and temporal trend for most days, suggesting common, relatively distant source influences on both sites. As previously indicated in Figure 11, the finer (Stage 7) Zn data at the 2 Shoreham sites were well correlated (R^2 = 0.78) on days during November 2006 when TDF fuel was not burned, but poorly correlated (R^2 = 0.38) on days of the TDF test burn. In Figure 34, it can be noted that $PM_{2.5}$ Zn is slightly higher on 11/8 at the north site and much higher on 11/9 at the south site. These results are consistent with the CALPUFF modeled IP plume impacts displayed in Figure 5. The model results also indicated likely IP plume impacts at the north site on 11/7, although any perceptible local source effect on 11/6 or 7th may well have been overwhelmed by the regional transport event indicated in Figures 4, 12, 13, 14, 19 and 20.

Fig. 32. Average Shoreham $PM_{2.5}$ Zn, 11/06

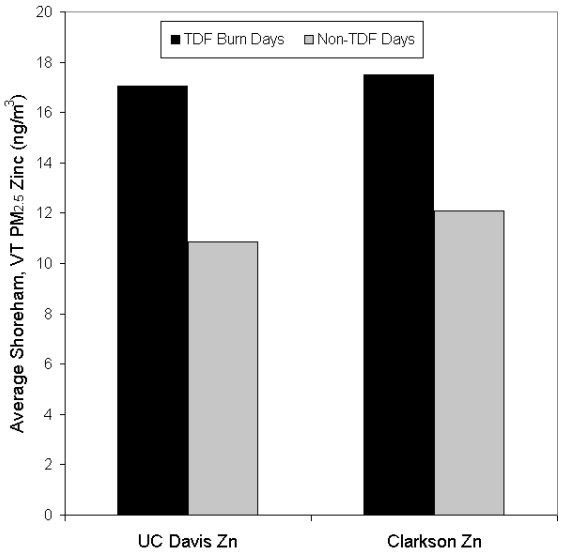
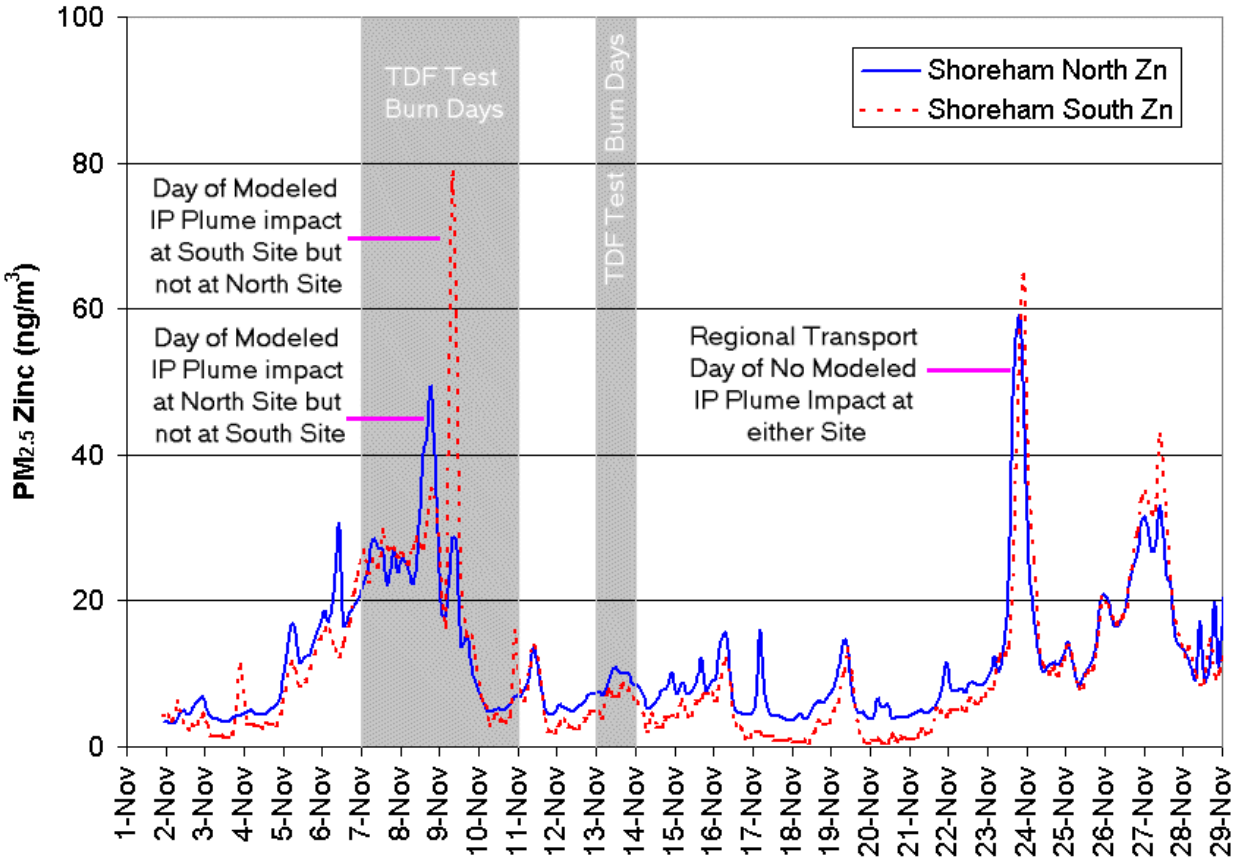
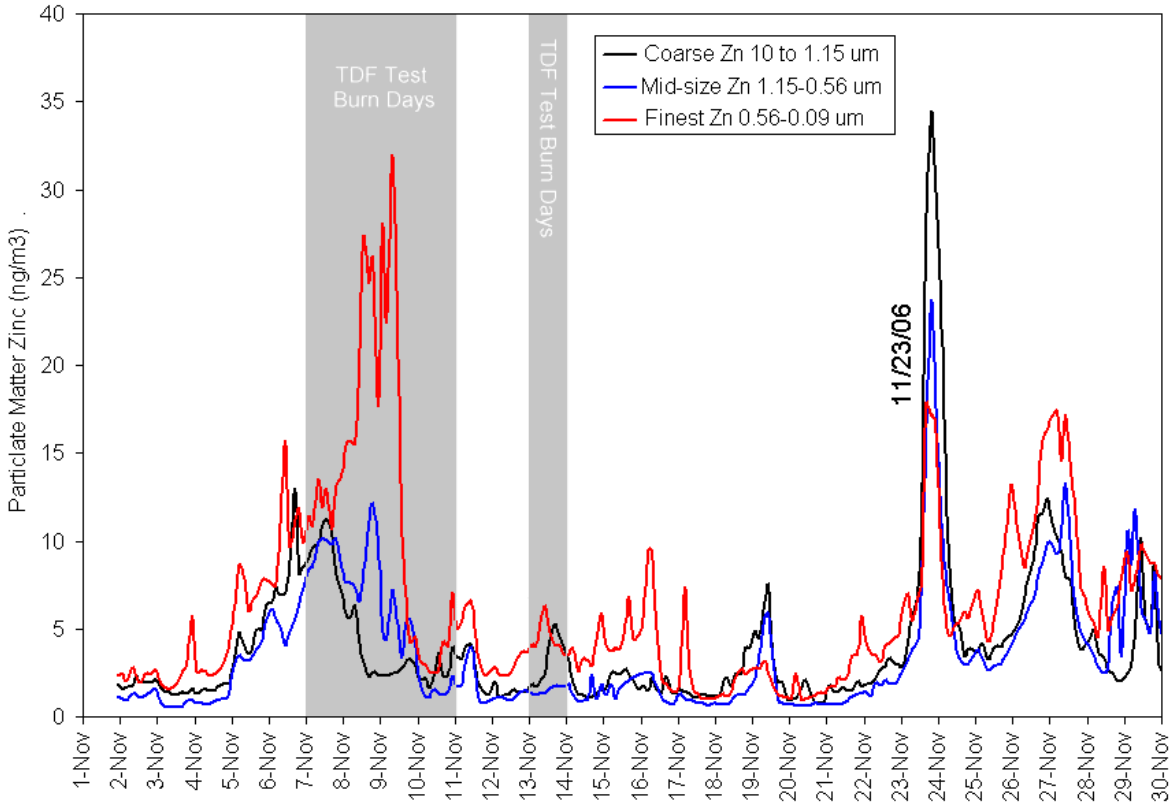


Figure 33. Time series of $PM_{2.5}$ Zn at Shoreham North and South Sites, Nov., 2006



An additional perspective on local vs. more distant Zn sources is provided in the particle size data plotted in Figure 34. The Shoreham DRUM Zn data were aggregated for both sites and 3 different particle size ranges (coarse = 10 to 1.15 microns; midsize = 1.15 to 0.56 microns and very fine = 0.56 to 0.09 microns). It can be noted that the coarse and midsize Zn initially peak on 11/6 and early on 11/7 (concurrent with the regional transport event), but then decline throughout 11/7th, 8th and 9th when the finest Zn particles are increasing (and when modeled impacts at the Shoreham sites during the TDF test are highest – first at the north site on 11/7 and 8, and then at the south site on 11/9. For contrast, another large Zn episode occurs (concurrently at both Shoreham sites) later in the month – on 11/23 and early on the 24th.

Figure 34. Time Series of Shoreham Zinc Particle Size Fractions, November, 2006

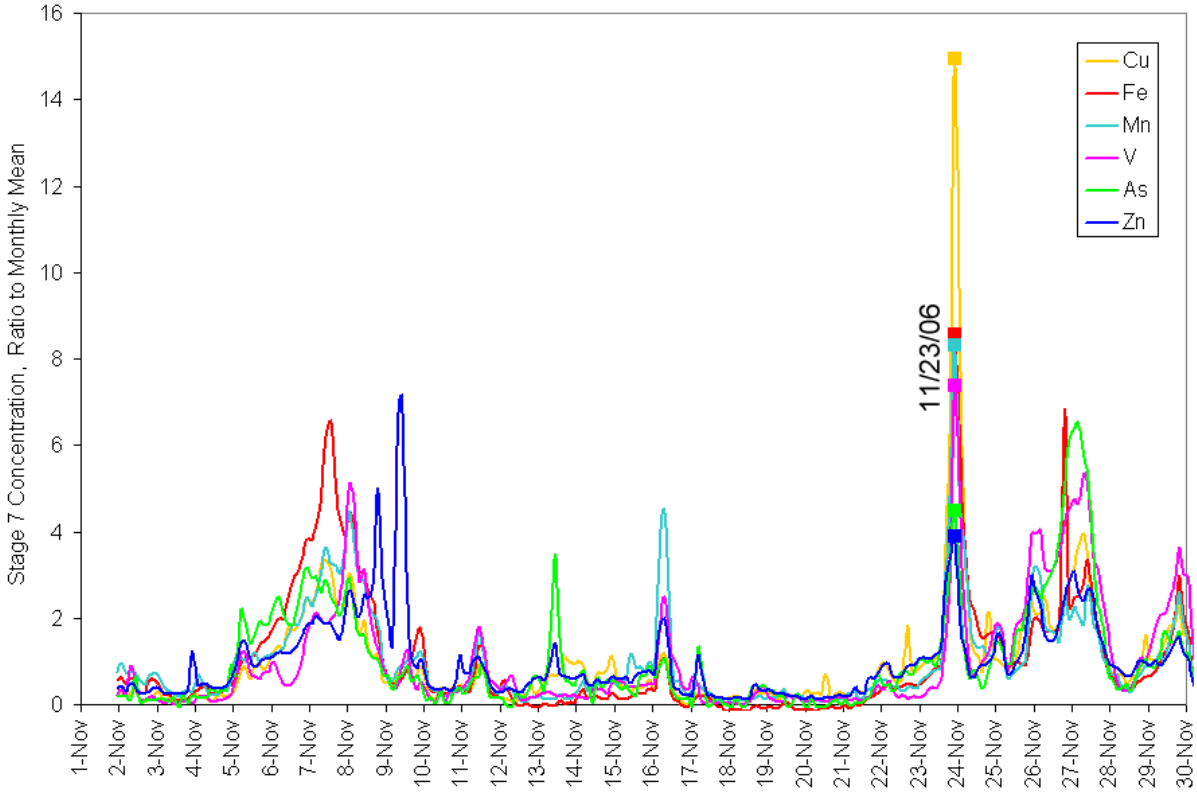


This second Zn event had the highest very fine Zn of any time outside the TDF burn period, but also had a much different particle size distribution – in which coarse particle Zn > midsize Zn > finest particle Zn. This is exactly the opposite to the pattern of fine>> midsize > coarse particle Zn that occurred during the days of TDF tire burn influence. The dominance of very fine particle Zn during the TDF test days is consistent with influence from a near-by source. The Zn size distribution for the 11/23-24 event is unusual, as Zn is typically found in fine mode particles, and coarse mode particles - such as wind blown soil, re-entrained road dust, tire wear and fugitive emissions from materials processing sources - rarely emit particles less than about 1 micron diameter. So it appears that the Zn on 11/23/06 (Thanksgiving Day) originated from a variety of very different kinds of sources.

As previously noted (Figure 17), the 11/23-24 event also resulted in the highest concentrations of gaseous elemental, reactive gaseous and particle-phase mercury observed at Shoreham north during November 2006. As displayed in Figure 35 below (based on the stage 7 DRUM

data for fine particles between 0.34 and 0.26 microns), the 11/23 event also included a highly unusual mixture of trace elements. In this case, the concentrations are normalized to a common Y-scale by dividing the individual 3-hr elemental concentrations by their monthly means.

Figure 35. Average Shoreham Trace Metals from Stage 7 DRUMs (0.26-0.34 microns)



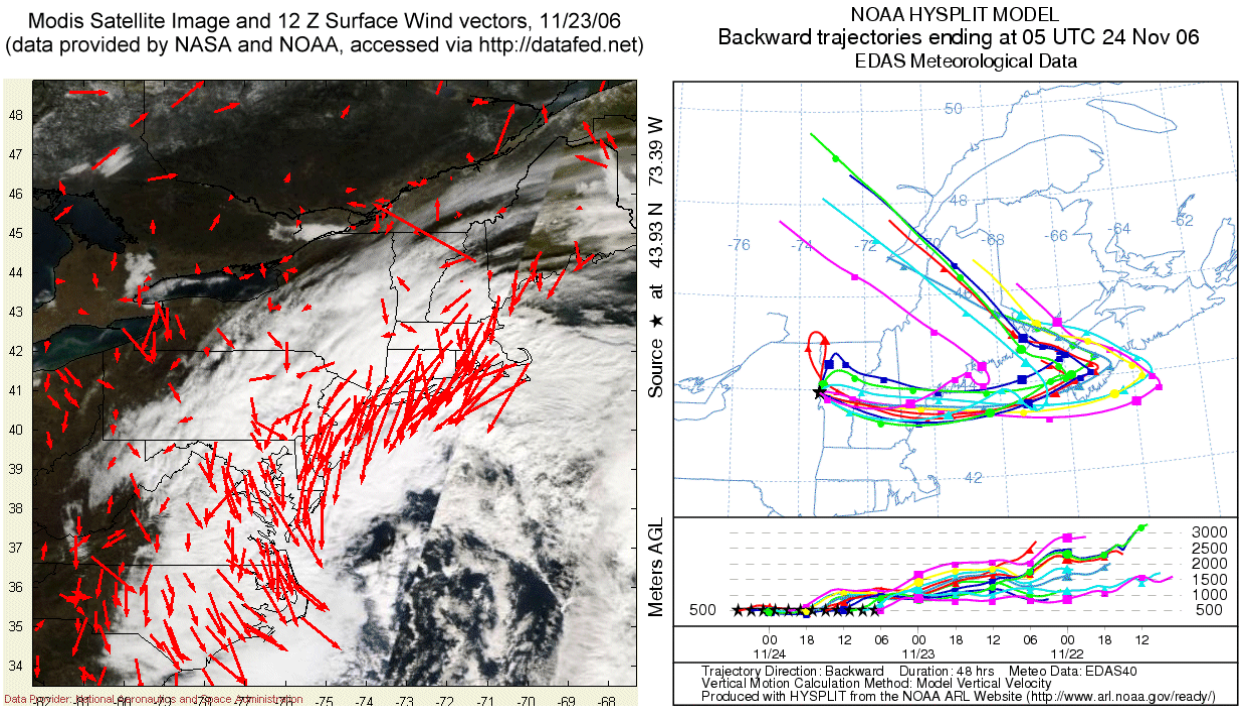
Typically, V is a good tracer for oil combustion (which tends to come to VT from the east coast urban corridor), As and Cu are often tracers for smelters (which typically come from the northwest of VT), Mn for steel production or diesel exhaust (usually coming from the west or north of VT), and Fe for soil (often of more local origin). Its highly unusual to see all of these metals plus Zn and Hg all present in relatively high concentrations in VT at the same time.

Figure 36 shows the 11/23 NASA MODIS satellite image, surface wind vectors and synoptic scale back trajectories from the NOAA HY-SPLIT model, run 48 hours back from Shoreham, starting at a height of 500 meters every 2 hours on 11/23/06.

The predominant regional weather feature on 11/23/06 was a strong extratropical cyclone (nor'easter) which had formed a few days earlier off the Southeastern US coast and traveled in a northeasterly direction, bringing strong winds and record rainfalls to the Mid-Atlantic and southern New England coast on 11/22 and 23. The winds later strengthened to hurricane force as the storm moved past Maritime Canada into the North Atlantic on November 25. In VT on the 23rd, the synoptic winds driven by strong, counterclockwise circulation around the top and back of the low pressure system, brought flows from an East-Northeasterly direction. The origin of pollutants associated with these northeasterly flows is unclear, but the unusual combination of particle sizes, chemical species and meteorological conditions suggest possible contributions

from areas east and northeast of VT, as well as coastal locations further south along the path of the storm. These pollutants were clearly not associated with TDF or other emissions from the IP plant, and the elevated Zn concentrations on 11/23 are clearly of a very different character than those observed on 11/7-9/06 during the TDF test burn.

Figure 36. MODIS Image, Surface Winds & HY-SPLIT Back Trajectories from Shoreham, 11/23/06



The increased concentration in azelaic acid, a compound employed in rubber production, in samples collected during the TDF test burn suggests a small but perceptible influence of the test burn in Shoreham. The elevated Shoreham Zn concentrations, only in the finest particle sizes, and specifically on days when IP source impacts were modeled at the Shoreham north (11/7-8) and south (11/9-10) sites respectively, provide the clearest pollutant measurement data that can reasonably be attributed to emissions associated with the TDF test burn. From Figure 34, if we assume that difference between the Shoreham sites during periods of modeled plume impact during the TDF test is an indicator of the TDF impact, then the largest 3-hour $PM_{2.5}$ Zn signal from the test burn was about 50 ng/m^3 observed from 6 to 9 AM on 11/9/06 at the Shoreham south site. This corresponded to daily $PM_{2.5}$ Zn, averaged over the 24 hours of 11/9/06, of 12 ng/m^3. These increased concentrations of Shoreham Zn, while perceptible, were well below the levels of VT (or federal) health standards - as were concentrations of all other measured metals (including Hg), PM_{10}, $PM_{2.5}$, SO_2 and measured organic compounds - throughout the month of November 2006, including the days of the IP TDF test burn. Shoreham concentrations of organic carbon, nickel and iron also increased slightly during the test burn, but these increases may well have been caused, at least in part, by a coincident regional transport event during the first few days of the test.

Appendix I

Trial Burn Field Observations/Site Reports

Agency of Natural Resources
Department of Environmental Conservation

Air Pollution Control Division
Building 3, South
802-241-3841

MEMORANDUM

To: Jeffrey Wennberg, Commissioner

Thru: Richard Valentinetti, Director

From: David Manning

Date: November 30, 2006

Subject: Site Visit & PM Testing at International Paper on 11/6/06

I made the following observations of the tire derived fuel (TDF) trial burn at International Paper (IP) in Ticonderoga, NY on Monday, November 6:

Today was spent with discussions of the upcoming TDF trial burn at IP and a walking tour of the boiler feed system, boiler control room, and boiler house roof area. These activities included one or more of the following individuals, along with myself:

Jim Witkowski, Atlantic Region Manager, EHS On-site Management, IP
Stephen Regan, Env. Performance Manager, IP Ticonderoga
Donna Wadsworth, Communications Manager, IP Ticonderoga
Amy Dostie, Environmental Engineer, IP Ticonderoga
Heather Perry, Process Engineer, IP Ticonderoga
various IP Ticonderoga boiler and process operators
Terry Grave, TDF Consultant

Marcus Kantz, USEPA Region 2
Alan Hicks, USEPA Region 1
Doug Elliott, Vermont APCD

IP personnel explained that they were hoping to discover if TDF would help with start-ups, shut-downs, and load swings on the power boiler. Because the recovery boiler must run "steady-state" the power boiler is left absorbing most of the changes in steam load. Their experience at other IP facilities indicated that burning TDF would help control irregularities in the combustion of wet bark, and also help prevent clumping of bark in the feed system.

IP Ticonderoga handles bark fuel using a pneumatic transport system. TDF, and in particular, the loose wires that accompany the tire chunks, may be difficult to handle in a pneumatic feed system because the wires would jam rotary seals and may damage other components. Mr. Grave, IP's TDF consultant, indicated that he looked at several TDF suppliers and tried to select the

supplier who could provide fuel with the least amount of loose wire. If TDF burning becomes permanent, IP may consider a different fuel feed system to avoid potential problems. A small amount of TDF was collected by Doug Elliott and brought back to the VT APCD office.

We spent a few minutes observing the handling of bark and TDF in the storage area. Bark and TDF is piled on the ground in open stockpiles until moved by a front-end loader into metering bins. Screw augers under the bins are powered by variable speed drives, which control the rate at which bark and TDF is delivered to the pneumatic transport system. Mr. Witkowski said that the amperage of the motors can be checked, and this is how the fuel feed rate is monitored. Just prior to the entrance to the pneumatic system there is a belt conveyor that combines bark and TDF delivered from the two metering bins. During the emissions testing program IP intends to take samples from this conveyor to verify the bark and TDF feed rates.

We briefly looked at the boiler controls, gages, and television monitors. In addition to the computerized boiler controls, there is a television camera showing fuel burning on the boiler grate. Unfortunately, the view does not show much detail. While in the boiler room I asked about soot blowing schedule and how the grates are cleaned. Boiler room personnel confirmed that soot blowing is automatic and relatively continuous. They also indicated that grates are emptied occasionally by simply allowing them to open downward. Ash then fall into a water-filled quench pit. A conveyor belt carries the wet ash from the bottom of the pit to a disposal area.

I asked how soot blowing and grate cleaning would be incorporated into the testing protocol. Because the soot-blow is automatic and one of the four banks blows every 45 minutes, it did not appear that any special test considerations were needed for this event; a soot blow would occur at least once during almost every test run. But the grate dumping only occurred two or three times per day. It appeared that this had not been considered in the test plan. I pointed out that in many test programs a special test run is performed specifically incorporating a grate cleaning to see what the emissions are during these events. Mr. Witkowski said that this would be discussed with the NY DEC representative prior to beginning the full stack test program.

We also briefly discussed the operation of the wet scrubber. This is a custom-built device unique to IP Ticonderoga. Mr. Witkowski said that he would get together with IP staff and have one of their engineers put together a presentation for us describing the scrubber and it’s operation (see 11/14 trip report).

IP personnel said that they intended to start by performing preliminary particulate matter (USEPA Method 5) testing at several TDF feed rates. When they had found the maximum TDF feed rate that appeared acceptable, the formal compliance testing (including metals and other toxic emissions) would begin at that rate. They anticipated that the compliance testing would not begin until late in the week, or, more likely, the beginning of next week.

dm

Agency of Natural Resources
Department of Environmental Conservation

Air Pollution Control Division
Building 3 South
802-241-3840

MEMORANDUM

To: Jeffrey Wennberg, Commissioner

Thru: Richard Valentinetti, Director

From: Doug Elliott

Date:

Subject: International Paper Trial Burn - Field Report for Monday, November 6, 2006

Field Report for 11/06/2006. See also Dave Manning's field report for same day.

Weather: partly sunny most of day; mild with temps 30's to 40's; winds light but steady from the South all day as evidenced by Power Boiler plume.

Dave Manning and I arrived at the facility at approximately 8:30 am on Monday November 6, 2006. All visitors are required to sign in and out at the security center upon entering or leaving the plant property and must always be escorted around the plant by IP personnel. First time visitors are also required by International Paper to view two safety videos on potential hazards at the facility. After signing in and viewing the safety videos we were escorted to a conference room that was reserved for VT APCD, U.S. EPA and NYDEC personnel for the duration of the trial burn.

The day began with general introductions of the on-site IP and regulatory personnel. IP personnel were represented by:

Jim Witkowski, IP Regional EHS Manager, Atlantic Region (Camden, SC)
Donna Wadsworth, IP Communications Manager (IP Ticonderoga)
Stephen Regan, IP Environmental Performance Manager, (IP Ticonderoga)
Amy Dostie, IP Environmental Engineer (IP Ticonderoga)
Heather Perry, IP Process Engineer (IP Ticonderoga)
Terry Gray, President T.A.G., Tire Derived Fuel Consultant (Houston, TX)

The following state and federal regulatory personnel were on site today:

Dave Manning, VT APCD
Doug Elliott, VT APCD
Alan Hicks, U.S. EPA Region 1 (Chelmsford, MA)
Marcus Kantz, U.S. EPA Region 2 (Edison, NJ)
Chad Siever's, NYDEC

The plan for the day was:

1. Following our viewing of the safety videos and introductions, we were expected to tour the bark feed and TDF feed areas and then proceed to the Power Boiler control room and then to the Continuous Emissions Monitors (CEMs) room on the roof of the Power Boiler building where the stack testing would be conducted.
2. IP intended to commence baseline testing for particulate matter to determine existing emission levels without any TDF. Testing was to consist of three individual Method 5 particulate test runs.
3. If baseline testing were to have proceeded on schedule, IP could have considered adding the first TDF to the boiler on this day. However, as discussed below, baseline testing was delayed due to problems with the bark feed system and IP never began adding TDF until Tuesday at approximately 8:15 AM.

Following our introductions we proceeded to the wood yard. At the wood yard a pile of TDF was on-site ready for the trial, however this was only a portion of what would be needed for the trial and IP expected to require several more loads as the trial proceeded. Mr. Gray discussed the TDF processing operations and pulled sample pieces from the pile that demonstrated certain aspects of the processing. The TDF for the trial was being supplied by a company in the Buffalo, NY area. I collected several pieces that showed various characteristics but did not collect a representative sample at that time. Most of the pieces in the pile were less than 1 to 1.5 inches square. The pile contained little to no "bead" wire; the thick cord wire embedded in the tire bead area. It was explained that this thicker wire would cause operational problems with the rotary air lock pneumatic feed system and had to be essentially eliminated. It was not clear whether this would be a problem with the more permanent TDF feed system that would be erected should IP pursue long term use of TDF.

Some of the TDF pieces still contained substantial amounts of tread wire; small strands of wire that criss-cross the tread area of the tire. It was evident on some pieces of tread that the tread wire had been ripped out by the processing but many pieces still contained some of this wire. The sidewall pieces contained no wire but had various types of rayon fiber cords. Failure to remove at least some of the tread wire has been reported as a problem for some facilities burning TDF in that it will bridge the boiler grates and prevent air from getting up through and ash from falling down through the grates. Without comparing this pile of TDF to that where no wire is attempted to be removed I was not able to estimate the percent of wire removal.

Near the TDF pile was a large hopper with a pair of screw augers in the bottom that dumped to a second screw auger leading to the existing bark fuel rotary air lock for pneumatic conveying to the Power Boiler fuel surge bin. The wood yard is also where the logs are stored in piles and sent to the debarking and chipping operations building. The bark is used as fuel for the boiler, the chips are processed into pulp for papermaking. The bark from the debarking operation (200 tpd) is supplemented with excess bark or wood fuel from the wood yard via a front end loader (225 tpd). Bark accumulates in the wood yard during times the Power Boiler operates without wood fuel such as during breakdowns in the bark feed system. IP is allowed to burn 547 volumetric tons of wood/bark per day but instead attempts to feed a consistent 425 tons per day of wood/bark (17.7 tons per hour, around the clock). This was the wood fuel target rate during

the trial. The combined fresh bark and wood yard bark fuel is dropped into a rotary air lock and pneumatically conveyed to the Power Boiler's solid fuel surge bin where it is metered into the boiler. Following debarking the logs are sent to the chipper and the chips sent either to the pulp mill or to outside pulp chip storage piles (this is of no direct relevance to the Power Boiler operation).

The plan during the TDF trial is to maintain wood/bark fuel firing rate at 425 tpd and add successively larger amounts of TDF as fuel oil firing is reduced. The augers in the TDF hopper were calibrated such that certain settings on the screw drive controller would yield a set amount of TDF per hour.

After viewing the wood yard and debarking operations we proceeded to the Power Boiler control room. The Power Boiler is a multi fuel boiler that provides steam for a 40 MW electric generator and for the mill operations. The boiler is rated at 855 million BTUs per hour heat input but generally runs well below this level. Generally the boiler is run with 177 million BTUs per hour coming from wood fuel when fired at 425 tpd (17.7 tph) and the remainder from No. 6 oil. While IP has approval for primary and secondary sludge, digester knots, and waste oil they typically do not burn these. Since the Recovery Boiler is tied to the pulping processes it must run at a constant rate, therefore the Power Boiler is used as the swing boiler, cutting fuel oil firing when steam demand drops. Both boilers provide steam to a common steam header.

The Power Boiler control room contains the CEM readouts which the boiler operators use to adjust the boiler. The control room also contains video images of the bark surge bin and the inside of the boiler overlooking the solid fuel grates. Wood firing was temporarily offline for most of Monday morning due to a problem with the bark feed system. While we were in the control room the wood fuel had been restarted which was evident from the fuel feed meter readouts as well as the video image of the inside of the boiler which showed sparks and flaming pieces of wood fuel flying around in the turbulence inside the boiler. There was some discussion of ensuring soot blowing was represented in the stack testing as well as grate dumping. Soot blowing is done automatically every 45 minutes for a portion of the boiler tubes with each tube eventually cleaned each 8 hours and therefore soot blowing would be represented in each one hour particulate test. The boiler grates are normally dumped once per 8 hour shift. It was requested that at least one of the three successive particulate matter tests include a grate dump cycle. For grate dumping, wood fuel feed and underfire air is shutoff and the grates dump (like a trap door) to drop accumulated ash to the bottom of the boiler where it can be removed. The grate dump process takes approximately 10-20 minutes (?).

After viewing the control room we proceeded to the roof where the CEMs are located and the stack testers were commencing the first of three particulate matter Method 5 runs. Below are readings I had taken from the readout screens during the particulate testing. These values are simply observations at a point in time during the testing and can not be assumed to represent the entire period, nor are the data values quality assured or presented in the averaging periods of the permit. The actual hourly averages for these parameters are reported on the printouts provided by IP for each day of operation during the trial.

Due to problems with the bark feed earlier in the day, the baseline particulate Method 5 runs were not completed until late in the day. IP decided not to begin TDF firing until the next day.

Parameter	Units	11/6 3:30 pm	11/6 6:00 pm
Oil firing rate	gpm	42	42
Bark/TDF firing rate	tons/day equivalent	425	426
Temp	Degree C?	--	--
SO_2	lbs/hr	252	260
SO_2	ppm	180	--
H_2O	%	17.1	17.4
NOx	Lbs/mmbtu	0.19	0.19
NOx	ppm	112	112
O_2	% dry	7.0	7.1
Pre scrubber opacity	%	64.7	55.8
Steam flow	1000 lbs/hr	412	415
CO	ppm	32.7	27

Agency of Natural Resources
Department of Environmental Conservation

Air Pollution Control Division
Building 3 South
802-241-3840

MEMORANDUM

To: Jeffrey Wennberg, Commissioner

Thru: Richard Valentinetti, Director

From: Doug Elliott

Date:

Subject: International Paper Trial Burn - Field Report for Tuesday, November 7, 2006

Field Report for 11/07/2006.

Weather: more clouds than sun; continued mild with temps 30's to 40's; winds still light and consistently from the South all day.

The plan for the day was:

1. Review of baseline stack particulate Method 5 testing from Monday.
2. Commence TDF firing at 0.5 tph and monitor boiler response.
3. Proceed to 1.0 tph TDF firing if all looks favorable and again monitor boiler response.

The results from the three baseline particulate testing runs were reported as:

Run 1	0.038 lbs/mmbtu
Run 2	0.040 lbs/mmbtu
Run 3	0.051 lbs/mmbtu
Average	0.043 lbs/mmbtu

These are very respectable emission rates for this boiler which is limited by its permit to 0.10 lbs/mmbtu. Prior stack testing has shown actual emissions to be in the 0.06 - 0.08 range. It will likely be difficult for TDF not to show some increase above this baseline level.

At 7:00 AM the boiler grates were dumped. At approximately 8:15 AM the TDF feed system was turned on, delivering TDF to the wood fuel rotary air lock in the wood yard where it is blended with the wood bark fuel and immediately blown to the boiler surge bin. If the boiler surge bin was full at that time it would take approximately one hour before it would reach the boiler as there is approximately one hour of solid fuel firing capacity in the surge bin at. As the TDF feed system is turned in the wood yard the solid fuel feed auger in the surge bin is increased accordingly to account for the increased 0.5 tph TDF feed rate and the oil firing is cut back accordingly to ensure consistent heat input to the boiler. Otherwise if the solid fuel feed auger is

not increased, the solid fuel firing rate into the boiler remains the same on a volumetric basis and wood fuel ends up being displaced by TDF. The purpose of the trial was to displace fuel oil usage. The solid fuel firing rate is monitored and recorded. This monitor records solid fuel volumetric federate, not actual heat input which must be calculated based on the heating value of the fuel. Since the wood fuel feed rate to the surge bin is being held steady at 425 tpd equivalent, when TDF if feed at a 0.5 tph feed rate in the wood yard (12 tpd equivalent) the solid fuel feed auger in the surge bin must be increased to 437 tpd equivalent to ensure the boiler is firing 425 tpd wood and 12 tpd TDF (0.5 tph).

At approximately 8:55 AM TDF was assumed to be entering the boiler and being burned. At the 0.5 tph TDF feed rate I could not discern a difference in the video image of the inside of the boiler verses no TDF. I recorded a set of reading from the CEM readouts at this point.

At approximately 10:45 AM the TDF feed rate in the wood yard was increased to 1.0 tph and the surge bin auger was increased from 437 to 449 tpd equivalent and oil was cut back. While steam demand from the boiler varies from minute to minute the solid fuel rate is maintained steady and oil is used to swing the load by increasing or decreasing as necessary. I recorded another set of CEM readings during the 1 tph TDF feed rate. Again, the hourly average data was provided by IP the following day. The boiler operators continued to monitor and adjust the boiler at the 1.0 tph TDF feed rate throughout the afternoon on Tuesday.

During the feeding of TDF we again visited the wood yard and the TDF feed system. From the wood yard one is able to view the TDF and bark fuel dropping into the rotary air lock. The amount of TDF entering the air lock appeared to be visibly very little and we requested to see the calibration data. After some discussion, we requested IP conduct a verification of the TDF feed rate. The calibration check was completed the following day on Wednesday and confirmed the accuracy of the TDF feed rate.

At approximately 7:00 PM the TDF feed was shut off in the wood yard and the boiler was returned to normal operation. By 8:00 PM TDF was assumed to be cleared from the surge bin and no longer entering the boiler. IP expected to resume at the 1.0 tph TDF feed Wednesday morning.

CEMs readout data taken during 0.5 and 1.0 TDF feed on following page. Again it must be noted that these are preliminary process control data and are only a point in time. The boiler was being adjusted all day and the values varied from minute to minute. The actual hourly average data was provided by IP the following day.

Parameter	Units	11/7 0.5 tph	11/7 1.0 tph
Oil firing rate	gpm	40.8	37.2
Bark/TDF firing rate	tons/day equivalent	437	448.7
Temp	Degree C?	135	135.9
SO_2	lbs/hr	231	269.7
SO_2	ppm	178	209.7
H_2O	%	17.3	17.5
NOx	Lbs/mmbtu	0.19	0.20
NOx	ppm	113	117.7
O_2	% dry	7.3	7.5
Pre scrubber opacity	%	55	61.7
Steam flow	1000 lbs/hr	393	387
CO	ppm	30.8	35.7

Agency of Natural Resources
Department of Environmental Conservation

Air Pollution Control Division
Building 3, South
802-241-3840

MEMORANDUM

To: Jeffrey Wennberg, Commissioner

Thru: Richard Valentinetti, Director

From: Steven Snook

Date: November 17, 2006

Subject: Site Visit & PM Testing at International Paper

Field Report for 11/8/2006.

The plan for the day was:

1. For the boiler operators to continue to gain experience controlling the boiler's operation with TDF feeding at a rate of 1 ton/hr. The control/distribution of combustion air is believed to be one of the parameters that need to be adjusted to ensure good combustion with this blend of fuels (oil, wood waste and TDF).
2. Validate the method that they use to control the TDF feed rate.
3. Have the vendor check the prescrubber opacity monitor. One of the process changes that has been noted is that the prescubber opacity is higher when burning TDF. They want to make sure that the opacity sensor is operating correctly.

At 5:15 am the TDF feed system was started at a 0.5 ton/hour feed rate. At 6:00 am, the feed rate was increased to 1.0 ton/hour.

The TDF feed system consists of a nominal 20 cubic yard hopper equipped with a pair of inclined feed screws located at the bottom of the hopper. The feed screw operate in parallel and work together to draw the TDF out of the bottom of the hopper. The RPM of these feed screws dictate the TDF feed rate and is controlled with a variable frequency drive (VFD). The VFD is controlled between 0 and 50 Hz output. International Paper has established the calibration curve for this auger feed system and set the output at 12.56 Hz for a 1 tph feed rate. The feed augers discharge into a constant speed auger that transfers the TDF into the solid fuel delivery system where it is mixed with the wood waste and pneumatically conveyed to a feed bin in the boiler house.

At approximately 10:20 am, the TDF feed rate was validated: While operating the VFD at a 12.56 Hz output, they diverted the flow of TDF from the constant speed transfer auger to a pre-weighed collection box and filled the box to approximately 90% full. The time to fill the box was recorded and the full box was weighed: 580 lbs of TDF was collected in 16.5 minutes, for a

rate of 1.05 tons/hour. This was considered to be sufficiently accurate and representative of a '1 ton/hr' feed rate.

International Paper decided to wait one more day before conducting the PM testing at the 1 tph TDF feed rate.

The 1 tph TDF feed rate was maintained throughout the rest of the day.

Other regulatory agency representatives on site today:
Michael Sundberg – NY DEC
Marcus Kantz, USEPA Region 2
Alan Hicks, USEPA Region 1

Agency of Natural Resources
Department of Environmental Conservation

Air Pollution Control Division
Building 3, South
802-241-3840

MEMORANDUM

To: Jeffrey Wennberg, Commissioner

Thru: Richard Valentinetti, Director

From: Steven Snook

Date: November 17, 2006

Subject: Site Visit & PM Testing at International Paper

Field Report for 11/9/2006.

The plan for the day was:

1. Shut down of the solid fuel feed system (wood waste and TDF) from approximately 2:00 – 4:00 am for routine maintenance in the wood chipping operation.
2. At a 1 tph TDF feed rate, run the series of three 1 hour PM stack tests to be conducted following EPA Method 5. This is to determine if the PM emission rate is in compliance with the permit limits and to help assess if a higher TDF feed rate can be evaluated.

After the wood chipping system's maintenance was completed, the TDF feed rate was turned on at 0.5 tph at 4:30 am. By 5:00 am, the TDF feed system was back up to a 1.0 ton/hour feed rate.

The first PM stack test run was done from approximately 9:15 am to 10:15 am. During this sampling run, the CEM system indicated that the NO_X and SO_2 emissions were within permit limits. The preliminary result was 0.089 lb/MMBtu for PM emissions.

The second PM stack test run was done from approximately 11:10 am to 12:10 pm. During this sampling run, the CEM system indicated that the NO_X and SO_2 emissions were within permit limits. The preliminary result was 0.082 lb/MMBtu for PM emissions.

Since the preliminary PM emission rates were higher than expected, International Paper decided to shut off the TDF feed at 4:00 pm.

Other regulatory agency representatives on site today:
Michael Sundberg – NY DEC
Marcus Kantz, USEPA Region 2
Alan Hicks, USEPA Region 1
Doug Elliott, VT DEC

Agency of Natural Resources
Department of Environmental Conservation

Air Pollution Control Division
Building 3 South
802-241-3840

MEMORANDUM

To: Jeffrey Wennberg, Commissioner

Thru: Richard Valentinetti, Director

From: Doug Elliott

Date:

Subject: International Paper Trial Burn - Field Report for Friday, November 10, 2006

Field Report for 11/10/2006.

Weather: mostly sunny with patchy clouds most of day; still mild with temps 30's to 40's+; winds light but steady and consistently from a northerly direction all day as evidenced by Power Boiler plume going right over our heads on roof…the saturated plume actually resulted in light precip falling on us…each drop contained visible black particles that resulted in black dots on our hard hats when it dried.

The plan for the day was:

1. Review/discussion of 1.0 tph TDF stack particulate Method 5 testing from Thursday.
2. Commence TDF firing at 0.5 tph and conduct PM testing at that level.

The results from the two 1.0 tph TDF particulate testing runs from Thursday were reported as:

	Preliminary	Refined
Run 1	0.089 lbs/mmbtu	0.109 lbs/mmbtu
Run 2	0.082 lbs/mmbtu	0.093 lbs/mmbtu

Based on the preliminary results IP obtained Thursday afternoon, TDF was shut off at approximately 4:00 PM on Thursday and did not commence again until Friday morning at 0.5 tph at approximately 5:00 AM. It should be noted that a Method 5 particulate test consists of that portion of particulates captured on the filter and weighed as well as the particulates that are captured in the sampling probe. At the end of each run, the probe is washed clean with acetone and placed in an oven (often overnight) to bake off the acetone so the remaining particulate can be weighed. The preliminary results include only the material captured on the filter since the probe wash weight is not available until the next day. The filter weight also changes over time and a final weight is not determined until successive readings are within a certain range of agreement. To express the emissions in units of lbs/mmbtu also requires process data that is not

final until it has been reviewed for accuracy. Thus final results are often not available until well after the testing.

At approximately 5:00 AM Friday morning the TDF feed was turned on at 0.5 tph. The first particulate test at this level was started at approximately 11:00 AM. The preliminary results (filter only) were reported as 0.077 lbs/mmbtu. The second particulate test run was started at approximately 3:45 PM. The preliminary results from this run were 0.083 lbs/mmbtu. At approximately 5:30 PM IP ceased TDF feed to the boiler for the weekend. IP intended to explore options for reducing emissions over the weekend, including ways to optimize the wet scrubber, before recommencing TDF firing on Monday morning November 13.

CEMs readout data taken during the 0.5 tph TDF feed. Again it must be noted that these are preliminary process control data and are only a point in time. The actual hourly average data for the entire day was later provided by IP.

Parameter	Units	11/10 11:00am	11/10 11:37	11/10 11:53	11/10 12:02	11/10 12:21	11/10 3:07	11/10 3:55	11/10 4:21
Oil firing rate	gpm	40.3	43.5	42.9	43.3	41.0	37.6	38.5	41.8
Bark/TDF firing rate	tons/day equivalent	437.1	437.1	437.1	437.1	437.1	437.1	437.1	437.1
Temp	Degree C?	136.3	136.1	135.9	136.5	137.2	134.6	136.6	135.8
SO_2	lbs/hr	265.3	246.0	266.5	179.0	309.6	284.0	253.5	232.5
SO_2	ppm	206.1	174.0	210.6	139.0	241.9	207.0	170.9	156.9
H_2O	%	17.5	17.6	17.6	17.8	18.1	16.8	17.8	17.4
NOx	Lbs/mmbtu	0.21	0.22	0.22	0.21	0.21	0.22	0.25	0.23
NOx	ppm	130.8	136.9	137.3	132.8	131.9	118.2	133.3	125.9
O_2	% dry	6.5	6.8	6.7	6.3	6.5	8.4	8.3	8.4
Pre scrubber opacity	%	66.5	69.6	64.8	67.0	68.3	67.4	81.2	75.1
Steam flow	1000 lbs/hr	413.8	426.5	405.8	416.8	414.0	378.7	418.3	417.6
CO	ppm	24.0	27.6	25.0	21.7	23.7	50.4	75.7	63.8
Heat input	MMbtu/hr	553	563	553	547	550	533	536	554

Agency of Natural Resources
Department of Environmental Conservation

Air Pollution Control Division
Building 3, South
802-241-3841

MEMORANDUM

To: Jeffrey Wennberg, Commissioner

Thru: Richard Valentinetti, Director

From: David Manning

Date: November 30, 2006

Subject: Site Visit & PM Testing at International Paper on 11/13/06

I made the following observations of the tire derived fuel (TDF) trial burn at International Paper (IP) in Ticonderoga, NY, on Monday, November 13:

IP had hoped to begin the formal compliance testing this week. Due to problems in finding an acceptable TDF feed rate, however, IP was still doing preliminary, particulate matter only, testing. Today's test observation involved principally the following management and regulatory personnel (as well as myself):

Jim Witkowski, Atlantic Region Manager, EHS On-site Management, IP
Donna Wadsworth, Communications Manager, IP Ticonderoga
Amy Dostie, Environmental Engineer, IP Ticonderoga
Heather Perry, Process Engineer, IP Ticonderoga
various IP Ticonderoga boiler operators
Jim Canora, and other TRC Corp. testing personnel

Mark Winter, USEPA Region 2
Alan Hicks, USEPA Region 1
Michael Sundberg, Project Engineer, NY State DEC

Mr. Witkowski and Ms. Wadsorth said that TDF was not burned over the weekend, so we spent most of the morning waiting for TDF burning to begin and the boiler to reach steady-state conditions. The TDF feed rate for today was ¼ ton per hour. Mr. Witkowski indicated that preliminary results from testing on 1 and ½ ton of TDF per hour (on the previous Thursday and Friday) were not encouraging. Particulate matter emissions appeared to be in compliance with their permit, but only just. IP personnel hoped that today would be the last of the preliminary testing, and that the full testing program would begin tomorrow (November 14th). Mr. Sundberg of the NY State DEC said he would provide audit samples once the full testing had begun.

The preliminary particulate test runs began in early afternoon at a TDF feed rate of ¼ ton per hour. According to process monitoring instruments on the control panels, five fuel oil burners were in operation at 53 gallons per minute, the bark feed rate was about 18 tons per hour. IP personnel compiled hourly averages of a variety of process data, and I obtained copies of these reports for November 10 (last Friday) and 13 (today), which are included in this trip report package.

After completion of the first test run there was a long delay while preliminary results (essentially a rough filter weight) were obtained. While waiting, we visited the boiler control room and confirmed that IP personnel considered the boiler operation normal.

Preliminary results indicated the filter weight may have been less than was noted during testing last Thursday and Friday. A rough, preliminary emissions estimate of around 0.07 lb/MMBtu was made by the test consultant. In making this estimate it was assumed that the probe wash weight was the same as in previous testing. The visual appearance of the probe wash was not conclusive in this regard, but the assumption was questionable. IP personnel decided to have two more test runs performed at ¼ ton TDF per hour to confirm these initial preliminary results.

The particulate sampling system failed a leak check on the third run, so these results were discarded and a substitute (fourth) test run was performed. IP personnel said that they stopped feeding TDF to the boiler at the end of this test run (approximately 10:00 p.m.) Testing was not expected to resume until the middle of the next day (November 14th). There was maintenance scheduled on one of the paper machines early the next morning, and steam demand during that period would not be sufficient to allow boiler emission testing.

dm

Agency of Natural Resources
Department of Environmental Conservation

Air Pollution Control Division
Building 3, South
802-241-3841

MEMORANDUM

To: Jeffrey Wennberg, Commissioner

Thru: Richard Valentinetti, Director

From: David Manning

Date: November 30, 2006

Subject: Site Visit & PM Testing at International Paper on 11/14/06

I made the following observations of the tire derived fuel (TDF) trial burn at International Paper (IP) in Ticonderoga, NY, on Tuesday, November 14:

Due to problems in finding an acceptable TDF feed rate, IP was still doing preliminary, particulate matter only, testing. Today's site visit involved the following management and regulatory personnel (as well as myself):

Jim Witkowski, Atlantic Region Manager, EHS On-site Management, IP
Donna Wadsworth, Communications Manager, IP Ticonderoga
Amy Dostie, Environmental Engineer, IP Ticonderoga
Heather Perry, Process Engineer, IP Ticonderoga
various IP Ticonderoga boiler operators and other personnel

Mark Winter, USEPA Region 2
Alan Hicks, USEPA Region 1

As was noted in my site visit report from yesterday, 11/13, we were waiting for more refined emissions results from three particulate matter test runs performed that day. Also, one of the paper machines was shut down for previously scheduled maintenance and, until restarted, the steam demand on the boiler would be too low to allow testing. While waiting, we received a detailed briefing on the operation of the power boiler's wet scrubber emission control device by IP personnel.

IP engineers said the scrubber was manufactured by Entoliter and is considered a "vortex" scrubber. It is a customized design and is the largest model, with an interior diameter of about 23 feet. Because Entoliter is no longer in business, IP personnel have taken over the task of repairs and maintenance.

In general, the scrubber is an upright cylinder divided into top and bottom sections. Flue gas from the boiler enters the lower section an angle, establishing a circular flow pattern. It then enters a section of turning vanes that direct the gas closer to the center of the scrubber. Associated with the turning vane section are spray nozzles and a pool of water, which generate a mist that is carried along with the flue gas.

From inside the turning vanes the flue gas/mist passes through a hole in a horizontal divider into the upper section of the scrubber. In the upper half the spinning stream of flue gas and mist expands and slows. Most of the mist drops out of the flue gas, taking most of the sulfur dioxide and particulate matter with it. The cleaned flue gas exits from the top of the scrubber. Liquid water and sludge is removed from the wet scrubber at the bottom.

Maintenance on the wet scrubber consists primarily of adding caustic to the water as needed to maintain the desired pH, and replacing turning vanes and nozzles when they wear out.

IP personnel said the scrubber has a design value for L/G of about 5 gallons of water per 1000 saturated cubic feet of flue gas. The water pH, and the amount of water added to the pool under the turning vanes (known as the “lower flow”) and to the turning vane spray nozzles themselves (known as the “upper flow”), are controlled to optimize scrubber efficiency. Historically, upper and lower flows have been maintained around 1580 and 170 gallons per minute, and the pH around 5.1. IP personnel said that a few weeks ago they tried to make the upper and lower water flows closer to equal, thinking that this might enhance scrubber efficiency. Based on the results of the particulate emission testing over the last few days, however, they have decided to go back to something closer to the historical flow settings.

After the briefing on the wet scrubber, Mr. Witkowski provided the following summary for the total particulate emissions testing to-date (8 particulate emission test runs):

Test Date	TDF (TPH)	PM Emissions (lb/MMBtu)	
11/9	1.0	0.11	
		0.096	Avg = 0.10
11/10	0.5	0.096	
		0.095	Avg = 0.096
11/13	0.25	0.105	
		0.105	
		0.070	Avg = 0.093

The emissions listed above are not necessarily the final, official results, but they are more accurate than the previous, “preliminary” results and thus should be close to what become the official results. The permit limit is 0.10 lb/MMBtu.

As can be seen from the 11/13 data, emissions were higher than the preliminary data (without probe wash results) had originally indicated. Probe wash results from 11/13 were higher than the other two days for unknown reasons. There was also no obvious explanation why one of the test

runs on 11/13 was so much different than the other two, or why the test results from the three days were so similar even though the TDF feed rate was significantly different on each day. It can be speculated that variation in the quality of the bark fuel had an impact on the test results.

Mr. Witkowski said that, in light of these updated results, the need for further testing is questionable. He noted that corporate officials from IP were reviewing the results, and that we were waiting for their comments before a final decision would be made about the next steps.

After a lengthy wait, Mr. Witkowski announced that the TDF trial burn was officially cancelled, and no further emission testing, or burning of TDF, would occur. He provided us with a written press release that provided further details about IP's decision, which I have included with this trip report.

This site visit concluded with a brief, casual meeting where all of the government observers present (the NY State observer was not there because stack sampling had not occurred that day) provided IP representatives with a short, verbal summary of their observations and comments about the trial burn. Generally, everyone thought the trial burn emission testing was well managed, that IP had provided test information to the observers in a timely manner, and that IP had made the correct decision in stopping the trial.

dm

International Paper, Ticonderoga N.Y.
TDF Trial Burn – November 2006

Probe and Filter/Impinger Box in Sampling Position on Power Boiler Stack.
Photograph by David Manning (11/13/06)

Another View of Probe and Filter/Impinger box on the Power Boiler Stack
Photograph by David Manning (11/13/06)

International Paper, Ticonderoga N.Y.
TDF Trial Burn – November 2006

Sampling Pumps and Other Controls in Action
Photograph by David Manning (11/13/06)

Preliminary Recovery of Particulate Sample
Photograph by David Manning (11/13/06)

Appendix II

Summary of Meteorological Analysis & Air Quality Modeling

Associated with IPC Test Burn of Tire-Derived Fuel

Paul Wishinski & Dan Riley

VT DEC: Air Pollution Control Division

November 28, 2006

The following discussion summarizes the process by which ground-level air quality monitoring locations were identified for use during a projected test burn of tire-derived fuel at the International Paper Company plant in Ticonderoga, New York. The test burn was announced in 2003 and the Vermont Air Pollution Control Division determined that is would establish some temporary monitoring locations across the state border in Vermont in order to try to identify (if possible) the impact of emission changes associated with the test burn. In order to assess the effect of burning TDF at the plant, it was felt that a period of baseline monitoring prior to the test burn period would be desirable. Monitors used for air quality sampling (both pre-test and during the test) were to be placed in locations which had the most likelihood of seeing a plume from the plant boiler stack impact at ground level.

The first step in identifying monitoring locations involved looking at historical meteorology from the area. Based on this historical data, we ran a numerical impact assessment model called CALPUFF (a puff dispersion model) to simulate the potential impact areas from emissions coming from the IPC main boiler stack. A test modeling year of 2000 was used for this detailed examination. Year 2000 meteorology was not deemed to be significantly different than the long-term climatological meteorology for the area. In addition to performing a detailed year-long model analysis, field visits to locations along the eastern shore of Lake Champlain across from the International Paper Company plant in New York were carried out on several days in the fall of 2003.

Running CALPUFF for the entire year 2000 using a detailed (2.0 kilometer gridded wind fields) set of meteorology and knowing the characteristics and details of the locations predicted to show potentially highest impacts gained through our field visits, two locations at about 4.5 to 5 kilometers from the IPC boiler stack were identified. It was determined that these two sites were acceptable for placing the sampling equipment needed and would give the best chance at getting transport from the IPC stack to the monitor locations during a short time period test burn. Both these locations were in Shoreham, Vermont.

Ticonderoga Modeling

To Determine Monitor Location Most Likely to Sample a Measurable Impact

Year 2000 CALMET run @ 2km

View of IPC plume blowing to NORTH on south winds 10/28/03

View of IPC from Vermont location in Shoreham : Plant is ~ 5 km to SW

Photographs showing the IPC plant and associated plume taken during Fall 2003 field survey.

View of IPC from Vermont side of Lake Champlain looking west

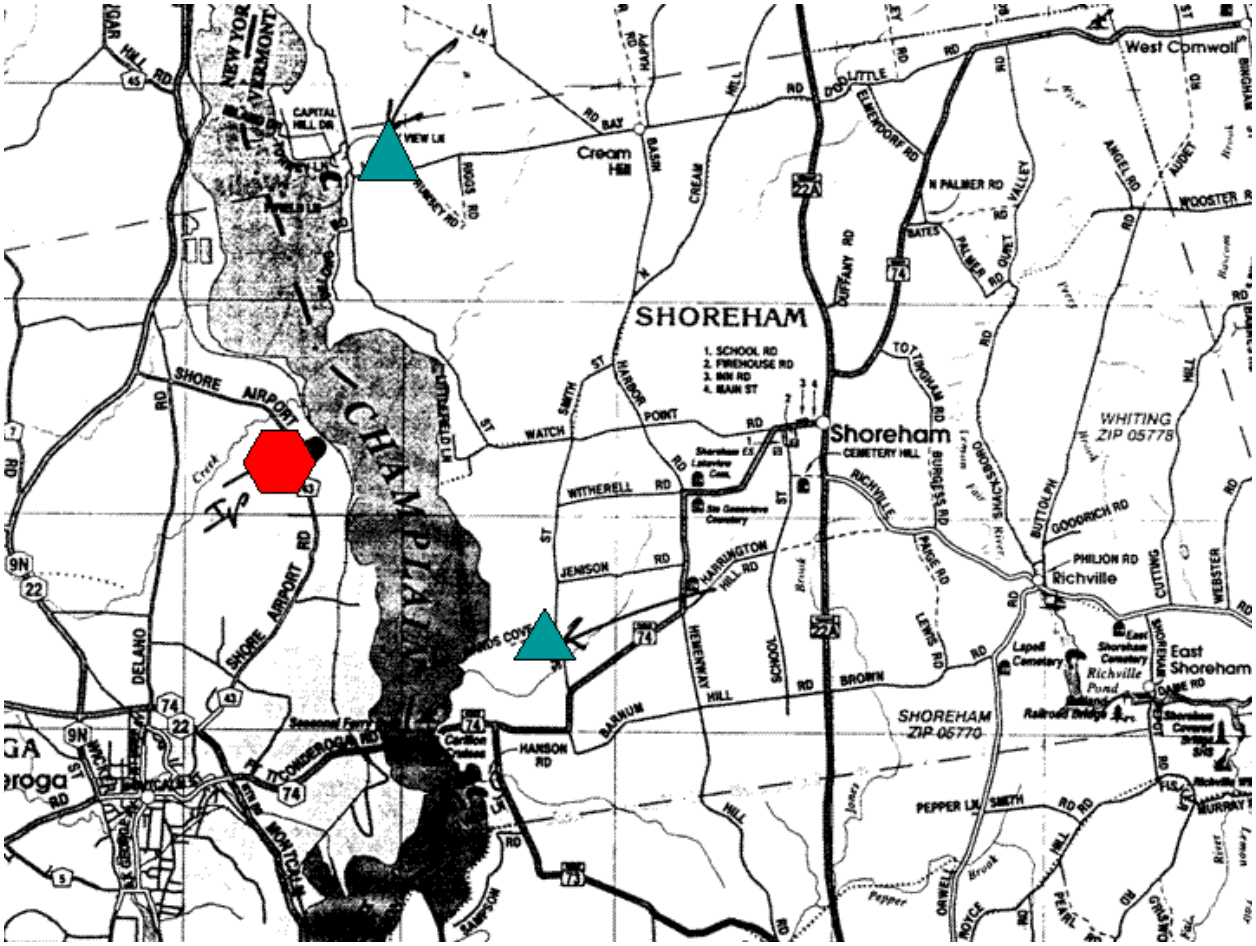
View from Lake Street Bridport North of IPC ~ Plant is 4.15km to S

Additional photographs showing the IPC plant and associated plume taken during Fall 2003 field survey.

Shoreham area ORTHOPHOTO

showing Ticonderoga Plant & Two Proposed Monitoring Locations

Ortho-photograph showing the IPC plant, southern Lake Champlain, and surrounding areas to the east (mostly in Vermont) of the plant's location at Ticonderoga, New York.



Detail from a land survey map showing the IPC plant, southern Lake Champlain, and surrounding areas to the east (mostly in Vermont) of the plant's location at Ticonderoga, New York. The IPC plant site is under the RED hexagon. The two air quality sampling sites identified using CALPUFF modeling and site visits are shown as BLUE triangles.

Proposed Monitoring Site NORTH of IPC ~ Plant seen 4.15 km to SSW

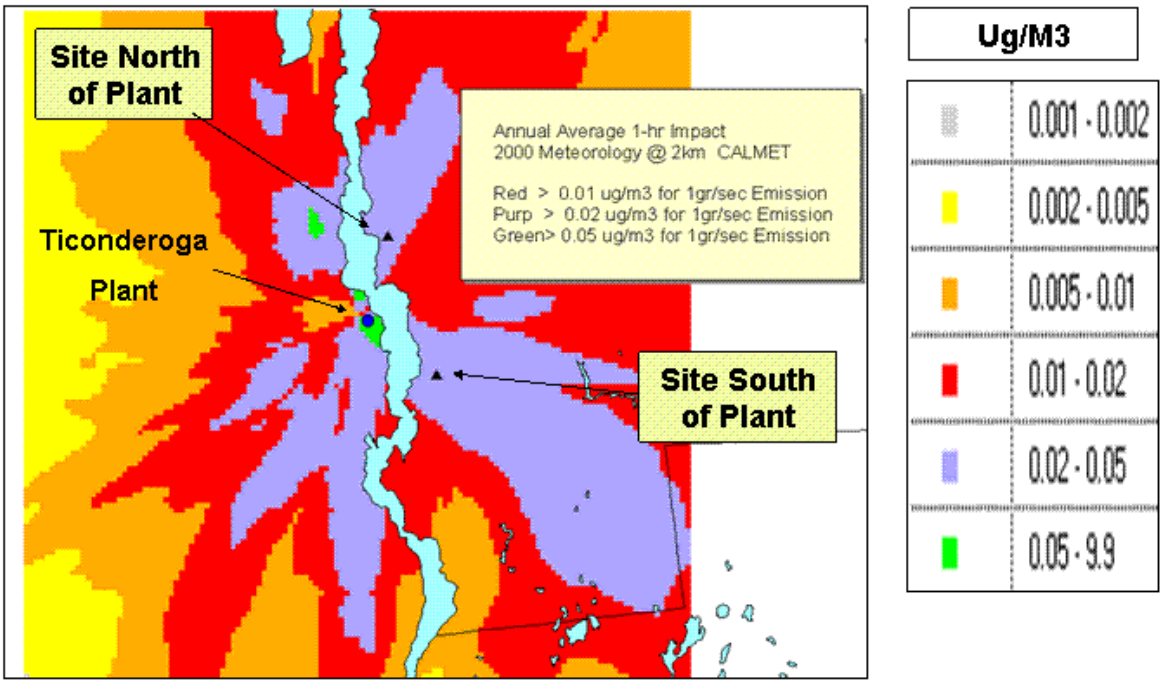
Proposed Monitoring Site SOUTH of IPC ~ Plant is behind us 4.15km to NW

Photographs showing the locations chosen for the two ambient air quality monitoring locations to be used for preliminary base case monitoring and for sampling during any potential tire-derived fuel burn.

CALPUFF MODEL
Run for full year of 2000

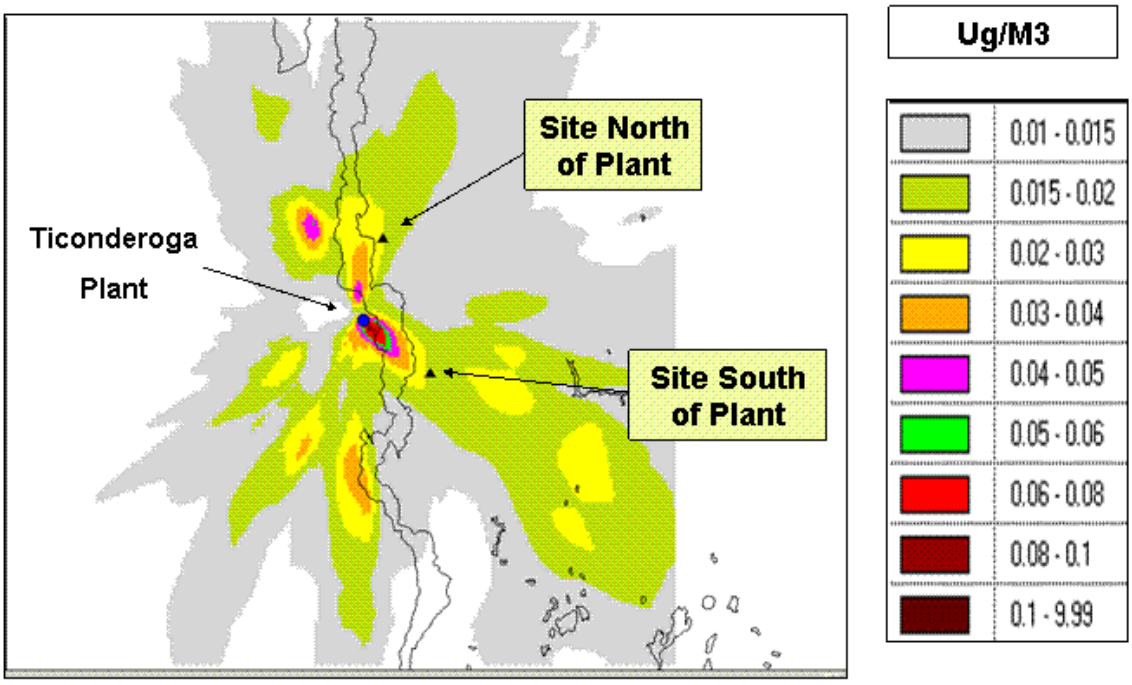
with an assumed emission rate
1 gram/sec

Annual Average 1-Hr Impact
Test Emission Rate of 1 gram/sec



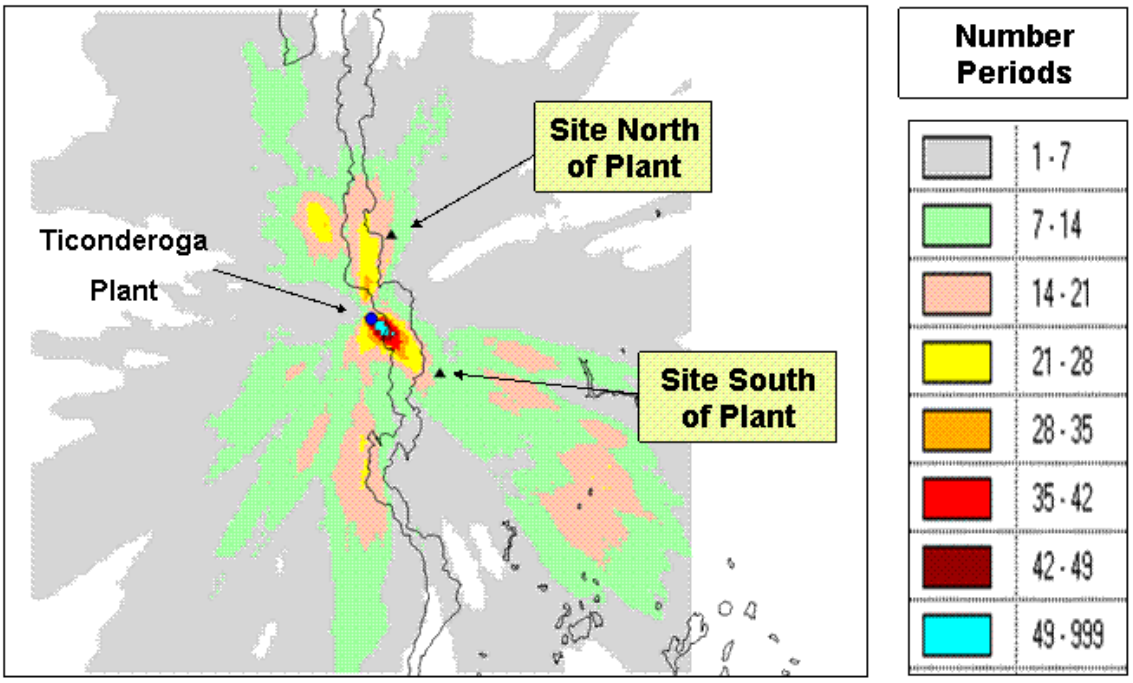
Pattern of annual average impacts predicted from a generic constant test emission rate from the IPC boiler stack modeled using the CALPUFF dispersion model for a one year time period. Two lobes of higher potential impact in Vermont are indicated, one to the north-northeast of the IPC plant and one to the south-west of the IPC plant. The specific locations selected for ambient monitoring based on this pattern were determined from considerations related to the availability of power, access, and security of expensive monitoring equipment that had to be placed in the field and operated for long time periods (the monitors placed actually ended up being operated for more than 3 years).

Annual Average 1-Hr Impact
Test Emission Rate of 1 gram/sec



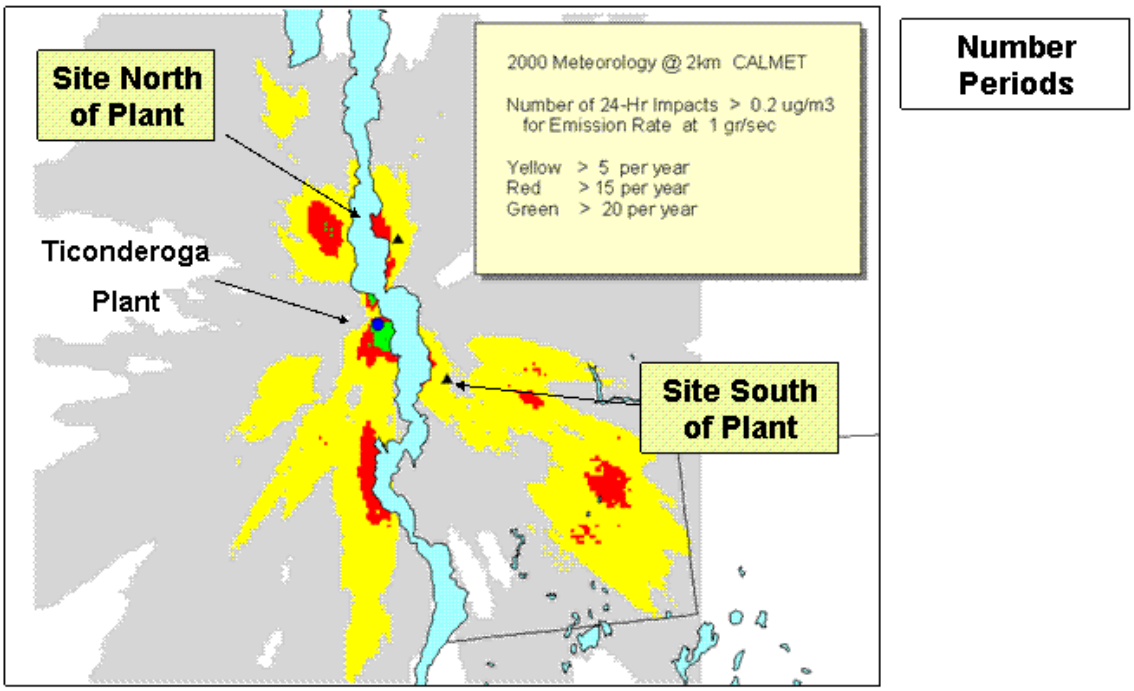
Another depiction of the pattern of annual average 1-hour impacts predicted from a generic constant test emission rate from the IPC boiler stack modeled using the CALPUFF dispersion model for a one year time period. Both chosen monitor locations are indicated as having the potential for about the same level of annual average impact (yellow pattern just touching these locations) and that impact being at about the highest impact level expected for an annual average for any location in Vermont, except for a few locations on higher terrain to the southeast and further away from the plant which could have slightly higher impact levels.

No. Annual 24-Hr Impacts > 0.20 ug/m3
Test Emission Rate of 1 gram/sec



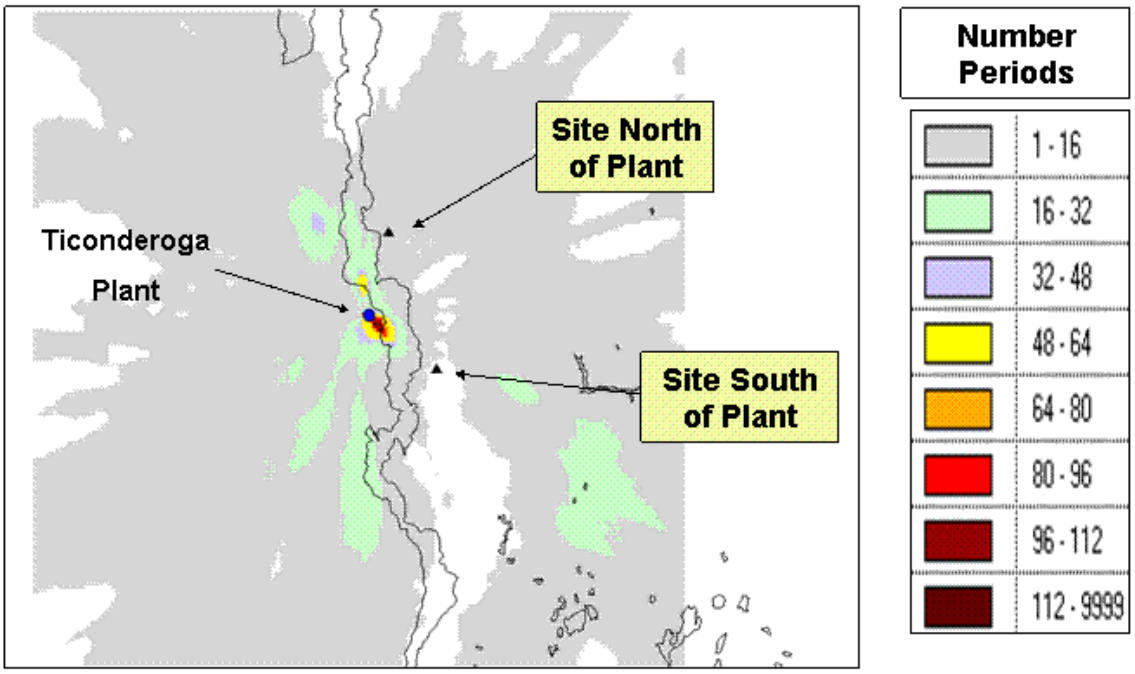
This depiction shows the pattern of the *number* of 24-hour impacts above a cutpoint level (0.20 ug/m3) predicted from a generic constant test emission rate from the IPC boiler stack modeled using the CALPUFF dispersion model for a one year time period. Both chosen monitor locations are indicated as having the potential for about the same number of 24-hour impacts higher than 0.20 ug/m3 (pink pattern just touching these locations). This indicates approximately 14 days during 2002 when the 24-Hr impact would have been higher than the cutoff chosen. It appears from the pattern that possibly a couple other locations on higher ground to the southeast and further away might have had as many or a few more such days.

No. Annual 24-Hr Impacts > 0.20 ug/m3 Test Emission Rate of 1 gram/sec



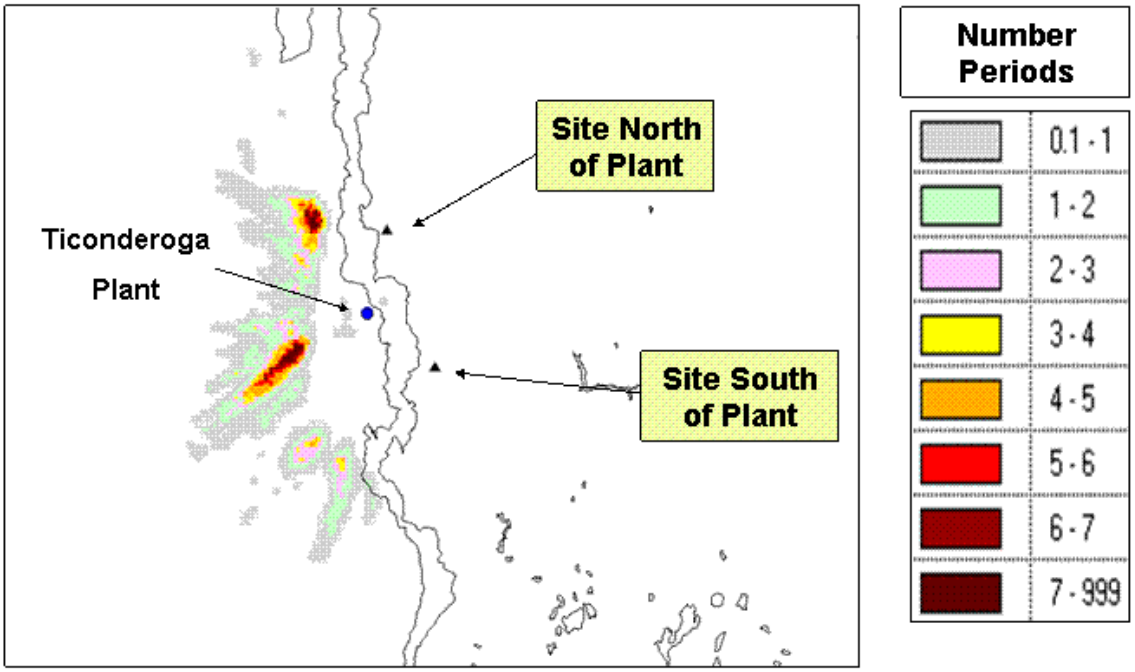
Another depiction showing the pattern of the *number* of 24-hour impacts above a cutpoint level (0.20 ug/m3) predicted from a generic constant test emission rate from the IPC boiler stack modeled using the CALPUFF dispersion model for a one year time period.

No. Annual 3-Hr Impacts > 10.0 ug/m3
Test Emission Rate of 1 gram/sec

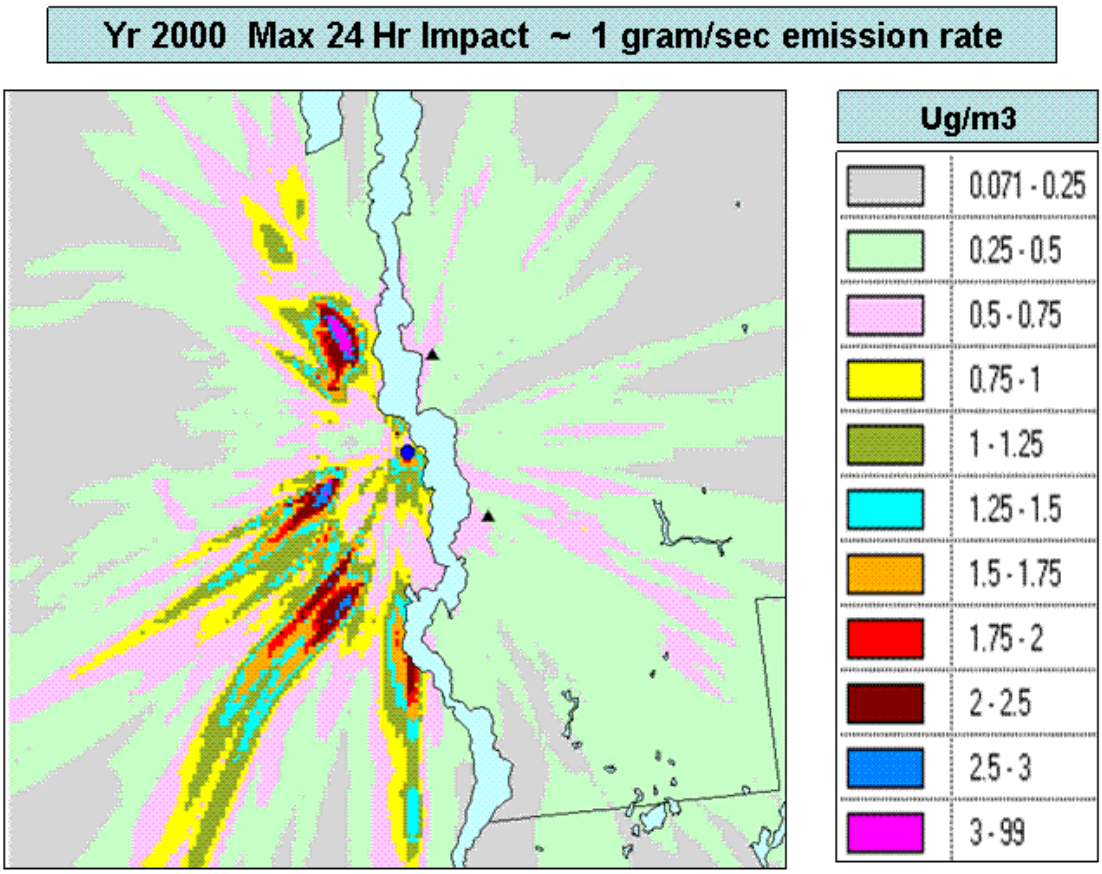


Another depiction showing the pattern of the *number* of 3-hour impacts above a cutpoint level (10.0 ug/m3) predicted from a generic constant test emission rate from the IPC boiler stack modeled using the CALPUFF dispersion model for a one year time period. The location on higher terrain to the southeast of the IPC Plant in Vermont State might be expected to have the most potential for these relatively short-term higher impacts.

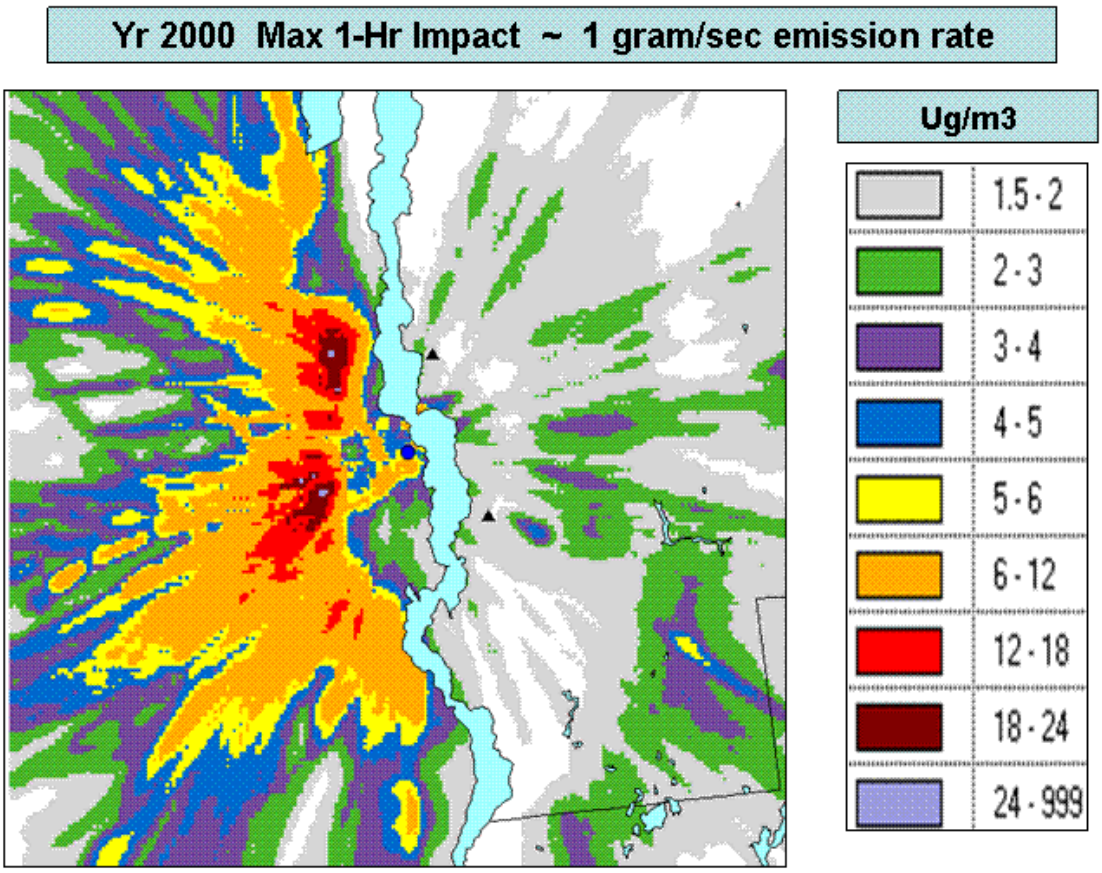
No. Annual 1-Hr Impacts > 100.0 ug/m3
Test Emission Rate of 1 gram/sec



Another depiction showing the pattern of the *number* of 1-hour impacts above a cutpoint level (100.0 ug/m3) predicted from a generic constant test emission rate from the IPC boiler stack modeled using the CALPUFF dispersion model for a one year time period. These high very short term impacts are predicted to occur only in the high terrain to the west of the IPC Plant in New York State.



This depiction shows the pattern of the highest 24-hour impacts predicted from a generic constant test emission rate of about 7.9 lbs/hour (1 gr/sec) from the IPC boiler stack modeled using the CALPUFF dispersion model for a one year time period. The predicted maximums in Vermont (0.50 –> 0.75 ug/m3) are in the pink zones showing predominantly to the northeast and southeast of the IPC Plant. Both sampling locations chosen are at the edge of one of those pink zones. NOTE that this *emission rate is only for reference* and DOES NOT REPRESENT ANY ACTUAL POTENTIAL EMISSION SPECIFIC TO THE IPC PLANT.



This depiction shows the pattern of the highest 1-hour impacts predicted from a generic constant test emission rate of about 7.9 lbs/hour (1 gr/sec) from the IPC boiler stack modeled using the CALPUFF dispersion model for a one year time period. The predicted maximums in Vermont (4 –> 6 ug/m3) are in the blue and yellow zones showing to the southeast of the IPC Plant. Neither sampling location chosen is within one of those zones, but for a short-term test period the location of the maximum 1-Hr potential impact point during a one year period is not necessarily the criterion that best locates sampling equipment for detection of the test emissions. NOTE that this *emission rate is only for reference* and DOES NOT REPRESENT ANY ACTUAL POTENTIAL EMISSION SPECIFIC TO THE IPC PLANT.

Appendix III

Summary Analysis of Transport Wind Fields

Period from November 5 to November 14, 2006

IPC Test Burn of Tire-Derived-Fuel

VT DEC: Air Pollution Control Division

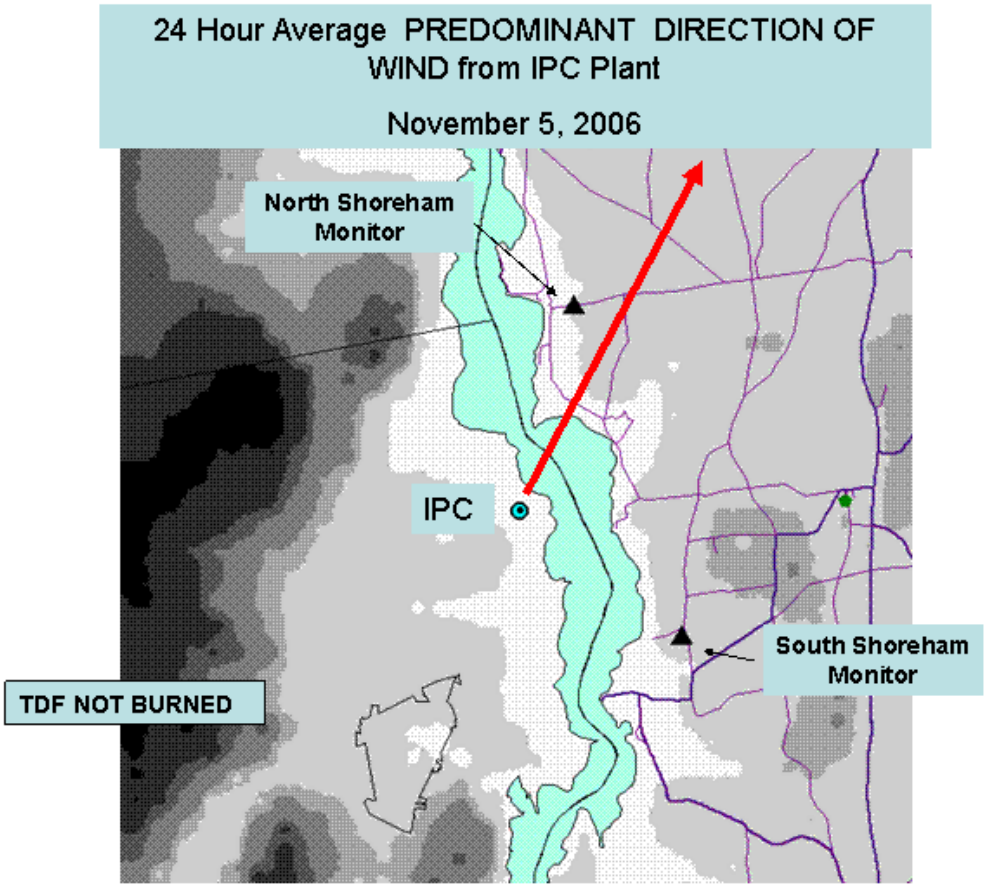
Paul Wishinski & Dan Riley
November 28, 2006

PRELIMINARY MODELING RESULTS for the TEST PERIOD (November 5, 2006 to November 14, 2006):

On the following pages are shown a set of daily maps of the area within about 10 kilometers of the IPC Plant which depict the average daily modeled impact from a generic test emission rate of 10 lbs/hour from the IPC boiler stack. There are two maps associated with each day in this 10 day period. For each day, the first map depicts the predominant wind directions seen from the modeled wind fields during that 24 hour period. The second map for each day depicts the location of highest average impacts from the IPC stack generic emission of 10 lbs/hour, which, if winds have been relatively persistent for the day shows up as the location of a plume of impact.emanating from the plant. If winds are less persistent in one direction, the pattern of impact can be seen to be more dispersed around the plant, rather than in only one narrow direction.

CALPUFF was run with the constant generic emission rate for the IPC boiler stack and used 3-dimensional wind fields developed from National Weather Service meteorological models that had been initialized with the most recent actual measurements for the 24 hour time period of the day. The wind fields used to drive CALPUFF were therefore only available for a given date at about 7 am of the following day. Each day these NWS Met fields were used to generate localized detailed 3-dimensional wind fields over the small domain included on the maps shown. The CALMET meteorological model was used in conjunction with detailed terrain representation to alter the initialization data obtained for the upper air from the NWS modeled fields while surface measurements at the northern ambient air quality sampling location were also incorporated. These results are preliminary for this initial report, and may be adjusted as more careful examination of the modeled output is performed and quality assurance of the input meteorological fields is done. As soon as any validated actual test emission data is available additional modeling will be done to more accurately represent impacts.

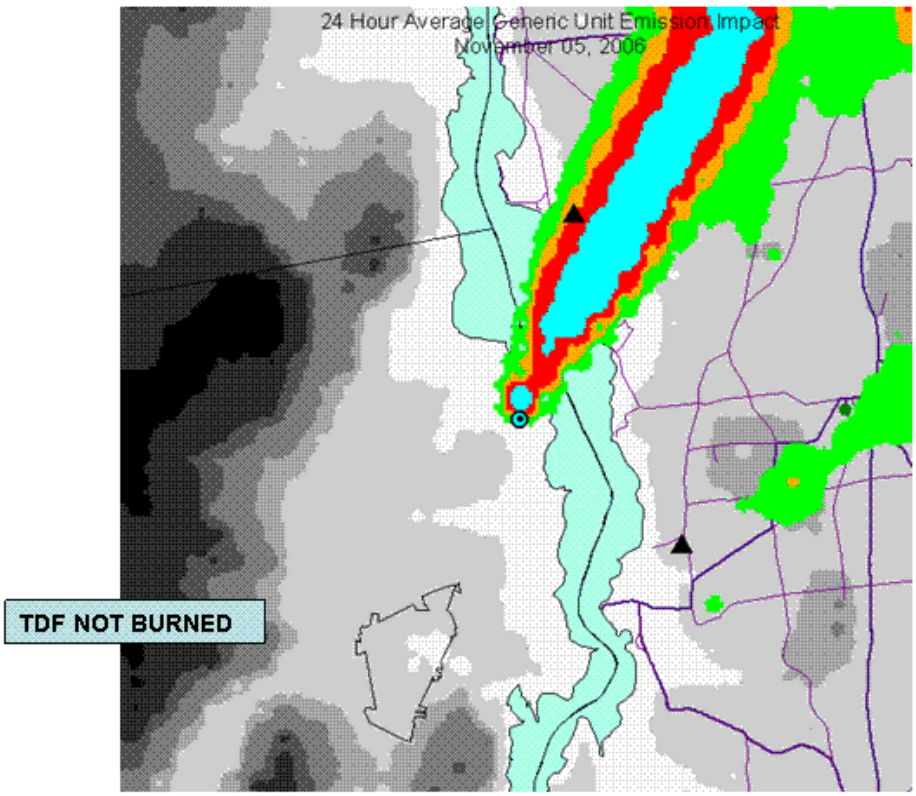
NOTE: The impacts depicted are not actual impacts but only relative spatial patterns based on a GENERIC 10 lbs/hour CONSTANT HOURLY EMISSION RATE.



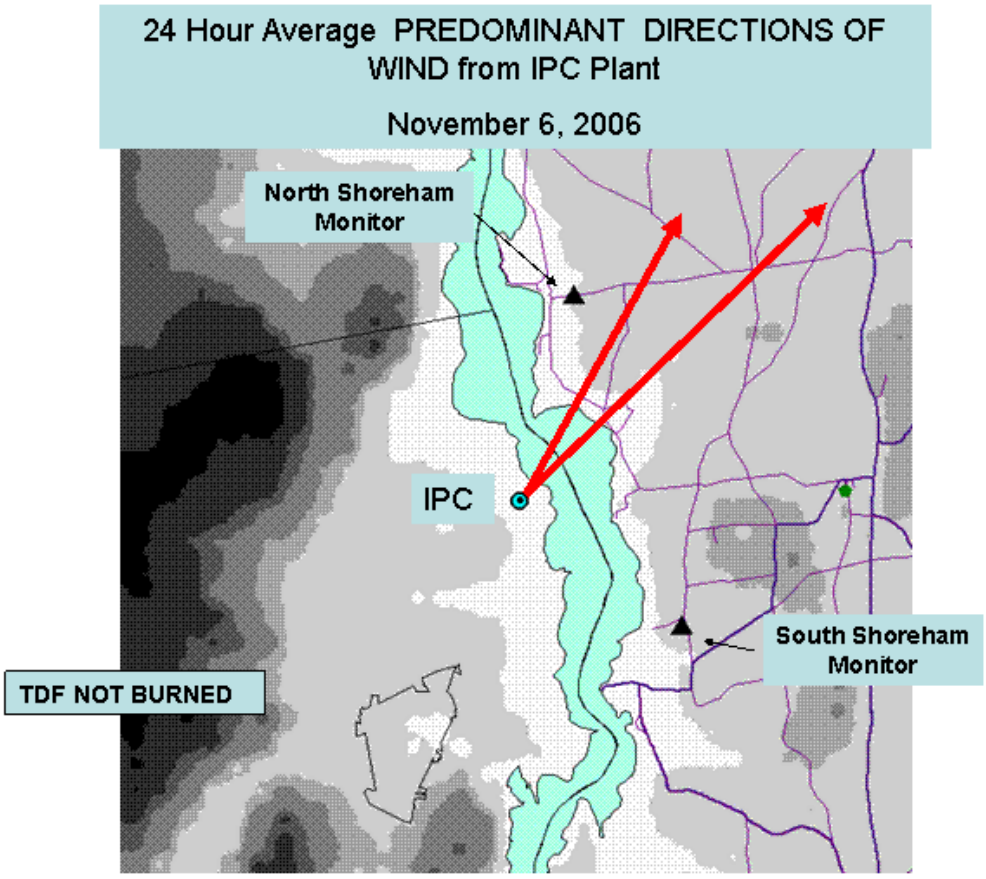
The red arrow is a subjective representation of the plume centerline for the time period identified based upon the output of the plume dispersion model.

24 Hour Average Generic Unit Emission Impact Field from IPC Plant

November 5, 2006



GREEN	=	**Generic Impact of**	>	**1 Unit**
ORANGE	=	**Generic Impact of**	>	**4 Units**
RED	=	**Generic Impact of**	>	**6 Units**
BLUE	=	**Generic Impact of**	>	**12 Units**



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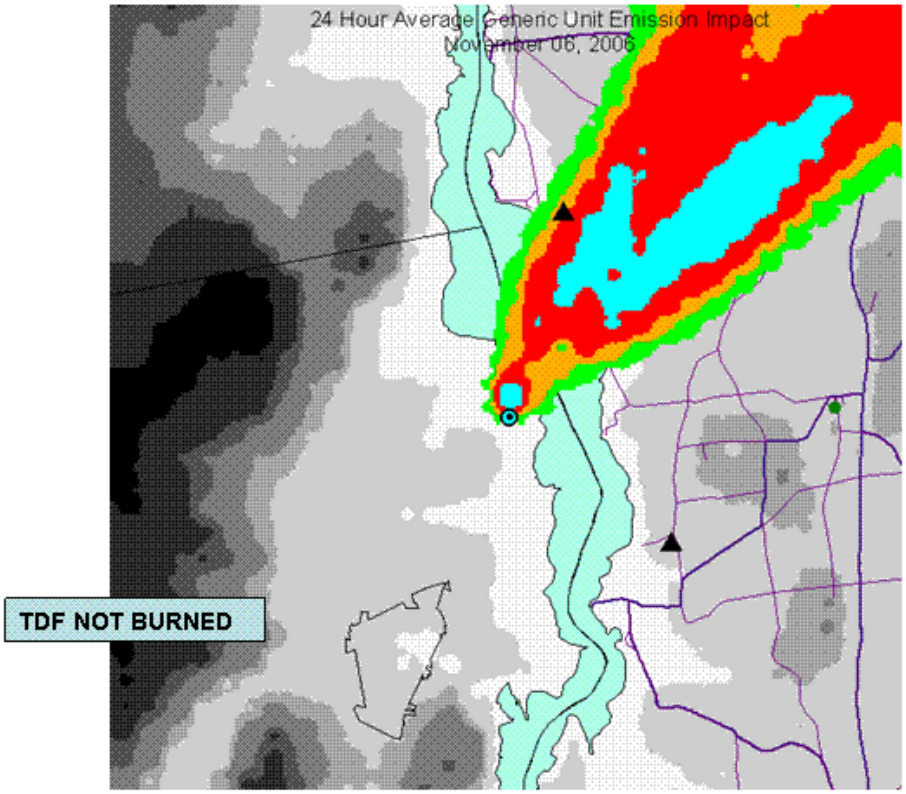
24 Hour Average Generic Unit Emission Impact Field from IPC Plant

November 6, 2006



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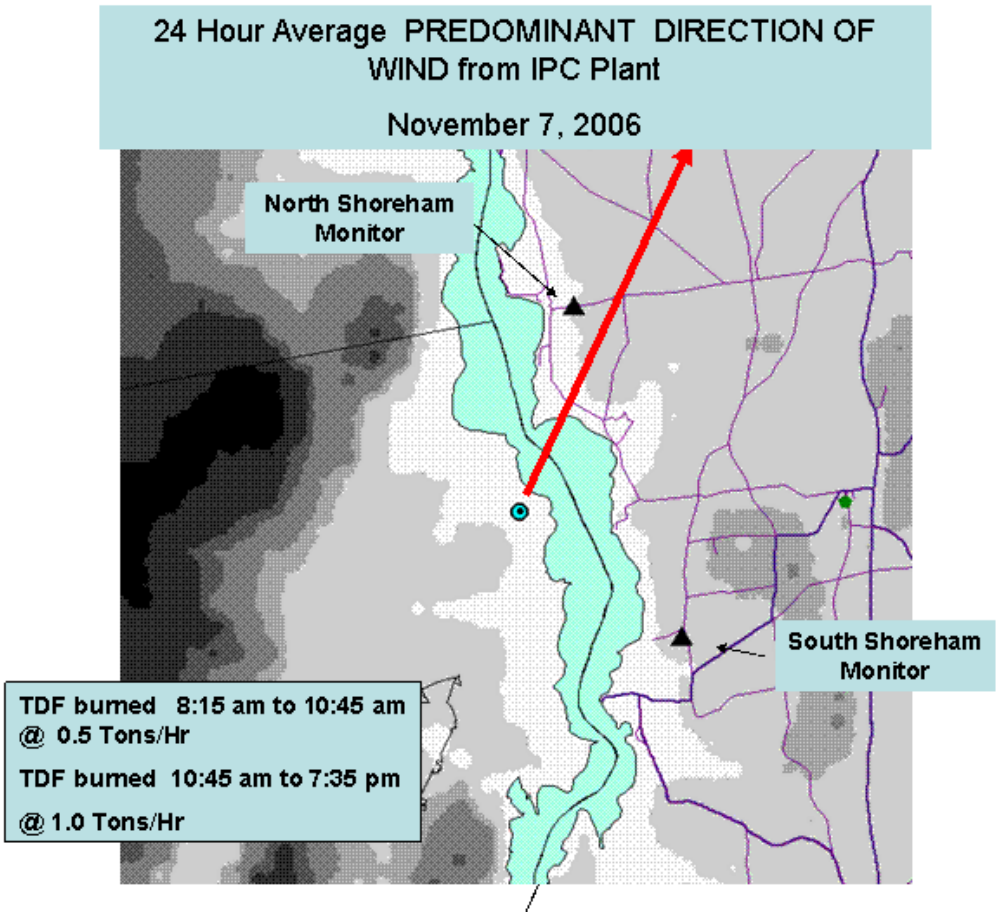

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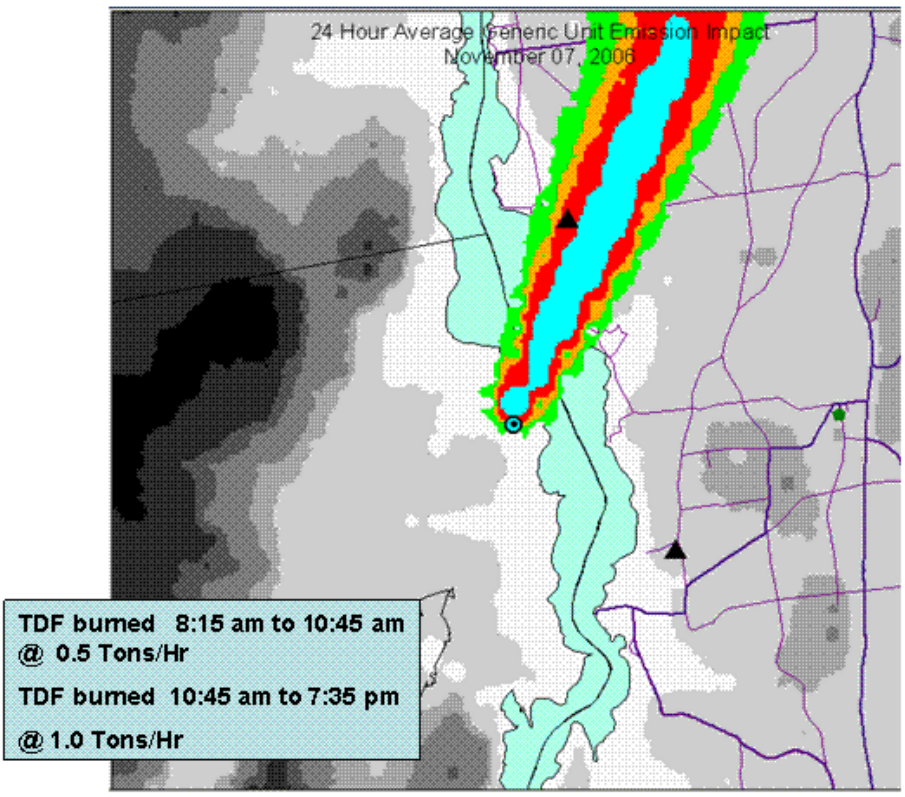
24 Hour Average Generic Unit Emission Impact Field from IPC Plant

November 7, 2006



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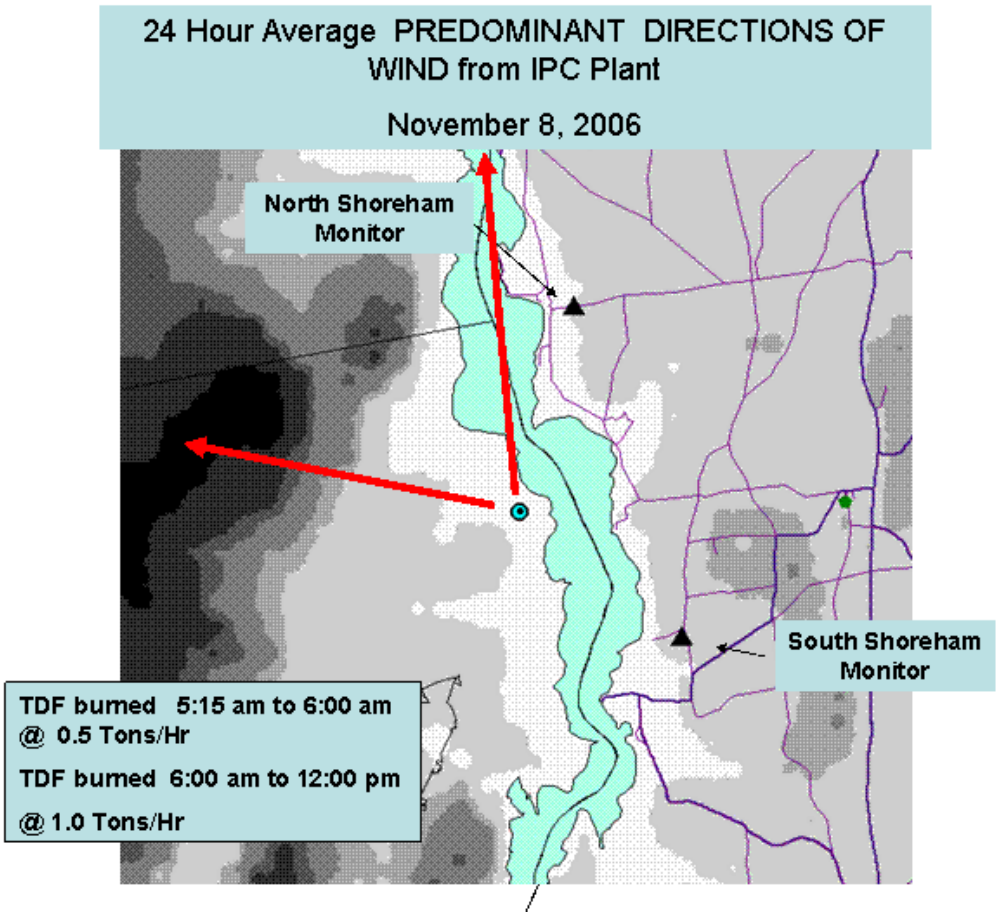

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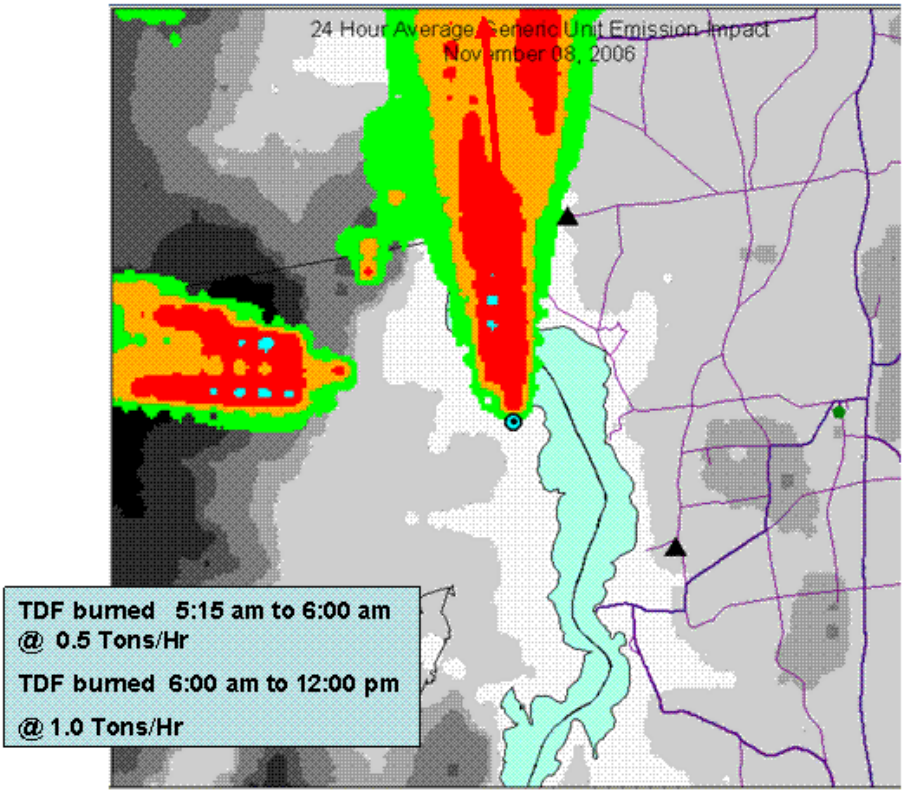
24 Hour Average Generic Unit Emission Impact Field from IPC Plant

November 8, 2006



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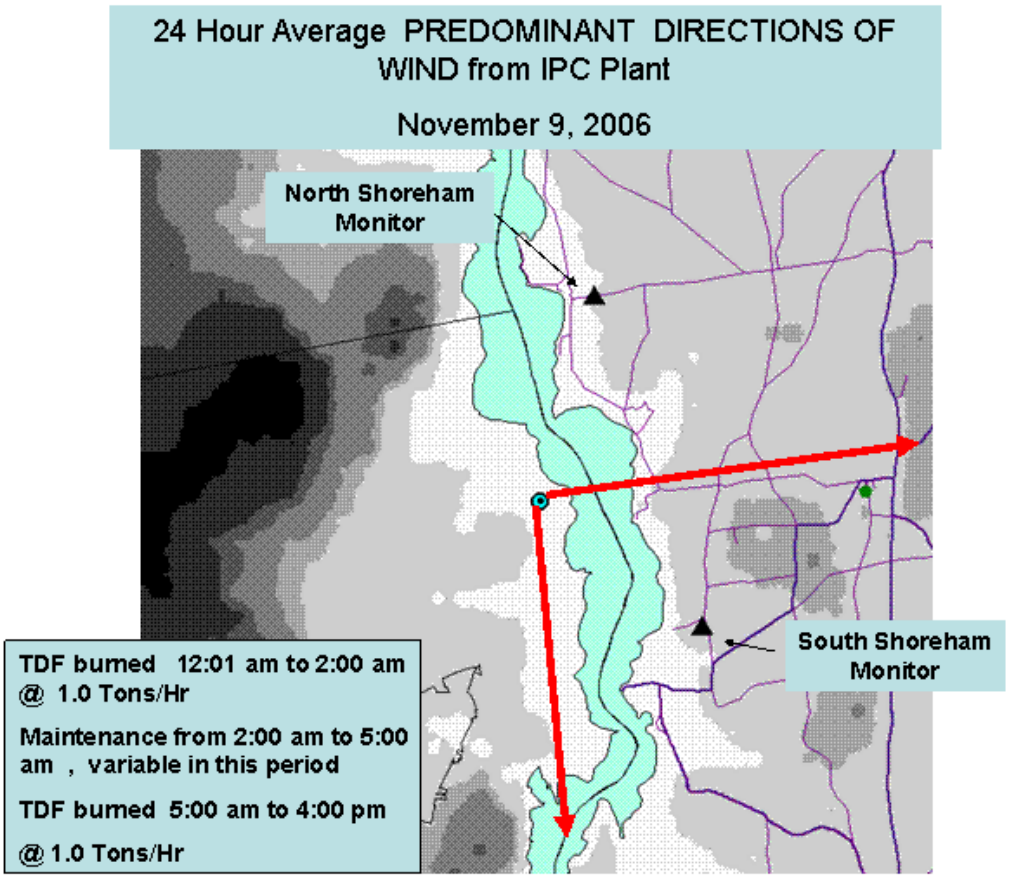

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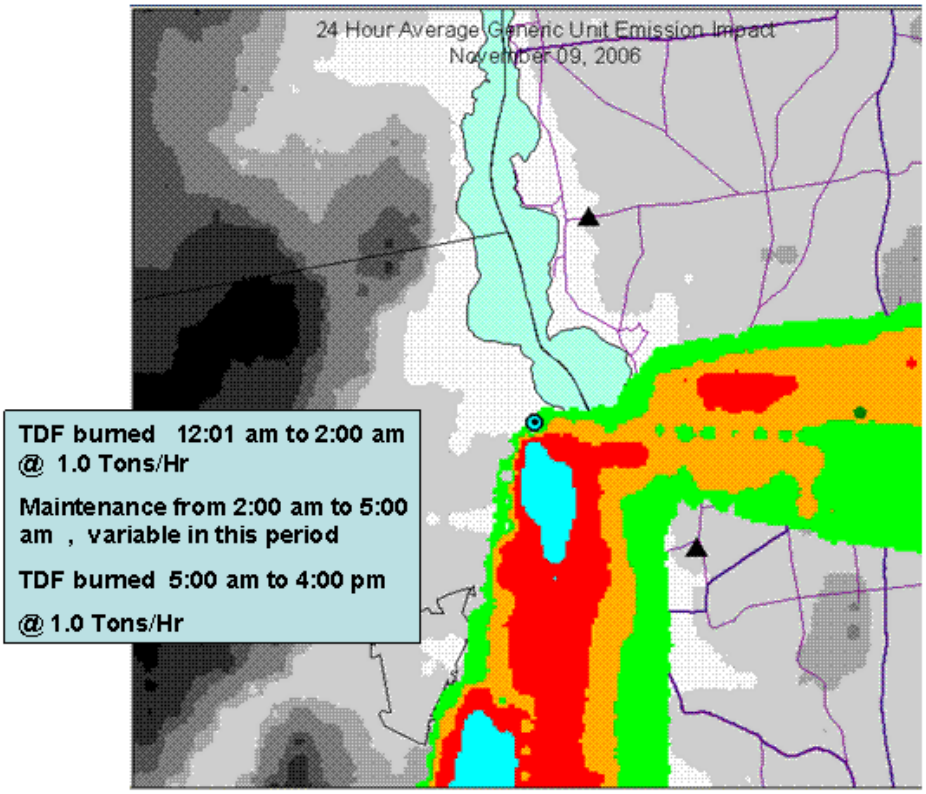
24 Hour Average Generic Unit Emission Impact Field from IPC Plant

November 9, 2006



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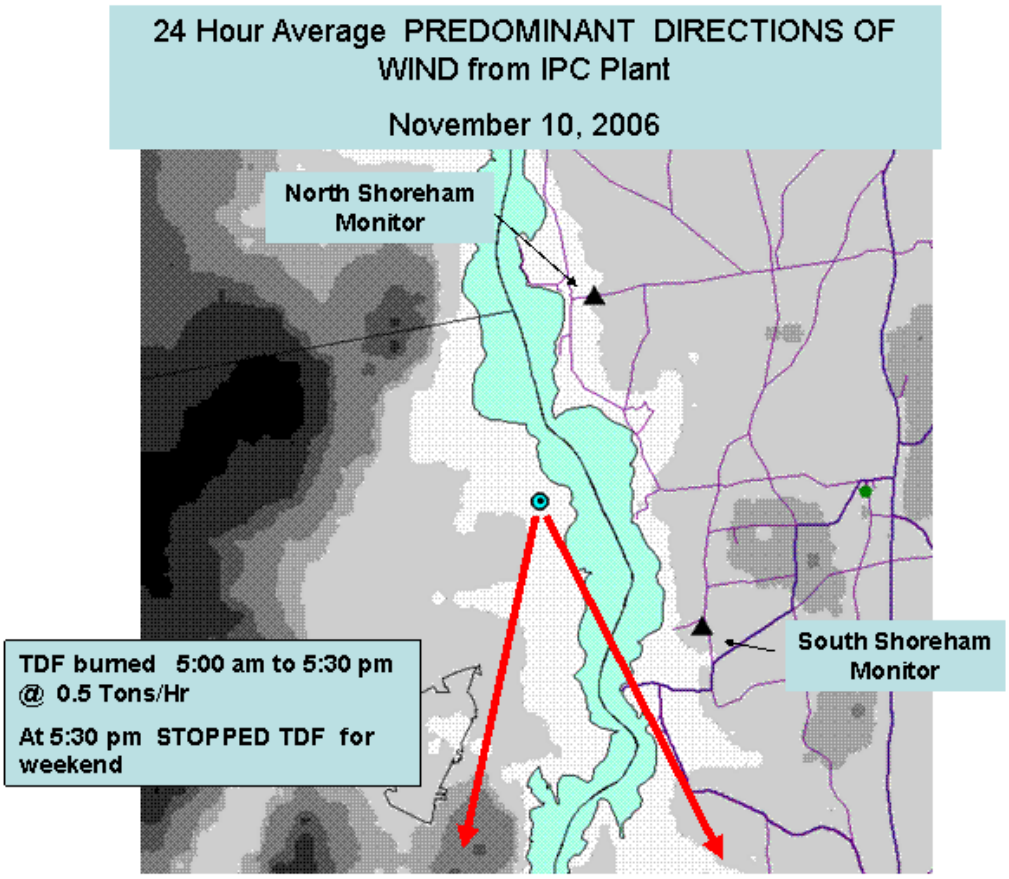

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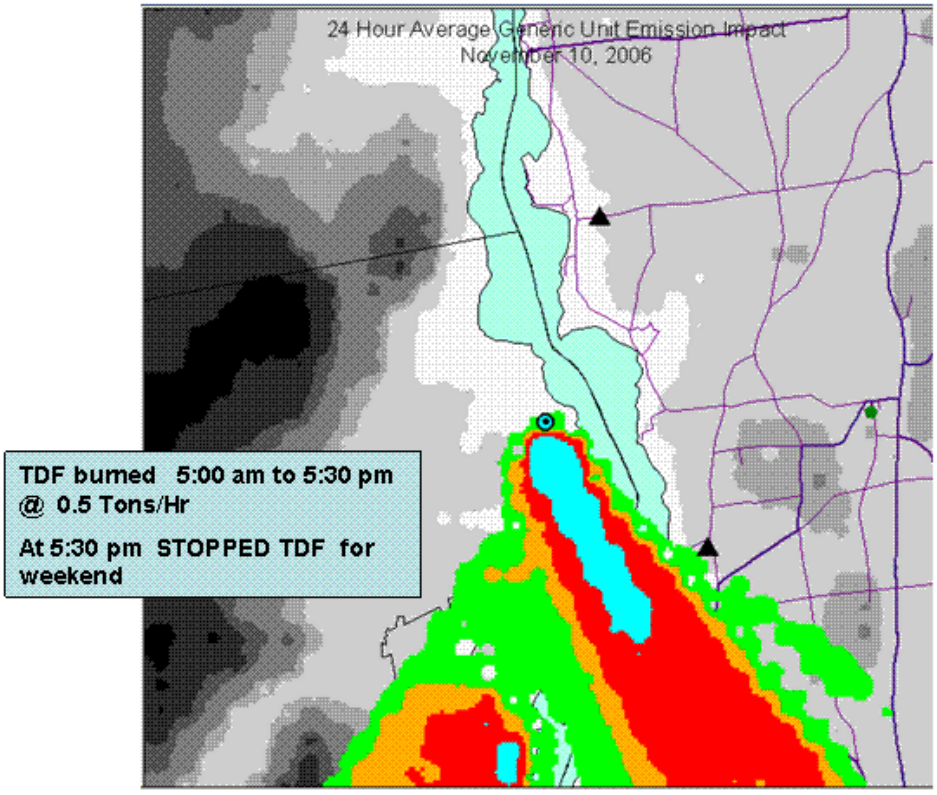
24 Hour Average Generic Unit Emission Impact Field from IPC Plant

November 10, 2006



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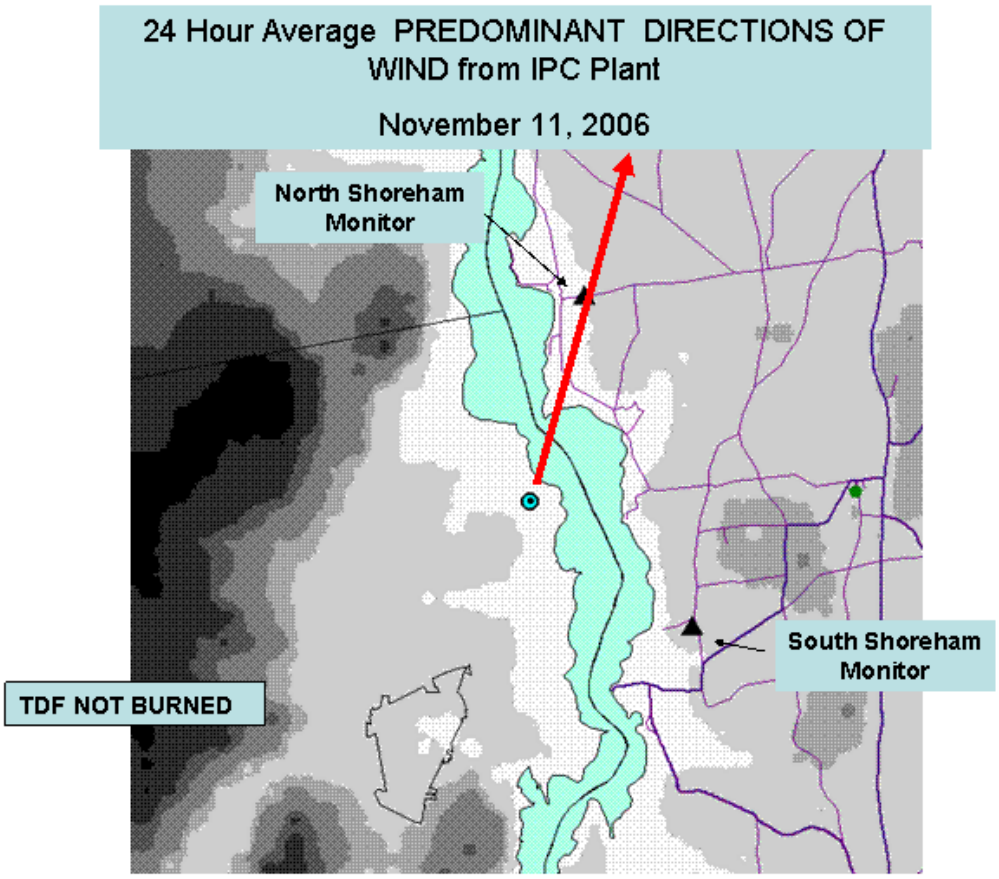
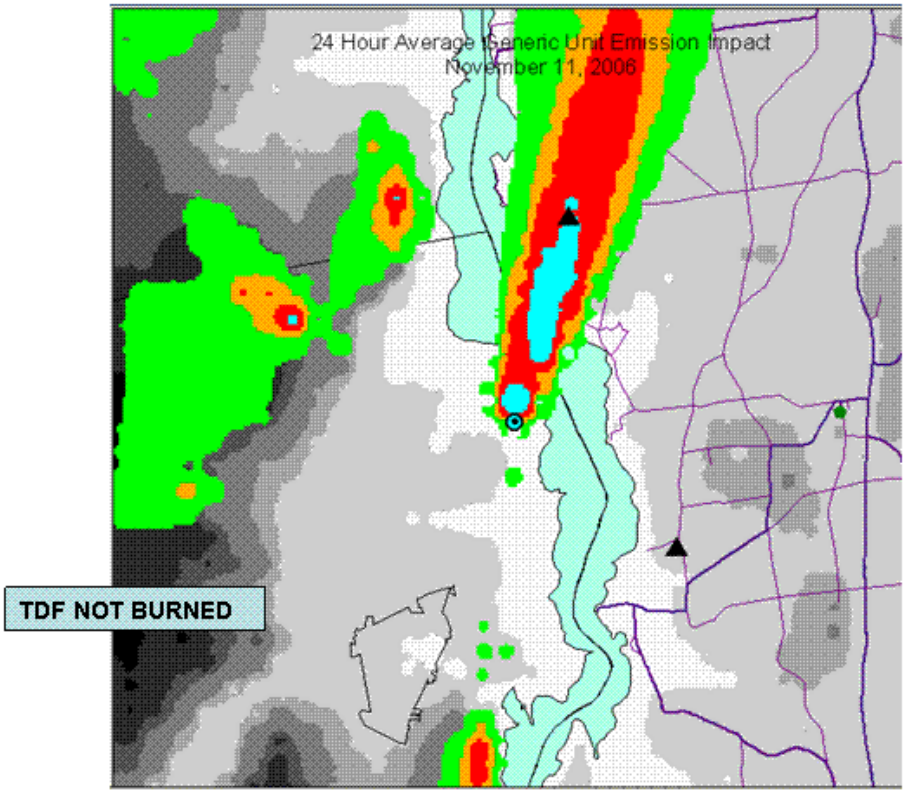


The red arrow is a subjective representation of the plume centerline for the time period identified based upon the output of the plume dispersion model.

24 Hour Average Generic Unit Emission Impact Field from IPC Plant

November 11, 2006



GREEN	=	**Generic Impact of**	>	**1 Unit**
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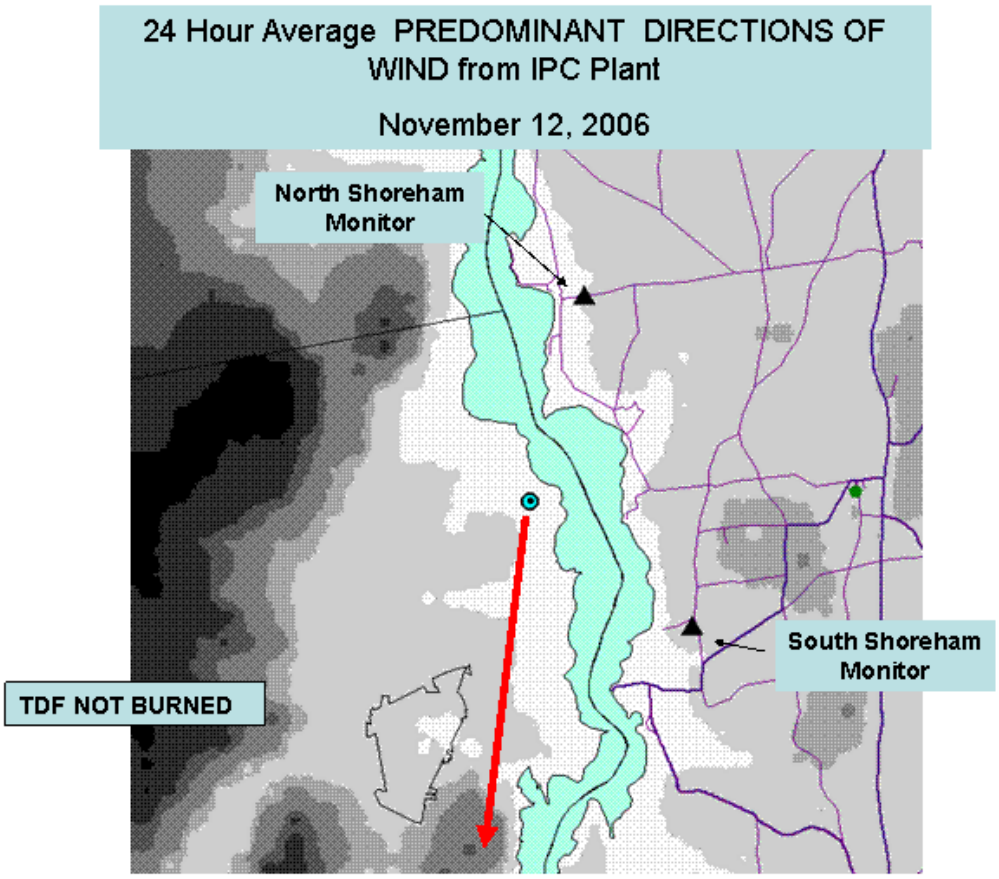
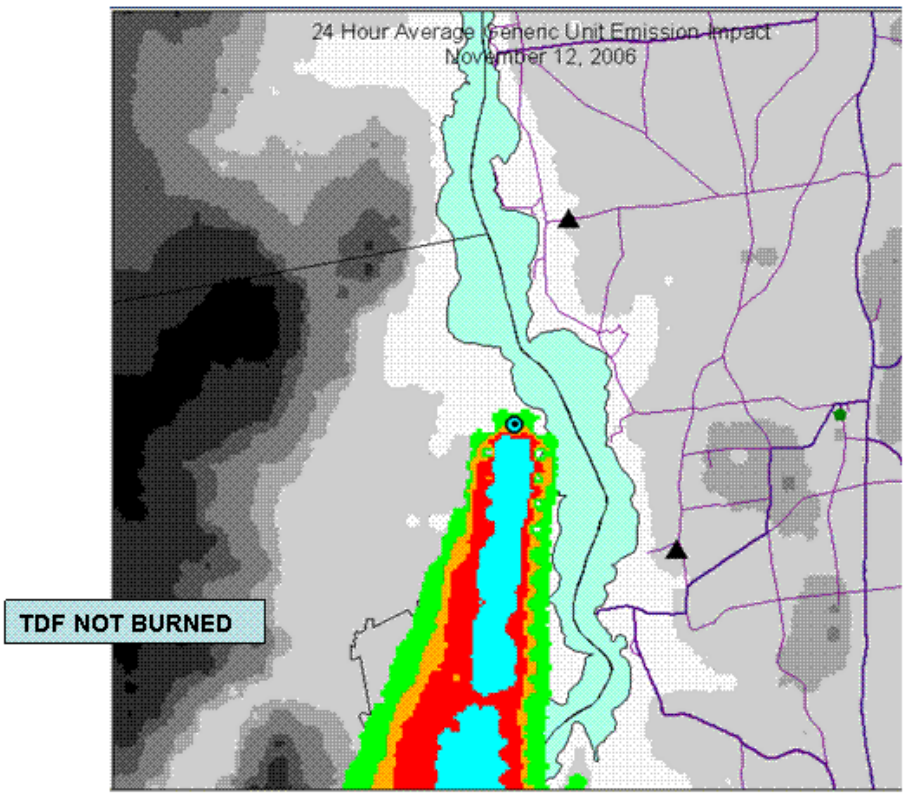


The red arrow is a subjective representation of the plume centerline for the time period identified based upon the output of the plume dispersion model.

24 Hour Average Generic Unit Emission Impact Field from IPC Plant

November 12, 2006



GREEN	=	**Generic Impact of**	>	**1 Unit**
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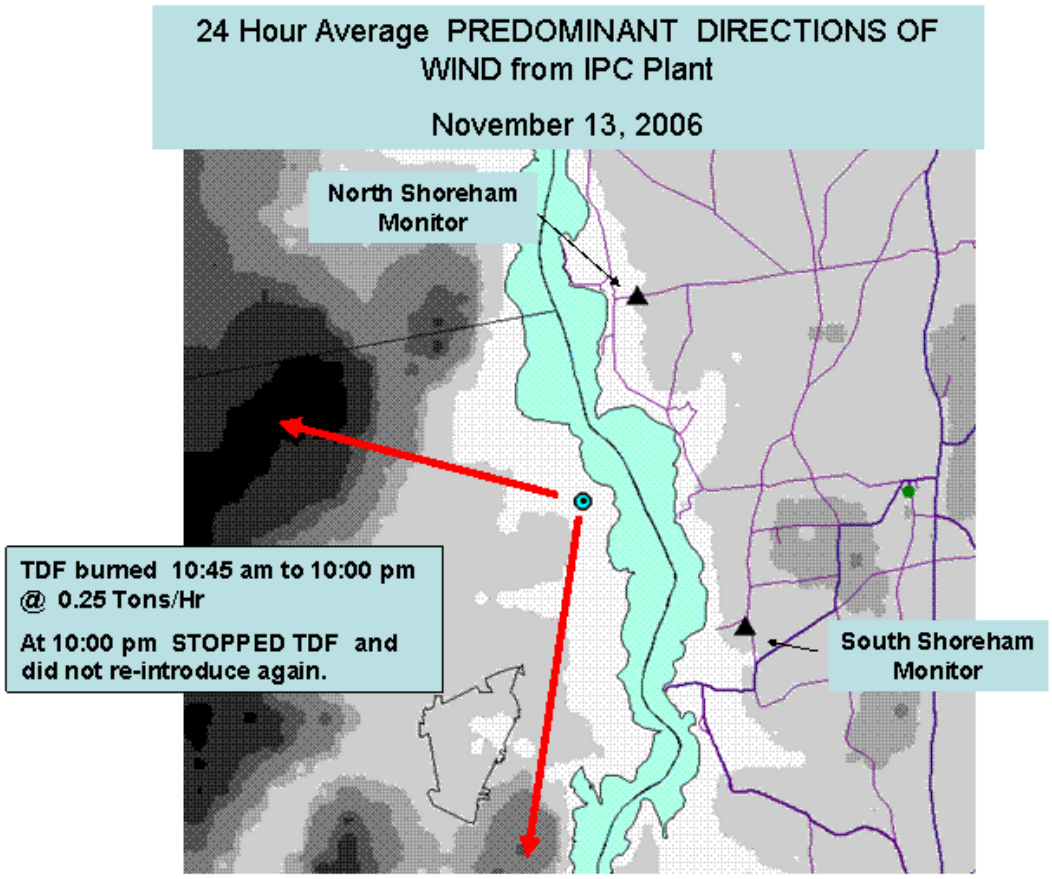

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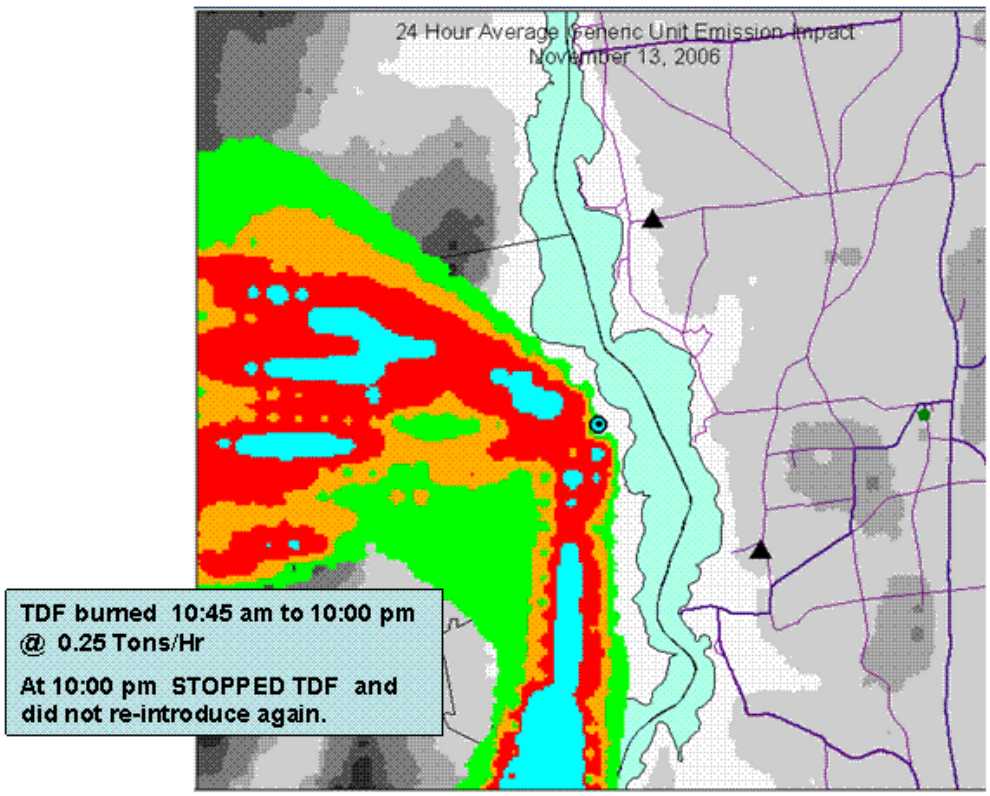
24 Hour Average Generic Unit Emission Impact Field from IPC Plant

November 13, 2006



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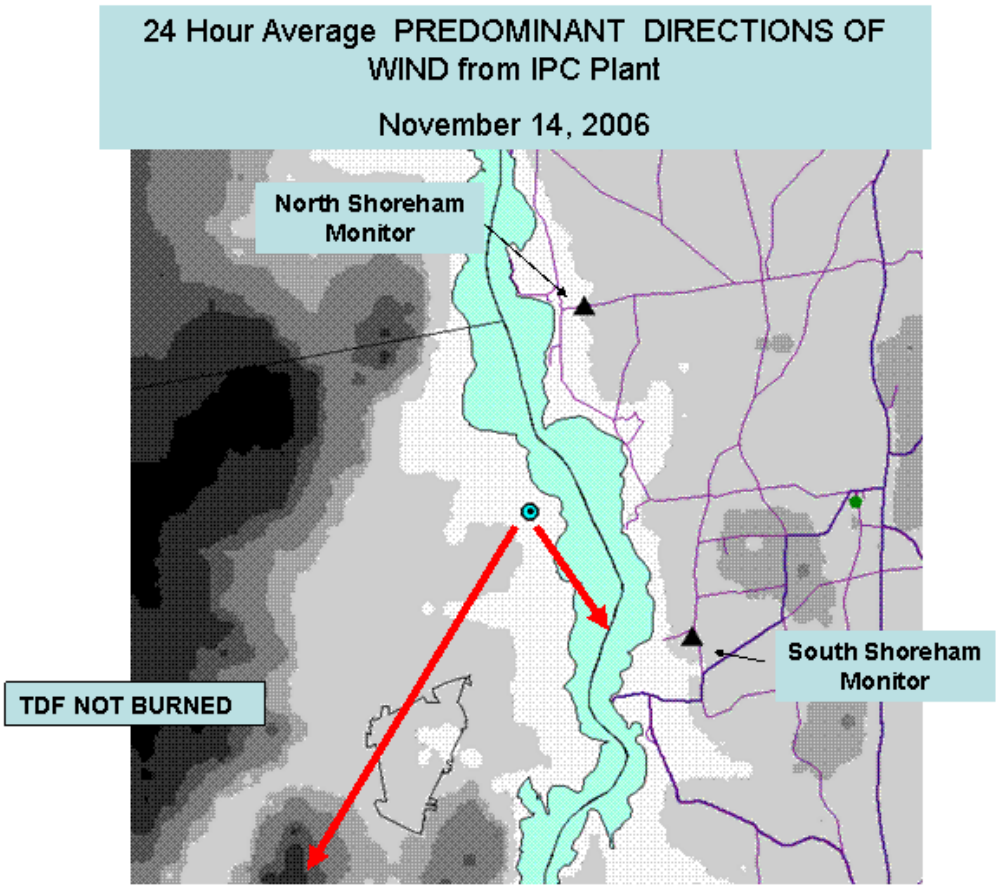

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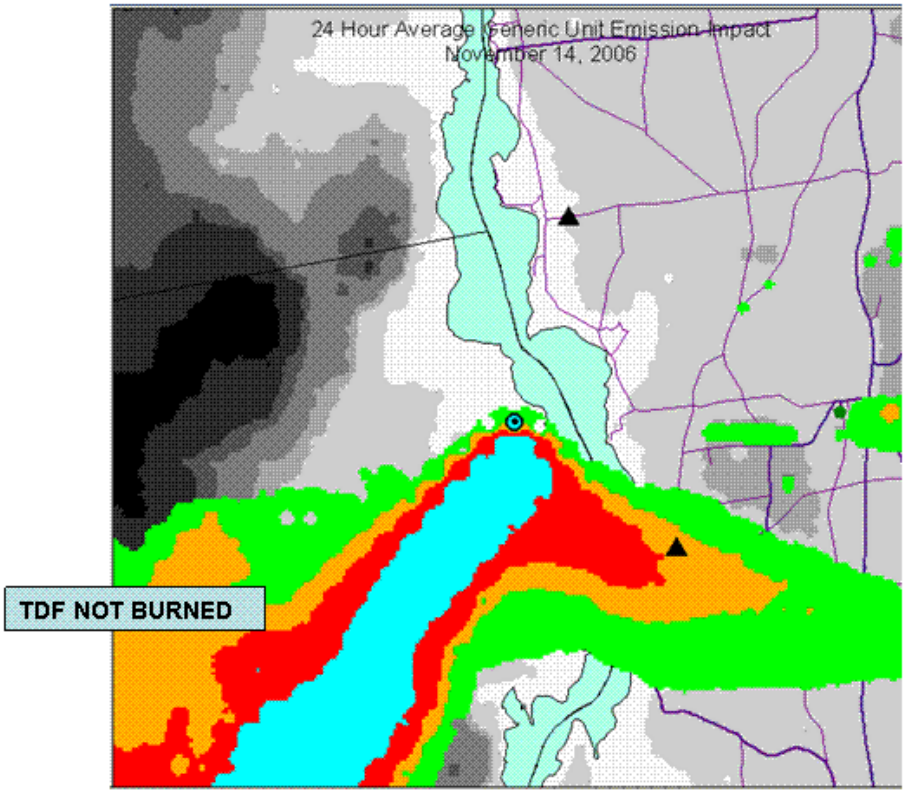
24 Hour Average Generic Unit Emission Impact Field from IPC Plant

November 14, 2006



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