

ASTER User Guide

ASsessment Tools for the Evaluation of Risk

Version 1.0

Prepared for

U.S. Environmental Protection Agency
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INTRODUCTION

Ecological risk assessments are utilized by the U.S. Environmental Protection Agency (EPA) and other governmental agencies to determine the probability and magnitude of deleterious effects of hazardous chemicals on plants and animals. These assessments are important steps in formulating regulatory decisions. Over 70,000 discrete organic chemicals are on the TSCA (Toxic Substances Control Act) Inventory of Industrial Organics and the number of commercially available chemicals continues to grow. More than 1200 new chemicals were submitted to the U.S. EPA for Premanufacturing Notification review between 1979 and 1988 (Auer et. al., 1990). Ecotoxicological hazard and environmental exposure information included in an ecological risk assessment can be used to evaluate the potential risk a chemical poses to humans and the environment. This information can also be used to rank the potential hazard of sites. Currently, more than 30,000 sites are under investigation for clean up and/or emergency remedial action by Superfund (Office of Emergency and Remedial Action).

ASTER (Assessment Tools for the Evaluation of Risk) was developed at the U.S. EPA, National Health and Environmental Effects Research Laboratory (NHEERL), Mid-Continent Ecology Division (MED-Duluth), with funding from the U.S. EPA Office of Solid Waste and Emergency Response. The objective was to devise software that could assist regulators in hazard ranking and the development of comprehensive risk assessments. ASTER is a UNIX based computer program which integrates aquatic toxicity database information and quantitative structure activity relationships (QSARs) to assess the environmental risk of discrete chemicals.

ASTER outputs are divided into four sections: (1) Chemical Identification, (2) Environmental Exposure Assessment, (3) Ecotoxicological Hazard Assessment, and (4) Ecological Risk Characterization. The Chemical Identification section provides general information such as name, Chemical Abstract Services (CAS) Registry number, molecular weight and structure. Environmental Exposure Assessment describes the potential hazard of exposure from the chemical due to the distribution of the compound within the environment. When empirical data are not available predictive models in ASTER are used to estimate physicochemical properties, biodegradation, hydrolysis half-life and environmental partitioning. The Ecotoxicological Hazard Assessment section of ASTER provides aquatic effects information from a variety of sources including U.S. EPA Water Quality Criteria Documents, the **AQUIRE (Aquatic toxicity Information REtrieval)** database, U.S. EPA Office of Pesticide Programs registration toxicity data and QSARs which are statistically-based relationships between physicochemical properties and biological activity. ASTER is designed to provide high quality data for discrete chemicals, when available in the associated databases, and mechanistically-based QSAR estimates when data are lacking. You are also provided with information regarding the potential carcinogenicity or mutagenicity of a compound. This information is based on a database of known carcinogens/mutagens and an expert system which identifies structural fragments suspected to be carcinogenic or mutagenic. Under the Ecological Risk Characterization section, data presented in the

Environmental Exposure Assessment and Ecotoxicological Hazard Identification sections are discussed in detail, and the acute and chronic mode of action is addressed. Information about the availability of additional information in the U.S. EPA, IRIS (Integrated Risk Information System) database, whether the chemical appears on SARA (Superfund Amendments and Reauthorization Act) Title III's Toxic Emissions Inventory (also known as section 313 of the Emergency Planning and Community Right-to-Know Act of 1986) is provided.

ASTER was designed to be flexible, allowing for additions of new software modules and models as they become available. Although this system may not supply all of the answers, the information presented provides a good foundation for a comprehensive assessment of the potential hazard of a chemical to the aquatic environment.

For more information on the ASTER system contact:

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ACCESS

This user guide provides an overview of the ASTER system. This system is currently not available on-line. Employees of government (tribal, local, state, national, international) agencies that require a search of the ASTER system must request a search through the MED-Duluth Scientific Outreach staff (E-mail: ecotox.support@epa.gov T: 218-529-5225). Searches are chemical specific, and clients should provide either a SMILES string(s) or Chemical Abstract Registry Number(s) for the chemical(s) of interest. The ASTER report will be E-mailed to the client. Persons affiliated with government contracts or other extramural agreements must submit their search requests through the funding governmental agency's Project Officer.

MED-Duluth is developing a web based ASTER software that is expected to be available in FY2002. The software will be available on the ECOTOX software web site (<http://www.epa.gov/ecotox>). Watch for ASTER release progress on the ECOTOX web site "What's New" area.

Please note that due to migration of ECOTOX to the web format, the AQUIRE data that appears in the ASTER reports does not include any data records added to AQUIRE after 1999. If you want a complete summary of available aquatic toxicity data should conduct separate searches of the ECOTOX database (www.epa.gov/ecotox).

SELECTING CHEMICALS

After accessing the ASTER system, the ASTER Main Menu will appear.

ASTER Main Menu

```

-----ASsessment Tools for the Evaluation of Risk-----
ASTER will allow you to enter one or more chemicals of interest.  After you
exit from the chemical entry screen you can watch the bottom of this screen
to follow ASTER's progress on preparing the reports for your chemicals.  As
the reports become available, you will be able to interactively examine
them or dump them to the screen in their entirety.

```

```

+Choose by letter or use arrows and ENTER +
| E  Enter chemicals for making reports.  |
| L  Leave this program.                 |
+------(press ? for help)-----+

```

The 'Enter chemicals for making reports' option can be selected by pressing E or using the arrow key, then press return.

Chemical Entry

ASTER is designed to present information on discrete chemicals. In order to retrieve and generate data, the compound must be identified. ASTER provides you with three chemical selection methods, CAS Registry Number, Chemical Name or SMILES String. ASTER requires that information for at least one of the above choices be entered. By pressing the CONTROL and Z keys simultaneously, ASTER will begin searching its database for structural information on the chemical.

ASTER Chemical Entry Screen

```

-----ASsessment Tools for the Evaluation of Risk-----
                          Chemical Entry

CAS Registry Number:  _____
Chemical Name:        _____
SMILES String:       _____

+ Choose by letter or use arrows and ENTER+
| E  Edit CAS, Name, or SMILES fields  |
| D  Done editing Chemical Entry fields |
+------(press ? for help)-----+

```

CAS Registry Number

A CAS number is a chemical identification code assigned by the Chemical Abstract Service. CAS numbers are available for mixtures of chemicals as well as for discrete

compounds. The ASTER system has more than 70,000 CAS numbers stored in its database. The CAS number is a more efficient way than the chemical name to retrieve information about chemicals in the ASTER system.

CAS numbers appear with hyphens (e.g., aniline 62-53-3) and sometimes with leading zeros (e.g. 00062533). To obtain information on a chemical by using the CAS number search, at the CAS Registry Number prompt enter the CAS number with or without hyphens and leading zeros.

The final digit in a CAS number is a check digit. ASTER will check this digit, and if the CAS number is in error the message 'ILLEGAL CAS REGISTRY NUMBER' will appear at the bottom of the screen. The ASTER prompt will return to the CAS entry section of the Chemical Entry Screen, and you should either edit or reenter the CAS number. After a correct number has been entered, the cursor will move to the Chemical Name entry line.

If you do not have a CAS number for your chemical of interest, you may either search CHEMNAME (selected from the TOX main menu) or you may want to skip this field and enter the chemical name or SMILES string.

Chemical Name

ASTER allows a user to search for a chemical by name. It should be noted that although more than 5,000 names are stored in ASTER, this may be a frustrating way to search for a chemical since ASTER does not contain a synonym index. For example, Benzenamine is the name stored in the ASTER database for Aniline. Therefore if a search was conducted on the chemical name 'Aniline', ASTER would not find any information. Sometimes ASTER will provide the common name, but the majority of names stored in the database follow nomenclature rules as defined by either the International Union of Pure and Applied Chemists (IUPAC) or the Collective Index of the CAS Registry system.

If the chemical cannot be located by a particular name, you may enter a synonym, skip the chemical name field and enter the appropriate CAS number or SMILES string.

SMILES String

SMILES strings provide ASTER modeling software with structural information about the chemical. Approximately 57,000 SMILES strings are stored in ASTER. SMILES strings may also be provided by the user.

The five basic rules used for composing SMILES strings are located in Appendix A. For more information on SMILES, refer to Anderson et al., 1987, Hunter et al., 1987, Weininger 1988, Weininger et al., 1989.

Undefined SMILES String Message

```
-----ASsessment Tools for the Evaluation of Risk-----  
                          Chemical Entry  
  
CAS Registry Number:  11097691  
      Chemical Name:   Aroclor 1254  
      SMILES String:  
  
Sorry, but no SMILES string is stored.  
  
      M. Formula:  
      CAS Number:    11097691  
      Name           : Aroclor 1254  
  
-----  
A SMILES string is needed to define a chemical structure  
Could not establish the chemical structure for chemical  
Aroclor 1254
```

If the SMILES string entered by the user has a syntax error the system will respond with one of the following messages at the bottom of the screen:

- SMILES error
- SMILES ERROR: SHOULD BE AN ATOMIC SYMBOL HERE
- IMPOSSIBLE AROMATIC RING

Recheck the SMILES composition and rules, then either reenter or edit the string.

Once the SMILES string has been accepted, ASTER will create a unique version of the string. Unique SMILES strings are stored in the ASTER database. If you have not entered a CAS number or name, but only the SMILES string, ASTER will search its database for the unique SMILES string. If a SMILES string it is found, any database information including CAS number and name will be retrieved.

After the SMILES string has been processed, ASTER will ask *'Is this your chemical?'* SMILES strings stored in ASTER do not contain geometric information. Therefore, if you enter a SMILES string for a compound such as 3-hexen-1-ol (CCC=CCCO), ASTER may not initially retrieve the desired isomeric form.

For example, there are three CAS registry numbers stored with the SMILES string (CCC=CCCO):

928-97-2	(E)-3-Hexene-1-ol
928-96-1	(Z)-3-Hexen-1-ol
544-12-7	Mixture of E and Z 3-Hexene-1-ol

Variable Geometric Chemical Example

CAS Registry Number:

Chemical Name:

SMILES String: CCC=CCCO

```
+Is this your chemical--+
| Y  Yes                    |
| N  No                      |
+-(press ? for help)----+
```

M. Formula: C6H12O
 CAS Number: 928972
 Name : (E)-3-Hexen-1-ol

If the SMILES string is entered, the first chemical, (E)-3-Hexene-1-ol will be identified. By answering **NO** to the question '*Is this your chemical?*', ASTER will bring up the next selection and will continue until there are no more isomers stored. Then ASTER will respond with '*CAS number:??????*' and '*Name: ???????*'. It is important to select the correct CAS number since some measured data may be stored for each isomer.

If the chemical you entered is not stored in the ASTER database, estimations will be made using the SMILES string entered, and geometric differences will not be incorporated.

After a SMILES string has been accepted, a screen similar to the one presented below appears.

Variable Geometric Chemical Example

```

CAS Registry Number:  928972
    Chemical Name:    (E)-3-Hexen-1-ol
    SMILES String:    CCC=CCCO
                    + Choose by letter or use arrows and ENTER+
                    | U Undo the most recent Editing          |
                    | E Edit CAS, Name or SMILES fields      |
                    | C Clear CAS, Name, and SMILES fields    |
                    | S Save this chemical entry data        |
                    | G Get saved chemical entry data        |
                    | D Done editing Chemical Entry fields   |
                    +-----(press ? for help)-----+
-----
M. Formula: C6H12O
CAS Number: 928972
Name       : (E)-3-Hexen-1-ol
    
```

This can save time in generating ASTER outputs for homologous series of compounds, because the SMILES strings can be retrieved and edited rather than reentered.

Completing Chemical Entry

By pressing the CONTROL and Z keys simultaneously, ASTER will begin searching its database for structural information on the chemical. The following screen will appear.

Chemical Entry Completed

```

-----ASsessment Tools for the Evaluation of Risk-----
                        Chemical Entry
CAS Registry Number:  62533
    Chemical Name:    Benzenamine
    SMILES String:    c(ccc1N)cc1
                    +Choose by letter or use arrows and ENTER+
                    | U Undo the most recent Editing          |
                    | E Edit CAS, Name, or SMILES fields      |
                    | C Clear CAS, Name, and SMILES fields    |
                    | D Done editing Chemical Entry fields   |
                    +-----(press ? for help)-----+
-----
M. Formula: C6H7N
CAS Number: 62533
Name       : Benzenamine
SMILES str: c(ccc1N)cc1
    
```

The options for the completing the Chemical Screen entries are:

- U** Undo returns you to the previous chemical entry screen
- E** Allows the user to edit information such as the SMILES string
- C** Clears all entries in the chemical entry fields so you can enter a new compound
- D** Leaves the entry screen and invokes the next window

Undefined SMILES Strings

If a SMILES string is not found for the CAS number or chemical name, ASTER responds with:

'A SMILES string is needed to identify a chemical structure'

ASTER will retrieve aquatic toxicity database information for both organic and inorganic chemicals. However, if the CAS number is stored in the ASTER database without information on the structure (SMILES string), all QSAR models will be disabled, since they require structural information to perform. QSAR models are disabled for inorganic compounds because only organic models are available in the ASTER system.

QSAR Disabled Message

QSAR models will be disabled if a structure is not identified because they require structural information for implementation. For instance, QSARs and other structural algorithms under the Environmental Exposure Section would not function. Also, if AQUIRE data are not available, QSAR models would not be implemented under the Hazard Identification Section. Therefore, if a SMILES string is not stored in the ASTER database for the selected CAS number, a SMILES string should also be entered under the Chemical Entry Screen in order to obtain a more complete evaluation of risk.

REPORT GENERATION

After you have identified a chemical by a CAS registry number, name, and /or SMILES entry, the next step is to create the report. To begin this process, at the Chemical Entry Screen, select the 'Done editing Chemical Entry fields' by typing the letter D or using the arrow key to highlight, then press ENTER.

```

ASTER Chemical Entry Screen
-----ASsessment Tools for the Evaluation of Risk-----
                          Chemical Entry

CAS Registry Number: 62533

    Chemical Name: Benzeneamine

    SMILES String: c(ccclN)ccl

                                + Choose by letter or use arrows and ENTER+
                                |   E Edit CAS, Name, or SMILES fields   |
                                |   D Done editing Chemical Entry fields   |
                                +------(press ? for help)-----+
-----
M. Formula: C6H7N
CAS Number: 62533
Name       : Benzenamine
SMILES str: c(ccclN)ccl

```

The next step in ASTER allows you to preview chemical properties and depict the chemical structure (if the correct graphical emulations are available).

```

ASTER Chemical Entry Screen
-----ASsessment Tools for the Evaluation of Risk-----
                          Chemical Entry

CAS Registry Number: 62533

    Chemical Name: Benzeneamine

    SMILES String: c(ccclN)ccl

                                + Choose by letter or use arrows and ENTER+
                                |   A Accept this chemical for processing   |
                                |   P Preview Properties of this chemical   |
                                |   D Draw chemical (Tek 4010 graphics)   |
                                |   E Edit the Chemical Entry fields     |
                                |   X eXit the Chemical Entry screen     |
                                +------(press ? for help)-----+
-----
M. Formula: C6H7N
CAS Number: 62533
Name       : Benzenamine
SMILES str: c(ccclN)ccl

```

Accept this Chemical for Processing**Report generation does not begin until you accept the chemical for processing.**

This allows you time to preview properties and make any modifications prior to the final report generation. To invoke the report generator, a screen similar to the one presented below appears. Select 'Accept this Chemical for Processing' by typing the letter A or using the arrow key to highlight, then press ENTER. Accepting the chemical selection will invoke the following screen that allows you to customize the ASTER output.

```

Report Generation Menu

CAS Registry Number:   62533

    Chemical Name:     Benzenamine

    SMILES String:     c(ccclN)ccl

+Select option settings you want to change.  Press CTRL-Z when done.+
| S  Off  Skip this request and go back          |
| C  On   Citations included for all references  |
| R  On   Report      file generated for this chemical |
| A  Off  Appendix   file generated (when applicable) |
| O  Off  Other Data  file generated (when applicable) |
+---(press ? for help)-----+

-----
The chemical structure is known; QSAR estimates may be possible.
-----

    272 matches found initially in AQUIRE for
62-53-3  Benzenamine
        30 test(s) would appear in the Report      file.
        24 test(s) would appear in the Appendix   file.
        218 test(s) would appear in the Other Data file.

```

Skip this Request and Go Back

By typing the letter S or using the arrow keys to highlight the letter, you can toggle the option ON or OFF. The default is OFF, which means that the other option settings that are ON will be implemented when the CONTROL and Z keys are typed simultaneously. If you switch the option to ON, when CONTROL and Z are typed, ASTER will return to the Chemical Entry Screen, and the chemical will not have been accepted for report generation.

Citations Included for All References

By typing the letter C or using the arrow keys to highlight the option, you can toggle ON or OFF the inclusion of citations in the ASTER report. The default is ON, meaning that for every reference cited in the ASTER output a full citation will appear at the end of the report. Citations are numbered in the text and printed in order of the citation number. If this option is turned OFF, citations would not be printed at the end of the report.

Report File Generated for this Chemical

By typing the letter R or using the arrow keys to highlight the option, you can toggle report generation ON or OFF. The default is ON, meaning that an ASTER report will be generated for this compound. You would normally select OFF when a report has already been generated but you want to look at the appendices.

Appendix File Generated (when applicable)

ASTER reports one value per endpoint per species. If more than one test value meets the above screening requirements for one species, the median value is reported under the Ecotoxicological Hazard Assessment screen. The additional test data are saved in this file.

The default option for Appendices is OFF. If you toggle this option ON, a separate Appendix report will be created with the data that was considered to be high quality, but was not the median species value for a particular endpoint.

Other Data File Generated (when applicable)

By typing the letter O or using the arrow keys to highlight the option, you can toggle ON and OFF the generation of a report of other data in AQUIRE that did not meet the ASTER filter requirements (Appendix B). The data in this report may include species that were not reported in the ASTER Report or the Appendix.

If you are satisfied with the options selected, press CONTROL and Z. The ASTER report and any appendices selected will be created.

Preview Properties of this Chemical

To preview the properties of the selected chemical, select the 'Preview Properties of this Chemical' by typing the letter P or using the arrow key to highlight, then press ENTER. Property preview allows you to modify physicochemical information that may be used in QSAR estimations and/or to obtain details on how a certain property was obtained. For instance, if the octanol/water partition coefficient (log P) cannot be estimated for the selected chemical, various models that use log P would not operate. The property preview allows you to change or obtain details of physicochemical property values.

QSAR Preview Properties Screen

Chemical and Physical Properties Worksheet

CAS : 62-53-3
 NAME : Benzenamine
 SMILES: c(ccc1N)ccl

#	Property	Value and Units	Source	Method Error
1	Mol Wgt.	93.13 g/mole	Calc.	
2	Parachor	234.	Calc.	????
3	Mol Ref.	30.6	ASTER	
4	Mol Vol.	91.0 cm ³ /g.m	Calc.	????
5	LogP	0.9150	CLogP	
6	Melt Pt.	-6.00 C	ASTER	
7	Boil Pt.	184. C @760mm	ASTER	
8	V.Press.	0.671 mm of Hg	ASTER	
9	Ht. Vpr.	1.04E+04 cal/mole	Calc.	Av. % Error = 1.85
10	Sol. H2O	0.440 moles/L	Calc.	????
11	pKa	4.58 @ 25 C.	Calc.	
12	FH TMOA	33.0 MOA num.	Calc.	Polar narcosis

Property C)hanged or D)etailed. Connectivity I)ndices or Q)uit:

The screen is divided into five sections: option number (#), Property, Value and Units, Source, and Method Error. Each property has a number associated with it which will be used when invoking the change or detail option. The properties are explained in greater detail in the Environmental Exposure section of this document. The method used to select the acute mode of action is explained in greater detail in the Ecological Risk Characterization section of this document. The source column will have 'Calc.' if the property is estimated using a QSAR or other method, or 'ASTER' if the reported value is from the literature and has been stored in ASTER.

Changing Property Values

Entering 'C' allows you to change the ASTER property value or selected mode of action. This modification is temporarily stored in ASTER, and any models using the changed parameter value will be stored in computer memory until you return to the Chemical Entry Screen and select another chemical. When a property value is changed, 'User' will appear in the source column for the changed property value. Any other properties that were recalculated using the revised value will have 'Recalc.' in the Source column.

Which Property do you want to change? Enter #:

Note: Enter the property number (1-12), and ASTER will respond with the property name. Then enter the new property value.

Details of Property Values

The detail option allows you to see details of how a property was calculated or a mode of action was determined. The Environmental Exposure Assessment section of this document gives, for each parameter, general information and sources of algorithms. The Ecological Risk Characterization section of this document describes the procedure used to determine the acute mode of action. The detail option displays the method used to obtain the selected property value.

Which Property do you want to detail? Enter #:

Note: Enter the property number (1-12) and ASTER will respond with the property detail.

Type the letter **Q** to exit the property screen and return to the Chemical Entry Screen.

Draw Chemical (Tek 4010 Graphics)

To draw the chemical structure, select the 'Draw Chemical' by typing the letter D or using the arrow key to highlight, then press ENTER. Structural depiction allows you to verify the structure. This is especially important if the chemical was identified using SMILES string entry and no corroborating database information was available.

Although any communications package can be used with proper emulations, the public domain software PC-Kermit supports the graphical display option in ASTER. If another communications package is used, the 'Draw Chemical' option may not function.

Edit the Chemical Entry Fields

To return to the Chemical Entry Menu, select the 'Edit the Chemical Entry Fields' by typing the letter E or using the arrow key to highlight, then press ENTER. You may enter a new chemical or edit the existing chemical.

Exit the Chemical Entry Screen

The exit option in the Report Generation Menu allows you to view the reports created during the user session or to leave the user session. To exit, type the letter X or using the arrow key to highlight, then press ENTER.

VIEWING REPORTS

The View Report Menu is divided into two sections; a display of Menu Options, and a Report Status area. Appendix C contains the AQUIRE data fields presented in the ASTER report. An example of a full ASTER report is presented in Appendix D.

```

View Report Menu
-----Assessment Tools for the Evaluation of Risk-----

          +Choose by letter or use arrows and ENTER+
          | E  Enter chemicals for making reports.  |
          | I  Interactively study a report.        |
          | M  Mail a report electronically.        |
          | D  Dump a report to the screen.         |
          | L  Leave this program.                  |
          +---(press ? for help)-----+

Report Status:

1.  Benzenamine
    62-53-3  Report      Done
2.  Benzeneamine
    62-53-3  Appendix   Incomplete
3.  Benzeneamine
    62-53-3  Other data Pending
    
```

Report Status

Report Status provides information on what outputs were selected during your session, and the completion status of these outputs. ASTER provides information as to the type of output(s) that was selected; Report, Appendix, and Other data. The differences between the generated files are documented in the previous section on Report Generation.

Done

The “done” option indicates the report is finished and all options in the menu regarding report manipulation have been selected.

Incomplete

Incomplete means that the report is not finished, but is in the process of being created. You can interactively (**I**) view an output that is incomplete, but the options dump (**D**) to a screen, electronically mail (**M**) or write (**W**) to a file will not function until the Report Status is identified as 'Done'.

Pending

Pending means the report generation has not begun, but is in the queue. The report generation will begin once the last incomplete report is finished. None of the menu

options regarding report manipulation are operational at this time.

View Report Menu Options

Enter Chemical for Making Reports

To return to the Report Generator Menu, select the 'Enter Chemical for Making Reports' by typing the letter E or using the arrow key to highlight, then press ENTER. You may enter a new chemical or edit the existing chemical.

Interactively Study a Report

Selecting option I allows you to interactively view an ASTER output. After selecting interactive viewing, the following window will appear.

```

Select Report Files Menu
+--Select Report Files (press Ctrl-Z when you are done with this screen)--+
|
|  Select all untried output files
|  Clear all current selections
|  Oth      50-32-8 Benzo(a)pyrene
|  Rep      62-53-3 Benzenamine
|  App 62-53-3 Benzeneamine
|
+------(press ? for help)-----+

```

You can select the interactive viewing of output(s) by either 1) using the arrow keys to move up and down the screen until at the interactive option then press enter, 2) by typing the letter **R**, **A**, or **O**, the first report, appendix or other report, respectively on the list that was not previously viewed will be selected, or (3) selecting all for viewing by typing the letter **S**. In the screen displayed above a dash (-) appears by the Benzeneamine Report and an asterisk (*) appears by the Benzeneamine Appendix. ASTER indicates that an output has already been viewed by placing a dash (-) before the output description. When you select a report for viewing an asterisk (*) appears before the output description. Once the outputs have been selected, press the CONTROL and Z keys simultaneously to exit the screen and begin viewing.

Details

Within an interactive session, you may request a detail of effect data listed under the Ecotoxicological Hazard Assessment section of the ASTER Report, with the exception of information taken from the Water Quality Criteria Documents. The detail information provided for AQUIRE and the MED-Duluth fathead minnow data are the AQUIRE data full record. The detail for QSAR estimates include the mode of action, QSAR equation used to estimate the effect and any related statistical information. To view this information, enter the number that appears above the species name at the far left on the screen. For instance, if the data presented below was on your screen, by entering '99926' you could display the spreadsheet of information stored in AQUIRE for that

particular data record. Scrolling options are the same as for previous screens. To exit this screen, press the control and Z keys simultaneously and ASTER will return to the previous screen.

CHRONIC DATA							
Species Common Name	Ex Ty	Dur (days)	Effect	Conc Type	Conc (ug/L)	Source	Ref No.
FRESH WATER							
99926 Fathead minnow Pimephales promelas	F	28.0	GRO		142000	AQUIRE	12567
99927 Fathead minnow Pimephales promelas	F	28.0	GRO		82500	AQUIRE	12567

Once you have viewed the report, press the CONTROL and Z keys simultaneously. Either the ASTER Main Menu will return to the screen, or, if you have selected more than one output, ASTER will begin viewing the next output.

Mail a Report Electronically

This option enables you to mail the report to an E-mail address. You will need to know the exact address of where the report is going. You may modify the subject for the E-mail message by pressing the TAB key. Enter the address for the E-mail message and then press CONTROL and Z to send the message.

Please complete EMAIL subject and address info.

Press Ctrl-Z when you are done. To cancel, make address blank.
 Subject for EMAIL message: Rep 62-53-3 Benzenamine
 Address for EMAIL message: (INSERT ADDRESS)
 Address Examples: smith.john@epamail.epa.gov
 smith.joe@abc.nop.xyz

Dump a Report to the Screen

If you are entering the ASTER system from a microcomputer (PC) environment, you may dump outputs to the screen and capture the results to a PC file using your communications software. After selecting **D**, a Select Report Files screen will appear that is similar to the one described in the Interactively Study a Report section of this document. From this screen you should select the output(s) to be dumped to the screen. Once the output(s) has been selected press the CONTROL and Z keys simultaneously to exit the screen.

ASTER will identify the first report selected and give a warning that the report is about to be sent to your screen and that you should set your capture on. You should be familiar with how the communications package capture option works and how to identify

a PC output file. The output will be saved as an ASCII file. Once the screen dump is finished, either the Main Menu will return to the screen, or, if you have selected more than one output, ASTER will present a warning that the next output is ready to be sent to the screen.

```

Screen (Dump) Output Option Warning Screen
+-----+
| If you want to capture this report onto your computer, |
| turn capture (or logging) on following the instructions |
| for your communication software. Remember to turn it   |
| off when the retrieval is complete                     |
+-----+
>>>>> (Press any key when ready) <<<<<<
*-----*
    
```

EXIT FROM ASTER

Selecting **L** at the ASTER Main Menu exits ASTER and returns you to the TOX main menu. **Any outputs created during the ASTER user session will be stored until you log out of the TOX account. This means that you can go into another MED-Duluth software and later reenter ASTER and all previous outputs will still be available to interactively view, E-mail, or dump to a screen as long as you have not typed and entered LO.**

```

ASTER Main Menu
-----Assessment Tools for the Evaluation of Risk-----
ASTER will allow you to enter one or more chemicals of interest. After you
exit from the chemical entry screen you can watch the bottom of this screen
to follow ASTER's progress on preparing the reports for your chemicals. As
the reports become available, you will be able to interactively examine
them or dump them to the screen in their entirety.

+Choose by letter or use arrows and ENTER +
| E Enter chemicals for making reports. |
| L Leave this program.                 |
+------(press ? for help)-----+
    
```

```

Leaving ASTER Menu
+ Are you sure you want to Leave ASTER now? -----+
| N No, please CANCEL that request. I don't want to leave yet. |
| Y Yes, I am done.                                           |
| R Yes, but please RETAIN these reports. I will return soon. |
+------(press ? for help)-----+
    
```

When you select Y from the ASTER Leaving menu, the program terminates and returns

your cursor to the TOX account main menu. Choose another option, such as one of the other databases, or COMMENTS if you wish to leave a message.

TOX Main Menu

Attention TOX account users:

Additional data from 1989 to 1996 has been added to the AQUIRE database.

Users can send messages to MED-Duluth by using the COMMENTS feature.

Available options include

AQUIRE	(AQUatic toxicity Information RETrieval)
ASTER	(ASsessment Tools for the Evaluation of Risk)
CHEMNAME	(CAS registry number and CHEMical NAME index)
ECOTOX	(ECOTOXicology Data Systems) Version 1.0
SCOMMON	(Species number and Species COMMON name index)
SLATIN	(Species number and Species LATIN name index)
COMMENTS	(We're interested in your comments and questions)
LOGOUT	(To leave)

You may abbreviate to as few as two characters

Please enter your preference: **LOGOUT** or **LO**

Type **Logout** or **Lo** to exit the TOX account and return to your own local system control.

REFERENCES

- Anderson, E., G.D. Veith, and D. Weininger. 1987. SMILES: A line notation and computerized interpreter for chemical structures. Report No. EPA/600/M-87/021. U.S. Environmental Protection Agency, Environmental Research Laboratory-Duluth, Duluth, MN 55804.
- Arcos, J.C. 1987. Structure-Activity Relationships: Criteria for Predicting Carcinogenic Activity of Chemical Compounds. *Environmental Science and Technology* 21(8):743-745.
- Arcos, J. and M. Argus. 1982a. *Chemical Induction of Cancer, Vol.IIA*. Academic Press, New York.
- Arcos, J. and M. Argus. 1982b. *Chemical Induction of Cancer, Vol. IIB*. Academic Press, New York.
- Arcos, J., M. Argus and G. Wolf. 1982a. *Chemical Induction of Cancer, Vol. I*, Academic Press, New York.
- Arcos, J., Y. Woo and M. Argus. 1982b. *Chemical Induction of Cancer, Vol. IIIA*. by Academic Press, New York.
- Arcos, J., Y. Woo and M. Argus. 1982c. *Chemical Induction of Cancer, Vol. IIIB*. Academic Press, New York.
- Ashby, J. and R.W. Tennant. 1988. Chemical Structure, Salmonella Mutagenicity and Extent of Carcinogenicity as Indicators of Genotoxic Carcinogenesis Among 222 Chemicals Tested in Rodents by the U.S. NCI/NTP. *Mutation Research* 204:17-115.
- Asher, I.M. and C. Zervos (Eds.) 1977. *Structural Correlates of Carcinogenesis and Mutagenesis*. The Office of Science, FDA, Washington, D.C.
- Auer, C.M., J.V. Nabholz, and K.P. Baetcke. 1990. Mode of action and the assessment of chemical hazards in the presence of limited data: use of Structure-Activity Relationships (SAR) under TSCA, Section 5. *Environmental Health Perspectives* 87:183-197.
- Bartsch, H., I. O'Neill, M. Castegnaro and M. Okada (Eds.) 1982. *N-Nitroso Compounds: Occurrence and Biological Effects*. Scientific Publications Series No. 41. IARC Monographs.
- Basak, S. 1992. *Chemical Carcinogenesis Assessment Program*. University of Minnesota-Duluth, Natural Resources Research Institute, Duluth, MN 55811.

- Bell, P. 1983-1985. Perspectives in Cancer Research reprinted from Cancer Research. Waverly Press Inc. Maryland.
- Bogovski, P. and E.A. Walker (Eds.) 1974. N-Nitroso Compounds in the Environment. Scientific Publications Series No. 9. IARC Monographs.
- Borszonyi, M., N. Day, K. Lapis and H. Yamasaki (Eds.) 1984. Models, Mechanisms, and Etiology of Tumor Promotion. Scientific Publications Series No. 56. IARC Monographs.
- Brooke, L.T., D.J. Call, D. L. Geiger, and C.E. Northcott. (Eds.) 1984. Acute Toxicities of Organic Chemicals to Fathead Minnows (*Pimephales promelas*). Center for Lake Superior Environmental Studies, University of Wisconsin-Superior. Volume I. 414 p.
- Colvin, M. 1981. Molecular Pharmacology of Alkylating Agents. IN: Chapter 16, Cancer and Chemotherapy, Vol. III. Academic Press, New York.
- Furihata C., Y. Yamawaki, S. Jin, H. Moriya, K. Kodama, T. Matsushima, T. Ishikawa, S. Takayama and M. Nakadate. 1984. Induction of Unscheduled DNA Synthesis in Rat Stomach Mucosa by Glandular Stomach Carcinogens. Journal of the National Cancer Institute 72:1327-1333.
- Geiger, D.L., C.E. Northcott, D.J. Call, and L.T. Brooke (Eds.) 1985. Acute Toxicities of Organic Chemicals to Fathead Minnows (*Pimephales promelas*). Center for Lake Superior Environmental Studies, University of Wisconsin-Superior. Volume II. 326 p.
- Geiger, D.L., S.H. Poirier, L.T. Brooke, and D.J. Call. (Eds.) 1986. Acute Toxicities of Organic Chemicals to Fathead Minnows (*Pimephales promelas*). Center for Lake Superior Environmental Studies, University of Wisconsin-Superior. Volume III. 328 p.
- Geiger, D.L., D.J. Call, and L.T. Brooke. 1988. Acute Toxicities of Organic Chemicals to Fathead Minnows (*Pimephales promelas*). Center for Lake Superior Environmental Studies, University of Wisconsin-Superior. Volume IV. 355 p.
- Geiger, D.L., D.J. Call, L.T. Brooke. 1990. Acute Toxicities of Organic Chemicals to Fathead Minnows (*Pimephales promelas*). Center for Lake Superior Environmental Studies, University of Wisconsin-Superior. Volume V. 332 p.
- Goel, S., N. Laiwani and J. Reddy. 1986. Peroxisome Proliferation and Lipid Peroxidation in Rat Liver. Cancer Research 46:1324-1330.
- Grain, C.F. 1982. Vapor Pressure. In: (W.J. Lyman, W.F. Reehl, D.H. Rosenblatt, Eds.) Handbook of Chemical Property Estimation Methods. Chapter 14. McGraw Hill Book Co., New York, NY.

- Harris, J.C. 1982. Rate of Hydrolysis. In: (W.J. Lyman, W.F. Reehl, D.H. Rosenblatt, Eds.) Handbook of Chemical Property Estimation Methods. Chapter 7. McGraw Hill Book Co., New York, NY.
- Hawley, G.G. 1981. The Condensed Chemical Dictionary. Tenth Edition. Van Nostrand Reinhold Co., Inc., New York, NY.
- Haworth, S., T. Lawlor, K. Mortelmans, W. Speck and E. Zeiger. 1983. Salmonella Mutagenicity Test Results for 250 Chemicals. Environmental Mutagenesis Supplement 1:3-142.
- Hunter, R.S. 1988. Computer calculation of pKa. In: (Turner, J.E., M.W. England, T.W. Schultz, and N.J. Kwaak, Eds.) Proceedings of the Third International Workshop on Quantitative Structure-Activity Relationships in Environmental Toxicology, May 22-26, 1988. Report No. CONF-880520-(DE88013180). National Technical Information Service, U.S. Dept. of Commerce, Springfield, VA 22161. pp. 33-42.
- Hunter, R.S., F.D. Culver, and A. Fitzgerald. 1987. SMILES User Manual. A Simplified Molecular Input Line Entry System. Includes extended SMILES for defining fragments. Review Draft, Internal Report, Montana State University, Institute for Biological and Chemical Process Control (IPA), Bozeman, MT.
- Leo, A. and D. Weininger. 1984. CLOGP version 3.2 User Reference Manual. Pomona Medicinal Chemistry Project, Pomona College, Claremont, CA 91711
- Leo, A. and D. Weininger. 1988. CLOGP software version 3.53 for VAX-11 under VMS 4.6+. Pomona Medicinal Chemistry Project, Pomona College, Claremont, CA 91711, distributed by Daylight Chemical Information Systems, Inc., Irvine, CA 92714.
- Lyman, W.J. 1982a. Solubility in Water. In: (W.J. Lyman, W.F. Reehl, D.H. Rosenblatt, Eds.) Handbook of Chemical Property Estimation Methods. Chapter 2. McGraw Hill Book Co., New York, NY.
- Lyman, W.J. 1982b. Adsorption Coefficient for Soils and Sediments. In: (W.J. Lyman, W.F. Reehl, D.H. Rosenblatt, Eds.) Handbook of Chemical Property Estimation Methods. Chapter 4. McGraw Hill Book Co., New York, NY.
- Mackay, D. 1988. Level 1 Environmental Partitioning/Fugacity Model. University of Toronto, Chemical Engineering Dept., Toronto, Ontario, M5S, 1A4, Canada.
- Montesano R. and L. Tomatis (Eds.) 1974. Chemical Carcinogenesis Essays. Scientific Publication Series No. 10. IARC Monographs.
- Montesano, R., H. Bartsch and L. Tomatis (Eds.) 1980. Molecular and Cellular Aspects of Carcinogen Screening Tests. Scientific Publications Series No. 27. IARC

- Montesano, R., H. Bartsch, H. Vainio, J. Wilbourn and H. Yamasaki (Eds.) 1986. Long-Term and Short-Term Assays for Carcinogens: A Critical Appraisal. Scientific Publications Series No. 83. IARC Monographs.
- Nesnow, S. M. Argus, H. Bergman, K. Chu, C. Firth, T. Helmes, R. McGaughy, V. Ray, T.J. Slaga, R. Tennant and E. Weisburger. 1986. Chemical Carcinogens : A Review and Analysis of the Literature of Selected Chemicals and the Establishment of the Gene-Tox Carcinogen Data Base. *Mutation Research* 185:1-195.
- Niemi, G.J., G.D. Veith, R.R. Regal, and D.D. Vaishnav. 1987. Structural features associated with degradable and persistent chemicals. *Environmental Toxicology and Chemistry* 6: 515-527.
- Oliver, B.G. and A.J. Nilmi. 1985. Bioconcentration factors of some halogenated organics for rainbow trout: limitations in their use for prediction of environmental residues. *Environmental Science and Technology* 19:842-849.
- O'Neill, I.K., R. VonBorstel, C. Miller, J. Long and H. Bartsch (Eds.) 1984. N-Nitroso Compounds: Occurrence, Biological Effects, and Relevance to Human Cancer Scientific Publications Series No. 57. IARC Monographs.
- Perrin, D.D., B. Dempsey, and E.P. Sergeant. 1981. pKa Prediction for Organic Acids and Bases. Chapman and Hill Publishing Co., New York, NY.
- QSAR. 1990. Quantitative Structure Activity Relationship database. U.S. Environmental Protection Agency, Environmental Research Laboratory-Duluth, Predictive Toxicology Branch, Duluth, MN 55804.
- Rechsteiner, C.E., Jr. 1982a. Boiling Point. In: (W.J. Lyman, W.F. Reehl, D.H. Rosenblatt, Eds.) *Handbook of Chemical Property Estimation Methods*. Chapter 12. McGraw Hill Book Co., New York, NY.
- Rechsteiner, C.E., Jr. 1982b. Heat of Vaporization. In: (W.J. Lyman, W.F. Reehl, D.H. Rosenblatt, Eds.) *Handbook of Chemical Property Estimation Methods*. Chapter 13. McGraw Hill Book Co., New York, NY.
- Russom, C.L., et al. In press.
- Russom, C.L., R.A. Drummond, and A.D. Hoffman. 1988. Acute toxicity and behavioral effects of acrylates and methacrylates to juvenile fathead minnows. *Bull. Environ. Contam. Toxicol.* 41: 589-596.
- Scow, K.M. 1982. Rate of Biodegradation. In: (W.J. Lyman, W.F. Reehl, D.H. Rosenblatt, Eds.) *Handbook of Chemical Property Estimation Methods*. Chapter 9. McGraw Hill Book Co., New York, NY.

Searle, C.E. (Ed.) 1984a. *Chemical Carcinogens, Vol. 1*. American Chemical Society, Washington, D. C.

Searle C.E. (Ed.) 1984b. *Chemical Carcinogens, Vol. 2*. American Chemical Society, Washington, D. C.

Soderman, J.V. (Ed.) 1982a. *Handbook of Identified Carcinogens and Noncarcinogens: Carcinogenicity-Mutagenicity Database, Vol. 1*. CRC Press, Inc., Boca Raton, Florida.

Soderman, J.V. (Ed.) 1982b. *Handbook of Identified Carcinogens and Noncarcinogens: Carcinogenicity-Mutagenicity Database, Vol. 2*. CRC Press, Inc., Boca Raton, Florida.

Thomas, R.G. 1982. Volatilization from Water. In: (W.J. Lyman, W.F. Reehl, D.H. Rosenblatt, Eds.) *Handbook of Chemical Property Estimation Methods*. Chapter 15. McGraw Hill Book Co., New York, NY.

Tomatis, L. and U. Mohr (Eds.) 1973. Transplacental Carcinogenesis Scientific Publications Series No. 4. IARC Monographs.

Tomatis, L., C. Agthe, H. Bartsch, J. Huff, R. Montesano, R. Saracci, E. Walker and J. Wilbourn. 1978. Evaluation of the Carcinogenicity of Chemicals: A review of the monograph Program of the International Agency for Research on Cancer (1971-1977). *Cancer Research* 38:1-877.

U.S. Department of Health and Human Services (U.S.DHHS). 1983. *Third Annual Report of Carcinogens*. U.S. Department of Health and Human Services, Washington, D.C.

Veith, G.D. and S.J. Broderius. 1987. Structure-toxicity relationships for industrial chemicals causing Type (II) narcosis syndrome. IN: K.L.E. Kaiser (Ed.) *QSAR in Environmental Toxicology-II*, D. Reidel Publishing Co., Dordrecht, Holland pp. 385-391.

Veith, G.D. and P. Kosian. 1983. Estimating Bioconcentration Potential from Octanol/Water Partition Coefficients. In: Mackay, D. et al., (Eds.) *Physical Behavior of PCBs in the Great Lakes*. Ann Arbor Science Publishers, Ann Arbor, MI: 269-282.

Veith, G.D., D.J. Call, and L.T. Brooke. 1983. Structure-toxicity relationships for the fathead minnow, *Pimephales promelas*: narcotic industrial chemicals. *Canadian Journal of Fisheries and Aquatic Sciences* 40(6):743-748.

Weininger, D. 1988. SMILES, a chemical language and information system. 1. Introduction to methodology and encoding rules. *Journal of Chemical Information and Computer Science* 28: 31-36.

Weininger, D., A. Weininger, and J.L. Weininger. 1989. SMILES. 2. Algorithm for generation of unique SMILES notation. *Journal of Chemical Information and Computer Science* 29: 97-101.

APPENDIX A: SMILES TUTORIAL

What is SMILES?

SMILES (**S**implified **M**olecular **I**nput **L**ine **E**ntry **S**ystem) is a chemical notation that allows a user to represent a chemical structure in a way that can be used by the computer. SMILES is an easily learned and flexible notation. The SMILES notation requires that you learn a handful of rules. You do not need to worry about ambiguous representations because the software will automatically reorder your entry into a unique SMILES string when necessary.

SMILES was developed through funding from the U.S. EPA, National Health and Environmental Research Laboratory (NHEERL), Mid-continent Ecology Division (MED-Duluth), to the Medicinal Chemistry Project at Pomona College, Claremont, CA and the Computer Sciences Corporation, Duluth, MN. Several publications discuss SMILES in more detail, including Anderson et al. 1987, Weininger 1988, Weininger et al. 1989, and Hunter et al., 1987.

SMILES has five basic syntax rules which must be observed. If basic rules of chemistry are not followed in SMILES entry, the system will warn the user and ask that the structure be edited or reentered. For example, if the user places too many bonds on an atom, a SMILES warning will appear that the structure is impossible. The rules are described below and some examples are provided. The rules below allow for the representation of a two-dimensional structure of a chemical. For the ASTER and QSAR systems, a two-dimensional depiction is adequate. Other rules are available for chemicals that are structural isomers, but will not be discussed in this basic tutorial.

Rule One: Atoms and Bonds

SMILES supports all elements in the periodic table. An atom is represented using its respective atomic symbol. Upper case letters refer to non-aromatic atoms; lower case letters refer to aromatic atoms. If the atomic symbol has more than one letter the second letter must be lower case. Bonds are denoted as:

- Single bond
- = Double bond
- # Triple bond
- * Aromatic bond
- . Disconnected structures

Single bonds are the default and therefore need not be entered. For example, 'CC' would mean that there is a non-aromatic carbon attached to another non-aromatic carbon by a single bond, and the computer would identify the structure as the chemical ethane. It is also assumed that the bond between two lower case atom symbols is aromatic. A blank terminates the SMILES string.

Rule Two: Simple Chains

By combining atomic symbols and bond symbols simple chain structures can be represented. The structures that are entered using SMILES are hydrogen-suppressed, that is to say that the molecules are represented without hydrogens. The SMILES software understands the number of possible connections that an atom can have. If enough bonds are not identified by the user through SMILES notation, the system will automatically assume that the other connections are satisfied by hydrogen bonds. Some examples:

CC	CH ₃ CH ₃	Ethane
C=C	CH ₂ CH ₂	Ethene
CBr	CH ₃ Br	Bromomethane
C#N	C≡N	Hydrocyanic acid
Na.Cl	NaCl	Sodium chloride

The user can explicitly identify the hydrogen bonds, but if one hydrogen bond is identified in the string, the SMILES interpreter will assume that the user has identified **all** hydrogens for that molecule.

HC(H)=C(H)(H) Ethene

Because SMILES allows entry of all elements in the periodic table, and also utilizes hydrogen suppression, the user should be aware of chemicals with two letters that could be misinterpreted by the computer. For example, 'Sc' could be interpreted as a sulfur atom connected to an aromatic carbon by a single bond, or it could be the symbol for scandium. The SMILES interpreter gives priority to the interpretation of a single bond connecting a sulfur atom and an aromatic carbon. To identify scandium the user should enter [Sc].

Rule Three: Branches

A branch from a chain is specified by placing the SMILES symbol(s) for the branch between a parenthesis. The string in parentheses is placed directly after the symbol for the atom to which it is connected. If it is connected by a double or triple bond, the bond symbol immediately follows the left parenthesis. Some examples:

CC(O)C	2-Propanol
CC(=O)C	2-Propanone
CC(CC)C	2-Methylbutane
CC(C)CC(=O)	2-Methylbutanal
c1c(N(=O)=O)cccc1	Nitrobenzene
CC(C)(C)CC	2,2-Dimethylbutane

Rule Four: Rings

SMILES allows a user to identify ring structures by using numbers to identify the

opening and closing ring atom. For example, in C1CCCCC1, the first carbon has a number '1' which connects by a single bond with the last carbon which also has a number '1'. The resulting structure is cyclohexane. Chemicals that have multiple rings may be identified by using different numbers for each ring. If a double, single, or aromatic bond is used for the ring closure, the bond symbol is placed before the ring closure number. Some examples:

C=1CCCCC1	Cyclohexene
C*1*C*C*C*C*1	
or c1cccc1	Benzene
C1OC1CC	Ethyloxirane
c1cc2cccc2cc1	Naphthalene

Rule Five: Charged Atoms

Charges on an atom can be used to override the knowledge regarding a valence that is built into SMILES software. The format for identifying a charged atom consists of the atom followed by brackets which enclose the charge on the atom. The number of charges may be explicitly stated ($\{-1\}$) or not ($\{-\}$). For example:

CCC(=O)O $\{-1\}$	Ionized form of propanoic acid
or CCC(=O)O $\{-\}$	
c1ccccn $\{+1\}$ 1CC(=O)O	1-Carboxylmethyl pyridinium

References:

Anderson, E., G.D. Veith, and D. Weininger. 1987. *SMILES: A line notation and computerized interpreter for chemical structures*. Report No. EPA/600/M-87/021. U.S. Environmental Protection Agency, Environmental Research Laboratory-Duluth, Duluth, MN 55804

Hunter, R.S., F.D. Culver, and A. Fitzgerald. 1987. *SMILES User Manual. A Simplified Molecular Input Line Entry System*. Includes extended SMILES for defining fragments. Review Draft, Internal Report, Montana State University, Institute for Biological and Chemical Process Control (IPA), Bozeman, MT.

Weininger, D. 1988. SMILES, a chemical language and information system. 1. Introduction to methodology and encoding rules. *Journal of Chemical Information and Computer Science* 28: 31-36.

Weininger, D., A. Weininger, and J.L. Weininger. 1989. SMILES. 2. Algorithm for generation of unique SMILES notation. *Journal of Chemical Information and Computer Science* 29: 97-101.

APPENDIX B : ECOTOXICITY PROFILE REPORTS

The ASTER Ecotoxicity Profile report contains four sections:

- 1) Chemical Identification
- 2) Environmental Exposure Assessment
- 3) Ecotoxicological Hazard Assessment
- 4) Risk Characterization.

In addition, references will be appended to the report if this default option of Reports ON was not modified when creating the report. The Appendix and Other data outputs will contain the Chemical Identification and Ecotoxicological Hazard Assessment sections, as well as the Reference section if this default option was not modified when creating the output.

CHEMICAL IDENTIFICATION

Chemical Identification briefly presents information which is stored in ASTER or has been supplied by the user for the name, CAS number, SMILES string, and formula of the compound. An example screen is given below.

Chemical Identification Section	
<pre> -----Assessment Tools for the Evaluation of Risk----- ---Rep 62-53-3 Benzenamine (Press Ctrl-Z to exit window or ? for help)--- 13-Aug-98 ASTER ECOTOXICITY PROFILE U.S. Environmental Protection Agency Office of Research and Development National Health and Environmental Effects Research Laboratory Mid-Continent Ecology Division (formerly the Environmental Research Laboratory-Duluth) Contact: Scientific Outreach Program 218-529-5225 or FAX 218-529-5003 Internet: ecotox.support@epa.gov I. CHEMICAL IDENTIFICATION Name Benzenamine CAS number 62-53-3 SMILES c(ccc1N)ccl Formula C6 H7 N </pre>	

ENVIRONMENTAL EXPOSURE ASSESSMENT

The Environmental Exposure Assessment section of the ASTER Report describes the potential hazard of exposure from the chemical due to the distribution of the compound within the environment. When empirical data are not available, predictive models in ASTER are used to estimate physicochemical properties, biodegradation, hydrolysis half-life and environmental partitioning. An example of an Environmental Exposure Assessment output is given below. The data presented in this section are available from these sources:

Source Definitions

ASTER From the ASTER database of literature values

Calc. Estimated value using method described above

User Value entered by user under Property Preview Display

Recalc. Value that was recalculated after user entry under Property Preview Display

When the reference is ASTER or CLOGP a reference number will be provided. This number along with a full reference citation will be printed in the Reference section of the Report if the default option of References ON was not modified.

Environmental Exposure Assessment Section

II. ENVIRONMENTAL EXPOSURE ASSESSMENT

Parameter	Value	Source	Reference
Molecular Weight (g/mole)	93.13	Calc.	
Melting Point (C)	-6.00	ASTER	
Boiling Point (C)	184.	ASTER	
Vapor Pressure (mm of Hg)	0.671	ASTER	
Ht Vaporization (cal/mole)	1.04E+04	Calc.	
Solubility in Water (mg/L)	4.10E+04	Calc.	
Log P	0.915	CLogP	17934
pKa	4.58	Calc.	
Adsorption Coef (log Koc)	1.83	Calc.	
Henry's Constant (atm-m ³ /mole)	2.01E-06	Calc.	
Log10(Henry's Constant) (atm-m ³ /mole)	-5.70	Calc.	
Hydrolysis Half-life (days)	hydrolysis unlikely		
BOD Half-life:		Calc.	
HALF LIFE 2 TO 16 DAYS			

Mackay Level 1 Environmental Partitioning @25 C Fugacity = 2.710E-06 Pa
 6.56 % into air
 0.06 % into soil
 93.32 % into water
 0.00 % into suspended solids
 0.00 % into aquatic biota
 0.06 % into sediment

Physicochemical Parameters

Molecular Weight

Calculated from the sum of the atomic weights of the atoms in a molecule. Molecular weight is a factor in estimating partitioning (Oliver and Nilmi, 1985).

Melting Point

Melting point is the temperature at which crystals are in equilibrium with the liquid phase at atmospheric pressure. The terms melting point and freezing point are used interchangeably, depending on whether the substance is being heated or cooled (Hawley, 1981). No model is stored in ASTER for estimating melting point. ASTER has a database of more than 6,000 measured melting point values.

Boiling Point

Boiling point is the temperature at which the vapor pressure of a liquid is equal to the pressure of the atmosphere (Rechsteiner, 1982a). The model used for estimating the boiling point of chemicals is the Meissner method (Rechsteiner 1982a). ASTER has measured boiling point values for approximately 3,000 compounds stored in its database.

Vapor Pressure

Vapor pressure is the pressure in mm of mercury at which a solid is in equilibrium with its own vapor. The method used for calculating vapor pressure in ASTER is a modified Watson correlation (Grain 1982). ASTER has measured vapor pressures for over 800 compounds stored in its database.

Heat of Vaporization

Heat of vaporization is the amount of heat required to convert a unit mass of liquid into a vapor without a rise in temperature, which implies a constant pressure process. The method for calculating heat of vaporization is a modified Kleig method (Rechsteiner 1982b).

Solubility in Water

Solubility reflects the maximum amount of chemical that will dissolve in pure water at a given temperature (Lyman, 1982a). Water solubility is calculated using various QSAR models developed at MED-Duluth (Veith, personal communication). ASTER also has measured water solubilities for approximately 200 compounds stored in its database.

Log P

Log P (the logarithm of the octanol-water partition coefficient) is the equilibrium concentration of solute in a non-polar solvent (octanol) divided by the concentration of the same species in a polar solvent (water) (Leo and Weininger, 1984). CLOGP software developed by the Pomona College Medicinal Chemistry Project is used to estimate Log P (Leo and Weininger, 1988).

pKa

pKa is an expression of the strength of an organic acid or base (Perrin et al., 1981). pKa is estimated using an algorithm by Hunter (1988) based on Perrin et al. (1981).

Adsorption Coefficient

The adsorption coefficient (Log K_{oc}) is the ratio of soluble fugacity coefficients in the aqueous and organic matter phase (Lyman, 1982b). The ASTER adsorption coefficient estimation model is from Lyman et al. (1982b).

Henry's Constant

Henry's Constant is the ratio of chemical concentration in air to concentration in water, when those two phases are in contact and are at equilibrium (Thomas 1982). The method described by Thomas (1982) is used to estimate Henry's Constant.

Log₁₀ Henry's Constant

The log in base ten of the Henry's Constant.

Hydrolysis Half-Life

The hydrolysis half-life is the time it takes to reduce a chemical to one-half of its original quantity through hydrolysis. This provides a measure of the stability of organic chemicals in the aquatic environment and is important in environmental fate processes.

The estimation is based on a method described in Harris, 1982.

BOD Half-Life

Biodegradation is the transformation of a chemical caused by the action of living organisms (Scow 1982). Half-life means the time required for biodegradation to transform a chemical to one-half of its original quantity. BOD is determined through an expert system which relates database information based on the biochemical oxygen demand (BOD) procedure and associated structural fragments (Niemi et al. 1987).

Mackay Level 1 Environmental Partitioning

Environmental partitioning is the relative deposition of a chemical into various environmental compartments. The model used in ASTER is the Level I model provided by Mackay (1988). In Mackay's Level I model, the compartments are air, water, soil, bottom sediment, suspended aquatic matter, and biota. The sizes of the compartments are fixed.

ECOTOXICOLOGICAL HAZARD ASSESSMENT

The Ecotoxicological Hazard Assessment section of the ASTER Report is divided into two sections: Aquatic Hazard Identification and Human Health Hazard Identification. The Aquatic Hazard Identification section of ASTER provides aquatic effects information from a variety of sources including U.S. EPA Water Quality Criteria Documents, the AQUIRE database and QSARs. ASTER is designed to provide high quality data for discrete chemicals, when available in the associated databases, and mechanistically-based QSAR estimates when data are lacking. In the Human Health Hazard Identification section, you are provided information regarding the potential carcinogenicity or mutagenicity of a compound. This information is based on a database of known carcinogens/mutagens and an expert system which identifies structural fragments suspected to be carcinogenic or mutagenic.

Aquatic Hazard Identification

A hierarchy is built into the ASTER system which preferentially retrieves information based on the level of confidence in the data. The different levels of information in order of confidence are:

- U.S. EPA Water Quality Criteria Documents
- U.S. EPA MED-Duluth Fathead Minnow database
- 'High quality' AQUIRE data
- QSAR estimates of effects

Data Tables

If a Water Quality Criteria Document is available for the chemical, the tables from the document will be presented first, followed by the best available data in ASTER. Five tables display a combination of U.S. EPA MED-Duluth Fathead Minnow database, 'High quality' AQUIRE data and QSAR estimates. ASTER screening requires only the median values for particular endpoints and species be reported. The non-median

values are reported in a separate Appendix file (see Viewing Report). The criteria for categorizing ASTER data into tables are:

Acute Data

The data reported in this table is for specific endpoints for 96 hour animal tests. The endpoints are LETH (100% mortality), LC50, EC50, LD50, ED50 (see Appendix C for complete definitions). The effects are for mortality, equilibrium or immobilization. An exception for this table are for crustacean species, which report 48 hour tests. Molluscan tests also include shell valve closure effect data.

Chronic Data

The chronic data table includes animal effects with MATC, NOEC or LOEC endpoints for:

- Cladocera: ≥ 21 day mortality, growth and reproduction tests
- Mysidacea: ≥ 7 day mortality, growth and reproduction tests
- Fish (non-Salmonidae): ≥ 24 day mortality, hatch, growth and reproduction tests
- Salmonidae: ≥ 60 day mortality, hatch, growth and reproduction tests

Plant Data

The plant data table includes effects for 96 hour algae and cyanobacteria tests, and ≥ 96 hours for bryophyta and tracheophyta (i.e., vascular plants). All other plant tests are reported in the Other data table.

Bioconcentration Data

Animal data that report a BCF calculation are reported in this table.

Other Data

Data that has passed the ASTER filters, but does not meet the criteria of the four tables previously listed will be reported in this table. **In contrast, the Other Data file contains data that did not pass the ASTER filter (see B-15).**

Each of these tables is divided into two sections based on test media; fresh water and salt water. The remaining sort hierarchy is species (alphabetical), effect and test duration.

Example Water Quality Criteria Document

Water Quality Criteria Document for Acrolein, 1980

Table 1. Acute values for acrolein

Species	Method*	LC50/EC50 (ug/l)	Species Mean Acute Value (ug/l)

FRESHWATER SPECIES			
Cladoceran, Daphnia magna	S, U	80	68
Bluegill, Lepomis macrochirus	S, U	90	95

Largemouth Bass,
Micropterus salmoides S, U 160 160

SALTWATER SPECIES

Eastern oyster,
Crassostrea virginica FT, U 55** 55

Table 2. Chronic values for acrolein

Species	Method*	Limits (ug/l)	Chronic Value (ug/l)

FRESHWATER SPECIES			
Cladoceran, Daphnia magna	LC	17-34	24
Fathead minnow, Pimephales promelas	LC	11-42	21

* LC = life cycle or partial life cycle.

ACUTE-CHRONIC RATIO

Species	Chronic Value (ug/l)	Acute Value (ug/l)	Ratio

Cladoceran, Daphnia magna	24	57	2.4

Table 3. Species mean acute and chronic values for acrolein

Species	Species Mean Acute Value* (ug/l)	Acute-Chronic Ratio
FRESHWATER SPECIES		
Cladoceran, Daphnia magna	68	2.4

Table 4. Residues for acrolein

Species	Tissue	Bioconcentration Factor	Duration (days)

FRESHWATER SPECIES			
Bluegill, Lepomis macrochirus	whole body	344	28

Example MED/AQUIRE/QSAR Report

** Researchers and managers using AQUIRE data for analysis or summary **
 ** projects should consult with the original scientific paper to ensure **
 ** an understanding of the content of the data retrieved from AQUIRE. **

ACUTE DATA

Species Common Name Species Latin Name	Ex Ty	Duratio (days)	Endpoint Effect	Conc Type	Conc (ug/L)	Source	Ref No.
FRESH WATER							
184205: Water flea Daphnia magna	S	2.00	LC50	MOR	59491 calculated	QSAR	9003
184202: Bluegill Lepomis macrochirus	F	4.00	LC50	MOR	91628 calculated	QSAR	9003
4833: Fathead minnow Pimephales promelas	F	4.00	LC50	MOR	114000	MED	3217
158268: Medaka, high-eyes Oryzias latipes	F	4.00	LC50	MOR	93500	AQUIRE	14908

Water Quality Criteria Documents

The Criteria and Standards Division of the U.S. EPA, Office of Water has generated more than 90 Water Quality Criteria Documents on 186 compounds. The tables from 49 of these documents (Table 1) have been stored within ASTER and are retrieved if a CAS number, name, or SMILES string for a Water Quality Criteria chemical is entered. This is considered the highest quality data because water quality standards are defined within these documents. Also, these documents have been peer reviewed as to the quality of the data. The tables will appear on your screen with some modifications from the original documents. These modifications do not involve raw data changes, but removal of some fields to allow for an 80 character width. For more detailed information refer to the original Water Quality Criteria Document (the citation appears in the Reference section of the ASTER output).

When these documents are retrieved, chemicals other than the selected chemical may appear in the output because many criteria documents were based on groups of chemicals, not discrete compounds.

Table 1: Water Quality Criteria Documents in ASTER

Acrolein, 1980 Aluminum, 1988 Ammonia, 1984, 1989 Antimony, 1980 Arsenic, 1984 Benzene, 1980 Benzidine, 1980 Beryllium, 1980 Cadmium, 1980 Carbon Tetrachloride, 1980 Chlordane, 1980 Chlorinated Phenols, 1980 Chlorinated Benzenes, 1980 Chlorinated Ethanes, 1980 Chlorine, 1984 Chloroalkyl Ethers, 1980 Chlorpyrifos, 1986 Chromium, 1984 Cyanide, 1984 Dichlorobenzenes, 1980 Dichloroethylenes, 1980 Dichloropropane, Dichloropropene, 1980 Dinitrotoluene, 1980 Ethylbenzene, 1980 Halomethanes, 1980	Heptachlor, 1980 Hexachlorobutadiene, 1980 Hexachlorocyclohexane, 1980 Hexachlorocyclopentadiene, 1980 Isophorone, 1980 Lead, 1984 Mercury, 1984 Naphthalene, 1980 Nickel, 1986 Nitrobenzene, 1980 Nitrophenols, 1980 Nitrosamines, 1980 Parathion, 1986 Pentachlorophenol, 1986 Phthalate Esters, 1980 Polychlorinated Biphenyls, 1980 Polynuclear Aromatic Hydrocarbons, 1980 Selenium, 1980 2,3,7,8-Tetrachlorodibenzo-p-dioxin, 1984 Tetrachloroethylene, 1980 Toluene, 1980 Toxaphene, 1986 Trichloroethylene, 1980 Zinc, 1987
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If a Water Quality Criteria Document is not available for the selected chemical, ASTER will proceed to the next level of data quality. For these chemicals, only the highest level of data will be presented for each species at each effect as information is available.

In addition to the presentation of the Water Quality Criteria Document, ASTER will present the best data from MED-Duluth database, AQUIRE and QSARs for each species and endpoint. ASTER will present only the median value if more than one value is available for a species at a particular endpoint and test duration. AQUIRE does not currently identify effect data that appear in the Water Quality Criteria Documents; therefore there may be overlap in the data presented for these compounds.

Duluth Fathead Minnow Database (MED)

The U.S. EPA, MED-Duluth has generated a systematic database of 96 hour acute LC50 values for fathead minnows (*Pimephales promelas*). This database has been published in five volumes through the University of Wisconsin-Superior (Brooke et al., 1984 and Geiger et al., 1985, 1986, 1988, 1990).

'MED' will appear under the source column if the value was retrieved from the MED-Duluth fathead minnow database. If the chemical does not appear in this database, ASTER will proceed to the next quality level of data and search for another fathead minnow acute LC50 value within AQUIRE as well as retrieving the best effect data for

other species.

'High Quality' AQUIRE Database (AQUIRE)

'AQUIRE' will appear under the source column if the exposure information is the median effect value for the identified species at the specified exposure duration. As mentioned in the Report Generation section of this document, ASTER uses a filter to remove effect data that may not be of the highest quality. Although these restrictions may substantially reduce the AQUIRE data presented in the ASTER Report, it ensures that volatile or easily degraded compounds were measured, and that whenever possible, the best test procedures were utilized. Also, by presenting the median value for each species/effect/test duration you will not be overwhelmed with data, but will get a representative data point to work with. The other data are available in AQUIRE by selecting the Appendix and Other Data outputs described in the Report Generation section of this document. U.S. EPA Office of Pesticide Programs registration toxicity data is also provided within the AQUIRE database.

AQUIRE does not give a review as to the quality of the data presented. A documentation code exists, but this indicates the level of documentation provided by the authors in the publication. A document code of C means thorough methods and results' documentation was provided by the author. A document code of M means that documentation is generally satisfactory, but one or more of the pieces of information coded into AQUIRE are missing from either the methods or results section of the article (e.g., control information). ASTER screens AQUIRE, and presents data which pass the following restrictions:

- Test must be conducted in a laboratory setting
- Test pH within the range of 6.5 - 8.5
- AQUIRE documentation codes are C or M.
- No formulations or carriers are used during the exposure.
- Only flow-through measured exposures for fish species.
- For invertebrates or plants, the tests must be measured, but can be flow-through, static renewal, or static. Flow-through data will be used before static renewal data, and static renewal will be used before static test data unless previous qualifications have not been met.

Data that do not pass this filter are placed in a file, Other Data, that can be retrieved (see Viewing Reports).

The ASTER Aquatic Hazard Identification Report contains the following information:

- Species Common Name
- Species Latin Name
- Exposure Type (ExTy)
- Exposure Duration (Dur days)
- Endpoint/Effect
- Concentration Type (Conc Type)
- Water Concentration Conc (ug/L)
- Source of data (e.g., MED, AQUIRE, QSAR)
- Reference Number (Ref No.)

Appendix C documents Aquatic Hazard Identification codes in detail.

Quantitative Structure Activity Relationships (QSAR)

After searching the Water Quality Criteria Documents, MED-Duluth fathead minnow database and AQUIRE, if the fathead minnow acute 96 hour LC50 value and/or chronic values are not available for the selected chemical, ASTER will estimate these endpoints using QSARs. QSARs are statistically-based relationships between physicochemical properties and biological activity.

If acute LC50 values were not available from Water Quality Criteria documents or AQUIRE for goldfish, catfish, rainbow trout, and *Daphnia magna*, ASTER will use QSARs to estimate these effects based on the fathead minnow acute LC50 selected under the Aquatic Hazard Identification section of the ASTER Report. ASTER will also estimate a bioconcentration factor using a QSAR described by Veith and Kosian (1983).

If the effect data are based on QSAR estimates, 'QSAR' appears in the source column, and 'Calculated' will appear under the 'Conc' column of the ASTER report below the estimated value to warn you that a QSAR estimate was used.

All QSAR estimates in this section, with the exception of BCF, are calculated based on the acute mode of toxic action of the compound. The Risk Characterization section of this document describes in greater detail how mode of action is determined. QSARs were developed using the MED-Duluth fathead minnow acute and chronic databases. QSARs for goldfish, catfish, rainbow trout, and *Daphnia magna* are based on comparisons of high quality AQUIRE data for these species with the MED-Duluth fathead minnow acute database. These interspecies estimates are only available for chemicals acting by nonpolar and polar narcosis modes of action. QSARs used to estimate chronic toxicity are selected based on the acute mode of action. Some compounds may become bioactivated during long exposures (chronic) and the acute mode of action may not be suitable. ASTER accounts for bioactivation for some classes of compounds. These issues are addressed in the Ecological Risk Characterization section of the ASTER Report.

Sources of the equations and information regarding the predominant chemical classes used to develop these QSARs are presented below.

Table 2. Acute LC50 QSARs for Fathead Minnows

Mode of action	Predominant Chemical Classes Used in QSAR	Reference
Nonpolar narcosis	Alcohols, Ketones, Ethers, Alkanes, Benzenes	Veith et al., 1983
Polar narcosis	Phenols, Anilines	Veith and Broderius, 1987
Uncouplers of Oxidative Phosphorylation	Phenols, Anilines	Russom, et al., in press
Reactive carbonyl (equation 1)	Aldehydes: aromatics other than salicylaldehydes	Russom, personal communication
Reactive carbonyl (equation 2)	Aldehydes: salicylaldehydes	Russom, personal communication
Reactive carbonyl (equation 3)	Aldehydes: aliphatic	Russom, personal communication
Diesters	Diesters	Russom, personal communication
Ester narcosis	Esters excluding diesters	Russom, et al., in press
Reactive: acrylates	Acrylates	Russom et al., 1988

Table 3. Chronic Value QSARs for Fathead Minnows

Mode of Action	Predominant Chemical Classes Used in QSAR	Reference
Nonpolar narcosis	Alkanes, Benzenes	Russom, personal communication
Polar narcosis	Phenols, Pyridines	Russom, personal communication
Uncouplers of oxidative phosphorylation	Phenols	Russom, personal communication

Table 4. Multiple Species LC50 Estimations for Nonpolar and Polar Narcosis Modes of Action

Species	Predominant Chemical Class Used in QSAR	Reference
Rainbow trout	Phenols, Benzenes, Alkanes, Alcohols	Russom, personal communication
Bluegill	Phenols, Benzenes, Alkanes, Alcohols	Russom, personal communication

Species	Predominant Chemical Class Used in QSAR	Reference
Daphnia	Phenols, Alkanes, Benzenes, Alcohols	Russom, personal communication
Catfish	Alcohols, Phenols	Russom, personal communication

QSARs are not currently available in ASTER for some of the more specific modes of action because of a lack of reliable parameters to explain variation in toxicity. The QSAR equations used to estimate acute and chronic toxicity use log P as the independent variable. QSARs for reactive toxicants and acetylcholinesterase inhibitors may require the use of electronic parameters which are not currently stored or estimated by the ASTER system.

Human Health Effects

The Human Health Effects section uses the Chemical Carcinogenesis Assessment Program (CCAP) (Basak 1992). CCAP gives information on the genotoxicity of a chemical by either retrieving information from a database of known carcinogens/mutagens or invoking an expert system which identifies structural fragments suspected to be potentially carcinogenic or mutagenic. Rules for CCAP are based on extensive literature searches (Arcos, 1987; Arcos and Argus, 1982a; 1982b; Arcos et al., 1982a; 1982b; 1982c; Ashby and Tennant, 1988; Asher and Zervos, 1977; Bartsch et al., 1982; Bell 1983-1985; Bogovski and Walker, 1974; Borszonyi et al., 1984; Colvin 1981; Furihata et al., 1984; Goel et al., 1986; Haworth et al., 1983; Montesano and Tomatis, 1974; Montesano et al., 1980; 1986; Nesnow et al., 1986; O; Neill et al., 1984; Searle 1984a; 1984b; Soderman 1982a; 1982b; Tomatis et al., 1973; 1978; U.S. DHHS 1983). Under the Ecological Risk Characterization section of the ASTER Report details on the relevant scientific findings of the cancer study along with reference information are given.

ECOLOGICAL RISK CHARACTERIZATION

The fourth section of the ASTER Ecotoxicity Profile is Ecological Risk Characterization. The Environmental Exposure Assessment and Ecotoxicological Hazard Assessment sections are presented as tables. The Ecological Risk Characterization section discusses data from the previous sections.

The first component reviews the data from the Environmental Exposure Assessment section. A discussion of the potential volatility, persistence in water and partitioning behavior of the compound is given.

The second component is a discussion of the data from the Ecotoxicological Hazard Assessment section. If the chemical is identified by CCAP as having known or potential mutagenic or carcinogenic characteristics, a more detailed discussion of the target site

and mechanism of action is given as well as reference information (Basak 1992).

The acute mode of action is determined by examining structural fragments present in the chemical, and is based on research conducted at the U.S. EPA, MED-Duluth laboratory (Russom, et al., in press). The acute toxicity modeling component of ASTER assesses the structural characteristics of chemicals and evaluates whether or not a compound contains specific functional moieties (or moieties capable of being bioactivated) that are associated with more specific modes of toxic action. When structural fragments associated with a mode of action are identified, ASTER calculates the toxicity based on that mode of action. If structural fragments for more than one mode of action are identified by ASTER, the mode of action that is determined to result in the greatest hazard to the organism (e.g. greatest toxicity) is selected. The nonpolar narcosis QSAR is invoked only if the structural characteristics of a chemical do not suggest that a more specific mode of action may be involved (e.g., the chemical has gone through all fragment checks in ASTER and no fragments were identified).

QSARs used to estimate chronic toxicity are selected based on the acute mode of action. Some compounds may become bioactivated during long exposures (chronic) and the acute mode of action may not be suitable. ASTER accounts for bioactivation for some classes of compounds. These issues are addressed in discussions regarding chronic toxicity which appear in the Ecological Risk Characterization section of the ASTER Report.

The third component of the Environmental Exposure Assessment section presents ancillary information that is stored in the ASTER database. You are advised when additional information on the compound is available from the U.S. EPA, IRIS (Integrated Risk Information System) database, and when the chemical appears on SARA (Superfund Amendments and Reauthorization Act) Title III's Toxic Emissions Inventory (also known as section 313 of the Emergency Planning and Community Right-to-Know Act of 1986). Information regarding the chemical's registered use is given for pesticides registered with the U.S. EPA, Office of Pesticide Programs.

REFERENCES

A list of references will appear at the end of the ASTER Report if the default option of Citations ON was not modified when creating the Report. The references are numbered and appear in numerical order. The numbers correspond to numbers appearing in reference columns in the Environmental Exposure Assessment and Ecotoxicological Hazard Assessment sections and numbers in square brackets [] in text portions of the ASTER Report.

APPENDIX REPORT

If you selected Appendix when creating the report, this output will appear on the Report Status screen. As discussed previously, ASTER uses a filter when creating the ASTER report. Appendix refers to other data that met the ASTER screening requirements, but were not median values for particular endpoints and species.

The Appendix will consist of Chemical Identification, Aquatic Hazard Identification and Reference (if option was selected) sections similar to those described in the ASTER Ecotoxicity Profile Report section of this document. All data presented in the Aquatic Hazard Identification Section are from the AQUIRE database, therefore the Source column is not included in the table.

OTHER DATA REPORT

If you selected Other Data when creating the report, this output will appear on the Report Status screen. As discussed previously, ASTER uses a filter when creating the ASTER report. The Other Data output contains AQUIRE data that did not meet the screening requirements of ASTER. These data may be high quality, but the assurance is less than for data which appears in the ASTER Report and Appendix. In addition, the Other Data report may include species which do not appear in the Report and Appendix outputs.

The Other Data output will consist of Chemical Identification, Aquatic Hazard Identification and Reference (if option was selected) sections similar to those described in the ASTER Ecotoxicity Profile Report section of this document. All data presented in the Aquatic Hazard Identification Section are from the AQUIRE database, therefore the Source column is not included in the table.

APPENDIX C: AQUATIC HAZARD IDENTIFICATION CODES

The Aquatic Hazard Identification tables of the ASTER report, Appendix or Other Data output files are listed below. For the AQUIRE codes displayed within the interactive Detail format, please refer to the ASTER online help (CONTROL-G) or the ECOTOX Technical Support Document.

Exposure Type:

- C** Topical exposure
- D** Diet or Oral exposure (includes simultaneous diet and water exposure)
- F** Flow-through
- I** Injection
- L** Leaching (used for leachate and sediment exposures, if water conc reported)
- P** Pulse (intermittent or fluctuating dosing)
- R** Renewal
- S** Static

Concentration Type

- A** Active Ingredient
- D** Dissolved Metal Ion
- F** Formulation
- L** Labile
- T** Total
- U** Unionized Inorganic, Non-metals

Endpoint Codes

CODE	ENDPOINT NAME:	ENDPOINT DEFINITION
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BCF Bioconcentration Factor: A unitless value describing the degree to which a chemical can be concentrated in the tissues of an organism in the aquatic environment. At apparent equilibrium during the uptake phase of a bioconcentration test, the BCF is the concentration of a chemical in one or more tissues of the aquatic organism divided by the average concentration in the water.

$$BCF = \frac{\text{g/kg chemical in organism tissue}}{\text{g/L chemical in H}_2\text{O}}$$

or it is calculated from a ratio of rate constants, if at steady state,

$$BCF = \frac{K1 \text{ (uptake)}}{K2 \text{ (elimination)}}$$

BCFD BCF dry-weight: Bioconcentration factor derived using dry weight.

EC50 Median Effective Concentration: Effective concentration for 50% of the organisms tested. Used when an effect other than death is the observed endpoint.

ECxx xx% Effective Concentration: Effective concentration for xx% of tested organisms.

ED50 Median Effective Dose: Effective dose for 50% of the organisms tested. Used when an effect other than death is the observed endpoint.

ET50 Median Effective Time: Median time to effect or estimated mean survival time.

ICxx xx% Inhibition Concentration: Statistically or graphically estimated concentration of test material, under specified concentrations, is expected to cause a xx% inhibition of a biological process for which the data are dichotomous.

IC50 Median Inhibition Concentration: Statistically or graphically estimated concentration of test material, under specified concentrations, is expected to cause a 50% inhibition of a biological process for which the data are dichotomous.

CODE ENDPOINT NAME: ENDPOINT DEFINITION

LC50	Median Lethal Concentration: Statistically estimated concentration that is expected to be lethal to 50% of a group of organisms tested. Death may be defined by the effect codes MOR, IMM, EQU, HAT. TLms and TL50s with death as the measured endpoint are reported as LC50*.
LDxx	xx% Lethal Concentration: Lethal concentration for xx% of the tested organisms.
LD50	Median Lethal Dose: A statistically estimated dose that is expected to be lethal to 50% of a group of organisms.
LDxx	xx% Lethal Dose: A statistically estimated dose that is expected to be lethal to xx% of a group of organisms.
LOEC	Lowest Observed Effect Concentration: Lowest concentration or level (LOEL) that has a statistically significant adverse effect on the tested organisms. The term MEC (Minimum Effective Concentration) is coded as LOEC.
LT50	Mean Survival Time: Represents time until death of 50% of the tested organisms.
LETC	Lethal Threshold Concentration: Toxicity curve asymptotic concentration indicating an incipient LC50 value. Acute lethal action has essentially ceased.
LTxx	xx% Death Time: Time until xx% test organisms are dead.
MATC	Maximum Acceptable Toxicant Concentration: Hypothetical threshold concentration that is the geometric mean between the NOEC and LOEC concentration. The term Chronic Value (ChV) is encoded as MATC.
NOEC	No Observed Effect Concentration: Highest concentration or level (NOEL) that has no statistically significant adverse effect on the tested organisms. The terms NOLC and NOEL are coded as NOEC.
NR-LETH	Lethal: 100% mortality or 0% survival including algicidal and herbicidal effects. (No statistically derived endpoint reported).
NR-ZERO	Zero Mortality: 0% mortality or 100% survival of organisms. (No statistically derived endpoint reported).

Effect Codes

Code	Code Name: Definition
ABD	Abundance: Number of individuals of a taxon per unit area equivalent to density. Comparison to controls; not related to time. Use for coding efficacy of removal of lice from fish.
ABN	Abnormality: Effects which occur to the organism that has been directly exposed (compare to TERatogenic effects). Includes physical malformations, eg., imposex, limb deformities, lesions, heart defects, edema, discoloration or absence of color, congestion, anomalies; in plants includes cell damage.
ASM	Assimilation Efficiency: Change in efficiency of trophic transfers between different levels in the food chain, e.g. between primary producers and grazers.
BEH	Behavior: Quantifiable change in activity including trained behavior.
BGC	Biogeochemical: Changes in whole system biogeochemical processes, e.g. sulfate reduction, denitrification, methanogenesis, nitrification, ammonification, net N or P removal.
BIO	Biochemical: Change in physiochemical levels including glycogen, cholesterol, lipids, and ions.
BMS	Biomass: Productivity measurement equivalent to yield and standing crop. Total mass or weight of a living organism per area or volume measured either directly through dry weight/ash-free dry weight or indirectly through ATP, chlorophyll a, absorbance, total carbon, or caloric content.
CAL	Case Leaving: Change in number of organisms emerging from a casing.
CEL	Cellular: Cytology, change in organelle structure, cell size or cell volume.
CLN	Rate of Colonization: Change in ability to colonize an uninhibited substrate under toxicant stress.
CLR	Chlorophyll: Measurable change in chlorophyll content including chlorophyll a content, chlorosis.
CYT	Cytogenetic: Changes in the genetic processes of cell (e.g. RNA, DNA).
DCM	Decomposition: Change in rate of degradation of plant material.
DET	Detachment: Change in ability of an organism to detach from or attach to a substrate.

Code	Code Name: Definition
DIV	Species Diversity: Change in number of species in a given area or index of species diversity (e.g. species richness, evenness).
DRF	Drift: Change in the number of larval aquatic insects to travel a given distance in a stream.
DVP	Development: Change in ability to grow to a more mature life stage and in time between separate life stages; molting, ability to germinate (not germination rate, use PGR), cell cleavage.
EMR	Emergence: Change in the emergence from larval stage into the adult stage.
ENZ	Enzyme: Change in enzyme activity or enzyme protein levels.
EQU	Equilibrium: Change in ability to maintain balance.
FLT	Filtration Rate: Change in rate of filtration.
FOC	Food Consumption: Change in feeding behavior.
GPR	Gross Primary Productivity/Respiration: Change in ratio of system-level gross primary productivity to respiration.
GRO	Growth: Measurable change in length and/or weight of test organism; for populations or colonies use PGR.
HAT	Hatchability: Change in percent hatch, time to hatch or number of eggs hatched.
HAT	Hatchability: Change in percent hatch, time to hatch or number of eggs hatched.
HEM	Hematological: Change in various blood parameters such as red blood cell count, hematocrit, and serum osmolarity.
HIS	Histology: Presence of physical damage or change to tissues or cells.
HMG	Hemorrhage: Change or presence of hemorrhaging.
HRM	Hormone: Change in hormone levels.
IMM	Immobilization: Change in the failure to respond or lack of movement after mechanical stimulation.
IMM	Immobilization: Change in the failure to respond or lack of movement after mechanical stimulation.

Code	Code Name: Definition
LOC	Locomotor: Quantifiable change in direct movement .
MIG	Migration: Change in migration behavior.
MOR	Mortality: Effect expressed as % death or % survival.
MUL	Multiple Effect: Change in more than one effect when data were reported as one result.
NFX	Nitrogen Fixation: Change in ability of aquatic plants to fix nitrogen.
NR	Not Reported: The author reported an endpoint, but not a specific effect.
OXC	OXYgen Consumption: Quantifiable change in oxygen uptake by the test organism; for plants see PSE (photosynthesis).
PCC	Population Carrying Capacity: Change in the carrying capacity of the population.
PGR	Population Growth: Rate of growth. Equivalent to intrinsic rate of increase and maximum possible rate of growth for species populations and colonies. Calculated by relating biomass or abundance to time. Life table data, germination rates are also included.
PHY	Physiological: Change in the organic processes or functions of a plant or an organism. Examples of effects in this category include caloric content, cough frequency, granule or concretion formation, heartbeat, heterocyst formation/frequency, membrane permeability, metabolic stress, osmoregulation, parasitic infection, urine frequency, ventilatory rate, water volume.
PIG	Pigment: Quantitative (ie., compared to the control) change in the pigment, e.g. melanization. Does not include chlorophyll (see CLR).
POP	Code as ABD, DIV or PGR.
PRB	Predatory Behavior: Change in ability to seek and capture prey.
PRP	Primary Productivity: Change in net or gross system-level primary production (e.g., CO ₂ uptake, O ₂ release).
PRV	Predation Vulnerability: Change in ability to avoid or escape capture.
PSE	Photosynthesis: Change in plant productivity indicated by change in 14C or CO ₂ uptake or oxygen production.
PSR	Code as ABD, DIV or PGR.

Code	Code Name: Definition
PTR	Phototactic Response: Attraction to or avoidance of light.
PUP	Pupation: Change in percent pupation or pupation duration.
REP	Reproduction: Change in male and/or female reproductive ability; fertilization and fertilization rate; vegetation reproductive processes.
RES	Respiration: Coded as PHYsiology (PHY), OXYgen Consumption (OXC) or PhotoSynthEsis (PSE).
RGN	Regeneration: Change in ability to regenerate a body part, byssus production.
RSD	Residue: Amount of test chemical remaining in tissue after exposure.
SHD	Shell Deposition: Change in the ability to grow a shell.
SMI	Somatic Index: Change in organ to body weight ratios.
SPR	Secondary Production: Change in production of consumer level organisms (e.g. macroinvertebrates).
SRE	System Respiration: Change in rate of oxygen uptake by entire ecosystem, as opposed to individual or groups of organisms.
STR	Stress: Observed physiological tension or irritation in animals or plants.
SVC	Shell Valve Closure: Change in the ability to open or close a shell valve upon mechanical stimulation and/or gaping response.
TER	Teratogenesis: Use this code when exposure of adults results in quantifiable occurrence of abnormal offspring.
THL	Thermal: Change in tolerance to temperature change.
TMR	Tumor: Presence or absence of tumors.
VTE	Vertebral: Physical change in vertebral structure and/or composition leading to scoliosis, lordosis, etc.
~XXX	Delayed Effect: An effect (xxx) reported after the organisms are transferred to toxicant-free test chambers.

Only documentation codes of “C” and “M” are available in ASTER.

ACQUIRE FIELD NAME		SCORE	
Test Methods			
EXPOSURE DURATION		20	
CONTROL TYPE		5	
ORGANISM CHARACTERISTICS		5	
CHEMICAL ANALYSIS METHOD		5	
EXPOSURE TYPE		5	
TEST LOCATION		4	
CHEMICAL GRADE		4	
TEST MEDIA		4	
HARDNESS (freshwater exposures)	SALINITY (salt-water exposures)	2	4
ALKALINITY (freshwater exposures)		2	
DISSOLVED OXYGEN		2	
TEMPERATURE		2	
pH		2	
Results			
ENDPOINT		20	
TREND OF EFFECT		5	
EFFECT PERCENT		5	
STATISTICAL SIGNIFICANCE		4	
SIGNIFICANCE LEVEL		4	
TOTAL		100	

* Score is assigned as long as the field is not empty or does not contain the code 'NR'

Documentation Scoring:
 86-100 DC=Complete
 51-85 DC=Moderate
 <51 DC=Incomplete

APPENDIX D: FULL ASTER REPORT EXAMPLE

-----Assessment Tools for the Evaluation of Risk-----
 ----Rep 62-53-3 Benzenamine (Press Ctrl-Z to exit window or ? for help)----

13-Aug-98

ASTER ECOTOXICITY PROFILE

U.S. Environmental Protection Agency
 Office of Research and Development
 National Health and Environmental Effects Research Laboratory
 Mid-Continent Ecology Division
 (formerly the Environmental Research Laboratory-Duluth)

Contact: Scientific Outreach Program
 218-529-5225 or FAX 218-529-5003
 Internet: ecotox.support@epa.gov

I. CHEMICAL IDENTIFICATION

Name Benzenamine
 CAS number 62-53-3
 SMILES c(ccc1N)ccl
 Formula C6 H7 N

II. ENVIRONMENTAL EXPOSURE ASSESSMENT

Parameter	Value	Source	Reference
Molecular Weight (g/mole)	93.13	Calc.	
Melting Point (C)	-6.00	ASTER	
Boiling Point (C)	184.	ASTER	
Vapor Pressure (mm of Hg)	0.671	ASTER	
Ht Vaporization (cal/mole)	1.04E+04	Calc.	
Solubility in Water (mg/L)	4.10E+04	Calc.	
Log P	0.915	CLogP	17934
pKa	4.58	Calc.	
Adsorption Coef (log Koc)	1.83	Calc.	
Henry's Constant (atm-m**3/mole)	2.01E-06	Calc.	
Log10(Henry's Constant) (atm-m**3/mole)	-5.70	Calc.	
Hydrolysis Half-life (days)	hydrolysis unlikely		
BOD Half-life: HALF LIFE 2 TO 16 DAYS		Calc.	
Mackay Level 1 Environmental Partitioning @25 C	Fugacity = 2.710E-06 Pa		
	6.56 % into air		
	0.06 % into soil		
	93.32 % into water		
	0.00 % into suspended solids		
	0.00 % into aquatic biota		
	0.06 % into sediment		

III. ECOTOXICOLOGICAL HAZARD ASSESSMENT

Aquatic Hazard Identification

** Researchers and managers using AQUIRE data for analysis or summary **
 ** projects should consult with the original scientific paper to ensure **
 ** an understanding of the content of the data retrieved from AQUIRE. **

ACUTE DATA

Species Common Name Species Latin Name	Ex Ty	Duratio (days)	Endpoint Effect	Conc Type	Conc (ug/L)	Source	Ref No.
FRESH WATER							
184205: Water flea Daphnia magna	S	2.00	LC50	MOR	59491 calculated	QSAR	9003
184202: Bluegill Lepomis macrochirus	F	4.00	LC50	MOR	91628 calculated	QSAR	9003
4833: Fathead minnow Pimephales promelas	F	4.00	LC50	MOR	114000	MED	3217
158268: Medaka, high-eyes Oryzias latipes	F	4.00	LC50	MOR	93500	AQUIRE	14908
184203: Channel catfish Ictalurus punctatus	F	4.00	LC50	MOR	52266 calculated	QSAR	9003
76393: Rainbow trout,donaldson tr Oncorhynchus mykiss	F	4.00	LC50	MOR	36200*	AQUIRE	10688

CHRONIC DATA

Species Common Name Species Latin Name	Ex Ty	Duratio (days)	Endpoint Effect	Conc Type	Conc (ug/L)	Source	Ref No.
FRESH WATER							
130176: Water flea Daphnia magna	R	21.0	MATC	MOR A	33.9	AQUIRE	662
130175: Water flea Daphnia magna	R	21.0	MATC	REP A	33.9	AQUIRE	662
158269: Medaka, high-eyes Oryzias latipes	F	28.0	MATC	GRO	<4610	AQUIRE	14908

BIOCONCENTRATION DATA

Species Common Name Species Latin Name	Ex Ty	Duratio (days)	Endpoint Effect	Conc Type	BCF	Source	Ref No.
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FRESH WATER

184207:
 Fathead minnow F 2.00- BCF RSD 2 QSAR 7
 Pimephales promelas 304 calculated

OTHER DATA

Species Common Name	Ex Ty	Duratio (days)	Endpoint Effect	Conc Type	Conc (ug/L)	Source	Ref No.
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FRESH WATER

20154:
 Water flea F 4.00 LC50 MOR 190 AQUIRE 4343
 Ceriodaphnia dubia

1837:
 Largemouth bass F 2.50 LC50 MOR 32700 AQUIRE 563
 Micropterus salmoides

54676:
 Largemouth bass F 6.50 LC50 MOR 10500 AQUIRE 538
 Micropterus salmoides

44:
 Largemouth bass F 7.50 LC50 MOR 7100 AQUIRE 563
 Micropterus salmoides

54677:
 Largemouth bass F 10.5 LC50 MOR 5200 AQUIRE 538
 Micropterus salmoides

1816:
 Goldfish F 3.50 LC50 MOR 9300 AQUIRE 563
 Carassius auratus

54670:
 Goldfish F 7.50 LC50 MOR 5600 AQUIRE 538
 Carassius auratus

22:
 Goldfish F 8.00 LC50 MOR 4600 AQUIRE 563
 Carassius auratus

54671:
 Goldfish F 11.5 LC50 MOR 5500 AQUIRE 538
 Carassius auratus

116431:
 Fathead minnow F 7.00 LC50 MOR 60220 AQUIRE 3910
 Pimephales promelas

116438:
 Fathead minnow F 7.00 LOEC GRO 23200 AQUIRE 3910
 Pimephales promelas

116436:
 Fathead minnow F 7.00 LOEC MOR 23200 AQUIRE 3910
 Pimephales promelas

116437:

Fathead minnow Pimephales promelas	F	7.00	NOEC	GRO	15700	AQUIRE	3910
116435: Fathead minnow Pimephales promelas	F	7.00	NOEC	MOR	15700	AQUIRE	3910
1838: Channel catfish Ictalurus punctatus	F	4.50	LC50	MOR	6300	AQUIRE	563
43: Channel catfish Ictalurus punctatus	F	8.50	LC50	MOR	6200	AQUIRE	563

Human Health Hazard Identification

There is no information in the QSAR SYSTEM which would suggest that this chemical is a potential carcinogen or mutagen.

IV. ECOLOGICAL RISK CHARACTERIZATION

A. Environmental Exposure Assessment

Henry's Constant = 2.01E-06 atm-m³/mole
 Log10 (Henry's Constant) = -5.70 atm-m³/mole

Lyman et al. 1982. would conclude that a chemical with these properties will volatilize slowly from open water. See page 15-15.

Hydrolysis is not likely to be an important transformation mechanism for this chemical

B. Ecotoxicological Hazard Assessment

Genetic/Mutagenic Assessment

There is no information in the QSAR SYSTEM which would suggest that this chemical is a potential carcinogen or mutagen.

POLAR NARCOSIS The acute mode of toxic action for these types of compounds is generally attributed to narcosis (the toxicologically induced and reversible stages of neural disruption). The narcosis syndrome elicited by these chemicals is distinct from the syndrome elicited by compounds thought to act via nonpolar narcosis. Polar narcotics are typically more toxic than what would be predicted from the nonpolar narcotic QSAR [3536].

When sufficient data is available from fathead minnow early life stage (ELS) tests (32-d exposures) completed at ERL-Duluth, QSAR models have been developed to predict chronic values for either survival or growth, which ever is the most sensitive endpoint. A chronic value is defined as the geometric mean of the LOEC (lowest observable effect concentration) and the NOEC (no observable effect concentration). These models have been

developed for groups of xenobiotics that have been classified based on their acute modes of toxic action. Empirical observations suggest that when a statistically robust ELS QSAR can be established and when 96-h LC50/32-d ELS chronic value ratios are within a factor of 20 it is reasonable to assume that adverse effects are elicited through the same mode of toxic action in both 4-d and 32-d exposures. If during a chronic exposure a different mode of action is involved, or if metabolic activation is significant, the ratios between acute and chronic endpoint values for a group of xenobiotics are generally quite variable and typically exceed two orders of magnitude. In addition, the statistical strength of ELS QSARs in these instances are poor.

Based on toxicity tests using fathead minnows performed at ERL-Duluth, 96-h LC50/32-d ELS Chronic value ratios range from 184 to 382 for aniline derivatives. This suggests that aniline compounds which act as polar narcotics in an acute exposure are acting through a different mode of action during chronic exposures.

C. Other Information

This chemical appears on the SARA (Superfund Amendments and Reauthorization Act) Title III Toxic Emissions Inventory.

More information on this chemical is available through the US EPA's Office of Health and Environmental Assessment's IRIS (Integrated Risk Information System) data base.

V. CITATION INFORMATION

REFERENCE NUMBER: 7
Veith,G.D. and P.Kosian
1983
Estimating Bioconcentration Potential from Octanol/Water
Partition Coefficients
In: D.Mackay, et al., (Eds.), Physical Behavior of PCBs in
the Great Lakes, Ann Arbor Sci. Publ., Ann Arbor, MI:269-282

REFERENCE NUMBER: 538
Birge,W.J., J.A.Black, J.E.Hudson, and D.M.Bruser
1979
Embryo-Larval Toxicity Tests with Organic Compounds
In: L.L.Marking and R.A.Kimerle (Eds.), Aquatic Toxicology
and Hazard Assessment, 2nd Symposium, ASTM STP 667,
Philadelphia, PA:131-147

REFERENCE NUMBER: 563
Birge,W.J., J.A.Black, and D.M.Bruser
1979
Toxicity of Organic Chemicals to Embryo-Larval Stages of
Fish
Ecol. Res. Ser. EPA-560/11-79-007, Office of Toxic
Substances, U.S. Environ. Prot. Agency, Washington, D.C.:
60 P.

REFERENCE NUMBER: 662

Gersich, F.M. and D.P. Milazzo
 1988
 Chronic Toxicity of Aniline and 2,4-Dichlorophenol to
 Daphnia magna Straus
 Bull. Environ. Contam. Toxicol. 40(1):1-7

REFERENCE NUMBER: 3217
 Geiger, D.L., L.T. Brooke, and D.J. Call
 1990
 Acute Toxicities of Organic Chemicals to Fathead Minnows
 (Pimephales promelas), Vol. 5
 Center for Lake Superior Environmental Studies, University
 of Wisconsin, Superior, WI:332 p. (Contains data also found
 in 10183, 15823)

REFERENCE NUMBER: 3536
 Veith, G.D. and S.J. Broderius
 1990
 Rules for Distinguishing Toxicants that Cause Type I and
 Type II Narcosis Syndromes
 Environ. Health Perspect 87:207-211

REFERENCE NUMBER: 3910
 Marchini, S., M.L. Tosato, T.J. Norberg-King,
 D.E. Hammermeister, and M.D. Høglund
 1992
 Lethal and Sublethal Toxicity of Benzene Derivatives to the
 Fathead Minnow, Using a Short-Term Test
 Environ. Toxicol. Chem. 11(2):187-195

REFERENCE NUMBER: 4343
 Marchini, S., M.D. Høglund, S.J. Borderius, and M.L. Tosato
 1993
 Comparison of the Susceptibility of Daphnids and Fish to
 Benzene Derivatives
 Sci. Total Environ. (Suppl.):799-808 (Author Communication
 Used) (Publ in Part As 3910)

REFERENCE NUMBER: 9003
 Russom, C.L.
 1991
 Personal Communication
 U.S. EPA, Environmental Research Laboratory-Duluth, Duluth,
 MN 55804

REFERENCE NUMBER: 10688
 Hodson, P.V., D.G. Dixon, and K.L.E. Kaiser
 1984
 Measurement of Median Lethal Dose As a Rapid Indication of
 Contaminant Toxicity to Fish
 Environ. Toxicol. Chem. 3(2):243-254

REFERENCE NUMBER: 14908
 Holcombe, G.W., D.A. Benoit, D.E. Hammermeister, E.N. Leonard,
 and R.D. Johnson
 1995
 Acute and Long-Term Effects of Nine Chemicals on the

Japanese Medaka (*Oryzias latipes*)
Arch. Environ. Contam. Toxicol. 28(3):87-297

REFERENCE NUMBER: 17934

Leo, A. and D. Weininger
1997

Daylight Software CLogP Version 3.15+ for Unix
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