# North Carolina Department of Environmental Quality Risk Calculator User Guide

*February 2018*

Environmental Quality

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## 1.0 INTRODUCTION

The North Carolina Department of Environmental Quality (NCDEQ) Risk Calculator has been developed to calculate risks associated with current, or potential future human exposure to contaminated soil, groundwater, surface water, and vapor and to estimate contaminant migration through soil and groundwater. The calculator is designed to evaluate multiple exposure routes associated with all contaminated environmental media at a site, however, its entire functionality may not be needed in all cases. In certain instances, the calculator can just be used to determine the human-health risk associated with a single media, such as soil or vapor, or to calculate a cleanup level for soil or groundwater.

### 1.1 Scope and Purpose

This Risk Calculator User Guide (Guide) describes the functionality of the Risk Calculator and provides instructions on its use. Prior to using the Risk Calculator, the most recent version of the *Technical Guidance for Risk-Based Environmental Remediation of Sites* document (Technical Guidance) should be accessed from the NCDEQ Risk-Based Remediation website and reviewed. General risk assessment procedures, data needs and concepts presented in this Guide are described in more detail in the Technical Guidance and not repeated here.

The Risk Calculator is an Excel-based, menu-driven program. Inputs, equations, and procedures used in the calculator are consistent with those described in U.S. Environmental Protection Agency (EPA) risk assessment guidance. Refer to the Risk Evaluation Resources page on the Risk-Based Remediation website for a link to the list of equations used in the calculator. Where EPA default equations or inputs are not available, the NCDEQ has established North Carolina specific inputs or adopted those used in other nearby States.

**NOTE: The Risk Calculator has been developed for use by project managers and toxicologists, and is built with multiple equations for all common exposure pathways in all media. As a result, some sheets or data entry fields may not be needed in all cases.**

### 1.2 Getting Started

The user should have already acquired the necessary site information:

1. Areas of similar use and potential exposure (exposure units or EUs) on all currently affected properties and those that could become affected in the future;
2. Current and potential future receptors;
3. The maximum concentration of each contaminant in each media detected in each EU; and
4. The exposure pathways that are complete for the identified receptor in each EU.

The Risk Calculator is designed to evaluate one exposure unit at a time. Therefore, if the subject site has more than one exposure unit, the user will need to resave a separate version of the calculator for each exposure unit. Throughout the file, cells where data entry is enabled are shown in yellow. All other cells are locked and cannot be changed without a password. Additional color codes and acronyms are defined in the table below.

Color Codes and Acronyms

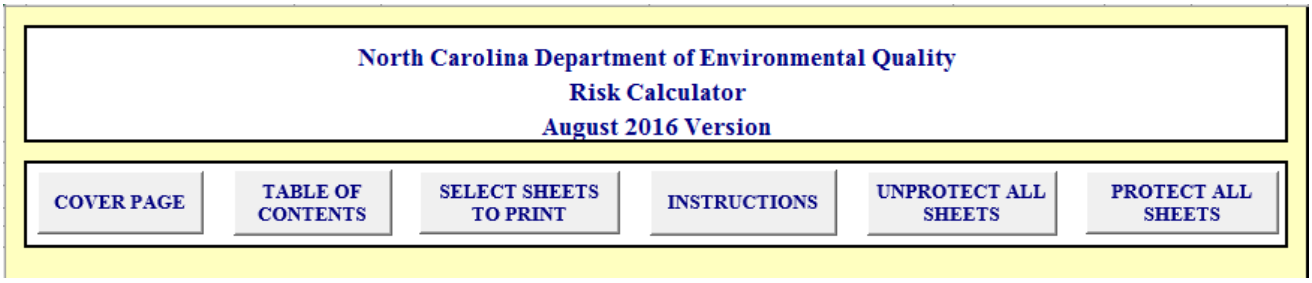
| | |
|---|---|
| | Data entry field |
| | Non-volatile chemical |
| | Soil concentration exceeds the soil saturation concentration, Csat |
| | Entry not required for pathways selected |
| red text | Entry has been modified from default value, or no defaults are established |
| NC | User identified this exposure pathway as 'not complete' |
| NM | 'Not modeled' due to lack of input data |

## 2.0 RISK CALCULATOR

### 2.1 General Sections

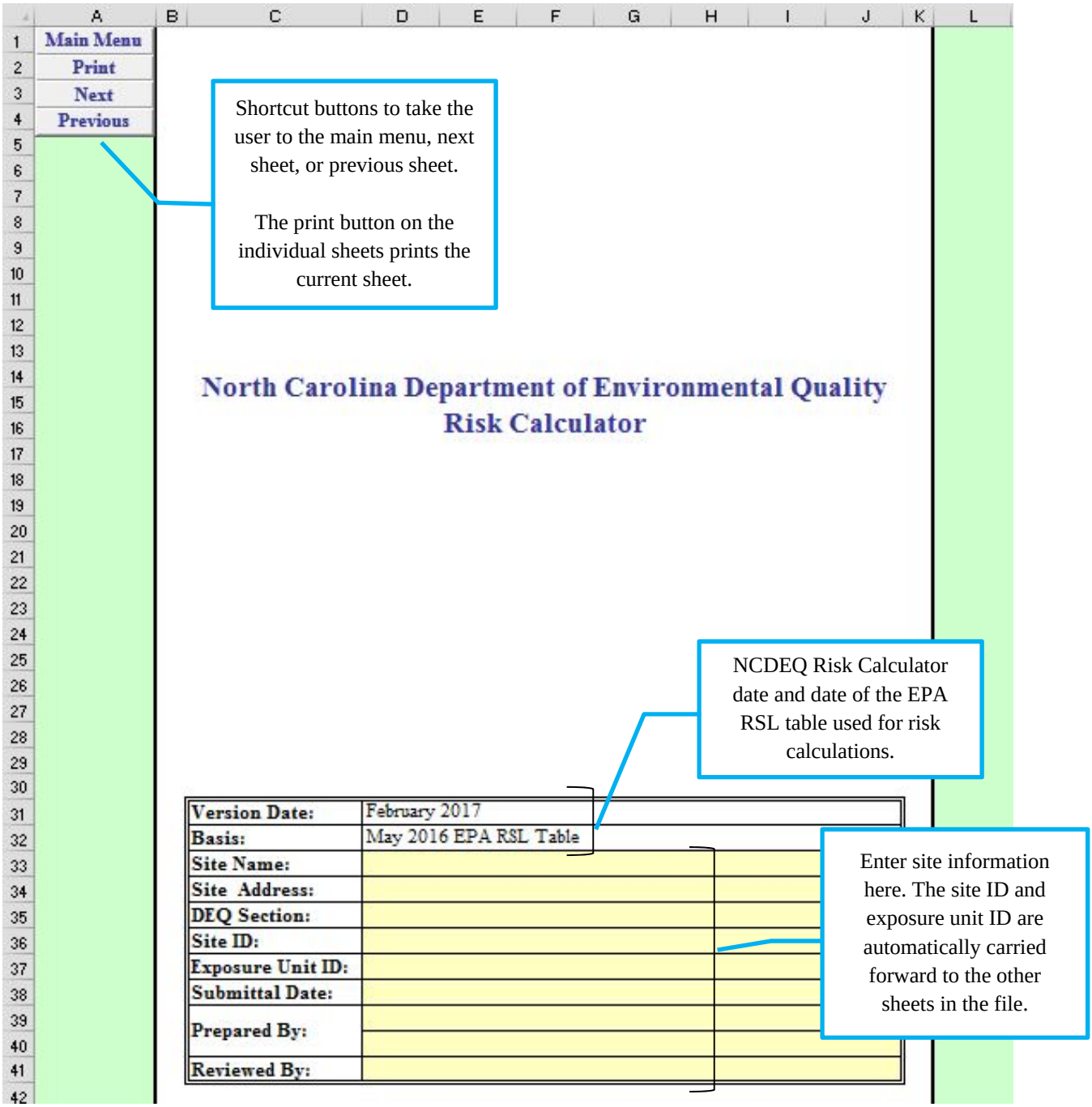
#### *2.1.1 Main Menu*

The Risk Calculator opens to the "Main Menu" sheet which is comprised of three general sections: a general information section, a series of data input sheets, and a series of data output sheets. The buttons on this sheet lead the user to the desired section of the Risk Calculator. All sheets contain a button for the user to go back to the main menu.



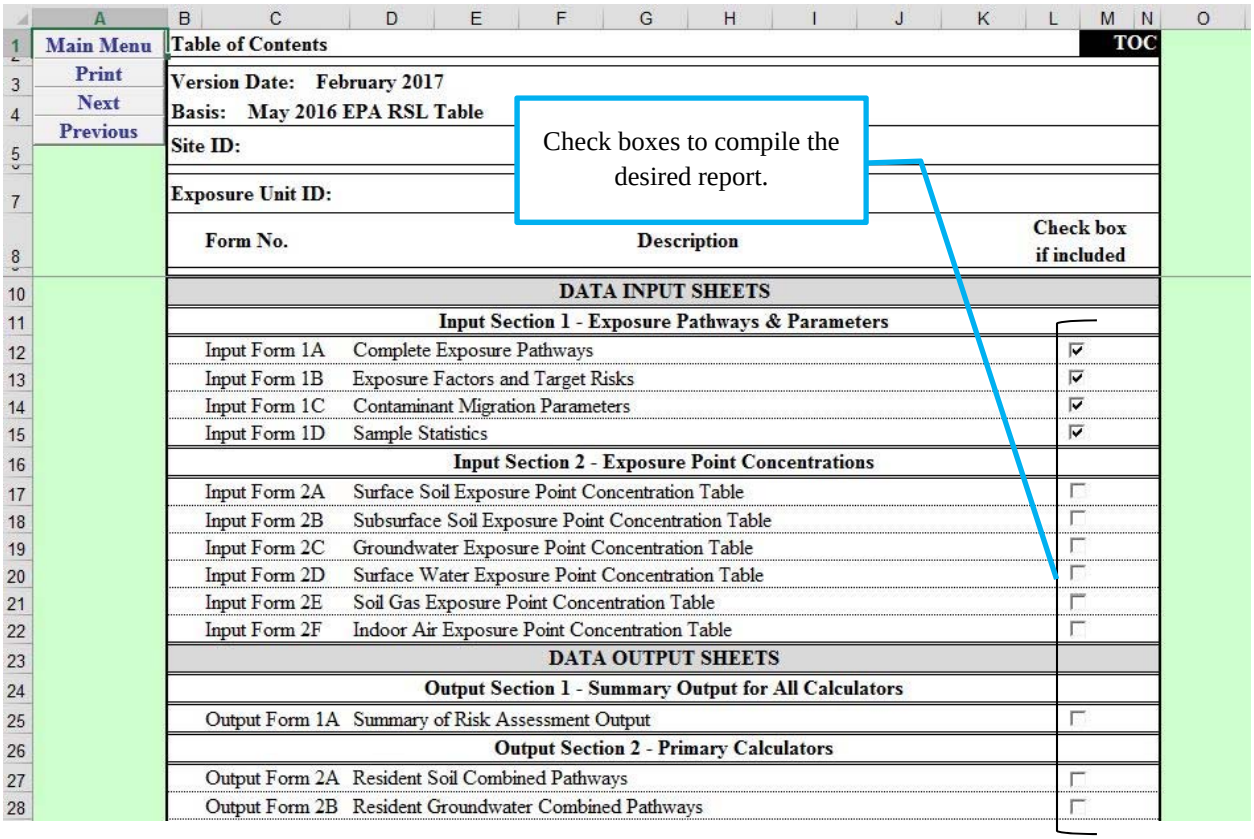

#### *2.1.2 Cover Page*

The user should enter the applicable site and exposure unit identification information in the yellow cells in the "Cover Page". The site and exposure unit identification is automatically carried through in the headings for other sheets in the calculator. The version date and the EPA Regional Screening Level (RSL) table date that are used for the risk assessment calculations are shown on the cover sheet to ensure that the user is using the most up-to-date version of the calculator.




### *2.1.3 Table of Contents*

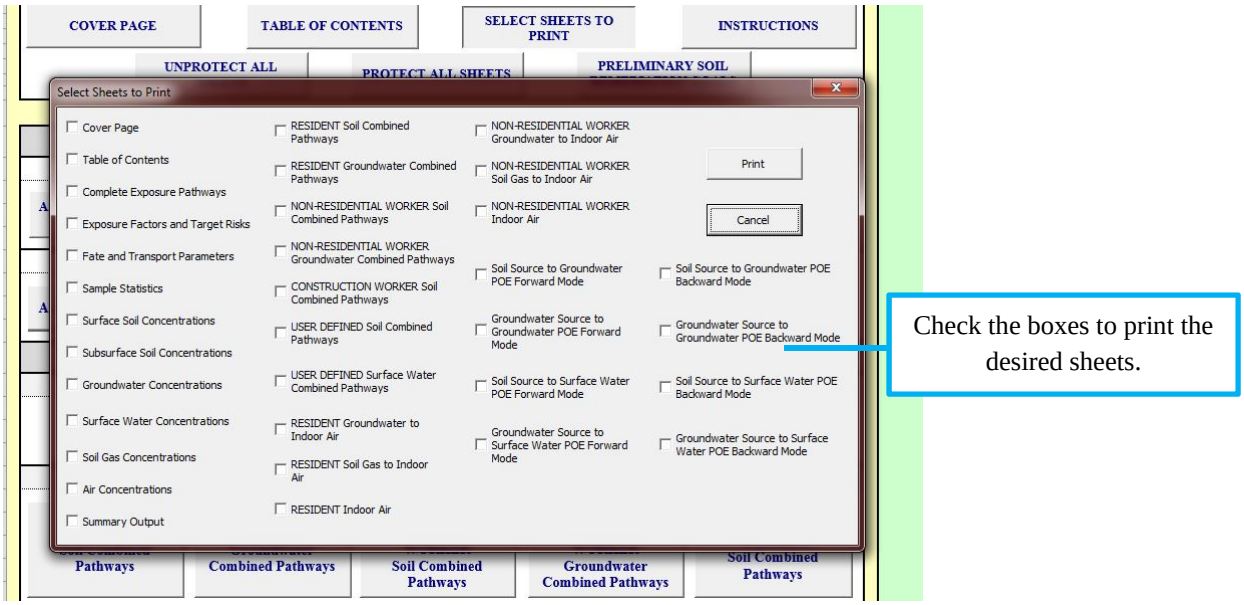
The "Table of Contents" sheet can be completed, if desired, to generate a complete report documenting the risk assessment results. The user should check the boxes for sheets to be included in the report. However, note that the check boxes are not linked to any other sheets in the risk calculator file and completion of this sheet is not needed to perform risk assessment calculations.




### *2.1.4 Select Sheets to Print Button*

The "Select Sheets to Print" button located on the main menu can be used to select multiple sheets in the Risk Calculator to print in one batch.

**NOTE: There is no option in this window to select the printer. The correct printer should be selected through Excel's File>>Print menu.**



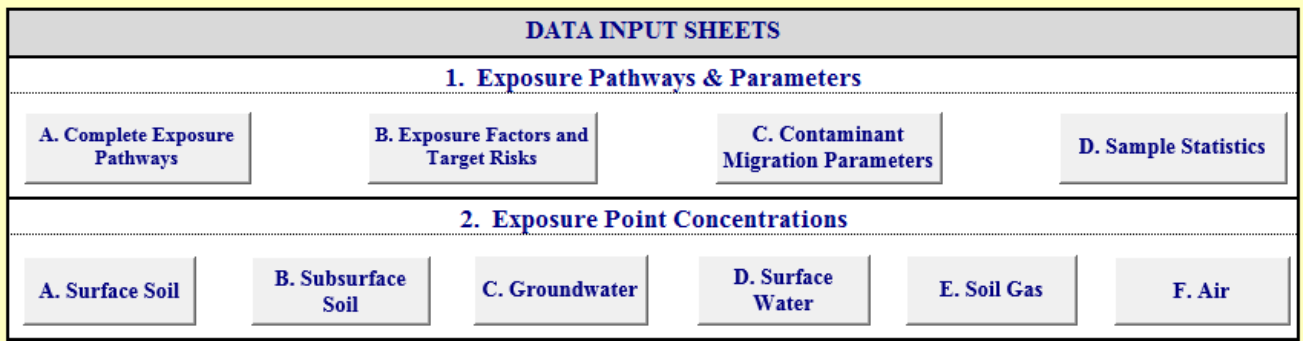
### *2.1.5 Instructions*

The "Instructions" sheet describes the general function of each of the buttons in the calculator. Detailed instructions on how to use the Risk Calculator are further explained in this Guide.

### *2.1.6 Unprotect All Sheet and Protect All Sheets*

These buttons are included for users who are authorized to make changes to the Risk Calculator file. A password is needed to unprotect the sheets with locked cells.

## 2.2 Data Input Sheets




### *2.2.1 Exposure Pathways & Parameters*

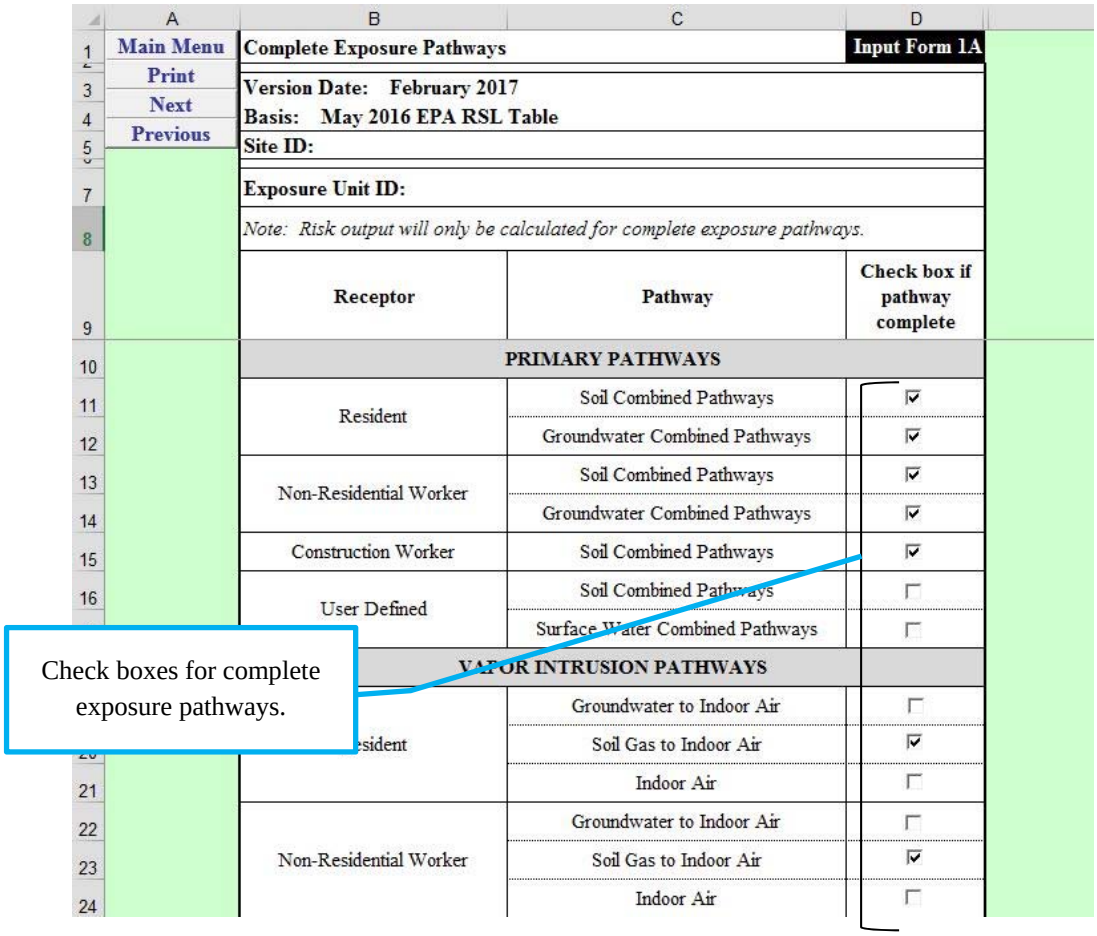
#### 2.2.1.1 Complete Exposure Pathways

Select the complete exposure pathways identified at the site by checking the boxes on the "Complete Exposure Pathways" sheet (Input Form 1A). Risk values will only be calculated for the complete exposure pathways marked with a check. If a pathway is not checked as complete, then the risk assessment result will report "NC" for not complete. The complete pathways selected on this sheet will indicate to the user what information needs to be entered on the "Exposure Factors and Target Risks" and "Contaminant Migration Parameters" sheets. For example, yellow cells indicate a value can be entered, and gray cells indicate that the information is not needed.

**NOTE: The term "combined pathway" refers to the three mechanisms of exposure that may occur when a person comes in contact with contaminated media - dermal contact, ingestion, and inhalation. The "Groundwater Combined Pathway" refers to risks associated with dermal contact, ingestion, and inhalation of contaminants in a potable tap-water supply. <u>The Groundwater Combined Pathway is included in the calculator to assist DEQ toxicologists with routine health risk evaluations. Do not evaluate this pathway for risk-based cleanups where groundwater use will be restricted (e.g., the ezposure pathway will be eliminated).</u>**

**NOTE: There is not a separate calculator for sediment combined pathways. The sediment combined pathways equations are the same as the soil combined pathways equations,**

**therefore, the "Soil Combined Pathways" calculator can be used to evaluate sediment exposure. The user should consult with NCDEQ if modifications to the exposure factors and contaminant migration parameters are appropriate to evaluate sediment exposure.**




### 2.2.1.2 Exposure Factors and Target Risks

Exposure factors and target risks are entered on the "Exposure Factors and Target Risks" sheet (Input Form 1B). Exposure factors are obtained primarily from EPA Regional Screening Level default values. If a default value is not used, the site-specific value text color changes to red to alert the user and/or reviewer. Justifications for changing the default value can be documented in the "Justification" column and may require NCDEQ approval.

The target risk range is typically established in rule or statute for given remediation programs, so the appropriate endpoint should be used. For example, some remediation programs use a target cumulative cancer risk range of $10^{-5}$, while others use $10^{-4}$.

Default exposure values are provided for both a recreator and a trespasser in the "User Defined" pathway. "NA" should be entered in the "User Defined Child" section if evaluating for the trespasser scenario.

Note that evaluation of risks for a recreator and trespasser is not required for all scenarios. DEQ is currently developing additional guidance related to evaluation of these receptors.

Main Menu | Print | Next | Previous

**Exposure Factors and Target Risks** — **Input Form 1B**

**Version Date: February 2017**
**Basis: May 2016 EPA RSL Table**
**Site ID:**

**Exposure Unit ID:**

| Exposure Parameter | Default Value | Site Specific Value | Justification |
|---|---|---|---|
| General | | | |
| Target Cancer Risk (individual) | 1.0E-06 | 1.0E-06 | |
| Target Cancer Risk (cumulative) | 1.0E-04 | 1.0E-05 | |
| Target Hazard Index (individual) | 2.0E-01 | 2.0E-01 | |
| Target Hazard Index (cumulative) | 1.0E+00 | 1.0E+00 | |
| Residential Child | | | |
| Lifetime (LT) (years) | 70 | 70 | |
| Body Weight (BW) (kg) | 15 | 15 | |
| Exposure Duration (ED) (yr) | 6 | 6 | |
| Exposure Frequency (EF) (d/yr) | 350 | 350 | |
| Exposure Time (ET) (hr) | 24 | 24 | |
| Skin Surface Area - Soil Exposure ($SA_s$) (cm2) | 2373 | 2373 | |
| Soil Adherence Factor (AF) (mg/cm$^2$) | 0.2 | 0.2 | |
| Soil Ingestion Rate (IRS) (mg/day) | 200 | 200 | |

If the text is red, then the NCDEQ default value is not being used.

Main Menu | Print | Next | Previous

**Exposure Factors and Target Risks** — **Input Form 1B**

**Version Date: February 2017**
**Basis: May 2016 EPA RSL Table**
**Site ID:**

**Exposure Unit ID:**

| Exposure Parameter | Default Value | Site Specific Value | Justification |
|---|---|---|---|
| Construction Worker | | | |
| Lifetime (LT) (years) | 70 | 70 | |
| Body Weight (BW) (kg) | 80 | 80 | |
| Working Weeks (EW) (wk/yr) | 50 | 50 | |
| Exposure Duration (ED) (yr) | 1 | 1 | |
| Exposure Frequency (EF) (d/yr) | 250 | 250 | |
| Exposure Time (ET) (hr) | 8 | 8 | |
| Skin Surface Area - Soil Exposure ($SA_s$) (cm$^2$) | 3527 | 3527 | |
| Soil Adherence Factor (AF) (mg/cm$^2$) | 0.3 | 0.3 | |
| Soil Ingestion Rate (IR) (mg/day) | 330 | 330 | |
| User Defined Child | | | |
| | Recreator | Trespasser | |
| Lifetime (LT) (years) | 70 | NA | 70 |
| Averaging Time (AT) (days/yr) | 365 | NA | 365 |
| Body Weight (BW) (kg) | 15 | NA | 15 |
| Exposure Duration 0-2 (ED) (yr) | 2 | NA | 2 |
| Exposure Duration 2-6 (ED) (yr) | 4 | NA | 4 |
| Exposure Frequency (EF) (d/yr) | 195 | NA | 195 |
| Exposure Time (ET) (hr) | 2 | NA | 2 |

Cells become grey when entries are not needed for the exposure pathways checked complete on the "Complete Exposure Pathways" sheet.

### 2.2.1.3 Contaminant Migration Parameters

To evaluate the vertical migration of contamination from soil to groundwater and/or the lateral migration to a point of exposure (a water supply well or property boundary, for example), check the "Contaminant Migration Pathways" on Input Form 1A. The contaminant migration parameters are then entered into Input Form 1C. If these pathways are not checked, the pertinent cells will become grey. Where a NCDEQ default value is not provided, a site-specific value is required. The site-specific value text color will change to red and a justification can be documented in the "Justification" column. If no

values are entered for these parameters, the subsequent Output Forms will show "NM" for "Not Modeled".

Note that water filled soil porosity, air filled soil porosity, and fraction organic carbon have two default values; one for soil to outdoor air pathway and one for soil to groundwater pathway. If a site-specific value is being used, the user should enter the same value for both pathways. The default values given are considered conservative for the given pathway.

#### 2.2.1.4 Sample Statistics

The "Sample Statistics" sheet is included to provide basic statistical calculations for convenience, if desired. However, the data entered on this sheet are not carried forward in the remainder of the risk assessment calculator.

### *2.2.2 Exposure Point Concentrations*

Maximum concentrations of each detected contaminant in the EU being evaluated should be entered in the "Exposure Point Concentration" column for each affected media: surface soil, subsurface soil, groundwater, surface water, soil gas, and indoor air using Input Forms A through F, respectively. The columns to the right of the chemical names are not used in the risk assessment calculations but are available to the NCDEQ toxicologists or other users.

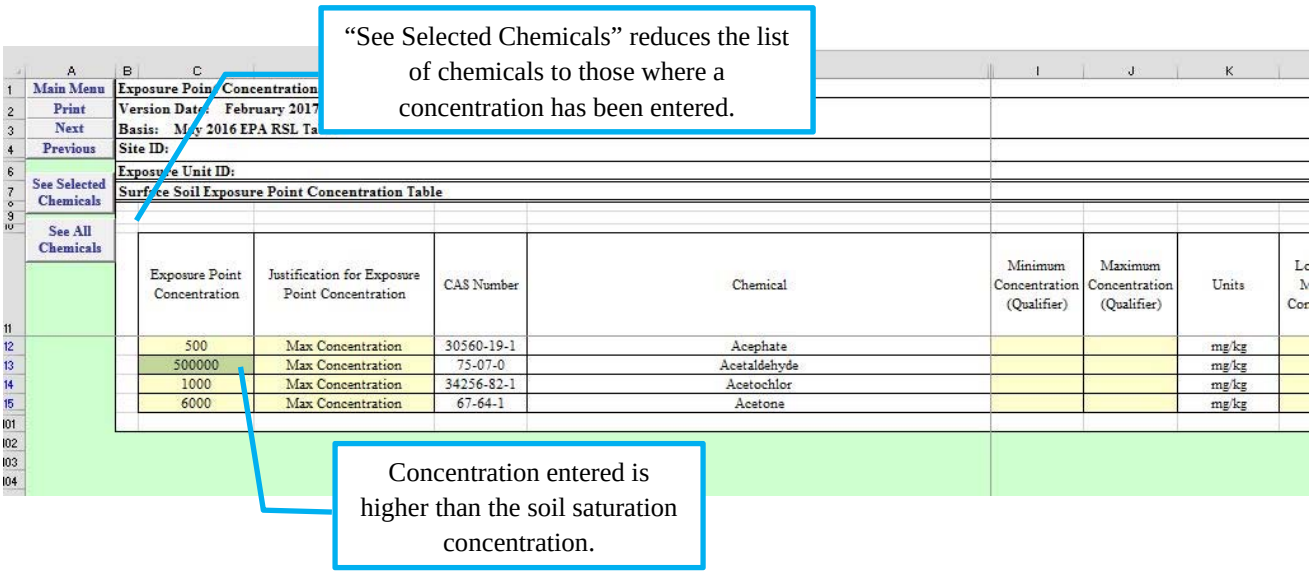
**NOTE: The definition of surface and subsurface soil varies among DEQ remediation programs. Some programs may not distinguish between surface and subsurface soil, and others may consider surface soil to extend to 1 or 3 feet below ground surface. To be conservative, the same maximum soil concentrations should be entered for both surface and subsurface soil intervals. Variations from this approach should be discussed with the remediation oversight program.**

Exposure point concentrations entered for each medium are used in the following calculations:

| Exposure Point Concentration For: | Risk Pathway Calculated |
|---|---|
| Surface Soil[1] | Residential soil combined<br>Non-residential worker soil combined<br>User-defined soil combined |
| Subsurface Soil[1] | Construction worker soil combined<br>Source soil to groundwater point of exposure (POE)<br>Source soil to surface water POE |
| Groundwater | **Residential groundwater combined[2]**<br>**Non-residential worker groundwater combined[2]**<br>Residential groundwater to indoor air<br>Non-residential worker groundwater to indoor air |

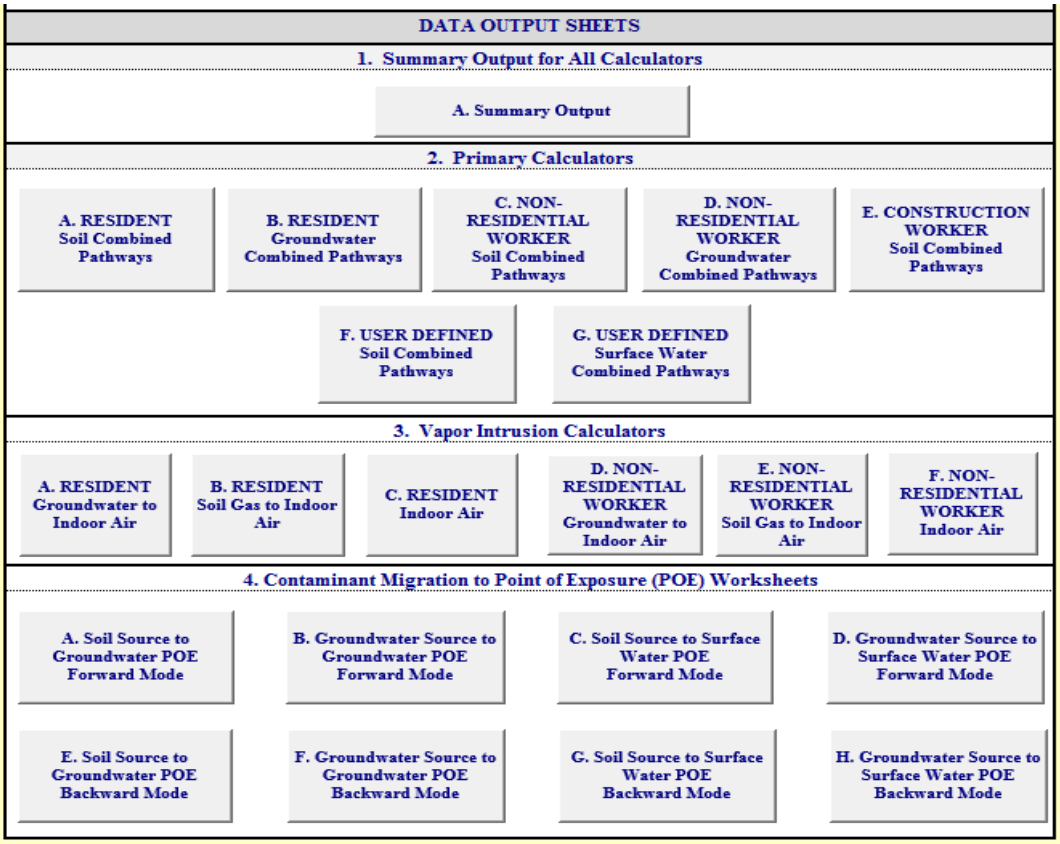
| | |
|---|---|
| Surface Water | User-defined surface water combined pathway |
| Soil Gas[3] | Residential soil gas to indoor air<br>Non-residential worker soil gas to indoor air |
| Indoor Air[3] | Residential indoor air<br>Non-residential worker indoor air |
| [1] If the soil concentration exceeds the soil saturation concentration (Csat), the cell will be highlighted green. | |
| [2] **This pathway is only associated with contaminated water supplies and will be evaluated by a State toxicologist as part of a health-risk evaluation. It is not a complete exposure pathway when a groundwater-use restriction is implemented.** | |
| [3] If a cell is highlighted in orange, the chemical is non-volatile. Risk from non-volatile contaminants in soil gas is not calculated because they are not considered to pose a vapor intrusion risk. However, indoor air risks are calculated for non-volatile contaminants if indoor air screening levels have been established. It should be noted that detections of these chemicals are likely not associated with vapor intrusion but may contribute to an exposure risk. | |

The "See Selected Chemicals" button can be used to limit the chemical list to those where exposure point concentrations have been entered into the table. This option is also available on the data output sheets.




"Override" sheets are available to authorized users for surface soil, subsurface soil, sediment, and surface water where variable concentrations can be entered for each individual exposure pathway. A password is necessary to edit the override sheets. If no values are entered in these sheets, the concentrations entered into the "Exposure Point Concentrations" sheets will be carried through for all chemicals.

## 2.3 Data Output Sheets




### *2.3.1 Summary Output*

The "Summary Output" sheet (Output Form 1A) shows a summary of the risk assessment results for all complete exposure pathways. For the "Primary Calculators" and "Vapor Intrusion Calculators", the "Risk exceeded?" column is marked "YES" if cumulative carcinogenic risk or hazard index values exceed the limits specified on the "Exposure Pathways and Target Risks" sheet. For the "Contaminant Migration to POE" calculators, the "Target POE Concentrations Exceeded?" column is marked "YES" if the calculated concentrations at the POE exceed the applicable risk criteria. For the Protection of Groundwater Use evaluation, the risk criteria are the 15A NCAC 02L Standards. For the Protection of Surface Water evaluation, the risk criteria are the 15A NCAC 02B Standards.

**NOTE: "NC" means the exposure pathway is not complete as defined on the "Complete Exposure Pathways" sheet. "NM" means the exposure pathway is not modeled because required input parameters are not entered on the "Contaminant Migration Parameters" sheet.**

Sections 2.3.2 through 2.3.4 describe the individual output sheets for each pathway that are the basis for the information reported in the "Summary Output" sheet.

### *2.3.2 Primary Calculators*

The "Primary Calculators" sheets evaluate risk associated with soil combined pathways, groundwater combined pathways, and surface water combined pathways. The calculations are based on the equations referenced on the EPA RSL website and NCDEQ approved default parameters. Additional details regarding calculations for the primary pathways are provided in the following sections.

*Resident, Non-Residential Worker, Construction Worker, and User-Defined Soil Combined Pathways*

The "Soil Combined Pathways" output sheets evaluate risk of ingestion, dermal contact, and outdoor inhalation of volatiles and particulates from contaminated soil by a resident, non-residential worker, construction worker, or user-defined receptor. For calculation of the volatilization factor (VF), which is used in the outdoor inhalation of volatiles equation, the calculators run both the unlimited source and mass limit equations, then whichever calculation indicates a higher risk value is carried through in the final output.

*Resident and Non-Residential Worker Groundwater Combined Pathways*

The "Groundwater Combined Pathways" output sheets evaluate risk for tapwater ingestion, dermal contact, and inhalation for a resident or non-residential worker. (Note that inhalation calculations on these sheets are associated with tapwater inhalation, not inhalation associated with vapor intrusion.) The Groundwater Combined Pathway is included in the calculator to assist DEQ toxicologists with routine health risk evaluations of contaminated water supply wells, however, **it does not need to be evaluated for risk-based cleanups where groundwater use will be restricted.** Also, note that groundwater use must be restricted whenever groundwater concentrations exceed 15A NCAC 02L Standards, even if concentrations indicate acceptable risk levels using the calculator.

*User-Defined Surface Water Combined Pathways*

The "User-Defined Surface Water Combined Pathways" sheet evaluates risk for ingestion and dermal contact by a user-defined receptor who could directly be at risk from contaminated surface water by wading or swimming, for example. Note that sites cannot be issued risk-based closure if concentrations exceed 15A NCAC 02B Standards, even if concentrations indicate acceptable risk levels using the calculator.

### *2.3.3 Vapor Intrusion Calculators*

The "Vapor Intrusion Calculators" sheets evaluate risk associated with indoor inhalation of contaminated vapor intruding into a structure from contaminated soil and/or groundwater. Calculations can be performed for a resident or a non-residential worker using either indoor air data ("Indoor Air" sheets), soil gas data ("Soil Gas to Indoor Air" sheets), or groundwater data ("Groundwater to Indoor Air" sheets), depending on the site-specific data availability. For example, if only soil gas data are available, then the calculator can be used to determine whether indoor air data are needed to further evaluate human-health risks. The calculations for indoor air are based on the equations specified on the EPA RSL website and NCDEQ approved input parameters. The calculations for soil gas and groundwater to indoor air are based on the equations specified on the EPA Vapor Intrusion Screening Level (VISL) Calculator and NCDEQ approved default parameters.

### *2.3.4 Contaminant Migration to Point of Exposure (POE) Calculators*

The "Contaminant Migration to POE Calculators" evaluate contaminant migration from either a soil source or groundwater source to either a groundwater POE or a surface water POE. Note that certain parameters on the "Contaminant Migration Parameters" sheet require entries or the "Contaminant Migration to POE Calculators" will show "NM" for "Not Modeled". The equations specified in the calculators are as follows:

- Equation 1: Soil leaching to groundwater is modeled using the equations specified on the EPA RSL website. The calculator models both the unlimited source and mass limit equations for soil leaching to groundwater, then the calculation that results in a higher concentration at the POE is used for the final output. Note that when the default parameters are input, the result will be similar to the Protection of Groundwater PSRG.
- Equation 2: Groundwater migration is modeled using one maximum concentration input and a simplified Domenico model that accounts for dispersion only with no biodegradation.
- Equation 3: Migration from groundwater to surface water adds a simple surface water dilution equation.

For the "Source Soil to Groundwater POE" calculator, if "0 feet" is entered for the distance to the POE on the "Contaminant Migration Parameters" sheet, the calculator will only model Equation 1 (soil leaching to groundwater) to determine the predicted groundwater concentration directly underneath the soil source area. If a distance to the POE of greater than 0 feet is entered on the "Contaminant Migration Parameters" sheet, the calculator will also apply Equation 2 (Domenico model) to the calculated groundwater concentration to determine a predicted groundwater concentration at the groundwater or surface water POE. Therefore, values other than 0 must be entered. For the Groundwater POE, the calculated groundwater concentrations are compared to the 15A NCAC 02L Standards.

The "Source Soil to Surface Water POE" and "Source Groundwater to Surface Water POE" calculators assume the plume has, or will discharge to, a surface water body with a known seepage area. Equations 1 and 2 are calculated, and a surface water dilution factor (Equation 3) is applied to calculate the predicted surface water concentration based on the predicted groundwater concentration adjacent to the surface water body. A value of "0" should be entered for the surface water flow rate unless published values are available or data have been collected. In both cases, the calculated surface water concentrations are compared to the 15A NCAC 02B Standards, which must be entered in manually.

**NOTE: The calculator incorporates the 15A NCAC 02L Standards as the target screening levels for the protection of groundwater use calculators. However, the 15A NCAC 02B Standards must be manually entered on the "Soil Source to Surface Water POE" and "Groundwater Source to Surface Water POE" sheets for the protection of surface water calculators.**

## 3.0 CALCULATING CLEANUP LEVELS

The Risk Calculator incorporates both "Forward Mode" and "Backward Mode" sheets for the contaminant migration calculations. For the "Forward Mode" calculators, the user enters source soil and groundwater concentrations in the "Exposure Point Concentrations" sheets, then the calculator predicts the concentration at the POE. For the "Backward Mode" calculators, the user enters the target concentrations at the POE (e.g., 15A NCAC 02L or 15A NCAC 02B Standards), then the calculator predicts the source area concentrations that would result in no exceedances of the designated target concentrations at the POE based on the transport parameters entered. The "2L Standard" column on the "Soil Source to Groundwater POE" and "Groundwater Source to Groundwater POE" sheets shows the 15A NCAC 02L Standards for reference. However, the user must manually enter the target concentrations in the "Target Groundwater Concentration at the POE" column. This is designed to account for scenarios where the user may want to enter a target groundwater concentration other than 15A NCAC 02L Standards, such as screening levels protective of vapor intrusion for example. On the Soil Source to Surface Water POE" and "Groundwater Source to Surface Water POE" sheets, the user must also manually enter 15A NCAC 02B Standards or other target screening levels.

## 4.0 SUMMING ALL RISKS

The calculator determines total risks of all contaminants for each pathway in each medium separately. However, the total cumulative risk to human health from <u>all</u> contaminated media must be less than the the acceptable levels provided for cancerous effects (1 in 10,000 or $10^{-4}$) and non-cancerous systemic effects (HI less than 1) for each receptor. Risk Calculator report forms are available on the Risk-Based Remediation website to document the results of the calculator output and facilitate summation of all risks from all contaminated media. Note that vapor risk can be calculated through three different pathways depending on the available data entered, so summing the risk from more than one vapor pathway will be inaccurate by overinflating the actual risk of site conditions.