Spatial Analysis and Decision Assistance Version 3.0

Windows based freeware designed to integrate scientific models with decision and cost analysis frameworks in a seamless, easy to use environment.

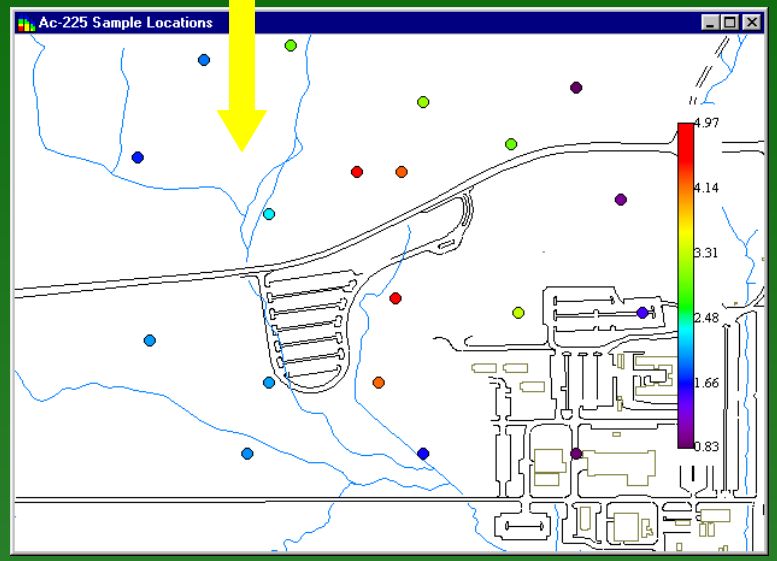
- Visualization
- Statistical Analysis
- Geospatial Interpolation
- Geospatial Uncertainty Analysis
- Human Health Risk Assessment
- Ecological Risk Assessment
- Custom Analysis
- Area of Concern Frameworks
- Cost Benefit Analysis
- Secondary Sampling Design

SADA has been supported by both the DOE and EPA and recently the NRC. SADA has had about 4000 downloads from the website.

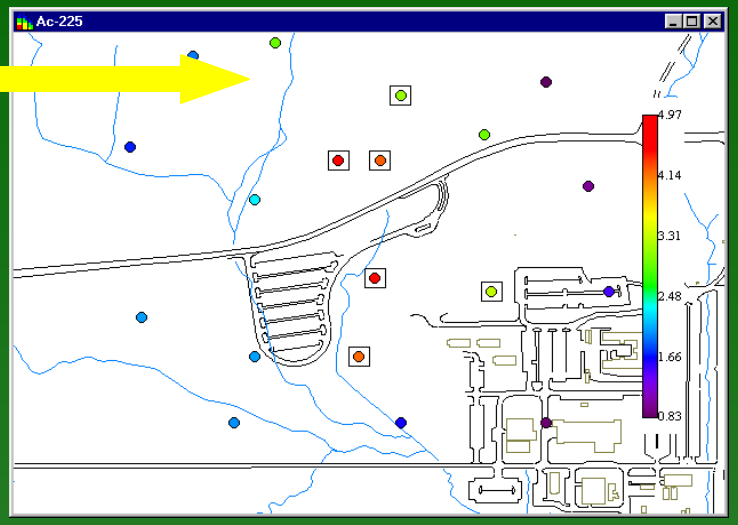
For more information contact Robert Stewart, Oak Ridge National Laboratory, 1060 Commerce Park, Oak Ridge, TN 37887. Email u74@ornl.gov.

SADA http://www.tiem.utk.edu/~sada/ Basic Data Exploration/Visualization

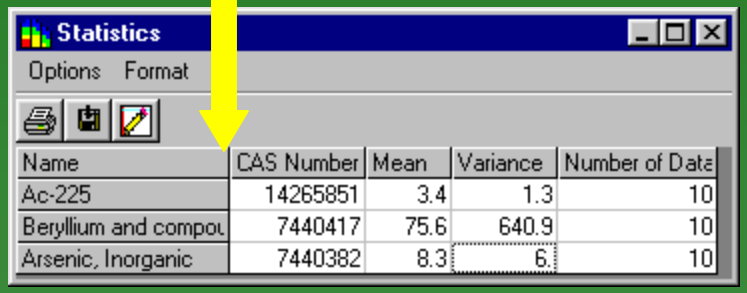
Data Plot/GIS Overlays



Spatial Data Screens

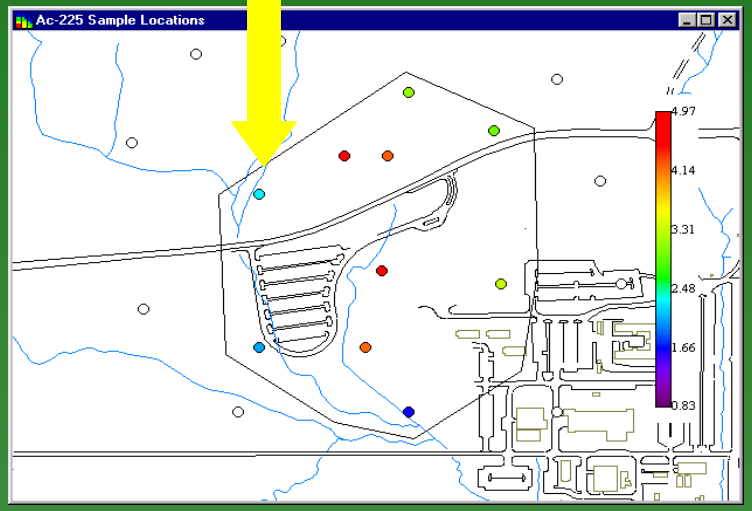


Statistics



Name	CAS Number	Mean	Variance	Number of Data
Ac-225	14265851	3.4	1.3	10
Beryllium and compou	7440417	75.6	640.9	10
Arsenic, Inorganic	7440382	8.3	6.	10

Polygon Selection/Cutaways



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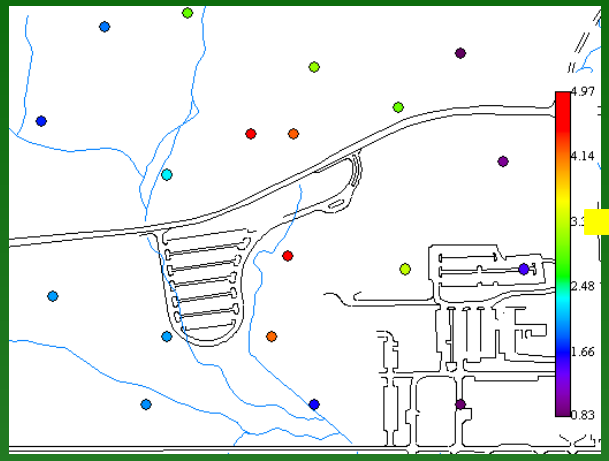
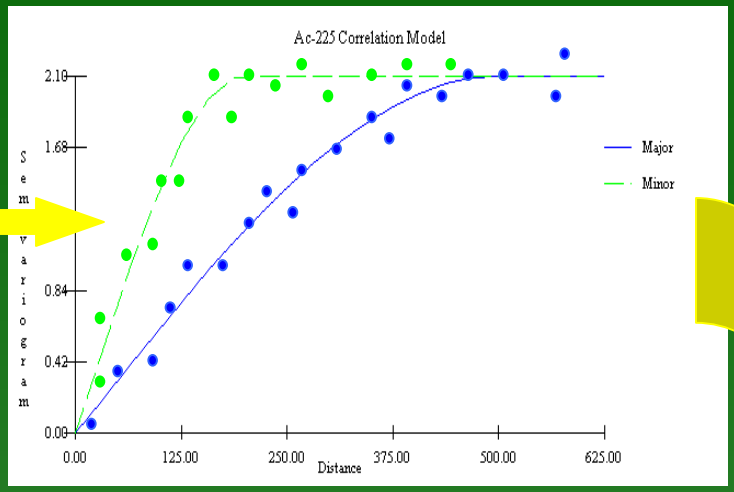
SADA http://www.tiem.utk.edu/~sada/

Spatial Analysis

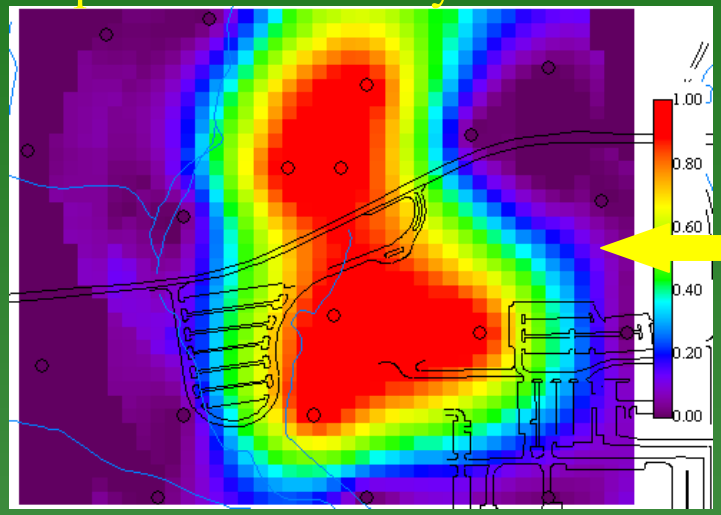
Begin with the data



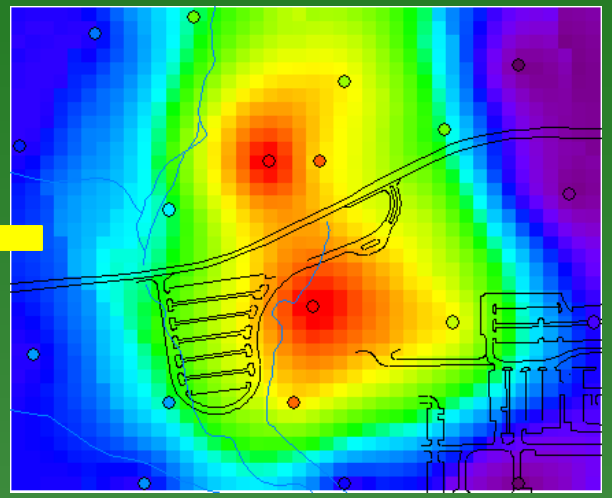
Model Spatial Covariance



Spatial Uncertainty



Spatial Estimation



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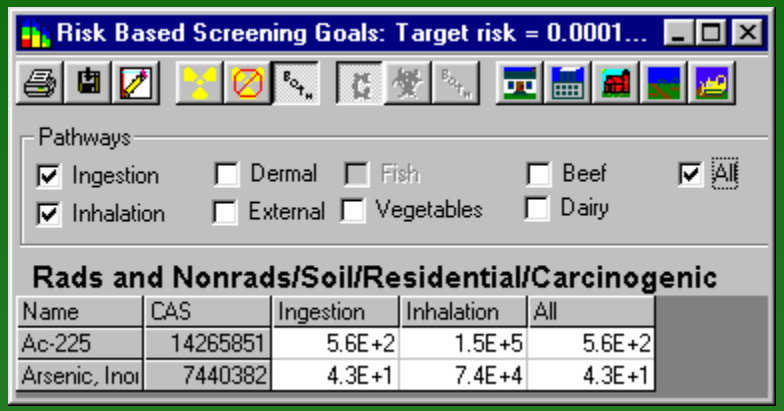
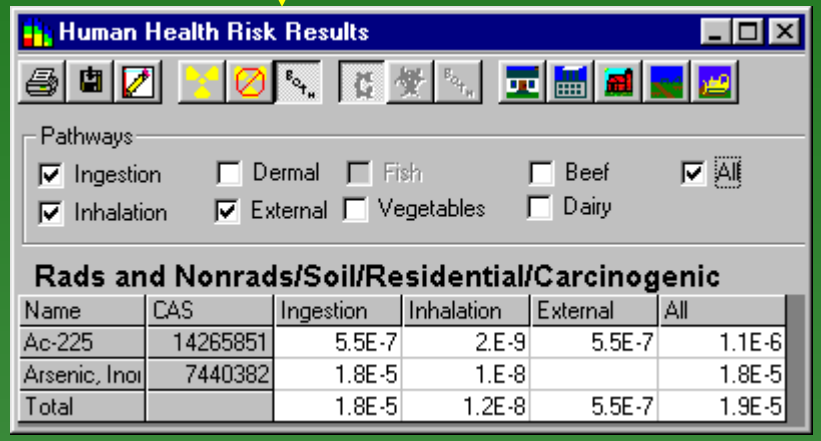
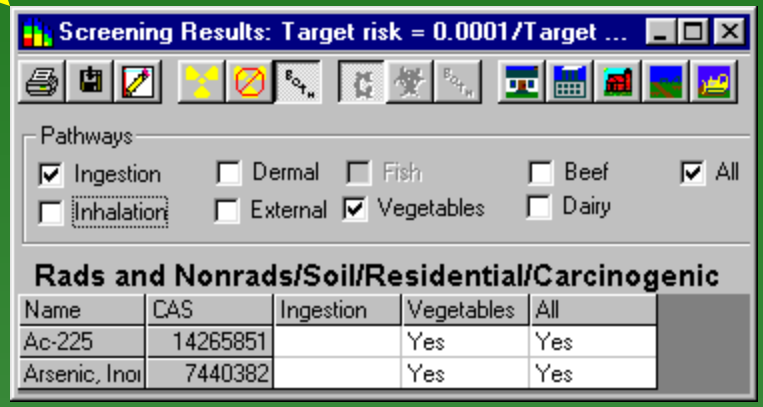
SADA http://www.tiem.utk.edu/~sada/ Human Health Risk Capabilities

- PRG Calculation
- PRG Screens
- Human Health Risk







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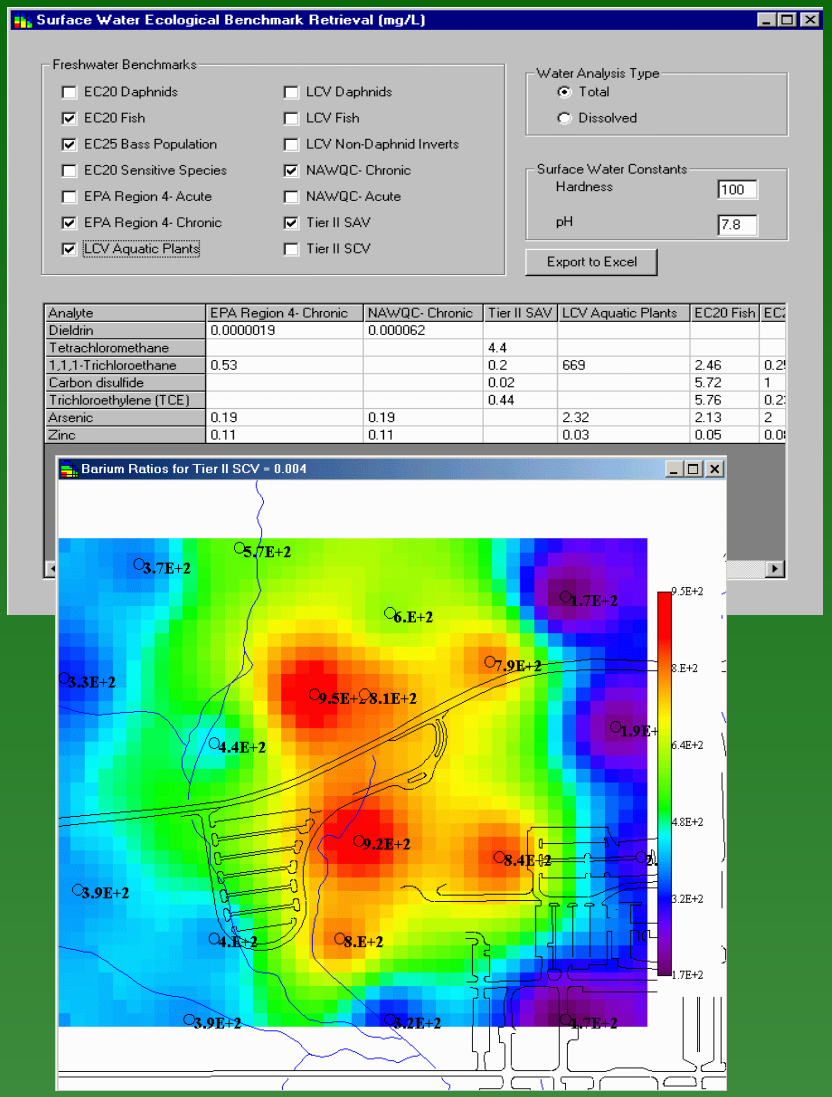
Ecological Risk Benchmarks

- Suitable for screening ERAs
- Compilation of ecological benchmarks for surface water, soil, and sediment
- Benchmarks a function of environmental variables where appropriate



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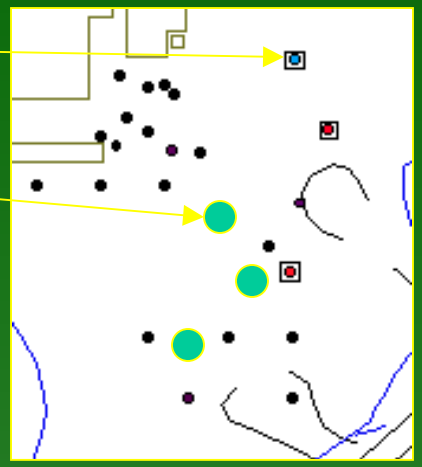
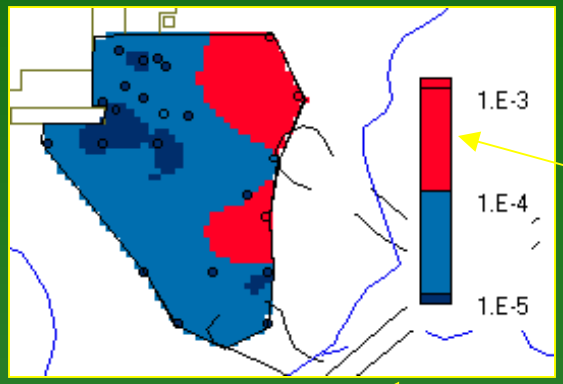
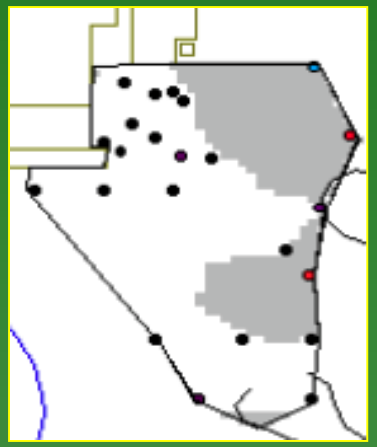
SADA http://www.tiem.utk.edu/~sada/ Spatial Decision Making

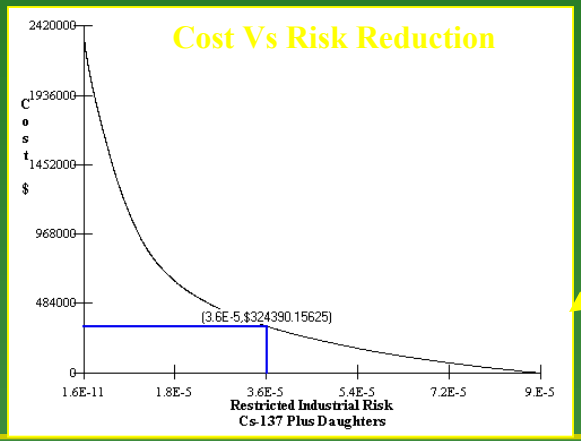
- Spatial Screens
- Sampling Strategies





- Spatial Risk
- Area of Concern
- Cost Benefit





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- Self-documentation of all assumptions
  - Exposure concentrations
  - Risk models
  - Exposure variables
  - Geospatial parameters
  - Toxicity data
  - Images as bitmaps
- HTML format, can be exported to popular word processors

Use of Spatial Analysis and Decision Assistance (SADA) Software to Model Wildlife Exposures

Christopher J.E. Welsh, S. Thomas Purucker, and Robert N. Stewart, The Institute for Environmental Modeling, University of Tennessee, Knoxville

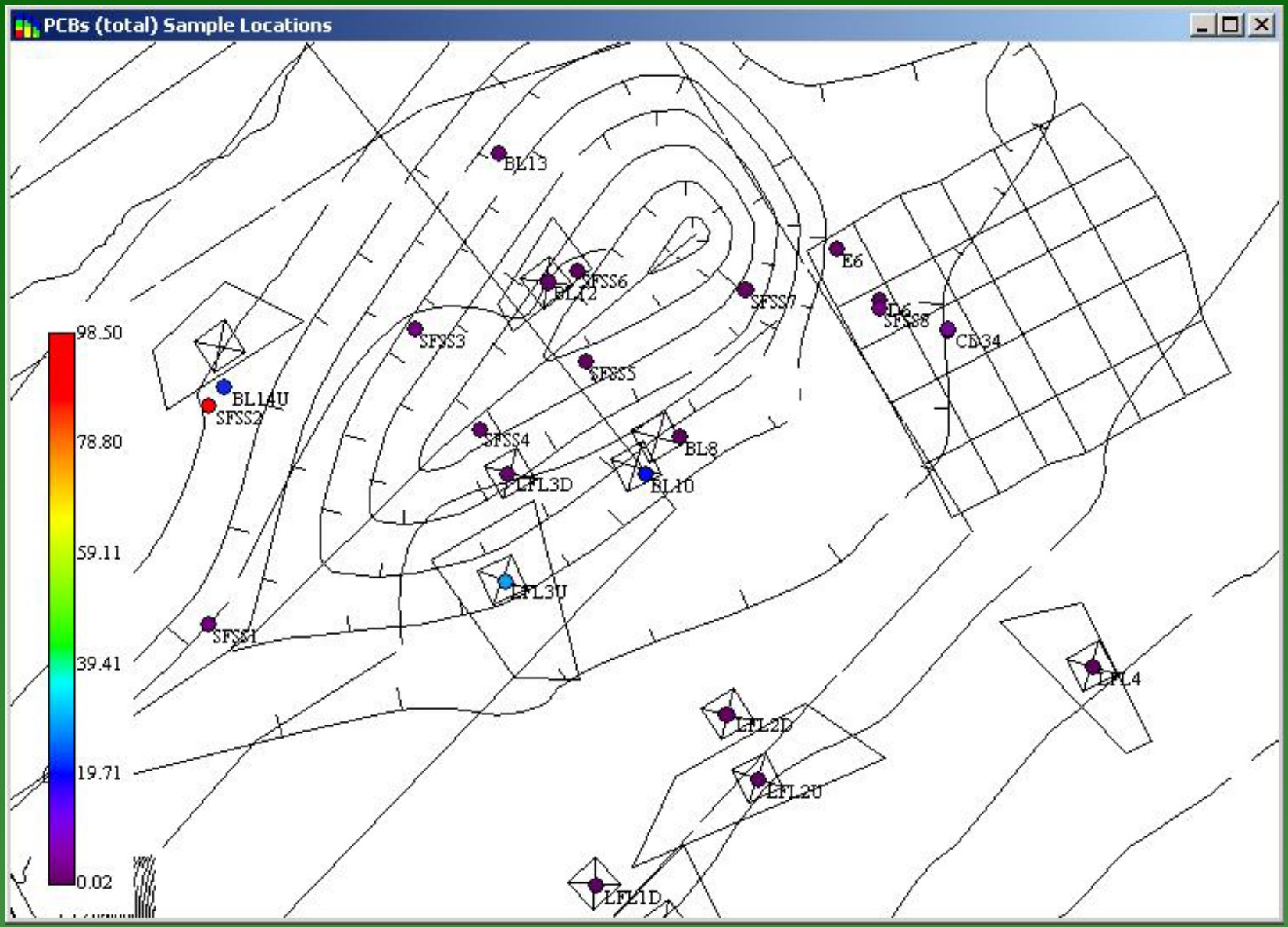
William L. Wilder, Environmental Systems Corporation, Knoxville, TN

I-40/I-640 Site

- Knoxville, TN
- Disposal (fluorescent light ballasts)
- Metals, PCBs, Pesticides

I-40/I-640 site

Layout


PCBs (total) Sample Locations
98.50
78.80
59.11
39.41
19.71
0.02
BL13
SFSS6
BL12
SFSS7
E6
SFSS8
CD34
SFSS3
SFSS5
BL14U
SFSS2
SFSS4
BL8
LFL3D
BL10
LFL3U
SFSS1
LFL4
LFL2D
LFL2U
LFL1D

Polychlorinated Biphenyls (PCBs)

- Persistent
- Bioaccumulative
- Toxic effects

Wildlife Receptors

- Herbivore -- Meadow vole
- Insectivore – Short-tailed shrew
- Carnivore – Long-tailed weasel

Model for Dose to Wildlife Receptor From Ingestion of Contaminated Food and Soil:

$$\text{Dose}_{\text{total}} = \text{Dose}_{\text{food}} + \text{Dose}_{\text{soil}}$$

$\text{Dose}_{\text{total}}$ = Total dose in mg/kg BW/d
$\text{Dose}_{\text{food}}$ = Dose from food ingestion
$\text{Dose}_{\text{soil}}$ = Dose from soil ingestion

Ingestion of Contaminated Prey

$$Dose_{food} = FIR_{BW} \times [(C_{plant} \times P_{plant}) + (C_{invert} \times P_{invert}) + (C_{mammprey} \times P_{mamm})] \times AF \times AUF$$

FIR_{BW} = Dry food ingestion rate (kg dry food/kg BW/d)

C_{plant} = Chemical concentration in plant (mg/kg dry wgt).

$C_{plant} = C_{soil} \times BAF_{plant}$

BAF_{plant} = soil to plant bioaccumulation factor (mg/kg dry plant per mg/kg soil)

P_{plant} = Plant ingestion as percentage of diet (unitless)

C_{invert} = Chemical concentration in invertebrate (mg/kg dry wgt).

$C_{invert} = C_{soil} \times BAF_{invert}$

BAF_{invert} = soil to invertebrate bioaccumulation factor (mg/kg dry invertebrate per mg/kg soil)

P_{invert} = Soil invertebrate ingestion as a percentage of diet (unitless)

$C_{mamm\ prey}$ = Chemical concentration in vertebrate, primarily small mammalian, prey (mg/kg dry weight). If transfer factor is diet-to-tissue, $C_{mamm\ prey} = C_{diet} \times BAF_{diet\text{-}to\text{-}mamm}$.

Ingestion of Contaminated Prey (cont.)

$$Dose_{food} = FIR_{BW} \times [(C_{plant} \times P_{plant}) + (C_{invert} \times P_{invert}) + (C_{mammprey} \times P_{mamm})] \times AF \times AUF$$

$C_{mamm\ prey}$ = Chemical concentration in vertebrate prey (mg/kg dry wgt). $C_{mamm\ prey} = C_{diet} \times BAF_{diet\text{-}to\text{-}mamm}$.

C_{diet} = Chemical concentration in diet of mammalian prey (mg/kg dry wgt), measured or estimated as $C_{diet} = (C_{plant} \times P_{plant}) + (C_{invert} \times P_{invert}) + (C_{soil} \times P_{soil})$ with $C_{plant,\ invert,}$ and $P_{plant,\ invert,\ soil}$ referring to mammalian prey parameters

$BAF_{diet\text{-}to\text{-}mamm}$ = food to mammal bioaccumulation factor (mg/kg dry mammal per mg/kg dry food)

P_{mamm} = Proportion vertebrate prey in diet (unitless)

AF = Fraction of chemical absorbed from food. Assumed = 1. (unitless)

AUF = Area use factor = ratio of animal's home range to area of site. Set to 1, assumes 100% on-site. (unitless)

Ingestion of Contaminated Soil

$$Dose_{soil} = FIR_{BW} \times C_{soil} \times P_{soil} \times AF_{soil} \times AUF$$

FIR_{BW} = Dry food ingestion rate as a function of body weight (kg dry food/kg BW/d)

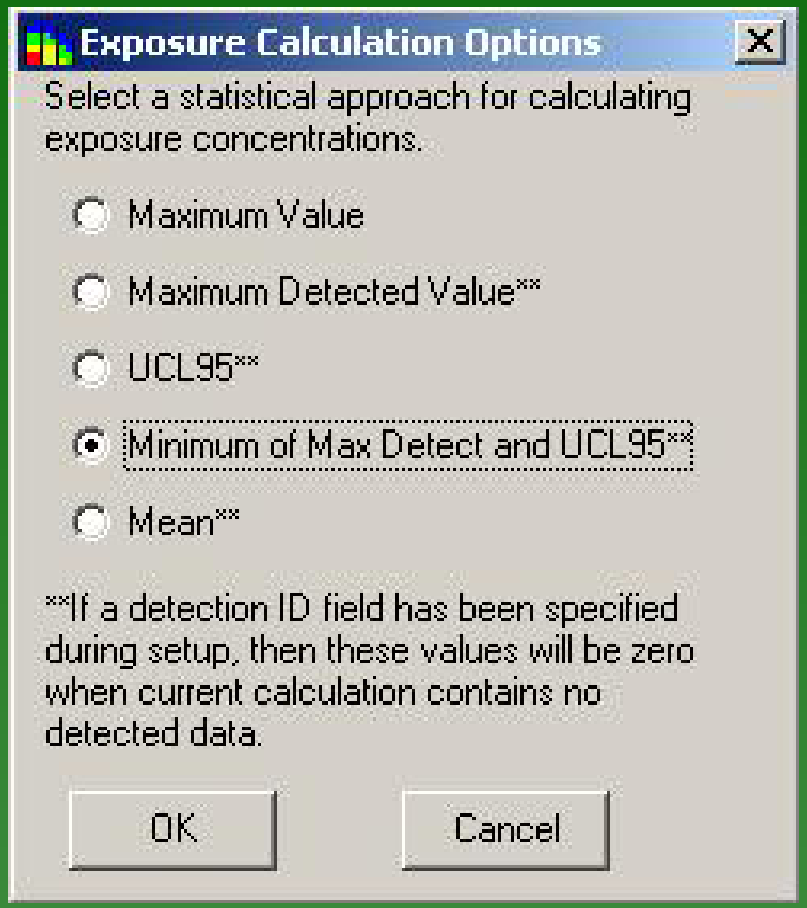
C_{soil} = Chemical concentration in dry soil (mg/kg)

P_{soil} = Soil ingestion as a percentage of diet (unitless)

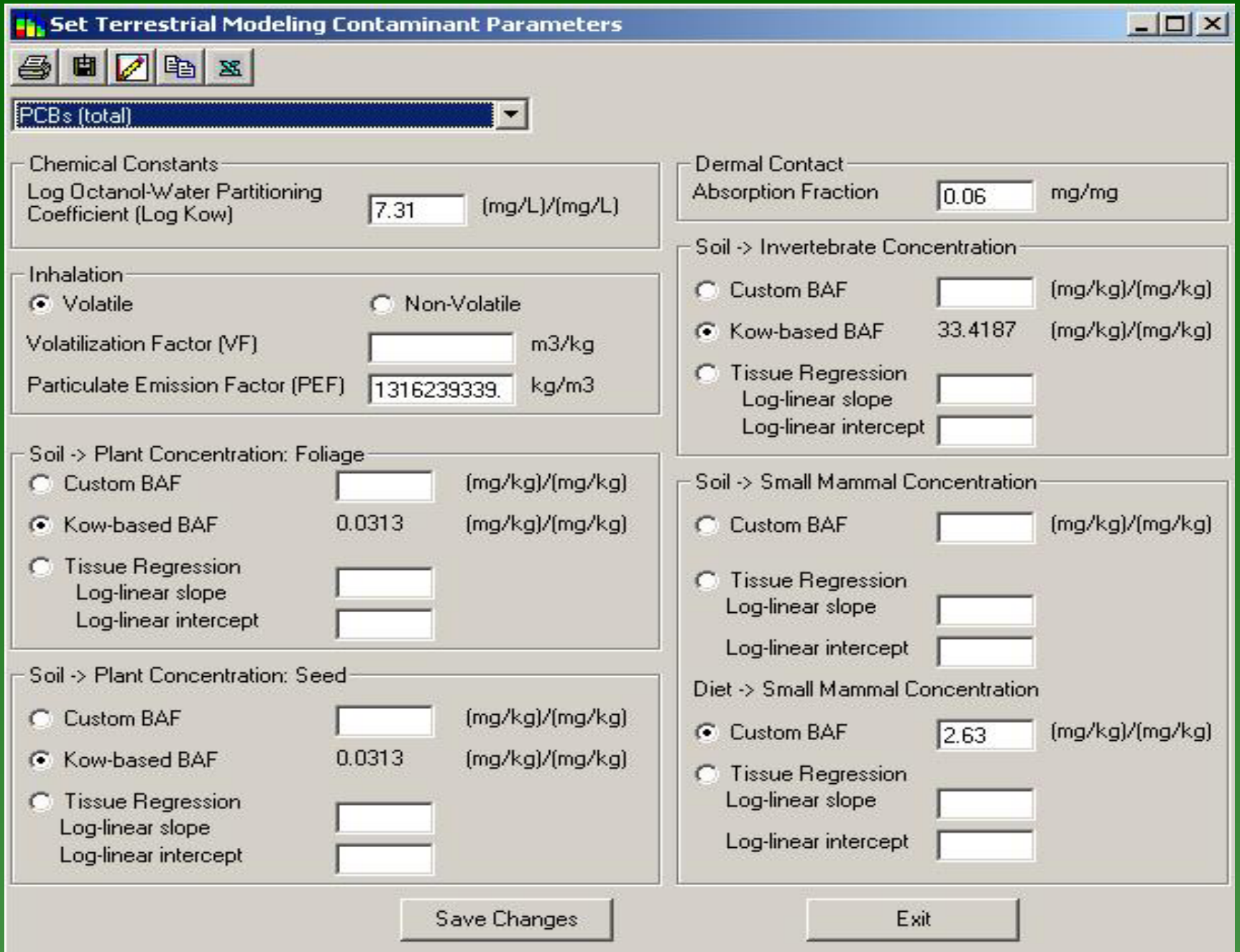
AF_{soil} = Absorbed fraction of chemical from soil. Assumed = 1. (unitless)

AUF = Area use factor = ratio of animal's home range to area of site. Assumed = 1. (unitless)

Set Screening Statistics



Set BAFs


Set Terrestrial Modeling Contaminant Parameters
PCBs (total)
Chemical Constants
Log Octanol-Water Partitioning Coefficient (Log Kow)
7.31
(mg/L)/(mg/L)
Inhalation
Volatile
Non-Volatile
Volatilization Factor (VF)
m3/kg
Particulate Emission Factor (PEF)
1316239339.
kg/m3
Soil -> Plant Concentration: Foliage
Custom BAF
(mg/kg)/(mg/kg)
Kow-based BAF
0.0313
(mg/kg)/(mg/kg)
Tissue Regression
Log-linear slope
Log-linear intercept
Soil -> Plant Concentration: Seed
Custom BAF
(mg/kg)/(mg/kg)
Kow-based BAF
0.0313
(mg/kg)/(mg/kg)
Tissue Regression
Log-linear slope
Log-linear intercept
Dermal Contact
Absorption Fraction
0.06
mg/mg
Soil -> Invertebrate Concentration
Custom BAF
(mg/kg)/(mg/kg)
Kow-based BAF
33.4187
(mg/kg)/(mg/kg)
Tissue Regression
Log-linear slope
Log-linear intercept
Soil -> Small Mammal Concentration
Custom BAF
(mg/kg)/(mg/kg)
Tissue Regression
Log-linear slope
Log-linear intercept
Diet -> Small Mammal Concentration
Custom BAF
2.63
(mg/kg)/(mg/kg)
Tissue Regression
Log-linear slope
Log-linear intercept
Save Changes
Exit

Soil → Plant

K_{ow}-based soil-to-plant BAFs were generated using the following equation from EPA (2000):

$$BAF_{plant} = 10^{1.31 - 0.385 \log K_{ow}}$$

BAF_{plant} = soil to plant foliage bioaccumulation factor (mg/kg dry plant/mg/kg soil)

K_{ow} = octanol-water partitioning coefficient.

Soil → Invertebrates

K_{ow}-based soil-to-invertebrate BAFs were generated using the following equation from EPA (2000):

$$BAF_{worm} = \frac{10^{\log K_{ow} - 0.6}}{f_{oc} \times 10^{0.983 \log K_{ow} + 0.00028}}$$

BAF_{worm} = soil to earthworm bioaccumulation factor (mg/kg dry invertebrate / mg/kg soil)

f_{oc} = fraction organic carbon in soil. Default is set to 1%.

K_{ow} = octanol-water partitioning coefficient.

Diet → Small Mammal

$$BAF_{diet-mamm} = \frac{C_{tissue}}{C_{diet}}$$

$BAF_{diet\text{-}to\text{-}mamm}$ = food to mammal bioaccumulation factor (mg/kg dry mammal per mg/kg dry food)

C tissue = Chemical concentration in vertebrate tissue (mg/kg dry wgt.)

C diet = Chemical concentration in vertebrate's diet (mg/kg dry wgt.)

[Using PCB $BAF_{diet\text{-}mamm}$ value from Fries et al. (1973)]

Set Exposure Parameters -- vole

Set Species-Specific Terrestrial Exposure Parameters

Select a species to view (and change if necessary) the default exposure parameters used in determining the daily contaminant dose received from exposure to soil.

Meadow vole | SSL

Microtus pennsylvanicus

Food Ingestion Parameters

Food ingestion rate	0.58	kg dw / kg bw day
Fraction foliage	1	0-1
Fraction seed	0	0-1
Fraction invert	0	0-1
Fraction mammal	0	0-1

Mammalian Prey Diet

Fraction foliage	0	0-1
Fraction seed	0	0-1
Fraction invert	0	0-1
Fraction soil	0	0-1

Soil Ingestion Parameters

Soil ingestion	0.03	fraction of food IR

Soil Inhalation Parameters

Inhalation Rate	0.124	m^3/ day

Dermal Contact Parameters

Adherence Factor	0.000001	kg/ cm^2
Surface area	135	cm^2

Physical Parameters

Body weight	0.039	kg
Area usage factor	1	fraction

Range:

East to west range is continuous from central Alaska to the Atlantic coast. South of the Canadian border, its western limit is the Rocky mountains. As far south as New Mexico and Georgia

Save Changes

Exit

Set Exposure Parameters -- shrew

Set Species-Specific Terrestrial Exposure Parameters

Select a species to view (and change if necessary) the default exposure parameters used in determining the daily contaminant dose received from exposure to soil.

Short-tailed shrew | SSL

Blarina brevicauda (Northern) or carolinensis (Southern)

Food Ingestion Parameters

Food ingestion rate	0.2	kg dw / kg bw day
Fraction foliage	0	0-1
Fraction seed	0	0-1
Fraction invert	1	0-1
Fraction mammal	0	0-1

Mammalian Prey Diet

Fraction foliage	0	0-1
Fraction seed	0	0-1
Fraction invert	0	0-1
Fraction soil	0	0-1

Soil Ingestion Parameters

Soil ingestion	0.03	fraction of food IR

Soil Inhalation Parameters

Inhalation Rate	0.065	m^3/ day

Dermal Contact Parameters

Adherence Factor	0.000001	kg/ cm^2
Surface area	80	cm^2

Physical Parameters

Body weight	0.017	kg
Area usage factor	1	fraction

Range:

most of North America from southern Saskatchewan and Nova Scotia to central Nebraska and Georgia.

Save Changes

Exit

Set Exposure Parameters -- weasel

Set Species-Specific Terrestrial Exposure Parameters

Select a species to view (and change if necessary) the default exposure parameters used in determining the daily contaminant dose received from exposure to soil.

Long-tailed weasel | SSL

Mustela frenata

Food Ingestion Parameters

Food ingestion rate	0.1	kg dw / kg bw day
Fraction foliage	0	0-1
Fraction seed	0	0-1
Fraction invert	0	0-1
Fraction mammal	1	0-1

Mammalian Prey Diet

Fraction foliage	0.485	0-1
Fraction seed	0	0-1
Fraction invert	0.485	0-1
Fraction soil	0.029	0-1

Soil Ingestion Parameters

Soil ingestion	0.039	fraction of food IR

Soil Inhalation Parameters

Inhalation Rate	0.456	m^3/ day

Dermal Contact Parameters

Adherence Factor	0.000001	kg/ cm^2
Surface area	388	cm^2

Physical Parameters

Body weight	0.202	kg
Area usage factor	1	fraction

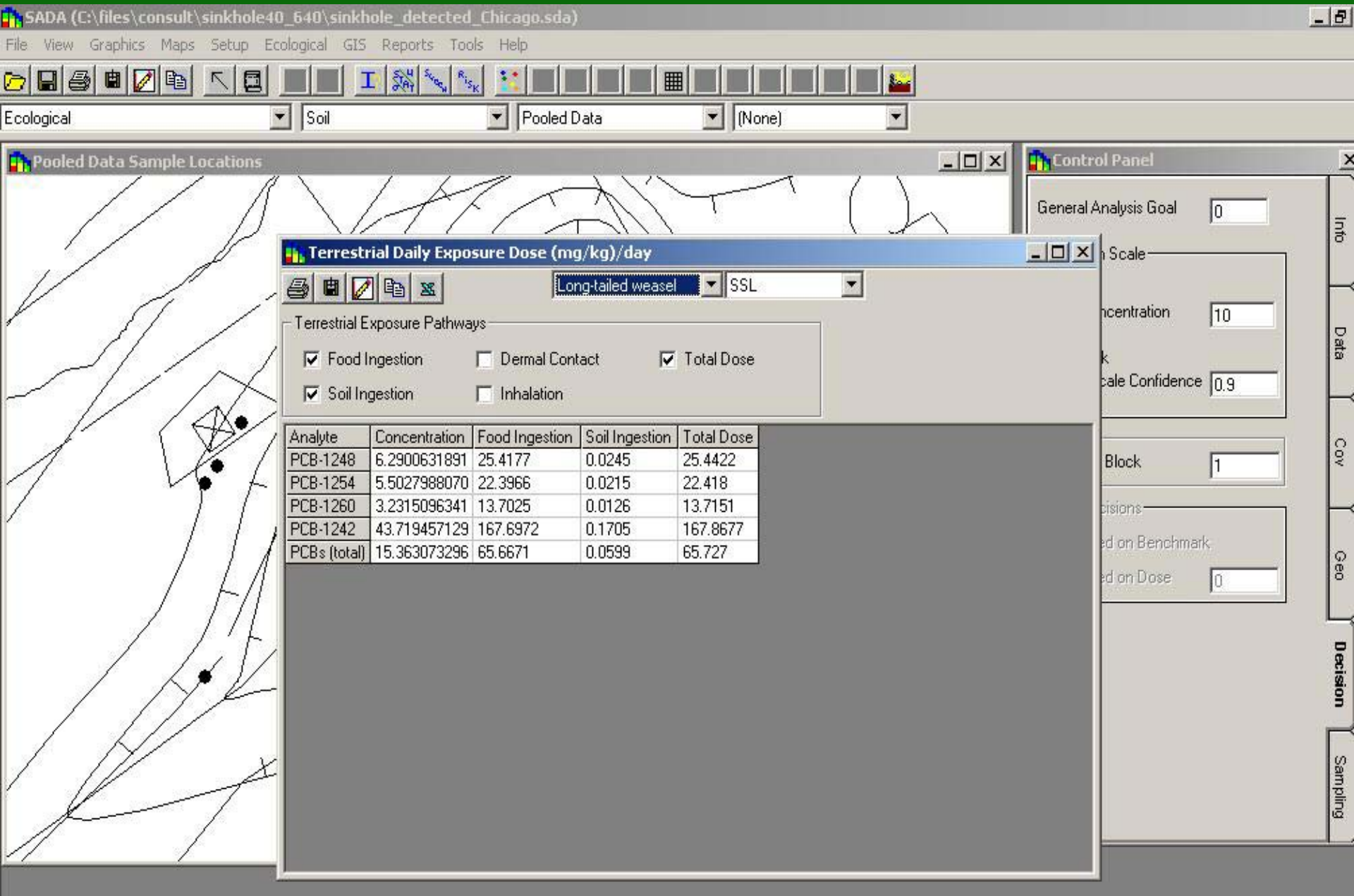
Range:

Extending from just north of the United States-Canadian border through Central America to northern South America.

Save Changes

Exit

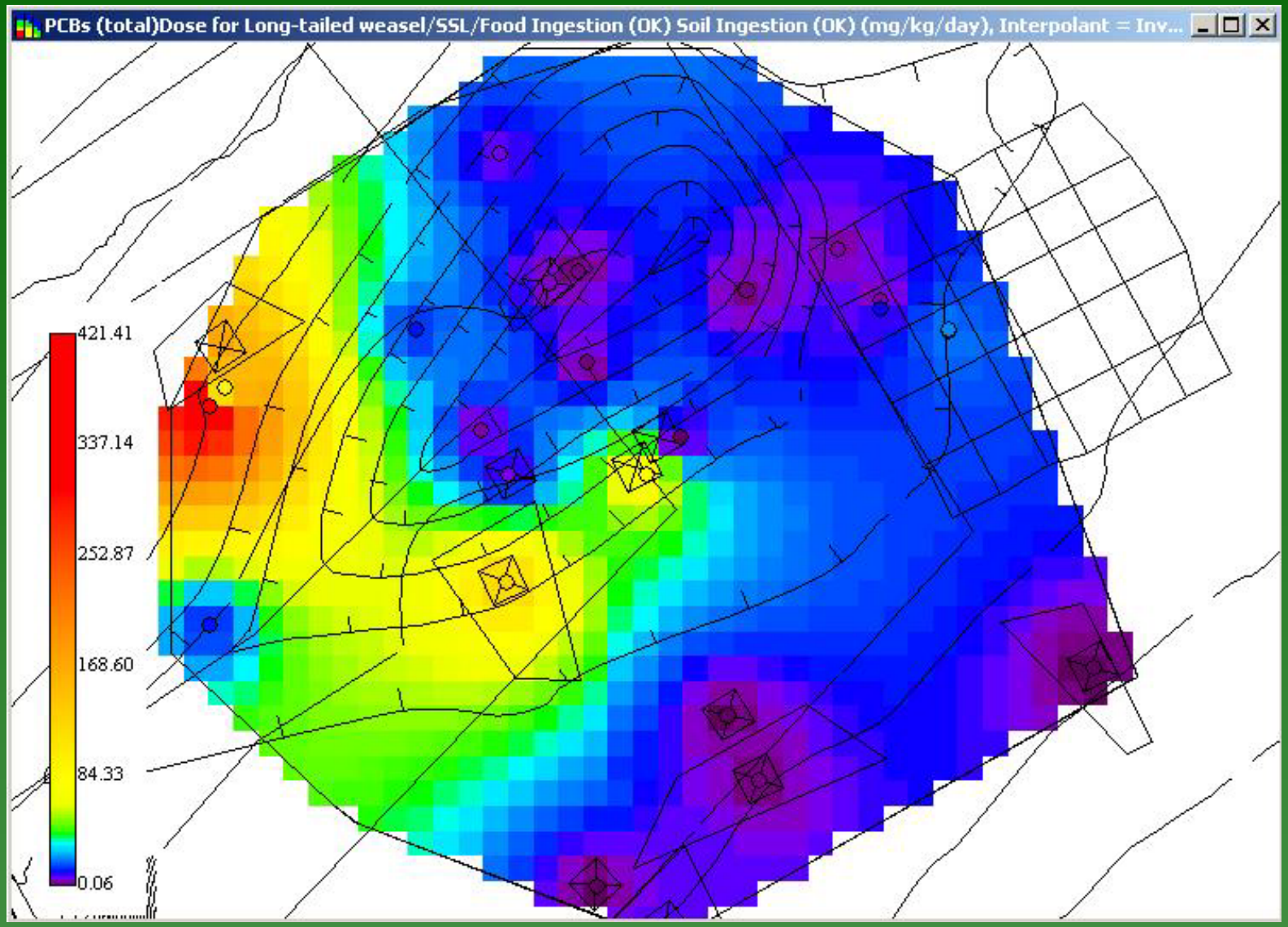
Exposure Dose Results



Estimated Doses (mg PCBs/kg BW/d) From Exposure to Total PCBs

Receptor	Food ingestion	Soil ingestion	Total dose
Meadow vole	0.28	0.27	0.55
Short-tailed shrew	257.71	0.09	102.78
Long-tailed weasel	65.67	0.06	65.73

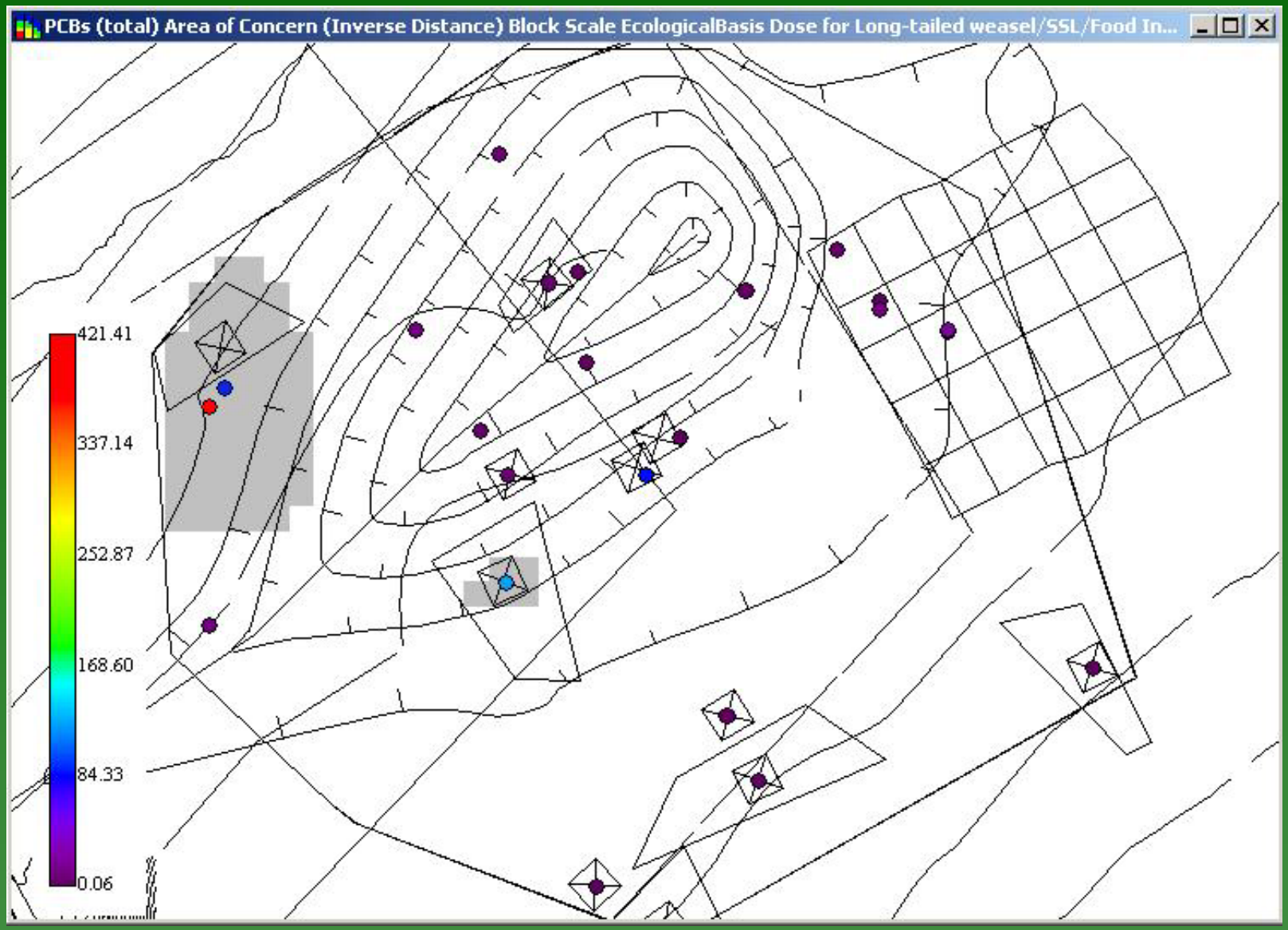
Point Dose map



At Risk?

Receptor	Total dose	NOAEL	LOAEL	NOAEL HQ	LOAEL HQ
Vole	0.55	0.051	0.51	10.8	1.1
Shrew	102.78	0.067	0.668	1534.0	153.9
Weasel	65.73	0.209	1.029	314.5	63.9

Clean Up?


PCBs (total) Area of Concern (Inverse Distance) Block Scale EcologicalBasis Dose for Long-tailed weasel/SSL/Food In...
421.41
337.14
252.87
168.60
84.33
0.06

Long term plans for SADA

1. Maintain SADA as a free software product.
2. Provide training and support to SADA users.
3. Continue development of SADA in several key areas.
4. Keep current functions and models up to date with latest guidance and scientific advances.
5. Provide annual SADA releases.
6. Continue exchanging ideas and components with FIELDS.

Maintain SADA as a free software product.

SADA is free to anyone and can be downloaded from the website.

SADA is stand alone software and requires no additional software purchases.

SADA has had over 4000 downloads to date.

Continued Development (currently)

3D Sample Design - expand current 2d and 3d sample capabilities to reflect more realistic 3d sampling scenarios in both initial and secondary designs.

Risk Assessment - add human health risk updates as well as expand ecological modeling functions.

Geospatial Characterization Advances - improve key geostatistical functions that serve as the basis for many SADA models.

Visualization and GIS - improve and add new features to SADA's current 2d and 3d visualization functions.

Statistical Analysis - broaden SADA's repetoire of statistical functions including nonparametric methods, hypothesis testing, etc.

FIELDS Compatability - Continue sharing developed modules with FIELDS.