

2018

Bioaccumulation Evaluation Screening Tool (BEST)

USER GUIDE

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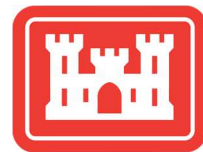


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Introduction

What is BEST?

BEST or the Bioaccumulation Evaluation Screening Tool is one of three models that compose the Bioaccumulation Risk Assessment Modeling System (BRAMS), a stand-alone tool for calculating the potential risk to human and ecological health associated with bioaccumulative contaminants in dredged sediments. BEST uses 28-day bioaccumulation laboratory data, along with inputs that characterize dredge site environment, indicator species, and attributes of chemicals that contaminate the sediments in question, to provide health- and ecologically-protective information about risk.

BEST estimates expected risks to human receptors by (1) calculating the edible tissue concentration in human diet species including invertebrate test organisms and their predators based on results of 28-day bioaccumulation testing, (2) calculating an average daily dose to humans that consume these species, and (3) using USEPA and USACE risk assessment guidance to determine potential carcinogenic and non-carcinogenic risks (USEPA, 1989a; 1997; USEPA/USACE, 1998; Cura et al., 1999). The BEST reports display risk results for dredged sediments compared side-by-side with reference site risks, and acceptable risk thresholds. Calculated tissue concentrations are also compared to regulatory thresholds.

Background

The US Environmental Protection Agency (EPA) and the US Army Corps of Engineers (USACE) share responsibility for the regulation of dredged material, including its disposal. Open-water disposal, a common method for discarding of dredged material, can potentially expose aquatic biota and humans to health risks if the material being discharged originates from a contaminated site. Harbors and near-coast waterways accumulate sediment and chemicals from the contributing landscape, including nearby, often urban, terrain and receive effluent directly from industry. The Marine Protection Research and Sanctuaries Act (MPRSA) requires that sediment toxicity be evaluated to determine suitability for open-water disposal, the protocol for which is outlined in the Ocean and Inland Testing Manuals, commonly referred to as the “Green Book” (OTM; ITM) (EPA/USACE, 1991; 1998). USEPA, 1989a; 1997; USEPA/USACE, 1998; Cura et al., 1999

The agencies engage in a “tiered approach” for the evaluation of potential environmental impacts of dredged material, to achieve the appropriate level of investigation required for a determination. BEST and the other BRAMS models are designed to support the consideration of environmental impacts, particularly from bioaccumulation of contaminants in dredged material, by modeling risk based on Tier III benthic-bioaccumulation test data. Generally, risks posed to human and ecological health by bioaccumulative chemicals associated with dredged materials must not exceed those associated with reference sediments, or ones that reflect the conditions of the disposal site. This level of consideration is required if contaminants of concern do not exceed federally established limits, which are toxicological measures indicative of a contaminant’s potential for adverse effects to human and ecological receptors, or if no standard exists.

Since 1999, EPA Region 1 has evaluated bioaccumulation potential using a screening tool that considers whether contaminants accumulated in invertebrates following lab-exposure to dredge material samples might result in a risk to human or ecological receptors by direct or indirect consumption (Battelle, 2005). EPA Region 1 uses 28-day bioaccumulation test data and a human exposure pathway to model the risk of adverse impacts which may occur due to the presence of bioaccumulative contaminants in the

material proposed for disposal. Two invertebrate species, *Macoma nasuta* (Bent-nose clam) and *Nereis virens* (Sandworm), are exposed to sampled substrate from the proposed dredge site for 28 days, and the resulting tissue concentration of various chemicals is determined. The same procedure is conducted using sediment from the designated reference location. A series of equations, along with the properties of the exposure pathway, are then used to model the transfer of contaminants present in the lab specimens through trophic levels. Properties of the chemicals (e.g. oral cancer slope factor and oral reference dose) are used to estimate potential cancer and non-cancer risks.

The BRAMS program, initially released in 2012, includes BEST, a fully customizable model that is based on the 1999 EPA Region 1 bioaccumulation risk assessment model framework. Recent improvements (2016-2018) have been made to ensure that BEST can reproduce the EPA Region 1 methodology, streamline the model operation for easy and efficient dredged material screening, and enhance flexibility so that the model can be applied in other EPA regions. BEST can now also be downloaded as a stand-alone tool.

Getting Started

Installation and Start Up

BRAMS is a portable application that does not have to be installed on a hard drive. Instead it is distributed as a stand-alone Java Archive (.jar), which contains an executable java program that is simply run.

Download BRAMS from <http://el.erdc.usace.army.mil/trophictrace/> and specify where to save the compressed folder. Use a file extractor to unzip the folder, keeping the contents together.

System Requirements

Central processor	Intel Pentium 1GHz or better
Operational memory	512 MB or more
Free space on hard disk	20MB
Operating system	Windows XP/Vista/7/10, macOS or Linux
Third-party software	Java Runtime Environment (JRE) Version 8 or later

Contents of download:

- BRAMS software
- Sample chemical list and 28-day bioaccumulation results Excel files to demonstrate the necessary formats for import into BEST
- Template: A .best file that is populated with EPA Region 1 model items, specifications, and chemical list.

To open BRAMS, select BRAMS Program → Bin → BRAMS.jar. Double clicking the file, BRAMS.jar, will open the program.

If it is the first time opening the software on a computer, a User Identification window will appear, prompting the user to enter their name before continuing to the main window. User name will appear at the end of reports generated by this software, along with date of use, and software version.

User Name can be changed by navigating to File → Change User.

What you will need to use BEST

Generally, before the model can be run, 1) the properties of the risk pathway need to be defined and 2) the user must add the laboratory results, which report the concentrations of chemicals that will be modeled along those pathways. The user can create entirely new models based on different trophic structures, human and ecological exposure scenarios and site-specific conditions or use an established template model. Existing templates are packaged with the BRAMS download.

BEST requires the following information to estimate risk to humans associated with contaminated sediment. See “Information for Running BEST for EPA Region 1” section for an example of BEST inputs.

BEST Model Inputs

Properties of invertebrates that are exposed to sediment samples

Lipid content of each invertebrate species (g lipid/g tissue)
28-Day Bioaccumulation Results

Properties of 2nd trophic level; predators

Lipid content of each predator species (g lipid/g tissue)
Predator diet (list of invertebrates)

Properties of humans and their exposure via diet species

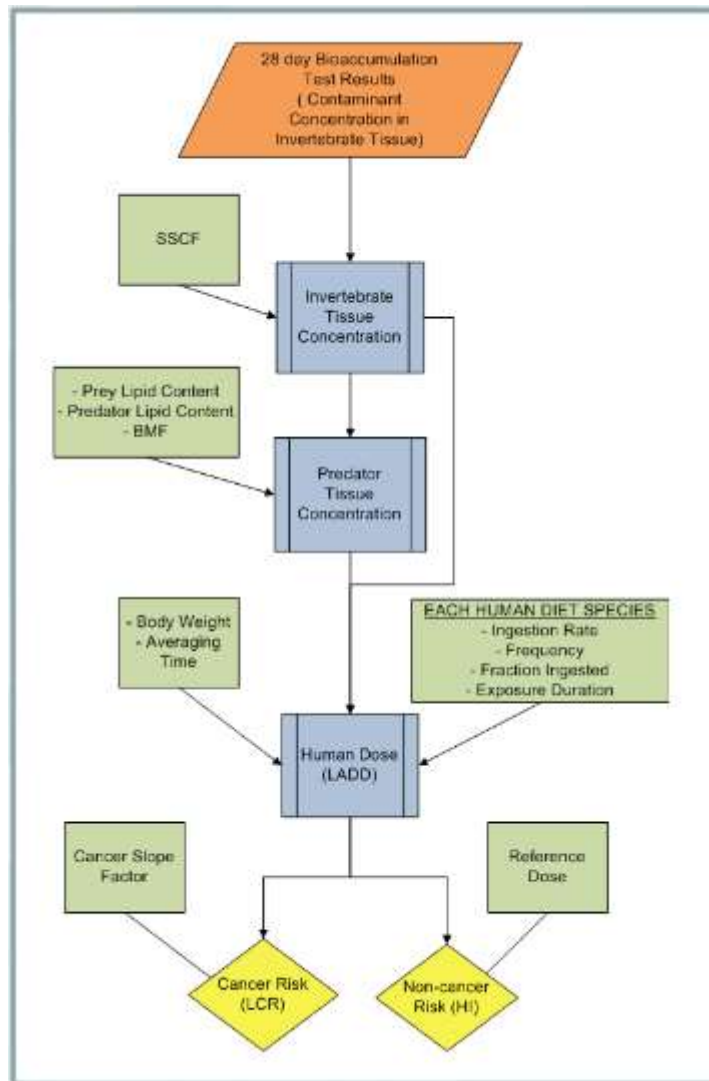
Body weight (kg)
Lifetime (years)
Human diet species and for each, Fraction ingested, Frequency of ingestion (days/year),
Ingested quantity (kg/day), Exposure duration (years)

Properties of Chemicals potentially detected in sediment

Name
Type (organic or metal)
Cancer slope factor (1/mg/kg-day)
Oral Reference dose (mg/kg-day)
Steady state correction factor
Biomagnification factor
Human toxicity equivalence factor
FDA Action Level (for organics) or FDA Level of Concern (for metals) (ppm)
Ecological Effects Level (ppm)

User Preferences/Choices

Use of mean vs maximum concentration values from lab results
Risk thresholds
Assignment of reference location
Daily dose settings
List of organic chemicals of concern to be used in risk estimates



Building a BEST Model


The user can create entirely new models based on different trophic structures, human and ecological exposure scenarios and site-specific conditions or use an established template model. With the exception of project site-specific laboratory results, many of the exposure pathway and chemical properties remain constant across projects, particularly for those within a single regulatory region.

BEST templates allow the user to start with all or most of the project components already entered into the model (except for certain project specific data), saving time and effort and ensuring consistency among related projects. Additionally, projects can be saved as templates so they can be reused and templates can be locked so that values are protected during future use (see section x for how to).

The following sections step the user through creating a new project without a template first, and then with a template. Once the necessary items are in the model and populated with their properties, the procedure for setting the final user preferences, adding the laboratory bioaccumulation results and selecting which to include, and running the model are the same for a project with or without a template.

Build a BEST Model from Scratch

Create a new project

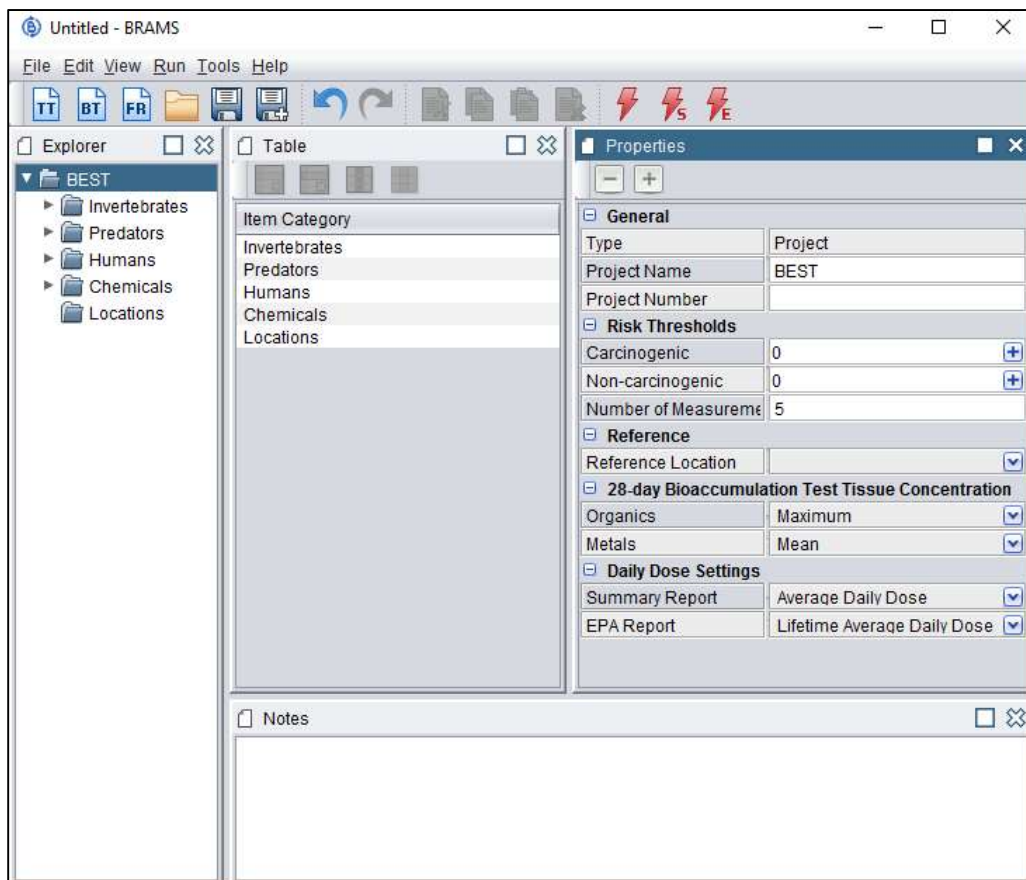
From the main window select File → New Project → New BEST Project from the Menu bar or click  in the toolbar. Then select “Yes” when the Create new project window appears.

The new project interface will consist of four panels:

- 1) **Explorer** is used to navigate among the model components
- 2) **Table** displays the model component properties in tabular form and is where the user can add or delete from lists of items
- 3) **Properties panel** contains the cells where property values can be edited
- 4) **Notes** provides a space where the user can make notes about the project and document decisions, for example

Additional panels can be brought into view using View → Panels:

- 5) **Graph** can be refreshed to prompt the program to draw the food chain, as the user has defined it the program
- 6) **Map & Layer** a visualization option. ESRI or similar GIS file formats (.shp) can be added to show the location of the study and sample sites. The bioaccumulation data can be linked to points or areas on the map for ease of use, but the map panel does not generate any additional data (e.g. calculate area).



Add and edit items and item properties


In a new, blank project, the user will need to add invertebrates that were tested in the laboratory with project sediment samples; predators through which human exposure to chemicals is mediated; human populations for which risk associated with exposure will be estimated.

Each of the following categories of model inputs must have “items” and their corresponding property values added manually into BEST with the exception of Chemicals, which can alternatively be imported from an Excel file along with their properties.

The user adds “items” to each category of model components in the Table panel and then specifies property values for each in the Properties pane. Because some value choices depend on other inputs, add property values to items in each category in the Properties Pane in the order:

1. Chemicals (see Importing a Chemical List and Properties on how to import a chemical list)
2. Invertebrates
3. Predators
4. Humans
5. Location

Add items:

In the Explorer pane, select the item category you wish to add to (e.g. predators) then click  in the Table pane to add a new item to that category. A new item will appear in the Explorer pane under the selected category and in the Table pane. Information for the new item is specified in the Properties pane.

Edit items:

In the Explorer pane, select an item category (e.g., predators). In the Table pane, select the specific item (e.g., predator #1) and type the appropriate name (e.g., fish fillet). Then in the Properties pane, edit properties. A description for each type of input is provided below.

Item property descriptions:

Chemicals*

Properties of chemicals that may be present in sediment**

Name of chemical
Chemical type (organic or metal)
Cancer slope factor (mg/kg-day)
Reference dose (mg/kg-day)
Biomagnification factor
Human toxicity equivalence factor
Steady state correction factor
FDA Action Level (ppm)
FDA Level of Concern (ppm)
Ecological Effect Level (ppm)
TEF Reference and relationship

*Importing a chemical list that has been generated in Excel is more convenient and efficient than adding each chemical directly into BEST.

**If the value of any property is unknown, enter NA in the text box.

Invertebrates*

Properties of invertebrates that are exposed to sediment samples

Name of invertebrate

Lipid content of invertebrate species (g lipid/g tissue)

*Bioaccumulation test results for each invertebrate will be imported later and will appear here




Predators

Properties of predators that are exposed to invertebrates and, in turn, are in the human diet

Name of predator

Lipid content of each predator species (g lipid/g tissue)

Predator diet

Click  to display a drop down window where you can add the prey (invertebrates) of the human diet predators. Click  in the bottom right corner of the drop down window to add a new prey species. Then click  to the right of the new row to specify which of the existing Invertebrate species to add. Note that the drop down arrow isn't visible until you click the area where the new row should be created.

Humans




Properties of humans that are exposed to predators via their diet

Name of human

Body weight (kg)

Life time (years)

Predator diet

Click  to display a drop down table where you can add species that make up the selected human's diet. Click  in the bottom right corner of the table to add a new row. Then click  below the Prey column in the new row to choose from the existing lower trophic level species*. Double click the space below each and enter the appropriate values for each:

fraction ingested

frequency (days/year)

ingestion rate (kg/day)

exposure duration (years)

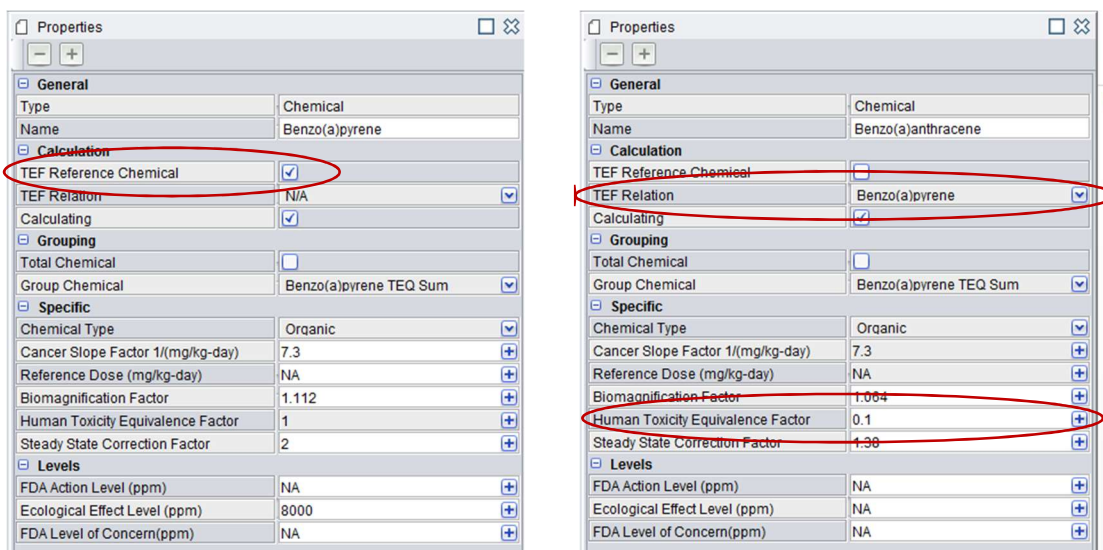
*Note that the human diet can consist of invertebrate species in addition to the predators of the invertebrates

[Set Toxicity Equivalent Factors and Relationships](#)

If you manually add chemicals to BEST, instead of importing them from an Excel file, you may need to set Toxicity Equivalent Relationships. In some instances, chemicals of uncertain or unavailable toxicity

are assigned a Toxicity Equivalent Relationship and Factor to indicate toxicity relative to a reference chemical of known or characterized toxicity (Battelle, 2005). For example, Benzo(a)anthracene is estimated be 10% (or 0.1) as toxic as its reference chemical Benzo(a)pyrene. In BEST, a chemical can be designated as a TEF Reference Chemical and then specified as the reference in the properties of other chemicals.

Navigate to the chemical section and start by 1) checking the box in the Properties pane next to “TEF Reference Chemical” to designate a chemical as such and then 2) select a different chemical in the list and assign the reference chemical in the dropdown menu next to “TEF Relationship”. A value between 0 and 1 should be entered as the “Human Toxicity Equivalence Factor”.



Import Chemical List and Properties

A list of chemicals and their properties can be entered manually; however, a much more efficient procedure is to import them from an Excel file. This is convenient because the chemical list will remain largely (if not completely) the same from one project to the next.

The Excel Inputs Templates folder that is packaged with the BRAMS software download has a sample file to demonstrate the format. In order for BEST to correctly import the information, the data must be in this format.

To import a chemical list, click File→Import→Chemicals then navigate to the Excel file that contains the table of chemicals and their properties.


Note that ‘NA’ will be assigned to properties that either have ‘NA’ or no contents in the corresponding Excel cells.

Also note that, once the list is imported into BEST, if chemical properties that correspond to blank cells in Excel appear as ‘0’ instead of ‘NA’, you should delete the imported chemicals, then go to the Excel file and use the Excel function ‘Clear Contents’ to make sure cells that appear empty actually are. Then

import the updated Excel file. A zero value where 'NA' should appear will have an unintended effect on the results.

Build a BEST Model from an Existing Template

Open a template

From the main window, select File → Open Project or Template or click , and then choose a file from the Templates folder in the downloaded BRAMS package or an existing model that you want to use as a template. There is no difference between a project and a template file; both have the extension .best. This means that an existing project (that already has bioaccumulation data) can be used to create a new project, and then saved under a new name, to preserve the original. Alternatively, a BEST file can be saved without bioaccumulation data so that it exists only as a template.

Note about locked projects/templates

Projects/templates can be locked so that property values cannot be edited without a password. When a locked project is opened, a message appears indicating that "Project locked with a password" and otherwise editable cells are "grayed out". This is an important feature for ensuring consistency across projects and generating credible results. When using a locked project as a template, Bioaccumulation Test results should be imported and then save the project under a new name. To lock or unlock a project, see Lock and Unlock BEST Model Properties.

Check and Modify Model Components' Properties

Because a template is simply a project that is recycled in order to save effort, the degree to which it is already populated with the necessary information can vary. Refer to the Getting Started section at the beginning of the manual to see what information is generally saved in a fully populated BEST model.

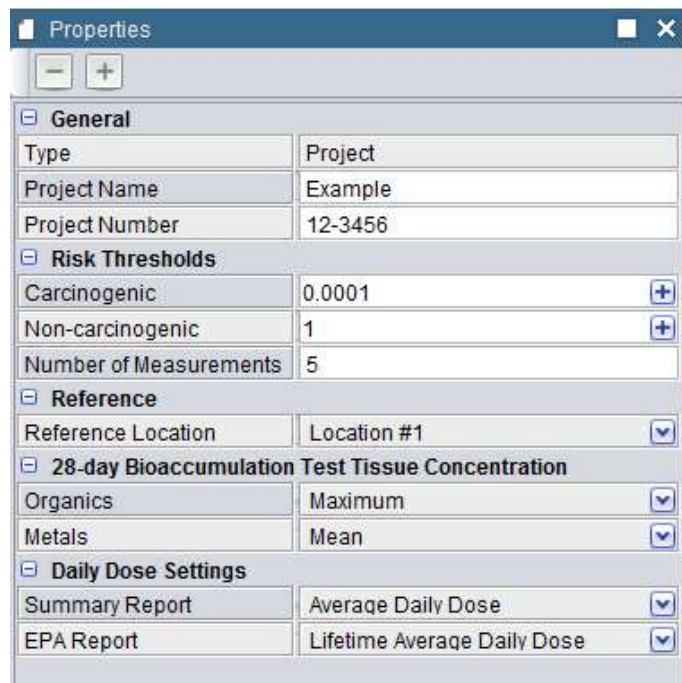
Click through and expand the folders in the Explorer window to see what already exists in the template (i.e., invertebrates, predators and their diets, humans and their diets, and chemicals and their properties). Use the instructions from Build a BEST Model from Scratch with details how to add and edit items and item properties.

User Preferences

There are a few user preferences that may be saved into a template or might be left blank and need to be selected for each individual project. These are risk thresholds, bioaccumulation test result moments, daily dose settings, and groups.

Set Risk Thresholds

Enter carcinogenic and non-carcinogenic risk thresholds in the General Project Properties pane by clicking inside the corresponding text boxes and entering values. Calculated risk levels exceeding these thresholds will be highlighted in red in the Total Risks and Contaminant Specific Risks sections of the BEST Summary and EPA reports.



Set Bioaccumulation Test Results Moment

The user can control whether the risk estimates are calculated using the maximum or mean invertebrate tissue concentration from the project locations. To specify which moment the model uses, click to the right of Organics and Metals in the Project Properties pane and select the desired choice. Note that moment can be saved into a project/ template.

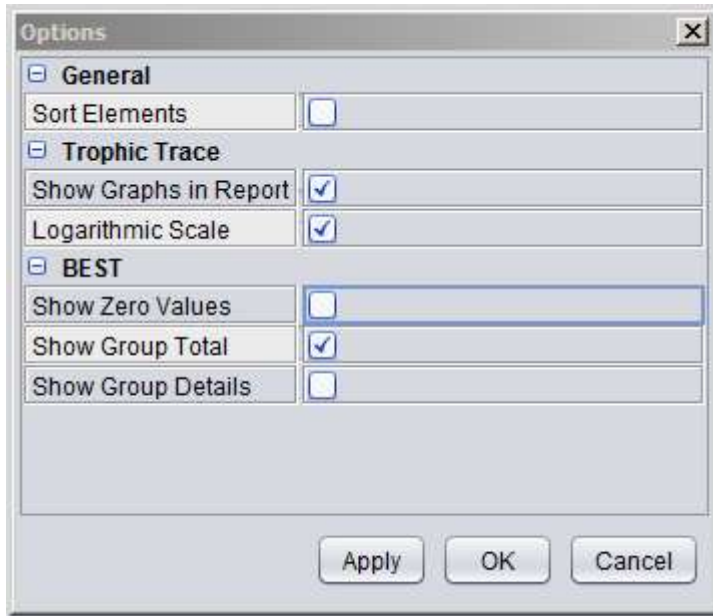
Set Daily Dose

The user can control whether the **non-cancer risk estimates for organics** are calculated using Average Daily Dose or Lifetime Average Daily Dose. See the Equations section of this manual for how those values differ and which are generally assigned for the different types of reports (EPA vs non-EPA). To specify which of the model uses, click to the right of Summary Report and EPA Report in the Project Properties pane and select the desired choice.

Set Groups

BEST has the capability to aggregate results. The user can designate groups of chemicals as well as items in the trophic levels. The BEST output will then report the sum of results for chemicals or items assigned to groups. This capability is important because, for example, there might be multiple analytes that compose a chemical group of interest. Note that group designations can be saved into a project/ template.

The user can control whether the output reports groups and/or ungrouped results in Options (Tools → Options).



Group Invertebrates, Predators, and Humans

To indicate that items in a trophic level should be summed for the report, a common name is assigned to each. This is illustrated with an example:

An analysis uses specifies both lobster hepatopancreas and lobster muscle in the risk pathway due to the large difference in lipid concentration in each part of the organism. However, when reporting the results, the user only cares about the total risk from consuming lobster. Navigate to the Predators folder in the Explorer panel and click on one of the first lobster parts to be summed. In the Properties panel under Grouping, type a name (e.g., Total Lobster) and then do the same in the other lobster part, taking care to use exactly the same group name. The risk summary will now report a risk from Total Lobster which is the sum of the risk from the two individual group members.


Name	Lipid (g lipid/g tissue)	Predator Diet
Lobster Hepatopancreas	0.089	[Macoma nasuta, Nereis virens]
Lobster Muscle	0.008	[Macoma nasuta, Nereis virens]
Fish Fillet	0.003	[Macoma nasuta, Nereis virens]

Properties	
General	
Type	Predator
Name	Lobster Hepatopancreas
Grouping	
Group Category	Total Lobster
Specific	
Lipid (g lipid/g tissue)	0.089
Diet	
Predator Diet	Macoma nasuta, Nereis virens

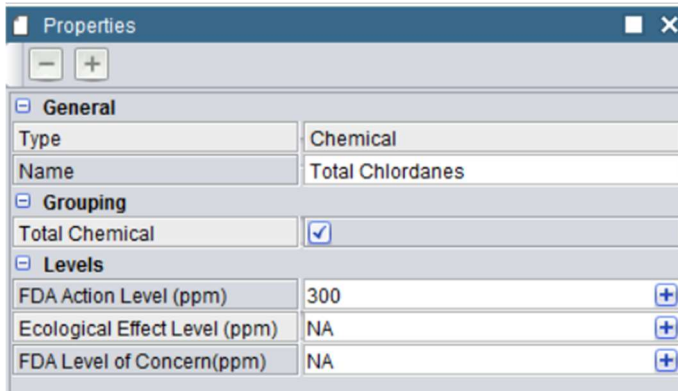
Group Chemicals

To indicate that results from particular chemicals should be summed in the report, a chemical is designated as the grouping chemical, and then constituent chemicals are assigned to the group. This is illustrated with an example:

Total Chlordanes concentration should not exceed a threshold concentration, which is set by FDA. However, the laboratory reports the concentration of multiple chlordane species. These effects of these species need to be summed so that the total chlordane concentration can be compared to the threshold.

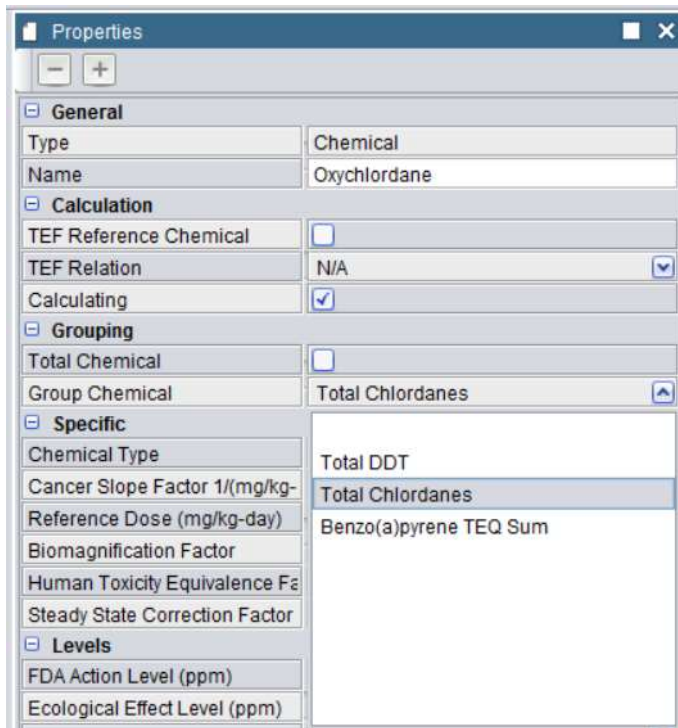
Start by 1) creating a new chemical in the chemical list by clicking  in the Table pane and entering the name of the group or 2) select an existing chemical from the list that will be designated as the grouping chemical. Total Chlordanes is an existing chemical in the EPA Region 1 chemical list. Indicate that this is a grouping chemical by checking the box next to Total Chemical in the Properties pane.

Next, navigate to each of the chemicals that should be assigned to the group and, in the Properties pane, choose the appropriate group from the dropdown list next to Group Chemical.



The screenshot shows the 'Properties' window for a chemical named 'Total Chlordanes'. The 'General' section shows 'Type' as 'Chemical' and 'Name' as 'Total Chlordanes'. The 'Grouping' section has 'Total Chemical' checked. The 'Levels' section shows 'FDA Action Level (ppm)' as 300, 'Ecological Effect Level (ppm)' as NA, and 'FDA Level of Concern(ppm)' as NA.

General	
Type	Chemical
Name	Total Chlordanes
Grouping	
Total Chemical	<input checked="" type="checkbox"/>
Levels	
FDA Action Level (ppm)	300
Ecological Effect Level (ppm)	NA
FDA Level of Concern(ppm)	NA



The screenshot shows the 'Properties' window for a chemical named 'Oxychlordane'. The 'General' section shows 'Type' as 'Chemical' and 'Name' as 'Oxychlordane'. The 'Calculation' section has 'TEF Reference Chemical' unchecked, 'TEF Relation' as 'N/A', and 'Calculating' checked. The 'Grouping' section has 'Total Chemical' unchecked and 'Group Chemical' set to 'Total Chlordanes'. The 'Specific' section has a dropdown menu with 'Total DDT', 'Total Chlordanes', and 'Benzo(a)pyrene TEQ Sum' as options. The 'Levels' section shows 'FDA Action Level (ppm)' and 'Ecological Effect Level (ppm)' as empty fields.

General	
Type	Chemical
Name	Oxychlordane
Calculation	
TEF Reference Chemical	<input type="checkbox"/>
TEF Relation	N/A
Calculating	<input checked="" type="checkbox"/>
Grouping	
Total Chemical	<input type="checkbox"/>
Group Chemical	Total Chlordanes
Specific	
Chemical Type	Total DDT
Cancer Slope Factor 1/(mg/kg-	Total Chlordanes
Reference Dose (mg/kg-day)	Benzo(a)pyrene TEQ Sum
Biomagnification Factor	
Human Toxicity Equivalence Fe	
Steady State Correction Factor	
Levels	
FDA Action Level (ppm)	
Ecological Effect Level (ppm)	

28-Day Bioaccumulation Results

Once you populate the BEST interface with model components or open an already-populated project to use as a template, and set user preferences, the next step is to import or add the concentrations of chemicals found in invertebrate tissue by the lab.

Import 28-Day Bioaccumulation Results


Ideally, the laboratory bioaccumulation results can be imported directly into BEST, avoiding manual input or user manipulation of the file. BEST is designed to read in data from the standard reporting format used in EPA Region 1, which is in the form of an Electronic Data Deliverable (EDD), and provided by the laboratory that conducts the chemical analysis. The Excel Inputs Templates folder that is packaged with the BRAMS software download has a sample file to demonstrate the format. In order for BEST to correctly import the information, the results must be in this format.

Note: A problem that came up during the development and testing of this version of BEST was incomplete data importation if the lab results file has formulas instead of values the cells. For example the lab might use a formula in a cell that reports the sum of other results like Total DDT, Total PCBs, etc. If you suspect a problem, double check the EDD to confirm that all data is entered as values.

In BEST, click File→Import→Import Bioaccumulation Results. The Open Excel window will appear where you can select the appropriate Excel file. Once you have selected the desired file, click Open.

Create missing chemicals and invertebrates

A dialogue box will ask if you want the “Create missing chemicals and invertebrate”. If the test results file has chemicals and/or invertebrates that do not exist in the BEST template/project you are working with, selecting “Yes” will add the names of new chemicals and invertebrates to the project but without any of the property fields populated. If the project is not locked and you have the properties to populate the new model components, you can select “Yes”. Otherwise, you should select “No”.

The window will then close and the data within the selected Excel file will be added to the model. To see the added data, select one of the invertebrate items in the Table pane. Bioaccumulation Test in the Properties pane will have lines that are labeled with sample site/composite names. Clicking the  sign to the far right will open a table that is populated with all the bioaccumulation data for that location.

Assign Reference Location

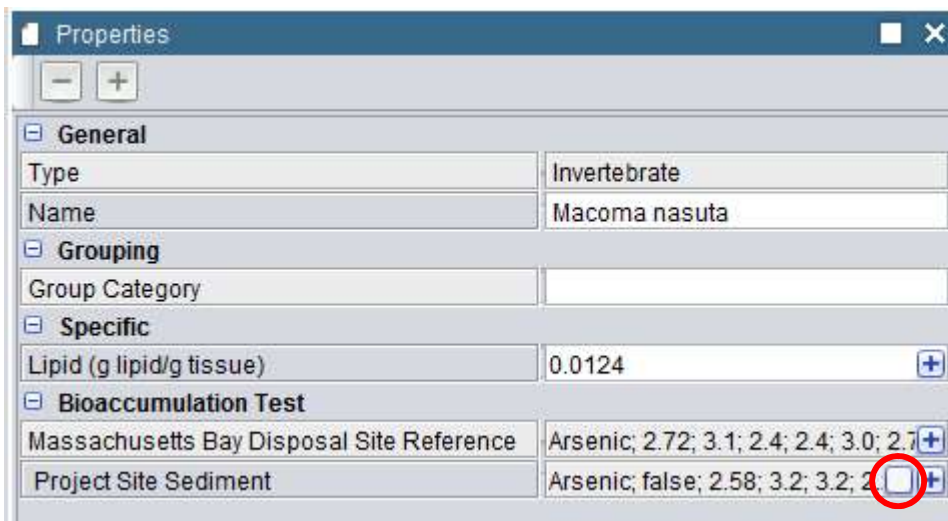
Navigate to the project properties by clicking the highest level folder in the Explorer panel, which should have been renamed with the project name when the bioaccumulation results were imported. In the Properties panel, select the reference location for the project from the dropdown list, which is populated with all of the locations, as read from the bioaccumulation results lab file.

Select Chemicals of Concern

The user can select among the chemicals reported on by the lab to include in the risk estimation. This is important because not all of the chemicals analyzed might be of concern, and different stakeholders might define what is of concern differently. See [How to Choose Chemicals of Concern](#) for a detailed description of how chemical are select according to the “Regional Implementation Manual for the Evaluation of Dredged Material” in New England.

A list of which chemicals should be included in the risk estimation must be assigned for each invertebrate in each sampling location, except for the reference location. The list of chemicals used in the calculations for the reference location will mirror the list used for sampling location for which the reference is serving as the basis for comparison.

Navigate to the Invertebrate properties by clicking the Invertebrates folder in the Explorer panel. Select an invertebrate and, in the Properties panel, expand the Bioaccumulation Test for the first location by first clicking . Check off the chemicals that should be included in the calculation and repeat the selection process for each location and then for each location for other invertebrates. To streamline this process, use the check box as shown below to toggle between “select all” and “deselect all.”



Note that the tabular form of the chemical list contains a column called “Calculating” and contains a checkbox for each chemical. These checkboxes do not perform the same function as those located in the bioaccumulation results and should not be used to choose the chemicals of concern.

Default selection of chemicals of concern

To further assist in selecting chemical of concern, the program can automatically select chemicals detected at statistically significant level in the invertebrates. When the bioaccumulation results are imported, a dialogue box will ask “Select chemicals based on rules?” The program relies on the qualifiers reported in the bioaccumulation results to make these default selections. In the figures below, note that the chemicals denoted with an “S” for “significant,” are automatically selected in the imported bioaccumulation results. These selections can be overridden by the user simply by clicking on a checkbox to remove or add a chemical or by toggling “select all” and “deselect all.”

Note that a statistical qualifier is not reported for Total PCBs, which means that it cannot be auto-selected by BEST. If the user wants Total PCBs to be included in risk calculations, they should manually select it in the bioaccumulation test portion of the program.

CONTAMINANT	MBDS	Project Site Sediment
Arsenic	2.72	2.58 NS
Cadmium	0.104	0.101 NS
Chromium	0.414	0.530 S ←
Copper	1.30	1.78 S ←
Lead	0.394	0.908 S ←
Mercury	0.004 a	0.004 ac
Nickel	0.500	0.444 NS
Zinc	11.14	11.40 NS
PAHs (ng/g wet weight)		
Acenaphthene	17.80	0.86 a NS
Acenaphthylene	15.80	0.49 a NS
Anthracene	0.17 a	4.50 ac b
Benzo(a)anthracene	0.30 a	18.60 c

File Edit View Run Tools Help

TT BT FR [Icons]

Explorer: Test1 > Invertebrates > Macoma nasuta, Nereis virens, Predators, Humans, Chemicals, Locations

Table:

Name	Lipid (g lipid/g tissue)
Macoma nasuta	0.0124
Nereis virens	0.0146

Properties:

General: Type: Invertebrate, Name: Macoma nasuta

Grouping: Group Category: [Empty]

Specific: Lipid (g lipid/g tissue): 0.0124

Bioaccumulation Test: Massachusetts Bay Dispo: Arsenic; 2.72; 3.1; 2.4; 2.4; 3.0; 2.7; 3.1; Cadmium; 0.1036; 0.12; ... Project Site Sediment: Arsenic; false; 2.58; 3.2; 3.2; 2.2; 2.5; 2.4; 2.6; Cadmium; false; ...

Chemical	Calculating	Mean Concentration	Max Concentration	REP1	REP2	REP3	REP4	REP5
Arsenic	<input type="checkbox"/>	2.58	3.2	3.2	2.2	2.5	2.4	2.6
Cadmium	<input type="checkbox"/>	0.1006	0.11	0.11	0.1	0.097	0.086	0.11
Chromium	<input checked="" type="checkbox"/> ←	0.53	0.62	0.54	0.62	0.48	0.55	0.46
Copper	<input checked="" type="checkbox"/> ←	1.78	2.1	2.1	1.8	1.6	1.7	1.7
Lead	<input checked="" type="checkbox"/> ←	0.908	1.0	0.96	1.0	0.81	0.97	0.8
Mercury	<input type="checkbox"/>	0.004	0.004	0.004	0.004	0.004	0.004	0.004
Nickel	<input type="checkbox"/>	0.444	0.47	0.47	0.46	0.39	0.45	0.45
Zinc	<input type="checkbox"/>	11.4	12.0	12.0	12.0	11.0	10.0	12.0
Acenaphthene	<input type="checkbox"/>	0.86	0.86	0.86	0.86	0.86	0.86	0.86
Acenaphthylene	<input type="checkbox"/>	0.49	0.49	0.49	0.49	0.49	0.49	0.49
Anthracene	<input type="checkbox"/>	4.50	11.0	11.0	0.17	9.0	0.17	0.17

Visualize Model Specifications

Graph food chain

The graphing function allows the user to visualize the food chain that they have defined, through the process of assigning model components to the diets of other components in the risk pathway (i.e., invertebrates as diet components of predators and predators as diet components of humans). Open the graph pane (View → Panels → Graph). Use the refresh button in the upper left corner to generate the food chain visual. Note that the user can navigate to the model components by selecting them in the visual.

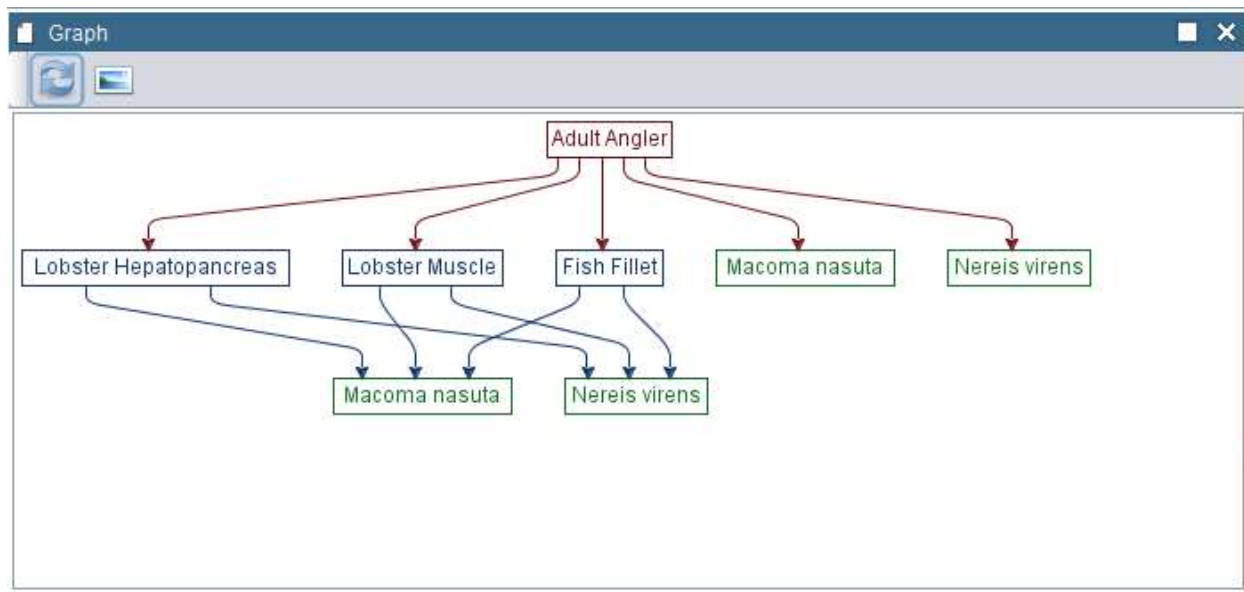


Figure 23: Example food chain summary in BEST. Arrows indicate the consumption.

Run the BEST Model

A BEST model is ready to run if:

- 1) The model components are populated and the relationships between them defined.
- 2) User preferences are set.
- 3) The program has a chemical list and 28-day bioaccumulation results to use in the risk estimate calculations.

Before running the model, be sure to save the file. If you used another project as a template and would like to preserve it for future use, be sure to use the Save As... function. See Saving, Locking, and Reusing BEST Projects for details about other options for saving the file.

Additionally, the user can identify themselves as such and their name will appear on the report generated by BEST. To do so, go to File → Change User then enter user name and click Continue.

Note that a report will automatically appear after a run button is clicked. In general, the run time is quite fast. However, if for some reason, run time is inordinately slow, reports can be generated without re-running calculations. To navigate to the reports for already-run models, use the Run drop down menu and select the appropriate type of report. The BEST model has three options for output reports:

Full Report

The full report includes the following sections for each location-invertebrate pair:

Selected Chemicals – reports which chemicals the user indicated should be included in risk calculations

Diet Report – reports the cancer risk and the non-cancer risk associated with each human diet species

Prey Report – reports the cancer risk and the non-cancer risk associated with each prey-predator-human exposure pathway

Chemical Report – reports the cancer risk and non-cancer risk associated with each chemical of concern via each human diet chain, along with intermediate calculations; edible tissue concentration, average daily dose, and lifetime average daily dose

Summary Report

The summary report compares risk estimates from sediment sample locations to those of the project reference site, both for total risk and contaminant specific risks. The summary report includes the following section for each location-invertebrate pair:

Selected Chemicals – reports which chemicals the user indicated should be included in risk calculations

Total Carcinogenic and Non-Carcinogenic Risks – reports total cancer risk and non-cancer risks in each human diet species for both the test and reference sites

FDA Action and Ecological Risk Levels – reports the mean tissue concentration and steady state corrected mean tissue concentration for chemicals in the current invertebrate, along with three thresholds: FDA action level, ecological effect level, and FDA level of concern, for comparison purposes

Contaminant Specific Carcinogenic and Non-Carcinogenic Risks – reports the cancer and non-cancer risks from each individual chemical in each of the human diet species for the test and reference sites

EPA Region 1 Report

The EPA Region 1 Report is designed to be easily comparable to the bioaccumulation risk analysis report produced by EPA Region 1. The comparable table from the EPA's report is in parentheses in the table headings for easy reference.

Selected Chemicals – reports which chemicals the user indicated should be included in risk calculations

Total Estimated Risks From Organics (see EPA Table Xa) - compares total risk estimates from sediment sample locations to those of the project reference site

Seafood Non-Cancer Risks (see EPA Table 6a, Columns F & G) – reports non-cancer risk from individual metal of concern along with reference location results

FDA Action Limit/ Tolerance (see EPA Table 3, Columns D & E) – reports the FDA threshold value of organics (and mercury) along with the steady state corrected mean tissue concentration in the current invertebrate

Ecological Effect Level - reports the ecological effect threshold of individual chemicals along with the steady state corrected mean tissue concentration in the current invertebrate

FDA Level of Concern - reports the FDA threshold value of metals along with the steady state corrected mean tissue concentration in the current invertebrate

Notes on Reading Reports

1. The Summary Report results for non-cancer risks are calculated using average daily dose whereas the EPA Region 1 Report results are calculated using lifetime average daily dose, unless otherwise specified by the user (see User Preferences section of this manual). See Calculations and Equations for formulas.
2. Risk estimates are only reported on those chemicals that are selected by the user (see Select Chemicals of Concern)
3. The FDA Action and Ecological Effects tables report on any chemical that has a threshold specified in the chemical list and appears in the bioaccumulation lab results, regardless of the user selecting it as a chemical of concern
4. If the user specified Carcinogenic and Non-carcinogenic risk thresholds on the General Properties Panel, the Summary and EPA reports will highlight any risk that exceeds the threshold. This does not apply to the FDA Action and Ecological Effect tables.
5. Chemical risks for any chemical detected may be very small, but they will not be zero. A “0” value in a risk report does not indicate zero risk. Instead, it indicates that some required parameter necessary to calculate the risk is missing. Check all of the species and chemical tables to ensure all of the data is entered correctly. To hide any zeros in the report, navigate to Tools → Options, and deselect “Show Zero Values”

Saving, Locking, and Reusing BEST Projects

Lock and Unlock BEST Model Properties

Many BEST model users should base their risk assessment models on templates with established property values and should only need to edit the 28-days Bioaccumulation Test Results. To prevent users from changing the established values (e.g. Lipid content of *N. virens*, Oral Cancer Slope Factor of DDT), these values can be locked. Property values other than 28 Day Bioaccumulation Results will become grayed-out and password protected.

Lock: To lock a project, select File → Lock Project. This will display the Password Protection window where the user should enter a password and click continue.

Unlock: To unlock a project, select File → Unlock Project. This will display the Password Protection window where the user should enter the previously set password and click continue. Property values should once again be freely editable.

Save and Save As

These features function in the same way as most programs.

Save Permanently

The Save Permanently feature allows users to save a project file so that it cannot be overwritten. A permanently saved file can be accessed and edited but then must be saved under a different name. This feature is designed to preserve templates for future use and finalized projects for future review.

To save a file permanently, select File → Save permanently. This will display the usual *Save Project As...* window where the user can name and specify a location to save the current project permanently.

Options

The user can set preferences for some general settings. Navigate to Options by clicking the Tools dropdown menu at the top of the program interface and selecting Options.

The most useful control pertains to how information appears in the reports. The user can indicate by selecting the checkboxes whether they want reports to:

- Show zero values
- Show group totals
- Show group details

*See the User Preferences section of this manual for more information on assigning groups of chemicals and items within trophic levels.

Information for Running BEST for EPA Region 1

Nearly all of the information in this section is saved into the template that is packaged with the BRAMS software download.

Model Item Details

Invertebrates

Species	Lipid Content (g lipid/g tissue)
Macoma nasuta	0.0124
Nereis virens	0.0146

Predators

Type	Lipid Content (g lipid/g tissue)	Diet Invertebrate
Lobster Hepatopancreas	0.089	<i>Macoma nasuta, Nereis virens</i>
Lobster Muscle	0.008	<i>Macoma nasuta, Nereis virens</i>
Fish Fillet	0.003	<i>Macoma nasuta, Nereis virens</i>

Note: All predators prey on both clam and worm equally

Human Population

Lifetime (years)	70
Body weight (kg)	70

Human Diet

Invertebrate	Predator	Fraction Ingested	Frequency (days/year)	Ingestion Rate (kg/day)	Exposure Duration (years)
	Lobster Hepatopancreas	1	365	0.006	30
	Lobster Muscle	1	365	0.03	30
	Fish Fillet	1	365	0.05	30
<i>Macoma nasuta</i>		1	365	0.014	30
<i>Nereis virens</i>		1	365	0.014	30

User Preferences

Risk Thresholds

Type	Threshold
Carcinogenic	0.0001
Non-carcinogenic	1

Invertebrate Tissue Concentration Moments

Chemical Type	Moment
Organics	Maximum
Metals	Mean

Chemical Groups

Group	Constituents
Total DDT	DDT DDE DDD
Total Chlordanes	cis-Chlordane cis-Nonachlor Oxychlordane trans-Chlordane trans-Nonachlor
Benzo(a)pyrene TEQ Sum	Benzo(a)anthracene

	Benzo(a)pyrene Benzo(b)fluoranthene Benzo(k)fluoranthene Chrysene Dibenzo(a,h)anthracene Indono(1,2,3-c,d)pyrene
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Trophic Groups

Group	Constituents
Total Lobster	Lobster Hepatopancreas Lobster Muscle

How to Choose Chemicals of Concern

Laboratory reports include the statistical significance of results compared to reference sites. All results that are found to be statistically significant are included in the risk assessment. Note, as previously described, that BEST has been updated so that it can auto-select those chemicals that should be included, by reading the qualifiers column of the lab results. Also note that Total PCBs needs to be manually selected by the user, as it is not assigned any qualifiers by the lab.

Calculations and Equations

EPA Region 1

Organic Contaminants

The following procedure is used for each individual chemical that the user chooses to include in the risk estimation. Total Estimated Risk is the sum of the individual risks.

- 1) Eq. 1a is used to calculate a steady state corrected invertebrate tissue concentration, or edible tissue concentration, using 28-day bioaccumulation test results and chemical properties in the following equations for metals and organics respectively. C_{prey} is the maximum concentration.
- 2) Eq. 2 applies a trophic transfer model to predict the chemical concentrations that will result in predator species that consume invertebrates
- 3) Eq. 3a is used to predict the Lifetime Average Daily Dose (LADD) of contaminants that humans could be exposed to. EPA Region 1 uses LADD to estimate cancer and non-cancer risk.
- 4) Finally, Eq 4a is used to determine the carcinogenic risk level, the Lifetime Average Daily Dose (LADD) is multiplied by an oral cancer slope factor (CSF). Eq 4b is used to determine the non-carcinogenic risk level, is divided by a reference dose (RfD) according to the following equations:

Metal Contaminants

Risk via metal is estimated with a somewhat different procedure than organic contaminants. Seafood non-cancer risk, as EPA Region 1 refers to it, is the non-cancer risk to humans posed by consuming *Macoma nasuta*, the bent-nose clam, that are contaminated by metals. The risk associated with individual metals is not summed.

- 1) Eq. 1b is used to calculate a steady state corrected invertebrate tissue concentration, or edible tissue concentration, using 28-day bioaccumulation test results and chemical properties in the following equations for metals and organics respectively. C_{prey} is the mean concentration.
- 2) Eq. 3a is used to predict the Lifetime Average Daily Dose (LADD) of contaminants that humans could be exposed to. ETC is that of the *Macoma nasuta*.
- 3) Eq. 4b is used to estimate the non-carcinogenic risk level.

Summary Report

Organic and Metal Contaminants

The only difference between the EPA Region 1 procedure for estimating risk and the BEST summary report procedure is the human dose equation that is used for non-cancer risk calculations. For the summary report procedure, see the EPA Region 1 section above. For non-cancer estimates, Eq. 3a Lifetime Average Daily Dose is replaced with Eq. 3b Average Daily Dose. Average Daily Dose is then used in Eq. 4c which estimates non-cancer risk. Note that the user can control which type of averaging time is ultimately applied in the calculations. The equations provided in this manual are prescribed based on EPA Region 1 history and a 2005 evaluation of that model by Battelle¹. See [Set Daily Dose](#) section of this report for instructions.

Equations

Invertebrate Edible Tissue Concentration

Organics

$$(1a) \text{ [Edible Tissue}_{\text{Invertebrate, Organic}}] \text{ (mg/kg)} = \frac{[C_{prey}] \times SSCF}{1000}$$

Where:

[C_{prey}] = mean or maximum (chosen by user, see Set Bioaccumulation Test Results Moment) tissue concentration from the 28-day bioaccumulation test data (ng/g)

SSCF = steady state correction factor (unitless)

[Edible Tissue_{Invertebrate, Organic}] = Concentration of organic contaminant in edible tissue of invertebrate species (mg/kg)

Metals

$$(1b) \text{ [Edible Tissue}_{\text{Invertebrate, Metal}}] \text{ (mg/kg)} = [C_{prey}] \times SSCF$$

Where:

[Edible Tissue_{Invertebrate, Metal}] = Concentration of metal contaminant in edible tissue of invertebrate species (µg/g)

¹ The Battelle (2005) report recommends that EPA model change from LADD to ADD for non-cancer risk. As of this date (2018), the risk calculations have not been updated.

[Cprey] = concentration of contaminant in the invertebrate in the maximum replicate of five replicates from the 28-day bioaccumulation test data depending on the user's choice (µg/g)

SSCF = steady state correction factor (unitless)

Predator Edible Tissue Concentration

$$(2) [\text{EdibleTissue}_{\text{Predator}}] \text{ (mg/kg)} = [\text{Edible Tissue}_{\text{Invertebrate}}] \times \text{BMF} \times \left(\frac{\text{Lipid}_{\text{Pred}}}{\text{Lipid}_{\text{Prey}}} \right)$$

Where:

[EdibleTissue_{Invertebrate}] = Concentration of contaminant in edible tissue of invertebrate prey species from equation 1 (mg/kg)

BMF = biomagnification factor (unitless)

Lipid_{Pred} = predator mean lipid fraction (g lipid/g tissue)

Lipid_{Prey} = invertebrate mean lipid fraction (g lipid/g tissue)

[EdibleTissue_{Predator}] = Concentration of contaminant in edible tissue of predator (mg/kg)

Dose to Humans

$$(3a) \text{ Lifetime Average Daily Dose (mg/kg-day)} = \frac{ETC \times FI \times F \times IR \times ED}{BW \times LT \times 365}$$

$$(3b) \text{ Average Daily Dose (mg/kg-day)} = \frac{ETC \times FI \times F \times IR \times ED}{BW \times ED \times 365}$$

Where:

ETC = Edible Tissue Concentration of human diet species (mg/kg) either [EdibleTissue_{Predator}] from equation 2 or [EdibleTissue_{Invertebrate}] from equation 1.

FI = Fraction Ingested (unitless)

F = Frequency (days/year)

IR = Diet Ingestion Rate (kg/day)

ED = Exposure Duration (yrs)

BW = Body Weight (kg)

LT = Lifetime (yrs)

365 = Conversion factor of exposure duration to days

LADD = Lifetime Average Daily Dose

Cancer and Non-cancer Risks

$$(4a) \quad \text{Cancer Risk} = \text{LADD} \times \text{CSF}$$

$$(4b) \quad \text{EPA Non-cancer Risk} = \text{LADD}/\text{RfD}$$

$$(4c) \quad \text{Non-cancer Risk} = \text{ADD}/\text{RfD}$$

Where:

LADD = Lifetime Average Daily Dose (mg/kg-day)

CSF = Oral Cancer Slope Factor (mg/kg)

RfD = Oral Reference Dose (mg/kg)

ADD = Average Daily Dose (mg/kg-day)

Glossary

Trophic Transfer

The BEST risk model predicts edible tissue concentrations in predator species by applying a trophic transfer model to the measured concentrations in invertebrate test species (Equation 1) based on the results of the 28-day bioaccumulation testing. This approach assumes that the test species represent the prey species typically consumed by predators, and that 100 percent of the organisms consumed are exposed to the dredged material.

Steady State Correction Factor

A steady state correction factor (SSCF) is used to correct for underestimates of prey tissue concentrations in standard 28-day bioaccumulation testing. Because the standard testing period (28 days) might not be long enough for the exposed organisms to reach a state of equilibrium with their environment, the SSCF is applied to further estimate prey tissue concentrations under natural exposure periods that are longer than the standard testing duration.

Biomagnification Factor

The biomagnification factor (BMF) accounts for accumulation of chemicals in predator tissues from consumption of invertebrate prey. Chemicals that biomagnify, or increase concentration up the food chain, will have BMFs >1 while those that do not biomagnify will have BMFs ≤ 1.

Risk

The BEST model estimates the carcinogenic and non-carcinogenic risk to human health based on the consumption of species directly exposed to contaminants in the sediment and their predators using standard risk equations (EPA, 1989b) based on the lifetime average daily dose (LADD) and average daily dose (ADD), respectively.

Cancer slope factor (mg/kg-day)

The slope factor is the cancer risk (proportion affected) per unit of dose

Reference dose (mg/kg-day)

The oral reference dose (RfD) is an estimate of a daily exposure to the human population that is likely to be without an appreciable risk of deleterious effects during a lifetime

Human toxicity equivalence factor

The toxicity equivalency factor (TEF) methodology was developed by the U.S. Environmental Protection Agency (EPA) to evaluate the toxicity and assess the risks of a mixture of structurally related chemicals with a common mechanism of action. A TEF is an estimate of the relative toxicity of a chemical compared to a reference chemical.

FDA Action Level (ppm)

Used to determine whether regulatory action is indicated for organics. Level of Concern is based on non-cancer endpoints, such as cardiovascular and dermatological effects, that could occur with consumption of higher levels of the target chemical over a limited period of time (short term, not lifetime)

FDA Level of Concern (ppm)

Used to determine whether regulatory action is indicated for metals. Level of Concern is based on non-cancer endpoints, such as cardiovascular and dermatological effects, that could occur with consumption of higher levels of metals over a limited period of time (short term, not lifetime)

Ecological Effect Level (ppm)

Threshold indicating potential effects of chemicals and other pollutants on ecological communities

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