Air Quality Impacts of the Keystone XL Project at Refineries in PADD 3

Prepared for the Natural Resources Defense Council

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April 22, 2013

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I. INTRODUCTION

The proposed Keystone XL project consists of an 875-mile long pipeline and related facilities to transport up to 830,000 barrels per day (BPD) of crude oil from Alberta, Canada and the Bakken Shale Formation in Montana. The pipeline would cross the U.S. border near Morgan, Montana and continue through Montana, South Dakota, and Nebraska where it would connect to existing pipeline facilities near Steele City, Nebraska for onward delivery to Cushing, Oklahoma and the Texas Gulf Coast region (Project).

I was asked to evaluate the air quality impacts at PADD 3 refineries from processing the Western Canadian Sedimentary Basin (WCSB) tar sands crudes that would be imported by this Project. My resume is included as Exhibit A to this report. I have worked on many heavy crude expansion projects, including the new tar sands refinery in South Dakota; tar sands expansion projects in Canada, Indiana, Michigan and Louisiana; an oil shale refinery in Colorado; and several heavy crude expansion projects in California and Texas, for both applicant/owners and others.

The Final Environmental Impact Statement (FEIS) and Draft Supplemental Environmental Impact Statement (DSEIS) do not evaluate air quality impacts of refining WCSB tar sands crudes, but rather set out excuses for failing to do so. These documents also do not contain the basic information required to prepare an air quality analysis.

In my opinion, based on my experience working on similar projects, the refining of up to 830,000 barrels per day (BPD) of WCSB crude in PADD 3 refineries would increase the amount of fuel that would be burned at nearly every fired source (heaters, boilers, flares, turbines) within receiving refineries and their off-site support facilities, compared to current crude slates. Further, pollutants in the diluent blended with these crudes would be emitted at nearly every single fugitive component, including compressors, pumps, valves, fittings, and tanks, in greater amounts than from other heavy crudes. This would result in significant air quality impacts including:

- causing or contributing to violations of National Ambient Air Quality Standards (NAAQS) of ozone in severe and marginal ozone nonattainment zones;
- increasing emissions of criteria pollutants, including nitrogen oxides (NO_x), sulfur oxides (SO_x), carbon monoxide (CO), volatile organic compounds (VOCs), particulate matter (PM10, PM2.5), hazardous air pollutants (HAPs), and highly odiferous sulfur compounds that would individually and cumulatively degrade ambient air quality and adversely affect the health of residents around the subject facilities;
- accelerate corrosion of refinery components, contributing to equipment failure and accidental releases.

According to the DSEIS, the Project would supply up to 830,000 BPD of crude oil to customers along the Gulf Coast in PADD 3, which covers six states from New

Mexico to Alabama. DSEIS, p. 4.15-72. Because up to 100,000 BPD is reserved for crude oil from Williston Basin and 155,000 BPD to pick-up crude oil from domestic producers delivering to Cushing, Oklahoma, it is estimated that approximately 600,000 BPD of tar sands crudes and up to 830,000 BPD of WCSB crudes will be delivered to PADD 3 refineries for the next decade or two by the Project. DSEIS, p. 4.15-72.

Currently, there are 57 refineries in PADD 3, which have a 2012 capacity to refine 9.2 million BPD of crude. There were 4.62 million BPD of crude oil imported by PADD 3 refineries in 2012, 2.16 million BPD of which was heavy crude, primarily from Venezuela and Mexico with smaller amounts from Columbia, Brazil, Canada and elsewhere. DSEIS, Table 1.4-4. Of these 57 refineries, 15 would be directly connected to hubs connected to the Project. These 15 refineries currently process 4.2 million BPD of crude, of which 1.4 million BPD or 33% is heavy crude. DSEIS, p. 4.15-73. However, heavy crude could be delivered to any of the 57 PADD 3 refineries through other existing pipelines or by tanker, barge, or rail. DSEIS, Table 4.15-18. This significant increase in the processing of WCSB tar sands crudes in PADD 3 refineries will have significant air quality impacts that have been swept under the rug in the DSEIS.

The DSEIS dismisses air quality impacts as insignificant based on four arguments. First, it argues the existing regulatory system would mitigate any impacts. DSEIS, p. 4.15-74. Second, it argues there would be no changes in emissions as the crude quality would not significantly change. DSEIS, p. 4.15-75. Third, the DSEIS argues these imports would not result in any incremental increases in refinery emissions as the crude oil transported by the Project would be replacing or displacing crude oil from other similar sources, e.g., heavy crudes from Mexico and Venezuela. DSEIS, p. 4.15-78. Fourth, and just in case reasons one through three are wrong, the DSEIS presents a range of potential criteria pollutant emissions that might be emitted from refining these imported crudes. The following sections discuss why none of these arguments have any merit. This is followed by a general discussion of the types of impacts that would be expected and the data that would be required (none of which is in the record) to evaluate these impacts.

II. THE EXISTING REGULATORY SYSTEM WOULD NOT MITIGATE AIR QUALITY IMPACTS

First, the DSEIS alleges that the processing of these heavy crudes would occur within existing permits and Consent Decrees. DSEIS, p. 4.15-74. The cumulative air quality impact analysis in the DSEIS rests on the assumption that the air permitting process, never identified specifically, is designed to avoid significant cumulative impacts to regional air quality. DSEIS, p. 4.15-75.

a. AIR PERMITS DO NOT MITIGATE AIR QUALITY IMPACTS OF REFINING WCSB TAR SANDS CRUDES

The claim that existing permits and Consent Decrees would take care of any adverse air quality impact issues is incorrect for several reasons.

First, it is inconsistent with the fact that many of the refineries that would process these crudes (DSEIS, Table 4.15-18) are located in or near areas that currently violate National Ambient Air Quality Standards (NAAQS) in PADD 3. See Exhibit B.

If the existing regulatory system was working, ambient air quality in the vicinity of the affected facilities would at least comply with NAAQS. Thus, the co-location of the subject facilities with areas that currently do not comply with NAAQS is proof that the existing permitting process and Consent Decrees have not prevented significant impacts to regional air quality. The subject refineries are currently causing or contributing to severe air quality impacts. The proposed crude imports will aggravate these impacts by significantly increasing emissions, as explained below.

Second, as discussed in this report, changes in crude quality will result in changes in emissions. Air permitting does not consider the impact of changes in crude quality on emissions.

Third, based on my experience, the air permitting process has proved to be very ineffective in the Gulf Coast states for controlling air pollution. Applicants generally employ a variety of strategies to avoid triggering New Source Review (NSR) permitting in the first place. These strategies include bogus netting analyses; piecemealing of projects (e.g., permitting them a tiny piece at a time as minor amendments to avoid triggering NSR permitting); failure to disclose debottlenecking[1] emission increases which are the *sine qua non* of WCSB tar sands crude upgrades; use of nonrepresentative emission factors to estimate emissions; cherrypicking stack tests to net out of PSD review; and the use of invalid or outdated emission offsets in nonattainment zones. In fact, Texas and Louisiana, the states where most of the subject refining capacity is located, are famous for their permitting shenanigans.

In Texas, for example, most refineries likely to use tar sands crudes have, or have recently had, permits issued under the State's "Flexible Permit" rules.[2] These rules were disapproved by EPA for inclusion in the State Implementation Plan (SIP) and new rules have been proposed, but even these will not cure the implementation problems in Texas.

"Flex" permits, or derivatives thereof, allow major modifications, such as would be required to retrofit a refinery to handle the subject crudes, to avoid NSR/PSD permitting as long as the modification does not exceed plant-wide emission caps. Unlike EPA's approved plantwide applicability limits (PAL) rules, Texas' flexible permit rules allowed refinery-wide emission caps that were calculated from maximum allowable hourly emissions, based on the highest throughputs ever, summed over all units, and then converted to annual averages. These plantwide "flex" permits also voided pre-existing

[1] A bottleneck is a limitation on the operation of an emission unit (e.g., its throughput) due to restrictions at upstream or downstream units that prevents it from reaching its full capacity. The bottleneck thus limits the potential to emit of the bottlenecked unit. Debottlenecking means removing the limitation(s), thus allowing the unit to emit at a higher rate.

[2] See, for example, TNRCC (now TCEQ) Interoffice Memorandum, Flexible Permits and the Plantwide Applicability Limit (PAL), December 31, 1999, Available at: http://www.tceq.texas.gov/assets/public/permitting/air/Guidance/Historical/palmemo.txt.

NSR/PSD limits and substituted the hugely inflated caps, to allow major modifications to occur with no regulatory oversight.

These flex permits with no source-specific limits have allowed major modifications, such as tar sands refinery upgrades, to occur without any offsets in nonattainment areas, BACT (best available control technology) analyses to assure emissions are adequately controlled, meaningful oversight by permitting authorities, netting analysis to determine if NSR permitting would be required, or public notice. The current derivatives of these flex permits raise similar concerns. Thus, recent and pending refinery changes to accommodate these new WCSB tar sands crudes have been treated by Texas as minor modifications or minor amendments to flex permits and have not required any evaluation of air quality impacts.

Further, permits for future projects under currently proposed 2010 rules would pose many of these same problems due to the existence of options such as PALs, permits by rule (allowing de minimus increases from a series of small projects), and minor amendments, among other devices discussed elsewhere in this report to escape any meaningful oversight and emission control.

Finally, permitting does not address cumulative air quality impacts. The Project involves supplying WCSB tar sands crudes to up to 57 separate refineries. Permitting requirements are triggered on a per-refinery basis. Cumulative effects, arising from modifications at several facilities, which individually may be insignificant, but cumulatively significant, would not be addressed even if permitting were triggered and properly executed. Thus, even setting aside the above arguments, permitting alone can never mitigate the cumulative air quality impacts of the Project as they only apply to one refinery at a time. This is particularly true at the PADD 3 refineries in Texas, which are located in or near ozone nonattainment zones, where any increase in NO_x or VOC emissions is *per se* significant.

b. Consent Decrees Do Not Mitigate Air Quality Impacts Of Refining WCSB Tar Sands Crudes

Consent Decrees also provide no assurance that increases in emissions from switching to a heavier dirtier crude will be mitigated.

First, not all refineries in PADD 3 are under Consent Decrees. A recent EPA review identified 10 refineries in PADD 3 that are not covered by Consent Decrees, including the 282,600 BPD Lyondell-Citgo Refinery in Houston, which has direct pipeline connection to the Project. DSEIS, Table 4.15-18.[3] These non-Consent Decree refineries have a combined refining capacity of 724,000 BPD.[4]

[3] This refinery is referred to as "Houston Refining" in the DSEIS (Table 4.15-18), but it is owned by LyondellBasell. See: http://www.lyondellbasell.com/WorldWideLocations/NorthAmerica/USA/Texas/HoustonRefining/.

[4] EPA Enforcement: National Petroleum Refinery Initiative, Draft 2/11/11, Slides, p. 18.

Second, the purpose of Consent Decrees is to bring the subject refineries into compliance with the "marquee" provisions of the Clean Air Act. They are developed to control emissions from refineries in their pre-Consent Decree configurations and to mitigate for existing violations, not to address changes that will be required to refine WCSB tar sands crudes and the resulting increases in emissions. In fact, crude switches are not addressed in Consent Decrees.

Third, the Consent Decrees do not require the best available control technology (BACT) to reduce emissions to the extent feasible nor offsets to assure that increases would not cause or contribute to violations of NAAQS in nonattainment zones. They are settlements, compromises by definition, rather than requirements to mitigate future increases in emissions. Consent Decrees often leave much room for improvement in emission reductions.

For example, a Fluidized Catalytic Cracking Unit or FCCU is required to refine the WCSB tar sands crudes. The FCCU regenerator is typically the main source of emissions at a refinery, contributing about 20% to 30% of the SO_x, 15% to 30% of the NO_x, and 30% to 40% of the PM on a refinery-wide basis. NO_x emissions are ozone precursors and contribute to existing violations of ozone NAAQS. The best control method for NO_x emissions from the FCCU is selective catalytic reduction or SCR, which can remove over 90% of the NO_x. The Consent Decrees for most of the PADD 3 refineries do not require SCRs to control NO_x emissions from the FCCUs, but rather, the much less effective Selective Noncatalytic Reduction (SNCR) method or additives, which remove less than 50% of the NO_x.

Similarly, refining WCSB tar sands crudes will significantly increase emissions from combustion sources, such as heaters and boilers. Refineries typically have many heaters; big refineries may have over a hundred as they supply process heat to nearly every refining process. Refining WCSB tar sands crudes will require large increases in process heat and steam requirements, as discussed elsewhere in this report. The combined emissions from heaters and boilers, especially for NO_x and CO, can be quite large if not adequately controlled.

Emissions from heaters and boilers are typically the major source of emissions from most of the processes that will be most affected by refining WCSB tar sands crudes, e.g., the Crude Unit, Hydrotreaters, Coker. The best available control technology for heaters and boilers for NO_x is SCR and for CO, oxidation catalysts. Very few of the heaters and boilers in PADD 3 refineries use these technologies. The Consent Decrees do not require these technologies at most refineries, but rather less aggressive controls, such as eliminating oil firing, installation of low NO_x burners, and compliance with NSPS Subparts A and J. These types of requirements are not adequate to address the substantial increases in combustion emissions that will result from processing WCSB tar sands crudes in or adjacent to severe ozone nonattainment zones or marginal nonattainment zones.

III. EMISSIONS WOULD INCREASE DUE TO CHANGES IN CRUDE QUALITY

The DSEIS concluded "there would be little, if any, difference in emissions associated with crude oil refining in PADD 3 with or without the proposed Project." DSEIS, p. 4.15-75. This conclusion relies on EnSys modeling in Section 3.13.3 of the FEIS, which concludes that the average API gravity and average sulfur content of the crude oil slate would be essentially the same with or without the proposed Project. DSEIS, p. 4.15-75. This is incorrect as explained below.

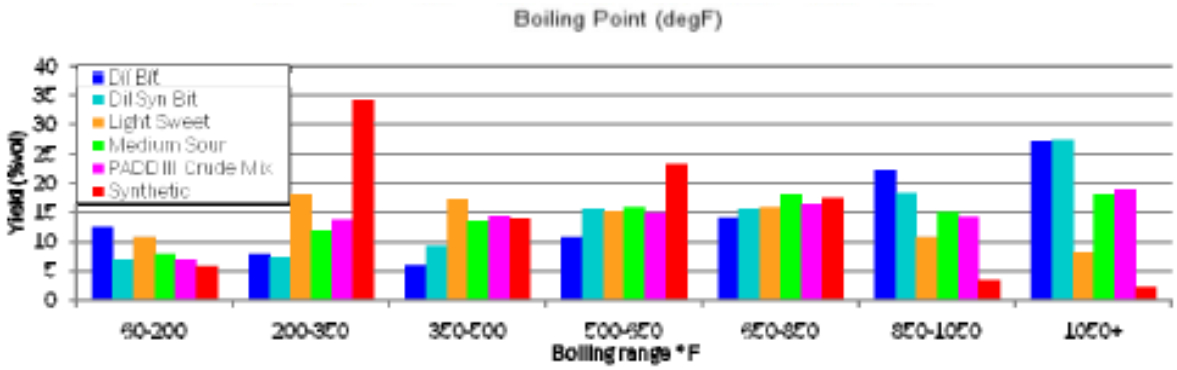
The DSEIS further concludes based on the FEIS that "refinery emissions were not correlated with fluctuations in crude slate quality." DSEIS, p. 4.15-6. This is based solely on a claimed correlation between SO_x emissions and total sulfur in the crude slate (FEIS, p. 3.14-35), which, as described below, is the wrong metric to ferret out changes in emissions due to changes in the crude slate. The underlying data and analysis relied on in the FEIS and DSEIS were not provided. However, one would expect no change in SO_x **emissions** in response to changes in crude total sulfur as most all of the crude sulfur is recovered as elemental sulfur cake in the Sulfur Plant and sold, not emitted. The FEIS did not include the sulfur cake in its analysis. The tiny fraction that is emitted as SO_x originates from sulfur partitioned into the fuel gas and burned in combustion sources. In refineries, this SO_x is typically controlled by permit limits on the amount of sulfur allowed in the fuel gas. Thus, one would expect no correlations between SO_x from combustion sources and crude slate sulfur content. This analysis is irrelevant to the issue at hand.

The DSEIS's claim that there would be little if any difference in emissions associated with refining WCSB tar sands crudes in PADD 3 refineries ignores the fact that there are major chemical differences between conventional and other heavy crudes and WCSB tar sands crude that were not considered in the FEIS or DSEIS.

This is illustrated in Figure 1, which shows the distillation column yields for various WCSB crudes—DilBit (diluted bitumen), DilSynBit (bitumen diluted with traditional diluents and synthetic crude oil), and SCO (synthetic crude oil)—compared to a typical PADD III crude mix and other crudes. The bright pink [ ] is the typical PADD III crude mix, the dark blue [ ] a typical DilBit, the dark geen a typical DilSynBit [ ], and the red [ ] an SCO. This bar chart demonstrates significant differences between the boiling ranges of the WCSB tar sands material and other conventional crudes currently refined in PADD III refineries.[5] These differences in boiling ranges are due to major differences in chemical composition, which directly impact emissions from refining these crudes.

[5] See, for example, Pat Swafford, Evaluating Canadian Crudes in US Gulf Coast Refineries, Crude Oil Quality Association Meeting, February 11, 2010, Available at: http://www.coqa-inc.org/20100211_Swafford_Crude_Evaluations.pdf.

Figure 1: Comparison of Boiling Range (°F) of Typical Gulf Coast Crude Slate with WCSB Tar Sands Crudes



Factors other than API gravity and sulfur content affect refinery emissions, particularly of uncontrolled or otherwise unregulated emissions. These include factors such as the chemical association of sulfur, nitrogen, and other contaminants; the distribution and speciation of organic compounds among the different crude oil fractions;[6] the amount of nitrogen, oxygen, and hydrogen; and trace element composition. See, for example, discussion of diluents elsewhere in this report. This has been totally overlooked in the EIS.

The air quality impacts of refining WCSB tar sands crudes depend on the chemical and physical composition of the refinery slate with WCSB tar sands crude compared to the current slate. There are various ways the WCSB tar sands crude could be integrated into a refinery. It could, for example, replace the current slate completely, as in a refinery built specifically for this purpose. It could replace a similar crude in similar or different amounts. Or it could increase the refining capacity, modifying the current crude slate while remaining within the design basis of the refinery. The DSEIS did not evaluate all of the possibilities, but rather assumed no change in crude slate.

Further, the air quality impacts of switching from current heavy crudes from Mexico and Venezuela to WCSB tar sands crudes depends on the relative composition of the crudes involved in the switch and specifically, the oil fields/formations in Mexico and Venezuela that currently supply the refineries. The EIS does not contain any of the fundamental information required to make this assessment.

The only summary crude composition information is in DSEIS Table 3.13-2. This table excludes most constituents important to estimating emissions (e.g., trace metals, BTEX, nitrogen) and does not include complete composition data for the crudes that it would displace (Mayan and Venezuelan heavy crudes). The type of data required to evaluate emissions would require, at a minimum, the following information for both the current slate, the proposed slate, and the WCSB tar sands crudes that would be substituted or additionally refined. (Note that one cannot eliminate the possibility that

[6] Relative amounts of naphtha, kerosene, diesel, VGO and residue. DilBit crudes, for example, contain large amount of light and heavy cuts and very little mid-range material.

these imported crudes will be used to increase refinery capacity, rather than replacing other crudes in the existing slate.)

- Trace elements (As, B, Cd, Cl, Co, Cr, Cu, Hg, Mn, Mo, Ni, Pb, Sb, Se, U, V, Zn)
- Nitrogen (total & basic)
- Sulfur (total, mercaptans, H_2S)
- Residue properties (saturates, aromatics, resins)
- Acidity
- Aromatics content
- Asphaltenes (pentane, hexane and heptane insolubles)
- Hydrogen content
- Carbon residue (Ramsbottom, Conradson)
- Distillation yields
- Properties by cut
- Hydrocarbon analysis by gas chromatography

None of this information is in the record, preventing any party from performing an analysis of air quality impacts. As none of the basic information required to assess air quality impacts is provided in the record, I will discuss in general some of the impacts that can reasonably be expected from replacing existing crude slates with WCSB tar sands crudes or increasing refinery throughputs with the increase comprised of 100% imported WCSB tar sands crudes. These scenarios are possible as the Project does not contain any restrictions on the end use of the imported crude, i.e., to replace other heavy crudes, to replace existing conventional crudes in current slates, or to increase throughput of the refinery itself.

The DSEIS states that "the Department assumes that the average crude oil flowing through the pipeline would consist of about 50 percent Western Canadian Select (DilBit) and 50 percent Suncor Synthetic A (SCO)." DSEIS, Appx. W, p. 56. DilBit is Canadian tar sands bitumen diluted to pipeline specifications, typically with 25% to 30% diluent. DSEIS, p. 1.4-47, 2-2. Suncor Synthetic A or SCO is a light sweet synthetic crude produced from the Suncor Canada Project located north of Fort McMurray Alberta. However, there are no restrictions on what can be run in the proposed pipeline. In a different section, the DSEIS speculates that KXL will likely move mostly DilBit as well as a variety of SynBits[7] and SCOs. DSEIS, p. 1.4-47, FEIS, p. 3.13-78 ("...the majority of crude oil that would likely be transported by the proposed Project would be DilBit crude oils..."). The temperature effects study in Appendix S of the DSEIS assumes 80% DilBit and 20% SCO. DSEIS, p. S-1 ("The analysis assumes that the pipeline ships 80 percent diluted bitumen and 20 percent synthetic crude.")

[7] SynBit is a combination of bitumen and SCO (synthetic crude oil), typically in an approximately 50-50 ratio. The properties of SynBit blends vary greatly, but blending lighter SCO with heavier bitumen results in a product more similar to conventional crude oil than either SCO or DilBit. FEIS, p. 3.13-30. See also DSEIS, p. 3.13-4 ("SCO may also be used as a diluent for bitumen, in which case the commodity is known as synbit (bitumen diluted with SCO).").

The DSEIS is based on the assumption that the composition of the crude slate will not change and thus will not impact air emissions. However, this is based only on a limited collection of gross or lumper crude quality parameters (DSEIS, Table 3.13-2) and ignores the actual chemical composition of the crudes, which is not disclosed in the DSEIS.

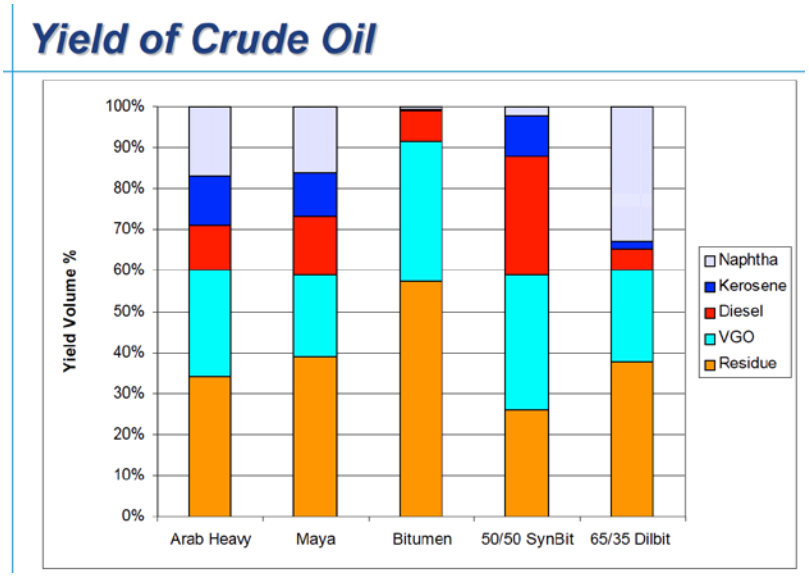
For example, sulfur is not simply sulfur, but is made up of a complex collection of individual chemical compounds such as hydrogen sulfide, mercaptans, thiophene, benzothiophene, methyl sulfonic acid, dimethyl sulfone, thiacyclohexane, etc. Each crude has a different suite of individual sulfur chemicals. The impacts of "sulfur" depend upon the specific sulfur chemicals and their relative concentrations, not on the "gross" amount of total sulfur. The fact that the total sulfur content of the crude slate is the same is irrelevant. This was clearly and tragically demonstrated in the recent (August 2012) catastrophic accident at the Chevron Richmond Refinery in California, caused by the erroneous assumption that sulfur is sulfur. See discussion elsewhere in this report.

The specific chemicals, for example, determine which ones will be volatile and lost through equipment leaks and outgassed from tanks, which ones will be difficult to remove in hydrotreaters and other refining processes (thus determining how much hydrogen and energy must be expended to remove them), and which ones might aggravate corrosion leading to accidental releases. The DSEIS failed to grasp this distinction and looked only to gross chemical characterization data. Thus, it has failed to disclose the impacts of refining WCSB tar sands crudes.

There are two significant differences between the WCSB tar sands crudes that would be transported by the Project and other heavy crudes: (1) the presence of large amounts of diluent[8] and (2) the chemical composition of the heavy ends or residuum, which must be broken down into lighter products, usually in a coker. This is illustrated in Figure 2, which is a bar chart of the output of the distillation column for two commonly refined conventional heavy crudes—Arab Heavy and Maya—and three WCSB crudes—raw bitumen, SynBit, and DilBit.

[8] The DSEIS is silent on whether the Mexican and Venezuelan heavy crudes the WCSB crudes could replace are also mixed with diluent.

Figure 2: Oil Distributions of Conventional and Canadian DilBit and SynBit[9]



The majority of the WCSB crudes that will be transported by the Project are DilBits, the last bar in Figure 2. These DilBits are sometimes referred to as "dumbell" or "barbell" crudes as the majority of the diluent is C_5 to C_{12} and the majority of the bitumen is C_{30}+ boiling range material, with very little in between.[10] This means these crudes have a lot of material boiling at each end of the boiling point curve, but little in the middle. Thus, they yield very little middle distillate fuels, such as diesel, heating oil, kerosene, and jet fuel and more coke, than other heavy crudes. A typical DilBit, for example, will have 15% to 20% by weight light material, basically the added diluent, 10% to 15% middle distillate, and the balance, >75% is heavy residual material (vacuum gas oil and residue) exiting the distillation column. These characteristics, which distinguish DilBits from the typical PADD 3 crude slate and conventional heavy crudes refined in PADD 3, have two major implications for emissions from refineries.

First, the large amount of light material that distills below 149 C is very volatile and can be emitted to the atmosphere from storage tanks and equipment leaks of fugitive components (pumps, compressors, valves, fittings) in much larger amounts than other heavy crudes that it would replace. The DSEIS does not indicate whether other heavy crudes processed in PADD 3 refineries currently arrive with diluent. However, as the heavy crudes from Venezuela and Mexico typically arrive at the Gulf Coast via tankers – as opposed to via pipeline – they do not need to be transported with diluents. Thus, the use of diluent to transport WCSB tar sands crudes is likely an important difference between the current heavy crude slates processed in PADD 3 refineries and the proposed

[9] Kevin Turini and others, Processing Heavy Crudes in Existing Refineries, Slides, 2011 AIChe Meeting, Chicago, IL.

[10] Gary R. Brierley and others, Changing Refinery Configuration for Heavy and Synthetic Crude Processing, 2006, Available at: https://www.edockets.state.mn.us/EFiling/edockets/searchDocuments.do?method=showPoup&documentId=%7BA07DE342-E9B1-402A-83F7-36B18DC3DD05%7D&documentTitle=5639138.

WCSB tar sands crudes that would replace them. This diluent will have impacts along the entire length of the pipeline as well as at all units within refineries that process it.

Second, the large amount of heavy material in the bitumen fraction means that existing equipment will have to work harder to convert it into desirable byproducts. This translates into more emissions from heaters, boilers, cokers, the hydrogen plant, and fluid catalytic crackers, among others. It also means much more highly contaminated coke will be produced and much more electricity will be used.

a. DILUENT WOULD INCREASE EMISSIONS

Most of the WCSB tar sands crudes are too heavy to flow in a pipeline. Thus, they must be diluted or thinned with a lighter hydrocarbon stream to reduce viscosity and density to meet pipeline specifications. More diluent is required in the winter than summer to maintain flow rates during cold weather. DilBit is a mixture of bitumen, the raw heavy oil, mixed with about 25% to 30% diluent, which is typically natural gas condensate, pentanes, or naphtha.[11] The DSEIS is silent on the composition and emissions from this diluent. These are significant omissions as the emissions from handling this material are large and significant.

The analyses in the DSEIS appear to assume that diluent mixed with bitumens and transported by pipeline would be processed with the bitumen at the receiving refineries. DSEIS, pp. 4.15-83, notes to Fig. 4.15.3-3; 4.15-84, notes to Fig. 4.15.3-4. Elsewhere, the DSEIS asserts that "once diluent and bitumen are mixed together to form dilbit, they behave as a conventional crude oil." See also DSEIS, Appx. W, p. 26 ("The estimates where diluent is refined with the raw bitumen at the refinery are representative of the proposed Project, since diluent will not be recirculated by the pipeline.") Therefore, the analysis in the DSEIS appears to treat the DilBit as a single substance. DSEIS, p. 4.13-17, 4.13-45.

However, one cannot eliminate the possibility that the diluent would be separated from the DilBit and returned to Canada or elsewhere at some point in the future. See DSEIS, p. 1.4-47. There is nothing in the DSEIS that requires diluent to be processed with the bitumen and not separated and sent elsewhere for processing. It is possible that at some point over the operation of the facility that it would be more economical to return the diluent to Canada or elsewhere rather than to refine it at U.S. refineries.
The DSEIS places no restrictions on the handling of diluent. Regardless of the actual disposition of the diluent, the EIS must consider impacts from processing bitumen blended with 20% to 30% diluent, a very large amount of light material compared to other heavy crudes currently processed in PADD 3 refineries. This will increase emissions of volatile organic compounds (VOCs), Hazardous Air Pollutants (HAPs) and other pollutants compared to current heavy crudes. Thus, the air quality impacts of both

[11] Gary R. Brierley, Visnja A. Gembicki, and Tim M. Cowan, Changing Refinery Configurations for Heavy and Synthetic Crude Processing, Available at: https://www.edockets.state.mn.us/EFiling/edockets/searchDocuments.do?method=showPoup&documentId=%7BA07DE342-E9B1-402A-83F7-36B18DC3DD05%7D&documentTitle=5639138.

options, separation and return to Canada or elsewhere, and processing at the local refinery, should have been evaluated. Neither was.

The mixture of diluent and bitumen does not behave the same as a conventional crude, as the distribution of hydrocarbons is very different. The blended lighter diluent generally evaporates readily when exposed to ambient conditions, leaving behind the heavy ends, the vacuum gas oil (VGO) and residuum.[12] Thus, when a DilBit is released accidentally, it will generally create a difficult to cleanup spill as the heavier bitumen will be left behind.[13] Further, in a storage tank, the diluent also is rapidly evaporated.

In the refinery, diluent distills in the atmospheric column in the Crude Unit, leaving the very heavy 6-8^{o} API feed to the vacuum unit, which requires more energy to process, thus releasing more emissions. This does not occur with other heavy crudes currently run in PADD 3 refineries. Thus, this affects all downstream refining operations and leads to conditions that increase emissions, e.g., heater coking, increased heater firing.[14]

The separated diluent would be hydrotreated in the Naptha Hydrotreater. This unit removes impurities in the naphtha, primarily sulfur as hydrogen sulfide (H_2S) by reacting hydrogen and naphtha in vapor phase over a fixed catalyst bed. Some of the hydrotreated material would be further upgraded, as required, and outputs blended into gasoline. The increased amounts of naphtha, compared to conventional heavy crudes, would require increased amounts of hydrogen and increased fuel consumption to generate heat. Further, in some cases, all of the light naphtha originating from the diluent may not be able to be blended into the gasoline pool without exceeding vapor pressure specifications. This would require shipping the recovered diluent elsewhere,[15] increasing VOC emissions.

The diluent is a low molecular weight organic material with a high vapor pressure that contains high levels of VOCs, sulfur compounds, and HAPs. These may all be emitted from storage tanks and leaks from many thousands of pumps, compressors, valves, and flanges in the system used to store and transport DilBits. The composition of some typical diluents/condensates is reported on the website, www.crudemonitor.ca.[16] The specific diluents that would be used by the Project are unknown.

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[12] The residuum is the residue obtained from the oil after nondestructive distillation has removed all of the volatile materials. Residua are black, viscous materials. They may be liquid at room temperature (from the atmospheric distillation tower) or almost solid (generally vacuum residua), depending upon the nature of the crude oil.

[13] A Dilbit Primer: How It's Different from Conventional Oil, Inside Climate News. Available at: http://insideclimatenews.org/news/20120626/dilbit-primer-diluted-bitumen-conventional-oil-tar-sands-Alberta-Kalamazoo-Keystone-XL-Enbridge?page=show.

[14] Steve White and Tony Barietta, Refiners Processing Heavy Crudes can Experience Crude Distillation Problems, Oil&Gas Journal, November 18, 2002.

[15] Brierley et al. 2006, p. 9.

[16] Condensate Blend (CRW) - http://www.crudemonitor.ca/condensate.php?acr=CRW; Fort Saskatchewan Condensate (CFT) - http://www.crudemonitor.ca/condensate.php?acr=CFT; Peace Condensate (CPR) - http://www.crudemonitor.ca/condensate.php?acr=CPR; Pembina Condensate (CPM) - http://www.crudemonitor.ca/condensate.php?acr=CPM; Rangeland Condensate (CRL) -

The CrudeMonitor information indicates that diluent contains very high concentrations (based on 5-year averages) of the hazardous air pollutants (HAPS) benzene (5,200 ppm to 9,800 ppm); toluene (10,300 ppm to 25,300 ppm); ethyl benzene (900 ppm to 2,900 ppm); and xylenes (4,600 ppm to 23,900 ppm).

The sum of these four compounds is known as "BTEX" or benzene-toluene-ethylbenzene-xylene. The BTEX in diluent ranges from 27,000 ppm to 60,900 ppm. The BTEX in DilBits, blended from these materials, ranges from 8,000 ppm, to 12,400 ppm.[17] Similarly, the BTEX in SCOs ranges from 6,100 ppm to 14,100 ppm.[18]

The FEIS conceded that DilBits would be delivered by the Project with a "slightly higher BTEX content than many other heavy crude oils, but a lower BTEX content than Mexican Maya...". However, an examination of the FEIS's supporting data in Table 3.14.3-6 indicates that even based on its own data, this is incorrect. Table 3.14.3-6 reports Mexican Maya crudes contain 5,500 to 9,773 ppm BTEX, while the single DilBit is reported at 9,800 ppm and SynCrude Synthetic at 13,100 ppm, above the upper end of the range of Mexican Maya. The more comprehensive collection of DilBit data reported on CrudeMonitor indicates a BTEX range of 8,000 ppm to 12,400 ppm, or much higher than Mexican Maya, or any other heavy crude. FEIS, Table 3.14.3-6. Thus, WCSB tar sands crudes will increase BTEX emissions from equipment leaks from compressors, pumps, valves, flanges, and tanks. These are hazardous air pollutants with public health implications for neighbors of the refineries.

The CrudeMontior information also indicates that these diluents contain elevated concentrations of volatile mercaptans (9.9 to 103.5 ppm), which are highly odiferous and toxic compounds that will create odor and nuisance problems along the pipeline and

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http://www.crudemonitor.ca/condensate.php?acr=CRL; Southern Lights Diluent (SLD) - http://www.crudemonitor.ca/condensate.php?acr=SLD.

[17] DilBits: Access Western Blend (AWB) -http://www.crudemonitor.ca/crude.php?acr=AWB; Borealis Heavy Blend (BHB) -http://www.crudemonitor.ca/crude.php?acr=BHB; Christina Dilbit Blend (CDB) - http://www.crudemonitor.ca/crude.php?acr=CBD; Cold Lake (CL) - http://www.crudemonitor.ca/crude.php?acr=CL; Peace River Heavy (PH) - http://www.crudemonitor.ca/crude.php?acr=PH; Seal Heavy (SH) - http://www.crudemonitor.ca/crude.php?acr=SH; Statoil Cheecham Blend (SCB) - http://www.crudemonitor.ca/crude.php?acr=SCB; Wabasca Heavy (WH) - http://www.crudemonitor.ca/crude.php?acr=WH; Western Canadian Select (WCS) - http://www.crudemonitor.ca/crude.php?acr=WCS; Albian Heavy Synthetic (AHS) (DilSynBit) - http://www.crudemonitor.ca/crude.php?acr=AHS.

[18] SCOs: CNRL Light Sweet Synthetic (CNS) -http://www.crudemonitor.ca/crude.php?acr=CNS; Husky Synthetic Blend (HSB) -http://www.crudemonitor.ca/crude.php?acr=HSB; Long Lake Light Synthetic (PSC) -http://www.crudemonitor.ca/crude.php?acr=PSC; Premium Albian Synthetic (PAS) - http://www.crudemonitor.ca/crude.php?acr=PAS; Shell Synthetic Light (SSX) - http://www.crudemonitor.ca/crude.php?acr=SSX; Suncor Synthetic A (OSA) - http://www.crudemonitor.ca/crude.php?acr=OSA; Syncrude Synthetic (SYN) - http://www.crudemonitor.ca/crude.php?acr=SYN.

around refineries where it is processed. Mercaptans can be detected at concentrations over a million times lower than will be present in emissions from the pipeline and its appurtenances.[19] In fact, mercaptans are added to natural gas in very tiny amounts so that the gas can be smelled to facilitate detecting leaks.

Thus, unloading, storing, handling and refining of bitumens mixed with diluent would emit VOCs, HAPs, and sulfur compounds, depending upon the DilBit source. There are no restrictions on the diluent source or composition nor any requirements to monitor emissions from tanks and leaking equipment where DilBit is handled. As the market has experienced shortages of diluents, any material with a suitable thinning ability could be used, which could contain currently unanticipated hazardous components.

Diluent would be present in the crude stored in crude storage tanks and would be present in component leaks from its entry into the refinery until it is recovered and marketed, or at least between the desalter and downstream units where some of it is recovered. The presence of diluent would increase the vapor pressure of the crude, substantially increasing VOC and HAPs emissions from tanks and fugitive component leaks compared to those from displaced heavy crudes not blended with diluent. The diluent byproduct removed during refining also will be stored in tanks for blending into gasoline or other products. These tanks also will emit VOCs and HAPs. The affected sources would include new tanks, existing tanks, new fugitive components, and existing fugitive components that would handle the diluent product, as well diluent-affected byproducts.

The FEIS and DSEIS made no attempt to estimate these emissions. The emissions from the Motiva and Hyperion projects, relied on to estimate a range of VOC emissions from the Project, do not include the contribution of VOCs from diluent as they are based on conventional fugitive and tank emission factors, developed for other materials.[20] In fact, these conventional emission factors have been demonstrated to underestimate emissions from even the conventional sources they purport to represent by significant amounts in PADD 3 refineries most likely to accept the imported WCSB tar sands crudes.

The increase in VOC and HAP emissions from handling diluent would not be discovered by monitoring or addressed by permitting, as these emissions are typically calculated using standard emission factors that do not consider the presence of diluent. Measurements are not made to confirm fugitive emissions. In the areas with the highest concentration of refineries likely to process these WCSB tar sands crudes, studies have demonstrated that existing methods of estimating emissions from the types of sources that

[19] American Industrial Hygiene Association, Odor Thresholds for Chemicals with Established Occupational Health Standards, 1989; American Petroleum Institute, Manual on Disposal of Refinery Wastes, Volume on Atmospheric Emissions, Chapter 16 - Odors, May 1976, Table 16-1.

[20] See, e.g., EPA, Protocol for Equipment Leak Emission Estimates, November 1995. This report is the basis for the emission factors used to estimate VOC emissions from fugitive components in refineries. It does not consider the increase in emissions due to elevated vapor pressure of diluent blended materials as they were unknown at the time of this work. These factors, or derivatives thereof, are used throughout PADD 3. They have not been updated since this report was published.

would emit diluent grossly underestimate emissions. And these underestimates occur in areas where the air quality already exceeds acceptable levels. Thus, any increases in VOC and HAP emissions from handling diluent-blended materials by the Project, which would not be detected by any existing regulatory program, must be prevented.

It is well known based on measurement studies that VOC emissions from equipment leaks of conventional petroleum products are underestimated by factors of 3 to 20.[21] The U.K.'s National Physical Laboratory (equivalent to the U.S. National Institute of Standards and Technology) has compared direct measurements of fugitive VOCs with those estimated by emission factors for over a decade and found the direct measurements were about three times higher on a plant-wide basis than calculated using emission factors relied on in the Project.[22] In support, U.S. EPA auditors have found far more leaks than reported by the facility's program, indicating higher routine emissions than belied by the data.[23]

Recent studies confirm the approach used to estimate fugitive VOC emissions from the Motiva and Hyperion projects relied on in the DSEIS to estimate emissions (and others not cited) result in significant underestimates in VOC emissions. Monitoring and modeling studies in Texas, where most of the imported tar sands crudes will be refined, have demonstrated "severe inconsistencies" between reported and measured emissions. One study concluded: "We believe that our results show that the inventory of industrial VOC emissions [prepared using TCEQ calculation methods such as those used in the Motiva and Hyperion applications] is inaccurate in its location, composition, and emission rates of major sources… Most of the emissions are so-called fugitive emissions from leaking valves, pipes, or connectors, of which there are tens of thousands in a large facility."[24]

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[21] Allan K. Chambers, et al., Direct Measurement of Fugitive Hydrocarbons from a Refinery, *J. Air & Waste Mgmt. Ass'n*, 58:1047-1056 (2008), at 1054 and Table 7; Clearstone Engineering Ltd., September 6, 2006; M. Kihlman, et al., *Monitoring of VOC Emissions from Refineries in Sweden Using the SOF Method*, http://www.fluxsense.se/reports/paper%202%20final%20lic.pdf; IMPEL, Diffuse VOC Emissions, December 2000, at p. 38; U.S. Environmental Protection Agency, Office of Inspector General, EPA Can Improve Emissions Factors Development and Management, Evaluation Report, Report No. 2006-P-00017 (March 22, 2006), pp. 11-12 (summarizing the Texas 2000 Air Quality Study… "This primarily involved under reporting of emissions from flares, process vents, and cooling towers, as well as from fugitive emissions (leaks). The under-reporting was caused largely due to the use of poor quality emissions factors."); U.S. Environmental Protection Agency, VOC Fugitive Losses: New Monitors, Emissions Losses, and Potential Policy Gaps, 2006 International Workshop (October 25-27, 2006), ("VOC Fugitive Losses") p. vii and p. 1 ("emissions from refinery and natural gas operations may be 10 to 20 times greater than the amount estimated using standard emission factors."); *Id*., p. 3 ("Typically, measurements did show some 10 to 20 times higher emissions than calculated at initial measurement activities…Today, after long term experience with the measurements and also after successful improvements of plant operations regarding emissions, emission levels of some 3 to 10 times higher than what is theoretically calculated are typically seen.")

[22] VOC Fugitive Losses at. 23. *See* also results of Swedish studies in this same report at p. 213.

[23] *See* U.S. EPA's recent refinery settlements at http://www.epa.gov/compliance/resources/cases/civil/caa/oil/index.html.

[24] Ronald C. Henry and others, Reported Emissions of Organic Gases are not Consistent with Observation, Proc. Natl. Acad. Sci., v. 94, June 1997, pp. 6596-6599; available at: http://www.pnas.org/content/94/13/6596.full.pdf.

This conclusion has been confirmed in numerous studies in the past decade, *viz*., "The analysis presented here for 2000, 2002, and 2006 measurements in the Houston-Galveston-Brazoria area indicates that emission inventory inaccuracies persist."[25] "We conclude that consistently large discrepancies between measurement-derived and tabulated (alkene/NO_x) ratios are due to consistently and substantially underestimated VOC emissions from the petrochemical facilities."[26] "The results… show that the emissions of ethene and propene, obtained by SOF [solar occultation flux], are on average an order of magnitude larger than what is reported in the 2006 daily EI [Emission Inventory]."[27]

A 2006 study reported: "… we do not find good agreement between the measured plume composition and the VOC speciation in the emissions inventory. These observations are not surprising, as previous research has shown that emission fluxes of individual VOCs may be underestimated by as much as 1-2 orders of magnitude in inventories for the Houston area… The frequent lack of correlation between large VOC enhancements and enhancements in SO_x, NO_x and CO suggests large, non-combustion sources of VOCs" [28] [*e.g.*, fugitive equipment leaks]. One study, for example, reported that measurements of ethene from petrochemical facilities were one to two orders of magnitude higher than reported in the emission inventory.[29] Monitoring data collected during the 2006 Texas Air Quality Study demonstrated that "[i]ndustrial ethylene and propylene emissions in the NEI05-REF are greatly underestimated relative to the estimates using SOF measurements in the Houston Ship Channel during the study period."[30]

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[25] R.A. Washenfelder and others, Characterization of NO_x, SO_2, Ethene, and Propene from Industrial Emission Sources in Houston, Texas, J. Geophys. Res., v. 115, D16311, 2010; J.A. de Gouw and others, Airborne Measurements of Ethene from Industrial Sources using Laser Photo-Acoustic Spectroscopy, Environ. Sci. Technol., v. 43, no. 7, 2009, pp. 2437-2442; B.T. Jobson and others, Hydrocarbon Source Signatures in Houston, Texas: Influence of the Petrochemical Industry, J. Geophys. Res., v. 109, 2004; T. Karl and others, Use of Proton-transfer-reaction Mass Spectrometry to Characterize Volatile Organic Compound Sources at the La Porte Super Site during the Texas Air Quality Study 2000, J. Geophys. Res., v. 108(D16), 2003; L.I. Kleinman and others, Ozone Production Rate and Hydrocarbon Reactivity in 5 Urban Areas: A Cause of High Ozone Concentration in Houston, Geophys. Res. Lett., v. 29, no. 10, 2002; J. Mellqvist and others, Measurements of Industrial Emissions of Alkenes in Texas using the Solar Occultation Flux Method, J. Geophys. Res., v. 115, 2010; T.B. Ryerson and others, Effect of Petrochemical Industrial Emissions of Reactive Alkenes and NO_x on Tropospheric Ozone Formation in Houston, Texas, J. Geophys. Res., v. 108(D8), 2003; B.P. Wert, Signatures of Terminal Alkene Oxidation in Airborne Formaldehyde Measurements during TexAQS 2000, J. Geophys. Res., v. 108(D3), 2003.

[26] T.B. Ryerson and others.

[27] J. Mellqvist and others.

[28] Daniel Bon and others, Evaluation of the Industrial Point Source Emission Inventory for the Houston Ship Channel Area Using Ship-Based, High Time Resolution Measurements of Volatile Organic Compounds, CIRES; available at: http://cires.colorado.edu/events/rendezvous/posters/detail.php?id=3866.

[29] E.B. Cowling and others, A Report to the Texas Commission on Environmental Quality by the TexAQSII Rapid Science Synthesis Team, Prepared by the Southern oxidants Study Office of the Director at North Carolina State University, August 31, 2007, available at: http://aqrp.ceer.utexas.edu/docs/RSSTFinalReportAug31.pdf.

[30] S.-W. Kim and others, Evaluations of NO_x and Highly Reactive VOC Emission Inventories in Texas and the Implications for Ozone Plume Simulations during the Texas Air Quality Study 2006, Atmos. Chem.

These and other studies have consistently shown based on actual monitoring that emissions estimated using TCEQ fugitive equipment leak emission factors have underestimated VOC emissions by significant amounts. The ability of current permitting procedures to mitigate air quality impacts from WCSB tar sands crudes is limited by the use of these long discredited emission factors.

The DSEIS should be revised to describe the handling of diluent-blended materials and any separated diluent. HAP and VOC emissions from these sources—tanks and fugitive equipment leaks—should be estimated using accurate emission factors that account for the type and amount of diluent that will be presented in WCSB tar sands crudes.

This is very important because VOCs are converted into ozone in the atmosphere and thus are ozone precursors. The VOC emissions from diluent are particularly important as they can cause or contribute to violations of ozone NAAQS. Most of the refineries that would be directly connected to the proposed pipeline are located within or near ozone nonattainment zones. An ozone nonattainment zone is an area where the ambient air quality currently exceeds NAAQS and thus is unhealthy to breath.

Exhibit B shows that eight out of the 15 refineries with direct pipeline access to the proposed Project (DSEIS, Table 4.15-18), responsible for refining 2.7 million barrels of crude or 60% of the refinery capacity with direct access to the Project, are located in **severe** nonattainment zones for the 1997 8-hour ozone standard and marginal nonattainment zones for the 2008 8-hour ozone standard. Two other refineries in Louisiana are also in marginal nonattainment zones for the 2008 8-hour ozone NAAQS. This means VOC emissions from handling DilBit crudes will cause or contribute to existing violations of ozone NAAQS, which is a per se significant air quality impact not disclosed in the DSEIS. The DSEIS did not even disclose that some of the refineries that would process the imported crudes would be located in or near ozone nonattainment zones. The DSEIS should be revised to include ozone modeling for all refineries in PADD 3 that will receive diluent-blended WCSB tar sands crudes.

Thus, in sum, the Project will increase the emission of VOC from the transport, handling, and processing of bitumens blended with high vapor pressure diluents. These increases will not be mitigated during the routine process of permitting or post-construction monitoring because the emission estimation procedure does not include the contribution of diluent, the emission factor approach used to estimate the emissions is known to grossly underestimate them, and post-construction monitoring will not be used, so VOC increases will never be detected and controlled.

Phys. Discuss, v. 11, 2011, pp. 21,201 - 21,265, available at: http://www.atmos-chem-phys-discuss.net/11/21201/2011/acpd-11-21201-2011.pdf.

b. Other Components of WCSB Tar Sands Crudes Would Increase Emissions Compared To Conventional Heavy Crudes

The composition of WCSB tar sands crudes are chemically different from other heavy crudes currently processed in PADD 3 refineries. They are unique for two major reasons: (1) presence of large quantities of volatile diluent full of VOCs and toxic chemicals and (2) unique chemical composition of the heavy ends or residuum. The previous section discussed diluent. The composition of the heavy ends, which have higher molecular weight chemicals and are deficient in hydrogen, means more energy will be required to convert them into the same slate of refined products. Thus, most fired sources in the refinery—flares, heaters, boilers, etc.—will have to work harder to generate the same quality of refined products. This section discusses the heavy ends and their impact on refining emissions.

The DSEIS makes a number of critical assumptions that determine the outcome of the analysis. If these assumptions are not required as conditions of Project approval, and they are not, the applicant will have the discretion to implement the Project unfettered. First, the air quality impacts assume that "oil that would be transported by the proposed Project (830,000 BPD) would replace historic crude oil supplies or supplant supplies from less stable or more costly sources." DSEIS, p. 4.15-77.

Many other options are possible, including: (1) increased refining capacity up to 830,000 BPD, of which 100% would be WCSB crude, either 100% DilBit or 100% SCO or some combination thereof is possible; (2) replacing current light oil blend stocks with WCSB tar sands crude without increasing total refining capacity. The Motiva upgrade relied on in the DSEIS to estimate emissions is actually a brand new 315,000 BPD refinery, capable to processing 38% of the WCSB crude input from the Project, without blending it with any other feedstock to meet a current crude slate. The composition of the oil was not even addressed in the Motiva Application.

Further, the DSEIS argues the crude slate would remain the same, based solely on API gravity and average sulfur content, two lumper parameters with little relevance for refinery emissions. DSEIS, p. 4.15-75. However, this ignores the fact that the factors that affect emissions are much more complex than belied by these lumper parameters. As noted previously, sulfur is not sulfur. Nor does API gravity tell you anything about emissions or corrosion that may lead to accidental releases. Many different chemicals can add up to the same API crude gravity, resulting in major differences in processing requirements and thus emissions.

The DSEIS argues that the physical and chemical properties of the crude oils that would be transported by the proposed pipeline would not be unique to the proposed Project. It goes on to state that: "A comparison of the crude oil that would be transported by the proposed pipeline with other conventional crude oils indicates that the characteristics of the proposed Project's crude oil are generally comparable to those of conventional crude oils..." DSEIS, p. 3.13-1. It then presents tables summarizing chemical characterization data for various crudes. DSEIS, Tables 3.13-1, 3.13-2.

However, the summarized data is mostly gross physical and chemical characterization data. It does not include the type of information required to determine the impact of these crudes on air emissions from crude transport, storage, and refining.

The chemical composition of the WCSB tar sands crude is different in important ways from current refinery slates[31] and will increase emissions far beyond those disclosed in the DSEIS. The U.S. Geological Survey ("USGS"), for example, reported that "natural bitumen," the source of all Canadian tar sands-derived oils, contains 102 times more copper, 21 times more vanadium, 11 times more sulfur, six times more nitrogen, 11 times more nickel, and 5 times more lead than conventional heavy crude oil.[32]

The environmental damage caused by these pollutants includes acid rain; bioaccumulation of toxic chemicals up the food chain; the formation of ground-level ozone and smog; visibility impairment in Class I areas, such as National Parks; odor impacts that affect residents along both the pipeline and downstream processing facilities; and depletion of soil nutrients.

Refining converts crude oils into transportation fuels. This is done by removing contaminants (sulfur, nitrogen, metals) and breaking down and reassembling chemicals present in the crude oil charge by adding hydrogen, removing carbon as coke, and applying heat, pressure, and steam in the presence of various catalysts. More intensive refining is required to convert WCSB tar sands crudes into useful products than other heavy crudes. This means a greater amount of energy must be expended to yield the same product slate. Thus, all of the combustion sources in a refinery, such as heaters and boilers, must work harder and thus emit more pollutants, than when refining conventional crudes. The DSEIS fails to adequately analyze the impact of crude composition on emissions.

Most refineries in PADD 3, even those that currently process heavy crudes, will have to be upgraded to handle WCSB tar sands crudes. The very fact that these refineries must be upgraded to handle these crudes is prima facie evidence that the WCSB tar sands crudes are unique and distinguishable from the heavy crude slates currently refined.

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[31] Brian Hitchon and R.H. Filby, Geochemical Studies - 1 Trace Elements in Alberta Crude Oils, http://www.ags.gov.ab.ca/publications/OFR/PDF/OFR_1983_02.PDF;
F.S. Jacobs and R.H. Filby, Trace Element Composition of Athabasca Tar Sands and Extracted Bitumens, Atomic and Nuclear Methods in Fossil Energy Research, 1982, pp 49-59; James G. Speight, The Desulfurization of Heavy Oils and Residua, Marcel Dekker, Inc., 1981, Tables 1-1, 2-2, 2-3, 2-4 and p. 13 and James G. Speight, Synthetic Fuels Handbook: Properties, Process, and Performance, McGraw-Hill, 2008, Tables A.2, A.3, and A.4; Pat Swafford, Evaluating Canadian Crudes in US Gulf Coast Refineries, Crude Oil Quality Association Meeting, February 11, 2010, Available at: http://www.coqa-inc.org/20100211_Swafford_Crude_Evaluations.pdf.

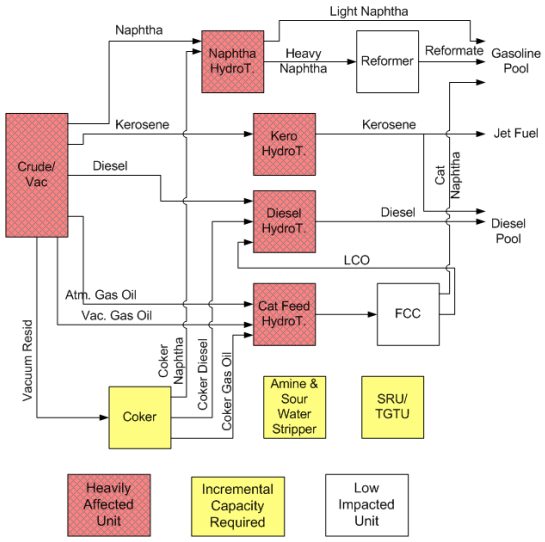
[32] R.F. Meyer, E.D. Attanasi, and P.A. Freeman, Heavy Oil and Natural Bitumen Resources in Geological Basins of the World, U.S. Geological Survey Open-File Report 2007-1084, 2007, p. 14, Table 1, Available at http://pubs.usgs.gov/of/2007/1084/OF2007-1084v1.pdf.

Some PADD 3 refineries have already been upgraded in anticipation of Keystone XL (FEIS, p. 3.14-30),[33] but most still require upgrades. The upgrades will increase emissions of criteria and HAP pollutants. Many of the required modifications will not be subject to permit restrictions, such as increased flaring, increased firing rates and throughputs that fall within Flex permit caps, debottlenecked emission units that escape identification, and accidental releases due to corrosion that results in equipment failures.

Further, while some individual changes may not by themselves be large enough to trigger any regulatory reviews, the cumulative air quality impacts from many facilities increasing emissions simultaneously will not be considered by any existing regulatory framework except the NEPA review process. Thus, it is very important to identify and quantify the potential increase in emission of all pollutants, not just GHG. Finally, most of the modified facilities are within or near severe ozone nonattainment areas where any increase in NO_x or VOC emissions is per se significant.

The red units in Figure 3 are the refining processes most likely to require major upgrades and/or new units, the yellow units are those that are fairly likely to require upgrades, and others will require minor changes. However, emissions from every unit in a refinery will be impacted in some way.

Figure 3: Simplified Refinery Flow Diagram Showing Units Most Impacted by Switching to WCSB Tar Sands Crudes



[33] See also: Motiva (DEIS, p. 4.15-76); Total Refinery, Port Arthur, See: http://www.hydrocarbonprocessing.com/Article/2819752/Total-completes-deep-conversion-at-Port-Arthur-refinery-new-units-on-stream.html); Valero Refinery in Port Arthur (listed in some places as Premcor Refining Group, which was acquired by Valero in 2005), recently expanded its coker by 10,000 BPD and its crude and vacuum units. See: http://www.valero.com/ourbusiness/ourlocations/refineries/pages/portarthur.aspx) and http://www.reuters.com/article/2012/07/31/refinery-operations-valero-idUSL2E8IV3LA20120731.

Canadian tar sands bitumen, the predominant source of WCSB crude, is distinguished from conventional petroleum by the small concentration of low molecular weight hydrocarbons and the abundance of high molecular weight polymeric material.[34] Crudes derived from Canadian tar sands bitumen—DilBits, SCOs and SynBits—are heavier, i.e., have larger, more complex molecules such as asphaltenes,[35] some with molecular weights above 15,000.[36] They generally have higher amounts of coke-forming precursors; larger amounts of contaminants (sulfur, nitrogen nickel, vanadium) and are deficient in hydrogen, compared to other heavy crudes. Thus, to convert them into the same refined products requires more energy, electricity, water, and hydrogen. This requires that more fuel be burned in most every fired source at the refinery and that more water be circulated in heat exchangers and cooling towers. Further, this requires more fuel to be burned in any supporting off-site facilities, such as power plants that may supply electricity or Steam-Methane Reforming Plants that may supply hydrogen. These increases in fuel consumption release increased amounts of NO_x, SO_x, VOCs, CO, PM10, PM2.5, and HAPs as well as greenhouse gas emissions. Some of the required refinery changes and their emission consequences are discussed below.

The DSEIS contains no information to estimate the magnitude of these types of increases nor does it even acknowledge that such increases would occur. In Texas, these types of increases would be glossed over in the Flex permitting system as they would occur within existing inflated plant-wide emission caps. Further, conventional refinery permitting does not consider the effect of crude composition on emissions. Air permits do not restrict refineries to a specific crude or crude composition. Thus, significant increases in emissions can occur that would not be subject to any controls and that would not be detected in areas with severely degraded air quality.

i. Crude Unit

The first step in the refining process is to separate the crude oil into fractions based on boiling point by distillation. This occurs in the crude unit where the crude is first heated in a furnace and charged to an atmospheric distillation tower, where it is separated into products: naphtha, kerosene, diesel, and residuum. The tower bottoms or residuum, which occurs in greater amounts in the WCSB tar sands crudes that would be transported by the Project than other heavy crudes, is sent to another furnace for more heating and charged to a vacuum tower to separate out heavier material into gas oil, lubricating oils, and vacuum residuum. The higher the density of the crude, the more heat required to prepare the crude for distillation. More heat means burning more fuel, which releases more NO_x, SO_x, CO, VOCs, PM10, and PM2.5.

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[34] O.P. Strausz, The Chemistry of the Alberta Oil Sand Bitumen, Available at: http://web.anl.gov/PCS/acsfuel/preprint%20archive/Files/22_3_MONTREAL_06-77_0171.pdf.

[35] Asphaltenes are nonvolatile fractions of petroleum that contain the highest proportions of heteroatoms, i.e., sulfur, nitrogen, oxygen. The asphaltene fraction is that portion of material that is precipitated when a large excess of a low-boiling liquid hydrocarbon such as pentane is added. They are dark brown to black amorphous solids that do not melt prior to decomposition and are soluble in benzene and aromatic naphthas.

[36] O.P. Strausz, The Chemistry of the Alberta Oil Sand Bitumen, Available at: http://web.anl.gov/PCS/acsfuel/preprint%20archive/Files/22_3_MONTREAL_06-77_0171.pdf.

ii. Hydrotreating

The various crude fractions from the crude distillation unit and coker (naphtha, diesel, gas oil) must be cleaned up to meet product specifications and to remove catalyst poisons prior to further processing. The key substances removed by hydrotreating are sulfur, nitrogen, oxygen, halides, and trace metals. These impurities are removed by reacting hydrogen with the crude fractions over a fixed catalyst bed at elevated temperature. The oil feed is mixed with substantial quantities of hydrogen either before or after it is preheated, generally to 500 F to 800 F. Hydrogen consumption is typically about 70 scf/bbl of feed per percent sulfur, about 320 scf/bbl feed per percent nitrogen, and 180 scf/bbl per percent oxygen removed.[37] Hydrogen demand for various hydroprocessing options for Western Canadian Select (WCS), a DilBit, range from 1,000 to 1,900 scf/bbl.[38] Emissions arise from heating the feed and generating increased amounts of hydrogen, compared to conventional heavy crudes and existing PADD 3 crude slates. More emissions are generated by hydrotreating WCSB tar sands crudes than conventional heavy crudes for several reasons as discussed below.

1. Higher Concentrations of Catalyst Contaminants

Tar sands bitumen contains about 1.5 times more sulfur, nitrogen, oxygen, nickel and vanadium than typical heavy crudes.[39] Thus, much more hydrogen per barrel of feed and higher temperatures would be required to remove the larger amounts of these poisons. Nitrogen content was not included in the DSEIS, Table 3.13-2. Canadian tar sands crudes generally have higher nitrogen content, 3,000 to >6,000 ppm[40] and specifically higher organic nitrogen content, particularly in the naphtha range, than other heavy crudes.[41] This nitrogen is mostly bound up in complex aromatic compounds that require a lot of hydrogen to remove. This affects emissions in five ways.

First, additional hydrotreating is required to remove them, which increases hydrogen and energy input. Second, they deactivate the cracking catalysts, which requires more energy and hence more emissions to achieve the same end result. Third, they increase the nitrogen content of the fuel gas fired in combustion sources, which increases NO_x emissions from all fired sources that use refinery fuel gas. Fourth, nitrogen in WCSB tar sands crudes is present in higher molecular weight compounds than in other heavy crudes and thus requires more hydrogen and energy to remove. Fifth, some of this nitrogen will be converted to ammonia and other chemically bound nitrogen compounds, such as pyridines and pyrroles. These become part of the fuel gas and could increase NO_x from fired sources. They further may be routed to the flares, where they would increase NO_x.

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[37] James H. Gary, Glenn E. Handwerk, and Mark J. Kaiser, Petroleum Refining: Technology and Economics, 5th Ed., CRC Press, 2007, p. 200.
[38] Brierley et al. 2006, Table 6.
[39] See, for example, USGS, 2007, Table 1.
[40] Murray R. Gray, Tutorial on Upgrading of Oilsands Bitumen, University of Alberta, Available at: http://www.ualberta.ca/~gray/Links%20&%20Docs/Web%20Upgrading%20Tutorial.pdf.
[41] See, e.g., James G. Speight, Synthetic Fuels Handbook: Properties, Process, and Performance, McGraw-Hill, 2008, Appendix A;

2. Higher Concentrations of Asphaltenes and Resins

The severity (e.g., temperature, amount of catalyst, hydrogen) of hydrotreating depends on the type of compound the contaminant is bound up in. Lower molecular weight compounds are easier to remove. The difficulty of removal increases in this order: paraffins, naphthenes, and aromatics.[42] Most of the contaminants of concern in WCSB tar sands crudes are bound up in high molecular weight aromatic compounds such as asphaltenes that are difficult to remove, meaning more heat, hydrogen, and catalyst are required. Some tar sands-derived vacuum gas oils (VGOs), for example, contain no paraffins of any kind. All of the molecules are aromatics, naphthenes, or sulfur species that require large amounts of hydrogen to hydrotreat, compared to other heavy crudes.[43]

Asphaltenes and resins generally occur in WCSB bitumens and their crudes in much higher amounts than in other heavy crudes. They are the nonvolatile fractions of petroleum and contain the highest proportions of sulfur, nitrogen, and oxygen.[44] They have a marked effect on refining and result in the deposition of high amounts of coke during thermal processing in the coker. They also form layers of coke in hydrotreating reactors, requiring increased heat input, leading to localized or even general overheating and thus even more coke deposition. This seriously affects catalyst activity resulting in a marked decrease in the rate of desulfurization. They also require more intense processing in the coker required to break them down into lighter products. These factors require increases in steam and heat input, both of which generate combustion emissions, NO_x, SO_x, CO, VOCs, PM10, and PM2.5.

Further, if the crude includes a synthetic crude, SCO, for example, the material has been previously hydrotreated. Thus, the remaining contaminants (e.g., sulfur, nitrogen), while present in small amounts, are much more difficult to remove (due to their chemical form, buried in complex aromatics), requiring higher temperatures, more catalyst, and more hydrogen.[45]

The higher amounts of asphaltenes and resins generate more heavy feedstocks that require more severe processing than lighter feedstocks. The coker, for example, makes more coker distillate and gas oil that must be hydrotreated, compared to conventional heavy crudes. Similarly, the Crude Unit makes more atmospheric and vacuum gas oils that must be hydrotreated.[46] This increases emissions from these units,

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[42] Gary et al., 2007, p. 200.

[43] See, for example, the discussion of hydrotreating and hydrocracking of Athabasca tar sands cuts in Brierley et al. 2006, pp. 11-17.

[44] James G. Speight, The Desulfurization of Heavy Oils and Residua, Marcel Dekker, Inc., 1981, Tables 1-1, 2-2, 2-3, 2-4 and p. 13 and James G. Speight, Synthetic Fuels Handbook: Properties, Process, and Performance, McGraw-Hill, 2008, Tables A.2, A.3, and A.4.

[45] See, for example, Brierley et al. 2006, p. 8 ("The sulfur and nitrogen species left in the kerosene and diesel cuts are the most refractory, difficult-to-treat species that could not be removed in the upgrader's relatively high-pressure hydrotreaters."); Turini et al. 2011 p. 4.

[46] See, for example, Turini et al. 2011, p. 9.

including fugitive VOC emissions from equipment leaks and combustion emissions from burning more fuel.

3. Hydrogen Deficient

WCSB tar sands crudes are hydrogen deficient compared to heavy and conventional crude oils and thus require substantial hydrogen addition during refining, beyond that required to remove contaminants (sulfur, nitrogen, metals). This again means more combustion emissions from burning more fuel.

iii. Hydrogen Production

The WCSB tar sands crudes transported by the Project will require substantial increases in hydrogen production to make up for the deficiency of hydrogen in the tar sands bitumen and to remove contaminants. This will likely require new hydrogen plants or increases in the capacity or throughput of existing hydrogen plants. Emissions from this source were not disclosed in the DSEIS.

Hydrogen is typically manufactured by the steam-methane reforming process in the refining industry. In this process, the feedstock is first desulfurized, mixed with steam, and passed over a catalyst at elevated temperature (1350-1550 F) and pressure (400 psi). Effluent gases are cooled using steam or condensate to about 700 F, at which point carbon monoxide reacts with steam in the presence of iron oxide in a shift converter to produce carbon dioxide and hydrogen. The carbon dioxide is removed by amine washing.

The primary emission sources are a steam methane reforming furnace, dearerator vents, a dedicated flare, a cooling tower, and equipment leaks from pumps, valves, and flanges. The DSEIS should estimate the increase in hydrogen production capacity required to refine up to 830,000 BPD of WCSB crudes and the corresponding increase in emissions from producing this hydrogen.

iv. Coking

The heavy residuum from the Crude Unit is most commonly further processed in a delayed coker at PADD 3 refineries. A coker converts heavy residuals into lighter products that are further treated in other units. A coker converts large hydrocarbon molecules into smaller, more useful molecules using thermal cracking. Carbon is removed as coke in order to produce other smaller, more valuable liquid hydrocarbons by rearranging the chemical bonds of the original molecules.

As WCSB tar sands crudes have significantly higher amounts of vacuum resid, the coker is typically one of the units that must be significantly upgraded. Cokers can be debottlenecked by improving drum cycle time, but most refineries will have to add additional coking capacity to handle the significant increase in heavy resid from refining of WCSB tar sands crudes. This means significant increases in emissions.

The coker feed is heated and charged into a drum where it is thermally cracked under high temperature and pressure (coking). Large hydrocarbon molecules are broken into smaller ones, which rise to the top of the drum, leave as vapors, and are separated in a fractionator column. The material left behind drops out and solidifies, eventually filling the drum with solid coke. After the drum fills with coke, it is switched off-line, steamed out to remove remaining hydrocarbons, and cooled with water. During these steps, the vapors exiting the drum are captured by a closed blowdown system and recovered in the coker fractionator. After steamout, the drum is depressurized by venting to atmosphere through a steam vent before the bottom and top heads are opened. The coke is cut from the drum by drilling with high-pressure water. The drilled coke drops into a pit or pad beneath the coke drum. Following decoking, coke is conveyed from the coker to various storage piles.[47]

Petroleum coke, or "pet coke" is formed as a solid byproduct of the coker. It is mostly carbon with low hydrogen content and high sulfur content. In general, more coke will be produced from the WCSB bitumen blends than from conventional heavy crudes due to the nature of the residuum. The amount of coke depends on the API gravity of the residuum sent to the coker. The API gravity of the residuum from refining DilBits ranges from 6 to 8, or much lower than any other material currently refined in PADD 3. DSEIS, Table 3.13-2. Thus, DilBit residuum will yield large amounts of petroleum coke. If delayed coking, for example, is used for further refining, which is the most common process at PADD 3 refineries, an API 6 residuum would contain 20% carbon by weight and yield 36% coke, or substantially more than most heavy crudes.[48] This coke may be stockpiled and contribute wind-blown fugitive dust or be burned elsewhere as a fuel source, creating additional combustion emissions.

There are five primary sources of air emissions from this process: (1) coker heaters; (2) steam vent; (3) fugitive VOC and H_2S emissions from equipment leaks (e.g., valves, connectors, seals); (4) fugitive dust from coke handling; and (5) combustion emissions if the coke is used as fuel. In addition, significant additional amounts of highly contaminated wastewaters will be generated.

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[47] Oil & Gas Journal, Modern Refinery: Delayed Coking, https://portal.mustangeng.com/pls/portal30/docs/FOLDER/MUSTANGENG/INDUSTRY_POSTERS_CONTENT/DELAYEDCOKINGPOSTERFINAL_SM.PDF. See also: John D. Elliott, Delayed Coker Revamps: Realization of Objectives, http://www.fwc.com/industries/pdf/DELAYED2004.pdf; Paul J. Ellis, Tutorial: Delayed Coking Fundamentals, AIChE 1998 Spring National Meeting, March 8-12, 1998, http://www.cia-inspection.com/DECOKTUT.PDF; Robert A. Meyers, Handbook of Petroleum Refining Processes, 2nd Ed., McGraw Hill, 1996, Chapter 12.2, FW Delayed-Coking Process, Fig. 12.2.9; Robert A. Meyers, Handbook of Petroleum Refining Processes, 3rd Ed., McGraw Hill, 2004, Chapter 12.2, FW Delayed-Coking Process, Fig. 12.2.9; James H. Gary, Glenn E. Handiwerk, and Mark J. Kaiser, Petroleum Refining Technology and Economics, 5th Ed., CRC Press, 2007, Chapter 5; Norman P. Lieberman, Troubleshooting Process Operations, 3rd Ed., PennWell Books, 1991, Chapters 2 and 3; Surinder Parkash, Refining Processes Handbook, Elsevier, 2003.

[48] James G. Speight, Upgrading and Refining of Natural Bitumen and Heavy Oil, In: Coal, Oil, Natural BItumen, Heavy Oil and Peat, Vol. II - Upgrading and Refining of Natural BItumen and Heavy Oil, 2009, p. 253.

Trace metals concentrate in heavy ends and coke is the end of the line. Coke contains very high concentrations of toxic trace metals, including arsenic, beryllium, cadmium, chromium, lead, manganese, mercury, nickel, selenium, and vanadium, among others,[49] which would be emitted from coke storage piles and coke combustion sources.

The high emissions that occur during these activities are so well known that the U.S. Chemical Emergency Preparedness and Prevention Office and the U.S. Occupational Safety & Health Administration ("OSHA") jointly issued a bulletin warning of their hazards in 2003. They report "coke cutting presents serious hazards to workers due to fugitive mists and vapors from cutting and the quench water. Hazardous gases associated with coking operations, such as hydrogen sulfide, carbon monoxide, and trace amounts of polynuclear aromatics, can be emitted from the coke through an opened drum or during processing operations."[50]

The DSEIS did not disclose the significant increase in coker capacity that would be required, the increase in resulting air emissions and wastewater, the increase in coke byproduct, and the potentially significant public health and worker health impacts.

v. Combustion Sources

Refining the WCSB tar sands crudes will require increased firing of virtually every combustion source within the refinery because more heat, steam, and electricity will be required to process the heavier, dirtier crude. The most common combustion sources found in refineries are heaters, boilers, turbines, and flares. Refineries typically have many heaters; big refineries may have over a hundred as they supply process heat to nearly every refining process. There are generally fewer boilers, which generate steam for many refining processes.

The combined emissions from heaters and boilers, especially for NO_x and CO, can be quite large if not adequately controlled. The emissions from heaters and boilers are typically the major source of emissions from many refining processes that are not otherwise separately discussed in this report, e.g., hydrocrackers, reformers, alkylation units. It is reasonable to expect the fired duty of every heater and boiler of every refinery that accepts WCSB tar sands crudes to increase, thus increasing emissions of NO_x, SO_x, CO, VOCs, PM10, and PM2.5.

vi. Wastewater Processing

Wastewaters originate from many sources at a refinery, including crude and product storage tanks, the desalter, coker, hydrotreaters, and hydrocrackers, among others. Condensed steam from coke drum purging and water from hydraulic decoking of coke drums is collected and treated. The hydrotreated naphtha, diesel and other products

[49] Las Brisas Energy Center, LLC, Table A-7. CFB Trace Compound Data.
[50] CEPPO and OSHA, Hazards of Delayed Coker Unit (DCU) Operations, August 2003, http://www.epa.gov/oem/docs/chem/delayed_coker.pdf and OSHA, Hazards of Delayed Coker Unit (DCU) Operations, SHIB 08-29-03, http://www.epa.gov/oem/docs/chem/delayed_coker.pdf, Accessed 11/29/08.

are water washed, generating sour wastewaters. These and other wastewaters reflect the composition of the crude slate and its byproducts.

Thus, wastewaters generated from processing WCSB tar sands crudes in PADD 3 refineries will contain higher concentrations of metals, H_2S and other sulfur compounds, ammonia, and hydrocarbons than from current crude slates. The types of changes discussed here that affect air emissions also affect the quantity and composition of the wastewater. The wastewaters from refining WCSB tar sands crudes would have higher concentrations of chemical oxygen demand (COD), oil and grease, metals, suspended solids, salts, benzene, phenols, and sulphides, among others. Further, emissions from fugitive components and water storage tanks in the sour water handling system would increase.

vii. Accidental Releases

Most of the refineries in PADD 3 were built before current American Petroleum Institute (API) standards were developed to control corrosion and before piping manufacturers began producing carbon steel in compliance with current metallurgical codes. Thus, the metallurgy used throughout these refineries is likely not adequate to handle the unique chemical composition of WCSB tar sands crudes without significant upgrades. There is no assurance that these metallurgical upgrades would occur as they are very expensive and not required by any regulatory framework. Experience with changes in crude slate in California suggest required metallurgical upgrades are ignored, leading to catastrophic accidents.[51]

Both DilBit and SynBit crudes have high Total Acid Numbers (TAN), which indicates high naphthenic acid content. These acids are known to cause corrosion at high temperatures, such as occur in many refining units, e.g., in the feed to cokers. Sulfidation corrosion from elevated concentrations of sulfur compounds in some of the heavier distillation cuts is also a major concern, especially in the vacuum distillation column, coker, and hydrotreater units. The specific suite of sulfur compounds may lead to increased corrosion.

A crude slate change could result in corrosion that leads to significant accidental releases, even if the crude slate is within the current design slate basis, due to compositional differences.

This recently occurred at the Chevron Richmond Refinery in California. This refinery gradually changed crude slates, while staying within its established crude unit design basis for total weight percent sulfur of the blended feed to the crude unit. This is the scenario the DSEIS assumes will mitigate all crude slate issues. However, the sulfur

[51] U.S. Chemical Safety and Hazard Investigation Board, Interim Investigation Report, Chevron Richmond Refinery Fire, Chevron Richmond Refinery, Richmond, California, August 6, 2012, Draft for Public Release, April 15, 2013, Available at; http://www.csb.gov/chevron-refinery-fire/.

composition at Chevron Richmond significantly changed over time.[52] This change increased corrosion rates in the 4-sidecut line, which led to a catastrophic pipe failure in the #4 Crude Unit on August 6, 2012. This release sent 15,000 people from the surrounding area for medical treatment due to the release and created huge black clouds of pollution billowing across the Bay.

These types of accidents can be reasonably expected to result from incorporating WCSB tar sands crudes into PADD 3 refinery slates unless significant upgrades in metallurgy occur, as these crudes have a significant concentration of sulfur in the heavy components of the crude coupled with high TAN and high solids, which aggravate corrosion. The gas oil and vacuum resid piping, for example, may not be able to withstand naphthenic acid or sulfidation corrosion from the WCSB tar sands crudes, leading to catastrophic releases.[53] Catastrophic releases of air pollution from these types of accidents were not considered in the DSEIS.

IV. THE DSEIS UNDERESTIMATED EMISSIONS INCREASES

After explaining why the Project would not affect emissions, the DSEIS presented what it called "[a] conservative hypothetical emissions estimate" for "illustrative purposes." DSEIS, p. 4.15-77. However, it ultimately dismisses these emissions, by arguing that crude oil transported by the proposed Project would be replacing or displacing crude oil from other sources and thus would not result in incremental emission increases. DSEIS, p. 4.15-78. The DSEIS's emission estimates are a gross underestimate for the reasons set out below. They further exclude many important constituents as well as any consideration whatsoever of resulting ambient air quality impacts or the cumulative impacts of modifications to multiple facilities.

a. THE DSEIS UNDERESTIMATES REFINERY EMISSIONS

The DSEIS's emission estimate for refineries processing the WCSB tar sands crudes is based on the potential increase in emissions from two projects: (1) the recently-completed 325,000 BPD Motiva Refinery expansion in Port Arthur, Texas and (2) the proposed new 400,000 BPD Hyperion Refinery in South Dakota. This is not a reasonable basis for estimating emissions from the Project.

First, the DSEIS presents a range of Project emissions for NO_x, CO, VOC, SO_2, and PM, calculated from the Motiva and Hyperion emission estimates. DSEIS, p. 4.15-78. The DSEIS does not explain how it calculated the Project ranges. I was able to reproduce the portion of the range based on Motiva emissions by scaling up the Motiva emissions based on the ratio of Project throughput to Motiva throughput (830,000/325,000 x Motiva emissions). However, I was not able to reproduce the portion

[52] US Chemical Safety and Hazard Investigation Board, 2013, p.34 ("While Chevron stayed under its established crude unit design basis for total wt. % sulfur of the blended feed to the crude unit, the sulfur composition significantly increased over time. This increase in sulfur composition likely increased corrosion rates in the 4-sidecut line.").
[53] See, for example, Turini and others, 2011.

of the range due to Hyperion using this scaling procedure. The portion of the range based on Hyperion emissions apparently contains an error or was calculated using an undisclosed procedure that is not obvious from the context. My calculations are shown in Exhibit C. My estimates of Project emissions, based on reported Motiva and Hyperion emissions, are in the "Project" columns of Exhibit C.

Second, the emissions reported for Hyperion in the DEIS (p. 4.15-77) are based on DENR's estimate in its response to comments. These emissions are inconsistent with the estimates in the revised Hyperion Permit Application. The Application reports much higher emissions of CO (2,005 to 13,955 ton/yr v. 810 ton/yr), NO_x (776 to 1,224 ton/yr v. 687 ton/yr), and SO_2 (853 to 863 ton/yr v. 183 ton/yr).[54]

Third, without limiting emissions to these ranges, there is no assurance that they would be achieved in practice. For reasons discussed elsewhere in this report, it is highly unlikely they would ever be achieved. In fact, they would be significantly exceeded. Thus, to the extent that the EIS relies on these emissions, they should be required as conditions of Project approval.

Fourth, the DSEIS emission estimates assume the imported crude would be processed at "upgraded" refineries. DSEIS, p. 4.15-77. "Upgraded" is not defined. However, most of the refineries in PADD 3 are not "upgraded" but rather are old, outdated refineries that do not have current emission controls or updated metallurgy. The two examples used in the DSEIS to estimate the range in emission increases are not representative of the refineries in PADD 3 or the range of refinery modifications that are possible.

The FEIS assumed that upgrades to accommodate WCSB tar sands crudes would require BACT emission controls at existing poorly controlled refineries, resulting in an overall reduction in emissions relative to baseline conditions. FEIS, p. 3.14-36. This result is highly unlikely due to the widespread permitting shenanigans in the states where most of these refineries are located. Further, in Texas, any facility with a flex permit, or derivative thereof, could skip BACT entirely. See discussion elsewhere in this report.

i. The Hyperion Refinery Is Not Representative of PADD 3 Refineries

Hyperion is not in PADD 3. It is a brand new refinery that is proposed to use current BACT as of 2010. Thus, emissions from this refinery will be substantially lower than from other refineries in PADD 3 that may run WCSB tar sands crudes but are not equipped with current day BACT controls and state of the art metallurgy. Thus, Hyperion represents a lower bound, certainly not representative of the old, poorly controlled refineries with outdated metallurgy in PADD 3. Further, VOC emissions from fugitive equipment leaks were estimated using conventional emission factors that do not

[54] Revised Section 2.2.11. Delayed Cokers, February 2, 2011, Available at: http://denr.sd.gov/Hyperion/Air/200805155RevisionsToApplicationText.pdf.

consider the presence of diluent, discussed elsewhere in this report. Thus, VOC emissions are underestimated.

ii. The Motiva Port Arthur Refinery Is Not Representative of PADD 3 Refineries

This refinery expansion is not representative of others that may be reasonably expected to result from the import of WCSB tar sands crudes for five principal reasons.

First, the Motiva Refinery Crude Expansion Project (CEP) is a new stand-alone refinery with a nominal capacity of 325,000 BPD that will operate side-by-side with the existing Motiva Port Arthur Refinery. As a brand new facility, it will be equipped with BACT as of 2006.[55] Thus, emissions from this expansion will be substantially lower than from other facilities in PADD 3 that may run WCSB tar sands crudes but are not equipped with current day BACT controls and state-of-the art metallurgy. Motiva is not representative of the other old, existing refineries in PADD 3 that were built prior to 1974 and may run WCSB tar sands crudes with only minor modifications to processing units, e.g., expansion in coking capacity or modifications to FCCU. These types of modifications would not reduce emissions or address corrosion problems that may lead to catastrophic accidental releases. In Texas, they likely would not even trigger New Source Review permitting.

Second, the Motiva Refinery expansion was designed primarily to process various grades of Saudi crude and crudes that Shell produces in the Gulf of Mexico. While the Motiva CEP reportedly has the flexibility to process WCSB tar sands crudes and heavy oils from elsewhere, its primary design basis is not WCSB tar sands crudes. This refinery also has significant Saudi investment.[56] The existence and impact of Saudi ownership on the future crude slate was not disclosed in the DSEIS.

Third, the DSEIS provides no support whatsoever for its Motiva emission estimates, not even a single citation.[57] The emissions simply appear in DSEIS Table 4.15-19. The TCEQ does not publish applications on its website and will not provide copies on request to members of the public. A copy may only be obtained through a formal Open Records Act request to TCEQ's Central Records, making public review of the DSEIS's claims as to these emissions more difficult. The DSEIS has failed in its obligation to disclose and inform the public as to Motiva emissions it used to estimate Project air quality impacts.

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[55] TCEQ, Flexible Permit Renewal & Amendment and New PSD Permit Source Analysis & Technical Review, Permit no 8404/PSD-TX-1062.

[56] Clifford Krauss, Texas Refinery Is Saudi Foothold in U.S. Market, The New York Times, April 5, 2013. Available at: http://mobile.nytimes.com/2013/04/05/business/texas-refinery-is-saudi-foothold-in-us-market.xml;jsessionid=610050473427C7436B2B3EDE5341096C?f=23.

[57] The FEIS cites these same emissions to TCEQ 2009. FEIS, Table 3.14.3-7. This is "Flexible Permit Renewal & Amendment and New PSD Permit Source Analysis & Technical Review". This document is not in the record and we were unable to obtain a copy from TCEQ.

I made numerous inquiries and ultimately assembled 22 TCEQ documents related to the Motiva CEP in an effort to confirm the reported emissions and develop an understanding of the Motiva project. The emissions reported in the DSEIS for this new refinery conflict with the most current information I was able to obtain from TCEQ. The most current emissions from this project that I found are compared to the DSEIS's estimate in Table 1.

Table 1: Comparison of DSEIS and TCEQ Estimates of Emissions from Motiva CEP (tons/yr)

	DSEIS Table 4.15-19	TCEQ Technical Review
N0x	592.74	-70.0
CO	1489.53	1631.0
VOC	-116.73	-29.0
SOx	1679.73	2056.0
PM	464.37	472.0
C6H6	-0.47	
H_2SO_4	22.24	22.0
H_2S	4.33	3.0
NH_3	125.69	
Cl_2	3.77	

Fourth, I note that as this is an entirely new refinery within an existing refinery, the emissions do not represent the actual increases from the CEP itself, but rather are the results of a netting analysis in which reductions due to shutdowns of other existing units were used to offset increases from the CEP. This is why both NO_x and VOC emissions appear to decrease. These decreases are due to shutdowns, not benefits from refining heavy crudes.

Finally, the VOC emissions estimate did not consider the presence of diluent and was based on widely discredited TCEQ canned VOC emission factors that have been demonstrated to grossly underestimate fugitive emissions from leaking equipment from refineries, as discussed elsewhere in this report.

In sum, the DSEIS has failed to disclose the true impacts of refining WCSB tar sands crudes at PADD 3 refineries.

b. THE DSEIS OMITS POLLUTANTS

The DSEIS included emission estimates for only five criteria pollutants—NO_x, CO, VOCs, SO_x, and PM. The Project can reasonably be expected to increase emissions of sulfuric acid mist, hydrogen sulfide, mercaptans, ammonia, trace metals including

mercury and arsenic, and benzene, among many others. The Hyperion estimates that the DSEIS relied on additionally included emission estimates for some of these other pollutants, including 130 tons/yr of organic hazardous air pollutants. As the refineries that would be processing these crudes are surrounded by residential areas, significant public health impacts can be reasonably expected and were not analyzed in the previous Keystone XL EISs or this current DSEIS.

c. THE NO NET INCREASE ASSUMPTION IS WRONG

The air quality impacts assume that "oil that would be transported by the proposed Project (830,000 BPD) would replace historic crude oil supplies or supplant supplies from less stable or more costly sources." DSEIS, p. 4.15-77. Other options are possible, including: (1) increased refining capacity in PADD 3 up to 830,000 BPD, of which 100% would be WCSB tar sands crude and (2) replacing current light oil blend stocks with WCSB tar sands crude without increasing total refining capacity. These other options were not evaluated for air quality impacts and must be considered in an EIS, unless conditions are imposed that would specifically exclude them from occurring.

Exhibit A to Fox Report

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Qualified Environmental Professional (QEP), Institute of Professional Environmental Practice (QEP #02-010007), 2001-present

PROFESSIONAL HISTORY

Environmental Management, Principal, 1981-present
Lawrence Berkeley National Laboratory, Principal Investigator, 1977-1981
University of California, Berkeley, Program Manager, 1976-1977
Bechtel, Inc., Engineer, 1971-1976, 1964-1966

PROFESSIONAL AFFILIATIONS

American Chemical Society (1981-2010)
Phi Beta Kappa (1970-present)
Sigma Pi Sigma (1970-present)

Who's Who Environmental Registry, PH Publishing, Fort Collins, CO, 1992.
Who's Who in the World, Marquis Who's Who, Inc., Chicago, IL, 11th Ed., p. 371, 1993-present.
Who's Who of American Women, Marquis Who's Who, Inc., Chicago, IL, 13th Ed., p. 264, 1984-present.
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Guide to Specialists on Toxic Substances, World Environment Center, New York, NY, p. 80, 1980.
National Research Council Committee on Irrigation-Induced Water Quality Problems (Selenium), Subcommittee on Quality Control/Quality Assurance (1985-1990).
National Research Council Committee on Surface Mining and Reclamation, Subcommittee on Oil Shale (1978-80)

REPRESENTATIVE EXPERIENCE

Performed environmental and engineering investigations, as outlined below, for a wide range of industrial and commercial facilities including petroleum refineries and upgrades thereto; reformulated fuels projects; petroleum distribution terminals; coal export terminals; LNG terminals; shale oil plants; coal gasification & liquefaction plants; conventional and thermally enhanced oil production; underground storage tanks; pipelines; gasoline stations; landfills; railyards; hazardous waste treatment facilities; nuclear, hydroelectric, geothermal, wood, biomass, waste, tire-derived fuel, gas, oil, coke and coal-fired power plants; transmission lines; airports; hydrogen plants; petroleum coke calcining plants; coke plants; activated carbon manufacturing facilities; asphalt plants; cement plants; incinerators; flares; manufacturing facilities (e.g., semiconductors, electronic assembly, aerospace components, printed circuit boards, amusement park rides); lanthanide processing plants; ammonia plants; nitric acid plants; urea plants; food processing plants; almond hulling facilities; composting facilities; grain processing facilities; grain elevators; ethanol production facilities; soy bean oil extraction plants; biodiesel plants; paint formulation plants; wastewater treatment plants; marine terminals and ports; gas processing plants; steel mills; iron nugget production facilities; pig iron plant, based on blast furnace technology; direct reduced iron plant; acid regeneration facilities; railcar refinishing facility; battery manufacturing plants; pesticide manufacturing and repackaging facilities; pulp and paper mills; selective catalytic reduction (SCR) systems; halogen acid furnaces; contaminated property redevelopment projects (e.g., Mission Bay, Southern Pacific Railyards, Moscone Center expansion, San Diego Padres Ballpark); residential developments; commercial office parks, campuses, and shopping centers; server farms; transportation plans; and a wide range of mines including sand and gravel, hard rock, limestone, nacholite, coal, molybdenum, gold, zinc, and oil shale.

EXPERT WITNESS/LITIGATION SUPPORT

- For plaintiffs, expert witness in civil action relating to alleged violations of the Clean Air Act, Prevention of Significant Deterioration, for historic modifications (1997-2000) at the Cemex cement plant in Lyons, Colorado. Reviewed produced documents, prepared expert and rebuttal reports on PSD applicability based on NOx emission calculations for a collection of changes considered both individually and collectively. Deposed August 2011. *United States v. Cemex, Inc.*, In U.S. District Court for the District of Colorado (Civil Action No. 09-cv-00019-MSK-MEH).
- For plaintiffs, in civil action relating to alleged violations of the Clean Air Act, Prevention of Significant Deterioration, for historic modifications (1988 – 2000) at James De Young Units 3, 4, and 5. Reviewed produced documents, analyzed CEMS and EIA data, and prepared netting and BACT analyses for NOx, SO2, and PM10. Expert report February 24, 2010 and affidavit February 20, 2010. *Sierra Club v. City of Holland, et al.*, U.S. District Court, Western District of Michigan.
- For plaintiffs, in civil action alleging failure to obtain MACT permit, expert on potential to emit hydrogen chloride (HCl) from a new coal-fired boiler. Reviewed record, estimated HCl emissions, wrote expert report June 2010 and deposed August 2010. *Wildearth Guardian et al. v. Lamar Utilities Board,* Civil Action No. 09-cv-02974, U.S. District Court, District of Colorado.
- For plaintiffs, expert witness on permitting, emission calculations, and wastewater treatment for coal to gasoline plant. Reviewed produced documents. Assisted in preparation of comments on draft minor source permit. Wrote two affidavits on key issues in case. Presented direct and rebuttal testimony 10/27 - 10/28/10 on permit enforceability and failure to properly calculate potential to emit, including underestimate of flaring emissions and omission of VOC and CO emissions from wastewater treatment, cooling tower, tank roof landings, and malfunctions. *Sierra Club, Ohio Valley Environmental Coalition, Coal River Mountain Watch, West Virginia Highlands Conservancy v. John Benedict, Director, Division of Air Quality, West Virginia Department of Environmental Protection and TransGas Development System, LLC,* Appeal No. 10-01-AQB.
- For plaintiffs, expert on BACT emission limits for gas-fired combined cycle power plant. Prepared declaration in support of CBE's Opposition to the United States' Motion for Entry of Proposed Amended Consent Decree. Assisted in settlement discussions. *U.S. EPA, Plaintiff, Communities for a Better Environment, Intervenor Plaintiff, v. Pacific Gas & Electric Company, et al.*, U.S. District Court, Northern District of California, San Francisco Division, Case No. C-09-4503 SI.

- Technical expert in confidential settlement discussions with large coal-fired utility on BACT control technology and emission limits for NOx, SO2, PM, PM2.5, and CO for new natural gas fired combined cycle and simple cycle turbines with oil backup. (July 2010). Case settled.
- For plaintiffs, expert witness in remedy phase of civil action relating to alleged violations of the Clean Air Act, Prevention of Significant Deterioration, for historic modifications (1998-99) at Gallagher Units 1 and 3. Reviewed produced documents, prepared expert and rebuttal reports on historic and current-day BACT for SO2, control costs, and excess emissions of SO2. Deposed 11/18/09. *United States et al. v. Cinergy, et al.*, In U.S. District Court for the Southern District of Indiana, Indianapolis Division, Civil Action No. IP99-1693 C-M/S. Settled 12/22/09.
- For plaintiffs, expert witness on MACT, BACT for NOx, and enforceability in an administrative appeal of draft state air permit issued for four 300-MW pet-coke-fired CFBs. Reviewed produced documents and prepared prefiled testimony. Deposed 10/8/09 and 11/9/09. Testified 11/10/09. *Application of Las Brisas Energy Center, LLC for State Air Quality Permit*; before the State Office of Administrative Hearings, Texas. Permit remanded 3/29/10 as LBEC failed to meet burden of proof on a number of issues including MACT.
- For defense, expert witness in unlawful detainer case involving a gasoline station, minimart, and residential property with contamination from leaking underground storage tanks. Reviewed agency files and inspected site. Presented expert testimony on July 6, 2009, on causes of, nature and extent of subsurface contamination. *A. Singh v. S. Assaedi,* in Contra Costa County Superior Court, CA. Settled August 2009.
- For plaintiffs, expert witness on netting and enforceability for refinery being upgraded to process tar sands crude. Reviewed produced documents. Prepared expert and rebuttal reports addressing use of emission factors for baseline, omitted sources including coker, flares, tank landings and cleaning, and enforceability. Deposed. *In the Matter of Objection to the Issuance of Significant Source Modification Permit No. 089-25484-00453 to BP Products North America Inc., Whiting Business Unit, Save the Dunes Council, Inc., Sierra Club., Inc., Hoosier Environmental Council et al., Petitioners, B. P. Products North American, Respondents/Permittee,* before the Indiana Office of Environmental Adjudication.
- For plaintiffs, expert witness on BACT, MACT, and enforceability in appeal of Title V permit issued to 600 MW coal-fired power plant burning Powder River Basin coal. Prepared technical comments on draft air permit. Reviewed record on appeal, drafted BACT, MACT, and enforceability pre-filed testimony. Drafted MACT and enforceability pre-filed rebuttal testimony. Deposed March 24, 2009. Testified June 10, 2009. *In Re: Southwestern Electric Power Company*, Arkansas Pollution Control and Ecology Commission, Consolidated Docket No. 08-006-P. Recommended Decision issued December 9, 2009 upholding issued permit. Commission adopted Recommended Decision January 22, 2010.

- For plaintiffs, expert witness in remedy phase of civil action relating to alleged violations of the Clean Air Act, Prevention of Significant Deterioration, for historic modifications (1989-1992) at Wabash Units 2, 3 and 5. Reviewed produced documents, prepared expert and rebuttal report on historic and current-day BACT for NOx and SO2, control costs, and excess emissions of NOx, SO2, and mercury. Deposed 10/21/08. *United States et al. v. Cinergy, et al.*, In U.S. District Court for the Southern District of Indiana, Indianapolis Division, Civil Action No. IP99-1693 C-M/S. Testified 2/3/09. Memorandum Opinion & Order 5-29-09 requiring shutdown of Wabash River Units 2, 3, 5 by September 30, 2009, run at baseline until shutdown, and permanently surrender SO2 emission allowances.
- For plaintiffs, expert witness in liability phase of civil action relating to alleged violations of the Clean Air Act, Prevention of Significant Deterioration, for three historic modifications (1997-2001) at two portland cement plants involving three cement kilns. Reviewed produced documents, analyzed CEMS data covering subject period, prepared netting analysis for NOx, SO_2 and CO, and prepared expert and rebuttal reports. *United States v. Cemex California Cement,* In U.S. District Court for the Central District of California, Eastern Division, Case No. ED CV 07-00223-GW (JCRx), Settled 1/15/09.
- For intervenors Clean Wisconsin and Citizens Utility Board, prepared data requests, reviewed discovery and expert report. Prepared prefiled direct, rebuttal and surrebuttal testimony on cost to extend life of existing Oak Creek Units 5-8 and cost to address future regulatory requirements to determine whether to control or shutdown one or more of the units. Oral testimony 2/5/08. Application for a Certificate of Authority to Install Wet Flue Gas Desulfurization and Selective Catalytic Reduction Facilities and Associated Equipment for Control of Sulfur Dioxide and Nitrogen Oxide Emissions at Oak Creek Power Plant Units 5, 6, 7 and 8, WPSC Docket No. 6630-CE-299.
- For plaintiffs, expert witness on alternatives analysis and BACT for NOx, SO2, total PM10, and sulfuric acid mist in appeal of PSD permit issued to 1200 MW coal fired power plant burning Powder River Basin and/or Central Appalachian coal (Longleaf). Assisted in drafting technical comments on NOx on draft permit. Prepared expert disclosure. Presented 8+ days of direct and rebuttal expert testimony. Attended all 21 days of evidentiary hearing from 9/5/07 – 10/30/07 assisting in all aspects of hearing. *Friends of the Chatahooche and Sierra Club v. Dr. Carol Couch, Director, Environmental Protection Division of Natural Resources Department, Respondent, and Longleaf Energy Associates, Intervener*. ALJ Final Decision 1/11/08 denying petition. ALJ Order vacated & remanded for further proceedings, Fulton County Superior Court, 6/30/08. Court of Appeals of GA remanded the case with directions that the ALJ's final decision be vacated to consider the evidence under the correct standard of review, July 9, 2009. The ALJ issued an opinion April 2, 2010 in favor of the applicant. Final permit issued April 2010.
- For plaintiffs, expert witness on diesel exhaust in inverse condemnation case in which Port expanded maritime operations into residential neighborhoods, subjecting plaintiffs to noise,

light, and diesel fumes. Measured real-time diesel particulate concentrations from marine vessels and tug boats on plaintiffs' property. Reviewed documents, depositions, DVDs, and photographs provided by counsel. Deposed. Testified October 24, 2006. *Ann Chargin, Richard Hackett, Carolyn Hackett, et al. v. Stockton Port District*, Superior Court of California, County of San Joaquin, Stockton Branch, No. CV021015. Judge ruled for plaintiffs.

- For plaintiffs, expert witness on NOx emissions and BACT in case alleging failure to obtain necessary permits and install controls on gas-fired combined-cycle turbines. Prepared and reviewed (applicant analyses) of NOx emissions, BACT analyses (water injection, SCR, ultra low NOx burners), and cost-effectiveness analyses based on site visit, plant operating records, stack tests, CEMS data, and turbine and catalyst vendor design information. Participated in negotiations to scope out consent order. *United States v. Nevada Power.* Case settled June 2007, resulting in installation of dry low NOx burners (5 ppm NOx averaged over 1 hr) on four units and a separate solar array at a local business.
- For plaintiffs, expert witness in appeal of PSD permit issued to 850 MW coal fired boiler burning Powder River Basin coal (Iatan Unit 2) on BACT for particulate matter, sulfuric acid mist and opacity and emission calculations for alleged historic violations of PSD. Assisted in drafting technical comments, petition for review, discovery requests, and responses to discovery requests. Reviewed produced documents. Prepared expert report on BACT for particulate matter. Assisted with expert depositions. Deposed February 7, 8, 27, 28, 2007. *In Re PSD Construction Permit Issued to Great Plains Energy, Kansas City Power & Light – Iatan Generating Station, Sierra Club v. Missouri Department of Natural Resources, Great Plains Energy, and Kansas City Power & Light.* Case settled March 27, 2007, providing offsets for over 6 million ton/yr of CO2 and lower NOx and SO_2 emission limits.
- For plaintiffs, expert witness in remedy phase of civil action relating to alleged violations of the Clean Air Act, Prevention of Significant Deterioration, for historic modifications of coal-fired boilers and associated equipment. Reviewed produced documents, prepared expert report on cost to retrofit 24 coal-fired power plants with scrubbers designed to remove 99% of the sulfur dioxide from flue gases. Prepared supplemental and expert report on cost estimates and BACT for SO2 for these 24 complaint units. Deposed 1/30/07 and 3/14/07. *United States and State of New York et al. v. American Electric Power*, In U.S. District Court for the Southern District of Ohio, Eastern Division, Consolidated Civil Action Nos. C2-99-1182 and C2-99-1250. Settlement announced 10/9/07.
- For plaintiffs, expert witness on BACT, enforceability, and alternatives analysis in appeal of PSD permit issued for a 270-MW pulverized coal fired boiler burning Powder River Basin coal (City Utilities Springfield Unit 2). Reviewed permitting file and assisted counsel draft petition and prepare and respond to interrogatories and document requests. Reviewed interrogatory responses and produced documents. Assisted with expert depositions. Deposed August 2005. Evidentiary hearings October 2005. *In the Matter of Linda*

Chipperfield and Sierra Club v. Missouri Department of Natural Resources. Missouri Supreme Court denied review of adverse lower court rulings August 2007.

- For plaintiffs, expert witness in civil action relating to plume touchdowns at AEP's Gavin coal-fired power plant. Assisted counsel draft interrogatories and document requests. Reviewed responses to interrogatories and produced documents. Prepared expert report "Releases of Sulfuric Acid Mist from the Gavin Power Station." The report evaluates sulfuric acid mist releases to determine if AEP complied with the requirements of CERCLA Section 103(a) and EPCRA Section 304. This report also discusses the formation, chemistry, release characteristics, and abatement of sulfuric acid mist in support of the claim that these releases present an imminent and substantial endangerment to public health under Section 7002(a)(1)(B) of the Resource Conservation and Recovery Act ("RCRA"). *Citizens Against Pollution v. Ohio Power Company*, In the U.S. District Court for the Southern District of Ohio, Eastern Division, Civil Action No. 2-04-cv-371. Case settled 12-8-06.

- For petitioners, expert witness in contested case hearing on BACT, enforceability, and emission estimates for an air permit issued to a 500-MW supercritical Power River Basin coal-fired boiler (Weston Unit 4). Assisted counsel prepare comments on draft air permit and respond to and draft discovery. Reviewed produced file, deposed (7/05), and prepared expert report on BACT and enforceability. Evidentiary hearings September 2005. *In the Matter of an Air Pollution Control Construction Permit Issued to Wisconsin Public Service Corporation for the Construction and Operation of a 500 MW Pulverized Coal-fired Power Plant Known as Weston Unit 4 in Marathon County, Wisconsin*, Case No. IH-04-21. The Final Order, issued 2/10/06, lowered the NOx BACT limit from 0.07 lb/MMBtu to 0.06 lb/MMBtu based on a 30-day average, added a BACT SO2 control efficiency, and required a 0.0005% high efficiency drift eliminator as BACT for the cooling tower. The modified permit, including these provisions, was issued 3/28/07. Additional appeals in progress.

- For plaintiffs, adviser on technical issues related to Citizen Suit against U.S. EPA regarding failure to update New Source Performance Standards for petroleum refineries, 40 CFR 60, Subparts J, VV, and GGG. *Our Children's Earth Foundation and Sierra Club v. U.S. EPA et al.* Case settled July 2005. CD No. C 05-00094 CW, U.S. District Court, Northern District of California – Oakland Division. Proposed revisions to standards of performance for petroleum refineries published 72 FR 27178 (5/14/07).

- For interveners, reviewed proposed Consent Decree settling Clean Air Act violations due to historic modifications of boilers and associated equipment at two coal-fired power plants. In response to stay order, reviewed the record, selected one representative activity at each of seven generating units, and analyzed to identify CAA violations. Identified NSPS and NSR violations for NOx, SO_2, PM/PM10, and sulfuric acid mist. Summarized results in an expert report. *United States of America, and Michael A. Cox, Attorney General of the State of Michigan, ex rel. Michigan Department of Environmental Quality, Plaintiffs, and Clean*

Wisconsin, Sierra Club, and Citizens' Utility Board, Intervenors, v. Wisconsin Electric Power Company, Defendant, U.S. District Court for the Eastern District of Wisconsin, Civil Action No. 2:03-CV-00371-CNC. Order issued 10-1-07 denying petition.

- For a coalition of Nevada labor organizations (ACE), reviewed preliminary determination to issue a Class I Air Quality Operating Permit to Construct and supporting files for a 250-MW pulverized coal-fired boiler (Newmont). Prepared about 100 pages of technical analyses and comments on BACT, MACT, emission calculations, and enforceability. Assisted counsel draft petition and reply brief appealing PSD permit to U.S. EPA Environmental Appeals Board (EAB). Order denying review issued 12/21/05. *In re Newmont Nevada Energy Investment, LLC, TS Power Plant*, PSD Appeal No. 05-04 (EAB 2005).
- For petitioners and plaintiffs, reviewed and prepared comments on air quality and hazardous waste based on negative declaration for refinery ultra low sulfur diesel project located in SCAQMD. Reviewed responses to comments and prepared responses. Prepared declaration and presented oral testimony before SCAQMD Hearing Board on exempt sources (cooling towers) and calculation of potential to emit under NSR. Petition for writ of mandate filed March 2005. Case remanded by Court of Appeals to trial court to direct SCAQMD to re-evaluate the potential environmental significance of NOx emissions resulting from the project in accordance with court's opinion. California Court of Appeals, Second Appellate Division, on December 18, 2007, affirmed in part (as to baseline) and denied in part. *Communities for a Better Environment v. South Coast Air Quality Management District and ConocoPhillips and Carlos Valdez et al v. South Coast Air Quality Management District and ConocoPhillips.* Certified for partial publication 1/16/08. Appellate Court opinion upheld by CA Supreme Court 3/15/10.
- For amici seeking to amend a proposed Consent Decree to settle alleged NSR violations at Chevron refineries, reviewed proposed settlement, related files, subject modifications, and emission calculations. Prepared declaration on emission reductions, identification of NSR and NSPS violations, and BACT/LAER for FCCUs, heaters and boilers, flares, and sulfur recovery plants. *U.S. et al. v. Chevron U.S.A.*, Northern District of California, Case No. C 03-04650. Memorandum and Order Entering Consent Decree issued June 2005. Case No. C 03-4650 CRB.
- For petitioners, prepared declaration on enforceability of periodic monitoring requirements, in response to EPA's revised interpretation of 40 CFR 70.6(c)(1). This revision limited additional monitoring required in Title V permits. 69 FR 3203 (Jan. 22, 2004). *Environmental Integrity Project et al. v. EPA* (U.S. Court of Appeals for the District of Columbia). Court ruled the Act requires all Title V permits to contain monitoring requirements to assure compliance. *Sierra Club v. EPA*, 536 F.3d 673 (D.C. Cir. 2008).
- For interveners in application for authority to construct a 500 MW supercritical coal-fired generating unit before the Wisconsin Public Service Commission, prepared pre-filed written

direct and rebuttal testimony with oral cross examination and rebuttal on BACT and MACT (Weston 4). Prepared written comments on BACT, MACT, and enforceability on draft air permit for same facility.

- For property owners in Nevada, evaluated the environmental impacts of a 1,450-MW coal-fired power plant proposed in a rural area adjacent to the Black Rock Desert and Granite Range, including emission calculations, air quality modeling, comments on proposed use permit to collect preconstruction monitoring data, and coordination with agencies and other interested parties. Project cancelled.
- For environmental organizations, reviewed draft PSD permit for a 600-MW coal-fired power plant in West Virginia (Longview). Prepared comments on permit enforceability; coal washing; BACT for SO_2 and PM10; Hg MACT; and MACT for HCl, HF, non-Hg metallic HAPs, and enforceability. Assist plaintiffs draft petition appealing air permit. Retained as expert to develop testimony on MACT, BACT, offsets, enforceability. Participate in settlement discussions. Case settled July 2004.
- For petitioners, reviewed record produced in discovery and prepared affidavit on emissions of carbon monoxide and volatile organic compounds during startup of GE 7FA combustion turbines to successfully establish plaintiff standing. *Sierra Club et al. v. Georgia Power Company* (Northern District of Georgia).
- For building trades, reviewed air quality permitting action for 1500-MW coal-fired power plant before the Kentucky Department for Environmental Protection (Thoroughbred).
- For petitioners, expert witness in administrative appeal of the PSD/Title V permit issued to a 1500-MW coal-fired power plant. Reviewed over 60,000 pages of produced documents, prepared discovery index, identified and assembled plaintiff exhibits. Deposed. Assisted counsel in drafting discovery requests, with over 30 depositions, witness cross examination, and brief drafting. Presented over 20 days of direct testimony, rebuttal and sur-rebuttal, with cross examination on BACT for NOx, SO_2, and PM/PM10; MACT for Hg and non-Hg metallic HAPs; emission estimates for purposes of Class I and II air modeling; risk assessment; and enforceability of permit limits. Evidentiary hearings from November 2003 to June 2004. *Sierra Club et al. v. Natural Resources & Environmental Protection Cabinet, Division of Air Quality and Thoroughbred Generating Company et al.* Hearing Officer Decision issued August 9, 2005 finding in favor of plaintiffs on counts as to risk, BACT (IGCC/CFB, NOx, SO_2, Hg, Be), single source, enforceability, and errors and omissions. Assist counsel draft exceptions. Cabinet Secretary issued Order April 11, 2006 denying Hearing Offer's report, except as to NOx BACT, Hg, 99% SO2 control and certain errors and omissions.
- For citizens group in Massachusetts, reviewed, commented on, and participated in permitting of pollution control retrofits of coal-fired power plant (Salem Harbor).

- Assisted citizens group and labor union challenge issuance of conditional use permit for a 317,000 ft^2 discount store in Honolulu without any environmental review. In support of a motion for preliminary injunction, prepared 7-page declaration addressing public health impacts of diesel exhaust from vehicles serving the Project. In preparation for trial, prepared 20-page preliminary expert report summarizing results of diesel exhaust and noise measurements at two big box retail stores in Honolulu, estimated diesel PM10 concentrations for Project using ISCST, prepared a cancer health risk assessment based on these analyses, and evaluated noise impacts.
- Assisted environmental organizations to challenge the DOE Finding of No Significant Impact (FONSI) for the Baja California Power and Sempra Energy Resources Cross-Border Transmissions Lines in the U.S. and four associated power plants located in Mexico (DOE EA-1391). Prepared 20-page declaration in support of motion for summary judgment addressing emissions, including CO_2 and NH_3, offsets, BACT, cumulative air quality impacts, alternative cooling systems, and water use and water quality impacts. Plaintiff's motion for summary judgment granted in part. U.S. District Court, Southern District decision concluded that the Environmental Assessment and FONSI violated NEPA and the APA due to their inadequate analysis of the potential controversy surrounding the project, water impacts, impacts from NH_3 and CO_2, alternatives, and cumulative impacts. *Border Power Plant Working Group v. Department of Energy and Bureau of Land Management*, Case No. 02-CV-513-IEG (POR) (May 2, 2003).
- For Sacramento school, reviewed draft air permit issued for diesel generator located across from playfield. Prepared comments on emission estimates, enforceability, BACT, and health impacts of diesel exhaust. Case settled. BUG trap installed on the diesel generator.
- Assisted unions in appeal of Title V permit issued by BAAQMD to carbon plant that manufactured coke. Reviewed District files, identified historic modifications that should have triggered PSD review, and prepared technical comments on Title V permit. Reviewed responses to comments and assisted counsel draft appeal to BAAQMD hearing board, opening brief, motion to strike, and rebuttal brief. Case settled.
- Assisted California Central Coast city obtain controls on a proposed new city that would straddle the Ventura-Los Angeles County boundary. Reviewed several environmental impact reports, prepared an air quality analysis, a diesel exhaust health risk assessment, and detailed review comments. Governor intervened and State dedicated the land for conservation purposes April 2004.
- Assisted Central California city to obtain controls on large alluvial sand quarry and asphalt plant proposing a modernization. Prepared comments on Negative Declaration on air quality, public health, noise, and traffic. Evaluated process flow diagrams and engineering reports to determine whether proposed changes increased plant capacity or substantially modified plant operations. Prepared comments on application for categorical exemption from CEQA. Presented testimony to County Board of Supervisors. Developed controls to mitigate impacts. Assisted counsel draft Petition for Writ. Case settled June 2002.

Substantial improvements in plant operations were obtained including cap on throughput, dust control measures, asphalt plant loadout enclosure, and restrictions on truck routes.

- Assisted oil companies on the California Central Coast in defending class action citizen's lawsuit alleging health effects due to emissions from gas processing plant and leaking underground storage tanks. Reviewed regulatory and other files and advised counsel on merits of case. Case settled November 2001.
- Assisted oil company on the California Central Coast in defending property damage claims arising out of a historic oil spill. Reviewed site investigation reports, pump tests, leachability studies, and health risk assessments, participated in design of additional site characterization studies to assess health impacts, and advised counsel on merits of case. Prepare health risk assessment.
- Assisted unions in appeal of Initial Study/Negative Declaration ("IS/ND") for an MTBE phaseout project at a Bay Area refinery. Reviewed IS/ND and supporting agency permitting files and prepared technical comments on air quality, groundwater, and public health impacts. Reviewed responses to comments and final IS/ND and ATC permits and assisted counsel to draft petitions and briefs appealing decision to Air District Hearing Board. Presented sworn direct and rebuttal testimony with cross examination on groundwater impacts of ethanol spills on hydrocarbon contamination at refinery. Hearing Board ruled 5 to 0 in favor of appellants, remanding ATC to district to prepare an EIR.
- Assisted Florida cities in challenging the use of diesel and proposed BACT determinations in prevention of significant deterioration (PSD) permits issued to two 510-MW simple cycle peaking electric generating facilities and one 1,080-MW simple cycle/combined cycle facility. Reviewed permit applications, draft permits, and FDEP engineering evaluations, assisted counsel in drafting petitions and responding to discovery. Participated in settlement discussions. Cases settled or applications withdrawn.
- Assisted large California city in federal lawsuit alleging peaker power plant was violating its federal permit. Reviewed permit file and applicant's engineering and cost feasibility study to reduce emissions through retrofit controls. Advised counsel on feasible and cost-effective NOx, SOx, and PM10 controls for several 1960s diesel-fired Pratt and Whitney peaker turbines. Case settled.
- Assisted coalition of Georgia environmental groups in evaluating BACT determinations and permit conditions in PSD permits issued to several large natural gas-fired simple cycle and combined-cycle power plants. Prepared technical comments on draft PSD permits on BACT, enforceability of limits, and toxic emissions. Reviewed responses to comments, advised counsel on merits of cases, participated in settlement discussions, presented oral and written testimony in adjudicatory hearings, and provided technical assistance as required. Cases settled or won at trial.

- Assisted construction unions in review of air quality permitting actions before the Indiana Department of Environmental Management ("IDEM") for several natural gas-fired simple cycle peaker and combined cycle power plants.
- Assisted coalition of towns and environmental groups in challenging air permits issued to 523 MW dual fuel (natural gas and distillate) combined-cycle power plant in Connecticut. Prepared technical comments on draft permits and 60 pages of written testimony addressing emission estimates, startup/shutdown issues, BACT/LAER analyses, and toxic air emissions. Presented testimony in adjudicatory administrative hearings before the Connecticut Department of Environmental Protection in June 2001 and December 2001.
- Assisted various coalitions of unions, citizens groups, cities, public agencies, and developers in licensing and permitting of over 110 coal, gas, oil, biomass, and pet coke-fired power plants generating over 75,000 MW of electricity. These included base-load, combined cycle, simple cycle, and peaker power plants in Alaska, Arizona, Arkansas, California, Colorado, Georgia, Florida, Illinois, Indiana, Kentucky, Michigan, Missouri, Ohio, Oklahoma, Oregon, Texas, West Virginia, Wisconsin, and elsewhere. Prepared analyses of and comments on applications for certification, preliminary and final staff assessments, and various air, water, wastewater, and solid waste permits issued by local agencies. Presented written and oral testimony before various administrative bodies on hazards of ammonia use and transportation, health effects of air emissions, contaminated property issues, BACT/LAER issues related to SCR and SCONOx, criteria and toxic pollutant emission estimates, MACT analyses, air quality modeling, water supply and water quality issues, and methods to reduce water use, including dry cooling, parallel dry-wet cooling, hybrid cooling, and zero liquid discharge systems.
- Assisted unions, cities, and neighborhood associations in challenging an EIR issued for the proposed expansion of the Oakland Airport. Reviewed two draft EIRs and prepared a health risk assessment and extensive technical comments on air quality and public health impacts. The California Court of Appeals, First Appellate District, ruled in favor of appellants and plaintiffs, concluding that the EIR "2) erred in using outdated information in assessing the emission of toxic air contaminants (TACs) from jet aircraft; 3) failed to support its decision not to evaluate the health risks associated with the emission of TACs with meaningful analysis," thus accepting my technical arguments and requiring the Port to prepare a new EIR. See *Berkeley Keep Jets Over the Bay Committee, City of San Leandro, and City of Alameda et al. v. Board of Port Commissioners* (August 30, 2001) 111 Cal.Rptr.2d 598.

- Assisted lessor of former gas station with leaking underground storage tanks and TCE contamination from adjacent property. Lessor held option to purchase, which was forfeited based on misrepresentation by remediation contractor as to nature and extent of contamination. Remediation contractor purchased property. Reviewed regulatory agency files and advised counsel on merits of case. Case not filed.
- Advised counsel on merits of several pending actions, including a Proposition 65 case involving groundwater contamination at an explosives manufacturing firm and two former gas stations with leaking underground storage tanks.
- Assisted defendant foundry in Oakland in a lawsuit brought by neighbors alleging property contamination, nuisance, trespass, smoke, and health effects from foundry operation. Inspected and sampled plaintiff's property. Advised counsel on merits of case. Case settled.
- Assisted business owner facing eminent domain eviction. Prepared technical comments on a negative declaration for soil contamination and public health risks from air emissions from a proposed redevelopment project in San Francisco in support of a CEQA lawsuit. Case settled.
- Assisted neighborhood association representing residents living downwind of a Berkeley asphalt plant in separate nuisance and CEQA lawsuits. Prepared technical comments on air quality, odor, and noise impacts, presented testimony at commission and council meetings, participated in community workshops, and participated in settlement discussions. Cases settled. Asphalt plant was upgraded to include air emission and noise controls, including vapor collection system at truck loading station, enclosures for noisy equipment, and improved housekeeping.
- Assisted a Fortune 500 residential home builder in claims alleging health effects from faulty installation of gas appliances. Conducted indoor air quality study, advised counsel on merits of case, and participated in discussions with plaintiffs. Case settled.
- Assisted property owners in Silicon Valley in lawsuit to recover remediation costs from insurer for large TCE plume originating from a manufacturing facility. Conducted investigations to demonstrate sudden and accidental release of TCE, including groundwater modeling, development of method to date spill, preparation of chemical inventory, investigation of historical waste disposal practices and standards, and on-site sewer and storm drainage inspections and sampling. Prepared declaration in opposition to motion for summary judgment. Case settled.
- Assisted residents in east Oakland downwind of a former battery plant in class action lawsuit alleging property contamination from lead emissions. Conducted historical research and dry deposition modeling that substantiated claim. Participated in mediation at JAMS. Case settled.

- Assisted property owners in West Oakland who purchased a former gas station that had leaking underground storage tanks and groundwater contamination. Reviewed agency files and advised counsel on merits of case. Prepared declaration in opposition to summary judgment. Prepared cost estimate to remediate site. Participated in settlement discussions. Case settled.
- Consultant to counsel representing plaintiffs in two Clean Water Act lawsuits involving selenium discharges into San Francisco Bay from refineries. Reviewed files and advised counsel on merits of case. Prepared interrogatory and discovery questions, assisted in deposing opposing experts, and reviewed and interpreted treatability and other technical studies. Judge ruled in favor of plaintiffs.
- Assisted oil company in a complaint filed by a resident of a small California beach community alleging that discharges of tank farm rinse water into the sanitary sewer system caused hydrogen sulfide gas to infiltrate residence, sending occupants to hospital. Inspected accident site, interviewed parties to the event, and reviewed extensive agency files related to incident. Used chemical analysis, field simulations, mass balance calculations, sewer hydraulic simulations with SWMM44, atmospheric dispersion modeling with SCREEN3, odor analyses, and risk assessment calculations to demonstrate that the incident was caused by a faulty drain trap and inadequate slope of sewer lateral on resident's property. Prepared a detailed technical report summarizing these studies. Case settled.
- Assisted large West Coast city in suit alleging that leaking underground storage tanks on city property had damaged the waterproofing on downgradient building, causing leaks in an underground parking structure. Reviewed subsurface hydrogeologic investigations and evaluated studies conducted by others documenting leakage from underground diesel and gasoline tanks. Inspected, tested, and evaluated waterproofing on subsurface parking structure. Waterproofing was substandard. Case settled.
- Assisted residents downwind of gravel mine and asphalt plant in Siskiyou County, California, in suit to obtain CEQA review of air permitting action. Prepared two declarations analyzing air quality and public health impacts. Judge ruled in favor of plaintiffs, closing mine and asphalt plant.
- Assisted defendant oil company on the California Central Coast in class action lawsuit alleging property damage and health effects from subsurface petroleum contamination. Reviewed documents, prepared risk calculations, and advised counsel on merits of case. Participated in settlement discussions. Case settled.
- Assisted defendant oil company in class action lawsuit alleging health impacts from remediation of petroleum contaminated site on California Central Coast. Reviewed documents, designed and conducted monitoring program, and participated in settlement discussions. Case settled.

- Consultant to attorneys representing irrigation districts and municipal water districts to evaluate a potential challenge of USFWS actions under CVPIA section 3406(b)(2). Reviewed agency files and collected and analyzed hydrology, water quality, and fishery data. Advised counsel on merits of case. Case not filed.
- Assisted residents downwind of a Carson refinery in class action lawsuit involving soil and groundwater contamination, nuisance, property damage, and health effects from air emissions. Reviewed files and provided advise on contaminated soil and groundwater, toxic emissions, and health risks. Prepared declaration on refinery fugitive emissions. Prepared deposition questions and reviewed deposition transcripts on air quality, soil contamination, odors, and health impacts. Case settled.
- Assisted residents downwind of a Contra Costa refinery who were affected by an accidental release of naphtha. Characterized spilled naphtha, estimated emissions, and modeled ambient concentrations of hydrocarbons and sulfur compounds. Deposed. Presented testimony in binding arbitration at JAMS. Judge found in favor of plaintiffs.
- Assisted residents downwind of Contra Costa County refinery in class action lawsuit alleging property damage, nuisance, and health effects from several large accidents as well as routine operations. Reviewed files and prepared analyses of environmental impacts. Prepared declarations, deposed, and presented testimony before jury in one trial and judge in second. Case settled.
- Assisted business owner claiming damages from dust, noise, and vibration during a sewer construction project in San Francisco. Reviewed agency files and PM10 monitoring data and advised counsel on merits of case. Case settled.
- Assisted residents downwind of Contra Costa County refinery in class action lawsuit alleging property damage, nuisance, and health effects. Prepared declaration in opposition to summary judgment, deposed, and presented expert testimony on accidental releases, odor, and nuisance before jury. Case thrown out by judge, but reversed on appeal and not retried.
- Presented testimony in small claims court on behalf of residents claiming health effects from hydrogen sulfide from flaring emissions triggered by a power outage at a Contra Costa County refinery. Analyzed meteorological and air quality data and evaluated potential health risks of exposure to low concentrations of hydrogen sulfide. Judge awarded damages to plaintiffs.
- Assisted construction unions in challenging PSD permit for an Indiana steel mill. Prepared technical comments on draft PSD permit, drafted 70-page appeal of agency permit action to the Environmental Appeals Board challenging permit based on faulty BACT analysis for electric arc furnace and reheat furnace and faulty permit conditions, among others, and drafted briefs responding to four parties. EPA Region V and the EPA General Counsel intervened as amici, supporting petitioners. EAB ruled in favor of petitioners, remanding permit to IDEM on three key issues, including BACT for the reheat furnace and lead

emissions from the EAF. Drafted motion to reconsider three issues. Prepared 69 pages of technical comments on revised draft PSD permit. Drafted second EAB appeal addressing lead emissions from the EAF and BACT for reheat furnace based on European experience with SCR/SNCR. Case settled. Permit was substantially improved. See *In re: Steel Dynamics, Inc.*, PSD Appeal Nos. 99-4 & 99-5 (EAB June 22, 2000).

- Assisted defendant urea manufacturer in Alaska in negotiations with USEPA to seek relief from penalties for alleged violations of the Clean Air Act. Reviewed and evaluated regulatory files and monitoring data, prepared technical analysis demonstrating that permit limits were not violated, and participated in negotiations with EPA to dismiss action. Fines were substantially reduced and case closed.
- Assisted construction unions in challenging PSD permitting action for an Indiana grain mill. Prepared technical comments on draft PSD permit and assisted counsel draft appeal of agency permit action to the Environmental Appeals Board challenging permit based on faulty BACT analyses for heaters and boilers and faulty permit conditions, among others. Case settled.
- As part of a consent decree settling a CEQA lawsuit, assisted neighbors of a large west coast port in negotiations with port authority to secure mitigation for air quality impacts. Prepared technical comments on mobile source air quality impacts and mitigation and negotiated a $9 million CEQA mitigation package. Represented neighbors on technical advisory committee established by port to implement the air quality mitigation program. Program successfully implemented.
- Assisted construction unions in challenging permitting action for a California hazardous waste incinerator. Prepared technical comments on draft permit, assisted counsel prepare appeal of EPA permit to the Environmental Appeals Board. Participated in settlement discussions on technical issues with applicant and EPA Region 9. Case settled.
- Assisted environmental group in challenging DTSC Negative Declaration on a hazardous waste treatment facility. Prepared technical comments on risk of upset, water, and health risks. Writ of mandamus issued.
- Assisted several neighborhood associations and cities impacted by quarries, asphalt plants, and cement plants in Alameda, Shasta, Sonoma, and Mendocino counties in obtaining mitigations for dust, air quality, public health, traffic, and noise impacts from facility operations and proposed expansions.
- For over 100 industrial facilities, commercial/campus, and redevelopment projects, developed the record in preparation for CEQA and NEPA lawsuits. Prepared technical comments on hazardous materials, solid wastes, public utilities, noise, worker safety, air quality, public health, water resources, water quality, traffic, and risk of upset sections of EIRs, EISs, FONSIs, initial studies, and negative declarations. Assisted counsel in drafting petitions and briefs and prepared declarations.

- For several large commercial development projects and airports, assisted applicant and counsel prepare defensible CEQA documents, respond to comments, and identify and evaluate "all feasible" mitigation to avoid CEQA challenges. This work included developing mitigation programs to reduce traffic-related air quality impacts based on energy conservation programs, solar, low-emission vehicles, alternative fuels, exhaust treatments, and transportation management associations.

SITE INVESTIGATION/REMEDIATION/CLOSURE

- Technical manager and principal engineer for characterization, remediation, and closure of waste management units at former Colorado oil shale plant. Constituents of concern included BTEX, As, 1,1,1-TCA, and TPH. Completed groundwater monitoring programs, site assessments, work plans, and closure plans for seven process water holding ponds, a refinery sewer system, and processed shale disposal area. Managed design and construction of groundwater treatment system and removal actions and obtained clean closure.
- Principal engineer for characterization, remediation, and closure of process water ponds at a former lanthanide processing plant in Colorado. Designed and implemented groundwater monitoring program and site assessments and prepared closure plan.
- Advised the city of Sacramento on redevelopment of two former railyards. Reviewed work plans, site investigations, risk assessment, RAPS, RI/FSs, and CEQA documents. Participated in the development of mitigation strategies to protect construction and utility workers and the public during remediation, redevelopment, and use of the site, including buffer zones, subslab venting, rail berm containment structure, and an environmental oversight plan.
- Provided technical support for the investigation of a former sanitary landfill that was redeveloped as single family homes. Reviewed and/or prepared portions of numerous documents, including health risk assessments, preliminary endangerment assessments, site investigation reports, work plans, and RI/FSs. Historical research to identify historic waste disposal practices to prepare a preliminary endangerment assessment. Acquired, reviewed, and analyzed the files of 18 federal, state, and local agencies, three sets of construction field notes, analyzed 21 aerial photographs and interviewed 14 individuals associated with operation of former landfill. Assisted counsel in defending lawsuit brought by residents alleging health impacts and diminution of property value due to residual contamination. Prepared summary reports.
- Technical oversight of characterization and remediation of a nitrate plume at an explosives manufacturing facility in Lincoln, CA. Provided interface between owners and consultants. Reviewed site assessments, work plans, closure plans, and RI/FSs.

- Consultant to owner of large western molybdenum mine proposed for NPL listing. Participated in negotiations to scope out consent order and develop scope of work. Participated in studies to determine premining groundwater background to evaluate applicability of water quality standards. Served on technical committees to develop alternatives to mitigate impacts and close the facility, including resloping and grading, various thickness and types of covers, and reclamation. This work included developing and evaluating methods to control surface runoff and erosion, mitigate impacts of acid rock drainage on surface and ground waters, and stabilize nine waste rock piles containing 328 million tons of pyrite-rich, mixed volcanic waste rock (andesites, rhyolite, tuff). Evaluated stability of waste rock piles. Represented client in hearings and meetings with state and federal oversight agencies.

REGULATORY (PARTIAL LIST)

- Prepared cost analyses and comments on New York's proposed BART determinations for NOx, SO2, and PM and EPA's proposed approval of BART determinations for Danskammer Generating Station under New York Regional Haze State Implementation Plan and Federal Implementation Plan, 77 FR 51915 (August 28, 21012).
- Prepared cost analyses and comments on NOx BART determinations for Regional Haze State Implementation Plan for State of Nevada, 77 FR 23191 (April 18, 2012) and 77 FR 25660 (May 1, 2012).
- Prepared analyses of and comments on New Source Performance Standards for Greenhouse Gas Emissions for New Stationary Sources: Electric Utility Generating Units, 77 FR 22392 (April 13, 2012).
- Prepared comments on CASPR-BART emission equivalency and NOx and PM BART determinations in EPA proposed approval of State Implementation Plan for Pennsylvania Regional Haze Implementation Plan, 77 FR 3984 (January 26, 2012).
- Prepared comments and statistical analyses on hazardous air pollutants (HAPs) emission controls, monitoring, compliance methods, and the use of surrogates for acid gases, organic HAPs, and metallic HAPs for proposed National Emission Standards for Hazardous Air Pollutants from Coal- and Oil-Fired Electric Utility Steam Generating Units, 76 FR 24976 (May 3, 2011).
- Prepared cost analyses and comments on NOx BART determinations and emission reductions for proposed Federal Implementation Plan for Four Corners Power Plant, 75 FR 64221 (October 19, 2010).

- Prepared cost analyses and comments on NOx BART determinations for Colstrip Units 1- 4 for Montana State Implementation Plan and Regional Haze Federal Implementation Plan, 77 FR 23988 (April 20, 2010).
- For EPA Region 8, prepared report: Revised BART Cost Effectiveness Analysis for Tail-End Selective Catalytic Reduction at the Basin Electric Power Cooperative Leland Olds Station Unit 2 Final Report, March 2011, in support of 76 FR 58570 (Sept. 21, 2011).
- For EPA Region 6, prepared report: Revised BART Cost-Effectiveness Analysis for Selective Catalytic Reduction at the Public Service Company of New Mexico San Juan Generating Station, November 2010, in support of 76 FR 52388 (Aug. 22, 2011).
- For EPA Region 6, prepared report: Revised BART Cost-Effectiveness Analysis for Flue Gas Desulfurization at Coal-Fired Electric Generating Units in Oklahoma: Sooner Units 1 & 2, Muskogee Units 4 & 5, Northeastern Units 3 &4, October 2010, in support of 76 FR 16168 (March 26, 2011).
- Identified errors in N_2O emission factors in the Mandatory Greenhouse Gas Reporting Rule, 40 CFR 98, and prepared technical analysis to support Petition for Rulemaking to Correct Emissions Factors in the Mandatory Greenhouse Gas Reporting Rule, filed with EPA on 10/28/10.
- Assist interested parties develop input for and prepare comments on the Information Collection Request for Petroleum Refinery Sector NSPS and NESHAP Residual Risk and Technology Review, 75 FR 60107 (9/29/10).
- Technical reviewer of EPA's "Emission Estimation Protocol for Petroleum Refineries," posted for public comments on CHIEF on 12/23/09, prepared in response to the City of Houston's petition under the Data Quality Act (March 2010).
- Prepared comments on SCR cost effectiveness for EPA's Advanced Notice of Proposed Rulemaking, Assessment of Anticipated Visibility Improvements at Surrounding Class I Areas and Cost Effectiveness of Best Available Retrofit Technology for Four Corners Power Plant and Navajo Generating Station, 74 FR 44313 (August 28, 2009).
- Prepared comments on Proposed Rule for Standards of Performance for Coal Preparation and Processing Plants, 74 FR 25304 (May 27, 2009).
- Reviewed and assisted interested parties prepare comments on proposed Kentucky air toxic regulations at 401 KAR 64:005, 64:010, 64:020, and 64:030 (June 2007).
- Prepared comments on proposed Standards of Performance for Electric Utility Steam Generating Units and Small Industrial-Commercial-Industrial Steam Generating Units, 70 FR 9706 (February 28, 2005).
- Prepared comments on Louisville Air Pollution Control District proposed Strategic Toxic Air Reduction regulations.

- Prepared comments and analysis of BAAQMD Regulation, Rule 11, Flare Monitoring at Petroleum Refineries.
- Prepared comments on Proposed National Emission Standards for Hazardous Air Pollutants; and, in the Alternative, Proposed Standards of Performance for New and Existing Stationary Sources: Electricity Utility Steam Generating Units (MACT standards for coal-fired power plants).
- Prepared Authority to Construct Permit for remediation of a large petroleum-contaminated site on the California Central Coast. Negotiated conditions with agencies and secured permits.
- Prepared Authority to Construct Permit for remediation of a former oil field on the California Central Coast. Participated in negotiations with agencies and secured permits.
- Prepared and/or reviewed hundreds of environmental permits, including NPDES, UIC, Stormwater, Authority to Construct, Prevention of Significant Deterioration, Nonattainment New Source Review, Title V, and RCRA, among others.
- Participated in the development of the CARB document, *Guidance for Power Plant Siting and Best Available Control Technology*, including attending public workshops and filing technical comments.
- Performed data analyses in support of adoption of emergency power restoration standards by the California Public Utilities Commission for "major" power outages, where major is an outage that simultaneously affects 10% of the customer base.
- Drafted portions of the Good Neighbor Ordinance to grant Contra Costa County greater authority over safety of local industry, particularly chemical plants and refineries.
- Participated in drafting BAAQMD Regulation 8, Rule 28, Pressure Relief Devices, including participation in public workshops, review of staff reports, draft rules and other technical materials, preparation of technical comments on staff proposals, research on availability and costs of methods to control PRV releases, and negotiations with staff.
- Participated in amending BAAQMD Regulation 8, Rule 18, Valves and Connectors, including participation in public workshops, review of staff reports, proposed rules and other supporting technical material, preparation of technical comments on staff proposals, research on availability and cost of low-leak technology, and negotiations with staff.
- Participated in amending BAAQMD Regulation 8, Rule 25, Pumps and Compressors, including participation in public workshops, review of staff reports, proposed rules, and other supporting technical material, preparation of technical comments on staff proposals, research on availability and costs of low-leak and seal-less technology, and negotiations with staff.
- Participated in amending BAAQMD Regulation 8, Rule 5, Storage of Organic Liquids, including participation in public workshops, review of staff reports, proposed rules, and other

supporting technical material, preparation of technical comments on staff proposals, research on availability and costs of controlling tank emissions, and presentation of testimony before the Board.

- Participated in amending BAAQMD Regulation 8, Rule 18, Valves and Connectors at Petroleum Refinery Complexes, including participation in public workshops, review of staff reports, proposed rules and other supporting technical material, preparation of technical comments on staff proposals, research on availability and costs of low-leak technology, and presentation of testimony before the Board.
- Participated in amending BAAQMD Regulation 8, Rule 22, Valves and Flanges at Chemical Plants, etc, including participation in public workshops, review of staff reports, proposed rules, and other supporting technical material, preparation of technical comments on staff proposals, research on availability and costs of low-leak technology, and presentation of testimony before the Board.
- Participated in amending BAAQMD Regulation 8, Rule 25, Pump and Compressor Seals, including participation in public workshops, review of staff reports, proposed rules, and other supporting technical material, preparation of technical comments on staff proposals, research on availability of low-leak technology, and presentation of testimony before the Board.
- Participated in the development of the BAAQMD Regulation 2, Rule 5, Toxics, including participation in public workshops, review of staff proposals, and preparation of technical comments.
- Participated in the development of SCAQMD Rule 1402, Control of Toxic Air Contaminants from Existing Sources, and proposed amendments to Rule 1401, New Source Review of Toxic Air Contaminants, in 1993, including review of staff proposals and preparation of technical comments on same.
- Participated in the development of the Sunnyvale Ordinance to Regulate the Storage, Use and Handling of Toxic Gas, which was designed to provide engineering controls for gases that are not otherwise regulated by the Uniform Fire Code.
- Participated in the drafting of the Statewide Water Quality Control Plans for Inland Surface Waters and Enclosed Bays and Estuaries, including participation in workshops, review of draft plans, preparation of technical comments on draft plans, and presentation of testimony before the SWRCB.
- Participated in developing Se permit effluent limitations for the five Bay Area refineries, including review of staff proposals, statistical analyses of Se effluent data, review of literature on aquatic toxicity of Se, preparation of technical comments on several staff proposals, and presentation of testimony before the Bay Area RWQCB.
- Represented the California Department of Water Resources in the 1991 Bay-Delta Hearings before the State Water Resources Control Board, presenting sworn expert testimony with

cross examination and rebuttal on a striped bass model developed by the California Department of Fish and Game.

- Represented the State Water Contractors in the 1987 Bay-Delta Hearings before the State Water Resources Control Board, presenting sworn expert testimony with cross examination and rebuttal on natural flows, historical salinity trends in San Francisco Bay, Delta outflow, and hydrodynamics of the South Bay.
- Represented interveners in the licensing of over 20 natural-gas-fired power plants and one coal gasification plant at the California Energy Commission and elsewhere. Reviewed and prepared technical comments on applications for certification, preliminary staff assessments, final staff assessments, preliminary determinations of compliance, final determinations of compliance, and prevention of significant deterioration permits in the areas of air quality, water supply, water quality, biology, public health, worker safety, transportation, site contamination, cooling systems, and hazardous materials. Presented written and oral testimony in evidentiary hearings with cross examination and rebuttal. Participated in technical workshops.
- Represented several parties in the proposed merger of San Diego Gas & Electric and Southern California Edison. Prepared independent technical analyses on health risks, air quality, and water quality. Presented written and oral testimony before the Public Utilities Commission administrative law judge with cross examination and rebuttal.
- Represented a PRP in negotiations with local health and other agencies to establish impact of subsurface contamination on overlying residential properties. Reviewed health studies prepared by agency consultants and worked with agencies and their consultants to evaluate health risks.

WATER QUALITY/RESOURCES

- Directed and participated in research on environmental impacts of energy development in the Colorado River Basin, including contamination of surface and subsurface waters and modeling of flow and chemical transport through fractured aquifers.
- Played a major role in Northern California water resource planning studies since the early 1970s. Prepared portions of the Basin Plans for the Sacramento, San Joaquin, and Delta basins including sections on water supply, water quality, beneficial uses, waste load allocation, and agricultural drainage. Developed water quality models for the Sacramento and San Joaquin Rivers.
- Conducted hundreds of studies over the past 40 years on Delta water supplies and the impacts of exports from the Delta on water quality and biological resources of the Central Valley, Sacramento-San Joaquin Delta, and San Francisco Bay. Typical examples include:

1. Evaluate historical trends in salinity, temperature, and flow in San Francisco Bay and upstream rivers to determine impacts of water exports on the estuary;
2. Evaluate the role of exports and natural factors on the food web by exploring the relationship between salinity and primary productivity in San Francisco Bay, upstream rivers, and ocean;
3. Evaluate the effects of exports, other in-Delta, and upstream factors on the abundance of salmon and striped bass;
4. Review and critique agency fishery models that link water exports with the abundance of striped bass and salmon;
5. Develop a model based on GLMs to estimate the relative impact of exports, water facility operating variables, tidal phase, salinity, temperature, and other variables on the survival of salmon smolts as they migrate through the Delta;
6. Reconstruct the natural hydrology of the Central Valley using water balances, vegetation mapping, reservoir operation models to simulate flood basins, precipitation records, tree ring research, and historical research;
7. Evaluate the relationship between biological indicators of estuary health and down-estuary position of a salinity surrogate (X2);
8. Use real-time fisheries monitoring data to quantify impact of exports on fish migration;
9. Refine/develop statistical theory of autocorrelation and use to assess strength of relationships between biological and flow variables;
10. Collect, compile, and analyze water quality and toxicity data for surface waters in the Central Valley to assess the role of water quality in fishery declines;
11. Assess mitigation measures, including habitat restoration and changes in water project operation, to minimize fishery impacts;
12. Evaluate the impact of unscreened agricultural water diversions on abundance of larval fish;
13. Prepare and present testimony on the impacts of water resources development on Bay hydrodynamics, salinity, and temperature in water rights hearings;
14. Evaluate the impact of boat wakes on shallow water habitat, including interpretation of historical aerial photographs;
15. Evaluate the hydrodynamic and water quality impacts of converting Delta islands into reservoirs;

16. Use a hydrodynamic model to simulate the distribution of larval fish in a tidally influenced estuary;
17. Identify and evaluate non-export factors that may have contributed to fishery declines, including predation, shifts in oceanic conditions, aquatic toxicity from pesticides and mining wastes, salinity intrusion from channel dredging, loss of riparian and marsh habitat, sedimentation from upstream land alternations, and changes in dissolved oxygen, flow, and temperature below dams.

- Developed, directed, and participated in a broad-based research program on environmental issues and control technology for energy industries including petroleum, oil shale, coal mining, and coal slurry transport. Research included evaluation of air and water pollution, development of novel, low-cost technology to treat and dispose of wastes, and development and application of geohydrologic models to evaluate subsurface contamination from in-situ retorting. The program consisted of government and industry contracts and employed 45 technical and administrative personnel.
- Coordinated an industry task force established to investigate the occurrence, causes, and solutions for corrosion/erosion and mechanical/engineering failures in the waterside systems (e.g., condensers, steam generation equipment) of power plants. Corrosion/erosion failures caused by water and steam contamination that were investigated included waterside corrosion caused by poor microbiological treatment of cooling water, steam-side corrosion caused by ammonia-oxygen attack of copper alloys, stress-corrosion cracking of copper alloys in the air cooling sections of condensers, tube sheet leaks, oxygen in-leakage through condensers, volatilization of silica in boilers and carry over and deposition on turbine blades, and iron corrosion on boiler tube walls. Mechanical/engineering failures investigated included: steam impingement attack on the steam side of condenser tubes, tube-to-tube-sheet joint leakage, flow-induced vibration, structural design problems, and mechanical failures due to stresses induced by shutdown, startup and cycling duty, among others. Worked with electric utility plant owners/operators, condenser and boiler vendors, and architect/engineers to collect data to document the occurrence of and causes for these problems, prepared reports summarizing the investigations, and presented the results and participated on a committee of industry experts tasked with identifying solutions to prevent condenser failures.
- Evaluated the cost effectiveness and technical feasibility of using dry cooling and parallel dry-wet cooling to reduce water demands of several large natural-gas fired power plants in California and Arizona.
- Designed and prepared cost estimates for several dry cooling systems (e.g., fin fan heat exchangers) used in chemical plants and refineries.
- Designed, evaluated, and costed several zero liquid discharge systems for power plants.

- Evaluated the impact of agricultural and mining practices on surface water quality of Central Valley steams. Represented municipal water agencies on several federal and state advisory committees tasked with gathering and assessing relevant technical information, developing work plans, and providing oversight of technical work to investigate toxicity issues in the watershed.

AIR QUALITY/PUBLIC HEALTH

- Prepared or reviewed the air quality and public health sections of hundreds of EIRs and EISs on a wide range of industrial, commercial and residential projects.
- Prepared or reviewed hundreds of NSR and PSD permits for a wide range of industrial facilities.
- Designed, implemented, and directed a 2-year-long community air quality monitoring program to assure that residents downwind of a petroleum-contaminated site were not impacted during remediation of petroleum-contaminated soils. The program included real-time monitoring of particulates, diesel exhaust, and BTEX and time integrated monitoring for over 100 chemicals.
- Designed, implemented, and directed a 5-year long source, industrial hygiene, and ambient monitoring program to characterize air emissions, employee exposure, and downwind environmental impacts of a first-generation shale oil plant. The program included stack monitoring of heaters, boilers, incinerators, sulfur recovery units, rock crushers, API separator vents, and wastewater pond fugitives for arsenic, cadmium, chlorine, chromium, mercury, 15 organic indicators (e.g., quinoline, pyrrole, benzo(a)pyrene, thiophene, benzene), sulfur gases, hydrogen cyanide, and ammonia. In many cases, new methods had to be developed or existing methods modified to accommodate the complex matrices of shale plant gases.
- Conducted investigations on the impact of diesel exhaust from truck traffic from a wide range of facilities including mines, large retail centers, light industrial uses, and sports facilities. Conducted traffic surveys, continuously monitored diesel exhaust using an aethalometer, and prepared health risk assessments using resulting data.
- Conducted indoor air quality investigations to assess exposure to natural gas leaks, pesticides, molds and fungi, soil gas from subsurface contamination, and outgasing of carpets, drapes, furniture and construction materials. Prepared health risk assessments using collected data.
- Prepared health risk assessments, emission inventories, air quality analyses, and assisted in the permitting of over 70 1 to 2 MW emergency diesel generators.
- Prepare over 100 health risk assessments, endangerment assessments, and other health-based studies for a wide range of industrial facilities.

- Developed methods to monitor trace elements in gas streams, including a continuous real-time monitor based on the Zeeman atomic absorption spectrometer, to continuously measure mercury and other elements.
- Performed nuisance investigations (odor, noise, dust, smoke, indoor air quality, soil contamination) for businesses, industrial facilities, and residences located proximate to and downwind of pollution sources.

PUBLICATIONS AND PRESENTATIONS (Partial List - Representative Publications)

J.P. Fox, T.P. Rose, and T.L. Sawyer, Isotope Hydrology of a Spring-fed Waterfall in Fractured Volcanic Rock, 2007.

C.E. Lambert, E.D. Winegar, and Phyllis Fox, Ambient and Human Sources of Hydrogen Sulfide: An Explosive Topic, Air & Waste Management Association, June 2000, Salt Lake City, UT.

San Luis Obispo County Air Pollution Control District and San Luis Obispo County Public Health Department, *Community Monitoring Program,* February 8, 1999.

The Bay Institute, *From the Sierra to the Sea. The Ecological History of the San Francisco Bay-Delta Watershed*, 1998.

J. Phyllis Fox, *Well Interference Effects of HDPP's Proposed Wellfield in the Victor Valley Water District*, Prepared for the California Unions for Reliable Energy (CURE), October 12, 1998.

J. Phyllis Fox, *Air Quality Impacts of Using CPVC Pipe in Indoor Residential Potable Water Systems*, Report Prepared for California Pipe Trades Council, California Firefighters Association, and other trade associations, August 29, 1998.

J. Phyllis Fox and others, *Authority to Construct Avila Beach Remediation Project*, Prepared for Unocal Corporation and submitted to San Luis Obispo Air Pollution Control District, June 1998.

J. Phyllis Fox and others, *Authority to Construct Former Guadalupe Oil Field Remediation Project*, Prepared for Unocal Corporation and submitted to San Luis Obispo Air Pollution Control District, May 1998.

J. Phyllis Fox and Robert Sears, *Health Risk Assessment for the Metropolitan Oakland International Airport Proposed Airport Development Program*, Prepared for Plumbers & Steamfitters U.A. Local 342, December 15, 1997.

Levine-Fricke-Recon (Phyllis Fox and others), *Preliminary Endangerment Assessment Work Plan for the Study Area Operable Unit, Former Solano County Sanitary Landfill, Benicia, California*, Prepared for Granite Management Co. for submittal to DTSC, September 26, 1997.

Phyllis Fox and Jeff Miller, "Fathead Minnow Mortality in the Sacramento River," *IEP Newsletter*, v. 9, n. 3, 1996.

Jud Monroe, Phyllis Fox, Karen Levy, Robert Nuzum, Randy Bailey, Rod Fujita, and Charles Hanson, *Habitat Restoration in Aquatic Ecosystems. A Review of the Scientific Literature Related to the Principles of Habitat Restoration*, Part Two, Metropolitan Water District of Southern California (MWD) Report, 1996.

Phyllis Fox and Elaine Archibald, *Aquatic Toxicity and Pesticides in Surface Waters of the Central Valley*, California Urban Water Agencies (CUWA) Report, September 1997.

Phyllis Fox and Alison Britton, *Evaluation of the Relationship Between Biological Indicators and the Position of X2*, CUWA Report, 1994.

Phyllis Fox and Alison Britton, *Predictive Ability of the Striped Bass Model*, WRINT DWR-206, 1992.

J. Phyllis Fox, *An Historical Overview of Environmental Conditions at the North Canyon Area of the Former Solano County Sanitary Landfill*, Report Prepared for Solano County Department of Environmental Management, 1991.

J. Phyllis Fox, *An Historical Overview of Environmental Conditions at the East Canyon Area of the Former Solano County Sanitary Landfill*, Report Prepared for Solano County Department of Environmental Management, 1991.

Phyllis Fox, *Trip 2 Report, Environmental Monitoring Plan, Parachute Creek Shale Oil Program*, Unocal Report, 1991.

J. P. Fox and others, "Long-Term Annual and Seasonal Trends in Surface Salinity of San Francisco Bay," *Journal of Hydrology*, v. 122, p. 93-117, 1991.

J. P. Fox and others, "Reply to Discussion by D.R. Helsel and E.D. Andrews on Trends in Freshwater Inflow to San Francisco Bay from the Sacramento-San Joaquin Delta," *Water Resources Bulletin*, v. 27, no. 2, 1991.

J. P. Fox and others, "Reply to Discussion by Philip B. Williams on Trends in Freshwater Inflow to San Francisco Bay from the Sacramento-San Joaquin Delta," *Water Resources Bulletin*, v. 27, no. 2, 1991.

J. P. Fox and others, "Trends in Freshwater Inflow to San Francisco Bay from the Sacramento-San Joaquin Delta," *Water Resources Bulletin*, v. 26, no. 1, 1990.

J. P. Fox, "Water Development Increases Freshwater Flow to San Francisco Bay," *SCWC Update*, v. 4, no. 2, 1988.

J. P. Fox, *Freshwater Inflow to San Francisco Bay Under Natural Conditions*, State Water Contracts, Exhibit 262, 58 pp., 1987.

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J. P. Fox, "El Mercurio en el Medio Ambiente: Aspectos Referentes al Peru," (Mercury in the Environment: Factors Relevant to Peru) Proceedings of Simposio Los Pesticidas y el Medio Ambiente," ONERN-CONCYTEC, Lima, Peru, April 25-27, 1984. (Also presented at Instituto Tecnologico Pesquero and Instituto del Mar del Peru.)

J. P. Fox, "Mercury, Fish, and the Peruvian Diet," *Boletin de Investigacion*, Instituto Tecnologico Pesquero, Lima, Peru, v. 2, no. 1, pp. 97-116, l984.

J. P. Fox, P. Persoff, A. Newton, and R. N. Heistand, "The Mobility of Organic Compounds in a Codisposal System," *Proceedings of the Seventeenth Oil Shale Symposium*, Colorado School of Mines Press, Golden, CO, 1984.

P. Persoff and J. P. Fox, "Evaluation of Control Technology for Modified In-Situ Oil Shale Retorts," *Proceedings of the Sixteenth Oil Shale Symposium*, Colorado School of Mines Press, Golden, CO, 1983.

J. P. Fox, *Leaching of Oil Shale Solid Wastes: A Critical Review*, University of Colorado Report, 245 pp., July 1983.

J. P. Fox, *Source Monitoring for Unregulated Pollutants from the White River Oil Shale Project*, VTN Consolidated Report, June 1983.

A. S. Newton, J. P. Fox, H. Villarreal, R. Raval, and W. Walker II, *Organic Compounds in Coal Slurry Pipeline Waters*, Lawrence Berkeley Laboratory Report LBL-15121, 46 pp., Sept. 1982.

M. Goldstein et al., *High Level Nuclear Waste Standards Analysis, Regulatory Framework Comparison*, Battelle Memorial Institute Report No. BPMD/82/E515-06600/3, Sept. 1982.

J. P. Fox et al., *Literature and Data Search of Water Resource Information of the Colorado, Utah, and Wyoming Oil Shale Basins*, Vols. 1-12, Bureau of Land Management, 1982.

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Exhibit B to Fox Report

Exhibit B - Eight-hour Ozone Standard Attainment Status of Refineries With Direct or Indirect Connections to Keystone XL

Refinery	Location	8-hour ozone (1997) nonattainment, if any*	8-hour ozone (2008) nonattainment, if any**
Gulf Coast Refineries With Direct Pipeline Access To The Proposed Project			
Motiva Enterprises, LLC	Port Arthur, TX	n/a	n/a
Total Petrochemicals	Port Arthur, TX	n/a	n/a
Premcor Refining Group	Port Arthur, TX	n/a	n/a
Exxon Mobil	Beaumont, TX	n/a	n/a
Pasadena Refining	Pasadena, TX	Severe 15	Marginal
Houston Refining	Houston, TX	Severe 15	Marginal
Valero Energy Corp.	Houston, TX	Severe 15	Marginal
Deer Park Refining	Deer Park, TX	Severe 15	Marginal
Exxon Mobil	Baytown, TX	Severe 15	Marginal
BP	Texas City, TX	Severe 15	Marginal
Marathon Petroleum Co.	Texas City, TX	Severe 15	Marginal
Valero Energy Corp.	Texas City, TX	Severe 15	Marginal
Calcasieu Refining	Lake Charles, LA	n/a	n/a
CITGO	Lake Charles, LA	n/a	n/a
ConocoPhillips	Lake Charles/Westlake, LA	n/a	n/a
Gulf Coast Refineries In PADD 3 Without Direct Pipeline Access To The Proposed Project			
Hunt Refining Co.	Tuscaloosa, AL	n/a	n/a
Shell Chemical	Saraland, AL	n/a	n/a
ConocoPhillips	Belle Chasse, LA	n/a	n/a
Exxon Mobil	Baton Rouge, LA	n/a	Marginal
Alon Refining	Krotz Springs, LA	n/a	n/a
Valero Energy Corp.	St. Charles/Norco, LA	n/a	n/a
Marathon Petroleum	Garyville, LA	n/a	n/a
Chalmette Refining	Chalmette, LA	n/a	n/a
Valero Energy Corp.	Meraux, LA	n/a	n/a
Motiva Enterprises LLC	Norco, LA	n/a	n/a
Motiva Enterprises LLC	Convent, LA	n/a	n/a
Placid Refining	Port Allen, LA	n/a	Marginal
Shell Chemical	Saint Rose, LA	n/a	n/a
ChevronTexaco	Pascagoula, MS	n/a	n/a

Refinery	Location	8-hour ozone (1997) nonattainment, if any*	8-hour ozone (2008) nonattainment, if any**
Gulf Coast Refineries In PADD 3 Without Direct Pipeline Access To The Proposed Project (cont.)			
ConocoPhillips	Sweeny, TX	Severe 15	Marginal
CITGO	Corpus Christi, TX	n/a	n/a
Valero Energy Corp.	Three Rivers, TX	n/a	n/a
Flint Hills Resources	Corpus Christi, TX	n/a	n/a
Valero Energy Corp.	Corpus Christi, TX	n/a	n/a
Inland PADD 3 Refineries With Possible Pipeline Connection To The Proposed Project			
Navajo Refining	Artesia, NM	n/a	n/a
WRB Refining	Borger, TX	n/a	n/a
Valero Energy Corp.	Sunray/McKee, TX	n/a	n/a
AlonUSA	Big Spring, TX	n/a	n/a
Delek	Tyler, TX	n/a	n/a
Inland PADD 3 Refineries Without Pipeline Access To The Proposed Project			
No refineries specified			

Sources: U.S. Dept. of State, Keystone XL Project Draft Supplemental Environmental Impact Report (March 2013), Table 4.15-18; U.S. EPA, The Green Book Nonattainment Areas for Criteria Pollutants, http://www.epa.gov/oaqps001/greenbk/ (accessed April 12, 2013).

*Key for severity of 8-hr ozone nonattainment - 1997 standard:

Severe 17
Severe 15
Serious
Moderate
Marginal

**Key for severity of 8-hr ozone nonattainment - 2008 standard:

Extreme
Severe 15
Serious
Moderate
Marginal

Exhibit C to Fox Report

Exhibit C: Verifications of Emissions Estimates									
	MOTIVA (DSEIS p 4.15-77)		**HYPERION** (DSEIS p 4.15-77)		**PROJECT** (calculated by scaling up Motiva and Hyperion emissions)			**DSEIS ESTIMATE** (DSEIS p 4.15-78)	
BPD	325,000		400,000		830,000			830,000	
					Motiva	**Hyperion**		**Motiva**	**Hyperion**
	ton/yr		ton/yr		ton/yr	ton/yr		ton/yr	ton/yr
NOx	592.74		687		1,514	1,426		1,514	1,604
CO	1489.53		810		3,804	1,681		3,804	4,148
VOC	-116.73		536		-298	1,112			1,718
SO2	1679.73		183		4,290	380		4,290	1,791
PM	464.37		1035		1,186	2,148		1,186	2,170