

The ReCLAIM Dose Assessment Tool

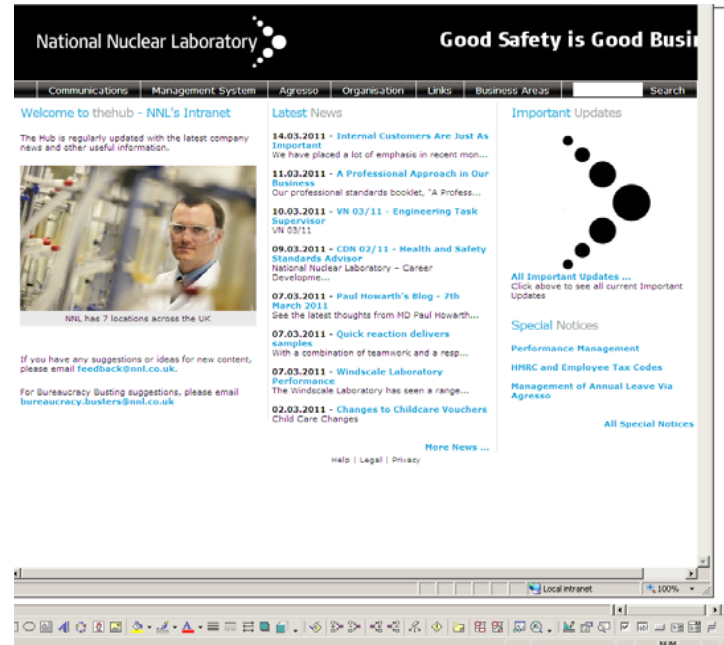
*Presentation for the RSC / SoBRA meeting on
"Current Issues in Contaminated Land Risk
Assessment – 2011"*

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Lennon and Nathalie Galais

Structure of this presentation

- What is ReCLAIM and why use it
- Simple theory of how it works and what it calculates
- How it fits with a tiered contaminated land assessment approach



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What is ReCLAIM and why should we use it?

Review of **C**ontamination **L**evels for **A**ssessment of *de minimis* **I**nventory **M**odel

- It is a radioactive contaminated land assessment tool developed by NNL and funded by the NDA
- Uses Microsoft Excel™
- User-friendly

Origin of ReCLAIM

1. Oatway and Mobbs (2003) NRPB-W36. Methodology for estimating the doses to members of the public from the future use of land previously contaminated with radioactivity (CONLAND).

Report provides future use of land scenarios (covering a variety of exposure pathways) which are emulated in ReCLAIM.

2. RADCONTAB 1.0 (2005): Look up tables spreadsheet tool for assessing doses (for various exposure pathways) from radioactive contamination on operational nuclear licensed sites (peer reviewed/publicised on www.safegrounds.com)

3. Radioactively Contaminated Land Exposure Assessment (RCLEA) tool (Defra, 2006; 2011)

ReCLAIM emulates scenarios and the dose and 'Radioactivity in Soil Guideline Values' (GRACsoil) associated with this tool

Support to management of land contaminated with radioactivity

- Calculation of doses to humans arising from radioactively contaminated land:
 - Individual exposure pathways
 - Multiple pathways / scenarios
- Calculation of soil / water screening values for individual radionuclides
- Assessment of remedial options, e.g. cap thickness
- Consideration of additivity
- Subtraction of background values
- Generic or site-specific

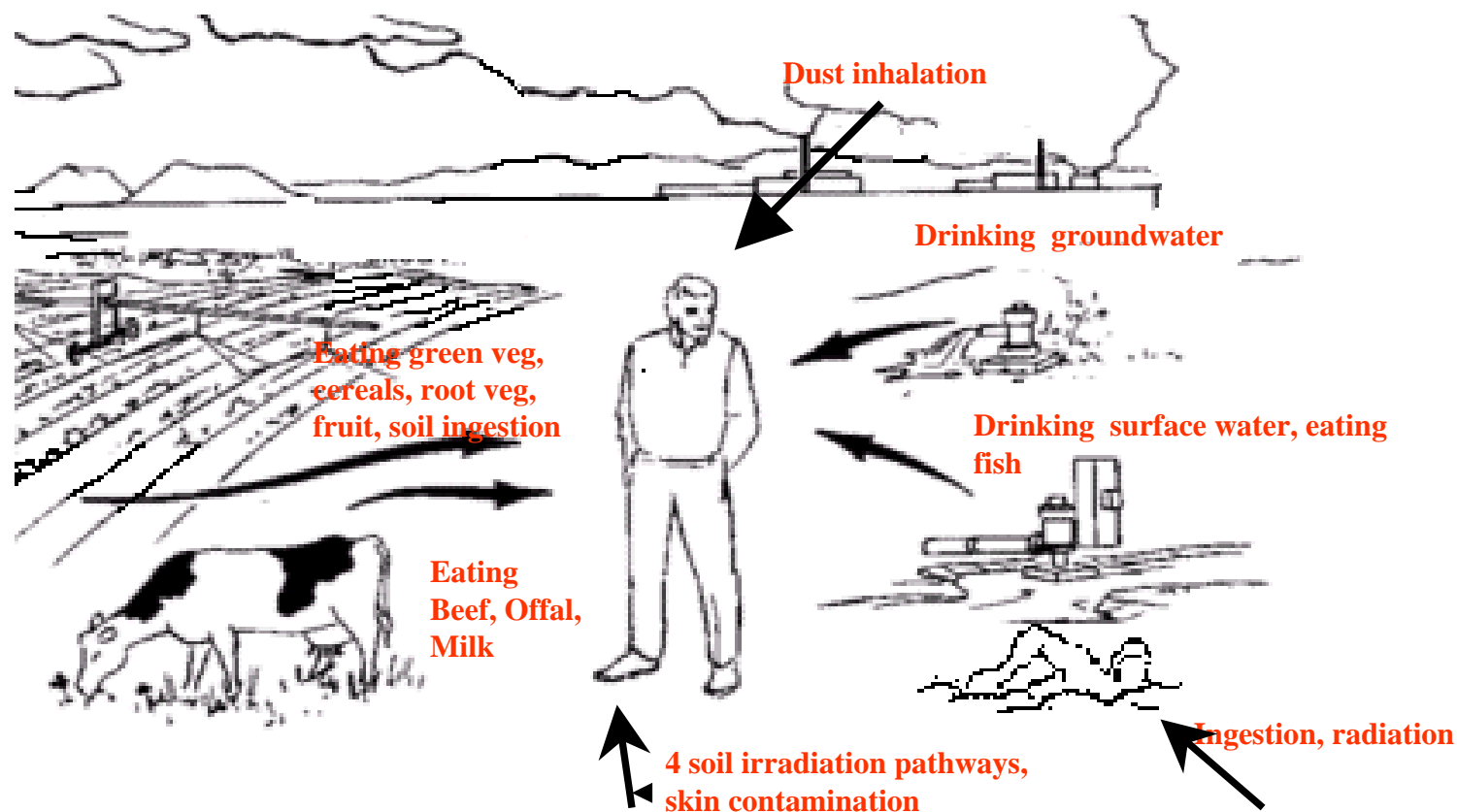
Radionuclides that can be considered by ReCLAIM v3

H-3	C-14	Cl-36	K-40	Fe-55
Co-60	Ni-63	Se-79	Sr+90	Mo-93
Nb-93m	Nb-94	Tc-99	Ru+106	Ag+108m
Sn+121m	Sn+126	Sb-125	I-129	Cs-134
Cs+137	Ce+144	Pm-147	Sm-147	Sm-151
Eu-152	Eu-154	Eu-155	Pb+210	Po-210
Ra+226	Ra+228	Ac+227	Th+228	Th+229
Th-230	Th-232	Pa-231	U-233	U-234
U+235	U-236	U+238	Np+237	Pu-238
Pu-239	Pu-240	Pu-241	Pu-242	Am-241
Cm-242	Cm-243	Cm-244		

where the '+' in the radionuclide name indicates the inclusion of short-lived progeny in secular equilibrium with the parent.

Radionuclides in bold are not included in RCLEA

Considers or assesses the exposure pathways associated with contaminated land (soil, water)



Exposure pathways

- External irradiation from soil (indoors & outdoors)
- External irradiation from immersion in water
- Dermal contact with soil (excluding open wounds)
- Ingestion of dust (indoors & outdoors)
- Ingestion of dust and soil
- Ingestion of plant-based foodstuffs
- Ingestion of animal based foodstuffs
- Ingestion of freshwater fish
- Ingestion of water

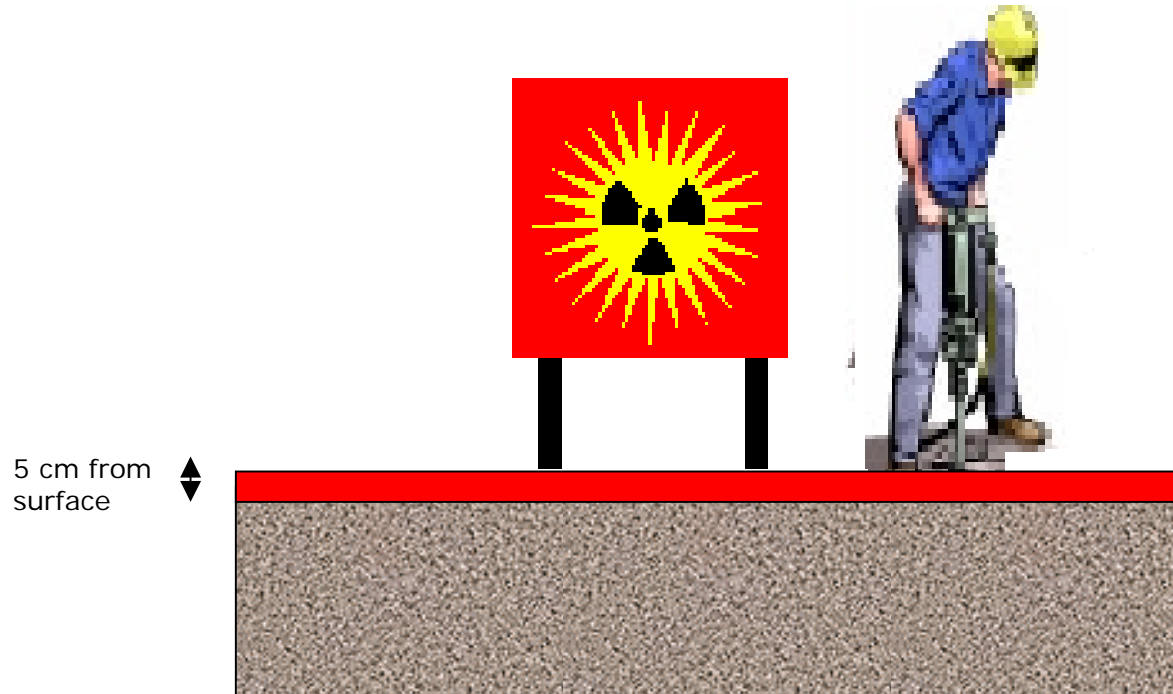
External irradiation dose – surface contamination

- surface contamination (Bq cm^{-2}) 'zero' thickness;



External irradiation dose – shallow contamination

- shallow contamination (Bq g^{-1}) 5 cm deep from the surface



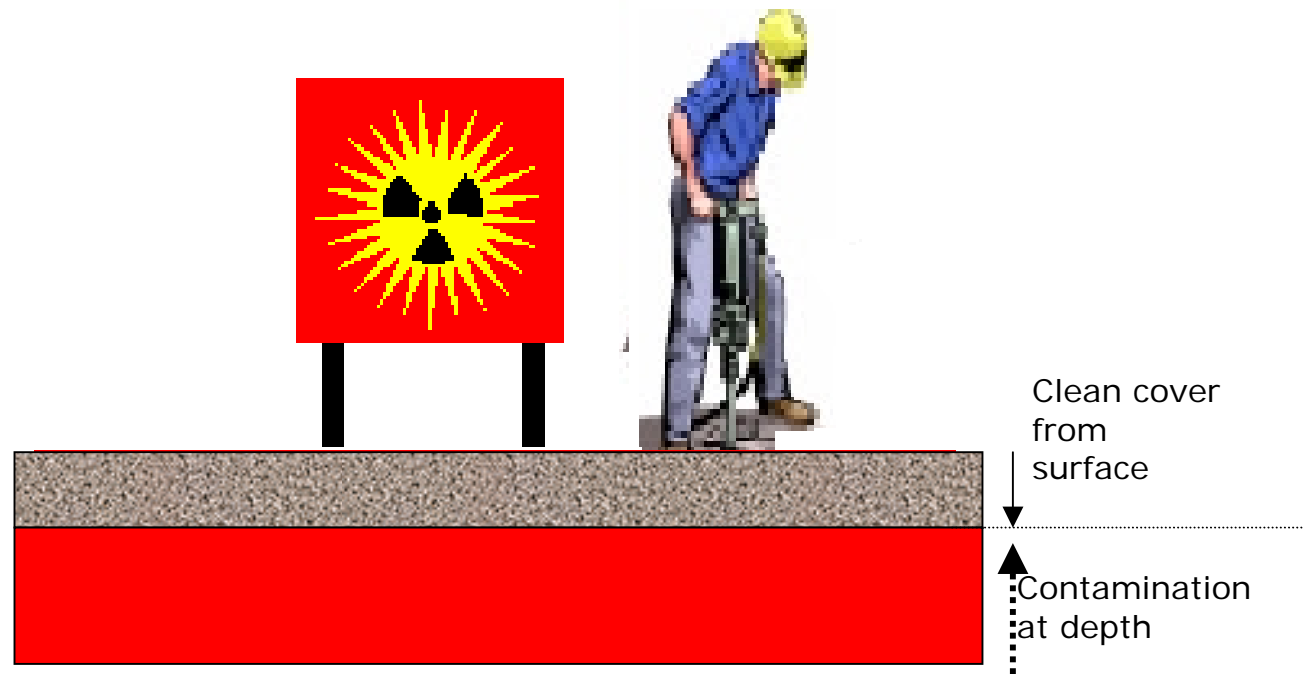
External irradiation dose – deep contamination

- deep contamination (Bq g^{-1}) extending to infinite depth from the surface (can be varied between 0.02 and 5 m)



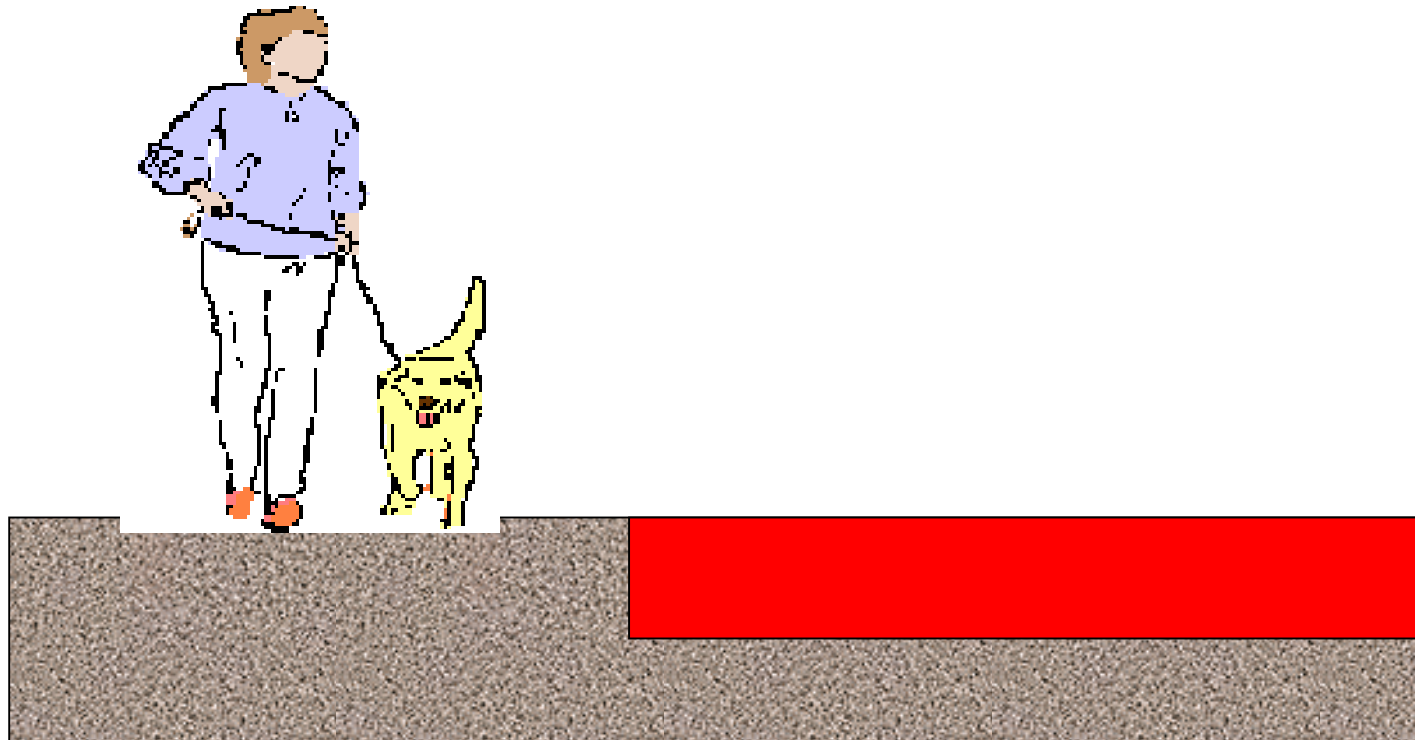
External irradiation dose – buried contamination

- Buried contamination (Bq g^{-1}) below a specified thickness between 0.02 and 3m of clean material (default soil)



External irradiation dose – on edge of contamination

- Can also be on the edge of a contaminated area:



Exposure pathway calculations: Total dose

For a given contaminated land scenario:

Total dose for a radionuclide I = sum of all necessary individual exposure pathway calculations for a radionuclide

Totaldose(I)
(mSv y⁻¹)

Total dose for all radionuclides = sum of **Totaldose (I)**

Totaldose(Allnucs)
(mSv y⁻¹)

Exposure Groups

- infants (1 year);
- children (10 years); and
- adults (16 years and above).

These three groups should provide sufficient coverage of the exposed population in general for radiological assessments of contaminated land.

Scenarios that can be emulated in ReCLAIM v3.0 for generic contaminated land assessments 1/2

Radioactively Contaminated Land Exposure Assessment (RCLEA) methodology (**d-mod2**)

- Residential land use with or without home grown produce.
- Allotment land use.
- Commercial/industrial use.

Scenarios that can be emulated in ReCLAIM v3.0 for generic contaminated land assessments 2/2

Oatway and Mobbs (2003) approach (**d-mod1**)

- Agricultural worker and their family.
- Recreation (general park user, swimmer in outdoor lake, fisherman and his family, park worker).
- Construction worker labouring outdoors and disturbing the soil.
- School (teacher, caretaker and school children).
- Office (industrial) worker.
- Householders (family).
- Drinking water.
- Covered area such as a car park.

Exposure pathway calculations: GRAC or screening levels

Soil and water screening levels of individual radionuclides also termed Generic Radioactive Assessment Criteria (GRAC) can be used to establish trace or residual levels of radionuclides that may be considered to be acceptable for delicensing purposes.

For a given scenario of a number of exposure pathways:

GRAC_{soil} (Bq g⁻¹) for radionuclide (I) equivalent to Dose target

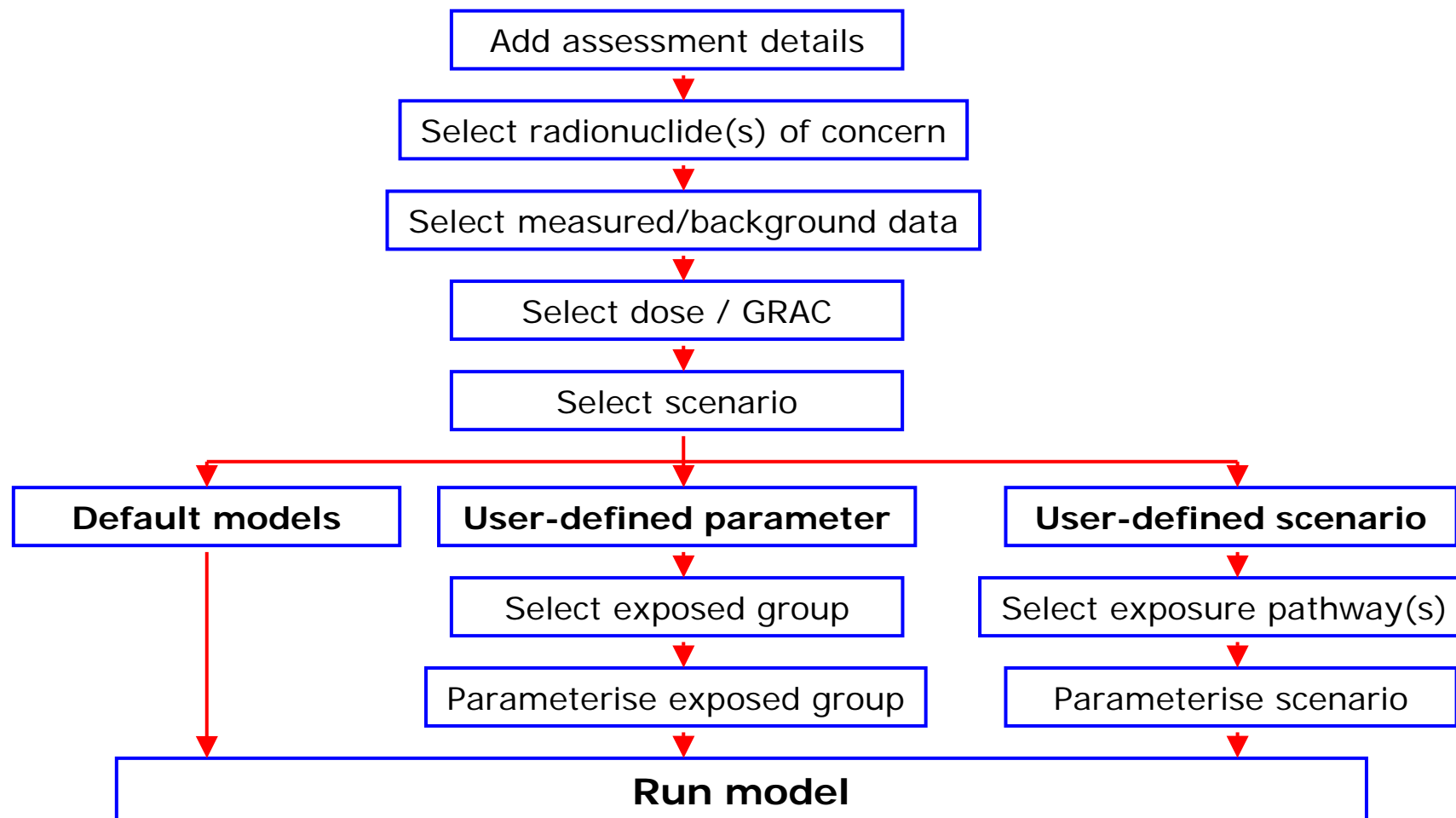
GRAC_{water} (Bq L⁻¹) for radionuclide (I) equivalent to Dose target

Other ReCLAIM features

Works in 3 modes:

1. emulates previous 2 sets of scenarios (default models mode) and works out doses, screening levels
 2. alter parameter(s) of an existing scenario (for a site specific assessment)
 3. User-defined site-specific assessment
- Considers radionuclide additivity.
 - Subtract background radioactivity measurements if these values are known.
 - Patchiness of contamination
 - Variability in depth of contamination and clean cover
 - Ability to import data files / export output

ReCLAIM assessment flowchart



Main page

MAIN PAGE

ReCLAIM: Review of Contamination Levels for Assessment of *de minimis* Inventory Model

A tool to be used in the derivation of Generic Radionuclide Assessment Criteria (GRACs) and dose assessments for contaminated land and water on Nuclear Licensed sites, Ministry of Defence sites and other radioactively contaminated sites.
Version : 3.03 Date : Mar 2011 Author : National Nuclear Laboratory Limited

Assessment Details

User ID	<input type="text" value="CL"/>	Reference	<input type="text" value="test"/>	<input type="button" value="Update Print Headers"/>
Date of Assessment	<input type="text" value="08/12/2011"/>	Site Name	<input type="text" value="Gas Mantles Ltd"/>	
Company Name	<input type="text" value="NNL"/>	Checked By	<input type="text"/>	Run Version <input type="text" value="1.0"/>

Description of Site for assessment
(provide description of potential exposure group)

Site of former gas mantle manufacturing works. Soil contaminated with Th-232. Requirement to remediate site to light industrial use.

Radionuclide Selection for Assessment

<input type="checkbox"/> H-3 (OBT)	<input type="checkbox"/> Ni-63	<input type="checkbox"/> Ru+106	<input type="checkbox"/> Cs+137	<input type="checkbox"/> Eu-155	<input type="checkbox"/> Th+229	<input type="checkbox"/> U-236	<input type="checkbox"/> Pu-242
<input type="checkbox"/> H-3 (H2O)	<input type="checkbox"/> Se-79	<input type="checkbox"/> Ag+108m	<input type="checkbox"/> Ce+144	<input type="checkbox"/> Pb+210	<input type="checkbox"/> Th-230	<input type="checkbox"/> U+238	<input type="checkbox"/> Am-241
<input type="checkbox"/> C-14	<input type="checkbox"/> Sr+90	<input type="checkbox"/> Sn+121m	<input type="checkbox"/> Pm-147	<input type="checkbox"/> Po-210	<input checked="" type="checkbox"/> Th-232	<input type="checkbox"/> Np+237	<input type="checkbox"/> Cm-242
<input type="checkbox"/> Cl-36	<input type="checkbox"/> Mo-93	<input type="checkbox"/> Sn+126	<input type="checkbox"/> Sm-147	<input type="checkbox"/> Ra+226	<input type="checkbox"/> Pa-231	<input type="checkbox"/> Pu-238	<input type="checkbox"/> Cm-243
<input type="checkbox"/> K-40	<input type="checkbox"/> Nb-93m	<input type="checkbox"/> Sb-125	<input type="checkbox"/> Sm-151	<input type="checkbox"/> Ra+228	<input type="checkbox"/> U-233	<input type="checkbox"/> Pu-239	<input type="checkbox"/> Cm-244
<input type="checkbox"/> Fe-55	<input type="checkbox"/> Nb-94	<input type="checkbox"/> I-129	<input type="checkbox"/> Eu-152	<input type="checkbox"/> Ac+227	<input type="checkbox"/> U-234	<input type="checkbox"/> Pu-240	<input type="button" value="select all nuclides"/>
<input type="checkbox"/> Co-60	<input type="checkbox"/> Tc-99	<input type="checkbox"/> Cs-134	<input type="checkbox"/> Eu-154	<input type="checkbox"/> Th+228	<input type="checkbox"/> U+235	<input type="checkbox"/> Pu-241	

Refresh not required

CLICK HERE to provide necessary user input >>>

Workbook

View Hidden Worksheets >>>

Optimised for 1024x768
Created with Microsoft Excel
2002 (c)

Help

Introduction

Instructions

Output

Archive or export model (.xml)

Import model (.xml)

Export model input parameters (.txt)

Export model results report (.txt)

User input page

USER INPUT TEMPLATE

<<< Return to MAIN

Patchiness (%)
100% - uniform
<10% - spots

100%

Dose Target (mSv y⁻¹)

3

RUN all default Scenarios >>>

Model Selection

default models

Scenario Selection

Value to be Used

Measured less Background

Assessment Type

DOSE

SITE SPECIFIC DATA

	Measured Values				Background Values (where known)			
	Soil	Surface Water	Aquifer Water	Surface Contamination	Soil	Surface Water	Aquifer Water	Surface Contamination
RADIONUCLIDE	Bq g ⁻¹	Bq L ⁻¹	Bq L ⁻¹	Bq cm ⁻²	Bq g ⁻¹	Bq L ⁻¹	Bq L ⁻¹	Bq cm ⁻²
Th-232	1.80E+01				1.00E+00			

Summary page - dose

SUMMARY PAGE

Assessment Details

User ID	CL	Reference	Test	Company Name	NNL
Date of Assessment	08/12/2011	Site Name	Gas Mantles Ltd	Checked by	

Description of Site for assessment	Site of former gas mantle manufacturing works. Soil contaminated with Th-232. Requirement to remediate site to light industrial use.
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Input Summary

Dose Target (mSv y ⁻¹)	3.00E+00	Model Parameters	default models	<<< Return to MAIN
Patchiness	100%			
Assessment Type	DOSE			

Radionuclide Measured less Background Values				
Radionuclide	Soil (Bq g ⁻¹)	Surface water (Bq l ⁻¹)	Aquifer water (Bq l ⁻¹)	Surface contamination (Bq cm ⁻²)
Th-232	1.70E+01	<= Background	<= Background	<= Background

Output Summary

Model Selected	default models
Dose Target (mSv y ⁻¹)	3.00E+00
Total Dose from Assessment (mSv y ⁻¹)	1.01E+00
Selected Nuclide	
Most limiting Scenario	Construction_Adult
Assessment Type	DOSE
Most limiting nuclide	Th-232

Select model to report
d-Mod1

Total Dose : Dose Target
0.34
PASS

Calculate depth at which model = PASS

[VIEW MOST LIMITING SCENARIO OVERVIEW >>>](#)

[HIDE ACTIVE PATHWAYS FOR MOST LIMITING SCENARIO](#)

Radionuclide	DOSE	Most Limiting Scenario	Ratio	PASS : FAIL (against Dose Target)	Dose Target	Total number of Scenarios with GRAC below Measured less Background Value in d-Mod1	View all default models output
Th-232	mSv / y 1.01E+00	Construction_Adult	0.34	PASS	mSv / y 3.00E+00	0	

Summary page - GRAC

SUMMARY PAGE

Assessment Details

User ID	CL	Reference	Test	Company Name	NNL
Date of Assessment	08/12/2011	Site Name	Gas Mantles Ltd	Checked by	

Description of Site for assessment	Site of former gas mantle manufacturing works. Soil contaminated with Th-232. Requirement to remediate site to light industrial use.
------------------------------------	--

Input Summary

Dose Target (mSv y ⁻¹)	3.00E+00	Model Parameters	default models	<<< Return to MAIN
Patchiness	100%			
Assessment Type	GRAC_S			

Radionuclide Measured less Background Values				
Radionuclide	Soil (Bq g ⁻¹)	Surface water (Bq l ⁻¹)	Aquifer water (Bq l ⁻¹)	Surface contamination (Bq cm ⁻²)
Th-232	1.70E+01	<= Background	<= Background	<= Background

Output Summary

Model Selected	default models	Select model to report	d-Mod1	Sum of Ratios	0.34	VIEW MOST LIMITING SCENARIO OVERVIEW >>>
Dose Target (mSv y ⁻¹)	3.00E+00	Calculate depth at which model = PASS		PASS		
Total Dose from Assessment (mSv y ⁻¹)	N/A					VIEW ACTIVE PATHWAYS FOR MOST LIMITING SCENARIO
Selected Nuclide	Th-232					
Most limiting Scenario	Construction_Adult					
Assessment Type	GRAC_S					
Most limiting nuclide	N/A					

Radionuclide	GRAC_S	Most Limiting Scenario	Ratio	PASS : FAIL (against Dose Target)	Measured less Background Value	Total number of Scenarios with GRAC below Measured less Background Value in d-Mod1	View all default models output
Th-232	Bq / g 5.03E+01	Construction_Adult	0.34	PASS	Bq / g 1.70E+01	0	

Most limiting scenario overview

Selected Scenario	Construction _Adult					
Model Selection	default models					
Assessment Type	DOSE					
Value	Measured less Background					
USER Defined Dose Target (mSv y ⁻¹)	3					
Reference :	Test					
Pathway	Inh Dust	Ing Soil	Skin Dose	Ext dose deep		
Parameters Used	d-Mod1	d-Mod1	d-Mod1	d-Mod1		
Age Group	Adult	Adult				
Ambient Dust Loading in air (g m ⁻³)	0.0005					
Enhanced Dust Loading in air (g m ⁻³)	0.0050					
Ambient Inhalation Rate (m ³ h ⁻¹)	1.2					
Nonambient Inhalation Rate (m ³ h ⁻¹)	1.7					
Time spent indoors (h y ⁻¹)	0					
Time spent manually digging (h y ⁻¹)	20					
Time spent outdoors when the ground is not disturbed (h y ⁻¹)	1800					
Enrichment Factor	1		1			
Time spent outdoors with soil on skin (h y ⁻¹)		1000	1000			
Soil Ingestion Rate (g h ⁻¹)		0.005				
Annual Soil Ingestion Rate (g y ⁻¹)		5				
Time spent at Deep Geometry 1 (h y ⁻¹)				2000		
Deep Geometry 1				1 m above - infinite uniform		
Radionuclide dose assessment (mSv y ⁻¹)						
Is the exposure pathway active for selected scenario	Y	Y	Y	Y		
Mechanism	Included in assessment	DOSE (mSv y ⁻¹)				
Th-232	Y	1.01E+00	9.90E-01	1.96E-02	4.11E-03	5.78E-04
Total Pathway Dose		1.01E+00	9.90E-01	1.96E-02	4.11E-03	5.78E-04
Percentage of Total Dose (%)		100.0%	97.6%	1.9%	0.4%	0.1%

User-defined parameters

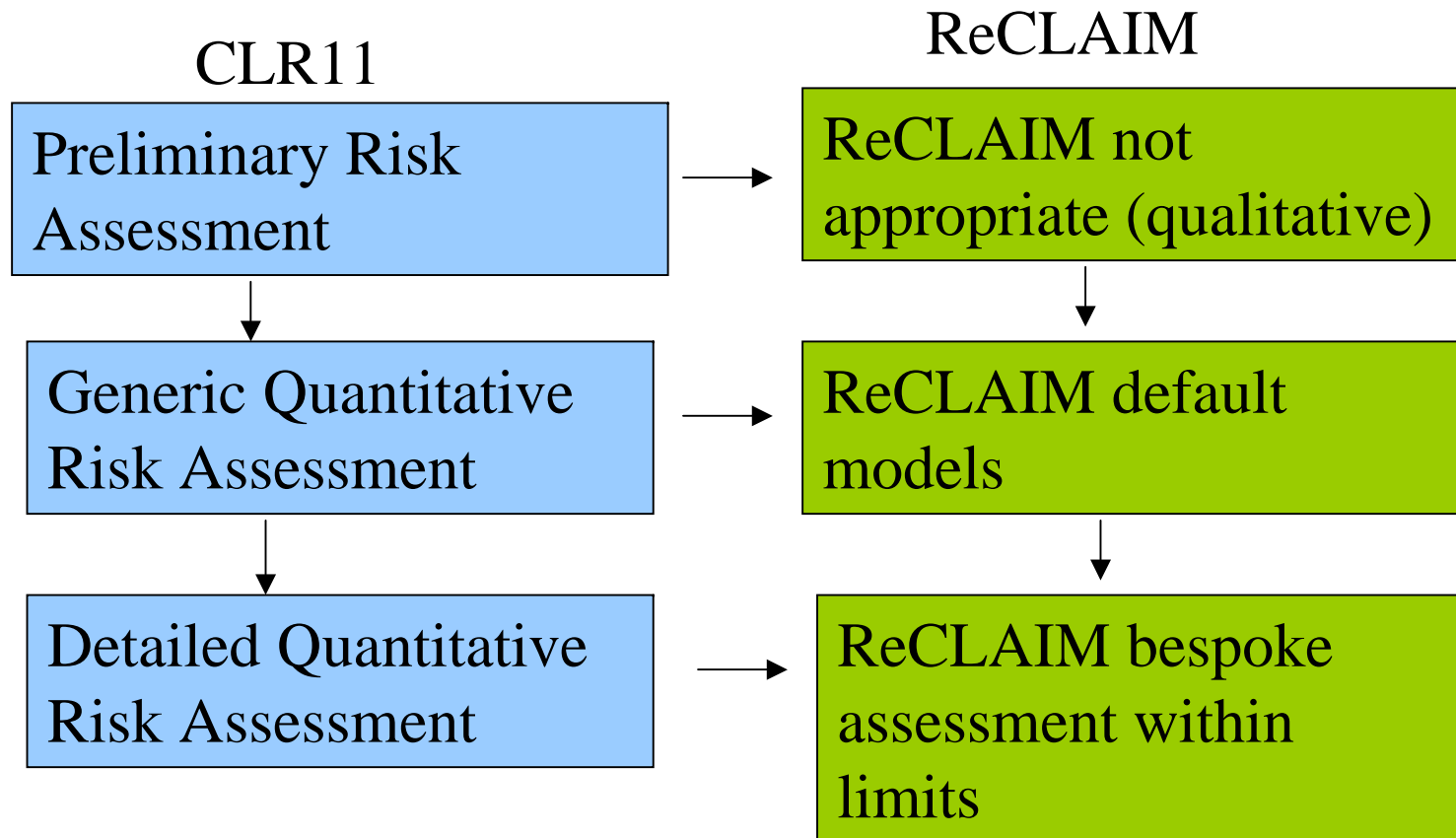
DEFAULT PARAMETERS				<<< Return to USER INPUT TEMPLATE		Show Selected Scenario		<<< Return to MAIN	
Run Parameterised Model									
Scenario Description	Exposure Pathway	Char	Parameter Description	d-Mod1 Default Model Parameters	d-Mod2 Default Model Parameters	USER Specified Parameters from model parameters Specified Value	USER Defined Parameters		
				Default Value	Default Value		USER Input	Params	
Allotments _AdultFemale	Inh Dust	Tos	Time spent outdoors (h y-1)		832			832	
Allotments _AdultFemale	Inh Dust	Tin	Time spent indoors (h y-1)		7300			7300	
Allotments _AdultFemale	Inh Dust	Toss	Time spent outdoors with soil on skin (h y-1)		2497			2497	
Allotments _AdultFemale	Inh Dust	Tiss	Time spent indoors with soil on skin (h y-1)		4380			4380	
Allotments _AdultFemale	Inh Dust	Tai	Time spent active indoors (h y-1)		1095			1095	
Allotments _AdultFemale	Inh Dust	Tpi	Time spent passive indoors (h y-1)		6205			6205	
Allotments _AdultFemale	Inh Dust	Tao	Time spent active outdoors (h y-1)		416			416	
Allotments _AdultFemale	Inh Dust	Tpo	Time spent passive outdoors (h y-1)		416			416	
Allotments _AdultFemale	Inh Dust	INHh	Nonambient Inhalation Rate (m3 h-1)		1.23			1.23	
Allotments _AdultFemale	Inh Dust	INHam	Ambient Inhalation Rate (m3 h-1)		0.41			0.41	
Allotments _AdultFemale	Inh Dust	Fdust	Fraction of indoor dust from contaminated land		0.375			0.375	
Allotments _AdultFemale	Inh Dust	EF	Enrichment Factor		3			3	
Allotments _AdultFemale	Ing Soil	INGas	Annual Soil Ingestion Rate (g y-1)		26			26	
Allotments _AdultFemale	Ing Green Veg	INGbs	Brussels Sprouts Ingestion Rate (kg y-1)		17			17	
Allotments _AdultFemale	Ing Green Veg	INGcab	Cabbage Ingestion Rate (kg y-1)		17			17	
Allotments _AdultFemale	Ing Root Veg	INGcar	Carrot Ingestion Rate (kg y-1)		16			16	
Allotments _AdultFemale	Ing Green Veg	INGifs	Leafy Salads Ingestion Rate (kg y-1)		12			12	
Allotments _AdultFemale	Ing Root Veg	INGon	Onion Ingestion Rate (kg y-1)		11			11	
Allotments _AdultFemale	Ing Root Veg	INGpot	Potato Ingestion Rate (kg y-1)		84			84	
Allotments _AdultFemale	Skin Dose	Toss	Time spent outdoors with soil on skin (h y-1)		2497			2497	
Allotments _AdultFemale	Skin Dose	Tiss	Time spent indoors with soil on skin (h y-1)		4380			4380	
Allotments _AdultFemale	Skin Dose	Fdust	Fraction of indoor dust from contaminated land		0.375			0.375	
Allotments _AdultFemale	Skin Dose	EF	Enrichment Factor		3			3	
Allotments _AdultFemale	Skin Dose	SLo	Soil loading for skin outdoors (g cm-2)		3.00E-04			0.0003	
Allotments _AdultFemale	Skin Dose	SLi	Soil loading for skin indoors (g cm-2)		6.00E-05			0.00006	
Allotments _AdultFemale	Skin Dose	Fskino	Fraction of exposed skin outdoors		0.26			0.26	
Allotments _AdultFemale	Skin Dose	Fskini	Fraction of exposed skin indoors		0.33			0.33	
Allotments _AdultFemale	Ext dose deep	FTi	Floor Type Indoors		wood			wood	
Allotments _AdultFemale	Ext dose deep	DeeGeo1	Deep Geometry 1		1 m above - infinite uniform			1 m above - infinite uniform	
Allotments _AdultFemale	Ext dose deep	FTo	Floor Type Outdoors		none			none	
Allotments _AdultFemale	Ext dose deep	DeeGeo2	Deep Geometry 2		1 m above - infinite uniform			1 m above - infinite uniform	

Scenario builder

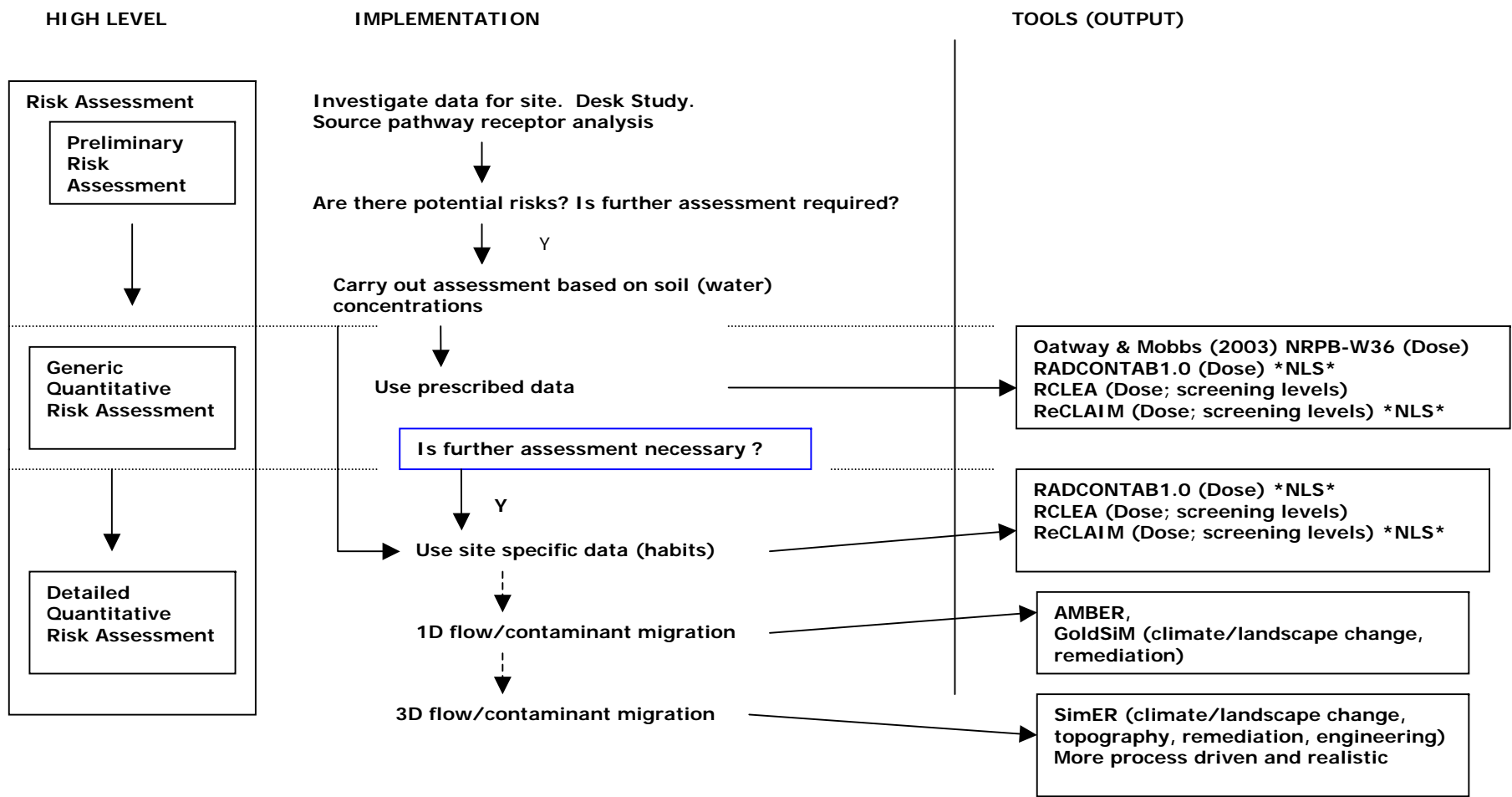
SCENARIO BUILDER		<<< Return to MAIN		<<< BACK to USER INPUT TEMPLATE			Build USER-defined Scenario >>>	
		d-USER	d-Mod1	d-Mod1	d-Mod1	d-Mod2	d-Mod2	
Exposure Pathway	Dose	USER Specified	Housing_Adult	Housing_Child	Housing_Infant	Residential Food_AdultMale	Residential Food_AdultFemale	
Inh Dust	<i>D_{inh,dust}</i>	-	x	x	x	x	x	
Ing Soil	<i>D_{ing,soil}</i>	-	x	x	x	x	x	
Ing Beef	<i>D_{ing,beef}</i>	-						
Ing Offal	<i>D_{ing,offal}</i>	-						
Ing Milk	<i>D_{ing,milk}</i>	-						
Ing Green Veg	<i>D_{ing,gveg}</i>	-	x	x	x	x	x	
Ing Root Veg	<i>D_{ing,rveg}</i>	-	x	x	x	x	x	
Ing Cereal	<i>D_{ing,cereal}</i>	-						
Ing Fruit	<i>D_{ing,fruit}</i>	-	x	x	x			
Ing Fish	<i>D_{ing,fish}</i>	-						
Ing Aquifer Water	<i>D_{ing,aq_water}</i>	-						
Ing Surface Water	<i>D_{ing,sur_water}</i>	-						
Skin Dose	<i>D_{skin}</i>	-	x	x	x	x	x	
Ext dose water	<i>D_{ext,water}</i>	-						
Ext dose surface	<i>D_{ext,surface}</i>	x						
Ext dose shallow	<i>D_{ext,shallow}</i>	-						
Ext dose deep	<i>D_{ext,deep}</i>	-	x	x	x	x	x	
Ext dose variable	<i>D_{ext,variable}</i>	-						
Ext dose buried	<i>D_{ext,buried}</i>	-	x	x	x			
		1	8	8	8	6	6	

Fit with Tiered approach to contaminated land assessments

Mapping ReCLAIM to Defra/EA CLR 11 "Model procedures..."



Where does ReCLAIM fit with other tools?



Peer review of ReCLAIM

We wish to thank M Pearl (Babcock International Group Plc), S Holdroyd (Research Sites Restoration Ltd), HG Richards (Magnox Ltd) and R Smith and W Oatway (HPA-RPD) for undertaking peer review of ReCLAIM.

Their helpful comments have significantly enhanced the production of the tool.

Further information

Reclaim v3.03 and the User Guide may be downloaded free of charge from the NNL website:

http://suppliers.nnl.co.uk/articles/?page_id=1075

Further reading:

- Willans *et al.*, 2007. ReCLAIM v2.0: a spreadsheet tool for calculating doses and soil/water radionuclide screening levels for assessment of radioactively contaminated land. *J. Rad Protect.* **27**, 87.
- Willans *et al.* ReCLAIM v3.03: comparison of calculated doses with other assessment tools when emulating contaminated land scenarios. *J. Rad. Protect*, in press.

