UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5
77 WEST JACKSON BOULEVARD
CHICAGO, IL 60604-3590

APR 05 2007

REPLY TO THE ATTENTION OF:
(AR-18J)

Richard Nelson, Field Supervisor
Rock Island Illinois Field Office
United States Fish and Wildlife Service
4469 48th Avenue Court
Rock Island, Illinois 61201

Dear Mr. Nelson:

Pursuant to Section 7 of the Endangered Species Act, (87 Stat. 884, as amended; 16 U.S. C. 1531 et seq.), the United States Environmental Protection Agency (USEPA) has reviewed the biological information and analysis related to a Prevention of Significant Deterioration (PSD) permit for Taylorville Energy Center (TEC) to determine what impact there may be to any threatened or endangered species in the area around the proposed facility. The purpose of this letter is to seek concurrence from the United States Fish and Wildlife Service (USFWS) on our determination that the proposed project is not likely to adversely affect any federally listed species in relation to the proposed air quality permit for this facility.

The parties utilized the informal consultation process as specified in the "Endangered Species Act (ESA) Consultation Handbook, procedures for conducting consultation and conference activities under Section 7 of the ESA, (March 1998 final)", by the USFWS and National Marine Fisheries Service. The USEPA prepared this biological assessment following the guidance provided in the ESA consultation handbook, as well as the recommended content suggested in the ESA regulations found in 50 CFR Part 402.12(f). As part of developing the biological assessment, the designated representative for USEPA prepared a Recommended Scope of Analysis for TEC, dated August 24, 2006, describing the general topics of need, species of concern, effects analysis, and literature search, needed in the biological assessment. TEC then prepared the December 11, 2006, document entitled, "ESA Screening Analysis, Christian County Generation LLC, Taylorville Energy Center".

Project Description

The Christian County Generation, L.L.C. (CCG) is proposing to construct an integrated gasification combined cycle Integrated Gasification Combined Cycle (IGCC) power plant in Christian County, Illinois. The TEC plant will combust synthesis gas (syngas), derived from Illinois coal as the primary fuel source.

Recycled/Recyclable • Printed with Vegetable Oil Based Inks on 100% Recycled Paper (50% Postconsumer)

The CCG has submitted an application for an air permit to construct a nominal 630 megawatt electric power plant to be located approximately 1.5 miles northeast of Taylorville. The proposed power plant will use IGCC technology to generate electric power. With IGCC technology, a feedstock is first processed by gasification to produce syngas. The syngas from the proposed plant would be a low Btu fuel gas with a heat content of approximately 250 Btu/cubic foot. The principal components of the syngas would be hydrogen and carbon monoxide. This syngas fuel is then burned in separate gas turbine combustion equipment to generate electric power. Electric power is also generated from heat energy recovered as steam from the gasification process.

The principal emission units at the proposed plant are the two combustion turbines. The potential emissions of the turbines are listed below. Potential emissions are based on continuous operation at the maximum load. Actual emissions will be less to the extent that the combustion turbines do not operate at their maximum capacity.

Pollutant	Potential Emissions (tons per year)
Particulate Matter (PM) – filterable	161
Total Particulate Matter	412
Sulfur Dioxide (SO_2)	299
Nitrogen Oxides (NOx)	629
Carbon Monoxide (CO)	920
Volatile Organic Compounds (VOC)	28
Flourides, as hydrogen fluoride	0.61
Sulfuric Acid Mist	67
Mercury	0.038
Hydrogen Chloride	7.5
Lead, as elemental lead	0.02

Action Area

The TEC site is located in rural Christian County about two miles northeast of Taylorville. Rather than defining the action area for this project, worst case surface water, sediment, air and soil concentrations were determined and compared to the appropriate benchmarks for each species.

List of Species

As listed in the Recommended Scope of Analysis, the impacts of the project on the following species were addressed:

Bald Eagle (Haliaeetus leucocephalus) - The Bald Eagle is a threatened species which has not been documented in Christian County, despite the presence of suitable habitat.

Indiana Bat (Myotis sodalis) - The Indiana Bat is an endangered species with suitable habitat within the study area. The habitat is the deciduous forest which lies to the southeast of the project site.

Eastern Fringed Prairie Orchid (Platanthera leucophaea) - The Eastern Fringed Prairie Orchid is an endangered species which is not known to exist in the study area.

Leafy Prairie Clover (Dalea foliosa) - The Leafy Prairie Clover is an endangered species which is known to exist in six counties in Illinois. These counties are in North and Northeast Illinois. This plant is found in prairie remnants along the Des Plaines River in Illinois, in thin soil over limestone substrate. This type of habitat does not exist in Christian County. Since suitable habitat for the Leafy Prairie Clover does not exist within the study area, a quantitative risk assessment was not performed.

Summary of Analysis

The ESA consultation process began in July 2006, with Michael McInnis, a representative of Kentuckiana Engineering Company for TEC, contacting Rachel Rineheart of USEPA. On August 24, 2006, USEPA provided a draft document titled "Recommended scope of Analysis for the TEC for Endangered Species" to USFWS and TEC. USEPA has conducted this analysis in accordance with this scoping document and the information submitted from TEC in response.

The scoping document provided by USFWS indicated that the modeling for this analysis should follow the general guidance provided in Chapter 3 of USEPA's Screening Level Ecological Risk Assessment protocol for assessing chemical fate and transport, the modeling should show air concentrations and deposition rates for appropriate pollutants, and that the total impacts should be evaluated looking at the combined effects of the vapor phase, particle phase and particle-bound phase of pollutants. The document indicated that Industrial Source Complex Short Term 3 was an acceptable model for the analysis.

ESA Effects Analysis

Criteria Pollutants

Criteria Pollutants were not evaluated by Kentuckiana Engineering since the National Ambient Air Quality Standards (NAAQS) have been promulgated for most of the constituents that are protective of human health and the environment, including where

appropriate, impacts to soil and vegetation. The demonstration of compliance with both the primary and secondary NAAQS, as indicated in the PSD permit application for the facility, precludes the need for additional analysis. In addition, a supplemental analysis of the criteria pollutants on soils, vegetation and visibility is conducted. The results of that analysis indicate that emissions from TEC would not impact solid or vegetation in the area surrounding the plant.

Hazardous Air Pollutants (HAPs)

A concentration-toxicity screen is used as an initial evaluation of the potential to cause adverse health effects in ecological receptors to identify the subset of HAPs that are quantitatively evaluated in the screening analysis.

The emphasis of the ESA screening analysis is on the potential for long-term adverse effects to the habitats of interest, constituent transfer through food webs, and chronic health effect in the species of interest. The volatile HAPs (formaldehyde, benzene, toluene, xylene, and propylene oxide) tend not to persist in the environment and tend not to be transferred through food chains. As such, they are not included in the quantitative analysis and are evaluated qualitatively in the ESA screening analysis.

A concentration-toxicity screening tool is used by TEC to evaluate impacts. The screening tool uses emissions (tons per year) as a related indicator of concentrations in the environment and ecological toxicity criteria represented by toxicity reference levels Toxicity Reference Value (TRVs) available. TRVs are available for soil, surface water, and sediment. These TRVs are protective of aquatic biota, invertebrates, and terrestrial vegetation. TRVs are also available for mammals and birds. The individual constituent scores can be found in Table 5-1 of the ESA screening analysis document and are calculated by dividing the emission rate by the TRV. The individual constituent scores are then summed for a total score according to the environmental receptors (e.g. soil invertebrates). The ratio of the individual constituent scores to the total receptor score approximates the percent contribution of each individual constituent to the overall potential for adverse effects for the indicated receptor.

Constituents with percent contributions to the overall potential for adverse effects greater than or equal to one percent are further evaluated. Constituents with percent contributions less than one percent are not expected to appreciably contribute to the risk estimates.

ESA Determination

After reviewing the analysis provided by Kentuckiana Engineering, the pollutants with the greatest potential for adverse impact would include arsenic, cadmium, chromium, mercury, selenium and lead. For these pollutants, the increment of change from the proposed facility falls below benchmark values for soil invertebrates, birds and mammals.

The increment of change plus the addition of current background data are greater than the benchmark values. However, the background contaminants have limited bioavailability and the Bald eagle and Indiana bat do not forage exclusively in the action area. Therefore, exposure to these contaminants will be diluted and adverse impacts are not predicted.

Considering this analysis (see enclosure) in its entirety, USEPA concludes that the proposed construction and operation of this facility may affect, but is not likely to adversely affect, any of the threatened and endangered species. USEPA respectfully requests USFWS concurrence on this determination.

Sincerely yours,

Pamela Blakley

Pamela Blakley, Chief
Air Permits Section

Enclosure

ESA SCREENING ANALYSIS

CHRISTIAN COUNTY GENERATION, LLC

TAYLORVILLE ENERGY CENTER

CHRISTIAN COUNTY, ILLINOIS

December 2006

RESPONSE TO COMMENTS

COMMENT

1) Page 14, Section 5.0 - Mike was not familiar with the screening method which divides the emission rate by the TRV. He indicated that this may or may not be a legitimate way to analyze the data and since the method may affect which chemicals/HAPs are eliminated from the analysis, he would like more information, i.e. did you see this method somewhere, what was your rationale, etc., etc.

RESPONSE

The qualitative analysis procedure performed in Section 5.0, Table 5-1, was taken from the "SCREENING LEVEL ECOLOGICAL RISK ASSESSMENT – FINAL" report submitted by Prairie State Generating Station, dated April 2004. This screening tool is a concentration-toxicity analysis used as an initial evaluation of the potential of the COPECs to cause adverse health effects in ecological receptors. This tool uses the emissions from TEC as a related indicator of concentrations in the environment and ecological toxicity criteria represented by the TRVs available in the USEPA SLERA Protocol. TRVs are available for the protection of environmental communities in the form of constituent concentrations (e.g, mg/kg or mg/L) in soil, surface water, and sediment. These TRVs are protective of aquatic biota, benthic invertebrates, terrestrial vegetation, and soil invertebrates. TRVs are also available for wildlife (i.e. measurement receptors) in the form of constituent doses (i.e. mg/kg body weight-day) that are protective of mammals and birds. Individual constituent scores are calculated by dividing the emission rate by the TRV. The individual scores are then summed for a total score according to environmental receptor (e.g. soil invertebrates). The ratio of the individual constituent scores to the total receptor score approximates the percent contribution of each individual constituent to the overall potential for adverse effects for the indicated receptor.

Constituents with percent contributions to the overall potential for adverse effects greater than or equal to one percent are evaluated quantitatively. While constituents with percent contributions less than one percent are not expected to appreciably contribute to the risk estimates, they were nevertheless evaluated qualitatively in the ESA screening analysis, by description of the potential for adverse health effects in ecological receptors.

COMMENT

2) Page 15, Table 5-1 - There are some HAPs where no TRVs are listed (some of the organic HAPs). In these cases, an analysis is not performed. Mike suggested that you instead analyze for total PAHs and use the most sensitive PAH benchmark to analyze.

RESPONSE

Table 5-1 has been revised to show the most sensitive PAH benchmark for those organics where no TRV had been listed. Additionally, the volatile organic compounds (acrolein, formaldehyde, benzene, toluene, and xylene) have been removed from the table and are qualitatively analyzed in Appendix C of the revised report.

COMMENT
3) Page 25, Table 6-8 - MIke recommends that background concentrations should be included in exposure estimates for final hazard quotient/screen.

RESPONSE
Table 6-8 has been revised to show the background concentrations added to the CS values and this total is then compared to the screening values.

COMMENT
4) Page 25, Table 6-8 - For the IN bat, a food chain analysis should be performed for mercury. Since there is no suitable habitat in the area for the bald eagle, no food chain analysis is necessary.

RESPONSE
As requested, a food chain analysis has been performed for mercury for the Indiana bat. In setting up this analysis, it was discovered that the computation of Ds for mercury did not use the Ds formula for mercury, but rather the Ds formula for all metals except mercury. By applying the 0.48 factor in the Ds for mercury, Ds value represented in Table 6-8 was reduced from 1.24E-04 mg/kg-yr to 5.952E-06 mg/kg-yr. This also resulted in the Cs value for mercury being reduced to 1.01E-04 mg/kg. Table 6-8 has been revised to show these revised values.

CONCLUSION
The draft report has been revised to show the above changes.

TABLE OF CONTENTS

1.0 INTRODUCTION 1
1.1 SPECIES TO BE EVALUATED 3
1.1.1 Bald Eagle 3
1.1.2 Indiana Bat 4
1.1.3 Eastern Fringed Prairie Orchid 4
1.1.4 Prairie Clover 5
2.0 FACILITIES CONSIDERED FOR MODELING 6
2.1 FACILITIES MODELED 6
2.2 FACILITIES NOT MODELED 6
3.0 ISCST3 MODEL INPUTS 8
3.1 STACK PARAMETERS 8
3.2 TOTAL DEPOSITION INPUTS 8
3.3 METEOROLOGICAL DATA 12
4.0 DETERMINATION OF POLLUTANTS TO MODEL 13
4.1 CRITERIA POLLUTANTS 13
4.2 HAZARDOUS AIR POLLUTANTS 13
5.0 QUALITATIVE ANALYSIS 14
5.1 HAZARDOUSE AIR POLLUTANTS 14
5.3 COPECs REQUIRING FURTHER ANALYSIS 18
6.0 COPEC QUANTITATIVE SCREENING ANALYSIS 19
6.1 SCREENING LEVELS 23
6.2 DETERMINATION OF COPEC CONCENTRATION IN SOIL (Cs in mg/kg) . 24
6.3 QUANTITATIVE ANALYSIS RESULTS 29
6.4 INDIANA BAT FOOD CHAIN ANALYSIS 29
7.0 CONCLUSION 31

APPENDIX A – "Recommended Scope of Analysis for Taylorville Energy Center ("TEC") for Endangered Species"
APPENDIX B – EASTERN FRINGED PRAIRIE ORCHID DATA
APPENDIX C – PRAIRIE CLOVER DATA
APPENDIX D – COOLING TOWER CHEMICALS
APPENDIX E – MODELING OUTPUT FILES ON CD
APPENDIX F – FOOD CHAIN ANALYSIS FOR THE INDIANA BAT
APPENDIX G – QUALITATIVE ANALYSIS OF OTHER COPECs

TABLE OF TABLES

Table 1-1: Contact Information 1
Table 3-1: Stack Parameters 8
Table 3-2: Particle Data 9
Table 3-3: Vapor Phase Scavenging Coefficients* 9
Table 3-4: Particle Phase Data* 10
Table 3-5: Particle-Bound Phase Data 11
Table 5-1: Concentration-Toxicity Screen 16
Table 6-1: Emissions 21
Table 6-2: Metal Specific Variables 21
Table 6-3: Variables for All Metals 22
Table 6-4: Comparison of Screening Level to Background Levels in Christian County 23
Table 6-5: Unitized Yearly Average Concentration from Vapor Phase ("Cyv") 25
Modeling Output Summary For Inorgancs Except Mercury(XXX_YYV.out) 25
Table 6-5A: Unitized Yearly Average Concentration from Vapor Phase ("Cyv") . 25
Modeling Output Summary For Mercury(XXX_YYM.out) 25
Table 6-6: Unitized Yearly Average Wet Deposition from Vapor Phase ("Dywv") Modeling Output Summary for Inorganics Except Mercury(XXX_YYV.out) 26
Table 6-6A: Unitized Yearly Average Wet Deposition from Vapor Phase ("Dywv") Modeling Output Summary for Mercury(XXX-YYM.out) 26
Table 6-7: Unitized Yearly Average Wet Deposition from Particle Phase ("Dywp") + Unitized Yearly Average Dry Deposition from Particle Phase ("Dydp") Modeling Summary for all Inorganics Except Mercury(XXX-YYP.out) 27
Table 6-7A: Unitized Yearly Average Wet Deposition from Particle Phase ("Dywp") + Unitized Yearly Average Dry Deposition from Particle Phase ("Dydp") Modeling Summary for Mercury(XXX-YYB.out) 27
Table 6-8: Comparison of Cs to Screening Levels 28
Table 6-9: Summary of Quantitative Analysis 29

1.0 INTRODUCTION

Christian County Generation, L.L.C. ("CCG") is proposing to construct an Integrated Gasification Combined Cycle ("IGCC") power plant in Christian County, IL (See Figure 1-1). The Taylorville Energy Center ("TEC" or the "Project") plant will combust Synthesis Gas ("Syngas") derived from Illinois coal as the primary fuel source.

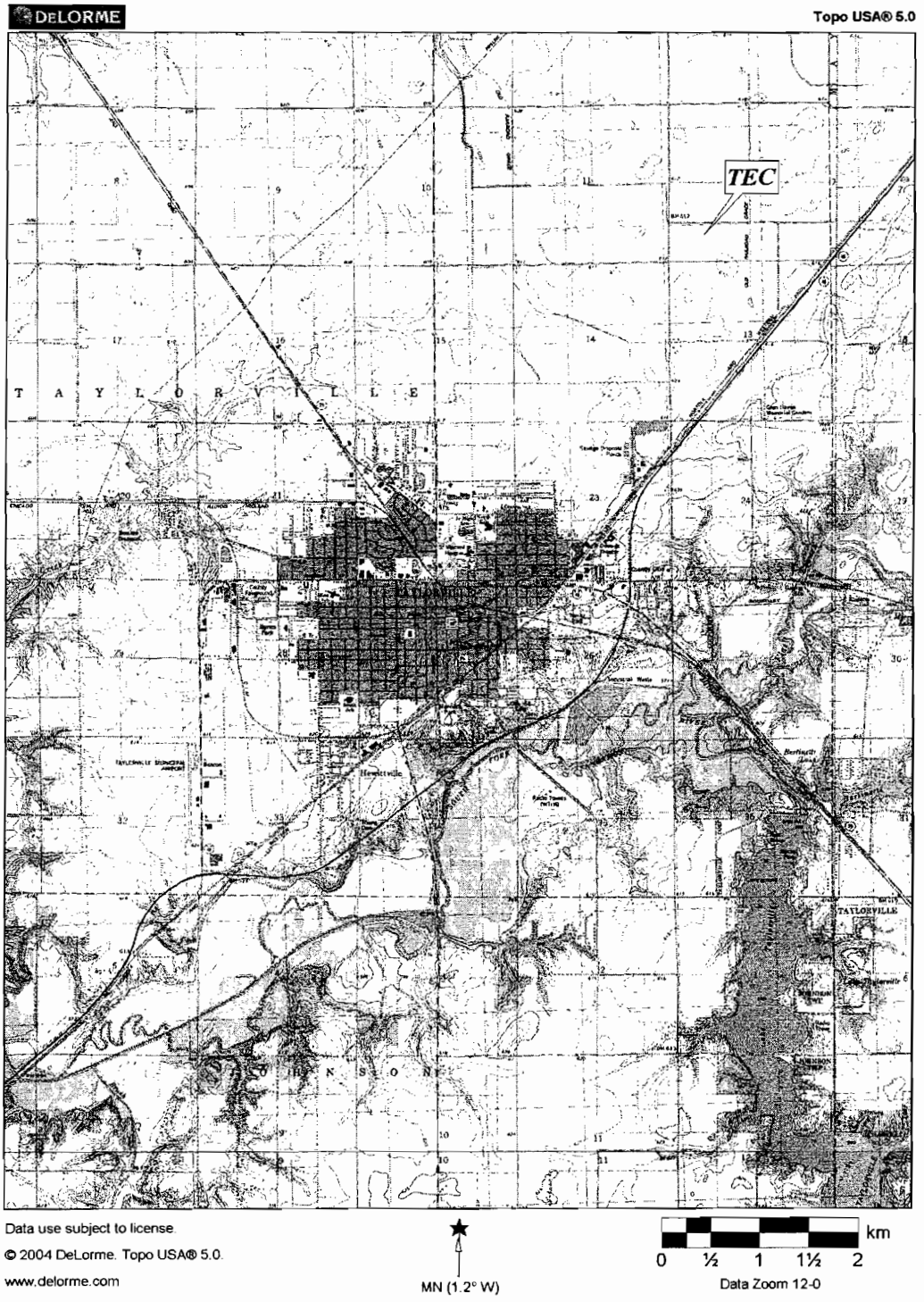
Kentuckiana Engineering Company, Inc. ("KEC") has prepared, for review by the Illinois Environmental Protection Agency ("IEPA") and the Environmental Protection Agency, Region V ("EPA Region V") for consultation with the United States Fish and Wildlife Service, the following modeling protocol methodology and results to address Class II impacts as they relate to the protection of endangered species.

Contact information, relating to the TEC, is contained within the table below.

Table 1-1: Contact Information

Applicant		
Christian County Generation, L.L.C.		
Project Technical Information and Development Contact	Mr. Michael McInnis 4350 Brownsboro Road Suite 110 Louisville, Kentucky 40207 Phone: (502) 357-9901 mmcinnis@erora.com	
Facility Location		
	Latitude	Longitude
Taylorville Energy Center 1630N 1400 E Road Taylorville, Illinois 62568	39:33:2 N	89:16:30 W
Air Permitting Consultant		
KENTUCKIAN ENGINEERING COMPANY, INC.		
Air Permit Application Contact	Mr. Bryan Handy 311 Townepark Circle Suite 100 Louisville, Kentucky 40243 Phone: (502) 489-8074 Fax: (502) 489-8078 Email: bhandy@kecco.net	
Dispersion Modeling Contact	Mr. J. Dwain Kincaid 311 Townepark Circle Suite 100 Louisville, Kentucky 40243 Phone: (502) 489-8074 Fax: (502) 489-8078 Email: dkincaid@kecco.net	

FIGURE 1-1: THE TEC SITE LOCATION



During review of CCG's Prevention of Significant Deterioration ("PSD") permit application for the TEC, IEPA requested that CCG contact EPA Region V regarding potential impacts of the TEC on endangered species. Subsequently, CCG did contact EPA Region V regarding their role in consultation with the United States Fish and Wildlife Service regarding PSD applications and potential impacts on endangered species. On August 24, 2006, EPA Region V provided CCG with a "Recommended Scope of Analysis for Taylorville Energy; Center ("TEC") for Endangered Species". That document is contained in Appendix A to this report. That document and subsequent communications with EPA Region V indicated that the Bald Eagle, Indiana Bat, Eastern Fringed Prairie Orchid and the Prairie Clover should be addressed in an endangered species analysis if suitable habitat exists in proximity to the TEC.

1.1 SPECIES TO BE EVALUATED

As noted above, the species of concern are the Bald Eagle, Indiana Bat, Eastern Fringed Prairie Orchid, and the Prairie Clover. In accordance with the "Recommended Scope of Analysis for Taylorville Energy; Center ("TEC") for Endangered Species", a study area within a 3 kilometer radius from the TEC's Heat Recovery Steam Generator Stack # 1 was reviewed to ascertain the locations of suitable habitat for each of the species mentioned above.

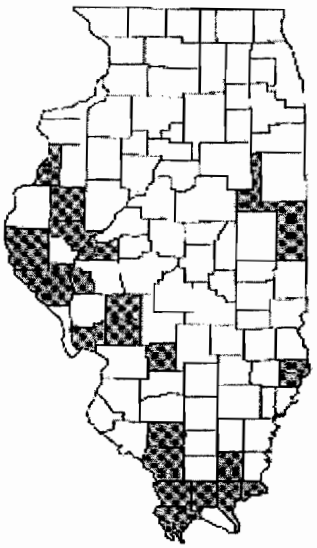
1.1.1 Bald Eagle

With respect to the Bald Eagle, there are no large bodies of water within the study area. However there are deciduous forests within the study area that could serve as suitable habitat for the Bald Eagle to the southeast of the project site. Based on review of data in the Nature Serve Explorer, the Bald Eagle has not been documented in Christian County, IL[1] despite the presence of suitable habitat.

[1] http://www.natureserve.org/explorer/servlet/NatureServe?searchName=Haliaeetus+leucocephalus

1.1.2 Indiana Bat

With respect to the Indiana Bat, there is suitable habitat within the study area. Again, this habitat is the deciduous forest which lies to the southeast of the project site. Based on a study performed by the US Fish and Wildlife Service, the following map of Illinois[2] shows the counties where the Indiana Bat has been found (shaded areas).



The map above indicates that the Indiana Bat has not been documented in Christian County, IL.

As requested by EPA Region V, a food chain analysis has been performed for the Indiana Bat and is shown in Appendix F.

1.1.3 Eastern Fringed Prairie Orchid

The eastern prairie fringed orchid occurs in a wide variety of habitats, from mesic prairie to wetlands such as sedge meadows, marsh edges, even bogs. It requires full sun for optimum growth and flowering and a grassy habitat with little or no woody encroachment. A symbiotic relationship between the seed and soil fungi, called mycorrhizae, is necessary for seedlings to become established. This fungi helps the seeds

[2] http://www.inhs.uiuc.edu/chf/pub/surveyreports/mar-apr96/bats.html

assimilate nutrients in the soil. This plant is found in 10 counties in Illinois[3] (see Appendix B), and Christian County is not listed.

In accordance with the directions given by Jennifer Darrow of EPA Region V, a search was performed looking for non-forested wetlands not associated with any streams within a 3 km radius of TEC. This search indicated there were no wetlands present within a 3 km radius of TEC. Since suitable habitat does not exist within the study area, a quantitative ecological risk assessment respecting this species was not performed.

1.1.4 Prairie Clover

The Prairie Clover (Dalea foliosa (gray) Barneby – leafy prairie clover) is known to exist in six counties in Illinois. These counties are in North and Northeast Illinois. This plant is found in prairie remnants along the Des Plains River in Illinois, in thin soils over limestone substrate. This type of habitat has not been found to exist in the Christian County study area (See Appendix C).). Since suitable habitat for the Prairie Clover does not exist within the study area, a quantitative ecological risk assessment respecting this species was not performed.

[3] NatureServe. 2006. NatureServe Explorer: An online encyclopedia of life [web application]. Version 6.0. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. (Accessed: October 26, 2006).

2.0 FACILITIES CONSIDERED FOR MODELING

2.1 FACILITIES MODELED

The sources modeled for this analysis were the two heat recovery steam generator ("HRSG") stacks and the flare stack.

2.2 FACILITIES NOT MODELED

There are other facilities located at the TEC including an auxiliary boiler, natural gas fueled fire pump, thermal oxidizer and a cooling tower (cooling system). The natural gas fired auxiliary boiler was not modeled as it is used only during cold gasifier startup and does not contribute to steady-state HRSG emissions. Similarly, the fire pump was not modeled as it operates only for limited testing purposes and during emergency fire events. The thermal oxidizer was modeled for criteria pollutants but not for Hazardous Air Pollutants ("HAP") consistent with its emissions profile as provided by the gasification process provider, General Electric.

A number of water treatment products are under consideration for the pretreatment of cooling water and clarification of influent water for the cooling system. No chromium-based water treatment chemicals will be used. Cooling system make-up water will consist of clarified influent water.

Potential water treatment products are listed in Appendix D to this analysis. Some chemical constituents of these products may be present in cooling system water, in dilute form, and may be present in cooling tower drift emissions. Also included in the listing in Appendix D is information for the water treatment products that addresses:

- Intended Application,
- Concentrations used
- Acute oral toxicity to mammals, and
- Acute toxicity to aquatic life.

The mammalian acute oral toxicity data indicates that most of the products are regarded as only moderately toxic (i.e. the dose that is lethal to 50 percent of the test organisms or LD_{50} is between 30 to 8200 mg/kg). The aquatic toxicity data also indicates that most of the products are regarded as slightly toxic (i.e. the concentration that is lethal to 50 percent of the test organism or LC_{50} is between 100 and 590 mg/L) or practically non toxic (i.e. the LC_{50} is greater than 100 mg/L).

Based on the anticipated dilute concentrations of these products in cooling water, the expected low concentrations of these products, if any, in air emissions (cooling tower drift) within the study area, and the weight-of-evidence approach regarding the possible toxicity of these products, constituent emissions from the cooling towers are not expected to have an adverse impact on ecological receptors in the study area and are not evaluated further in this analysis.

3.0 ISCST3 MODEL INPUTS

Prior to performing an ecological risk assessment for the subject endangered species, KEC ran the ISCST3 model in the risk mode to generate the necessary vapor phase, particle phase, and particle bound phase files required to determine the total deposition and concentrations of toxic air pollutants within the project domain. In the Class II TEC modeling submitted on October 4, 2006 to IEPA, the largest significant impact area ("SIA") for any criteria pollutant was a 5.24 kilometer radius domain. This is the domain that was used to set receptors for this analysis.

3.1 STACK PARAMETERS

In the Prevention of Significant Deterioration ("PSD") permit application submitted to the IEPA, the Additional Impacts Analysis section addressed air toxics emissions from the two HRSG units and the Flare.

Table 3-1 depicts the stack parameters for each of these stacks.

Table 3-1: Stack Parameters

Facility	UTM-X* m	UTM-Y* m	Base Elev m	Release Height m	Gas Exit Temperature °K	Gas Exit Velocity m/sec	Stack Diameter m
HRSG1	305415.70	4383934.0	187.0	60.66	402.59	22.86	5.64
HRSG2	305415.60	4383886.80	187.0	60.66	402.59	22.86	5.64
FLARE	305313.74	4384258.54	187.0	61.81	1273.0	20.0	0.46

* - UTM Zone 16, NAD27

3.2 TOTAL DEPOSITION INPUTS

Per the guidance in EPA's Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities document[4] ("EPA Screening Document"), a unitized emission rate of one (1) gram per second was modeled using the ISCST3 model.

[4] EPA-530-D-99-001A – Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities

Prior to ISCST3 modeling, in accordance with the EPA Screening Document and the requirement to model total deposition, the following required information was obtained:

1. particle size data
2. liquid and frozen scavenging coefficients for the vapor phase, particle phase and particle bound phase modeling.

The particle size data was taken from the EPA Screening Document, Table 3-1 and is shown in Table 3-2 below.

Table 3-2: Particle Data

Mean Particle Diameter (μm)	Particle Radius (μm)	Surface Area/Volume (μm^{-1})	Fraction of Total Mass	Proportion Available Surface Area	Fraction of Total Surface Area
>15	7.5	0.4	0.128	0.0512	0.0149
12.5	6.25	0.48	0.105	0.0504	0.0146
8.1	4.05	0.741	0.104	0.0771	0.0224
5.5	2.75	1.091	0.073	0.0796	0.0231
3.6	1.80	1.667	0.103	0.1717	0.0499
2.0	1.0	3.0	0.105	0.3150	0.0915
1.1	0.55	3.455	0.082	0.4473	0.1290
0.7	0.40	7.5	0.076	0.5700	0.1656
<0.7	0.40	7.5	0.224	1.6800	0.4880

The vapor phase scavenging coefficients used were as follows:

Table 3-3: Vapor Phase Scavenging Coefficients*

Facility	**Scavenging Coef. Liquid [(s-mm/hr)$^{-1}$]**	**Scavenging Coef. Frozen [(s-mm/hr)$^{-1}$]**
HRSG1	0.0001	0.00003
HRSG2	0.0001	0.00003
FLARE	0.0001	0.00003

*Obtained from EPA Screening Document.

The Particle Phase data used was as follows:

*Table 3-4: Particle Phase Data**

FACILITY	Particle Diameter [microns]	Mass Fraction [0-1]	Particle Density [g/cm^3]	Scavenging Coef. Liquid [(s-mm/hr)$^{-1}$]*	Scavenging Coef. Frozen [(s-mm/hr)$^{-1}$]*
FLARE	0.7	0.3	1	0.00007	0.0000233
	1.1	0.082	1	0.00006	0.00002
	2	0.105	1	0.00013	0.0000533
	3.6	0.103	1	0.00026	0.0000867
	5.5	0.073	1	0.00039	0.00013
	8.1	0.104	1	0.00052	0.000173
	12.5	0.105	1	0.00067	0.000223
	15	0.128	1	0.00067	0.000223
HRSG1	0.7	0.3	1	0.00007	0.0000233
	1.1	0.082	1	0.00006	0.00002
	2	0.105	1	0.00013	0.0000533
	3.6	0.103	1	0.00026	0.0000867
	5.5	0.073	1	0.00039	0.00013
	8.1	0.104	1	0.00052	0.000173
	12.5	0.105	1	0.00067	0.000223
	15	0.128	1	0.00067	0.000223
HRSG2	0.7	0.3	1	0.00007	0.0000233
	1.1	0.082	1	0.00006	0.00002
	2	0.105	1	0.00013	0.0000533
	3.6	0.103	1	0.00026	0.0000867
	5.5	0.073	1	0.00039	0.00013
	8.1	0.104	1	0.00052	0.000173
	12.5	0.105	1	0.00067	0.000223
	15	0.128	1	0.00067	0.000223

* Data obtained from the EPA Screening Document, Chapter 3, page 3-51.

The Particle-Bound Phase data was generated by the Lakes Environmental ISC-AERMOD View model and is shown below.

Table 3-5: Particle-Bound Phase Data

FACILITY	Particle Diameter [microns]	Mass Fraction [0-1]	Particle Density [g/cm^3]	Scavenging Coef. Liquid [(s-mm/hr)$^{-1}$]	Scavenging Coef. Frozen [(s-mm/hr)$^{-1}$]
FLARE	0.7	0.6832	1	0.00007	0.0000233
	1.1	0.1188	1	0.00006	0.00002
	2	0.0837	1	0.00013	0.0000433
	3.6	0.0456	1	0.00026	0.0000867
	5.5	0.0212	1	0.00039	0.00013
	8.1	0.0205	1	0.00052	0.000173
	12.5	0.0134	1	0.00067	0.000223
	15	0.0136	1	0.00067	0.000223
HRSG1	0.7	0.6832	1	0.00007	0.0000233
	1.1	0.1188	1	0.00006	0.00002
	2	0.0837	1	0.00013	0.0000433
	3.6	0.0456	1	0.00026	0.0000867
	5.5	0.0212	1	0.00039	0.00013
	8.1	0.0205	1	0.00052	0.000173
	12.5	0.0134	1	0.00067	0.000223
	15	0.0136	1	0.00067	0.000223
HRSG2	0.7	0.6832	1	0.00007	0.0000233
	1.1	0.1188	1	0.00006	0.00002
	2	0.0837	1	0.00013	0.0000433
	3.6	0.0456	1	0.00026	0.0000867
	5.5	0.0212	1	0.00039	0.00013
	8.1	0.0205	1	0.00052	0.000173
	12.5	0.0134	1	0.00067	0.000223
	15	0.0136	1	0.00067	0.000223

Building downwash was utilized in the model and the regulatory defaults were selected along with total deposition and wet and dry plume depletion.

The receptor grid used in the ISCST3 model was generated by the Multi-Tiered Risk Grid generator in the Lakes Environmental ISC-AERMOD View modeling software and consisted of receptors placed at 100 meter intervals out to 3 kilometers and receptors placed at 500 meter intervals from 3 kilometers out to 10 kilometers. Digital elevation maps were used to extract the receptor base elevations.

3.3 METEOROLOGICAL DATA

The meteorological data ("met") data used was from the Springfield, IL airport (surface data) and the Peoria, IL airport (upper air data). The surface data was taken from the SAMSON database which contains precipitation data which is required for deposition modeling. In order to use the met data, the data had to be processed through the RAMMET View software package from Lakes Environmental. To process this data, the following information was input into RAMMET View.

- Anemometer Height – 9.54 meters
- Monin-Obukhov Length – 2.0 meters
- Surface Roughness for the Airport Site – 1.0
- Surface Roughness for the Project Site – 0.04025
- Noon Time Albedo – 0.29
- Bowen Ratio – 0.7
- Anthropological Heat Flux – 0.0
- Net Radiation – 0.15

This data was used to generate 5 years of met data (1986-1990). The ISCST3 model was then run in the Risk Mode to generate the necessary vapor phase, particle phase, and particle bound phase plot files and output files for use in the ecological risk assessment.

4.0 DETERMINATION OF POLLUTANTS TO MODEL

4.1 CRITERIA POLLUTANTS

The criteria pollutants are typically not evaluated in a SLERA since the National Ambient Air Quality Standards ("NAAQS") have been promulgated for most of the constituents that are protective of human health and the environment, including where appropriate, impacts to soil and vegetation. The demonstration of compliance with both the primary and secondary NAAQS, as indicated in the PSD Permit Application for the facility, precludes the need for additional analysis. In addition, CCG conducted a supplemental analysis of the criteria pollutants on soils, vegetation, and visibility. The results of that analysis indicate that emissions from the CCG would not impact soils or vegetation in the area surrounding the plant.

4.2 HAZARDOUS AIR POLLUTANTS

Hazardous air pollutants ("HAPS") have the potential to cause adverse health effects in ecological receptors and are selected as Constituents of Potential Ecological Concern ("COPEC"). However, much of the potential for such effects is associated with a limited number of these constituents. Therefore, a concentration-toxicity screen was used, as an initial evaluation of this potential, to identify the subset of these constituents that were quantitatively evaluated in this analysis.

The emphasis of this analysis is on the potential for long-term adverse effects to the habitats of interest, constituent transfer through food webs, and chronic health effects in the species of interest. Radionuclides are not evaluated in this analysis since the USEPA in their report to Congress (USEPA, 1998) indicated that risks due to exposure to radionuclides emitted from electric generating stations are substantially lower than the risks due to natural background radiation.

5.0 QUALITATIVE ANALYSIS

5.1 HAZARDOUSE AIR POLLUTANTS

HAPs have the potential to cause adverse health effects in ecological receptors and are selected as COPECs. However, much of the potential for such effects is associated with just a few of these constituents. Therefore, a concentration-toxicity screen is used, as an initial evaluation of this potential, to identify the subset of HAPs that is quantitatively evaluated in this ESA screening analysis.

The emphasis of this ESA screening analysis is on the potential for long-term adverse effects to the habitats of interest, constituent transfer through food webs, and chronic health effects in the species of interest. The volatile HAPs (formaldehyde, benzene, toluene, xylene, and propylene oxide) tend not to persist in the environment and tend not to be transferred through webs. As such, they are not included in the quantitative analysis and are evaluated qualitatively in this ESA screening analysis

The concentration-toxicity screen is presented in Table 5-1. The screening tool uses the TEC emissions (in tons per year) provided by CCG for two HRSG units and the Flare, as a related indicator of concentrations in the environment and ecological toxicity criteria represented by toxicity reference levels ("TRV") available in the EPA Screening Document. TRVs are available for protection of environmental communities in the form of constituent concentrations (e.g. mg/kg or mg/L) in soil, surface water, and sediment. These TRVs are protective of aquatic biota, benthic invertebrates, terrestrial vegetation, and soil invertebrates. TRVs are also available for wildlife (i.e. measurement receptors) in the form of constituent doses (i.e. mg/kg body weight-day) that are protective of mammals and birds. The individual constituent scores in Table 5-1are calculated by dividing the emission rate by the TRV. The individual constituent scores are then summed for a total score according to environmental receptors (e.g. soil invertebrates). The ratio of the individual constituent scores to the total receptor score approximates the

percent contribution of each individual constituent to the overall potential for adverse effects for the indicated receptor.

Constituents with percent contributions to the overall potential for adverse effects greater than or equal to one percent are evaluated quantitatively in this analysis. Constituents with percent contributions less than one percent are not expected to appreciably contribute to the risk estimates, based on this qualitative analysis that addresses the potential for adverse health effects in ecological receptors. Table 5-1 depicts those HAPs requiring quantitative analysis by highlighting in yellow those instances where a given HAP has the overall potential for adverse effects greater than or equal to one percent.

Table 5-1: Concentration-Toxicity Screen

		Community Level Receptor						Class Specific Guild-Level Receptor					
		Terrestrial Plant			Soil Invertibrate			Mammalian			Bird		
Hazardous Air Pollutant	TEC Emission Factors (Tons/Yr)	TRV (mg/kg)	Score	Percent of Total Score	TRV (mg/kg)	Score	Percent of Total Score	TRV (mg/kg-d)	Score	Percent of Total Score	TRV (mg/kg-d)	Score	Percent of Total Score
Arsenic	5.11E-03	1	5.11E-03	0.07%	0.25	2.04E-02	4.01%	1.25	4.09E-03	0.09%	2.46	2.08E-03	0.02%
Beryllium	5.11E-03	0.1	5.11E-02	0.70%	NA	NA	NA	0.66	7.74E-03	0.17%	NA	NA	NA
Cadmium	1.15E-02	0.2	5.75E-02	0.79%	10	1.15E-03	0.23%	0.0252	4.56E-01	9.82%	1.45	7.93E-03	0.07%
Chromium	8.94E-02	0.018	4.97E+00	68.07%	0.2	4.47E-01	87.66%	3.5	2.56E-02	0.55%	1	8.94E-02	0.75%
Cobalt	2.56E+00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Manganesse	2.56E-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Mercury*	6.75E-02	0.349	1.93E-01	2.65%	2.5	2.70E-02	5.29%	0.032	2.11E+00	45.41%	0.0064	1.05E+01	88.10%
Nickle	1.01E-01	25	4.03E-03	0.06%	100	1.01E-03	0.20%	50	2.01E-03	0.04%	65	1.55E-03	0.01%
Selenium	1.01E-01	0.05	2.01E+00	27.59%	7.7	1.31E-02	2.56%	0.076	1.32E+00	28.52%	0.5	2.01E-01	1.68%
Organic HAPS*													
2-Methylnaphthalene	2.68E-08	1200	2.23E-11	0.00%	25000	1.07E-12	0.00%	2	1.34E-08	0.00%	0.39	6.87E-08	0.00%
3-Methylchloranthrene	2.01E-09	1200	1.68E-12	0.00%	25000	8.04E-14	0.00%	2	1.01E-09	0.00%	0.39	5.15E-09	0.00%
7,12-Dimethylbenz(a)anthracene	1.79E-08	1200	1.49E-11	0.00%	25000	7.15E-13	0.00%	2	8.94E-09	0.00%	0.39	4.58E-08	0.00%
Acenaphthene	2.01E-09	1200	1.68E-12	0.00%	25000	8.04E-14	0.00%	2	1.01E-09	0.00%	0.39	5.15E-09	0.00%
Acenaphthylene	6.39E-03	1200	5.32E-06	0.00%	25000	2.56E-07	0.00%	2	3.19E-03	0.07%	0.39	1.64E-02	0.14%
Anthracene	2.68E-09	1200	2.23E-12	0.00%	25000	1.07E-13	0.00%	2	1.34E-09	0.00%	0.39	6.87E-09	0.00%
Benz(a)anthracene	5.88E-05	1200	4.90E-08	0.00%	25000	2.35E-09	0.00%	167	3.52E-07	0.00%	0.14	4.20E-04	0.00%
Benzo(a)pyrene	1.43E-04	1200	1.19E-07	0.00%	25000	5.72E-09	0.00%	100	1.43E-06	0.00%	1	1.43E-04	0.00%
Benzo(b)fluoranthene	2.01E-09	1200	1.68E-12	0.00%	25000	8.04E-14	0.00%	2	1.01E-09	0.00%	0.14	1.44E-08	0.00%
Benzo(g,h,i)perylene	2.45E-04	1200	2.04E-07	0.00%	25000	9.81E-09	0.00%	2	1.23E-04	0.00%	0.39	6.29E-04	0.01%
Benzo(k)fluoranthene	2.01E-09	1200	1.68E-12	0.00%	25000	8.04E-14	0.00%	2	1.01E-09	0.00%	0.14	1.44E-08	0.00%

		Community Level Receptor						Class Specific Guild-Level Receptor					
		Terrestrial Plant			Soil Invertibrate			Mammalian			Bird		
Hazardous Air Pollutant	TEC Emission Factors (Tons/Yr)	TRV (mg/kg)	Score	Percent of Total Score	TRV (mg/kg)	Score	Percent of Total Score	TRV (mg/kg-d)	Score	Percent of Total Score	TRV (mg/kg-d)	Score	Percent of Total Score
Chrysene	2.01E-09	1200	1.68E-12	0.00%	25000	8.04E-14	0.00%	2	1.01E-09	0.00%	1	2.01E-09	0.00%
Dibenzo(a,h)anthracene (PAH)	1.34E-09	1200	1.12E-12	0.00%	25000	5.36E-14	0.00%	2	6.70E-10	0.00%	0.39	3.44E-09	0.00%
Dichlorobenzene	1.34E-06	1200	1.12E-09	0.00%	25000	5.36E-11	0.00%	2	6.70E-07	0.00%	0.39	3.44E-06	0.00%
Ethyl Benzene	0.00E+00	1200	0.00E+00	0.00%	25000	0.00E+00	0.00%	2	0.00E+00	0.00%	0.39	0.00E+00	0.00%
Fluoranthene	3.35E-09	1200	2.79E-12	0.00%	25000	1.34E-13	0.00%	2	1.68E-09	0.00%	0.39	8.59E-09	0.00%
Fluorene	3.13E-09	1200	2.61E-12	0.00%	25000	1.25E-13	0.00%	2	1.56E-09	0.00%	0.39	8.02E-09	0.00%
HCl (assume all Chlorides are HCl)	1.53E+01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Hexane	2.01E-03	1200	1.68E-06	0.00%	25000	8.04E-08	0.00%	2	1.01E-03	0.02%	0.39	5.15E-03	0.04%
HF (assume all Fluorides are HF)	7.67E-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Indeno(1,2,3-cd)pyrene	2.01E-09	1200	1.68E-12	0.00%	25000	8.04E-14	0.00%	2	1.01E-09	0.00%	0.39	5.15E-09	0.00%
Lead	2.63E-02	4.6	5.72E-03	0.08%	100	2.63E-04	0.05%	0.0375	7.02E-01	15.11%	0.025	1.05E+00	8.79%
Naphthalene	1.82E-02	1200	1.52E-05	0.00%	25000	7.29E-07	0.00%	2	9.12E-03	0.20%	0.39	4.68E-02	0.39%
Phenanthrene	1.90E-08	1200	1.58E-11	0.00%	25000	7.59E-13	0.00%	2	9.49E-09	0.00%	0.39	4.87E-08	0.00%
Pyrene	5.58E-09	1200	4.65E-12	0.00%	25000	2.23E-13	0.00%	2	2.79E-09	0.00%	0.39	1.43E-08	0.00%
			7.30E+00	100%		5.10E-01	100%		4.65E+00	100%		1.20E+01	100%

* - Worst Case – Assumes no loss to the Global Cycle

** - Worst Case Scenario - US DOE report states that Dioxin, Furans and PAH emissions are expected to be less than one part per trillion by volume.

5.3 COPECs REQUIRING FURTHER ANALYSIS

Based upon the analysis in Table 5-1, the following metals are further analyzed in this report:

- Arsenic
- Cadmium
- Chromium
- Lead
- Mercury
- Selenium

6.0 COPEC QUANTITATIVE SCREENING ANALYSIS

In determining the effects that metals have on the soil, the deposition concentration of the trace elements on soils were calculated using the techniques described in the EPA Screening Document[5]. The formula for calculating the soil concentration is as follows:

$$Cs = \frac{Ds - [1 - \exp(-ks \ x \ tD]}{ks}$$

Where:

Cs = COPEC concentration in soil (mg/kg)

Ds = Deposition Term (mg/kg-yr

Ks = COPEC soil loss constant due to all processes (yr^{-1})

tD = Total time period over which deposition occurs (yr – 30)

The deposition term (Ds) and the soil loss constant (Ks) are both calculated using more in-depth equations which are shown below:

Deposition Term Equation (All Metals except Mercury):

$$Ds = \frac{100 x Q}{Z_s \ x BD} \ x \left[F_v (0.31536 \ \ x \ Vdv \ \ x \ \ Cyv + Dywv) + (Dydp + Dywp) x \left(1 - F_v \right) \right]$$

Deposition Term Equation For Mercury:

$$Ds_{Mercury} = \frac{(100 x 0.48 Q_{Total\ Mercury})}{Z_s \ x BD} \ x \left[F_{v_{Hg^{2+}}} (0.31536 \ \ x \ Vdv \ \ x \ \ Cyv + Dywv) + (Dydp + Dywp) x \left(1 - F_{v_{Hg^{2+}}} \right) \right]$$

Soil Loss Constant Due to All Processes:

KS = Ksg + Kse + Ksr + Ksl + Ksv

[5] ibid

Loss Constant due to abiotic and biotic degradation

Ksg = 0 for all metals

Loss Constant due to soil erosion:

Kse = 0 for all metals

Loss Constant due to Surface Runoff:

$$ksr = \frac{RO}{\theta_{sw}\ x\ Z_s}\ x\left(\frac{1}{1+\left(Kd_s\ x\ BD/\theta_{sw}\right)}\right)$$

Loss Constant due to Volatilization:

$$ksv = \left[\frac{3.1536\ x\ 10^7\ x\ H}{Z_s\ x\ Kd_s\ x\ R\ x\ T_a\ x\ BD}\right] x\left(\frac{D_a}{Z_s}\right) x\left[1-\left(\frac{BD}{\rho_s}\right)-\vartheta_{sw}\right]$$

Loss Constant due to Leaching:

$$ksl = \frac{P+I-RO-E_v}{\theta_{sw}\ x\ Z_s\ x\left[1.0+\left(BD\ x\ Kd_s/\theta_{sw}\right)\right]}$$

The following variables were used in the above equations:

Table 6-1: Emissions

POLLUTANT	EMISSION RATE		
	TONS/YR	LBS/HR	G/SEC
Arsenic	5.11E-03	1.17E-03	1.47E-04
Cadmium	1.15E-02	2.63E-03	3.31E-04
Chromium	8.94E-02	2.04E-02	2.57E-03
Mercury*	6.75E-02	1.54E-02	1.94E-03
Selenium	1.01E-01	2.30E-02	2.90E-03
Lead	2.63E-02	6.01E-03	7.57E-04

*** Assumes no loss to the Global Cycle - worst case. Assuming 15% methylation rate this equals 2.91e-4**

Table 6-2: Metal Specific Variables

POLLUTANT	Fv	Kds(pH=6.8 (cm^3/g)	Da (cm^2/s)	H (atm m^3/mol)	Source
Arsenic	0.00	29	0.107	0.00	Appendix A-2, Table A-2-14
Cadmium	0.00	75	8.16E-02	0.00	Appendix A-2, Table A-2-35
Chromium	0.00	1.80E+06	0.101	0.00	Appendix A-2, Table A-2-52
Total Mercury	1.00	1.00E+03	0.0109	7.10E-03	Appendix A-2, Table A-2-131
Mercury (methylated)	0.00	7.00E+03	5.28E-02	4.70E-07	Appendix A-2, Table A-2-140
Selenium	0.00	5	0.103	0.00	Appendix A-2, Table A-2-172
Lead	0.00	9.00E+02	0.0543	0.00	Appendix A-2, Table A-2-128

Table 6-3: Variables for All Metals

Variables for All Metals		**Units**	Source
tD Time Period	30	years	Site Specific
Zs: Soil Mixing Depth	20	cm	Appendix B, Table B-1-1
BD: Soil Bulk Density	1.5	g/cm^3	Appendix B, Table B-1-1
Vdv: Dry Deposition Velocity	3	cm/s	Appendix B, Table B-1-1
Kse: Loss Constant due to erosion	0	1/yr	Appendix B, Table B-1-3
Θsw: Soil Volumetric Water Content	0.2	mL/cm^3	Appendix B, Table B-1-4
R: Universal Gas Constant	8.21E-05	$atm\text{-}m^3/mol\text{-}K$	Appendix B, Table B-1-6
Ta: Ambient Temperature	298	K	Appendix B, Table B-1-6
ρs: Solids Particle Density	2.7	g/cm^3	Appendix B, Table B-1-6
RO: Average Annual Surface Runoff	25.4	cm/yr	USGS MAP
P: Average Annual Precipitation	91.44	cm/yr	NATIONAL WEATHER SERVICE
I: Average Annual Irrigation	40	cm/yr	USGS MAP
Ev: Average Annual Evapotranspiration	76.2	cm/yr	USGS MAP

By applying the equations described above using the ground level concentration terms and the ground level deposition terms that were modeled for the TEC (see Tables 6-5, 6-6 and 6-7 in Section 6.2 below), soil concentrations can be compared to the acceptable background and screening levels designated by the EPA, both values in mg/kg. Background concentrations were obtained from the IEPA document "A Summary of Selected Background Conditions for Inorganics in Soils"[6] These background concentrations are specific to Illinois and are different for metropolitan/non-metropolitan counties. Christian County, where the TEC will be located, is considered non-metropolitan.

6.1 SCREENING LEVELS

The soil screening levels used were No Observed Adverse Effects Levels ("NOAEL") and are specific to different animal species. For this ecological risk assessment, the species of concern are the Bald Eagle and the Indiana Bat. As NOAEL screening levels are not available for the Bald Eagle or Indiana Bat, the most similar species (Great Blue Heron) for which screening levels are available was selected as a proxy species. Screening levels were available for the proxy species for all of the metals to be compared. Also shown in Table 6-4 are Eco-Soil Screening Levels ("EcO-SSL") which the USEPA has developed. These screening levels are much higher than the NOAEL values used.

Table 6-4 compares the screening levels to the background concentrations used.

Table 6-4: Comparison of Screening Level to Background Levels in Christian County

POLLUTANT	NOAEL Screening Level (mg/kg)	EcO-SSL Levels (mg/kg)	Background Concentrations (mg/kg)
Arsenic	5.1	18	6.7
Chromium	1.0	26	17.3
Cadmium	1.47	0.36	0.92
Lead	3.85	11	49.2
Mercury	0.45	NA	0.11
Selenium	0.5	NA	0.5

The next step in the analysis involved the calculation of the total metal constituent concentration in the soil.

[6] IEPA, 1994

6.2 DETERMINATION OF COPEC CONCENTRATION IN SOIL (Cs in mg/kg)

Using the equations described above the Cs term was calculated. However, prior to performing these calculations, the following terms were needed:

Cyv – Unitized yearly average concentration from vapor phase
Dywp – Unitized yearly average wet deposition from particle phase
Dydp – Unitized yearly average dry deposition from particle phase
Dywv – Unitized yearly average wet deposition from vapor phase

The values for Cyv, Dywp, Dydp, and Dywv were taken from the output modeling files generated by the Risk Generator (attached as Appendix E). The output files use the following naming convention:

XXX-YY__.out

Where:
XXX represents the facility modeled:
- 001 – HRSG1
- 002 – HRSG2
- 003 – FLARE

YY represents the year modeled

__ - represents the phase modeled:
- B – Particle Bound Phase
- P – Particle Phase
- V – Vapor Phase

Based upon EPA guidance, for all inorganics except mercury, the Cyv, Dydp, Dywp come from the Vapor phase and Particle Phase output files. For mercury, the Cyv, Dydp, Dywp come from the Mercury Vapor Phase and the Particle Bound Phase output files.

The following table summarizes the modeling outputs for these variables:

Table 6-5: Unitized Yearly Average Concentration from Vapor Phase ("Cyv") Modeling Output Summary For Inorganics Except Mercury (XXX_YYV.out)

Year	HRSG1 Cyv ug/m^3	HRSG2 Cyv ug/m^3	FLARE Cyv ug/m^3	TOTAL Cyv ug/m^3
1986	0.28055	0.34024	0.1012	0.72199
1987	0.20948	0.25911	0.0912	0.55979
1988	0.27013	0.32718	0.09591	0.69322
1989	0.1963	0.24233	0.08241	0.52104
1990	0.41847	0.41789	0.11384	**0.9502**
			MAX	**0.9502**

The sum of the data from the year with the highest modeled output (1990) was used for Cyv (0.9502) except mercury and the sum of the data from the year with the highest modeled output (1990) was used for mercury Cyv (0.6594, see Table 6-5A below).

Table 6-5A: Unitized Yearly Average Concentration from Vapor Phase ("Cyv") Modeling Output Summary For Mercury (XXX_YYM.out)

Year	HRSG1 Cyv ug/m^3	HRSG2 Cyv ug/m^3	TOTAL Cyv ug/m^3
1986	0.24119	0.29351	0.5347
1987	0.1772	0.21986	0.39706
1988	0.23094	0.2807	0.51164
1989	0.16886	0.20914	0.378
1990	0.29649	0.36291	**0.6594**
		MAX	**0.6594**

Table 6-6: Unitized Yearly Average Wet Deposition from Vapor Phase ("Dywv") Modeling Output Summary for Inorganics Except Mercury (XXX_YYV.out)

Year	HRSG1 Dywv g/m^2-yr	HRSG2 Dywv g/m^2-yr	FLARE Dywv g/m^2-yr	TOTAL Dywv g/m^2-yr
1986	0	0	0	0
1987	0	0	0	0
1988	0	0	0	0
1989	0	0	0	0
1990	0	0	0	0
			MAX	**0**

For all metals except mercury, 0.0 is used since the Fv term is 0.0 for all metals.

Table 6-6A: Unitized Yearly Average Wet Deposition from Vapor Phase ("Dywv") Modeling Output Summary for Mercury (XXX-YYM.out)

Year	HRSG1 Dywv g/m^2-yr	HRSG2 Dywv g/m^2-yr	TOTAL Dywv g/m^2-yr
1986	0	0	0
1987	0	0	0
1988	0	0	0
1989	0	0	0
1990	0	0	**0**
		MAX	**0**

For Mercury, 0.0 was also used.

Table 6-7: Unitized Yearly Average Wet Deposition from Particle Phase ("Dywp") + Unitized Yearly Average Dry Deposition from Particle Phase ("Dydp") Modeling Summary for all Inorganics Except Mercury (XXX-YYP.out)

Year	HRSG1 Dywp + Dydp g/m^2-yr	HRSG2 Dywp + Dydp g/m^2-yr	FLARE Dywp + Dydp g/m^2-yr	TOTAL Dywp + Dydp g/m^2-yr
1986	1.14622	0.53066	0.78372	2.4606
1987	0.40455	0.22048	0.06836	0.69339
1988	0.27231	0.28677	0.14154	0.70062
1989	0.43853	0.19878	0.20572	0.84303
1990	1.50164	0.72938	1.0385	**3.26952**
			MAX	**3.26952**

The sum of the data from the year with the highest modeled output (1990) was used for Dywp + Dydp (3.27) except mercury and the sum of the data from the year with the highest modeled output (1990) was used for mercury Dywp + Dydp (0.83, see Table 6-7A below).

Table 6-7A: Unitized Yearly Average Wet Deposition from Particle Phase ("Dywp") + Unitized Yearly Average Dry Deposition from Particle Phase ("Dydp") Modeling Summary for Mercury (XXX-YYB.out)

Year	HRSG1 Dywp + Dydp g/m^2-yr	HRSG2 Dywp + Dydp g/m^2-yr	TOTAL Dywp + Dydp g/m^2-yr
1986	0.42523	0.15322	0.57845
1987	0.40868	0.17402	0.5827
1988	0.27509	0.07817	0.35326
1989	0.443	0.12888	0.57188
1990	0.55536	0.27715	**0.83251**
		MAX	**0.83251**

Using the data from Tables 6-5, 6-5A, 6-6, 6-6A, 6-7, and 6-7A, Cs was calculated. The results of these calculations are contained in Table 6-8. Table 6-8 also compares the Cs values to the Background Concentration, NOAEL Screening Level and the Eco-SSL Level where applicable

Table 6-8: Comparison of Cs to Screening Levels

POLLUTANT	Ksr (1/yr)	Ksl (1/yr)	Ksv (1/yr)	Ksg (1/yr)	KS (1/yr)	DS (mg/kg-yr)	CS (mg/kg)	Background Concentration (mg/kg)	NOAEL Screening Levels (mg/kg)	TOTAL (CS + Background) (mg/kg)	CS Exceed Background?	Background Exceed NOAEL Screening?	Total Exceed NOAEL Screening?	Eco-SSL Levels mg/kg	CS Exceed Eco-SSL Levels?	Background Exceed Eco-SSL Levels?	TOTAL Exceed Eco-SSL Levels?
Arsenic	2.91E-02	3.41E-02	0.00E+00	0.00E+00	6.32E-02	1.60E-03	2.15E-02	6.7	5.1	6.72E+00	NO	YES	YES	18	NO	NO	NO
Cadmium	1.13E-02	1.32E-02	0.00E+00	0.00E+00	2.45E-02	3.61E-03	7.66E-02	0.97	1.47	1.05E+00	NO	NO	NO	0.36	NO	YES	YES
Chromium	4.70E-07	5.53E-07	0.00E+00	0.00E+00	1.02E-06	2.80E-02	8.41E-01	17.3	1	1.81E+01	NO	YES	YES	26	NO	NO	NO
Total Mercury*	8.47E-04	9.95E-04	4.07E-02	0.00E+00	4.25E-02	1.94E-03	3.29E-02	0.11	0.45	1.43E-01	NO	NO	NO	NA	NA	NA	NA
Mercury(methyl)**	1.21E-04	1.42E-04	1.86E-06	0.00E+00	2.65E-04	3.88E-04	1.16E-02	NA	0.2	1.16E-02	NO	NA	NO	NA	NA	NA	NA
Selenium	1.65E-01	1.94E-01	0.00E+00	0.00E+00	3.59E-01	3.16E-02	8.80E-02	0.5	0.5	5.88E-01	NO	YES	YES	NA	NA	NA	NA
Lead	9.41E-04	1.11E-03	0.00E+00	0.00E+00	2.05E-03	8.25E-03	2.40E-01	49.2	3.85	4.94E+01	NO	YES	YES	11	NO	YES	YES

6.3 QUANTITATIVE ANALYSIS RESULTS

The following table summarizes the results in Table 6-8 above, showing the soil concentrations as a percent of the NOAEL Screening Level, percent of the Background Concentration and percent of the EcO-SSL level where applicable.

Table 6-9: Summary of Quantitative Analysis

POLLUTANT	Percent of NOAEL Screening Level	Percent of Background Concentration	Percent of EcO-SSL
Arsenic	0.32%	0.32%	0.12%
Cadmium	5.21%	7.90%	21.28%
Chromium	84.12%	4.86%	3.24%
Total Mercury*	7.30%	29.87%	NA
Mercury (methyl)**	5.80%	NA	NA
Selenium	17.6%	17.6%	NA
Lead	6.24%	0.49%	2.18%

***TOTAL MERCURY**

The modeled maximum deposition composition for mercury represents total mercury and not what is bioavailable, but the bioavailable portion is less than the total. Based upon the ECORISK View Model Mercury wizard, the elemental mercury is 3.88E-6 g/sec of the total mercury modeled of 1.94E-3 g/sec modeled. The concentration of elemental mercury contributed from the project is 29.87% of the current estimated background so the risk analysis will not realistically be able to provide a meaningful number for a hazard estimate.

****MERCURY (METHYL)**

The total modeled mercury (methyl) concentrations in the soil are 7.30% of the NOAEL screening level, and if it is assumed that the background concentration of Mercury (methyl) is equal to the elemental mercury concentration (0.11) then the modeled concentration is 41.4% of the Background level.

Based on comparison of the total modeled pollutant (including mercury (methyl)) concentrations in the soil to the NOAEL, EcO-SSL and the Background concentrations, there is no predicted adverse impact on the bald eagle or the Indiana bat from TEC emissions of these pollutants.

6.4 INDIANA BAT FOOD CHAIN ANALYSIS

A food chain analysis has been prepared under the direction of the National Forest Service. This analysis is in Appendix F. One analysis was prepared showing that the Indiana Bat consumed 100% of its daily diet of terrestrial insects inside the study area. This results in a NOAEL Hazard Quotient of 1.78 and a LOAEL Hazard Quotient of 0.22. The NOAEL Hazard quotient is mitigated by the fact that the LOAEL Hazard Quotient is low and the fact that the habitat for the Indiana Bat is located on the perimeter of the study area and the calculation of Cs was based

on the maximum impacts inside the study area which were near to the proposed project site and not within the potential habitat.

Another food chain analysis was performed assuming that the Indiana Bat consumed 50% of the terrestrial insects inside the study area and 50% of the Infaunal aquatic insects outside the study area (since there were no identified aquatic receptors inside the study area). This resulted in a NOAEL Hazard quotient of 0.89 and a LOAEL Hazard quotient of 0.11.

7.0 CONCLUSION

Based upon the modeling results, calculations, and comparisons to (i) the NOAEL screening level, (ii) EcO-SSL, and (iii) soil background concentrations delineated above, emissions of HAPs from the TEC are not expected to have a material adverse impact on potential endangered species of concern (Bald Eagle and Indiana Bat) that could occur in proximity to the Project.

APPENDIX A

"Recommended Scope of Analysis for Taylorville Energy Center ("TEC") for Endangered Species"

Recommended Scope of Analysis for Taylorville Energy; Center (TEC)
for Endangered Species August 24, 2006

Purpose of analysis:

The analysis is intended to determine whether the proposed construction of the Taylorville Energy Center (TEC) is likely to directly or indirectly adversely affect federally listed species. This recommended scope of analysis or roadmap recommends using USEPA's ecological risk assessment process to inform the decision points in section 7 of the Endangered Species Act. Portions of the USEPA's draft Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities (EPA 530-D-99-001A) provides useful guidance for this analysis. Although this guidance was designed specifically to assess the impact of hazardous waste combustion facilities, it offers general approaches for assessing the fate of chemicals released to the air that can be applied to all types of industrial facilities.

Overall, the evaluation should focus on emissions from the facility. To complete this analysis we need an understanding of the background concentrations and deposition patterns. The anticipated emissions from permitted but not yet operational facilities should be included in background. The anticipated concentration in air or deposition at sites supporting listed species should be compared against NOEL (No observed effects level) benchmarks thought to be protective of the appropriate group (e.g., plants). The evaluation should look at the incremental addition in the context of background concentrations.

Benchmarks:

For these analyses, commonly accepted NOEL (no observed effects levels) benchmarks should be used. Where more than one benchmark can be found, the most conservative value should be used, unless an explanation is given to justify a less conservative benchmark. When there is no commonly accepted benchmark, there should be a search of the scientific literature for relevant toxicity information to provide a basis for risk assessment for the species of concern.

Modeling protocol:

Modeling should follow the general guidance provided in Chapter 3 of USEPA's SLERA protocol for assessing chemical fate and transport. The modeling should show air concentrations and deposition rates for all pollutants (where appropriate). The air emissions resulting from the project should be modeled at the facility level, not on a unit basis. Total impacts should be evaluated looking at the combined effects of the vapor phase, particle phase and particle-bound phase of pollutants. ISCST3 is an acceptable model for this analysis. For chemicals amenable to deposition, models in the SLERA guidance should be used to estimate concentrations in soil, surface water, and sediment in conjunction with relevant fate and transport parameters.

Background Levels:

Site specific background concentrations in air, soil, water and sediment should be considered in the effects analysis.

Suite of pollutants to consider:

The assessment should cover all air pollutants emitted from the facility including ozone, sulfur compounds, oxides of nitrogen, carbon monoxide, particulates, and hazardous air pollutants. USEPA will provide the analysis for ozone for this project.

Types of impact to consider:

1) Long term, depending upon pollutant. Compare the worst year of concentrations in air or deposition on soil (over the last 5 years) with appropriate bench marks for chronic effects.
2) Direct effects to listed plants and animals from exposure to the vapor phase, particle phase and particle-bound phase of pollutants.
3) The indirect effects to animals from ingestion of plants, fish, and invertebrates that have accumulated these pollutants.

Listed Species:

The species that should be evaluated for impacts from the project are the Bald Eagle and Indiana Bat.

APPENDIX B
EASTERN FRINGED PRAIRIE ORCHID

U.S. Fish & Wildlife Service

Orchid, eastern prairie fringed

Platanthera leucophaea
Family: Orchidaceae
Group: Flowering Plants

Current Status: Threatened (see below)

- Status Details regarding information on Recovery Plans, Special Rules and Critical Habitat for specific designations.
- Federal Register documents that apply to the Eastern prairie fringed orchid.
- Conservation Plans (Habitat Conservation Plans, Safe Harbor Agreements, Candidate Conservation Agreements) in which Eastern prairie fringed orchid occurrence has been recorded.
- Petitions received on the Eastern prairie fringed orchid.
- USFWS Refuges on which the Eastern prairie fringed orchid is reported.
- Virtual Newsroom
- Current News Releases
- NatureServe Explorer Species Reports.

Status Details

Threatened

The Eastern prairie fringed orchid was first listed on **September 28, 1989**. It is currently designated as **Threatened** in the **Entire Range**. The published range of this species includes: **Arkansas, Iowa, Illinois, Indiana, Maine, Michigan, Missouri, Nebraska, New Jersey, New York, Ohio, Oklahoma, Pennsylvania, Virginia, Wisconsin; Canada (N.B,Ont.)** (please note, the current range of this species may be quite different from the published range). The U.S. Fish and Wildlife Service **Great Lakes-Big Rivers Region (Region 3)** is the lead region for this entity.

- A recovery plan (Eastern Prairie Fringed Orchid) details specific tasks needed to recover this species. (This file is in PDF format with a file size of **933 kb**).
- Go to Federal Register documents.

NatureServe EXPLORER
An Online Encyclopedia of Life
Search | About the Data | About Us | Contact Us | Help
Return To Search Results | Change Criteria | New Search
<< Previous | Next >> View Glossary

Platanthera leucophaea - (Nutt.) Lindl.

Eastern Prairie White-fringed Orchid

Google
Search for Images on Google

Other Related Names: *Habenaria leucophaea* (Nutt.) Gray
Unique Identifier: ELEMENT_GLOBAL.2.134537
Element Code: PMORC1Y0F0
Informal Taxonomy: Plants, Vascular - Flowering Plants - Orchid Family

Kingdom	Phylum	Class	Order	Family	Genus
Plantae	Anthophyta	Monocotyledoneae	Orchidales	Orchidaceae	Platanthera

Check this box to expand all report sections: ☑

Concept Reference

Concept Reference: Kartesz, J.T. 1994. A synonymized checklist of the vascular flora of the United States, Canada, and Greenland. 2nd edition. 2 vols. Timber Press, Portland, OR.
Concept Reference Code: B94KAR01HQUS
Name Used in Concept Reference: *Platanthera leucophaea*
Taxonomic Comments: The western prairie white-fringed orchid (Platanthera praeclara) is now distinguished from P. leucophaea. In the currently accepted sense (e.g., Kartesz, 1999 checklist), P. leucophaea is primarily east of the Mississippi River, and P. praeclara is essentially west of that river.

Conservation Status

NatureServe Status

Global Status: G3
Global Status Last Reviewed: 11Oct2004
Global Status Last Changed: 11Oct2004
Rounded Global Status: G3 - Vulnerable
Reasons:
Extirpated in much of its large historic range and is very rare throughout its current range. Most of this species' wet prairie habitat has been destroyed due to drainage and conversion to agriculture, fire suppression, and intensive mowing. Because of the destruction of most of the natural grasslands east of the Mississippi River, large populations no longer occur anywhere in the United States (the only population with more than 2000 individuals is in Ontario, Canada). The mostly small, isolated populations that remain are not representative of populations supported by the once-vast prairie habitat, and many are only infrequently visited by appropriate pollinators.
Nation: United States
National Status: N3
Nation: Canada
National Status:N2

U.S. & Canada State/Province Status	
United States	Illinois (S1), Indiana (S1), Iowa (S1), Maine (S1), Michigan (S1), Missouri (SH), New York (SH), Ohio (S2), Oklahoma (SH), Pennsylvania (SX), Virginia (S1), Wisconsin (S2S3)

Canada	Ontario (S2)

Other Statuses

U.S. Endangered Species Act: LT: Listed threatened (28Sep1989)
U.S. Fish & Wildlife Service Lead Region: R3 - North Central
Committee on the Status of Endangered Wildlife in Canada (COSEWIC): Endangered (01May2003)

NatureServe Conservation Status Factors

Global Short Term Trend Comments: Declining throughout its range.

Threats: Loss of habitat from draining and ditching for crop production, and commercial and residential development. Populations along the shores of the Great Lakes are threatened by high water levels and invasion of purple loosestrife. Grazing by cattle and deer. Cutting hay in midsummer prevents populations from dispersing seed. Fire exclusion allows woody shrubs to invade prairie sites. Collection by orchid fanciers and wildflower gardeners.

Distribution

U.S. States and Canadian Provinces

State/Province Conservation Status

- SX: Presumed Extirpated
- SH: Possibly Extirpated
- S1: Critically Imperiled
- S2: Imperiled
- S3: Vulnerable
- S4: Apparently Secure
- S5: Secure
- Not Ranked/Under Review (SNR/SU)

Conservation Status Not Applicable (SNA)

- Exotic
- Hybrid without Conservation Value

U.S. & Canada State/Province Distribution	
United States	IA, IL, IN, ME, MI, MO, NY, OH, OK, PA, VA, WI
Canada	ON

Range Map
No map available.

U.S. Distribution by County (based on available natural heritage records) ?	
State	**County Name (FIPS Code)**
IA	Decatur (19053), Jackson (19097), Johnson (19103), Jones (19105)
IL	Cook (17031), DuPage (17043), Grundy (17063), Hancock (17067), Henry (17073), Iroquois (17075), Kane (17089), Lake (17097), Mchenry (17111), Will (17197)
IN	White (18181)
ME	Aroostook (23003)
MI	Bay (26017), Huron (26063), Livingston (26093), Monroe (26115), Saginaw (26145), St. Clair (26147), St. Joseph (26149), Tuscola (26157), Washtenaw (26161), Wayne (26163)
OH	Clark (39023), Holmes (39075), Lucas (39095), Ottawa (39123), Sandusky (39143), Wayne (39169)
VA	Augusta (51015)
WI	Dane (55025), Jefferson (55055), Kenosha (55059), Ozaukee (55089), Rock (55105), Walworth (55127), Waukesha (55133), Winnebago (55139)

U.S. Distribution by Watershed (based on available natural heritage records) ?	
Watershed Region ?	**Watershed Name (Watershed Code)**
01	Mattawamkeag (01020003)
02	South Fork Shenandoah (02070005)
04	Upper Fox (04030201), Wolf (04030202), Pike-Root (04040002), Milwaukee (04040003), St. Joseph (04050001), Pigeon-Wiscoggin (04080103), Saginaw (04080206), Lake Huron (04080300), Lake St. Clair (04090002), Detroit (04090004), Huron (04090005), Ottawa-Stony (04100001), Cedar-Portage (04100010), Sandusky (04100011), Lake Erie (04120200)
05	Walhonding (05040003), Upper Great Miami (05080001), Tippecanoe (05120106)
07	Maquoketa (07060006), Lower Wapsipinicon (07080103), Flint-Henderson (07080104), Middle Iowa (07080208), Upper Rock (07090001), Crawfish (07090002), Pecatonica (07090003), Sugar (07090004), Green (07090007), Bear-Wyaconda (07110001), Kankakee (07120001), Iroquois (07120002), Chicago (07120003), Des Plaines (07120004), Upper Illinois (07120005), Upper Fox (07120006), Lower Fox (07120007)
10	Thompson (10280102)

Ecology & Life History **Not yet assessed** ?

Economic Attributes **Not yet assessed** ?

Management Summary **Not yet assessed** ?

Population/Occurrence Delineation ?

Alternate Separation Procedure: Use the Habitat-based Plant Element Occurrence Delimitation Guidance (2004).
Date: 01Oct2004

Population/Occurrence Viability **Not yet assessed** ?

U.S. Invasive Species Impact Rank (I-Rank) **Not yet assessed** ?

Authors/Contributors ?

NatureServe Conservation Status Factors Edition Date: 21Jul1992
NatureServe Conservation Status Factors Author: S. Gottlieb (1992), EO specs and rank specs by Mike Penskar (1995), rev. L. Morse (1995), rev. Maybury/Penskar (1996)

Botanical data developed by NatureServe and its network of natural heritage programs (see **Local Programs**), The North Carolina Botanical Garden, and other contributors and cooperators (see **Sources**).

References ?

- Bowles, M.L. 1983. The tallgrass orchids Platanthera leucophaea (Nutt.) Lindl. and Cypripedium candidum Muhl. ex Willd., and implications toward management. Natural Areas J. 3(4): 14-37.
- Bowles, M.L. 1983. The tallgrass prairie orchids PLATANTHERA LEUCOPHAEA (Nutt.) Lindl. and CYPRIPEDIUM CANDIDUM Muhl. ex Willd.: some aspecits of their status, biology, and ecology, and implications towards manangement. Natural Areas Journal 3(4):14-37.
- Bowles, M.L. 1983. The tallgrass prairie orchids PLATANTHERA LEUCOPHAEA (Nutt.) Lindl. and CYPRIPEDIUM CANDIDUM Muhl. ex Willd.: some aspects of their status, biology, and ecology, and implications towards management. Nat Areas J. 3(4):14-37.
- Bowles, M.L., K.A. Jacobs, L.W. Zettler, and T.W. Delaney. 2002. Crossing effects on seed viability and experimental germination of the federal threatened Platanthera leucophaea (Orchidaceae). Rhodora 104(917):14-30.
- Bowles, Marlin, Robyn Flakne and Russ Dombeck. 1992. Status and Population Fluctuations of the Eastern Prairie Fringed Orchid (Platanthera leucophaea (Nutt.) Lindl.) in Illinois. Erigenia 12:26-40
- Brown, J.R. 1985. PLATANTHERA LEUCOPHAEA (Nutt.) Lind. (prairie fringed orchid) on Walpole Island, Lambton County. The plant Press 3(4):126-128
- Brownell, V.R. 1986. Status report on the eastern prairie white-fringed orchid PLATANTHERA LEUCOPHAEA. Committee on the Status of Endangered Wildlife in Canada. 38 pp.
- Catling, P.M., V.R. Brownell, and G. Allen. 1999. A new natural hybrid fringed-orchid from Ontario. Lindleyana 14(2):77-86.
- Catling, P.M., and V.R. Brownell. 1999. Platanthera lacera x leucophaea, a new cryptic natural hybrid, and a key to northeastern North American fringed-orchids. Canadian Journal of Botany 77:1144-1149.
- Correll, D.S. 1950 [1978]. Native orchids of North America north of Mexico. Stanford Univ. Press, Stanford, California. 400 pp.
- Gates, F.C. 1912. The vegetation of the beach area in northeastern Illinois and southeastern Wisconsin. Bull. Ill. State Lab. Nat. Hist. 9:255-372.
- Kartesz, J.T. 1994. A synonymized checklist of the vascular flora of the United States, Canada, and Greenland. 2nd edition. 2 vols. Timber Press, Portland, OR.
- Kartesz, John T. 1991. Synonym names from 1991 checklist, as extracted by Larry Morse, TNC, June 1991.
- Lewis, D. and M. Tae. 1994. Northern Wetland Evaluation, Data and Scoring Record- Conroy Marsh. First Edition. July 4-8 & 24-25, 1994. Manuscript. 39 pp + 25 pp supplement.
- Luer, C.A. 1975. The native orchids of the United States and Canada excluding Florida. New York Botanical Garden. 361 pp.
- Mitchell, Richard S. and Gordon C. Tucker. 1997. Revised Checklist of New York State Plants. Contributions to a Flora of New York State. Checklist IV. Bulletin No. 490. New York State Museum. Albany, New York. 400 pp.
- Myers, R.M., and R.D. Henry. 1976. Some changes that have occurred in the indigenous flora of two adjoining west-central Illinois counties (Hancock and McDonough) during the last 140 years. Trans. Ill. State Acad. Sci. 69:19-36.
- Pepoon, H.S. 1916. Peculiar plant distributions. Trans. Ill. State Acad. Sci. 9:128-137.
- Reddoch, J.M. and A.H. Reddoch. 1997. The orchids in the Ottawa District: floristics, phytogeography, population studies and historical review. Canadian Field-Naturalist 111(1):1-185.
- Sheviak, C. 1974. An introduction to the ecology of the Illinois Orchidaceae. Illinios State Museum, Springfield, IL. 89p.
- Sheviak, C.J. 1974. An introduction to the ecology of the Illinois Orchidaceae. Illinois State Museum Scientific Papers XIV. Ill. State Mus., Springfield, IL. 89pp.
- Sheviak, C.J., and M.L. Bowles. 1986. The prairie fringed orchids: A pollinator-isolator species pair. Rhodora 88: 267-290.
- Sieg, C.J. & R.M. King. 1995. Influence of environmental factors and preliminary demographic analyses of a threatened orchid, PLATANTHERA PRAECLARA. Am. Midl. Nat. 134:307-323.
- Zanoni, T.A., J.L. Gentry, Jr., R.J. Tyrl and P.G. Risser. 1979. Endangered and threatened plants of Oklahoma. Univ. of Oklahoma and Oklahoma State Univ., Norman. 64 pp.
- Zettler, L.W., Stewart, S.L., Bowles, M.L., Jacobs, K.A. 2001. Mycorrhizal Fungi and Cold-assisted Symbiotic Germination of the Federally Threatened Eastern Prairie Fringed Orchid, Platanthera leucophaea (Nuttall) Lindley. The American Midland Naturalist 145:168-175.

Use Guidelines & Citation

The Small Print: Trademark, Copyright, Citation Guidelines, Restrictions on Use, and Information Disclaimer.

Note: Ecological systems data presented in NatureServe Explorer at http://www.natureserve.org/explorer were updated to be current with NatureServe's central databases as of **July 18, 2006**. All other data were updated as of **June 9, 2006**.
Note: This report was printed on **October 26, 2006**

Trademark Notice: "NatureServe", NatureServe, NatureServe Explorer, The NatureServe logo, and all other names of NatureServe programs referenced herein are trademarks of NatureServe. Any other product or company names mentioned herein are the trademarks of their respective owners.

Copyright Notice: Copyright © 2006 NatureServe, 1101 Wilson Boulevard, 15th Floor, Arlington Virginia 22209, U.S.A. All Rights Reserved. Each document delivered from this server or web site may contain other proprietary notices and copyright information relating to that document. The following citation should be used in any published materials which reference the web site.

Citation for data on website including Watershed and State Distribution maps:
NatureServe. 2006. NatureServe Explorer: An online encyclopedia of life [web application]. Version 6.0. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. (Accessed: October 26, 2006).

Citation for Bird Range Maps of North America:
Ridgely, R.S., T.F. Allnutt, T. Brooks, D.K. McNicol, D.W. Mehlman, B.E. Young, and J.R. Zook. 2003. Digital Distribution Maps of the Birds of the Western Hemisphere, version 1.0. NatureServe, Arlington, Virginia, USA.

Acknowledgement Statement for Bird Range Maps of North America:
"Data provided by NatureServe in collaboration with Robert Ridgely, James Zook, The Nature Conservancy - Migratory Bird Program, Conservation International - CABS, World Wildlife Fund - US, and Environment Canada - WILDSPACE."

Citation for Mammal Range Maps of North America:
Patterson, B.D., G. Ceballos, W. Sechrest, M.F. Tognelli, T. Brooks, L. Luna, P. Ortega, I. Salazar, and B.E. Young. 2003. Digital Distribution Maps of the Mammals of the Western Hemisphere, version 1.0. NatureServe, Arlington, Virginia, USA.

Acknowledgement Statement for Mammal Range Maps of North America:
"Data provided by NatureServe in collaboration with Bruce Patterson, Wes Sechrest, Marcelo Tognelli, Gerardo Ceballos, The Nature Conservancy-Migratory Bird Program, Conservation International-CABS, World Wildlife Fund-US, and Environment Canada-WILDSPACE."

NOTE: Full metadata for the Bird Range Maps of North America is available at:
http://www.natureserve.org/library/birdDistributionmapsmetadatav1.pdf.

Full metadata for the Mammal Range Maps of North America is available at:
http://www.natureserve.org/library/mammalsDistributionmetadatav1.pdf.

Restrictions on Use: Permission to use, copy and distribute documents delivered from this server is hereby granted under the following conditions:

1. The above copyright notice must appear in all copies;
2. Any use of the documents available from this server must be for informational purposes only and in no instance for commercial purposes;
3. Some data may be downloaded to files and altered in format for analytical purposes, however the data should still be referenced using the citation above;
4. No graphics available from this server can be used, copied or distributed separate from the accompanying text. Any rights not expressly granted herein are reserved by NatureServe. Nothing contained herein shall be construed as conferring by implication, estoppel, or otherwise any license or right under any trademark of NatureServe. No trademark owned by NatureServe may be used in advertising or promotion pertaining to the distribution of documents delivered from this server without specific advance permission from NatureServe. Except as expressly provided above, nothing contained herein shall be construed as conferring any license or right under any NatureServe copyright.

Information Warranty Disclaimer: All documents and related graphics provided by this server and any other documents which are referenced by or linked to this server are provided "as is" without warranty as to the currentness, completeness, or accuracy of any specific data. NatureServe hereby disclaims all warranties and conditions with regard to any documents provided by this server or any other documents which are referenced by or linked to this server, including but not limited to all implied warranties and conditions of merchantibility, fitness for a particular purpose, and non-infringement. NatureServe makes no representations about the suitability of the information delivered from this server or any other documents that are referenced to or linked to this server. In no event shall NatureServe be liable for any special, indirect, incidental, consequential damages, or for damages of any kind arising out of or in connection with the use or performance of information contained in any documents provided by this server or in any other documents which are referenced by or linked to this server, under any theory of liability used. NatureServe may update or make changes to the documents provided by this server at any time without notice; however, NatureServe makes no commitment to update the information contained herein. Since the data in the central databases are continually being updated, it is advisable to refresh data retrieved at least once a year after its receipt. The data provided is for planning, assessment, and informational purposes. Site specific projects or

activities should be reviewed for potential environmental impacts with appropriate regulatory agencies. If ground-disturbing activities are proposed on a site, the appropriate state natural heritage program(s) or conservation data center can be contacted for a site-specific review of the project area (see **Visit Local Programs**).

Feedback Request: NatureServe encourages users to let us know of any errors or significant omissions that you find in the data through (see **Contact Us**). Your comments will be very valuable in improving the overall quality of our databases for the benefit of all users.

NatureServe

Version 6.0 (16 October, 2006)
Ecological systems data last updated: July 18, 2006
All other data last updated: June 9, 2006

APPENDIX C – PRAIRIE CLOVER DATA

USDA United States Department of Agriculture
Natural Resources Conservation Service

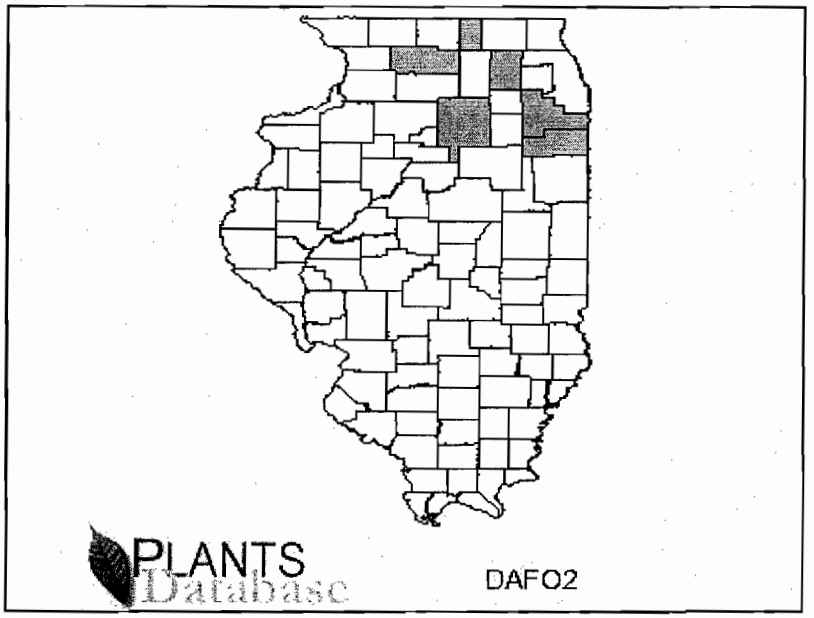
NRCS

PLANTS Database

PLANTS Profile

County Distribution

Dalea foliosa (Gray) Barneby - leafy prairie clover
DAFO2
in the state of Illinois



Our county data are based primarily on the literature, herbarium specimens, and confirmed observations. Not all populations have been documented, however, and significant gaps in the distribution shown above may not be real. Please use the Distribution Update module to improve the data by adding your new distribution information to PLANTS. Remember that only native and naturalized populations are mapped!

Time Generated: 10/27/2006 06:40 AM MDT

U.S. Fish & Wildlife Service
Great Lakes - Big Riv
Region 3

Endangered Species

Endangered Species Facts - pdf version

Leafy Prairie-Clover
(Dalea foliosa)

Status: Endangered

Habitat: This plant is found in prairie remnants along the Des Plains River in

Illinois, in thin soils over limestone substrate. In Alabama and Tennessee it lives in prairie-like areas on the edges of cedar glades. It favors sites with a wet spring and fall and a dry summer.

Why It's Threatened: Surviving today at only 14 sites, this clover and its habitat are threatened by land development. Leafy prairie-clover is especially vulnerable to commercial and residential development and to road construction. Other threats include off-road vehicle use and grazing by rabbits and deer.

Fire suppression practices have eliminated the wildfires which once regularly cleared prairie grasslands of the encroaching woods. Now the expansion of shrubs and trees threatens this clover, which needs hot, sunny sites to survive.

E-Mail Us!
Phone: 612/713-5360
V/TTY: 800-657-3775

Disclaimer

Region 3 Endangered Species Home Page
National Endangered Species Home Page
Region 3 Home Page USFWS Home Page

U.S. Fish and Wildlife Service
Division of Endangered Species
BHW Federal Building
1 Federal Drive
Fort Snelling, Minnesota 55111-4056

U.S. FISH AND WILDLIFE SERVICE
DIVISION OF ENDANGERED SPECIES

SPECIES ACCOUNTS

Source: *Endangered and Threatened Species of the Southeastern United States (The Red Book)* FWS Region 4 -- As of 2/92

LEAFY PRAIRIE-CLOVER

(*Dalea (=Petalostemum) foliosa*)

FAMILY: Fabaceae

STATUS: Endangered, *Federal Register*, May 1, 1991

DESCRIPTION: Leafy prairie-clover is a perennial with erect 0.5-meter (1.5-foot-) tall stems that arise from a hardened root crown. The plant's pinnately compound alternate leaves are 3.5 to 4.5 centimeters (1.4 to 1.8 inches) long and are composed of 2O to 3O leaflets. The small purple flowers are borne in dense spikes at the end of the stems (Smith and Wofford 1980). Flowering begins in late July and continues through August. Seeds ripen by early October and the above-ground portion of the plant dies soon afterward. The dead stems remain erect and disperse ripened seeds from late fall to early spring (Baskin and Baskin 1973).

RANGE AND POPULATION LEVEL: This species is known from three states: Alabama, Tennessee, and Illinois. There are four known locations for leafy prairie-clover in Alabama. At the present time two of these are believed to be extant and two extirpated (Scott Gunn, Alabama Natural Heritage Program, personal communication, 1990).

In Illinois, leafy prairie-clover was originally known from six counties in the northeastern portion of the State (Kurz and Bowles 1981). Currently there are three known populations. All are in prairie remnants along the Des Plaines River in Will County. Historically, the species was also found in Boone, Ogle, Kane, La Salle, and Kankakee Counties.

The U.S. Fish and Wildlife Service believes that there are currently only nine viable leafy prairie-clover populations in Tennessee. Most of these populations are small and contain fewer than 50 individual plants.

HABITAT: Leafy prairie-clover is typically found growing in close association with the cedar glades of central Tennessee and northern Alabama. However, it seems to prefer the deeper soil of the prairie-like areas along the boundaries of and within the rocky cedar glades (Smith and Wofford 1980). In Illinois, the species is now found only along the Des Plaines River, growing in prairie remnants that occur on thin-soil areas overlying dolomite (Kurz and Bowles 1981).

REASONS FOR CURRENT STATUS: Most of the known populations of this plant are threatened with destruction or adverse modification of their habitat. The leafy prairie-clover is best protected in Illinois, where two of the three known extant sites are being managed to protect the species. A fourth Illinois population was recently destroyed; it is not known if the site can be acquired and the leafy prairie-clover restored (De Mauro *in litt.*, Kurz and Bowles 1981).

An extirpated population in Franklin County, Alabama, was apparently destroyed by a series of construction activities which included road-widening and associated construction and, later, installation of an underground pipeline (Cary Norquist, U.S. Fish and Wildlife Service, personal communication, 1989). The small Morgan County, Alabama, population is vulnerable to loss or alteration by residential construction or conversion to livestock pasture (Smith and Wofford 1980). Two of Tennessee's nine currently confirmed viable populations are partially protected. Most of the Williamson County population was acquired by The Nature Conservancy through donation and is protected from outright destruction. Another portion of this population is still privately owned and is thereby vulnerable to loss in the future.

The best and largest Tennessee population is located on land owned by the Tennessee Valley Authority (TVA) in Maury County. This site was acquired as a part of the proposed Columbia Dam project area. Completion of this project has been delayed while TVA has been pursuing a mussel conservation plan aimed at avoiding jeopardy to federally-listed endangered mussels that inhabit the project impact area. Several alternatives to the original project are currently being evaluated by the TVA (Tennessee Valley Authority 1988). These alternatives could involve lower floodpool levels than originally proposed. Should they be chosen, the altered project would have no impact on the Leafy prairie-clover population. If the full-pool alternative is implemented, approximately 5O percent of this Maury County population would be inundated.

An additional factor which threatens Leafy prairie-clover is the extended drought condition which the species has faced during the past few years. The extremely dry summer of 1988 is probably responsible for the low survival rate of plants reintroduced to one of the Kankakee County, Illinois, locations. Only 6 of 1O5 plants transplanted to the site survived to the end of the summer. These conditions can be expected to be causing higher than normal mortality of seedlings in the natural populations and could, if they continue over an extended period of time, have an adverse effect on the survival of the plant.

MANAGEMENT AND PROTECTION: The Illinois Department of Conservation recently attempted to reestablish the species at one of the historic Kankakee County sites. The results of this effort are addressed above. Williamson County Tennessee, supports one population of the species, and most of this site was donated to The Nature Conservancy and is protected.

Recovery actions needed for the species include:

(1) Determination of the relative importance of all known populations;

(2) Provision of the protection needed to ensure survival of populations determined to be essential to recovery of the species;

(3) Provision of the management needed to ensure survival of species;

(4) Enforcement of laws prohibiting inappropriate trade and taking; and,

(5) Protection of genetic material through cultivation and seed banks.

Research needed to ascertain the protection requirements of the species:

(1) Determination of the habitat requirements of the species;

(2) Determination of the biology and life history of the species;

(3) Determination of the appropriate means of maintaining the species habitat in a manner conducive to its survival; and,

(4) Development of the techniques needed to reestablish the species at sites from which it has been extirpated.

REFERENCES:

Barneby, Rupert C. 1977. Daleae Imagines, An Illustrated Revision of *Errazurizia* Phillippi, *Psorothamnus* Rydberg, *Marina* Liebmann, and *Dalea* Lucanus emend. Barneby, including all species of Leguminosae tribe Amorpheae Borissova ever referred to Dalea--*Dalea foliosa*, Mem. New York Bot. Garden 27:244-245, 702-703.

Baskin, J.M., and C. Caudle. 1967. Petalostemon Foliosus in Alabama. Rhodora 69:383-384.

Baskin, J.M., and C. Baskin. 1973. The Past and Present Geographical Distribution of Petalostemon Foliosus and Notes on Its Ecology. Rhodora 75:132-140.

Gray, Asa. 1868. Proceedings Amer. Acad. 7:336 (type description).

Kral, Robert. 1983. A Report on Some Rare, Threatened, or Endangered Forest-related Vascular Plants of the South. USDA, Forest Service Tech. Pub. R8-TP2 Vol. 1. 718 pp.

Kurz, D.R., and M.L. Bowles. 1981. Report on the Status of Illinois Vascular Plants Potentially Endangered or Threatened in the United States. Unpublished report, Natural Land Institute, Rockford, Illinois. 7 pp.

Smith, D.K., and B.E. Wofford. 1980. Status Report - Petalostemum Foliosum Gray (*Dalea foliosa* [Gray] Barneby). Unpublished report for the USDI, Fish and Wildlife Service, Southeast Region, Atlanta, Georgia. 31 pp.

Tennessee Valley Authority. 1988. Biological Assessment of Columbia Dam Alternatives, Duck River, Tennessee. Unpublished report, Knoxville, Tennessee. 28 pp., plus 3 appendices.

For more information please contact:

US Fish and Wildlife Service
330 Ridgefield Court
Asheville, North Carolina 28806

Telephone 704/665-1195, ext. 224

APPENDIX D
COOLING TOWER CHEMICALS

POTENTIAL CHEMICALS FOR USE IN THE COOLING TOWERS AT TEC

COOLING WATER CHEMICALS	NOTES	MAMMAL LD_{50}	AQUATIC LC_{50}
Corrosion inhibitors			
Zinc	4.0 to 6.0 ppm dose rate	ND	ND
Sodium 2 mercaptobenzothiazole with polyacrylamides	50 to 150 ppm dose rate	ND	ND
Polydiol		ND	ND
Polystyrene		ND	ND
Benzotriazole with a combination of polyamines, phosphoramides, phosphonium compounds	50 to 150 ppm dose rate	560	ND
1 hydroxyethlidene-1, 1-diphophonic acid	3.1 ppm per 1 ppm alkalinity dose rate	2400	ND
Organo-phosphate	> 10 ppm active	ND	ND
Polyphosphate	1 to 3 ppm dose rate	>2000	>101
Scale Control			
Oxydiacetates	Chelating agent	2440	ND
Iminodiacetates	Chelating agent	8070	ND
Oxydisuccinates	Chelating agent	ND	ND
Polyphosphonates	Chelating agent	>2000	>101
Phosphate esters	Chelating agent	500	ND
Polyacrylates	Chelating agent	>5000	590
Iminodiacetates	Chelating agent	8070	ND
Nitilotriacetic acid	Chelating agent	1100	ND
Sulfuric Acid	Alkalinity Control 1 ppm Acid per 1 ppm Calcium bicarbonate	2140	100
Fouling Control			
Polyacrylate		5000	ND
Polyacrylamides		>8200	ND
Lignosuphonates		>5000	ND
Biocides			
Bromine	Oxidizing, 0.2 to 0.5 ppm residual, Shock 25 ppm two times per week	2600	ND
Ozone	Oxidizing, typically not used for cooling towers	ND	ND
Sodium Hypochlorite14.7 % solution	Oxidizing, 1ppm free Chlorine residual for 2 hours for shock biological control, 0.42 lb/1000 gal	ND	ND
Alkyl dimethyl benzyl ammonium chloride, 15 % solution, with Bis(tributyltin) oxide, 3.2 % solution	Non-oxidizing biocide, 0.83 LB/1000 gal	ND	ND

APPENDIX E
MODELING OUTPUT FILES ON CD

APPENDIX F
FOOD CHAIN ANALYSIS FOR THE INDIANA BAT

Indiana bat (*Myotis sodalis*) food exposure pathway risk calculation for Taylorville IGCC project
Chemical: Mercury (Total)
100% Terestrial Insects from Study Area

Future Soil Concentration	3.29E-02	mg/Kg dw
Existing Soil Concentration	0.11	mg/Kg dw
Soil to Invert BAF	8.5	unitless
Future Sediment Concentration	0	mg/Kg dw
Existing Sediment Concentration	0	mg/Kg dw
Sediment to Invert BAF	0	unitless
Future Water Concentration	0	mg/L
Water to Invert BAF	0	unitless
Normalized Food Ingestion Rate	0.333	Kg/Kg-bw/d ww
Percent terrestrial insects	1	%
Percent infaunal aquatic insects	0	%
Percent epifaunal aquatic insects	0	%
Normalized Water Intake Rate	0	L/Kg-bw/d
Area Use Factor	1	unitless
Seasonal Use Factor	1	unitless
Incidental Exposures (*e.g on insects*)	0.01	% of food rate
Body Weight	0.0075	Kg
Toxicity Reference Value NOAEL	0.23	mg/kg-bw/d
Toxicity Reference Value LOAEL?	1.9	mg/kg-bw/d
Soil to bug burden	1.21429865	mg/kg/d
Sediment to bug burden	0	mg/kg/d
Water to bug burden	0	mg/L/d
Normalized Food dose	0.40436145	mg/kg-bw/d
Drinking water dose	0	mg/kg-bw/d
Normalized Food & Water Dose	0.408405065	mg/kg-bw/d
Hazard Quotient NOAEL	1.7757	unitless
Hazard Quotient LOAEL	0.2150	unitless

Assume all exposure from soil and diet of soil invertebrates

Did not consider existing water concentration because retention time assumed low

Diet rates from Sample *et al.* 1996 for little brown bat

These three values must be < 1 - assume all terrestrial for this example

1. Agency for Toxic Substances and Disease Registry. Toxicological Profile for Mercury. Atlanta: ATSDR, May 1994; DHHS publication no. ATSDR/TP-93/10.

2. NTP. 1983. Toxicology and carcinogenesis studies of mercuric chloride (CAS no. 7487-94-7) in F344/N rats and B6C3F1 mice (gavage studies) as modified based on peer review). National Toxicology Program, U.S. Department of Health and Human Services, Public Health Service, National Institutes of Health, Research Triangle Park, NC. NTP TR 408. NIH publication no. 91-3139.

Σ Weighted (Abiotic Media Concentration X Bioaccumulation Factor) X Food Ingestion Rate/Body Weight X Use Factors = Dose / Toxicity Reference Value = Hazard Quotient

1 ng = 0.001 µg = 0.00001 mg
ppm = mg/Kg = µg/g = ng/mg = 1000 ppb
ppb = µg/Kg = ng/g = pg/mg 0.001 ppm
ppt = ng/Kg = pg/g = fg/mg

1.5E-03 = 0.0015

Indiana bat (*Myotis sodalis*) food exposure pathway risk calculation for Taylorville IGCC project
Chemical: Mercury (Total)
50% Terrestrial Insects from Study Area, 50% Infaunal aquatic insects outside study area

Future Soil Concentration	3.29E-02	mg/Kg dw	
Existing Soil Concentration	0.11	mg/Kg dw	Assume all exposure from soil and diet of soil invertebrates
Soil to Invert BAF	8.5	unitless	
Future Sediment Concentration	3.29E-02	mg/Kg dw	Assume equal to Future Soil Concentration - Worst Case
Existing Sediment Concentration	0.075	mg/Kg dw	
Sediment to Invert BAF	0.48	unitless	
Future Water Concentration	0	mg/L	Did not consider existing water concentration because retention time assumed low
Water to Invert BAF	55000	unitless	
Normalized Food Ingestion Rate	0.333	Kg/Kg-bw/d ww	Diet rates from Sample *et al.* 1996 for little brown bat
Percent terrestrial insects	0.5	%	
Percent infaunal aquatic insects	0.5	%	These three values must be < 1 - assume all terrestrial for this example
Percent epifaunal aquatic insects	0	%	
Normalized Water Intake Rate	0	L/Kg-bw/d	
Area Use Factor	1	unitless	
Seasonal Use Factor	1	unitless	
Incidental Exposures (*e.g on insects*)	0.01	% of food rate	
Body Weight	0.0075	Kg	
Toxicity Reference Value NOAEL	0.23	mg/kg-bw/d	1. Agency for Toxic Substances and Disease Registry. Toxicological Profile for Mercury. Atlanta: ATSDR, May 1994; DHHS publication no. ATSDR/TP-93/10.
Toxicity Reference Value LOAEL?	1.9	mg/kg-bw/d	2. NTP. 1983. Toxicology and carcinogenesis studies of mercuric chloride (CAS no. 7487-94-7) in F344/N rats and B6C3F1 mice (gavage studies) as modified based on peer review). National Toxicology Program, U.S. Department of Health and Human Services, Public Health Service, National Institutes of Health, Research Triangle Park, NC. NTP TR 408. NIH publication no. 91-3139.
Soil to bug burden	1.21429865	mg/kg/d	
Sediment to bug burden	0.051772159	mg/kg/d	
Water to bug burden	0	mg/L/d	
Normalized Food dose	0.21080079	mg/kg-bw/d	
Drinking water dose	0	mg/kg-bw/d	
Normalized Food & Water Dose	0.212908798	mg/kg-bw/d	
Hazard Quotient NOAEL	0.9257	unitless	
Hazard Quotient LOAEL	0.1121	unitless	

Σ Weighted (Abiotic Media Concentration X Bioaccumulation Factor) X Food Ingestion Rate/Body Weight X Use Factors = Dose / Toxicity Reference Value = Hazard Quotient

1 ng = 0.001 µg = 0.00001 mg
ppm = mg/Kg = µg/g = ng/mg = 1000 ppb
ppb = µg/Kg = ng/g = pg/mg 0.001 ppm
ppt = ng/Kg = pg/g = fg/mg

1.5E-03 = 0.0015

APPENDIX G

QUALITATIVE ASSESSMENT OF OTHER COPECs

This attachment provides a qualitative assessment of the potential for adverse effects from the emissions of those constituents of potential ecological concern (COPECs) not evaluated quantitatively in this ESA Screening Analysis.

C.1 VOLATILE ORGANIC COMPOUNDS

Brief profiles summarizing information in the readily available scientific literature on sources, environmental fate, and ecological effects are presented for the following volatile organic compounds: formaldehyde, benzene, toluene, xylene, and propylene oxide.

The following emissions for the TEC plant are used in this analysis:

COPEC	EMISSIONS TONS/YR	EMISSIONS G/S
Formaldehyde	0.434	0.01248
Benzene	0.511	0.01467
Toluene	0.0843	0.002425
Xylene	0.895	0.0257
Propylene Oxide	0.406	0.01168

To evaluate the potential for adverse effects on these COPECs, the emission (g/s) are multiplied by the following unitized (i.e. ug/m3 per 1 g/s) maximum short term and annual average concentration impacts for the IGCC units combined from the ISCST3 modeling to predict maximum average concentrations of each COPEC in air.

AVERAGING TIME	MAXIMUM UNITIZED IMPACT IN STUDY AREA (ug/m3 per g/s)
1-HOUR	32.97135
3-HOUR	21.01314
8-HOUR	13.1634
24-HOUR	8.7595
ANNUAL	0.63655

C.1.1 Formaldehyde

Sources and Environmental Fate Characteristics

Formaldehyde enters the environment from natural and anthropogenic sources. Secondary formation also occurs, by the oxidation of natural and anthropogenic organic compounds present in air. Formaldehyde does not persist in the environment, but its continuous release and formation can result in chronic exposure of biota near sources of release and formation.

Formaldehyde emitted to air primarily reacts with photochemically generated hydroxyl radicals in the troposphere or undergoes direct photolysis. The atmospheric half-life of formaldehyde, based on hydroxyl radical reaction rate constants, is calculated to be between 7 and 70 hours. Small amounts of formaldehyde may also transfer into rain, fog, and clouds or be removed by dry deposition. Formaldehyde is not expected to absorb to soil particles to a great degree and would be considered mobile in soil.

Potential Ecological Effects

Formaldehyde in air does not cause significant effects in terrestrial plants at low concentrations. The most sensitive effect found for plants was an increase in the growth of shoots, but not roots, in a study on the common bean plant. Other effects on plants include reduction of pollen tube length in lily and reductions in leaf area, leaf dry weight, stem dry weight, flower number, and number of mature seed pods that produce seed in winter wheat, aspen, rapeseed (*Brassica rapa*) when exposed to formaldehyde in fog water.

Formaldehyde is known to be an effective disinfectant, killing bacteria, viruses, fungi, and parasites at relatively high concentrations. Sensitive effects for terrestrial invertebrates include mortality of nematodes in peat fumigation applications and destruction of eggs and largae of cattle parasites using formaldehyde solutions.

No acute chronic toxicity data are available for wild animals, birds, reptiles, or terrestrial invertebrates. However, laboratory animals experienced histopathological effects and an

increase in cell proliferation in the nasal and respiratory tracts when exposed repeatedly to formaldehyde by inhalation for up to 13 weeks. Most short term and subchronic studies have been conducted on rats and have determined that histopathological and sustained proliferative response occurred in the nasal cavity at concentrations of 3,700 ug/m^3 and above.

Qualitative Evaluation

Formaldehyde concentrations in air within the study area were predicted from the ISCST3 modeling described in Section 3. The predicted maximum 1-hour, 3-hour, 8-hour, 24-hour, and annual average concentrations within the study area are represented in Table C-1. Effect levels reported in scientific literature for exposure of plants and laboratory animals (mammals) to formaldehyde in air are also presented. Effect levels for birds were not found in the readily available literature. As indicated in Table C-1, the predicted maximum average formaldehyde concentrations, at all averaging times, are orders of magnitude less than the exposure levels associated with adverse effects in plants and mammals.

References

Environment Canada and Health Canada. 2001. Priority Substances List Assessment Report. Formaldehyde. Canadian Environmental Protection Act, 1999. (February 2001)

Prairie State Screening Level Ecological Risk Assessment, 2004. Prepared by Malcolm Pirnie, Inc. (April 2004)

Table C-1: Qualitative Assessment for Formaldehyde

Predicted Maximum Average Concentrations in Study Area		
	ug/m^3	ppm
1-Hour	*0.411482*	*0.000335076*
3-Hour	*0.262244*	*0.000213549*
8-Hour	*0.164279*	*0.000133775*
24-Hour	*0.109319*	*8.90201E-05*
Annual	*0.007944*	*6.46892E-06*

Summary of Toxicological Effects from Inhalation Studies (ug/m^3)				
	Concentration	**Exposure Regime**	**Test Species**	**Effects**
Plants				
	78-438	7 h/d, 3d/w, 4 w	Common bean	Increased shoot growth, not root growth
	440	5 h	Lily	Reduction of pollen tube length
	840	5 h	Alfalfa	Atypical signs of injury
Mammals				
	Acute			
	3700	22 h/d, 3 d	Rat	LOAEL histopathological effects and increased cell proliferation in the nasal cavity
	3800	6 h/d, 3 d	Rat	LOAEL histopathological effects and increased cell proliferation in the nasal cavity
	6000	8 h/d, 5 d/w, 4 w	Rat	LOAEL histopathological effects and increased cell proliferation in the nasal cavity
	7100	6 h/d, 5 d/w, 1 to 14 d	Rat	LOAEL histopathological effects in nasal cavity
	7200	6 h/d, 3 d	Rat	LOAEL increased cell proliferation in nasal cavity
	7200	6 h/d, 5 d/w, 1 to 6 w	Monkey	LOAEL histopathological effects and increased cell proliferation in nasal cavity and upper portions of respiratory tract
	7400	6 h/d, 5 d/w,1,4 or 9 d or 6 w	Rat	LOAEL histopathological effects and increased cell proliferation in the nasal cavity
	18000	6 h/d, 3 d	Mouse	LOAEL increased cell proliferation in nasal cavity
	Subchronic			
	3600	5 d/w, 13 w	Rat	LOAEL histopathological effects and increased cell proliferation in the nasal cavity
	4800	5 d/w, 13 w	Rat	LOAEL histopathological effects in the nasal cavity
	7100	6 hr/d, 5 d/w, 11 w	Rat	LOAEL histopathological effects and increased cell proliferation in the nasal cavity

Summary of Toxicological Effects from Inhalation Studies (ug/m^3)				
	Concentration	**Exposure Regime**	**Test Species**	**Effects**
	11600	6 h/d, 5 d/w, 13 w	Rat	LOAEL histopathological effects in the nasal cavity
	11300	6 h/d, 5 d/w, 13 w	Rat	LOAEL histopathological effects in the nasal cavity
	Chronic			
	2400	6 h/d, 5 d/w, 24 mo	Rat	LOAEL histopathological effects in the nasal cavity
	2600	6 h/d, 5 d/w, 28 mo	Rat	LOAEL histopathological effects in the nasal cavity
	3600	22 h/d, 7 d/w, 26 w	Monkey, Rat	LOAEL histopathological effects in the nasal cavity
	7200	6 h/d, 5 d/w, 24 mo	Rat	LOAEL histopathological effects and increased cell proliferation in the nasal cavity
	11000	6 h/d, 5 d/w, 3 mo	Rat	LOAEL histopathological effects in the nasal cavity
	11300	6 h/d, 5 d/w, 52 w	Rat	LOAEL histopathological effects in the nasal cavity
	11800	6 h/d, 5 d/w, 28 mo	Rat	LOAEL histopathological effects in the nasal cavity

C.1.2 Benzene

Sources and Environmental Fate Characteristics

Benzene is commonly found in the environment. Industrial processes are the main sources of benzene in the environment. Benzene levels in the air can increase from emissions from burning coal and oil, benzene waste and storage operations, motor vehicle exhaust, evaporation from gasoline service stations, and use of industrial solvents. Since tobacco contains high levels of benzene, tobacco smoke is another source of benzene in air. Industrial discharge, disposal of products containing benzene, and gasoline leaks from underground storage tanks can release benzene into water and soil.

If benzene is released to soil, it will be subject to rapid volatilization near the surface and that which does not evaporate will be highly to very highly mobile in the soil and may leach to groundwater. It may be subject to biodegradation based on reported biodegradation of 24% and 47% of the initial 20 ppm benzene in a base-rich para-brownish soil in 1 and 10 weeks, respectively. It may be subject to biodegradation in shallow, aerobic groundwaters, but probably not under anaerobic conditions.

If benzene is released to water, it will be subject to rapid volatilization; the half-life for evaporation in a wind-wave tank with a moderate wind speed of 7.09 m/sec was 5.23 hrs; the estimated half-life for volatilization of benzene from a model river one meter deep flowing 1 m/sec with a wind velocity of 3 m/sec is estimated to be 2.7 hrs at 20 deg C. It will not be expected to significantly adsorb to sediment, bioconcentrate in aquatic organisms or hydrolyze.

It may be subject to biodegradation based on a reported biodegradation half-life of 16 days in an aerobic river die-away test. In a marine ecosystem biodegradation occurred in 2 days after an acclimation period of 2 days and 2 weeks in the summer and spring, respectively, whereas no degradation occurred in winter. According to one experiment, benzene has a half-life of 17 days due to photodegradation which could contribute to benzene's removal in situations of cold water, poor nutrients, or other conditions less conductive to microbial degradation.

If benzene is released to the atmosphere, it will exist predominantly in the vapor phase. Gas-phase benzene will not be subject to direct photolysis but it will react with photochemically produced hydroxyl radicals with a half-life of 13.4 days calculated using an experimental rate constant for the reaction. The reaction time in polluted atmospheres which contain nitrogen oxides or sulfur dioxide is accelerated with the half-life being reported as 4-6 hours. Products of photooxidation include phenol, nitrophenols, nitrobenzene, formic acid, and peroxyacetyl nitrate.

Benzene is fairly soluble in water and is removed from the atmosphere in rain. The primary routes of exposure are inhalation of contaminated air, especially in areas with high traffic, and in the vicinity of gasoline service stations and consumption of contaminated drinking water.

Potential Ecological Effects

Acute toxic effects may include the death of animals, birds, or fish, and death or low growth rate in plants. Acute effects are seen two to four days after animals or plants come in contact with a toxic chemical substance.

Benzene has high acute toxicity to aquatic life. It can cause death in plants and roots and membrane damage in leaves of various agricultural crops. No data are available on the short-term effects of benzene on birds or land animals.

Chronic toxic effects may include shortened lifespan, reproductive problems, lower fertility, and changes in appearance or behavior. Chronic effects can be seen long after first exposure(s) to a toxic chemical.

Benzene has high chronic toxicity to aquatic life. No data are available on the long-term effects of benzene on plants, birds, or land animals.

Qualitative Evaluation

Benzene concentrations in air within the study area were predicted from the ISCST3 modeling described in Section 3. The predicted maximum 1-hour, 3-hour, 8-hour, 24-hour, and annual average concentrations within the study area are represented in Table C-2. Effect levels reported

in scientific literature for exposure of plants and laboratory animals (mammals) to benzene in air are also presented. Effect levels for birds were not found in the readily available literature. As indicated in Table C-2, the predicted maximum average benzene concentrations, at all averaging times, are orders of magnitude less than the exposure levels associated with adverse effects in plants and mammals.

References

Toxicological Profile for Benzene August 1995 Update, Agency for Toxic Substances and Disease Registry, United States Public Health Service

http://www.epa.gov/safewater/dwh/t-voc/benzene.html

http://rais.ornl.gov/tox/profiles/benzene.shtml

Table C-2: Qualitative Assessment for Benzene

Predicted Maximum Average Concentrations in Study Area		
	(ug/m^3)	(ppm)
1-Hour	*0.48369*	*0.000151429*
3-Hour	*0.308263*	*9.65078E-05*
8-Hour	*0.193107*	*6.0456E-05*
24-Hour	*0.128502*	*4.02301E-05*
Annual	*0.009338*	*2.92345E-06*

Summary of Toxicological Effects from Inhalation Studies (ug/m^3)				
	Concentration	**Exposure Regime**	**Test Species**	**Effects**
Plants				
	NO DATA			
Mammals				
	Acute			
	25 ppm	5 d/w, 2 w	mice	NOAEL lymphocytopenia
	21 ppm	4 to 10 d	mice	LOAEL increased micronuclei and decreased number of cells per tibea and colony forming units
	100 ppm	1 w	rats	Leukopenia
	25 ppm	2 w	mice	Lymphopenia
	30 ppm	6 h/d, 12 d	mice	NOAEL (10 ppm) Decreased resistance to infection
	50 ppm		mice	Depressed T-lymphocytes and B-lymphocytes
	45,000 ppm		rabbits	Narcosis
	Subchronic			
	300 ppm	6 h/d, 5 d/w, 13w	Mice, rats	LOAEL luekopenia and lynphopenia NOAEL (30 ppm)
	10 ppm	6 h/d, 5 d/w, 24 w	mice	NOAEL depressed numbers of circulating lymphcytes and progenitor red blood cells in the spleen
	300 ppm	4-16 w	mice	Stem cell depression in bone marrow
	Chronic			
	100 ppm	6 h/d, 5 d/w, life	mice	LOAEL Anemia, lymphopenia, bone marrow hypoplasia

C.1.3 Toluene

Sources and Environmental Fate Characteristics

Toluene enters the environment when you use materials that contain it, such as paints, paint thinners, adhesives, fingernail polish, and gasoline or combust fuel such as coal based on AP-42 emission factors for coal combustion. As you work with these materials, the toluene evaporates and becomes mixed with the air you breathe. Toluene enters surface water and groundwater (wells) from spills of solvents and petroleum products as well as from leaking underground storage tanks at gasoline stations and other facilities. Leaking underground storage tanks also contaminate the soil with toluene and other petroleum-product components.

When toluene-containing products are placed in landfills or waste disposal sites, the toluene can enter the soil and water near the waste site. Toluene does not usually stay in the environment; it is readily broken down to other chemicals by microorganisms in soil and evaporates from surface water and surface soils. Toluene dissolved in well water does not break down quickly while the water is under the ground because there are few microorganisms in underground water. Once the water is brought to the surface, the toluene will evaporate into the air. Windows and doors in rooms where toluene-containing products are used should be opened to allow the toluene gas to escape. The toluene in the air will combine with oxygen and form benzaldehyde and cresol. These compounds can be harmful to humans.

Toluene can be taken up into fish and shellfish, plants, and animals living in water containing toluene, but it does not concentrate or build up to high levels because most animal species can make the toluene into other compounds that are excreted.

Because of its relatively high vapour pressure and moderate solubility in water, the atmosphere plays an important role in the distribution and ultimate fate of toluene (SRI, 1980; Mackay *et al.,* 1992). Based on various modelling simulations, it has been predicted that about 99% of toluene released into the environment should be present in the atmosphere (Slooff and Blokzijl, 1988; Nielsen and Howe, 1991; Mackay *et al.,* 1992). Once released to the atmosphere, either directly or by volatilization from other media, toluene photooxidizes relatively quickly in a reaction with

hydroxyl radicals to yield cresols, benzaldehyde, and a number of other products that are themselves degraded further (NRC, 1980; Finlayson-Pitts and Pitts, 1986; Atkinson, 1990). The minimum tropospheric lifetime for toluene has been calculated to be 4.5 hours (Finlayson-Pitts and Pitts, 1986), but half-lives as long as 10 days have been calculated for northern latitudes in winter [Syracuse Research Corporation, 1983]. Toluene is not associated with depletion of stratospheric ozone or with global warming because of its relatively short atmospheric lifetime and because it does not absorb ultraviolet radiation (NRC, 1980).

Gilbert *et al.* (1983) calculated a half-life of 9 seconds for volatilization of toluene from the soil surface. For the top centimetres of soil, the half-lives were calculated to be less than 1 hour for volatilization from dry soil and less than 1 day from wet soil; for the top 10 cm of soil, half-lives were less than 3 days for dry soil and less than 1 month for wet soil (SRI, 1980).

Potential Ecological Effects

In animals, the main effect of toluene is on the nervous system. Animals exposed to moderate or high levels of toluene may also show slightly adverse effects in their liver, kidneys, and lungs.

Several studies have shown that unborn animals were harmed when high levels of toluene were breathed in by their mothers.

No data could be found on the ecological effects of toluene on plants.

Qualitative Evaluation

Toluene concentrations in air within the study area were predicted from the ISCST3 modeling described in Section 3. The predicted maximum 1-hour, 3-hour, 8-hour, 24-hour, and annual average concentrations within the study area are represented in Table C-3. Effect levels reported in scientific literature for exposure of laboratory animals (mammals) to toluene in air are also presented. Effect levels for birds were not found in the readily available literature. As indicated in Table C-3, the predicted maximum average toluene concentrations, at all averaging times, are

orders of magnitude less than the exposure levels associated with adverse effects in plants and mammals.

References

http://www.eco-usa.net/toxics/toluene.shtml

Canadian Environmental Protection Act, Priority Substances List, Assessment Report No.4

http://rais.ornl.gov/tox/profiles/toluene_f_V1.shtml#t32

Table C-3: Qualitative Assessment for Toluene

Predicted Maximum Average Concentrations in Study Are a		
	(ug/m^3)	(ppm)
1-Hour	*0.079956*	*2.1218E-05*
3-Hour	*0.050957*	*1.35225E-05*
8-Hour	*0.031921*	*8.47089E-06*
24-Hour	*0.021242*	*5.637E-06*
Annual	*0.001544*	*4.09732E-07*

Summary of Toxicological Effects from Inhalation Studies (ug/m^3)				
	Concentration	**Exposure Regime**	**Test Species**	**Effects**
Plants				
	NO DATA			
Mammals				
	Acute			
	100 ppm	14 w	mice	LOAEL decreased body weight
	12200	6 to 7 h	rats	LC50
	5300-7000 ppm	6 to 7 h	mice	LC50
	10000 to 15000 ppm	60 min	rats	Initial increase in locomotor activity
	125, 250, 500 ppm	4 h	rats	Decline in trained neuromuscular responses
	7500 mg/m3	8 h/d, 3 d	Rats	Hearing Loss
	5660 mg/m3	14 h	rats	Hearing Loss
	Subchronic			
	1200 ppm	12 h/d, 5 w	rats	Irreversible hearing loss
	1000 mg/m3	6 h/d, 6 d/w, 6 mo	rats	Females exhibited increased cytchrome levels
	3000 ppm	6.5 h/d, 5 d/w, 15 w	rats	8/10 males rats died
	3000 ppm	6.5 h/d, 5 d/w, 14 w	mice	LC50
	Chronic			
	0, 600, 1200 ppm	6.5 h/d, 5 d/w, 15 mo	mice	LC50
	600 ppm		rats	LOEL increased histopathological effects on olfactory epithelium

C.1.\4 Xylene

Sources and Environmental Fate Characteristics

Xylene isomers are highly volatile and have been found to disappear rapidly from solution (WHO, 1997); for example, the half-life of o-xylene has been estimated to be 39 minutes in agitated water, 1 meter deep and with a 1 m^2 surface for evaporation. Both m-xylene and p-xylene are readily biodegradable; however, in soil and water, o-xylene has been observed to be more persistent. Bioaccumulation of all three xylene isomers has been reported to be low. Based on experimental K_{oc} values, xylene is expected to have moderate to high mobility in soils, and based on measured K_{oc} values, xylene is expected to adsorb somewhat to sediment or particulate matter in water (HSBD, 2005).

The EFED Science Chapter reports the following: "The most important fate property for xylenes applied to a drainage ditch is volatilization. Xylenes are also susceptible to biodegradation under aerobic conditions, but the rate of volatilization (half-life of about 2 days in a shallow water body; 1.2 days in typical river and 6.0 days in a pond http://www.epa.gov/OGWDW/dwh/t-voc/xylenes.html) is significantly greater than the rate of degradation (half-life on the order of 20 days) (API 1994). Abiotic degradation mechanisms, such as hydrolysis and photolysis, are not important for aromatic petroleum solvents. Although xylenes have high to moderate mobility in soils when applied directly to water, leaching to groundwater is considered unlikely." In addition, additional information is presented indicating that photolysis and hydrolysis are not important environmental fate pathways because the xylene isomers do not absorb photons of light with a wavelength greater than 290 nm, nor do they possess functional groups that are susceptible to hydrolysis under environmental conditions.

Mean background levels of the xylene isomers are around 1 $\mu g/m^3$ and 0.1 µg/L in ambient air and in surface waters, respectively (WHO, 1997). Higher values have been measured in industrial areas, particularly around oil industries associated with discharge pipes. High levels of xylenes have been reported in groundwater associated with underground tanks and pipes.

Potential Ecological Effects

WHO (1997) has described xylene as having moderate to low acute toxicity for aquatic organisms. The variation between each isomer with regard to aquatic toxicity is small. The lowest LC_{50} value, 1 mg/L, is based on a 24-hour exposure with *Daphnia magna*. This value is much higher (close to 10,000 times higher) than the mean background concentrations in surface water, as reported in the WHO (0.1 µg/L). In the WHO (1997) review, the lowest 96-hour LC_{50} value for any fish species was 1.7 mg/L, to the striped bass, a marine species, and the lowest 96-hour LC_{50} value to a freshwater species was 2.6 mg/L to the rainbow trout. Studies on terrestrial organisms (e.g., Japanese quail) have reported no overt toxicity at concentrations as high as 5000 mg/kg and LC_{50}'s of greater than 20,000 mg/kg. No studies on terrestrial plants invertebrates or field effects have been reported. Limited information is available on the chronic exposure of aquatic organisms and none of the effect levels were lower than those observed in the acute studies. The overall risk to the aquatic environment has been determined to be low, considering the rapid volatilization and degradation of xylenes and their low to moderate toxicity to organisms (WHO, 1997).

The EFED Science Chapter characterizes the ecotoxicity data as follows: "In general, results of acute toxicity studies indicate that mixed xylenes and xylene isomers are moderately to highly toxic to aquatic species. The acute toxicity values used to estimate risks to aquatic organisms are as follows:

freshwater fish: 96-hour LC_{50} value of 2.6 mg/L for p-xylene in rainbow trout (*Salmo gairdneri*);

freshwater invertebrates: 24-hour LC_{50} value of 1.0 mg/L for m-xylene in water flea (*Daphnia magna*);

estuarine/marine fish: 24-hour LC_{50} value of 2.0 mg/L for p-xylene in striped bass *(Morone saxatilis)*;

estuarine/marine invertebrates: 96-hour LC_{50} value of 1.3 mg/L for o-xylene in bay shrimp *(Crago francisocrum)*;

algae: 72-hour LC_{50} value of 3.2 mg/L for p-xylene in green algae (*Selenastrum capricornutum*)."

In addition, due to the rapid volatilization of xylenes from water (half-lives range from less than 2 days in a shallow flowing water body to 6 days in a pond), chronic exposure of aquatic and terrestrial ecosystems is not expected. Thus, chronic toxicity studies were not assessed, and there are no requirements for additional chronic toxicity testing.

No data could be found on the ecological effects of toluene on plants.

Qualitative Evaluation

Xylene concentrations in air within the study area were predicted from the ISCST3 modeling described in Section 3. The predicted maximum 1-hour, 3-hour, 8-hour, 24-hour, and annual average concentrations within the study area are represented in Table C-4. Effect levels reported in scientific literature for exposure of laboratory animals (mammals) to toluene in air are also presented. Effect levels for birds were not found in the readily available literature. As indicated in Table C-4, the predicted maximum average toluene concentrations, at all averaging times, are orders of magnitude less than the exposure levels associated with adverse effects in plants and mammals.

References

Re-registration Eligibility Decision for Xylene, List C, Case No. 3020, September 26, 2005

Table C-4: Qualitative Assessment for Xylene

Predicted Maximum Average Concentrations in Study Are a		
	(ug/m^3)	(ppm)
1-Hour	*0.847364*	*0.00019519*
3-Hour	*0.540038*	*0.000124397*
8-Hour	*0.338299*	*7.79269E-05*
24-Hour	*0.225119*	*5.1856E-05*
Annual	*0.016359*	*3.76828E-06*

Route:	Oral (gavage)			
Study	Organism	Doses	Chemical	Results
NTP Chronic 2-year study (1986)	Rats	0, 250, or 500 mg/kg-day	Mixed xylenes (60% m-xylene, 13.6% p-xylene, 9.1% o-xylene, 17.0% ethylbenzene)	NOAEL: 250 mg/kg-day LOAEL: 500 mg/kg-day (based on decreased body weight and decreased survival)
NTP Chronic 2-year study (1986)	Mice	0, 500, or 1000 mg/kg-day		NOAEL: 500 mg/kg-day LOAEL: 1000 mg/kg-day (based on hyperactivity)
NTP 13-week study (1986)	Rats	0, 62.5, 125, 250, 500, or 1000 mg/kg-day	Mixed xylenes (60% m-xylene, 13.6% p-xylene, 17.0% ethylbenzene, 9.1% o-xylene)	NOAEL: 500 mg/kg-day LOAEL: 1000 mg/kg-day (based on decreased body weight in male rats without tissue lesions)
NTP 13-week study (1986)	Mice	0, 125, 250, 500, 1000, and 2000 mg/kg-day		NOAEL: 1000 mg/kg-day LOAEL: 2000 mg/kg-day (based on transient signs of nervous system depression in mice without tissue lesions)
Wolfe (1988a) 90-day study	Rats	0, 100, 200, or 800 mg/kg-day	*m-xylene (99% purity)*	NOAEL: 200 mg/kg-day LOAEL: 800 mg/kg-day (based on decreased body weight)
Wolfe (1988b) 90-day study	Rats	0, 100, 200, or 800 mg/kg-day	*p-xylene (99% purity)*	NOAEL: 200 mg/kg-day LOAEL: 800 mg/kg-day (based on early mortality in male rats that showed signs of test material aspiration into the lungs)
Condie (1988) 90-day study	Rats	0, 150, 750, or 1500 mg/kg-day	Mixed xylenes (17.6% o-xylene, 62.3% m-xylene and p-xylene [which coeluted], 20% ethyl benzene)	NOAEL: 150 mg/kg-day LOAEL: 750 mg/kg-day (based on increased kidney weights and early appearance of mild nephropathy in female rats)

NTP (1986) study:

Chronic 2-year study

- Target organisms:
  - 50 male and 50 female Fischer 344 rats
  - 50 male and 50 female B6C3F1 mice
- Doses/Length of study:
  - Mixed xylenes (60% m-xylene, 13.6% p-xylene, 9.1% o-xylene, 17.0% ethylbenzene)
  - Administered by gavage in corn oil
  - Rats: 0, 250, or 500 mg/kg-day
  - Mice: 0, 500, or 1000 mg/kg-day
  - 5 days/week for 103 weeks
- Results:
  - Rats: LOAEL is 500 mg/kg-day and the NOAEL is 250 mg/kg-day for decreased body weight and decreased survival
  - Mice: The LOAEL is 1000 mg/kg-day and the NOAEL is 500 mg/kg-day for hyperactivity

Route	Inhalation			
Study	Organism	Doses	Chemical	Results
Korsak et al. (1992) 6-month study	Rats	0 or 100 ppm for 6 months or 1000 ppm for 3 months	toluene, m-xylene, or a 1:1 mixture	NOAEL: not identified LOAEL: 100 ppm (based on decreased rotarod performance and decreased spontaneous motor activity)
Korsak et al. (1994) 3-month study	Rats	0, 50, or 100 ppm	m-xylene or n-butyl alcohol or a 1:1 mixture	NOAEL: 50 ppm LOAEL: 100 ppm (based on decreased rotarod performance and decreased latency in the paw-lick response in the hot-plate test)
Gralewicz et al. (1995) 3-month study	Rats	0, 100, or 1000 ppm	"pure" m-xylene (exact purity not provided)	NOAEL: Not identified LOAEL: 100 ppm (based on deficits in radial maze performance)
Gralewicz and Wiaderna (2001) 4-week study	Rats	0 or 100 ppm	m-xylene	NOAEL: Not identified LOAEL: 100 ppm (based on neurobehavioral effects)

Korsak et al. (1992):

- Target organisms:
  - 12 male Wistar rats
- Doses/Length of study:
  - toluene, m-xylene, or a 1:1 mixture
  - 6 hours per day, 5 days per week
  - Concentration of 0 or 100 ppm for 6 months or 1000 ppm for 3 months
- Results:
  - The LOAEL is 100 ppm, based on decreased rotarod performance and decreased spontaneous motor activity. No NOAEL was identified.

Korsak et al. (1994):

- Target organisms:
  - 12 male Wistar rats
- Doses/Length of study:
  - 0, 50, or 100 ppm
  - m-xylene or n-butyl alcohol or a 1:1 mixture (purity of chemicals not provided)
  - 6 hours per day, 5 days per week, for 3 months
- Results:
  - The LOAEL is 100 ppm, based on decreased rotarod performance and decreased latency in the paw-lick response in the hot-plate test, and the NOAEL is 50 ppm.

C.1.5 Propylene Oxide

Sources and Environmental Fate Characteristics

Source of propylene oxide can be from the combustion of coal. The emissions stated herein are based on emission factors contained within AP-42.

The environmental fate of propylene oxide is summarized in table below[1].

Table 2-3 Environmental Fate of Propylene Oxide (based on Verschueren, 2001; Toxnet, 2001; Genium, 1999; IARC, 1994; Howard, 1989)

System	Fate	Halflife
Water	Hydrolysis with formation of propylene glycol; hydrolysis is accelerated by the presence of chloride ions (reaction with chloride produces 1-chloro-2-propanol and 2-chloro-1-propanol); loss by volatilization; adsorption to sediment or suspended particulate matter, bioconcentration in aquatic organisms and reactions with hydroxyl radicals in water are negligible	• *Hydrolysis*: 11.6 days (pH=7-9) and 6.6 days (pH=5); 4.5 days (pH=7-9) and 1.5 days (pH=5) • *Volatilization*: = 3 to 18 days
Soil	Rapid volatilization from dry soils; significant hydrolysis and some volatilization from moist soils; negligible adsorption to soil; high mobility in soil; potential for leaching	
Air	Degradation by reaction with hydroxyl radicals; no significant reaction with ozone; photooxidation may lead to the formation of acetylformyloxide, formaldehyde, formandehyde and methylglyoxan; physical removal is negligible; some removal by rainfall	• *Photochemical reactions with hydroxyl radicals*: 14 to 31 days • *Atmospheric half life*: 3 to 20 days

[1] ASSESSMENT REPORT ON *PROPYLENE OXIDE* FOR DEVELOPING AN AMBIENT AIR QUALITY GUIDELINE ,Alberta Environment, March 2002

Due to its high vapour pressure and its tendency to hydrolyze, propylene oxide does not persist in soil or water (Howard, 1989; EC, 1985). The suggested values for the organic carbon partition coefficient and bioconcentration factor also indicate that partitioning to soil or sediment or bioaccumulation will be negligible. If propylene oxide is released to the atmosphere, it will react photochemically with hydroxyl radicals. Due to its relatively high water solubility, propylene oxide may be removed from air by rainfall (Ontario MOE, 2000).

Potential Ecological Effects

No published literature could be found on the effects of propylene oxide on terrestrial vegetation,although structural derivatives of this compound have been used as herbicides. The primary route of propylene oxide exposure in humans would be through inhalation, although there may be some exposure through residues in food after sterilization and fumigation. It is unlikely that significant exposure to propylene oxide would occur in the absence of an industrial source or hazardous waste facility emitting this substance.

The literature reports that acute (short-term) exposure of animals to propylene oxide causes a number of adverse responses. These include tearing of the eyes, salivation, respiratory irritation (lung, nasal passages), vomiting, central nervous system depression, and death. These types of responses have been observed in controlled animal studies at concentrations ranging from 48 to 38,000 mg/m3 (20 to 16,000 ppm) over exposure durations ranging from 30 minutes to 7 hours.

Qualitative Evaluation

Propylene Oxide concentrations in air within the study area were predicted from the ISCST3 modeling described in Section 3. The predicted maximum 1-hour, 3-hour, 8-hour, 24-hour, and annual average concentrations within the study area are represented in Table C-5. Effect levels reported in scientific literature for exposure of laboratory animals (mammals) to propylene oxide in air are also presented. Effect levels for birds were not found in the readily available literature. As indicated in Table C-5 and the tables (Table 4-1 and Table 4-2) from the Assessment Report on Propylene Oxide from Alberta Environment, the predicted maximum average propylene oxide concentrations, at all averaging times, are orders of magnitude less than the exposure levels associated with adverse effects in plants and mammals.

References

Re-registration Eligibility Decision for Propylene Oxide, EPA 738-R-06-029, August 2006

ASSESSMENT REPORT ON *PROPYLENE OXIDE* FOR DEVELOPING AN AMBIENT AIR QUALITY GUIDELINE ,Alberta Environment, March 2002

Table C-5: Qualitative Assessment for Propylene Oxide

Predicted Maximum Average Concentrations in Study Area		
	(ug/m^3)	(ppm)
1-Hour	*0.385105*	*0.000162144*
3-Hour	*0.245433*	*0.000103337*
8-Hour	*0.153749*	*6.47342E-05*
24-Hour	*0.102311*	*4.30768E-05*
Annual	*0.007435*	*3.13042E-06*

Table 4-1 Examples of NOAELs and LOAELs Associated with Acute Exposures in Animal Species

Effects Reported	Exposure Period	Air Concentration mg/m^3 (ppm)[a]	Species	References[b]
LC_{50}; with laboured breathing and CNS depression.	4h	9,500 (4,008)	Rats	Jacobson et al., 1956
1% mortality level.		5,250 (2,215)		
100% mortality.		17,000 (7,173)		
LC_{50}; with laboured breathing and CNS depression.		4,100 (1,730)	Mice	
1% mortality level.		900 (380)		
100% mortality.		17,000 (7,173)		
Lacrymation, salivation, nasal discharge and vomiting. LOAEL		3,230 (1,363)	Dogs	
Congestion in lungs and trachea oedema of pulmonary tissue, necrosis of bronchiolar epithelium NOAEL		4,750 (2,004)		
Congestion in lungs and trachea oedema of pulmonary tissue, necrosis of bronchiolar epithelium LOAEL		4,810 (2,030) & 5,880 (2,481)		
Death.		4,750 (2,004)		
Organ injury NOAELs	0.5h	9,480 (4,000)	Rats	Rowe et al., 1956
	2h	4,740 (2,000)		
	7h	2,370 (1,000)		
4 of 10 animals died.	4h	9,480 (4,000)		
100% mortality.	30min	38,000 (16,034)		
100% mortality.	7h	9,500 (4,008)		
Lung host defenses NOAEL	3h	48.2 (20)	Mice	Aranyi et al., 1986
CNS depression (increases with level and length of exposure)		Single high (unspecified dose)	Rats & Mice	Rowe et al., 1956

[a] Conversion factor: 1ppm=2.37 mg/m^3, air at 25°C and 101.3 kPa (760mmHg) (IPCS, 1985).
[b] Cited In: IPCS (1985).

Table 4-2 Examples of NOAEL's and LOAEL's Associated with Chronic Exposures in Animals

Effects Reported	Air Concentration (ppm (mg/m³)*)	Species	Reference
No clinical signs.	100 (237)	Rats	Lynch et al., 1984a.
NOAEL	302 (717)	Monkeys	Sprinz et al. 1982.
Gross or histopathological effects	1 434 (3 400)	Rats	US NTP, 1984.
NOAELs	485 (1 150)	Mice	
Decrease body weight	200 (474)	Rats&Mice	Renne et al., 1986.
NOAEL		Mice	US NTP, 1985.
Decrease body weight	100 (237)	Rats	Kuper et al., 1988; Lynch et al., 1984a
LOAELs	300 (711)		Kuper et al., 1988.
		Rats&Mice	Renne et al., 1986.
	400 (948)	Mice	US NTP, 1985; 1984
General health, biochemistry, urinalysis, haematology, gross histopathology NOAEL	300 (712)	Rats	Reuzel and Kuper, 1984.
General health, biochemistry, urinalysis, haematology, gross histopathology LOAEL	456 (1,080)	Rabbits and Monkeys	Rowe et al., 1956.
Irritation of eyes and respiratory passages.	200 (474)	Rats&Mice	US NTP, 1983.
Histopathological changes in the lungs and nasal mucosa	100 (237)	Rats	Lynch et al., 1984a.
LOAEL	102 (242)		Reuzel and Kuper, 1984.
	200 (474)	Rats&Mice	Renne et al., 1986.
	100 (237)	Rats	Kuper et al., 1988.
Increased mortality rate	456 (1080)	Guinea Pigs	Rowe et al., 1956.
NOAELs	200 (474)	Mice	Renne et al., 1986.
	400 (948)	Rats	
	400 (948)	Rats	US NTP, 1985.
	30 (71)	Female Rats	Kuper et al., 1988.
Increased mortality rate	456 (1,080)	Rats & Guinea Pigs	Rowe et al., 1956.
LOAELs	400 (948)	Mice	US NTP, 1985.
	100	Rats	Lynch et al., 1984a.
	400 (948)	Mice	Renne et al., 1986.
	100 (237)	Female Rats	Kuper et al., 1988.
	300 (711)	Rats	
Neurological NOAEL (peripheral neuropathy)	300 (711)	Monkeys	Setzer et al., 1996.
Neurological LOAEL(Lesions in the medulla oblongata of the brain and axonial dystrophy in the nucleus gracilis).	100 (237)		Sprinz et al. 1982.
Reproductive	304 (720)	Mice	Hardin et al., 1983a.
NOAELs (sperm head abnormalities)	302 (717)	Monkeys	Lynch et al., 1984c.
Reproductive NOAEL (reproductive function)	300 (711)	Rats	Hayes et al., 1988.
Ovarian atrophy NOAEL LOAEL	198 (470) 397 (940)	Mice	US NTP, 1984.
LOAEL (testicular atrophy)	198 (470)	Rats	
LOAEL (decreased rel. testis wt.)	100 (237)	Rats	Lynch et al., 1984a.
Carcinogenic NOAEL (Nasal)	198 (470)	Rats	US NTP, 1984.
Carcinogenic NOAEL (Mammary)	102 (242)		Reuzel and Kuper, 1984.
	400 (948)	Rats&Mice	Renne et al., 1986.
Carcinogenic LOAELs (Nasal)	397 (940)	Rats	US NTP, 1984.
		Mice	
	400 (948)		Renne et al., 1986.
	400 (948)	Rats	US NTP, 1985.
		Mice	
Carcinogenic LOAELs (Mammary)	300(711)	Rats	Lynch et al., 1984a.
	397 (940)	Rats (female)	US NTP, 1984.
Carcinogenic LOAELs (Adrenal)	100 (237)	Rats	Kuper et al., 1988.
	100(237)		Lynch et al., 1984a

*When study did not describe concentrations in mg/m³ and/or ppm the following conversion factor and assumptions were used: 1 ppm=2.37 mg/m³, air at 25°C and 101.3 kPa (760mmHg) (IPCS, 1995)