Supplemental Information for the
Endangered Species Impacts Assessment for the
ExxonMobil Oil Corporation - Joliet Refinery
Unit Reliability - Efficiency Improvement Projects

Prepared by:

ExxonMobil

September 1, 2005

A teleconference was conducted on August 22, 2005 with the purpose of reviewing the report "Endangered Species Impacts Assessment, ExxonMobil Oil Corporation - Joliet Refinery, Unit Reliability - Efficiency Improvement Projects, August 3, 2005", prepared by ExxonMobil Oil Corporation (ExxonMobil) and submitted August 4, 2005. During this call, several specific items were identified for follow-up either by ExxonMobil, Cambridge Environmental (Cambridge), or the United States Environmental Protection Agency (USEPA).

This report and the attached report from Cambridge address the eleven items that were assigned to ExxonMobil and/or Cambridge. The items are addressed individually, and are provided in the same order in which they were discussed during the conference call. The discussion for each item begins with a brief description of the item followed by the supplemental information.

Item #1 - Additional Language to Document the Basis for No Short-Term Effects

On the July 7, 2005 teleconference call to review the Roadmap, the nature of the Crude/Coker Utilization Project (CCUP) was discussed and there was agreement by all that the project and associated permit limitations are such that no short-term or acute effects are realizable. This determination was noted on Page 19 of the August 3, 2005 report. During the August 22, 2005 call, the United States Fish & Wildlife Service (USFWS) requested further documentation of the basis of this determination. The following basis is provided.

The CCUP permit will approve several projects which allow for an increase in the annual fuels production at the refinery by improving efficiency of equipment, reducing planned downtime of equipment, and alleviating seasonal constraints that can be encountered during ambient temperature extremes. For the proposed CCUP project, the design rates of the existing equipment is not changing, and therefore, the maximum hourly and daily emission rates will remain at or below the historically demonstrated maximum hourly and daily emission rates. Additionally, the associated permit limits will not be changed.

The project should be reviewed for chronic impacts, as the project will result in emission rates from the existing equipment approaching the maximum hourly and daily demonstrated rates more frequently over the course of a year.

Item #2 - Further Support for No Acid Fog Effects

USFWS requested additional language to support the acid fog discussion in the August 3, 2005 report. In particular, Ms. Karla Kramer requested a focused review of impacts from acid fog during the growing season from May to August.

As discussed in Item #1, the CCUP project focuses on reducing the number and duration of planned maintenance events and on alleviating seasonal constraints. Each of these is discussed below.

Portions of the project will allow for a reduction in the scheduled maintenance for existing equipment at the refinery. Historically, and in all existing future business plans, major scheduled maintenance activities are planned to occur outside the summer travel season (late April to Mid September) when gasoline demand is high. During this season, every effort is made to maintain high production levels to meet the marketplace demand. Note, minor maintenance activities occasionally occur, such as maintenance work on the Auxiliary Boiler, as steam demand may be lower during the summer months when ambient temperatures lessen the refinery demand for steam.

The objective of the portions of the project that are focusing on alleviating seasonal constraints, is primarily to address "overhead" constraints that occur when the ambient temperature is in excess of 85 - 90ºF. As the temperature increases, there is generally less need for steam production, but as the fractionation process occurs, less cooling is available (primarily air cooling). The result is that lighter fractions of material processed cannot be cooled sufficiently to condense to liquid form in the fractionation tower, resulting in more overhead material (gaseous in nature) that must be compressed in the overhead system. As the quantity of overhead material increases, the maximum design rates of the compressors are reached. Improvements are being made to the efficiency of the overhead cooling system that will minimize the impact of high ambient temperatures on the directional increase in overhead material production. As a result, the refinery will experience fewer rate cuts during the heat of the day in the summer months. Other rate cuts are due to insufficient cooling of intermediate product streams, which will be improved by more efficient equipment. Since these seasonal constraints are experienced during high temperatures (summer - midday hours), there will not be any increase in the probability of increased production coinciding with periods of the day when fog occurs (as fog does not form during the hot hours of the day). Additionally, since the seasonal constraint that is met is an overhead or product cooling constraint, and not a firing duty constraint, emissions from combustion devices during such times are still below levels that occur when firing duty becomes the primary constraint.

Due to the nature of the project, the impacts of this project during the May to August growing season (planned shutdowns and relaxation of seasonal constraints during hot summer days) do not coincide with conditions for fog formation and, as a result, there is no added potential for acid fog formation as a result of the proposed CCUP project.

ExxonMobil maintains its claim in the August 3, 2005 report that the Chicago area does not provide conditions (meteorological or topographic) that are conducive to acid fog formation and, to our knowledge, there is no historical documentation of acid fog occurrences in the area.

Item #3 - Clarification on Table 4-19 of Benchmark Value & Confirmation of Nitrogen Deposition Benchmark Value

USFWS asked for clarification on Table 4-19. The purpose of this table was to demonstrate that the project does not result in a nitrogen deposition flux that exceeds the established benchmark of 1 g/m^2-yr, which was presented earlier in the report in Table 4-17. For clarification purposes, a revised version of the table with additional text (in red) is provided below, explicitly specifying the nitrogen benchmark value.

Chemical	Highest Modeled Deposition Rate at a Receptor Location	Published Representative Background Deposition Rate	Indeck Elwood Addition to Background Deposition Rate	Total Background	Combined Effect	% Project Increase over Background Deposition Rate	Combined Effect Exceeds Benchmark [1 g/m^2-yr]?
	[A]	[B]	[C]	=[B]+[C]	[D] = [A]+[B]+[C]	[A]/([B]+[C])	[D] < 1
	[g/m^2-yr]	[g/m^2-yr]	[g/m^2-yr]	[g/m^2-yr]	[g/m^2-yr]	%	Y or N
Nitrogen (ISC)	8.3E-02	7.1E-01	1.1E-02	7.2E-01	8.0E-01	11.5%	N
Nitrogen (Calpuff est.)	9.5E-03	7.1E-01	1.1E-02	7.2E-01	7.3E-01	1.3%	N

Regarding the appropriateness of the benchmark, USFWS requested clarification on the establishment of the value 1 g/m^2-yr by Cambridge Environmental. Cambridge noted that literature from various sources was reviewed and that the value was ultimately selected from European guidelines. USFWS requested further review of North American studies to confirm that they are consistent with the European studies. This review has been provided in the attached supplemental information report from Cambridge Environmental. Cambridge reaffirms in their supplemental report the established value of 1 g/m^2-yr.

Also in context to Table 4-19, there was discussion regarding the merits of juxtaposing data from two models (Calpuff and ISC) employed for another consultation, and using this data to infer lower nitrogen deposition fluxes by the employment of a more advanced model. This discussion was concluded with the remark that the model selection does not change the finding. As a result, USEPA has concluded that it can base its determination on the ISC model results and ignore the Calpuff-based results. For future reference, Ms. Barbara Mazur of USEPA recommended that this information be included within the uncertainty discussion.

Item #4 - NOEL vs. LOAEL

USFWS has requested clarification of the benchmark values provided in Table 4-19 of the August 3, 2005 report. Specifically, USFWS would like clarification of which values are "No Observed Effects Level" ("NOEL") versus "Low Observed Adverse Effects Level" ("LOAEL").

Table 4-17 of the report is a compilation of the benchmarks established by literature research conducted and summarized by Cambridge Environmental, and provided as Attachment C of the August 3, 2005 report. As noted in the Cambridge report and discussed during teleconference calls on July 7, 2005 and July 12, 2005, although the desired benchmark value for comparison is a NOEL, the literature does not provide documentation of any impact studies of the effects of the specific pollutants of concern from the proposed project on the specific species of concern. Thus, no clear distinction can be drawn between whether values correspond to NOEL or LOAEL.

As a result of not being able to discern whether values are NOEL or LOAEL, all values that were provided by Cambridge should be treated as "relevant toxicity information to provide a basis for risk assessment for the species of concern", which is the alternative approach identified in the Benchmark section of the July 7, 2005 Roadmap.

Item #5 - Hydrogen Chloride - Acute Effect vs. Chronic Effect

USFWS requested clarification on why, in some cases, Cambridge Environmental's August 2, 2005 letter report "Ecotoxicological Benchmarks for the ExxonMobil Refinery Consultation" (Attachment C of the August 3, 2005 report), addresses acute effects rather than chronic. For example, with hydrogen chloride, Cambridge's report notes that "a search of toxicological benchmark references failed to yield useful information on hydrogen chloride (HCl) phytotoxicity". As there was no discussion in the literature of any chronic effects, Cambridge noted that the literature does provide some references regarding short-term toxicity. Although no chronic effects were noted in the literature, to be conservative, Cambridge reviewed the literature on short-term effects and established a chronic benchmark screening level by applying a factor of 10 reduction to the level at which short-term effects were documented in the literature (not specifically for the listed threatened and endangered species of concern for this consultation). This approach was also applied with carbonyl sulfide (COS), as noted in the August 2, 2005 Cambridge report.

Item #6 - Sediment Impacts for Hine's Emerald Dragonfly

Although the template USFWS document provided to ExxonMobil for assessment of impacts to the Hine's Emerald Dragonfly (HED) did not address sediment impacts from pollutant deposition, USFWS has requested that ExxonMobil augment the August 3, 2005 assessment to address sediment. As found in Attachment A, Cambridge Environmental has addressed this issue, including modeling and benchmark identification. For the chemicals of discussed concern, Nickel and Phosphorus, Cambridge was able to conclude that the project is not likely to adversely impact the HED through sediment toxicity, as it would take tens to hundreds of thousands of years for sediment concentrations to concentrate to benchmark levels.

Item #7 - Treatment of "de Minimis HAP"

In Section 3.2.1 of the report, the de minimis HAP threshold from the recent Indeck Elwood ESA consultation was employed based on the fact that ambient concentrations from emissions at the de minimis level are "so low it [they] cannot be typically measured". USFWS requested confirmation of this or further assessment of individual HAPs.

For the non-zero HAPs that were treated as "de minimis" in the August 3, 2005 report, ExxonMobil has researched detection limits and has compared them to highest modeled concentrations from any of the habitat locations. The following table provides the compiled data from this analysis. All modeled concentrations are a small fraction of the minimum reported detection limit from referenced U.S. EPA sources. In a few instances where detection limits were not reported for organic compounds, the detection limit for a similar compound was used (e.g., benzene for a volatile organic compound, napthalene for a semivolatile organic compound). The highest concentration relative to detection limits was for zinc, which was modeled at 0.3% of the detection limit.

Modeled HAP Concentrations vs. Minimum Detection Limits for De Minimis HAP from the August 3, 2005 Endangered Species Impact Assessment Report

Pollutant	**Emission Increases (Past-Actual to Future-Potential)**	Documented MDL for Air Sampling	Reference[1]	Note	Highest Modeled Concentration	Highest Air Concentration as a Fraction of MDL
	[pounds / yr]	[μg/m³]			[μg/m³]	
Metal HAP						
Antimony	2.5	1.0E-02	A		9.8E-07	0.0%
Arsenic	4.1	1.0E-02	A		1.6E-06	0.0%
Barium	22.0	1.0E-02	A		8.5E-06	0.1%
Beryllium	0.8	1.0E-02	A		3.1E-07	0.0%
Cadmium	2.0	1.0E-02	A		7.9E-07	0.0%
Chromium (Total)	7.2	1.0E-02	A		2.8E-06	0.0%
Cobalt	1.2	1.0E-02	A		4.6E-07	0.0%
Copper	12.2	1.0E-02	A		4.7E-06	0.0%
Cyanide Compounds	34.3	1.0E-02	A		1.3E-05	0.1%
Lead	8.5	1.0E-02	A		3.3E-06	0.0%
Manganese	11.9	1.0E-02	A		4.6E-06	0.0%
Mercury	1.1	1.0E-02	A		4.3E-07	0.0%
Selenium	2.1	1.0E-02	A		8.0E-07	0.0%
Silver	1.4	1.0E-02	A		5.5E-07	0.0%
Thallium	18.0	1.0E-02	A		7.0E-06	0.1%
Zinc	86.3	1.0E-02	A		3.3E-05	0.3%
Organic HAP						
1,3-Butadiene	12.3	2.2E+00	B		1.3E-06	0.0%
2-Methylnaphthalene	0.2	1.4E+04	B	2	1.8E-08	0.0%
Acetaldehyde	177.1	2.4E+00	B		1.9E-05	0.0%
Benzene	97.2	1.1E+00	B		1.0E-05	0.0%
Cumene	3.9	1.7E+00	B		4.1E-07	0.0%
Ethylbenzene	61.3	1.2E+00	B		6.5E-06	0.0%
Fluorene	0.1	1.9E+04	B		5.5E-09	0.0%
Formaldehyde	173.1	1.8E+00	B		1.8E-05	0.0%
n-Hexane	57.4	1.2E+00	B		6.1E-06	0.0%
Methanol	0.9	4.5E-01	B		9.7E-08	0.0%
Naphthalene	27.7	1.4E+04	B		3.0E-06	0.0%
Phenanthrene	0.1	1.4E+04	B	2	1.3E-08	0.0%
Phenol	9.5	1.3E+00	B	3	1.0E-06	0.0%
Propylene	108.4	5.8E-01	B		1.2E-05	0.0%

[1] Reference A National Monitoring Strategy - Air Toxics Component, Final Draft, July 2004, US EPA OAQPS; Reference B USEPA Quality Assurance Guidance Document, EPA Document 454/R-01-007.

[2]Assumed equal to naphthalene

[3]Assumed equal to benzene

Item #8 Analysis of Effects for HAP

USFWS requested a clarification of combined effects for the project with Indeck for comparison to environmental benchmarks.

As discussed earlier for Item #3, the presentation in Table 4-19 resulted in some confusion. Specifically for chloride and phosphorus deposition fluxes, Cambridge was unable to obtain any literature data to support the establishment of benchmarks and, instead, noted representative background data. For these two chemicals, Table 4-19 denotes that the highest modeled concentrations (annual, worst one year from five modeled years) at any of the receptor locations are 0.9% and 0.1% of background, respectively. As there is no established benchmark in the literature, and values are close to background, the conclusion has been drawn that a small increase to background will result in no observed effects.

For nickel accumulation in soils, it was calculated that tens of thousands to hundreds of thousands of years of operation would be necessary to accumulate benchmark levels of nickel. This benchmark value was used for the recent Indeck Elwood ESA consultation. As noted by Ms. Karla Kramer during the call, the Indeck report indicated thousands of years of operation to accumulate benchmark levels of nickel. The combined effects of the projects would again conclude that thousands of years of operation would be necessary before benchmark levels of nickel would accumulate.

Item #9 Time Periods for each Modeling Table in Section 4

For each of the tables in Section 4.3 that provide model results for the specified habitat, the results are based on the average annual concentration or deposition rate from the worst (highest) one of the five years (1986 to 1990) modeled. The complete data set is provided as Attachment D to the report.

Item #10 Particulate Matter & Stomatal Uptake

USFWS was concerned whether the particulate matter deposition benchmark was thoroughly evaluated, including three specific references provided by USFWS. It was noted by ExxonMobil and Cambridge that the references, although not discussed in the August 3, 2005 Impact Assessment report, were likely reviewed. Cambridge agreed to confirm this by reviewing the specifics of these references and providing a summary of the findings of these documents as they relate to the August 3 report's benchmark. This review is included in the Cambridge supplemental report included as Attachment A. In conclusion, Cambridge concludes in their supplement that the 10 g/m^2-yr benchmark is inclusive of the additional reports.

Item #11 With Respect to Figure 3-1, is the Use of F_V Acceptable?

The definition of the factor F_V, was reviewed. This factor and values for it were taken from USFWS the SLERA protocol, which was referenced in the Roadmap. USFWS air modeler Tim Allen accepted that this is a reasonable approach and this issue was considered closed.

ATTACHMENT A

Supplemental Infomation for the Endangered Species Impact Assessment
for the ExxonMobil Joliet Refinery
August 25, 2005,
Cambridge Environmental, Inc.

Supplemental Information for the Endangered Species Impact Assessment for the ExxonMobil Joliet Refinery

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Cambridge Environmental Inc.
August 25, 2005

Assessment of pollutant deposition to sediments in Hines' emerald dragonfly habitats

The August 3, 2005 Endangered Species Impact Assessment (ESIA) models pollutant concentrations in the water column of habitat areas of the Hines' emerald dragonfly to gauge the potential for deposition of pollutant emissions from the ExxonMobil refinery to adversely affect the species. The aquatic habitat is viewed as the critical life stage of this dragonfly as the larval stage dominates its overall life cycle. Since the larvae spend considerable time in sediments, however, consideration of the water column alone may be insufficient to gauge the potential toxicity of pollutant deposition, as some pollutants can be expected to deposit to sediments based on their fate and transport characteristics. Since the larvae principally reside in sediments, potential increases in pollutant concentrations in the sediments are more directly relevant to adverse effects on the dragonfly.

For reasons detailed further on, the model used to estimate increases in pollutant concentrations in soil that could result from deposition of refinery emissions is also an appropriate model for estimating potential increases in pollutant concentrations in sediments. The model mixes pollutant deposition within a shallow layer:

$$C_{POLsed} = \frac{D_{POLsed}\,T_{Exxon}}{d_{sed}\,\rho_{sed}}$$

where the terms are:

C_{POLsed}	Concentration (mass fraction) of the pollutant in sediment (mg/kg);
D_{POLsed}	Project-related increase in pollutant deposition rate, as estimated by air dispersion modeling (mg/m^2–year);
T_{Exxon}	Years from modification of the ExxonMobil facility;
d_{sed}	Depth of the shallow sediment layer (m); and
ρ_{sed}	Bulk density of sediment (kg/m^3).

The mixing model assumes no pollutant removal from the shallow sediment layer, even though the processes of erosion, leaching, volatilization, or degradation are relevant to many pollutants and serve to reduce their concentrations in sediment over time. As such, the mixing model will likely overestimate actual pollutant concentrations that are likely to result while the facility is operating.

The above equation can be rearranged to predict the number of years of facility operation, $T_{SSC,,}$ necessary to reach a pollutant-specific sediment screening concentration, C_{POLssc}:

$$T_{SSC} = \frac{d_{sed} r_{sed} C_{POLssc}}{D_{POLsed}}$$

As acknowledged in the ESIA, modeling of pollutant behavior in aquatic systems is complex. Chapter 3 of the Screening-Level Ecological Risk Assessment (SLERA) guidance (U.S. EPA. 1999) describes the general framework for evaluating pollutant deposition to watersheds. Loadings to streams and other water bodies generally have two components: direct deposition to the water surface and the erosion/runoff of surface soils that have also received and incorporated pollutant deposition. Limiting cases suggest that the simple mixing model is an adequate screening tool to evaluate potential accumulation of pollutants in sediment. In the case in which soil erosion is minimal, direct deposition to the water surface contributes all of the pollutant loading, and direct application of the sediment mixing model is appropriate. At the other extreme in which soil erosion is high and contributes the majority of pollutant loading, the sediments essentially maintain the same composition as the soils that enter the water and settle as sediments. In this case, assuming that the mixing depths and bulk densities of the sediments and soils are similar, the simple mixing model remains an applicable screening tool. A potential situation for which the mixing model would be inadequate is the case in which pollutants that first deposit to soil fail to mix within the soil layer prior to their erosion and runoff into a water body. An example of this occurrence might be the deposition of pollutants to an impervious surface (*e.g.*, a paved parking lot) with subsequent washoff/runoff into a water body during a storm event. In this case, the effective pollutant loading to sediments is larger than that considered by the simple mixing model.

For the purpose of screening-level estimates, it is assumed that the watershed habitat areas of the Hines' emerald dragonfly are not dominated by impervious surfaces. Of the pollutants of concern, nickel is the only chemical likely to deposit to wastersheds and accumulate in sediments. Chloride and phosphorus are likely to deposit but remain soluble, although phosphorus could deposit and accumulate depending on its chemical speciation, and so is also evaluated. An appropriate sediment screening criteria for nickel is 22.7 mg/kg (U.S. EPA, 2005; U.S. EPA, 2003), a value considered to be protective of all species. Few regulatory sediment screening-levels are available for phosphorus, although the Risk Assessment Information System (RAIS, 2005) provides a value of 600 mg/kg established by Ontario as a Low Sediment Screening Benchmark. As a second gauge of phosphorus benchmarks, a compendium of measurements of background concentrations of phosphorus in sediments provides a range of 14 to 88,000 mg/kg in

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Midwestern states including Illinois (USGS, 2005) among 846 measurements (median concentration: 971 mg/kg).

U.S. EPA (1999) recommends a sediment mixing depth of 3 cm (the recommended depth of the upper benthic sediment layer) and a bulk sediment density of 1 g/cm^3 (the benthic solids concentration). Converting units, parameter values for the sediment mixing equation are d_{sed} =0.03 m and $?_{sed}$ =1000 kg/m^3. Maximum projected deposition rates for nickel and phosphorus are 0.032 mg/m^2-yr and 0.046 mg/m^2-yr, respectively, at the habitat locations relevant to the Hines' emerald dragonfly. Based on these rates and sediment parameters, more than 21,000 years of facility operation are required to reach the nickel sediment screening criterion of 22.7 mg/kg, and more than 390,000 years to reach the phosphorus screening criterion of 600 mg/kg. Based on these results, emissions from the ExxonMobil refinery are not likely to adversely affect the Hines' emerald dragonfly through sediment toxicity.

Further assessment of the nitrogen deposition benchmark

The World Health Organisation (WHO) Air Quality Guidelines for Europe (2002) document suggests 1-1.5 g/m^2-yr[1] as the lowest range of deposition rates for nitrogen that produce an observable adverse effect on species-rich heathland, a description applicable to the Joliet refinery location. Based on this information, 1 g N/m^2-yr is recommended as the benchmark value for nitrogen deposition pertaining to the ExxonMobil refinery proposal. However, because the WHO document provides guidelines for Europe (and relies on data collected principally in European nations), other sources were consulted, as recommended, in an attempt to establish a more appropriate value for nitrogen deposition in the Illinois tallgrass prairie that surrounds the Joliet refinery.

Weiss (1999) examined the danger of nitrogen deposition from air pollution to biodiversity in the San Francisco Bay area grassland. Specifically, this paper examines the changes in the Bay checkerspot butterfly population due to fluctuations in the total nitrogen present in the grassland system. Conceptually, Weiss determined that air pollution deposits nitrogen to the grassland and allows invading grass species to take hold. Controlled cattle grazing, however, decreases nitrogen levels in the system and inhibits growth of invading species. As the checkerspot butterfly depends on indigenous plant species to house its larvae, elimination of the controlled cattle grazing has apparently led to increases in the available nitrogen in the grassland system and allowed invading species to crowd out the indigenous ones, causing checkerspot butterfly populations to dramatically decrease over short periods of time.

[1] Reported units of pollutant deposition vary among sources. Frequently, units of kg/ha-yr or g/m^2-yr are used. Both sets of units have been used in the ESIA, in part to maintain consistency with the reporting conventions used in references. Here, units of g/m^2-yr are used exclusively for convenience of comparison. Values reported in kg/ha-yr in the ESIA can be reconciled with the conversion factor of 1 g/m^2-yr = 10 kg/ha-yr.

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Weiss estimates nitrogen deposition rates for two areas near San Francisco: 1–1.5 g/m^2-yr in the south San Jose grasslands, where the checkerspot butterfly population precipitously declined after cessation of cattle grazing. No changes in butterfly populations have been observed in San Francisco Peninsula grasslands, where grazing has not occurred since 1960 and the estimated nitrogen deposition rate is 0.4–0.6g/m^2-yr. Weiss does not account for wet nitrogen deposition, which is less significant in California, but probably adds 0.1–0.2 g/m^2-yr, based on limited monitoring in the area (NADP, 2005). Assuming that the observed reduction in butterfly populations has resulted from increased availability of nitrogen in the areas of higher nitrogen deposition, a nitrogen deposition rate of about 1.1 g/m^2-yr (1 g/m^2-yr dry plus 0.1 g/m^2-yr wet) represents the low-end of the estimated range that could have caused the effect, while 0.7 g/m^2-yr (0.6 g/m^2-yr dry plus 0.1 g/m^2-yr wet) corresponds to a deposition level tolerated at the Peninsula grasslands. The threshold level, or critical nitrogen loading, appears to be in the range of 0.7–1.1 g/m^2-yr, and hence the benchmark of 1 g N/m^2-yr derived from the WHO (2002) guidelines is consistent with the Weiss (1999) data. It should be noted that, as with any study, the findings of Weiss (1999) must be interpreted within the realm of its uncertainties and applicability. Significant declines in checkerspot butterfly populations occur at locations that continued to be grazed (Weiss, 1999), suggesting that stressors other than increased nitrogen deposition may be contributing to habitat changes. Also, there are differences in habitats between the San Francisco area grasslands examined in Weiss and the tallgrass prairie of concern in the ExxonMobil proposal; it is unclear how they may affect the relative benchmark values for each location.

Another source consulted on recommendation, Stevens et al. (2004), suggests that there may not be a threshold benchmark value for nitrogen deposition at all. In this study of British grasslands subjected to a wide range of ambient annual nitrogen deposition (0.5-3.5 kg/ha-yr), Stevens et al. correlate the adverse effects of elevated nitrogen deposition in terms of decreasing biodiversity. They report a linear relationship between nitrogen deposition and biodiversity, claiming that for every 0.25 g N/m^2-yr deposited, the species number declines by one. The data underlying the correlation are considerably scattered, but "by eye" support a discernible trend. The scatter makes it impossible, however, to gauge the existence of a threshold effect level.

Even if the findings of Stevens et al. (2004) are valid and there is no threshold for adverse effects of nitrogen deposition on biodiversity decrease, the slope of the correlation suggests that the proposed changes in emissions from the Joliet refinery will not contribute to discernible differences in species diversity. Table 4-19 of the ESIA indicates the highest anticipated increase in nitrogen at any of the threatened and endangered species will be 0.08 g/m^2-yr, and this value is less than the 0.25 g/m^2-yr that Stevens et al. estimate is needed to decrease biodiversity by a single species.[2] As with

[2] The difference is even larger if the approximate 0.01 g/m^2-yr maximum increase in nitrogen deposition estimated by extrapolating the Indeck CALPUFF modeling is considered. At this value, the increased level

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the Weiss study (1999), there are uncertainties with respect to the applicability of the Stevens et al. (2004) findings). The study considers acidic grasslands in the United Kingdom that may differ markedly in character from the alkaline soils of the tallgrass prairie surrounding the Joliet refinery.

Finally, a third source, Suding et al. (2005), examined 967 plant species' responses to increased nitrogen deposition from 34 separate experiments conducted across nine sites representing major herbaceous ecosystems in temperate North America. One of the nine regions, called Konza Prairie, is similar in nature and in the same region of the country as the prairie habitats addressed in the ESIA. Through comparison of nitrogen-fertilized to non-fertilized areas, Suding et al. investigated the effects of elevated nitrogen deposition on biodiversity. To measure these effects, plant species were divided into functional groups according to six traits (C_3 or C_4 photosynthesis; association with a nitrogen-fixing symbiont; annual/biennial or perennial; height relative to the canopy; nonclonal, caepitose, or rhizomatous; and native or nonnative to North America). Subsequently, plants' responses to increased nitrogen deposition were evaluated functionally (trait-based analysis) and numerically (abundance-based analysis). Suding et al. found that both functional and numerical mechanisms are related to the decline in species diversity due to increased nitrogen deposition.

Although this study is intricate in design, it affords little application to ExxonMobil's Joliet refinery as the nitrogen levels examined by Suding et al. are at least ten times higher than those identified for benchmark value. Specifically, the lowest rate of nitrogen deposition examined by Suding et al. in the Konza Prairie region is 10 g/m^2-yr, or ten times the 1 g/m^2-yr established earlier as a benchmark value, and more than ten times greater than the background nitrogen deposition rate of 0.7 g/m^2-yr. Suding et al. studied the consequences of soil fertilization, *i.e.*, intentional soil amendment, and the rates of nitrogen amendment in their study are too large to yield information relevant to background nitrogen deposition levels.

Examination of these three recommended sources resulted in a reaffirmation of the initially established 1 g/m^2-yr as an appropriate benchmark value for nitrogen deposition around the Joliet refinery location.

Further assessment of the particulate deposition benchmark

An e-mail communication with the U.S. Fish and Wildlife Service (USF&WS, 2005) provided three suggested sources of initial information on the adverse effects of particulate matter on vegetation. These sources are in fact considered in the derivation of the particulate matter deposition benchmark used in the ESIA, as they led to the

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of nitrogen deposition is twenty-five times smaller than that required to cause an observable change in biodiversity.

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investigation of related studies. Details of the particulate matter benchmark are provided in the ESIA. The benchmark deposition rate of 10 g/m^2-yr is derived from a series of studies that examined changes in plant metabolic functions (specifically a reduction in the rate of photosynthesis) that have been observed at sufficiently high coatings of dust on leaf surfaces. The particulate matter benchmark is based on a level of dust coating at which a reduction in photosynthesis is first observed, and hence represents a threshold effects level.

U.S. EPA (2004) describes the physical effects of particulate matter deposition to vegetation. Dust coating of leaves results in a reduction of the solar radiation received by vegetation and can result in the clogging of stomata. Both of these physical effects can produce symptomatic metabolic effects, including increases in leaf temperature and reductions in the rate of photosynthesis. Consequently, the reduction in photosynthesis selected as the endpoint of the benchmark derivation is directly tied to the concerns over stomata clogging expressed by USF&WS (2005).

Some additional observations on the specific references provided by USF&WS (2005) are noted. The first reference:

http://www.plantphys.net/printer.php?ch=25&id=262

is an essay associated with a textbook on plant physiology, and provides a general overview on the adverse effects of air pollution on plants. The essay states generically that "dust on leaves blocks stomata and lowers their conductance to CO_2, simultaneously interfering with photosystem." No quantitative details or references are provided, but the gist of the statement supports the symptomatic effects-based threshold (reduced photosynthesis associated with dust deposition) used to develop the particulate matter deposition benchmark.

The second source of information:

http://smelter.csir.co.za/air_emission_impacts_vegetation_agriculture.pdf

is a third-party assessment of the potential effects of emissions from an industrial source on vegetation (similar in many aspects to the ESIA). Relevant portions of the report include Section 4.4:

> "Armbrust (1986) indicated that wind-erodible dust of particle size less than 0.106 mm, applied at concentrations greater than 15.2 $\mu g/m^2$, resulted in a reduction in dry weight of cotton plants, brought about by a reduction in photosynthesis and an increase in respiration. The response of different plant species to particulates will depend largely on the nature and composition of the particulates."

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and Section 5.4.1:

> "… plants being covered with a dust layer, especially in areas close to earthworks, quarries and roads. The degree to which photosynthesis and growth of such plants will be decreased due to the shading effects and obstruction of stomates, will depend on the dust load, prevailing winds and frequency of rain fall."

Both statements regarding the physiological effects of particulate matter deposition support the derivation of the particulate matter deposition benchmark, with the symptom of reduced photosynthesis serving as a marker of the effects of dust coating (including stomata clogging). Note that the referenced paper is one of those included in the review article that serves as the basis of the particulate matter deposition benchmark. The dust application rate of 15.2 $\mu g/m^2$ is erroneously quoted from the source article, and should instead be 15.2 g/m^2.

The final information source:

http://www.ext.vt.edu/pubs/nursery/430-022/430-022.html

further affirms the physiological cause-and-effect mechanism underlying the derivation of the particulate matter deposition benchmark:

> "Particulates (dusts), classified as point-source pollutants, are generated by major industrial processes as well as by quarries, rock-crushing plants, cement plants, soil erosion, and auto exhaust emissions. Particulates are not extremely damaging, but can inhibit or reduce photosynthesis by plugging stomates. Particulates are usually washed from leaves by rain or irrigation, and are therefore more harmful during dry periods."

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