Weston Solutions, Inc.
5301 Southwest Parkway, Suite 450
Austin, TX 78735
512-651-7100
WestonSolutions.com

31 March 2025

Texas Commission on Environmental Quality
Industrial and Hazardous Waste Permits Section
Waste Permits Division
Building F, 2nd Floor
P.O. Box 13087
12100 Park 35 Circle
Austin, Texas 78711-3087

Via: [redacted]

RE: Transmittal of Class 3 Permit Modification for IHW 50345
RN 101898948 (Former) Texas Electric Cooperatives – Treating Division
CN 600128243 Texas Electric Cooperatives, Inc.

Dear Sir or Madam:

Weston Solutions, Inc. (WESTON®) is pleased to submit this Class 3 permit modification application for the above-referenced facility on behalf of Texas Electric Cooperatives, Inc. One original will be transmitted separately.

Payment for the permit application fee has been made through EPay; documentation is included in the application.

Please contact me at 512-651-7104 or [redacted] should you have any questions regarding this application.

Very truly yours,
Weston Solutions, Inc.

N. L. Koch

Nancy L. Koch, P.E.
Project Manager

cc: Archie Lopez, Texas Electric Cooperatives

Texas Commission on Environmental Quality

Waste Permits Division Correspondence Cover Sheet

Date: 4/18/25
Facility Name: Texas Electric Cooperatives - Treating Division
Permit or Registration No.: HW 50345

Nature of Correspondence:
☒ Initial/New
☐ Response/Revision to TCEQ Tracking No.: _____ (from subject line of TCEQ letter regarding initial submission)

Affix this cover sheet to the front of your submission to the Waste Permits Division. Check appropriate box for type of correspondence. Contact WPD at (512) 239-2335 if you have questions regarding this form.

Table 1 - Municipal Solid Waste Correspondence

Applications	Reports and Notifications
☐ New Notice of Intent	☐ Alternative Daily Cover Report
☐ Notice of Intent Revision	☐ Closure Report
☐ New Permit (including Subchapter T)	☐ Compost Report
☐ New Registration (including Subchapter T)	☐ Groundwater Alternate Source Demonstration
☐ Major Amendment	☐ Groundwater Corrective Action
☐ Minor Amendment	☐ Groundwater Monitoring Report
☐ Limited Scope Major Amendment	☐ Groundwater Background Evaluation
☐ Notice Modification	☐ Landfill Gas Corrective Action
☐ Non-Notice Modification	☐ Landfill Gas Monitoring
☐ Transfer/Name Change Modification	☐ Liner Evaluation Report
☐ Temporary Authorization	☐ Soil Boring Plan
☐ Voluntary Revocation	☐ Special Waste Request
☐ Subchapter T Disturbance Non-Enclosed Structure	☐ Other:
☐ Other:	

Table 2 - Industrial & Hazardous Waste Correspondence

Applications	Reports and Responses
☐ New	☐ Annual/Biennial Site Activity Report
☐ Renewal	☐ CPT Plan/Result
☐ Post-Closure Order	☐ Closure Certification/Report
☐ Major Amendment	☐ Construction Certification/Report
☐ Minor Amendment	☐ CPT Plan/Result
☐ CCR Registration	☐ Extension Request
☐ CCR Registration Major Amendment	☐ Groundwater Monitoring Report
☐ CCR Registration Minor Amendment	☐ Interim Status Change
☒ Class 3 Modification	☐ Interim Status Closure Plan
☐ Class 2 Modification	☐ Soil Core Monitoring Report
☐ Class 1 ED Modification	☐ Treatability Study
☐ Class 1 Modification	☐ Trial Burn Plan/Result
☐ Endorsement	☐ Unsaturated Zone Monitoring Report
☐ Temporary Authorization	☐ Waste Minimization Report
☐ Voluntary Revocation	☐ Other:
☐ 335.6 Notification	
☐ Other:	

TEXAS ELECTRIC COOPERATIVES – TREATING DIVISION
CLASS 3 PERMIT MODIFICATION

TEXAS ELECTRIC COOPERATIVES, INC.
JASPER, TEXAS FACILITY
IHW Permit HW-50345
SWR 31340

March 2025, Revision 0
Volume 1

Prepared for:
TEXAS COMMISSION ON ENVIRONMENTAL QUALITY
12100 Park 35 Circle
Austin, TX 78753

On behalf of:
TEXAS ELECTRIC COOPERATIVES, INC.
100 Cooperative Way
Georgetown, TX 78626

Prepared by:
WESTON SOLUTIONS, INC.
5301 Southwest Parkway, Suite 450
Austin, Texas 75035
512-651-7100

March 2025

W.O. No. 10472.003.025

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PLAIN LANGUAGE SUMMARY AND PIP

Texas Commission on Environmental Quality

Plain Language Summary

Industrial and Hazardous Waste Permit Applications

Instructions: Complete this form and submit with any industrial hazardous waste, or industrial solid waste, permit application that is subject to 30 Texas Administrative Code §39.405(k) [applications for a Class 3 permit modification, permit amendment, permit renewals, and for a new permit]. Please be concise.

Application Information

Purpose of application: ☐New ☐Renewal ☒Modification/Amendment	
Date Submitted to TCEQ: 3/31/2025	
Customer Name: Texas Electric Cooperatives, Inc.	
Facility Name: (Former) Texas Electric Cooperatives Treating Division	
CN: 600128243	**RN:** 101898948
Permit Number: 50345	**Solid Waste Registration Number:** 31340
Facility Street Address: 2240 Bevil Loop Road, Jasper, Texas, 75951	
Weblink to Street Address: https://www.google.com/maps/place/2240+Bevil+Loop,+Jasper,+TX+75951/@30.902	

Facility Information *(check all that apply)*

What is the primary type of business?	☐Chemical manufacturing ☐ Oil refinery ☐ Treatment, storage or disposal facility plant ☒Other **If other, enter description:** Post closure care of surface impoundments
What does the facility produce?	☐Chemicals ☐Fuels / lubricants ☒No products ☐Other **If other, enter description:**

Waste Management Information *(check all that apply)*

What types of wastes are managed?	☐Nonhazardous industrial ☒Hazardous ☐Other **If other, enter description:**
Where does the waste come from?	☐Off-site source ☒On-site source
How is the waste managed?	☒Storage ☐Process / Treatment ☐Disposal ☐Other **If other, enter description:**
What type of units manage the waste?	☐Active ☒Post-Closure **Type and count:** Three closed surface impoundments (Waste Management Areas [WMAs])
What happens to waste managed at the facility?	☐Transported off-site ☒Disposed on-site ☐Other **If other, enter description:**

Pollution Control Methods *(check all that apply)*	
How will the facility prevent spills, leaks, and releases?	☒Routine inspections ☐Engineered liner systems ☐Spill containment ☒Proper waste handling ☐Operations in enclosed buildings ☒Groundwater monitoring ☐Other **If other, enter description:**
How will the facility clean up spills, leaks, and releases?	☐Spill clean-up supplies ☐Decontamination equipment ☒Other **If other, enter description:** WMAs have been closed for over 30 years. Ongoing remediation occurs for WMA I.
How will the facility prevent / minimize air emissions?	☐Air monitoring / control systems ☐Filters / scrubbers ☐Routine inspections ☒Proper waste handling ☐Operations in enclosed buildings ☒Other **If other, enter description:** No air emissions from closed impoundments.

Description of Update *(for Class 3 Modifications and Amendments only)*

List and explain any changes this modification or amendment would make to the two sections above—**Waste Management Information** and **Pollution Control Methods**.

Groundwater monitoring is no longer required for WMA II and WMA III; the permit amendment will remove the groundwater monitoring associated with those WMAs.

Clear Form

Comisión de Calidad Ambiental de Texas

Resumen en Lenguaje Sencillo

Solicitudes de Permisos de Desechos Industriales y Peligrosos

Instrucciones

Complete este formulario y envíe con cualquier solicitud de permiso de desechos industriales peligrosos, o desechos sólidos industriales, que esté sujeta al Código Administrativo de Texas 30 §39.405 (k) [es decir, solicitudes para una modificación de permiso de Clase 3, enmienda de permiso, renovaciones de permisos y para un nuevo permiso].

Sea conciso: toda la información debe caber en dos páginas.

Información de la Solicitud

Propósito de la solicitud:	☐Nuevo	☐Renovación	☒Modificación/Enmienda

Sometido a TCEQ: 3/31/2025

Nombre del Cliente: Texas Electric Cooperatives, Inc.

Nombre de la Instalación: (Anterior) Texas Electric Cooperatives Treating Division

CN: 600128243	**RN:**101898948
Número de Permiso:50345	**Número de Registro de Desechos Sólidos:** 31340

Dirección de la Instalación: 2240 Bevil Loop Road, Jasper, Texas 75921

Enlace Web a la Dirección Postal:
https://www.google.com/maps/place/2240+Bevil+Lopp,+Jasper,+TX+75951/@30.902

Información de la Instalación *(marque todas lo que correspondan)*

¿Cuál es el tipo principal de negocio?	☐Planta de manufactura química	☐Refinería de aceite	☐ Instalación de tratamiento, almacenamiento o eliminación
	☒Otro **Si es otro, introduzca la descripción:** Cuidado posterior al cierre de los embalses superficiales		
¿Qué produce la instalación?	☐Químicos	☐Combustibles / lubricantes	☒Sin productos
	☐Otro **Si es otro, introduzca la descripción:** Introduzca la descripción		

Información sobre la Gestión de Desechos *(marque todas las que correspondan)*

¿Qué tipos de desechos se gestionan?	☐Industrial no peligroso	☒Peligroso
	☐Otro **Si es otro, introduzca la descripción:** Introduzca la descripción	
¿De dónde provienen los desechos?	☐Fuente externa	☒Fuente interna
¿Cómo se gestionan los desechos?	☒Almacenar	☐Procesar / Tratar ☐Eliminación
	☐Otro **Si es otro, introduzca la descripción:** Introduzca la descripción	

¿Qué tipo de unidades gestionan los desechos?	☐ Activo ☒ Postcierre **Teclee y cuente:** Tres embalses superficiae cerrados (Áreas de Gestión de Residuos [WMA])
¿Qué sucede con los desechos gestionados en la instalación?	☐Transportados fuera del sitio ☒Eliminado en el sitio ☐Otro **Si es otro, introduzca la descripción:** Introduzca la descripción

Métodos de Control de la Contaminación *(marque todos los que correspondan)*			
¿Cómo evitará la instalación derrames, fugas y liberaciones?	☒Inspecciones de Rutina	☐Sistemas de revestimiento de ingeniería	☐Contención de derrames
	☒Manejo adecuado de desechos	☐Operaciones en edificios cerrados	☒Monitoreo de aguas subterráneas
	☐Otro **Si es otro, introduzca la descripción:** Introduzca la descripción		
¿Cómo limpiará la instalación los derrames, fugas y liberaciones?	☐Suministros de limpieza de derrames	☐Equipos de descontaminación	
	☒Otro **Si es otro, introduzca la descripción:** Las WMA han estado cerradas por más de 30 años. Se produce una remediación continua para WMA I.		
¿Cómo evitará / minimizará la instalación las emisiones atmosféricas?	☐Sistemas de monitoreo / control de aire	☐Filtros / depuradores	☐Inspecciones de rutina
	☐Manejo adecuado de desechos	☐Operaciones en edificios cerrados	
	☒Otro **Si es otro, introduzca la descripción:** No hay emisiones atmosféricas de embalses cerrados.		

Descripción de la Actualización (*solo para Modificaciones y Enmiendas de Clase 3)*

Liste y explique cualquier cambio que esta modificación o enmienda haría a las dos secciones anteriores: **Información de Gestión de Desechos** y **Métodos de Control de la Contaminación**.

El monitoreo de aguas subterráneas ya no es necesario para WMA II y WMA III; la enmienda del permiso eliminará el monitoreo de aguas subterráneas asociado con esas WMA.

Texas Commission on Environmental Quality

Public Involvement Plan Form for Permit and Registration Applications

The Public Involvement Plan is intended to provide applicants and the agency with information about how public outreach will be accomplished for certain types of applications in certain geographical areas of the state. It is intended to apply to new activities; major changes at existing plants, facilities, and processes; and to activities which are likely to have significant interest from the public. This preliminary screening is designed to identify applications that will benefit from an initial assessment of the need for enhanced public outreach.

All applicable sections of this form should be completed and submitted with the permit or registration application. For instructions on how to complete this form, see TCEQ-20960-inst.

Section 1. Preliminary Screening

☐ New Permit or Registration Application

☒ New Activity – modification, registration, amendment, facility, etc. (see instructions)

If neither of the above boxes are checked, completion of the form is not required and does not need to be submitted.

Section 2. Secondary Screening

☒ Requires public notice,

☐ Considered to have significant public interest, **and**

☐ Located within any of the following geographical locations:

- Austin
- Dallas
- Fort Worth
- Houston
- San Antonio
- West Texas
- Texas Panhandle
- Along the Texas/Mexico Border
- Other geographical locations should be decided on a case-by-case basis

If all the above boxes are not checked, a Public Involvement Plan is not necessary. Stop after Section 2 and submit the form.

☒ Public Involvement Plan not applicable to this application. Provide **brief** explanation.

Significant public interest is not anticipated. No public comments were received during the permit renewal . No new wastes or units are to be added to the permit.

Section 3. Application Information

Type of Application (check all that apply):

Air ☐ Initial ☐ Federal ☒ Amendment ☐ Standard Permit ☐ Title V

Waste ☐ Municipal Solid Waste ☒ Industrial and Hazardous Waste ☐ Scrap Tire
☐ Radioactive Material Licensing ☐ Underground Injection Control

Water Quality

☐ Texas Pollutant Discharge Elimination System (TPDES)

- ☐ Texas Land Application Permit (TLAP)
- ☐ State Only Concentrated Animal Feeding Operation (CAFO)
- ☐ Water Treatment Plant Residuals Disposal Permit

☐ Class B Biosolids Land Application Permit

☐ Domestic Septage Land Application Registration

Water Rights New Permit

☐ New Appropriation of Water

☐ New or existing reservoir

Amendment to an Existing Water Right

☐ Add a New Appropriation of Water

☐ Add a New or Existing Reservoir

☐ Major Amendment that could affect other water rights or the environment

Section 4. Plain Language Summary

Provide a brief description of planned activities.

The permit addresses post closure care of closed surface impoundments (Waste Management Area [WMA] 1, WMA II and WMA III. Groundwater detection monitoring is no longer required for WMA II and WMA III; therefore, a permit modification is required to remove the detection monitoring requirements.

Section 5. Community and Demographic Information

Community information can be found using EPA's EJ Screen, U.S. Census Bureau information, or generally available demographic tools.

Information gathered in this section can assist with the determination of whether alternative language notice is necessary. Please provide the following information.

Alternative notice is required in Spanish.

(City)

(County)

(Census Tract)

Please indicate which of these three is the level used for gathering the following information.

☐ City ☐ County ☐ Census Tract

(a) Percent of people over 25 years of age who at least graduated from high school

(b) Per capita income for population near the specified location

(c) Percent of minority population and percent of population by race within the specified location

(d) Percent of Linguistically Isolated Households by language within the specified location

(e) Languages commonly spoken in area by percentage

(f) Community and/or Stakeholder Groups

(g) Historic public interest or involvement

Section 6. Planned Public Outreach Activities

(a) Is this application subject to the public participation requirements of Title 30 Texas Administrative Code (30 TAC) Chapter 39?

☒ Yes ☐ No

(b) If yes, do you intend at this time to provide public outreach other than what is required by rule?

☐ Yes ☒ No

If Yes, please describe.

If you answered "yes" that this application is subject to 30 TAC Chapter 39, answering the remaining questions in Section 6 is not required.

(c) Will you provide notice of this application in alternative languages?

☐ Yes ☐ No

Please refer to Section 5. If more than 5% of the population potentially affected by your application is Limited English Proficient, then you are required to provide notice in the alternative language.

If yes, how will you provide notice in alternative languages?

☐ Publish in alternative language newspaper

☐ Posted on Commissioner's Integrated Database Website

☐ Mailed by TCEQ's Office of the Chief Clerk

☐ Other (specify)

(d) Is there an opportunity for some type of public meeting, including after notice?

☐ Yes ☐ No

(e) If a public meeting is held, will a translator be provided if requested?

☐ Yes ☐ No

(f) Hard copies of the application will be available at the following (check all that apply):

☐ TCEQ Regional Office ☐ TCEQ Central Office

☐ Public Place (specify)

Section 7. Voluntary Submittal

For applicants voluntarily providing this Public Involvement Plan, who are not subject to formal public participation requirements.

Will you provide notice of this application, including notice in alternative languages?

☐ Yes ☐ No

What types of notice will be provided?

☐ Publish in alternative language newspaper

☐ Posted on Commissioner's Integrated Database Website

☐ Mailed by TCEQ's Office of the Chief Clerk

☐ Other (specify)

APPENDIX I

GENERAL INFORMATION

Part B Application Form, Section I

I.a – General Information

Table 1 – General Information

Table 1.1 – Description of Proposed Application Changes

I.b – Core Data Form

I.c – Signature Page

I.e – Landowner Information

APPENDIX I.A

TABLE 1 AND TABLE 1.1

Table I: General Information

A. Applicant: Facility Operator

Name[1]	Texas Electric Cooperatives, Inc.
Address[2]	100 Cooperative Way
City, State[2]	Georgetown, Texas
Zip Code[2]	78626
Telephone Number	512-763-3325
Alternate Telephone Number	
TCEQ Solid Waste Registration No.	31340
EPA I.D. No.	TXD041468836
Permit No.	HW 50345
County	Jasper
Regulated Entity Name	Texas Electric Cooperatives Treating Division
Regulated Entity Reference Number (RN)	RN 101898948
Customer Name[2]	Texas Electric Cooperatives, Inc.
Customer Reference Number:	CN 600128243
Charter Number[3]	7986201
Previous or Former Names of the Facility (if applicable)	

B. Facility Owner: Identify the Facility Owner if different than the Facility Operator[4]

☑ Same as Facility Operator?

Name	
Address	
City, State	
Zip Code	
Telephone Number	
Alternate Telephone Number	

C. Facility Contact

1. Persons or firms who will act as primary contact:

Name, Title:	Nancy L. Koch, P.E. - Consultant Weston Solutions, Inc
Address	5301 Southwest Parkway, Suite 450
City, State:	Austin, Texas
Zip Code	78735
Telephone Number	512.651.7104
Alternate Telephone Number	
E-mail	[redacted]

Persons or firms who will act as primary contact (if more than one):

Name, Title:	Archie Lopez
Address	100 Cooperative Way
City, State:	Georgetown, Texas
Zip Code	78626
Telephone Number	512.763.3325
Alternate Telephone Number	
E-mail	[redacted]

2. Agent in Service or Agent of Service (if you are an out-of-state company)[5]:

Name, Title:	
Address	
City, State:	
Zip Code	

3. Individual responsible for causing notice to be published:

Name:	Nancy L. Koch, P.E. Consultant Weston Solutions, Inc.
Address	5301 Southwest Parkway, Suite 450
City, State:	Austin, Texas
Zip Code	78735
Telephone Number	512.651.7104
Alternate Telephone Number	
E-mail	[redacted]

4. Public place in county where application will be made available[6]:

Name	Jasper Public Library
Address	175 E. Water Street
City, State	Jasper, Texas
Zip Code	76951

D. Application Type and Facility Status

1. Application Type

☐ **Permit**	☐ **Amendment**	☑ **Modification**
☐ New	☐ Major	☑ Class 3
☐ Renewal	☐ Minor	☐ Class 2
☐ Interim Status		☐ Class 1[1]
☐ Compliance Plan		☐ Class 1
☐ RD&D		

2. Part of a Consolidated Permit Processing request? [30 TAC Chapter 33] No

3. Does the application contain confidential material?[7] No

4. Facility Status. Check all that apply

☐ Proposed	☑ On-Site
☑ Existing	☐ Off-site
	☐ Commercial
	☐ Recycle
	☑ Land Disposal
	☐ Areal or capacity expansion
	☑ Compliance plan

5. Is the facility within the Coastal Management Program boundary? No

6. Description of Application Changes

Complete Table I.1 - Description of Proposed Application Changes

Note: List all changes requested in Table. Unlisted requests risk remaining unaddressed or possibly denied if brought to the permit application reviewer's attention at a later time.

7. Total acreage of the facility being permitted: 6

8. Identify the name of the drainage basin and segment where the facility is located[8]

River Segment	Neches River Below B.A. Steinhagen Lake
River Basin	Neches River Basin

E. Facility Siting Summary:

Is the facility located or proposed to be located:

1. Within a 100-year floodplain?	No
2. in wetlands?	No
3. In the critical habitat of an endangered species of plant or animal?	No
4. On the recharge zone of a sole-source aquifer?	No
5. In an area overlying a regional aquifer?	Yes
6. Withing 0.5 mile (2,640 feet) of an established residence, church, school , day care center, surface water body used for public drinking water supply, or dedicated public park?[9] [30 TAC 335.202] If Yes: the TCEQ shall not issue a permit for this facility.	No
7. In an area in which the governing body of the country or municipality has prohibited the processing or disposal of municipal hazardous waste or industrial solid waste? If yes: provide a copy of the ordinance or order.	No

F. Wastewater and Stormwater Disposition

1. Is the disposal of any waste to be accomplished by a waste disposal well at this facility?	No
If Yes: List WDW Permit No(s):	
2. Will any point source discharge of effluent or rainfall runoff occur as a result of the proposed activities?	Yes

3. If Yes, is this discharge regulated by a TPDES or TCEQ permit?

☑ Yes

TCEQ Permit No.

TDPES Permit No. WQ0001766000

☐ No

Date TCEQ discharge permit application filed:

Date TPDES discharge application filed:

G. Information Required to Provide Notice

State Officials List [30 TAC 39]

State Senator

Name:	Texas State Senate District 3, Robert Nichols
Address	329 Neches Street; [redacted]
City, State:	Jacksonville, Texas
Zip Code:	75766

State Representative

Name:	Texas State House District 21 - Dade Phelan
Address	812 N 16th Street; [redacted]
City, State:	Orange, Texas
Zip Code	77630

Local Officials List [30 TAC 39]

Mayor

Name:	City of Jasper Mayor - Anderson Land
Address	139 W. Lamar Street; [redacted]
City, State:	Jasper, Texas
Zip Code	75951

Local Health Authority

Name:	Jasper Newton Public Health District - Diane Rashall, Administ
Address	139 W Lamar Street; [redacted]
City, State:	Jasper, Texas
Zip Code	75951

County Judge

Name:	Jasper County Judge - Mark Allen
Address	121 N Austin Street, Room 106; [redacted]
City, State:	Jasper, Texas
Zip Code	75951

County Health Authority

Name:	Same as Local Health Authority
Address	
City, State:	
Zip Code	

Based on the questions in the Bilingual Notice Instructions for this form, are you required to make alternate (Bilingual) notice for this application?	Yes
Bilingual Language(s):	Spanish
TCEQ Core Data Form Submitted?(Required)	Yes
Has any information changed on the TCEQ Core Data Form since the last submittal?	Yes
Signature on Application Submitted? (see Section I Instructions, Item c)	Yes

1. Individual, Corporation, or Other Legal Entity Name on the Permit - must match the Secretary of State's database records for the Facility).
2. The legal name and address must match the Core Data Form.
3. If the application is submitted on behalf of a corporation, please identify the Charter Number as recorded with the Office of the Secretary of State for Texas.
4. The operator has the duty to submit an application if the facility is owned by one person and operated by another [30 TAC 305.43(b)]. The permit will specify the operator and the owner who is listed on Part A of this application [Section 361.087, Texas Health and Safety Code].
5. If the application is submitted by a corporation or by a person residing out of state, the applicant register an Agent in Service or Agent of Service with the Texas Secretary of State's office and provide a complete mailing address for the agent. The agent must be a Texas resident.
6. For applications for new permits, renewals, major amendments and Class 3 modifications a copy of the administratively complete application must be made available at a public place in the county where the facility is, or will be, located for review and copying by the public. Identify the public place in the county (e.g., public library, county court house, city hall), including the address, where the application will be made available for review and copying by the public.
7. For confidential information cross-reference the confidential material throughout the application to Section XIII: Confidential Material, and submit as a separate Section XIII document or binder conspicuously marked "CONFIDENTIAL".
8. Use the segments line map created by TCEQ GIS Team to find the Segment Name and Basin Name.
9. Use only for a new commercial hazardous waste management facility or areal expansion of an existing hazardous waste management facility or unit of that facility as defined in 30 TAC 335.202.

Table I.1-Description of Proposed Application Changes

Permit/Compliance Plan Application Appendix/Section	Brief Description of Proposed Change	Modification or Amendment Type	Supporting Regulatory Citation
CP Table III and CP Table IIIA	Add new analytes to CP Table III and CP Table IIIA	3	30 TAC 305.69(k)(C)(5)(a)
CP Table II, CP Figure 2	Add AOCs and SWMUs	1	30 TAC 305.69(a)(A)(1)
VI.A-H; Table VI.B.3.b.1, Table VI.B.3.c, Table VII.E.2	Remove detection monitoring requirements for WMA II and WMA III and revise to "Reserved"	2	30 TAC 305.69(k)(C)(1)(a)
VI.A-H; Table VI.B.3.b, Table VI.B.3.c, Table VII.E.2	Remove detection monitoring program	2	30 TAC 305.69(k)(C)(5)(b)
VI.A-H; Table VI.B.3.b, Table VI.B.3.c, Table VII.E.2	Remove detection monitoring program	2	30 TAC 306.69(k)(C)(6)
CP Table VIII	Remove requirement for triennial sampling; Approved sampling and analysis plan does not include this sampling	1-1	30 TAC 306.69(k)(C)(2)

APPENDIX I.B

CORE DATA FORM

TCEQ Use Only

TCEQ Core Data Form

For detailed instructions on completing this form, please read the Core Data Form Instructions or call 512-239-5175.

SECTION I: General Information

1. Reason for Submission (*If other is checked please describe in space provided.*)

☐ New Permit, Registration or Authorization (*Core Data Form should be submitted with the program application.*)

☐ Renewal (*Core Data Form should be submitted with the renewal form*)

☒ Other **Class 3 Modification**

2. Customer Reference Number *(if issued)*	Follow this link to search for CN or RN numbers in Central Registry**	**3. Regulated Entity Reference Number** *(if issued)*
CN 600128243		**RN 101898948**

SECTION II: Customer Information

4. General Customer Information	**5. Effective Date for Customer Information Updates** (mm/dd/yyyy)	3/31/2025

☐ New Customer ☒ Update to Customer Information ☐ Change in Regulated Entity Ownership
☐ Change in Legal Name (Verifiable with the Texas Secretary of State or Texas Comptroller of Public Accounts)

The Customer Name submitted here may be updated automatically based on what is current and active with the Texas Secretary of State (SOS) or Texas Comptroller of Public Accounts (CPA).

6. Customer Legal Name *(If an individual, print last name first: eg: Doe, John)*	*If new Customer, enter previous Customer below:*
Texas Electric Cooperatives, Inc.	

7. TX SOS/CPA Filing Number	**8. TX State Tax ID** (11 digits)	**9. Federal Tax ID** (9 digits)	**10. DUNS Number** *(if applicable)*
7986201	17410078293	74-1007829	

11. Type of Customer:	☒ Corporation	☐ Individual	Partnership: ☐ General ☐ Limited
Government: ☐ City ☐ County ☐ Federal ☐ Local ☐ State ☐ Other		☐ Sole Proprietorship	☐ Other:

12. Number of Employees	**13. Independently Owned and Operated?**
☐ 0-20 ☐ 21-100 ☒ 101-250 ☐ 251-500 ☐ 501 and higher	☒ **Yes** ☐ **No**

14. Customer Role (Proposed or Actual) – *as it relates to the Regulated Entity listed on this form. Please check one of the following*

☐ Owner ☐ Operator ☒ Owner & Operator
☐ Occupational Licensee ☐ Responsible Party ☐ VCP/BSA Applicant ☐ Other:

15. Mailing Address:	100 Cooperative Way						
	City	Georgetown	**State**	TX	**ZIP**	78626	**ZIP + 4**

16. Country Mailing Information *(if outside USA)*	**17. E-Mail Address** *(if applicable)*
	[redacted]

18. Telephone Number	19. Extension or Code	20. Fax Number *(if applicable)*
(512) 763-3325		( ) -

SECTION III: Regulated Entity Information

21. General Regulated Entity Information *(If 'New Regulated Entity" is selected, a new permit application is also required.)*

☐ New Regulated Entity ☐ Update to Regulated Entity Name ☒ Update to Regulated Entity Information

The Regulated Entity Name submitted may be updated, in order to meet TCEQ Core Data Standards (removal of organizational endings such as Inc, LP, or LLC).

22. Regulated Entity Name *(Enter name of the site where the regulated action is taking place.)*

Texas Electric Cooperatives Treating Division

23. Street Address of the Regulated Entity: ***(No PO Boxes)***	2240 Bevil Loop							
	City	Jasper	**State**	TX	**ZIP**	75951	**ZIP + 4**	5655
24. County	Jasper							

If no Street Address is provided, fields 25-28 are required.

25. Description to Physical Location:	

26. Nearest City	**State**	**Nearest ZIP Code**

Latitude/Longitude are required and may be added/updated to meet TCEQ Core Data Standards. (Geocoding of the Physical Address may be used to supply coordinates where none have been provided or to gain accuracy).

27. Latitude (N) In Decimal:	30.911667		**28. Longitude (W) In Decimal:**	-93.975	
Degrees	Minutes	Seconds	Degrees	Minutes	Seconds
30	54	42	-93	58	30

29. Primary SIC Code (4 digits)	**30. Secondary SIC Code** (4 digits)	**31. Primary NAICS Code** (5 or 6 digits)	**32. Secondary NAICS Code** (5 or 6 digits)
0	None		

33. What is the Primary Business of this entity? *(Do not repeat the SIC or NAICS description.)*

Remediation only. No SIC

34. Mailing Address:	**100 Cooperative Way**							
	City	**Georgetown**	**State**	**TX**	**ZIP**	**78626**	**ZIP + 4**	

35. E-Mail Address:	

36. Telephone Number	**37. Extension or Code**	**38. Fax Number** *(if applicable)*
(512) 763-3325		( ) -

39. TCEQ Programs and ID Numbers Check all Programs and write in the permits/registration numbers that will be affected by the updates submitted on this form. See the Core Data Form Instructions for additional guidance.

☐ Dam Safety	☐ Districts	☐ Edwards Aquifer	☐ Emissions Inventory Air	☒ Industrial Hazardous Waste
				50345
☐ Municipal Solid Waste	☐ New Source Review Air	☐ OSSF	☐ Petroleum Storage Tank	☐ PWS
☐ Sludge	☐ Storm Water	☐ Title V Air	☐ Tires	☐ Used Oil
☐ Voluntary Cleanup	☐ Wastewater	☐ Wastewater Agriculture	☐ Water Rights	☐ Other:

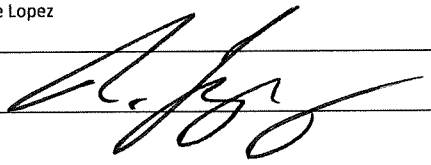
SECTION IV: Preparer Information

40. Name:	Nancy L. Koch	**41. Title:**	Project Manager

42. Telephone Number	**43. Ext./Code**	**44. Fax Number**	**45. E-Mail Address**
(512) 651-7104		( ) -	Nancy.Koch@westonsolutions.com

SECTION V: Authorized Signature

46. By my signature below, I certify, to the best of my knowledge, that the information provided in this form is true and complete, and that I have signature authority to submit this form on behalf of the entity specified in Section II, Field 6 and/or as required for the updates to the ID numbers identified in field 39.

Company:	Texas Electric Cooperative, Inc.	**Job Title:**	Vice President
Name *(In Print):*	Archie Lopez	**Phone:**	(512) 763- 3325
Signature:		**Date:**	3/28/25

APPENDIX I.C

SIGNATURE PAGE

Signature Page

I, Archie Lopez, Executive Director,

(Operator) *(Title)*

certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Signature: _____ Date: 4/21/25

To be completed by the Operator if the application is signed by an Authorized Representative for the Operator

I, _____, hereby designate _____

[Print or Type Name] *[Print or Type Name]*

as my representative and hereby authorize said representative to sign any application, submit additional information as may be requested by the Commission; and/or appear for me at any hearing or before the Texas Commission on Environmental Quality in conjunction with this request for a Texas Water Code or Texas Solid Waste Disposal Act permit. I further understand that I am responsible for the contents of this application, for oral statements given by my authorized representative in support of the application, and for compliance with the terms and conditions of any permit which might be issued based upon this application.

_____

Printed or Typed Name of Operator or Principal Executive Officer

_____

Signature

SUBSCRIBED AND SWORN to before me by the said Archie Lopez

On this 21st day of April, 2025

My commission expires on the 22 day of Oct, 2027

Notary Public in and for WILLIAMSON County, Texas

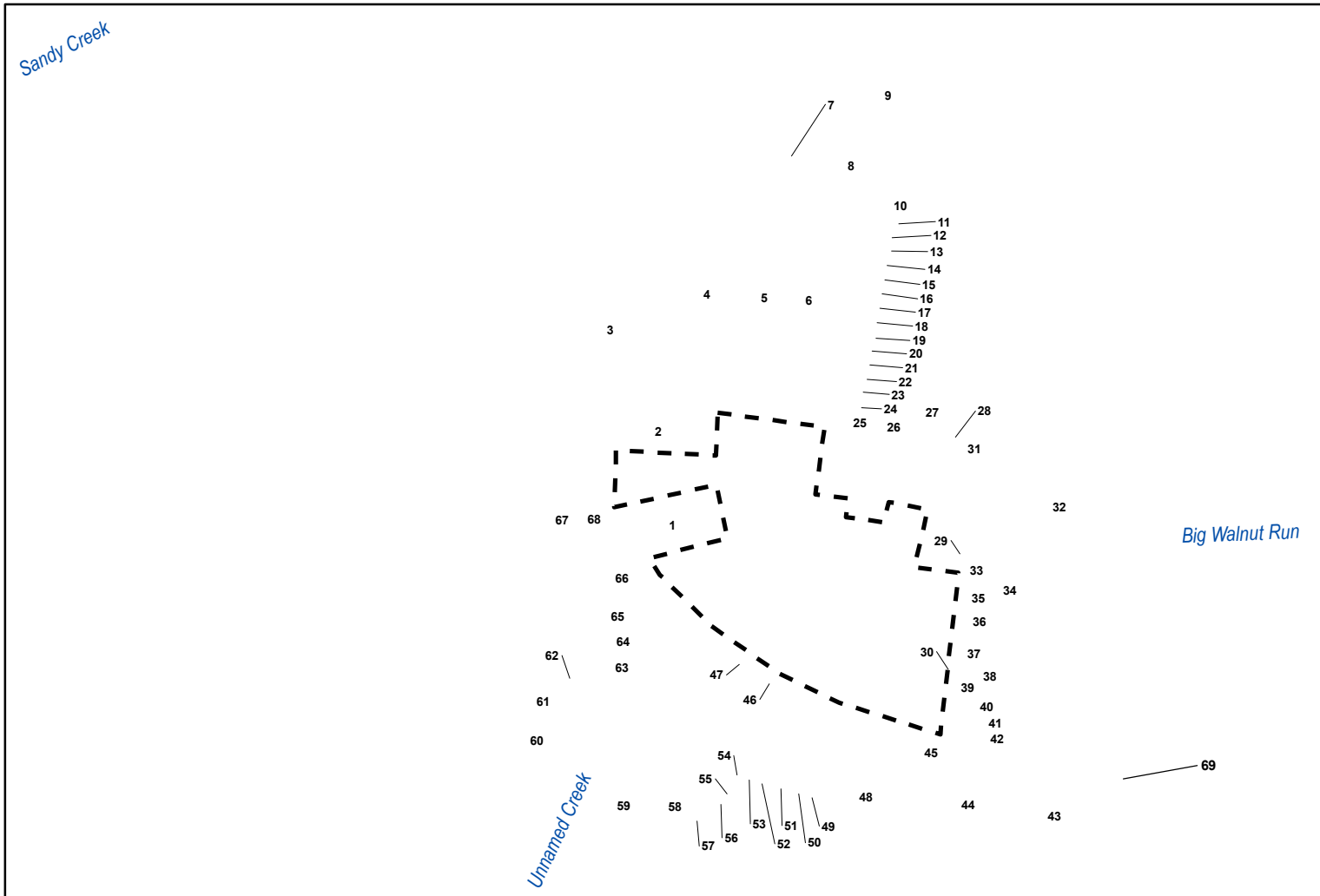
*[**Note**: Application Must Bear Signature & Seal of Notary Public]*

MICHELLE DELOSSANTOS
My Notary ID # 130414602
Expires October 22, 2027

Michelle De Los Santos

APPENDIX I.E

LANDOWNER INFORMATION



LEGEND

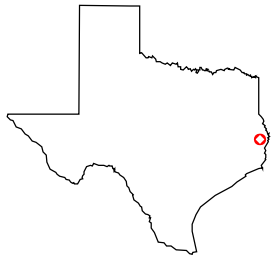
- Facility Boundary
- Surface Water

Property

- Texas Electric Cooperatives Inc
- Adjacent Land Owner Parcel
- Right-Of-Way

1 Refer to attached table for associated parcel details

0 1,000
Feet



N

[redacted]

APPENDIX I

ADJACENT LANDOWNER MAP

TEXAS ELECTRICAL COOPERATIVES, INC.
RCRA PERMIT NUMBER: HW-50345
JASPER, JASPER COUNTY, TEXAS

DATE	PROJECT NO	SCALE
MARCH 2025	10472.006.001.0001	1:14,000

SOURCES: Jasper County Appraisal District
Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community©

FILE: G:\Commercial\Texas Electrical Coop\Jasper\RCRA_Permit\mxd\Appendix I\Appendix I - Adjacent Landowner Map 3.mxd 3:20:53 PM 3/27/2025 letartes

MAP ID	STREET ADDRESS	OWNER NAME	OWNER MAILING ADDRESS	COUNTY OWNER ID
1	1360 BEVIL LOOP	PETERSON CHARLOTTE ANN	ATTN: CHARLES D PREWITT 1360 BEVIL LOOP JASPER TX 75951-5234	62936
2	E GIBSON ST (ST NUMBER NOT ASSIGNED)	MCDONALD TODD & KIM DAVIS	1011 E GIBSON ST JASPER TX 75951-5202	1369
3	1011 E GIBSON ST	MCDONALD MARVIN	1011 E GIBSON ST JASPER TX 75951-5202	1770
4	1203 E GIBSON ST	MCLEOD MAX REID FAMILY PARTNERSHIP LTD	PO BOX 315 JASPER TX 75951-0004	2303
5	1255 E GIBSON ST	WEEKS DANA	3465 STATE HIGHWAY 63 E JASPER , TX 75951-7607	1350
6	1325 E GIBSON ST	KINNEAR MICHAEL B & PAULA	714 W GIBSON ST STE 7 JASPER , TX 75951-4960	1433
7	1340 E GIBSON ST	R V SERVICES INC / COLLISION AND CUSTOMS REPAIR	1328 E GIBSON ST JASPER, TX 75951	48841
8	1360 E GIBSON ST	LAROUX WESLEY & CASSI	6616 STATE HIGHWAY 63 E BURKEVILLE TX 75932-4408	77708
9	1388 E GIBSON ST	PICKLE WAYNE	PO BOX 598 JASPER TX 75951-0034	2235
10	1395 GIBSON ST	CREST NATURAL RESOURCES LLC	PO BOX 6115 ALEXANDRIA LA 71307-6115	8532
11	DONNA DR (ST NUMBER NOT ASSIGNED)	CREST NATURAL RESOURCES LLC	PO BOX 6115 ALEXANDRIA LA 71307-6115	8532
12	2427 DONNA DR	ROSS MURPHY	2427 DONNA DR JASPER TX 75951-5916	30698
13	2425 DONNA DR	STP PARTNERS LTD	PO BOX 8570 LUMBERTON TX 77657-0570	67447
14	2423 DONNA DR	LEACH JESSEE R JR	282 COUNTY ROAD 2135 BURKEVILLE TX 75932-3806	68164
15	DONNA DR (ST NUMBER NOT ASSIGNED)	MILLER GERALD & JOYCE	430 W WATER ST JASPER TX 75951-4429	30702
16	2419 DONNA DR	CORDOVA DENNIS & DEBRA	2419 DONNA DR JASPER TX 75951-5916	30703
17	2417 DONNA DR	HOLLY MAYOLA	2417 DONNA DR JASPER TX 75951-5916	62922
18	2415 DONNA DR	BONDS TOMMY	2415 DONNA DR JASPER TX 75951-5916	4052
19	2413 DONNA DR	GRANT TAVI	2413 DONNA DR # 9 JASPER TX 75951-5916	30710
20	2406 DONNA DR	COCHRAN RANDY & NICOLE	2406 DONNA DR JASPER TX 75951-5915	30712
21	2409 DONNA DR	MARTINEZ ROSA L	2409 DONNA DR # 11 JASPER TX 75951-5916	30715
22	2407 DONNA DR	LAKEY DARA	2407 DONNA DR JASPER TX 75951-5916	55304
23	2405 DONNA DR	KARBER KACE	2405 DONNA DR JASPER TX 75951-5916	78759
24	2417 DONNA DR	BAILEY LAWANDA	2403 DONNA DR JASPER TX 75951-5916	30719
25	2401 DONNA DR	WILLMAN JOSEPH & MARY	2401 DONNA DR LOT 15 JASPER TX 75951-5916	53754
26	2400 DONNA DR	GRISSOM JOHN W	2400 DONNA DR JASPER TX 75951-5915	57405
27	BEVIL LOOP (ST NUMBER NOT ASSIGNED)	COLD SPRINGS CEMETERY	PO BOX 610 JASPER TX 75951	0
28	BEVIL LOOP (ST NUMBER NOT ASSIGNED)	CITY OF JASPER	PO BOX 610 JASPER TX 75951	0
29	BEVIL LOOP (ST NUMBER NOT ASSIGNED)	CITY OF JASPER	PO BOX 610 JASPER TX 75951	0
30	BEVIL LOOP (ST NUMBER NOT ASSIGNED)	CITY OF JASPER	PO BOX 610 JASPER TX 75951	0
31	104 CINNAMON OAK	DUQUETTE ALLAN & EVELYN	104 CINNAMON OAK ST JASPER TX 75951-5906	25867
32	BEVIL LOOP (ST NUMBER NOT ASSIGNED)	LINDSAY FAMILY LTD PARTNERSHIP	C/O LOUIS LINDSEY, TRUSTEE, PO BOX 2067 JASPER , TX 75951-0022	47025
33	604 PRIVATE ROAD 8005	PENNEY CARLTON	124 BEECHWOOD ST JASPER TX 75951-5534	25825
34	604 PRIVATE ROAD 8005	PENNEY CARLTON	124 BEECHWOOD ST JASPER TX 75951-5534	25825
35	2229 BEVIL LOOP	SPIKES DONALD SR	2229 BEVIL LOOP JASPER TX 75951-6982	1836
36	1980 BEVIL LOOP	MAYS DENT E SR	2987 COUNTY ROAD 265 JASPER TX 75951-6441	15400
37	2159 BEVIL LOOP	SPIKES KWAME	PO BOX 896 JASPER TX 75951-0010	78421
38	2149 BEVIL LOOP	CORLEY GEORGE W & LINDA CORLEY ESTATE	2149 BEVIL LOOP JASPER TX 75951-5590	1311
39	2139 BEVIL LOOP	CORLEY SHANA R CONNER	2139 BEVIL LOOP JASPER TX 75951	2389
40	2129 BEVIL LOOP	DOWDEN DANNY	PO BOX 465 JASPER TX 75951-0006	19366
41	2119 BEVIL LOOP	DOWDEN RICHARD WAYNE	2119 BEVIL LOOP JASPER TX 75951-5590	1016
42	BEVIL LOOP (ST NUMBER NOT ASSIGNED)	CITY OF JASPER	PO BOX 610 JASPER TX 75951	0
43	2075 BEVIL LOOP	ALEXANDER HARLAN & NEVA	PO BOX 784 JASPER TX 75951-0009	1068

MAP ID	STREET ADDRESS	OWNER NAME	OWNER MAILING ADDRESS	COUNTY OWNER ID
44	2467 S US HIGHWAY 96	MCDONALD MARVIN	1011 E GIBSON ST JASPER TX 75951	1770
45	BEVIL LOOP (ST NUMBER NOT ASSIGNED)	CITY OF JASPER	PO BOX 610 JASPER TX 75951	0
46	BEVIL LOOP (ST NUMBER NOT ASSIGNED)	CITY OF JASPER	PO BOX 610 JASPER TX 75951	0
47	BEVIL LOOP (ST NUMBER NOT ASSIGNED)	CITY OF JASPER	PO BOX 610 JASPER TX 75951	0
48	2010 BEVIL LOOP	BISON GERALD	2012 BEVIL LOOP JASPER TX 75951-5592	1163
49	44 SUNCREST CIR	MCDONALD MOBILE HOMES	1011 E GIBSON ST JASPER TX 75951-5202	44564
50	45 SUNCREST CIR	MCDONALD MOBILE HOMES	1011 E GIBSON ST JASPER TX 75951-5202	44564
51	46 SUNCREST CIR	GILL TERESA D & GERALDINE "JERRI"	ATTN: LYNN HARRIS NADINE WATKINS PO BOX 1167 JASPER TX 75951-0012	62976
52	47 SUNCREST CIR	Y'BARBO ALLEN III & SHEILA	654 COUNTY ROAD 340 JASPER TX 75951-6883	36831
53	48 SUNCREST CIR	TAYLOR CASSIE	48 SUNCREST CIR JASPER TX 75951-5913	54994
54	49 SUNCREST CIR	LEE LINDA NELL	49 SUNCREST CIR JASPER TX 75951-5913	36835
55	34 SUNCREST CIR	NELSON JAMES A ESTATE	34 SUNCREST CIR JASPER TX 75951-5912	68750
56	33 SUNCREST CIR	LEIDIG DONALD E ESTATE & LINDA L	33 SUNCREST CIR JASPER TX 75951-5912	36814
57	57 SUNCREST CIR	GALLOWAY ROBERT L	57 SUNCREST CIR JASPER TX 75951	36771
58	57 SUNCREST CIR	GALLOWAY ROBERT L	57 SUNCREST CIR JASPER TX 75951	36771
59	1660 BEVIL LOOP	WILSON MARY	1660 BEVIL LOOP JASPER TX 75951-5255	2355
60	1551 BEVIL LOOP	HETLER MARY JANELLE PARRIE	PO BOX 2272 JASPER TX 75951-0024	53233
61	1481 BEVIL LOOP	SCOTT LEANER	1481 BEVIL LOOP JASPER TX 75951-5235	2633
62	1471 BEVIL LOOP	(NOT LISTED)	(NOT LISTED)	0
63	1452 BEVIL LOOP	H & M ELECTRIC	L H MARTINDALE 595 WILLOW DR JASPER TX 75951-3328	1621
64	1442 BEVIL LOOP	JORDAN RAMSEY TAYLOR	PO BOX 1287 JASPER TX 75951	1555
65	BEVIL LOOP (ST NUMBER NOT ASSIGNED)	CAULEY TOMMY & LILLIE	1505 S BOWIE ST JASPER TX 75951-5001	1291
66	BEVIL LOOP (ST NUMBER NOT ASSIGNED)	(NOT LISTED)	(NOT LISTED)	0
67	1351 BEVIL LOOP	MORGAN KEITH	PO BOX 1468 JASPER TX 75951-0015	56127
68	BEVIL LOOP (ST NUMBER NOT ASSIGNED)	CITY OF JASPER	PO BOX 610 JASPER TX 75951	0
69	RAILROAD (NUMBER NOT ASSIGNED)	(NOT LISTED) - TIMBER ROCK RAILROAD OWNED BY WATCO COMPANIES[1]	315 W 3RD ST PITTSBURG PA 66762	0

(1) National Rail Network Map, watco.com/service/rail/timber-rock-railroad-tibr/

APPENDIX VII

CLOSURE AND POST CLOSURE PLAN

APPENDIX VII.D
POST CLOSURE COST ESTIMATE

TABLE VII.D

Table VII.D. - Unit Post-Closure Cost Estimate

Task	Cost
Name of permitted unit: **Waste Management Area I**	
Verbal description of task: **Routine cap maintenance (8 hrs annually @ 100/hour)**	$800
Verbal description of task: Cap regrading ($5,000 PER event once every 10 years annualized)	$500
Verbal description of task: Cost to plug and abandon monitoring wells (22 wells @ ($1,000 each, once, annualized)	$2,200
Verbal description of task:	
Other tasks:	
Other tasks:	
Subtotal	$3,500
Contingency (10% minimum)	$350
Year(s) of Post-Closure	10
Total Unit Closure Cost (Annual Cost X Years of Post-Closure) Year 2024	$38,500

The estimates listed above were derived from the following sources:
Experience-based duration estimates for years 2020-2024; 3rd-party billing rates of Weston Solutions, Inc.; estimate of regrading effort including locally-available equipment, materials, and labor; recent quotes for well P&A at Jasper site and similar sites.

Table VII.D. - Unit Post-Closure Cost Estimate

Task	Cost
Name of permitted unit: **Waste Management Area II**	
Verbal description of task: **Routine cap maintenance (8 hrs annually @ 100hour)**	$800
Verbal description of task: Cap regrading ($5,000/event once every 10 years annualized)	$500
Verbal description of task: Fence and gate repair (once every 2 years, $210/event, annualized)	$105
Verbal description of task:	
Other tasks:	
Other tasks:	
Subtotal	$1,405
Contingency (10% minimum)	$141
Year(s) of Post-Closure	10
Total Unit Closure Cost (Annual Cost X Years of Post-Closure) Year 2024	$15,460

The estimates listed above were derived from the following sources:
SAME AS ABOVE (WMA I)

Table VII.D. - Unit Post-Closure Cost Estimate

Task	Cost
Name of permitted unit: Waste Management Area III	
Verbal description of task: Routine cap maintenance (8 hrs annually @ 100hour)	$800
Verbal description of task: Cap regrading ($5,000/event once every 10 years annualized)	$500
Verbal description of task:	
Verbal description of task: Fence and gate repair (once every 2 years, $210/event, annualized)	$105
Other tasks:	
Other tasks:	
Subtotal	$1,405
Contingency (10% minimum)	$141
Year(s) of Post-Closure	10
Total Unit Closure Cost (Annual Cost X Years of Post-Closure) Year 2024	$15,460

The estimates listed above were derived from the following sources: SAME AS ABOVE (WMA I)

APPENDIX VII.E
CLOSURE AND POST CLOSURE COST SUMMARY

TABLE VII.E.2

Table VII.E.2. - Permitted Unit Post-Closure Cost Summary

Existing Unit Closure Cost Estimate	
Unit	Cost
Waste Management Area I	34,230
Waste Management Area II	$45,893
Waste Management Area III	64,300
Total Existing Unit Post-Closure Cost Estimate[1]	144,423 (2019)

Proposed Unit Post-Closure Cost Estimate	
Unit	Cost
Waste Management Area I	$38,500
Waste Management Area II	$15,460
Waste Management Area III	$15,460
Total Proposed Unit Post-Closure Cost Estimate	$69,410

1. As units are added or deleted from these tables through future permit amendments or modifications, the remaining itemized unit costs should be updated for inflation when re-calculating the revised total cost in current dollars.

APPENDIX IX

RELEASES FROM SOLID WASTE UNITS AND CORRECTIVE ACTION

- Cover Page
- Table of Contents
- Preliminary Review Facility Checklist
- Preliminary Review Units Checklist
    - Appendix I. Facility and SWMU Location Maps
    - Appendix II. Wastes Managed
    - Appendix III. Evidence of Release
    - Appendix IV. Pollutant Dispersal Pathways

PRELIMINARY REVIEW CHECKLIST
CLASS 3 PERMIT MODIFICATION

TEXAS ELECTRIC COOPERATIVES, INC.
JASPER, TEXAS FACILITY
IHW Permit HW-50345
SWR 31340

Prepared for:
TEXAS COMMISSION ON ENVIRONMENTAL QUALITY
12100 Park 35 Circle
Austin, TX 78753

On behalf of:
TEXAS ELECTRIC COOPERATIVES, INC.
100 Cooperative Way
Georgetown, TX 78626

Prepared by:
WESTON SOLUTIONS, INC.
5301 Southwest Parkway, Suite 450
Austin, Texas 75035
512-651-7100

March 2025

W.O. No. 10472.003.025

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Page

PRELIMINARY REVIEW FACILITY CHECKLIST 1

PRELIMINARY REVIEW UNIT CHECKLIST 4

APPENDIX I - FACILITY AND SWMU LOCATION MAPS

- Regional Location Map
- Facility Waste Management Unit Map
- Facility SWMU Map

APPENDIX II - WASTES MANAGED

APPENDIX III - EVIDENCE OF RELEASE

APPENDIX IV - POLLUTANT DISPERSAL PATHWAYS

Preliminary Review Facility Checklist

Facility: Texas Electric Cooperatives Treating Division City: Jasper

ISW Reg No:31340 Date:03/31/2025

Permit No:50345 Reviewer:

EPA ID No:TXD041468836

A. Waste Management Units:

RCRA Regulated Units:

NOR No.	Description	Status
002, 003, 004, 005, 006, 011 (SWMU), AOC 1	Waste Management Area I	Closed, 1991; Post Closure Care
007,008	Waste Management Area II	Closed, 1991; Post Closure Care
009, 010	Waste Management Area III	Closed, 1991; Post Closure Care

Solid Waste Management Units:

NOR No.	Description	Status
001	Bark Pile	Closed
011	Pond A (Included in Waste Management Area I)	Closed
012	Surface Impoundment (Pond B) (SWMU 5)	Active
013	Boiler	Closed
014	Tank (65,000 gallon EQ tank)	Closed
015	Tank (65,000 gallon Creosote)	Closed
016	Tank (Oil/water separator)	Closed
017	Tank (Flash mix tank)	Closed
018	Tank (Sludge tank from oil/water separator prior to vacuum filtration)	Closed
019	Tank (Blowdown tank)	Closed
020	Tank (Biological Treatment tank)	Closed
021	Tank (Silver Tank #1)	Closed
022	Tank (Silver Tank #2)	Closed

023	Tank (Rotary Vacuum Filter)	Closed
024	Misc Storage Containers (Filter Hopper)	Closed
025	Container Storage Area (Waste Container Storage Area)	Closed
026	Misc Storage Containers (Drip Pad) (Transferred to SWR 98534)	Closed
027	Tank (Waste Oil)	Closed
028	Tank (Waste Oil)	Closed
029	Waste Pile (Covered Bark Storage)	Closed
030	Misc Storage Containers (Pole Machine Truck Hopper)	Closed
031	Misc Storage Containers (Boiler Truck Hopper)	Closed
032	Container Storage Area (Ash container storage area)	Closed
033	Misc Storage Containers (Trash Dumpster)	Closed
034	Waste pile (metal scrap pile)	Closed
035	Waste water treatment plant	Closed
036	Container Storage Area (Wood Storage Yard)	Closed
040	Container Storage Area (Temporary Roll-Off)	Closed
041	Container Storage Area (Stella-Jones Accumulation Area)	Closed
042	Container Storage Area (Liquid Remediation Wastewater)	Active
A	SWMU 15 (former Oil-water separator)	Inactive
B	SWMU 16 (Tank E Containment)	Inactive
C	AOC 1 (Loading Track Area/Drip Area)	Closed
D	AOC 3 (TPDES Outfall 001)	Closed
E	AOC 5 (Run-off ditch south of retorts)	Inactive
F	AOC 6 (Run-off ditch south of Pond 1)	Inactive
G	AOC 7 (Abandoned pipe release)	Inactive

B. Reviewed Documents:

RCRA:

Part A **Yes**

Part B **Yes**

Permit **50345**

CERCLA:

Inspection Reports:_____

Enforcement Actions:_____

Exposure Information:_____

Other Information:_____

C. Summary:

The facility has nine hazardous waste management units in post closure care, included in WMA I, WMA II and WMA III. WMA I is under corrective action currently. WMA II and III are in post closure.

Two WMUs on the Notice of Registration are active (Pond B NOR 012, SWMU 5) and NOR 042 (for remediation wastewater) and 5 WMUs are inactive. The five inactive WMUs include two SWMUs (SWMU 15 and SWMU 16) and three Areas of Concern (AOC) (AOC 5, AOC 6 and AOC 7).

D. Recommended Action:

Continue Post Closure Activities and Corrective Action activities for RCRA permitted units. Discontinue the Detection Monitoring Program for WMAs II and III, and plug and abandon associated monitoring wells.

Pond B and the 5 inactive waste management units are undergoing RCRA Facility Investigation activities.

The remaining unit (NOR 042) is associated with groundwater monitoring waste and continues to be active; no actions are recommended.

Preliminary Review Unit Checklist

Facility: Texas Electric Cooperatives Treating Division City: Jasper

ISW Reg No:31340 Date:02/01/2025

Permit No:50345 Reviewer:

EPA ID No:TXD041468836

Waste Management Unit(s):

A. NOR No.:	001 – Bark Pile
B. Description	Waste Pile – S03
C. Dates of Operation	1965 – 2023; Closed
Waste Managed:	Bark and Wood Chips (00064882), Class II Non-Haz; Wash Water and Well Water (00141011), Class I Non-Haz; Paint Waste (01232091) Class I Non-Haz.
Evidence of Release:	None
Pollutant Dispersal Pathways:	Possible: Soil and Groundwater
Summary:	Bark pile from processing logs with low potential for release. Unit has been administratively closed under TEC since 7 August 2023 and has been transferred to Stella-Jones Corp., SWR 98534 as WMU 003.
Recommended Action:	No Further Action.
A. NOR No.:	002 - Pond 1, Part of Waste Management Area I
B. Description	Surface Impoundment (Disposal) – D83
C. Dates of Operation	1965 – 1991; Closed, Post Closure Care
Waste Managed:	Creosote Wastewater Sludge (0001504H), Hazardous; Wash Water and Well Water (00141011), Class I Non-Haz; Paint Waste (01232091) Class I Non-Haz.
Evidence of Release:	Possible release; possibly related to CA Well TW-101 DNAPL accumulation; previous NFA of soil and backfill material issued in January 2000.
Pollutant Dispersal Pathways:	Soil and Groundwater
Summary:	Former wastewater treatment pond that was emptied, scraped, backfilled, and capped. The Closure Certificate was submitted 27 June 1991 and was approved by the Texas Water Commission on 11 June 1993.

Recommended Action:	Currently included in WMA I and recommended action is accounted for in the Compliance Plan
A. NOR No.:	003 - Pond 2, included in WMA I
B. Description	Surface Impoundment (Disposal) – D83
C. Dates of Operation	1965 – 1991; Closed, Post Closure Care
Waste Managed:	Creosote Wastewater Sludge (0001504H), Hazardous; Wash Water and Well Water (00141011), Class I Non-Haz; Paint Waste (01232091) Class I Non-Haz.
Evidence of Release:	No release suspected; soil and backfill material received NFA in January 2000
Pollutant Dispersal Pathways:	Soil and Groundwater
Summary:	Former wastewater treatment pond that was emptied, scraped, backfilled, and capped. The Closure Certificate was submitted 27 June 1991 and was approved by the Texas Water Commission on 11 June 1993.
Recommended Action:	Currently included in WMA I and recommended action is accounted for in the Compliance Plan
A. NOR No.:	004 Vacuum Cooling Pond, included in WMA I
B. Description	Surface Impoundment (Disposal) – D83
C. Dates of Operation	1965 – 1991; Closed, Post Closure Care
Waste Managed:	Creosote Wastewater Sludge (0001504H), Hazardous; Wash Water and Well Water (00141011), Class I Non-Haz; Paint Waste (01232091) Class I Non-Haz.
Evidence of Release:	Possible release; being addressed under WMA I Compliance Plan.
Pollutant Dispersal Pathways:	Soil and Groundwater
Summary:	Former wastewater treatment pond that was emptied, scraped, backfilled, and capped. The Closure Certificate was submitted 27 June 1991 and was approved by the Texas Water Commission on 11 June 1993.
Recommended Action:	Currently included in WMA I and recommended action is accounted for in the Compliance Plan
A. NOR No.:	005 - Oil Pit, included in WMA I
B. Description	Surface Impoundment (Disposal) – D83
C. Dates of Operation	1965 – 1991; Closed, Post Closure Care

Waste Managed:	Creosote Wastewater Sludge (0001504H), Hazardous; Wash Water and Well Water (00141011), Class I Non-Haz; Paint Waste (01232091) Class I Non-Haz.
Evidence of Release:	No release suspected; soil and backfill material received NFA in January 2000
Pollutant Dispersal Pathways:	Soil and Groundwater
Summary:	Wastewater treatment pond that was emptied, scraped, backfilled and capped. The Closure Certificate was submitted 27 June 1991 and was approved by the Texas Water Commission on 11 June 1993.
Recommended Action:	Currently included in WMA I and recommended action is accounted for in the Compliance Plan
A. NOR No.:	006 - Sump, included in WMA I
B. Description	Surface Impoundment (Disposal) – D83
C. Dates of Operation	1965 – 1991; Closed, Post Closure Care
Waste Managed:	Creosote Wastewater Sludge (0001504H), Hazardous; Wash Water and Well Water (00141011), Class I Non-Haz; Paint Waste (01232091) Class I Non-Haz.
Evidence of Release:	No release suspected; soil and backfill material received NFA in January 2000
Pollutant Dispersal Pathways:	Soil and Groundwater
Summary:	Former wastewater treatment pond that was emptied, scraped, backfilled and capped. The Closure Certificate was submitted 27 June 1991 and was approved by the Texas Water Commission on 11 June 1993.
Recommended Action:	Currently included in WMA I and recommended action is accounted for in the Compliance Plan
A. NOR No.:	007 – Pond C, Included in Waste Management Area II
B. Description	Surface Impoundment (Disposal) – D83
C. Dates of Operation	1972 – 1991; Closed, Post Closure Care
Waste Managed:	Creosote Wastewater Sludge (0001504H), Hazardous; Wash Water and Well Water (00141011), Class I Non-Haz; Paint Waste (01232091) Class I Non-Haz.
Evidence of Release:	None
Pollutant Dispersal Pathways:	Possible: Soil and Groundwater

Summary:	Former wastewater treatment pond that was dried out, then wastes were stabilized, and capped with clay. The Closure Certificate was submitted 27 June 1991 and was approved by the Texas Water Commission on 11 June 1993. Groundwater Detection Monitoring conducted since closure has not identified a release.
Recommended Action:	No Further Action; Termination of the Detection Monitoring Program is recommended for this unit.
A. NOR No.:	008 Pond D, included in Waste Management Area II
B. Description	Surface Impoundment (Disposal) – D83
C. Dates of Operation	1972 – 1991; Closed, Post Closure Care
Waste Managed:	Creosote Wastewater Sludge (0001504H), Hazardous; Wash Water and Well Water (00141011), Class I Non-Haz; Paint Waste (01232091) Class I Non-Haz.
Evidence of Release:	None
Pollutant Dispersal Pathways:	Possible: Soil and Groundwater
Summary:	Former wastewater treatment pond that was dried out, then wastes were stabilized and encapsulated within a bottom and top HDPE liner and then capped with clay. The Closure Certificate was submitted 27 June 1991 and was approved by the Texas Water Commission on 11 June 1993. Groundwater Detection Monitoring conducted since closure has not identified a release.
Recommended Action:	No Further Action; Termination of the Detection Monitoring Program is recommended for this unit.
A. NOR No.:	009, Pond E, included in Waste Management Area III
B. Description	Surface Impoundment (Disposal) – D83
C. Dates of Operation	1977 – 1991; Closed, Post Closure Care
Waste Managed:	Creosote Wastewater Sludge (0001504H), Hazardous; Wash Water and Well Water (00141011), Class I Non-Haz; Paint Waste (01232091) Class I Non-Haz.
Evidence of Release:	None
Pollutant Dispersal Pathways:	Possible: Soil and Groundwater
Summary:	Former wastewater treatment pond that was dried out, then wastes were stabilized and encapsulated within a folded-over bottom HDPE liner and then capped with clay. The Closure Certificate was submitted 27 June 1991 and was approved by the Texas Water Commission on 11 June 1993. Groundwater

	monitoring since closure has not identified a release.
Recommended Action:	No Further Action; Termination of the Detection Monitoring Program is recommended for this unit.
A. NOR No.:	010 – Pond F, included in Waste Management Area III
B. Description	Surface Impoundment (Disposal) – D83
C. Dates of Operation	1977 – 1991; Closed, Post Closure Care
Waste Managed:	Creosote Wastewater Sludge (0001504H), Hazardous; Wash Water and Well Water (00141011), Class I Non-Haz; Paint Waste (01232091) Class I Non-Haz.
Evidence of Release:	None
Pollutant Dispersal Pathways:	Possible: Soil and Groundwater
Summary:	Former wastewater treatment pond that was dried out, then wastes were stabilized and capped with clay. The Closure Certificate was submitted 27 June 1991 and was approved by the Texas Water Commission on 11 June 1993. Groundwater monitoring since closure has not identified a release.
Recommended Action:	No Further Action; Termination of the Detection Monitoring Program recommended for this unit.
A. NOR No.:	011 – Pond A, SWMU included in Waste Management Area I
B. Description	Surface Impoundment (Disposal) – D83
C. Dates of Operation	1965 – 1981; Closed 1981 (Pre-RCRA), Post Closure Care
Waste Managed:	Creosote Wastewater Sludge (0001504H), Hazardous; Wash Water and Well Water (00141011), Class I Non-Haz; Paint Waste (01232091) Class I Non-Haz.
Evidence of Release:	Possible release suspected; being addressed under WMA I Compliance Plan. Previous NFA for Pond A soil issued in January 2000.
Pollutant Dispersal Pathways:	Soil and Groundwater
Summary:	Former wastewater treatment pond – residual waste left in place was capped. The Closure Certificate was submitted 27 June 1991 and was approved by the Texas Water Commission on 11 June 1993.
Recommended Action:	Currently included in WMA I and recommended action is accounted for in the Compliance Plan
A. NOR No.:	012, Pond B (SWMU 5)
B. Description	Surface Impoundment (Stormwater Retention/Storage) – S04

C. Dates of Operation	1965 - current
Waste Managed:	Current: Boiler blowdown – formerly managed in Pond B. subsequently discharged to POTW (20271021), Class I Non-Haz; Stormwater associated with industrial activity (20281022), Class II Non-Haz. Formerly: Creosote wastewater sludge (0001504H), Hazardous; Wash Water and Treated CA groundwater (00141011), Class I Non-Haz; Paint Waste (01232091) Class I Non-Haz; Boiler blowdown (20271021), Class 1 Non-Haz.
Evidence of Release:	None. Surface water and sediment samples from Pond B, and soil and groundwater samples from around Pond B, have not identified impacts attributable to Pond B.
Pollutant Dispersal Pathways:	Possible: Soil, Groundwater, Surface Water
Summary:	Surface stormwater retention pond that ceased receiving non-storm wastewater in 2022 . Discharges to surface Outfall 001 under a TPDES permit. Sub-floor/liner soil investigation underway to support closure of Pond B as SWMU 5 (EPA,1987).
Recommended Action:	Soils beneath Pond B are being investigated as part of SWMU 5 closure effort under the Compliance Plan.
A. NOR No.:	013 - Boiler
B. Description	Boiler – T80
C. Dates of Operation	1965 - 2023; Closed
Waste Managed:	Bark Wood and Chips (00064882), Class II Non-Haz; Fly Ash (00093033), Class III Non-Haz; Fly Ash (00113032), Class II Non-Haz; Well Water and Wash Water (00141011), Class I Non-Haz; Paint Waste (01232091), Class I Non-Haz; Fly Ash (01243042), Class II Non-Haz.
Evidence of Release:	None
Pollutant Dispersal Pathways:	Possible: Soil and Groundwater
Summary:	Creates steam for processing logs. Administratively closed on 7 August 2023 and transferred to Stella-Jones Corp., SWR 98534 as WMU 013.
Recommended Action:	No Further Action
A. NOR No.:	014 - Tank (65,000 gallon EQ tank)
B. Description	Tank (Storage) – S02
C. Dates of Operation	1989 - 2023; Closed

Waste Managed:	Creosote Wastewater Sludge (0001504H), Hazardous (K001); Creosote Wastewater (0002205H), Hazardous (F034); Creosote Sludge/Solids/PPE/Wood Fiber (0003606H), Hazardous (F034); Wash Water and Well Water (00141011), Class I Non-Haz; Paint Waste (01232091), Class I Non-Haz.
Evidence of Release:	None
Pollutant Dispersal Pathways:	Possible: Soil and Groundwater
Summary:	65,000-gallon wastewater holding tank at the wastewater treatment plant. Administratively closed on 7 August 2023 and transferred to Stella-Jones Corp., SWR 98534 as WMU 014.
Recommended Action:	No Further Action
A. NOR No.:	015 - Tank (65,000 gallon Creosote)
B. Description	Tank (Surface)(Storage) – S02
C. Dates of Operation	1989 - 2023; Closed
Waste Managed:	Creosote Wastewater Sludge (0001504H), Hazardous (K001); Creosote Wastewater (0002205H), Hazardous (F034); Creosote Sludge/Solids/PPE/Wood Fiber (0003606H), Hazardous (F034); Wash Water and Well Water (00141011), Class I Non-Haz; Paint Waste (01232091), Class I Non-Haz.
Evidence of Release:	None
Pollutant Dispersal Pathways:	Possible: Soil and Groundwater
Summary:	65,000-gallon tank for creosote process wastewater within secondary containment. Administratively closed on 7 August 2023 and transferred to Stella-Jones Corp., SWR 98534 as WMU 015
Recommended Action:	No Further Action
A. NOR No.:	016 - Tank (Oil/water separator)
B. Description	Tank (Surface)(Treatment) – T01
C. Dates of Operation	1989 - 2023; Closed
Waste Managed:	Creosote Wastewater Sludge (0001504H), Hazardous (K001); Creosote Wastewater (0002205H), Hazardous (F034); Creosote Sludge/Solids/PPE/Wood Fiber (0003606H), Hazardous (F034); Wash Water and Well Water (00141011), Class I Non-Haz; Paint Waste (01232091), Class I Non-Haz.
Evidence of Release:	None
Pollutant Dispersal Pathways:	Possible: Soil and Groundwater

Summary:	Oil-water separator at the wastewater treatment plan. Administratively closed on 7 August 2023 and transferred to Stella-Jones Corp., SWR 98534 as WMU 016
Recommended Action:	No Further Action
A. NOR No.:	017 - Tank (Flash mix tank)
B. Description	Tank (Surface) (Treatment) – T01
C. Dates of Operation	1989 - 1994; Closed
Waste Managed:	Creosote Wastewater Sludge (0001504H), Hazardous (K001); Creosote Wastewater (0002205H), Hazardous (F034); Creosote Sludge/Solids/PPE/Wood Fiber (0003606H), Hazardous (F034); Wash Water and Well Water (00141011), Class I Non-Haz; Paint Waste (01232091), Class I Non-Haz.
Evidence of Release:	None
Pollutant Dispersal Pathways:	Possible: Soil and Groundwater
Summary:	500-gallon, cone bottom, HDPE tank used to mix polymer with wastewater at the wastewater treatment plan. Inactive as of 11 January 1994. Tank was cleaned and washed as documented in 4 November 2024 letter. Closed 3 March 2025.
Recommended Action:	No Further Action
A. NOR No.:	018 - Tank (Sludge tank from oil/water separator prior to vacuum filtration)
B. Description	Tank (Storage) – S02
C. Dates of Operation	1989 - 1994; Closed
Waste Managed:	Creosote Wastewater Sludge (0001504H), Hazardous (K001); Creosote Wastewater (0002205H), Hazardous (F034); Creosote Sludge/Solids/PPE/Wood Fiber (0003606H), Hazardous (F034); Wash Water and Well Water (00141011), Class I Non-Haz; Paint Waste (01232091), Class I Non-Haz.
Evidence of Release:	None
Pollutant Dispersal Pathways:	Possible: Soil and Groundwater
Summary:	12,000-gallon sludge tank used to collect solids from oil/water separator within wastewater treatment plant prior to processing in the vacuum filter. Inactive as of 11 January 1994. Closed 17 July 2024.
Recommended Action:	No Further Action
A. NOR No.:	019 - Tank (Blowdown tank)

B. Description	Tank (Storage) – S02
C. Dates of Operation	1989 - 2023; Closed
Waste Managed:	Creosote Wastewater Sludge (0001504H), Hazardous (K001); Creosote Wastewater (0002205H), Hazardous (F034); Creosote Sludge/Solids/PPE/Wood Fiber (0003606H), Hazardous (F034); Wash Water and Well Water (00141011), Class I Non-Haz; Steaming Sludge (00356091), Class I Non-Haz; Paint Waste (01232091), Class I Non-Haz.
Evidence of Release:	None
Pollutant Dispersal Pathways:	Possible: Soil and Groundwater
Summary:	Unit was administratively closed 7 August 2023 and transferred to Stella-Jones Corp., SWR 98534 as WMU 019
Recommended Action:	No Further Action
A. NOR No.:	020 - Tank (Biological Treatment tank)
B. Description	Tank (Treatment) – T01
C. Dates of Operation	1989 - 2023; Closed
Waste Managed:	Creosote Wastewater Sludge (0001504H), Hazardous (K001); Creosote Wastewater (0002205H), Hazardous (F034); Creosote Sludge/Solids/PPE/Wood Fiber (0003606H), Hazardous (F034); Wash Water and Well Water (00141011), Class I Non-Haz; Paint Waste (01232091), Class I Non-Haz.
Evidence of Release:	None
Pollutant Dispersal Pathways:	Possible: Soil and Groundwater
Summary:	100,000-gal tank was administratively closed 7 August 2023 and transferred to Stella-Jones Corp., SWR 98534 as WMU 020
Recommended Action:	No Further Action
A. NOR No.:	021 - Tank (Silver Tank #1)
B. Description	Tank (Storage) – S02
C. Dates of Operation	1992 - 2003; Closed
Waste Managed:	Creosote Wastewater Sludge (0001504H), Hazardous (K001); Creosote Wastewater (0002205H), Hazardous (F034); Creosote Sludge/Solids/PPE/Wood Fiber (0003606H), Hazardous (F034); Wash Water and Well Water (00141011), Class I Non-Haz; Paint Waste (01232091), Class I Non-Haz.

Evidence of Release:	None
Pollutant Dispersal Pathways:	Possible: Soil and Groundwater
Summary:	Approximately 10,000-gallon above ground storage tank used for temporary wastewater storage. Located just north and west of the treatment cylinders. Listed as Inactive as of 26 June 2003. Soil samples were collected and analyzed at the former tank location(s) as documented in 4 November 2024 closure request letter. Closed 3 March 2025.
Recommended Action:	No Further Action
A. NOR No.:	022 - Tank (Silver Tank #2)
B. Description	Tank (Storage) – S02
C. Dates of Operation	1992 - 2003; Closed
Waste Managed:	Creosote Wastewater Sludge (0001504H), Hazardous (K001); Creosote Wastewater (0002205H), Hazardous (F034); Creosote sludge/Solids/PPE/wood Fiber (0003606H), Hazardous (F034); Wash Water and Well Water (00141011), Class I Non-Haz; Paint Waste (01232091), Class I Non-Haz.
Evidence of Release:	None
Pollutant Dispersal Pathways:	Possible: Soil and Groundwater
Summary:	Approximately 10,000-gallon above ground storage tank used for temporary wastewater storage. Located just north and west of the treatment cylinders. Listed as Inactive as of 26 June 2003. Soil samples were collected and analyzed at the former tank location(s) as documented in 4 November 2024 closure request letter. Closed 3 March 2025.
Recommended Action:	No Further Action
A. NOR No.:	023 - Tank (Rotary Vacuum Filter)
B. Description	Tank (Storage) – S02
C. Dates of Operation	1992 - 2021; Closed
Waste Managed:	Creosote Wastewater Sludge (0001504H), Hazardous (K001); Creosote Wastewater (0002205H), Hazardous (F034); Creosote Sludge/Solids/PPE/Wood Fiber (0003606H), Hazardous (F034); Pine Pitch (00134032), Class II Non-Haz; Wash Water and Well Water (00141011), Class I Non-Haz; Paint Waste (01232091), Class I Non-Haz.
Evidence of Release:	None
Pollutant Dispersal Pathways:	Possible: Soil and Groundwater

Summary:	Rotary vacuum within wastewater treatment plant used to dewater solids. Removed from service between 2003 and 2005, and sold in 2006. Closed 17 July 2024 based on closure request dated 24 April 2024.
Recommended Action:	No Further Action
A. NOR No.:	024 - Misc. Storage Containers (Filter Hopper)
B. Description	Other Storage – S99
C. Dates of Operation	1992 - 2021; Closed
Waste Managed:	Creosote Wastewater Sludge (0001504H), Hazardous (K001); Creosote Sludge/Solids/PPE/Wood Fiber (0003606H), Hazardous (F034); Wash Water and Well Water (00141011), Class I Non-Haz; Paint Waste (01232091), Class I Non-Haz.
Evidence of Release:	None
Pollutant Dispersal Pathways:	Possible: Soil and Groundwater
Summary:	Portable (fork-lift attachment) filter hopper associated with the rotary vacuum filter used to temporarily store filter cake prior to off-site disposal. Hopper was cleaned and washed as documented in 4 November 2024 closure report letter. Closed 3 March 2025.
Recommended Action:	No Further Action
A. NOR No.:	025 - Container Storage Area (Waste Container Storage Area)
B. Description	Other Storage – S99; Container Storage Area at Drip Pad
C. Dates of Operation	1992 - 2023; Closed
Waste Managed:	Creosote Wastewater Sludge (0001504H), Hazardous (K001); Creosote Wastewater (0002205H), Hazardous (F034); Creosote Sludge/Solids/PPE/Wood Fiber (0003606H), Hazardous (F034); Spent COD Vials (0010001H), Hazardous (D009); Wash Water and Well Water (00141011), Class I Non-Haz; Spent Carbon (0025404H), Hazardous (F034); Petroleum Contaminated Soil (00264891); Class I Non-Haz; Chromated Copper Arsenate Treating Waste (0027119H), Hazardous (D007); Chromated Copper Arsenate Debris (0028319H), Hazardous (F035); Waste Toluene (0050203H), Hazardous (F005); Lab Solids Toluene (0051409H), Hazardous (F005); Paint Waste (01232091), Class I Non-Haz; QA Lab Toluene Waste (2023203H), Hazardous (F005).
Evidence of Release:	None
Pollutant Dispersal Pathways:	Possible: Soil and Groundwater

Summary:	Unit was administratively closed 7 August 2023 and transferred to Stella-Jones Corp., SWR 98534 as WMU 025
Recommended Action:	No Further Action
A. NOR No.:	026 - Misc Storage Containers (Drip Pad)
B. Description	Other Storage – S99; concrete Subpart W Drip Pad
C. Dates of Operation	1990 - 2023; Closed
Waste Managed:	Creosote Wastewater (0002205H), Hazardous (F034); Creosote sludge/solids/PPE/wood fiber (0003606H), Hazardous, (F034); Wash Water and Well Water (00141011), Class I Non- Haz; Paint Waste (01232091), Class I Non-Haz.
Evidence of Release:	None
Pollutant Dispersal Pathways:	Possible: Soil and Groundwater
Summary:	Unit was administratively closed 7 August 2023 and transferred to Stella-Jones Corp., SWR 98534 as WMU 026
Recommended Action:	No Further Action
A. NOR No.:	027 - Tank (Waste Oil)
B. Description	Tank (Storage) – S02; 500-gal capacity
C. Dates of Operation	1992 - 2023; Closed
Waste Managed:	Waste Crankcase Oil (00052061), Class I Non-Haz; Wash Water and Well Water (00141011), Class I Non-Haz; Paint Waste (01232091), Class I Non-Haz.
Evidence of Release:	None
Pollutant Dispersal Pathways:	Possible: Soil and Groundwater
Summary:	Unit was administratively closed 7 August 2023 and transferred to Stella-Jones Corp., SWR 98534 as WMU 027
Recommended Action:	No Further Action
A. NOR No.:	028 - Tank (Waste Oil)
B. Description	Tank (Storage) – S02; 1,000-gal capacity
C. Dates of Operation	1992 - 2023; Closed
Waste Managed:	Waste Crankcase Oil (00052061), Class I Non-Haz; Wash Water and Well Water (00141011), Class I Non-Haz; Paint Waste (01232091), Class I Non-Haz.
Evidence of Release:	None

Pollutant Dispersal Pathways:	Possible: Soil and Groundwater
Summary:	Unit was administratively closed 7 August 2023 and transferred to Stella-Jones Corp., SWR 98534 as WMU 028
Recommended Action:	No Further Action
A. NOR No.:	029 - Waste Pile (Covered Bark Storage)
B. Description	Waste Pile – S03
C. Dates of Operation	1992 - 2023; Closed
Waste Managed:	Bark and Wood Chips (00064882), Class II Non-Haz; Wash Water and Well Water (00141011), Class I Non-Haz; Paint Waste (01232091), Class I Non-Haz.
Evidence of Release:	None
Pollutant Dispersal Pathways:	Possible: Soil and Groundwater
Summary:	Unit was administratively closed 7 August 2023 and transferred to Stella-Jones Corp., SWR 98534 as WMU 029
Recommended Action:	No Further Action
A. NOR No.:	030 - Misc Storage Containers (Pole Machine Truck Hopper) -
B. Description	Other Storage – S99
C. Dates of Operation	1992 - 2023; Closed
Waste Managed:	Bark and Wood Chips (00064882), Class II Non-Haz; Wash Water and Well Water (00141011), Class I Non-Haz; Paint Waste (01232091), Class I Non-Haz.
Evidence of Release:	None
Pollutant Dispersal Pathways:	Possible: Soil and Groundwater
Summary:	Unit was administratively closed 7 August 2023 and transferred to Stella-Jones Corp., SWR 98534 as WMU 030
Recommended Action:	No Further Action
A. NOR No.:	031 - Misc Storage Containers (Boiler Truck Hopper)
B. Description	Other Storage – S99
C. Dates of Operation	1992 - 2023; Closed
Waste Managed:	Bark and Wood Chips (00064882), Class II Non-Haz; Wash Water and Well Water (00141011), Class I Non-Haz; Paint Waste (01232091), Class I Non-Haz.

Evidence of Release:	None
Pollutant Dispersal Pathways:	Possible: Soil and Groundwater
Summary:	Unit was administratively closed 7 August 2023 and transferred to Stella-Jones Corp., SWR 98534 as WMU 031
Recommended Action:	No Further Action
A. NOR No.:	032 - Container Storage Area (Ash container storage area) - 032
B. Description	Other Storage – S99
C. Dates of Operation	1992 - 2023; Closed
Waste Managed:	Fly Ash (00093033), Class III Non-Haz; Fly Ash (00113032), Class II Non-Haz; Wash Water and Well Water (00141011), Class I Non- Haz; Paint Waste (01232091), Class I Non-Haz; Fly Ash (01243042), Class II Non-Haz.
Evidence of Release:	None
Pollutant Dispersal Pathways:	Possible: Soil and Groundwater
Summary:	Unit was administratively closed 7 August 2023 and transferred to Stella-Jones Corp., SWR 98534 as WMU 032
Recommended Action:	No Further Action
A. NOR No.:	033 - Misc Storage Containers (Trash Dumpster)
B. Description	Other Disposal – D99
C. Dates of Operation	1992 - 2023; Closed
Waste Managed:	Plant Trash (0079032) Class II Non-Haz; Wash Water and Well Water (00141011), Class I Non-Haz; Paint Waste (01232091), Class I Non-Haz.
Evidence of Release:	None
Pollutant Dispersal Pathways:	Possible: Soil and Groundwater
Summary:	Unit was administratively closed 7 August 2023 and transferred to Stella-Jones Corp., SWR 98534 as WMU 033
Recommended Action:	No Further Action
A. NOR No.:	034 - Waste pile (metal scrap pile)
B. Description	Waste pile – S03
C. Dates of Operation	1992 - 2023; Closed

Waste Managed:	Scrap Metal (00083072), Class II Non-Haz; Wash Water and Well Water (00141011), Class I Non-Haz; Paint Waste (01232091), Class I Non-Haz.
Evidence of Release:	None
Pollutant Dispersal Pathways:	Possible: Soil and Groundwater
Summary:	Unit was administratively closed 7 August 2023 and transferred to Stella-Jones Corp., SWR 98534 as WMU 034
Recommended Action:	No Further Action
A. NOR No.:	035 - Waste water treatment plant
B. Description	Waste water treatment System; non-contact wastewater (biological treatment)
C. Dates of Operation	2007 - 2023; Closed
Waste Managed:	Pine Pitch (00134032), Class II Non-Haz; Paint Waste (01232091), Class I Non-Haz.
Evidence of Release:	None
Pollutant Dispersal Pathways:	Possible: Soil and Groundwater
Summary:	Unit was administratively closed 7 August 2023 and transferred to Stella-Jones Corp., SWR 98534 as WMU 035
Recommended Action:	No Further Action
A. NOR No.:	036 - Container Storage Area (wood storage yard)
B. Description	Other Storage – S99
C. Dates of Operation	2017 - 2023; Closed
Waste Managed:	Treated Wood Debris (00304881), Class I Non-Haz; Paint Waste (01232091), Class I Non-Haz.
Evidence of Release:	None
Pollutant Dispersal Pathways:	Possible: Soil and Groundwater
Summary:	Unit was administratively closed 7 August 2023 and transferred to Stella-Jones Corp., SWR 98534 as WMU 036
Recommended Action:	No Further Action

Break In table – NOR Nos. 037, 038, and 039 do not exist.	
A. NOR No.:	40 - Container Storage Area (Temporary Roll-Off)
B. Description	Temporary Roll-off for spill response and cleanup; Other Storage – S99
C. Dates of Operation	Week of 4/10/2023; Closed
Waste Managed:	Creosote sludge/solids/PPE/wood fiber (0003606H), Hazardous (F034).
Evidence of Release:	None
Pollutant Dispersal Pathways:	Possible: Soil and Groundwater
Summary:	Unit was administratively closed 7 August 2023 and transferred to Stella-Jones Corp., SWR 98534 as WMU 040
Recommended Action:	No Further Action
A. NOR No.:	41 - Container Storage Area (Stella-Jones New Accumulation Area)
B. Description	Less than 90-day Accumulation Area; Other Storage – S99
C. Dates of Operation	2023; Closed
Waste Managed:	Creosote Wastewater Sludge (0001504H), Hazardous (K001); Creosote Sludge/Solids/PPE/Wood Fiber (0003606H), Hazardous (F034); Chromate Copper Arsenate Treating Waste (0027119H), Hazardous (D007); Chromate Copper Arsenate Debris (0028319H), Hazardous (F035); Waste Toluene (0050203H), Hazardous (F005 and F034); Lab Solids Toluene (0051409H), Hazardous (F005 and F034).
Evidence of Release:	None
Pollutant Dispersal Pathways:	Possible: Soil and Groundwater
Summary:	Unit was administratively closed 7 August 2023 and transferred to Stella-Jones Corp., SWR 98534 as WMU 041.
Recommended Action:	No Further Action

A. NOR No.:	42 - Container Storage Area (Liquid Remediation Wastewater)
B. Description	Less than 90 day storage; Other Storage – S99
C. Dates of Operation	2024 - Current
Waste Managed:	Well Purge Water and Decontamination Water (2024102H), Hazardous (F034); DNAPL from remediation activities (2025219H); Hazardous (F034); Filters Used in Remediation System (2026310H), Hazardous (F034)
Evidence of Release:	None
Pollutant Dispersal Pathways:	Possible: Soil and Groundwater
Summary:	Monitoring well purge water; drilling equipment decontamination water; DNAPL (creosote) and groundwater from CA recovery wells TW-101, -104, -105, -106, and -107; Less than 90 day storage; spent sediment filters from MW-20B groundwater treatment system;
Recommended Action:	No Further Action
A. NOR No.:	A - SWMU 15 (Historical Oil-water separator)
B. Description	Tank (Treatment) – T01
C. Dates of Operation	1970 - 1985
Waste Managed:	Wastewater from bottom-draining retorts
Evidence of Release:	1987 EPA Inspection report identified stained soil around the unit, but noted it was not a “continuous” release. Investigation conducted in 2024 identified elevated COCs in soil, but no groundwater impacts directly below. Soil impacts possibly attributable to other nearby historical sources.
Pollutant Dispersal Pathways:	Soil; Groundwater Possible
Summary:	Former above-ground, oil/water separator identified in 1987 EPA inspection. RCRA Facility Investigation activities conducted in 2024 were documented in 6 September 2024 Revised APAR.
Recommended Action:	No Further Action requested on 6 September 2024. Observed soil impacts (groundwater not impacted) are attributable to WMA I RCRA Unit(s) and will therefore be adequately addressed under the Compliance Plan.
A. NOR No.:	B – SWMU 16 (Tank E Containment)
B. Description	Containment Building – S06
C. Dates of Operation	1985 - current

Waste Managed:	Mixture of creosote and water generated during treatment process and reused in same process until “spent” (exits to WWTP)
Evidence of Release:	1987 EPA Inspection Report did not identify visual evidence of a release. The 1987 EPA Sampling Report reported a sample at SWMU 16 with several SVOC chemicals above detection limit concentrations. Samples collected in 2021-2024 as part of RCRA RFI did not identify a release; see Sept 2024 Revised APAR.
Pollutant Dispersal Pathways:	Possible: Soil and Groundwater
Summary:	Concrete spill containment area for a 45,000-gallon “work tank” that temporarily stores a mixture of process water and creosote between transfers. RCRA Facility Investigation conducted in 2024 was documented in 6 September 2024 Revised APAR.
Recommended Action:	No Further Action requested on 6 September 2024.
A. NOR No.:	C – AOC 1 (Loading Track Area/Drip Area); a.k.a. “Drip Area” (historical)
B. Description	Other Subpart X – X99
C. Dates of Operation	1964 - 1990
Waste Managed:	Post-treatment drippage from product as it was transferred from cylinders to drying piles.
Evidence of Release:	Stained soil identified in 1987 EPA Inspection report. Soil sampling/analysis conducted during 1980s/1990s (Phase I RFI of Drip Area)
Pollutant Dispersal Pathways:	Possible: Soil and Groundwater
Summary:	Area of a release observed and named in the 1987 EPA inspection report. The AOC 1 area was excavated and verification sampled in 1990 prior to construction of the Subpart W-compliant Drip Pad, which now covers the entire former Drip Area. TCEQ approved the Phase II RFI Soil Report for the Drip Area (letter dated 6 October 1997), which was AOC 1. NFA was granted in a TNRCC letter dated 26 January 2000, and confirmed by TCEQ in a letter dated 5 January 2022.
Recommended Action:	No Further Action – NFA issued in Jan 2000
A. NOR No.:	D – AOC 3 (TPDES Outfall 001)
B. Description	Other Subpart X – X99
C. Dates of Operation	1964 - Current

Waste Managed:	Pond B water (see NOR WMU 012 for Pond B details).
Evidence of Release:	1987 EPA Inspection noted the outfall could possibility receive runoff from the process area.
Pollutant Dispersal Pathways:	Possible: Soil, Groundwater, Surface water, Sediment
Summary:	NFA granted by TCEQ in letter dated May 2021 based on water quality at AOC 3 is currently regulated under the Clean Water Act/Texas TPDES program and not under RCRA.
Recommended Action:	No Further Action – NFA issued May 2021
A. NOR No.:	E - AOC 5 (Run-off ditch south of retorts)
B. Description	Other Subpart X – X99
C. Dates of Operation	1964 - 1991
Waste Managed:	Stormwater runoff
Evidence of Release:	1987 EPA Inspection report noted discolored soil in the drainage area.
Pollutant Dispersal Pathways:	Possible: Soil and Groundwater
Summary:	Described in 1987 EPA Inspection as “run off ditch south of the retorts”. Believed to be currently obscured by subsequent improvements at plant. RCRA Facility Investigation conducted in 2021-2022 and 2024 were submitted in 6 September 2024 Revised APAR.
Recommended Action:	No Further Action requested on 6 September 2024.
A. NOR No.:	F- AOC 6 (Run-off ditch south of Pond 1)
B. Description	Other Subpart X – X99
C. Dates of Operation	1964 - 1991
Waste Managed:	Stormwater runoff
Evidence of Release:	1987 EPA Inspection report noted stained soil in the area. Investigations conducted in 2021-2022 and 2024 identified minimal impacts that were attributable to WMA I/Pond 1.
Pollutant Dispersal Pathways:	Possible: Soil and Groundwater
Summary:	Described in 1987 EPA Inspection as “a ditch that runs along the south (downgradient) end of Pond 1”. RCRA Facility Investigations conducted in 2021-22 and 2024 were documented in 6 September 2024 Revised APAR. Minimal soil impacts and groundwater impacts were reported, but were attributed to WMA I/Pond1.

Recommended Action:	No Further Action requested on 6 September 2024. Observed soil and groundwater/DNAPL impacts are attributable to WMA I RCRA Unit(s) and will therefore be adequately addressed under the Compliance Plan.
A. NOR No.:	G - AOC 7 (Abandoned pipe release)
B. Description	Other Subpart X – X99
C. Dates of Operation	Discovered November 2020
Waste Managed:	Unknown- virgin creosote or creosote wastewater possible, pre-1990.
Evidence of Release:	Investigations conducted 2021-22 and 2024 as part of a RCRA RFI identified soil impacts, but no groundwater impacts.
Pollutant Dispersal Pathways:	Soil; Groundwater Possible
Summary:	Underground piping discovered and removed from ground from 2020 through 2021. Investigation activities conducted in 2021-22 and 2024 were documented in 6 September 2024 Revised APAR.
Recommended Action:	No Further Action requested on 6 September 2024. Soil impacts are of minimal risk to human receptors and do not represent a potential risk to underlying groundwater.

APPENDIX I

FACILITY AND SWMU LOCATION MAPS

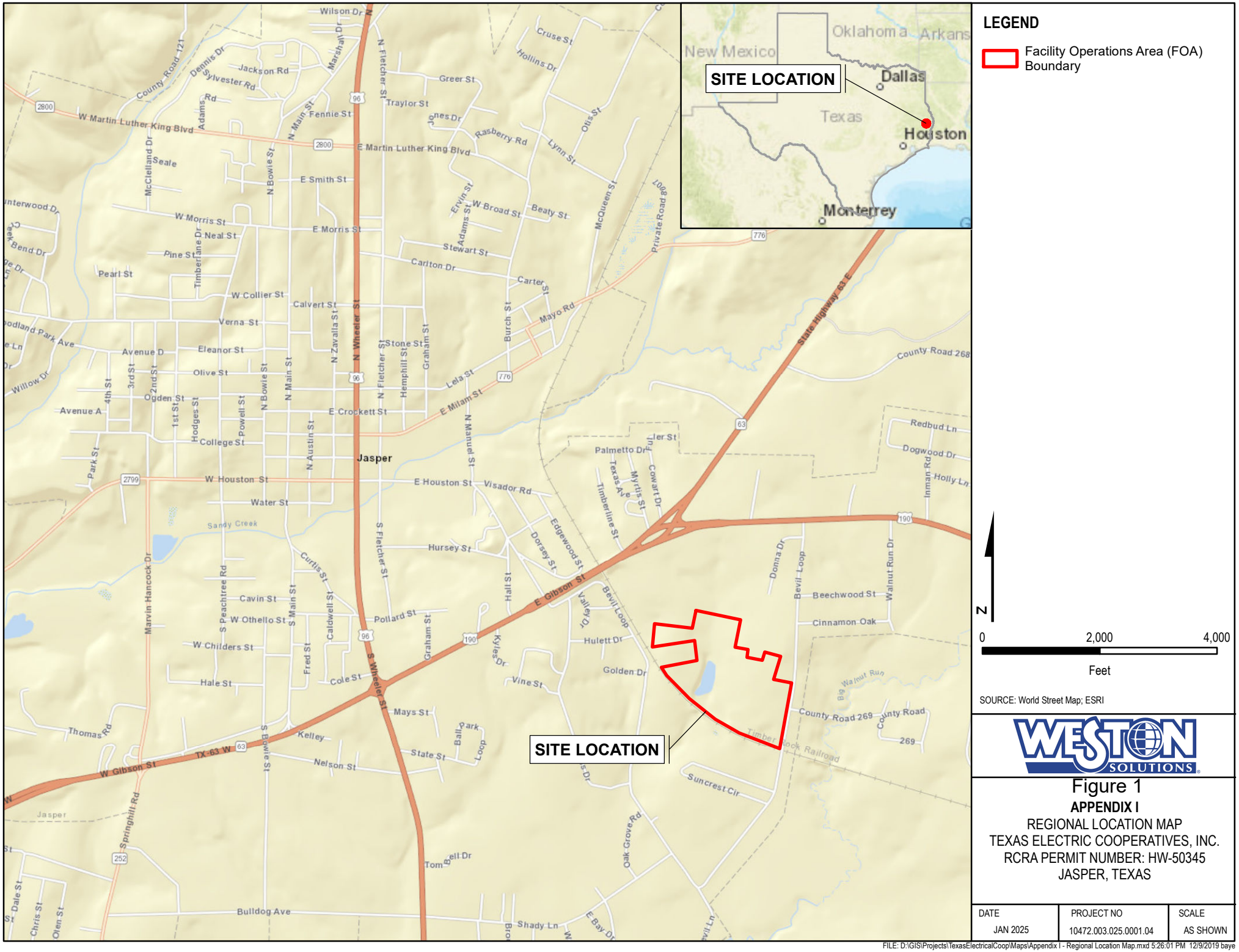

Figure 1

APPENDIX I

REGIONAL LOCATION MAP
TEXAS ELECTRIC COOPERATIVES, INC.
RCRA PERMIT NUMBER: HW-50345
JASPER, TEXAS

DATE	PROJECT NO	SCALE
JAN 2025	10472.003.025.0001.04	AS SHOWN

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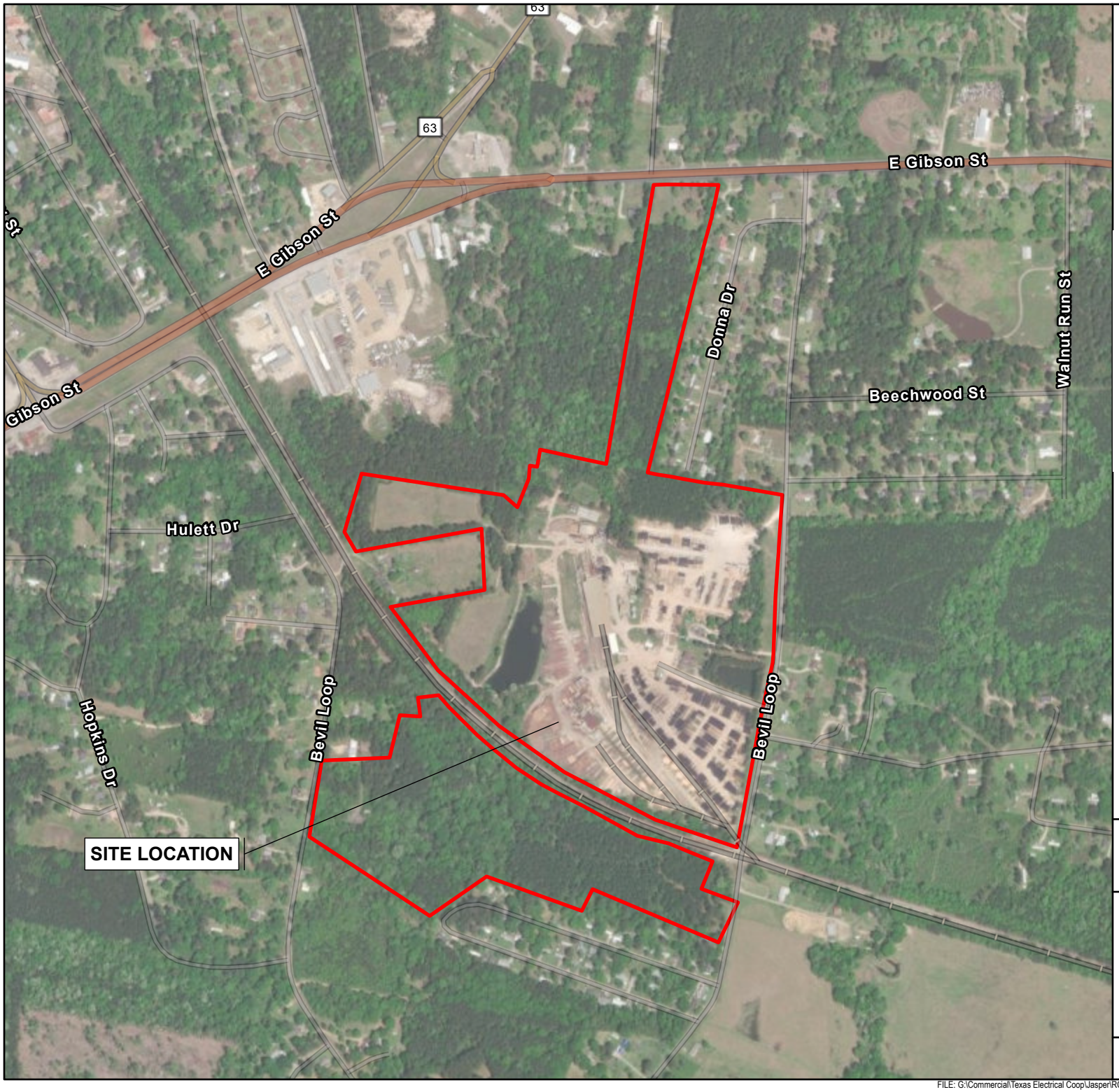
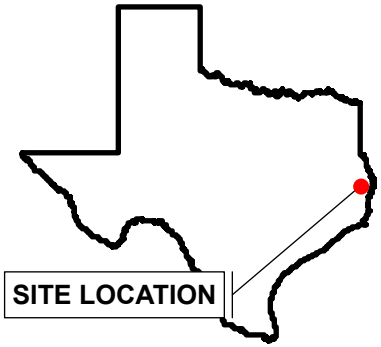
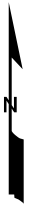


LEGEND

Applicant Property Boundary





0 750 1,500

Feet

SOURCE: World Street Map; ESRI

WESTON SOLUTIONS

APPENDIX I

FIGURE 2: SITE LOCATION MAP
TEXAS ELECTRICAL COOPERATIVES, INC.
RCRA PERMIT NUMBER: HW-50345
JASPER, JASPER COUNTY, TEXAS

DATE	PROJECT NO	SCALE
MAR 2025	10472.006.001.0001	AS SHOWN

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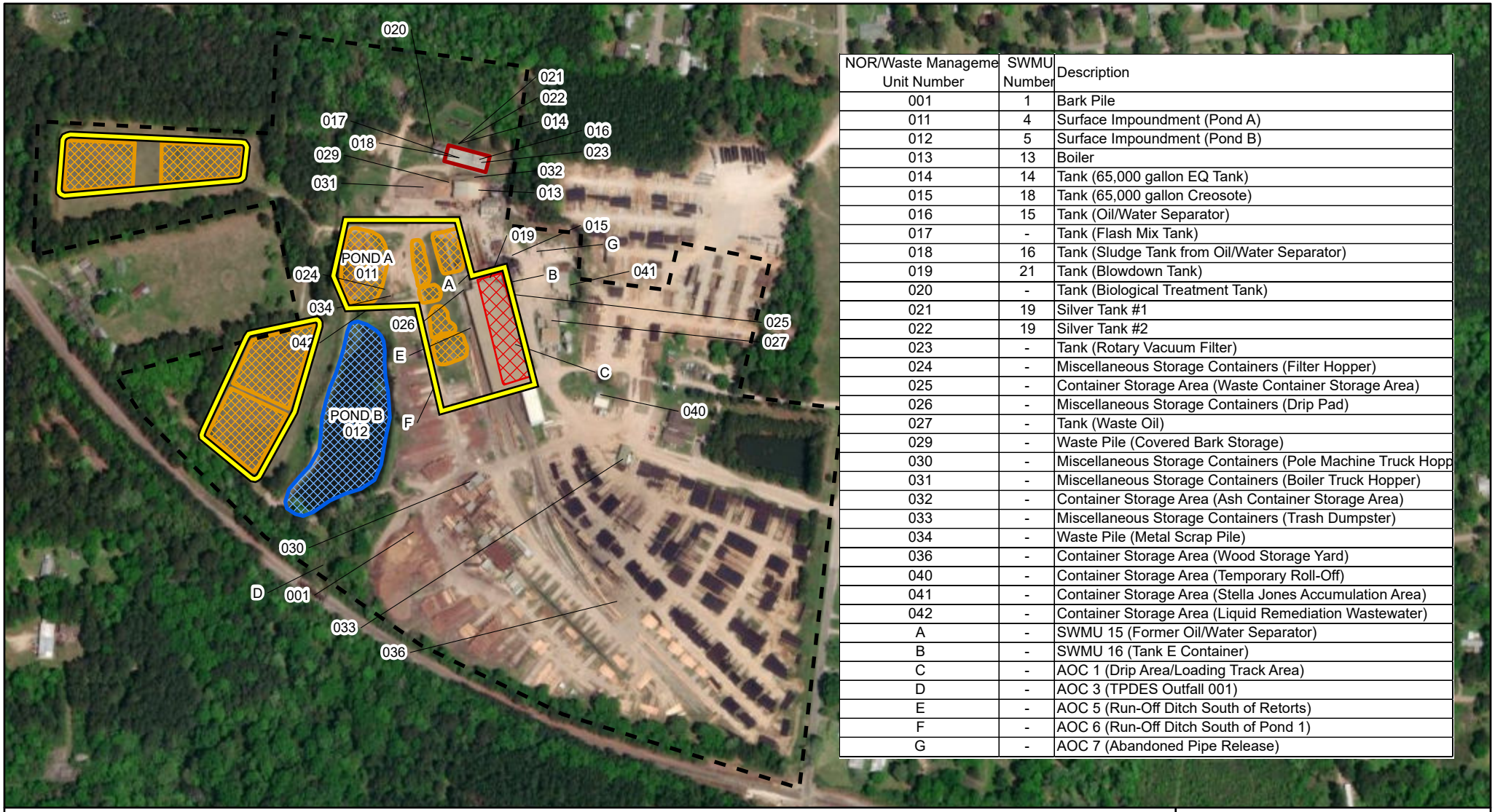

NOR/Waste Manageme Unit Number	SWMU Number	Description
001	1	Bark Pile
011	4	Surface Impoundment (Pond A)
012	5	Surface Impoundment (Pond B)
013	13	Boiler
014	14	Tank (65,000 gallon EQ Tank)
015	18	Tank (65,000 gallon Creosote)
016	15	Tank (Oil/Water Separator)
017	-	Tank (Flash Mix Tank)
018	16	Tank (Sludge Tank from Oil/Water Separator)
019	21	Tank (Blowdown Tank)
020	-	Tank (Biological Treatment Tank)
021	19	Silver Tank #1
022	19	Silver Tank #2
023	-	Tank (Rotary Vacuum Filter)
024	-	Miscellaneous Storage Containers (Filter Hopper)
025	-	Container Storage Area (Waste Container Storage Area)
026	-	Miscellaneous Storage Containers (Drip Pad)
027	-	Tank (Waste Oil)
029	-	Waste Pile (Covered Bark Storage)
030	-	Miscellaneous Storage Containers (Pole Machine Truck Hopp
031	-	Miscellaneous Storage Containers (Boiler Truck Hopper)
032	-	Container Storage Area (Ash Container Storage Area)
033	-	Miscellaneous Storage Containers (Trash Dumpster)
034	-	Waste Pile (Metal Scrap Pile)
036	-	Container Storage Area (Wood Storage Yard)
040	-	Container Storage Area (Temporary Roll-Off)
041	-	Container Storage Area (Stella Jones Accumulation Area)
042	-	Container Storage Area (Liquid Remediation Wastewater)
A	-	SWMU 15 (Former Oil/Water Separator)
B	-	SWMU 16 (Tank E Container)
C	-	AOC 1 (Drip Area/Loading Track Area)
D	-	AOC 3 (TPDES Outfall 001)
E	-	AOC 5 (Run-Off Ditch South of Retorts)
F	-	AOC 6 (Run-Off Ditch South of Pond 1)
G	-	AOC 7 (Abandoned Pipe Release)

LEGEND

- Wastewater Treatment Plant
- Facility Boundary
- Pond
- Former Surface Impoundment
- Area of Concern
- Waste Management Area Boundary

0 500

Feet

N

SOURCE: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community©

WESTON SOLUTIONS

APPENDIX I

FIGURE 2 - FACILITY SWMU

TEXAS ELECTRIC COOPERATIVES, INC.

RCRA PERMIT NUMBER: HW-50345

JASPER, JASPER COUNTY, TEXAS

DATE	PROJECT NO	SCALE
FEBRUARY 2025	10472.006.001.0001	AS SHOWN

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APPENDIX II

WASTES MANAGED

WMA 1 contained K001 listed hazardous waste. Constituents in that waste are shown in the table below.

1. WMA I	Constituent
K001 constituents	Naphthalene
	Benzene
	Carbazole
	Phenanthrene
	Fluoranthene
	Phenol
	2,4-Dimethylphenol
	2,4-Dinitrophenol
	Acenaphthylene
	Chrysene
	Benzo(b)fluoroanthene
	Benzo(a)anthracene
	Benzo(a)pyrene
	Indeno(1,2,3-cd)pyrene

SAFETY DATA SHEET

Version 6.16
Revision Date 12/18/2024
Print Date 12/19/2024

SECTION 1. IDENTIFICATION

1.1 Product identifiers

Product name : Benzene

Product Number : 319953
Brand : SIGALD
Index-No. : 601-020-00-8
CAS-No. : 71-43-2

1.2 Relevant identified uses of the substance or mixture and uses advised against

Identified uses : Laboratory chemicals, Synthesis of substances

Uses advised against : The product is being supplied under the TSCA R&D Exemption (40 CFR Section 720.36). It is the recipient's responsibility to comply with the requirements of the R&D exemption. The product may not be used for a non-exempt commercial purpose under TSCA unless appropriate consent is granted in writing by MilliporeSigma.

1.3 Details of the supplier of the safety data sheet

Company : Sigma-Aldrich Inc.
3050 SPRUCE ST
ST. LOUIS MO 63103
UNITED STATES

Telephone : +1 314 771-5765
Fax : +1 800 325-5052

1.4 Emergency telephone

Emergency Phone # : 800-424-9300 CHEMTREC (USA) +1-703-527-3887 CHEMTREC (International) 24 Hours/day; 7 Days/week

SECTION 2. HAZARDS IDENTIFICATION

GHS classification in accordance with the OSHA Hazard Communication Standard (29 CFR 1910.1200)

Flammable liquids : Category 2

Skin irritation : Category 2

Eye irritation : Category 2A

Germ cell mutagenicity : Category 1B

Carcinogenicity : Category 1A

Specific target organ toxicity - repeated exposure : Category 1 (Blood)

Aspiration hazard : Category 1

Long-term (chronic) aquatic hazard : Category 3

GHS label elements

Hazard pictograms :

Signal Word : Danger

Hazard Statements : H225 Highly flammable liquid and vapor.
H304 May be fatal if swallowed and enters airways.
H315 Causes skin irritation.
H319 Causes serious eye irritation.
H340 May cause genetic defects.
H350 May cause cancer.
H372 Causes damage to organs (Blood) through prolonged or repeated exposure.
H412 Harmful to aquatic life with long lasting effects.

Precautionary Statements :

Prevention:

P201 Obtain special instructions before use.
P202 Do not handle until all safety precautions have been read and understood.
P210 Keep away from heat/ sparks/ open flames/ hot surfaces. No smoking.
P233 Keep container tightly closed.
P240 Ground/bond container and receiving equipment.
P241 Use explosion-proof electrical/ ventilating/ lighting/ equipment.
P242 Use only non-sparking tools.
P243 Take precautionary measures against static discharge.
P260 Do not breathe mist or vapors.
P264 Wash skin thoroughly after handling.
P270 Do not eat, drink or smoke when using this product.
P273 Avoid release to the environment.

P280 Wear protective gloves/ protective clothing/ eye protection/ face protection.

Response:

P301 + P310 IF SWALLOWED: Immediately call a POISON CENTER/ doctor.
P303 + P361 + P353 IF ON SKIN (or hair): Take off immediately all contaminated clothing. Rinse skin with water/ shower.
P305 + P351 + P338 IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.
P308 + P313 IF exposed or concerned: Get medical advice/ attention.
P331 Do NOT induce vomiting.
P332 + P313 If skin irritation occurs: Get medical advice/ attention.
P337 + P313 If eye irritation persists: Get medical advice/ attention.
P362 Take off contaminated clothing and wash before reuse.
P370 + P378 In case of fire: Use dry sand, dry chemical or alcohol-resistant foam to extinguish.

Storage:

P403 + P235 Store in a well-ventilated place. Keep cool.
P405 Store locked up.

Disposal:

P501 Dispose of contents/ container to an approved waste disposal plant.

Other hazards

None known.

SECTION 3. COMPOSITION/INFORMATION ON INGREDIENTS

Substance / Mixture : Substance

Components

Chemical name	CAS-No.	Concentration (% w/w)
benzene	71-43-2	>= 90 - <= 100

Actual concentration is withheld as a trade secret

SECTION 4. FIRST AID MEASURES

General advice : Show this material safety data sheet to the doctor in attendance.

If inhaled : After inhalation: fresh air. Call in physician.

In case of skin contact : In case of skin contact: Take off immediately all contaminated clothing. Rinse skin with water/ shower. Consult a physician.

In case of eye contact : After eye contact: rinse out with plenty of water. Call in ophthalmologist. Remove contact lenses.

If swallowed : After swallowing: caution if victim vomits. Risk of aspiration! Keep airways free. Pulmonary failure possible after aspiration of vomit. Call a physician immediately.

Most important symptoms and effects, both acute and delayed : The most important known symptoms and effects are described in the labelling (see section 2.2) and/or in section 11

Protection of first-aiders : For personal protection see section 8.

Notes to physician : No data available

SECTION 5. FIRE-FIGHTING MEASURES

Suitable extinguishing media : Carbon dioxide (CO2)
Foam
Dry powder

Unsuitable extinguishing media : For this substance/mixture no limitations of extinguishing agents are given.

Specific hazards during fire fighting : Flash back possible over considerable distance. Container explosion may occur under fire conditions.

Combustible.

Pay attention to flashback.

Vapors are heavier than air and may spread along floors.

Development of hazardous combustion gases or vapours possible in the event of fire.

Forms explosive mixtures with air at ambient temperatures.

Hazardous combustion products : Carbon oxides

Specific extinguishing methods : No data available

Further information : Remove container from danger zone and cool with water.
Prevent fire extinguishing water from contaminating surface water or the ground water system.

Special protective equipment for fire-fighters : Stay in danger area only with self-contained breathing apparatus. Prevent skin contact by keeping a safe distance or by wearing suitable protective clothing.

SECTION 6. ACCIDENTAL RELEASE MEASURES

Personal precautions, protective equipment and emergency procedures : Advice for non-emergency personnel:
Do not breathe vapors, aerosols.
Avoid substance contact.
Ensure adequate ventilation.
Keep away from heat and sources of ignition.
Evacuate the danger area, observe emergency procedures, consult an expert.
Advice for emergency responders:
For personal protection see section 8.

Environmental precautions : Do not let product enter drains.
Risk of explosion.

Methods and materials for containment and cleaning up : Cover drains. Collect, bind, and pump off spills.
Observe possible material restrictions (see sections 7 and 10).
Take up carefully with liquid-absorbent material (e.g. Chemizorb®). Dispose of properly. Clean up affected area.

SECTION 7. HANDLING AND STORAGE

For precautions see section 2.2.

Advice on protection against fire and explosion : Keep away from open flames, hot surfaces and sources of ignition.
Take precautionary measures against static discharge.

Advice on safe handling : Work under hood. Do not inhale substance/mixture.
Avoid generation of vapours/aerosols.

Further information on storage conditions : Keep container tightly closed in a dry and well-ventilated place.
Keep away from heat and sources of ignition.
Keep locked up or in an area accessible only to qualified or authorized persons.

Storage class : 3, Flammable liquids

Recommended storage temperature : Recommended storage temperature see product label.

Packaging material : Suitable material: Any Metal Drum

SECTION 8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Ingredients with workplace control parameters

Components	CAS-No.	Value type (Form of exposure)	Control parameters / Permissible concentration	Basis
benzene	71-43-2	TWA	0.5 ppm	ACGIH
		STEL	2.5 ppm	ACGIH
		TWA	10 ppm	OSHA Z-2
		CEIL	25 ppm	OSHA Z-2
		Peak	50 ppm	OSHA Z-2
		TWA	0.1 ppm	NIOSH REL
		ST	1 ppm	NIOSH REL

Engineering measures : No data available

Personal protective equipment

Respiratory protection : required when vapours/aerosols are generated.
Our recommendations on filtering respiratory protection are based on the following standards: DIN EN 143, DIN 14387 and other accompanying standards relating to the used respiratory protection system.

Recommended Filter type: : Filter A-(P3)

The entrepeneur has to ensure that maintenance, cleaning and testing of respiratory protective devices are carried out according to the instructions of the producer. These measures have to be properly documented.

Hand protection

Material : Fluorinated rubber
Break through time : 480 min
Glove thickness : 0.7 mm
Protective index : Full contact
Manufacturer : Vitoject® (KCL 890 / Aldrich Z677698, Size M)

Material : Fluorinated rubber
Break through time : 480 min
Glove thickness : 0.7 mm
Protective index : Splash contact
Manufacturer : Vitoject® (KCL 890 / Aldrich Z677698, Size M)

Manufacturer : data source: KCL GmbH, D-36124 Eichenzell, phone +49 (0)6659 87300, [redacted] test method: EN374

Remarks : Handle with gloves. Gloves must be inspected prior to use. Use proper glove removal technique (without touching glove's outer surface) to avoid skin contact with this product. Dispose of contaminated gloves after use in accordance with applicable laws and good laboratory practices. Wash and dry hands.
If used in solution, or mixed with other substances, and under conditions which differ from EN 374, contact the supplier of the EC approved gloves. This recommendation is advisory only and must be evaluated by an industrial hygienist and safety officer familiar with the specific situation of anticipated use by our customers. It should not be construed as offering an approval for any specific use scenario.

Eye protection : Use equipment for eye protection tested and approved under appropriate government standards such as NIOSH (US) or EN 166(EU).
Safety glasses

Skin and body protection : Flame retardant antistatic protective clothing.

Hygiene measures : Immediately change contaminated clothing. Apply preventive skin protection. Wash hands and face after working with substance.

SECTION 9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance : liquid

Color : clear, colorless

Odor : No data available

Odor Threshold : No data available
pH : No data available

Melting point/ range : 41.9 °F / 5.5 °C
Method: lit.

Boiling point/boiling range : 176 °F / 80 °C
Method: lit.

Flash point : 12 °F / -11 °C
(1,013.5 hPa)
Method: DIN 51755 Part 1

Evaporation rate : No data available

Flammability (solid, gas) : No data available

Flammability (liquids) : No data available

Burning rate : No data available

Self-ignition : 928 °F / 498 °C
1,013.5 hPa

Upper explosion limit / Upper flammability limit : Upper explosion limit
8.0 %(V)

Lower explosion limit / Lower flammability limit : Lower explosion limit
1.2 %(V)

Vapor pressure : 100 hPa (68 °F / 20 °C)

Relative vapor density : No data available

Relative density : No data available

Density : 0.874 g/cm3 (77 °F / 25 °C)
Method: lit.

Solubility(ies)
Water solubility : ca. 1.88 g/l soluble (74.3 °F / 23.5 °C)
pH: 7

Partition coefficient: n-octanol/water : log Pow: 2.13 (77 °F / 25 °C)
pH: 7
Bioaccumulation is not expected. (ECHA)

Autoignition temperature : 928 °F / 498 °C (1,013.5 hPa)

Decomposition temperature	:	No data available
Viscosity		
Viscosity, dynamic	:	No data available
Viscosity, kinematic	:	0.604 mm2/s (77 °F / 25 °C)
Flow time	:	No data available
Explosive properties	:	Not classified as explosive.
Oxidizing properties	:	none
Molecular weight	:	78.11 g/mol
Particle characteristics		
Particle size	:	No data available

SECTION 10. STABILITY AND REACTIVITY

Reactivity	:	Vapors may form explosive mixture with air.
Chemical stability	:	The product is chemically stable under standard ambient conditions (room temperature) .
Possibility of hazardous reactions	:	Exothermic reaction with: halogens Halogenated hydrocarbon in the presence of: Light metals Risk of explosion with: halogen-halogen compounds Nitric acid Boranes Ozone peroxi compounds perchlorates permanganic acid perchloryl fluoride Strong oxidizing agents Chlorine fluorides uranium hexafluoride Oxygen liquid Risk of ignition or formation of inflammable gases or vapours with: chromium(VI) oxide Fluorine

nitryl compounds
Oxygen
oxyhalogenic compounds
Violent reactions possible with:
mineral acids
sulfur

Conditions to avoid	:	Warming.
Incompatible materials	:	No data available
Hazardous decomposition products	:	In the event of fire: see section 5

SECTION 11. TOXICOLOGICAL INFORMATION

11.1 Information on toxicological effects

Acute toxicity
LD50 Oral - Rat - male - > 2,000 mg/kg
(OECD Test Guideline 401)
Symptoms: Nausea
LD50 Oral - Rat - male and female - 3,002 mg/kg
(OECD Test Guideline 401)
Symptoms: Risk of aspiration upon vomiting., Aspiration may cause pulmonary edema and pneumonitis.
Inhalation: No data available
Symptoms: mucosal irritations
LD50 Dermal - Rabbit - 13,630 mg/kg
Remarks: (IUCLID)
No data available

Skin corrosion/irritation
Skin - Rabbit
Result: irritating
(OECD Test Guideline 404)
Remarks: (ECHA)

Serious eye damage/eye irritation
Eyes - Rabbit
Result: Irritating to eyes.
(OECD Test Guideline 405)
Remarks: (IUCLID)
Remarks: Classified according to Regulation (EU) 1272/2008, Annex VI (Table 3.1/3.2)

Respiratory or skin sensitization
Maximization Test - Guinea pig
Result: negative
(OECD Test Guideline 406)

Germ cell mutagenicity
May cause genetic defects.
Test Type: Ames test
Test system: Escherichia coli/Salmonella typhimurium

Metabolic activation: with and without metabolic activation
Method: OECD Test Guideline 471
Result: negative
Test Type: In vitro mammalian cell gene mutation test
Test system: mouse lymphoma cells
Metabolic activation: with and without metabolic activation
Method: OECD Test Guideline 476
Result: negative
Test Type: Chromosome aberration test in vitro
Test system: Chinese hamster lung cells
Metabolic activation: with and without metabolic activation
Method: OECD Test Guideline 473
Result: negative

Test Type: Mutagenicity (mammal cell test): micronucleus.
Species: Mouse
Cell type: Bone marrow
Application Route: inhalation (vapor)
Method: OECD Test Guideline 474
Result: positive

Carcinogenicity
May cause cancer. Positive evidence from human epidemiological studies.

IARC:	1 - Group 1: Carcinogenic to humans (benzene)
NTP:	Known - Known to be human carcinogen (benzene)
OSHA:	OSHA specifically regulated carcinogen (benzene)

Reproductive toxicity
No data available

Specific target organ toxicity - single exposure
No data available

Specific target organ toxicity - repeated exposure
Causes damage to organs through prolonged or repeated exposure.
- Blood
Remarks: Classified according to Regulation (EU) 1272/2008, Annex VI (Table 3.1/3.2)

Aspiration hazard
Aspiration may cause pulmonary edema and pneumonitis.

11.2 Additional Information

Repeated dose toxicity - Rat - male and female - Oral - 13 Weeks - NOAEL (No observed adverse effect level) - 600 mg/kg

RTECS: CY1400000
Nausea, Dizziness, Headache, narcosis, Inhalation of high concentrations of benzene may have an initial stimulatory effect on the central nervous system characterized by exhilaration, nervous excitation and/or giddiness, depression, drowsiness, or fatigue. The victim may experience tightness in the chest, breathlessness, and loss of consciousness. Tremors, convulsions, and death due to respiratory paralysis or circulatory collapse can occur in a few minutes to several hours following

severe exposures. Aspiration of small amounts of liquid immediately causes pulmonary edema and hemorrhage of pulmonary tissue. Direct skin contact may cause erythema. Repeated or prolonged skin contact may result in drying, scaling dermatitis, or development of secondary skin infections. The chief target organ is the hematopoietic system. Bleeding from the nose, gums, or mucous membranes and the development of purpuric spots, pancytopenia, leukopenia, thrombocytopenia, aplastic anemia, and leukemia may occur as the condition progresses. The bone marrow may appear normal, aplastic or hyperplastic, and may not correlate with peripheral blood-forming tissues. The onset of effects of prolonged benzene exposure may be delayed for many months or years after the actual exposure has ceased., Blood disorders
To the best of our knowledge, the chemical, physical, and toxicological properties have not been thoroughly investigated.

After absorption of large quantities:

narcosis
respiratory arrest
Convulsions

Possible damages:

Damage to:

Liver
Kidney
Central nervous system

Handle in accordance with good industrial hygiene and safety practice.

Stomach - Irregularities - Based on Human Evidence

SECTION 12. ECOLOGICAL INFORMATION

Ecotoxicity

Components:

benzene:

Toxicity to fish	:	LC50 (Oryzias latipes (Orange-red killifish)): > 100 mg/l End point: mortality Exposure time: 96 h Test Type: semi-static test Analytical monitoring: yes Method: OECD Test Guideline 203 GLP: yes
Toxicity to daphnia and other aquatic inverte-	:	EC50 (Daphnia magna (Water flea)): > 1,000 mg/l End point: Immobilization

brates | Exposure time: 48 h
Test Type: semi-static test
Analytical monitoring: yes
Method: OECD Test Guideline 202
GLP: yes

NOEC (Daphnia magna (Water flea)): > 1,000 mg/l
End point: Immobilization
Exposure time: 48 h
Test Type: semi-static test
Analytical monitoring: yes
Method: OECD Test Guideline 202
GLP: yes

Toxicity to algae/aquatic plants : ErC50 (Pseudokirchneriella subcapitata (green algae)): > 1,000 mg/l
Exposure time: 72 h
Test Type: static test
Analytical monitoring: yes
Method: OECD Test Guideline 201
GLP: yes

NOEC (Pseudokirchneriella subcapitata (green algae)): >= 1,000 mg/l
Exposure time: 72 h
Test Type: static test
Analytical monitoring: yes
Method: OECD Test Guideline 201
GLP: yes

Toxicity to fish (Chronic toxicity) : NOEC (Pimephales promelas (fathead minnow)): 0.8 mg/l
Exposure time: 32 d
Test Type: flow-through test
Analytical monitoring: yes
Remarks: (ECHA)

Toxicity to daphnia and other aquatic invertebrates (Chronic toxicity) : LC50 (Daphnia magna (Water flea)): > 100 mg/l
End point: mortality
Exposure time: 21 d
Test Type: semi-static test
Analytical monitoring: yes
Method: OECD Test Guideline 211
GLP: yes

Toxicity to microorganisms : EC50 (activated sludge): > 1,000 mg/l
Exposure time: 3 h
Test Type: static test
Method: OECD Test Guideline 209
GLP: yes

Ecotoxicology Assessment

Chronic aquatic toxicity : Harmful to aquatic life with long lasting effects.

Persistence and degradability

Components:

benzene:

Biodegradability : aerobic
Inoculum: activated sludge, non-adapted
Concentration: 17 mg/l
Result: Readily biodegradable.
Biodegradation: 96 %
Exposure time: 28 d
Method: OECD Test Guideline 301F
GLP: yes

Bioaccumulative potential

Components:

benzene:

Bioaccumulation : Species: Leuciscus idus (Golden orfe)
Bioconcentration factor (BCF): 10
Exposure time: 3 d
Concentration: 0.05 mg/l

Partition coefficient: n-octanol/water : log Pow: 2.13 (77 °F / 25 °C)
pH: 7
Remarks: Bioaccumulation is not expected.
(ECHA)

Mobility in soil

No data available

Other adverse effects

Product:

Ozone-Depletion Potential : Regulation: 40 CFR Protection of Environment; Part 82 Protection of Stratospheric Ozone - CAA Section 602 Class I Substances
Remarks: This product neither contains, nor was manufactured with a Class I or Class II ODS as defined by the U.S. Clean Air Act Section 602 (40 CFR 82, Subpt. A, App.A + B).

Components:

benzene:

Additional ecological information : Endangers drinking-water supplies if allowed to enter soil or water.

Discharge into the environment must be avoided.

SECTION 13. DISPOSAL CONSIDERATIONS

Disposal methods

Waste from residues : Waste material must be disposed of in accordance with the national and local regulations. Leave chemicals in original containers. No mixing with other waste. Handle uncleaned containers like the product itself.

SECTION 14. TRANSPORT INFORMATION

International Regulations

IATA-DGR

UN/ID No. : UN 1114
Proper shipping name : Benzene
Class : 3
Packing group : II
Labels : Class 3 - Flammable liquids
Packing instruction (cargo aircraft) : 364
Packing instruction (passenger aircraft) : 353

IMDG-Code

UN number : UN 1114
Proper shipping name : BENZENE

Class : 3
Packing group : II
Labels : 3
EmS Code : F-E, S-D
Marine pollutant : no

Transport in bulk according to Annex II of MARPOL 73/78 and the IBC Code

Not applicable for product as supplied.

National regulation

49 CFR Road

UN/ID/NA number : UN 1114
Proper shipping name : Benzene

Class : 3
Packing group : II
Labels : Class 3 - Flammable liquids
ERG Code : 130
Marine pollutant : no

Poison Inhalation Hazard : No

Special precautions for user

The transport classification(s) provided herein are for informational purposes only, and solely based upon the properties of the unpackaged material as it is described within this Safety Data Sheet. Transportation classifications may vary by mode of transportation, package sizes, and variations in regional or country regulations.

SECTION 15. REGULATORY INFORMATION

CERCLA Reportable Quantity

Components	CAS-No.	Component RQ (lbs)	Calculated product RQ (lbs)
benzene	71-43-2	10	10
benzene	71-43-2	10	10 (D018)

SARA 304 Extremely Hazardous Substances Reportable Quantity

This material does not contain any components with a section 304 EHS RQ.

SARA 302 Extremely Hazardous Substances Threshold Planning Quantity

This material does not contain any components with a section 302 EHS TPQ.

SARA 311/312 Hazards : Fire Hazard
Acute Health Hazard
Chronic Health Hazard

SARA 313 : The following components are subject to reporting levels established by SARA Title III, Section 313:

benzene 71-43-2 >= 90 - <= 100 %

Clean Air Act

This product neither contains, nor was manufactured with a Class I or Class II ODS as defined by the U.S. Clean Air Act Section 602 (40 CFR 82, Subpt. A, App.A + B).
The following chemical(s) are listed as HAP under the U.S. Clean Air Act, Section 112 (40 CFR 61):
benzene 71-43-2 >= 90 - <= 100 %
This product does not contain any chemicals listed under the U.S. Clean Air Act Section 112(r) for Accidental Release Prevention (40 CFR 68.130, Subpart F).
The following chemical(s) are listed under the U.S. Clean Air Act Section 111 SOCMI Intermediate or Final VOC's (40 CFR 60.489):
benzene 71-43-2 >= 90 - <= 100 %

Clean Water Act

The following Hazardous Substances are listed under the U.S. CleanWater Act, Section 311, Table 116.4A:
benzene 71-43-2 >= 90 - <= 100 %
The following Hazardous Chemicals are listed under the U.S. CleanWater Act, Section 311, Table 117.3:
benzene 71-43-2 >= 90 - <= 100 %
This product contains the following toxic pollutants listed under the U.S. Clean Water Act Section 307
benzene 71-43-2 >= 90 - <= 100 %

This product contains the following priority pollutants related to the U.S. Clean Water Act:

benzene	71-43-2	>= 90 - <= 100 %

US State Regulations

Massachusetts Right To Know

benzene	71-43-2

Pennsylvania Right To Know

benzene	71-43-2

Maine Chemicals of High Concern

benzene	71-43-2

Vermont Chemicals of High Concern

benzene	71-43-2

Washington Chemicals of High Concern

benzene	71-43-2

California Prop. 65

WARNING: This product can expose you to chemicals including benzene, which is/are known to the State of California to cause cancer and birth defects or other reproductive harm. For more information go to www.P65Warnings.ca.gov.

The ingredients of this product are reported in the following inventories:

TSCA : All substances listed as active on the TSCA inventory

TSCA list

No substances are subject to a Significant New Use Rule.

No substances are subject to TSCA 12(b) export notification requirements.

SECTION 16. OTHER INFORMATION

Full text of other abbreviations

ACGIH	:	USA. ACGIH Threshold Limit Values (TLV)
NIOSH REL	:	USA. NIOSH Recommended Exposure Limits
OSHA Z-2	:	USA. Occupational Exposure Limits (OSHA) - Table Z-2
ACGIH / TWA	:	8-hour, time-weighted average
ACGIH / STEL	:	Short-term exposure limit
NIOSH REL / TWA	:	Time-weighted average concentration for up to a 10-hour workday during a 40-hour workweek
NIOSH REL / ST	:	STEL - 15-minute TWA exposure that should not be exceeded at any time during a workday
OSHA Z-2 / TWA	:	8-hour time weighted average
OSHA Z-2 / CEIL	:	Acceptable ceiling concentration
OSHA Z-2 / Peak	:	Acceptable maximum peak above the acceptable ceiling concentration for an 8-hr shift

AIIC - Australian Inventory of Industrial Chemicals; ASTM - American Society for the Testing of Materials; bw - Body weight; CERCLA - Comprehensive Environmental Response, Compensation, and Liability Act; CMR - Carcinogen, Mutagen or Reproductive Toxicant; DIN - Standard of the German Institute for Standardisation; DOT - Department of Transportation; DSL - Domestic Substances List (Canada); ECx - Concentration associated with x% response; EHS - Extremely Hazardous Substance; ELx - Loading rate associated with x% response; EmS - Emergency Schedule; ENCS - Existing and New Chemical Substances (Japan); ErCx - Concentration associated with x% growth rate response; ERG - Emergency Response Guide; GHS - Globally Harmonized System; GLP - Good Laboratory Practice; HMIS - Hazardous Materials Identification System; IARC - International Agency for Research on Cancer; IATA - International Air Transport Association; IBC - International Code for the Construction and Equipment of Ships carrying Dangerous Chemicals in Bulk; IC50 - Half maximal inhibitory concentration; ICAO - International Civil Aviation Organization; IECSC - Inventory of Existing Chemical Substances in China; IMDG - International Maritime Dangerous Goods; IMO - International Maritime Organization; ISHL - Industrial Safety and Health Law (Japan); ISO - International Organisation for Standardization; KECI - Korea Existing Chemicals Inventory; LC50 - Lethal Concentration to 50 % of a test population; LD50 - Lethal Dose to 50% of a test population (Median Lethal Dose); MARPOL - International Convention for the Prevention of Pollution from Ships; MSHA - Mine Safety and Health Administration; n.o.s. - Not Otherwise Specified; NFPA - National Fire Protection Association; NO(A)EC - No Observed (Adverse) Effect Concentration; NO(A)EL - No Observed (Adverse) Effect Level; NOELR - No Observable Effect Loading Rate; NTP - National Toxicology Program; NZIoC - New Zealand Inventory of Chemicals; OECD - Organization for Economic Co-operation and Development; OPPTS - Office of Chemical Safety and Pollution Prevention; PBT - Persistent, Bioaccumulative and Toxic substance; PICCS - Philippines Inventory of Chemicals and Chemical Substances; (Q)SAR - (Quantitative) Structure Activity Relationship; RCRA - Resource Conservation and Recovery Act; REACH - Regulation (EC) No 1907/2006 of the European Parliament and of the Council concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals; RQ - Reportable Quantity; SADT - Self-Accelerating Decomposition Temperature; SARA - Superfund Amendments and Reauthorization Act; SDS - Safety Data Sheet; TCSI - Taiwan Chemical Substance Inventory; TECI - Thailand Existing Chemicals Inventory; TSCA - Toxic Substances Control Act (United States); UN - United Nations; UNRTDG - United Nations Recommendations on the Transport of Dangerous Goods; vPvB - Very Persistent and Very Bioaccumulative

The information is believed to be correct but is not exhaustive and will be used solely as a guideline, which is based on current knowledge of the chemical substance or mixture and is applicable to appropriate safety precautions for the product. It does not represent any guarantee of the properties of the product. Sigma-Aldrich Corporation and its Affiliates shall not be held liable for any damage resulting from handling or from contact with the above product. See www.sigma-aldrich.com and/or the reverse side of invoice or packing slip for additional terms and conditions of sale.

Revision Date : 12/18/2024

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information in the document regarding the product remains unchanged and matches

[redacted]

US / EN

Naphthalene; CASRN 91-20-3

Human health assessment information on a chemical substance is included in the IRIS database only after a comprehensive review of toxicity data, as outlined in the IRIS assessment development process. Sections I (Health Hazard Assessments for Noncarcinogenic Effects) and II (Carcinogenicity Assessment for Lifetime Exposure) present the conclusions that were reached during the assessment development process. Supporting information and explanations of the methods used to derive the values given in IRIS are provided in the guidance documents located on the IRIS website.

STATUS OF DATA FOR Naphthalene

File First On-Line 12/01/1990

Category (section)	Assessment Available?	Last Revised
Oral RfD (I.A.)	yes	09/17/1998
Inhalation RfC (I.B.)	yes	09/17/1998
Carcinogenicity Assessment (II.)	yes	09/17/1998

I. Chronic Health Hazard Assessments for Noncarcinogenic Effects

I.A. Reference Dose for Chronic Oral Exposure (RfD)

Substance Name — Naphthalene
CASRN — 91-20-3
Last Revised — 09/17/1998

The oral Reference Dose (RfD) is based on the assumption that thresholds exist for certain toxic effects such as cellular necrosis. It is expressed in units of mg/kg-day. In general, the RfD is an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime. Please refer to the Background Document for an elaboration of these concepts. RfDs can also be derived for the noncarcinogenic health effects of substances that are also carcinogens. Therefore, it is

essential to refer to other sources of information concerning the carcinogenicity of this substance. If the U.S. EPA has evaluated this substance for potential human carcinogenicity, a summary of that evaluation will be contained in Section II of this file.

I.A.1. Oral RfD Summary

Critical Effect	Experimental Doses*	UF	MF	RfD
Decreased mean terminal body weight in males **Subchronic oral rat study** **BCL, 1980a**	NOAEL: 100 mg/kg-day; 71 mg/kg-day (adjusted) LOAEL: 200 mg/kg-day; 142 mg/kg-day (adjusted)	3000	1	2E-2 mg/kg-day

*Conversion Factors and Assumptions — MW = 128.19. Duration adjustment (5/7) of the doses (100, 200 mg/kg-day) arrived at a critical NOAEL/LOAEL pair of 71 and 143 mg/kg-day for decreased mean terminal body weight in male rats.

I.A.2. Principal and Supporting Studies (Oral RfD)

Battelle's Columbus Laboratories (BCL). (1980a) Unpublished subchronic toxicity study: Naphthalene (C52904), Fischer 344 rats. Prepared by Battelle Laboratories under NTP Subcontract No. 76-34-106002.

Naphthalene (> 99% pure) in corn oil was administered by gavage to groups of 10 male and 10 female Fischer 344 rats at dose levels of 0, 25, 50, 100, 200, or 400 mg/kg (duration-adjusted 0, 17.9, 35.7, 71.4, 142.9, and 285.7 mg/kg-day), 5 days/week for 13 weeks (BCL, 1980a). Measured parameters included food consumption and body weight weekly, twice-daily observation for clinical signs of toxicity, hematological parameters for blood collected at termination (hemoglobin, hematocrit, total and differential white blood cell count, red blood cell count, mean cell volume, mean cell hemoglobin concentration), necropsy of all rats in the study, and complete histopathological examination of 27 organs and tissues (including the eyes, lungs, stomach, liver, kidney, reproductive organs, thymus, and kidney) from all control and 400-mg/kg rats. Male kidneys and female thymuses from the 200-mg/kg group were also examined histopathologically (according to the histopathology tables; however, the report text states that the 100-mg/kg group was examined). Organ weight data were not reported.

At the highest dose level, two males died during the last week of treatment, and rats of both sexes displayed diarrhea, lethargy, hunched posture, and rough coats at intermittent intervals throughout the study (BCL, 1980a). Food consumption was not affected by exposure, but mean decreases in terminal body weight greater than 10% compared with control values were found in several groups of exposed rats (over the 13-week period); namely, 23% depression in females at 400 mg/kg and a 29% and 12% depression in males at 400 and 200 mg/kg-day, respectively. Differences between mean values of hematological parameters in exposed groups and control groups were < 10% of control values, except for a 94% increase in numbers of mature neutrophils and a 25.1% decrease in numbers of lymphocytes in male 400-mg/kg rats and a 37.2% increase in mature neutrophils in 400-mg/kg females. Histological examinations revealed low incidences of lesions in exposed male kidneys and exposed female thymuses; no lesions were observed in respective control kidneys or thymuses. Lesions such as focal cortical lymphocytic infiltration or focal tubular regeneration were observed in kidneys of 2/10 male rats exposed to 200 mg/kg naphthalene, and diffuse renal tubular degeneration occurred in 1/10 male rats exposed to 400 mg/kg naphthalene. Other lesions include lymphoid depletion of the thymus, which occurred in 2/10 females exposed to 400 mg/kg naphthalene, but not in any other females. No other tissue lesions were detected. Decreased body weight was the most sensitive effect noted in this study and was identified as the most appropriate critical effect for the purposes of RfD derivation. Mean terminal body weight decreases greater than 10% compared with control values were found in male rats following a 90-day gavage exposure to 200 mg/kg-day (LOAEL). The NOAEL for a > 10% decrease in body weight in this study was 100 mg/kg-day (71 mg/kg-day duration-adjusted).

Shopp, GM; White, KL, Jr.; Holsapple, MP; et al. (1984) Naphthalene toxicity in CD-1 mice: general toxicology and immunotoxicology. Fundam Appl Toxicol 4(3 pt 1):406-419.

Groups of male and female albino CD-1 mice (approximately 6 weeks old at the start) were administered gavage doses of 0, 5.3, 53, or 133 mg/kg naphthalene (99.3% pure) in corn oil for 90 consecutive days (Shopp et al., 1984). A naive control group and the 5.3- and 53-mg/kg dose groups each contained 76 male mice and 40 female mice. The vehicle control group contained 112 male mice and 76 female mice. The high-dose group contained 96 male mice and 60 female mice. Significant chemical-related decreases in terminal body weights or survival were not observed in either sex. No significant alterations in absolute or relative organ weights occurred in exposed male mice. Significant decreases in absolute weights of brain, liver, and spleen and relative weight of spleen occurred in high-dose females; however, organ-to-body weight ratios were significantly different only for the spleen. Histopathological examination of organs was not conducted, but the authors noted that cataracts were not formed in exposed mice (methods used to assess the presence of cataracts were not specified). Examination of hematological parameters (including numbers of leukocytes, erythrocytes, and platelets and determination of hematocrit and hemoglobin) at termination revealed only slight,

but statistically significant, increases in hemoglobin in high-dose females only; however, the hematological data were not shown in the report. Chemical analysis of serum showed statistically significant decreased blood urea nitrogen in all exposed female groups, and increased serum globulin and protein in the two highest female dose groups. In the same study, no exposure-related responses were found in a battery of immunological assays (humoral immune response, lymphocyte responsiveness, delayed-type hypersensitivity response, popliteal lymph node response, and bone marrow function); immunotoxic responses were observed in positive controls given intraperitoneal injections of 50 mg/kg cyclophosphamide on days 87, 88, 89, and 90. The study identified a LOAEL of 133 mg/kg-day and a NOAEL of 53 mg/kg-day with significant decreases in absolute weight of brain, liver, and spleen and relative weight of spleen in high-dose females. Therefore, the LOAEL of 133 mg/kg-day is based on the observed organ effects, especially the decrease in the relative weight of the spleen along with the suggestive evidence for effects on hepatic enzyme function. The toxicological significance of the statistically significant alterations in hematological and serum chemical parameters is not clear.

The use of the BCL (1980a) study in deriving the RfD was based on the following reasons:

The verification of the chemical dose, animal maintenance, and study design (10 rats/sex/dose group for 5 dose groups and 1 control group) are consistent with GLP guidelines submitted for 90-day studies, unlike the Shopp et al. (1984) study, in which the numbers of animals actually evaluated compared to those exposed for most endpoints (organ weights, clinical chemistry, and immunological testing) were small.

The decrease in mean terminal body weight in the BCL (1980a) study was not a result of decreased food consumption and was accompanied by clinical signs (diarrhea, lethargy, and rough coats) consistent with sick animals.

Decreases in mean terminal body weight of at least 10% were observed in females and males in the case of the BCL (1980a) study, unlike the Shopp et al. (1984) study, in which no significant changes in body weight were reported at any dose level.

The statistically significant alterations ($p < 0.05$) observed in the absolute (brain, liver, and spleen) and relative weight (spleen) of some organs in the absence of any decrease in body weight (Shopp et al., 1984) is not consistent with the absence of lesions and the lack of significant alterations in the clinical chemistry data, hematology, mixed-function oxidase activity, or the immunotoxicity assays for either sex.

Although the gross and histopathological examination was limited to the control and high-dose group in the BCL (1980a) study, renal lesions of low incidence were observed in the kidneys

(focal cortical lymphocytic infiltration, focal and diffuse tubular regeneration) and thymus (lymphoid depletion) in males and females, respectively, at 100 mg/kg (71 mg/kg-day), unlike the Shopp et al. (1984) study, in which gross necropsy (no histopathological examination of tissues) on a randomly selected number of animals revealed no lesions.

I.A.3. Uncertainty and Modifying Factors (Oral RfD)

UF = 3000.

The duration-adjusted NOAEL for terminal body weight decrease (> 10% of control) in male rats from the BCL (1980a) 90-day gavage study, 71 mg/kg-day, was divided by an uncertainty factor of 3000 (10 to extrapolate from rats to humans, 10 to protect sensitive humans, 10 to extrapolate from subchronic to chronic exposure, and 3 for database deficiencies including the lack of chronic oral exposure studies and 2-generation reproductive toxicity studies) to arrive at a chronic RfD for naphthalene of 2E-2 mg/kg-day.

MF = 1.

I.A.4. Additional Studies/Comments (Oral RfD)

In deriving the RfD additional studies were evaluated for a variety of critical effects. Nervous system depression in pregnant rats (NTP, 1991) occurring at a lower dose (50 mg/kg-day), was judged to be nonadverse, because the effect was considered to be transient in nature. Data from studies of mice exposed acutely to injections of naphthalene, or 1- or 2-methylnaphthalene (Buckpitt and Franklin, 1989), or chronically to 1- or 2-methylnaphthalene in the diet (Murata et al., 1993, 1997) provide suggestive evidence that chronic oral exposure to naphthalene at low doses may produce lung injury. However, deriving an RfD for naphthalene based on the methylnaphthalene data was judged to be too uncertain, because of metabolic differences between naphthalene and methylnaphthalenes and the absence of lung injury in subchronic oral studies in rats (BCL, 1980a) and mice with naphthalene (BCL, 1980b; Shopp et al., 1984).

A benchmark dose (BMD) approach to modeling the male rat body weight data fits mathematical models for a continuous variable to the data using maximum likelihood methods (see Appendix B to the Toxicological Review of Naphthalene, "Benchmark Dose Calculations"). In this approach, maximum likelihood estimates (MLEs) of dose (with no duration adjustment) associated with a 10% decrease in mean body weight compared with nonexposure conditions were 171 and 172 mg/kg-day using a polynomial and power model, respectively; respective 95% confidence lower limits on these doses, taken as BMDs, were 130 and 135 mg/kg-day. Assuming that either of these BMDs are surrogates for NOAELs, as

suggested by the analysis of developmental toxicity data by Allen et al. (1994a,b) and Kavlock et al. (1995), making duration adjustments (BMD x 5/7) and applying the same 3000 uncertainty factor used for the NOAEL/LOAEL approach arrives at a prospective RfD for naphthalene, 3E-2 mg/kg-day, that is comparable to the RfD derived with the NOAEL/LOAEL approach.

Benchmark dose approaches to deriving a chronic RfD for naphthalene were also examined using data for maternal body weight decreases in the NTP (1991) rat developmental toxicity study and data for lung proteinosis in mice exposed for 81 weeks to 1-methylnaphthalene in the diet (Murata et al., 1993). Decreased maternal body weight was not selected as the basis of chronic RfD derivation because the pregnant rats were exposed for only a small percentage of their lives. As discussed earlier, deriving the naphthalene RfD based on 1-methylnaphthalene data was judged to be too uncertain because of metabolic differences between naphthalene and methylnaphthalenes and the absence of lung injury in rats and mice orally exposed to naphthalene for subchronic periods.

The benchmark methodology for naphthalene is contained within an appendix of the Toxicological Review for the readers' information, however it was decided to use the LOAEL/NOAEL approach rather than the benchmark approach in the derivation of the RfD/RfC.

For more detail on Susceptible Populations, exit to the toxicological review, Section 4.7 (PDF).

I.A.5. Confidence in the Oral RfD

Study — High
Database — Low
RfD — Low

The principal study was given a high confidence rating because adequate numbers of animals were included and experimental protocols were adequately designed, conducted, and reported. Confidence in the database was rated low because of the lack of adequate chronic oral data for naphthalene; the lack of any dose-response data for naphthalene-induced hemolytic anemia, probably one of the most well-known health Hazards to humans exposed to naphthalene; and the lack of two-generation reproductive toxicity studies. Humans exposed via inhalation, combined inhalation and dermal exposure, and combined inhalation and oral exposure have developed hemolytic anemia. Hemolytic anemia is characterized by findings of lowered hemoglobin, hematocrit, and erythrocyte values, elevated reticulocyte counts, Heinz bodies, elevated serum bilirubin, and fragmentation of erythrocytes. In severe cases, the hemolytic

anemia was accompanied by jaundice, high serum levels of bilirubin, cyanosis, and kernicterus with pronounced neurological signs. Neither oral nor inhalation exposure levels were available in human studies reporting anemia (Melzer-Lange and Walsh-Kelly, 1989; Owa, 1989; Owa et al., 1993). Infants deficient in G6PDH are thought to be especially sensitive to naphthalene-induced hemolytic anemia. Resulting confidence in the RfD is low. A quantitative comparison of the acute dog study (7 days at 262 mg/kg-day; free-standing LOAEL of 262 mg/kg-day based hemolytic anemia) with the RfD (chronic oral rat study based on decrease in mean terminal body weight) to determine whether the RfD is protective of hemolytic anemia in humans is not possible since adequate dose-response data in a subchronic or chronic dog study are lacking. Therefore, because of the absence of an appropriate animal model one cannot extrapolate either qualitatively or quantitatively to humans with respects to hemolytic anemia.

For more detail on Characterization of Hazard and Dose Response, exit to the toxicological review, Section 6 (PDF).

I.A.6. EPA Documentation and Review of the Oral RfD

Source Document — U.S. EPA, 1998

This assessment was peer reviewed by external scientists. Their comments have been evaluated carefully and incorporated in finalization of this IRIS Summary. A record of these comments is included in an appendix to the Toxicological Review of Naphthalene in support of Summary Information on the Integrated Risk Information System (IRIS) (U.S. EPA, 1998). ***To review this appendix, exit to the toxicological review, Appendix A, Summary of and Response to External Peer Review Comments (PDF).***

Other EPA Documentation — U.S. EPA, 1980, 1986, 1987a, 1988

Agency Consensus Date - 07/01/98

I.A.7. EPA Contacts (Oral RfD)

Please contact the IRIS Hotline for all questions concerning this assessment or IRIS, in general, at (202)566-1676 (phone), (202)566-1749 (fax), or [redacted] Internet address).

I.B. Reference Concentration for Chronic Inhalation Exposure (RfC)

Naphthalene
CASRN — 91-20-3
Last Revised — 09/17/1998

The inhalation Reference Concentration (RfC) is analogous to the oral RfD and is likewise based on the assumption that thresholds exist for certain toxic effects such as cellular necrosis. The inhalation RfC considers toxic effects for both the respiratory system (portal-of-entry) and for effects peripheral to the respiratory system (extrarespiratory effects). It is generally expressed in units of mg/m^3. In general, the RfC is an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily inhalation exposure of the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime. Inhalation RfCs were derived according to the Interim Methods for Development of Inhalation Reference Doses (EPA/600/8-88/066F, August 1989), and subsequently according to Methods for Derivation of Inhalation Reference Concentrations and Application of Inhalation Dosimetry (EPA/600/8-90/066F, October 1994). RfCs can also be derived for the noncarcinogenic health effects of substances that are carcinogens. Therefore, it is essential to refer to other sources of information concerning the carcinogenicity of this substance. If the U.S. EPA has evaluated this substance for potential human carcinogenicity, a summary of that evaluation will be contained in Section II of this file.

I.B.1. Inhalation RfC Summary

Critical Effect	Experimental Doses*	UF	MF	RfC
Nasal effects: hyperplasia and metaplasia in respiratory and olfactory epithelium, respectively **Chronic mouse inhalation study** **NTP, 1992a**	NOAEL: None LOAEL(HEC): 9.3 mg/m^3	3000	1	3E-3 mg/m^3

*Conversion Factors and Assumptions — Following the Category 3 guidance (U.S. EPA, 1994), experimental exposure concentrations of 0, 10, and 30 ppm were converted to 0, 52, and 157 mg/m^3, respectively; adjusted to a continuous exposure basis in mg/m^3 (6/24 hr x 5/7 days) equals mg/m^3 x 0.1786: 0, 9.3, and 28 mg/m^3. Because the blood:gas (air) coefficients for naphthalene were not available, the default ratio of 1 was used and the values for the LOAEL(HEC) were 0, 9.3, and 28 mg/m^3. Scenario -- The LOAEL human equivalent concentration (HEC) was calculated for an extrarespiratory effect for a category 3 gas. Since the b:a lambda for humans (h) is unknown, a default value of 1.0 is used for this ratio. LOAEL(HEC) x [b:a lambda(animal)/b:a lambda(human)] = 9.3 mg/m^3.

I.B.2. Principal and Supporting Studies (Inhalation RfC)

National Toxicology Program (NTP). (1992a) Toxicology and carcinogenesis studies of naphthalene in B6C3F1 mice (inhalation studies). Technical Report Series No. 410. NIH Publication No. 92-3141.

B6C3F1 mice (75/sex/group) were exposed to naphthalene (scintillation grade, > 99% pure) at target concentrations of 0, 10, and 30 ppm (0, 52, 157 mg/m^3) for 6 hr/day, 5 days/week, for 103 weeks (NTP, 1992a). The duration-adjusted levels were 0, 9.3, and 28 mg/m^3, respectively. Additional groups of 75 male and 75 female replacement animals were exposed to 30 ppm to ensure that a sufficient number of mice lived to study termination. Naphthalene vapor was generated by direct sublimation and monitored by a software feedback arrangement. Average weekly concentrations were within 20% of target concentrations, except one week when the mean concentration in the low-concentration chamber was 5.5 ppm. Supplemental hematology studies were scheduled with 25 animals/sex/group, but only the first sacrifice (at 14 days) was conducted because of high mortality in the male control group from fighting. Serial slit-lamp biomicroscopy and indirect ophthalmoscopic examinations were conducted on 5 animals/sex/group at 6-mo intervals. Gross necropsies were conducted on all animals. Complete histopathologic examinations of major tissues were conducted on all animals, except that the only tissues examined from low-concentration animals dying or killed after 21 mo of exposure were the lungs and nasal cavities.

Survival of the male controls was significantly lower than in the exposed males. Reduced survival was related to wound trauma and lesions from increased fighting in this group. Similar effects were not seen in the exposed males, because they tended to huddle in cage corners during exposure periods and so fought less. There was no significant difference in survival between the treatment and control females. There were no treatment-related ocular lesions in the selected mice that underwent ophthalmologic examinations at 6-mo intervals. There were no biologically significant changes in hematology parameters at day 14 of the

study. Final mean body weights of the treated animals were within 10% of the corresponding controls.

Inflammation, metaplasia of the olfactory epithelium, and hyperplasia of the respiratory epithelium were noted in the noses of virtually all exposed mice of both sexes, but in only one control female mouse. These effects were slightly more severe in the high-concentration group. See Table 1 for incidence data. The lesions were focal or multifocal, occurred mainly in the posterior nasal cavity, and were minimal to mild in severity. Inflammatory lesions included substantia propria edema, congestion, mixed inflammatory cell infiltrates, necrotic debris, and intraluminal serous to fibrinopurulent exudate. Respiratory epithelial hyperplasia resulted in a thickened, folded, irregular mucosal surface. Olfactory epithelial metaplasia often involved ciliated columnar or pseudocolumnar respiratory-like epithelial cells replacing the usual olfactory cell layer. The lesions were collectively considered features of a generalized inflammatory and regenerative process.

Table 1. Incidence of nonneoplastic respiratory lesions in B6C3F1 mice exposed by inhalation to naphthalene, 6 hr/day, 5 days/week for 2 years

Exposure level/sex (ppm)	Respiratory lesion		
	Inflammation, lung	Hyperplasia, nasal respiratory epithelium	Metaplasia, nasal olfactory epithelium
0/male	0/70	0/70	0/70
0/female	3/69	0/69	0/69
10/male	21/69	66/69	66/69
10/female	13/65	65/65	65/65
30/male	56/135	134/135	134/135
30/female	52/135	135/135	135/135

Source: NTP, 1992a.

Minimal to mild lung lesions, including infiltration of histiocytes or lymphocytes, inflammation, hyperplasia of the alveolar epithelium, and bronchial submucosal gland distension, were observed in both controls and treated mice. The incidence and severity were generally higher in the treated groups of both sexes, but there was no clear concentration-response relationship.

Females in the high-exposure group had elevated incidences of alveolar/bronchiolar adenomas and carcinomas (combined incidence 22%, compared with 7% in the control group and 3% in the low-exposure group). The incidence was also above that of historical controls and was considered compound-related. The incidences of alveolar/bronchiolar adenomas and carcinomas in treated males were marginally increased (10%, 25%, and 23%, in the control, low-concentration, and high-concentration groups, respectively). However, because the increase was not statistically significant and was within the range of historical controls, it was not considered exposure related. Instead, it was attributed to the longer life span of the treated animals. Nasal adenomas occurred in the anterior nasal cavities of two females in the low-concentration group. They were not considered compound related because the increase was not concentration related or statistically significant. Therefore, the nasal lesions discussed above should not be considered preneoplastic.

Calculation of the Human Equivalent Concentration (HEC)

Dose conversion: Because of its low water solubility and low reactivity, naphthalene-related effects on the nasal epithelium are expected to result following absorption of naphthalene and metabolism to reactive oxygenated metabolites, rather than being a result of direct contact. This hypothesis is supported by data on naphthalene metabolism indicating that toxic effects on the respiratory tract are due to a naphthalene metabolite that may be formed either in the liver or in the respiratory tract. For example, necrosis of bronchial epithelial (Clara) cells in mice (O'Brien et al., 1985, 1989; Tong et al., 1981) and necrosis of olfactory epithelium in mice, rats, and hamsters (Plopper et al., 1992) occur following intraperitoneal injection of naphthalene. The nasal effects from inhalation exposure to naphthalene were considered to be extra-respiratory effects of a category 3 gas, as defined in the U.S. EPA guidance for deriving RfCs (U.S. EPA, 1994). Following this guidance, experimental exposure concentrations were adjusted to a mg/m^3 basis (0, 52, and 157 mg/m^3), adjusted to a continuous exposure basis (mg/m^3 x 6h/24h x 5d/7d = mg/m^3 x 0.1786: 0, 9.3, and 28 mg/m^3), and converted to human equivalent concentrations (HECs) by multiplying the adjusted concentrations by the ratio of mouse:human blood/gas partition coefficients. Because the blood/gas coefficients for naphthalene were not available, the default ratio of 1 was used.

Dose-response modeling: Whereas the data from the NTP (1992a) study show nasal effects to be the most sensitive effects from chronic inhalation exposure to naphthalene, they provide no indication of the shape of the dose-response curve because the incidence of nasal lesions at the lowest exposure level was 100% in females and nearly 100% in males (see Table 1). In this case, application of a BMD approach, in which quantal mathematical models are fit to the incidence data for nasal effects, does not sensibly assist in extrapolating to a NOAEL, and a NOAEL/LOAEL approach was taken for deriving an RfC for naphthalene.

I.B.3. Uncertainty and Modifying Factors (Inhalation RfC)

UF = 3000.

The adjusted LOAEL(HEC) of 9.3 mg/m^3 for nasal effects (hyperplasia in respiratory epithelium and metaplasia in olfactory epithelium) was divided by an uncertainty factor of 3000 (10 to extrapolate from mice to humans, 10 to protect sensitive humans, 10 to extrapolate from a LOAEL to a NOAEL, and 3 for database deficiencies including the lack of a 2-generation reproductive toxicity study and chronic inhalation data for other animal species) to arrive at a chronic RfC for naphthalene of 3E-3 mg/m^3.

MF = 1.

I.B.4. Additional Studies/Comments (Inhalation RfC)

SUPPORTING STUDIES

Human experience with acute accidental exposures to naphthalene identifies the development of hemolytic anemia and cataracts as health Hazards of concern. However, information is not available regarding dose-response relationships for these effects in humans with acute, subchronic, or chronic exposure by any route. Animal inhalation studies are restricted to three studies of mice: a 2-year study (NTP, 1992), a 6-mo study (Adkins et al., 1986), and a 4-hr study (Buckpitt, 1982). Results from the chronic study, supported by the subchronic and acute studies, identify nasal and pulmonary injuries as critical effects from chronic inhalation exposure to naphthalene; effects in other organs or tissues were not found. Incidence data for male and female mice with hyperplasia of the nasal respiratory epithelium, metaplasia of the nasal olfactory epithelium, and chronic pulmonary inflammation clearly show that the nose is more sensitive than the lung to chronic inhalation exposure to naphthalene. At both exposure levels (10 and 30 ppm, 6 hr/day, 5 days/week), > 95% of mice of either sex showed nasal lesions, whereas pulmonary lesions were found in < 1/3 and < 1/2 of mice exposed at 10 and 30 ppm, respectively (Table 1). Nasal lesions in the respiratory and olfactory epithelium in mice found in the NTP (1992a) study were therefore selected as the critical effects for the purpose of RfC derivation.

Adkins et al. (1986) exposed female A/J mice (30/group) to 0, 10, or 30 ppm (0, 52, or 157 mg/m^3) naphthalene for 6 hr/day, 5 days/week for 6 mo, and counted the number of adenomas in each lung. The duration-adjusted concentrations were 0, 9.2, and 28 mg/m^3, respectively. Exposure to naphthalene caused increases in the total number of adenomas and the percentage of animals with adenomas, but the differences were not significant. The number of tumors per tumor-bearing mouse lung was significantly increased at both exposure levels.

Buckpitt (1982) subjected groups of five male mice (Swiss Webster) plus control group to 1-hr exposures to naphthalene concentrations of 0, 52.4, 95.8, 204, or 380 mg/m^3. Adverse effects were seen only at the highest concentration, and included swelling of cells and sloughing into the airway lumen of cells from either the major and/or terminal airways. The effects were milder in the presence of cytochrome P450 inhibitor and stronger in the presence of a glutathione depletor, suggesting that cytotoxicity is due to a naphthalene metabolite produced by P450 and that glutathione plays a protective role. Naphthalene reduced glutathione levels in the lung, liver, and kidney, but the concentration-response curve was flat.

Following a single 4-hr exposure of five male and five female Wistar Albino rats to 77.7 ppm (407 mg/m^3), closed eyes, lacrimation, and mouth breathing were observed (Bushy Run Research Center, 1986). No signs of toxicity were observed postexposure or during the 14-day observation period, and gross necropsy revealed no exposure-related lesions.

For more detail on Susceptible Populations, exit to the toxicological review, Section 4.7 (PDF).

I.B.5. Confidence in the Inhalation RfC

Study — Medium
Database — Low to Medium
RfC -- Low to Medium

The principal study was given medium confidence because adequate numbers of animals were used, and the severity of nasal effects increased at the higher exposure concentration. However, the study produced high mortality, (< 40% survival in the male control group due to wound trauma and secondary lesions resulting from increased fighting). Also, hematological evaluation was not conducted beyond 14 days. The database was given a low-to-medium confidence rating because there are no chronic or subchronic inhalation studies in other animal species, and there are no reproductive or developmental studies for inhalation exposure. In the absence of human or primate toxicity data, the assumption is made that nasal responses in mice to inhaled naphthalene are relevant to humans; however, it cannot be said with certainty that this RfC for naphthalene based on nasal effects will be protective for hemolytic anemia and cataracts, the more well-known human effects from naphthalene exposure. Medium confidence in the RfC follows.

For more detail on Characterization of Hazard and Dose Response, exit to the toxicological review, Section 6 (PDF).

I.B.6. EPA Documentation and Review of the Inhalation RfC

Source Document — U.S. EPA, 1998

This assessment was peer reviewed by external scientists. Their comments have been evaluated carefully and incorporated in finalization of this IRIS Summary. A record of these comments is included in an appendix to the Toxicological Review of Naphthalene in support of Summary Information on the Integrated Risk Information System (IRIS) (U.S. EPA, 1998). ***To review this appendix, exit to the toxicological review, Appendix A, Summary of and Response to External Peer Review Comments (PDF).***

Other EPA Documentation — U.S. EPA, 1980, 1986, 1987a, 1988

Agency Consensus Date - 7/1/98

I.B.7. EPA Contacts (Inhalation RfC)

Please contact the IRIS Hotline for all questions concerning this assessment or IRIS, in general, at (202)566-1676 (phone), (202)566-1749 (fax), or [redacted] (Internet address).

II. Carcinogenicity Assessment for Lifetime Exposure

Naphthalene
CASRN — 91-20-3
Last Revised — 09/17/1998

Section II provides information on three aspects of the carcinogenic assessment for the substance in question, the weight-of-evidence judgment of the likelihood that the substance is a human carcinogen, and quantitative estimates of risk from oral exposure and from inhalation exposure. The quantitative risk estimates are presented in three ways. The slope factor is the result of application of a low-dose extrapolation procedure and is presented as the risk per (mg/kg)/day. The unit risk is the quantitative estimate in terms of either risk per µg/L drinking water or risk per µg/m^3 air breathed. The third form in which risk is presented is a concentration of the chemical in drinking water or air associated with cancer risks of 1 in 10,000, 1 in 100,000, or 1 in 1,000,000. The rationale and methods used to develop the

carcinogenicity information in IRIS are described in the Risk Assessment Guidelines of 1986 (EPA/600/8-87/045) and in the IRIS Background Document. IRIS summaries developed since the publication of EPA's more recent Proposed Guidelines for Carcinogen Risk Assessment (U.S. EPA, 1996) also utilize those Guidelines where indicated. Users are referred to Section I of this IRIS file for information on long-term effects other than carcinogenicity.

II.A. Evidence for Human Carcinogenicity

II.A.1. Weight-of-Evidence Characterization

Using criteria of the 1986 Guidelines for Carcinogen Risk Assessment, naphthalene is classified in Group C, a possible human carcinogen. This is based on the inadequate data of carcinogenicity in humans exposed to naphthalene via the oral and inhalation routes, and the limited evidence of carcinogenicity in animals via the inhalation route.

Using the 1996 Proposed Guidelines for Carcinogen Risk Assessment, the human carcinogenic potential of naphthalene via the oral or inhalation routes "cannot be determined" at this time based on human and animal data; however, there is suggestive evidence (observations of benign respiratory tumors and one carcinoma in female mice only exposed to naphthalene by inhalation [NTP, 1992a]). Additional support includes increase in respiratory tumors associated with exposure to 1-methylnaphthalene.

At the present time the mechanism whereby naphthalene produces benign respiratory tract tumors are not fully understood, but are hypothesized to involve oxygenated reactive metabolites produced via the cytochrome P-450 monooxygenase system. However, based on the many negative results obtained in genotoxicity tests, a genotoxic mechanism appears unlikely.

For more detail on Characterization of Hazard and Dose Response, exit to the toxicological review, Section 6 (PDF).

For more detail on Susceptible Populations, exit to the toxicological review, Section 4.7 (PDF).

II.A.2. Human Carcinogenicity Data

Available data are inadequate to establish a causal association between exposure to naphthalene and cancer in humans. Adequately scaled epidemiological studies designed to examine a possible association between naphthalene exposure and cancer were not located.

Overall, no data are available to evaluate the carcinogenic potential in exposed human populations.

II.A.3. Animal Carcinogenicity Data

Inhalation: In an NTP (1992a) cancer bioassay, groups of male and female B6C3F1 mice were exposed (whole-body) to naphthalene (> 99% pure) vapors at concentrations of 0 (75 mice/sex), 10 (75 mice/sex), or 30 ppm (150 mice/sex) 6 hr/day, 5 days/week for 2 years. Mice were housed five to a cage. There were 150 mice housed in each of 4 inhalation chambers; 2 chambers were used for the high-exposure level. A comprehensive histological examination was performed on all control and high-dose mice and on low-dose mice that died or were sacrificed before 21 months of exposure. After 21 months of exposure, only the nasal cavity and lung were examined in the low-dose group. In each chamber, 50 animals per sex were designated for the 2-year studies; 5 animals per sex were designated for hematological evaluations at 14 days and 3, 6, 12, and 18 mo. However, because of high mortality in the male control group (see next paragraph), only the 14-day hematological evaluation was conducted. The other surviving interim mice were incorporated into the 2-year study.

Statistically significant decreases in survival were observed in the control male mice compared with the exposed groups. Exposed male mice were observed to huddle in corners of the cages during exposure and were less inclined to fight. Survival percentages at the end of the study were 37% (26/70), 75% (52/69), and 89% (118/133) for the 0, 10, and 30 ppm male groups, respectively. Survival percentages did not include mice sacrificed at 14 days, mice that died before the study began, mice that were accidentally killed, or mice that were lost during the study. Survival at 2 years in the control female mice (86%; 59/69) was comparable to survival in the exposed groups; survival percentages were 88% (57/65) and 76% (102/135) for low- and high-dose females. Body weights were not affected by exposure in either sex.

Statistically significant increases in incidences of nonneoplastic lesions were found in the lung and nose of males and females at both exposure levels. Observed nonneoplastic effects included the following (with respective incidences listed in the order of control, low-, and high-exposure groups): chronic inflammation of the lung (0/70, 21/69, and 56/135 for males; 3/69, 13/65, and 52/135 for females); chronic inflammation (0/70, 67/69, and 133/135 for males and 1/69, 65/65, and 135/135 for females); metaplasia of the olfactory epithelium (0/70, 66/69, and 134/135 for males; 0/69, 65/65, and 135/135 for females); and hyperplasia of the respiratory epithelium in the nose (0/70, 66/69, and 134/135 for males; 0/69, 65/65, and 135/135 for females).

The lung inflammation in the exposed mice was described as consisting of "focal intra-alveolar mixed inflammatory cell exudates and interstitial fibrosis" that in more advanced

lesions consisted "primarily of large foamy macrophages, sometimes accompanied by multinucleated giant cells." Foci of alveolar epithelial hyperplasia were noted to occur generally in regions distant to inflammation.

A statistically significant increase in the incidence of alveolar/bronchiolar adenomas was observed in the 30 ppm group of females (28/135), but not in the 10 ppm group (2/65), relative to the control female group (5/69). Among females, an additional mouse in the 30-ppm group displayed an alveolar/bronchiolar carcinoma. The historical combined incidence of alveolar/bronchiolar adenomas and carcinomas in control B6C3F1 female mice from NTP inhalation studies was cited as 39/466 (8.4%, range 0-12%). The authors commented that alveolar/bronchiolar adenomas and carcinomas constitute a morphologic continuum. The incidences of male mice with alveolar/bronchiolar adenomas were 7/70, 15/69, and 27/135 for the control, 10 ppm, and 30 ppm groups, respectively; for combined adenomas and carcinomas of the alveolar/bronchiolar region, the respective incidences were 7/70, 17/69, and 31/135. A statistical analysis that adjusted for intercurrent mortality (logistics regression analysis) determined that the tumor incidences for control and exposed groups of male mice were not significantly different (NTP, 1992a). Historical incidence for combined alveolar/bronchiolar adenomas and carcinomas in control male B6C3F1 mice from NTP inhalation studies was cited as 94/478 (19.7%, range 10%-30%). The adenomas were described as "locally compressive nodular masses consisting of cords of well-differentiated epithelial cells," whereas the carcinoma was "composed of ribbons and/or coalescing sheets of smaller, more anaplastic, cells which sometimes extended into adjacent parenchyma."

Hemangiosarcomas occurred at various sites within the vascular endothelium in five high-dose female mice (5/135), but not within the other groups of female mice (0/69 and 0/65 for control and 10 ppm females, respectively). The high-dose female incidence (3.7%) was not significantly different from the concurrent control incidence and was within the range of historical control incidences from NTP inhalation studies (range: 0-8%; overall incidence: 17/467 or 3.6%). No significantly elevated incidences of tumors were found at other tissue sites in exposed male or female mice (NTP, 1992a).

Adkins et al. (1986) exposed groups of 30 female A/J strain mice (6 to 8 weeks old) to 0, 10, or 30 ppm naphthalene (98%-99% pure) vapors, 6 hr/day, 5 days/week for 6 mo. After the 6-mo exposure period, excised lungs were examined for tumors. Tumors were examined histologically. The authors did not describe any noncancer histopathological effects that their examinations may have revealed. Survival was not different between the exposed and control groups. Lung tumors were found in all 20 positive control mice given single intraperitoneal injections of 1 g urethane/kg; the mean number of tumors per mouse in the positive control was 28.9. Increased numbers of lung tumors were found in the naphthalene-exposed groups compared with the control group, but the differences were not statistically significant (6, 10,

and 11 for the 0, 10, and 30 ppm groups). Tumors were described as alveolar adenomas consisting of "large cuboidal or columnar pithelial cells supported by a sparse fibroblastic stroma and arranged in poorly defined acinar structures with papillary formations." No carcinomas were found. Naphthalene exposure did not significantly increase the percentage of animals with tumors (21%, 29%, and 30% for 0, 10, and 30 ppm mice, respectively). Statistically significant increases in the number of adenomas per tumor-bearing lung were observed in the exposed mice, but there was no increase in response with increasing dose. Mean numbers of tumors per tumor-bearing lung (sd noted in parentheses) were: 1.00 (0.00), 1.25 (0.07), and 1.25 (0.07) for 0, 10, and 30 ppm mice, respectively. Applicability of this study to the assessment of risk for lifetime exposure is limited due to the less-than-lifetime exposure and observation periods, and the limited tissue evaluation examining only the lung. Nevertheless, the finding that only 6 months of exposure caused statistically significant increased numbers of lung tumors per tumor-bearing lung in the exposed groups, coupled with the results of the NTP (1992a) mouse bioassay, provides further suggestive evidence that naphthalene produces a tumorigenic response in the mouse lung.

Oral: Schmahl (1955) reported that naphthalene administered in food did not cause cancer in a group of 28 rats (in-house strains BDI and BDII). Naphthalene (purchased from Merck Co. and described as "Naphthalene puriss. cryst. alcoh. depur. [54935]") was dissolved in oil and given 6 times/week in food. The absorption spectrum of the test material displayed no atypical peaks compared with published data for naphthalene, suggesting high purity. The daily dose was reported to vary between 10 and 20 mg, but further details regarding dose variation were not provided. After reaching a total dose of 10 g/rat (food intake and body weights were not reported), treatment was stopped on the 700th experimental day, and animals were observed until spontaneous death, between 700 and 800 days of age. Assuming an average daily dose of 15 mg/rat and a body weight of 0.36 kg (U.S. EPA, 1987b, reference body weight for male Fischer 344 rats), an estimated average daily dose of 42 mg/kg is calculated. Autopsies were performed on dead animals, and organs that appeared unusual were examined histologically (the report did not specify which organs were histologically examined). The number of rats in the control group was not reported; survival for control and exposed rats was reported to be similar. Reported results from the autopsy and histological examinations were restricted to the statement that no toxic effects were seen, including eye damage and tumors. Inadequacies in experimental design (e.g., only one dose level was administered, the histopathological examination was not complete, hematological endpoints were not evaluated, and some rats lived as long as 300 days beyond exposure before being examined) and inadequacies in reporting of experimental details and results limit the conclusions that can be drawn from this study regarding either the carcinogenicity or noncarcinogenic toxicity of naphthalene. This study is considered inadequate as a cancer bioassay because of reporting and design inadequacies and the likelihood that the maximum tolerated dose may not have been approached.

Other Routes of Administration: Schmähl (1955) reported that naphthalene repeatedly administered by subcutaneous or intraperitoneal injection did not produce tumors in rats (in-house strains BDI and BDIII). Groups of 10 rats were given either subcutaneous or intraperitoneal weekly injections of naphthalene in oil (20 mg/rat per injection) starting at 100 days of age and continuing for 40 weeks (the total doses were 820 mg/rat). Rats were maintained until spontaneous death occurred. Life spans were reported to be 700 or 900 days for rats with subcutaneous or intraperitoneal doses, respectively. Autopsies were performed on dead animals, and organs which appeared unusual were examined histologically (the report did not specify which organs were examined, if any). The author reported that no toxic effects were found with parenteral administration of naphthalene. No tumors developed in either group. Reported information on control rats was restricted to the statement that lifespan for exposed rats was similar to lifespan for control rats (700 days with subcutaneous doses and 900 days with intraperitoneal doses).

Boyland et al. (1964) implanted naphthalene into the bladder of stock Chester Beatty mice and examined them after 30 weeks in an effort to determine the suitability of naphthalene as a potential vehicle for carcinogenicity testing. The original number of mice implanted with naphthalene was not reported, but 23 mice were reported to have survived 30 weeks. One mouse developed a bladder carcinoma (1/23; 4%); no adenomas or papillomas were found. Tumor incidence was as low as when paraffin wax was used (2-4%), and lower than with the implantation of cholesterol (12%). There are limitations of this study that make it an inadequate lifetime cancer bioassay including the short exposure and observation periods, and the lack of untreated controls.

Coal tar-derived naphthalene that contained approximately 10% unidentified impurities was tested for carcinogenicity by Knake (1956). White rats (40, sex unspecified) were given seven subcutaneous injections of 0 or 500 mg/kg naphthalene in sesame oil at 2-week intervals over an approximate 3.5-month period. Thirty-four of 38 naphthalene rats and 32/38 control rats survived the injection period. Survival was somewhat reduced in the naphthalene-exposed rats compared with the vehicle-control rats during the following 18-month period. Survival incidences at 6, 11, and 17 months after the injection period were 21/34, 6/34, and 0/34 for the naphthalene-exposed rats and 17/32, 12/32, and 4/32 for the control rats. Lymphosarcomas were found in 5/34 (14.7%) exposed rats during the 18-month observation period; one exposed rat showed a mammary fibrosarcoma. Vehicle controls showed a 6% (2/32) incidence of tumors (one with lymphosarcoma and one with mammary fibrosarcoma). Mice (25, inbred black) were painted with 0.5% naphthalene in benzene 5 days/week for life; 21 control mice were painted with benzene alone. Four treated mice developed lymphomatic leukemia, three had lung adenomas, one had lymphosarcoma, and one had a non-specified tumor (9/25 with tumors). In the benzene controls, one had lymphosarcoma, one had lung adenoma, and one had a non-specified tumor (3/21 with tumors). These studies are limited for the assessment of

carcinogenicity due to the presence of unknown impurities that may have carcinogenic properties. Moreover, the vehicle (benzene) in the mouse study has been shown to cause leukemia in humans and rodents, and the site of injection in the rat study was painted, prior to injection, with carbolfuchsin, a known carcinogen.

La Voie et al. (1988) gave intraperitoneal naphthalene doses (in dimethylsulfoxide) of 0.25, 0.50, and 1.0 µmole to male and female newborn CD-1 mice on days 1, 8, and 15 of life (total dose = 1.75 µmole naphthalene). The report did not specify the purity of the naphthalene tested. Forty-nine pups were treated with naphthalene and 46 control pups were treated with dimethylsulfoxide alone. Mice were maintained (10 mice/cage) until moribund or until 52 weeks when survivors were killed. All gross lesions as well as liver sections from all mice were examined histologically. No statistically significant increased incidence of liver tumors (adenomas or hepatomas) was found in the exposed mice. Reported incidences for the number of mice with liver tumors were (denominators are for the number of mice that lived at least 6 months): 0/16 and 2/31 for exposed females and males, and 0/21 and 4/21 for vehicle-control females and males. This assay is inadequate to assess the carcinogenicity of lifetime exposure to naphthalene because the exposure period (2 weeks) and observation period (52 weeks) were significantly less than the lifetime for mice (approximately 2 years), and complete histological examinations were not conducted.

II.A.4. Supporting Data for Carcinogenicity

The genotoxic potential of naphthalene has been evaluated in many test systems. Most studies provided negative results. Naphthalene was not mutagenic in *Salmonella typhimurium* assays in the presence or absence of liver metabolic preparations (Bos et al., 1988; Connor et al., 1985; Florin et al., 1980; Godek et al., 1985; McCann et al., 1975; Nakamura et al., 1987; Narbonne et al., 1987; NTP, 1992a; Sakai et al., 1985). Naphthalene did not damage DNA (as assayed by the induction of the SOS-repair system) in *E. coli* PQ37 (Mersch-Sundermann et al., 1993).

NTP (1992a) found that naphthalene induced, in cultured Chinese hamster ovary cells, sister chromatid exchanges within a concentration range of 27 to 90 µg/mL in the presence or absence of metabolic activation, and chromosomal aberrations within a range of 30 to 67.5 µg/mL only in the presence of metabolic activation.

Naphthalene was mutagenic in the marine bacterium *Vibrio fischeri* (Arfsten et al., 1994) and in the *Drosophila melanogaster* wing somatic mutation and recombination test (Delgado-Rodriguez et al., 1995). Culture of mouse embryos in medium containing 0.16 mM naphthalene produced a 10-fold increase in chromosomal damage compared to untreated

controls; the genotoxic response to naphthalene was amplified by the inclusion of a hepatic metabolic activation system in the medium (Gollahon et al., 1990).

Incubation of human peripheral lymphocytes in medium containing naphthalene and a human liver metabolic activation system did not produce increased frequency of sister chromatid exchanges compared with controls (Tingle et al., 1993; Wilson et al., 1995). Naphthalene did not induce unscheduled DNA synthesis in cultured rat hepatocytes (Barfknecht et al., 1985) or increased numbers of micronuclei in bone marrow cells of mice following intraperitoneal injection of single 250-mg/kg doses (Sorg et al., 1985). Single oral doses of naphthalene as high as 500 mg/kg did not increase the frequency of micronucleated erythrocytes in exposed mice compared with untreated control mice (Harper et al., 1984). Naphthalene did not induce in vitro transformations of Fischer rat embryo cells (Freeman et al., 1973) or Swiss mouse embryo cells (Rhim et al., 1974). Sina et al. (1983) reported that naphthalene did not induce single-strand DNA breaks in cultured rat hepatocytes as detected by alkaline dilution.

Naphthalene metabolites 1-naphthol and 2-naphthol were not mutagenic in *S. typhimurium*, with or without metabolic activation (Florin et al., 1980; McCann et al., 1975; Narbonne et al., 1987). Another proposed naphthalene metabolite, naphthoquinone, was not mutagenic in several strains of *S. typhimurium* with or without metabolic activation (Sakai et al., 1985), but Flowers-Geary et al. (1994) reported that naphthalene-1,2-dione was mutagenic in strains of *S. typhimurium* without metabolic activation. The naphthalene metabolite, 1-naphthol, failed to produce positive results in several other genotoxicity assays including tests for sex- linked recessive lethal mutations in *Drosophila melanogaster* (Gocke et al., 1981), mutations in mouse L5178Y cells (Amacher and Turner, 1982), unscheduled DNA synthesis in cultured rat hepatocytes (Probst and Hill, 1980), and induction of micronuclei in bone marrow cells of mice (Gocke et al., 1981) and rats (Hossack and Richardson, 1977) after acute in vivo exposure.

Tsuda et al. (1980) found no evidence for neoplastic transformation of liver cells in a group of 10 young adult F344 rats (sex not specified) treated with single gavage doses of 100 mg/kg naphthalene in corn oil compared with a group of 10 vehicle control rats. Rats were given gavage doses of naphthalene or vehicle following partial hepatectomy, but before dietary treatment with an anti-cell proliferation agent (2-acetylaminofluorene) and a necrotizing agent (carbon tetrachloride). Gamma-glutamyl transpeptidase foci (observed following the dietary treatments of exposed and control rats) were used as an indicator of neoplastic transformation. In contrast to naphthalene, a single gavage dose of 200 mg/kg benzo[a]pyrene induced significant increases in the number, area, and size of gamma-glutamyl transpeptidase foci.

II.B. Quantitative Estimate of Carcinogenic Risk from Oral Exposure

An oral slope factor for naphthalene was not derived because of a lack of chronic oral naphthalene studies.

II.C. Quantitative Estimate of Carcinogenic Risk from Inhalation Exposure

An inhalation unit risk estimate for naphthalene was not derived because of the weakness of the evidence (observations of predominant benign respiratory tumors in mice at high dose only) that naphthalene may be carcinogenic in humans.

II.D. EPA Documentation, Review, and Contacts (Carcinogenicity Assessment)

II.D.1. EPA Documentation

Source Document — U.S. EPA, 1998

This assessment was peer reviewed by external scientists. Their comments have been evaluated carefully and incorporated in finalization of this IRIS Summary. A record of these comments is included in an appendix to the Toxicological Review of Naphthalene in support of Summary Information on the Integrated Risk Information System (IRIS) (U.S. EPA, 1998). ***To review this appendix, exit to the toxicological review, Appendix A, Summary of and Response to External Peer Review Comments (PDF)***.

II.D.2. EPA Review (Carcinogenicity Assessment)

Agency Consensus Date - 07/01/1998

II.D.3. EPA Contacts (Carcinogenicity Assessment)

Please contact the IRIS Hotline for all questions concerning this assessment or IRIS, in general, at (202)566-1676 (phone), (202)566-1749 (fax), or [redacted] (Internet address).

III. [reserved]
IV. [reserved]
V. [reserved]

VI. Bibliography

Naphthalene
CASRN — 91-20-3

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VII. Revision History

Naphthalene
CASRN — 91-20-3
Last Revised — 09/17/1998

Date	Section	Description
12/01/1990	II.	Carcinogen assessment on-line
09/17/1998	I., II., VI.	Revised RfD, RfC, carcinogenicity assessments

VIII. Synonyms

Naphthalene
CASRN — 91-20-3
Last Revised — 12/01/1990

- 91-20-3
- Naphthalene
- Albocarbon
- Caswell No. 587
- Dezodorator
- EPA Pesticide Chemical Code 055801
- HSDB 184
- MOTH BALLS
- MOTH FLAKES
- Naftalen [Polish]
- Naftaleno [Spanish]
- Naphtalene [French]
- Naphthalene
- Naphthalin
- Naphthaline
- Naphthene

- NAPTHALENE, molten
- NCI-C52904
- NSC 37565
- RCRA WASTE NUMBER U165
- TAR CAMPHOR
- UN 1334
- UN 2304
- WHITE TAR

Phenanthrene; CASRN 85-01-8

Human health assessment information on a chemical substance is included in the IRIS database only after a comprehensive review of toxicity data, as outlined in the IRIS assessment development process. Sections I (Health Hazard Assessments for Noncarcinogenic Effects) and II (Carcinogenicity Assessment for Lifetime Exposure) present the conclusions that were reached during the assessment development process. Supporting information and explanations of the methods used to derive the values given in IRIS are provided in the guidance documents located on the IRIS website.

STATUS OF DATA FOR Phenanthrene

File First On-Line 12/01/1990

Category (section)	Assessment Available?	Last Revised
Oral RfD (I.A.)	not evaluated	
Inhalation RfC (I.B.)	not evaluated	
Carcinogenicity Assessment (II.)	yes	12/01/1990

I. Chronic Health Hazard Assessments for Noncarcinogenic Effects

I.A. Reference Dose for Chronic Oral Exposure (RfD)

Substance Name — Phenanthrene
CASRN — 85-01-8

Not available at this time.

I.B. Reference Concentration for Chronic Inhalation Exposure (RfC)

Substance Name — Phenanthrene
CASRN — 85-01-8

Not available at this time.

II. Carcinogenicity Assessment for Lifetime Exposure

Substance Name — Phenanthrene
CASRN — 85-01-8
Last Revised — 12/01/1990

Section II provides information on three aspects of the carcinogenic assessment for the substance in question; the weight-of-evidence judgment of the likelihood that the substance is a human carcinogen, and quantitative estimates of risk from oral exposure and from inhalation exposure. The quantitative risk estimates are presented in three ways. The slope factor is the result of application of a low-dose extrapolation procedure and is presented as the risk per (mg/kg)/day. The unit risk is the quantitative estimate in terms of either risk per ug/L drinking water or risk per ug/cu.m air breathed. The third form in which risk is presented is a drinking water or air concentration providing cancer risks of 1 in 10,000, 1 in 100,000 or 1 in 1,000,000. The rationale and methods used to develop the carcinogenicity information in IRIS are described in The Risk Assessment Guidelines of 1986 (EPA/600/8-87/045) and in the IRIS Background Document. IRIS summaries developed since the publication of EPA's more recent Proposed Guidelines for Carcinogen Risk Assessment also utilize those Guidelines where indicated (Federal Register 61(79):17960-18011, April 23, 1996). Users are referred to Section I of this IRIS file for information on long-term toxic effects other than carcinogenicity.

II.A. Evidence for Human Carcinogenicity

II.A.1. Weight-of-Evidence Characterization

Classification — D, not classifiable as to human carcinogenicity

Basis — Based on no human data and inadequate data from a single gavage study in rats and skin painting and injection studies in mice.

II.A.2. Human Carcinogenicity Data

None.

II.A.3. Animal Carcinogenicity Data

Inadequate. Data from a rat gavage study and mouse skin application and injection studies are not adequate to assess the carcinogenicity of phenanthrene. Ten female Sprague-Dawley rats received a single oral dose of 200 mg phenanthrene in sesame oil (Huggins and Yang, 1962). No mammary tumors occurred. The observation period was not specified; however, based on the discussion of other experiments in the report it was probably at least 60 days. Controls were not reported.

Complete carcinogenic activity was not shown in two skin painting assays. Kennaway (1924) reported no tumors in 100 mice (strain and sex not specified) treated with phenanthrene (purity not specified) in 90% benzene (dose not reported) for 9 months. Roe and Grant (1964) reported in an abstract that mice (number, sex and strain not specified) did not develop tumors after dermal exposure to 5% phenanthrene (purity not specified, vehicle not specified) 3 times/week for 1 year.

Five studies of cancer-initiating activity in skin painting assays in mice have yielded one positive result. Groups of 30 female CD-1 mice received a single dermal application of 1.8 mg phenanthrene in benzene, followed by twice-weekly applications of tetradecanoylphorbol acetate (TPA, 3 mg), a promoter, for 35 weeks (Scribner, 1973). Phenanthrene used in the study was purified by preparative thin-layer chromatography (TLC) and determined to be homogeneous on TLC. It is stated in the report that the dose of TPA was 3 mg (5 umol); however, it is not clear whether this refers to the twice weekly or total dose. Controls were treated with TPA (6 mg); it is not clear whether controls received benzene (vehicle). The tumor incidence (skin papilloma) at 35 weeks was 12/30 (40%) in treated mice and 0/30 in TPA controls.

Tumor-initiating activity was not shown in the four other mouse skin painting studies. In the first study, male Swiss albino (Ha/ICR) mice (15 to 20/group) received 10 applications of a 0.1% solution of phenanthrene in acetone (total dose 1 mg) or acetone alone, followed by repeated applications of TPA (2.5 ug in acetone) 3 times/week for 20 weeks (LaVoie et al., 1981). Phenanthrene was >99.5% pure as determined by high pressure liquid chromatography (HPLC). No tumors occurred in treated or control mice. Wood et al. (1979) exposed female CD-1 mice (30/group) to a single application of 1.8 mg phenanthrene in acetone:ammonium hydroxide (1000:1) or vehicle alone, followed by TPA (10 ug) twice weekly for 35 weeks. Phenanthrene used in this study was >98% pure and homogeneous on HPLC. Tumor incidence (skin papillomas) out of 27-29 survivors in each group was 17% in treated mice and 7% in vehicle controls (not statistically different). In another study, albino mice (10/sex/dose, strain not specified) received four dermal applications of phenanthrene (total dose 1.2 mg, purity not specified) in acetone or to acetone alone, followed by croton oil once each week for 20 weeks (Roe, 1962). Tumor incidence (skin papillomas) was 4/19 (21%) in treated mice and 2/20 (10%)

in vehicle controls. In the last study (Salaman and Roe, 1956), groups of 20 "S" strain mice (sex unspecified) received 10 dermal applications (3 times/week) of 18% phenanthrene (total dose 0.54 g, purity not specified) in acetone, followed by 18 weekly applications of croton oil. Controls were treated with 18 applications of croton oil; 10 controls survived until termination. The tumor incidence (skin papillomas) was 5/20 (25%) in treated mice and 4/10 (40%) in croton oil controls.

Parenterally administered phenanthrene was not shown to have tumorigenic activity in three studies. In the first (Buening et al., 1979), groups of Swiss Webster BLU:Ha ICR mice (100/group, approximately 50% of each sex) received intraperitoneal injections of phenanthrene (total dose 0.25 mg) in dimethyl sulfoxide (DMSO) or DMSO alone on days 1, 8, and 15 after birth. Phenanthrene was >98% pure and homogeneous on HPLC. Incidence of pulmonary tumors (adenomas) at 38 to 42 weeks was 1/18 (6%) and 5/17 (30%) in female and male treated mice and 7/38 (18%) and 2/10 (19%) in female and male controls; the apparent differences were not statistically significant. No hepatic tumors occurred in treated or control mice. One treated female mouse developed malignant lymphoma. In the second study (Grant and Roe, 1963), albino mice (sex, strain and group size not specified) received single subcutaneous injections of phenanthrene (40 ug, purity not specified) in an acetone/gelatin vehicle or only the vehicle. Incidence of pulmonary adenomas after 52-62 weeks was 3/39 (6%) in treated mice and 8/34 (24%) in vehicle controls. Other tumors reported were 4 hepatomas and 2 skin papillomas in treated mice, and 1 mammary adenocarcinoma, 1 hepatoma and 1 hemangioma in control mice. Finally in the Steiner (1955) study, groups of 40 to 50 male and female C57BL mice (numbers per sex not specified) received single subcutaneous injections of 5 mg phenanthrene (purity not specified) in tricaprylin. No tumors were reported in 27 surviving mice after 4 months. Vehicle controls were not reported.

II.A.4. Supporting Data for Carcinogenicity

Phenanthrene has not yielded positive results in assays for DNA damage in Bacillus subtilis and Escherichia coli (Rosenkrantz and Poirier, 1979; McCarroll et al., 1981). Tests for mutagenicity in Salmonella typhimurium have yielded positive (Oesch et al., 1981; Sakai et al., 1985; Bos et al., 1988) and negative results (Wood et al., 1979; McCann et al., 1975; LaVoie et al., 1981; Kaden et al., 1979; Bos et al., 1988). The results of phenanthrene in a fungi recombination assay (Simmon, 1979) and in tests for DNA damage in several mammalian cell cultures were not positive (Lake et al., 1978; Probst et al., 1981; Rice et al., 1984). A test for forward mutation in Chinese hamster ovary cells exposed to 1 ug/mL was not positive (Huberman and Sachs, 1976), whereas a test in human lymphoblast TK6 cells incubated with rat liver S9 (Arochlor) and 9 ug/mL phenanthrene yielded positive results (Barfknecht et al., 1981). Phenanthrene did not yield positive results in sister chromatid exchange and chromosome aberration assays in mammalian cell cultures (Popescu et al., 1977) or in cell transformation assays in several types

of mammalian cells (5-40 ug/mL) (Marquardt and Heidelberger, 1972; Kakunaga, 1973; Evans and DiPaolo, 1975; Pienta et al., 1977).

Current theories regarding the mechanisms of metabolic activation of polycyclic aromatic hydrocarbons lead to predictions of a carcinogenic potential for phenanthrene. Jerina et al. (1978) considered phenanthrene to have a "bay-region" structure. It is metabolized by mixed function oxidases to reactive diol epoxides (Nordqvist et al., 1981; Vyas et al., 1982) that have been shown to be weakly mutagenic in some bacterial and mammalian cell assays (Wood et al., 1979). Evidence from in vivo assays indicates, however, that phenanthrene metabolites have a relatively low tumorigenic potential. The 1,2-, 3,4- and 9,10-dihydrodiol metabolites of phenanthrene did not show tumor initiating activity in mouse skin painting assays (Wood et al., 1979). The 1,2-diol-3,4-epoxides of phenanthrene did not produce lung tumors when injected into newborn mice (Buening et al., 1979). The relatively weak mutagenic and tumorigenic activity of phenanthrene diol epoxides is inconsistent with the "bay region theory" of PAH carcinogenesis. The reason for the inconsistency has not been elucidated. Phenanthrene epoxides have a relatively small molecular size (relative to other more active PAH epoxides such as chrysene diol epoxides) and as a result may have a lower affinity for DNA or may be transported less efficiently into the mammalian nucleus (Wood et al., 1979). While some studies have considered phenanthrene to have a "bay- region" structure, it may not clearly fall into this category.

II.B. Quantitative Estimate of Carcinogenic Risk from Oral Exposure

None.

II.C. Quantitative Estimate of Carcinogenic Risk from Inhalation Exposure

None.

II.D. EPA Documentation, Review, and Contacts (Carcinogenicity Assessment)

The 1990 Drinking Water Criteria Document for Polycyclic Aromatic Hydrocarbons (PAHs) has received Agency and external review.

II.D.1. EPA Documentation

Source Document — U.S. EPA, 1990

The 1990 Drinking Water Criteria Document for Polycyclic Aromatic Hydrocarbons has received Agency and external review.

II.D.2. EPA Review (Carcinogenicity Assessment)

Agency Work Group Review — 02/07/1990, 05/03/1990

Verification Date — 05/03/1990

II.D.3. EPA Contacts (Carcinogenicity Assessment)

Please contact the IRIS Hotline for all questions concerning this assessment or IRIS, in general, at (202)566-1676 (phone), (202)566-1749 (FAX) or [redacted] (internet address).

III. [reserved]
IV. [reserved]
V. [reserved]

VI. Bibliography

Substance Name — Phenanthrene
CASRN — 85-01-8

VI.A. Oral RfD References

None

VI.B. Inhalation RfC References

None

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VII. Revision History

Substance Name — Phenanthrene
CASRN — 85-01-8

Date	Section	Description
12/01/1990	II.	Carcinogen assessment on-line

VIII. Synonyms

Substance Name — Phenanthrene
CASRN — 85-01-8
Last Revised — 12/01/1990

- 85-01-8
- Phenanthrene
- HSDB 2166
- NSC 26256
- Phenanthren [German]
- Phenanthrene

Fluoranthene; CASRN 206-44-0

Human health assessment information on a chemical substance is included in the IRIS database only after a comprehensive review of toxicity data, as outlined in the IRIS assessment development process. Sections I (Health Hazard Assessments for Noncarcinogenic Effects) and II (Carcinogenicity Assessment for Lifetime Exposure) present the conclusions that were reached during the assessment development process. Supporting information and explanations of the methods used to derive the values given in IRIS are provided in the guidance documents located on the IRIS website.

STATUS OF DATA FOR Fluoranthene

File First On-Line 09/01/1990

Category (section)	Assessment Available?	Last Revised
Oral RfD (I.A.)	yes	09/01/1990
Inhalation RfC (I.B.)	not evaluated	
Carcinogenicity Assessment (II.)	yes	12/01/1990

I. Chronic Health Hazard Assessments for Noncarcinogenic Effects

I.A. Reference Dose for Chronic Oral Exposure (RfD)

Substance Name — Fluoranthene
CASRN — 206-44-0
Last Revised — 09/01/1990

The oral Reference Dose (RfD) is based on the assumption that thresholds exist for certain toxic effects such as cellular necrosis. It is expressed in units of mg/kg-day. In general, the RfD is an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime. Please refer to the Background Document for an elaboration of these concepts. RfDs can also be derived for the noncarcinogenic health effects of substances that are also carcinogens. Therefore, it is essential to refer to other sources of

information concerning the carcinogenicity of this substance. If the U.S. EPA has evaluated this substance for potential human carcinogenicity, a summary of that evaluation will be contained in Section II of this file.

I.A.1. Oral RfD Summary

Critical Effect	Experimental Doses*	UF	MF	RfD
Nephropathy, increased liver weights, hematological alterations, and clinical effects **Mouse Subchronic Study** **U.S. EPA, 1988**	NOAEL: 125 mg/kg/day LOAEL: 250 mg/kg/day	3000	1	4E-2 mg/kg/day

*Conversion Factors: None

I.A.2. Principal and Supporting Studies (Oral RfD)

U.S. EPA. 1988. 13-Week mouse oral subchronic toxicity study. Prepared by Toxicity Research Laboratories, Ltd., Muskegon, MI for the Office of Solid Waste, Washington, DC.

Male and female CD-1 mice (20/sex/group) were gavaged for 13 weeks with 0, 125, 250, or 500 mg/kg/day fluoranthene. A fifth group of mice (30/sex) was established in the study for baseline blood evaluations. Body weight, food consumption, and hematological and serum parameter values were recorded at regular intervals during the experiment. At the end of 13 weeks, the animals were sacrificed and autopsied, which included organ weight measurement and histological evaluation. All treated mice exhibited nephropathy, increased salivation, and increased liver enzyme levels in a dose-dependent manner. However, these effects were either not significant, not dose-related, or not considered adverse at 125 mg/kg/day. Mice exposed to 500 mg/kg/day had increased food consumption and increased body weight. Mice exposed to 250 and 500 mg/kg/day had statistically increased SGPT values and increased absolute and relative liver weights. Compound-related microscopic liver lesions (indicated by pigmentation) were observed in 65 and 87.5% of the mid- and high-dose mice, respectively. Based on increased SGPT levels, kidney and liver pathology, and clinical and hematological changes, the LOAEL is considered to be 250 mg/kg/day, and the NOAEL is 125 mg/kg/day.

I.A.3. Uncertainty and Modifying Factors (Oral RfD)

UF — An uncertainty factor of 3000 reflects 10 for interspecies conversion, 10 for intraspecies variability, and 30 for use of a subchronic study for chronic RfD derivation, and for lack of supporting reproductive/developmental toxicity data and toxicity data in a second species.

MF — None

I.A.4. Additional Studies/Comments (Oral RfD)

A developmental study was performed in which fluoranthene was administered once via intraperitoneal injection to pregnant C57/B6 mice on gestational day 6, 7, 8 or 9 (Irvin and Martin, 1987). An increased rate of embryo resorption was observed. The data were reported in an abstract, but a complete report was not located. No inhalation studies were located.

IARC (1983) cites several acute studies in which fluoranthene was administered to mice or rats intraperitoneally. No adverse effects were observed; however, only survival or body weight was monitored. Gerarde (1960, cited by IARC, 1983) administered 500 mg/kg/day for 7 days to mice, and Haddow et al. (1937) administered a single 30 mg dose of fluoranthene to rats.

I.A.5. Confidence in the Oral RfD

Study — Medium
Database — Low
RfD — Low

Confidence in the principal study is medium, as it is a well-designed study that identified both a LOAEL and a NOAEL for several sensitive endpoints using an adequate number of animals. Confidence in the database is low; developmental, reproductive, or toxicity data in a second species following oral exposure to fluoranthene has not been adequately tested. Reflecting medium confidence in the principal study and low confidence in the database, confidence in the RfD is low.

I.A.6. EPA Documentation and Review of the Oral RfD

Source Document — This assessment is not presented in any existing U.S. EPA document.

Other EPA Documentation — U.S. EPA, 1988

Agency Work Group Review — 01/22/1986, 10/19/1989, 11/15/1989

Verification Date — 11/15/1989

I.A.7. EPA Contacts (Oral RfD)

Please contact the IRIS Hotline for all questions concerning this assessment or IRIS, in general, at (202)566-1676 (phone), (202)566-1749 (FAX) or [redacted] (internet address).

I.B. Reference Concentration for Chronic Inhalation Exposure (RfC)

Substance Name — Fluoranthene
CASRN — 206-44-0

Not available at this time.

II. Carcinogenicity Assessment for Lifetime Exposure

Substance Name — Fluoranthene
CASRN — 206-44-0
Last Revised — 12/01/1990

Section II provides information on three aspects of the carcinogenic assessment for the substance in question; the weight-of-evidence judgment of the likelihood that the substance is a human carcinogen, and quantitative estimates of risk from oral exposure and from inhalation exposure. The quantitative risk estimates are presented in three ways. The slope factor is the result of application of a low-dose extrapolation procedure and is presented as the risk per (mg/kg)/day. The unit risk is the quantitative estimate in terms of either risk per ug/L drinking water or risk per ug/cu.m air breathed. The third form in which risk is presented is a drinking water or air concentration providing cancer risks of 1 in 10,000, 1 in 100,000 or 1 in 1,000,000. The rationale and methods used to develop the carcinogenicity information in IRIS are described in The Risk Assessment Guidelines of 1986 (EPA/600/8-87/045) and in the IRIS Background Document. IRIS summaries developed since the publication of EPA's more recent Proposed Guidelines for Carcinogen Risk Assessment also utilize those Guidelines where indicated (Federal Register 61(79):17960-18011, April 23, 1996). Users are referred to Section I of this IRIS file for information on long-term toxic effects other than carcinogenicity.

II.A. Evidence for Human Carcinogenicity

II.A.1. Weight-of-Evidence Characterization

Classification — D; not classifiable as to human carcinogenicity

Basis — Based on no human data and inadequate data from animal bioassays.

II.A.2. Human Carcinogenicity Data

None.

II.A.3. Animal Carcinogenicity Data

Inadequate. Data from fluoranthene skin-painting bioassays was judged inadequate because no increases in tumor incidences were observed and the group sizes tested were small.

Fluoranthene has been tested as a complete carcinogen in mouse skin- painting assays at doses ranging approximately from 1.5 mg/mouse/week for 52 weeks to 100 mg/mouse/week for 82 weeks; the results of these studies have been consistently non-positive (Suntzeff et al., 1957; Wynder and Hoffmann, 1959; Hoffmann et al., 1972; Horton and Christian, 1974).

Suntzeff et al. (1957) administered a 10% solution of fluoranthene in acetone by topical application 3 times/week to unspecified numbers of CAF, Jackson, Swiss and Millerton mice. No tumors were found by 13 months. Wynder and Hoffmann (1959) administered a 0.1% solution of fluoranthene in acetone onto the backs of 20 female Swiss (Millerton) mice 3 times/week for life. No tumors were found. Hoffmann et al. (1972) administered 50 uL of a 1% fluoranthene solution to the backs of 20 female Swiss-albino Ha/ICR/Mill mice 3 times/week for 12 months. All treated mice survived and no tumors were observed. As part of the same study, 30 mice received 0.1 mg fluoranthene in 50 uL acetone every second day for a total of 10 doses. Promotion by dermal application of 2.5% croton oil in acetone was initiated 10 days later and continued for 20 weeks. A single papilloma was noted in 29 surviving mice. Horton and Christian (1974) administered 50 mg fluoranthene in decalin or in decalin:n-dodecane (50:50) to the backs of 15 male C3H mice. The mice were treated 2 times/week for 82 weeks. No skin tumors were observed.

II.A.4. Supporting Data for Carcinogenicity

In a short-term in vivo lung tumor assay by Busby et al. (1984), CD-1 mice (20-30/sex/dose) received intraperitoneal injections of dimethyl sulfoxide (DMSO) or fluoranthene in DMSO on days 1, 8, and 15 after birth; total doses were 0, 700 ug (163 mg/kg) or 3500 ug (815 mg/kg) fluoranthene. Animals were necropsied at 24 weeks of age. Visible lung tumors were tabulated at necropsy and examined histologically; all tissue masses and organs exhibiting abnormal growth were examined histologically. A statistically significant increase in the incidence of combined lung adenomas and adenocarcinomas occurred in the male-female combined high-dose group (28/48) when compared with vehicle controls (5/55). In the combined high-dose groups 80% of the lung tumors were adenomas and 20% adenocarcinomas; no adenocarcinomas occurred in the control groups. Lung tumor response in the combined low-dose groups (10/51) was not statistically different from controls. Lung tumor incidence was significantly elevated in high-dose males (20/27 vs. 1/27 controls) but not in low-dose males (7/31) or in high- or low-dose females (8/21 and 3/20, respectively, vs. 4/28 in the controls).

Fluoranthene produced positive results in mouse co-carcinogen skin- painting assays with benzo[a]pyrene. This combination of chemicals increased the formation of benzo[a]pyrene-DNA adducts (Van Duuren and Goldschmidt, 1976; Rice et al., 1988).

Barry et al. (1935) administered 300 mg fluoranthene in benzene by dermal application (number of applications not stated) to 20 mice (type unspecified). The survival rate was 35% after 6 months and 20% at 1 year. No tumors were found by 501 days. Shear (1938) administered four doses of 10 mg fluoranthene in glycerol by subcutaneous injection to strain A mice. Six out of 14 mice survived for 18 months; no tumors were found by 19 months. In a skin-painting assay fluoranthene (100 ug) was administered to 20 Swiss albino Ha/ICR mice, 3 times/week for 1 year; 3.3% of the mice in both this group and in a similar acetone-control group tumors were observed in 3.3% of the mice in both the treated and acetone-control groups (LaVoie et al., 1979).

Evidence for mutagenicity of fluoranthene is equivocal. The results of mutagenicity assays of fluoranthene in several strains of Salmonella typhimurium have been positive (Kaden et al., 1979; Kinae et al., 1981; LaVoie et al., 1982; Babson et al., 1986; Bos et al., 1988) and not positive (Tokiwa et al., 1977; Kinae et al., 1981; Bos et al., 1987). Evidence for mutagenicity in mammalian cells is also equivocal: results of tests for chromosomal effects in Chinese hamster cells have been both positive (Palitti et al., 1986) and not positive (DeSaliva et al., 1988). A test for gene mutations in human lymphoblast cells was not positive (Crespi and Thilly, 1984), whereas results of tests in different mutant Chinese hamster ovary cell lines have been both positive (Hoy et al., 1984; Li, 1984) and not positive (Hoy et al., 1984).

II.B. Quantitative Estimate of Carcinogenic Risk from Oral Exposure

None.

II.C. Quantitative Estimate of Carcinogenic Risk from Inhalation Exposure

None.

II.D. EPA Documentation, Review, and Contacts (Carcinogenicity Assessment)

II.D.1. EPA Documentation

Source Document — U.S. EPA, 1990

The 1990 Drinking Water Criteria Document for Polycyclic Aromatic Hydrocarbons has received Agency and external review.

II.D.2. EPA Review (Carcinogenicity Assessment)

Agency Work Group Review — 05/03/1990

Verification Date — 05/03/1990

II.D.3. EPA Contacts (Carcinogenicity Assessment)

Please contact the IRIS Hotline for all questions concerning this assessment or IRIS, in general, at (202)566-1676 (phone), (202)566-1749 (FAX) [redacted] address).

III. [reserved]
IV. [reserved]
V. [reserved]

VI. Bibliography

Substance Name — Fluoranthene
CASRN — 206-44-0

VI.A. Oral RfD References

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VI.B. Inhalation RfC References

None

VI.C. Carcinogenicity Assessment References

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VII. Revision History

Substance Name — Fluoranthene
CASRN — 206-44-0

Date	Section	Description
09/01/1990	I.A.	Oral RfD summary on-line
12/01/1990	II.	Carcinogen assessment on-line

VIII. Synonyms

Substance Name — Fluoranthene
CASRN — 206-44-0
Last Revised — 09/01/1990

- 206-44-0
- 1,2-BENZACENAPHTHENE
- BENZENE, 1,2-(1,8-NAPHTHALENEDIYL)-
- BENZENE, 1,2-(1,8-NAPHTHYLENE)-
- BENZO(JK)FLUORENE
- FLUORANTHENE
- HSDB 5486
- IDRYL
- 1,2-(1,8-NAPHTHYLENE)BENZENE
- NSC 6803
- RCRA WASTE NUMBER U120

Phenol; CASRN 108-95-2

Human health assessment information on a chemical substance is included in the IRIS database only after a comprehensive review of toxicity data, as outlined in the IRIS assessment development process. Sections I (Health Hazard Assessments for Noncarcinogenic Effects) and II (Carcinogenicity Assessment for Lifetime Exposure) present the conclusions that were reached during the assessment development process. Supporting information and explanations of the methods used to derive the values given in IRIS are provided in the guidance documents located on the IRIS website.

STATUS OF DATA FOR Phenol

File First On-Line 01/31/1987

Category (section)	Assessment Available?	Last Revised
Oral RfD (I.A.)	yes	09/30/2002
Inhalation RfC (I.B.)	qualitative discussion	09/30/2002
Carcinogenicity Assessment (II.)	yes	09/30/2002

I. Chronic Health Hazard Assessments for Noncarcinogenic Effects

I.A. Reference Dose for Chronic Oral Exposure (RfD)

Phenol
CASRN — 108-95-2
Last Revised — 09/30/2002

The oral RfD is based on the assumption that thresholds exist for certain toxic effects such as cellular necrosis. It is expressed in units of mg/kg-day. In general, the RfD is an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime. Please refer to the Background Document for an elaboration of these concepts. RfDs can also be derived for the noncarcinogenic health effects of substances that are also carcinogens. Therefore, it is essential to refer to other sources of

information concerning the carcinogenicity of this substance. If the U.S. EPA has evaluated this substance for potential human carcinogenicity, a summary of that evaluation will be contained in Section II of this file.

I.A.1. Oral RfD Summary

This RfD replaces the previous RfD of 0.6 mg/kg-day entered on IRIS 6/1/89, which was based on a developmental toxicity study in rats (NTP, 1983a), with a NOAEL of 60 mg/kg-day. New studies published since the previous RfD include a new two-generation study (Ryan et al., 2001; available in unpublished form as IIT Research Institute, 1999), a new developmental toxicity study using divided gavage dosing (Argus Research Laboratories, 1997), and a 13-week drinking water neurotoxicity study (ClinTrials BioResearch, 1998). Although these new studies result in a stronger database, another new study (Hsieh et al., 1992) raises questions as to whether the critical effect has been appropriately identified, or whether immunotoxicity is the critical effect. A database uncertainty factor of 3 was added to account for this uncertainty. The new developmental toxicity study (Argus Research Laboratories, 1997) is the new principal study, with a NOAEL of 60 mg/kg-day and a BMDL of 93 mg/kg-day. The RfD is based on the BMDL because, unlike the NOAEL, the BMDL is not limited to one of the experimental doses. The NTP (1983a) study was not considered appropriate as a co-principal study due to the equivocal nature of the identified LOAEL and because the effect observed was not supported in the more recent study in rats using a more environmentally relevant dosing protocol (divided gavage dosing rather than a single bolus dose).

Critical Effect	Experimental Doses*	UF	MF	RfD
Decreased maternal weight gain **Rat developmental study** **Argus Research Laboratories, 1997**	BMDL: 93 mg/kg-day BMD: 157 mg/kg-day	300	1	3E-1 mg/kg-day

*Conversion Factors and Assumptions — This RfD is applied to ingested phenol only and is in addition to phenol formed endogenously in the gut by bacterial metabolism of protein.
BMDL = 95% lower confidence limit on the maximum likelihood estimate of the dose

corresponding to a one standard deviation change in the mean
BMD = Maximum likelihood estimate of the dose corresponding to a one standard deviation change in the mean

I.A.2. Principal and Supporting Studies (Oral RfD)

Argus Research Laboratories. (1997) Oral (gavage) developmental toxicity study of phenol in rats. Horsham, PA. Protocol number: 916-011.

In an unpublished developmental toxicity study conducted according to GLP guidelines (Argus Research Laboratories, 1997), pregnant Crl:CDRBR VAF/Plus Sprague-Dawley rats (25/group) received phenol by oral gavage on gestation days (GDs) 6 through 15. Dosing was three times daily with 0, 20, 40, or 120 mg phenol/kg/dosage, using a dosing volume of 10 mL/kg. The corresponding daily doses were 0, 60, 120, and 360 mg/kg-day. The exposed dams were observed twice a day for viability and daily for clinical signs, abortions, and premature deliveries. In addition, the maternal body weights were recorded every day, and food consumption was also recorded periodically. The rats were sacrificed on GD 20 and gross necropsy was performed and the number of corpora lutea in each ovary was recorded. The uterus of each rat was excised and examined for number and distribution of implantations, live and dead fetuses, and early and late resorptions. Each fetus was weighed, sexed, and examined for gross external alterations. One half of the fetuses were examined for soft tissue alterations and the rest were examined for skeletal alterations.

One high-dose dam died on GD 11. The study authors attributed this death to phenol treatment, because it occurred only at the high dose, although there were no adverse clinical observations and no abnormal necropsy findings in this animal. Other high-dose animals exhibited excess salivation and tachypnea (rapid breathing). There were no other treatment-related clinical observations and no treatment-related necropsy findings. Dose-dependent decreases in body weight of the exposed animals as compared with the controls were observed. Statistically significant decreases in both maternal body weight (8%) and body weight gain (38% for GDs 6-16) were observed at the high dose; although a statistically significant decrease in body weight gain (11%) was observed at the mid dose, the decrease at the mid dose (relative to controls) in absolute maternal weight at the end of dosing (3%) was not statistically significant. Dose-dependent decreases in food consumption were also observed during the dosing period.

Fetal body weights in the high-dose group were significantly lower than those of controls-by 5-7%. The high-dose group had a statistically significant decrease in ossification sites on the hindlimb metatarsals, but it is unlikely that this small change is biologically significant. The incidence of litters with incompletely ossified or unossified sternal centra was 0/23, 0/25, 3/23,

and 3/24; this increase was not statistically significant. There were small, dose-related increases in the number of litters with fetuses with "any alteration" and with "any variation" at 120 mg/kg/day and higher. However, neither of these changes was statistically significant, and the response was not clearly dose-related. In addition, an increase in total variations is of questionable significance in the absence of any increase in individual variations. No other treatment-related effects were observed in uterine contents, malformations, or variations.

The maternal NOAEL was 60 mg/kg-day, based on small decreases in maternal body weight gain at 120 mg/kg-day, and the developmental NOAEL was 120 mg/kg-day, based on decreased fetal body weight and delayed ossification at 360 mg/kg-day. Benchmark dose (BMD) modeling was also conducted for the decreased maternal weight. Defining the benchmark response as a one-standard-deviation decrease in maternal body weight gain, the 95% lower confidence limit on the BMD (i.e., the BMDL) was 93 mg/kg-day. This BMDL was calculated using the polynomial model, which gave slightly better fit than the power and Hill models, using BMDS Version 1.3.

No human studies that addressed the developmental toxicity of phenol were identified. In a well-designed developmental toxicity study (NTP, 1983a), timed-mated CD rats were administered phenol by gavage at 0, 30, 60, or 120 mg/kg-day in 5 mL/kg distilled water on GD 6 to 15 and sacrificed on GD 20. Females were weighed on GDs 0, 6 through 15 (prior to daily dosing), and 20 (immediately following sacrifice), and they were also observed during treatment for clinical signs of toxicity. A total of 20-22 females per group were confirmed to be pregnant at sacrifice on GD 20. The dams were evaluated at sacrifice for body weight, liver weight, gravid uterine weight, and status of uterine implantation sites. Live fetuses were weighed, sexed, and examined for gross morphological abnormalities and malformations in the viscera and skeleton. Results of this study did not show any dose-related signs of maternal toxicity or any clinical symptoms of toxicity related to phenol treatment. The number of implantation sites was slightly higher in the dosed groups, but this change could not be treatment-related, because implantations in this strain take place prior to GD 6 (prior to dosing).

Significant increases in the litters with nonlive (dead plus resorbed) were observed in the low- and mid-dose groups but not in the high-dose group, but this effect was not considered treatment related, because this response was not dose dependent, and the response in the high-dose group was comparable with that of the control. In addition, there was no effect on the more appropriate measure of nonlive per litter. There was also no effect on live fetuses, sex ratio, malformations, or variations. However, a clear dose-related downward trend in fetal body weight was observed, although the changes at the two lower doses were small and the effect was statistically significant only at the high dose. Fetal body weights in the high-dose group were 93% of the average in the control group; fetal body weights were not reported

separately for males and females. Historical control data from the supplier report the average fetal body weight in this strain as being well below the weight in the high-dose group (Charles River Laboratories, 1988). (Concurrent control weight was 4.14 g, high-dose weight was 3.84 g, and historical control weight was 3.39 g.)

The litter size in the high-dose group was also somewhat higher (but not statistically significant) than in the controls, possibly contributing to the smaller fetal weight at the high dose. The total pup burden (total fetal weight) and the gravid uterine weight were highest in the low-dose group, and then in the high-dose group; both of these values were higher than those in the control group. In addition, the treatment-period maternal weight gain was very similar in the control and high-dose groups (but higher in the low-dose group), but the absolute maternal weight gain (i.e., adjusted for the gravid uterine weight) was much lower in the high-dose group than in the controls. The results from the low-dose group suggest that the dams could have borne a somewhat higher burden of the total in utero package. However, the results also suggest that the dams were near the limit of what they could carry, based on the lower absolute weight gain but unaffected treatment-period weight gain in the high-dose group. No dose-related signs of maternal toxicity and no clinical symptoms of toxicity related to phenol treatment were observed in this study. On the basis of these considerations and the potential for the decreased fetal weight to reflect primarily the larger litter size, the decreased fetal weight in this study could be considered an equivocal LOAEL. Thus, on the basis of decreased fetal body weight, the mid dose in this study of 60 mg/kg-day was a NOAEL for developmental toxicity and the high dose of 120 mg/kg-day was an equivocal LOAEL. The high dose (120 mg/kg-day) was a maternal NOAEL. BMD modeling could not be done for the decreased fetal weight, because NTP did not have information on the fetal weight by sex, either in the report or in its archives. Data on fetal weight by sex is needed for meaningful modeling, because the average weight of males and females is different and the number of males per group varied.

Although the same NOAEL of 60 mg/kg-day was identified for this study as in the principal study (Argus Research Laboratories, 1997), this study was not considered adequate to be a co-principal study in light of the equivocal nature of the LOAEL and the absence of an effect on fetal weight in another gavage developmental study in rats (Argus Research Laboratories, 1997) at a maternally toxic dose in that study of 120 mg/kg-day.

In a standard mouse developmental toxicity study (NTP, 1983b), phenol was administered by gavage in water at 0, 70, 140, or 280 mg/kg-day on GDs 6 to 15 to groups of 31-36 plug-positive female CD-1 mice. The pregnancy rate in the controls was only 83%; the pregnancy rate in dosed animals ranged from approximately 83% in the low- and mid-dose groups to 71% at the high dose. In addition, 4/36 high-dose mice died; no deaths occurred in any other groups. The average maternal body weight gain during treatment was statistically significantly

reduced at the high dose, as was the maternal body weight at terminal sacrifice on GD 17 (by 10%, compared with the control group). In addition, tremors were observed at the high dose throughout the dosing period. As in the rat study, a highly statistically significant decrease in fetal body weight per litter (18%) was observed at the high dose. An increased incidence of cleft palate was also reported at the highest dose level, although the incidence was not significantly different from that of the other groups, and there was no statistically significant increase in the incidence of litters with malformations. There was no other evidence of altered prenatal viability or structural development.

Thus, the high dose of 280 mg/kg-day was a maternal frank effect level based on the observed deaths; tremors and decreased body weight also occurred at this dose. The high dose was also a developmental LOAEL based on decreased fetal body weight (accompanied by a possible increase in the incidence of cleft palate) in the fetuses, an effect that was likely secondary to the severe toxicity in the dams. The study NOAEL for maternal and developmental toxicity was 140 mg/kg-day.

Hsieh et al. (1992) investigated the effects of phenol exposure on hematological, immune, and neurochemical endpoints in a study of 6-week-old male CD-1 mice (5 per dose) administered actual concentrations of 0, 4.7, 19.5, or 95.2 ppm in drinking water for 28 days. On the basis of measured concentrations and water intake, the authors reported that the corresponding daily doses were 0, 1.8, 6.3, and 33.6 mg/kg-day. After 28 days, the mice were sacrificed by decapitation, gross pathological examinations were performed, and the liver, spleen, thymus, and kidney were weighed. Blood was taken at sacrifice for analysis. Splenocytes were prepared for analysis of antibody production response, mitogen-stimulated lymphocyte proliferation, mixed lymphocyte response, and cell-mediated cytolysis response.

During the 28-day exposure, no mortality and no overt clinical signs occurred in exposed mice. Phenol treatment had no effects on food or water consumption or on body weight gain. Exposed mice had no gross lesions in the liver, kidney, spleen, thymus, lung, heart, and brain, and no effect on organ weights for the liver, kidney, spleen, and thymus was seen. A dose-related decrease in erythrocyte counts was statistically significant at all doses. The hematocrit was decreased only at the high dose. A decreased erythrocyte count in the absence of an effect on hematocrit may have been due to macrocytosis (enlarged erythrocytes), but insufficient data were provided to evaluate this possibility. The erythrocyte counts in all dosed groups were markedly lower than the historical control values provided by the animal distributor (Charles River Laboratories, 1986), although the hematocrit concentration in all groups was above the historical control mean. There was no effect on total or differential leukocyte counts.

A decreased antibody response to sheep red blood cells was observed, as indicated by both the plaque-forming cell (PFC) assay (expressed as PFC/million spleen cells and PFC/spleen) and the antibody titer using an enzyme-linked immunosorbent assay (ELISA). Two of these measures were statistically significantly decreased at the mid dose, and PFC/spleen was significantly decreased only at the high dose. These decreases reached 40% (a value often used by immunotoxicologists as a rule of thumb for clinically relevant decreases) at the high dose. Decreases in the absolute splenocyte lymphoproliferative responses to mitogens and the mixed lymphocyte response (the proliferative ability of splenic lymphocytes in response to alloantigens) were also observed at the high dose; there was no effect on the cytolytic response to tumor cells at any dose.

Although these assays were conducted according to the methods of the day, the latter two do not conform to modern protocols, and there is little biological significance to the results of the mitogen response assay. Identification of a NOAEL in this study is somewhat problematic, because immunotoxicity risk assessment guidelines have not been developed. The determination of what degree of decrease is adverse is also problematic, because the clinical relevance of a decrement in immune function will depend on the magnitude and type of immune challenge, with a sufficiently large challenge resulting in illness even for unimpaired individuals. In a report on the use of immunotoxicity data for risk assessment, Selgrade (1999) recommended that any statistically significant and consistent change be considered a risk for the purposes of hazard identification, but the degree of change considered adverse for the purposes of dose-response assessment was not addressed.

On the basis of the magnitude of the decreases in antibody response observed in three related assays, supported by decreased hematocrit and red blood cells, the high dose (33.6 mg/kg-day) can be considered the study LOAEL, and the mid dose (6.2 mg/kg-day) can be considered the study NOAEL. There is, however, considerable uncertainty regarding the reliability of these values due to issues of study interpretation and because the study used only 5 animals per group as compared with the recommended 8 per group (U.S. EPA, 1998).

I.A.3. Uncertainty and Modifying Factors (Oral RfD)

UF = 300

A factor of 10 is used to protect sensitive human subpopulations (intraspecies variability). The data on the within-human variability in the toxicokinetics and toxicodynamics of ingested phenol are insufficient to adjust the default uncertainty factor for intraspecies variability. In a sample of liver fractions from 10 people, Seaton et al. (1995) found that the kinetics of phenol sulfation and hydroquinone conjugation varied by up to approximately threefold. Much larger variability is observed in CYP2E1 (the cytochrome P450 enzyme that oxidizes phenol to

potentially toxic metabolites), particularly between neonates and adults (Vieira et al., 1996). These data on inter-individual variability in enzymatic metabolism are not adequate to move from the default UF_H of 10 because they do not reflect potential variability in portal-of-entry metabolism of phenol or uncertainty regarding the identity of the toxic moiety.

A factor of 10 is used to extrapolate from animals to humans (UF_A). The absorption, distribution, and metabolism of ingested phenol in rats and humans appear to be generally qualitatively similar, although the data are insufficient for a quantitative comparison. Comparison of laboratory animal and human phenol toxicokinetics is also limited by the lack of knowledge regarding the identity of the toxic moiety. It is not possible to quantitatively use the toxicokinetic data to adjust the default 10-fold factor for interspecies variability, and the default UFA of 10 is judged to be appropriate. It may be possible to reduce this default value of 10 following review and evaluation of data comparing the toxicokinetics of phenol and its metabolites in rats and humans (perhaps supplemented by a physiologically based pharmacokinetic model), if such data become available.

The BMDL was based on an effect of minimal severity (decreased maternal weight *gain*), and a higher BMDL and NOAEL were obtained for the related endpoint of effects on maternal weight. The BMDL is also within 50% of the NOAEL identified for the decreased maternal weight endpoint. Therefore, no uncertainty factor is required for extrapolation from a NOAEL to a LOAEL. No uncertainty factor for extrapolation across duration is needed, because this developmental study is supported by chronic bioassays in two species in which toxicity was observed only at higher doses. An additional uncertainty factor for sensitive populations such as infants and children is not needed for phenol because sufficient studies of reproductive and developmental toxicity have been performed, with the observation of decreased fetal body weight (in the absence of other indications of fetal toxicity or teratogenicity) only at doses equal to or higher than the LOAEL for the endpoint used for developing the oral RfD.

The toxicity database for phenol by the oral route can be considered complete. It includes 2-year drinking water studies conducted in rats and mice (NCI, 1980), a two-generation drinking water study conducted in rats (Ryan et al., 2001; available in unpublished form as IIT Research Institute, 1999), and gavage developmental toxicity studies in rats (Argus Research Laboratories, 1997; NTP, 1983a; Narotsky and Kavlock, 1995) and mice (NTP, 1983b). However, the range of endpoints evaluated in the chronic toxicity studies was limited and did not include hematological or serum biochemistry evaluations. Immunological and hematological effects in mice were observed at low doses by Hsieh et al. (1992) in a 28-day drinking water study. These endpoints were evaluated, and no significant hematological or serum biochemistry effects were observed at doses of up to >300 mg/kg-day in the two-generation rat study (IIT Research Institute, 1999; Ryan et al., 2001). The difference in these results suggest species differences between mice and rats, but confirmation of the

immunological and hematological effects in an assay done according to modern test methods would be useful.

The results of a study of the effects of phenol on bone marrow cellularity in mice dosed intraperitoneally at up to 300 mg/kg-day (Eastmond et al., 1987) and an in vitro study with mouse bone marrow cells (Corti and Snyder, 1998) also do not indicate that mouse blood cells are highly susceptible to effects of phenol. However, these studies did not evaluate the same parameter measured by Hsieh et al. (1992), and significant interspecies differences in immunotoxicity are not unusual. It is of interest that the endpoints affected in the Hsieh et al. (1992) study (two measures of effects on antibody production, the PFC and ELISA) are the immune endpoints most highly predictive of effects on host resistance (Luster et al., 1992, 1993). Therefore, to account for the uncertainties regarding the immunological and hematological effects in mice, a database uncertainty factor of 3 is used. The database factor could be reconsidered with results of an immunotoxicity study in mice that is compliant with EPA immunotoxicity test guidelines (U.S. EPA, 1998).

An additional degree of public health protection may also be provided by the use of a gavage study rather than the more environmentally relevant route of drinking water. This is because gavage administration results in a higher peak blood level-presumably even using a divided dosing protocol-than does ingestion of the same daily dose in drinking water, and at least some effects of phenol are related to peak blood levels. Thus, a composite uncertainty factor of 300 was used, based on default factors of 10 each for interspecies extrapolation and intraspecies variability and a database factor of 3 to account for uncertainties regarding the immunotoxic potential of phenol.

MF = 1

No MF is applied because the existing uncertainties have been addressed with the standard uncertainty factors.

I.A.4. Additional Studies/Comments (Oral RfD)

Phenol is produced endogenously by bacteria in the gut at a rate estimated at 1 to 10 mg/day, corresponding to approximately 0.014-0.14 mg/kg-day (Bone et al., 1976; Lawrie and Renwick, 1987; Renwick et al., 1988), based on total phenol (free plus conjugated) levels in urine. Because endogenous phenol is formed in the gut, the toxicokinetics would be similar to that of ingested phenol. Both humans and laboratory animals efficiently conjugate and excrete phenol at low doses, resulting in only a small degree of systemic exposure to free phenol (or any of its oxidative metabolites) at these low levels. The phenol conjugation capacity of the liver is an important determinant of the ingested dose that would result in toxicity, but there is

no information on the degree of phenol conjugation by humans at doses in the range of the RfD.

Human variability exists in both the levels of endogenous phenol production and in the conjugative capacity of the liver. In the absence of more detailed information, it is reasonable to assume that humans have adapted by having adequate conjugation capacity for the range of endogenous phenol production. Therefore, the default total uncertainty factor of 10 for human variability in toxicokinetics and toxicodynamics described above is considered adequate. Determining whether oxidative metabolites are formed in people with high endogenous levels of phenol formation would enhance the confidence in the determination of the intraspecies uncertainty factor. The RfD is at least twice the endogenous rate of phenol formation in humans, meaning that endogenous production is approximately 5-50% of the RfD.

An extensive database for the effects of orally administered phenol in laboratory animals is available. Two-year drinking water studies have been conducted in groups of F344 rats and B6C3F1 mice (50 animals/sex/dose/species). The rats were exposed to 0, 2500, or 5000 ppm, corresponding to 0, 260, and 585 mg/kg-day for male rats and 0, 280, and 630 mg/kg-day for female rats. The mice were exposed to 0, 2500, or 5000 ppm in drinking water, corresponding to estimated doses of 0, 450, and 660 mg/kg-day for both sexes. These studies identified NOAELs of 260 mg/kg-day and 480 mg/kg-day for rats and mice, respectively, based on decreased body weight gain and decreased water consumption (NCI, 1980). A complete histopathology evaluation was included, but no increases in noncancer lesions were found. Hematology and serum biochemical evaluations were not included in those chronic studies, but they were included in a recent two-generation drinking water study conducted in Sprague-Dawley rats (Ryan et al., 2001; available in unpublished form as IIT Research Institute, 1999), as described below.

Toxicity in gavage studies with phenol is typically much higher than that in drinking water studies. NOAELs for systemic effects were 5- to10-fold lower in gavage studies (Berman et al., 1995; Moser et al., 1995; Dow Chemical Co., 1945) than those seen in drinking water studies. Many (but not all) of the effects in drinking water studies appeared to be due to decreased water consumption resulting from poor palatability. Effects observed in gavage studies included tremor and liver and kidney histopathology; effects in drinking water studies were less severe. As described in greater detail in the Toxicological Review, this difference between gavage and drinking water exposure is consistent with toxicokinetic data that suggest that toxicity is correlated with peak blood concentrations rather than being a measure of total dose, such as the area under the phenol blood concentration curve (AUC). Due to this marked difference in toxicity between gavage and drinking water, the RfD was not based on gavage studies of systemic effects, even though those effects occurred at lower doses.

Although the principal study for the development of the RfD (Argus Research Laboratories, 1997) used gavage dosing, it is not clear whether this difference in toxicity also applies to the endpoint of decreased maternal weight gain. In addition, Argus Research Laboratories (1997) used a divided dosing protocol, a significant enhancement that made the gavage dosing more closely resemble an environmentally relevant route of exposure.

In an unpublished 13-week neurotoxicity study conducted according to good laboratory practice (GLP) guidelines (ClinTrials BioResearch Ltd., 1998), groups of 15 male and 15 female Sprague-Dawley rats received phenol via drinking water at concentrations of 0, 200, 1000, or 5000 ppm for 13 weeks followed by a 4-week recovery period. The study authors calculated that the average doses were 0, 18.1, 83.1, and 308.2 mg/kg-day for males and 0, 24.6, 107.0, and 359.8 mg/kg-day for females. During the exposure period, clinical signs and water intake were recorded daily and body weight and food consumption were recorded weekly. In addition, a functional observational battery and a motor activity test were conducted pre-study and once each during weeks 4, 8, 13, and 17. At the end of the exposure and at the end of the recovery period, five rats/sex in the control and 5000 ppm groups underwent neuropathological evaluations (including a thorough evaluation of the brain and several nerves). The rest of the rats were sacrificed at the end of the 4-week recovery and were subjected to gross necropsy.

The primary clinical sign was dehydration, which was associated with marked decreases in water consumption at the high dose and smaller decreases at the mid-dose. Decreases in water consumption were more pronounced in females than in males and were most evident during the first week of dosing. Water consumption was decreased to approximately 90% of the control level in mid-dose males and females, to approximately 60% of control levels in high-dose males, and to approximately 55% (40% during the first week) of control levels in high-dose females. Water consumption rebounded to levels higher than those of controls during the recovery period. The decreased water consumption was likely due to the poor palatability of phenol at high concentrations rather than being a manifestation of an overt toxicological effect. In addition, the high-dose group had decreased body weights as compared with the controls (8% for males and 12% for females) and decreased food intake (approximately 10% for males and 10-20% for females). The only toxicologically significant neurological effect was decreased motor activity in females. A statistically significant reduction in total group mean motor activity counts was observed at week 4 in the 5000 ppm group. The authors reported that the rate of linear change of motor activity with time was also significantly decreased at weeks 8 and 13 in the 1000 ppm and 5000 ppm groups. The authors attributed the decreased activity to dehydration, noting that the control group mean total activity increased by >20% at week 4 as compared with prestudy levels, whereas activity of the dehydrated females in the 5000 ppm group at week 4 was decreased by 17% and activity of the females in this group that were not dehydrated increased by 2%. However, a detailed analysis of the

individual animal data, as discussed in the Toxicological Review, did not support the hypothesis that all of the decreased motor activity could be attributed to dehydration; phenol at least contributed to the decreased motor activity. On the basis of decreased motor activity, the study NOAEL in females was 1000 ppm phenol (107 mg/kg-day) and the LOAEL was 5000 ppm (360 mg/kg-day). No LOAEL was identified in males; the high dose of 308 mg/kg-day was a NOAEL. A BMDL of 219 mg/kg-day was calculated for decreased motor activity in females in week 4 in this study

In a two-generation reproductive toxicity study following modern GLP guidelines (Ryan et al., 2001; full unpublished study available as IIT Research Institute, 1999), 30 Sprague-Dawley rats/sex/group were exposed to 0, 200, 1000, or 5000 ppm phenol in drinking water. The authors calculated that the average daily phenol intake during week 10 was 0, 14.7, 70.9, and 301.0 mg/kg-day for P1 males and 0, 20.0, 93.0, and 320.5 mg/kg-day for P1 females. For the F1 generation, the average phenol intake during week 10 was 0, 13.5, 69.8, and 319.1 mg/kg-day for males and 0, 20.9, 93.8, and 379.5 mg/kg-day for females. Most of the treatment-related changes in P1 rats were observed in the high-dose groups.

The only significant observed clinical sign was redness around the nose fur, which occurred in the high-dose males and females of the F1 generation before mating and in P1 dams during lactation. This redness likely reflected a nonspecific stress response. A significant decrease in water consumption was observed throughout the study in both P1 and F1 animals of both sexes, which was attributed to poor palatability. The low water consumption at the high dose was accompanied by decreased body weights as compared with the controls.

Decreased absolute organ weights and increased relative organ weights were observed for a number of organs at the high dose in both the P1 and F1 generations. Most of these changes likely reflected the lower body weight and overall dehydration in these groups. F1 females had a statistically significant, dose-related decrease in absolute uterine weights at all doses, but P1 females were not affected. The decreased uterine weight was not considered adverse because there was no evidence of a dose-response relationship for relative uterine weight, no effect on reproductive function, and no histopathological changes in the uterus and the individual animal data showed that the uterine weight was below the control range for only a few rats in each dose group. No other organ weight changes in either the P1 or the F1 generation were considered adverse. The histopathological examinations showed no treatment-related lesions in the kidneys, spleen, liver, thymus, or reproductive organs.

An immunotoxicity screen in this study found no significant effects on spleen weight, cellularity, or antibody-forming cells for any test group as compared with the control group. Complete hematological evaluations and serum biochemical evaluations were conducted on P1 males prior to sacrifice, and no biologically significant changes were observed. No effect

on fecundity or fertility in either generation was observed. In addition, there was no effect on other indicators of reproductive toxicity, including the frequency of estrus, testicular sperm count, sperm motility and sperm morphology.

The survival of the high-dose F1 pups was significantly decreased on prenatal day 4 (pre-culling), although there was no effect on overall F1 pup survival. In the F2 generation, high-dose pup survival was significantly decreased throughout the lactation period. This decreased survival of both generations of pups was likely secondary to the decreased maternal water intake and associated decreases in milk production. In the F1 generation, delayed vaginal patency and delayed preputial separation were observed at the high dose. The delay was considered secondary to decreased fetal growth at the high dose and as resulting from decreased water consumption due to poor palatability and associated decreased food consumption.

Thus, all of the adverse systemic and reproductive effects of phenol in the Ryan et al. (2001) study occurred at the high dose, and they appear to be secondary to decreased water consumption due to poor palatability rather than a toxic effect of phenol. On the basis of decreased parental and pup body weight (compared with the controls) and decreased pup survival, the high dose is a LOAEL. The study NOAEL is 70.9 mg/kg-day (based on the NOAEL corresponding to the lowest LOAEL in this study, in P1 males). BMD modeling was not conducted for this study because the observed effects appeared to be secondary to decreased water consumption and not reflective of phenol toxicity.

Phenol is readily absorbed by the inhalation, oral, and dermal routes (Piotrowski, 1971; Capel et al., 1972; Dow Chemical Co., 1994). Portal-of-entry metabolism for the inhalation and oral routes appears to be extensive and involves sulfate and glucuronide conjugation and, to a lesser extent, oxidation, primarily by CYP2E1. The primary oxidative metabolites include hydroquinone and catechol, which are also substrates for conjugation. Secondary products of hydroquinone or catechol metabolism, including benzoquinone and trihydroxybenzene, can also be formed (Capel et al., 1972; Dow Chemical Co., 1994; Kenyon et al., 1995). Once absorbed, phenol is widely distributed in the body, although the levels in the lung, liver, and kidney are often reported as being higher than those in other tissues (on a per-gram-tissue basis) (Tanaka et al., 1998; Liao and Oehme, 1981; Dow Chemical Co., 1994). Elimination from the body is rapid, primarily as sulfate and glucuronide conjugates in the urine, regardless of route of administration; phenol does not appear to accumulate significantly in the body (Ohtsuji and Ikeda, 1972; Deichmann and Witherup, 1944; Dow Chemical Co., 1994).

For more detail on Susceptible Populations, exit to the toxicological review, Section 4.7 (PDF).

I.A.5. Confidence in the Oral RfD

Study — Medium
Database — Medium to high
RfD — Medium to high

The principal study (Argus Research Laboratories, 1997) used an adequate number of animals and evaluated an appropriate array of endpoints for a developmental toxicity study. Although gavage dosing was used, the divided-dosing protocol provided a significant enhancement that made the gavage dosing more closely resemble an environmentally relevant route of exposure. Although the use of gavage dosing lowers the confidence in the study, the dosing frequency in the divided-dose gavage study may be fairly similar to that in drinking water studies, in which rodents typically consume water in a few larger doses, often in association with food consumption.

Confidence in the supporting database is medium to high. Although the oral toxicity database meets the minimal criteria for a high-confidence database (chronic studies in two species, developmental toxicity studies in two species, and a multigeneration reproduction study), the chronic studies did not evaluate a sufficient array of endpoints. In particular, the chronic mouse study (NCI, 1980) did not evaluate hematological and immunological effects, making interpretation of the results of the Hsieh et al. (1992) study difficult. Considering the above issues results in medium to high confidence in the RfD.

For more detail on Characterization of Hazard and Dose Response, exit to the toxicological review, Section 6 (PDF).

I.A.6. EPA Documentation and Review of the Oral RfD

Source Document — U.S. EPA, 2002

This assessment was peer reviewed by external scientists. Their comments have been evaluated carefully and incorporated in the finalization of this IRIS Summary. A record of these comments is included as an appendix to the Toxicological Review. ***To review this appendix, exit to the toxicological review, Appendix A, Summary of and Response to External Peer Review Comments (PDF).***

Other EPA Documentation — Summary Review of the Health Effects Associated with Phenol: Health Issue Assessment. Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office, Cincinnati, OH. U.S. EPA. 1986.

Agency Consensus Date — 08/28/2002

Screening-Level Literature Review Findings — A screening-level review conducted by an EPA contractor of the more recent toxicology literature pertinent to the RfD for phenol conducted in August 2003 did not identify any critical new studies. IRIS users who know of important new studies may provide that information to the IRIS Hotline at [redacted] or 202-566-1676.

I.A.7. EPA Contacts (Oral RfD)

Please contact the IRIS Hotline for all questions concerning this assessment or IRIS in general at (202)566-1676 (phone), (202)566-1749 (FAX), [redacted] (email address).

I.B. Reference Concentration for Chronic Inhalation Exposure (RfC)

Phenol
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The inhalation RfC is analogous to the oral RfD and is likewise based on the assumption that thresholds exist for certain toxic effects such as cellular necrosis. The inhalation RfC considers toxic effects for the respiratory system (portal of entry) and effects peripheral to the respiratory system (extrarespiratory effects). It is generally expressed in units of mg/m^3. In general, the RfC is an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily inhalation exposure of the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime. Inhalation RfCs were derived according to *Interim Methods for Development of Inhalation Reference Doses* (EPA/600/8-88/066F August 1989) and, subsequently, according to *Methods for Derivation of Inhalation Reference Concentrations and Application of Inhalation Dosimetry* (EPA/600/8-90/066F October 1994). RfCs can also be derived for the noncarcinogenic health effects of substances that are carcinogens. Therefore, it is essential to refer to other sources of information concerning the carcinogenicity of this substance. If EPA has evaluated this substance for potential human carcinogenicity, a summary of that evaluation will be contained in Section II of this file.

I.B.1. Inhalation RfC Summary

Not applicable. No adequate inhalation exposure studies exist from which an inhalation RfC may be derived. A route-to-route extrapolation is not appropriate, because phenol can be a direct contact irritant, and so portal-of-entry effects are a potential concern.

The minimal database needed for the development of an RfC is a well-conducted subchronic inhalation study that adequately evaluates a comprehensive array of endpoints, including the respiratory tract, and establishes a NOAEL and a LOAEL (U.S. EPA, 1994). This criterion was not met for phenol. Neither of the two available subchronic studies (Deichmann et al., 1944; Sandage, 1961) are adequate for exposure-response assessment because neither included adequate documentation of the histopathology results and neither used modern methods for generating or monitoring exposure levels. These studies can, however, be used for hazard identification, and they identify the respiratory tract, liver, and kidney as targets of inhalation exposure to phenol.

The phenol database also includes a well-conducted, 2-week inhalation study with rats that used modern exposure methods, evaluated a wide array of endpoints, and included a thorough histopathology evaluation of the respiratory tract (Hoffman et al., 2001; the full unpublished study report is available as Huntingdon, 1998). The only treatment-related effect observed was a red nasal discharge in male rats, which was observed with a statistically significant duration-related, and concentration-related incidence in the mid- and high-concentration groups. However, because the red nasal discharge was likely due to a nonspecific response to stress, this response is not considered adverse. The 2-week study is of insufficient duration for the derivation of an RfC.

I.B.2. Principal and Supporting Studies (Inhalation RfC)

Not applicable.

I.B.3. Uncertainty and Modifying Factors (Inhalation RfC)

Not applicable.

I.B.4. Additional Studies/Comments (Inhalation RfC)

Not applicable.

I.B.5. Confidence in the Inhalation RfC

Not applicable.

I.B.6. EPA Documentation and Review of the Inhalation RfC

Source Document — U.S. EPA, 2002

Screening-Level Literature Review Findings — A screening-level review conducted by an EPA contractor of the more recent toxicology literature pertinent to the RfC for phenol conducted in August 2003 did not identify any critical new studies. IRIS users who know of important new studies may provide that information to the IRIS Hotline at [redacted] or 202-566-1676.

I.B.7. EPA Contacts (Inhalation RfC)

Please contact the IRIS Hotline for all questions concerning this assessment or IRIS in general at (202)566-1676 (phone), (202)566-1749 (FAX), or [redacted] (email address).

II. Carcinogenicity Assessment for Lifetime Exposure

Phenol
CASRN — 108-95-2
Last Revised — 09/30/2002

Section II provides information on three aspects of the carcinogenic assessment for the substance in question: the weight-of-evidence judgment of the likelihood that the substance is a human carcinogen and quantitative estimates of risk from oral exposure and from inhalation exposure. The quantitative risk estimates are presented in three ways. The slope factor is the result of application of a low-dose extrapolation procedure and is presented as the risk per mg/kg/day. The unit risk is the quantitative estimate in terms of either risk per µg/L drinking water or risk per µg/m^3 air breathed. The third form in which risk is presented is as a concentration of the chemical in drinking water or in air that is associated with cancer risks of 1 in 10,000, 1 in 100,000, or 1 in 1,000,000. The rationale and methods used to develop the carcinogenicity information in IRIS are described in the risk assessment guidelines of 1986 (EPA/600/8-87/045) and in the IRIS background document. IRIS summaries developed since the publication of EPA's more recent *Proposed Guidelines for Carcinogen Risk Assessment* also use those guidelines where indicated (Federal Register 61[79]:17960-18011, April 23,

1996). Users are referred to Section I of this IRIS file for information on long-term toxic effects other than carcinogenicity.

II.A. Evidence for Human Carcinogenicity

II.A.1. Weight-of-Evidence Characterization

This carcinogenicity assessment replaces the previous assessment of 11/01/90.

Under the current guidelines (U.S. EPA, 1987), phenol would be characterized as Group D, not classifiable as to human carcinogenicity. Under *Draft Guidelines for Carcinogen Risk Assessment* (U.S. EPA, 1999), the data regarding the carcinogenicity of phenol via the oral, inhalation, and dermal exposure routes *are inadequate for an assessment of human carcinogenic potential*. Phenol was negative in oral carcinogenicity studies in rats and mice, but questions remain regarding increased leukemia in male rats in the bioassay as well as the positive gene mutation data and the positive results in dermal initiation/promotion studies at doses at or above the maximum tolerated dose (MTD). No inhalation studies of an appropriate duration exist. Therefore, no quantitative assessment of carcinogenic potential via any route is possible.

For more detail on Characterization of Hazard and Dose Response, exit to the toxicological review, Section 6 (PDF).

For more detail on Susceptible Populations, exit to the toxicological review, Section 4.7 (PDF).

II.A.2. Human Carcinogenicity Data

Inadequate.

The epidemiology data on phenol are limited. Kauppinen et al. (1986) reported a significant increase in respiratory cancer in phenol-exposed workers, but this observation appears to be due to confounding exposures, as there was no dose-response and the effect decreased after accounting for latency. No effect on cancer mortality was observed in workers exposed to phenol in the rubber industry (Wilcosky et al., 1984) or in workers exposed to formaldehyde and phenol (Dosemeci et al., 1991). However, the usefulness of each of these studies for risk assessment is limited by (depending on the study) an absence of an effect when latency was considered, a lack of a dose-response, and the potential for confounding. Because all of the subjects were also exposed to other chemicals and there was no correction for smoking, these studies are not adequate for reaching conclusions on the carcinogenic potential of phenol.

II.A.3. Animal Carcinogenicity Data

Inadequate.

NCI (1980) conducted a carcinogenicity bioassay in which F344 rats (50/sex/group) received phenol in drinking water at concentrations of 0, 2500, or 5000 ppm for 103 weeks and were sacrificed 1-2 weeks later. Using the reference water intake of 0.13 and 0.14 L/kg-day for chronic exposure of male and female F344 rats, respectively (U.S. EPA, 1988), the doses can be estimated as 0, 260, and 585 mg/kg-day for male rats and 0, 280, and 630 mg/kg-day for female rats. The doses shown here were adjusted to account for the reported water consumption of 80% and 90% of control at the low and high doses, respectively. The animals were observed daily for clinical signs and examined weekly for palpable masses. Body weights and food consumption were recorded every 2 weeks for the first 12 weeks and monthly thereafter; water consumption was recorded weekly.

At the end of study, the animals were sacrificed and complete gross and histopathological examinations were performed. Organs and tissues examined included the bone marrow, spleen, cervical and mesenteric lymph nodes, heart, liver, kidney, thyroid, reproductive organs, brain, and other major tissues. The survival rate at study termination was comparable among all three groups of males (approximately 50%) and females (approximately 75%). Dose-related decreases in body weight as compared with the controls were observed in male and female rats, with a decrease of approximately 15% in high-dose males and approximately 10% in high-dose females. Water consumption was reduced by approximately 10% at the high dose.

The authors stated that the non-neoplastic lesions were similar to those naturally occurring in aged F344 rats. However, an analysis conducted for this assessment found statistically significant increases in chronic kidney inflammation in high-dose males and females; there were no significant changes at the low dose. No other differences in the incidence of non-neoplastic lesions between the controls and the exposed rats were observed. The increased kidney inflammation and the decreased body weight as compared with controls at the high dose of 5000 ppm (585 mg/kg-day for males and 630 mg/kg-day for females) indicate that the MTD was reached.

There were no dose-related trends in cancer incidence in male or female rats, but the study authors reported several tumors for which statistically significant increases were seen in low-dose males only, as indicated by pairwise comparisons. These increases were seen in the incidences of pheochromocytomas of the adrenal medulla (13/50, 22/50, and 9/50 in the control, low-, and high-dose groups, respectively) and "leukemias or lymphomas" (18/50, 31/50, and 25/50). The incidence of interstitial cell tumors of the testes was also elevated in

the low-dose group (42/48, 49/50, and 47/50). The historical control incidence of pheochromocytomas in the bioassay program was 9% (data for the test laboratory were not reported), and the historical control incidence of leukemias or lymphomas in the test laboratory was 26%. The authors stated that the leukemias were "of the type usually seen in untreated F344 rats." There were no significant increases in tumor incidence in any tissue in female rats.

In light of the absence of a clear dose-response in males, the high spontaneous testicular tumor rate in the matched controls and the absence of tumors in female rats, an association between the tumors and phenol exposure cannot be established. NCI concluded that phenol was "not carcinogenic in male or female F344 rats." However, the report noted uncertainties regarding the possible increase in leukemia in male rats, and the NCI reviewers recommended that phenol be considered for a retest. The increases in leukemia are of particular interest in light of the leukemogenic effects of benzene (for which phenol is a metabolite) in humans. (Benzene has not been shown to induce leukemia in experimental animals, although increases in lymphoma have been observed [e.g., NTP, 1986].)

In a parallel study, NCI (1980) administered phenol at 0, 2500, or 5000 ppm in drinking water to B6C3F1 mice (50/sex/group) for 103 weeks and sacrificed the mice 1-2 weeks later. For B6C3F1 mice, the reference water intake is 0.24 L/kg-day for both sexes. The study reported that water consumption was decreased to 75% and 50-60% of the control levels at the low and high doses, respectively. The resulting doses (adjusting for decreased water intake) were 0, 450, and 660 mg/kg-day for both sexes. Dose-related decreases in body weight as compared with the controls were attributed to the decrease in water consumption. Besides the decreased water consumption, no clinical signs of toxicity were observed, and mortality rates (approximately 10% in males and 20% in females) were comparable between experimental and control groups. Histopathological examination and statistical analyses revealed no phenol-related signs of toxicity or carcinogenicity; lesions in all systems observed in the dosed groups were comparable with those in the controls. NCI concluded that, under the conditions of the assay, phenol was not carcinogenic in male or female B6C3F1 mice (NCI, 1980).

Although the only sign of toxicity in the mouse study was decreased body weight (compared to the controls) secondary to decreased water consumption, higher doses probably could not have been tested in light of the decreased water consumption. If the authors had attempted to overcome the palatability issue by administering the high dose in the NCI (1980) mouse study by gavage instead of in drinking water, high toxicity would have been expected, considering the higher toxicity of phenol administered by gavage than that of phenol in drinking water. These considerations suggest that an MTD was also reached in mice, although a definitive conclusion is difficult. No other long-term oral carcinogenicity studies of phenol are available. No inhalation studies of phenol were of a sufficient duration to assess phenol carcinogenicity.

II.A.4. Supporting Data for Carcinogenicity

In contrast with the negative carcinogenicity results for oral administration of phenol, dermally administered phenol has been consistently observed to be a promoter. Several authors (Salaman and Glendenning, 1957; Boutwell and Bosch, 1959; Wynder and Hoffmann, 1961) observed that dermally applied phenol promoted DMBA-initiated skin tumors. These studies have generally reported significant skin ulceration at all doses tested. The exception is Wynder and Hoffman (1961), who reported that 5% phenol promoted DMBA-initiated tumors in mice in the absence of any toxic reactions. When the same phenol dose was administered in different volumes, higher promotion activity was exhibited by the more concentrated solution, which also produced severe skin ulceration, suggesting that some of the promotion activity may have been related to the rapid cell division in the repairing of skin damage (Salaman and Glendenning, 1957). The observed response was dose-related (Boutwell and Bosch, 1959), but marked systemic toxicity was also observed at these doses.

Co-carcinogenesis with dermally administered benzo[a]pyrene has also been observed (Wynder and Hoffmann, 1961). Because the benzo[a]pyrene was co-administered with the phenol, this assay cannot be classified as a true initiation/promotion assay. Production of papillomas by dermally administered phenol (in the absence of an initiator) was observed only at a concentration that caused ulceration and hence was above the MTD.

Genotoxicity studies have found that phenol tends not to be mutagenic in bacteria (Pool and Lin, 1982; Rapson et al., 1980; Haworth et al., 1983), but positive or equivocal results have been obtained in gene mutation assays in mammalian cells (McGregor et al., 1988a, b; Paschin and Bahitova, 1982; Tsutsui et al., 1997). Increases were larger in the presence of S9 activation. Phenol tended to induce micronuclei in mice when administered intraperitoneally (Marrazzini et al., 1994; Chen and Eastmond, 1995; Ciranni et al., 1988), but negative (or positive only at very high doses) when administered orally (Ciranni et al., 1988; Gocke et al., 1981). This difference is likely due to the first-pass conjugation and inactivation of orally administered phenol. Phenol was also positive in vitro micro nucleus tests with human lymphocytes (Yarer et al., 1990) and Chinese hamster ovary (WHO) cells (Miller et al., 1995) and caused chromosome aberrations in the presence of S9 activation in WHO cells (Aviate et al., 1989). Phenol has been observed to act synergistically with hydroquinone in the production of genotoxic effects (Marrazzini et al., 1994; Barale et al., 1990; Chen and Eastmond, 1995).

II.B. Quantitative Estimate of Carcinogenic Risk from Oral Exposure

Not applicable.

II.C. Quantitative Estimate of Carcinogenic Risk from Inhalation Exposure

Not applicable.

II.D. EPA Documentation, Review, and Contacts (Carcinogenicity Assessment)

II.D.1. EPA Documentation

Source Document — U.S. EPA, 2002

This assessment was peer reviewed by external scientists. Their comments have been evaluated carefully and incorporated in the finalization of this IRIS Summary. A record of these comments is included as an appendix to the Toxicological Review of Phenol. ***To review this appendix, exit to the toxicological review, Appendix A, Summary of and Response to External Peer Review Comments (PDF)***.

Other EPA Documentation - Updated Health Effects Assessment for Phenol. Prepared by the Office of Health and Environment Assessment, Environmental Criteria and Assessment Office, Cincinnati, OH for the Office of Solid Waste and Emergency Response, Washington, DC. U.S. EPA. 1988.

II.D.2. EPA Review (Carcinogenicity Assessment)

Agency Consensus Date — 08/28/2002

Screening-Level Literature Review Findings — A screening-level review conducted by an EPA contractor of the more recent toxicology literature pertinent to the cancer assessment for phenol conducted in August 2003 did not identify any critical new studies. IRIS users who know of important new studies may provide that information to the IRIS Hotline at [redacted] 202-566-1676.

II.D.3. EPA Contacts (Carcinogenicity Assessment)

Please contact the IRIS Hotline for all questions concerning this assessment or IRIS, in general, at (202)566-1676 (phone), (202)566-1749 (FAX) or [redacted] (internet address).

III. [reserved]
IV. [reserved]
V. [reserved]

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CASRN — 108-95-2

VI.A. Oral RfD References

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U.S. Environmental Protection Agency. (1988). Recommendations for and documentation of biological values for use in risk assessment. EPA 600/6-87/008. NTIS PB88-179874/AS.

U.S. Environmental Protection Agency. (1999). Guidelines for carcinogen risk assessment. Review Draft, NCEA-F-0644, July 1999. Risk Assessment Forum, Washington, DC.

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VII. Revision History

Phenol
CASRN — 108-95-2

Date	Section	Description
12/01/1988	I.A.	Withdrawn; RfD verified (in preparation)
06/01/1989	I.A.	Oral RfD summary replaced; RfD changed
06/01/1990	I.B.	Data judged inadequate for derivation of inhalation RfD
07/01/1990	I.B.	Not verified; data inadequate
11/01/1990	II.	Carcinogen assessment on-line

Date	Section	Description
03/01/1991	I.B.	Inhalation RfC message on-line
09/30/2002	I.,II.,VII	RfD, RfC, cancer assessment sections updated.
10/28/2003	I.A.6, I.B.6, II.D.2	Screening-Level Literature Review Findings message has been added.

VIII. Synonyms

Phenol
CASRN — 108-95-2
Last Revised — 01/31/87

- 108-95-2
- Benzenol
- Carbolic Acid
- Hydroxybenzene
- Izal
- Monohydroxybenzene
- Monophenol
- NCI-C50124
- Oxybenzene
- Phenic Acid
- Phenol
- Phenyl Alcohol
- Phenyl Hydrate
- Phenyl Hydroxide
- Phenylic Acid
- Phenylic Alcohol

2,4-Dimethylphenol; CASRN 105-67-9

Human health assessment information on a chemical substance is included in the IRIS database only after a comprehensive review of toxicity data, as outlined in the IRIS assessment development process. Sections I (Health Hazard Assessments for Noncarcinogenic Effects) and II (Carcinogenicity Assessment for Lifetime Exposure) present the conclusions that were reached during the assessment development process. Supporting information and explanations of the methods used to derive the values given in IRIS are provided in the guidance documents located on the IRIS website.

STATUS OF DATA FOR 2,4-Dimethylphenol

File First On-Line 11/01/1990

Category (section)	Assessment Available?	Last Revised
Oral RfD (I.A.)	yes	11/01/1990
Inhalation RfC (I.B.)	not evaluated	
Carcinogenicity Assessment (II.)	not evaluated	

I. Chronic Health Hazard Assessments for Noncarcinogenic Effects

I.A. Reference Dose for Chronic Oral Exposure (RfD)

Substance Name — 2,4-Dimethylphenol
CASRN — 105-67-9
Last Revised — 11/01/1990

The oral Reference Dose (RfD) is based on the assumption that thresholds exist for certain toxic effects such as cellular necrosis. It is expressed in units of mg/kg-day. In general, the RfD is an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime. Please refer to the Background Document for an elaboration of these concepts. RfDs can also be derived for the noncarcinogenic health effects of substances that are also carcinogens. Therefore, it is essential to refer to other sources of

information concerning the carcinogenicity of this substance. If the U.S. EPA has evaluated this substance for potential human carcinogenicity, a summary of that evaluation will be contained in Section II of this file.

I.A.1. Oral RfD Summary

Critical Effect	Experimental Doses*	UF	MF	RfD
Clinical signs (lethargy, prostration, and ataxia) and hematological changes **Mouse Subchronic Oral Gavage** **U.S. EPA, 1989**	NOAEL: 50 mg/kg/day LOAEL: 250 mg/kg/day	3000	1	2E-2 mg/kg/day

* Conversion Factors: None

I.A.2. Principal and Supporting Studies (Oral RfD)

U.S. EPA. 1989. Ninety-day gavage study in Albino mice using 2,4- dimethylphenol. Study No. 410-2831, prepared by Dynamac Corporation, Rockville, MD, for the Office of Solid Waste and Emergency Response, Washington, DC.

2,4-Dimethylphenol was administered daily to male and female albino mice by gavage. The animals (30/sex/group) were dosed for 90 days with 5.0, 50.0, or 250 mg 2,4-dimethylphenol/kg/day. Two control groups, untreated and vehicle (corn oil), of similar size were also established. Effects examined included mortality, clinical signs, body weights, food consumption, opthalmology, hematology and clinical chemistry, organ weights, and gross histopathology. Although 15 deaths occurred during this study (mostly because of errors in technical procedure), only one was considered as possibly treatment-related: a male in the 5 mg/kg/day-dose group died during the first 30 days of the experiment. No significant differences were found between treated and vehicle control groups in mean body weight, body weight gains, food consumption, or eye examinations at any dosage. Toxicologically relevant clinical signs observed only after week 6 in the high-dose groups of both genders included: squinting, lethargy, prostration, and ataxia, with onset shortly after dosing. Statistically significant hematological

changes ($p<0.05$) included lower mean corpuscular volume and mean corpuscular hemoglobin concentration in females at terminal, but not interim, sacrifice.

At interim sacrifice in female mid- and high-dose groups, blood urea nitrogen (BUN) levels were significantly below vehicle controls; whereas at final sacrifice in the female mid-dose group, BUN levels were significantly higher than vehicle controls. Low-dose males at interim sacrifice had significantly higher cholesterol levels. Significant differences were not found in gross necropsy or histopathological evaluations, or in organ weights, except for an increase in adrenal weights of low-dose females. The LOAEL and NOAEL for this study were 250 and 50 mg/kg/day, respectively.

I.A.3. Uncertainty and Modifying Factors (Oral RfD)

UF — An uncertainty factor of 3000 was established: 10 each for inter- and intraspecies variability and 30 for lack of chronic toxicity data, data in a second species and reproductive/developmental studies.

MF — None

I.A.4. Additional Studies/Comments (Oral RfD)

A 14-day gavage study with 2,4-dimethylphenol conducted by the same laboratory that conducted the principal study, revealed lethargy, prostration, and ataxia in males and females in the 250 mg/kg/day-dose group, the same dose at which effects were found in the principal study (U.S. EPA, 1987).

No other long-term toxicity, reproductive, or developmental studies of 2,4- dimethylphenol were found in the databases searched. Literature concerning 2,6-dimethylphenol was identified, but an SAR-based RfD is considered inappropriate when a valid long-term toxicity study for 2,4-dimethylphenol is available.

I.A.5. Confidence in the Oral RfD

Study — Medium
Database — Low
RfD — Low

Confidence in the study is medium, since it examined appropriate endpoints and identified both a LOAEL and a NOAEL. The results of this study are consistent with those of a 14-day gavage

study. The database provides no information on chronic and reproductive studies. Low confidence in both the database and oral RfD follows.

I.A.6. EPA Documentation and Review of the Oral RfD

Source Document — This assessment is not presented in any existing U.S. EPA document.

Other EPA Documentation — None

Agency Work Group Review — 02/21/1990

Verification Date — 02/21/1990

Screening-Level Literature Review Findings — A screening-level review conducted by an EPA contractor of the more recent toxicology literature pertinent to the RfD for 2,4-Dimethylphenol conducted in September 2002 identified one or more significant new studies. IRIS users may request the references for those studies from the IRIS Hotline at [redacted] or (202)566-1676.

I.A.7. EPA Contacts (Oral RfD)

Please contact the IRIS Hotline for all questions concerning this assessment or IRIS, in general, at (202)566-1676 (phone), (202)566-1749 (FAX) or [redacted] (internet address).

I.B. Reference Concentration for Chronic Inhalation Exposure (RfC)

Substance Name — 2,4-Dimethylphenol
CASRN — 105-67-9

Not available at this time.

II. Carcinogenicity Assessment for Lifetime Exposure

Substance Name — 2,4-Dimethylphenol
CASRN — 105-67-9

This substance/agent has not undergone a complete evaluation and determination under US EPA's IRIS program for evidence of human carcinogenic potential.

III. [reserved]
IV. [reserved]
V. [reserved]

VI. Bibliography

Substance Name — 2,4-Dimethylphenol
CASRN — 105-67-9

VI.A. Oral RfD References

U.S. EPA. 1987. Fourteen-day gavage study in Albino mice using 2,4- dimethylphenol. Study No. 410-2830, prepared by Dynamac Corporation, Rockville, MD for the Office of Solid Waste and Emergency Response, Washington, DC.

U.S. EPA. 1989. Ninety-day gavage study in Albino mice using 2,4- dimethylphenol. Study No. 410-2831, prepared by Dynamac Corporation, Rockville, MD, for the Office of Solid Waste and Emergency Response, Washington, DC.

VI.B. Inhalation RfC References

None

VI.C. Carcinogenicity Assessment References

None

VII. Revision History

Substance Name — 2,4-Dimethylphenol
CASRN — 105-67-9

Date	Section	Description
11/01/1990	I.A.	Oral RfD summary on-line
12/03/2002	I.A.6.	Screening-Level Literature Review Findings message has been added.

VIII. Synonyms

Substance Name — 2,4-Dimethylphenol
CASRN — 105-67-9
Last Revised — 11/01/1990

- 105-67-9
- Phenol, 2,4-dimethyl-
- Caswell No. 907A
- EPA Pesticide Chemical Code 086804
- HSDB 4253
- m-XYLENOL
- NSC 3829
- RCRA WASTE NUMBER U101
- 1-HYDROXY-2,4-DIMETHYLBENZENE
- 2,4-dimethylphenol
- 2,4-Xylenol
- 4-HYDROXY-1,3-DIMETHYLBENZENE
- 4,6-DIMETHYLPHENOL

2,4-Dinitrophenol; CASRN 51-28-5

Human health assessment information on a chemical substance is included in the IRIS database only after a comprehensive review of toxicity data, as outlined in the IRIS assessment development process. Sections I (Health Hazard Assessments for Noncarcinogenic Effects) and II (Carcinogenicity Assessment for Lifetime Exposure) present the conclusions that were reached during the assessment development process. Supporting information and explanations of the methods used to derive the values given in IRIS are provided in the guidance documents located on the IRIS website.

STATUS OF DATA FOR 2,4-Dinitrophenol

File First On-Line 03/31/1987

Category (section)	Assessment Available?	Last Revised
Oral RfD (I.A.)	yes	03/31/1987*
Inhalation RfC (I.B.)	message	10/01/1991*
Carcinogenicity Assessment (II.)	not evaluated	

*A comprehensive review of toxicological studies was completed (05/27/05) - please see sections I.A.6. and I.B. for more information.

I. Chronic Health Hazard Assessments for Noncarcinogenic Effects

I.A. Reference Dose for Chronic Oral Exposure (RfD)

Substance Name — 2,4-Dinitrophenol
CASRN — 51-28-5
Last Revised — 03/31/1987

The oral Reference Dose (RfD) is based on the assumption that thresholds exist for certain toxic effects such as cellular necrosis. It is expressed in units of mg/kg-day. In general, the RfD is an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk

of deleterious effects during a lifetime. Please refer to the Background Document for an elaboration of these concepts. RfDs can also be derived for the noncarcinogenic health effects of substances that are also carcinogens. Therefore, it is essential to refer to other sources of information concerning the carcinogenicity of this substance. If the U.S. EPA has evaluated this substance for potential human carcinogenicity, a summary of that evaluation will be contained in Section II of this file.

NOTE: The Oral RfD for 2,4-dinitrophenol may change in the near future pending the outcome of a further review now being conducted by the RfD/RfC Work Group.

I.A.1. Oral RfD Summary

Critical Effect	Experimental Doses*	UF	MF	RfD
Cataract formation **Human Chronic and Subchronic Exposures** **Horner, 1942**	NOEL: none LOAEL: 2 mg/kg/day	1000	1	2E-3 mg/kg/day

*Conversion Factors -- none

I.A.2. Principal and Supporting Studies (Oral RfD)

Horner, W.D. 1942. Dinitrophenol and its relation to formation of cataracts. Arch. Ophthal. 27: 1097.

Over 100 anecdotal cases of cataracts resulting from therapeutic use of 2,4- dinitrophenol were reviewed. The length of time and amount of drug taken varied among the population. It was estimated that over 1% of the population administered 2,4-dinitrophenol developed cataracts. Data did not allow for calculation of a NOEL; cataracts were observed in patients receiving as little as 2 mg/kg/day, the lower range of the recommended therapeutic dose.

In the Ambient Water Quality Criteria Document for Nitrophenols (U.S. EPA, 1980), an ADI was also calculated based on a 6-month feeding study in rats administered five dietary levels of 2,4-dinitrophenol (Spencer et al., 1948). A NOEL between 5.4 mg/kg and 20 mg/kg was

demonstrated. If one uses the lower figure of 5.4 mg/kg and an uncertainty factor of 1000, the resulting RfD of 0.005 is comparable to that determined from the human data.

I.A.3. Uncertainty and Modifying Factors (Oral RfD)

UF — The UF of 1000 includes uncertainties in the following areas: extrapolation of an approximately subchronic exposure to chronic exposure, the range of human sensitivity, and extrapolation from a LOAEL to a hypothetical no-effect level.

MF — None

I.A.4. Additional Studies/Comments (Oral RfD)

Embryotoxicity, but not teratogenicity, was observed in mice treated with doses of 2,4-dinitrophenol producing overt signs of toxicity (Gibson, 1973).

I.A.5. Confidence in the Oral RfD

Study — Low
Database — Low
RfD — Low

Since the chosen study only describes anecdotal data and the supporting data base is meager, the confidences in the chosen study, database and RfD are rated low.

I.A.6. EPA Documentation and Review of the Oral RfD

Source Document — This assessment is not presented in any existing U.S. EPA document.

Other EPA Documentation — U.S. EPA, 1980

Agency Work Group Review — 11/06/1985, 02/05/1986

Verification Date — 02/05/1986

A comprehensive review of toxicological studies published through May 2005 was conducted. No new health effects data were identified that would be directly useful in the revision of the existing RfD for 2,4-Dinitrophenol and a change in the RfD is not warranted at this time. For more information, IRIS users may contact the IRIS Hotline at [redacted] 202-566-1676.

I.A.7. EPA Contacts (Oral RfD)

Please contact the IRIS Hotline for all questions concerning this assessment or IRIS, in general, at (202)566-1676 (phone), (202)566-1749 (FAX) or [redacted] (internet address).

I.B. Reference Concentration for Chronic Inhalation Exposure (RfC)

Substance Name — 2,4-Dinitrophenol
CASRN — 51-28-5

The health effects data for 2,4-dinitrophenol were reviewed by the U.S. EPA RfD/RfC Work Group and determined to be inadequate for the derivation of an inhalation RfC. For additional information on the health effects of this chemical, interested parties are referred to the documentation listed below.

U.S. EPA. 1980. Ambient Water Quality Criteria Document for Nitrophenols. Prepared by the Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office, Cincinnati, OH for the Office of Water Regulations and Standards, Criteria and Standards Division, Washington, DC. EPA 440/5-80-063.

U.S. EPA. 1984. Health and Environmental Effects Profile for Dinitrophenols (Selected). Prepared by the Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office, Cincinnati, OH for the Office of Solid Waste and Emergency Response, Washington, DC.

Agency Work Group Review — 06/13/1991

EPA Contacts:

Please contact the IRIS Hotline for all questions concerning this assessment or IRIS, in general, at (202)566-1676 (phone), (202)566-1749 (FAX) [redacted] (internet address).

A comprehensive review of toxicological studies published through May 2005 indicated that there is insufficient health effects data to derive an RfC for 2,4-Dinitrophenol at this time. For more information, IRIS users may contact the IRIS Hotline [redacted] 202-566-1676.

II. Carcinogenicity Assessment for Lifetime Exposure

Substance Name — 2,4-Dinitrophenol
CASRN — 51-28-5

This substance/agent has not undergone a complete evaluation and determination under US EPA's IRIS program for evidence of human carcinogenic potential.

III. [reserved]
IV. [reserved]
V. [reserved]

VI. Bibliography

Substance Name — 2,4-Dinitrophenol
CASRN — 51-28-5

VI.A. Oral RfD References

Gibson, J.E. 1973. Teratology studies in mice with 2-secbutyl-4, 6- dinitrophenol (dinoseb). Food Cosmet. Toxicol. 11: 31.

Horner, W.D. 1942. Dinitrophenol and its relation to formation of cataracts. Arch. Ophthal. 27: 1097.

Spencer, H.C., V.K. Rowe, E.M. Adams and D.D. Irish. 1948. Toxicological studies on laboratory animals of certain alkyl dinitrophenols used in agriculture. J. Ind. Hyg. Toxicol. 30: 10-25.

U.S. EPA. 1980. Ambient Water Quality Criteria Document for Nitrophenols. Prepared by the Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office for the Office of Water Regulations and Standards, Criteria and Standards Division, Washington, DC.

VI.B. Inhalation RfD References

U.S. EPA. 1980. Ambient Water Quality Criteria Document for Nitrophenols. Prepared by the Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office, Cincinnati, OH for the Office of Water Regulations and Standards, Criteria and Standards Division, Washington, DC. EPA 440/5-80-063.

U.S. EPA. 1984. Health and Environmental Effects Profile for Dinitrophenols (Selected). Prepared by the Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office, Cincinnati, OH for the Office of Solid Waste and Emergency Response, Washington, DC.

VI.C. Carcinogenicity Assessment References

None

VII. Revision History

Substance Name — 2,4-Dinitrophenol
CASRN — 51-28-5

Date	Section	Description
10/01/1991	I.B.	Inhalation RfC message on-line
10/28/2003	I.A.6., I.B.	Screening-Level Literature Review Findings message has been added.
06/22/2005	I.A.6., I.B.	Screening-Level Literature Review Findings message has been removed and replaced by comprehensive literature review conclusions.

VIII. Synonyms

Substance Name — 2,4-Dinitrophenol
CASRN — 51-28-5
Last Revised — 03/31/1987

- 51-28-5
- ALDIFEN
- CHEMOX PE
- 2,4-DINITROFENOL
- DINITROFENOLO
- 2,4-Dinitrophenol
- Dinitrophenol, 2,4-
- alpha-DINITROPHENOL
- 2,4-DNP
- FENOXYL CARBON N
- 1-HYDROXY-2,4-DINITROBENZENE
- MAROXOL-50
- NITRO KLEENUP
- NSC 1532
- PHENOL, 2,4-DINITRO-
- PHENOL, alpha-DINITRO-
- RCRA WASTE NUMBER P048
- SOLFO BLACK 2B SUPRA
- SOLFO BLACK B
- SOLFO BLACK BB
- SOLFO BLACK G
- SOLFO BLACK SB
- TERTROSULPHUR BLACK PB
- TERTROSULPHUR PBR

Acenaphthylene; CASRN 208-96-8

Human health assessment information on a chemical substance is included in the IRIS database only after a comprehensive review of toxicity data, as outlined in the IRIS assessment development process. Sections I (Health Hazard Assessments for Noncarcinogenic Effects) and II (Carcinogenicity Assessment for Lifetime Exposure) present the conclusions that were reached during the assessment development process. Supporting information and explanations of the methods used to derive the values given in IRIS are provided in the guidance documents located on the IRIS website.

STATUS OF DATA FOR Acenaphthylene

File First On-Line 01/01/1991

Category (section)	Assessment Available?	Last Revised
Oral RfD (I.A.)	not evaluated	
Inhalation RfC (I.B.)	not evaluated	
Carcinogenicity Assessment (II.)	yes	01/01/1991

I. Chronic Health Hazard Assessments for Noncarcinogenic Effects

I.A. Reference Dose for Chronic Oral Exposure (RfD)

Substance Name — Acenaphthylene
CASRN — 208-96-8

Not available at this time.

I.B. Reference Concentration for Chronic Inhalation Exposure (RfC)

Substance Name — Acenaphthylene
CASRN — 208-96-8

Not available at this time.

II. Carcinogenicity Assessment for Lifetime Exposure

Substance Name — Acenaphthylene
CASRN — 208-96-8
Last Revised — 01/01/1991

Section II provides information on three aspects of the carcinogenic assessment for the substance in question; the weight-of-evidence judgment of the likelihood that the substance is a human carcinogen, and quantitative estimates of risk from oral exposure and from inhalation exposure. The quantitative risk estimates are presented in three ways. The slope factor is the result of application of a low-dose extrapolation procedure and is presented as the risk per (mg/kg)/day. The unit risk is the quantitative estimate in terms of either risk per ug/L drinking water or risk per ug/cu.m air breathed. The third form in which risk is presented is a drinking water or air concentration providing cancer risks of 1 in 10,000, 1 in 100,000 or 1 in 1,000,000. The rationale and methods used to develop the carcinogenicity information in IRIS are described in The Risk Assessment Guidelines of 1986 (EPA/600/8-87/045) and in the IRIS Background Document. IRIS summaries developed since the publication of EPA's more recent Proposed Guidelines for Carcinogen Risk Assessment also utilize those Guidelines where indicated (Federal Register 61(79):17960-18011, April 23, 1996). Users are referred to Section I of this IRIS file for information on long-term toxic effects other than carcinogenicity.

II.A. Evidence for Human Carcinogenicity

II.A.1. Weight-of-Evidence Characterization

Classification — D; not classifiable as to human carcinogenicity

Basis — Based on no human data and inadequate data from animal bioassays.

II.A.2. Human Carcinogenicity Data

None.

II.A.3. Animal Carcinogenicity Data

Inadequate. No tumors were observed in a lifetime study, when 0.25% acenaphthylene (purity not specified) was applied to the skin (dose, frequency and duration not stated) of mice (sex and strain not specified) (Cook, 1932). Survival was 65% at 6 months, and 35% at 1 year. It is not stated whether a control group was used. In the series of experiments, however, the dermal application of other polycyclic aromatic hydrocarbons did result in the formation of mouse skin tumors.

II.A.4. Supporting Data for Carcinogenicity

Acenaphthylene (1 mM) yielded positive results in a Salmonella typhimurium forward mutation assay (Kaden et al., 1979) and was not positive in a Salmonella typhimurium TA98 and TA100 in the presence of hepatic homogenates (Bos et al., 1988).

II.B. Quantitative Estimate of Carcinogenic Risk from Oral Exposure

None.

II.C. Quantitative Estimate of Carcinogenic Risk from Inhalation Exposure

None.

II.D. EPA Documentation, Review, and Contacts (Carcinogenicity Assessment)

II.D.1. EPA Documentation

Source Document — U.S. EPA, 1990

The 1990 Drinking Water Criteria Document for Polycyclic Aromatic Hydrocarbons has received Agency and external review.

II.D.2. EPA Review (Carcinogenicity Assessment)

Agency Work Group Review — 02/07/1990

Verification Date — 02/07/1990

II.D.3. EPA Contacts (Carcinogenicity Assessment)

Please contact the IRIS Hotline for all questions concerning this assessment or IRIS, in general, at (202)566-1676 (phone), (202)566-1749 (FAX) or [redacted] (internet address).

III. [reserved]
IV. [reserved]
V. [reserved]

VI. Bibliography

Substance Name — Acenaphthylene
CASRN — 208-96-8

VI.A. Oral RfD References

None

VI.B. Inhalation RfC References

None

VI.C. Carcinogenicity Assessment References

Bos, R.P., J.L.G. Theuws, F.J. Jongeneelen and P.Th. Henderson. 1988. Mutagenicity of bi-, tri-, and tetra-cyclic aromatic hydrocarbons in the "taped-plate assay" and in the conventional Salmonella mutagenicity assay. Mutat. Res. 204: 203-206.

Cook, J.W. 1932. The production of cancer by pure hydrocarbons -- Part II. Proc. Royal Soc. London S.B. 11: 485-496.

Kaden, D.A., R.A. Hites and W.G. Thilly. 1979. Mutagenicity of soot and associated polycyclic aromatic hydrocarbons to Salmonella typhimurium. Cancer Res. 39: 4152-4159.

U.S. EPA. 1990. Drinking Water Criteria Document for Polycyclic Aromatic Hydrocarbons (PAHs). Prepared by the Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office, Cincinnati, OH for the Office of Drinking Water, Washington, DC. (Final Draft)

VII. Revision History

Substance Name — Acenaphthylene
CASRN — 208-96-8

Date	Section	Description
01/01/1991	II.	Carcinogen assessment on-line

VIII. Synonyms

Substance Name — Acenaphthylene
CASRN — 208-96-8
Last Revised — 01/01/1991

- 208-96-8
- Acenaphthylene
- Cyclopenta(de)naphthalene
- HSDB 2661
- NSC 59821

Chrysene; CASRN 218-01-9

Human health assessment information on a chemical substance is included in the IRIS database only after a comprehensive review of toxicity data, as outlined in the IRIS assessment development process. Sections I (Health Hazard Assessments for Noncarcinogenic Effects) and II (Carcinogenicity Assessment for Lifetime Exposure) present the conclusions that were reached during the assessment development process. Supporting information and explanations of the methods used to derive the values given in IRIS are provided in the guidance documents located on the IRIS website.

STATUS OF DATA FOR Chrysene

File First On-Line 12/01/1990

Category (section)	Assessment Available?	Last Revised
Oral RfD (I.A.)	not evaluated	
Inhalation RfC (I.B.)	not evaluated	
Carcinogenicity Assessment (II.)	yes	12/01/1990

I. Chronic Health Hazard Assessments for Noncarcinogenic Effects

I.A. Reference Dose for Chronic Oral Exposure (RfD)

Substance Name — Chrysene
CASRN — 218-01-9

Not available at this time.

I.B. Reference Concentration for Chronic Inhalation Exposure (RfC)

Substance Name — Chrysene
CASRN — 218-01-9

Not available at this time.

II. Carcinogenicity Assessment for Lifetime Exposure

Substance Name — Chrysene
CASRN — 218-01-9
Last Revised — 12/01/1990

Section II provides information on three aspects of the carcinogenic assessment for the substance in question; the weight-of-evidence judgment of the likelihood that the substance is a human carcinogen, and quantitative estimates of risk from oral exposure and from inhalation exposure. The quantitative risk estimates are presented in three ways. The slope factor is the result of application of a low-dose extrapolation procedure and is presented as the risk per (mg/kg)/day. The unit risk is the quantitative estimate in terms of either risk per ug/L drinking water or risk per ug/cu.m air breathed. The third form in which risk is presented is a drinking water or air concentration providing cancer risks of 1 in 10,000, 1 in 100,000 or 1 in 1,000,000. The rationale and methods used to develop the carcinogenicity information in IRIS are described in The Risk Assessment Guidelines of 1986 (EPA/600/8-87/045) and in the IRIS Background Document. IRIS summaries developed since the publication of EPA's more recent Proposed Guidelines for Carcinogen Risk Assessment also utilize those Guidelines where indicated (Federal Register 61(79):17960-18011, April 23, 1996). Users are referred to Section I of this IRIS file for information on long-term toxic effects other than carcinogenicity.

II.A. Evidence for Human Carcinogenicity

II.A.1. Weight-of-Evidence Characterization

Classification — B2; probable human carcinogen

Basis — No human data and sufficient data from animal bioassays. Chrysene produced carcinomas and malignant lymphoma in mice after intraperitoneal injection and skin carcinomas in mice following dermal exposure. Chrysene produced chromosomal abnormalities in hamsters and mouse germ cells after gavage exposure, positive responses in bacterial gene mutation assays and transformed mammalian cells exposed in culture.

II.A.2. Human Carcinogenicity Data

None. Although there are no human data that specifically link exposure to chrysene to human cancers, chrysene is a component of mixtures that have been associated with human cancer. These include coal tar, soots, coke oven emissions and cigarette smoke (U.S. EPA, 1984, 1990; IARC, 1983, 1984).

II.A.3. Animal Carcinogenicity Data

Sufficient. Intraperitoneal chrysene injections in male mice caused an increased incidence of liver tumors (Wislocki et al., 1986; Buening et al., 1979) and increased incidences of malignant lymphoma and lung tumors (Wislocki et al., 1986). In mouse skinpainting assays chrysene tested positive in both initiation and complete carcinogen studies (Wynder and Hoffman, 1959).

On days 1, 8, and 15 of age, groups of male (28 to 35/group) and female (24 to 34/group) CD-1 mice received intraperitoneal injections of chrysene in dimethyl sulfoxide (DMSO) (total dose = 0, 160 ug or 640 ug/mouse) (Wislocki et al., 1986). The low-dose and high-dose experiments were initiated 10 weeks apart and had separate concurrent vehicle controls. Tumors were evaluated in animals that died spontaneously after weaning and in all remaining animals at 1 year after exposure. A statistically significant increase in the incidence of liver adenomas or carcinomas occurred in treated male mice relative to their respective controls: 10/35 (29%) and 5/45 (11%) in the low-dose mice and controls, respectively; and 14/34 (41%) and 2/28 (7%) in the high-dose mice and controls, respectively. The majority of the liver tumors in the high-dose males were carcinomas and the incidence was statistically significantly greater than in its respective control group, whereas the majority of tumors in the low-dose males were adenomas. Liver adenonas, but no carcinomas were observed in the control groups. In female mice no tumors were observed. The incidence of lung adenomas or carcinomas in the low-dose male mice was 6/35 (17%) (one of which was a carcinoma) and 4/45 (9%) (two of which were carcinomas) in their control group. The incidence of lung adenomas was statistically elevated in high-dose males 7/34 (21%) when compared with their control group (1/28, 4%). The incidence of malignant lymphoma was significantly elevated (3/35, 9%) in low-dose males relative to the controls (0/45), but not in the high-dose males (1/34) relative to their controls (1/28). In females, there was no statistically significant increase in lung tumors or lymphoma. This is generally regarded as a short-term exposure study with a less-than-lifetime (1 year) experiment.

Male and female Swiss Webster BLU/Ha(ICR) mice received intraperitoneal injections of chrysene in DMSO (total dose = 320 ug/mouse) or DMSO alone on days 1, 8 and 15 after birth (Buening et al., 1979). Mice were killed at 38- 42 weeks of age. The incidences of lung tumors in the treated group appeared to be elevated (5/24 (21%) and 1/11 (9%) in males and females, respectively), although not statistically significantly, when compared with the control groups (2/21 (10%) and 7/38 (18%) in males and females, respectively). The incidence of hepatic tumors in the treated males was statistically significantly greater (6/24, 25%) than in control

males (0/21), whereas no hepatic tumors were found in the females. In a replication of this study, lung tumor incidence was not increased; however, the incidence of hepatic tumors in treated male mice was significantly elevated (6/27, 22%) over the incidence in the control group (0/52) (Chang et al., 1983). No liver tumors were reported in the females. These studies are regarded as short-term exposure, less-than-lifetime experiments.

Chrysene has been tested for complete carcinogenic activity and initiating activity in mouse skin painting assays. It was shown to be a complete carcinogen (Wynder and Hoffmann, 1959). Chrysene has produced positive results for initiating activity in several mouse strains (C3H, ICR/Ha Swiss, Ha/ICR/Mil Swiss, CD-1, Sencar) when applied in combination with various promoting agents (decahydronaphthalene, croton oil, TPA) producing skin papillomas and carcinomas (Van Duuren et al., 1966; Scribner, 1973; Horton and Christian, 1974; Hecht et al., 1974; Levin et al., 1978; Wood et al., 1979, 1980; Slaga et al., 1980; Rice et al., 1985).

II.A.4. Supporting Data for Carcinogenicity

Chrysene produced positive results in tests for reverse mutation in three strains of Salmonella typhimurium and positive results for forward mutation in one strain (McCann et al., 1975; Tokiwa et al., 1977; Wood et al., 1977; LaVoie et al., 1979; Dunkel and Simmon, 1980; Sakai et al., 1985; Kaden et al., 1979).

Chromosomal effects were observed in Chinese hamster cells, mouse oocytes and hamster spermatogonia following gavage doses of 450 or 900 mg/kg (Basler et al., 1977; Roszinsky-Kocher et al., 1979). Positive results were obtained (10 ug/mL) in tests for cell transformation in Syrian hamster embryo cells and negative results in mouse prostrate C3HG23 cells (Marquardt and Heidelberger, 1972; Pienta et al., 1977).

Current theories on mechanisms of metabolic activation of polycyclic aromatic hydrocarbons are consistent with a carcinogenic potential for chrysene. Chrysene has a "bay-region" in structure (Jerina et al., 1978). It is metabolized by mixed function oxidases to reactive "bay-region" diol epoxides (Nordqvist et al., 1981; Vyas et al., 1982) that are mutagenic in bacteria and tumorigenic in mouse skin painting assays and when injected into newborn mice (Levin et al., 1978; Wood et al., 1977, 1979; Slaga et al., 1980; Chang et al., 1983).

II.B. Quantitative Estimate of Carcinogenic Risk from Oral Exposure

Not available.

II.C. Quantitative Estimate of Carcinogenic Risk from Inhalation Exposure

Not available.

II.D. EPA Documentation, Review, and Contacts (Carcinogenicity Assessment)

II.D.1. EPA Documentation

Source Document — U.S. EPA, 1984, 1990

The 1990 Drinking Water Criteria Document for Polychlorinated Aromatic Hydrocarbons has received Agency and external review.

II.D.2. EPA Review (Carcinogenicity Assessment)

Agency Work Group Review — 02/07/1990, 08/05/1993, 09/21/1993, 02/02/1994

Verification Date — 02/07/1990

II.D.3. EPA Contacts (Carcinogenicity Assessment)

Please contact the IRIS Hotline for all questions concerning this assessment or IRIS, in general, at (202)566-1676 (phone), (202)566-1749 (FAX) or [redacted] (internet address).

III. [reserved]
IV. [reserved]
V. [reserved]

VI. Bibliography

Substance Name — Chrysene
CASRN — 218-01-9

VI.A. Oral RfD References

None

VI.B. Inhalation RfC References

None

VI.C. Carcinogenicity Assessment References

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U.S. EPA. 1990. Drinking Water Criteria Document for Polycyclic Aromatic Hydrocarbons (PAHs). Prepared by the Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office, Cincinnati, OH for the Office of Drinking Water, Washington, DC. Final Draft. ECAO-CIN-D010, September, 1990.

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Wynder, E.L. and D. Hoffmann. 1959. A study of tobacco carcinogenesis. VII. The role of higher polycyclic hydrocarbons. Cancer. 12: 1079-1086.

VII. Revision History

Substance Name — Chrysene
CASRN — 218-01-9

Date	Section	Description
12/01/1990	II.	Carcinogen assessment on-line

VIII. Synonyms

Substance Name — Chrysene
CASRN — 218-01-9
Last Revised — 12/01/1990

- 218-01-9
- Chrysene
- BENZ(a)PHENANTHRENE
- BENZO(a)PHENANTHRENE
- Chrysene
- HSDB 2810
- NSC 6175
- RCRA WASTE NUMBER U050
- 1,2-BENZOPHENANTHRENE
- 1,2-BENZPHENANTHRENE
- 1,2,5,6-DIBENZONAPHTHALENE

Benzo[b]fluoranthene; CASRN 205-99-2

Human health assessment information on a chemical substance is included in the IRIS database only after a comprehensive review of toxicity data, as outlined in the IRIS assessment development process. Sections I (Health Hazard Assessments for Noncarcinogenic Effects) and II (Carcinogenicity Assessment for Lifetime Exposure) present the conclusions that were reached during the assessment development process. Supporting information and explanations of the methods used to derive the values given in IRIS are provided in the guidance documents located on the IRIS website.

STATUS OF DATA FOR Benzo[b]fluoranthene

File First On-Line 12/01/1990

Category (section)	Assessment Available?	Last Revised
Oral RfD (I.A.)	not evaluated	
Inhalation RfC (I.B.)	not evaluated	
Carcinogenicity Assessment (II.)	yes	12/01/1990

I. Chronic Health Hazard Assessments for Noncarcinogenic Effects

I.A. Reference Dose for Chronic Oral Exposure (RfD)

Substance Name — Benzo[b]fluoranthene
CASRN — 205-99-2

Not available at this time.

I.B. Reference Concentration for Chronic Inhalation Exposure (RfC)

Substance Name — Benzo[b]fluoranthene
CASRN — 205-99-2

Not available at this time.

II. Carcinogenicity Assessment for Lifetime Exposure

Substance Name — Benzo[b]fluoranthene
CASRN — 205-99-2
Last Revised — 12/01/1990

Section II provides information on three aspects of the carcinogenic assessment for the substance in question; the weight-of-evidence judgment of the likelihood that the substance is a human carcinogen, and quantitative estimates of risk from oral exposure and from inhalation exposure. The quantitative risk estimates are presented in three ways. The slope factor is the result of application of a low-dose extrapolation procedure and is presented as the risk per (mg/kg)/day. The unit risk is the quantitative estimate in terms of either risk per ug/L drinking water or risk per ug/cu.m air breathed. The third form in which risk is presented is a drinking water or air concentration providing cancer risks of 1 in 10,000, 1 in 100,000 or 1 in 1,000,000. The rationale and methods used to develop the carcinogenicity information in IRIS are described in The Risk Assessment Guidelines of 1986 (EPA/600/8-87/045) and in the IRIS Background Document. IRIS summaries developed since the publication of EPA's more recent Proposed Guidelines for Carcinogen Risk Assessment also utilize those Guidelines where indicated (Federal Register 61(79):17960-18011, April 23, 1996). Users are referred to Section I of this IRIS file for information on long-term toxic effects other than carcinogenicity.

II.A. Evidence for Human Carcinogenicity

II.A.1. Weight-of-Evidence Characterization

Classification — B2; probable human carcinogen

Basis — Based on no human data and sufficient data from animal bioassays. Benzo[b]fluoranthene produced tumors in mice after lung implantation, intraperitoneal (i.p.) or subcutaneous (s.c.) injection, and skin painting.

II.A.2. Human Carcinogenicity Data

None. Although there are no human data that specifically link exposure to benzo[b]fluoranthene to human cancers, benzo[b]fluoranthene is a component of mixtures that have been associated with human cancer. These include coal tar, soots, coke oven emissions and cigarette smoke (U.S. EPA, 1984, 1990; IARC, 1984).

II.A.3. Animal Carcinogenicity Data

Sufficient. In a lifetime implant study, 3-month-old female Osborne- Mendel rats (35/group) received a single lung implant of either 0.1 mg (0.4 mg/kg), 0.3 mg (1.2 mg/kg) or 1 mg (4.1 mg/kg) benzo[b]fluoranthene in 0.05 mL of a 1:1 (v:v) mixture of beeswax and trioctanoin (Deutsch-Wenzel et al., 1983). Controls consisted of an untreated group and a group receiving an implant of the vehicle. The median survival times were: 118, 104, 110, 113 and 112 weeks, for the untreated, vehicle control, low-, mid- and high-dose groups, respectively. The incidences of epidermoid carcinomas and pleomorphic sarcomas in the lung and thorax (combined) were: untreated controls, 0/35; vehicle controls, 0/35; low-dose group, 1/35; mid-dose group, 3/35; and high- dose group, 13/35. These incidences showed a statistically significant dose- response relationship.

Groups of 15-17 male and 17-18 female CD-1 mice received i.p. injections of benzo[b]fluoranthene in DMSO on days 1, 8 and 15 after birth (total dose was approximately 126 ug/mouse) and were sacrificed at 52 weeks of age (LaVoie et al., 1987). A statistically significant increase in the incidence of liver adenomas and hepatomas (combined) occurred in treated males (8/15) relative to vehicle controls (1/17), but not in females. Lung adenomas (2/15 males, 3/17 females) were reported in treated animals, whereas none were found in controls.

Injection site sarcomas occurred in 18/24 survivors of a total of 16 male and 14 female XVIInc/Z mice that received three s.c. injections of benzo[b]fluoranthene (total dose = 2.6 mg) over a period of 2 months (Lacassagne et al., 1963).

Benzo[b]fluoranthene has yielded positive results for complete carcinogenic activity and initiating activity in mouse skin-painting assays. In skin-painting assays groups of 20 female Swiss mice were treated 3 times/week with 0.01, 0.1 or 0.5% solutions of benzo[b]fluoranthene in acetone (Wynder and Hoffmann, 1959). The high dose produced papillomas in 100% of the mice and carcinomas in 90% of the mice within 8 months. The middle dose produced papillomas in 65% and carcinomas in 85% within 12 months, while the low dose produced a papilloma in only 1 animal among 10 survivors at 14 months. No concurrent controls were observed. LaVoie et al. (1982) applied solutions of 0, 10, 30 or 100 ug benzo[b]fluoranthene in 0.1 mL acetone (10 doses, one every other day) to the skins of groups of 20 Crl:CD-1 mice. This regimen was followed by treatment with 2.5 ug 12-0-tetradecanoyl-phorbol-13- acetone (TPA) (a tumor promoter), 3 times/week for 20 weeks. Increases in the percentage of tumor-bearing animals (0,

45, 60, 80) as well as the number of skin tumors/animal (0, 0.9, 2.3, 7.1) appeared to be dose-related. Similar studies by Amin et al. (1985a,b) resulted in comparable elevations of tumor incidence.

II.A.4. Supporting Data for Carcinogenicity

Positive results have been reported for a reverse mutation assay in Salmonella TA98 and the results for Salmonella TA100 have been positive and not positive (Mossanda et al., 1979; LaVoie et al., 1979; Hermann, 1981; Amin et al., 1985a,b).

Current theories on mechanisms of metabolic activation of polycyclic aromatic hydrocarbons are consistent with a carcinogenic potential for benzo[b]fluoranthene. Benzo[b]fluoranthene does not have a "classic bay- region" structure (Jerina et al., 1978). It is metabolized by mixed function oxidases to dihydrodiols (Amin et al., 1982). The 9,10-dihydrodiol is tumorigenic in mouse skin-painting assays, suggesting the possible formation of a reactive diol-epoxide (LaVoie et al., 1982).

II.B. Quantitative Estimate of Carcinogenic Risk from Oral Exposure

Not available.

II.C. Quantitative Estimate of Carcinogenic Risk from Inhalation Exposure

Not available.

II.D. EPA Documentation, Review, and Contacts (Carcinogenicity Assessment)

II.D.1. EPA Documentation

Source Document — U.S. EPA, 1984, 1990

The 1990 Drinking Water Criteria Document for Polycyclic Aromatic Hydrocarbons has received Agency and external review.

II.D.2. EPA Review (Carcinogenicity Assessment)

Agency Work Group Review — 02/07/1990, 08/05/1993, 09/21/1993, 02/02/1994

Verification Date — 02/07/1990

II.D.3. EPA Contacts (Carcinogenicity Assessment)

Please contact the IRIS Hotline for all questions concerning this assessment or IRIS, in general, at (202)566-1676 (phone), (202)566-1749 (FAX) or [redacted] (internet address).

III. [reserved]
IV. [reserved]
V. [reserved]

VI. Bibliography

Substance Name — Benzo[b]fluoranthene
CASRN — 205-99-2

VI.A. Oral RfD References

None

VI.B. Inhalation RfC References

None

VI.C. Carcinogenicity Assessment References

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Amin, S., K. Huie and S.S. Hecht. 1985a. Mutagenicity and tumor initiating activity of methylated benzo[b]fluoranthene. Carcinogenesis. 6(7): 1023- 1025.

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Jerina, D.M., H. Yagi, R.E. Lehr, et al. 1978. The Bay-region theory of carcinogenisis by polycyclic aromatic hydrocarbons. In: Polycyclic Hydrocarbons and Cancer, Vol. 1. Environment, Chemistry and Metabolism, H.V. Gelboin and P.O.P. Ts'o, Ed. Academic Press, NY.

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LaVoie, E.J., S. Amin., S.S. Hecht, K. Furuya and D. Hoffmann. 1982. Tumor initiating activity of dihydrodiols of benzo[b]fluoranthene, benzo[j]fluoranthene and benzo[k]fluoranthene. Carcinogenesis. 3(1): 49-52.

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U.S. EPA. 1984. Carcinogen Assessment of Coke Oven Emissions. Office of Health and Environmental Assessment, Washington, DC. EPA 600/6-82-003F. NTIS PB 84-170181.

U.S. EPA. 1990. Drinking Water Criteria Document for Polycyclic Aromatic Hydrocarbons (PAHs). Prepared by the Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office, Cincinnati, OH for the Office of Drinking Water, Washington, DC. Final Draft. ECAO-CIN-D010, September, 1990.

Wynder, E.L. and D. Hoffmann. 1959. A study of tobacco carcinogenesis. VII. The role of higher polycyclic hydrocarbons. Cancer. 12: 1079-1086.

VII. Revision History

Substance Name — Benzo[b]fluoranthene
CASRN — 205-99-2

Date	Section	Description
12/01/1990	II.	Carcinogen assessment on-line

VIII. Synonyms

Substance Name — Benzo[b]fluoranthene
CASRN — 205-99-2
Last Revised — 12/01/1990

- 205-99-2
- Benz(e)acephenanthrylene
- B(b)F
- BENZ(e)ACEPHENANTHRYLENE
- Benzo(b)fluoranthene
- Benzo(e)fluoranthene
- HSDB 4035

- NSC 89265
- 2,3-BENZFLUORANTHENE
- 2,3-BENZOFLUORANTHENE
- 2,3-BENZOFLUORANTHRENE
- 3,4-BENZ(e)ACEPHENANTHRYLENE
- 3,4-BENZFLUORANTHENE
- 3,4-Benzofluoranthene

Benz[a]anthracene; CASRN 56-55-3

Human health assessment information on a chemical substance is included in the IRIS database only after a comprehensive review of toxicity data, as outlined in the IRIS assessment development process. Sections I (Health Hazard Assessments for Noncarcinogenic Effects) and II (Carcinogenicity Assessment for Lifetime Exposure) present the conclusions that were reached during the assessment development process. Supporting information and explanations of the methods used to derive the values given in IRIS are provided in the guidance documents located on the IRIS website.

STATUS OF DATA FOR Benz[a]anthracene

File First On-Line 12/01/1990

Category (section)	Assessment Available?	Last Revised
Oral RfD (I.A.)	not evaluated	
Inhalation RfC (I.B.)	not evaluated	
Carcinogenicity Assessment (II.)	yes	12/01/1990

I. Chronic Health Hazard Assessments for Noncarcinogenic Effects

I.A. Reference Dose for Chronic Oral Exposure (RfD)

Substance Name — Benz[a]anthracene
CASRN — 56-55-3

Not available at this time.

I.B. Reference Concentration for Chronic Inhalation Exposure (RfC)

Substance Name — Benz[a]anthracene
CASRN — 56-55-3

Not available at this time.

II. Carcinogenicity Assessment for Lifetime Exposure

Substance Name — Benz[a]anthracene
CASRN — 56-55-3
Last Revised — 12/01/1990

Section II provides information on three aspects of the carcinogenic assessment for the substance in question; the weight-of-evidence judgment of the likelihood that the substance is a human carcinogen, and quantitative estimates of risk from oral exposure and from inhalation exposure. The quantitative risk estimates are presented in three ways. The slope factor is the result of application of a low-dose extrapolation procedure and is presented as the risk per (mg/kg)/day. The unit risk is the quantitative estimate in terms of either risk per ug/L drinking water or risk per ug/cu.m air breathed. The third form in which risk is presented is a drinking water or air concentration providing cancer risks of 1 in 10,000, 1 in 100,000 or 1 in 1,000,000. The rationale and methods used to develop the carcinogenicity information in IRIS are described in The Risk Assessment Guidelines of 1986 (EPA/600/8-87/045) and in the IRIS Background Document. IRIS summaries developed since the publication of EPA's more recent Proposed Guidelines for Carcinogen Risk Assessment also utilize those Guidelines where indicated (Federal Register 61(79):17960-18011, April 23, 1996). Users are referred to Section I of this IRIS file for information on long-term toxic effects other than carcinogenicity.

II.A. Evidence for Human Carcinogenicity

II.A.1. Weight-of-Evidence Characterization

Classification — B2; probable human carcinogen

Basis — Based on no human data and sufficient data from animal bioassays. Benz[a]anthracene produced tumors in mice exposed by gavage; intraperitoneal, subcutaneous or intramuscular injection; and topical application. Benz[a]anthracene produced mutations in bacteria and in mammalian cells, and transformed mammalian cells in culture.

II.A.2. Human Carcinogenicity Data

None. Although there are no human data that specifically link exposure to benz[a]anthracene to human cancers, benz[a]anthracene is a component of mixtures that have been associated with human cancer. These include coal tar, soots, coke oven emissions and cigarette smoke (U.S. EPA, 1984, 1990; IARC, 1984; Lee et al., 1976; Brockhaus and Tomingas, 1976).

II.A.3. Animal Carcinogenicity Data

Sufficient. Benz[a]anthracene administration caused an increase in the incidence of tumors by gavage (Klein, 1963); dermal application (IARC, 1973); and both subcutaneous injection (Steiner and Faulk, 1951; Steiner and Edgecomb, 1952) and intraperitoneal injection (Wislocki et al., 1986) assays. A group of male B6AF1/J mice was exposed to gavage solutions containing 3% benz[a]anthracene in Methocel-Aerosol O.T. (dioctyl ester of sodium sulfo- succinic acid), 3 doses/week for 5 weeks (total dose of approximately 225 mg/mouse, 500 mg/kg/day) or the vehicle (Klein, 1963). Mice were evaluated for tumors on days 437-444 and 547 after treatment was initiated. A statistical analysis was not reported. Increased incidences of pulmonary adenoma and hepatoma in treated vs. control mice were reported by the authors at both observation times. The incidence of pulmonary adenoma at 437-444 days was 37/39 (95%) in treated animals vs. 10/38 (26%) in controls; whereas at 547 days, 19/20 (95%) treated animals and 7/20 (35%) controls had pulmonary adenomas. The incidence of hepatomas at 437 to 440 days was 18/39 (46%) in treated animals compared with 0/38 among the vehicle controls. After 547 days, the hepatoma incidences increased to 20/20 for the treated animals versus 2/20 (10%) for vehicle controls.

Mice (strain and sex not specified) were exposed to a single gavage dose of 0.5 mg benz[a]anthracene in mineral oil (approximately 17 mg/kg). No tumors were reported in 13 mice examined 16 months after exposure. In another part of the study, multiple gavage treatments, 8 or 16 treatments at 3-7 day intervals over a 16-month period, resulted in forestomach papillomas in 2/27 treated mice compared with 0/16 in vehicle controls (Bock and King, 1959).

Groups of male and female CD-1 mice (n=90-100) received intraperitoneal injections of benz[a]anthracene in DMSO on days 1, 8, and 15 of age (total dose = 638 ug/mouse) (Wislocki et al., 1986). Tumors were evaluated in animals that died spontaneously after weaning and in all remaining animals at 1 year after exposure. In treated male mice, a statistically significant increase in the incidence of liver adenomas or carcinomas (31/39 treated vs. 2/28 controls) occurred; 25/39 had carcinomas. Female mice did not develop liver tumors. The incidence of pulmonary adenomas or carcinomas in benz[a]anthracene-treated males (6/39, with a majority of adenomas) was increased but not statistically significantly relative to the vehicle controls (1/28).

In the female mice, however, the incidence of pulmonary adenomas was significantly elevated in the treated group (6/32) when compared with vehicle controls (0/31).

Benz[a]anthracene yielded positive results in tests for complete carcinogenicity and initiating activity in skin painting assays in C3H/He, CAF1 and ICR/Ha mouse strains. These studies are reviewed in IARC (1973).

Subcutaneous injection of benz[a]anthracene in tricaprylin into C57Bl mice (40-50/group) produced injection site sarcomas 9 months after treatment (Steiner and Falk, 1951; Steiner and Edgecomb, 1952). The sarcoma incidences were: uninjected controls, 0/76; tricaprylin controls, 3/28 (11%); 0.05 mg, 5/43 (12%); 0.2 mg, 11/43 (26%); 1.0 mg, 15/31 (48%); 5.0 mg, 49/145 (34%); and 10 mg, 5/16 (31%). The results of similar experiments in this series were combined (Steiner and Edgecomb, 1952). A statistical analysis of the results was not reported. Survival was roughly equivalent in all groups (70%).

Klein (1952) showed that an intramuscular injection of benz[a]anthracene in combination with 1 or 3% croton oil produced injection site fibrosarcomas and hemangioendotheliomas in Strain A-derived albino mice; 3/24 mice injected with benz[a]anthracene and 1% croton oil and 1/26 mice injected with benz[a]anthracene and 3% croton oil developed tumors. None of the 30 mice injected with benz[a]anthracene and 0.1% croton oil and none of the 30 mice injected with benz[a]anthracene and 5% croton oil developed tumors. In the control groups none of the 35 mice injected only with 1% croton oil and none of the 32 mice injected only with benz[a]anthracene developed tumors. The survival rate for all groups was roughly equivalent (74%).

II.A.4. Supporting Data for Carcinogenicity

The results of tests for DNA damage in Escherichia coli have not been positive at concentrations of benz[a]anthracene up to 250 ug/mL and 1000 ug/well (Rosenkrantz and Poirier, 1979; DeFlora et al., 1984). Positive results were obtained in tests for reverse mutation in five different strains of Salmonella typhimurium and for forward mutation in one strain (McCann et al., 1975; Coombs et al., 1976; Simmon, 1979; Salamone et al., 1979; Bartsch et al., 1980; DeFlora et al., 1984; Norpoth et al., 1984; Utesch et al., 1987; Bos et al., 1988; Kaden et al. 1979).

Benz[a]anthracene produced positive results in an assay for mutations in Drosophila melongaster (Fahmy and Fahmy, 1973).

Tests for DNA damage, mutation, chromosomal effects and cell transformation in a variety of eukaryotic cell preparations have yielded mostly positive results. Benz[a]anthracene tested positive for DNA damage in primary rat hepatocytes and HeLa cells (Probst et al., 1981; Martin

et al., 1978). It also tested positive for forward mutation in Chinese hamster cells, V79 cells, mouse lymphoma L5178Y cells and rat liver epithelial cells (Slaga et al., 1978; Krahn and Heidelberger, 1977; Amacher et al., 1980; Amacher and Turner, 1980; Tong et al., 1981). Benz[a]anthracene tested positive for chromosomal affects in Chinese hamster ovary cells (Pal, 1981). Tests for cell transformation (cell morphology) have yielded positive results in Syrian hamster embryo cells and mouse prostate C3HG23 cells (Pienta et al., 1977; DiPaolo et al., 1969, 1971; Marquardt and Heidelberger, 1972).

Current theories on mechanisms of metabolic activation of polycyclic aromatic hydrocarbons are consistent with a carcinogenic potential for benz[a]anthracene. Benz[a]anthracene has a "bay-region" structure (Jerina et al., 1978). It is metabolized by mixed function oxidases to reactive "bay- region" diol epoxides that are mutagenic in bacteria and tumorigenic in mouse skin painting assays (Booth and Sims, 1974; Wood et al., 1977a,b).

II.B. Quantitative Estimate of Carcinogenic Risk from Oral Exposure

Not available.

II.C. Quantitative Estimate of Carcinogenic Risk from Inhalation Exposure

Not available.

II.D. EPA Documentation, Review, and Contacts (Carcinogenicity Assessment)

II.D.1. EPA Documentation

Source Document — U.S. EPA, 1984

The 1990 Drinking Water Criteria Document for Polycyclic Aromatic Hydrocarbons has received Agency and external review.

II.D.2. EPA Review (Carcinogenicity Assessment)

Agency Work Group Review — 02/07/1990, 08/05/1993, 09/21/1993, 02/02/1994

Verification Date — 02/07/1990

II.D.3. EPA Contacts (Carcinogenicity Assessment)

Please contact the IRIS Hotline for all questions concerning this assessment or IRIS, in general, at (202)566-1676 (phone), (202)566-1749 (FAX) or [redacted] (internet address).

III. [reserved]
IV. [reserved]
V. [reserved]

VI. Bibliography

Substance Name — Benz[a]anthracene
CASRN — 56-55-3

VI.A. Oral RfD References

None

VI.B. Inhalation RfC References

None

VI.C. Carcinogenicity Assessment References

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VII. Revision History

Substance Name — Benz[a]anthracene
CASRN — 56-55-3

Date	Section	Description
12/01/1990	II.	Carcinogen assessment on-line

VIII. Synonyms

Substance Name — Benz[a]anthracene
CASRN — 56-55-3
Last Revised — 12/01/1990

- 56-55-3
- Benz(a)anthracene
- benz(a)anthracene
- Benzanthracene
- Benzanthrene
- BENZO(a)ANTHRACENE
- BENZO(b)PHENANTHRENE
- Benzoanthracene
- HSDB 4003
- NSC 30970
- RCRA WASTE NUMBER U018
- Tetraphene
- 1,2-BENZ(a)ANTHRACENE
- 1,2-Benzanthracene
- 1,2-BENZANTHRAZEN [German]
- 1,2-BENZANTHRENE
- 1,2-BENZOANTHRACENE
- 2,3-Benzophenanthrene

EPA

EPA/635/R-17/003Fc
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Toxicological Review of Benzo[a]pyrene

Executive Summary

[CASRN 50-32-8]

January 2017

Integrated Risk Information System
National Center for Environmental Assessment
Office of Research and Development
U.S. Environmental Protection Agency
Washington, DC

EXECUTIVE SUMMARY

Summary of Occurrence and Health Effects

Benzo[a]pyrene is a five-ring polycyclic aromatic hydrocarbon (PAH). Benzo[a]pyrene (along with other PAHs) is released into the atmosphere as a component of smoke from forest fires, industrial processes, vehicle exhaust, cigarettes, and through the burning of fuel (such as wood, coal, and petroleum products). Oral exposure to benzo[a]pyrene can occur by eating certain food products, such as charred meats, where benzo[a]pyrene is formed during the cooking process, or by eating foods grown in areas contaminated with benzo[a]pyrene (from the air and soil). Dermal exposure may occur from contact with soils or materials that contain soot, tar, or crude petroleum products or by using certain pharmaceutical products containing coal tars, such as those used to treat the skin conditions, eczema and psoriasis. The magnitude of human exposure to benzo[a]pyrene and other PAHs depends on factors such as lifestyle (e.g., diet, tobacco smoking), occupation, and living conditions (e.g., urban versus rural setting, domestic heating, and cooking methods).

Animal studies demonstrate that exposure to benzo[a]pyrene is associated with developmental (including developmental neurotoxicity), reproductive, and immunological effects. In addition, epidemiology studies involving exposure to PAH mixtures have reported associations between internal biomarkers of exposure to benzo[a]pyrene (benzo[a]pyrene diol epoxide-DNA adducts) and adverse birth outcomes (including reduced birth weight, postnatal body weight, and head circumference), neurobehavioral effects, and decreased fertility.

Studies in multiple animal species demonstrate that benzo[a]pyrene is carcinogenic at multiple tumor sites (alimentary tract, liver, kidney, respiratory tract, pharynx, and skin) by all routes of exposure. In addition, there is strong evidence of carcinogenicity in occupations involving exposure to PAH mixtures containing benzo[a]pyrene, such as aluminum production, chimney sweeping, coal gasification, coal-tar distillation, coke production, iron and steel founding, and paving and roofing with coal tar pitch. An increasing number of occupational studies demonstrate a positive exposure-response relationship with cumulative benzo[a]pyrene exposure and lung cancer.

Effects Other Than Cancer Observed Following Oral Exposure

In animals, oral exposure to benzo[a]pyrene has been shown to result in developmental toxicity (including developmental neurotoxicity), reproductive toxicity, and immunotoxicity. Developmental effects in rats and mice include neurobehavioral changes and cardiovascular effects following gestational exposures. Reproductive and immune effects include decreased sperm counts, ovary weight, and follicle numbers, and decreased immunoglobulin and B cell numbers and thymus weight following oral exposures in adult animals. In humans, benzo[a]pyrene exposure occurs in conjunction with other PAHs and, as such, attributing the observed effects to

benzo[a]pyrene is complicated. However, some human studies report associations between particular health endpoints and internal measures of exposure, such as benzo[a]pyrene-deoxyribonucleic acid (DNA) adducts, or external measures of benzo[a]pyrene exposure. Overall, the human studies report developmental, neurobehavioral, reproductive, and immune effects that are generally analogous to those observed in animals, and provide qualitative, supportive evidence for hazards associated with benzo[a]pyrene exposure.

Oral Reference Dose (RfD) for Effects Other Than Cancer

Organ- or system-specific RfDs were derived for hazards associated with benzo[a]pyrene exposure where data were amenable (see Table ES-1). These organ- or system-specific reference values may be useful for subsequent cumulative risk assessments that consider the combined effect of multiple agents acting at a common site.

Developmental toxicity, represented by neurobehavioral changes persisting into adulthood, was chosen as the basis for the overall oral RfD as the available data indicate that developmental neurotoxicity represents the most sensitive hazard of benzo[a]pyrene exposure. The neurodevelopmental study by Chen et al. (2012) was used to derive the RfD. Altered responses in three behavioral tests (i.e., Morris water maze, elevated plus maze, and open field tests) were selected to represent the critical effect of abnormal behavior, due to the consistency (i.e., each of these responses were affected in two separate cohorts of rats, including testing as juveniles and as adults; similar effects in these behavioral tests were observed across studies) and sensitivity of these responses, and the observed dose-response relationship of effects across dose groups. Benchmark dose (BMD) modeling for each of the three endpoints resulted in $BMDL_{1SD}$ values that clustered in the range 0.092–0.16 mg/kg-day. The lower end of this range of BMDLs, 0.092 mg/kg-day, was selected to represent the point of departure (POD) from these three endpoints for RfD derivation.

The overall RfD was calculated by dividing the POD for altered behavior in three tests of nervous system function by a composite uncertainty factor (UF) of 300 to account for the extrapolation from animals to humans (10), for interindividual differences in human susceptibility (10), and for deficiencies in the toxicity database (3).

Table ES-1. Organ/system-specific RfDs and overall RfD for benzo[a]pyrene

Effect	Basis	RfD (mg/kg-d)	Confidence
Developmental	Neurobehavioral changes Gavage neurodevelopmental study in rats (postnatal days [PNDs] 5–11) Chen et al. (2012)	3×10^{-4}	Medium
Reproductive	Decreased ovarian follicles and ovary weight Gavage subchronic (60 d) reproductive toxicity study in rats Xu et al. (2010)	4×10^{-4}	Medium
Immunological	Decreased thymus weight and serum IgM Gavage subchronic (35 d) study in rats De Jong et al. (1999) and Kroese et al. (2001)	2×10^{-3}	Low
Overall RfD	**Developmental toxicity (including developmental neurotoxicity)**	3×10^{-4}	**Medium**

Confidence in the Overall Oral RfD

The overall confidence in the RfD is medium. Confidence in the principal study (Chen et al., 2012) is medium. The design, conduct, and reporting of this neurodevelopmental study was good and a wide variety of neurotoxicity endpoints were measured across 40 litters of rats. However, some uncertainty exists regarding the authors' use of dam rotation across litters (an attempt to reduce potential nurturing bias) and a within-litter dosing design, by potentially introducing maternal stress or other unanticipated consequences in the pups, and some informative experimental details were omitted, including the sensitivity of some assays at the indicated developmental ages and lack of reporting of individual animal- or gender-specific data for all outcomes. Several subchronic and developmental studies covering a wide variety of endpoints are also available; however, a multigeneration toxicity study with exposure throughout development and across generations is not available, and the available neurotoxicity studies did not comprehensively evaluate all potentially vulnerable lifestages of nervous system development. Therefore, confidence in the database is medium.

Effects Other Than Cancer Observed Following Inhalation Exposure

In animals, inhalation exposure to benzo[a]pyrene has been shown to result in developmental and reproductive toxicity. Studies in rats following inhalation exposure show decreased embryo/fetal survival and nervous system effects in offspring, and decreased testes weight and sperm counts in adult animals. Overall, the available human PAH mixtures studies report developmental and reproductive effects that are generally analogous to those observed in animals, and provide qualitative, supportive evidence for the hazards associated with benzo[a]pyrene exposure.

Inhalation Reference Concentration (RfC) for Effects Other Than Cancer

An attempt was made to derive organ- or system-specific RfCs for hazards associated with benzo[a]pyrene exposure where data were amenable (see Table ES-2). These organ- or system-specific reference values may be useful for subsequent cumulative risk assessments that consider the combined effect of multiple agents acting at a common site.

Developmental toxicity, represented by decreased embryo/fetal survival, was chosen as the basis for the proposed inhalation RfC as the available data indicate that developmental effects represent a sensitive hazard of benzo[a]pyrene exposure. The developmental inhalation study in rats by Archibong et al. (2002) and the observed decreased embryo/fetal survival (i.e., increased resorptions) following exposure to benzo[a]pyrene on gestation days (GDs) 11–20 were used to derive the overall RfC. The lowest-observed-adverse-effect level (LOAEL) of 25 μg/m^3 based on decreased embryo/fetal survival was selected as the POD. The LOAEL was adjusted to account for the discontinuous daily exposure to derive the POD_{ADJ} and the human equivalent concentration (HEC) was calculated from the POD_{ADJ} by multiplying by the regional deposited dose ratio ($RDDR_{ER}$) for extrarespiratory (i.e., systemic) effects, as described in *Methods for Derivation of Inhalation Reference Concentrations and Application of Inhalation Dosimetry* (U.S. EPA, 1994b). These adjustments resulted in a POD_{HEC} of 4.6 μg/m^3, which was used as the POD for RfC derivation.

The RfC was calculated by dividing the POD by a composite UF of 3,000 to account for toxicodynamic differences between animals and humans (3), interindividual differences in human susceptibility (10), LOAEL-to-no-observed-adverse-effect level (NOAEL) extrapolation (10), and deficiencies in the toxicity database (10).

Table ES-2. Organ/system-specific RfCs and overall RfC for benzo[a]pyrene

Effect	Basis	RfC (mg/m^3)	Confidence
Developmental	Decreased embryo/fetal survival Developmental toxicity study in rats (GDs 11–20) Archibong et al. (2002)	2×10^{-6}	Low-medium
Reproductive	Reduced ovulation rate and ovary weight Premating study in rats (14 d) Archibong et al. (2012)	3×10^{-6}	Low-medium
Overall RfC	**Developmental toxicity**	2×10^{-6}	Low-medium

Confidence in the Overall Inhalation RfC

The overall confidence in the RfC is low-to-medium. Confidence in the principal study (Archibong et al., 2002) is medium. The conduct and reporting of this developmental inhalation study were adequate; however, a NOAEL was not identified. Confidence in the database is low due to the lack of a multigeneration toxicity study and the lack of information on varied toxicity

endpoints following subchronic and chronic inhalation exposure. However, confidence in the RfC is bolstered by consistent systemic effects observed by the oral route (including reproductive and developmental effects) and similar effects observed in human populations exposed to PAH mixtures.

Evidence for Human Carcinogenicity

Under EPA's *Guidelines for Carcinogen Risk Assessment* (U.S. EPA, 2005a), benzo[a]pyrene is "carcinogenic to humans" based on strong and consistent evidence in animals and humans. The evidence includes an extensive number of studies demonstrating carcinogenicity in multiple animal species exposed via all routes of administration and increased cancer risks, particularly in the lung and skin, in humans exposed to different PAH mixtures containing benzo[a]pyrene. Mechanistic studies provide strong supporting evidence that links the metabolism of benzo[a]pyrene to DNA-reactive agents with key mutational events in genes that can lead to tumor development. These events include formation of specific DNA adducts and characteristic mutations in oncogenes and tumor suppressor genes that have been observed in humans exposed to PAH mixtures. This combination of human, animal, and mechanistic evidence provides the basis for characterizing benzo[a]pyrene as "carcinogenic to humans."

Quantitative Estimate of Carcinogenic Risk From Oral Exposure

Lifetime oral exposure to benzo[a]pyrene has been associated with forestomach, liver, oral cavity, jejunum or duodenum, and auditory canal tumors in male and female Wistar rats, forestomach tumors in male and female Sprague-Dawley rats, and forestomach, esophagus, tongue, and larynx tumors in female $B6C3F_1$ mice (male mice were not tested). Less-than-lifetime oral exposure to benzo[a]pyrene has also been associated with forestomach tumors in more than 10 additional bioassays with several strains of mice. The Kroese et al. (2001) and Beland and Culp (1998) studies were selected as the best available studies for dose-response analysis and extrapolation to lifetime cancer risk following oral exposure to benzo[a]pyrene. These studies included histological examinations for tumors in many different tissues, contained three exposure levels and controls, contained adequate numbers of animals per dose group (~50/sex/group), treated animals for up to 2 years, and included detailed reporting methods and results (including individual animal data).

Time-weighted average (TWA) daily doses were converted to human equivalent doses (HEDs) on the basis of (body weight [BW])$^{3/4}$ scaling (U.S. EPA, 1992). EPA then used the multistage-Weibull model for the derivation of the oral slope factor. This model was used because it incorporates the time at which death-with-tumor occurred and can account for differences in mortality observed between the exposure groups. Using linear extrapolation from the $BMDL_{10}$, human equivalent oral slope factors were derived for each gender/tumor site combination (slope factor = $0.1/BMDL_{10}$) reported by Kroese et al. (2001) and Beland and Culp (1998). The oral slope factor of **1 per mg/kg-day** based on the tumor response in the alimentary tract (forestomach,

esophagus, tongue, and larynx) of female $B6C3F_1$ mice (Beland and Culp, 1998) was selected as the factor with the highest value (most sensitive) among a range of slope factors derived.

Quantitative Estimate of Carcinogenic Risk From Inhalation Exposure

Inhalation exposure to benzo[a]pyrene has been associated with squamous cell neoplasia in the larynx, pharynx, trachea, nasal cavity, esophagus, and forestomach of male Syrian golden hamsters exposed for up to 130 weeks to benzo[a]pyrene condensed onto sodium chloride particles (Thyssen et al., 1981). Supportive evidence for the carcinogenicity of inhaled benzo[a]pyrene comes from additional studies with hamsters exposed to benzo[a]pyrene via intratracheal instillation. The Thyssen et al. (1981) bioassay represents the only study of lifetime exposure to inhaled benzo[a]pyrene.

A time-to-tumor dose-response model was fit to the TWA continuous exposure concentrations and the individual animal incidence data for the overall incidence of tumors in the upper respiratory tract or pharynx. The inhalation unit risk of **6×10^{-4} per μg/m^3** was calculated by linear extrapolation (slope factor = $0.1/BMCL_{10}$) from a $BMCL_{10}$ of 0.16 mg/m^3 for the occurrence of upper respiratory and upper digestive tract (forestomach) tumors in male hamsters chronically exposed by inhalation to benzo[a]pyrene (Thyssen et al., 1981).

Quantitative Estimate of Carcinogenic Risk From Dermal Exposure

Skin cancer in humans has been documented to result from occupational exposure to complex mixtures of PAHs including benzo[a]pyrene, such as coal tar, coal tar pitches, unrefined mineral oils, shale oils, and soot. In animal models, numerous dermal bioassays have demonstrated an increased incidence of skin tumors with increasing dermal exposure of benzo[a]pyrene in all species tested, although most benzo[a]pyrene bioassays have been conducted in mice.

Carcinogenicity studies in animals by the dermal route of exposure are available for benzo[a]pyrene and are supportive of the overall cancer hazard. A quantitative estimate of skin cancer risk from dermal exposure is not included in this assessment, as methodology for interspecies extrapolation of dermal toxicokinetics and carcinogenicity are still under development.

Susceptible Populations and Lifestages

Benzo[a]pyrene has been determined to be carcinogenic by a mutagenic mode of action in this assessment. According to the *Supplemental Guidance for Assessing Susceptibility from Early Life Exposure to Carcinogens* (U.S. EPA, 2005b), individuals exposed during early life to carcinogens with a mutagenic mode of action are assumed to have an increased risk for cancer. The oral slope factor of 1 per mg/kg-day and inhalation unit risk of 0.0006 per μg/m^3, calculated from data applicable to adult exposures, do not reflect presumed early life susceptibility to this chemical. Although some chemical-specific data exist for benzo[a]pyrene that demonstrate increased early life susceptibility to cancer, these data were not considered sufficient to develop separate risk estimates for childhood exposure. In the absence of adequate chemical-specific data to evaluate differences in

age-specific susceptibility, the *Supplemental Guidance* (U.S. EPA, 2005b) recommends that age-dependent adjustment factors (ADAFs) be applied in estimating cancer risk. The ADAFs are 10- and 3-fold adjustments that are combined with age specific exposure estimates when estimating cancer risks from early life (<16 years of age) exposures to benzo[a]pyrene.

Regarding effects other than cancer, there are epidemiological studies that report associations between developmental effects (decreased postnatal growth, decreased head circumference, and neurodevelopmental delays), reproductive effects, and internal biomarkers of exposure to benzo[a]pyrene. Studies in animals also indicate alterations in neurological development and heightened susceptibility to reproductive effects following gestational or early postnatal exposure to benzo[a]pyrene. More preliminary data suggest that effects on cardiovascular, kidney, pulmonary, and immune system development may result from early life exposures, although few in vivo developmental studies exist to confirm these findings.

Key Issues Addressed in Assessment

The overall RfD and RfC were developed based on effects observed following exposure to benzo[a]pyrene during a critical window of development. The derivation of a general population toxicity value based on exposure during development has implications regarding the evaluation of populations exposed outside of the developmental period and the averaging of exposure to durations outside of the critical window of susceptibility. Discussion of these considerations is provided in Sections 2.1.5 and 2.2.5.

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Indeno[1,2,3-cd]pyrene; CASRN 193-39-5

Human health assessment information on a chemical substance is included in the IRIS database only after a comprehensive review of toxicity data, as outlined in the IRIS assessment development process. Sections I (Health Hazard Assessments for Noncarcinogenic Effects) and II (Carcinogenicity Assessment for Lifetime Exposure) present the conclusions that were reached during the assessment development process. Supporting information and explanations of the methods used to derive the values given in IRIS are provided in the guidance documents located on the IRIS website.

STATUS OF DATA FOR Indeno[1,2,3-cd]pyrene

File First On-Line 12/01/1990

Category (section)	Assessment Available?	Last Revised
Oral RfD (I.A.)	not evaluated	
Inhalation RfC (I.B.)	not evaluated	
Carcinogenicity Assessment (II.)	yes	12/01/1990

I. Chronic Health Hazard Assessments for Noncarcinogenic Effects

I.A. Reference Dose for Chronic Oral Exposure (RfD)

Substance Name — Indeno[1,2,3-cd]pyrene
CASRN — 193-39-5

Not available at this time.

I.B. Reference Concentration for Chronic Inhalation Exposure (RfC)

Substance Name — Indeno[1,2,3-cd]pyrene
CASRN — 193-39-5

Not available at this time.

II. Carcinogenicity Assessment for Lifetime Exposure

Substance Name — Indeno[1,2,3-cd]pyrene
CASRN — 193-39-5
Last Revised — 12/01/1990

Section II provides information on three aspects of the carcinogenic assessment for the substance in question; the weight-of-evidence judgment of the likelihood that the substance is a human carcinogen, and quantitative estimates of risk from oral exposure and from inhalation exposure. The quantitative risk estimates are presented in three ways. The slope factor is the result of application of a low-dose extrapolation procedure and is presented as the risk per (mg/kg)/day. The unit risk is the quantitative estimate in terms of either risk per ug/L drinking water or risk per ug/cu.m air breathed. The third form in which risk is presented is a drinking water or air concentration providing cancer risks of 1 in 10,000, 1 in 100,000 or 1 in 1,000,000. The rationale and methods used to develop the carcinogenicity information in IRIS are described in The Risk Assessment Guidelines of 1986 (EPA/600/8-87/045) and in the IRIS Background Document. IRIS summaries developed since the publication of EPA's more recent Proposed Guidelines for Carcinogen Risk Assessment also utilize those Guidelines where indicated (Federal Register 61(79):17960-18011, April 23, 1996). Users are referred to Section I of this IRIS file for information on long-term toxic effects other than carcinogenicity.

II.A. Evidence for Human Carcinogenicity

II.A.1. Weight-of-Evidence Characterization

Classification — B2, probable human carcinogen

Basis — Based on no human data and sufficient data from animal bioassays. Indeno[1,2,3-cd]pyrene produced tumors in mice following lung implants, subcutaneous injection and dermal exposure. Indeno[1,2,3-cd]pyrene tested positive in bacterial gene mutation assays.

II.A.2. Human Carcinogenicity Data

None. Although there are no human data that specifically link exposure to indeno[1,2,3-cd]pyrene to human cancers, indeno[1,2,3-cd]pyrene is a component of mixtures that have been associated with human cancer. These include coal tar, soots, coke oven emissions and cigarette smoke (U.S. EPA, 1984, 1990; IARC, 1984).

II.A.3. Animal Carcinogenicity Data

Sufficient. In carcinogen bioassays indeno[1,2,3-cd]pyrene exposure resulted in increased incidences of epidermoid carcinomas in a lung implantation study (Deutsch-Wenzel et al., 1983), injection site sarcomas in a subcutaneous injection assay (Lacassagne et al., 1963) and skin tumors in dermal application studies (Hoffman and Wynder, 1966; Rice et al., 1985a, 1986).

In a lifetime implant study, 3-month-old female Osborne-Mendel rats (35/group) received lung implants of indeno[1,2,3-cd]pyrene in 0.05 mL of a 1:1 (v:v) mixture of beeswax and trioctanoin (Deutsch-Wenzel et al., 1983). Rats received either 0.16 mg (0.65 mg/kg), 0.83 mg (3.4 mg/kg) or 4.15 mg (17 mg/kg) indeno[1,2,3-cd]pyrene. Controls consisted of an untreated group and a group receiving an implant of the vehicle. Median survival times in weeks were as follows: untreated controls, 118; vehicle controls, 104; low-dose, 116; mid-dose, 109; and high-dose, 92. Incidence of epidermoid carcinomas in the lung and thorax (combined) showed a statistically significant dose-related increase. The incidences were: untreated controls, 0/35; vehicle controls, 0/35; low-dose, 4/35 (11%); mid-dose, 8/35 (23%); and high-dose, 21/35 (60%).

Groups of male and female CD-1 mice (n=32) received intraperitoneal injections of indeno[1,2,3-cd]pyrene in dimethyl sulfoxide (DMSO) on days 1, 8 and 15 after birth (total dose = 580 ug/mouse) and were evaluated for tumors upon sacrifice at 52 weeks of age (LaVoie et al., 1987). One male mouse (1/11) developed a lung adenoma, no tumors occurred in female mice. Tumor incidence was not significantly different from vehicle controls. This test is considered to be a short-term lung tumor assay.

In mouse skin painting assays, indeno[1,2,3-cd]pyrene tested positive for cancer-initiating activity in several mouse strains (Hoffmann and Wynder, 1966; Rice et al., 1985a, 1986). In the Hoffmann and Wynder (1966) study female Swiss albino Ha/ICR/Mil mice (20/group) were given topical applications of indeno[1,2,3-cd]pyrene prepared as dioxane (at 0.05 and 0.1%) or in acetone solutions (at 0.01, 0.05 and 0.1%). Dioxane preparations did not induce skin tumors. By contrast, acetone solutions of indeno[1,2,3-cd]pyrene produced skin tumors in a dose-related fashion. No tumors were observed in animals painted with 0.01 or 0.05% indeno[1,2,3-cd]pyrene in acetone; 0.1% induced six papillomas and three carcinomas beginning at 9 months; and 0.5% resulted in seven papillomas and five carcinomas with the first tumor appearing at 3 months. The authors also reported that a total dose of 250 mg indeno[1,2,3- cd]pyrene delivered in 10 applications in 2 days was a sufficient initiating dose when followed by promotion with croton oil.

To examine the initiating capability of the compound's major metabolites in mouse skin, indeno[1,2,3-cd]pyrene was applied to the shaved backs of 20 Crl:CD-1(ICR)BR female mice (Rice et al., 1986). Acetone solutions were applied every other day for 10 days for a total

initiating dose of 1 mg indeno[1,2,3-cd]pyrene. This was followed 10 days later by applications of the promotor tetradecanoylphorbol (TPA) (0.0025% in 100 mL acetone) 3 times/week for 20 weeks. Tumor incidence was essentially 100%. Indeno[1,2,3- cd]pyrene-1,2-diol and -1,2-oxide treatment both resulted in 80% tumor incidence in contrast to 8-hydroxy- and acetone-treated controls (approximately 25 and 5%, respectively).

An earlier initiation-promotion bioassay performed by Rice et al. (1985a) showed a pronounced dose-response relationship for tumors. Following the same protocol described above, an 80% tumor incidence was observed in mice receiving a total initiating dose of 1 mg indeno[1,2,3-cd]pyrene with an average of about four tumors/mouse after 22 weeks of promotion. However, when the total initiating dose was decreased to 100 or 300 mg/mouse, the number of tumor-bearing mice was not significantly increased.

Injection site sarcomas were reported in 10/14 male and 1/14 female XVIIc/Z mice administered 3 injections at 1-month intervals of 0.6 mg indeno[1,2,3-cd]pyrene. No concurrent controls appear to have been run in this experiment; the authors report, however, that in this mouse strain no spontaneous subcutaneous tumors have been reported (Lacassagne et al., 1963).

II.A.4. Supporting Data for Carcinogenicity

Indeno[1,2,3-cd]pyrene produced positive results in reverse mutation assays in Salmonella typhimurium strains TA100 and TA98 (2-3 ug/plate) (LaVoie et al., 1979; Hermann et al., 1980; Rice et al., 1985b).

II.B. Quantitative Estimate of Carcinogenic Risk from Oral Exposure

Not available.

II.C. Quantitative Estimate of Carcinogenic Risk from Inhalation Exposure

Not available.

II.D. EPA Documentation, Review, and Contacts (Carcinogenicity Assessment)

II.D.1. EPA Documentation

Source Document — U.S. EPA, 1984, 1990

The 1990 Drinking Water Criteria Document for Polycyclic Aromatic Hydrocarbons has received Agency and external review.

II.D.2. EPA Review (Carcinogenicity Assessment)

Agency Work Group Review — 02/07/1990, 08/05/1993, 09/21/1993, 02/02/1994

Verification Date — 02/07/1990

II.D.3. EPA Contacts (Carcinogenicity Assessment)

Please contact the IRIS Hotline for all questions concerning this assessment or IRIS, in general, at (202)566-1676 (phone), (202)566-1749 (FAX) or [redacted] address).

III. [reserved]
IV. [reserved]
V. [reserved]

VI. Bibliography

Substance Name — Indeno[1,2,3-cd]pyrene
CASRN — 193-39-5

VI.A. Oral RfD References

None

VI.B. Inhalation RfC References

None

VI.C. Carcinogenicity Assessment References

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VII. Revision History

Substance Name — Indeno[1,2,3-cd]pyrene
CASRN — 193-39-5

Date	Section	Description
12/01/1990	II.	Carcinogen assessment on-line

VIII. Synonyms

Substance Name — Indeno[1,2,3-cd]pyrene
CASRN — 193-39-5
Last Revised — 12/01/1990

- 193-39-5
- Indeno(1,2,3-cd)pyrene
- HSDB 5101
- indeno(1,2,3-cd)pyrene
- o-PHENYLENEPYRENE
- RCRA WASTE NUMBER U137
- 1,10-(O-PHENYLENE)PYRENE
- 1,10-(1,2-Phenylene)pyrene

- 2,3-o-PHENYLENEPYRENE
- 2,3-PHENYLENEPYRENE

APPENDIX III
EVIDENCE OF RELEASE

There has been no release from the property. Appendix I shows the map of the release location and identification (WMA 1) and path travelled.

APPENDIX IV

POLLUTANT DISPERSAL PATHWAYS

Appendix I includes regional and site location maps. Appendix I Figure 2 shows the pollutant dispersal pathway from WMA I. Any release from another waste management unit or solid waste management unit would be expected to have the same pollutant dispersal pathway.

APPENDIX XII

HAZARDOUS WASTE PERMIT APPLICATION FEE

Table XII.A – Hazardous Waste Units
Table XII.B Hazardous Waste Permit Application Fee Worksheet

Table XII.A. - Hazardous Waste Units (For Application Fee Calculations)

Verbal Description of Unit	Rated Capacity	Surface Acreage[1]	# of Unit Types[2]	Identical Unit Justification[3]
WMA I	0	0.990	1	None
WMA II	4,000 cubic yards	2.672	1	Areas II and III are both closed surface impoundments in post closure care. both have the same capacity, stored the same material (K001) and are constructed in the same manner.
WMA III	4,000 cubic yards	1.856		See above
		Total[4] 3.662	Total[4] 2	

1. Number of calculated acres.
2. Enter number of units except for units identical in type and use which only count toward a single $500.00 fee.
3. Explain justification for any units claimed as identical in type and use.
4. Enter these totals on the worksheet.

Table XII.B. - Hazardous Waste Permit Application Fee Worksheet

Name of Facility: Texas Electric Cooperatives, Inc., Treating Division

Solid Waste Registration Number: 31340

1. Process Analysis - $1,000..... $ 1,000
2. Facility Management Analysis - $500..... $ 500
3. Unit Analysis - 2 units @ $500 per unit..... $ 1,000
4. Site Evaluation - 3.662 acres @ $100 per acre..... $ 366

   (Maximum of 300 acres)

5. Minor amendment, Class 1, or Class 1[1] modification - $100..... $
6. Cost of Providing Notice - $50 (+ $15 for a renewal)..... $ 50

Pay This Amount **Total** $ 2,916

Pay Online through ePay portal www3.tceq.texas.gov/epay/

Enter ePay Trace Number: 582EA000661461

For Payment by check, make checks Payable To:

Texas Commission on Environmental Quality - Fund 549
(your canceled check will be your receipt)

Complete And Return With Payment To:

Texas Commission on Environmental Quality
Financial Administration Division - MC 214
P.O. BOX 13088
Austin, Texas 78711-3088

The applicant's fees are subject to evaluation by the technical staff of the Texas Commission on Environmental Quality (TCEQ). However, the TCEQ reserves the right to assess further fees as may be necessitated.

Please do not submit a photocopy of the check (or equivalent transaction submittal) with your application packet but provide only the following account information:

Check No.	Date of Check	Check Amount