# Appendix F: Sampling Location Plans

PHASE 3B

Main Foul Infrastructure to be laid by St. Modwen Developments

Foul Pumping Station #4

Blueway Reen

Blueway Ree

Lake

Greenway

Cycleway

5.5m Road Location tbc

5.5m Road Location tbc

+6.35 FGL

+6.35 FGL

FGL 6.35 +

FGL 6.35 +

FGL 6.35 +

POC

POC

POC

6.50

6.75

6.50

6.75

25

A B C D E F

1 2 3 4 5 6 7 8

A1 B1 C1 D1 E1 F1

A2 B2 C2 D2 E2 F2

A3 B3 C3 D3 E3 F3

B4 C4 D4 E4 F4

B5 C5 D5 E5 F5

B6 C6 D6 E6 F6

C7 D7 E7 F7

B8 C8 D8 E8 F8

| N° | M | P |
|---|---|---|
| C1 | 335762.257 | 186956.550 |
| D1 | 335787.174 | 186954.507 |
| E1 | 335812.090 | 186952.464 |
| F1 | 335837.006 | 186950.422 |
| A2 | 335710.382 | 186935.719 |
| B2 | 335735.298 | 186933.676 |
| C2 | 335760.214 | 186931.633 |
| D2 | 335785.131 | 186929.591 |
| E2 | 335810.047 | 186927.548 |
| F2 | 335834.964 | 186925.505 |
| A3 | 335708.339 | 186910.802 |
| B3 | 335733.255 | 186908.760 |
| C3 | 335758.172 | 186906.717 |
| D3 | 335783.088 | 186904.674 |
| E3 | 335808.005 | 186902.632 |
| F3 | 335832.921 | 186900.589 |
| B4 | 335731.213 | 186883.843 |
| C4 | 335756.129 | 186881.801 |
| D4 | 335781.045 | 186879.758 |
| E4 | 335805.962 | 186877.715 |
| F4 | 335830.878 | 186875.672 |
| B5 | 335729.170 | 186858.927 |
| C5 | 335754.086 | 186856.884 |
| D5 | 335779.003 | 186854.841 |
| E5 | 335803.919 | 186852.799 |
| F5 | 335828.836 | 186850.756 |
| C6 | 335752.044 | 186831.968 |
| D6 | 335776.960 | 186829.925 |
| E6 | 335801.876 | 186827.882 |
| F6 | 335826.793 | 186825.840 |
| C7 | 335750.001 | 186807.091 |
| D7 | 335774.917 | 186805.009 |
| E7 | 335799.834 | 186802.966 |
| F7 | 335824.750 | 186800.923 |
| B8 | 335723.042 | 186784.178 |
| C8 | 335747.958 | 186782.135 |
| D8 | 335772.875 | 186780.092 |
| E8 | 335797.791 | 186778.050 |
| F8 | 335822.707 | 186776.007 |

Revision: | Details | Date

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Reference Grid: Ordnance Survey National Grid (OSGB36) via the Active GNSS Network

Reference Datum: Ordnance Survey National Grid (OSGB36) via the Active GNSS Network

All dimensions in Metres

Client: St Modwen

Project Title:

Drawing Title:

For Information Only

Scale: | Sheet Size: | Drawn: | Date: 13.03.2018

Drawing Number: *XXXX* | Revision: *R1

Sheet Size: A0

# AMOUNT OF POSITIONS = 114

North Woods

Phase 3c

Plot 3C
7.50 FGL
6.90 formation

0.0HA

Phase 3d

Plot 3D

Plot 3D

Timber footbridge

Timber footbridge

Timber footbridge

Existing Culvert 1350dia IL 5.10

Gardens to back onto Northern Reen.
Min 1m standoff to top of bank

Footpath to follow Reen

Any Reen crossing to be culverted

Any Reen crossing to be culverted

Up to 2No. Site Entrance's

Pedestrian Crossing

Pedestrian Crossing

6.50 FGL
5.90 formation

6.94 FGL
6.34 formation

7.70 FGL
7.10 formation

6.70 FGL
6.10 formation

1:100

Cut/Fill Summary

If we cut everything up to level 4.50

If we carry out a cleaning, using the levels on blue footprint

For Information Only

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|---|---|
| Ordnance Survey National Grid (OSGB36) via the Active GNSS Network | Ordnance Survey National Grid (OSGB36) via the Active GNSS Network |

All dimensions in metres

Client: St Modwen

Project Title:

Drawing Title:

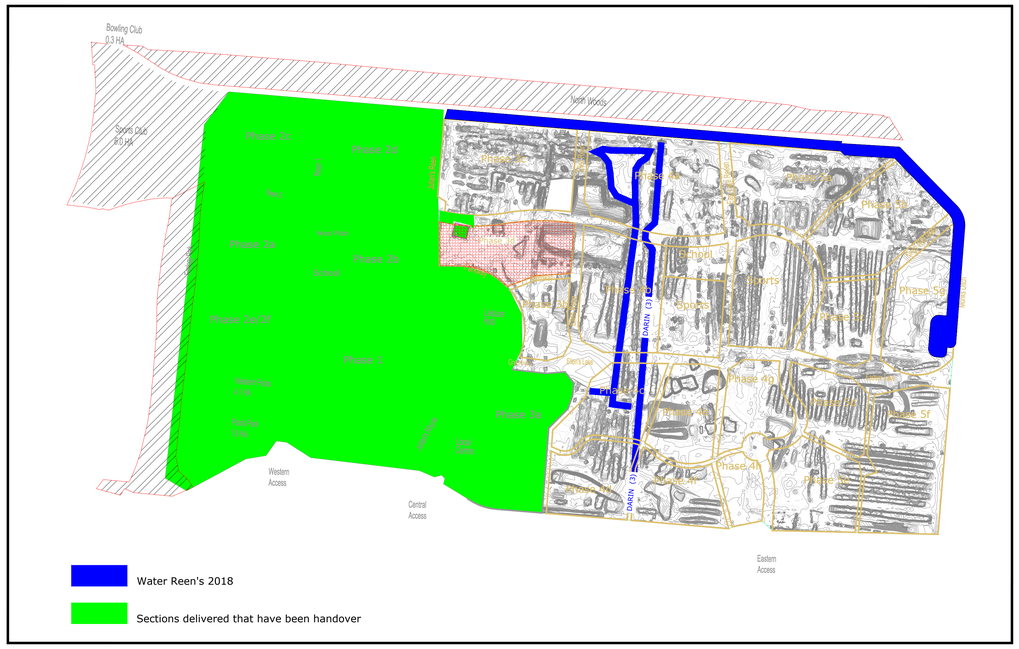
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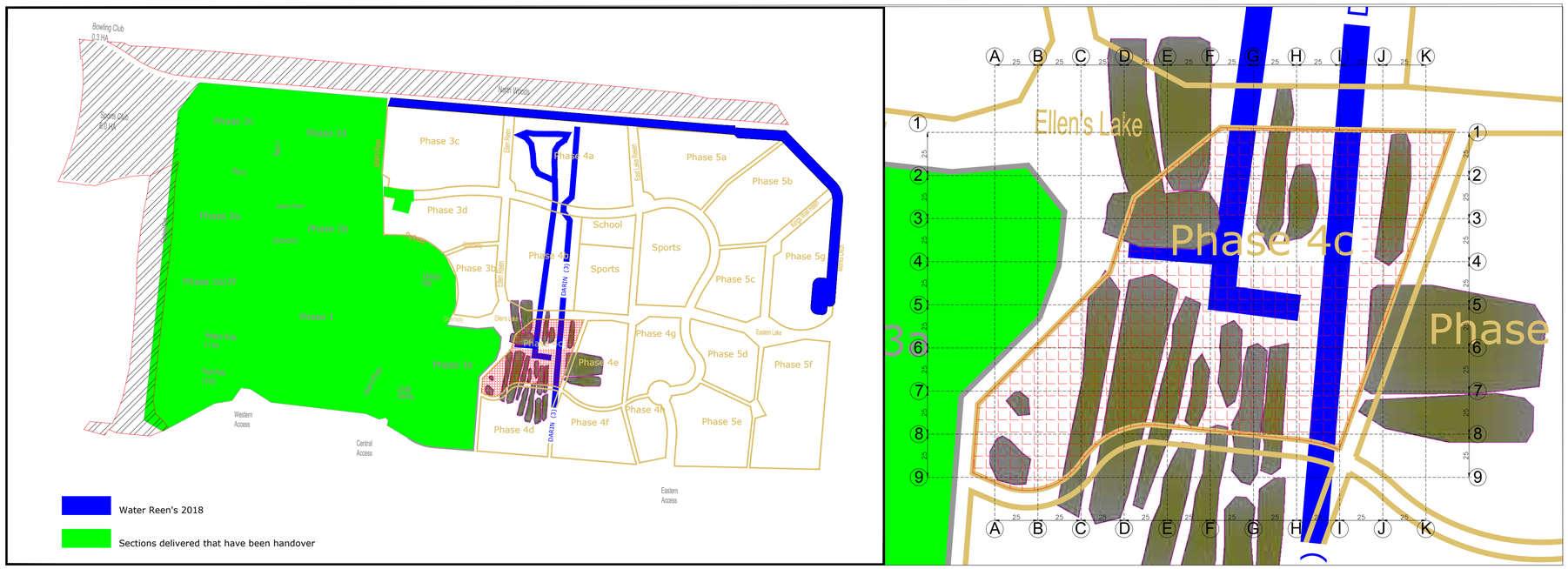
Drawing Number: *XXXX*

Revision: *RXX*

| Revision | Details | Date |
|---|---|---|

Millimetres 0 10 100


Bowling Club
0.3 HA
Sports Club
0.6 HA
Nant Woods
Phase 2c
Phase 2d
Phase 2a
Phase 2b
Phase 2e/2f
Phase 1
Phase 3a
Phase 3b
Phase 3c
Phase 3d
Phase 4a
Phase 4b
Phase 4c
Phase 5a
Phase 5b
Phase 5c
Phase 5d
Phase 5e
Phase 5f
Phase 6
Phase 7
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Phase 49
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Phase 59
Phase 60
Phase 61
Phase 62
Road
Road
Road

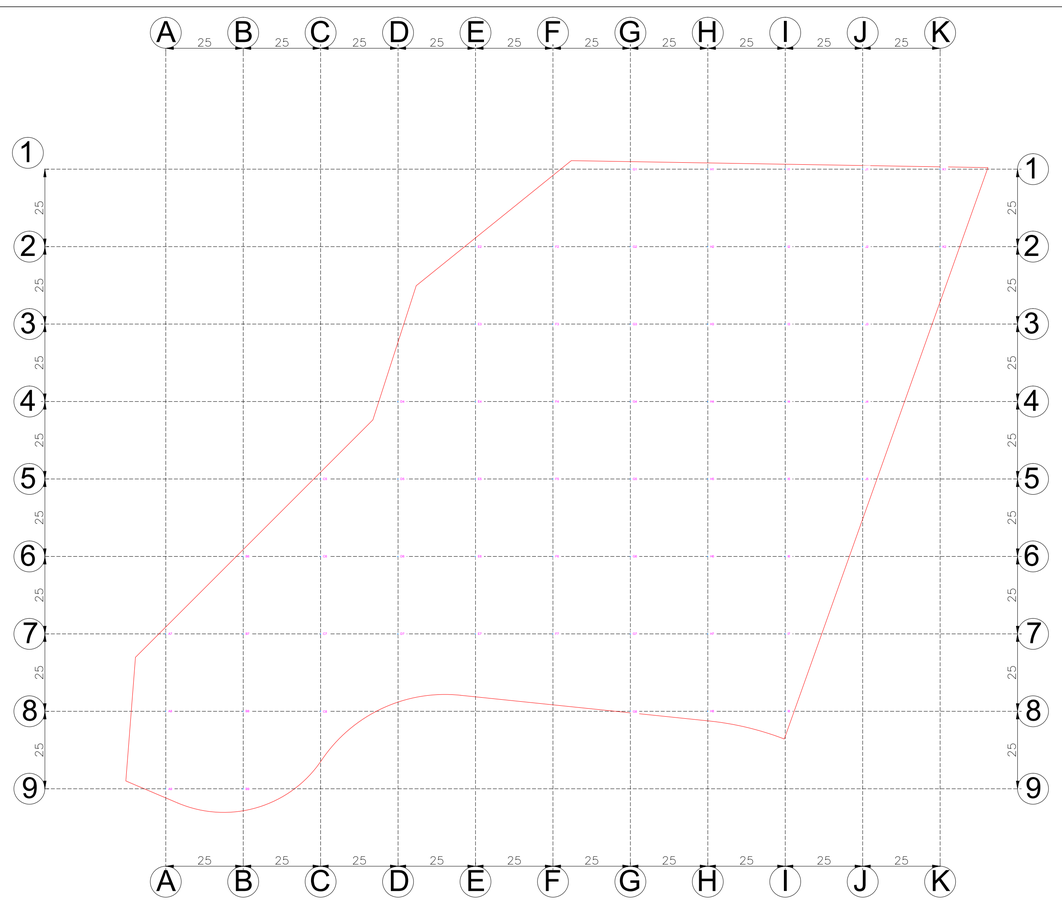






58 POSITIONS

| Log | X | y |
|---|---|---|
| A7 | 335808.8769 | 186607.028 |
| A8 | 335808.8769 | 186582.028 |
| A9 | 335808.8769 | 186557.028 |
| B6 | 335833.8769 | 186632.028 |
| B7 | 335833.8769 | 186607.028 |
| B8 | 335833.8769 | 186582.028 |
| B9 | 335833.8769 | 186557.028 |
| C5 | 335858.8769 | 186657.028 |
| C6 | 335858.8769 | 186632.028 |
| C7 | 335858.8769 | 186607.028 |
| C8 | 335858.8769 | 186582.028 |
| D4 | 335883.8769 | 186682.028 |
| D5 | 335883.8769 | 186657.028 |
| D6 | 335883.8769 | 186632.028 |
| D7 | 335883.8769 | 186607.028 |
| E2 | 335908.8769 | 186732.028 |
| E3 | 335908.8769 | 186707.028 |
| E4 | 335908.8769 | 186682.028 |
| E5 | 335908.8769 | 186657.028 |
| E6 | 335908.8769 | 186632.028 |
| E7 | 335908.8769 | 186607.028 |
| F2 | 335933.8769 | 186732.028 |
| F3 | 335933.8769 | 186707.028 |
| F4 | 335933.8769 | 186682.028 |
| F5 | 335933.8769 | 186657.028 |
| F6 | 335933.8769 | 186632.028 |
| F7 | 335933.8769 | 186607.028 |
| G1 | 335958.8769 | 186757.028 |
| G2 | 335958.8769 | 186732.028 |
| G3 | 335958.8769 | 186707.028 |
| G4 | 335958.8769 | 186682.028 |
| G5 | 335958.8769 | 186657.028 |
| G6 | 335958.8769 | 186632.028 |
| G7 | 335958.8769 | 186607.028 |
| G8 | 335958.8769 | 186582.028 |
| H1 | 335983.8769 | 186757.028 |
| H2 | 335983.8769 | 186732.028 |
| H3 | 335983.8769 | 186707.028 |
| H4 | 335983.8769 | 186682.028 |
| H5 | 335983.8769 | 186657.028 |
| H6 | 335983.8769 | 186632.028 |
| H7 | 335983.8769 | 186607.028 |
| H8 | 335983.8769 | 186582.028 |
| I1 | 336008.8769 | 186757.028 |
| I2 | 336008.8769 | 186732.028 |
| I3 | 336008.8769 | 186707.028 |
| I4 | 336008.8769 | 186682.028 |
| I5 | 336008.8769 | 186657.028 |
| I6 | 336008.8769 | 186632.028 |
| I7 | 336008.8769 | 186607.028 |
| I8 | 336008.8769 | 186582.028 |
| J1 | 336033.8769 | 186757.028 |
| J2 | 336033.8769 | 186732.028 |
| J3 | 336033.8769 | 186707.028 |
| J4 | 336033.8769 | 186682.028 |
| J5 | 336033.8769 | 186657.028 |
| K1 | 336058.8769 | 186757.028 |
| K2 | 336058.8769 | 186732.028 |



N

| REV. | DATE | NOTES | Ds. | Rev. | Ap. |
|---|---|---|---|---|---|
| 4C.1 | 26/09/18 | Phase 4C -Geotechnical Engineer Grid 25x25 | GF | JF | CR |

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|---|---|
| Ordnance Survey National Grid (OSGB36) via the Active GNSS Network | Ordnance Survey National Datum (OSGB36) via the Active GNSS Network |

All dimensions in metres

Client:

St Modwen

Project Title:

LLANWERN-Glan Llyn Primary
Phase 4C

Drawing Title:

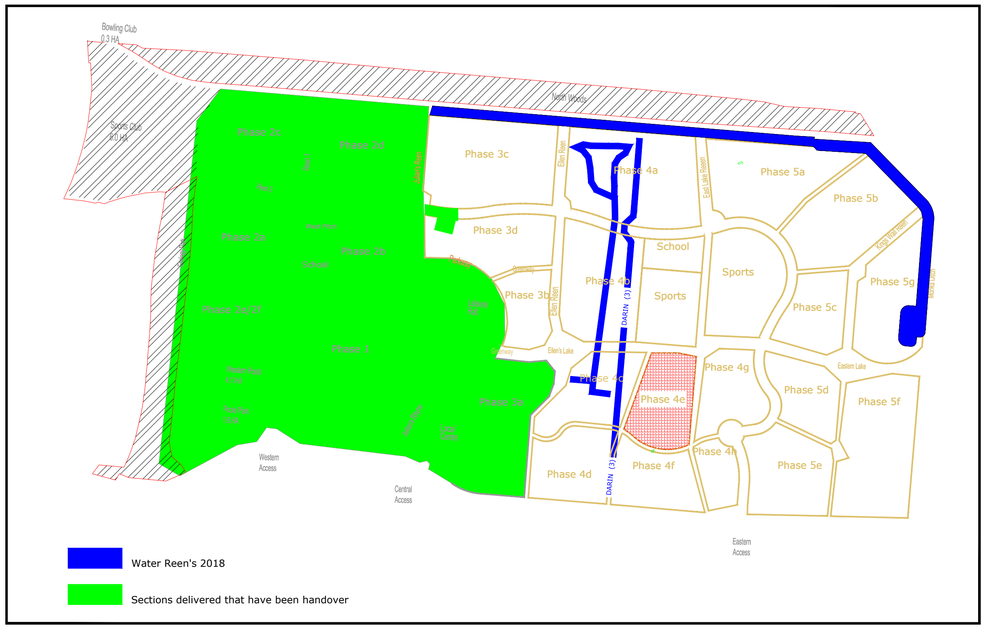
Phase 4C -Geotechnical Engineer Testing Grid
Grid 25x25

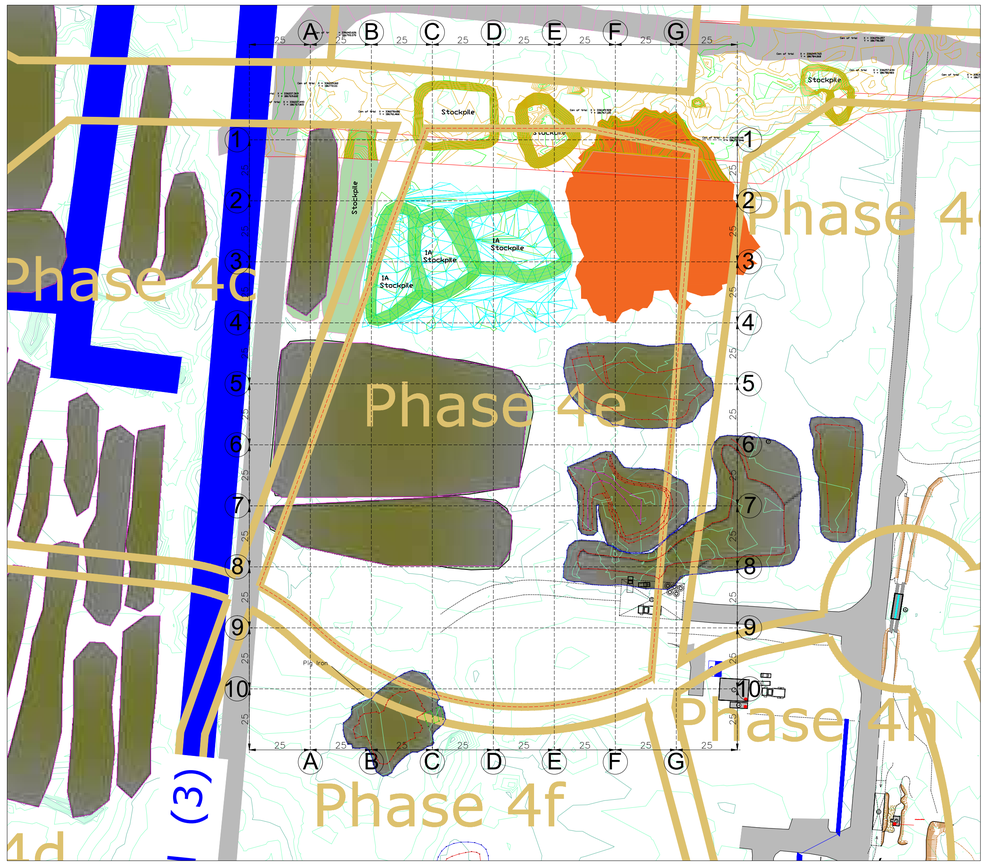
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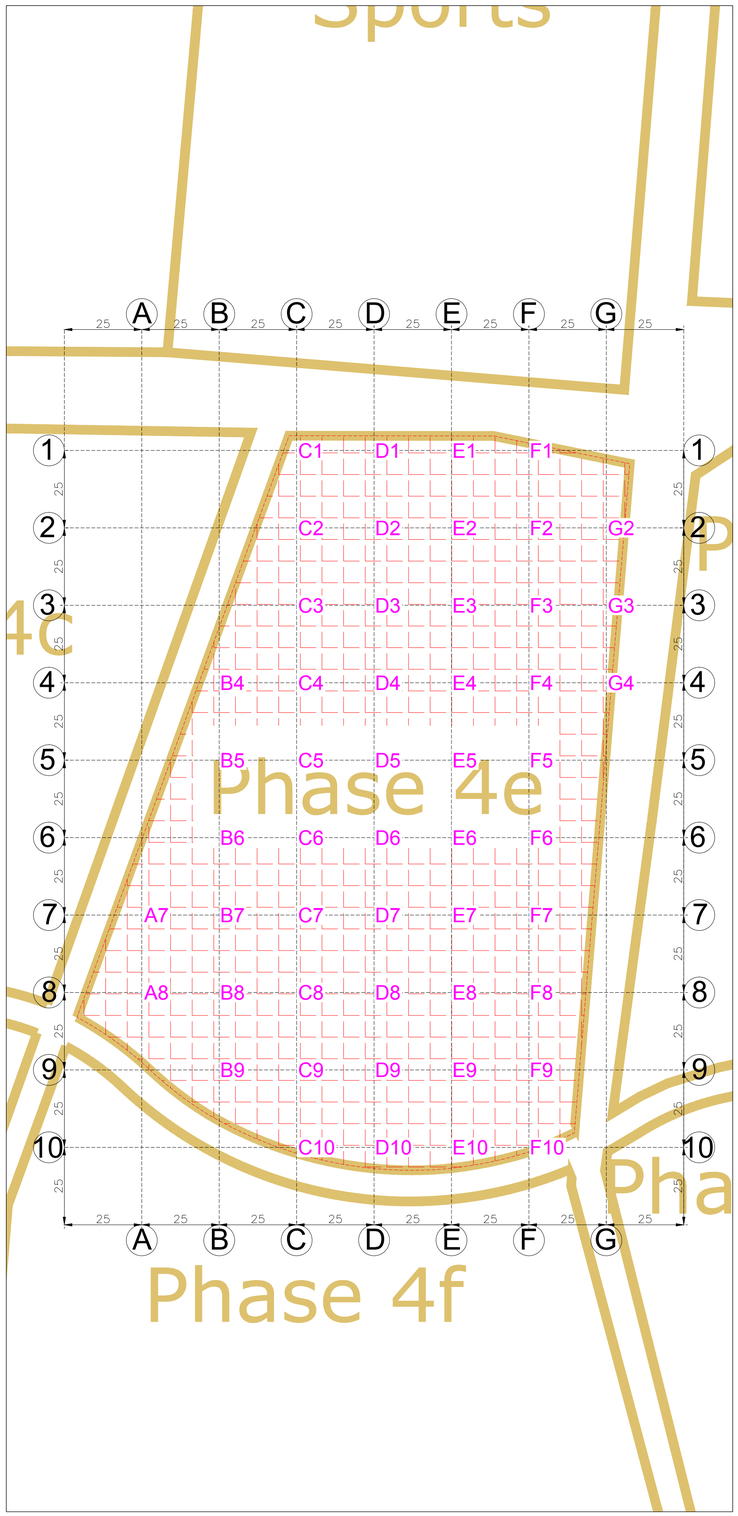
| Drawing Number: | Revision: |
|---|---|
| Geotechnical Grid 25x25 | 4C.1 |

For Information Only

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User: gfuse
Date: 26/09/18 16:50:43
Filename: E:\LLanwern 2014 Ph4\Drawings\Phase 4C\Phase 4C Geotechnical Engineer Grid 25x25_4C.1.dwg




51 POSITIONS

| Log | X | y |
|---|---|---|
| A7 | 336039.0603 | 186601.7624 |
| A8 | 336039.0603 | 186576.7624 |
| B4 | 336064.0603 | 186676.7624 |
| B5 | 336064.0603 | 186651.7624 |
| B6 | 336064.0603 | 186626.7624 |
| B7 | 336064.0603 | 186601.7624 |
| B8 | 336064.0603 | 186576.7624 |
| B9 | 336064.0603 | 186551.7624 |
| C1 | 336089.0603 | 186751.7624 |
| C2 | 336089.0603 | 186726.7624 |
| C3 | 336089.0603 | 186701.7624 |
| C4 | 336089.0603 | 186676.7624 |
| C5 | 336089.0603 | 186651.7624 |
| C6 | 336089.0603 | 186626.7624 |
| C7 | 336089.0603 | 186601.7624 |
| C8 | 336089.0603 | 186576.7624 |
| C9 | 336089.0603 | 186551.7624 |
| C10 | 336089.0603 | 186526.7624 |
| D1 | 336114.0603 | 186751.7624 |
| D2 | 336114.0603 | 186726.7624 |
| D3 | 336114.0603 | 186701.7624 |
| D4 | 336114.0603 | 186676.7624 |
| D5 | 336114.0603 | 186651.7624 |
| D6 | 336114.0603 | 186626.7624 |
| D7 | 336114.0603 | 186601.7624 |
| D8 | 336114.0603 | 186576.7624 |
| D9 | 336114.0603 | 186551.7624 |
| D10 | 336114.0603 | 186526.7624 |
| E1 | 336139.0603 | 186751.7624 |
| E2 | 336139.0603 | 186726.7624 |
| E3 | 336139.0603 | 186701.7624 |
| E4 | 336139.0603 | 186676.7624 |
| E5 | 336139.0603 | 186651.7624 |
| E6 | 336139.0603 | 186626.7624 |
| E7 | 336139.0603 | 186601.7624 |
| E8 | 336139.0603 | 186576.7624 |
| E9 | 336139.0603 | 186551.7624 |
| E10 | 336139.0603 | 186526.7624 |
| F1 | 336164.0603 | 186751.7624 |
| F2 | 336164.0603 | 186726.7624 |
| F3 | 336164.0603 | 186701.7624 |
| F4 | 336164.0603 | 186676.7624 |
| F5 | 336164.0603 | 186651.7624 |
| F6 | 336164.0603 | 186626.7624 |
| F7 | 336164.0603 | 186601.7624 |
| F8 | 336164.0603 | 186576.7624 |
| F9 | 336164.0603 | 186551.7624 |
| F10 | 336164.0603 | 186526.7624 |
| G2 | 336189.0603 | 186726.7624 |
| G3 | 336189.0603 | 186701.7624 |
| G4 | 336189.0603 | 186676.7624 |

| REV. | DATE | NOTES | Ds. | Rev. | Ap. |
|---|---|---|---|---|---|
| 4E.1 | 29/10/18 | Phase 4E -Geotechnical Engineer Grid 25x25 | GF | JF | CR |
| 4E.2 | 30/10/18 | Phase 4E - Key number of logs ( 51) | GF | JF | CR |

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| Reference Grid: | Reference Datum: |
|---|---|
| Ordnance Survey National Grid (OSGB36) via the Active GNSS Network | Ordnance Survey National Datum (OSGB36) via the Active GNSS Network |

All dimensions in metres

Client:

St Modwen

Project Title:

LLANWERN-Glan Llyn Primary
Phase 4C

Drawing Title:

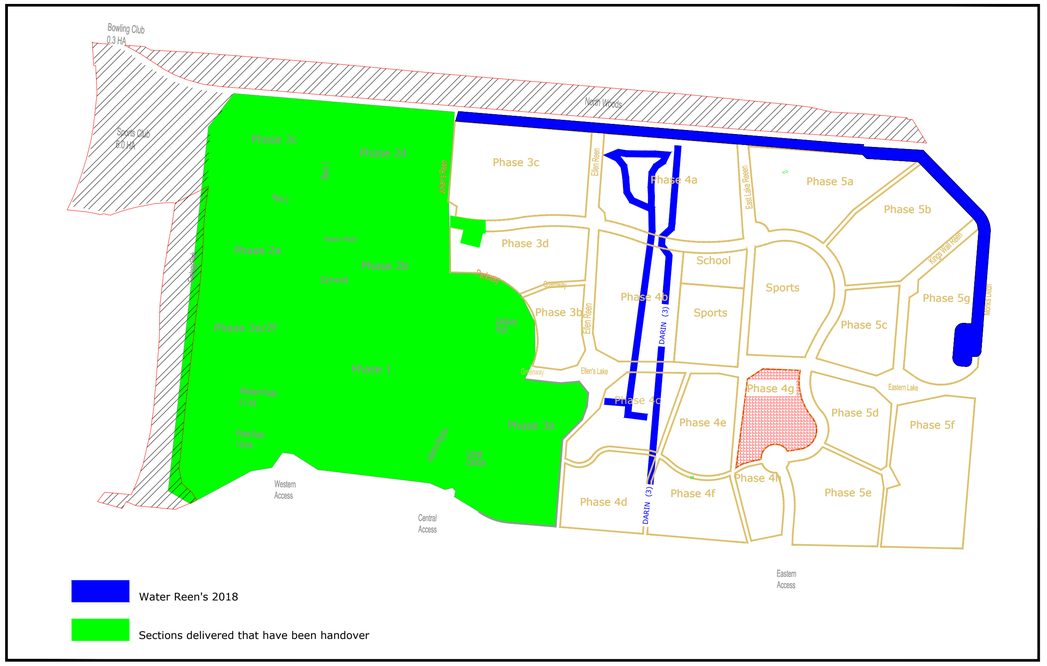
Phase 4E -Geotechnical Engineer
Testing Grid
Grid 25x25

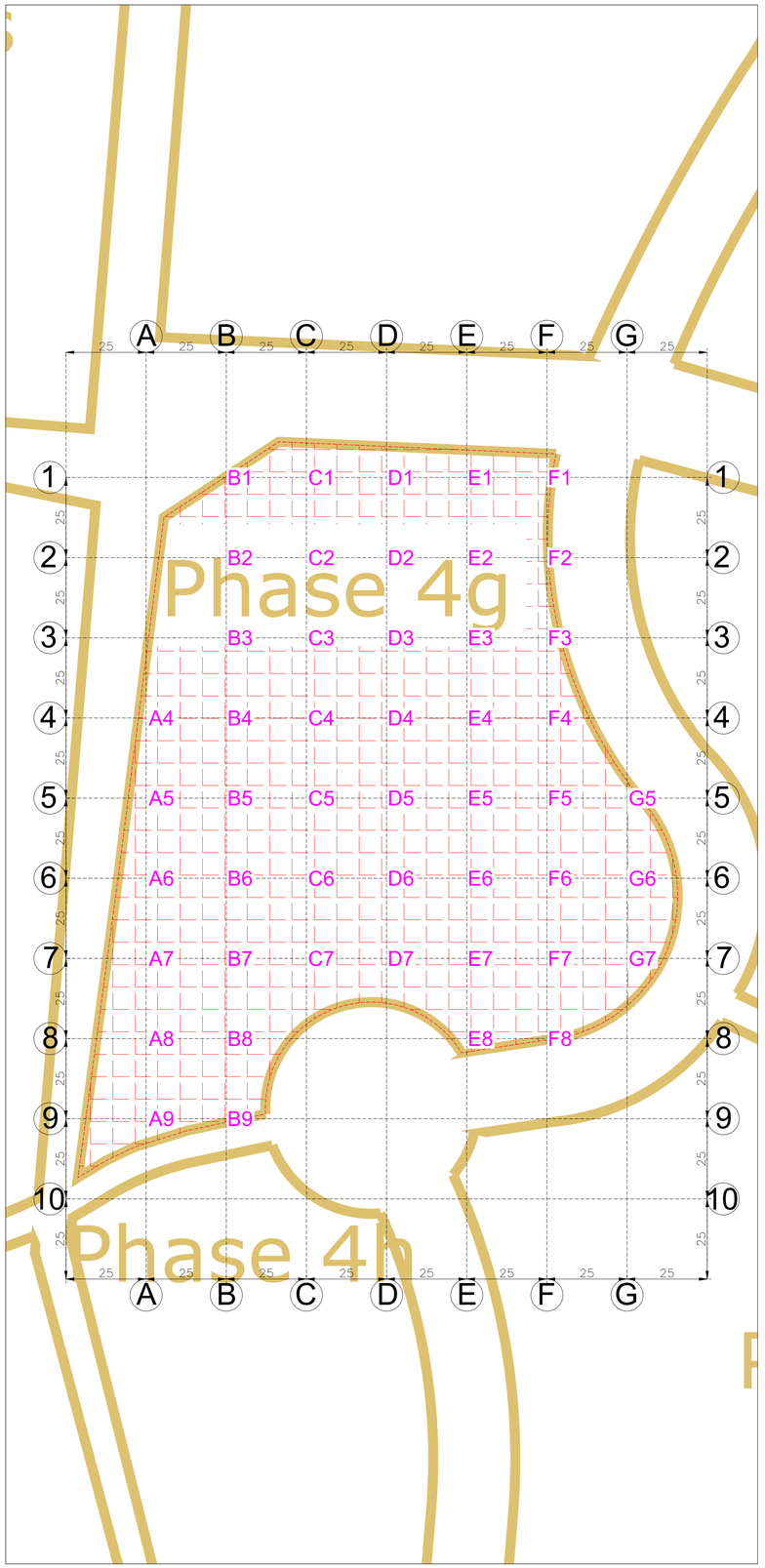
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|---|---|---|---|
| DO NOT SCALE | | | 30/10/2018 |

| Drawing Number: | Revision: |
|---|---|
| Geotechnical Grid 25x25 | 4E.2 |

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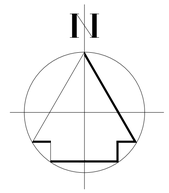







48 POSITIONS

| Lag | X | y | N' |
|---|---|---|---|
| A4 | 336212.3946 | 186681.2165 | 1 |
| A5 | 336212.3946 | 186656.2165 | 2 |
| A6 | 336212.3946 | 186631.2165 | 3 |
| A7 | 336212.3946 | 186606.2165 | 4 |
| A8 | 336212.3946 | 186581.2165 | 5 |
| A9 | 336212.3946 | 186556.2165 | 6 |
| B1 | 336237.3946 | 186756.2165 | 7 |
| B2 | 336237.3946 | 186731.2165 | 8 |
| B3 | 336237.3946 | 186706.2165 | 9 |
| B4 | 336237.3946 | 186681.2165 | 10 |
| B5 | 336237.3946 | 186656.2165 | 11 |
| B6 | 336237.3946 | 186631.2165 | 12 |
| B7 | 336237.3946 | 186606.2165 | 13 |
| B8 | 336237.3946 | 186581.2165 | 14 |
| B9 | 336237.3946 | 186556.2165 | 15 |
| C1 | 336262.3946 | 186756.2165 | 16 |
| C2 | 336262.3946 | 186731.2165 | 17 |
| C3 | 336262.3946 | 186706.2165 | 18 |
| C4 | 336262.3946 | 186681.2165 | 19 |
| C5 | 336262.3946 | 186656.2165 | 20 |
| C6 | 336262.3946 | 186631.2165 | 21 |
| C7 | 336262.3946 | 186606.2165 | 22 |
| D1 | 336287.3946 | 186756.2165 | 23 |
| D2 | 336287.3946 | 186731.2165 | 24 |
| D3 | 336287.3946 | 186706.2165 | 25 |
| D4 | 336287.3946 | 186681.2165 | 26 |
| D5 | 336287.3946 | 186656.2165 | 27 |
| D6 | 336287.3946 | 186631.2165 | 28 |
| D7 | 336287.3946 | 186606.2165 | 29 |
| E1 | 336312.3946 | 186756.2165 | 30 |
| E2 | 336312.3946 | 186731.2165 | 31 |
| E3 | 336312.3946 | 186706.2165 | 32 |
| E4 | 336312.3946 | 186681.2165 | 33 |
| E5 | 336312.3946 | 186656.2165 | 34 |
| E6 | 336312.3946 | 186631.2165 | 35 |
| E7 | 336312.3946 | 186606.2165 | 36 |
| E8 | 336312.3946 | 186581.2165 | 37 |
| F1 | 336337.3946 | 186756.2165 | 38 |
| F2 | 336337.3946 | 186731.2165 | 39 |
| F3 | 336337.3946 | 186706.2165 | 40 |
| F4 | 336337.3946 | 186681.2165 | 41 |
| F5 | 336337.3946 | 186656.2165 | 42 |
| F6 | 336337.3946 | 186631.2165 | 43 |
| F7 | 336337.3946 | 186606.2165 | 44 |
| F8 | 336337.3946 | 186581.2165 | 45 |
| G5 | 336362.3946 | 186656.2165 | 46 |
| G6 | 336362.3946 | 186631.2165 | 47 |
| G7 | 336362.3946 | 186606.2165 | 48 |




| REV. | DATE | NOTES | Ds. | Rev. | Ap. |
|---|---|---|---|---|---|
| 4G.1 | 01/11/18 | Phase 4G -Geotechnical Engineer Grid 25x25 | GF | JF | CR |

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|---|---|
| Ordnance Survey National Grid (OSGB36) via the Active GNSS Network | Ordnance Survey National Datum (OSGB36) via the Active GNSS Network |

All dimensions in Metres

Client:

St Modwen

Project Title:

LLANWERN-Glan Llyn Primary
Phase 4G

Drawing Title:

Phase 4G -Geotechnical Engineer Testing Grid
Grid 25x25

| Scale: | Sheet Size: | Drawn: | Date: |
|---|---|---|---|
| DO NOT SCALE | | | 01/11/2018 |

Drawing Number: Geotechnical Grid 25x25

Revision: 4G.1

For Information Only

Millimetres 0 10 100

ATKINS

5111373-LLA-DWG-EG-0422

Phase 4a

Phase 5a

Phase 4b

School

Sports

Sports

East Lake Reen

Pumping Stn

Pavilion

TP1 TP2 TP3 TP4 TP5 TP6 TP7 TP8 TP9 TP10 TP11 TP12 TP13 TP14 TP15 TP16 TP17 TP19 TP20 TP21 TP22 TP23 TP24 TP25 TP26 TP27 TP28 TP29 TP30 TP31 TP32 TP33 TP34 TP35 TP36 TP37 TP38 TP39 TP40 TP41 TP43 TP44 TP45 TP46 TP47 TP48 TP49 TP50 TP52 TP53 TP54 TP56 TP57 TP58 TP59 TP60 TP61 TP62 TP63 TP64 TP65 TP66 TP67 TP68 TP69 TP70 TP71 TP72 TP73 TP74 TP75 TP78 TP79 TP80 TP81 TP82 TP83 TP84 TP85 TP86 TP87 TP88 TP89 TP90 TP92 TP93 TP94 TP95 TP96 TP97 TP98 TP99 TP100 TP101 TP102 TP103 TP104 TP105 TP106 TP107 TP109 TP110 TP111 TP113 TP114 TP115 TP116 TP118 TP119 TP120 TP121 TP122 TP123 TP124

KEY

- COKING WORKS BOUNDRY
- 125No. TRIAL PIT - 3m
- 20No. CABLE PERCUSSIVE BOREHOLE - 10m
- 10No. DYNAMIC SAMPLING WITH ROTARY FOLLOW-ON BOREHOLE - 20m
- WINDOW SAMPLING - 5m (LOCATIONS TO BE DECIDED FOLLOWING TRIAL PITTING)

N

| REVISIONS | Drawn By | Checked By | Date |
|---|---|---|---|
| | | | |

| PURPOSE OF ISSUE | Rev. | Authorised for issue | Date |
|---|---|---|---|
| | | | |


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The Axis, 10 Holliday Street
Birmingham West Midlands B1 1TF
Tel 0121 483 5000
Fax 0121 483 5252


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CLIENT

PROJECT
LLANWERN

DRAWING TITLE
COKING WORKS
EXPLORATORY HOLE LOCATION PLAN

| SCALES | DRAWN | CHECKED | CO-ORD CHECK |
|---|---|---|---|
| 1:1250 | RJ | SD | |
| | DATE | DATE | DATE |
| | 05/09/18 | 05/09/18 | |

0

SHEET A3

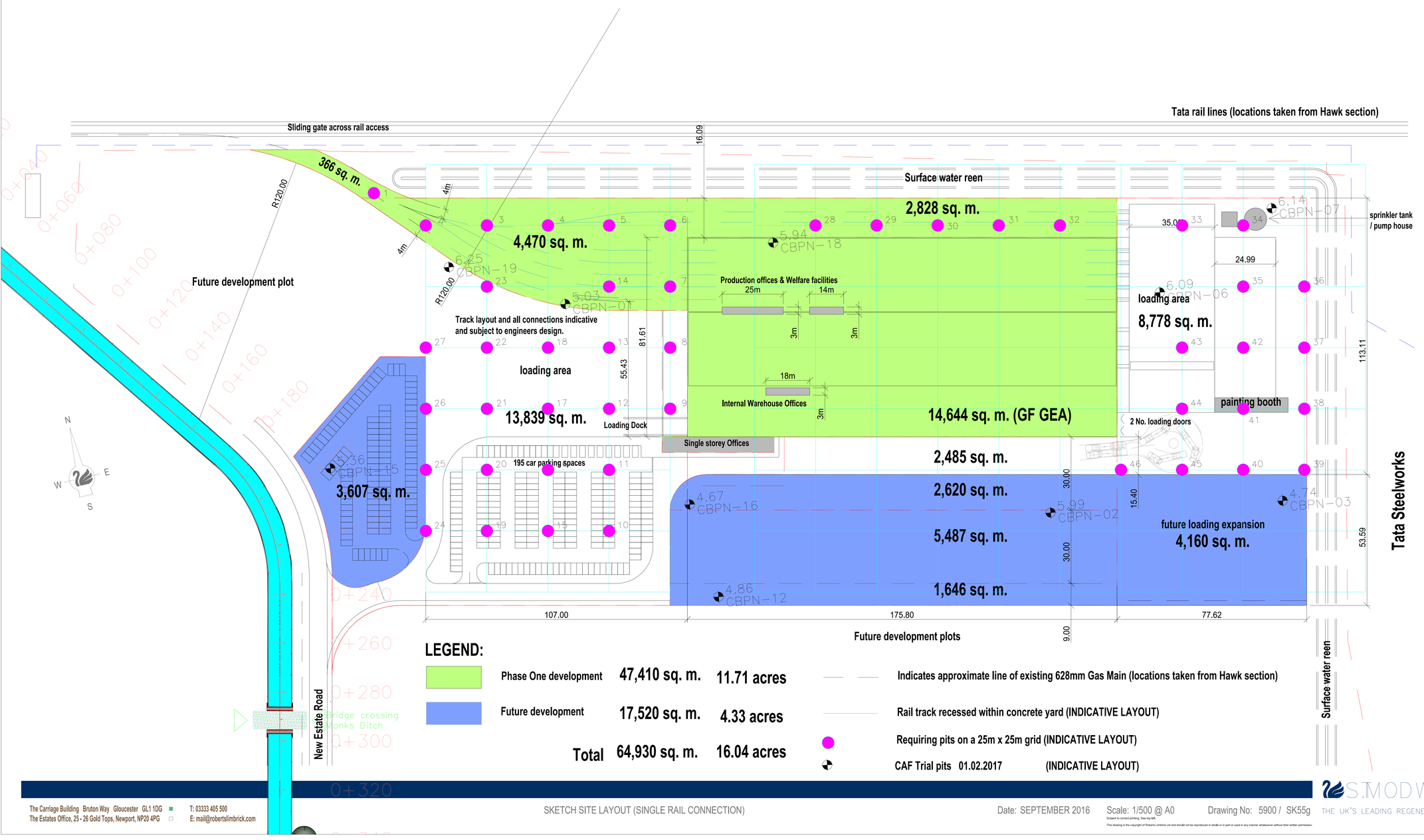
PLOT DATE

DRAWING NO

REV

Roberts Limbrick ARCHITECTS

# Swansea to Paddington mainline




## LEGEND:

| | | | |
|---|---|---|---|
| Phase One development | 47,410 sq. m. | 11.71 acres | Indicates approximate line of existing 628mm Gas Main (locations taken from Hawk section) |
| Future development | 17,520 sq. m. | 4.33 acres | Rail track recessed within concrete yard (INDICATIVE LAYOUT) |
| Total | 64,930 sq. m. | 16.04 acres | Requiring pits on a 25m x 25m grid (INDICATIVE LAYOUT) |
| | | | CAF Trial pits 01.02.2017 (INDICATIVE LAYOUT) |

## POSITIONS OF THE PITS

| NAME –N.: | M | P |
|---|---|---|
| CAFTP– 1 | 336841.7298 | 187239.1315 |
| CAFTP– 2 | 336861.8005 | 187224.2262 |
| CAFTP– 3 | 336886.7157 | 187222.1686 |
| CAFTP– 4 | 336911.6309 | 187220.1110 |
| CAFTP– 5 | 336936.5461 | 187218.0534 |
| CAFTP– 6 | 336961.4612 | 187215.9958 |
| CAFTP– 7 | 336959.4036 | 187191.0806 |
| CAFTP– 8 | 336957.3460 | 187166.1654 |
| CAFTP– 9 | 336955.2884 | 187141.2502 |
| CAFTP–10 | 336926.2580 | 187093.4775 |
| CAFTP–11 | 336928.3156 | 187118.3927 |
| CAFTP–12 | 336930.3732 | 187143.3078 |
| CAFTP–13 | 336932.4308 | 187168.2230 |
| CAFTP–14 | 336934.4884 | 187193.1382 |
| CAFTP–15 | 336901.3428 | 187095.5351 |
| CAFTP–16 | 336903.4004 | 187120.4503 |
| CAFTP–17 | 336905.4580 | 187145.3655 |
| CAFTP–18 | 336907.5156 | 187170.2806 |
| CAFTP–19 | 336876.4276 | 187097.5927 |
| CAFTP–20 | 336878.4852 | 187122.5079 |
| CAFTP–21 | 336880.5428 | 187147.4231 |
| CAFTP–22 | 336882.6005 | 187172.3383 |
| CAFTP–23 | 336884.6581 | 187197.2534 |
| CAFTP–24 | 336851.5124 | 187099.6503 |
| CAFTP–25 | 336853.5700 | 187124.5655 |
| CAFTP–26 | 336855.6277 | 187149.4807 |
| CAFTP–27 | 336857.6853 | 187174.3959 |
| CAFTP–28 | 337020.7036 | 187211.1032 |
| CAFTP–29 | 337045.6188 | 187209.0456 |
| CAFTP–30 | 337070.5340 | 187206.9880 |
| CAFTP–31 | 337095.4491 | 187204.9304 |
| CAFTP–32 | 337120.3643 | 187202.8727 |
| CAFTP–33 | 337170.1947 | 187198.7575 |
| CAFTP–34 | 337195.1099 | 187196.6999 |
| CAFTP–35 | 337193.0522 | 187171.7847 |
| CAFTP–36 | 337217.9674 | 187169.7271 |
| CAFTP–37 | 337215.9098 | 187144.8119 |
| CAFTP–38 | 337213.8522 | 187119.8967 |
| CAFTP–39 | 337211.7945 | 187094.9815 |
| CAFTP–40 | 337186.8794 | 187097.0392 |
| CAFTP–41 | 337188.9370 | 187121.9543 |
| CAFTP–42 | 337190.9946 | 187146.8695 |
| CAFTP–43 | 337166.0794 | 187148.9271 |
| CAFTP–44 | 337164.0218 | 187124.0120 |
| CAFTP–45 | 337161.9642 | 187099.0968 |
| CAFTP–46 | 337137.0490 | 187101.1544 |

| | | |
|---|---|---|
| CBPN–01 | 336916.049 | 187187.471 |
| CBPN–02 | 337106.901 | 187086.047 |
| CBPN–03 | 337201.924 | 187083.142 |
| CBPN–06 | 337158.875 | 187172.229 |
| CBPN–07 | 337207.296 | 187202.742 |
| CBPN–12 | 336968.688 | 187062.952 |
| CBPN–15 | 336814.747 | 187128.39 |
| CBPN–16 | 336960.014 | 187101.55 |
| CBPN–18 | 337002.866 | 187205.527 |
| CBPN–19 | 336869.829 | 187206.442 |


The Carriage Building Bruton Way Gloucester GL1 1DG T: 03333 405 500
The Estates Office, 25 - 26 Gold Tops, Newport, NP20 4PG E: mail@robertslimbrick.com

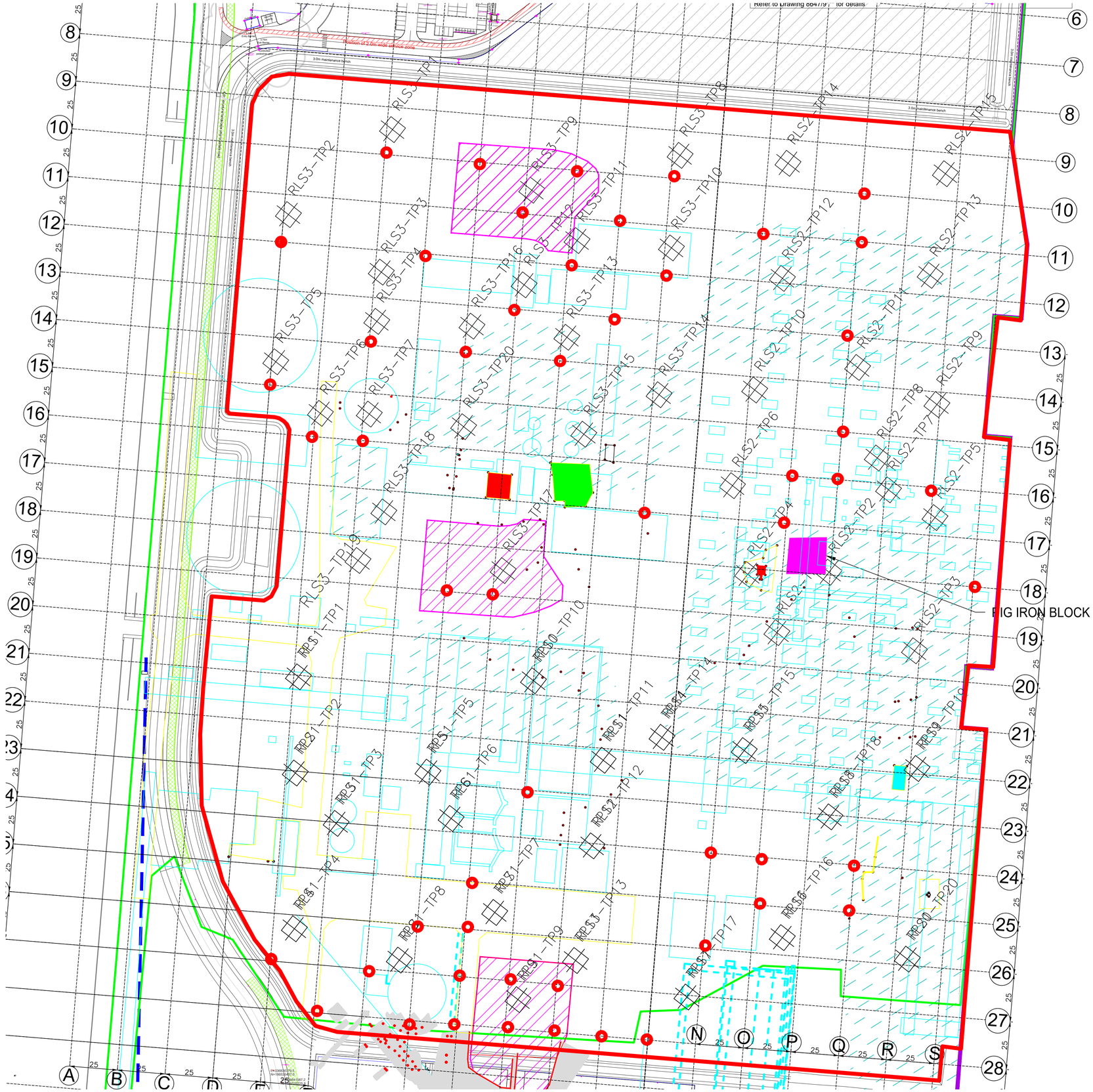

SKETCH SITE LAYOUT (SINGLE RAIL CONNECTION)

Date: SEPTEMBER 2016 Scale: 1/500 @ A0 Drawing No: 5900 / SK55g

Subject to correct printing. See top left.


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S.MODWEN THE UK'S LEADING REGENERATION SPECIALIST




# GENERAL NOTES

NO DIMENSIONS TO BE SCALED OFF THIS DRAWING.

THIS DRAWING TO BE READ IN CONJUNCTION WITH ALL RELEVANT ARCHITECT'S AND ENGINEER'S DRAWINGS.

ALL DIMENSIONS ARE IN MILLIMETRES UNLESS NOTED OTHERWISE.

ALL LEVELS ARE IN METRES UNLESS NOTED OTHERWISE.

ANY DISCREPANCIES NOTED ON SITE ARE TO BE REPORTED TO THE ENGINEER IMMEDIATELY.

# Key

Boundary

Atkins Trial pit location

| Rev | Date | Amendments | By | Chk |
|---|---|---|---|---|
| B | 16/08/18 | All trial pits added | ET | |
| A | 22/05/18 | First draft | ET | |

Client

St Modwen Developments

Project

Llanwern
40 Acre Plot
Trial Pit Location Map

Drawing Title

Trial Pit location

Status

For infomation

| Scale | Drawn | Checked | Date |
|---|---|---|---|
| A1@NTS | ET | CW | 16/08/18 |

Drawing No. | Rev.

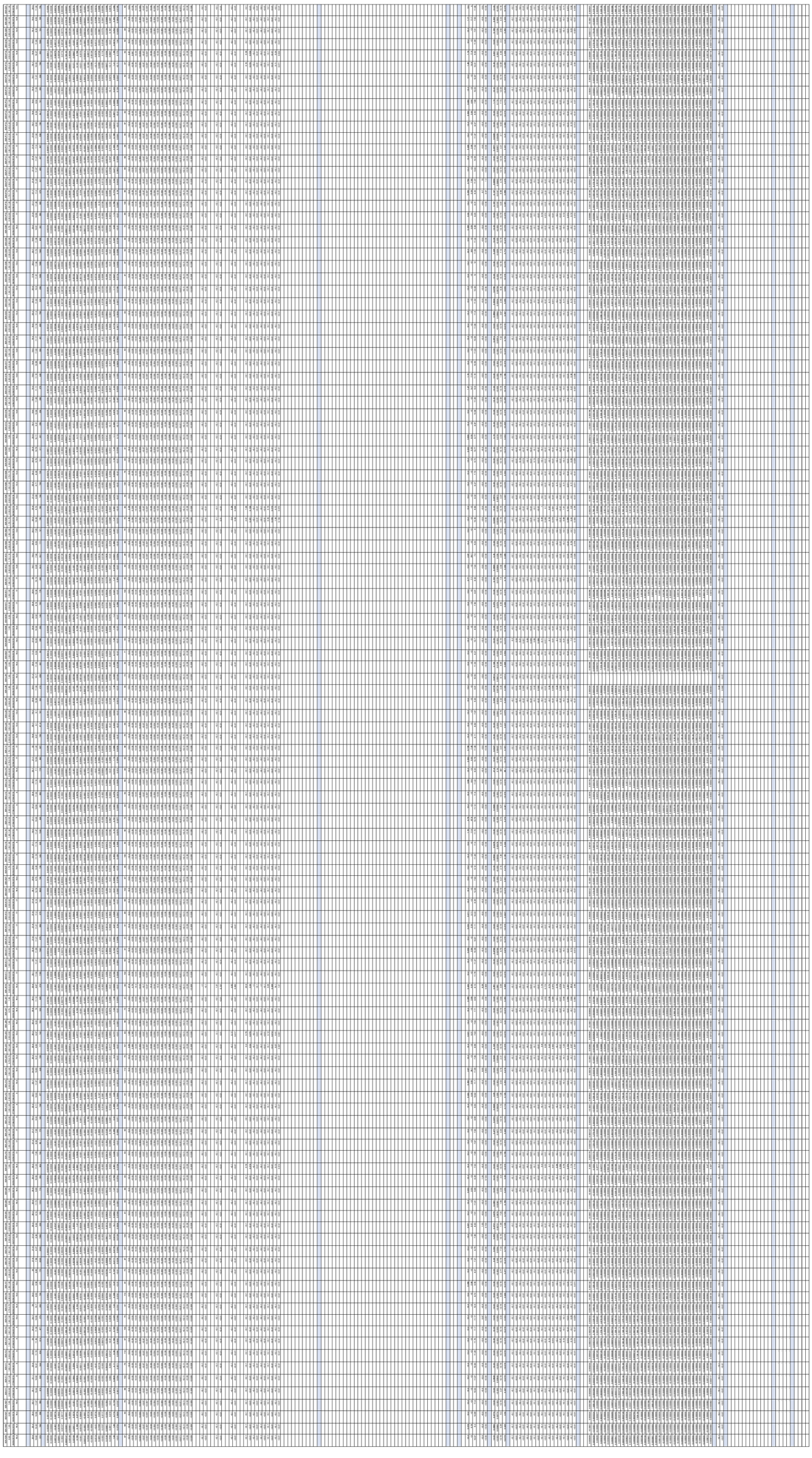
17480-RLE-18-DR-O-1002 | B

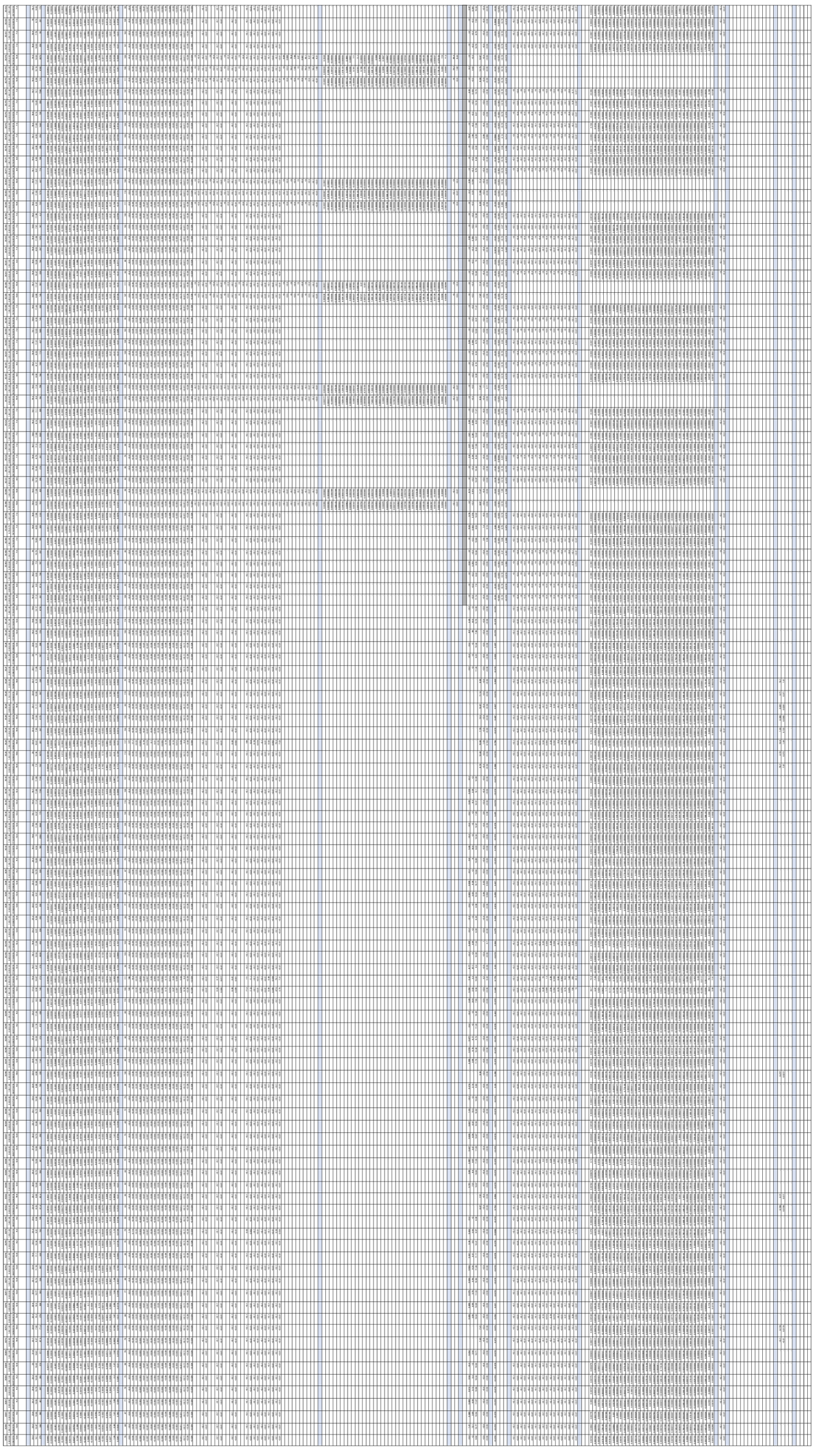
Seven House • 18 High Street • Longbridge • B31 2UQ • Tel: 0121 475 8462 • Fax: 01332 291728 • www.rodgersleask.co.uk

# Appendix G: Soil Leachate Analysis

Other Users Lab Number Data

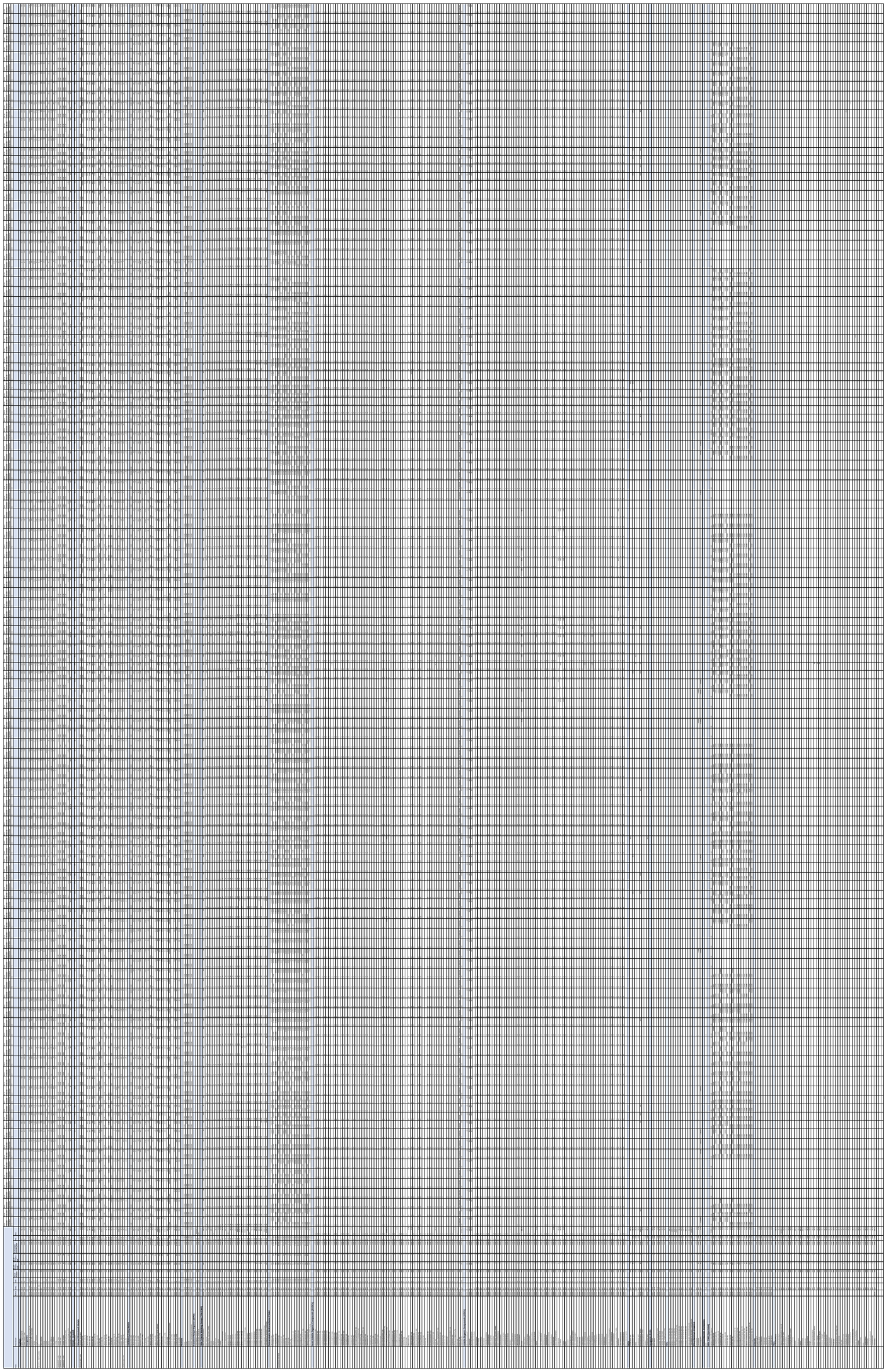
| | Reference # | Method | LOR | Number of samples | No. of samples < LOR | No. of samples < MDL | Min | Max | Mean | Sample ID | 20-JUL-21 | 20-JUL-21 | 20-JUL-21 





# Appendix H: Surface Waters Analysis

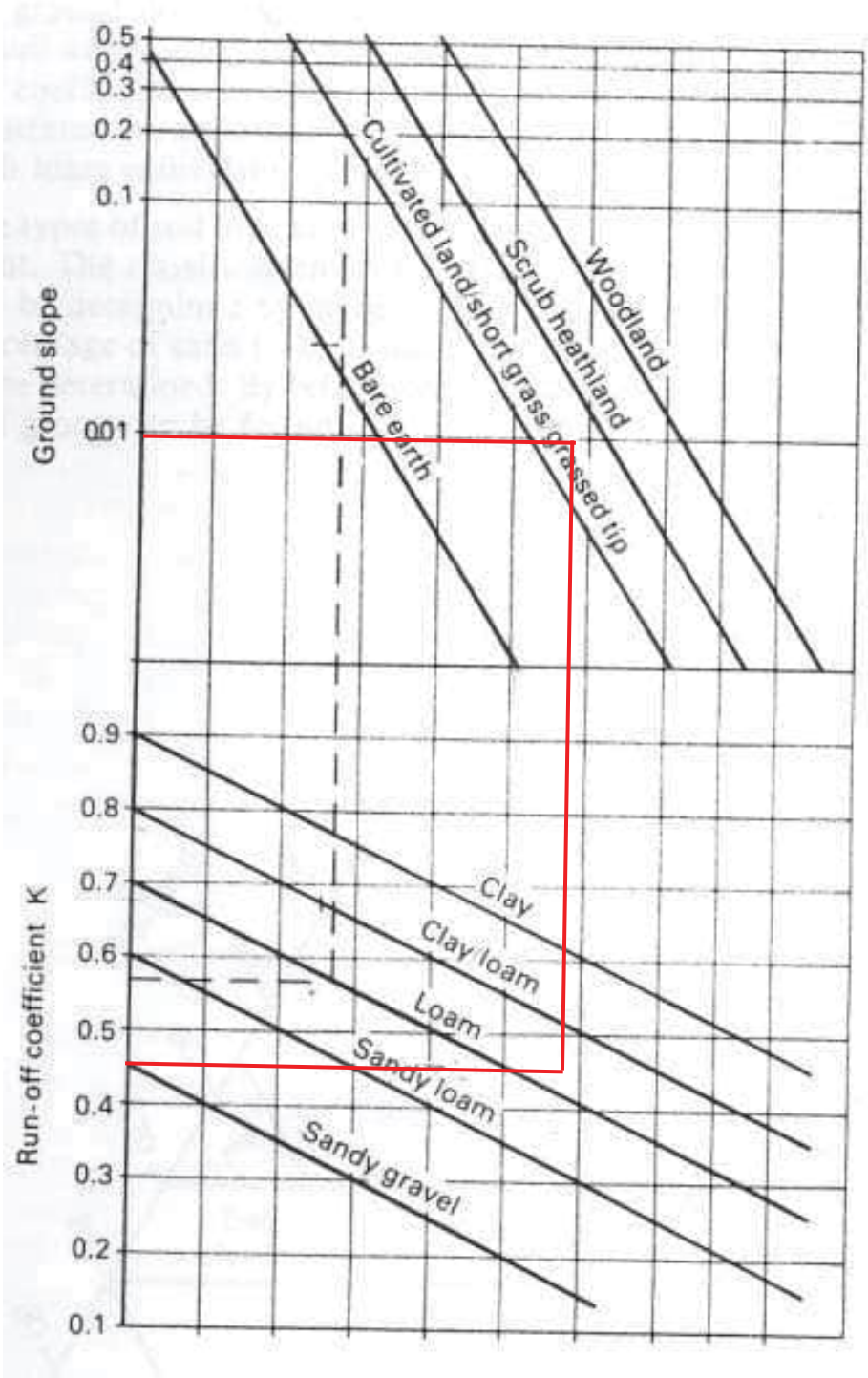
| | | |



| Area | Determinand | Units | Min | Max | Min Detection Limit | Max Detection Limit | Determination Accuracy | No. | 2000-01 Winter | 2000-01 Summer | 2001-02 Winter | 2001-02 Summer | 2002-03 Winter | 2002-03 Summer | 2003-04 Winter | 2003-04 Summer | 2004-05 Winter | 2004-05 Summer | 2005-06 Winter | 2005-06 Summer | 2006-07 Winter | 2006-07 Summer | 2007-08 Winter | 2007-08 Summer | 2008-09 Winter | 2008-09 Summer | 2009-10 Winter | 2009-10 Summer | 2010-11 Winter | 2010-11 Summer | 2011-12 Winter | 2011-12 Summer | 2012-13 Winter | 2012-13 Summer | 2013-14 Winter | 2013-14 Summer | 2014-15 Winter | 2014-15 Summer | 2015-16 Winter | 2015-16 Summer | 2016-17 Winter | 2016-17 Summer | 2017-18 Winter | 2017-18 Summer | 2018-19 Winter | 2018-19 Summer | 2019-20 Winter | 2019-20 Summer | 2020-21 Winter | 2020-21 Summer | 2021-22 Winter | 2021-22 Summer | 2022-23 Winter | 2022-23 Summer | 2023-24 Winter | 2023-24 Summer | 2024-25 Winter | 2024-25 Summer |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Cations** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Calcium, Dissolved | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Calcium, Total | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | **Inorganics** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Cyanide, Free (as CN) | mg/l | 0.001 | 1000 | 0.001 | 0.01 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Cyanide, Total (as CN) | mg/l | 0.001 | 1000 | 0.001 | 0.01 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Organotin Determinand | Cyanide, Weak Acid | mg/l | 0.001 | 1000 | 0.001 | 0.01 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | **Metals - Dissolved** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | **Mineral Dissolved Metals** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Contaminated Land | Aluminium, Dissolved | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Antimony, Dissolved | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Arsenic, Dissolved | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Barium, Dissolved | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Beryllium, Dissolved | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Boron, Dissolved | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Cadmium, Dissolved | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Chromium (III), Dissolved | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Chromium (VI), Dissolved | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Cobalt, Dissolved | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Copper, Dissolved | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Iron, Dissolved | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Lead, Dissolved | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Lithium, Dissolved | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Magnesium, Dissolved | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Manganese, Dissolved | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Mercury, Dissolved | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Molybdenum, Dissolved | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Nickel, Dissolved | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Selenium, Dissolved | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Silver, Dissolved | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Strontium, Dissolved | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Thallium, Dissolved | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Tin, Dissolved | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Titanium, Dissolved | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Uranium, Dissolved | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Vanadium, Dissolved | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Zinc, Dissolved | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | **Phenols** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Phenol | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Total Phenols | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | **Polycyclic Aromatic Hydrocarbons (PAHs)** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | **Other Compounds** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | **Other Compounds - Miscellaneous (Water)** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Acrylamide | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Epichlorohydrin | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Contaminated Land | Epoxybutane | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Methyl Acrylate | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Methyl Methacrylate | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Methyl Tert-Butyl Ether | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Tetrahydrofuran | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Vinyl Acetate | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | **Speciated Volatile Organic Compounds (SVOCs)** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 1,2,3-Trichlorobenzene | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 1,2,3-Trichloropropane | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 1,2,4-Trichlorobenzene | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 1,2,4-Trimethylbenzene | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 1,2-Dibromoethane | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 1,2-Dichlorobenzene | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 1,2-Dichloroethane | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 1,2-Dichloropropane | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 1,3,5-Trichlorobenzene | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 1,3,5-Trimethylbenzene | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 1,3-Dichlorobenzene | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 1,3-Dichloropropane | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 1,4-Dichlorobenzene | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 2,2-Dichloropropane | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 2-Chlorotoluene | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 4-Chlorotoluene | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Benzene | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Bromobenzene | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Bromochloromethane | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Bromodichloromethane | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Bromoform | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Bromomethane | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Carbon Tetrachloride | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Chlorobenzene | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Chloroethane | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Chloroform | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Chloromethane | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | cis-1,2-Dichloroethene | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | cis-1,3-Dichloropropene | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Dibromochloromethane | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Dibromomethane | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Dichlorodifluoromethane | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Ethylbenzene | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Hexachlorobutadiene | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Isopropylbenzene | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | m & p-Xylene | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Methylene Chloride | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | n-Butylbenzene | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | n-Propylbenzene | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | o-Xylene | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | p-Isopropyltoluene | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | sec-Butylbenzene | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Styrene | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | tert-Butylbenzene | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Tetrachloroethene | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Toluene | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | trans-1,2-Dichloroethene | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | trans-1,3-Dichloropropene | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Trichloroethene | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Trichlorofluoromethane | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Vinyl Chloride | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | **Volatile Organic Compounds (VOCs)** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 1,1,1,2-Tetrachloroethane | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 1,1,1-Trichloroethane | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 1,1,2,2-Tetrachloroethane | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 1,1,2-Trichloroethane | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 1,1-Dichloroethane | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 1,1-Dichloroethene | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 1,1-Dichloropropene | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | **Pesticides** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Atrazine | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Simazine | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | **Semi-Volatile Organic Compounds (SVOCs)** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | **Speciated Polycyclic Aromatic Hydrocarbons (PAHs)** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Acenaphthene | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Acenaphthylene | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Anthracene | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Benz(a)anthracene | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Benzo(a)pyrene | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Benzo(b)fluoranthene | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Benzo(ghi)perylene | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Benzo(k)fluoranthene | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Chrysene | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Dibenz(ah)anthracene | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Fluoranthene | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Fluorene | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Indeno(123cd)pyrene | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Naphthalene | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Phenanthrene | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Pyrene | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | **Speciated Total Petroleum Hydrocarbons** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Aliphatic >C5-C6 | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Aliphatic >C6-C8 | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Aliphatic >C8-C10 | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Aliphatic >C10-C12 | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Aliphatic >C12-C16 | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Aliphatic >C16-C21 | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Aliphatic >C21-C35 | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Aliphatic >C35-C44 | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Aromatic >C5-C7 | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Aromatic >C7-C8 | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Aromatic >C8-C10 | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Aromatic >C10-C12 | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Aromatic >C12-C16 | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Aromatic >C16-C21 | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Aromatic >C21-C35 | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Aromatic >C35-C44 | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | **Speciated Total Petroleum Hydrocarbons** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Aliphatic >C5-C6 | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Aliphatic >C6-C8 | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Aliphatic >C8-C10 | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Aliphatic >C10-C12 | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Aliphatic >C12-C16 | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Aliphatic >C16-C21 | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Aliphatic >C21-C35 | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Aliphatic >C35-C44 | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Aromatic >C5-C7 | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Aromatic >C7-C8 | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Aromatic >C8-C10 | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Aromatic >C10-C12 | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Aromatic >C12-C16 | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Aromatic >C16-C21 | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Aromatic >C21-C35 | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Aromatic >C35-C44 | mg/l | 0.1 | 1000 | 0.1 | 1 | 5% | 1 | | | | | | |

# Appendix I: Chemical Input Parameters and Justifications

**Runoff Coefficient Nomogram (National Coal Board, 1982)**



**Determinand-Specific Parameters**

| Determinand | Henrys Law Coefficient (H) | Ref. | Soil Organic Carbon-Water Partitioning Coefficient (koc) | Ref. | Solid/Liquid Partition Coefficient (Kd) | Ref. |
|---|---|---|---|---|---|---|
| **Units** | **($cm^3/cm^3$)** | | **(-)** | | **l/kg** | |
| **Inorganic Metals and Metalloids** | | | | | | |
| Arsenic | 1 | - | - | - | 134 | 6 |
| Cadmium | 1 | - | - | - | 776 | 6 |
| Chromium | 1 | - | - | - | 5,336 | 6 |
| Copper | 1 | - | - | - | 1,199 | 6 |
| Iron | 1 | - | - | - | 810 | 5 |
| Lead | 1 | - | - | - | 34,877 | 6 |
| Manganese | 1 | - | - | - | 720 | 5 |
| Mercury | 1 | - | - | - | 5,000 | 6 |
| Nickel | 1 | - | - | - | 7,652 | 6 |
| Selenium | 1 | - | - | - | 186 | 6 |
| Vanadium | 1 | - | - | - | 213 | 6 |
| Zinc | 1 | - | - | - | 33,558 | 6 |
| **Other Inorganics** | | | | | | |
| Ammoniacal Nitrogen | 1 | - | - | - | 1 | 5 |
| Cyanide | 1 | - | - | - | 5 | 7 |
| **Organics** | | | | | | |
| Benzene | 0.182 | 1 | 27 | 5 | 0.64 | koc*foc |
| Toluene | 0.221 | 1 | 178 | 1 | 4.25 | koc*foc |
| Ethylbenzene | 0.3 | 1 | 432 | 1 | 10.31 | koc*foc |
| Xylene* | 0.22 | 1 | 260 | 5 | 6.20 | koc*foc |
| Phenol | 0.000068 | 1 | 28.8 | 1 | 0.69 | koc*foc |
| **TPH Criteria Working Group** | | | | | | |
| TPH Aliphatic >C5-C6 | 33 | 2 | 794 | 3 | 19 | koc*foc |
| TPH Aliphatic >$C_6$-$C_8$ | 50 | 2 | 3,981 | 3 | 95 | koc*foc |
| TPH Aliphatic >$C_8$-$C_{10}$ | 80 | 2 | 31,623 | 3 | 755 | koc*foc |
| TPH Aliphatic >$C_{10}$-$C_{12}$ | 120 | 2 | 25,1189 | 3 | 5,996 | koc*foc |
| TPH Aliphatic >$C_{12}$-$C_{16}$ | 520 | 2 | 501,1872 | 3 | 119,643 | koc*foc |

| | | | | | | |
|---|---|---|---|---|---|---|
| TPH Aliphatic >$C_{16}$-$C_{21}$ | 4,900 | 2 | 630,957,344 | 3 | 15,062,116 | koc*foc |
| TPH Aliphatic >$C_{21}$-$C_{35}$ | 4,900 | 2 | 630,957,344 | 3 | 15,062,116 | koc*foc |
| TPH Aliphatic >$C_{35}$-$C_{44}$ | 4,900 | 2 | 630,957,344 | 3 | 15,062,116 | koc*foc |
| TPH Aromatic >$C_5$-$C_7$ | 0.23 | 2 | 79 | 5 | 2 | koc*foc |
| TPH Aromatic >$C_7$-$C_8$ | 0.27 | 2 | 251 | 5 | 6 | koc*foc |
| TPH Aromatic >$C_8$-$C_{10}$ | 0.48 | 2 | 1,585 | 3 | 38 | koc*foc |
| TPH Aromatic >$C_{10}$-$C_{12}$ | 0.14 | 2 | 2,512 | 3 | 60 | koc*foc |
| TPH Aromatic >$C_{12}$-$C_{16}$ | 0.05 | 2 | 5,012 | 3 | 120 | koc*foc |
| TPH Aromatic >$C_{16}$-$C_{21}$ | 0.01 | 2 | 15,849 | 3 | 378 | koc*foc |
| TPH Aromatic >$C_{21}$-$C_{35}$ | 0.00067 | 2 | 125,893 | 3 | 3,005 | koc*foc |
| TPH Aromatic >$C_{35}$-$C_{44}$ | 0.00067 | 2 | 125,893 | 3 | 3,005 | koc*foc |
| TPH Aromatic >$C_{40}$-$C_{44}$ | 0.00067 | 2 | 125,893 | 3 | 3,005 | koc*foc |
| **Polyaromatic Hydrocarbons** | | | | | | |
| Acenaphthene | 0.0049 | 1 | 18,621 | 4 | 445 | koc*foc |
| Acenaphthylene | 0.0034 | 1 | 33,113 | 4 | 791 | koc*foc |
| Anthracene | 0.0016 | 1 | 38,019 | 4 | 908 | koc*foc |
| Benzo(a)anthracene | 0.00024 | 1 | 676,083 | 4 | 16,139 | koc*foc |
| Benzo(a)pyrene | 0.000019 | 1 | 426,580 | 4 | 10,183 | koc*foc |
| Benzo(b)fluoranthene | 0.0002 | 1 | 2,238,721 | 4 | 53,442 | koc*foc |
| Benzo(k)fluoranthene | 0.000034 | 1 | 3,311,311 | 4 | 79,047 | koc*foc |
| Benzo(g,h,i)perylene | 0.00003 | 1 | 8,709,636 | 4 | 207,915 | koc*foc |
| Chrysene | 0.000026 | 1 | 691,831 | 4 | 16,515 | koc*foc |
| Di-benz(a,h)anthracene | 0.0000006 | 1 | 933,254 | 4 | 22,279 | koc*foc |
| Indeno(1,2,3-cd)pyrene | 0.000066 | 1 | 16,595,869 | 4 | 396,174 | koc*foc |
| Fluoranthene | 0.00042 | 1 | 117,490 | 4 | 2,805 | koc*foc |
| Fluorene | 0.0032 | 1 | 30,200 | 4 | 721 | koc*foc |
| Naphthalene | 0.017 | 1 | 1,514 | 4 | 36 | koc*foc |
| Phenanthrene | 0.0013 | 1 | 30,200 | 4 | 721 | koc*foc |
| Pyrene | 0.00037 | 1 | 85,114 | 4 | 2,032 | koc*foc |

* Parameterised as total xylene

**Determinand-Specific Parameter References:**

1 - Environment Agency/Atkins, 2003. Review of the Fate and Transport of Selected Contaminants in the Soil Environment. Tables 2.4, 3.2 & 4.3

2 - Total Petroleum Hydrocarbon Criteria Working Group Series (TPHCWG), 1999. Human Health Risk-Based Evaluation of Petroleum Release Sites: Implementing the Working Group Approach, Volume 5, Table 1

3 - Total Petroleum Hydrocarbon Criteria Working Group Series (TPHCWG), 1997. Selection of representative TPH fractions based on fate & transport considerations, Volume 3, Table 7

4 - Geometric mean of koc values from Physical-Chemical Properties and Environmental Fate for Organic Chemicals, Mackay ET. al. 2006. 2nd Ed.

5 - ConSim Help files

6. Site specific Kd

7. Kow x 0.35 after USEPA FIRST User Manual. Kow value from EA Science Report SC040038/SR6.

# Appendix J: Table 5-4 CWDQRA Reuse Criteria for 5% & 40% Infiltration

**Table 5.4 CWDQRA Reuse Criteria for 5% Infiltration of Incident Rainfall into Engineered Made Ground - Comparison of Calculated CWDQRA Reuse Criteria against Maximum Soil Concentrations Determined (Soils 2017 onwards)**

| Determinand | Commercial Area | | | Residential Area | | |
|---|---|---|---|---|---|---|
| | Re-use Criteria $C_{mg}$ (mg/kg) | Maximum Soil Sample Value* (mg/kg) | Average Soil Sample Value* (mg/kg) | Re-use Criteria (mg/kg) | Maximum Soil Sample Value* (mg/kg) | Average Soil Sample Value* (mg/kg) |
| **Inorganic Metals and Metalloids** | | | | | | |
| Arsenic | 65439.545 | 397 | 12.11 | 16578.248 | 397 | 12.11 |
| Cadmium | 1886.085 | 31 | 0.66 | 477.815 | 31 | 0.66 |
| Chromium | 243635.930 | 3090 | 123.01 | 61721.958 | 3090 | 123.01 |
| Copper | 11652.851 | 1790 | 25.56 | 2952.097 | 1790 | 25.56 |
| Iron | 7871354.891 | 2390000 | 92031 | 1994104.220 | 2390000 | 103039 |
| Lead | 406523.383 | 4220 | 91.58 | 102987.352 | 4220 | 91.58 |
| Manganese | 860650.486 | 408000 | 8645 | 218034.479 | 408000 | 8645 |
| Mercury | 3399.904 | 6 | 0.68 | 861.321 | 6 | 0.68 |
| Nickel | 297329.948 | 313 | 25.73 | 75324.631 | 313 | 25.73 |
| Selenium | 18132.616 | 52 | 6.09 | 4593.660 | 52 | 6.09 |
| Vanadium | 41486.276 | 2880 | 206.93 | 10510.002 | 2880 | 206.93 |
| Zinc | 3552996.685 | 13300 | 291.45 | 900104.973 | 13300 | 291.45 |
| **Other Inorganics** | | | | | | |
| Ammoniacal Nitrogen | 3989.985 | 1590 | 62.20 | 1010.810 | 1590 | 62.20 |
| Cyanide | 52.153 | 272 | 2.53 | 13.212 | 272 | 2.53 |
| **Organics** | | | | | | |
| Benzene | 98.257 | <0.01 | | 24.89205686 | <0.01 | |
| Toluene | 3318.139 | <0.002 | | 840.6068862 | <0.002 | |
| Ethylbenzene | 2074.757 | <0.003 | | 525.6124567 | <0.003 | |
| Xylene | 1915.601 | 3.0 | | 485.292 | 80.0 | |
| Phenol | 78.835 | 1.0 | 0.2 | 19.972 | 1.0 | 0.2 |
| **TPH Criteria Working Group** | | | | | | |
| Aliphatics >C5-C6 | 1886.153 | 1 | 0.03 | 477.8320875 | 1 | 0.03 |
| Aliphatics >C6-C8 | 9279.877 | 4 | 0.04 | 2350.934674 | 4 | 0.04 |
| Aliphatics >C8-C10 | 73381.790 | 74 | 0.20 | 18590.31119 | 74 | 0.20 |
| Aliphatics >C10-C12 | 582509.060 | 987 | 2.06 | 147571.008 | 987 | 2.06 |
| Aliphatics >C12-C16 | 11621414.418 | 1330 | 7.40 | 2944132.472 | 1330 | 7.40 |
| Aliphatics >C16-C21 | 1463028965.50 | 3530 | 26.11 | 370639143.4 | 3530 | 26.11 |
| Aliphatics >C21-C35 | 1463028965.50 | 3580 | 73.67 | 370639143.4 | 3580 | 73.67 |
| Aliphatics >C35-C44 | 1463028965.50 | 1380 | 24.12 | 370639143.4 | 1380 | 24.12 |
| Aromatics >EC5-EC7 | 219.848 | 5 | 0.04 | 55.69550796 | 5 | 0.04 |
| Aromatics >EC7-EC8 | 4574.056 | 20 | 0.05 | 1158.777006 | 20 | 0.05 |
| Aromatics >EC8-EC10 | 3710.689 | 50 | 0.15 | 940.0541488 | 50 | 0.15 |
| Aromatics >EC10-EC12 | 5860.058 | 658 | 1.38 | 1484.568497 | 658 | 1.38 |
| Aromatics >EC12-EC16 | 11656.858 | 5280 | 11.65 | 2953.111706 | 5280 | 11.65 |
| Aromatics >EC16-EC21 | 36785.199 | 9800 | 46.76 | 9319.04624 | 9800 | 46.76 |
| Aromatics >EC21-EC35 | 291947.994 | 9010 | 113.58 | 73961.1839 | 9010 | 113.58 |
| Aromatics >EC35-EC44 | 291947.994 | 1580 | 40.00 | 73961.1839 | 1580 | 40.00 |
| Aromatics >EC40-EC44 | 291947.994 | 724 | 14.87 | 73961.1839 | 724 | 14.87 |
| **Polyaromatic Hydrocarbons** | | | | | | |
| Acenaphthylene | 432.126 | *2100* | 2.34950 | 109.4734647 | *2100* | 2.34950 |
| Acenaphthene | 768.164 | 193 | 0.37333 | 194.6042079 | 193 | 0.37333 |
| Anthracene | 881.917 | *1860* | 2.77187 | 223.4221618 | *1860* | 2.77187 |
| Benz(a)anthracene | 15676.980 | 1150 | 3.61643 | 3971.556563 | 1150 | 3.61643 |
| Benzo(a)pyrene | 890.247 | 714 | 2.91263 | 225.5324461 | *714* | 2.91263 |
| Benzo(b)fluoranthene | 88.248 | *1110* | 4.13642 | 22.35644724 | *1110* | 4.13642 |
| Benzo(k)fluoranthene | 130.528 | *373* | 1.62573 | 33.06753518 | *373* | 1.62573 |
| Benzo(g,h,i)perylene | 343.322 | 333 | 1.97508 | 86.97622939 | *333* | 1.97508 |
| Chrysene | 16042.135 | 1090 | 3.30131 | 4064.063898 | 1090 | 3.30131 |
| Dibenzo(a,h)anthracene | 21640.121 | 177 | 0.57527 | 5482.239877 | 177 | 0.57527 |
| Indeno(1,2,3-cd)pyrene | 654.187 | 374 | 2.03839 | 165.7296497 | *374* | 2.03839 |
| Fluoranthene | 171.652 | *2940* | 8.95256 | 43.48587282 | *2940* | 8.95256 |
| Fluorene | 700.605 | *1890* | 2.16433 | 177.4890832 | *1890* | 2.16433 |
| Naphthalene | 709.033 | *4680* | 8.40311 | 179.6242411 | *4680* | 8.40311 |
| Phenanthrene | 700.605 | *3810* | 7.54997 | 177.4890819 | *3810* | 7.54997 |
| Pyrene | 1973.926 | 15 | 0.00781 | 500.0681883 | 15 | 0.00781 |

***Recent analyses carried out from 2017(Master Results)**

**Table 5.4 CWDQRA Reuse Criteria for 40% Infiltration of Incident Rainfall into Engineered Made Ground - Comparison of Calculated CWDQRA Reuse Criteria against Maximum Soil Concentrations Determined (Soils 2017 onwards)**

| Determinand | Commercial Area | | | Residential Area | | |
|---|---|---|---|---|---|---|
| | Re-use Criteria $C_{mg}$ (mg/kg) | Maximum Soil Sample Value* (mg/kg) | Average Soil Sample Value* (mg/kg) | Re-use Criteria (mg/kg) | Maximum Soil Sample Value (mg/kg) | Average Soil Sample Value* (mg/kg) |
| **Inorganic Metals and Metalloids** | | | | | | |
| Arsenic | 11468.786 | 397 | 12.11 | 2902.688 | 397 | 12.11 |
| Cadmium | 330.551 | 31 | 0.66 | 83.661 | 31 | 0.66 |
| Chromium | 42699.080 | 3090 | 123.01 | 10806.907 | 3090 | 123.01 |
| Copper | 2042.252 | 1790 | 25.56 | 516.883 | 1790 | 25.56 |
| Iron | 1379515.806 | *2390000* | 92031 | 349148.010 | *2390000* | 92031 |
| Lead | 71246.366 | 4220 | 91.58 | 18032.071 | 4220 | 91.58 |
| Manganese | 150835.652 | *408000* | 8645 | 38175.690 | *408000* | 8645 |
| Mercury | 595.859 | *6* | 0.68 | 150.809 | *6* | 0.68 |
| Nickel | 52109.372 | 313 | 25.73 | 13188.601 | 313 | 25.73 |
| Selenium | 3177.881 | 52 | 6.06 | 804.305 | 52 | 6.09 |
| Vanadium | 7270.791 | 2880 | 206.93 | 1840.198 | *2880* | 206.93 |
| Zinc | 622690.141 | 13300 | 291.45 | 157599.516 | 13300 | 291.45 |
| **Other Inorganics** | | | | | | |
| Ammoniacal Nitrogen | 699.276 | *1590* | 62.20 | 176.983 | *1590* | 62.20 |
| Cyanide | 9.140 | *272* | 2.53 | 2.313 | *272* | 2.53 |
| **Organics** | | | | | | |
| Benzene | 17.220 | <0.01 | | 4.358 | <0.01 | |
| Toluene | 581.530 | <0.002 | | 147.182 | <0.002 | |
| Ethylbenzene | 363.617 | <0.003 | | 92.030 | <0.003 | |
| Xylene | 335.724 | 3.0 | | 84.970 | 80.0 | |
| Phenol | 13.816 | 1.0 | 0.2 | 3.497 | 1.0 | 0.2 |
| **TPH Criteria Working Group** | | | | | | |
| Aliphatics >C5-C6 | 330.563 | 1 | 0.03 | 83.664 | 1 | 0.03 |
| Aliphatics >C6-C8 | 1626.370 | 4 | 0.04 | 411.626 | 4 | 0.04 |
| Aliphatics >C8-C10 | 12860.726 | 74 | 0.20 | 3254.980 | 74 | 0.20 |
| Aliphatics >C10-C12 | 102089.217 | 987 | 2.06 | 25838.230 | 987 | 2.06 |
| Aliphatics >C12-C16 | 2036742.733 | 1330 | 7.40 | 515488.601 | 1330 | 7.40 |
| Aliphatics >C16-C21 | 256407138.283 | 3530 | 26.11 | 64895263.78 | 3530 | 26.11 |
| Aliphatics >C21-C35 | 256407138.283 | 3580 | 73.67 | 64895263.78 | 3580 | 73.67 |
| Aliphatics >C35-C44 | 256407138.283 | 1380 | 24.12 | 64895263.78 | 1380 | 24.12 |
| Aromatics >EC5-EC7 | 38.530 | 5 | 0.04 | 9.752 | 5 | 0.04 |
| Aromatics >EC7-EC8 | 801.639 | 20 | 0.05 | 202.890 | 20 | 0.05 |
| Aromatics >EC8-EC10 | 650.327 | 50 | 0.15 | 164.594 | 50 | 0.15 |
| Aromatics >EC10-EC12 | 1027.020 | 658 | 1.38 | 259.933 | *658* | 1.38 |
| Aromatics >EC12-EC16 | 2042.955 | *5280* | 11.65 | 517.061 | *5280* | 11.65 |
| Aromatics >EC16-EC21 | 6446.891 | *9800* | 46.76 | 1631.673 | *9800* | 46.76 |
| Aromatics >EC21-EC35 | 51166.143 | 9010 | 113.58 | 12949.875 | 9010 | 113.58 |
| Aromatics >EC35-EC44 | 51166.143 | 1580 | 40.00 | 12949.875 | 1580 | 40.00 |
| Aromatics >EC40-EC44 | 51166.143 | 724 | 14.87 | 12949.875 | 724 | 14.87 |
| **Polyaromatic Hydrocarbons** | | | | | | |
| Acenaphthylene | 75.733 | *2100* | 2.34950 | 19.168 | *2100* | 2.34950 |
| Acenaphthene | 134.627 | *193* | 0.37333 | 34.073 | *193* | 0.37333 |
| Anthracene | 154.563 | *1860* | 2.77187 | 39.119 | *1860* | 2.77187 |
| Benz(a)anthracene | 2747.512 | 1150 | 3.61643 | 695.380 | *1150* | 3.61643 |
| Benzo(a)pyrene | 156.023 | *714* | 2.91263 | 39.489 | *714* | 2.91263 |
| Benzo(b)fluoranthene | 15.466 | *1110* | 4.13642 | 3.914 | *1110* | 4.13642 |
| Benzo(k)fluoranthene | 22.876 | *373* | 1.62573 | 5.790 | *373* | 1.62573 |
| Benzo(g,h,i)perylene | 60.170 | *333* | 1.97508 | 15.229 | *333* | 1.97508 |
| Chrysene | 2811.508 | 1090 | 3.30131 | 711.578 | *1090* | 3.30131 |
| Dibenzo(a,h)anthracene | 3792.598 | 177 | 0.57527 | 959.886 | 177 | 0.57527 |
| Indeno(1,2,3-cd)pyrene | 114.651 | *374* | 2.03839 | 29.018 | *374* | 2.03839 |
| Fluoranthene | 30.083 | *2940* | 8.95256 | 7.614 | *2940* | 8.95256 |
| Fluorene | 122.786 | *1890* | 2.16433 | 31.077 | *1890* | 2.16433 |
| Naphthalene | 124.264 | *4680* | | 31.450 | *4680* | |
| Phenanthrene | 122.786 | *3810* | | 31.077 | *3810* | |
| Pyrene | 345.946 | 15 | | 87.557 | 15 | |

***Recent analyses carried out from 2017(Master Results)**

**Indicates maximum soil concentration exceeds calculated Re-use Criteria**

# Appendix K: Level 3 Groundwater Excel worksheets

# Hydrogeological risk assessment for land contamination

## Remedial Targets Worksheet , Release 3.2

**First released: 2006. Version 3.2: January 2013**

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination ( Environment Agency 2006).

**Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.**

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The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

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IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

| Details to be completed for each assessment | | | | |
|---|---|---|---|---|
| Site Name: | Glan Llyn | | | |
| Site Address: | Llanwern | | | |
| Completed by: | Ross Cameron | | | |
| Date: | 24-Feb-20 | | Version: | 1 |
| Contaminant | Benzo(a)pyrene | | | |
| Target Concentration ($C_T$) | 0.00000017 | mg/l | Origin of $C_T$: | Proposed Water Framework Directive EQS |

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparision with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).
Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.
Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.
Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.
Data carried forward from an earlier worksheet are identified by a light green background
It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

# Remedial Targets Worksheet , Release 3.2

## Level 1 - Soil

**Select the method of calculating the soil water Partition Co-efficient by using the pull down menu below**

**User specified value for partition coefficient**

| | | | | |
|---|---|---|---|---|
| **Contaminant** | | **Benzo(a)pyrene** | | |
| **Target concentration** | **$C_T$** | **0.00000017** | **mg/l** | |

| **Input Parameters** | **Variable** | **Value** | **Unit** | **Source of parameter value** |
|---|---|---|---|---|
| ***Standard entry*** | | | | |
| Water filled soil porosity | $\theta_W$ | 5.00E-01 | fraction | 0.5 |
| Air filled soil porosity | $\theta a$ | 3.70E-01 | fraction | 0.0037 |
| Bulk density of soil zone material | $\rho$ | 1.36E+00 | g/cm$^3$ | 1.36 |
| Henry's Law constant | H | 1.00E+00 | dimensionless | *1* |
| ***Entry if specify partition coefficient (option)*** | | | | |
| Soil water partition coefficient | Kd | 1.34E+02 | l/kg | *1.34E+02* |
| ***Entry for non-polar organic chemicals (option)*** | | | | |
| Fraction of organic carbon (in soil) | foc | | fraction | |
| Organic carbon partition coefficient | Koc | | l/kg | |
| ***Entry for ionic organic chemicals (option)*** | | | | |
| Sorption coefficient for neutral species | $K_{oc,n}$ | | l/kg | |
| Sorption coefficient for ionised species | $K_{oc,i}$ | | l/kg | |
| pH value | pH | | pH units | |
| Acid dissociation constant | pKa | | | |
| Fraction of organic carbon (in soil) | foc | | fraction | |

This sheet calculates the Level 1 remedial target for soils(mg/kg) based on a selected target concentration and theoretical calculation of soil water partitioning. Three options are included for determining the partition coefficient.

The measured soil concentration as mg/kg should be compared with the Level 1 remedial target to determine the need for further action.

| | | | | |
|---|---|---|---|---|
| **Soil water partition coefficient used in Level Assessment** | **Kd** | **1.34E+02** | **l/kg** | *Specified value* |

### Level 1 Remedial Target

| | | | |
|---|---|---|---|
| **Level 1 Remedial Target** | **2.29E-05** | **mg/kg** | **(for comparison with soil analyses)** |
| | **or** | | |
| | **0.00000017** | **mg/l** | **(for comparison with leachate test results)** |

| | |
|---|---|
| Site being assessed: | Glan Llyn |
| Completed by: | Ross Cameron |
| Date: | 24-Feb-20 |
| Version: | 1 |

# Remedial Targets Worksheet , Release 3.2

## Level 2 - Soil

| | | | | |
|---|---|---|---|---|
| **Contaminant** | | **Benzo(a)pyrene** | | from Level 1 |
| **Target concentration** | **$C_T$** | **0.00000017** | **mg/l** | from Level 1 |

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamiantion' (Environment Agency 2006)

| **Input Parameters** | **Variable** | **Value** | **Unit** | **Source of parameter value** | |
|---|---|---|---|---|---|
| *Standard entry* | | | | | |
| Infiltration | Inf | 0.00E+00 | m/d | | |
| Area of contaminant source | A | 0.00E+00 | $m^2$ | | Not used in calculation |
| *Entry for groundwater flow below site* | | | | | |
| Length of contaminant source in direction of groundwater flow | L | 0.00E+00 | m | | |
| Saturated aquifer thickness | da | 0.00E+00 | m | | |
| Hydraulic Conductivity of aquifer in which dilution occurs | K | 0.00E+00 | m/d | | |
| Hydraulic gradient of water table | i | 0.00E+00 | fraction | | |
| Width of contaminant source perpendicular to groundwater flow | w | 0.00E+00 | m | | Not used in calculation |
| Background concentration of contaminant in groundwater beneath site | Cu | 0.00E+00 | mg/l | | |
| Define mixing zone depth by specifying or calculating depth (using pull down list) | | **Specify** | | | |
| Enter mixing zone thickness | Mz | 0.00E+00 | m | | |
| Calculated mixing zone thickness | Mz | | m | | |

### Calculated Parameters

| | | | | |
|---|---|---|---|---|
| **Dilution Factor** | **DF** | **#DIV/0!** | | |
| **Level 2 Remedial Target** | | **#DIV/0!** | **mg/l** | **For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentrati** |
| | | **or** | | |
| | | **#DIV/0!** | **mg/kg** | **For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water** |

### *Additional option*

**Calculation of impact on receptor**

| | | | | |
|---|---|---|---|---|
| Concentration of contaminant in contaminated discharge (entering receptor) | Cc | 0.00E+00 | mg/l | |
| Calculated concentration within receptor (dilution only) | | #DIV/0! | mg/l | 0 |

| | |
|---|---|
| Site being assessed: | Glan Llyn |
| Completed by: | Ross Cameron |
| Date: | 24-Feb-20 |
| Version: | 1 |

# Remedial Targets Worksheet , Release 3.2

## Level 3 - Soil

See Note

| Input Parameters | Variable | Value | Unit | Source |
|---|---|---|---|---|
| Contaminant | | Benzo(a)pyrene | | from Level 1 |
| Target Concentration | $C_T$ | 0.00000017 | mg/l | from Level 1 |
| Dilution Factor | DF | #DIV/0! | | from Level 2 |

**Select analytical solution (click on brown cell below, then on pull-down menu)**

Ogata Banks — Equations in HRA publication

**Select nature of decay rate (click on brown cell below, then on pull-down menu)**

Approach for simulating degradation of pollutants: Apply degradation rate to pollutants in all phases (e.g. field derived value, l

| | Variable | Value | Unit | Source of parameter value |
|---|---|---|---|---|
| Enter source concentration | | Soil concentration as mg/kg | | |
| Enter soil concentration | | 0 | mg/kg | |
| Half life for degradation of contaminant in water | $t_{1/2}$ | 1.00E+100 | days | |
| Calculated decay rate | λ | 6.93E-101 | $days^{-1}$ | calculated |
| Width of plume in aquifer at source | Sz | 0.00E+00 | m | from Level 2 |
| Plume thickness in aquifer at source | Sy | 0.00E+00 | m | from Level 2 |
| Bulk density of aquifer materials | ρ | 0.00E+00 | $g/cm^3$ | |
| Effective porosity of aquifer | n | 0.00E+00 | fraction | |
| Hydraulic gradient | i | #DIV/0! | fraction | from Level 2 (adjusted) |
| Hydraulic conductivity of saturated aquifer | K | 0.00E+00 | m/d | from Level 2 |
| Distance to compliance point | x | 0.00E+00 | m | |
| Distance (lateral) to compliance point perpendicular to flow direction | z | | m | |
| Distance (depth) to compliance point perpendicular to flow direction | y | | m | |
| Time since pollutant entered groundwater | t | 1.00E+99 | days | *time variant options only* |
| *Parameters values determined from options* | | | | |
| Partition coefficient | Kd | 0.00E+00 | l/kg | *see options* |
| Longitudinal dispersivity | ax | 0.000 | m | *see options* |
| Transverse dispersivity | az | 0.000 | m | *see options* |
| Vertical dispersivity | ay | 0.000 | m | *see options* |

***Parameter values should be checked against Level 1 and 2***

| Calculated Parameters | Variable | | |
|---|---|---|---|
| Groundwater flow velocity | v | #DIV/0! | m/d |
| Retardation factor | Rf | #DIV/0! | fraction |
| Decay rate used | λ | 6.93E-101 | $d^{-1}$ |
| Hydraulic gradient used in aquifer flow down-gradient | i | #DIV/0! | fraction |
| Rate of contaminant flow due to retardation | u | #DIV/0! | m/d |
| Ratio of Compliance Point to Source Concentration | $C_{ED}/C_0$ | #DIV/0! | fraction |
| **Attenuation factor ($C_O/C_{ED}$)** | **AF** | **#DIV/0!** | **fraction** |
| Calculated soil leachate concentration | Co | 0.00E+00 | mg/l |

**Remedial Targets**

| | | | | |
|---|---|---|---|---|
| **Level 3 Remedial Target** | | **#DIV/0!** | **mg/l** | For comparison with measured pore water concentration. |
| Ogata Banks | | **or** | | This assumes Level 1 Remedial Target is based on Target Concentration. |
| | | **#DIV/0!** | **mg/kg** | For comparison with measured soil concentration. This |
| **Distance to compliance point** | | **0** | **m** | assumes Level 1 Remedial Target calculated from soil-water partitioning equation. |
| **Ratio of Compliance Point to Source Concentration** | **$C_{ED}/C_0$** | **#DIV/0!** | **fraction** | Ogata Banks |

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99

**Enter method of defining partition co-efficient (using pull down list)**

Calculate for ionic organic chemicals (acids)

***Entry if specify partition coefficient (option)***

Soil water partition coefficient — Kd — l/kg

***Entry for non-polar organic chemicals (option)***

Fraction of organic carbon in aquifer — foc — fraction
Organic carbon partition coefficient — Koc — l/kg

***Entry for ionic organic chemicals (option)***

| | | | |
|---|---|---|---|
| Sorption coefficient for related species | $K_{oc,n}$ | 0.00E+00 | l/kg |
| Sorption coefficient for ionised species | $K_{oc,i}$ | 0.00E+00 | l/kg |
| pH value | pH | 0.00E+00 | |
| Acid dissociation constant | pKa | 0.00E+00 | |
| Fraction of organic carbon in aquifer | foc | 0.00E+00 | fraction |

Soil water partition coefficient — Kd — 0.00E+00 — l/kg

**Define dispersivity (click brown cell and use pull down list)**

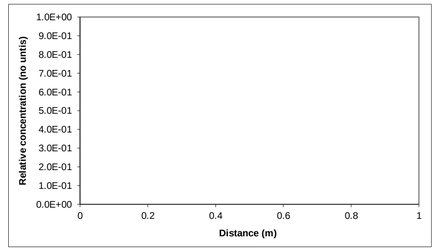
User defined values for dispersivity

| | | Enter value | Calc value | Xu & Eckstein | |
|---|---|---|---|---|---|
| **Longitudinal dispersivity** | **ax** | 0.00E+00 | 0.00E+00 | #NUM! | m |
| **Transverse dispersivity** | **az** | 0.00E+00 | 0.00E+00 | #NUM! | m |
| **Vertical dispersivity** | **ay** | 0.00E+00 | 0.00E+00 | #NUM! | m |

**Note values of dispersivity must be > 0**

Xu & Eckstein (1995) report ax = $0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed

Note
This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by $O_2$, $NO_3$, $SO_4$ etc than an alternative solution should be used




Note: 'Relative concentration' is the ratio of calculated concentation at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

| | |
|---|---|
| Site being assessed: | Glan Llyn |
| Completed by: | Ross Cameron |
| Date: | ######## |
| Version: | 1 |

**Calculated (relative) concentrations for distance-concentration graph**

**Ogata Banks**
**From calculation sheet**

| Distance | Relative concentration (No units) | Concentration mg/l |
|---|---|---|
| **0** | **1.0E+00** | **#DIV/0!** |
| **0.0** | **#DIV/0!** | **#DIV/0!** |
| **0.0** | **#DIV/0!** | **#DIV/0!** |
| **0.0** | **#DIV/0!** | **#DIV/0!** |
| **0.0** | **#DIV/0!** | **#DIV/0!** |
| **0.0** | **#DIV/0!** | **#DIV/0!** |
| **0.0** | **#DIV/0!** | **#DIV/0!** |
| **0.0** | **#DIV/0!** | **#DIV/0!** |
| **0.0** | **#DIV/0!** | **#DIV/0!** |
| **0.0** | **#DIV/0!** | **#DIV/0!** |
| **0.0** | **#DIV/0!** | **#DIV/0!** |
| **0.0** | **#DIV/0!** | **#DIV/0!** |
| **0.0** | **#DIV/0!** | **#DIV/0!** |
| **0.0** | **#DIV/0!** | **#DIV/0!** |
| **0.0** | **#DIV/0!** | **#DIV/0!** |
| **0.0** | **#DIV/0!** | **#DIV/0!** |
| **0.0** | **#DIV/0!** | **#DIV/0!** |
| **0.0** | **#DIV/0!** | **#DIV/0!** |
| **0.0** | **#DIV/0!** | **#DIV/0!** |
| **0.0** | **#DIV/0!** | **#DIV/0!** |
| **0.0** | **#DIV/0!** | **#DIV/0!** |
| **0.0** | **#DIV/0!** | **#DIV/0!** |
| **0.0** | **#DIV/0!** | **#DIV/0!** |
| **0.0** | **#DIV/0!** | **#DIV/0!** |
| **0.0** | **#DIV/0!** | **#DIV/0!** |

# Remedial Targets Worksheet , Release 3.2

## Calculation of contaminant concentration in groundwater from a soil source

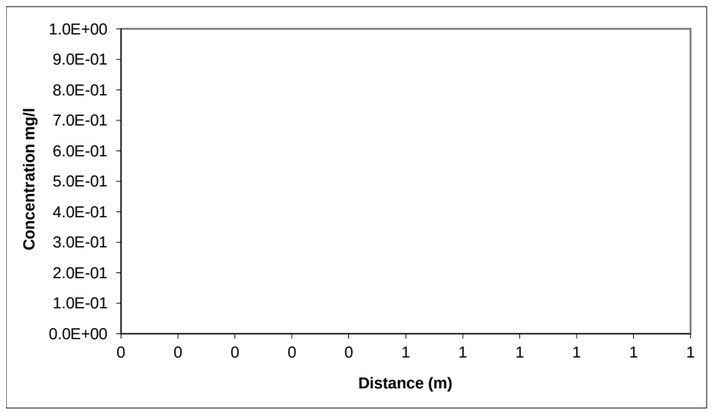
Only input required is Soil Contaminant Concentration

| | | | | |
|---|---|---|---|---|
| | Input Parameters | | | |
| | Soil contaminant concentration | $C_0$ | 0.00E+00 | mg/kg |
| **Level 1 Parameters** | | | | |
| | Water filled soil porosity | $\theta_W$ | 5.00E-01 | fraction |
| | Air filled soil porosity | $\theta a$ | 3.70E-01 | fraction |
| | Bulk density | $\rho$ | 1.36E+00 | g/cm$^3$ |
| | Henry's Law constant | H | 1.00E+00 | dimensionless |
| | Soil water partition coefficient used in Level Assessment | Kd | 1.34E+02 | l/kg |
| | Factor (partitioning between soil and water) | | 1.35E+02 | dimensionless |
| **Level 2 Parameters** | **Dilution Factor** | DF | #DIV/0! | |
| **Level 3 Parameters** | **Attenuation factor ($C_O/C_{ED}$)** | AF | #DIV/0! | |

### Predicted concentrations at compliance point

| | | | | |
|---|---|---|---|---|
| **Level 1** | C | 0.00E+00 | mg/l | No dilution or attenuation |
| **Level 2** | C | #DIV/0! | mg/l | Dilution taken into account |
| **Level 3** | C | #DIV/0! | mg/l | Dilution and attenuation taken into account |

### Predicted concentrations between source and compliance point - Level 3




| Distance m | Concentration mg/l |
|---|---|
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |

# R&D Publication 20 Remedial Targets Worksheet, Release 3.2

## Level 3 - Groundwater

See Note

**Input Parameters (using pull down menu)** | **Variable** | **Value** | **Unit** | **Source**

| | | | | |
|---|---|---|---|---|
| Contaminant | | Benzo(a)pyrene | | from Level 1 |
| Target Concentration | $C_T$ | 1.70E-07 | mg/l | from Level 1 |

**Select analytical solution (click on brown cell below, then on pull-down menu)**

**Domenico - Steady state** — Equations in HRA publication

Approach for simulating vertical dispersion: **Simulate vertical dispersion in 1 direction**

**Select nature of decay rate (click on brown cell below, then on pull-down menu)**

Approach for simulating degradation of pollutants: **Apply degradation rate to dissolved pollutants only**

| | | | | Source of parameter value |
|---|---|---|---|---|
| Initial contaminant concentration in groundwater at plume core | $C_0$ | 2.85E-04 | mg/l | *Based on average soil conc of 2.9mg/kg* |
| Half life for degradation of contaminant in water | $t_{1/2}$ | 3.65E+04 | days | *10 year half life estimation* |
| Calculated decay rate | λ | 1.90E-05 | $days^{-1}$ | |
| Width of plume in aquifer at source (perpendicular to flow) | Sz | 5.00E+02 | m | *Site data* |
| Plume thickness at source | Sy | 1.50E+00 | m | *Thickness of re-engineered MG* |
| Saturated aquifer thickness | da | 2.00E+00 | m | *Based upon proposed total MG and cappir* |
| Bulk density of aquifer materials | ρ | 1.36E+00 | $g/cm^3$ | *Site data* |
| Effective porosity of aquifer | n | 8.00E-02 | fraction | *Estimate* |
| Hydraulic gradient | i | 1.00E-02 | fraction | *Estimate* |
| Hydraulic conductivity of aquifer | K | 8.64E-03 | m/d | *Proposed best achievable* |
| Distance to compliance point | x | 2.00E+01 | m | *Site data* |
| Distance (lateral) to compliance point perpendicular to flow direction | z | | m | |
| Distance (depth) to compliance point perpendicular to flow direction | y | | m | |
| Time since pollutant entered groundwater | t | 1.00E+100 | days | *time variant options only* |
| *Parameters values determined from options* | | | | |
| Partition coefficient | Kd | 1.02E+04 | l/kg | *see options* |
| Longitudinal dispersivity | ax | 2.00E+00 | m | *see options* |
| Transverse dispersivity | az | 2.00E-01 | m | *see options* |
| Vertical dispersivity | ay | 2.00E-02 | m | *see options* |

**Calculated Parameters** | **Variable**

| | | | |
|---|---|---|---|
| Groundwater flow velocity | v | 1.08E-03 | m/d |
| Retardation factor | Rf | 1.73E+05 | fraction |
| Decay rate used | λ | 1.10E-10 | $d^{-1}$ |
| Rate of contaminant flow due to retardation | u | 6.24E-09 | m/d |
| Contaminant concentration at distance x, assuming one-way vertical dispersion | $C_{ED}$ | 1.84E-04 | mg/l |
| **Attenuation factor (one way vertical dispersion, CO/CED)** | **AF** | **1.55E+00** | |

**Select Method for deriving Partition Co-efficient (using pull down menu)**

**User specified value for partition coefficient**

| | | | |
|---|---|---|---|
| ***Entry if specify partition coefficient (option)*** | | | |
| Soil water partition coefficient | Kd | 1.02E+04 | l/kg |
| ***Entry for non-polar organic chemicals (option)*** | | | |
| Fraction of organic carbon in aquifer | foc | | fraction |
| Organic carbon partition coefficient | Koc | | l/kg |
| ***Entry for ionic organic chemicals (option)*** | | | |
| Sorption coefficient for related species | $K_{oc,n}$ | | l/kg |
| Sorption coefficient for ionised species | $K_{oc,i}$ | | l/kg |
| pH value | pH | | |
| acid dissociation constant | pKa | | |
| Fraction of organic carbon in aquifer | foc | | fraction |
| Soil water partition coefficient | Kd | 1.02E+04 | l/kg |

**Define dispersivity (click brown cell and use pull down list)**

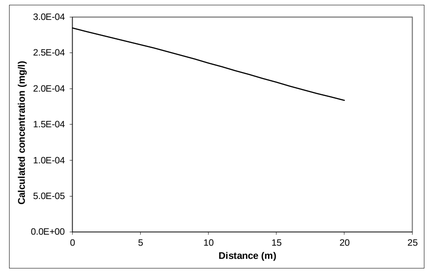
**Dispersivities 10%, 1%, 0.1% of pathway length**

| | | Enter value | Calc value Xu & Eckstein | | |
|---|---|---|---|---|---|
| **Longitudinal dispersivity** | **ax** | 0.00E+00 | 2.00E+00 | 1.57E+00 | m |
| **Transverse dispersivity** | **az** | 0.00E+00 | 2.00E-01 | 1.57E-01 | m |
| **Vertical dispersivity** | **ay** | 0.00E+00 | 2.00E-02 | 1.57E-02 | m |

**Note values of dispersivity must be > 0**

For calculated value, assumes ax = 0.1 *x, az = 0.01 * x, ay = 0.001 * x

Xu & Eckstein (1995) report ax = $0.83(\log_{10}x)^{2.414}$ ; az = ax/10, ay = ax/100 are assumed




Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O2, NO3, SO4 etc than an alternative solution should be used

**Calculated concentrations for distance-concentration graph**

**Domenico - Steady state**
**From calculation sheet**

| Distance | Concentration |
|---|---|
| | mg/l |
| 0 | 2.8E-04 |
| 1.0 | 2.80E-04 |
| 2.0 | 2.75E-04 |
| 3.0 | 2.71E-04 |
| 4.0 | 2.66E-04 |
| 5.0 | 2.61E-04 |
| 6.0 | 2.57E-04 |
| 7.0 | 2.52E-04 |
| 8.0 | 2.47E-04 |
| 9.0 | 2.41E-04 |
| 10.0 | 2.36E-04 |
| 11.0 | 2.31E-04 |
| 12.0 | 2.25E-04 |
| 13.0 | 2.20E-04 |
| 14.0 | 2.14E-04 |
| 15.0 | 2.09E-04 |
| 16.0 | 2.04E-04 |
| 17.0 | 1.99E-04 |
| 18.0 | 1.94E-04 |
| 19.0 | 1.89E-04 |
| 20.0 | 1.84E-04 |

| | |
|---|---|
| Site being assessed: | Glan Llyn |
| Completed by: | Ross Cameron |
| Date: | ######## |
| Version: | 1 |

**Remedial Targets**

| | | | | |
|---|---|---|---|---|
| **Remedial Target** | | **2.64E-07** | **mg/l** | For comparison with measured groundwater concentration. |
| Domenico - Steady state | | | | |
| **Distance to compliance point** | | **20** | **m** | |
| **Concentration of contaminant at compliance point** | **$C_{ED}/C_0$** | **1.84E-04** | **mg/l** | Domenico - Steady state |

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99.

# Porosity Calculator

These results are not carried through to any of the other worksheets

## DRY BULK DENSITY DATA

| Variable | Value | Unit | justification |
|---|---|---|---|
| Natural Moisture Content | 0.00 | % wt | |
| Particle Density | 2.78 | tonnes/m$^3$ | (Change this number only if you have specific information) |
| Dry Bulk Density | 0.00 | tonnes/m$^3$ | |
| *Calculated Parameters* | | | |
| Voids Ratio | #DIV/0! | fraction | |
| Initial Saturation | #DIV/0! | % | |
| **Total porosity** | **1.000** | **fraction** | |
| **Air Filled Porosity** | **#DIV/0!** | **fraction** | |
| **Water Filled Porosity** | **#DIV/0!** | **fraction** | |

## WET BULK DENSITY DATA

| Variable | Value | Unit | |
|---|---|---|---|
| Moisture Content | 0.00 | % wt | |
| Particle Density | 2.78 | tonnes/m$^3$ | (Change this number only if you have specific information) |
| Actual (wet) Bulk Density ( i.e. at natural MC) | 0.00 | tonnes/m$^3$ | |
| *Calculated Parameters* | | | |
| Voids Ratio | #DIV/0! | fraction | |
| dry bulk density | 0.00 | tonnes/m$^3$ | |
| Initial Saturation | #DIV/0! | % | |
| **Total porosity** | **1.000** | **fraction** | **#DIV/0!** |
| **Air Filled Porosity** | **#DIV/0!** | **fraction** | |
| **Water Filled Porosity** | **#DIV/0!** | **fraction** | |

*Analytical solutions provided by David Hall, Golder Associates (UK) Ltd*

# Simple hydrogeological calculations

**(These are not specific to, or required in, the Remedial Targets Methodology)**

| Parameter | symbol | | unit | justification |
|---|---|---|---|---|
| Hydraulic conductivity | K | 0.00E+00 | m/d | |
| Hydraulic gradient | i | 0.00E+00 | unitless | |
| Effective porosity of aquifer | n | 0.00E+00 | fraction | |
| Thickness of saturated aquifer | b | 0.00E+00 | m | |
| Width of aquifer perpendicular to flow | w | 0.00E+00 | m | |
| Distance to receptor | x | 0.00E+00 | m | |
| Bulk density of aquifer materials | ρ | 0.00E+00 | g/cm$^3$ | |
| Soil-water partition co-efficient | Kd | 0.00E+00 | l/kg | |
| Retardation factor of pollutant | R | #DIV/0! | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Groundwater flow velocity | v(GW) | #DIV/0! | m/s | #DIV/0! | m/day | #DIV/0! | m/year |
| Time for groundwater to reach receptor | t(GW) | #DIV/0! | seconds | #DIV/0! | days | #DIV/0! | years |
| Rate of groundwater flow through aquifer | Q | 0.00E+00 | m$^3$/s | 0.00E+00 | m$^3$/day | 0.00E+00 | m$^3$/year |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Contaminant flow velocity | v(contam) | #DIV/0! | m/s | #DIV/0! | m/day | #DIV/0! | m/year |
| Time for contaminant to reach receptor | t(contam) | #DIV/0! | seconds | #DIV/0! | days | #DIV/0! | years |

## Level 1 Calculation Sheet

**Contaminant** **Benzo(a)pyrene**

| **Parameter** (carried over from input sheet) | **Value** | **Units** |
|---|---|---|
| $C_T$ | 1.70E-07 | mg/l |
| Kd | 1.34E+02 | l/kg |
| foc | | fraction |
| koc | | l/kg |
| $\theta_W$ | 5.00E-01 | fraction |
| $\theta a$ | 3.70E-01 | fraction |
| $\rho$ | 1.36E+00 | g/cm3 |
| H | 1.00E+00 | dimensionless |
| Koc,n | | l/kg |
| Koc,i | | l/kg |
| pH | | pH units |
| pKa | | |
| foc (ionic) | | fraction |

**Calculations (Refer toTable 4.3, R&D Publication 20)**

**Selected option** User specified value for partition coefficient

| | calc | calc | Calc Kd | l/kg |
|---|---|---|---|---|
| Calculation of partition coefficient for ionic organic chemical | | | | |
| Partition coefficient used in Level 1 Assessment | | | 1.34E+02 | l/kg |

**Calculated Remedial Target** **2.29E-05 mg/kg** **for Benzo(a)pyrene**

Factor (partitioning between soil and water) 1.35E+02

| | |
|---|---|
| Site being assessed: | Glan Llyn |
| Completed by: | Ross Cameron |
| Date: | 24/02/2020 |
| Version: | 1 |

## Level 2 Calculation Sheet

**Contaminant** **Benzo(a)pyrene**

| Site assessed: | Glan Llyn |
|---|---|
| Date: | 24/02/2020 |
| Version: | 1 |

| Parameter | Value | Units |
|---|---|---|
| (carried over from input sheet) | | |
| Mz | 0.00E+00 | m |
| L | 0.00E+00 | m |
| da | 0.00E+00 | m |
| Inf | 0.00E+00 | m/d |
| K | 0.00E+00 | m/d |
| i | 0.00E+00 | m3/d |
| A | 0.00E+00 | m2 |
| Cc | 0.00E+00 | m3/d mg/l |
| $C_T$ | 1.70E-07 | mg/l |
| Cu | 0.00E+00 | mg/l |
| w | 0.00E+00 | m |

Calculated Dilution Factor

Calculation based on target concentration #DIV/0!

Calculation based on observed contaminant concentration #DIV/0!



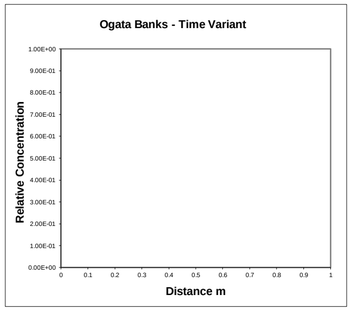
**Contaminant** **Benzo(a)pyrene**

**OGATA BANKS SOLUTION**

Calculations for source located in centre of aquifer (ie vertical dispersion in two directions)

| Input | Value | Units |
|---|---|---|
| $C_T$ | 1.700E-07 | mg/l |
| DF | #DIV/0! | |
| | | |
| λ | 6.931E-101 | days$^{-1}$ |
| Sz | 0.000E+00 | m |
| Sy | 0.000E+00 | m |
| Kd | 0.000E+00 | l/kg |
| ρ | 0.000E+00 | g/cm3 |
| n | 0.000E+00 | |
| i | #DIV/0! | |
| K | 0.000E+00 | m/d |
| x | 0.000E+00 | m |
| z | 0.000E+00 | m |
| y | 0.000E+00 | m |
| t | 1.000E+99 | days |
| ax | 0.000E+00 | m |
| az | 0.000E+00 | m |
| ay | 0.000E+00 | m |

| | X | Term 1 | Term 2 | EXP | Term 3 | ERFC | Term 4 | EXP | Term 5 | ERFC | Term 6a | ERF | Term 6b | ERF | Term 7a | ERF | Term 7b | ERF | Relative Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 2 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 3 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 4 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 5 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 6 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 7 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 8 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 9 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 10 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 11 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 12 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 13 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 14 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 15 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 16 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 17 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 18 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 19 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 20 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |

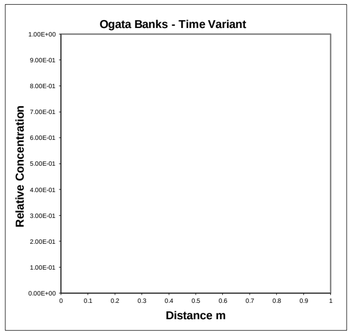



**Calc** **Value**

| | | |
|---|---|---|
| v | #DIV/0! | m/d |
| Rc | #DIV/0! | |
| u | #DIV/0! | m/d |

Calculations for source located at top of aquifer (ie vertical dispersion in one direction) -USED FOR LEVEL ASSESSMENT

| | X | Term 1 | Term 2 | EXP | Term 3 | ERFC | Term 4 | EXP | Term 5 | ERFC | Term 6a | ERF | Term 6b | ERF | Term 7a | ERF | Term 7b | ERF | Relative Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 2 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 3 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 4 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 5 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 6 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 7 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 8 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 9 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 10 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 11 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 12 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 13 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 14 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 15 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 16 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 17 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 18 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 19 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 20 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |




| | |
|---|---|
| Date: | 24/02/2020 |
| Version: | 1 |

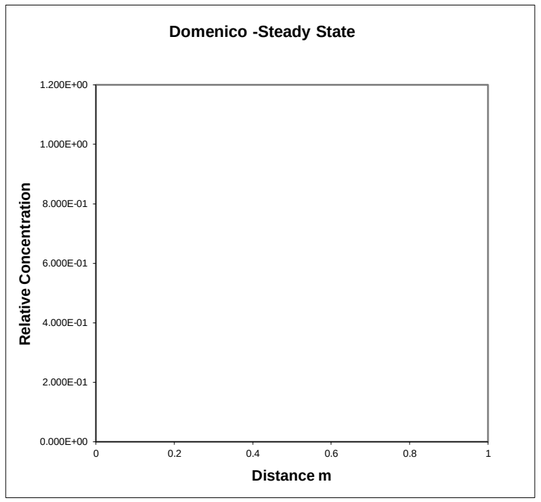
**Contaminant** **Benzo(a)pyrene**

**DOMENICO (STEADY STATE)**

Calculations for source located in centre of aquifer (ie vertical dispersion in two directions)

| Input | Value | Units |
|---|---|---|
| $C_T$ | 1.700E-07 | mg/l |
| DF | #DIV/0! | |
| | | |
| λ | 6.931E-101 | $days^{-1}$ |
| Sz | 0.000E+00 | m |
| Sy | 0.000E+00 | m |
| Kd | 0.000E+00 | l/kg |
| ρ | 0.000E+00 | g/cm3 |
| n | 0.000E+00 | |
| i | #DIV/0! | |
| K | 0.000E+00 | m/d |
| x | 0.000E+00 | m |
| z | 0.000E+00 | m |
| y | 0.000E+00 | m |
| ax | 0.000E+00 | m |
| az | 0.000E+00 | m |
| ay | 0.000E+00 | m |

| | X | Term 1 | Term 2 | EXP | Term 3A | ERF | Term 3B | ERF | Term 4A | ERF | Term 4B | ERF | Relative Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 2 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 3 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 4 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 5 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 6 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 7 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 8 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 9 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 10 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 11 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 12 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 13 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 14 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 15 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 16 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 17 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 18 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 19 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 20 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |

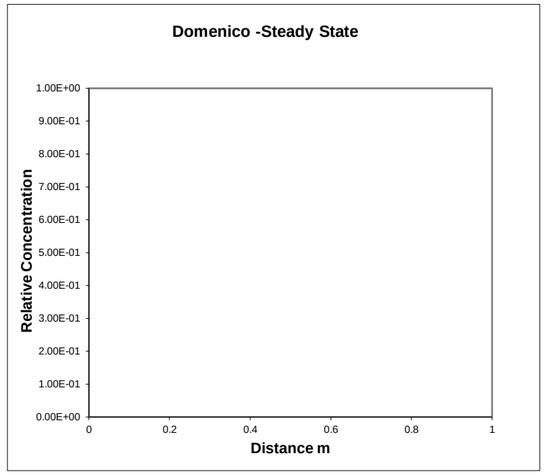



| Calc | Value | Units |
|---|---|---|
| v | #DIV/0! | m/d |
| Rc | #DIV/0! | |
| u | #DIV/0! | m/d |

**DOMENICO (STEADY STATE)**

Calculations for source located at top of aquifer (ie vertical dispersion in one direction) - USED FOR LEVEL ASSESSMENT

| | X | Term 1 | Term 2 | EXP | Term 3A | ERF | Term 3B | ERF | Term 4A | ERF | Term 4B | ERF | Relative Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 2 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 3 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 4 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 5 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 6 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 7 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 8 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 9 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 10 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 11 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 12 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 13 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 14 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 15 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 16 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 17 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 18 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 19 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 20 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |




| | |
|---|---|
| Date: | 24/02/2020 |
| Version: | 1 |

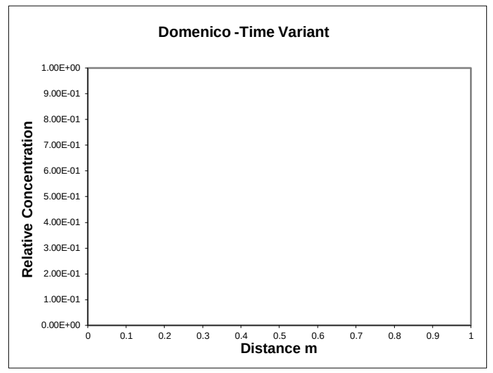
**DOMENICO (TIME VARIANT)**

**Contaminant** Benzo(a)pyrene

| Input | Value | Units |
|---|---|---|
| $C_T$ | 0.00000017 | mg/l |
| DF | #DIV/0! | |
| | | |
| | | |
| λ | 6.931E-101 | $days^{-1}$ |
| Sz | 0.000E+00 | m |
| Sy | 0.000E+00 | m |
| Kd | 0.000E+00 | l/kg |
| ρ | 0.000E+00 | g/cm3 |
| n | 0.000E+00 | |
| i | #DIV/0! | |
| K | 0.000E+00 | m/d |
| x | 0.000E+00 | m |
| z | 0.000E+00 | m |
| y | 0.000E+00 | m |
| t | 1.000E+99 | days |
| ax | 0.000E+00 | m |
| az | 0.000E+00 | m |
| ay | 0.000E+00 | m |

Calculations for source located in centre of aquifer (ie vertical dispersion in two directions)

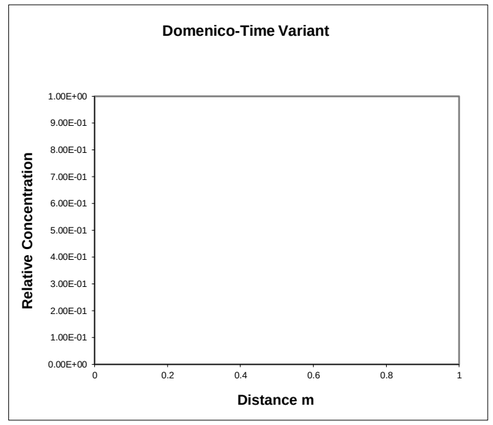
| | X | Term 1 | Term 2 | EXP | Term 3 | ERFC | Term 4A | ERF | Term 4B | ERF | Term 5A | ERF | Term 5B | ERF | Relative Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | m | | | | | | | | | | | | | | |
| 1 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 2 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 3 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 4 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 5 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 6 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 7 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 8 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 9 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 10 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 11 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 12 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 13 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 14 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 15 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 16 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 17 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 18 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 19 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 20 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |




| Calc | Value | |
|---|---|---|
| v | #DIV/0! | m/d |
| Rc | #DIV/0! | |
| u | #DIV/0! | m/d |

Calculations for source located at top of aquifer (ie vertical dispersion in one direction only) - USED FOR LEVEL ASSESSMENT

| | X | Term 1 | Term 2 | EXP | Term 3 | ERFC | Term 4A | ERF | Term 4B | ERF | Term 5A | ERF | Term 5B | ERF | Relative Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | m | | | | | | | | | | | | | | |
| 1 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 2 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 3 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 4 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 5 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 6 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 7 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 8 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 9 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 10 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 11 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 12 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 13 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 14 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 15 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 16 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 17 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 18 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 19 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 20 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |




| | |
|---|---|
| Date: | 24/02/2020 |
| Version: | 1 |

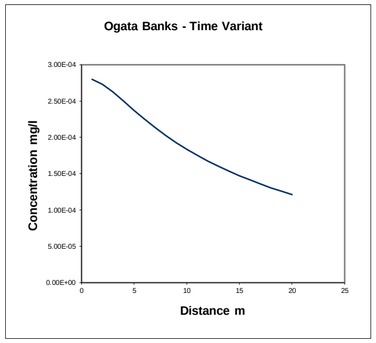
**OGATA BANKS SOLUTION**

| Contaminant | Benzo(a)pyrene | |
|---|---|---|
| **Input** | **Value** | **Units** |
| $C_T$ | 0.00000017 | mg/l |
| Co | 2.85E-04 | mg/l |
| λ | 1.10E-10 | days$^{-1}$ |
| Sz | 5.00E+02 | m |
| Sy | 1.50E+00 | m |
| Kd | 1.02E+04 | l/kg |
| ρ | 1.36E+00 | g/cm3 |
| n | 8.00E-02 | |
| i | 1.00E-02 | |
| K | 8.64E-03 | m/d |
| x | 2.00E+01 | m |
| z | 0.00E+00 | m |
| y | 0.00E+00 | m |
| t | 1.00E+100 | days |
| ax | 2.00E+00 | m |
| az | 2.00E-01 | m |
| ay | 2.00E-02 | m |

Vertical dispersion option Simulate vertical dispersion in 1 direction

Calculations for source located in centre of aquifer (ie vertical dispersion in two directions)

| | X | Term 1 | Term 2 | EXP | Term 3 | ERFC | Term 4 | EXP | Term 5 | ERFC | Term 6a | ERF | Term 6b | ERF | Term 7a | ERF | Term 7b | ERF | Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 3.6E-05 | -1.7E-02 | 9.8E-01 | -3.0E+45 | 2.000 | 5.2E-01 | 1.7E+00 | 3.0E+45 | 0.000 | 2.8E+02 | 1 | -2.8E+02 | -1 | 2.7E+00 | 0.9998 | -2.7E+00 | -0.99982 | 2.80E-04 |
| 2 | 2 | 3.6E-05 | -3.4E-02 | 9.7E-01 | -3.0E+45 | 2.000 | 1.0E+00 | 2.8E+00 | 3.0E+45 | 0.000 | 2.0E+02 | 1 | -2.0E+02 | -1 | 1.9E+00 | 0.992 | -1.9E+00 | -0.99199 | 2.73E-04 |
| 3 | 3 | 3.6E-05 | -5.1E-02 | 9.5E-01 | -3.0E+45 | 2.000 | 1.6E+00 | 4.7E+00 | 3.0E+45 | 0.000 | 1.6E+02 | 1 | -1.6E+02 | -1 | 1.5E+00 | 0.9696 | -1.5E+00 | -0.96962 | 2.62E-04 |
| 4 | 4 | 3.6E-05 | -6.8E-02 | 9.3E-01 | -3.0E+45 | 2.000 | 2.1E+00 | 7.9E+00 | 3.0E+45 | 0.000 | 1.4E+02 | 1 | -1.4E+02 | -1 | 1.3E+00 | 0.9392 | -1.3E+00 | -0.93921 | 2.50E-04 |
| 5 | 5 | 3.6E-05 | -8.5E-02 | 9.2E-01 | -3.0E+45 | 2.000 | 2.6E+00 | 1.3E+01 | 3.0E+45 | 0.000 | 1.3E+02 | 1 | -1.3E+02 | -1 | 1.2E+00 | 0.9065 | -1.2E+00 | -0.90647 | 2.37E-04 |
| 6 | 6 | 3.6E-05 | -1.0E-01 | 9.0E-01 | -3.0E+45 | 2.000 | 3.1E+00 | 2.2E+01 | 3.0E+45 | 0.000 | 1.1E+02 | 1 | -1.1E+02 | -1 | 1.1E+00 | 0.8742 | -1.1E+00 | -0.87421 | 2.25E-04 |
| 7 | 7 | 3.6E-05 | -1.2E-01 | 8.9E-01 | -3.0E+45 | 2.000 | 3.6E+00 | 3.7E+01 | 3.0E+45 | 0.000 | 1.1E+02 | 1 | -1.1E+02 | -1 | 1.0E+00 | 0.8436 | -1.0E+00 | -0.84362 | 2.13E-04 |
| 8 | 8 | 3.6E-05 | -1.4E-01 | 8.7E-01 | -3.0E+45 | 2.000 | 4.1E+00 | 6.3E+01 | 3.0E+45 | 0.000 | 9.9E+01 | 1 | -9.9E+01 | -1 | 9.4E-01 | 0.8151 | -9.4E-01 | -0.8151 | 2.03E-04 |
| 9 | 9 | 3.6E-05 | -1.5E-01 | 8.6E-01 | -3.0E+45 | 2.000 | 4.7E+00 | 1.0E+02 | 3.0E+45 | 0.000 | 9.3E+01 | 1 | -9.3E+01 | -1 | 8.8E-01 | 0.7887 | -8.8E-01 | -0.7887 | 1.93E-04 |
| 10 | 10 | 3.6E-05 | -1.7E-01 | 8.4E-01 | -3.0E+45 | 2.000 | 5.2E+00 | 1.8E+02 | 3.0E+45 | 0.000 | 8.8E+01 | 1 | -8.8E+01 | -1 | 8.4E-01 | 0.7643 | -8.4E-01 | -0.76432 | 1.84E-04 |
| 11 | 11 | 3.6E-05 | -1.9E-01 | 8.3E-01 | -3.0E+45 | 2.000 | 5.7E+00 | 3.0E+02 | 3.0E+45 | 0.000 | 8.4E+01 | 1 | -8.4E+01 | -1 | 8.0E-01 | 0.7418 | -8.0E-01 | -0.7418 | 1.75E-04 |
| 12 | 12 | 3.6E-05 | -2.0E-01 | 8.2E-01 | -3.0E+45 | 2.000 | 6.2E+00 | 4.9E+02 | 3.0E+45 | 0.000 | 8.1E+01 | 1 | -8.1E+01 | -1 | 7.7E-01 | 0.721 | -7.7E-01 | -0.72098 | 1.67E-04 |
| 13 | 13 | 3.6E-05 | -2.2E-01 | 8.0E-01 | -3.0E+45 | 2.000 | 6.7E+00 | 8.3E+02 | 3.0E+45 | 0.000 | 7.8E+01 | 1 | -7.8E+01 | -1 | 7.4E-01 | 0.7017 | -7.4E-01 | -0.70169 | 1.60E-04 |
| 14 | 14 | 3.6E-05 | -2.4E-01 | 7.9E-01 | -3.0E+45 | 2.000 | 7.2E+00 | 1.4E+03 | 3.0E+45 | 0.000 | 7.5E+01 | 1 | -7.5E+01 | -1 | 7.1E-01 | 0.6838 | -7.1E-01 | -0.68377 | 1.53E-04 |
| 15 | 15 | 3.6E-05 | -2.6E-01 | 7.7E-01 | -3.0E+45 | 2.000 | 7.8E+00 | 2.3E+03 | 3.0E+45 | 0.000 | 7.2E+01 | 1 | -7.2E+01 | -1 | 6.8E-01 | 0.6671 | -6.8E-01 | -0.66708 | 1.47E-04 |
| 16 | 16 | 3.6E-05 | -2.7E-01 | 7.6E-01 | -3.0E+45 | 2.000 | 8.3E+00 | 3.9E+03 | 3.0E+45 | 0.000 | 7.0E+01 | 1 | -7.0E+01 | -1 | 6.6E-01 | 0.6515 | -6.6E-01 | -0.6515 | 1.41E-04 |
| 17 | 17 | 3.6E-05 | -2.9E-01 | 7.5E-01 | -3.0E+45 | 2.000 | 8.8E+00 | 6.6E+03 | 3.0E+45 | 0.000 | 6.8E+01 | 1 | -6.8E+01 | -1 | 6.4E-01 | 0.6369 | -6.4E-01 | -0.63692 | 1.36E-04 |
| 18 | 18 | 3.6E-05 | -3.1E-01 | 7.4E-01 | -3.0E+45 | 2.000 | 9.3E+00 | 1.1E+04 | 3.0E+45 | 0.000 | 6.6E+01 | 1 | -6.6E+01 | -1 | 6.3E-01 | 0.6232 | -6.3E-01 | -0.62324 | 1.31E-04 |
| 19 | 19 | 3.6E-05 | -3.2E-01 | 7.2E-01 | -3.0E+45 | 2.000 | 9.8E+00 | 1.8E+04 | 3.0E+45 | 0.000 | 6.4E+01 | 1 | -6.4E+01 | -1 | 6.1E-01 | 0.6104 | -6.1E-01 | -0.61038 | 1.26E-04 |
| 20 | 20 | 3.6E-05 | -3.4E-01 | 7.1E-01 | -3.0E+45 | 2.000 | 1.0E+01 | 3.1E+04 | 3.0E+45 | 0.000 | 6.3E+01 | 1 | -6.3E+01 | -1 | 5.9E-01 | 0.5983 | -5.9E-01 | -0.59826 | 1.21E-04 |




| Calc | Value | |
|---|---|---|
| v | 1.08E-03 | m/d |
| Rc | 1.73E+05 | |
| u | 6.24E-09 | m/d |

Calculations for source located at top of aquifer (ie vertical dispersion in one direction) - USED FOR LEVEL ASSESSMENT

| | X | Term 1 | Term 2 | EXP | Term 3 | ERFC | Term 4 | EXP | Term 5 | ERFC | Term 6a | ERF | Term 6b | ERF | Term 7a | ERF | Term 7b | ERF | Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 3.6E-05 | -1.7E-02 | 9.8E-01 | -3.0E+45 | 2.000 | 5.2E-01 | 1.7E+00 | 3.0E+45 | 0.000 | 2.8E+02 | 1 | -2.8E+02 | -1 | 5.3E+00 | 1 | -5.3E+00 | -1 | 2.80E-04 |
| 2 | 2 | 3.6E-05 | -3.4E-02 | 9.7E-01 | -3.0E+45 | 2.000 | 1.0E+00 | 2.8E+00 | 3.0E+45 | 0.000 | 2.0E+02 | 1 | -2.0E+02 | -1 | 3.8E+00 | 1 | -3.8E+00 | -1 | 2.75E-04 |
| 3 | 3 | 3.6E-05 | -5.1E-02 | 9.5E-01 | -3.0E+45 | 2.000 | 1.6E+00 | 4.7E+00 | 3.0E+45 | 0.000 | 1.6E+02 | 1 | -1.6E+02 | -1 | 3.1E+00 | 1 | -3.1E+00 | -0.99999 | 2.71E-04 |
| 4 | 4 | 3.6E-05 | -6.8E-02 | 9.3E-01 | -3.0E+45 | 2.000 | 2.1E+00 | 7.9E+00 | 3.0E+45 | 0.000 | 1.4E+02 | 1 | -1.4E+02 | -1 | 2.7E+00 | 0.9998 | -2.7E+00 | -0.99982 | 2.66E-04 |
| 5 | 5 | 3.6E-05 | -8.5E-02 | 9.2E-01 | -3.0E+45 | 2.000 | 2.6E+00 | 1.3E+01 | 3.0E+45 | 0.000 | 1.3E+02 | 1 | -1.3E+02 | -1 | 2.4E+00 | 0.9992 | -2.4E+00 | -0.9992 | 2.61E-04 |
| 6 | 6 | 3.6E-05 | -1.0E-01 | 9.0E-01 | -3.0E+45 | 2.000 | 3.1E+00 | 2.2E+01 | 3.0E+45 | 0.000 | 1.1E+02 | 1 | -1.1E+02 | -1 | 2.2E+00 | 0.9978 | -2.2E+00 | -0.9978 | 2.57E-04 |
| 7 | 7 | 3.6E-05 | -1.2E-01 | 8.9E-01 | -3.0E+45 | 2.000 | 3.6E+00 | 3.7E+01 | 3.0E+45 | 0.000 | 1.1E+02 | 1 | -1.1E+02 | -1 | 2.0E+00 | 0.9954 | -2.0E+00 | -0.99541 | 2.52E-04 |
| 8 | 8 | 3.6E-05 | -1.4E-01 | 8.7E-01 | -3.0E+45 | 2.000 | 4.1E+00 | 6.3E+01 | 3.0E+45 | 0.000 | 9.9E+01 | 1 | -9.9E+01 | -1 | 1.9E+00 | 0.992 | -1.9E+00 | -0.99199 | 2.47E-04 |
| 9 | 9 | 3.6E-05 | -1.5E-01 | 8.6E-01 | -3.0E+45 | 2.000 | 4.7E+00 | 1.0E+02 | 3.0E+45 | 0.000 | 9.3E+01 | 1 | -9.3E+01 | -1 | 1.8E+00 | 0.9876 | -1.8E+00 | -0.98758 | 2.41E-04 |
| 10 | 10 | 3.6E-05 | -1.7E-01 | 8.4E-01 | -3.0E+45 | 2.000 | 5.2E+00 | 1.8E+02 | 3.0E+45 | 0.000 | 8.8E+01 | 1 | -8.8E+01 | -1 | 1.7E+00 | 0.9823 | -1.7E+00 | -0.98229 | 2.36E-04 |
| 11 | 11 | 3.6E-05 | -1.9E-01 | 8.3E-01 | -3.0E+45 | 2.000 | 5.7E+00 | 3.0E+02 | 3.0E+45 | 0.000 | 8.4E+01 | 1 | -8.4E+01 | -1 | 1.6E+00 | 0.9763 | -1.6E+00 | -0.97626 | 2.31E-04 |
| 12 | 12 | 3.6E-05 | -2.0E-01 | 8.2E-01 | -3.0E+45 | 2.000 | 6.2E+00 | 4.9E+02 | 3.0E+45 | 0.000 | 8.1E+01 | 1 | -8.1E+01 | -1 | 1.5E+00 | 0.9696 | -1.5E+00 | -0.96962 | 2.25E-04 |
| 13 | 13 | 3.6E-05 | -2.2E-01 | 8.0E-01 | -3.0E+45 | 2.000 | 6.7E+00 | 8.3E+02 | 3.0E+45 | 0.000 | 7.8E+01 | 1 | -7.8E+01 | -1 | 1.5E+00 | 0.9625 | -1.5E+00 | -0.96249 | 2.20E-04 |
| 14 | 14 | 3.6E-05 | -2.4E-01 | 7.9E-01 | -3.0E+45 | 2.000 | 7.2E+00 | 1.4E+03 | 3.0E+45 | 0.000 | 7.5E+01 | 1 | -7.5E+01 | -1 | 1.4E+00 | 0.955 | -1.4E+00 | -0.95498 | 2.14E-04 |
| 15 | 15 | 3.6E-05 | -2.6E-01 | 7.7E-01 | -3.0E+45 | 2.000 | 7.8E+00 | 2.3E+03 | 3.0E+45 | 0.000 | 7.2E+01 | 1 | -7.2E+01 | -1 | 1.4E+00 | 0.9472 | -1.4E+00 | -0.94719 | 2.09E-04 |
| 16 | 16 | 3.6E-05 | -2.7E-01 | 7.6E-01 | -3.0E+45 | 2.000 | 8.3E+00 | 3.9E+03 | 3.0E+45 | 0.000 | 7.0E+01 | 1 | -7.0E+01 | -1 | 1.3E+00 | 0.9392 | -1.3E+00 | -0.93921 | 2.04E-04 |
| 17 | 17 | 3.6E-05 | -2.9E-01 | 7.5E-01 | -3.0E+45 | 2.000 | 8.8E+00 | 6.6E+03 | 3.0E+45 | 0.000 | 6.8E+01 | 1 | -6.8E+01 | -1 | 1.3E+00 | 0.9311 | -1.3E+00 | -0.93109 | 1.99E-04 |
| 18 | 18 | 3.6E-05 | -3.1E-01 | 7.4E-01 | -3.0E+45 | 2.000 | 9.3E+00 | 1.1E+04 | 3.0E+45 | 0.000 | 6.6E+01 | 1 | -6.6E+01 | -1 | 1.3E+00 | 0.9229 | -1.3E+00 | -0.9229 | 1.94E-04 |
| 19 | 19 | 3.6E-05 | -3.2E-01 | 7.2E-01 | -3.0E+45 | 2.000 | 9.8E+00 | 1.8E+04 | 3.0E+45 | 0.000 | 6.4E+01 | 1 | -6.4E+01 | -1 | 1.2E+00 | 0.9147 | -1.2E+00 | -0.91468 | 1.89E-04 |
| 20 | 20 | 3.6E-05 | -3.4E-01 | 7.1E-01 | -3.0E+45 | 2.000 | 1.0E+01 | 3.1E+04 | 3.0E+45 | 0.000 | 6.3E+01 | 1 | -6.3E+01 | -1 | 1.2E+00 | 0.9065 | -1.2E+00 | -0.90647 | 1.84E-04 |




| | |
|---|---|
| Date: | 24/02/2020 |
| Version: | 1 |

**Contaminant** **Benzo(a)pyrene**

| Input | Value | Units |
|---|---|---|
| $C_T$ | 0.00000017 | mg/l |
| | | |
| Co | 2.85E-04 | mg/l |
| λ | 1.10E-10 | days$^{-1}$ |
| Sz | 5.00E+02 | m |
| Sy | 1.50E+00 | m |
| Kd | 1.02E+04 | l/kg |
| ρ | 1.36E+00 | g/cm3 |
| n | 8.00E-02 | |
| i | 1.00E-02 | |
| K | 8.64E-03 | m/d |
| x | 2.00E+01 | m |
| z | 0.00E+00 | m |
| y | 0.00E+00 | m |
| | | |
| ax | 2.00E+00 | m |
| az | 2.00E-01 | m |
| ay | 2.00E-02 | m |

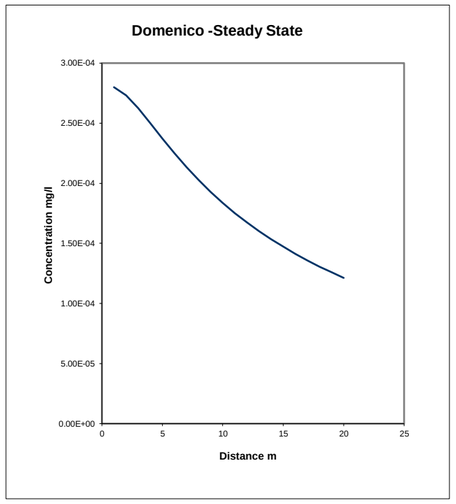
Vertical dispersion optio Simulate vertical dispersion in 1 direction

| Calc | Value | Units |
|---|---|---|
| v | 1.08E-03 | m/d |
| Rc | 1.73E+05 | |
| u | 6.24E-09 | m/d |

**DOMENICO (STEADY STATE)**

Calculations for source located in centre of aquifer (ie vertical dispersion in two directions)

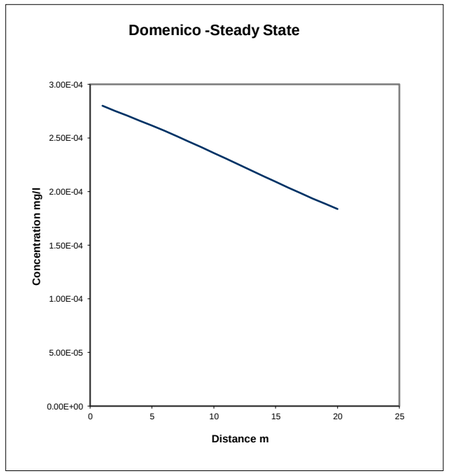
| | X | Term 1 | Term 2 | EXP | Term 3A | ERF | Term 3B | ERF | Term 4A | ERF | Term 4B | ERF | Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 7.1E-05 | -1.70E-02 | 9.83E-01 | 2.80E+02 | 1 | -2.80E+02 | -1 | 2.65E+00 | 0.9998 | -2.65E+00 | -0.9998 | 2.80E-04 |
| 2 | 2 | 7.1E-05 | -3.40E-02 | 9.67E-01 | 1.98E+02 | 1 | -1.98E+02 | -1 | 1.88E+00 | 0.992 | -1.88E+00 | -0.992 | 2.73E-04 |
| 3 | 3 | 7.1E-05 | -5.10E-02 | 9.50E-01 | 1.61E+02 | 1 | -1.61E+02 | -1 | 1.53E+00 | 0.9696 | -1.53E+00 | -0.9696 | 2.62E-04 |
| 4 | 4 | 7.1E-05 | -6.80E-02 | 9.34E-01 | 1.40E+02 | 1 | -1.40E+02 | -1 | 1.33E+00 | 0.9392 | -1.33E+00 | -0.9392 | 2.50E-04 |
| 5 | 5 | 7.1E-05 | -8.50E-02 | 9.18E-01 | 1.25E+02 | 1 | -1.25E+02 | -1 | 1.19E+00 | 0.9065 | -1.19E+00 | -0.9065 | 2.37E-04 |
| 6 | 6 | 7.1E-05 | -1.02E-01 | 9.03E-01 | 1.14E+02 | 1 | -1.14E+02 | -1 | 1.08E+00 | 0.8742 | -1.08E+00 | -0.8742 | 2.25E-04 |
| 7 | 7 | 7.1E-05 | -1.19E-01 | 8.88E-01 | 1.06E+02 | 1 | -1.06E+02 | -1 | 1.00E+00 | 0.8436 | -1.00E+00 | -0.8436 | 2.13E-04 |
| 8 | 8 | 7.1E-05 | -1.36E-01 | 8.73E-01 | 9.88E+01 | 1 | -9.88E+01 | -1 | 9.38E-01 | 0.8151 | -9.38E-01 | -0.8151 | 2.03E-04 |
| 9 | 9 | 7.1E-05 | -1.53E-01 | 8.58E-01 | 9.32E+01 | 1 | -9.32E+01 | -1 | 8.84E-01 | 0.7887 | -8.84E-01 | -0.7887 | 1.93E-04 |
| 10 | 10 | 7.1E-05 | -1.70E-01 | 8.44E-01 | 8.84E+01 | 1 | -8.84E+01 | -1 | 8.39E-01 | 0.7643 | -8.39E-01 | -0.7643 | 1.84E-04 |
| 11 | 11 | 7.1E-05 | -1.87E-01 | 8.29E-01 | 8.43E+01 | 1 | -8.43E+01 | -1 | 8.00E-01 | 0.7418 | -8.00E-01 | -0.7418 | 1.75E-04 |
| 12 | 12 | 7.1E-05 | -2.04E-01 | 8.15E-01 | 8.07E+01 | 1 | -8.07E+01 | -1 | 7.65E-01 | 0.721 | -7.65E-01 | -0.721 | 1.67E-04 |
| 13 | 13 | 7.1E-05 | -2.21E-01 | 8.02E-01 | 7.75E+01 | 1 | -7.75E+01 | -1 | 7.35E-01 | 0.7017 | -7.35E-01 | -0.7017 | 1.60E-04 |
| 14 | 14 | 7.1E-05 | -2.38E-01 | 7.88E-01 | 7.47E+01 | 1 | -7.47E+01 | -1 | 7.09E-01 | 0.6838 | -7.09E-01 | -0.6838 | 1.53E-04 |
| 15 | 15 | 7.1E-05 | -2.55E-01 | 7.75E-01 | 7.22E+01 | 1 | -7.22E+01 | -1 | 6.85E-01 | 0.6671 | -6.85E-01 | -0.6671 | 1.47E-04 |
| 16 | 16 | 7.1E-05 | -2.72E-01 | 7.62E-01 | 6.99E+01 | 1 | -6.99E+01 | -1 | 6.63E-01 | 0.6515 | -6.63E-01 | -0.6515 | 1.41E-04 |
| 17 | 17 | 7.1E-05 | -2.89E-01 | 7.49E-01 | 6.78E+01 | 1 | -6.78E+01 | -1 | 6.43E-01 | 0.6369 | -6.43E-01 | -0.6369 | 1.36E-04 |
| 18 | 18 | 7.1E-05 | -3.06E-01 | 7.36E-01 | 6.59E+01 | 1 | -6.59E+01 | -1 | 6.25E-01 | 0.6232 | -6.25E-01 | -0.6232 | 1.31E-04 |
| 19 | 19 | 7.1E-05 | -3.23E-01 | 7.24E-01 | 6.41E+01 | 1 | -6.41E+01 | -1 | 6.08E-01 | 0.6104 | -6.08E-01 | -0.6104 | 1.26E-04 |
| 20 | 20 | 7.1E-05 | -3.40E-01 | 7.12E-01 | 6.25E+01 | 1 | -6.25E+01 | -1 | 5.93E-01 | 0.5983 | -5.93E-01 | -0.5983 | 1.21E-04 |




**DOMENICO (STEADY STATE)**

Calculations for source located at top of aquifer (ie vertical dispersion in one direction) - USED FOR LEVEL ASSESSMENT

| | X | Term 1 | Term 2 | EXP | Term 3A | ERF | Term 3B | ERF | Term 4A | ERF | Term 4B | ERF | Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 7.1E-05 | -1.70E-02 | 9.83E-01 | 2.80E+02 | 1 | -2.80E+02 | -1 | 5.30E+00 | 1 | -5.30E+00 | -1 | 2.80E-04 |
| 2 | 2 | 7.1E-05 | -3.40E-02 | 9.67E-01 | 1.98E+02 | 1 | -1.98E+02 | -1 | 3.75E+00 | 1 | -3.75E+00 | -1 | 2.75E-04 |
| 3 | 3 | 7.1E-05 | -5.10E-02 | 9.50E-01 | 1.61E+02 | 1 | -1.61E+02 | -1 | 3.06E+00 | 1 | -3.06E+00 | -1 | 2.71E-04 |
| 4 | 4 | 7.1E-05 | -6.80E-02 | 9.34E-01 | 1.40E+02 | 1 | -1.40E+02 | -1 | 2.65E+00 | 0.9998 | -2.65E+00 | -0.9998 | 2.66E-04 |
| 5 | 5 | 7.1E-05 | -8.50E-02 | 9.18E-01 | 1.25E+02 | 1 | -1.25E+02 | -1 | 2.37E+00 | 0.9992 | -2.37E+00 | -0.9992 | 2.61E-04 |
| 6 | 6 | 7.1E-05 | -1.02E-01 | 9.03E-01 | 1.14E+02 | 1 | -1.14E+02 | -1 | 2.17E+00 | 0.9978 | -2.17E+00 | -0.9978 | 2.57E-04 |
| 7 | 7 | 7.1E-05 | -1.19E-01 | 8.88E-01 | 1.06E+02 | 1 | -1.06E+02 | -1 | 2.00E+00 | 0.9954 | -2.00E+00 | -0.9954 | 2.52E-04 |
| 8 | 8 | 7.1E-05 | -1.36E-01 | 8.73E-01 | 9.88E+01 | 1 | -9.88E+01 | -1 | 1.88E+00 | 0.992 | -1.88E+00 | -0.992 | 2.47E-04 |
| 9 | 9 | 7.1E-05 | -1.53E-01 | 8.58E-01 | 9.32E+01 | 1 | -9.32E+01 | -1 | 1.77E+00 | 0.9876 | -1.77E+00 | -0.9876 | 2.41E-04 |
| 10 | 10 | 7.1E-05 | -1.70E-01 | 8.44E-01 | 8.84E+01 | 1 | -8.84E+01 | -1 | 1.68E+00 | 0.9823 | -1.68E+00 | -0.9823 | 2.36E-04 |
| 11 | 11 | 7.1E-05 | -1.87E-01 | 8.29E-01 | 8.43E+01 | 1 | -8.43E+01 | -1 | 1.60E+00 | 0.9763 | -1.60E+00 | -0.9763 | 2.31E-04 |
| 12 | 12 | 7.1E-05 | -2.04E-01 | 8.15E-01 | 8.07E+01 | 1 | -8.07E+01 | -1 | 1.53E+00 | 0.9696 | -1.53E+00 | -0.9696 | 2.25E-04 |
| 13 | 13 | 7.1E-05 | -2.21E-01 | 8.02E-01 | 7.75E+01 | 1 | -7.75E+01 | -1 | 1.47E+00 | 0.9625 | -1.47E+00 | -0.9625 | 2.20E-04 |
| 14 | 14 | 7.1E-05 | -2.38E-01 | 7.88E-01 | 7.47E+01 | 1 | -7.47E+01 | -1 | 1.42E+00 | 0.955 | -1.42E+00 | -0.955 | 2.14E-04 |
| 15 | 15 | 7.1E-05 | -2.55E-01 | 7.75E-01 | 7.22E+01 | 1 | -7.22E+01 | -1 | 1.37E+00 | 0.9472 | -1.37E+00 | -0.9472 | 2.09E-04 |
| 16 | 16 | 7.1E-05 | -2.72E-01 | 7.62E-01 | 6.99E+01 | 1 | -6.99E+01 | -1 | 1.33E+00 | 0.9392 | -1.33E+00 | -0.9392 | 2.04E-04 |
| 17 | 17 | 7.1E-05 | -2.89E-01 | 7.49E-01 | 6.78E+01 | 1 | -6.78E+01 | -1 | 1.29E+00 | 0.9311 | -1.29E+00 | -0.9311 | 1.99E-04 |
| 18 | 18 | 7.1E-05 | -3.06E-01 | 7.36E-01 | 6.59E+01 | 1 | -6.59E+01 | -1 | 1.25E+00 | 0.9229 | -1.25E+00 | -0.9229 | 1.94E-04 |
| 19 | 19 | 7.1E-05 | -3.23E-01 | 7.24E-01 | 6.41E+01 | 1 | -6.41E+01 | -1 | 1.22E+00 | 0.9147 | -1.22E+00 | -0.9147 | 1.89E-04 |
| 20 | 20 | 7.1E-05 | -3.40E-01 | 7.12E-01 | 6.25E+01 | 1 | -6.25E+01 | -1 | 1.19E+00 | 0.9065 | -1.19E+00 | -0.9065 | 1.84E-04 |




| | |
|---|---|
| Date: | 24/02/2020 |
| Version: | 1 |

## DOMENICO (TIME VARIANT)

**Contaminant** Benzo(a)pyrene

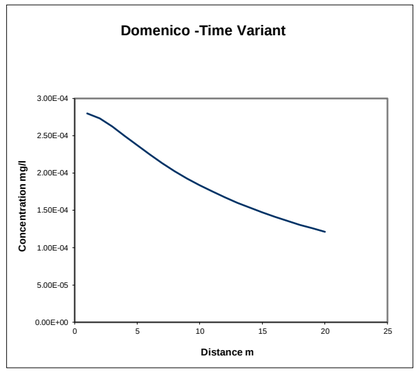
| Input | Value | Units |
|---|---|---|
| $C_T$ | 0.00000017 | mg/l |
| Co | 2.85E-04 | mg/l |
| λ | 1.10E-10 | $days^{-1}$ |
| Sz | 5.00E+02 | m |
| Sy | 1.50E+00 | m |
| Kd | 1.02E+04 | l/kg |
| ρ | 1.36E+00 | g/cm3 |
| n | 8.00E-02 | |
| i | 1.00E-02 | |
| K | 8.64E-03 | m/d |
| x | 2.00E+01 | m |
| z | 0.00E+00 | m |
| y | 0.00E+00 | m |
| t | 1.00E+100 | days |
| ax | 2.00E+00 | m |
| az | 2.00E-01 | m |
| ay | 2.00E-02 | m |

Vertical dispersion option Simulate vertical dispersion in 1 direction

| Calc | Value | |
|---|---|---|
| v | 1.08E-03 | m/d |
| Rc | 1.73E+05 | |
| u | 6.24E-09 | m/d |

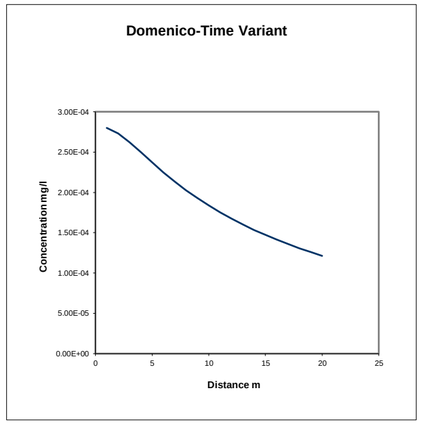
Calculations for source located in centre of aquifer (ie vertical dispersion in two directions)

| | X | Term 1 | Term 2 | EXP | Term 3 | ERFC | Term 4A | ERF | Term 4B | ERF | Term 5A | ERF | Term 5B | ERF | Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | m | | | | | | | | | | | | | | |
| 1 | 1 | 3.6E-05 | -1.70E-02 | 9.83E-01 | -2.98E+45 | 2 | 2.80E+02 | 1 | -2.80E+02 | -1 | 2.65E+00 | 0.9998 | -2.65E+00 | -1 | 2.80E-04 |
| 2 | 2 | 3.6E-05 | -3.40E-02 | 9.67E-01 | -2.98E+45 | 2 | 1.98E+02 | 1 | -1.98E+02 | -1 | 1.88E+00 | 0.992 | -1.88E+00 | -0.992 | 2.73E-04 |
| 3 | 3 | 3.6E-05 | -5.10E-02 | 9.50E-01 | -2.98E+45 | 2 | 1.61E+02 | 1 | -1.61E+02 | -1 | 1.53E+00 | 0.9696 | -1.53E+00 | -0.97 | 2.62E-04 |
| 4 | 4 | 3.6E-05 | -6.80E-02 | 9.34E-01 | -2.98E+45 | 2 | 1.40E+02 | 1 | -1.40E+02 | -1 | 1.33E+00 | 0.9392 | -1.33E+00 | -0.939 | 2.50E-04 |
| 5 | 5 | 3.6E-05 | -8.50E-02 | 9.18E-01 | -2.98E+45 | 2 | 1.25E+02 | 1 | -1.25E+02 | -1 | 1.19E+00 | 0.9065 | -1.19E+00 | -0.906 | 2.37E-04 |
| 6 | 6 | 3.6E-05 | -1.02E-01 | 9.03E-01 | -2.98E+45 | 2 | 1.14E+02 | 1 | -1.14E+02 | -1 | 1.08E+00 | 0.8742 | -1.08E+00 | -0.874 | 2.25E-04 |
| 7 | 7 | 3.6E-05 | -1.19E-01 | 8.88E-01 | -2.98E+45 | 2 | 1.06E+02 | 1 | -1.06E+02 | -1 | 1.00E+00 | 0.8436 | -1.00E+00 | -0.844 | 2.13E-04 |
| 8 | 8 | 3.6E-05 | -1.36E-01 | 8.73E-01 | -2.98E+45 | 2 | 9.88E+01 | 1 | -9.88E+01 | -1 | 9.38E-01 | 0.8151 | -9.38E-01 | -0.815 | 2.03E-04 |
| 9 | 9 | 3.6E-05 | -1.53E-01 | 8.58E-01 | -2.98E+45 | 2 | 9.32E+01 | 1 | -9.32E+01 | -1 | 8.84E-01 | 0.7887 | -8.84E-01 | -0.789 | 1.93E-04 |
| 10 | 10 | 3.6E-05 | -1.70E-01 | 8.44E-01 | -2.98E+45 | 2 | 8.84E+01 | 1 | -8.84E+01 | -1 | 8.39E-01 | 0.7643 | -8.39E-01 | -0.764 | 1.84E-04 |
| 11 | 11 | 3.6E-05 | -1.87E-01 | 8.29E-01 | -2.98E+45 | 2 | 8.43E+01 | 1 | -8.43E+01 | -1 | 8.00E-01 | 0.7418 | -8.00E-01 | -0.742 | 1.75E-04 |
| 12 | 12 | 3.6E-05 | -2.04E-01 | 8.15E-01 | -2.98E+45 | 2 | 8.07E+01 | 1 | -8.07E+01 | -1 | 7.65E-01 | 0.721 | -7.65E-01 | -0.721 | 1.67E-04 |
| 13 | 13 | 3.6E-05 | -2.21E-01 | 8.02E-01 | -2.98E+45 | 2 | 7.75E+01 | 1 | -7.75E+01 | -1 | 7.35E-01 | 0.7017 | -7.35E-01 | -0.702 | 1.60E-04 |
| 14 | 14 | 3.6E-05 | -2.38E-01 | 7.88E-01 | -2.98E+45 | 2 | 7.47E+01 | 1 | -7.47E+01 | -1 | 7.09E-01 | 0.6838 | -7.09E-01 | -0.684 | 1.53E-04 |
| 15 | 15 | 3.6E-05 | -2.55E-01 | 7.75E-01 | -2.98E+45 | 2 | 7.22E+01 | 1 | -7.22E+01 | -1 | 6.85E-01 | 0.6671 | -6.85E-01 | -0.667 | 1.47E-04 |
| 16 | 16 | 3.6E-05 | -2.72E-01 | 7.62E-01 | -2.98E+45 | 2 | 6.99E+01 | 1 | -6.99E+01 | -1 | 6.63E-01 | 0.6515 | -6.63E-01 | -0.651 | 1.41E-04 |
| 17 | 17 | 3.6E-05 | -2.89E-01 | 7.49E-01 | -2.98E+45 | 2 | 6.78E+01 | 1 | -6.78E+01 | -1 | 6.43E-01 | 0.6369 | -6.43E-01 | -0.637 | 1.36E-04 |
| 18 | 18 | 3.6E-05 | -3.06E-01 | 7.36E-01 | -2.98E+45 | 2 | 6.59E+01 | 1 | -6.59E+01 | -1 | 6.25E-01 | 0.6232 | -6.25E-01 | -0.623 | 1.31E-04 |
| 19 | 19 | 3.6E-05 | -3.23E-01 | 7.24E-01 | -2.98E+45 | 2 | 6.41E+01 | 1 | -6.41E+01 | -1 | 6.08E-01 | 0.6104 | -6.08E-01 | -0.61 | 1.26E-04 |
| 20 | 20 | 3.6E-05 | -3.40E-01 | 7.12E-01 | -2.98E+45 | 2 | 6.25E+01 | 1 | -6.25E+01 | -1 | 5.93E-01 | 0.5983 | -5.93E-01 | -0.598 | 1.21E-04 |




Calculations for source located at top of aquifer (ie vertical dispersion in one direction only) - USED FOR LEVEL ASSESSMENT

| | X | Term 1 | Term 2 | EXP | Term 3 | ERFC | Term 4A | ERF | Term 4B | ERF | Term 5A | ERF | Term 5B | ERF | Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | m | | | | | | | | | | | | | | |
| 1 | 1 | 3.6E-05 | -1.70E-02 | 9.83E-01 | -2.98E+45 | 2 | 2.80E+02 | 1 | -2.80E+02 | -1 | 5.30E+00 | 1 | -5.30E+00 | -1 | 2.80E-04 |
| 2 | 2 | 3.6E-05 | -3.40E-02 | 9.67E-01 | -2.98E+45 | 2 | 1.98E+02 | 1 | -1.98E+02 | -1 | 3.75E+00 | 1 | -3.75E+00 | -1 | 2.75E-04 |
| 3 | 3 | 3.6E-05 | -5.10E-02 | 9.50E-01 | -2.98E+45 | 2 | 1.61E+02 | 1 | -1.61E+02 | -1 | 3.06E+00 | 1 | -3.06E+00 | -1 | 2.71E-04 |
| 4 | 4 | 3.6E-05 | -6.80E-02 | 9.34E-01 | -2.98E+45 | 2 | 1.40E+02 | 1 | -1.40E+02 | -1 | 2.65E+00 | 0.9998 | -2.65E+00 | -1 | 2.66E-04 |
| 5 | 5 | 3.6E-05 | -8.50E-02 | 9.18E-01 | -2.98E+45 | 2 | 1.25E+02 | 1 | -1.25E+02 | -1 | 2.37E+00 | 0.9992 | -2.37E+00 | -0.999 | 2.61E-04 |
| 6 | 6 | 3.6E-05 | -1.02E-01 | 9.03E-01 | -2.98E+45 | 2 | 1.14E+02 | 1 | -1.14E+02 | -1 | 2.17E+00 | 0.9978 | -2.17E+00 | -0.998 | 2.57E-04 |
| 7 | 7 | 3.6E-05 | -1.19E-01 | 8.88E-01 | -2.98E+45 | 2 | 1.06E+02 | 1 | -1.06E+02 | -1 | 2.00E+00 | 0.9954 | -2.00E+00 | -0.995 | 2.52E-04 |
| 8 | 8 | 3.6E-05 | -1.36E-01 | 8.73E-01 | -2.98E+45 | 2 | 9.88E+01 | 1 | -9.88E+01 | -1 | 1.88E+00 | 0.992 | -1.88E+00 | -0.992 | 2.47E-04 |
| 9 | 9 | 3.6E-05 | -1.53E-01 | 8.58E-01 | -2.98E+45 | 2 | 9.32E+01 | 1 | -9.32E+01 | -1 | 1.77E+00 | 0.9876 | -1.77E+00 | -0.988 | 2.41E-04 |
| 10 | 10 | 3.6E-05 | -1.70E-01 | 8.44E-01 | -2.98E+45 | 2 | 8.84E+01 | 1 | -8.84E+01 | -1 | 1.68E+00 | 0.9823 | -1.68E+00 | -0.982 | 2.36E-04 |
| 11 | 11 | 3.6E-05 | -1.87E-01 | 8.29E-01 | -2.98E+45 | 2 | 8.43E+01 | 1 | -8.43E+01 | -1 | 1.60E+00 | 0.9763 | -1.60E+00 | -0.976 | 2.31E-04 |
| 12 | 12 | 3.6E-05 | -2.04E-01 | 8.15E-01 | -2.98E+45 | 2 | 8.07E+01 | 1 | -8.07E+01 | -1 | 1.53E+00 | 0.9696 | -1.53E+00 | -0.97 | 2.25E-04 |
| 13 | 13 | 3.6E-05 | -2.21E-01 | 8.02E-01 | -2.98E+45 | 2 | 7.75E+01 | 1 | -7.75E+01 | -1 | 1.47E+00 | 0.9625 | -1.47E+00 | -0.962 | 2.20E-04 |
| 14 | 14 | 3.6E-05 | -2.38E-01 | 7.88E-01 | -2.98E+45 | 2 | 7.47E+01 | 1 | -7.47E+01 | -1 | 1.42E+00 | 0.955 | -1.42E+00 | -0.955 | 2.14E-04 |
| 15 | 15 | 3.6E-05 | -2.55E-01 | 7.75E-01 | -2.98E+45 | 2 | 7.22E+01 | 1 | -7.22E+01 | -1 | 1.37E+00 | 0.9472 | -1.37E+00 | -0.947 | 2.09E-04 |
| 16 | 16 | 3.6E-05 | -2.72E-01 | 7.62E-01 | -2.98E+45 | 2 | 6.99E+01 | 1 | -6.99E+01 | -1 | 1.33E+00 | 0.9392 | -1.33E+00 | -0.939 | 2.04E-04 |
| 17 | 17 | 3.6E-05 | -2.89E-01 | 7.49E-01 | -2.98E+45 | 2 | 6.78E+01 | 1 | -6.78E+01 | -1 | 1.29E+00 | 0.9311 | -1.29E+00 | -0.931 | 1.99E-04 |
| 18 | 18 | 3.6E-05 | -3.06E-01 | 7.36E-01 | -2.98E+45 | 2 | 6.59E+01 | 1 | -6.59E+01 | -1 | 1.25E+00 | 0.9229 | -1.25E+00 | -0.923 | 1.94E-04 |
| 19 | 19 | 3.6E-05 | -3.23E-01 | 7.24E-01 | -2.98E+45 | 2 | 6.41E+01 | 1 | -6.41E+01 | -1 | 1.22E+00 | 0.9147 | -1.22E+00 | -0.915 | 1.89E-04 |
| 20 | 20 | 3.6E-05 | -3.40E-01 | 7.12E-01 | -2.98E+45 | 2 | 6.25E+01 | 1 | -6.25E+01 | -1 | 1.19E+00 | 0.9065 | -1.19E+00 | -0.906 | 1.84E-04 |




| | |
|---|---|
| Date: | 24/02/2020 |
| Version: | 1 |

# Hydrogeological risk assessment for land contamination

## Remedial Targets Worksheet , Release 3.2

**First released: 2006. Version 3.2: January 2013**

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination ( Environment Agency 2006).

**Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.**

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The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

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IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

| Details to be completed for each assessment | | | | |
|---|---|---|---|---|
| Site Name: | Glan Llyn | | | |
| Site Address: | Llanwern | | | |
| Completed by: | Ross Cameron | | | |
| Date: | 24-Feb-20 | | Version: | 1 |
| Contaminant | Benzo(b)fluoranthene | | | |
| Target Concentration ($C_T$) | 0.00000017 | mg/l | Origin of $C_T$: | Proposed Water Framework Directive EQS |

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparision with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).
Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.
Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.
Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.
Data carried forward from an earlier worksheet are identified by a light green background
It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

# Remedial Targets Worksheet , Release 3.2

## Level 1 - Soil

**Select the method of calculating the soil water Partition Co-efficient by using the pull down menu below**

**User specified value for partition coefficient**

| | | | |
|---|---|---|---|
| **Contaminant** | | **Benzo(b)fluoranthene** | |
| **Target concentration** | **$C_T$** | **0.00000017** | **mg/l** |

| **Input Parameters** | **Variable** | **Value** | **Unit** | **Source of parameter value** |
|---|---|---|---|---|
| ***Standard entry*** | | | | |
| Water filled soil porosity | $\theta_W$ | 5.00E-01 | fraction | 0.5 |
| Air filled soil porosity | $\theta a$ | 3.70E-01 | fraction | 0.0037 |
| Bulk density of soil zone material | $\rho$ | 1.36E+00 | g/cm$^3$ | 1.36 |
| Henry's Law constant | H | 1.00E+00 | dimensionless | *1* |
| ***Entry if specify partition coefficient (option)*** | | | | |
| Soil water partition coefficient | Kd | 1.34E+02 | l/kg | *1.34E+02* |
| ***Entry for non-polar organic chemicals (option)*** | | | | |
| Fraction of organic carbon (in soil) | foc | | fraction | |
| Organic carbon partition coefficient | Koc | | l/kg | |
| ***Entry for ionic organic chemicals (option)*** | | | | |
| Sorption coefficient for neutral species | $K_{oc,n}$ | | l/kg | |
| Sorption coefficient for ionised species | $K_{oc,i}$ | | l/kg | |
| pH value | pH | | pH units | |
| Acid dissociation constant | pKa | | | |
| Fraction of organic carbon (in soil) | foc | | fraction | |

This sheet calculates the Level 1 remedial target for soils(mg/kg) based on a selected target concentration and theoretical calculation of soil water partitioning. Three options are included for determining the partition coefficient.

The measured soil concentration as mg/kg should be compared with the Level 1 remedial target to determine the need for further action.

| | | | | |
|---|---|---|---|---|
| **Soil water partition coefficient used in Level Assessment** | **Kd** | **1.34E+02** | **l/kg** | *Specified value* |

### Level 1 Remedial Target

| | | | |
|---|---|---|---|
| **Level 1 Remedial Target** | **2.29E-05** | **mg/kg** | **(for comparison with soil analyses)** |
| | **or** | | |
| | **0.00000017** | **mg/l** | **(for comparison with leachate test results)** |

| | |
|---|---|
| Site being assessed: | Glan Llyn |
| Completed by: | Ross Cameron |
| Date: | 24-Feb-20 |
| Version: | 1 |

# Remedial Targets Worksheet , Release 3.2

## Level 2 - Soil

| | | | | |
|---|---|---|---|---|
| **Contaminant** | | **Benzo(b)fluoranthene** | | from Level 1 |
| **Target concentration** | **$C_T$** | **0.00000017** | **mg/l** | from Level 1 |

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamiantion' (Environment Agency 2006)

| **Input Parameters** | **Variable** | **Value** | **Unit** | **Source of parameter value** | |
|---|---|---|---|---|---|
| *Standard entry* | | | | | |
| Infiltration | Inf | 0.00E+00 | m/d | | |
| Area of contaminant source | A | 0.00E+00 | $m^2$ | | Not used in calculation |
| *Entry for groundwater flow below site* | | | | | |
| Length of contaminant source in direction of groundwater flow | L | 0.00E+00 | m | | |
| Saturated aquifer thickness | da | 0.00E+00 | m | | |
| Hydraulic Conductivity of aquifer in which dilution occurs | K | 0.00E+00 | m/d | | |
| Hydraulic gradient of water table | i | 0.00E+00 | fraction | | |
| Width of contaminant source perpendicular to groundwater flow | w | 0.00E+00 | m | | Not used in calculation |
| Background concentration of contaminant in groundwater beneath site | Cu | 0.00E+00 | mg/l | | |
| Define mixing zone depth by specifying or calculating depth (using pull down list) | | **Specify** | | | |
| Enter mixing zone thickness | Mz | 0.00E+00 | m | | |
| Calculated mixing zone thickness | Mz | | m | | |

### Calculated Parameters

| | | | | |
|---|---|---|---|---|
| **Dilution Factor** | **DF** | **#DIV/0!** | | |
| **Level 2 Remedial Target** | | **#DIV/0!** | **mg/l** | **For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentrati** |
| | | **or** | | |
| | | **#DIV/0!** | **mg/kg** | **For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water** |

### *Additional option*

**Calculation of impact on receptor**

| | | | | |
|---|---|---|---|---|
| Concentration of contaminant in contaminated discharge (entering receptor) | Cc | 0.00E+00 | mg/l | |
| Calculated concentration within receptor (dilution only) | | #DIV/0! | mg/l | 0 |

| | |
|---|---|
| Site being assessed: | Glan Llyn |
| Completed by: | Ross Cameron |
| Date: | 24-Feb-20 |
| Version: | 1 |

## Remedial Targets Worksheet , Release 3.2

### Level 3 - Soil

See Note

| Input Parameters | Variable | Value | Unit | Source |
|---|---|---|---|---|
| Contaminant | | Benzo(b)fluoranthene | | from Level 1 |
| Target Concentration | $C_T$ | 0.00000017 | mg/l | from Level 1 |
| Dilution Factor | DF | #DIV/0! | | from Level 2 |

**Select analytical solution (click on brown cell below, then on pull-down menu)**

Ogata Banks — Equations in HRA publication

**Select nature of decay rate (click on brown cell below, then on pull-down menu)**

Approach for simulating degradation of pollutants: Apply degradation rate to pollutants in all phases (e.g. field derived value, l

| | Variable | Value | Unit | Source of parameter value |
|---|---|---|---|---|
| Enter source concentration | | Soil concentration as mg/kg | | |
| Enter soil concentration | | 0 | mg/kg | |
| Half life for degradation of contaminant in water | $t_{1/2}$ | 1.00E+100 | days | |
| Calculated decay rate | λ | 6.93E-101 | $days^{-1}$ | calculated |
| Width of plume in aquifer at source | Sz | 0.00E+00 | m | from Level 2 |
| Plume thickness in aquifer at source | Sy | 0.00E+00 | m | from Level 2 |
| Bulk density of aquifer materials | ρ | 0.00E+00 | $g/cm^3$ | |
| Effective porosity of aquifer | n | 0.00E+00 | fraction | |
| Hydraulic gradient | i | #DIV/0! | fraction | from Level 2 (adjusted) |
| Hydraulic conductivity of saturated aquifer | K | 0.00E+00 | m/d | from Level 2 |
| Distance to compliance point | x | 0.00E+00 | m | |
| Distance (lateral) to compliance point perpendicular to flow direction | z | | m | |
| Distance (depth) to compliance point perpendicular to flow direction | y | | m | |
| Time since pollutant entered groundwater | t | 1.00E+99 | days | *time variant options only* |
| *Parameters values determined from options* | | | | |
| Partition coefficient | Kd | 0.00E+00 | l/kg | *see options* |
| Longitudinal dispersivity | ax | 0.000 | m | *see options* |
| Transverse dispersivity | az | 0.000 | m | *see options* |
| Vertical dispersivity | ay | 0.000 | m | *see options* |

***Parameter values should be checked against Level 1 and 2***

| Calculated Parameters | Variable | | |
|---|---|---|---|
| Groundwater flow velocity | v | #DIV/0! | m/d |
| Retardation factor | Rf | #DIV/0! | fraction |
| Decay rate used | λ | 6.93E-101 | $d^{-1}$ |
| Hydraulic gradient used in aquifer flow down-gradient | i | #DIV/0! | fraction |
| Rate of contaminant flow due to retardation | u | #DIV/0! | m/d |
| Ratio of Compliance Point to Source Concentration | $C_{ED}/C_0$ | #DIV/0! | fraction |
| **Attenuation factor ($C_O/C_{ED}$)** | **AF** | **#DIV/0!** | **fraction** |
| Calculated soil leachate concentration | Co | 0.00E+00 | mg/l |

**Remedial Targets**

| | | | | |
|---|---|---|---|---|
| **Level 3 Remedial Target** | | **#DIV/0!** | **mg/l** | For comparison with measured pore water concentration. |
| Ogata Banks | | **or** | | This assumes Level 1 Remedial Target is based on Target Concentration. |
| | | **#DIV/0!** | **mg/kg** | For comparison with measured soil concentration. This |
| **Distance to compliance point** | | **0** | **m** | assumes Level 1 Remedial Target calculated from soil-water partitioning equation. |
| **Ratio of Compliance Point to Source Concentration** | **$C_{ED}/C_0$** | **#DIV/0!** | **fraction** | Ogata Banks |

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99

**Enter method of defining partition co-efficient (using pull down list)**

Calculate for ionic organic chemicals (acids)

***Entry if specify partition coefficient (option)***

Soil water partition coefficient — Kd — l/kg

***Entry for non-polar organic chemicals (option)***

Fraction of organic carbon in aquifer — foc — fraction
Organic carbon partition coefficient — Koc — l/kg

***Entry for ionic organic chemicals (option)***

| | | | |
|---|---|---|---|
| Sorption coefficient for related species | $K_{oc,n}$ | 0.00E+00 | l/kg |
| Sorption coefficient for ionised species | $K_{oc,i}$ | 0.00E+00 | l/kg |
| pH value | pH | 0.00E+00 | |
| Acid dissociation constant | pKa | 0.00E+00 | |
| Fraction of organic carbon in aquifer | foc | 0.00E+00 | fraction |
| Soil water partition coefficient | Kd | 0.00E+00 | l/kg |

**Define dispersivity (click brown cell and use pull down list)**

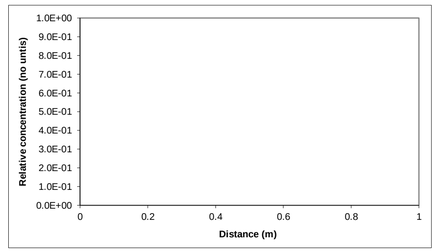
User defined values for dispersivity

| | | Enter value | Calc value | Xu & Eckstein | |
|---|---|---|---|---|---|
| **Longitudinal dispersivity** | **ax** | 0.00E+00 | 0.00E+00 | #NUM! | m |
| **Transverse dispersivity** | **az** | 0.00E+00 | 0.00E+00 | #NUM! | m |
| **Vertical dispersivity** | **ay** | 0.00E+00 | 0.00E+00 | #NUM! | m |

**Note values of dispersivity must be > 0**

Xu & Eckstein (1995) report ax = $0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed

Note
This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by $O_2$, $NO_3$, $SO_4$ etc than an alternative solution should be used




Note: 'Relative concentration' is the ratio of calculated concentation at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

| | |
|---|---|
| Site being assessed: | Glan Llyn |
| Completed by: | Ross Cameron |
| Date: | ######## |
| Version: | 1 |

**Calculated (relative) concentrations for distance-concentration graph**

**Ogata Banks**
**From calculation sheet**

| Distance | Relative concentration (No units) | Concentration mg/l |
|---|---|---|
| **0** | **1.0E+00** | **#DIV/0!** |
| **0.0** | **#DIV/0!** | **#DIV/0!** |
| **0.0** | **#DIV/0!** | **#DIV/0!** |
| **0.0** | **#DIV/0!** | **#DIV/0!** |
| **0.0** | **#DIV/0!** | **#DIV/0!** |
| **0.0** | **#DIV/0!** | **#DIV/0!** |
| **0.0** | **#DIV/0!** | **#DIV/0!** |
| **0.0** | **#DIV/0!** | **#DIV/0!** |
| **0.0** | **#DIV/0!** | **#DIV/0!** |
| **0.0** | **#DIV/0!** | **#DIV/0!** |
| **0.0** | **#DIV/0!** | **#DIV/0!** |
| **0.0** | **#DIV/0!** | **#DIV/0!** |
| **0.0** | **#DIV/0!** | **#DIV/0!** |
| **0.0** | **#DIV/0!** | **#DIV/0!** |
| **0.0** | **#DIV/0!** | **#DIV/0!** |
| **0.0** | **#DIV/0!** | **#DIV/0!** |
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| **0.0** | **#DIV/0!** | **#DIV/0!** |
| **0.0** | **#DIV/0!** | **#DIV/0!** |
| **0.0** | **#DIV/0!** | **#DIV/0!** |
| **0.0** | **#DIV/0!** | **#DIV/0!** |
| **0.0** | **#DIV/0!** | **#DIV/0!** |
| **0.0** | **#DIV/0!** | **#DIV/0!** |
| **0.0** | **#DIV/0!** | **#DIV/0!** |

# Remedial Targets Worksheet , Release 3.2

## Calculation of contaminant concentration in groundwater from a soil source

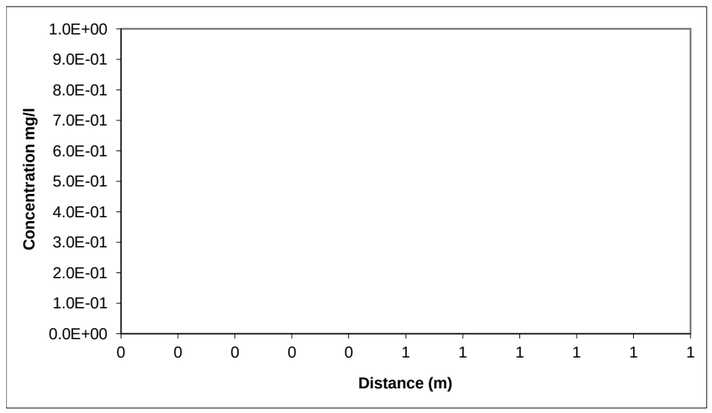
Only input required is Soil Contaminant Concentration

| | | | | |
|---|---|---|---|---|
| | Input Parameters | | | |
| | Soil contaminant concentration | $C_0$ | 0.00E+00 | mg/kg |
| **Level 1 Parameters** | | | | |
| | Water filled soil porosity | $\theta_W$ | 5.00E-01 | fraction |
| | Air filled soil porosity | $\theta a$ | 3.70E-01 | fraction |
| | Bulk density | $\rho$ | 1.36E+00 | g/cm$^3$ |
| | Henry's Law constant | H | 1.00E+00 | dimensionless |
| | Soil water partition coefficient used in Level Assessment | Kd | 1.34E+02 | l/kg |
| | Factor (partitioning between soil and water) | | 1.35E+02 | dimensionless |
| **Level 2 Parameters** | **Dilution Factor** | DF | #DIV/0! | |
| **Level 3 Parameters** | **Attenuation factor ($C_O/C_{ED}$)** | AF | #DIV/0! | |

### Predicted concentrations at compliance point

| | | | | |
|---|---|---|---|---|
| **Level 1** | C | 0.00E+00 | mg/l | No dilution or attenuation |
| **Level 2** | C | #DIV/0! | mg/l | Dilution taken into account |
| **Level 3** | C | #DIV/0! | mg/l | Dilution and attenuation taken into account |

### Predicted concentrations between source and compliance point - Level 3




| Distance m | Concentration mg/l |
|---|---|
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
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| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |

# R&D Publication 20 Remedial Targets Worksheet, Release 3.2

## Level 3 - Groundwater

See Note

**Input Parameters (using pull down menu)**

| | Variable | Value | Unit | Source |
|---|---|---|---|---|
| Contaminant | | Benzo(b)fluoranthene | | from Level 1 |
| Target Concentration | $C_T$ | 1.70E-07 | mg/l | from Level 1 |

**Select analytical solution (click on brown cell below, then on pull-down menu)**

Domenico - Steady state — Equations in HRA publication

Approach for simulating vertical dispersion: Simulate vertical dispersion in 1 direction

**Select nature of decay rate (click on brown cell below, then on pull-down menu)**

Approach for simulating degradation of pollutants: Apply degradation rate to dissolved pollutants only

| | | | | Source of parameter value |
|---|---|---|---|---|
| Initial contaminant concentration in groundwater at plume core | $C_0$ | 7.67E-02 | mg/l | *Based on average soil conc of 4.1mg/kg* |
| Half life for degradation of contaminant in water | $t_{1/2}$ | 3.65E+04 | days | *10 year half life estimation* |
| Calculated decay rate | $\lambda$ | 1.90E-05 | $days^{-1}$ | |
| Width of plume in aquifer at source (perpendicular to flow) | Sz | 5.00E+02 | m | *Site data* |
| Plume thickness at source | Sy | 1.50E+00 | m | *Thickness of re-engineered MG* |
| Saturated aquifer thickness | da | 2.00E+00 | m | *Based upon proposed total MG and cappir* |
| Bulk density of aquifer materials | ρ | 1.36E+00 | $g/cm^3$ | *Site data* |
| Effective porosity of aquifer | n | 8.00E-02 | fraction | *Estimate* |
| Hydraulic gradient | i | 1.00E-02 | fraction | |
| Hydraulic conductivity of aquifer | K | 8.64E-03 | m/d | *Proposed best achievable* |
| Distance to compliance point | x | 2.00E+01 | m | *Site data* |
| Distance (lateral) to compliance point perpendicular to flow direction | z | | m | |
| Distance (depth) to compliance point perpendicular to flow direction | y | | m | |
| Time since pollutant entered groundwater | t | 1.00E+100 | days | *time variant options only* |
| *Parameters values determined from options* | | | | |
| Partition coefficient | Kd | 5.34E+04 | l/kg | *see options* |
| Longitudinal dispersivity | ax | 2.00E+00 | m | *see options* |
| Transverse dispersivity | az | 2.00E-01 | m | *see options* |
| Vertical dispersivity | ay | 2.00E-02 | m | *see options* |

**Calculated Parameters**

| | Variable | | |
|---|---|---|---|
| Groundwater flow velocity | v | 1.08E-03 | m/d |
| Retardation factor | Rf | 9.09E+05 | fraction |
| Decay rate used | λ | 2.09E-11 | $d^{-1}$ |
| Rate of contaminant flow due to retardation | u | 1.19E-09 | m/d |
| Contaminant concentration at distance x, assuming one-way vertical dispersion | $C_{ED}$ | 4.95E-02 | mg/l |
| **Attenuation factor (one way vertical dispersion, CO/CED)** | **AF** | **1.55E+00** | |

**Remedial Targets**

| | | | | |
|---|---|---|---|---|
| **Remedial Target** | | **2.64E-07** | **mg/l** | For comparison with measured groundwater concentration. |
| Domenico - Steady state | | | | |
| **Distance to compliance point** | | **20** | **m** | |
| **Concentration of contaminant at compliance point** | **$C_{ED}/C_0$** | **4.95E-02** | **mg/l** | Domenico - Steady state |

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99.

**Select Method for deriving Partition Co-efficient (using pull down menu)**

User specified value for partition coefficient

| | | | |
|---|---|---|---|
| ***Entry if specify partition coefficient (option)*** | | | |
| Soil water partition coefficient | Kd | 5.34E+04 | l/kg |
| ***Entry for non-polar organic chemicals (option)*** | | | |
| Fraction of organic carbon in aquifer | foc | | fraction |
| Organic carbon partition coefficient | Koc | | l/kg |
| ***Entry for ionic organic chemicals (option)*** | | | |
| Sorption coefficient for related species | $K_{oc,n}$ | | l/kg |
| Sorption coefficient for ionised species | $K_{oc,i}$ | | l/kg |
| pH value | pH | | |
| acid dissociation constant | pKa | | |
| Fraction of organic carbon in aquifer | foc | | fraction |
| Soil water partition coefficient | Kd | 5.34E+04 | l/kg |

**Define dispersivity (click brown cell and use pull down list)**

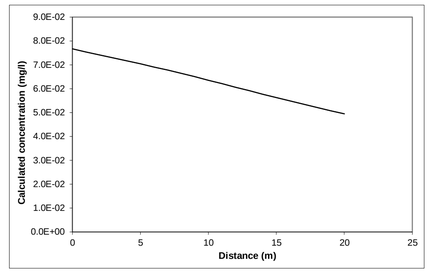
Dispersivities 10%, 1%, 0.1% of pathway length

| | | Enter value | Calc value Xu & Eckstein | | |
|---|---|---|---|---|---|
| **Longitudinal dispersivity** | **ax** | 0.00E+00 | 2.00E+00 | 1.57E+00 | m |
| **Transverse dispersivity** | **az** | 0.00E+00 | 2.00E-01 | 1.57E-01 | m |
| **Vertical dispersivity** | **ay** | 0.00E+00 | 2.00E-02 | 1.57E-02 | |

**Note values of dispersivity must be > 0**

For calculated value, assumes ax = 0.1 *x, az = 0.01 * x, ay = 0.001 * x

Xu & Eckstein (1995) report ax = $0.83(\log_{10}x)^{2.414}$ ; az = ax/10, ay = ax/100 are assumed




Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared
with the Level 3 remedial target to determine the need for further action.
Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O2, NO3, SO4 etc than an alternative solution should be used

| | |
|---|---|
| Site being assessed: | Glan Llyn |
| Completed by: | Ross Cameron |
| Date: | ######## |
| Version: | 1 |

**Calculated concentrations for distance-concentration graph**

**Domenico - Steady state**
**From calculation sheet**

| Distance | Concentration |
|---|---|
| | mg/l |
| 0 | 7.7E-02 |
| 1.0 | 7.54E-02 |
| 2.0 | 7.41E-02 |
| 3.0 | 7.29E-02 |
| 4.0 | 7.16E-02 |
| 5.0 | 7.04E-02 |
| 6.0 | 6.91E-02 |
| 7.0 | 6.78E-02 |
| 8.0 | 6.64E-02 |
| 9.0 | 6.50E-02 |
| 10.0 | 6.36E-02 |
| 11.0 | 6.21E-02 |
| 12.0 | 6.06E-02 |
| 13.0 | 5.92E-02 |
| 14.0 | 5.77E-02 |
| 15.0 | 5.63E-02 |
| 16.0 | 5.49E-02 |
| 17.0 | 5.35E-02 |
| 18.0 | 5.21E-02 |
| 19.0 | 5.08E-02 |
| 20.0 | 4.95E-02 |

# Porosity Calculator

These results are not carried through to any of the other worksheets

## DRY BULK DENSITY DATA

| Variable | Value | Unit | justification |
|---|---|---|---|
| Natural Moisture Content | 0.00 | % wt | |
| Particle Density | 2.78 | tonnes/m$^3$ | (Change this number only if you have specific information) |
| Dry Bulk Density | 0.00 | tonnes/m$^3$ | |
| *Calculated Parameters* | | | |
| Voids Ratio | #DIV/0! | fraction | |
| Initial Saturation | #DIV/0! | % | |
| **Total porosity** | **1.000** | **fraction** | |
| **Air Filled Porosity** | **#DIV/0!** | **fraction** | |
| **Water Filled Porosity** | **#DIV/0!** | **fraction** | |

## WET BULK DENSITY DATA

| Variable | Value | Unit | |
|---|---|---|---|
| Moisture Content | 0.00 | % wt | |
| Particle Density | 2.78 | tonnes/m$^3$ | (Change this number only if you have specific information) |
| Actual (wet) Bulk Density ( i.e. at natural MC) | 0.00 | tonnes/m$^3$ | |
| *Calculated Parameters* | | | |
| Voids Ratio | #DIV/0! | fraction | |
| dry bulk density | 0.00 | tonnes/m$^3$ | |
| Initial Saturation | #DIV/0! | % | |
| **Total porosity** | **1.000** | **fraction** | **#DIV/0!** |
| **Air Filled Porosity** | **#DIV/0!** | **fraction** | |
| **Water Filled Porosity** | **#DIV/0!** | **fraction** | |

*Analytical solutions provided by David Hall, Golder Associates (UK) Ltd*

# Simple hydrogeological calculations

**(These are not specific to, or required in, the Remedial Targets Methodology)**

| Parameter | symbol | | unit | justification |
|---|---|---|---|---|
| Hydraulic conductivity | K | 0.00E+00 | m/d | |
| Hydraulic gradient | i | 0.00E+00 | unitless | |
| Effective porosity of aquifer | n | 0.00E+00 | fraction | |
| Thickness of saturated aquifer | b | 0.00E+00 | m | |
| Width of aquifer perpendicular to flow | w | 0.00E+00 | m | |
| Distance to receptor | x | 0.00E+00 | m | |
| Bulk density of aquifer materials | ρ | 0.00E+00 | g/cm$^3$ | |
| Soil-water partition co-efficient | Kd | 0.00E+00 | l/kg | |
| Retardation factor of pollutant | R | #DIV/0! | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Groundwater flow velocity | v(GW) | #DIV/0! | m/s | #DIV/0! | m/day | #DIV/0! | m/year |
| Time for groundwater to reach receptor | t(GW) | #DIV/0! | seconds | #DIV/0! | days | #DIV/0! | years |
| Rate of groundwater flow through aquifer | Q | 0.00E+00 | m$^3$/s | 0.00E+00 | m$^3$/day | 0.00E+00 | m$^3$/year |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Contaminant flow velocity | v(contam) | #DIV/0! | m/s | #DIV/0! | m/day | #DIV/0! | m/year |
| Time for contaminant to reach receptor | t(contam) | #DIV/0! | seconds | #DIV/0! | days | #DIV/0! | years |

## Level 1 Calculation Sheet

**Contaminant** **nzo(b)fluoranthene**

| Parameter | Value | Units |
|---|---|---|
| (carried over from input sheet) | | |
| $C_T$ | 1.70E-07 | mg/l |
| Kd | 1.34E+02 | l/kg |
| foc | | fraction |
| koc | | l/kg |
| $\theta_W$ | 5.00E-01 | fraction |
| θa | 3.70E-01 | fraction |
| ρ | 1.36E+00 | g/cm3 |
| H | 1.00E+00 | dimensionless |
| Koc,n | | l/kg |
| Koc,i | | l/kg |
| pH | | pH units |
| pKa | | |
| foc (ionic) | | fraction |

**Calculations (Refer toTable 4.3, R&D Publication 20)**

**Selected option** User specified value for partition coefficient

| | calc | calc | Calc Kd | l/kg |
|---|---|---|---|---|
| Calculation of partition coefficient for ionic organic chemical | | | | |
| Partition coefficient used in Level 1 Assessment | | | 1.34E+02 | l/kg |

**Calculated Remedial Target** **2.29E-05 mg/kg** **for Benzo(b)fluoranthene**

Factor (partitioning between soil and water) 1.35E+02

| | |
|---|---|
| Site being assessed: | Glan Llyn |
| Completed by: | Ross Cameron |
| Date: | 24/02/2020 |
| Version: | 1 |

## Level 2 Calculation Sheet

**Contaminant** **enzo(b)fluoranthene**

| Site assessed: | Glan Llyn |
|---|---|
| Date: | 24/02/2020 |
| Version: | 1 |

| Parameter | Value | Units |
|---|---|---|
| (carried over from input sheet) | | |
| Mz | 0.00E+00 | m |
| L | 0.00E+00 | m |
| da | 0.00E+00 | m |
| Inf | 0.00E+00 | m/d |
| K | 0.00E+00 | m/d |
| i | 0.00E+00 | |
| | | m3/d |
| A | 0.00E+00 | m2 |
| | | m3/d |
| Cc | 0.00E+00 | mg/l |
| $C_T$ | 1.70E-07 | mg/l |
| Cu | 0.00E+00 | mg/l |
| w | 0.00E+00 | m |

Calculated Dilution Factor

Calculation based on target concentration #DIV/0!

Calculation based on observed contaminant concentration #DIV/0!



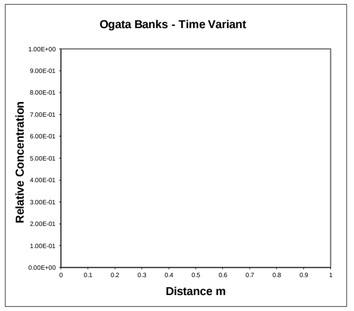
**Contaminant** **nzo(b)fluoranthene**

**OGATA BANKS SOLUTION**

Calculations for source located in centre of aquifer (ie vertical dispersion in two directions)

| Input | Value | Units |
|---|---|---|
| $C_T$ | 1.700E-07 | mg/l |
| DF | #DIV/0! | |
| | | |
| | | |
| λ | 6.931E-101 | days$^{-1}$ |
| Sz | 0.000E+00 | m |
| Sy | 0.000E+00 | m |
| Kd | 0.000E+00 | l/kg |
| ρ | 0.000E+00 | g/cm3 |
| n | 0.000E+00 | |
| i | #DIV/0! | |
| K | 0.000E+00 | m/d |
| x | 0.000E+00 | m |
| z | 0.000E+00 | m |
| y | 0.000E+00 | m |
| t | 1.000E+99 | days |
| ax | 0.000E+00 | m |
| az | 0.000E+00 | m |
| ay | 0.000E+00 | m |

| | X | Term 1 | Term 2 | EXP | Term 3 | ERFC | Term 4 | EXP | Term 5 | ERFC | Term 6a | ERF | Term 6b | ERF | Term 7a | ERF | Term 7b | ERF | Relative Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 2 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 3 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 4 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 5 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 6 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 7 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 8 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 9 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 10 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 11 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 12 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 13 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 14 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 15 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 16 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 17 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 18 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 19 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 20 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |




**Calc** **Value**

| | | |
|---|---|---|
| v | #DIV/0! | m/d |
| Rc | #DIV/0! | |
| u | #DIV/0! | m/d |

Calculations for source located at top of aquifer (ie vertical dispersion in one direction) -USED FOR LEVEL ASSESSMENT

| | X | Term 1 | Term 2 | EXP | Term 3 | ERFC | Term 4 | EXP | Term 5 | ERFC | Term 6a | ERF | Term 6b | ERF | Term 7a | ERF | Term 7b | ERF | Relative Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 2 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 3 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 4 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 5 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 6 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 7 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 8 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 9 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 10 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 11 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 12 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 13 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 14 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 15 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 16 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 17 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 18 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 19 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 20 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |




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|---|---|
| Date: | 24/02/2020 |
| Version: | 1 |

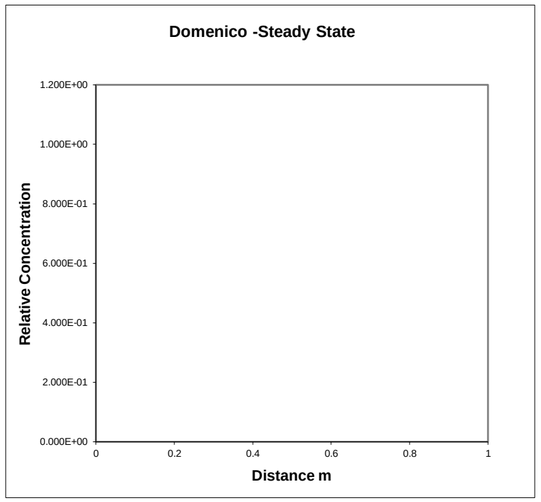
**Contaminant** **zo(b)fluoranthene**

**DOMENICO (STEADY STATE)**

Calculations for source located in centre of aquifer (ie vertical dispersion in two directions)

| Input | Value | Units |
|---|---|---|
| $C_T$ | 1.700E-07 | mg/l |
| DF | #DIV/0! | |
| | | |
| λ | 6.931E-101 | days$^{-1}$ |
| Sz | 0.000E+00 | m |
| Sy | 0.000E+00 | m |
| Kd | 0.000E+00 | l/kg |
| ρ | 0.000E+00 | g/cm3 |
| n | 0.000E+00 | |
| i | #DIV/0! | |
| K | 0.000E+00 | m/d |
| x | 0.000E+00 | m |
| z | 0.000E+00 | m |
| y | 0.000E+00 | m |
| ax | 0.000E+00 | m |
| az | 0.000E+00 | m |
| ay | 0.000E+00 | m |

| | X | Term 1 | Term 2 | EXP | Term 3A | ERF | Term 3B | ERF | Term 4A | ERF | Term 4B | ERF | Relative Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 2 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 3 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 4 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 5 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 6 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 7 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 8 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 9 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 10 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 11 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 12 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 13 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 14 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 15 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 16 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 17 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 18 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 19 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 20 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |



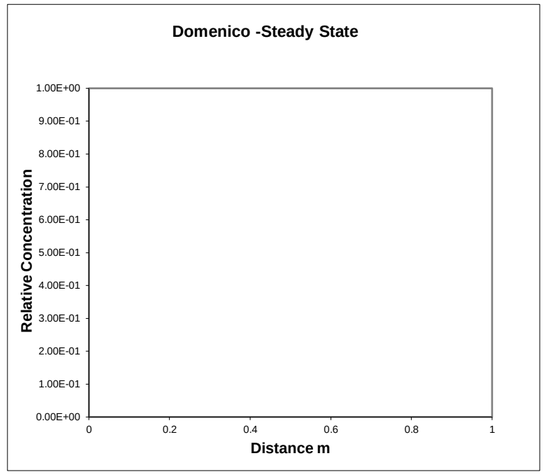

**Calc** **Value**

| | | |
|---|---|---|
| v | #DIV/0! | m/d |
| Rc | #DIV/0! | |
| u | #DIV/0! | m/d |

**DOMENICO (STEADY STATE)**

Calculations for source located at top of aquifer (ie vertical dispersion in one direction) - USED FOR LEVEL ASSESSMENT

| | X | Term 1 | Term 2 | EXP | Term 3A | ERF | Term 3B | ERF | Term 4A | ERF | Term 4B | ERF | Relative Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 2 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 3 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 4 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 5 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 6 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 7 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 8 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 9 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 10 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 11 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 12 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 13 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 14 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 15 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 16 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 17 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 18 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 19 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 20 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |




| | |
|---|---|
| Date: | 24/02/2020 |
| Version: | 1 |

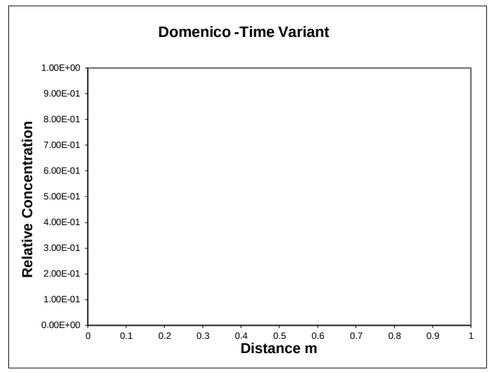
**DOMENICO (TIME VARIANT)**

**Contaminant** **zo(b)fluoranthene**

| Input | Value | Units |
|---|---|---|
| $C_T$ | 0.00000017 | mg/l |
| DF | #DIV/0! | |
| | | |
| | | |
| λ | 6.931E-101 | $days^{-1}$ |
| Sz | 0.000E+00 | m |
| Sy | 0.000E+00 | m |
| Kd | 0.000E+00 | l/kg |
| ρ | 0.000E+00 | g/cm3 |
| n | 0.000E+00 | |
| i | #DIV/0! | |
| K | 0.000E+00 | m/d |
| x | 0.000E+00 | m |
| z | 0.000E+00 | m |
| y | 0.000E+00 | m |
| t | 1.000E+99 | days |
| ax | 0.000E+00 | m |
| az | 0.000E+00 | m |
| ay | 0.000E+00 | m |

Calculations for source located in centre of aquifer (ie vertical dispersion in two directions)

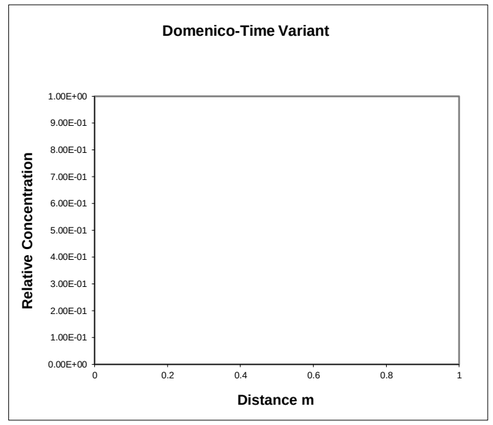
| | X | Term 1 | Term 2 | EXP | Term 3 | ERFC | Term 4A | ERF | Term 4B | ERF | Term 5A | ERF | Term 5B | ERF | Relative Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | m | | | | | | | | | | | | | | |
| 1 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 2 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 3 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 4 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 5 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 6 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 7 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 8 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 9 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 10 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 11 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 12 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 13 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 14 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 15 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 16 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 17 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 18 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 19 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 20 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |




| Calc | Value | |
|---|---|---|
| v | #DIV/0! | m/d |
| Rc | #DIV/0! | |
| u | #DIV/0! | m/d |

Calculations for source located at top of aquifer (ie vertical dispersion in one direction only) - USED FOR LEVEL ASSESSMENT

| | X | Term 1 | Term 2 | EXP | Term 3 | ERFC | Term 4A | ERF | Term 4B | ERF | Term 5A | ERF | Term 5B | ERF | Relative Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | m | | | | | | | | | | | | | | |
| 1 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 2 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 3 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 4 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 5 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 6 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 7 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 8 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 9 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 10 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 11 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 12 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 13 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 14 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 15 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 16 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 17 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 18 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 19 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 20 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |




| | |
|---|---|
| Date: | 24/02/2020 |
| Version: | 1 |

**OGATA BANKS SOLUTION**

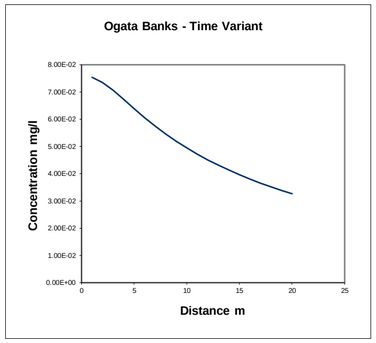
**Contaminant** **nzo(b)fluoranthene**

Calculations for source located in centre of aquifer (ie vertical dispersion in two directions)

| Input | Value | Units |
|---|---|---|
| $C_T$ | 0.00000017 | mg/l |
| Co | 7.67E-02 | mg/l |
| λ | 2.09E-11 | days$^{-1}$ |
| Sz | 5.00E+02 | m |
| Sy | 1.50E+00 | m |
| Kd | 5.34E+04 | l/kg |
| ρ | 1.36E+00 | g/cm3 |
| n | 8.00E-02 | |
| i | 1.00E-02 | |
| K | 8.64E-03 | m/d |
| x | 2.00E+01 | m |
| z | 0.00E+00 | m |
| y | 0.00E+00 | m |
| t | 1.00E+100 | days |
| ax | 2.00E+00 | m |
| az | 2.00E-01 | m |
| ay | 2.00E-02 | m |

Vertical dispersion option Simulate vertical dispersion in 1 direction

| X | Term 1 | Term 2 | EXP | Term 3 | ERFC | Term 4 | EXP | Term 5 | ERFC | Term 6a | ERF | Term 6b | ERF | Term 7a | ERF | Term 7b | ERF | Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.00959 | -1.7E-02 | 9.8E-01 | -1.3E+45 | 2.000 | 5.2E-01 | 1.7E+00 | 1.3E+45 | 0.000 | 2.8E+02 | 1 | -2.8E+02 | -1 | 2.7E+00 | 0.9998 | -2.7E+00 | -0.99982 | 7.54E-02 |
| 2 | 0.00959 | -3.4E-02 | 9.7E-01 | -1.3E+45 | 2.000 | 1.0E+00 | 2.8E+00 | 1.3E+45 | 0.000 | 2.0E+02 | 1 | -2.0E+02 | -1 | 1.9E+00 | 0.992 | -1.9E+00 | -0.99199 | 7.35E-02 |
| 3 | 0.00959 | -5.1E-02 | 9.5E-01 | -1.3E+45 | 2.000 | 1.6E+00 | 4.7E+00 | 1.3E+45 | 0.000 | 1.6E+02 | 1 | -1.6E+02 | -1 | 1.5E+00 | 0.9696 | -1.5E+00 | -0.96962 | 7.07E-02 |
| 4 | 0.00959 | -6.8E-02 | 9.3E-01 | -1.3E+45 | 2.000 | 2.1E+00 | 7.9E+00 | 1.3E+45 | 0.000 | 1.4E+02 | 1 | -1.4E+02 | -1 | 1.3E+00 | 0.9392 | -1.3E+00 | -0.93921 | 6.73E-02 |
| 5 | 0.00959 | -8.5E-02 | 9.2E-01 | -1.3E+45 | 2.000 | 2.6E+00 | 1.3E+01 | 1.3E+45 | 0.000 | 1.3E+02 | 1 | -1.3E+02 | -1 | 1.2E+00 | 0.9065 | -1.2E+00 | -0.90647 | 6.39E-02 |
| 6 | 0.00959 | -1.0E-01 | 9.0E-01 | -1.3E+45 | 2.000 | 3.1E+00 | 2.2E+01 | 1.3E+45 | 0.000 | 1.1E+02 | 1 | -1.1E+02 | -1 | 1.1E+00 | 0.8742 | -1.1E+00 | -0.87421 | 6.05E-02 |
| 7 | 0.00959 | -1.2E-01 | 8.9E-01 | -1.3E+45 | 2.000 | 3.6E+00 | 3.7E+01 | 1.3E+45 | 0.000 | 1.1E+02 | 1 | -1.1E+02 | -1 | 1.0E+00 | 0.8436 | -1.0E+00 | -0.84362 | 5.74E-02 |
| 8 | 0.00959 | -1.4E-01 | 8.7E-01 | -1.3E+45 | 2.000 | 4.1E+00 | 6.3E+01 | 1.3E+45 | 0.000 | 9.9E+01 | 1 | -9.9E+01 | -1 | 9.4E-01 | 0.8151 | -9.4E-01 | -0.8151 | 5.46E-02 |
| 9 | 0.00959 | -1.5E-01 | 8.6E-01 | -1.3E+45 | 2.000 | 4.7E+00 | 1.0E+02 | 1.3E+45 | 0.000 | 9.3E+01 | 1 | -9.3E+01 | -1 | 8.8E-01 | 0.7887 | -8.8E-01 | -0.7887 | 5.19E-02 |
| 10 | 0.00959 | -1.7E-01 | 8.4E-01 | -1.3E+45 | 2.000 | 5.2E+00 | 1.8E+02 | 1.3E+45 | 0.000 | 8.8E+01 | 1 | -8.8E+01 | -1 | 8.4E-01 | 0.7643 | -8.4E-01 | -0.76432 | 4.95E-02 |
| 11 | 0.00959 | -1.9E-01 | 8.3E-01 | -1.3E+45 | 2.000 | 5.7E+00 | 3.0E+02 | 1.3E+45 | 0.000 | 8.4E+01 | 1 | -8.4E+01 | -1 | 8.0E-01 | 0.7418 | -8.0E-01 | -0.7418 | 4.72E-02 |
| 12 | 0.00959 | -2.0E-01 | 8.2E-01 | -1.3E+45 | 2.000 | 6.2E+00 | 4.9E+02 | 1.3E+45 | 0.000 | 8.1E+01 | 1 | -8.1E+01 | -1 | 7.7E-01 | 0.721 | -7.7E-01 | -0.72098 | 4.51E-02 |
| 13 | 0.00959 | -2.2E-01 | 8.0E-01 | -1.3E+45 | 2.000 | 6.7E+00 | 8.3E+02 | 1.3E+45 | 0.000 | 7.8E+01 | 1 | -7.8E+01 | -1 | 7.4E-01 | 0.7017 | -7.4E-01 | -0.70169 | 4.31E-02 |
| 14 | 0.00959 | -2.4E-01 | 7.9E-01 | -1.3E+45 | 2.000 | 7.2E+00 | 1.4E+03 | 1.3E+45 | 0.000 | 7.5E+01 | 1 | -7.5E+01 | -1 | 7.1E-01 | 0.6838 | -7.1E-01 | -0.68377 | 4.13E-02 |
| 15 | 0.00959 | -2.6E-01 | 7.7E-01 | -1.3E+45 | 2.000 | 7.8E+00 | 2.3E+03 | 1.3E+45 | 0.000 | 7.2E+01 | 1 | -7.2E+01 | -1 | 6.8E-01 | 0.6671 | -6.8E-01 | -0.66708 | 3.96E-02 |
| 16 | 0.00959 | -2.7E-01 | 7.6E-01 | -1.3E+45 | 2.000 | 8.3E+00 | 3.9E+03 | 1.3E+45 | 0.000 | 7.0E+01 | 1 | -7.0E+01 | -1 | 6.6E-01 | 0.6515 | -6.6E-01 | -0.6515 | 3.81E-02 |
| 17 | 0.00959 | -2.9E-01 | 7.5E-01 | -1.3E+45 | 2.000 | 8.8E+00 | 6.6E+03 | 1.3E+45 | 0.000 | 6.8E+01 | 1 | -6.8E+01 | -1 | 6.4E-01 | 0.6369 | -6.4E-01 | -0.63692 | 3.66E-02 |
| 18 | 0.00959 | -3.1E-01 | 7.4E-01 | -1.3E+45 | 2.000 | 9.3E+00 | 1.1E+04 | 1.3E+45 | 0.000 | 6.6E+01 | 1 | -6.6E+01 | -1 | 6.3E-01 | 0.6232 | -6.3E-01 | -0.62324 | 3.52E-02 |
| 19 | 0.00959 | -3.2E-01 | 7.2E-01 | -1.3E+45 | 2.000 | 9.8E+00 | 1.8E+04 | 1.3E+45 | 0.000 | 6.4E+01 | 1 | -6.4E+01 | -1 | 6.1E-01 | 0.6104 | -6.1E-01 | -0.61038 | 3.39E-02 |
| 20 | 0.00959 | -3.4E-01 | 7.1E-01 | -1.3E+45 | 2.000 | 1.0E+01 | 3.1E+04 | 1.3E+45 | 0.000 | 6.3E+01 | 1 | -6.3E+01 | -1 | 5.9E-01 | 0.5983 | -5.9E-01 | -0.59826 | 3.27E-02 |

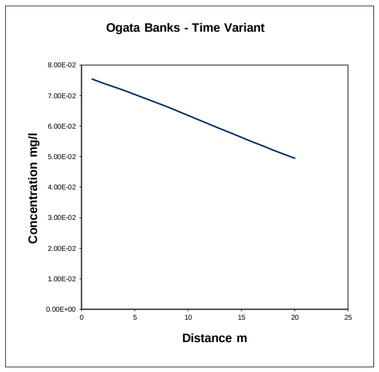



**Calc** **Value**

| | | |
|---|---|---|
| v | 1.08E-03 | m/d |
| Rc | 9.09E+05 | |
| u | 1.19E-09 | m/d |

Calculations for source located at top of aquifer (ie vertical dispersion in one direction) - USED FOR LEVEL ASSESSMENT

| X | Term 1 | Term 2 | EXP | Term 3 | ERFC | Term 4 | EXP | Term 5 | ERFC | Term 6a | ERF | Term 6b | ERF | Term 7a | ERF | Term 7b | ERF | Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.00959 | -1.7E-02 | 9.8E-01 | -1.3E+45 | 2.000 | 5.2E-01 | 1.7E+00 | 1.3E+45 | 0.000 | 2.8E+02 | 1 | -2.8E+02 | -1 | 5.3E+00 | 1 | -5.3E+00 | -1 | 7.54E-02 |
| 2 | 0.00959 | -3.4E-02 | 9.7E-01 | -1.3E+45 | 2.000 | 1.0E+00 | 2.8E+00 | 1.3E+45 | 0.000 | 2.0E+02 | 1 | -2.0E+02 | -1 | 3.8E+00 | 1 | -3.8E+00 | -1 | 7.41E-02 |
| 3 | 0.00959 | -5.1E-02 | 9.5E-01 | -1.3E+45 | 2.000 | 1.6E+00 | 4.7E+00 | 1.3E+45 | 0.000 | 1.6E+02 | 1 | -1.6E+02 | -1 | 3.1E+00 | 1 | -3.1E+00 | -0.99999 | 7.29E-02 |
| 4 | 0.00959 | -6.8E-02 | 9.3E-01 | -1.3E+45 | 2.000 | 2.1E+00 | 7.9E+00 | 1.3E+45 | 0.000 | 1.4E+02 | 1 | -1.4E+02 | -1 | 2.7E+00 | 0.9998 | -2.7E+00 | -0.99982 | 7.16E-02 |
| 5 | 0.00959 | -8.5E-02 | 9.2E-01 | -1.3E+45 | 2.000 | 2.6E+00 | 1.3E+01 | 1.3E+45 | 0.000 | 1.3E+02 | 1 | -1.3E+02 | -1 | 2.4E+00 | 0.9992 | -2.4E+00 | -0.9992 | 7.04E-02 |
| 6 | 0.00959 | -1.0E-01 | 9.0E-01 | -1.3E+45 | 2.000 | 3.1E+00 | 2.2E+01 | 1.3E+45 | 0.000 | 1.1E+02 | 1 | -1.1E+02 | -1 | 2.2E+00 | 0.9978 | -2.2E+00 | -0.9978 | 6.91E-02 |
| 7 | 0.00959 | -1.2E-01 | 8.9E-01 | -1.3E+45 | 2.000 | 3.6E+00 | 3.7E+01 | 1.3E+45 | 0.000 | 1.1E+02 | 1 | -1.1E+02 | -1 | 2.0E+00 | 0.9954 | -2.0E+00 | -0.99541 | 6.78E-02 |
| 8 | 0.00959 | -1.4E-01 | 8.7E-01 | -1.3E+45 | 2.000 | 4.1E+00 | 6.3E+01 | 1.3E+45 | 0.000 | 9.9E+01 | 1 | -9.9E+01 | -1 | 1.9E+00 | 0.992 | -1.9E+00 | -0.99199 | 6.64E-02 |
| 9 | 0.00959 | -1.5E-01 | 8.6E-01 | -1.3E+45 | 2.000 | 4.7E+00 | 1.0E+02 | 1.3E+45 | 0.000 | 9.3E+01 | 1 | -9.3E+01 | -1 | 1.8E+00 | 0.9876 | -1.8E+00 | -0.98758 | 6.50E-02 |
| 10 | 0.00959 | -1.7E-01 | 8.4E-01 | -1.3E+45 | 2.000 | 5.2E+00 | 1.8E+02 | 1.3E+45 | 0.000 | 8.8E+01 | 1 | -8.8E+01 | -1 | 1.7E+00 | 0.9823 | -1.7E+00 | -0.98229 | 6.36E-02 |
| 11 | 0.00959 | -1.9E-01 | 8.3E-01 | -1.3E+45 | 2.000 | 5.7E+00 | 3.0E+02 | 1.3E+45 | 0.000 | 8.4E+01 | 1 | -8.4E+01 | -1 | 1.6E+00 | 0.9763 | -1.6E+00 | -0.97626 | 6.21E-02 |
| 12 | 0.00959 | -2.0E-01 | 8.2E-01 | -1.3E+45 | 2.000 | 6.2E+00 | 4.9E+02 | 1.3E+45 | 0.000 | 8.1E+01 | 1 | -8.1E+01 | -1 | 1.5E+00 | 0.9696 | -1.5E+00 | -0.96962 | 6.06E-02 |
| 13 | 0.00959 | -2.2E-01 | 8.0E-01 | -1.3E+45 | 2.000 | 6.7E+00 | 8.3E+02 | 1.3E+45 | 0.000 | 7.8E+01 | 1 | -7.8E+01 | -1 | 1.5E+00 | 0.9625 | -1.5E+00 | -0.96249 | 5.92E-02 |
| 14 | 0.00959 | -2.4E-01 | 7.9E-01 | -1.3E+45 | 2.000 | 7.2E+00 | 1.4E+03 | 1.3E+45 | 0.000 | 7.5E+01 | 1 | -7.5E+01 | -1 | 1.4E+00 | 0.955 | -1.4E+00 | -0.95498 | 5.77E-02 |
| 15 | 0.00959 | -2.6E-01 | 7.7E-01 | -1.3E+45 | 2.000 | 7.8E+00 | 2.3E+03 | 1.3E+45 | 0.000 | 7.2E+01 | 1 | -7.2E+01 | -1 | 1.4E+00 | 0.9472 | -1.4E+00 | -0.94719 | 5.63E-02 |
| 16 | 0.00959 | -2.7E-01 | 7.6E-01 | -1.3E+45 | 2.000 | 8.3E+00 | 3.9E+03 | 1.3E+45 | 0.000 | 7.0E+01 | 1 | -7.0E+01 | -1 | 1.3E+00 | 0.9392 | -1.3E+00 | -0.93921 | 5.49E-02 |
| 17 | 0.00959 | -2.9E-01 | 7.5E-01 | -1.3E+45 | 2.000 | 8.8E+00 | 6.6E+03 | 1.3E+45 | 0.000 | 6.8E+01 | 1 | -6.8E+01 | -1 | 1.3E+00 | 0.9311 | -1.3E+00 | -0.93109 | 5.35E-02 |
| 18 | 0.00959 | -3.1E-01 | 7.4E-01 | -1.3E+45 | 2.000 | 9.3E+00 | 1.1E+04 | 1.3E+45 | 0.000 | 6.6E+01 | 1 | -6.6E+01 | -1 | 1.3E+00 | 0.9229 | -1.3E+00 | -0.9229 | 5.21E-02 |
| 19 | 0.00959 | -3.2E-01 | 7.2E-01 | -1.3E+45 | 2.000 | 9.8E+00 | 1.8E+04 | 1.3E+45 | 0.000 | 6.4E+01 | 1 | -6.4E+01 | -1 | 1.2E+00 | 0.9147 | -1.2E+00 | -0.91468 | 5.08E-02 |
| 20 | 0.00959 | -3.4E-01 | 7.1E-01 | -1.3E+45 | 2.000 | 1.0E+01 | 3.1E+04 | 1.3E+45 | 0.000 | 6.3E+01 | 1 | -6.3E+01 | -1 | 1.2E+00 | 0.9065 | -1.2E+00 | -0.90647 | 4.95E-02 |




| | |
|---|---|
| Date: | 24/02/2020 |
| Version: | 1 |

**Contaminant** **zo(b)fluoranthene**

| Input | Value | Units |
|---|---|---|
| $C_T$ | 0.00000017 | mg/l |
| Co | 7.67E-02 | mg/l |
| λ | 2.09E-11 | days$^{-1}$ |
| Sz | 5.00E+02 | m |
| Sy | 1.50E+00 | m |
| Kd | 5.34E+04 | l/kg |
| ρ | 1.36E+00 | g/cm3 |
| n | 8.00E-02 | |
| i | 1.00E-02 | |
| K | 8.64E-03 | m/d |
| x | 2.00E+01 | m |
| z | 0.00E+00 | m |
| y | 0.00E+00 | m |
| ax | 2.00E+00 | m |
| az | 2.00E-01 | m |
| ay | 2.00E-02 | m |

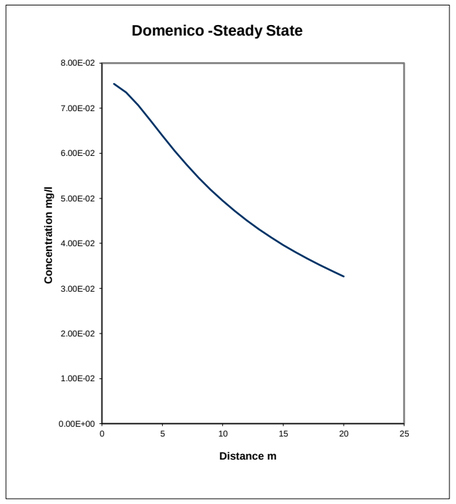
Vertical dispersion optio Simulate vertical dispersion in 1 direction

| Calc | Value | |
|---|---|---|
| v | 1.08E-03 | m/d |
| Rc | 9.09E+05 | |
| u | 1.19E-09 | m/d |

**DOMENICO (STEADY STATE)**

Calculations for source located in centre of aquifer (ie vertical dispersion in two directions)

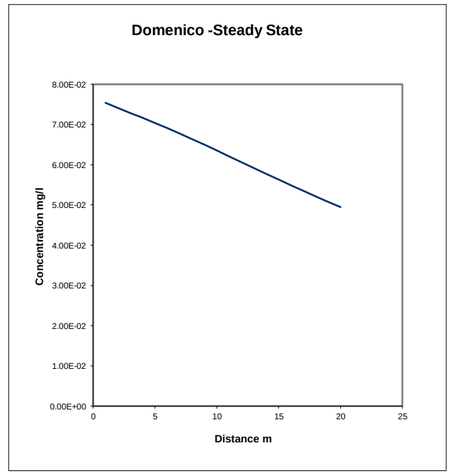
| | X | Term 1 | Term 2 | EXP | Term 3A | ERF | Term 3B | ERF | Term 4A | ERF | Term 4B | ERF | Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 0.01918 | -1.70E-02 | 9.83E-01 | 2.80E+02 | 1 | -2.80E+02 | -1 | 2.65E+00 | 0.9998 | -2.65E+00 | -0.9998 | 7.54E-02 |
| 2 | 2 | 0.01918 | -3.40E-02 | 9.67E-01 | 1.98E+02 | 1 | -1.98E+02 | -1 | 1.88E+00 | 0.992 | -1.88E+00 | -0.992 | 7.35E-02 |
| 3 | 3 | 0.01918 | -5.10E-02 | 9.50E-01 | 1.61E+02 | 1 | -1.61E+02 | -1 | 1.53E+00 | 0.9696 | -1.53E+00 | -0.9696 | 7.07E-02 |
| 4 | 4 | 0.01918 | -6.80E-02 | 9.34E-01 | 1.40E+02 | 1 | -1.40E+02 | -1 | 1.33E+00 | 0.9392 | -1.33E+00 | -0.9392 | 6.73E-02 |
| 5 | 5 | 0.01918 | -8.50E-02 | 9.18E-01 | 1.25E+02 | 1 | -1.25E+02 | -1 | 1.19E+00 | 0.9065 | -1.19E+00 | -0.9065 | 6.39E-02 |
| 6 | 6 | 0.01918 | -1.02E-01 | 9.03E-01 | 1.14E+02 | 1 | -1.14E+02 | -1 | 1.08E+00 | 0.8742 | -1.08E+00 | -0.8742 | 6.05E-02 |
| 7 | 7 | 0.01918 | -1.19E-01 | 8.88E-01 | 1.06E+02 | 1 | -1.06E+02 | -1 | 1.00E+00 | 0.8436 | -1.00E+00 | -0.8436 | 5.74E-02 |
| 8 | 8 | 0.01918 | -1.36E-01 | 8.73E-01 | 9.88E+01 | 1 | -9.88E+01 | -1 | 9.38E-01 | 0.8151 | -9.38E-01 | -0.8151 | 5.46E-02 |
| 9 | 9 | 0.01918 | -1.53E-01 | 8.58E-01 | 9.32E+01 | 1 | -9.32E+01 | -1 | 8.84E-01 | 0.7887 | -8.84E-01 | -0.7887 | 5.19E-02 |
| 10 | 10 | 0.01918 | -1.70E-01 | 8.44E-01 | 8.84E+01 | 1 | -8.84E+01 | -1 | 8.39E-01 | 0.7643 | -8.39E-01 | -0.7643 | 4.95E-02 |
| 11 | 11 | 0.01918 | -1.87E-01 | 8.29E-01 | 8.43E+01 | 1 | -8.43E+01 | -1 | 8.00E-01 | 0.7418 | -8.00E-01 | -0.7418 | 4.72E-02 |
| 12 | 12 | 0.01918 | -2.04E-01 | 8.15E-01 | 8.07E+01 | 1 | -8.07E+01 | -1 | 7.65E-01 | 0.721 | -7.65E-01 | -0.721 | 4.51E-02 |
| 13 | 13 | 0.01918 | -2.21E-01 | 8.02E-01 | 7.75E+01 | 1 | -7.75E+01 | -1 | 7.35E-01 | 0.7017 | -7.35E-01 | -0.7017 | 4.31E-02 |
| 14 | 14 | 0.01918 | -2.38E-01 | 7.88E-01 | 7.47E+01 | 1 | -7.47E+01 | -1 | 7.09E-01 | 0.6838 | -7.09E-01 | -0.6838 | 4.13E-02 |
| 15 | 15 | 0.01918 | -2.55E-01 | 7.75E-01 | 7.22E+01 | 1 | -7.22E+01 | -1 | 6.85E-01 | 0.6671 | -6.85E-01 | -0.6671 | 3.96E-02 |
| 16 | 16 | 0.01918 | -2.72E-01 | 7.62E-01 | 6.99E+01 | 1 | -6.99E+01 | -1 | 6.63E-01 | 0.6515 | -6.63E-01 | -0.6515 | 3.81E-02 |
| 17 | 17 | 0.01918 | -2.89E-01 | 7.49E-01 | 6.78E+01 | 1 | -6.78E+01 | -1 | 6.43E-01 | 0.6369 | -6.43E-01 | -0.6369 | 3.66E-02 |
| 18 | 18 | 0.01918 | -3.06E-01 | 7.36E-01 | 6.59E+01 | 1 | -6.59E+01 | -1 | 6.25E-01 | 0.6232 | -6.25E-01 | -0.6232 | 3.52E-02 |
| 19 | 19 | 0.01918 | -3.23E-01 | 7.24E-01 | 6.41E+01 | 1 | -6.41E+01 | -1 | 6.08E-01 | 0.6104 | -6.08E-01 | -0.6104 | 3.39E-02 |
| 20 | 20 | 0.01918 | -3.40E-01 | 7.12E-01 | 6.25E+01 | 1 | -6.25E+01 | -1 | 5.93E-01 | 0.5983 | -5.93E-01 | -0.5983 | 3.27E-02 |




**DOMENICO (STEADY STATE)**

Calculations for source located at top of aquifer (ie vertical dispersion in one direction) - USED FOR LEVEL ASSESSMENT

| | X | Term 1 | Term 2 | EXP | Term 3A | ERF | Term 3B | ERF | Term 4A | ERF | Term 4B | ERF | Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 0.01918 | -1.70E-02 | 9.83E-01 | 2.80E+02 | 1 | -2.80E+02 | -1 | 5.30E+00 | 1 | -5.30E+00 | -1 | 7.54E-02 |
| 2 | 2 | 0.01918 | -3.40E-02 | 9.67E-01 | 1.98E+02 | 1 | -1.98E+02 | -1 | 3.75E+00 | 1 | -3.75E+00 | -1 | 7.41E-02 |
| 3 | 3 | 0.01918 | -5.10E-02 | 9.50E-01 | 1.61E+02 | 1 | -1.61E+02 | -1 | 3.06E+00 | 1 | -3.06E+00 | -1 | 7.29E-02 |
| 4 | 4 | 0.01918 | -6.80E-02 | 9.34E-01 | 1.40E+02 | 1 | -1.40E+02 | -1 | 2.65E+00 | 0.9998 | -2.65E+00 | -0.9998 | 7.16E-02 |
| 5 | 5 | 0.01918 | -8.50E-02 | 9.18E-01 | 1.25E+02 | 1 | -1.25E+02 | -1 | 2.37E+00 | 0.9992 | -2.37E+00 | -0.9992 | 7.04E-02 |
| 6 | 6 | 0.01918 | -1.02E-01 | 9.03E-01 | 1.14E+02 | 1 | -1.14E+02 | -1 | 2.17E+00 | 0.9978 | -2.17E+00 | -0.9978 | 6.91E-02 |
| 7 | 7 | 0.01918 | -1.19E-01 | 8.88E-01 | 1.06E+02 | 1 | -1.06E+02 | -1 | 2.00E+00 | 0.9954 | -2.00E+00 | -0.9954 | 6.78E-02 |
| 8 | 8 | 0.01918 | -1.36E-01 | 8.73E-01 | 9.88E+01 | 1 | -9.88E+01 | -1 | 1.88E+00 | 0.992 | -1.88E+00 | -0.992 | 6.64E-02 |
| 9 | 9 | 0.01918 | -1.53E-01 | 8.58E-01 | 9.32E+01 | 1 | -9.32E+01 | -1 | 1.77E+00 | 0.9876 | -1.77E+00 | -0.9876 | 6.50E-02 |
| 10 | 10 | 0.01918 | -1.70E-01 | 8.44E-01 | 8.84E+01 | 1 | -8.84E+01 | -1 | 1.68E+00 | 0.9823 | -1.68E+00 | -0.9823 | 6.36E-02 |
| 11 | 11 | 0.01918 | -1.87E-01 | 8.29E-01 | 8.43E+01 | 1 | -8.43E+01 | -1 | 1.60E+00 | 0.9763 | -1.60E+00 | -0.9763 | 6.21E-02 |
| 12 | 12 | 0.01918 | -2.04E-01 | 8.15E-01 | 8.07E+01 | 1 | -8.07E+01 | -1 | 1.53E+00 | 0.9696 | -1.53E+00 | -0.9696 | 6.06E-02 |
| 13 | 13 | 0.01918 | -2.21E-01 | 8.02E-01 | 7.75E+01 | 1 | -7.75E+01 | -1 | 1.47E+00 | 0.9625 | -1.47E+00 | -0.9625 | 5.92E-02 |
| 14 | 14 | 0.01918 | -2.38E-01 | 7.88E-01 | 7.47E+01 | 1 | -7.47E+01 | -1 | 1.42E+00 | 0.955 | -1.42E+00 | -0.955 | 5.77E-02 |
| 15 | 15 | 0.01918 | -2.55E-01 | 7.75E-01 | 7.22E+01 | 1 | -7.22E+01 | -1 | 1.37E+00 | 0.9472 | -1.37E+00 | -0.9472 | 5.63E-02 |
| 16 | 16 | 0.01918 | -2.72E-01 | 7.62E-01 | 6.99E+01 | 1 | -6.99E+01 | -1 | 1.33E+00 | 0.9392 | -1.33E+00 | -0.9392 | 5.49E-02 |
| 17 | 17 | 0.01918 | -2.89E-01 | 7.49E-01 | 6.78E+01 | 1 | -6.78E+01 | -1 | 1.29E+00 | 0.9311 | -1.29E+00 | -0.9311 | 5.35E-02 |
| 18 | 18 | 0.01918 | -3.06E-01 | 7.36E-01 | 6.59E+01 | 1 | -6.59E+01 | -1 | 1.25E+00 | 0.9229 | -1.25E+00 | -0.9229 | 5.21E-02 |
| 19 | 19 | 0.01918 | -3.23E-01 | 7.24E-01 | 6.41E+01 | 1 | -6.41E+01 | -1 | 1.22E+00 | 0.9147 | -1.22E+00 | -0.9147 | 5.08E-02 |
| 20 | 20 | 0.01918 | -3.40E-01 | 7.12E-01 | 6.25E+01 | 1 | -6.25E+01 | -1 | 1.19E+00 | 0.9065 | -1.19E+00 | -0.9065 | 4.95E-02 |




| | |
|---|---|
| Date: | 24/02/2020 |
| Version: | 1 |

## DOMENICO (TIME VARIANT)

**Contaminant** **zo(b)fluoranthene**

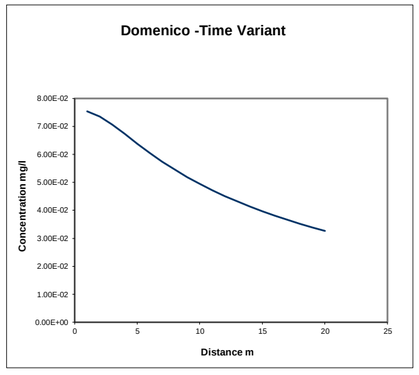
| Input | Value | Units |
|---|---|---|
| $C_T$ | 0.00000017 | mg/l |
| Co | 7.67E-02 | mg/l |
| λ | 2.09E-11 | $days^{-1}$ |
| Sz | 5.00E+02 | m |
| Sy | 1.50E+00 | m |
| Kd | 5.34E+04 | l/kg |
| ρ | 1.36E+00 | g/cm3 |
| n | 8.00E-02 | |
| i | 1.00E-02 | |
| K | 8.64E-03 | m/d |
| x | 2.00E+01 | m |
| z | 0.00E+00 | m |
| y | 0.00E+00 | m |
| t | 1.00E+100 | days |
| ax | 2.00E+00 | m |
| az | 2.00E-01 | m |
| ay | 2.00E-02 | m |

Vertical dispersion option Simulate vertical dispersion in 1 direction

| Calc | Value | |
|---|---|---|
| v | 1.08E-03 | m/d |
| Rc | 9.09E+05 | |
| u | 1.19E-09 | m/d |

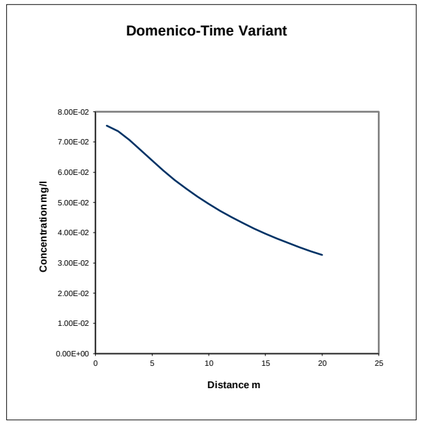
Calculations for source located in centre of aquifer (ie vertical dispersion in two directions)

| | X | Term 1 | Term 2 | EXP | Term 3 | ERFC | Term 4A | ERF | Term 4B | ERF | Term 5A | ERF | Term 5B | ERF | Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | m | | | | | | | | | | | | | | |
| 1 | 1 | 0.00959 | -1.70E-02 | 9.83E-01 | -1.30E+45 | 2 | 2.80E+02 | 1 | -2.80E+02 | -1 | 2.65E+00 | 0.9998 | -2.65E+00 | -1 | 7.54E-02 |
| 2 | 2 | 0.00959 | -3.40E-02 | 9.67E-01 | -1.30E+45 | 2 | 1.98E+02 | 1 | -1.98E+02 | -1 | 1.88E+00 | 0.992 | -1.88E+00 | -0.992 | 7.35E-02 |
| 3 | 3 | 0.00959 | -5.10E-02 | 9.50E-01 | -1.30E+45 | 2 | 1.61E+02 | 1 | -1.61E+02 | -1 | 1.53E+00 | 0.9696 | -1.53E+00 | -0.97 | 7.07E-02 |
| 4 | 4 | 0.00959 | -6.80E-02 | 9.34E-01 | -1.30E+45 | 2 | 1.40E+02 | 1 | -1.40E+02 | -1 | 1.33E+00 | 0.9392 | -1.33E+00 | -0.939 | 6.73E-02 |
| 5 | 5 | 0.00959 | -8.50E-02 | 9.18E-01 | -1.30E+45 | 2 | 1.25E+02 | 1 | -1.25E+02 | -1 | 1.19E+00 | 0.9065 | -1.19E+00 | -0.906 | 6.39E-02 |
| 6 | 6 | 0.00959 | -1.02E-01 | 9.03E-01 | -1.30E+45 | 2 | 1.14E+02 | 1 | -1.14E+02 | -1 | 1.08E+00 | 0.8742 | -1.08E+00 | -0.874 | 6.05E-02 |
| 7 | 7 | 0.00959 | -1.19E-01 | 8.88E-01 | -1.30E+45 | 2 | 1.06E+02 | 1 | -1.06E+02 | -1 | 1.00E+00 | 0.8436 | -1.00E+00 | -0.844 | 5.74E-02 |
| 8 | 8 | 0.00959 | -1.36E-01 | 8.73E-01 | -1.30E+45 | 2 | 9.88E+01 | 1 | -9.88E+01 | -1 | 9.38E-01 | 0.8151 | -9.38E-01 | -0.815 | 5.46E-02 |
| 9 | 9 | 0.00959 | -1.53E-01 | 8.58E-01 | -1.30E+45 | 2 | 9.32E+01 | 1 | -9.32E+01 | -1 | 8.84E-01 | 0.7887 | -8.84E-01 | -0.789 | 5.19E-02 |
| 10 | 10 | 0.00959 | -1.70E-01 | 8.44E-01 | -1.30E+45 | 2 | 8.84E+01 | 1 | -8.84E+01 | -1 | 8.39E-01 | 0.7643 | -8.39E-01 | -0.764 | 4.95E-02 |
| 11 | 11 | 0.00959 | -1.87E-01 | 8.29E-01 | -1.30E+45 | 2 | 8.43E+01 | 1 | -8.43E+01 | -1 | 8.00E-01 | 0.7418 | -8.00E-01 | -0.742 | 4.72E-02 |
| 12 | 12 | 0.00959 | -2.04E-01 | 8.15E-01 | -1.30E+45 | 2 | 8.07E+01 | 1 | -8.07E+01 | -1 | 7.65E-01 | 0.721 | -7.65E-01 | -0.721 | 4.51E-02 |
| 13 | 13 | 0.00959 | -2.21E-01 | 8.02E-01 | -1.30E+45 | 2 | 7.75E+01 | 1 | -7.75E+01 | -1 | 7.35E-01 | 0.7017 | -7.35E-01 | -0.702 | 4.31E-02 |
| 14 | 14 | 0.00959 | -2.38E-01 | 7.88E-01 | -1.30E+45 | 2 | 7.47E+01 | 1 | -7.47E+01 | -1 | 7.09E-01 | 0.6838 | -7.09E-01 | -0.684 | 4.13E-02 |
| 15 | 15 | 0.00959 | -2.55E-01 | 7.75E-01 | -1.30E+45 | 2 | 7.22E+01 | 1 | -7.22E+01 | -1 | 6.85E-01 | 0.6671 | -6.85E-01 | -0.667 | 3.96E-02 |
| 16 | 16 | 0.00959 | -2.72E-01 | 7.62E-01 | -1.30E+45 | 2 | 6.99E+01 | 1 | -6.99E+01 | -1 | 6.63E-01 | 0.6515 | -6.63E-01 | -0.651 | 3.81E-02 |
| 17 | 17 | 0.00959 | -2.89E-01 | 7.49E-01 | -1.30E+45 | 2 | 6.78E+01 | 1 | -6.78E+01 | -1 | 6.43E-01 | 0.6369 | -6.43E-01 | -0.637 | 3.66E-02 |
| 18 | 18 | 0.00959 | -3.06E-01 | 7.36E-01 | -1.30E+45 | 2 | 6.59E+01 | 1 | -6.59E+01 | -1 | 6.25E-01 | 0.6232 | -6.25E-01 | -0.623 | 3.52E-02 |
| 19 | 19 | 0.00959 | -3.23E-01 | 7.24E-01 | -1.30E+45 | 2 | 6.41E+01 | 1 | -6.41E+01 | -1 | 6.08E-01 | 0.6104 | -6.08E-01 | -0.61 | 3.39E-02 |
| 20 | 20 | 0.00959 | -3.40E-01 | 7.12E-01 | -1.30E+45 | 2 | 6.25E+01 | 1 | -6.25E+01 | -1 | 5.93E-01 | 0.5983 | -5.93E-01 | -0.598 | 3.27E-02 |




Calculations for source located at top of aquifer (ie vertical dispersion in one direction only) - USED FOR LEVEL ASSESSMENT

| | X | Term 1 | Term 2 | EXP | Term 3 | ERFC | Term 4A | ERF | Term 4B | ERF | Term 5A | ERF | Term 5B | ERF | Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | m | | | | | | | | | | | | | | |
| 1 | 1 | 0.00959 | -1.70E-02 | 9.83E-01 | -1.30E+45 | 2 | 2.80E+02 | 1 | -2.80E+02 | -1 | 5.30E+00 | 1 | -5.30E+00 | -1 | 7.54E-02 |
| 2 | 2 | 0.00959 | -3.40E-02 | 9.67E-01 | -1.30E+45 | 2 | 1.98E+02 | 1 | -1.98E+02 | -1 | 3.75E+00 | 1 | -3.75E+00 | -1 | 7.41E-02 |
| 3 | 3 | 0.00959 | -5.10E-02 | 9.50E-01 | -1.30E+45 | 2 | 1.61E+02 | 1 | -1.61E+02 | -1 | 3.06E+00 | 1 | -3.06E+00 | -1 | 7.29E-02 |
| 4 | 4 | 0.00959 | -6.80E-02 | 9.34E-01 | -1.30E+45 | 2 | 1.40E+02 | 1 | -1.40E+02 | -1 | 2.65E+00 | 0.9998 | -2.65E+00 | -1 | 7.16E-02 |
| 5 | 5 | 0.00959 | -8.50E-02 | 9.18E-01 | -1.30E+45 | 2 | 1.25E+02 | 1 | -1.25E+02 | -1 | 2.37E+00 | 0.9992 | -2.37E+00 | -0.999 | 7.04E-02 |
| 6 | 6 | 0.00959 | -1.02E-01 | 9.03E-01 | -1.30E+45 | 2 | 1.14E+02 | 1 | -1.14E+02 | -1 | 2.17E+00 | 0.9978 | -2.17E+00 | -0.998 | 6.91E-02 |
| 7 | 7 | 0.00959 | -1.19E-01 | 8.88E-01 | -1.30E+45 | 2 | 1.06E+02 | 1 | -1.06E+02 | -1 | 2.00E+00 | 0.9954 | -2.00E+00 | -0.995 | 6.78E-02 |
| 8 | 8 | 0.00959 | -1.36E-01 | 8.73E-01 | -1.30E+45 | 2 | 9.88E+01 | 1 | -9.88E+01 | -1 | 1.88E+00 | 0.992 | -1.88E+00 | -0.992 | 6.64E-02 |
| 9 | 9 | 0.00959 | -1.53E-01 | 8.58E-01 | -1.30E+45 | 2 | 9.32E+01 | 1 | -9.32E+01 | -1 | 1.77E+00 | 0.9876 | -1.77E+00 | -0.988 | 6.50E-02 |
| 10 | 10 | 0.00959 | -1.70E-01 | 8.44E-01 | -1.30E+45 | 2 | 8.84E+01 | 1 | -8.84E+01 | -1 | 1.68E+00 | 0.9823 | -1.68E+00 | -0.982 | 6.36E-02 |
| 11 | 11 | 0.00959 | -1.87E-01 | 8.29E-01 | -1.30E+45 | 2 | 8.43E+01 | 1 | -8.43E+01 | -1 | 1.60E+00 | 0.9763 | -1.60E+00 | -0.976 | 6.21E-02 |
| 12 | 12 | 0.00959 | -2.04E-01 | 8.15E-01 | -1.30E+45 | 2 | 8.07E+01 | 1 | -8.07E+01 | -1 | 1.53E+00 | 0.9696 | -1.53E+00 | -0.97 | 6.06E-02 |
| 13 | 13 | 0.00959 | -2.21E-01 | 8.02E-01 | -1.30E+45 | 2 | 7.75E+01 | 1 | -7.75E+01 | -1 | 1.47E+00 | 0.9625 | -1.47E+00 | -0.962 | 5.92E-02 |
| 14 | 14 | 0.00959 | -2.38E-01 | 7.88E-01 | -1.30E+45 | 2 | 7.47E+01 | 1 | -7.47E+01 | -1 | 1.42E+00 | 0.955 | -1.42E+00 | -0.955 | 5.77E-02 |
| 15 | 15 | 0.00959 | -2.55E-01 | 7.75E-01 | -1.30E+45 | 2 | 7.22E+01 | 1 | -7.22E+01 | -1 | 1.37E+00 | 0.9472 | -1.37E+00 | -0.947 | 5.63E-02 |
| 16 | 16 | 0.00959 | -2.72E-01 | 7.62E-01 | -1.30E+45 | 2 | 6.99E+01 | 1 | -6.99E+01 | -1 | 1.33E+00 | 0.9392 | -1.33E+00 | -0.939 | 5.49E-02 |
| 17 | 17 | 0.00959 | -2.89E-01 | 7.49E-01 | -1.30E+45 | 2 | 6.78E+01 | 1 | -6.78E+01 | -1 | 1.29E+00 | 0.9311 | -1.29E+00 | -0.931 | 5.35E-02 |
| 18 | 18 | 0.00959 | -3.06E-01 | 7.36E-01 | -1.30E+45 | 2 | 6.59E+01 | 1 | -6.59E+01 | -1 | 1.25E+00 | 0.9229 | -1.25E+00 | -0.923 | 5.21E-02 |
| 19 | 19 | 0.00959 | -3.23E-01 | 7.24E-01 | -1.30E+45 | 2 | 6.41E+01 | 1 | -6.41E+01 | -1 | 1.22E+00 | 0.9147 | -1.22E+00 | -0.915 | 5.08E-02 |
| 20 | 20 | 0.00959 | -3.40E-01 | 7.12E-01 | -1.30E+45 | 2 | 6.25E+01 | 1 | -6.25E+01 | -1 | 1.19E+00 | 0.9065 | -1.19E+00 | -0.906 | 4.95E-02 |




| | |
|---|---|
| Date: | 24/02/2020 |
| Version: | 1 |

# Hydrogeological risk assessment for land contamination

## Remedial Targets Worksheet , Release 3.2

**First released: 2006. Version 3.2: January 2013**

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination ( Environment Agency 2006).

**Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.**

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The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

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IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions)

| **Details to be completed for each assessment** | | | | |
|---|---|---|---|---|
| **Site Name:** | **Glan Llyn** | | | |
| **Site Address:** | **Llanwern** | | | |
| **Completed by:** | **Ross Cameron** | | | |
| **Date:** | **24-Feb-20** | | **Version:** | **1** |
| **Contaminant** | **Iron** | | | |
| **Target Concentration ($C_T$)** | **1** | **mg/l** | **Origin of $C_T$:** | **Water Framework Directive EQS** |

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparision with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).
Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.
Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.
Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.
Data carried forward from an earlier worksheet are identified by a light green background
It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

## Remedial Targets Worksheet , Release 3.2

# Level 1 - Soil

Environment Agency

**Select the method of calculating the soil water Partition Co-efficient by using the pull down menu below**

**User specified value for partition coefficient**

| | | | | |
|---|---|---|---|---|
| **Contaminant** | | **Iron** | | |
| **Target concentration** | **$C_T$** | **1** | **mg/l** | |

| **Input Parameters** | **Variable** | **Value** | **Unit** | **Source of parameter value** |
|---|---|---|---|---|
| ***Standard entry*** | | | | |
| Water filled soil porosity | $\theta_w$ | 5.00E-01 | fraction | 0.5 |
| Air filled soil porosity | θa | 3.70E-01 | fraction | 0.0037 |
| Bulk density of soil zone material | ρ | 1.36E+00 | g/cm$^3$ | 1.36 |
| Henry's Law constant | H | 1.00E+00 | dimensionless | *1* |
| ***Entry if specify partition coefficient (option)*** | | | | |
| Soil water partition coefficient | Kd | 1.34E+02 | l/kg | *1.34E+02* |
| ***Entry for non-polar organic chemicals (option)*** | | | | |
| Fraction of organic carbon (in soil) | foc | | fraction | |
| Organic carbon partition coefficient | Koc | | l/kg | |
| ***Entry for ionic organic chemicals (option)*** | | | | |
| Sorption coefficient for neutral species | $K_{oc,n}$ | | l/kg | |
| Sorption coefficient for ionised species | $K_{oc,i}$ | | l/kg | |
| pH value | pH | | pH units | |
| Acid dissociation constant | pKa | | | |
| Fraction of organic carbon (in soil) | foc | | fraction | |

This sheet calculates the Level 1 remedial target for soils(mg/kg) based on a selected target concentration and theoretical calculation of soil water partitioning. Three options are included for determining the partition coefficient.

The measured soil concentration as mg/kg should be compared with the Level 1 remedial target to determine the need for further action.

| | | | | |
|---|---|---|---|---|
| **Soil water partition coefficient used in Level Assessment** | **Kd** | **1.34E+02** | **l/kg** | *Specified value* |

## Level 1 Remedial Target

| | | | |
|---|---|---|---|
| **Level 1 Remedial Target** | **1.35E+02** | **mg/kg** | **(for comparison with soil analyses)** |
| | **or** | | |
| | **1** | **mg/l** | **(for comparison with leachate test results)** |

| | |
|---|---|
| Site being assessed: | Glan Llyn |
| Completed by: | Ross Cameron |
| Date: | 24-Feb-20 |
| Version: | 1 |

## Remedial Targets Worksheet , Release 3.2

# Level 2 - Soil

| | | | | |
|---|---|---|---|---|
| **Contaminant** | | **Iron** | | from Level 1 |
| **Target concentration** | $C_T$ | **1** | **mg/l** | from Level 1 |

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamiantion' (Environment Agency 2006)

| **Input Parameters** | **Variable** | **Value** | **Unit** | **Source of parameter value** | |
|---|---|---|---|---|---|
| *Standard entry* | | | | | |
| Infiltration | Inf | 0.00E+00 | m/d | | |
| Area of contaminant source | A | 0.00E+00 | $m^2$ | | Not used in calculation |
| *Entry for groundwater flow below site* | | | | | |
| Length of contaminant source in direction of groundwater flow | L | 0.00E+00 | m | | |
| Saturated aquifer thickness | da | 0.00E+00 | m | | |
| Hydraulic Conductivity of aquifer in which dilution occurs | K | 0.00E+00 | m/d | | |
| Hydraulic gradient of water table | i | 0.00E+00 | fraction | | |
| Width of contaminant source perpendicular to groundwater flow | w | 0.00E+00 | m | | Not used in calculation |
| Background concentration of contaminant in groundwater beneath site | Cu | 0.00E+00 | mg/l | | |
| Define mixing zone depth by specifying or calculating depth (using pull down list) | | **Specify** | | | |
| Enter mixing zone thickness | Mz | 0.00E+00 | m | | |
| Calculated mixing zone thickness | Mz | | m | | |

## Calculated Parameters

| | | | | |
|---|---|---|---|---|
| **Dilution Factor** | **DF** | **#DIV/0!** | | |
| **Level 2 Remedial Target** | | **#DIV/0!** | **mg/l** | **For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentra** |
| | | **or** | | |
| | | **#DIV/0!** | **mg/kg** | **For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water** |

## *Additional option*

**Calculation of impact on receptor**

| | | | | |
|---|---|---|---|---|
| Concentration of contaminant in contaminated discharge (entering receptor) | Cc | 0.00E+00 | mg/l | |
| Calculated concentration within receptor (dilution only) | | #DIV/0! | mg/l | 0 |

| | |
|---|---|
| Site being assessed: | Glan Llyn |
| Completed by: | Ross Cameron |
| Date: | 24-Feb-20 |
| Version: | 1 |

**Remedial Targets Worksheet , Release 3.2**

## Level 3 - Soil

See Note

### Input Parameters

| | Variable | Value | Unit | Source |
|---|---|---|---|---|
| Contaminant | | Iron | | from Level 1 |
| Target Concentration | $C_T$ | 1 | mg/l | from Level 1 |
| Dilution Factor | DF | #DIV/0! | | from Level 2 |

**Select analytical solution (click on brown cell below, then on pull-down menu)**

Ogata Banks — Equations in HRA publication

**Select nature of decay rate (click on brown cell below, then on pull-down menu)**

Approach for simulating degradation of pollutants: Apply degradation rate to pollutants in all phases (e.g. field derived value, l

| | Variable | Value | Unit | Source of parameter value |
|---|---|---|---|---|
| Enter source concentration | | Soil concentration as mg/kg | | |
| Enter soil concentration | | 0 | mg/kg | |
| Half life for degradation of contaminant in water | $t_{1/2}$ | 1.00E+100 | days | |
| Calculated decay rate | $\lambda$ | 6.93E-101 | $days^{-1}$ | calculated |
| Width of plume in aquifer at source | Sz | 0.00E+00 | m | from Level 2 |
| Plume thickness in aquifer at source | Sy | 0.00E+00 | m | from Level 2 |
| Bulk density of aquifer materials | $\rho$ | 0.00E+00 | $g/cm^3$ | |
| Effective porosity of aquifer | n | 0.00E+00 | fraction | |
| Hydraulic gradient | i | #DIV/0! | fraction | from Level 2 (adjusted) |
| Hydraulic conductivity of saturated aquifer | K | 0.00E+00 | m/d | from Level 2 |
| Distance to compliance point | x | 0.00E+00 | m | |
| Distance (lateral) to compliance point perpendicular to flow direction | z | | m | |
| Distance (depth) to compliance point perpendicular to flow direction | y | | m | |
| Time since pollutant entered groundwater | t | 1.00E+99 | days | *time variant options only* |
| *Parameters values determined from options* | | | | |
| Partition coefficient | Kd | 0.00E+00 | l/kg | *see options* |
| Longitudinal dispersivity | ax | 0.000 | m | *see options* |
| Transverse dispersivity | az | 0.000 | m | *see options* |
| Vertical dispersivity | av | 0.000 | m | *see options* |

***Parameter values should be checked against Level 1 and 2***

### Calculated Parameters

| | Variable | | |
|---|---|---|---|
| Groundwater flow velocity | v | #DIV/0! | m/d |
| Retardation factor | Rf | #DIV/0! | fraction |
| Decay rate used | $\lambda$ | 6.93E-101 | $d^{-1}$ |
| Hydraulic gradient used in aquifer flow down-gradient | i | #DIV/0! | fraction |
| Rate of contaminant flow due to retardation | u | #DIV/0! | m/d |
| Ratio of Compliance Point to Source Concentration | $C_{ED}/C_0$ | #DIV/0! | fraction |
| **Attenuation factor ($C_0/C_{ED}$)** | **AF** | **#DIV/0!** | **fraction** |
| Calculated soil leachate concentration | Co | 0.00E+00 | mg/l |

### Remedial Targets

| | | | |
|---|---|---|---|
| **Level 3 Remedial Target** | **#DIV/0!** | **mg/l** | For comparison with measured pore water concentration. |
| Ogata Banks | **or** | | This assumes Level 1 Remedial Target is based on Target Concentration. |
| | **#DIV/0!** | **mg/kg** | For comparison with measured soil concentration. This |
| **Distance to compliance point** | **0** | **m** | assumes Level 1 Remedial Target calculated from soil-water partitioning equation. |
| **Ratio of Compliance Point to Source Concentration** | **$C_{ED}/C_0$** | **#DIV/0!** | **fraction** Ogata Banks |

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99

**Enter method of defining partition co-efficient (using pull down list)**

Calculate for ionic organic chemicals (acids)

***Entry if specify partition coefficient (option)***

Soil water partition coefficient — Kd — l/kg

***Entry for non-polar organic chemicals (option)***

Fraction of organic carbon in aquifer — foc — fraction
Organic carbon partition coefficient — Koc — l/kg

***Entry for ionic organic chemicals (option)***

| | | | |
|---|---|---|---|
| Sorption coefficient for related species | $K_{oc,n}$ | 0.00E+00 | l/kg |
| Sorption coefficient for ionised species | $K_{oc,i}$ | 0.00E+00 | l/kg |
| pH value | pH | 0.00E+00 | |
| Acid dissociation constant | pKa | 0.00E+00 | |
| Fraction of organic carbon in aquifer | foc | 0.00E+00 | fraction |
| Soil water partition coefficient | Kd | 0.00E+00 | l/kg |

**Define dispersivity (click brown cell and use pull down list)**

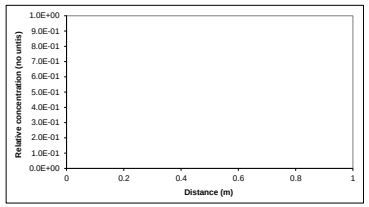
User defined values for dispersivity

| | | Enter value | Calc value | Xu & Eckstein | |
|---|---|---|---|---|---|
| **Longitudinal dispersivity** | **ax** | 0.00E+00 | 0.00E+00 | #NUM! | m |
| **Transverse dispersivity** | **az** | 0.00E+00 | 0.00E+00 | #NUM! | m |
| **Vertical dispersivity** | **ay** | 0.00E+00 | 0.00E+00 | #NUM! | m |

**Note values of dispersivity must be > 0**

Xu & Eckstein (1995) report ax = $0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed

Note
This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by $O_2$, $NO_3$, $SO_4$ etc than an alternative solution should be used




Note: 'Relative concentration' is the ratio of calculated concentation at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

| | |
|---|---|
| Site being assessed: | Glan Llyn |
| Completed by: | Ross Cameron |
| Date: | ######## |
| Version: | 1 |

**Calculated (relative) concentrations for distance-concentration graph**

Ogata Banks
From calculation sheet

| Distance | Relative concentration (No units) | Concentration mg/l |
|---|---|---|
| 0 | 1.0E+00 | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |

# Remedial Targets Worksheet , Release 3.2

## Calculation of contaminant concentration in groundwater from a soil source

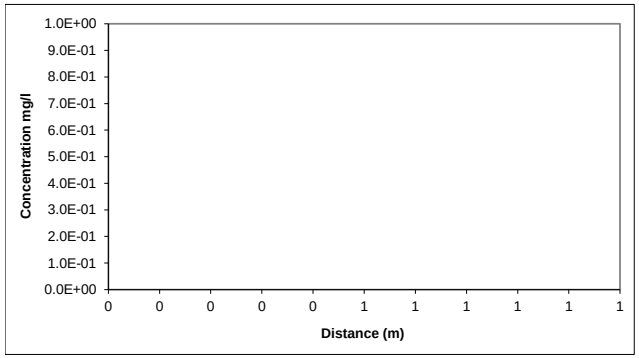
Only input required is Soil Contaminant Concentration

| | | | | |
|---|---|---|---|---|
| | Input Parameters | | | |
| | Soil contaminant concentration | $C_0$ | 0.00E+00 | mg/kg |
| **Level 1 Parameters** | | | | |
| | Water filled soil porosity | $\theta_w$ | 5.00E-01 | fraction |
| | Air filled soil porosity | $\theta a$ | 3.70E-01 | fraction |
| | Bulk density | $\rho$ | 1.36E+00 | g/cm$^3$ |
| | Henry's Law constant | H | 1.00E+00 | dimensionless |
| | Soil water partition coefficient used in Level Assessment | Kd | 1.34E+02 | l/kg |
| | Factor (partitioning between soil and water) | | 1.35E+02 | dimensionless |
| **Level 2 Parameters** | **Dilution Factor** | DF | #DIV/0! | |
| **Level 3 Parameters** | **Attenuation factor ($C_O/C_{ED}$)** | AF | #DIV/0! | |

### Predicted concentrations at compliance point

| | | | | |
|---|---|---|---|---|
| **Level 1** | C | 0.00E+00 | mg/l | No dilution or attenuation |
| **Level 2** | C | #DIV/0! | mg/l | Dilution taken into account |
| **Level 3** | C | #DIV/0! | mg/l | Dilution and attenuation taken into account |

### Predicted concentrations between source and compliance point - Level 3




| Distance m | Concentration mg/l |
|---|---|
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
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| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |

# R&D Publication 20 Remedial Targets Worksheet, Release 3.2

## Level 3 - Groundwater

See Note

**Input Parameters (using pull down menu)** | **Variable** | **Value** | **Unit** | **Source**

| | | | | |
|---|---|---|---|---|
| Contaminant | | Iron | | from Level 1 |
| Target Concentration | $C_T$ | 1.00E+00 | mg/l | from Level 1 |

**Select analytical solution (click on brown cell below, then on pull-down menu)**

Domenico - Steady state — Equations in HRA publication

Approach for simulating vertical dispersion: Simulate vertical dispersion in 1 direction

**Select nature of decay rate (click on brown cell below, then on pull-down menu)**

Approach for simulating degradation of pollutants: Apply degradation rate to dissolved pollutants only

| | | | | Source of parameter value |
|---|---|---|---|---|
| Initial contaminant concentration in groundwater at plume core | $C_0$ | 1.14E+02 | mg/l | *Based on average soil conc of 92031mg/kg* |
| Half life for degradation of contaminant in water | $t_{1/2}$ | 9.00E+99 | days | *100 day half life estimation* |
| Calculated decay rate | λ | 7.70E-101 | $days^{-1}$ | |
| Width of plume in aquifer at source (perpendicular to flow) | Sz | 5.00E+02 | m | *Site data* |
| Plume thickness at source | Sy | 1.50E+00 | m | *Thickness of re-engineered MG* |
| Saturated aquifer thickness | da | 2.00E+00 | m | *Based upon proposed total MG and cappir* |
| Bulk density of aquifer materials | ρ | 1.36E+00 | $g/cm^3$ | *Site data* |
| Effective porosity of aquifer | n | 8.00E-02 | fraction | *Estimate* |
| Hydraulic gradient | i | 1.00E-02 | fraction | |
| Hydraulic conductivity of aquifer | K | 8.64E-03 | m/d | *Proposed best achievable* |
| Distance to compliance point | x | 2.00E+01 | m | *Site data* |
| Distance (lateral) to compliance point perpendicular to flow direction | z | | m | |
| Distance (depth) to compliance point perpendicular to flow direction | y | | m | |
| Time since pollutant entered groundwater | t | 1.00E+100 | days | *time variant options only* |
| *Parameters values determined from options* | | | | |
| Partition coefficient | Kd | 8.10E+02 | l/kg | *see options* |
| Longitudinal dispersivity | ax | 1.57E+00 | m | *see options* |
| Transverse dispersivity | az | 1.57E-01 | m | *see options* |
| Vertical dispersivity | ay | 1.57E-02 | m | *see options* |

**Calculated Parameters** | **Variable**

| | | | |
|---|---|---|---|
| Groundwater flow velocity | v | 1.08E-03 | m/d |
| Retardation factor | Rf | 1.38E+04 | fraction |
| Decay rate used | λ | 5.59E-105 | $d^{-1}$ |
| Rate of contaminant flow due to retardation | u | 7.84E-08 | m/d |
| Contaminant concentration at distance x, assuming one-way vertical dispersion | $C_{ED}$ | 1.07E+02 | mg/l |
| **Attenuation factor (one way vertical dispersion, CO/CED)** | **AF** | **1.06E+00** | |

**Remedial Targets**

| | | | | |
|---|---|---|---|---|
| **Remedial Target** | | **1.06E+00** | **mg/l** | For comparison with measured groundwater concentration. |
| Domenico - Steady state | | | | |
| **Distance to compliance point** | | **20** | **m** | |
| **Concentration of contaminant at compliance point** | **$C_{ED}/C_0$** | **1.07E+02** | **mg/l** | Domenico - Steady state |

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.E+99.

**Select Method for deriving Partition Co-efficient (using pull down menu)**

User specified value for partition coefficient

| | | | |
|---|---|---|---|
| ***Entry if specify partition coefficient (option)*** | | | |
| Soil water partition coefficient | Kd | 8.10E+02 | l/kg |
| ***Entry for non-polar organic chemicals (option)*** | | | |
| Fraction of organic carbon in aquifer | foc | | fraction |
| Organic carbon partition coefficient | Koc | | l/kg |
| ***Entry for ionic organic chemicals (option)*** | | | |
| Sorption coefficient for related species | $K_{oc,n}$ | | l/kg |
| Sorption coefficient for ionised species | $K_{oc,i}$ | | l/kg |
| pH value | pH | | |
| acid dissociation constant | pKa | | |
| Fraction of organic carbon in aquifer | foc | | fraction |
| Soil water partition coefficient | Kd | 8.10E+02 | l/kg |

**Define dispersivity (click brown cell and use pull down list)**

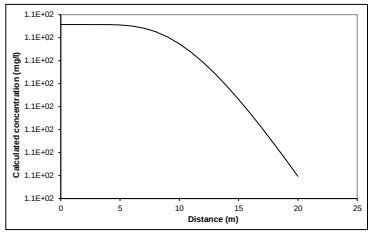
Dispersivity based on Xu & Eckstein (1995)

| | | Enter value | Calc value Xu & Eckstein | | |
|---|---|---|---|---|---|
| **Longitudinal dispersivity** | **ax** | 0.00E+00 | 2.00E+01 | 1.57E+00 | m |
| **Transverse dispersivity** | **az** | 0.00E+00 | 2.00E+00 | 1.57E-01 | m |
| **Vertical dispersivity** | **ay** | 0.00E+00 | 2.00E-01 | 1.57E-02 | |

**Note values of dispersivity must be > 0**

For calculated value, assumes ax = 0.1 *x, az = 0.01 * x, ay = 0.001 * x

Xu & Eckstein (1995) report ax = $0.83(\log_{10}x)^{2.414}$ ; az = ax/10, ay = ax/100 are assumed




Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared with the Level 3 remedial target to determine the need for further action.
Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O2, NO3, SO4 etc than an alternative solution should be used

| | |
|---|---|
| Site being assessed: | Glan Llyn |
| Completed by: | Ross Cameron |
| Date: | ######## |
| Version: | 1 |

**Calculated concentrations for distance-concentration graph**

**Domenico - Steady state**
**From calculation sheet**

| Distance | Concentration |
|---|---|
| | mg/l |
| 0 | 1.1E+02 |
| 1.0 | 1.14E+02 |
| 2.0 | 1.14E+02 |
| 3.0 | 1.14E+02 |
| 4.0 | 1.14E+02 |
| 5.0 | 1.14E+02 |
| 6.0 | 1.14E+02 |
| 7.0 | 1.13E+02 |
| 8.0 | 1.13E+02 |
| 9.0 | 1.13E+02 |
| 10.0 | 1.13E+02 |
| 11.0 | 1.12E+02 |
| 12.0 | 1.12E+02 |
| 13.0 | 1.11E+02 |
| 14.0 | 1.11E+02 |
| 15.0 | 1.10E+02 |
| 16.0 | 1.10E+02 |
| 17.0 | 1.09E+02 |
| 18.0 | 1.08E+02 |
| 19.0 | 1.08E+02 |
| 20.0 | 1.07E+02 |

# Porosity Calculator

These results are not carried through to any of the other worksheets

## DRY BULK DENSITY DATA

| Variable | Value | Unit | justification |
|---|---|---|---|
| Natural Moisture Content | 0.00 | % wt | |
| Particle Density | 2.78 | tonnes/m$^3$ | (Change this number only if you have specific information) |
| Dry Bulk Density | 0.00 | tonnes/m$^3$ | |
| *Calculated Parameters* | | | |
| Voids Ratio | #DIV/0! | fraction | |
| Initial Saturation | #DIV/0! | % | |
| **Total porosity** | **1.000** | **fraction** | |
| **Air Filled Porosity** | **#DIV/0!** | **fraction** | |
| **Water Filled Porosity** | **#DIV/0!** | **fraction** | |

## WET BULK DENSITY DATA

| Variable | Value | Unit | |
|---|---|---|---|
| Moisture Content | 0.00 | % wt | |
| Particle Density | 2.78 | tonnes/m$^3$ | (Change this number only if you have specific information) |
| Actual (wet) Bulk Density ( i.e. at natural MC) | 0.00 | tonnes/m$^3$ | |
| *Calculated Parameters* | | | |
| Voids Ratio | #DIV/0! | fraction | |
| dry bulk density | 0.00 | tonnes/m$^3$ | |
| Initial Saturation | #DIV/0! | % | |
| **Total porosity** | **1.000** | **fraction** | **#DIV/0!** |
| **Air Filled Porosity** | **#DIV/0!** | **fraction** | |
| **Water Filled Porosity** | **#DIV/0!** | **fraction** | |

*Analytical solutions provided by David Hall, Golder Associates (UK) Ltd*

# Simple hydrogeological calculations

**(These are not specific to, or required in, the Remedial Targets Methodology)**

| Parameter | symbol | | unit | justification |
|---|---|---|---|---|
| Hydraulic conductivity | K | 0.00E+00 | m/d | |
| Hydraulic gradient | i | 0.00E+00 | unitless | |
| Effective porosity of aquifer | n | 0.00E+00 | fraction | |
| Thickness of saturated aquifer | b | 0.00E+00 | m | |
| Width of aquifer perpendicular to flow | w | 0.00E+00 | m | |
| Distance to receptor | x | 0.00E+00 | m | |
| Bulk density of aquifer materials | ρ | 0.00E+00 | g/cm$^3$ | |
| Soil-water partition co-efficient | Kd | 0.00E+00 | l/kg | |
| Retardation factor of pollutant | R | #DIV/0! | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Groundwater flow velocity | v(GW) | #DIV/0! | m/s | #DIV/0! | m/day | #DIV/0! | m/year |
| Time for groundwater to reach receptor | t(GW) | #DIV/0! | seconds | #DIV/0! | days | #DIV/0! | years |
| Rate of groundwater flow through aquifer | Q | 0.00E+00 | m$^3$/s | 0.00E+00 | m$^3$/day | 0.00E+00 | m$^3$/year |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Contaminant flow velocity | v(contam) | #DIV/0! | m/s | #DIV/0! | m/day | #DIV/0! | m/year |
| Time for contaminant to reach receptor | t(contam) | #DIV/0! | seconds | #DIV/0! | days | #DIV/0! | years |

## Level 1 Calculation Sheet

**Contaminant** **Iron**

| Parameter (carried over from input sheet) | Value | Units |
|---|---|---|
| $C_T$ | 1.00E+00 | mg/l |
| Kd | 1.34E+02 | l/kg |
| foc | | fraction |
| koc | | l/kg |
| $\theta_w$ | 5.00E-01 | fraction |
| $\theta a$ | 3.70E-01 | fraction |
| $\rho$ | 1.36E+00 | g/cm3 |
| H | 1.00E+00 | dimensionless |
| Koc,n | | l/kg |
| Koc,i | | l/kg |
| pH | | pH units |
| pKa | | |
| foc (ionic) | | fraction |

**Calculations (Refer toTable 4.3, R&D Publication 20)**

**Selected option** User specified value for partition coefficient

| | calc | calc | Calc Kd | l/kg |
|---|---|---|---|---|
| Calculation of partition coefficient for ionic organic chemical | | | | |
| Partition coefficient used in Level 1 Assessment | | | 1.34E+02 | l/kg |

**Calculated Remedial Target** **1.35E+02 mg/kg** **for Iron**

Factor (partitioning between soil and water) 1.35E+02

| | |
|---|---|
| Site being assessed: | Glan Llyn |
| Completed by: | Ross Cameron |
| Date: | 24/02/2020 |
| Version: | 1 |

## Level 2 Calculation Sheet

**Contaminant** **Iron**

| Site assessed: | Glan Llyn |
|---|---|
| Date: | 24/02/2020 |
| Version: | 1 |

| Parameter | Value | Units |
|---|---|---|
| (carried over from input sheet) | | |
| Mz | 0.00E+00 | m |
| L | 0.00E+00 | m |
| da | 0.00E+00 | m |
| Inf | 0.00E+00 | m/d |
| K | 0.00E+00 | m/d |
| i | 0.00E+00 | |
| | | m3/d |
| A | 0.00E+00 | m2 |
| | | m3/d |
| Cc | 0.00E+00 | mg/l |
| $C_T$ | 1.00E+00 | mg/l |
| Cu | 0.00E+00 | mg/l |
| w | 0.00E+00 | m |

Calculated Dilution Factor

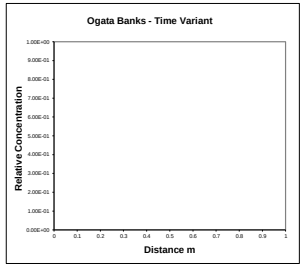
Calculation based on target concentration #DIV/0!

Calculation based on observed contaminant concentration #DIV/0!

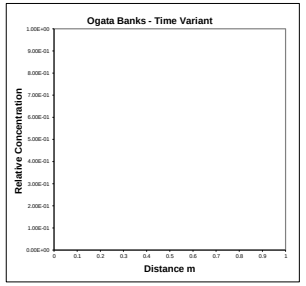


**OGATA BANKS SOLUTION**

| Contaminant | Iron | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Calculations for source located in centre of aquifer (ie vertical dispersion in two directions) | | | | | | | | | | | | | | | | | | |
| **Input** | **Value** | **Units** | | X | Term 1 | Term 2 | EXP | Term 3 | ERFC | Term 4 | EXP | Term 5 | ERFC | Term 6a | ERF | Term 6b | ERF | Term 7a | ERF | Term 7b | ERF | Relative Concentration |
| $C_T$ | 1.000E+00 | mg/l | 1 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| DF | #DIV/0! | | 2 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| | | | 3 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| | | | 4 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| λ | 6.931E-101 | $days^{-1}$ | 5 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| Sz | 0.000E+00 | m | 6 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| Sy | 0.000E+00 | m | 7 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| Kd | 0.000E+00 | l/kg | 8 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| ρ | 0.000E+00 | g/cm3 | 9 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| n | 0.000E+00 | | 10 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| i | #DIV/0! | | 11 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| K | 0.000E+00 | m/d | 12 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| x | 0.000E+00 | m | 13 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| z | 0.000E+00 | m | 14 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| y | 0.000E+00 | m | 15 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| t | 1.000E+99 | days | 16 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| ax | 0.000E+00 | m | 17 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| az | 0.000E+00 | m | 18 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| ay | 0.000E+00 | m | 19 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| | | | 20 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |




| Calc | Value | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Calculations for source located at top of aquifer (ie vertical dispersion in one direction) -USED FOR LEVEL ASSESSMENT | | | | | | | | | | | | | | | | | | |
| | | | | X | Term 1 | Term 2 | EXP | Term 3 | ERFC | Term 4 | EXP | Term 5 | ERFC | Term 6a | ERF | Term 6b | ERF | Term 7a | ERF | Term 7b | ERF | Relative Concentration |
| v | #DIV/0! | m/d | | | | | | | | | | | | | | | | | | | |
| Rc | #DIV/0! | | 1 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| u | #DIV/0! | m/d | 2 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| | | | 3 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| | | | 4 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| | | | 5 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| | | | 6 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| | | | 7 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| | | | 8 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| | | | 9 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| | | | 10 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| | | | 11 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| | | | 12 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| | | | 13 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| | | | 14 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| | | | 15 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| | | | 16 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| | | | 17 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| | | | 18 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| | | | 19 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| | | | 20 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |




| | |
|---|---|
| Date: | 24/02/2020 |
| Version: | 1 |

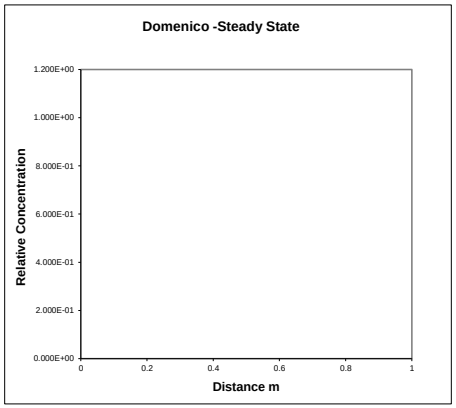
**Contaminant** **Iron**

**DOMENICO (STEADY STATE)**

Calculations for source located in centre of aquifer (ie vertical dispersion in two directions)

| Input | Value | Units |
|---|---|---|
| $C_T$ | 1.000E+00 | mg/l |
| DF | #DIV/0! | |
| | | |
| λ | 6.931E-101 | days$^{-1}$ |
| Sz | 0.000E+00 | m |
| Sy | 0.000E+00 | m |
| Kd | 0.000E+00 | l/kg |
| ρ | 0.000E+00 | g/cm3 |
| n | 0.000E+00 | |
| i | #DIV/0! | |
| K | 0.000E+00 | m/d |
| x | 0.000E+00 | m |
| z | 0.000E+00 | m |
| y | 0.000E+00 | m |
| ax | 0.000E+00 | m |
| az | 0.000E+00 | m |
| ay | 0.000E+00 | m |

| | X | Term 1 | Term 2 | EXP | Term 3A | ERF | Term 4A | ERF | Term 4B | ERF | Relative Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 2 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 3 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 4 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 5 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 6 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 7 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 8 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 9 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 10 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 11 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 12 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 13 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 14 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 15 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 16 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 17 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 18 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 19 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 20 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |



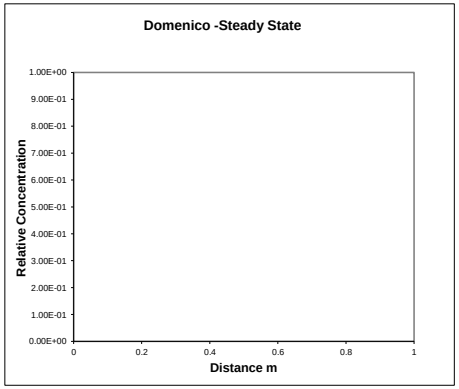

**Calc** **Value**

| | | |
|---|---|---|
| v | #DIV/0! | m/d |
| Rc | #DIV/0! | |
| u | #DIV/0! | m/d |

**DOMENICO (STEADY STATE)**

Calculations for source located at top of aquifer (ie vertical dispersion in one direction) - USED FOR LEVEL ASSESSMENT

| | X | Term 1 | Term 2 | EXP | Term 3A | ERF | Term 4A | ERF | Term 4B | ERF | Relative Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 2 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 3 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 4 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 5 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 6 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 7 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 8 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 9 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 10 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 11 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 12 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 13 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 14 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 15 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 16 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 17 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 18 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 19 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 20 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |



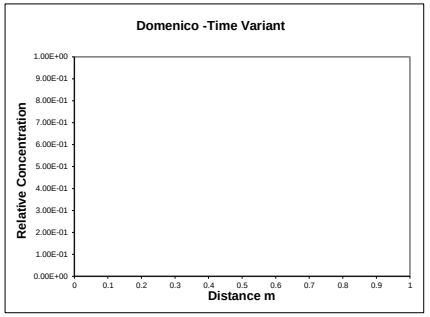

| | |
|---|---|
| Date: | 24/02/2020 |
| Version: | 1 |

**DOMENICO (TIME VARIANT)**

| Contaminant | Iron | |
|---|---|---|
| **Input** | **Value** | **Units** |
| $C_T$ | 1 | mg/l |
| DF | #DIV/0! | |
| λ | 6.931E-101 | days$^{-1}$ |
| Sz | 0.000E+00 | m |
| Sy | 0.000E+00 | m |
| Kd | 0.000E+00 | l/kg |
| ρ | 0.000E+00 | g/cm3 |
| n | 0.000E+00 | |
| i | #DIV/0! | |
| K | 0.000E+00 | m/d |
| x | 0.000E+00 | m |
| z | 0.000E+00 | m |
| y | 0.000E+00 | m |
| t | 1.000E+99 | days |
| ax | 0.000E+00 | m |
| az | 0.000E+00 | m |
| ay | 0.000E+00 | m |

Calculations for source located in centre of aquifer (ie vertical dispersion in two directions)

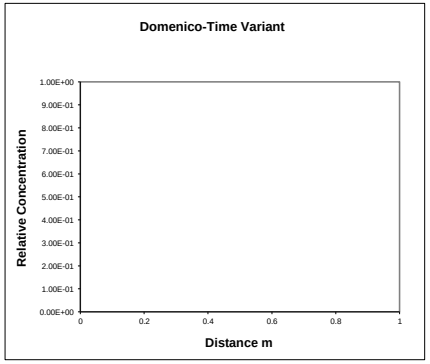
| | X | Term 1 | Term 2 | EXP | Term 3 | ERFC | Term 4A | ERF | Term 4B | ERF | Term 5A | ERF | Term 5B | ERF | Relative Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | m | | | | | | | | | | | | | | |
| 1 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 2 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 3 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 4 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 5 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 6 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 7 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 8 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 9 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 10 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 11 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 12 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 13 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 14 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 15 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 16 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 17 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 18 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 19 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 20 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |




| Calc | Value | |
|---|---|---|
| v | #DIV/0! | m/d |
| Rc | #DIV/0! | |
| u | #DIV/0! | m/d |

Calculations for source located at top of aquifer (ie vertical dispersion in one direction only) - USED FOR LEVEL ASSESSMENT

| | X | Term 1 | Term 2 | EXP | Term 3 | ERFC | Term 4A | ERF | Term 4B | ERF | Term 5A | ERF | Term 5B | ERF | Relative Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | m | | | | | | | | | | | | | | |
| 1 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 2 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 3 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 4 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 5 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 6 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 7 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 8 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 9 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 10 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 11 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 12 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 13 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 14 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 15 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 16 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 17 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 18 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 19 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 20 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |



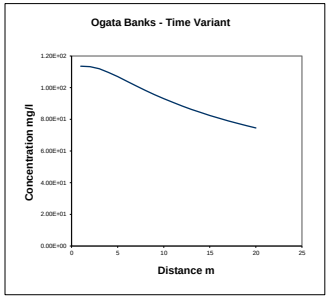

| | |
|---|---|
| Date: | 24/02/2020 |
| Version: | 1 |

**OGATA BANKS SOLUTION**

| Contaminant | Iron | |
|---|---|---|
| **Input** | **Value** | **Units** |
| $C_T$ | 1 | mg/l |
| Co | 1.14E+02 | mg/l |
| λ | 5.59E-105 | $days^{-1}$ |
| Sz | 5.00E+02 | m |
| Sy | 1.50E+00 | m |
| Kd | 8.10E+02 | l/kg |
| ρ | 1.36E+00 | g/cm3 |
| n | 8.00E-02 | |
| i | 1.00E-02 | |
| K | 8.64E-03 | m/d |
| x | 2.00E+01 | m |
| z | 0.00E+00 | m |
| y | 0.00E+00 | m |
| t | 1.00E+100 | days |
| ax | 1.57E+00 | m |
| az | 1.57E-01 | m |
| ay | 1.57E-02 | m |

Calculations for source located in centre of aquifer (ie vertical dispersion in two directions)

| | X | Term 1 | Term 2 | EXP | Term 3 | ERFC | Term 4 | EXP | Term 5 | ERFC | Term 6a | ERF | Term 6b | ERF | Term 7a | ERF | Term 7b | ERF | Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 14.1963 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 6.4E-01 | 1.9E+00 | 1.1E+46 | 0.000 | 3.2E+02 | 1 | -3.2E+02 | -1 | 3.0E+00 | 1 | -3.0E+00 | -0.99998 | 1.14E+02 |
| 2 | 2 | 14.1963 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 1.3E+00 | 3.6E+00 | 1.1E+46 | 0.000 | 2.2E+02 | 1 | -2.2E+02 | -1 | 2.1E+00 | 0.9973 | -2.1E+00 | -0.99726 | 1.13E+02 |
| 3 | 3 | 14.1963 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 1.9E+00 | 6.8E+00 | 1.1E+46 | 0.000 | 1.8E+02 | 1 | -1.8E+02 | -1 | 1.7E+00 | 0.9856 | -1.7E+00 | -0.98557 | 1.12E+02 |
| 4 | 4 | 14.1963 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 2.6E+00 | 1.3E+01 | 1.1E+46 | 0.000 | 1.6E+02 | 1 | -1.6E+02 | -1 | 1.5E+00 | 0.9659 | -1.5E+00 | -0.96587 | 1.10E+02 |
| 5 | 5 | 14.1963 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 3.2E+00 | 2.4E+01 | 1.1E+46 | 0.000 | 1.4E+02 | 1 | -1.4E+02 | -1 | 1.3E+00 | 0.9419 | -1.3E+00 | -0.94189 | 1.07E+02 |
| 6 | 6 | 14.1963 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 3.8E+00 | 4.6E+01 | 1.1E+46 | 0.000 | 1.3E+02 | 1 | -1.3E+02 | -1 | 1.2E+00 | 0.9163 | -1.2E+00 | -0.91633 | 1.04E+02 |
| 7 | 7 | 14.1963 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 4.5E+00 | 8.7E+01 | 1.1E+46 | 0.000 | 1.2E+02 | 1 | -1.2E+02 | -1 | 1.1E+00 | 0.8907 | -1.1E+00 | -0.89072 | 1.01E+02 |
| 8 | 8 | 14.1963 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 5.1E+00 | 1.7E+02 | 1.1E+46 | 0.000 | 1.1E+02 | 1 | -1.1E+02 | -1 | 1.1E+00 | 0.8659 | -1.1E+00 | -0.86587 | 9.83E+01 |
| 9 | 9 | 14.1963 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 5.7E+00 | 3.1E+02 | 1.1E+46 | 0.000 | 1.1E+02 | 1 | -1.1E+02 | -1 | 1.0E+00 | 0.8422 | -1.0E+00 | -0.84215 | 9.56E+01 |
| 10 | 10 | 14.1963 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 6.4E+00 | 5.9E+02 | 1.1E+46 | 0.000 | 1.0E+02 | 1 | -1.0E+02 | -1 | 9.5E-01 | 0.8197 | -9.5E-01 | -0.81971 | 9.31E+01 |
| 11 | 11 | 14.1963 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 7.0E+00 | 1.1E+03 | 1.1E+46 | 0.000 | 9.5E+01 | 1 | -9.5E+01 | -1 | 9.0E-01 | 0.7986 | -9.0E-01 | -0.79858 | 9.07E+01 |
| 12 | 12 | 14.1963 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 7.7E+00 | 2.1E+03 | 1.1E+46 | 0.000 | 9.1E+01 | 1 | -9.1E+01 | -1 | 8.6E-01 | 0.7787 | -8.6E-01 | -0.77872 | 8.84E+01 |
| 13 | 13 | 14.1963 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 8.3E+00 | 4.0E+03 | 1.1E+46 | 0.000 | 8.8E+01 | 1 | -8.8E+01 | -1 | 8.3E-01 | 0.7601 | -8.3E-01 | -0.76006 | 8.63E+01 |
| 14 | 14 | 14.1963 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 8.9E+00 | 7.6E+03 | 1.1E+46 | 0.000 | 8.4E+01 | 1 | -8.4E+01 | -1 | 8.0E-01 | 0.7425 | -8.0E-01 | -0.74253 | 8.43E+01 |
| 15 | 15 | 14.1963 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 9.6E+00 | 1.4E+04 | 1.1E+46 | 0.000 | 8.2E+01 | 1 | -8.2E+01 | -1 | 7.7E-01 | 0.726 | -7.7E-01 | -0.72604 | 8.25E+01 |
| 16 | 16 | 14.1963 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 1.0E+01 | 2.7E+04 | 1.1E+46 | 0.000 | 7.9E+01 | 1 | -7.9E+01 | -1 | 7.5E-01 | 0.7105 | -7.5E-01 | -0.71052 | 8.07E+01 |
| 17 | 17 | 14.1963 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 1.1E+01 | 5.2E+04 | 1.1E+46 | 0.000 | 7.7E+01 | 1 | -7.7E+01 | -1 | 7.3E-01 | 0.6959 | -7.3E-01 | -0.69588 | 7.90E+01 |
| 18 | 18 | 14.1963 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 1.1E+01 | 9.8E+04 | 1.1E+46 | 0.000 | 7.4E+01 | 1 | -7.4E+01 | -1 | 7.1E-01 | 0.6821 | -7.1E-01 | -0.68205 | 7.75E+01 |
| 19 | 19 | 14.1963 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 1.2E+01 | 1.8E+05 | 1.1E+46 | 0.000 | 7.2E+01 | 1 | -7.2E+01 | -1 | 6.9E-01 | 0.669 | -6.9E-01 | -0.66897 | 7.60E+01 |
| 20 | 20 | 14.1963 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 1.3E+01 | 3.5E+05 | 1.1E+46 | 0.000 | 7.1E+01 | 1 | -7.1E+01 | -1 | 6.7E-01 | 0.6566 | -6.7E-01 | -0.65658 | 7.46E+01 |

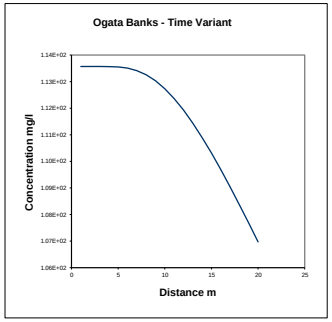



Vertical dispersion option Simulate vertical dispersion in 1 direction

| Calc | Value | |
|---|---|---|
| v | 1.08E-03 | m/d |
| Rc | 1.38E+04 | |
| u | 7.84E-08 | m/d |

Calculations for source located at top of aquifer (ie vertical dispersion in one direction) - USED FOR LEVEL ASSESSMENT

| | X | Term 1 | Term 2 | EXP | Term 3 | ERFC | Term 4 | EXP | Term 5 | ERFC | Term 6a | ERF | Term 6b | ERF | Term 7a | ERF | Term 7b | ERF | Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 14.1963 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 6.4E-01 | 1.9E+00 | 1.1E+46 | 0.000 | 3.2E+02 | 1 | -3.2E+02 | -1 | 6.0E+00 | 1 | -6.0E+00 | -1 | 1.14E+02 |
| 2 | 2 | 14.1963 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 1.3E+00 | 3.6E+00 | 1.1E+46 | 0.000 | 2.2E+02 | 1 | -2.2E+02 | -1 | 4.2E+00 | 1 | -4.2E+00 | -1 | 1.14E+02 |
| 3 | 3 | 14.1963 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 1.9E+00 | 6.8E+00 | 1.1E+46 | 0.000 | 1.8E+02 | 1 | -1.8E+02 | -1 | 3.5E+00 | 1 | -3.5E+00 | -1 | 1.14E+02 |
| 4 | 4 | 14.1963 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 2.6E+00 | 1.3E+01 | 1.1E+46 | 0.000 | 1.6E+02 | 1 | -1.6E+02 | -1 | 3.0E+00 | 1 | -3.0E+00 | -0.99998 | 1.14E+02 |
| 5 | 5 | 14.1963 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 3.2E+00 | 2.4E+01 | 1.1E+46 | 0.000 | 1.4E+02 | 1 | -1.4E+02 | -1 | 2.7E+00 | 0.9998 | -2.7E+00 | -0.99985 | 1.14E+02 |
| 6 | 6 | 14.1963 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 3.8E+00 | 4.6E+01 | 1.1E+46 | 0.000 | 1.3E+02 | 1 | -1.3E+02 | -1 | 2.4E+00 | 0.9995 | -2.4E+00 | -0.99946 | 1.14E+02 |
| 7 | 7 | 14.1963 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 4.5E+00 | 8.7E+01 | 1.1E+46 | 0.000 | 1.2E+02 | 1 | -1.2E+02 | -1 | 2.3E+00 | 0.9986 | -2.3E+00 | -0.99864 | 1.13E+02 |
| 8 | 8 | 14.1963 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 5.1E+00 | 1.7E+02 | 1.1E+46 | 0.000 | 1.1E+02 | 1 | -1.1E+02 | -1 | 2.1E+00 | 0.9973 | -2.1E+00 | -0.99726 | 1.13E+02 |
| 9 | 9 | 14.1963 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 5.7E+00 | 3.1E+02 | 1.1E+46 | 0.000 | 1.1E+02 | 1 | -1.1E+02 | -1 | 2.0E+00 | 0.9953 | -2.0E+00 | -0.99527 | 1.13E+02 |
| 10 | 10 | 14.1963 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 6.4E+00 | 5.9E+02 | 1.1E+46 | 0.000 | 1.0E+02 | 1 | -1.0E+02 | -1 | 1.9E+00 | 0.9926 | -1.9E+00 | -0.99263 | 1.13E+02 |
| 11 | 11 | 14.1963 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 7.0E+00 | 1.1E+03 | 1.1E+46 | 0.000 | 9.5E+01 | 1 | -9.5E+01 | -1 | 1.8E+00 | 0.9894 | -1.8E+00 | -0.98938 | 1.12E+02 |
| 12 | 12 | 14.1963 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 7.7E+00 | 2.1E+03 | 1.1E+46 | 0.000 | 9.1E+01 | 1 | -9.1E+01 | -1 | 1.7E+00 | 0.9856 | -1.7E+00 | -0.98557 | 1.12E+02 |
| 13 | 13 | 14.1963 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 8.3E+00 | 4.0E+03 | 1.1E+46 | 0.000 | 8.8E+01 | 1 | -8.8E+01 | -1 | 1.7E+00 | 0.9812 | -1.7E+00 | -0.98124 | 1.11E+02 |
| 14 | 14 | 14.1963 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 8.9E+00 | 7.6E+03 | 1.1E+46 | 0.000 | 8.4E+01 | 1 | -8.4E+01 | -1 | 1.6E+00 | 0.9765 | -1.6E+00 | -0.97647 | 1.11E+02 |
| 15 | 15 | 14.1963 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 9.6E+00 | 1.4E+04 | 1.1E+46 | 0.000 | 8.2E+01 | 1 | -8.2E+01 | -1 | 1.5E+00 | 0.9713 | -1.5E+00 | -0.97133 | 1.10E+02 |
| 16 | 16 | 14.1963 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 1.0E+01 | 2.7E+04 | 1.1E+46 | 0.000 | 7.9E+01 | 1 | -7.9E+01 | -1 | 1.5E+00 | 0.9659 | -1.5E+00 | -0.96587 | 1.10E+02 |
| 17 | 17 | 14.1963 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 1.1E+01 | 5.2E+04 | 1.1E+46 | 0.000 | 7.7E+01 | 1 | -7.7E+01 | -1 | 1.5E+00 | 0.9601 | -1.5E+00 | -0.96015 | 1.09E+02 |
| 18 | 18 | 14.1963 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 1.1E+01 | 9.8E+04 | 1.1E+46 | 0.000 | 7.4E+01 | 1 | -7.4E+01 | -1 | 1.4E+00 | 0.9542 | -1.4E+00 | -0.95421 | 1.08E+02 |
| 19 | 19 | 14.1963 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 1.2E+01 | 1.8E+05 | 1.1E+46 | 0.000 | 7.2E+01 | 1 | -7.2E+01 | -1 | 1.4E+00 | 0.9481 | -1.4E+00 | -0.94812 | 1.08E+02 |
| 20 | 20 | 14.1963 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 1.3E+01 | 3.5E+05 | 1.1E+46 | 0.000 | 7.1E+01 | 1 | -7.1E+01 | -1 | 1.3E+00 | 0.9419 | -1.3E+00 | -0.94189 | 1.07E+02 |



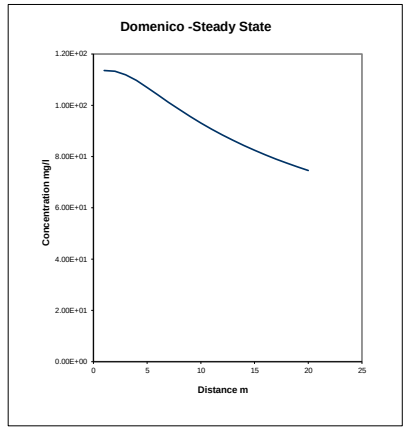

| | |
|---|---|
| Date: | 24/02/2020 |
| Version: | 1 |

**Contaminant** **Iron**

**DOMENICO (STEADY STATE)**

Calculations for source located in centre of aquifer (ie vertical dispersion in two directions)

| Input | Value | Units | | X | Term 1 | Term 2 | EXP | Term 3A | ERF | Term 3B | ERF | Term 4A | ERF | Term 4B | ERF | Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $C_T$ | 1 | mg/l | 1 | 1 | 28.3925 | 0.00E+00 | 1.00E+00 | 3.16E+02 | 1 | -3.16E+02 | -1 | 3.00E+00 | 1 | -3.00E+00 | -1 | 1.14E+02 |
| | | | 2 | 2 | 28.3925 | 0.00E+00 | 1.00E+00 | 2.23E+02 | 1 | -2.23E+02 | -1 | 2.12E+00 | 0.997 | -2.12E+00 | -0.9973 | 1.13E+02 |
| | | | 3 | 3 | 28.3925 | 0.00E+00 | 1.00E+00 | 1.82E+02 | 1 | -1.82E+02 | -1 | 1.73E+00 | 0.986 | -1.73E+00 | -0.9856 | 1.12E+02 |
| Co | 1.14E+02 | mg/l | 4 | 4 | 28.3925 | 0.00E+00 | 1.00E+00 | 1.58E+02 | 1 | -1.58E+02 | -1 | 1.50E+00 | 0.966 | -1.50E+00 | -0.9659 | 1.10E+02 |
| λ | 5.59E-105 | $days^{-1}$ | 5 | 5 | 28.3925 | 0.00E+00 | 1.00E+00 | 1.41E+02 | 1 | -1.41E+02 | -1 | 1.34E+00 | 0.942 | -1.34E+00 | -0.9419 | 1.07E+02 |
| Sz | 5.00E+02 | m | 6 | 6 | 28.3925 | 0.00E+00 | 1.00E+00 | 1.29E+02 | 1 | -1.29E+02 | -1 | 1.22E+00 | 0.916 | -1.22E+00 | -0.9163 | 1.04E+02 |
| Sy | 1.50E+00 | m | 7 | 7 | 28.3925 | 0.00E+00 | 1.00E+00 | 1.19E+02 | 1 | -1.19E+02 | -1 | 1.13E+00 | 0.891 | -1.13E+00 | -0.8907 | 1.01E+02 |
| Kd | 8.10E+02 | l/kg | 8 | 8 | 28.3925 | 0.00E+00 | 1.00E+00 | 1.12E+02 | 1 | -1.12E+02 | -1 | 1.06E+00 | 0.866 | -1.06E+00 | -0.8659 | 9.83E+01 |
| ρ | 1.36E+00 | g/cm3 | 9 | 9 | 28.3925 | 0.00E+00 | 1.00E+00 | 1.05E+02 | 1 | -1.05E+02 | -1 | 9.99E-01 | 0.842 | -9.99E-01 | -0.8422 | 9.56E+01 |
| n | 8.00E-02 | | 10 | 10 | 28.3925 | 0.00E+00 | 1.00E+00 | 9.99E+01 | 1 | -9.99E+01 | -1 | 9.47E-01 | 0.82 | -9.47E-01 | -0.8197 | 9.31E+01 |
| i | 1.00E-02 | | 11 | 11 | 28.3925 | 0.00E+00 | 1.00E+00 | 9.52E+01 | 1 | -9.52E+01 | -1 | 9.03E-01 | 0.799 | -9.03E-01 | -0.7986 | 9.07E+01 |
| K | 8.64E-03 | m/d | 12 | 12 | 28.3925 | 0.00E+00 | 1.00E+00 | 9.12E+01 | 1 | -9.12E+01 | -1 | 8.65E-01 | 0.779 | -8.65E-01 | -0.7787 | 8.84E+01 |
| x | 2.00E+01 | m | 13 | 13 | 28.3925 | 0.00E+00 | 1.00E+00 | 8.76E+01 | 1 | -8.76E+01 | -1 | 8.31E-01 | 0.76 | -8.31E-01 | -0.7601 | 8.63E+01 |
| z | 0.00E+00 | m | 14 | 14 | 28.3925 | 0.00E+00 | 1.00E+00 | 8.44E+01 | 1 | -8.44E+01 | -1 | 8.01E-01 | 0.743 | -8.01E-01 | -0.7425 | 8.43E+01 |
| y | 0.00E+00 | m | 15 | 15 | 28.3925 | 0.00E+00 | 1.00E+00 | 8.15E+01 | 1 | -8.15E+01 | -1 | 7.74E-01 | 0.726 | -7.74E-01 | -0.726 | 8.25E+01 |
| | | | 16 | 16 | 28.3925 | 0.00E+00 | 1.00E+00 | 7.90E+01 | 1 | -7.90E+01 | -1 | 7.49E-01 | 0.711 | -7.49E-01 | -0.7105 | 8.07E+01 |
| ax | 1.57E+00 | m | 17 | 17 | 28.3925 | 0.00E+00 | 1.00E+00 | 7.66E+01 | 1 | -7.66E+01 | -1 | 7.27E-01 | 0.696 | -7.27E-01 | -0.6959 | 7.90E+01 |
| az | 1.57E-01 | m | 18 | 18 | 28.3925 | 0.00E+00 | 1.00E+00 | 7.44E+01 | 1 | -7.44E+01 | -1 | 7.06E-01 | 0.682 | -7.06E-01 | -0.6821 | 7.75E+01 |
| ay | 1.57E-02 | m | 19 | 19 | 28.3925 | 0.00E+00 | 1.00E+00 | 7.25E+01 | 1 | -7.25E+01 | -1 | 6.87E-01 | 0.669 | -6.87E-01 | -0.669 | 7.60E+01 |
| | | | 20 | 20 | 28.3925 | 0.00E+00 | 1.00E+00 | 7.06E+01 | 1 | -7.06E+01 | -1 | 6.70E-01 | 0.657 | -6.70E-01 | -0.6566 | 7.46E+01 |



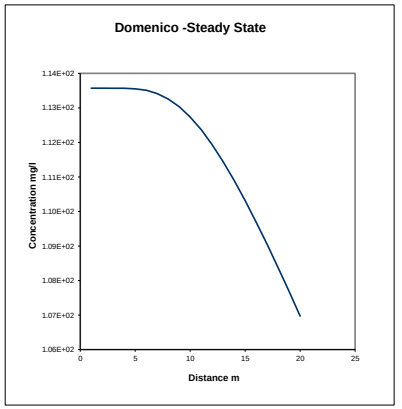

Vertical dispersion optio Simulate vertical dispersion in 1 direction

**Calc** **Value**

**DOMENICO (STEADY STATE)**

Calculations for source located at top of aquifer (ie vertical dispersion in one direction) - USED FOR LEVEL ASSESSMENT

| | | | | X | Term 1 | Term 2 | EXP | Term 3A | ERF | Term 3B | ERF | Term 4A | ERF | Term 4B | ERF | Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| v | 1.08E-03 | m/d | | | | | | | | | | | | | | |
| Rc | 1.38E+04 | | | | | | | | | | | | | | | |
| u | 7.84E-08 | m/d | 1 | 1 | 28.3925 | 0.00E+00 | 1.00E+00 | 3.16E+02 | 1 | -3.16E+02 | -1 | 5.99E+00 | 1 | -5.99E+00 | -1 | 1.14E+02 |
| | | | 2 | 2 | 28.3925 | 0.00E+00 | 1.00E+00 | 2.23E+02 | 1 | -2.23E+02 | -1 | 4.24E+00 | 1 | -4.24E+00 | -1 | 1.14E+02 |
| | | | 3 | 3 | 28.3925 | 0.00E+00 | 1.00E+00 | 1.82E+02 | 1 | -1.82E+02 | -1 | 3.46E+00 | 1 | -3.46E+00 | -1 | 1.14E+02 |
| | | | 4 | 4 | 28.3925 | 0.00E+00 | 1.00E+00 | 1.58E+02 | 1 | -1.58E+02 | -1 | 3.00E+00 | 1 | -3.00E+00 | -1 | 1.14E+02 |
| | | | 5 | 5 | 28.3925 | 0.00E+00 | 1.00E+00 | 1.41E+02 | 1 | -1.41E+02 | -1 | 2.68E+00 | 1 | -2.68E+00 | -0.9998 | 1.14E+02 |
| | | | 6 | 6 | 28.3925 | 0.00E+00 | 1.00E+00 | 1.29E+02 | 1 | -1.29E+02 | -1 | 2.45E+00 | 0.999 | -2.45E+00 | -0.9995 | 1.14E+02 |
| | | | 7 | 7 | 28.3925 | 0.00E+00 | 1.00E+00 | 1.19E+02 | 1 | -1.19E+02 | -1 | 2.26E+00 | 0.999 | -2.26E+00 | -0.9986 | 1.13E+02 |
| | | | 8 | 8 | 28.3925 | 0.00E+00 | 1.00E+00 | 1.12E+02 | 1 | -1.12E+02 | -1 | 2.12E+00 | 0.997 | -2.12E+00 | -0.9973 | 1.13E+02 |
| | | | 9 | 9 | 28.3925 | 0.00E+00 | 1.00E+00 | 1.05E+02 | 1 | -1.05E+02 | -1 | 2.00E+00 | 0.995 | -2.00E+00 | -0.9953 | 1.13E+02 |
| | | | 10 | 10 | 28.3925 | 0.00E+00 | 1.00E+00 | 9.99E+01 | 1 | -9.99E+01 | -1 | 1.89E+00 | 0.993 | -1.89E+00 | -0.9926 | 1.13E+02 |
| | | | 11 | 11 | 28.3925 | 0.00E+00 | 1.00E+00 | 9.52E+01 | 1 | -9.52E+01 | -1 | 1.81E+00 | 0.989 | -1.81E+00 | -0.9894 | 1.12E+02 |
| | | | 12 | 12 | 28.3925 | 0.00E+00 | 1.00E+00 | 9.12E+01 | 1 | -9.12E+01 | -1 | 1.73E+00 | 0.986 | -1.73E+00 | -0.9856 | 1.12E+02 |
| | | | 13 | 13 | 28.3925 | 0.00E+00 | 1.00E+00 | 8.76E+01 | 1 | -8.76E+01 | -1 | 1.66E+00 | 0.981 | -1.66E+00 | -0.9812 | 1.11E+02 |
| | | | 14 | 14 | 28.3925 | 0.00E+00 | 1.00E+00 | 8.44E+01 | 1 | -8.44E+01 | -1 | 1.60E+00 | 0.976 | -1.60E+00 | -0.9765 | 1.11E+02 |
| | | | 15 | 15 | 28.3925 | 0.00E+00 | 1.00E+00 | 8.15E+01 | 1 | -8.15E+01 | -1 | 1.55E+00 | 0.971 | -1.55E+00 | -0.9713 | 1.10E+02 |
| | | | 16 | 16 | 28.3925 | 0.00E+00 | 1.00E+00 | 7.90E+01 | 1 | -7.90E+01 | -1 | 1.50E+00 | 0.966 | -1.50E+00 | -0.9659 | 1.10E+02 |
| | | | 17 | 17 | 28.3925 | 0.00E+00 | 1.00E+00 | 7.66E+01 | 1 | -7.66E+01 | -1 | 1.45E+00 | 0.96 | -1.45E+00 | -0.9601 | 1.09E+02 |
| | | | 18 | 18 | 28.3925 | 0.00E+00 | 1.00E+00 | 7.44E+01 | 1 | -7.44E+01 | -1 | 1.41E+00 | 0.954 | -1.41E+00 | -0.9542 | 1.08E+02 |
| | | | 19 | 19 | 28.3925 | 0.00E+00 | 1.00E+00 | 7.25E+01 | 1 | -7.25E+01 | -1 | 1.37E+00 | 0.948 | -1.37E+00 | -0.9481 | 1.08E+02 |
| | | | 20 | 20 | 28.3925 | 0.00E+00 | 1.00E+00 | 7.06E+01 | 1 | -7.06E+01 | -1 | 1.34E+00 | 0.942 | -1.34E+00 | -0.9419 | 1.07E+02 |




| | |
|---|---|
| Date: | 24/02/2020 |
| Version: | 1 |

**DOMENICO (TIME VARIANT)**

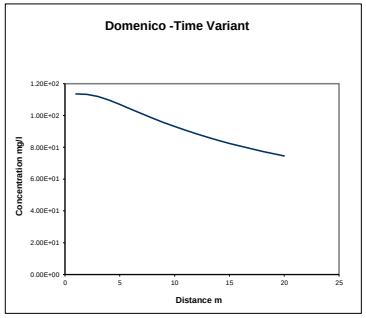
| Contaminant | Iron | |
|---|---|---|
| **Input** | **Value** | **Units** |
| $C_T$ | 1 | mg/l |
| Co | 1.14E+02 | mg/l |
| λ | 5.59E-105 | days$^{-1}$ |
| Sz | 5.00E+02 | m |
| Sy | 1.50E+00 | m |
| Kd | 8.10E+02 | l/kg |
| ρ | 1.36E+00 | g/cm3 |
| n | 8.00E-02 | |
| i | 1.00E-02 | |
| K | 8.64E-03 | m/d |
| x | 2.00E+01 | m |
| z | 0.00E+00 | m |
| y | 0.00E+00 | m |
| t | 1.00E+100 | days |
| ax | 1.57E+00 | m |
| az | 1.57E-01 | m |
| ay | 1.57E-02 | m |

Vertical dispersion option: Simulate vertical dispersion in 1 direction

| Calc | Value | |
|---|---|---|
| v | 1.08E-03 | m/d |
| Rc | 1.38E+04 | |
| u | 7.84E-08 | m/d |

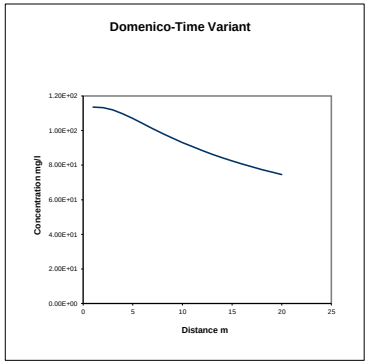
Calculations for source located in centre of aquifer (ie vertical dispersion in two directions)

| | X | Term 1 | Term 2 | EXP | Term 3 | ERFC | Term 4A | ERF | Term 4B | ERF | Term 5A | ERF | Term 5B | ERF | Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | m | | | | | | | | | | | | | | |
| 1 | 1 | 14.1963 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 3.16E+02 | 1 | -3.16E+02 | -1 | 3.00E+00 | 1 | -3.00E+00 | -1 | 1.14E+02 |
| 2 | 2 | 14.1963 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 2.23E+02 | 1 | -2.23E+02 | -1 | 2.12E+00 | 0.9973 | -2.12E+00 | -0.997 | 1.13E+02 |
| 3 | 3 | 14.1963 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 1.82E+02 | 1 | -1.82E+02 | -1 | 1.73E+00 | 0.9856 | -1.73E+00 | -0.986 | 1.12E+02 |
| 4 | 4 | 14.1963 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 1.58E+02 | 1 | -1.58E+02 | -1 | 1.50E+00 | 0.9659 | -1.50E+00 | -0.966 | 1.10E+02 |
| 5 | 5 | 14.1963 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 1.41E+02 | 1 | -1.41E+02 | -1 | 1.34E+00 | 0.9419 | -1.34E+00 | -0.942 | 1.07E+02 |
| 6 | 6 | 14.1963 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 1.29E+02 | 1 | -1.29E+02 | -1 | 1.22E+00 | 0.9163 | -1.22E+00 | -0.916 | 1.04E+02 |
| 7 | 7 | 14.1963 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 1.19E+02 | 1 | -1.19E+02 | -1 | 1.13E+00 | 0.8907 | -1.13E+00 | -0.891 | 1.01E+02 |
| 8 | 8 | 14.1963 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 1.12E+02 | 1 | -1.12E+02 | -1 | 1.06E+00 | 0.8659 | -1.06E+00 | -0.866 | 9.83E+01 |
| 9 | 9 | 14.1963 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 1.05E+02 | 1 | -1.05E+02 | -1 | 9.99E-01 | 0.8422 | -9.99E-01 | -0.842 | 9.56E+01 |
| 10 | 10 | 14.1963 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 9.99E+01 | 1 | -9.99E+01 | -1 | 9.47E-01 | 0.8197 | -9.47E-01 | -0.82 | 9.31E+01 |
| 11 | 11 | 14.1963 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 9.52E+01 | 1 | -9.52E+01 | -1 | 9.03E-01 | 0.7986 | -9.03E-01 | -0.799 | 9.07E+01 |
| 12 | 12 | 14.1963 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 9.12E+01 | 1 | -9.12E+01 | -1 | 8.65E-01 | 0.7787 | -8.65E-01 | -0.779 | 8.84E+01 |
| 13 | 13 | 14.1963 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 8.76E+01 | 1 | -8.76E+01 | -1 | 8.31E-01 | 0.7601 | -8.31E-01 | -0.76 | 8.63E+01 |
| 14 | 14 | 14.1963 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 8.44E+01 | 1 | -8.44E+01 | -1 | 8.01E-01 | 0.7425 | -8.01E-01 | -0.743 | 8.43E+01 |
| 15 | 15 | 14.1963 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 8.15E+01 | 1 | -8.15E+01 | -1 | 7.74E-01 | 0.726 | -7.74E-01 | -0.726 | 8.25E+01 |
| 16 | 16 | 14.1963 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 7.90E+01 | 1 | -7.90E+01 | -1 | 7.49E-01 | 0.7105 | -7.49E-01 | -0.711 | 8.07E+01 |
| 17 | 17 | 14.1963 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 7.66E+01 | 1 | -7.66E+01 | -1 | 7.27E-01 | 0.6959 | -7.27E-01 | -0.696 | 7.90E+01 |
| 18 | 18 | 14.1963 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 7.44E+01 | 1 | -7.44E+01 | -1 | 7.06E-01 | 0.6821 | -7.06E-01 | -0.682 | 7.75E+01 |
| 19 | 19 | 14.1963 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 7.25E+01 | 1 | -7.25E+01 | -1 | 6.87E-01 | 0.669 | -6.87E-01 | -0.669 | 7.60E+01 |
| 20 | 20 | 14.1963 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 7.06E+01 | 1 | -7.06E+01 | -1 | 6.70E-01 | 0.6566 | -6.70E-01 | -0.657 | 7.46E+01 |




Calculations for source located at top of aquifer (ie vertical dispersion in one direction only) - USED FOR LEVEL ASSESSMENT

| | X | Term 1 | Term 2 | EXP | Term 3 | ERFC | Term 4A | ERF | Term 4B | ERF | Term 5A | ERF | Term 5B | ERF | Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | m | | | | | | | | | | | | | | |
| 1 | 1 | 14.1963 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 3.16E+02 | 1 | -3.16E+02 | -1 | 5.99E+00 | 1 | -5.99E+00 | -1 | 1.14E+02 |
| 2 | 2 | 14.1963 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 2.23E+02 | 1 | -2.23E+02 | -1 | 4.24E+00 | 1 | -4.24E+00 | -1 | 1.14E+02 |
| 3 | 3 | 14.1963 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 1.82E+02 | 1 | -1.82E+02 | -1 | 3.46E+00 | 1 | -3.46E+00 | -1 | 1.14E+02 |
| 4 | 4 | 14.1963 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 1.58E+02 | 1 | -1.58E+02 | -1 | 3.00E+00 | 1 | -3.00E+00 | -1 | 1.14E+02 |
| 5 | 5 | 14.1963 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 1.41E+02 | 1 | -1.41E+02 | -1 | 2.68E+00 | 0.9998 | -2.68E+00 | -1 | 1.14E+02 |
| 6 | 6 | 14.1963 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 1.29E+02 | 1 | -1.29E+02 | -1 | 2.45E+00 | 0.9995 | -2.45E+00 | -0.999 | 1.14E+02 |
| 7 | 7 | 14.1963 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 1.19E+02 | 1 | -1.19E+02 | -1 | 2.26E+00 | 0.9986 | -2.26E+00 | -0.999 | 1.13E+02 |
| 8 | 8 | 14.1963 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 1.12E+02 | 1 | -1.12E+02 | -1 | 2.12E+00 | 0.9973 | -2.12E+00 | -0.997 | 1.13E+02 |
| 9 | 9 | 14.1963 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 1.05E+02 | 1 | -1.05E+02 | -1 | 2.00E+00 | 0.9953 | -2.00E+00 | -0.995 | 1.13E+02 |
| 10 | 10 | 14.1963 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 9.99E+01 | 1 | -9.99E+01 | -1 | 1.89E+00 | 0.9926 | -1.89E+00 | -0.993 | 1.13E+02 |
| 11 | 11 | 14.1963 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 9.52E+01 | 1 | -9.52E+01 | -1 | 1.81E+00 | 0.9894 | -1.81E+00 | -0.989 | 1.12E+02 |
| 12 | 12 | 14.1963 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 9.12E+01 | 1 | -9.12E+01 | -1 | 1.73E+00 | 0.9856 | -1.73E+00 | -0.986 | 1.12E+02 |
| 13 | 13 | 14.1963 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 8.76E+01 | 1 | -8.76E+01 | -1 | 1.66E+00 | 0.9812 | -1.66E+00 | -0.981 | 1.11E+02 |
| 14 | 14 | 14.1963 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 8.44E+01 | 1 | -8.44E+01 | -1 | 1.60E+00 | 0.9765 | -1.60E+00 | -0.976 | 1.11E+02 |
| 15 | 15 | 14.1963 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 8.15E+01 | 1 | -8.15E+01 | -1 | 1.55E+00 | 0.9713 | -1.55E+00 | -0.971 | 1.10E+02 |
| 16 | 16 | 14.1963 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 7.90E+01 | 1 | -7.90E+01 | -1 | 1.50E+00 | 0.9659 | -1.50E+00 | -0.966 | 1.10E+02 |
| 17 | 17 | 14.1963 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 7.66E+01 | 1 | -7.66E+01 | -1 | 1.45E+00 | 0.9601 | -1.45E+00 | -0.96 | 1.09E+02 |
| 18 | 18 | 14.1963 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 7.44E+01 | 1 | -7.44E+01 | -1 | 1.41E+00 | 0.9542 | -1.41E+00 | -0.954 | 1.08E+02 |
| 19 | 19 | 14.1963 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 7.25E+01 | 1 | -7.25E+01 | -1 | 1.37E+00 | 0.9481 | -1.37E+00 | -0.948 | 1.08E+02 |
| 20 | 20 | 14.1963 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 7.06E+01 | 1 | -7.06E+01 | -1 | 1.34E+00 | 0.9419 | -1.34E+00 | -0.942 | 1.07E+02 |




| | |
|---|---|
| Date: | 24/02/2020 |
| Version: | 1 |

# Hydrogeological risk assessment for land contamination

## Remedial Targets Worksheet , Release 3.2

**First released: 2006. Version 3.2: January 2013**

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination ( Environment Agency 2006).

**Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.**

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The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

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IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions)

| Details to be completed for each assessment | | | | |
|---|---|---|---|---|
| Site Name: | Glan Llyn | | | |
| Site Address: | Llanwern | | | |
| Completed by: | Ross Cameron | | | |
| Date: | 24-Feb-20 | | Version: | 1 |
| Contaminant | Manganese | | | |
| Target Concentration ($C_T$) | 0.123 | mg/l | Origin of $C_T$: | Water Framework Directive (EQS |

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparision with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).
Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.
Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.
Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.
Data carried forward from an earlier worksheet are identified by a light green background
It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

## Remedial Targets Worksheet , Release 3.2

# Level 1 - Soil

Environment Agency

**Select the method of calculating the soil water Partition Co-efficient by using the pull down menu below**

**User specified value for partition coefficient**

| | | | | |
|---|---|---|---|---|
| **Contaminant** | | **Manganese** | | |
| **Target concentration** | **$C_T$** | **0.123** | **mg/l** | |

| **Input Parameters** | **Variable** | **Value** | **Unit** | **Source of parameter value** |
|---|---|---|---|---|
| ***Standard entry*** | | | | |
| Water filled soil porosity | $\theta_w$ | 5.00E-01 | fraction | 0.5 |
| Air filled soil porosity | θa | 3.70E-01 | fraction | 0.0037 |
| Bulk density of soil zone material | ρ | 1.36E+00 | g/cm$^3$ | 1.36 |
| Henry's Law constant | H | 1.00E+00 | dimensionless | *1* |
| ***Entry if specify partition coefficient (option)*** | | | | |
| Soil water partition coefficient | Kd | 1.34E+02 | l/kg | *1.34E+02* |
| ***Entry for non-polar organic chemicals (option)*** | | | | |
| Fraction of organic carbon (in soil) | foc | | fraction | |
| Organic carbon partition coefficient | Koc | | l/kg | |
| ***Entry for ionic organic chemicals (option)*** | | | | |
| Sorption coefficient for neutral species | $K_{oc,n}$ | | l/kg | |
| Sorption coefficient for ionised species | $K_{oc,i}$ | | l/kg | |
| pH value | pH | | pH units | |
| Acid dissociation constant | pKa | | | |
| Fraction of organic carbon (in soil) | foc | | fraction | |

This sheet calculates the Level 1 remedial target for soils(mg/kg) based on a selected target concentration and theoretical calculation of soil water partitioning. Three options are included for determining the partition coefficient.
The measured soil concentration as mg/kg should be compared with the Level 1 remedial target to determine the need for further action.

| | | | | |
|---|---|---|---|---|
| **Soil water partition coefficient used in Level Assessment** | **Kd** | **1.34E+02** | **l/kg** | *Specified value* |

## Level 1 Remedial Target

| | | | |
|---|---|---|---|
| **Level 1 Remedial Target** | **1.66E+01** | **mg/kg** | **(for comparison with soil analyses)** |
| | **or** | | |
| | **0.123** | **mg/l** | **(for comparison with leachate test results)** |

| | |
|---|---|
| Site being assessed: | Glan Llyn |
| Completed by: | Ross Cameron |
| Date: | 24-Feb-20 |
| Version: | 1 |

## Remedial Targets Worksheet , Release 3.2

# Level 2 - Soil

| | | | | |
|---|---|---|---|---|
| **Contaminant** | | **Manganese** | | from Level 1 |
| **Target concentration** | $C_T$ | **0.123** | **mg/l** | from Level 1 |

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamiantion' (Environment Agency 2006)

| **Input Parameters** | **Variable** | **Value** | **Unit** | **Source of parameter value** | |
|---|---|---|---|---|---|
| *Standard entry* | | | | | |
| Infiltration | Inf | 0.00E+00 | m/d | | |
| Area of contaminant source | A | 0.00E+00 | $m^2$ | | Not used in calculation |
| *Entry for groundwater flow below site* | | | | | |
| Length of contaminant source in direction of groundwater flow | L | 0.00E+00 | m | | |
| Saturated aquifer thickness | da | 0.00E+00 | m | | |
| Hydraulic Conductivity of aquifer in which dilution occurs | K | 0.00E+00 | m/d | | |
| Hydraulic gradient of water table | i | 0.00E+00 | fraction | | |
| Width of contaminant source perpendicular to groundwater flow | w | 0.00E+00 | m | | Not used in calculation |
| Background concentration of contaminant in groundwater beneath site | Cu | 0.00E+00 | mg/l | | |
| Define mixing zone depth by specifying or calculating depth (using pull down list) | | **Specify** | | | |
| Enter mixing zone thickness | Mz | 0.00E+00 | m | | |
| Calculated mixing zone thickness | Mz | | m | | |

## Calculated Parameters

| | | | | |
|---|---|---|---|---|
| **Dilution Factor** | **DF** | **#DIV/0!** | | |
| **Level 2 Remedial Target** | | **#DIV/0!** | **mg/l** | **For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentra** |
| | | **or** | | |
| | | **#DIV/0!** | **mg/kg** | **For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water** |

## *Additional option*

**Calculation of impact on receptor**

| | | | | |
|---|---|---|---|---|
| Concentration of contaminant in contaminated discharge (entering receptor) | Cc | 0.00E+00 | mg/l | |
| Calculated concentration within receptor (dilution only) | | #DIV/0! | mg/l | 0 |

| | |
|---|---|
| Site being assessed: | Glan Llyn |
| Completed by: | Ross Cameron |
| Date: | 24-Feb-20 |
| Version: | 1 |

**Remedial Targets Worksheet , Release 3.2**

## Level 3 - Soil

See Note

### Input Parameters

| | Variable | Value | Unit | Source |
|---|---|---|---|---|
| Contaminant | | Manganese | | from Level 1 |
| Target Concentration | $C_T$ | 0.123 | mg/l | from Level 1 |
| Dilution Factor | DF | #DIV/0! | | from Level 2 |

**Select analytical solution (click on brown cell below, then on pull-down menu)**

Ogata Banks — Equations in HRA publication

**Select nature of decay rate (click on brown cell below, then on pull-down menu)**

Approach for simulating degradation of pollutants: Apply degradation rate to pollutants in all phases (e.g. field derived value, lab

| | Variable | Value | Unit | Source of parameter value |
|---|---|---|---|---|
| Enter source concentration | | Soil concentration as mg/kg | | |
| Enter soil concentration | | 0 | mg/kg | |
| Half life for degradation of contaminant in water | $t_{1/2}$ | 1.00E+100 | days | |
| Calculated decay rate | $\lambda$ | 6.93E-101 | $days^{-1}$ | calculated |
| Width of plume in aquifer at source | Sz | 0.00E+00 | m | from Level 2 |
| Plume thickness in aquifer at source | Sy | 0.00E+00 | m | from Level 2 |
| Bulk density of aquifer materials | $\rho$ | 0.00E+00 | $g/cm^3$ | |
| Effective porosity of aquifer | n | 0.00E+00 | fraction | |
| Hydraulic gradient | i | #DIV/0! | fraction | from Level 2 (adjusted) |
| Hydraulic conductivity of saturated aquifer | K | 0.00E+00 | m/d | from Level 2 |
| Distance to compliance point | x | 0.00E+00 | m | |
| Distance (lateral) to compliance point perpendicular to flow direction | z | | m | |
| Distance (depth) to compliance point perpendicular to flow direction | y | | m | |
| Time since pollutant entered groundwater | t | 1.00E+99 | days | *time variant options only* |
| *Parameters values determined from options* | | | | |
| Partition coefficient | Kd | 0.00E+00 | l/kg | *see options* |
| Longitudinal dispersivity | ax | 0.000 | m | *see options* |
| Transverse dispersivity | az | 0.000 | m | *see options* |
| Vertical dispersivity | av | 0.000 | m | *see options* |

***Parameter values should be checked against Level 1 and 2***

### Calculated Parameters

| | Variable | | |
|---|---|---|---|
| Groundwater flow velocity | v | #DIV/0! | m/d |
| Retardation factor | Rf | #DIV/0! | fraction |
| Decay rate used | $\lambda$ | 6.93E-101 | $d^{-1}$ |
| Hydraulic gradient used in aquifer flow down-gradient | i | #DIV/0! | fraction |
| Rate of contaminant flow due to retardation | u | #DIV/0! | m/d |
| Ratio of Compliance Point to Source Concentration | $C_{ED}/C_0$ | #DIV/0! | fraction |
| **Attenuation factor ($C_0/C_{ED}$)** | **AF** | **#DIV/0!** | **fraction** |
| Calculated soil leachate concentration | Co | 0.00E+00 | mg/l |

### Remedial Targets

| | | | |
|---|---|---|---|
| **Level 3 Remedial Target** | **#DIV/0!** | **mg/l** | For comparison with measured pore water concentration. |
| Ogata Banks | **or** | | This assumes Level 1 Remedial Target is based on Target Concentration. |
| | **#DIV/0!** | **mg/kg** | For comparison with measured soil concentration. This |
| **Distance to compliance point** | **0** | **m** | assumes Level 1 Remedial Target calculated from soil-water partitioning equation. |
| **Ratio of Compliance Point to Source Concentration** | **$C_{ED}/C_0$** | **#DIV/0!** | **fraction** Ogata Banks |

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99

**Enter method of defining partition co-efficient (using pull down list)**

Calculate for ionic organic chemicals (acids)

*Entry if specify partition coefficient (option)*

| | | |
|---|---|---|
| Soil water partition coefficient | Kd | l/kg |

*Entry for non-polar organic chemicals (option)*

| | | |
|---|---|---|
| Fraction of organic carbon in aquifer | foc | fraction |
| Organic carbon partition coefficient | Koc | l/kg |

*Entry for ionic organic chemicals (option)*

| | | | |
|---|---|---|---|
| Sorption coefficient for related species | $K_{oc,n}$ | 0.00E+00 | l/kg |
| Sorption coefficient for ionised species | $K_{oc,i}$ | 0.00E+00 | l/kg |
| pH value | pH | 0.00E+00 | |
| Acid dissociation constant | pKa | 0.00E+00 | |
| Fraction of organic carbon in aquifer | foc | 0.00E+00 | fraction |
| Soil water partition coefficient | Kd | 0.00E+00 | l/kg |

**Define dispersivity (click brown cell and use pull down list)**

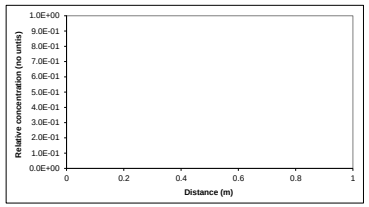
User defined values for dispersivity

| | | Enter value | Calc value | Xu & Eckstein | |
|---|---|---|---|---|---|
| **Longitudinal dispersivity** | **ax** | 0.00E+00 | 0.00E+00 | #NUM! | m |
| **Transverse dispersivity** | **az** | 0.00E+00 | 0.00E+00 | #NUM! | m |
| **Vertical dispersivity** | **ay** | 0.00E+00 | 0.00E+00 | #NUM! | m |

**Note values of dispersivity must be > 0**

Xu & Eckstein (1995) report ax = $0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed

Note
This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by $O_2$, $NO_3$, $SO_4$ etc than an alternative solution should be used




Note: 'Relative concentration' is the ratio of calculated concentation at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

| | |
|---|---|
| Site being assessed: | Glan Llyn |
| Completed by: | Ross Cameron |
| Date: | ######## |
| Version: | 1 |

**Calculated (relative) concentrations for distance-concentration graph**

Ogata Banks
From calculation sheet

| Distance | Relative concentration (No units) | Concentration mg/l |
|---|---|---|
| 0 | 1.0E+00 | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |

# Remedial Targets Worksheet , Release 3.2

## Calculation of contaminant concentration in groundwater from a soil source

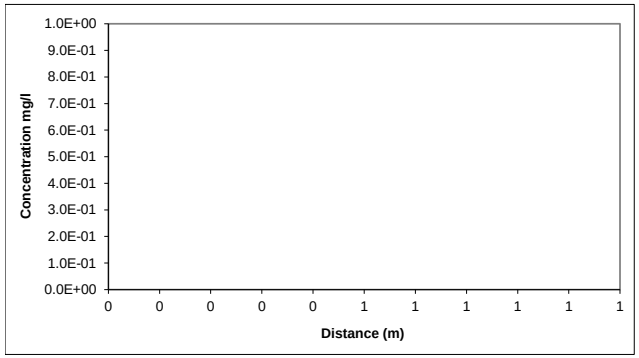
Only input required is Soil Contaminant Concentration

| | | | | |
|---|---|---|---|---|
| | Input Parameters | | | |
| | Soil contaminant concentration | $C_0$ | 0.00E+00 | mg/kg |
| **Level 1 Parameters** | | | | |
| | Water filled soil porosity | $\theta_w$ | 5.00E-01 | fraction |
| | Air filled soil porosity | $\theta a$ | 3.70E-01 | fraction |
| | Bulk density | $\rho$ | 1.36E+00 | g/cm$^3$ |
| | Henry's Law constant | H | 1.00E+00 | dimensionless |
| | Soil water partition coefficient used in Level Assessment | Kd | 1.34E+02 | l/kg |
| | Factor (partitioning between soil and water) | | 1.35E+02 | dimensionless |
| **Level 2 Parameters** | **Dilution Factor** | DF | #DIV/0! | |
| **Level 3 Parameters** | **Attenuation factor ($C_O/C_{ED}$)** | AF | #DIV/0! | |

### Predicted concentrations at compliance point

| | | | | |
|---|---|---|---|---|
| **Level 1** | C | 0.00E+00 | mg/l | No dilution or attenuation |
| **Level 2** | C | #DIV/0! | mg/l | Dilution taken into account |
| **Level 3** | C | #DIV/0! | mg/l | Dilution and attenuation taken into account |

### Predicted concentrations between source and compliance point - Level 3




| Distance m | Concentration mg/l |
|---|---|
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |

# R&D Publication 20 Remedial Targets Worksheet, Release 3.2

## Level 3 - Groundwater

See Note

**Input Parameters (using pull down menu)** | **Variable** | **Value** | **Unit** | **Source**

| | | | | |
|---|---|---|---|---|
| Contaminant | | Manganese | | from Level 1 |
| Target Concentration | $C_T$ | 1.23E-01 | mg/l | from Level 1 |

**Select analytical solution (click on brown cell below, then on pull-down menu)**

Domenico - Steady state — Equations in HRA publication

Approach for simulating vertical dispersion: Simulate vertical dispersion in 1 direction

**Select nature of decay rate (click on brown cell below, then on pull-down menu)**

Approach for simulating degradation of pollutants: Apply degradation rate to dissolved pollutants only

| | | | | Source of parameter value |
|---|---|---|---|---|
| Initial contaminant concentration in groundwater at plume core | $C_0$ | 1.20E+01 | mg/l | *Based on average soil conc of 8645mg/kg* |
| Half life for degradation of contaminant in water | $t_{1/2}$ | 9.00E+99 | days | *Estimation* |
| Calculated decay rate | λ | 7.70E-101 | $days^{-1}$ | |
| Width of plume in aquifer at source (perpendicular to flow) | Sz | 5.00E+02 | m | *Site data* |
| Plume thickness at source | Sy | 1.50E+00 | m | *Thickness of re-engineered MG* |
| Saturated aquifer thickness | da | 2.00E+00 | m | *Based upon proposed total MG and cappir* |
| Bulk density of aquifer materials | ρ | 1.36E+00 | $g/cm^3$ | *Site data* |
| Effective porosity of aquifer | n | 8.00E-02 | fraction | *Estimate* |
| Hydraulic gradient | i | 1.00E-02 | fraction | |
| Hydraulic conductivity of aquifer | K | 8.64E-03 | m/d | *Proposed best achievable* |
| Distance to compliance point | x | 2.00E+01 | m | *Site data* |
| Distance (lateral) to compliance point perpendicular to flow direction | z | | m | |
| Distance (depth) to compliance point perpendicular to flow direction | y | | m | |
| Time since pollutant entered groundwater | t | 1.00E+100 | days | *time variant options only* |
| *Parameters values determined from options* | | | | |
| Partition coefficient | Kd | 7.20E+02 | l/kg | *see options* |
| Longitudinal dispersivity | ax | 1.57E+00 | m | *see options* |
| Transverse dispersivity | az | 1.57E-01 | m | *see options* |
| Vertical dispersivity | ay | 1.57E-02 | m | *see options* |

**Calculated Parameters** | **Variable**

| | | | |
|---|---|---|---|
| Groundwater flow velocity | v | 1.08E-03 | m/d |
| Retardation factor | Rf | 1.22E+04 | fraction |
| Decay rate used | λ | 6.29E-105 | $d^{-1}$ |
| Rate of contaminant flow due to retardation | u | 8.82E-08 | m/d |
| Contaminant concentration at distance x, assuming one-way vertical dispersion | $C_{ED}$ | 1.13E+01 | mg/l |
| **Attenuation factor (one way vertical dispersion, CO/CED)** | **AF** | **1.06E+00** | |

**Remedial Targets**

| | | | | |
|---|---|---|---|---|
| **Remedial Target** | | **1.31E-01** | **mg/l** | For comparison with measured groundwater concentration. |
| Domenico - Steady state | | | | |
| **Distance to compliance point** | | **20** | **m** | |
| **Concentration of contaminant at compliance point** | **$C_{ED}/C_0$** | **1.13E+01** | **mg/l** | Domenico - Steady state |

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99.

**Select Method for deriving Partition Co-efficient (using pull down menu)**

User specified value for partition coefficient

| | | | |
|---|---|---|---|
| ***Entry if specify partition coefficient (option)*** | | | |
| Soil water partition coefficient | Kd | 7.20E+02 | l/kg |
| ***Entry for non-polar organic chemicals (option)*** | | | |
| Fraction of organic carbon in aquifer | foc | | fraction |
| Organic carbon partition coefficient | Koc | | l/kg |
| ***Entry for ionic organic chemicals (option)*** | | | |
| Sorption coefficient for related species | $K_{oc,n}$ | | l/kg |
| Sorption coefficient for ionised species | $K_{oc,i}$ | | l/kg |
| pH value | pH | | |
| acid dissociation constant | pKa | | |
| Fraction of organic carbon in aquifer | foc | | fraction |
| Soil water partition coefficient | Kd | 7.20E+02 | l/kg |

**Define dispersivity (click brown cell and use pull down list)**

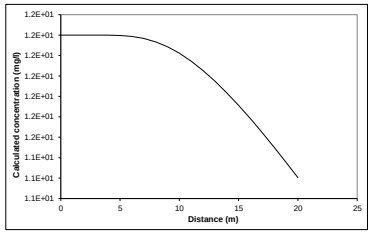
Dispersivity based on Xu & Eckstein (1995)

| | | Enter value | Calc value Xu & Eckstein | | |
|---|---|---|---|---|---|
| **Longitudinal dispersivity** | **ax** | 0.00E+00 | 2.00E+01 | 1.57E+00 | m |
| **Transverse dispersivity** | **az** | 0.00E+00 | 2.00E+00 | 1.57E-01 | m |
| **Vertical dispersivity** | **ay** | 0.00E+00 | 2.00E-01 | 1.57E-02 | |

**Note values of dispersivity must be > 0**

For calculated value, assumes ax = 0.1 *x, az = 0.01 * x, ay = 0.001 * x

Xu & Eckstein (1995) report ax = $0.83(\log_{10}x)^{2.414}$ ; az = ax/10, ay = ax/100 are assumed




Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared with the Level 3 remedial target to determine the need for further action.
Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O2, NO3, SO4 etc than an alternative solution should be used

| | |
|---|---|
| Site being assessed: | Glan Llyn |
| Completed by: | Ross Cameron |
| Date: | ######## |
| Version: | 1 |

**Calculated concentrations for distance-concentration graph**

**Domenico - Steady state**
**From calculation sheet**

| Distance | Concentration |
|---|---|
| | mg/l |
| 0 | 1.2E+01 |
| 1.0 | 1.20E+01 |
| 2.0 | 1.20E+01 |
| 3.0 | 1.20E+01 |
| 4.0 | 1.20E+01 |
| 5.0 | 1.20E+01 |
| 6.0 | 1.20E+01 |
| 7.0 | 1.20E+01 |
| 8.0 | 1.20E+01 |
| 9.0 | 1.19E+01 |
| 10.0 | 1.19E+01 |
| 11.0 | 1.19E+01 |
| 12.0 | 1.18E+01 |
| 13.0 | 1.18E+01 |
| 14.0 | 1.17E+01 |
| 15.0 | 1.17E+01 |
| 16.0 | 1.16E+01 |
| 17.0 | 1.15E+01 |
| 18.0 | 1.15E+01 |
| 19.0 | 1.14E+01 |
| 20.0 | 1.13E+01 |

# Porosity Calculator

These results are not carried through to any of the other worksheets

## DRY BULK DENSITY DATA

| Variable | Value | Unit | justification |
|---|---|---|---|
| Natural Moisture Content | 0.00 | % wt | |
| Particle Density | 2.78 | tonnes/m$^3$ | (Change this number only if you have specific information) |
| Dry Bulk Density | 0.00 | tonnes/m$^3$ | |
| *Calculated Parameters* | | | |
| Voids Ratio | #DIV/0! | fraction | |
| Initial Saturation | #DIV/0! | % | |
| **Total porosity** | **1.000** | **fraction** | |
| **Air Filled Porosity** | **#DIV/0!** | **fraction** | |
| **Water Filled Porosity** | **#DIV/0!** | **fraction** | |

## WET BULK DENSITY DATA

| Variable | Value | Unit | |
|---|---|---|---|
| Moisture Content | 0.00 | % wt | |
| Particle Density | 2.78 | tonnes/m$^3$ | (Change this number only if you have specific information) |
| Actual (wet) Bulk Density ( i.e. at natural MC) | 0.00 | tonnes/m$^3$ | |
| *Calculated Parameters* | | | |
| Voids Ratio | #DIV/0! | fraction | |
| dry bulk density | 0.00 | tonnes/m$^3$ | |
| Initial Saturation | #DIV/0! | % | |
| **Total porosity** | **1.000** | **fraction** | **#DIV/0!** |
| **Air Filled Porosity** | **#DIV/0!** | **fraction** | |
| **Water Filled Porosity** | **#DIV/0!** | **fraction** | |

*Analytical solutions provided by David Hall, Golder Associates (UK) Ltd*

# Simple hydrogeological calculations

**(These are not specific to, or required in, the Remedial Targets Methodology)**

| Parameter | symbol | | unit | justification |
|---|---|---|---|---|
| Hydraulic conductivity | K | 0.00E+00 | m/d | |
| Hydraulic gradient | i | 0.00E+00 | unitless | |
| Effective porosity of aquifer | n | 0.00E+00 | fraction | |
| Thickness of saturated aquifer | b | 0.00E+00 | m | |
| Width of aquifer perpendicular to flow | w | 0.00E+00 | m | |
| Distance to receptor | x | 0.00E+00 | m | |
| Bulk density of aquifer materials | ρ | 0.00E+00 | g/cm$^3$ | |
| Soil-water partition co-efficient | Kd | 0.00E+00 | l/kg | |
| Retardation factor of pollutant | R | #DIV/0! | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Groundwater flow velocity | v(GW) | #DIV/0! | m/s | #DIV/0! | m/day | #DIV/0! | m/year |
| Time for groundwater to reach receptor | t(GW) | #DIV/0! | seconds | #DIV/0! | days | #DIV/0! | years |
| Rate of groundwater flow through aquifer | Q | 0.00E+00 | m$^3$/s | 0.00E+00 | m$^3$/day | 0.00E+00 | m$^3$/year |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Contaminant flow velocity | v(contam) | #DIV/0! | m/s | #DIV/0! | m/day | #DIV/0! | m/year |
| Time for contaminant to reach receptor | t(contam) | #DIV/0! | seconds | #DIV/0! | days | #DIV/0! | years |

## Level 1 Calculation Sheet

**Contaminant** **Manganese**

| **Parameter** (carried over from input sheet) | **Value** | **Units** |
|---|---|---|
| $C_T$ | 1.23E-01 | mg/l |
| Kd | 1.34E+02 | l/kg |
| foc | | fraction |
| koc | | l/kg |
| $\theta_w$ | 5.00E-01 | fraction |
| $\theta a$ | 3.70E-01 | fraction |
| $\rho$ | 1.36E+00 | g/cm3 |
| H | 1.00E+00 | dimensionless |
| Koc,n | | l/kg |
| Koc,i | | l/kg |
| pH | | pH units |
| pKa | | |
| foc (ionic) | | fraction |

**Calculations (Refer toTable 4.3, R&D Publication 20)**

**Selected option** User specified value for partition coefficient

| | calc | calc | Calc Kd | l/kg |
|---|---|---|---|---|
| Calculation of partition coefficient for ionic organic chemical | | | | |
| Partition coefficient used in Level 1 Assessment | | | 1.34E+02 | l/kg |

**Calculated Remedial Target** **1.66E+01 mg/kg** **for Manganese**

Factor (partitioning between soil and water) 1.35E+02

| | |
|---|---|
| Site being assessed: | Glan Llyn |
| Completed by: | Ross Cameron |
| Date: | 24/02/2020 |
| Version: | 1 |

## Level 2 Calculation Sheet

**Contaminant** **Manganese**

| Site assessed: | Glan Llyn |
|---|---|
| Date: | 24/02/2020 |
| Version: | 1 |

| Parameter | Value | Units | | |
|---|---|---|---|---|
| (carried over from input sheet) | | | | |
| Mz | 0.00E+00 | m | | |
| L | 0.00E+00 | m | | |
| da | 0.00E+00 | m | | Calculated Dilution Factor |
| Inf | 0.00E+00 | m/d | | |
| K | 0.00E+00 | m/d | | |
| i | 0.00E+00 | m3/d | Calculation based on target concentration | #DIV/0! |
| A | 0.00E+00 | m2 | Calculation based on observed contaminant concentration | #DIV/0! |
| Cc | 0.00E+00 | m3/d mg/l | | |
| $C_T$ | 1.23E-01 | mg/l | | |
| Cu | 0.00E+00 | mg/l | | |
| w | 0.00E+00 | m | | |

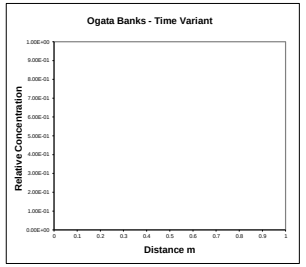


**OGATA BANKS SOLUTION**

| Contaminant | Manganese | |
|---|---|---|
| **Input** | **Value** | **Units** |
| $C_T$ | 1.230E-01 | mg/l |
| DF | #DIV/0! | |
| λ | 6.931E-101 | $days^{-1}$ |
| Sz | 0.000E+00 | m |
| Sy | 0.000E+00 | m |
| Kd | 0.000E+00 | l/kg |
| ρ | 0.000E+00 | g/cm3 |
| n | 0.000E+00 | |
| i | #DIV/0! | |
| K | 0.000E+00 | m/d |
| x | 0.000E+00 | m |
| z | 0.000E+00 | m |
| y | 0.000E+00 | m |
| t | 1.000E+99 | days |
| ax | 0.000E+00 | m |
| az | 0.000E+00 | m |
| ay | 0.000E+00 | m |

Calculations for source located in centre of aquifer (ie vertical dispersion in two directions)

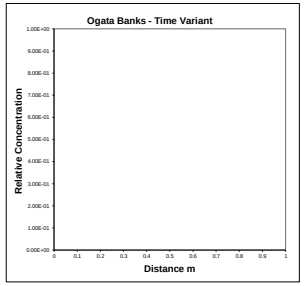
| | X | Term 1 | Term 2 | EXP | Term 3 | ERFC | Term 4 | EXP | Term 5 | ERFC | Term 6a | ERF | Term 6b | ERF | Term 7a | ERF | Term 7b | ERF | Relative Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 2 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 3 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 4 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 5 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 6 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 7 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 8 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 9 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 10 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 11 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 12 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 13 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 14 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 15 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 16 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 17 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 18 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 19 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 20 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |




| Calc | Value | |
|---|---|---|
| v | #DIV/0! | m/d |
| Rc | #DIV/0! | |
| u | #DIV/0! | m/d |

Calculations for source located at top of aquifer (ie vertical dispersion in one direction) -USED FOR LEVEL ASSESSMENT

| | X | Term 1 | Term 2 | EXP | Term 3 | ERFC | Term 4 | EXP | Term 5 | ERFC | Term 6a | ERF | Term 6b | ERF | Term 7a | ERF | Term 7b | ERF | Relative Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 2 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 3 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 4 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 5 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 6 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 7 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 8 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 9 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 10 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 11 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 12 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 13 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 14 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 15 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 16 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 17 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 18 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 19 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 20 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |




| | |
|---|---|
| Date: | 24/02/2020 |
| Version: | 1 |

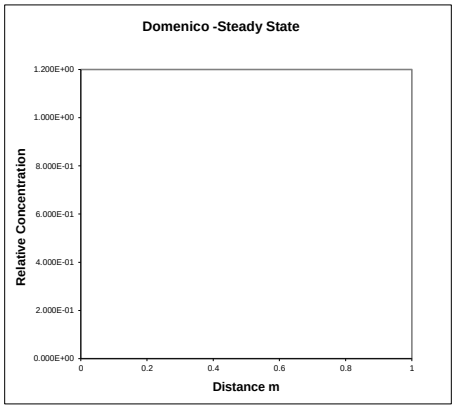
**Contaminant** **Manganese**

**DOMENICO (STEADY STATE)**

Calculations for source located in centre of aquifer (ie vertical dispersion in two directions)

| Input | Value | Units |
|---|---|---|
| $C_T$ | 1.230E-01 | mg/l |
| DF | #DIV/0! | |
| λ | 6.931E-101 | days$^{-1}$ |
| Sz | 0.000E+00 | m |
| Sy | 0.000E+00 | m |
| Kd | 0.000E+00 | l/kg |
| ρ | 0.000E+00 | g/cm3 |
| n | 0.000E+00 | |
| i | #DIV/0! | |
| K | 0.000E+00 | m/d |
| x | 0.000E+00 | m |
| z | 0.000E+00 | m |
| y | 0.000E+00 | m |
| ax | 0.000E+00 | m |
| az | 0.000E+00 | m |
| ay | 0.000E+00 | m |

| | X | Term 1 | Term 2 | EXP | Term 3A | ERF | Term 3B | ERF | Term 4A | ERF | Term 4B | ERF | Relative Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 2 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 3 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 4 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 5 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 6 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 7 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 8 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 9 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 10 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 11 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 12 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 13 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 14 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 15 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 16 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 17 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 18 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 19 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 20 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |



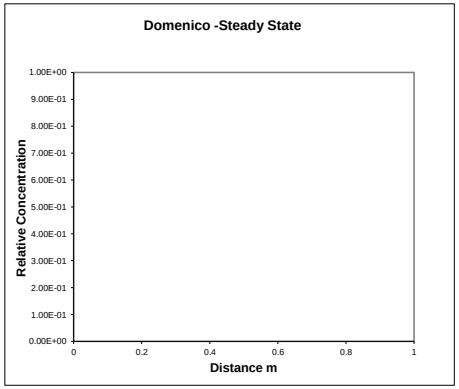

**Calc** **Value**

| | | |
|---|---|---|
| v | #DIV/0! | m/d |
| Rc | #DIV/0! | |
| u | #DIV/0! | m/d |

**DOMENICO (STEADY STATE)**

Calculations for source located at top of aquifer (ie vertical dispersion in one direction) - USED FOR LEVEL ASSESSMENT

| | X | Term 1 | Term 2 | EXP | Term 3A | ERF | Term 3B | ERF | Term 4A | ERF | Term 4B | ERF | Relative Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 2 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 3 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 4 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 5 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 6 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 7 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 8 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 9 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 10 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 11 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 12 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 13 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 14 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 15 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 16 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 17 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 18 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 19 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 20 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |




| | |
|---|---|
| Date: | 24/02/2020 |
| Version: | 1 |

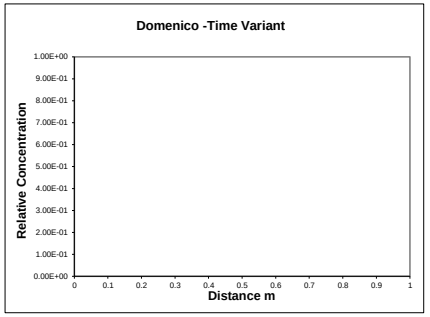
## DOMENICO (TIME VARIANT)

**Contaminant** **Manganese**

| Input | Value | Units |
|---|---|---|
| $C_T$ | 0.123 | mg/l |
| DF | #DIV/0! | |
| λ | 6.931E-101 | days$^{-1}$ |
| Sz | 0.000E+00 | m |
| Sy | 0.000E+00 | m |
| Kd | 0.000E+00 | l/kg |
| ρ | 0.000E+00 | g/cm3 |
| n | 0.000E+00 | |
| i | #DIV/0! | |
| K | 0.000E+00 | m/d |
| x | 0.000E+00 | m |
| z | 0.000E+00 | m |
| y | 0.000E+00 | m |
| t | 1.000E+99 | days |
| ax | 0.000E+00 | m |
| az | 0.000E+00 | m |
| ay | 0.000E+00 | m |

Calculations for source located in centre of aquifer (ie vertical dispersion in two directions)

| | X | Term 1 | Term 2 | EXP | Term 3 | ERFC | Term 4A | ERF | Term 4B | ERF | Term 5A | ERF | Term 5B | ERF | Relative Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | m | | | | | | | | | | | | | | |
| 1 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 2 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 3 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 4 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 5 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 6 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 7 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 8 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 9 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 10 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 11 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 12 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 13 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 14 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 15 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 16 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 17 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 18 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 19 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 20 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |

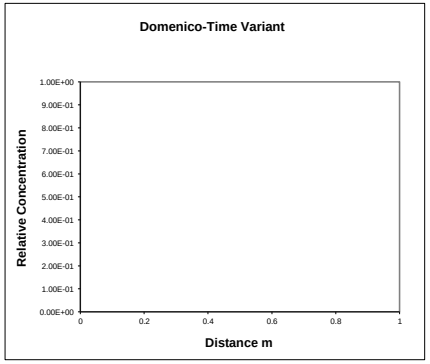



**Calc** **Value**

| | | |
|---|---|---|
| v | #DIV/0! | m/d |
| Rc | #DIV/0! | |
| u | #DIV/0! | m/d |

Calculations for source located at top of aquifer (ie vertical dispersion in one direction only) - USED FOR LEVEL ASSESSMENT

| | X | Term 1 | Term 2 | EXP | Term 3 | ERFC | Term 4A | ERF | Term 4B | ERF | Term 5A | ERF | Term 5B | ERF | Relative Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | m | | | | | | | | | | | | | | |
| 1 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 2 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 3 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 4 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 5 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 6 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 7 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 8 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 9 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 10 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 11 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 12 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 13 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 14 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 15 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 16 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 17 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 18 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 19 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 20 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |



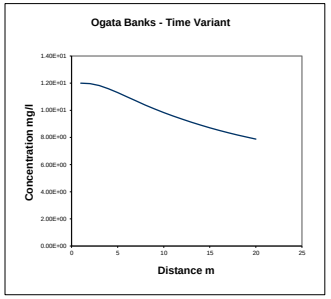

| | |
|---|---|
| Date: | 24/02/2020 |
| Version: | 1 |

**OGATA BANKS SOLUTION**

| Contaminant | Manganese | |
|---|---|---|
| **Input** | **Value** | **Units** |
| $C_T$ | 0.123 | mg/l |
| Co | 1.20E+01 | mg/l |
| λ | 6.29E-105 | $days^{-1}$ |
| Sz | 5.00E+02 | m |
| Sy | 1.50E+00 | m |
| Kd | 7.20E+02 | l/kg |
| ρ | 1.36E+00 | g/cm3 |
| n | 8.00E-02 | |
| i | 1.00E-02 | |
| K | 8.64E-03 | m/d |
| x | 2.00E+01 | m |
| z | 0.00E+00 | m |
| y | 0.00E+00 | m |
| t | 1.00E+100 | days |
| ax | 1.57E+00 | m |
| az | 1.57E-01 | m |
| ay | 1.57E-02 | m |

Calculations for source located in centre of aquifer (ie vertical dispersion in two directions)

| | X | Term 1 | Term 2 | EXP | Term 3 | ERFC | Term 4 | EXP | Term 5 | ERFC | Term 6a | ERF | Term 6b | ERF | Term 7a | ERF | Term 7b | ERF | Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 1.5 | 0.0E+00 | 1.0E+00 | -1.2E+46 | 2.000 | 6.4E-01 | 1.9E+00 | 1.2E+46 | 0.000 | 3.2E+02 | 1 | -3.2E+02 | -1 | 3.0E+00 | 1 | -3.0E+00 | -0.99998 | 1.20E+01 |
| 2 | 2 | 1.5 | 0.0E+00 | 1.0E+00 | -1.2E+46 | 2.000 | 1.3E+00 | 3.6E+00 | 1.2E+46 | 0.000 | 2.2E+02 | 1 | -2.2E+02 | -1 | 2.1E+00 | 0.9973 | -2.1E+00 | -0.99726 | 1.20E+01 |
| 3 | 3 | 1.5 | 0.0E+00 | 1.0E+00 | -1.2E+46 | 2.000 | 1.9E+00 | 6.8E+00 | 1.2E+46 | 0.000 | 1.8E+02 | 1 | -1.8E+02 | -1 | 1.7E+00 | 0.9856 | -1.7E+00 | -0.98557 | 1.18E+01 |
| 4 | 4 | 1.5 | 0.0E+00 | 1.0E+00 | -1.2E+46 | 2.000 | 2.6E+00 | 1.3E+01 | 1.2E+46 | 0.000 | 1.6E+02 | 1 | -1.6E+02 | -1 | 1.5E+00 | 0.9659 | -1.5E+00 | -0.96587 | 1.16E+01 |
| 5 | 5 | 1.5 | 0.0E+00 | 1.0E+00 | -1.2E+46 | 2.000 | 3.2E+00 | 2.4E+01 | 1.2E+46 | 0.000 | 1.4E+02 | 1 | -1.4E+02 | -1 | 1.3E+00 | 0.9419 | -1.3E+00 | -0.94189 | 1.13E+01 |
| 6 | 6 | 1.5 | 0.0E+00 | 1.0E+00 | -1.2E+46 | 2.000 | 3.8E+00 | 4.6E+01 | 1.2E+46 | 0.000 | 1.3E+02 | 1 | -1.3E+02 | -1 | 1.2E+00 | 0.9163 | -1.2E+00 | -0.91633 | 1.10E+01 |
| 7 | 7 | 1.5 | 0.0E+00 | 1.0E+00 | -1.2E+46 | 2.000 | 4.5E+00 | 8.7E+01 | 1.2E+46 | 0.000 | 1.2E+02 | 1 | -1.2E+02 | -1 | 1.1E+00 | 0.8907 | -1.1E+00 | -0.89072 | 1.07E+01 |
| 8 | 8 | 1.5 | 0.0E+00 | 1.0E+00 | -1.2E+46 | 2.000 | 5.1E+00 | 1.7E+02 | 1.2E+46 | 0.000 | 1.1E+02 | 1 | -1.1E+02 | -1 | 1.1E+00 | 0.8659 | -1.1E+00 | -0.86587 | 1.04E+01 |
| 9 | 9 | 1.5 | 0.0E+00 | 1.0E+00 | -1.2E+46 | 2.000 | 5.7E+00 | 3.1E+02 | 1.2E+46 | 0.000 | 1.1E+02 | 1 | -1.1E+02 | -1 | 1.0E+00 | 0.8422 | -1.0E+00 | -0.84215 | 1.01E+01 |
| 10 | 10 | 1.5 | 0.0E+00 | 1.0E+00 | -1.2E+46 | 2.000 | 6.4E+00 | 5.9E+02 | 1.2E+46 | 0.000 | 1.0E+02 | 1 | -1.0E+02 | -1 | 9.5E-01 | 0.8197 | -9.5E-01 | -0.81971 | 9.84E+00 |
| 11 | 11 | 1.5 | 0.0E+00 | 1.0E+00 | -1.2E+46 | 2.000 | 7.0E+00 | 1.1E+03 | 1.2E+46 | 0.000 | 9.5E+01 | 1 | -9.5E+01 | -1 | 9.0E-01 | 0.7986 | -9.0E-01 | -0.79858 | 9.58E+00 |
| 12 | 12 | 1.5 | 0.0E+00 | 1.0E+00 | -1.2E+46 | 2.000 | 7.7E+00 | 2.1E+03 | 1.2E+46 | 0.000 | 9.1E+01 | 1 | -9.1E+01 | -1 | 8.6E-01 | 0.7787 | -8.6E-01 | -0.77872 | 9.34E+00 |
| 13 | 13 | 1.5 | 0.0E+00 | 1.0E+00 | -1.2E+46 | 2.000 | 8.3E+00 | 4.0E+03 | 1.2E+46 | 0.000 | 8.8E+01 | 1 | -8.8E+01 | -1 | 8.3E-01 | 0.7601 | -8.3E-01 | -0.76006 | 9.12E+00 |
| 14 | 14 | 1.5 | 0.0E+00 | 1.0E+00 | -1.2E+46 | 2.000 | 8.9E+00 | 7.6E+03 | 1.2E+46 | 0.000 | 8.4E+01 | 1 | -8.4E+01 | -1 | 8.0E-01 | 0.7425 | -8.0E-01 | -0.74253 | 8.91E+00 |
| 15 | 15 | 1.5 | 0.0E+00 | 1.0E+00 | -1.2E+46 | 2.000 | 9.6E+00 | 1.4E+04 | 1.2E+46 | 0.000 | 8.2E+01 | 1 | -8.2E+01 | -1 | 7.7E-01 | 0.726 | -7.7E-01 | -0.72604 | 8.71E+00 |
| 16 | 16 | 1.5 | 0.0E+00 | 1.0E+00 | -1.2E+46 | 2.000 | 1.0E+01 | 2.7E+04 | 1.2E+46 | 0.000 | 7.9E+01 | 1 | -7.9E+01 | -1 | 7.5E-01 | 0.7105 | -7.5E-01 | -0.71052 | 8.53E+00 |
| 17 | 17 | 1.5 | 0.0E+00 | 1.0E+00 | -1.2E+46 | 2.000 | 1.1E+01 | 5.2E+04 | 1.2E+46 | 0.000 | 7.7E+01 | 1 | -7.7E+01 | -1 | 7.3E-01 | 0.6959 | -7.3E-01 | -0.69588 | 8.35E+00 |
| 18 | 18 | 1.5 | 0.0E+00 | 1.0E+00 | -1.2E+46 | 2.000 | 1.1E+01 | 9.8E+04 | 1.2E+46 | 0.000 | 7.4E+01 | 1 | -7.4E+01 | -1 | 7.1E-01 | 0.6821 | -7.1E-01 | -0.68205 | 8.18E+00 |
| 19 | 19 | 1.5 | 0.0E+00 | 1.0E+00 | -1.2E+46 | 2.000 | 1.2E+01 | 1.8E+05 | 1.2E+46 | 0.000 | 7.2E+01 | 1 | -7.2E+01 | -1 | 6.9E-01 | 0.669 | -6.9E-01 | -0.66897 | 8.03E+00 |
| 20 | 20 | 1.5 | 0.0E+00 | 1.0E+00 | -1.2E+46 | 2.000 | 1.3E+01 | 3.5E+05 | 1.2E+46 | 0.000 | 7.1E+01 | 1 | -7.1E+01 | -1 | 6.7E-01 | 0.6566 | -6.7E-01 | -0.65658 | 7.88E+00 |

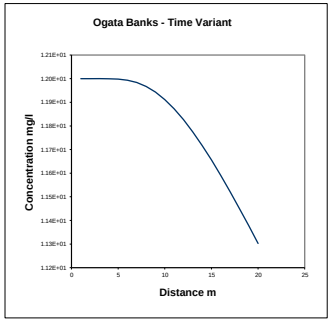



Vertical dispersion option Simulate vertical dispersion in 1 direction

| Calc | Value | |
|---|---|---|
| v | 1.08E-03 | m/d |
| Rc | 1.22E+04 | |
| u | 8.82E-08 | m/d |

Calculations for source located at top of aquifer (ie vertical dispersion in one direction) - USED FOR LEVEL ASSESSMENT

| | X | Term 1 | Term 2 | EXP | Term 3 | ERFC | Term 4 | EXP | Term 5 | ERFC | Term 6a | ERF | Term 6b | ERF | Term 7a | ERF | Term 7b | ERF | Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 1.5 | 0.0E+00 | 1.0E+00 | -1.2E+46 | 2.000 | 6.4E-01 | 1.9E+00 | 1.2E+46 | 0.000 | 3.2E+02 | 1 | -3.2E+02 | -1 | 6.0E+00 | 1 | -6.0E+00 | -1 | 1.20E+01 |
| 2 | 2 | 1.5 | 0.0E+00 | 1.0E+00 | -1.2E+46 | 2.000 | 1.3E+00 | 3.6E+00 | 1.2E+46 | 0.000 | 2.2E+02 | 1 | -2.2E+02 | -1 | 4.2E+00 | 1 | -4.2E+00 | -1 | 1.20E+01 |
| 3 | 3 | 1.5 | 0.0E+00 | 1.0E+00 | -1.2E+46 | 2.000 | 1.9E+00 | 6.8E+00 | 1.2E+46 | 0.000 | 1.8E+02 | 1 | -1.8E+02 | -1 | 3.5E+00 | 1 | -3.5E+00 | -1 | 1.20E+01 |
| 4 | 4 | 1.5 | 0.0E+00 | 1.0E+00 | -1.2E+46 | 2.000 | 2.6E+00 | 1.3E+01 | 1.2E+46 | 0.000 | 1.6E+02 | 1 | -1.6E+02 | -1 | 3.0E+00 | 1 | -3.0E+00 | -0.99998 | 1.20E+01 |
| 5 | 5 | 1.5 | 0.0E+00 | 1.0E+00 | -1.2E+46 | 2.000 | 3.2E+00 | 2.4E+01 | 1.2E+46 | 0.000 | 1.4E+02 | 1 | -1.4E+02 | -1 | 2.7E+00 | 0.9998 | -2.7E+00 | -0.99985 | 1.20E+01 |
| 6 | 6 | 1.5 | 0.0E+00 | 1.0E+00 | -1.2E+46 | 2.000 | 3.8E+00 | 4.6E+01 | 1.2E+46 | 0.000 | 1.3E+02 | 1 | -1.3E+02 | -1 | 2.4E+00 | 0.9995 | -2.4E+00 | -0.99946 | 1.20E+01 |
| 7 | 7 | 1.5 | 0.0E+00 | 1.0E+00 | -1.2E+46 | 2.000 | 4.5E+00 | 8.7E+01 | 1.2E+46 | 0.000 | 1.2E+02 | 1 | -1.2E+02 | -1 | 2.3E+00 | 0.9986 | -2.3E+00 | -0.99864 | 1.20E+01 |
| 8 | 8 | 1.5 | 0.0E+00 | 1.0E+00 | -1.2E+46 | 2.000 | 5.1E+00 | 1.7E+02 | 1.2E+46 | 0.000 | 1.1E+02 | 1 | -1.1E+02 | -1 | 2.1E+00 | 0.9973 | -2.1E+00 | -0.99726 | 1.20E+01 |
| 9 | 9 | 1.5 | 0.0E+00 | 1.0E+00 | -1.2E+46 | 2.000 | 5.7E+00 | 3.1E+02 | 1.2E+46 | 0.000 | 1.1E+02 | 1 | -1.1E+02 | -1 | 2.0E+00 | 0.9953 | -2.0E+00 | -0.99527 | 1.19E+01 |
| 10 | 10 | 1.5 | 0.0E+00 | 1.0E+00 | -1.2E+46 | 2.000 | 6.4E+00 | 5.9E+02 | 1.2E+46 | 0.000 | 1.0E+02 | 1 | -1.0E+02 | -1 | 1.9E+00 | 0.9926 | -1.9E+00 | -0.99263 | 1.19E+01 |
| 11 | 11 | 1.5 | 0.0E+00 | 1.0E+00 | -1.2E+46 | 2.000 | 7.0E+00 | 1.1E+03 | 1.2E+46 | 0.000 | 9.5E+01 | 1 | -9.5E+01 | -1 | 1.8E+00 | 0.9894 | -1.8E+00 | -0.98938 | 1.19E+01 |
| 12 | 12 | 1.5 | 0.0E+00 | 1.0E+00 | -1.2E+46 | 2.000 | 7.7E+00 | 2.1E+03 | 1.2E+46 | 0.000 | 9.1E+01 | 1 | -9.1E+01 | -1 | 1.7E+00 | 0.9856 | -1.7E+00 | -0.98557 | 1.18E+01 |
| 13 | 13 | 1.5 | 0.0E+00 | 1.0E+00 | -1.2E+46 | 2.000 | 8.3E+00 | 4.0E+03 | 1.2E+46 | 0.000 | 8.8E+01 | 1 | -8.8E+01 | -1 | 1.7E+00 | 0.9812 | -1.7E+00 | -0.98124 | 1.18E+01 |
| 14 | 14 | 1.5 | 0.0E+00 | 1.0E+00 | -1.2E+46 | 2.000 | 8.9E+00 | 7.6E+03 | 1.2E+46 | 0.000 | 8.4E+01 | 1 | -8.4E+01 | -1 | 1.6E+00 | 0.9765 | -1.6E+00 | -0.97647 | 1.17E+01 |
| 15 | 15 | 1.5 | 0.0E+00 | 1.0E+00 | -1.2E+46 | 2.000 | 9.6E+00 | 1.4E+04 | 1.2E+46 | 0.000 | 8.2E+01 | 1 | -8.2E+01 | -1 | 1.5E+00 | 0.9713 | -1.5E+00 | -0.97133 | 1.17E+01 |
| 16 | 16 | 1.5 | 0.0E+00 | 1.0E+00 | -1.2E+46 | 2.000 | 1.0E+01 | 2.7E+04 | 1.2E+46 | 0.000 | 7.9E+01 | 1 | -7.9E+01 | -1 | 1.5E+00 | 0.9659 | -1.5E+00 | -0.96587 | 1.16E+01 |
| 17 | 17 | 1.5 | 0.0E+00 | 1.0E+00 | -1.2E+46 | 2.000 | 1.1E+01 | 5.2E+04 | 1.2E+46 | 0.000 | 7.7E+01 | 1 | -7.7E+01 | -1 | 1.5E+00 | 0.9601 | -1.5E+00 | -0.96015 | 1.15E+01 |
| 18 | 18 | 1.5 | 0.0E+00 | 1.0E+00 | -1.2E+46 | 2.000 | 1.1E+01 | 9.8E+04 | 1.2E+46 | 0.000 | 7.4E+01 | 1 | -7.4E+01 | -1 | 1.4E+00 | 0.9542 | -1.4E+00 | -0.95421 | 1.15E+01 |
| 19 | 19 | 1.5 | 0.0E+00 | 1.0E+00 | -1.2E+46 | 2.000 | 1.2E+01 | 1.8E+05 | 1.2E+46 | 0.000 | 7.2E+01 | 1 | -7.2E+01 | -1 | 1.4E+00 | 0.9481 | -1.4E+00 | -0.94812 | 1.14E+01 |
| 20 | 20 | 1.5 | 0.0E+00 | 1.0E+00 | -1.2E+46 | 2.000 | 1.3E+01 | 3.5E+05 | 1.2E+46 | 0.000 | 7.1E+01 | 1 | -7.1E+01 | -1 | 1.3E+00 | 0.9419 | -1.3E+00 | -0.94189 | 1.13E+01 |




| | |
|---|---|
| Date: | 24/02/2020 |
| Version: | 1 |

**Contaminant** **Manganese**

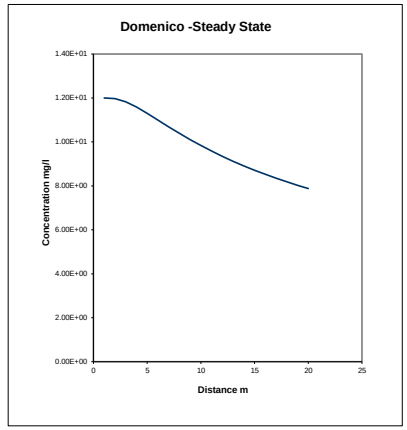
**DOMENICO (STEADY STATE)**

Calculations for source located in centre of aquifer (ie vertical dispersion in two directions)

| Input | Value | Units |
|---|---|---|
| $C_T$ | 0.123 | mg/l |
| Co | 1.20E+01 | mg/l |
| λ | 6.29E-105 | days$^{-1}$ |
| Sz | 5.00E+02 | m |
| Sy | 1.50E+00 | m |
| Kd | 7.20E+02 | l/kg |
| ρ | 1.36E+00 | g/cm3 |
| n | 8.00E-02 | |
| i | 1.00E-02 | |
| K | 8.64E-03 | m/d |
| x | 2.00E+01 | m |
| z | 0.00E+00 | m |
| y | 0.00E+00 | m |
| ax | 1.57E+00 | m |
| az | 1.57E-01 | m |
| ay | 1.57E-02 | m |

Vertical dispersion optio Simulate vertical dispersion in 1 direction

| | X | Term 1 | Term 2 | EXP | Term 3A | ERF | Term 3B | ERF | Term 4A | ERF | Term 4B | ERF | Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 3 | 0.00E+00 | 1.00E+00 | 3.16E+02 | 1 | -3.16E+02 | -1 | 3.00E+00 | 1 | -3.00E+00 | -1 | 1.20E+01 |
| 2 | 2 | 3 | 0.00E+00 | 1.00E+00 | 2.23E+02 | 1 | -2.23E+02 | -1 | 2.12E+00 | 0.997 | -2.12E+00 | -0.9973 | 1.20E+01 |
| 3 | 3 | 3 | 0.00E+00 | 1.00E+00 | 1.82E+02 | 1 | -1.82E+02 | -1 | 1.73E+00 | 0.986 | -1.73E+00 | -0.9856 | 1.18E+01 |
| 4 | 4 | 3 | 0.00E+00 | 1.00E+00 | 1.58E+02 | 1 | -1.58E+02 | -1 | 1.50E+00 | 0.966 | -1.50E+00 | -0.9659 | 1.16E+01 |
| 5 | 5 | 3 | 0.00E+00 | 1.00E+00 | 1.41E+02 | 1 | -1.41E+02 | -1 | 1.34E+00 | 0.942 | -1.34E+00 | -0.9419 | 1.13E+01 |
| 6 | 6 | 3 | 0.00E+00 | 1.00E+00 | 1.29E+02 | 1 | -1.29E+02 | -1 | 1.22E+00 | 0.916 | -1.22E+00 | -0.9163 | 1.10E+01 |
| 7 | 7 | 3 | 0.00E+00 | 1.00E+00 | 1.19E+02 | 1 | -1.19E+02 | -1 | 1.13E+00 | 0.891 | -1.13E+00 | -0.8907 | 1.07E+01 |
| 8 | 8 | 3 | 0.00E+00 | 1.00E+00 | 1.12E+02 | 1 | -1.12E+02 | -1 | 1.06E+00 | 0.866 | -1.06E+00 | -0.8659 | 1.04E+01 |
| 9 | 9 | 3 | 0.00E+00 | 1.00E+00 | 1.05E+02 | 1 | -1.05E+02 | -1 | 9.99E-01 | 0.842 | -9.99E-01 | -0.8422 | 1.01E+01 |
| 10 | 10 | 3 | 0.00E+00 | 1.00E+00 | 9.99E+01 | 1 | -9.99E+01 | -1 | 9.47E-01 | 0.82 | -9.47E-01 | -0.8197 | 9.84E+00 |
| 11 | 11 | 3 | 0.00E+00 | 1.00E+00 | 9.52E+01 | 1 | -9.52E+01 | -1 | 9.03E-01 | 0.799 | -9.03E-01 | -0.7986 | 9.58E+00 |
| 12 | 12 | 3 | 0.00E+00 | 1.00E+00 | 9.12E+01 | 1 | -9.12E+01 | -1 | 8.65E-01 | 0.779 | -8.65E-01 | -0.7787 | 9.34E+00 |
| 13 | 13 | 3 | 0.00E+00 | 1.00E+00 | 8.76E+01 | 1 | -8.76E+01 | -1 | 8.31E-01 | 0.76 | -8.31E-01 | -0.7601 | 9.12E+00 |
| 14 | 14 | 3 | 0.00E+00 | 1.00E+00 | 8.44E+01 | 1 | -8.44E+01 | -1 | 8.01E-01 | 0.743 | -8.01E-01 | -0.7425 | 8.91E+00 |
| 15 | 15 | 3 | 0.00E+00 | 1.00E+00 | 8.15E+01 | 1 | -8.15E+01 | -1 | 7.74E-01 | 0.726 | -7.74E-01 | -0.726 | 8.71E+00 |
| 16 | 16 | 3 | 0.00E+00 | 1.00E+00 | 7.90E+01 | 1 | -7.90E+01 | -1 | 7.49E-01 | 0.711 | -7.49E-01 | -0.7105 | 8.53E+00 |
| 17 | 17 | 3 | 0.00E+00 | 1.00E+00 | 7.66E+01 | 1 | -7.66E+01 | -1 | 7.27E-01 | 0.696 | -7.27E-01 | -0.6959 | 8.35E+00 |
| 18 | 18 | 3 | 0.00E+00 | 1.00E+00 | 7.44E+01 | 1 | -7.44E+01 | -1 | 7.06E-01 | 0.682 | -7.06E-01 | -0.6821 | 8.18E+00 |
| 19 | 19 | 3 | 0.00E+00 | 1.00E+00 | 7.25E+01 | 1 | -7.25E+01 | -1 | 6.87E-01 | 0.669 | -6.87E-01 | -0.669 | 8.03E+00 |
| 20 | 20 | 3 | 0.00E+00 | 1.00E+00 | 7.06E+01 | 1 | -7.06E+01 | -1 | 6.70E-01 | 0.657 | -6.70E-01 | -0.6566 | 7.88E+00 |



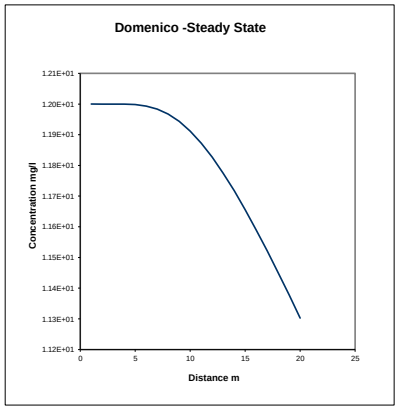

**Calc** **Value**

**DOMENICO (STEADY STATE)**

Calculations for source located at top of aquifer (ie vertical dispersion in one direction) - USED FOR LEVEL ASSESSMENT

| | | |
|---|---|---|
| v | 1.08E-03 | m/d |
| Rc | 1.22E+04 | |
| u | 8.82E-08 | m/d |

| | X | Term 1 | Term 2 | EXP | Term 3A | ERF | Term 3B | ERF | Term 4A | ERF | Term 4B | ERF | Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 3 | 0.00E+00 | 1.00E+00 | 3.16E+02 | 1 | -3.16E+02 | -1 | 5.99E+00 | 1 | -5.99E+00 | -1 | 1.20E+01 |
| 2 | 2 | 3 | 0.00E+00 | 1.00E+00 | 2.23E+02 | 1 | -2.23E+02 | -1 | 4.24E+00 | 1 | -4.24E+00 | -1 | 1.20E+01 |
| 3 | 3 | 3 | 0.00E+00 | 1.00E+00 | 1.82E+02 | 1 | -1.82E+02 | -1 | 3.46E+00 | 1 | -3.46E+00 | -1 | 1.20E+01 |
| 4 | 4 | 3 | 0.00E+00 | 1.00E+00 | 1.58E+02 | 1 | -1.58E+02 | -1 | 3.00E+00 | 1 | -3.00E+00 | -1 | 1.20E+01 |
| 5 | 5 | 3 | 0.00E+00 | 1.00E+00 | 1.41E+02 | 1 | -1.41E+02 | -1 | 2.68E+00 | 1 | -2.68E+00 | -0.9998 | 1.20E+01 |
| 6 | 6 | 3 | 0.00E+00 | 1.00E+00 | 1.29E+02 | 1 | -1.29E+02 | -1 | 2.45E+00 | 0.999 | -2.45E+00 | -0.9995 | 1.20E+01 |
| 7 | 7 | 3 | 0.00E+00 | 1.00E+00 | 1.19E+02 | 1 | -1.19E+02 | -1 | 2.26E+00 | 0.999 | -2.26E+00 | -0.9986 | 1.20E+01 |
| 8 | 8 | 3 | 0.00E+00 | 1.00E+00 | 1.12E+02 | 1 | -1.12E+02 | -1 | 2.12E+00 | 0.997 | -2.12E+00 | -0.9973 | 1.20E+01 |
| 9 | 9 | 3 | 0.00E+00 | 1.00E+00 | 1.05E+02 | 1 | -1.05E+02 | -1 | 2.00E+00 | 0.995 | -2.00E+00 | -0.9953 | 1.19E+01 |
| 10 | 10 | 3 | 0.00E+00 | 1.00E+00 | 9.99E+01 | 1 | -9.99E+01 | -1 | 1.89E+00 | 0.993 | -1.89E+00 | -0.9926 | 1.19E+01 |
| 11 | 11 | 3 | 0.00E+00 | 1.00E+00 | 9.52E+01 | 1 | -9.52E+01 | -1 | 1.81E+00 | 0.989 | -1.81E+00 | -0.9894 | 1.19E+01 |
| 12 | 12 | 3 | 0.00E+00 | 1.00E+00 | 9.12E+01 | 1 | -9.12E+01 | -1 | 1.73E+00 | 0.986 | -1.73E+00 | -0.9856 | 1.18E+01 |
| 13 | 13 | 3 | 0.00E+00 | 1.00E+00 | 8.76E+01 | 1 | -8.76E+01 | -1 | 1.66E+00 | 0.981 | -1.66E+00 | -0.9812 | 1.18E+01 |
| 14 | 14 | 3 | 0.00E+00 | 1.00E+00 | 8.44E+01 | 1 | -8.44E+01 | -1 | 1.60E+00 | 0.976 | -1.60E+00 | -0.9765 | 1.17E+01 |
| 15 | 15 | 3 | 0.00E+00 | 1.00E+00 | 8.15E+01 | 1 | -8.15E+01 | -1 | 1.55E+00 | 0.971 | -1.55E+00 | -0.9713 | 1.17E+01 |
| 16 | 16 | 3 | 0.00E+00 | 1.00E+00 | 7.90E+01 | 1 | -7.90E+01 | -1 | 1.50E+00 | 0.966 | -1.50E+00 | -0.9659 | 1.16E+01 |
| 17 | 17 | 3 | 0.00E+00 | 1.00E+00 | 7.66E+01 | 1 | -7.66E+01 | -1 | 1.45E+00 | 0.96 | -1.45E+00 | -0.9601 | 1.15E+01 |
| 18 | 18 | 3 | 0.00E+00 | 1.00E+00 | 7.44E+01 | 1 | -7.44E+01 | -1 | 1.41E+00 | 0.954 | -1.41E+00 | -0.9542 | 1.15E+01 |
| 19 | 19 | 3 | 0.00E+00 | 1.00E+00 | 7.25E+01 | 1 | -7.25E+01 | -1 | 1.37E+00 | 0.948 | -1.37E+00 | -0.9481 | 1.14E+01 |
| 20 | 20 | 3 | 0.00E+00 | 1.00E+00 | 7.06E+01 | 1 | -7.06E+01 | -1 | 1.34E+00 | 0.942 | -1.34E+00 | -0.9419 | 1.13E+01 |




| | |
|---|---|
| Date: | 24/02/2020 |
| Version: | 1 |

## DOMENICO (TIME VARIANT)

**Contaminant** **Manganese**

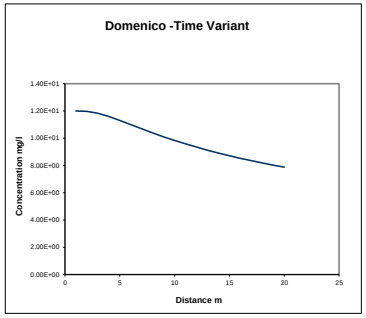
| **Input** | **Value** | **Units** |
|---|---|---|
| $C_T$ | 0.123 | mg/l |
| Co | 1.20E+01 | mg/l |
| λ | 6.29E-105 | days$^{-1}$ |
| Sz | 5.00E+02 | m |
| Sy | 1.50E+00 | m |
| Kd | 7.20E+02 | l/kg |
| ρ | 1.36E+00 | g/cm3 |
| n | 8.00E-02 | |
| i | 1.00E-02 | |
| K | 8.64E-03 | m/d |
| x | 2.00E+01 | m |
| z | 0.00E+00 | m |
| y | 0.00E+00 | m |
| t | 1.00E+100 | days |
| ax | 1.57E+00 | m |
| az | 1.57E-01 | m |
| ay | 1.57E-02 | m |

Vertical dispersion option: Simulate vertical dispersion in 1 direction

| **Calc** | **Value** | |
|---|---|---|
| v | 1.08E-03 | m/d |
| Rc | 1.22E+04 | |
| u | 8.82E-08 | m/d |

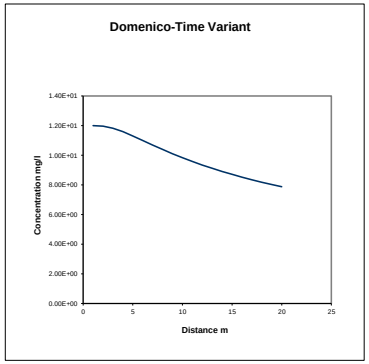
Calculations for source located in centre of aquifer (ie vertical dispersion in two directions)

| | X | Term 1 | Term 2 | EXP | Term 3 | ERFC | Term 4A | ERF | Term 4B | ERF | Term 5A | ERF | Term 5B | ERF | Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | m | | | | | | | | | | | | | | |
| 1 | 1 | 1.5 | 0.00E+00 | 1.00E+00 | -1.19E+46 | 2 | 3.16E+02 | 1 | -3.16E+02 | -1 | 3.00E+00 | 1 | -3.00E+00 | -1 | 1.20E+01 |
| 2 | 2 | 1.5 | 0.00E+00 | 1.00E+00 | -1.19E+46 | 2 | 2.23E+02 | 1 | -2.23E+02 | -1 | 2.12E+00 | 0.9973 | -2.12E+00 | -0.997 | 1.20E+01 |
| 3 | 3 | 1.5 | 0.00E+00 | 1.00E+00 | -1.19E+46 | 2 | 1.82E+02 | 1 | -1.82E+02 | -1 | 1.73E+00 | 0.9856 | -1.73E+00 | -0.986 | 1.18E+01 |
| 4 | 4 | 1.5 | 0.00E+00 | 1.00E+00 | -1.19E+46 | 2 | 1.58E+02 | 1 | -1.58E+02 | -1 | 1.50E+00 | 0.9659 | -1.50E+00 | -0.966 | 1.16E+01 |
| 5 | 5 | 1.5 | 0.00E+00 | 1.00E+00 | -1.19E+46 | 2 | 1.41E+02 | 1 | -1.41E+02 | -1 | 1.34E+00 | 0.9419 | -1.34E+00 | -0.942 | 1.13E+01 |
| 6 | 6 | 1.5 | 0.00E+00 | 1.00E+00 | -1.19E+46 | 2 | 1.29E+02 | 1 | -1.29E+02 | -1 | 1.22E+00 | 0.9163 | -1.22E+00 | -0.916 | 1.10E+01 |
| 7 | 7 | 1.5 | 0.00E+00 | 1.00E+00 | -1.19E+46 | 2 | 1.19E+02 | 1 | -1.19E+02 | -1 | 1.13E+00 | 0.8907 | -1.13E+00 | -0.891 | 1.07E+01 |
| 8 | 8 | 1.5 | 0.00E+00 | 1.00E+00 | -1.19E+46 | 2 | 1.12E+02 | 1 | -1.12E+02 | -1 | 1.06E+00 | 0.8659 | -1.06E+00 | -0.866 | 1.04E+01 |
| 9 | 9 | 1.5 | 0.00E+00 | 1.00E+00 | -1.19E+46 | 2 | 1.05E+02 | 1 | -1.05E+02 | -1 | 9.99E-01 | 0.8422 | -9.99E-01 | -0.842 | 1.01E+01 |
| 10 | 10 | 1.5 | 0.00E+00 | 1.00E+00 | -1.19E+46 | 2 | 9.99E+01 | 1 | -9.99E+01 | -1 | 9.47E-01 | 0.8197 | -9.47E-01 | -0.82 | 9.84E+00 |
| 11 | 11 | 1.5 | 0.00E+00 | 1.00E+00 | -1.19E+46 | 2 | 9.52E+01 | 1 | -9.52E+01 | -1 | 9.03E-01 | 0.7986 | -9.03E-01 | -0.799 | 9.58E+00 |
| 12 | 12 | 1.5 | 0.00E+00 | 1.00E+00 | -1.19E+46 | 2 | 9.12E+01 | 1 | -9.12E+01 | -1 | 8.65E-01 | 0.7787 | -8.65E-01 | -0.779 | 9.34E+00 |
| 13 | 13 | 1.5 | 0.00E+00 | 1.00E+00 | -1.19E+46 | 2 | 8.76E+01 | 1 | -8.76E+01 | -1 | 8.31E-01 | 0.7601 | -8.31E-01 | -0.76 | 9.12E+00 |
| 14 | 14 | 1.5 | 0.00E+00 | 1.00E+00 | -1.19E+46 | 2 | 8.44E+01 | 1 | -8.44E+01 | -1 | 8.01E-01 | 0.7425 | -8.01E-01 | -0.743 | 8.91E+00 |
| 15 | 15 | 1.5 | 0.00E+00 | 1.00E+00 | -1.19E+46 | 2 | 8.15E+01 | 1 | -8.15E+01 | -1 | 7.74E-01 | 0.726 | -7.74E-01 | -0.726 | 8.71E+00 |
| 16 | 16 | 1.5 | 0.00E+00 | 1.00E+00 | -1.19E+46 | 2 | 7.90E+01 | 1 | -7.90E+01 | -1 | 7.49E-01 | 0.7105 | -7.49E-01 | -0.711 | 8.53E+00 |
| 17 | 17 | 1.5 | 0.00E+00 | 1.00E+00 | -1.19E+46 | 2 | 7.66E+01 | 1 | -7.66E+01 | -1 | 7.27E-01 | 0.6959 | -7.27E-01 | -0.696 | 8.35E+00 |
| 18 | 18 | 1.5 | 0.00E+00 | 1.00E+00 | -1.19E+46 | 2 | 7.44E+01 | 1 | -7.44E+01 | -1 | 7.06E-01 | 0.6821 | -7.06E-01 | -0.682 | 8.18E+00 |
| 19 | 19 | 1.5 | 0.00E+00 | 1.00E+00 | -1.19E+46 | 2 | 7.25E+01 | 1 | -7.25E+01 | -1 | 6.87E-01 | 0.669 | -6.87E-01 | -0.669 | 8.03E+00 |
| 20 | 20 | 1.5 | 0.00E+00 | 1.00E+00 | -1.19E+46 | 2 | 7.06E+01 | 1 | -7.06E+01 | -1 | 6.70E-01 | 0.6566 | -6.70E-01 | -0.657 | 7.88E+00 |




Calculations for source located at top of aquifer (ie vertical dispersion in one direction only) - USED FOR LEVEL ASSESSMENT

| | X | Term 1 | Term 2 | EXP | Term 3 | ERFC | Term 4A | ERF | Term 4B | ERF | Term 5A | ERF | Term 5B | ERF | Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | m | | | | | | | | | | | | | | |
| 1 | 1 | 1.5 | 0.00E+00 | 1.00E+00 | -1.19E+46 | 2 | 3.16E+02 | 1 | -3.16E+02 | -1 | 5.99E+00 | 1 | -5.99E+00 | -1 | 1.20E+01 |
| 2 | 2 | 1.5 | 0.00E+00 | 1.00E+00 | -1.19E+46 | 2 | 2.23E+02 | 1 | -2.23E+02 | -1 | 4.24E+00 | 1 | -4.24E+00 | -1 | 1.20E+01 |
| 3 | 3 | 1.5 | 0.00E+00 | 1.00E+00 | -1.19E+46 | 2 | 1.82E+02 | 1 | -1.82E+02 | -1 | 3.46E+00 | 1 | -3.46E+00 | -1 | 1.20E+01 |
| 4 | 4 | 1.5 | 0.00E+00 | 1.00E+00 | -1.19E+46 | 2 | 1.58E+02 | 1 | -1.58E+02 | -1 | 3.00E+00 | 1 | -3.00E+00 | -1 | 1.20E+01 |
| 5 | 5 | 1.5 | 0.00E+00 | 1.00E+00 | -1.19E+46 | 2 | 1.41E+02 | 1 | -1.41E+02 | -1 | 2.68E+00 | 0.9998 | -2.68E+00 | -1 | 1.20E+01 |
| 6 | 6 | 1.5 | 0.00E+00 | 1.00E+00 | -1.19E+46 | 2 | 1.29E+02 | 1 | -1.29E+02 | -1 | 2.45E+00 | 0.9995 | -2.45E+00 | -0.999 | 1.20E+01 |
| 7 | 7 | 1.5 | 0.00E+00 | 1.00E+00 | -1.19E+46 | 2 | 1.19E+02 | 1 | -1.19E+02 | -1 | 2.26E+00 | 0.9986 | -2.26E+00 | -0.999 | 1.20E+01 |
| 8 | 8 | 1.5 | 0.00E+00 | 1.00E+00 | -1.19E+46 | 2 | 1.12E+02 | 1 | -1.12E+02 | -1 | 2.12E+00 | 0.9973 | -2.12E+00 | -0.997 | 1.20E+01 |
| 9 | 9 | 1.5 | 0.00E+00 | 1.00E+00 | -1.19E+46 | 2 | 1.05E+02 | 1 | -1.05E+02 | -1 | 2.00E+00 | 0.9953 | -2.00E+00 | -0.995 | 1.19E+01 |
| 10 | 10 | 1.5 | 0.00E+00 | 1.00E+00 | -1.19E+46 | 2 | 9.99E+01 | 1 | -9.99E+01 | -1 | 1.89E+00 | 0.9926 | -1.89E+00 | -0.993 | 1.19E+01 |
| 11 | 11 | 1.5 | 0.00E+00 | 1.00E+00 | -1.19E+46 | 2 | 9.52E+01 | 1 | -9.52E+01 | -1 | 1.81E+00 | 0.9894 | -1.81E+00 | -0.989 | 1.19E+01 |
| 12 | 12 | 1.5 | 0.00E+00 | 1.00E+00 | -1.19E+46 | 2 | 9.12E+01 | 1 | -9.12E+01 | -1 | 1.73E+00 | 0.9856 | -1.73E+00 | -0.986 | 1.18E+01 |
| 13 | 13 | 1.5 | 0.00E+00 | 1.00E+00 | -1.19E+46 | 2 | 8.76E+01 | 1 | -8.76E+01 | -1 | 1.66E+00 | 0.9812 | -1.66E+00 | -0.981 | 1.18E+01 |
| 14 | 14 | 1.5 | 0.00E+00 | 1.00E+00 | -1.19E+46 | 2 | 8.44E+01 | 1 | -8.44E+01 | -1 | 1.60E+00 | 0.9765 | -1.60E+00 | -0.976 | 1.17E+01 |
| 15 | 15 | 1.5 | 0.00E+00 | 1.00E+00 | -1.19E+46 | 2 | 8.15E+01 | 1 | -8.15E+01 | -1 | 1.55E+00 | 0.9713 | -1.55E+00 | -0.971 | 1.17E+01 |
| 16 | 16 | 1.5 | 0.00E+00 | 1.00E+00 | -1.19E+46 | 2 | 7.90E+01 | 1 | -7.90E+01 | -1 | 1.50E+00 | 0.9659 | -1.50E+00 | -0.966 | 1.16E+01 |
| 17 | 17 | 1.5 | 0.00E+00 | 1.00E+00 | -1.19E+46 | 2 | 7.66E+01 | 1 | -7.66E+01 | -1 | 1.45E+00 | 0.9601 | -1.45E+00 | -0.96 | 1.15E+01 |
| 18 | 18 | 1.5 | 0.00E+00 | 1.00E+00 | -1.19E+46 | 2 | 7.44E+01 | 1 | -7.44E+01 | -1 | 1.41E+00 | 0.9542 | -1.41E+00 | -0.954 | 1.15E+01 |
| 19 | 19 | 1.5 | 0.00E+00 | 1.00E+00 | -1.19E+46 | 2 | 7.25E+01 | 1 | -7.25E+01 | -1 | 1.37E+00 | 0.9481 | -1.37E+00 | -0.948 | 1.14E+01 |
| 20 | 20 | 1.5 | 0.00E+00 | 1.00E+00 | -1.19E+46 | 2 | 7.06E+01 | 1 | -7.06E+01 | -1 | 1.34E+00 | 0.9419 | -1.34E+00 | -0.942 | 1.13E+01 |




| | |
|---|---|
| Date: | 24/02/2020 |
| Version: | 1 |

# Hydrogeological risk assessment for land contamination

## Remedial Targets Worksheet , Release 3.2

**First released: 2006. Version 3.2: January 2013**

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination ( Environment Agency 2006).

**Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.**

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The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

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IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

| Details to be completed for each assessment | | | | |
|---|---|---|---|---|
| Site Name: | Glan Llyn | | | |
| Site Address: | Llanwern | | | |
| Completed by: | Ross Cameron | | | |
| Date: | 24-Feb-20 | | Version: | 1 |
| Contaminant | Naphthalene | | | |
| Target Concentration ($C_T$) | 0.002 | mg/l | Origin of $C_T$: | Proposed Water Framework Directive EQS |

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparision with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).
Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.
Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.
Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.
Data carried forward from an earlier worksheet are identified by a light green background
It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

## Remedial Targets Worksheet , Release 3.2

# Level 1 - Soil

Environment Agency

**Select the method of calculating the soil water Partition Co-efficient by using the pull down menu below**

**User specified value for partition coefficient**

| | | | | |
|---|---|---|---|---|
| **Contaminant** | | **Naphthalene** | | |
| **Target concentration** | **$C_T$** | **0.002** | **mg/l** | |

| **Input Parameters** | **Variable** | **Value** | **Unit** | **Source of parameter value** |
|---|---|---|---|---|
| ***Standard entry*** | | | | |
| Water filled soil porosity | $\theta_w$ | 5.00E-01 | fraction | 0.5 |
| Air filled soil porosity | θa | 3.70E-01 | fraction | 0.0037 |
| Bulk density of soil zone material | ρ | 1.36E+00 | g/cm$^3$ | 1.36 |
| Henry's Law constant | H | 1.00E+00 | dimensionless | *1* |
| ***Entry if specify partition coefficient (option)*** | | | | |
| Soil water partition coefficient | Kd | 1.34E+02 | l/kg | *1.34E+02* |
| ***Entry for non-polar organic chemicals (option)*** | | | | |
| Fraction of organic carbon (in soil) | foc | | fraction | |
| Organic carbon partition coefficient | Koc | | l/kg | |
| ***Entry for ionic organic chemicals (option)*** | | | | |
| Sorption coefficient for neutral species | $K_{oc,n}$ | | l/kg | |
| Sorption coefficient for ionised species | $K_{oc,i}$ | | l/kg | |
| pH value | pH | | pH units | |
| Acid dissociation constant | pKa | | | |
| Fraction of organic carbon (in soil) | foc | | fraction | |

This sheet calculates the Level 1 remedial target for soils(mg/kg) based on a selected target concentration and theoretical calculation of soil water partitioning. Three options are included for determining the partition coefficient.

The measured soil concentration as mg/kg should be compared with the Level 1 remedial target to determine the need for further action.

| | | | | |
|---|---|---|---|---|
| **Soil water partition coefficient used in Level Assessment** | **Kd** | **1.34E+02** | **l/kg** | *Specified value* |

## Level 1 Remedial Target

| | | | |
|---|---|---|---|
| **Level 1 Remedial Target** | **2.69E-01** | **mg/kg** | **(for comparison with soil analyses)** |
| | **or** | | |
| | **0.002** | **mg/l** | **(for comparison with leachate test results)** |

| | |
|---|---|
| Site being assessed: | Glan Llyn |
| Completed by: | Ross Cameron |
| Date: | 24-Feb-20 |
| Version: | 1 |

## Remedial Targets Worksheet , Release 3.2

# Level 2 - Soil

| | | | | |
|---|---|---|---|---|
| **Contaminant** | | **Naphthalene** | | from Level 1 |
| **Target concentration** | **$C_T$** | **0.002** | **mg/l** | from Level 1 |

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamiantion' (Environment Agency 2006)

| **Input Parameters** | **Variable** | **Value** | **Unit** | **Source of parameter value** | |
|---|---|---|---|---|---|
| *Standard entry* | | | | | |
| Infiltration | Inf | 0.00E+00 | m/d | | |
| Area of contaminant source | A | 0.00E+00 | $m^2$ | | Not used in calculation |
| *Entry for groundwater flow below site* | | | | | |
| Length of contaminant source in direction of groundwater flow | L | 0.00E+00 | m | | |
| Saturated aquifer thickness | da | 0.00E+00 | m | | |
| Hydraulic Conductivity of aquifer in which dilution occurs | K | 0.00E+00 | m/d | | |
| Hydraulic gradient of water table | i | 0.00E+00 | fraction | | |
| Width of contaminant source perpendicular to groundwater flow | w | 0.00E+00 | m | | Not used in calculation |
| Background concentration of contaminant in groundwater beneath site | Cu | 0.00E+00 | mg/l | | |
| Define mixing zone depth by specifying or calculating depth (using pull down list) | | **Specify** | | | |
| Enter mixing zone thickness | Mz | 0.00E+00 | m | | |
| Calculated mixing zone thickness | Mz | | m | | |

## Calculated Parameters

| | | | | |
|---|---|---|---|---|
| **Dilution Factor** | **DF** | **#DIV/0!** | | |
| **Level 2 Remedial Target** | | **#DIV/0!** | **mg/l** | **For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentra** |
| | | **or** | | |
| | | **#DIV/0!** | **mg/kg** | **For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water** |

## *Additional option*

**Calculation of impact on receptor**

| | | | | |
|---|---|---|---|---|
| Concentration of contaminant in contaminated discharge (entering receptor) | Cc | 0.00E+00 | mg/l | |
| Calculated concentration within receptor (dilution only) | | #DIV/0! | mg/l | 0 |

| | |
|---|---|
| Site being assessed: | Glan Llyn |
| Completed by: | Ross Cameron |
| Date: | 24-Feb-20 |
| Version: | 1 |

**Remedial Targets Worksheet , Release 3.2**

## Level 3 - Soil

See Note

Environment Agency

### Input Parameters

| | Variable | Value | Unit | Source |
|---|---|---|---|---|
| Contaminant | | Naphthalene | | from Level 1 |
| Target Concentration | $C_T$ | 0.002 | mg/l | from Level 1 |
| Dilution Factor | DF | #DIV/0! | | from Level 2 |

**Select analytical solution (click on brown cell below, then on pull-down menu)**

Ogata Banks — Equations in HRA publication

**Select nature of decay rate (click on brown cell below, then on pull-down menu)**

Approach for simulating degradation of pollutants: Apply degradation rate to pollutants in all phases (e.g. field derived value, lab derived value)

| | Variable | Value | Unit | Source of parameter value |
|---|---|---|---|---|
| Enter source concentration | | Soil concentration as mg/kg | | |
| Enter soil concentration | | 0 | mg/kg | |
| Half life for degradation of contaminant in water | $t_{1/2}$ | 1.00E+100 | days | |
| Calculated decay rate | $\lambda$ | 6.93E-101 | $days^{-1}$ | calculated |
| Width of plume in aquifer at source | Sz | 0.00E+00 | m | from Level 2 |
| Plume thickness in aquifer at source | Sy | 0.00E+00 | m | from Level 2 |
| Bulk density of aquifer materials | $\rho$ | 0.00E+00 | $g/cm^3$ | |
| Effective porosity of aquifer | n | 0.00E+00 | fraction | |
| Hydraulic gradient | i | #DIV/0! | fraction | from Level 2 (adjusted) |
| Hydraulic conductivity of saturated aquifer | K | 0.00E+00 | m/d | from Level 2 |
| Distance to compliance point | x | 0.00E+00 | m | |
| Distance (lateral) to compliance point perpendicular to flow direction | z | | m | |
| Distance (depth) to compliance point perpendicular to flow direction | y | | m | |
| Time since pollutant entered groundwater | t | 1.00E+99 | days | *time variant options only* |
| *Parameters values determined from options* | | | | |
| Partition coefficient | Kd | 0.00E+00 | l/kg | *see options* |
| Longitudinal dispersivity | ax | 0.000 | m | *see options* |
| Transverse dispersivity | az | 0.000 | m | *see options* |
| Vertical dispersivity | av | 0.000 | m | *see options* |

***Parameter values should be checked against Level 1 and 2***

### Calculated Parameters

| | Variable | | |
|---|---|---|---|
| Groundwater flow velocity | v | #DIV/0! | m/d |
| Retardation factor | Rf | #DIV/0! | fraction |
| Decay rate used | $\lambda$ | 6.93E-101 | $d^{-1}$ |
| Hydraulic gradient used in aquifer flow down-gradient | i | #DIV/0! | fraction |
| Rate of contaminant flow due to retardation | u | #DIV/0! | m/d |
| Ratio of Compliance Point to Source Concentration | $C_{ED}/C_0$ | #DIV/0! | fraction |
| **Attenuation factor ($C_0/C_{ED}$)** | **AF** | **#DIV/0!** | **fraction** |
| Calculated soil leachate concentration | Co | 0.00E+00 | mg/l |

### Remedial Targets

| | | | |
|---|---|---|---|
| **Level 3 Remedial Target** | **#DIV/0!** | **mg/l** | For comparison with measured pore water concentration. |
| Ogata Banks | **or** | | This assumes Level 1 Remedial Target is based on Target Concentration. |
| | **#DIV/0!** | **mg/kg** | For comparison with measured soil concentration. This |
| **Distance to compliance point** | **0** | **m** | assumes Level 1 Remedial Target calculated from soil-water partitioning equation. |
| **Ratio of Compliance Point to Source Concentration** | **$C_{ED}/C_0$** | **#DIV/0!** | **fraction** Ogata Banks |

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99

**Enter method of defining partition co-efficient (using pull down list)**

Calculate for ionic organic chemicals (acids)

*Entry if specify partition coefficient (option)*

Soil water partition coefficient — Kd — l/kg

*Entry for non-polar organic chemicals (option)*

Fraction of organic carbon in aquifer — foc — fraction
Organic carbon partition coefficient — Koc — l/kg

*Entry for ionic organic chemicals (option)*

| | | | |
|---|---|---|---|
| Sorption coefficient for related species | $K_{oc,n}$ | 0.00E+00 | l/kg |
| Sorption coefficient for ionised species | $K_{oc,i}$ | 0.00E+00 | l/kg |
| pH value | pH | 0.00E+00 | |
| Acid dissociation constant | pKa | 0.00E+00 | |
| Fraction of organic carbon in aquifer | foc | 0.00E+00 | fraction |
| Soil water partition coefficient | Kd | 0.00E+00 | l/kg |

**Define dispersivity (click brown cell and use pull down list)**

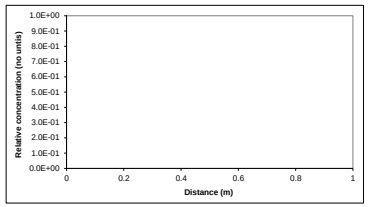
User defined values for dispersivity

| | | Enter value | Calc value | Xu & Eckstein | |
|---|---|---|---|---|---|
| **Longitudinal dispersivity** | **ax** | 0.00E+00 | 0.00E+00 | #NUM! | m |
| **Transverse dispersivity** | **az** | 0.00E+00 | 0.00E+00 | #NUM! | m |
| **Vertical dispersivity** | **ay** | 0.00E+00 | 0.00E+00 | #NUM! | m |

**Note values of dispersivity must be > 0**

Xu & Eckstein (1995) report ax = $0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed

Note
This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by $O_2$, $NO_3$, $SO_4$ etc than an alternative solution should be used




Note: 'Relative concentration' is the ratio of calculated concentation at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

| | |
|---|---|
| Site being assessed: | Glan Llyn |
| Completed by: | Ross Cameron |
| Date: | ######## |
| Version: | 1 |

**Calculated (relative) concentrations for distance-concentration graph**

Ogata Banks
From calculation sheet

| Distance | Relative concentration (No units) | Concentration mg/l |
|---|---|---|
| 0 | 1.0E+00 | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |

# Remedial Targets Worksheet , Release 3.2

## Calculation of contaminant concentration in groundwater from a soil source

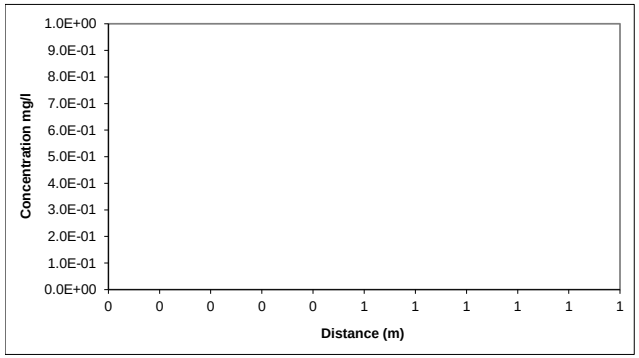
Only input required is Soil Contaminant Concentration

| | | | | |
|---|---|---|---|---|
| | Input Parameters | | | |
| | Soil contaminant concentration | $C_0$ | 0.00E+00 | mg/kg |
| **Level 1 Parameters** | | | | |
| | Water filled soil porosity | $\theta_w$ | 5.00E-01 | fraction |
| | Air filled soil porosity | $\theta a$ | 3.70E-01 | fraction |
| | Bulk density | $\rho$ | 1.36E+00 | g/cm$^3$ |
| | Henry's Law constant | H | 1.00E+00 | dimensionless |
| | Soil water partition coefficient used in Level Assessment | Kd | 1.34E+02 | l/kg |
| | Factor (partitioning between soil and water) | | 1.35E+02 | dimensionless |
| **Level 2 Parameters** | **Dilution Factor** | DF | #DIV/0! | |
| **Level 3 Parameters** | **Attenuation factor ($C_O/C_{ED}$)** | AF | #DIV/0! | |

### Predicted concentrations at compliance point

| | | | | |
|---|---|---|---|---|
| **Level 1** | C | 0.00E+00 | mg/l | No dilution or attenuation |
| **Level 2** | C | #DIV/0! | mg/l | Dilution taken into account |
| **Level 3** | C | #DIV/0! | mg/l | Dilution and attenuation taken into account |

### Predicted concentrations between source and compliance point - Level 3




| Distance m | Concentration mg/l |
|---|---|
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
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| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |

# R&D Publication 20 Remedial Targets Worksheet, Release 3.2

## Level 3 - Groundwater

See Note

**Input Parameters (using pull down menu)**

| | Variable | Value | Unit | Source |
|---|---|---|---|---|
| Contaminant | | Naphthalene | | from Level 1 |
| Target Concentration | $C_T$ | 2.00E-03 | mg/l | from Level 1 |

**Select analytical solution (click on brown cell below, then on pull-down menu)**

Domenico - Steady state — Equations in HRA publication

Approach for simulating vertical dispersion: Simulate vertical dispersion in 1 direction

**Select nature of decay rate (click on brown cell below, then on pull-down menu)**

Approach for simulating degradation of pollutants: Apply degradation rate to dissolved pollutants only

| | | | | Source of parameter value |
|---|---|---|---|---|
| Initial contaminant concentration in groundwater at plume core | $C_0$ | 2.31E-01 | mg/l | *Based on average soil conc of 8.4mg/kg* |
| Half life for degradation of contaminant in water | $t_{1/2}$ | 1.00E+02 | days | *100 day half life estimation* |
| Calculated decay rate | λ | 6.93E-03 | $days^{-1}$ | |
| Width of plume in aquifer at source (perpendicular to flow) | Sz | 5.00E+02 | m | *Site data* |
| Plume thickness at source | Sy | 1.50E+00 | m | *Thickness of re-engineered MG* |
| Saturated aquifer thickness | da | 2.00E+00 | m | *Based upon proposed total MG and cappi* |
| Bulk density of aquifer materials | ρ | 1.36E+00 | $g/cm^3$ | *Site data* |
| Effective porosity of aquifer | n | 8.00E-02 | fraction | *Estimate* |
| Hydraulic gradient | i | 1.00E-02 | fraction | |
| Hydraulic conductivity of aquifer | K | 8.64E-03 | m/d | *Proposed best achievable* |
| Distance to compliance point | x | 2.00E+01 | m | *Site data* |
| Distance (lateral) to compliance point perpendicular to flow direction | z | | m | |
| Distance (depth) to compliance point perpendicular to flow direction | y | | m | |
| Time since pollutant entered groundwater | t | 1.00E+100 | days | *time variant options only* |
| *Parameters values determined from options* | | | | |
| Partition coefficient | Kd | 3.60E+01 | l/kg | *see options* |
| Longitudinal dispersivity | ax | 2.00E+00 | m | *see options* |
| Transverse dispersivity | az | 2.00E-01 | m | *see options* |
| Vertical dispersivity | ay | 2.00E-02 | m | *see options* |

**Calculated Parameters**

| | Variable | | |
|---|---|---|---|
| Groundwater flow velocity | v | 1.08E-03 | m/d |
| Retardation factor | Rf | 6.13E+02 | fraction |
| Decay rate used | λ | 1.13E-05 | $d^{-1}$ |
| Rate of contaminant flow due to retardation | u | 1.76E-06 | m/d |
| Contaminant concentration at distance x, assuming one-way vertical dispersion | $C_{ED}$ | 6.05E-15 | mg/l |
| **Attenuation factor (one way vertical dispersion, CO/CED)** | **AF** | **3.82E+13** | |

**Remedial Targets**

| | | | | |
|---|---|---|---|---|
| **Remedial Target** | | **7.64E+10** | **mg/l** | For comparison with measured groundwater concentration. |
| Domenico - Steady state | | | | |
| **Distance to compliance point** | | **20** | **m** | |
| **Concentration of contaminant at compliance point** | **$C_{ED}/C_0$** | **6.05E-15** | **mg/l** | Domenico - Steady state |

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99.

**Select Method for deriving Partition Co-efficient (using pull down menu)**

User specified value for partition coefficient

***Entry if specify partition coefficient (option)***

Soil water partition coefficient — Kd — 3.60E+01 l/kg

***Entry for non-polar organic chemicals (option)***

Fraction of organic carbon in aquifer — foc — fraction

Organic carbon partition coefficient — Koc — l/kg

***Entry for ionic organic chemicals (option)***

Sorption coefficient for related species — $K_{oc,n}$ — l/kg

Sorption coefficient for ionised species — $K_{oc,i}$ — l/kg

pH value — pH

acid dissociation constant — pKa

Fraction of organic carbon in aquifer — foc — fraction

Soil water partition coefficient — Kd — 3.60E+01 — l/kg

**Define dispersivity (click brown cell and use pull down list)**

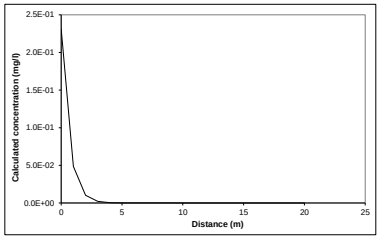
Dispersivities 10%, 1%, 0.1% of pathway length

| | | Enter value | Calc value Xu & Eckstein | | |
|---|---|---|---|---|---|
| **Longitudinal dispersivity** | **ax** | 0.00E+00 | 2.00E+00 | 1.57E+00 | m |
| **Transverse dispersivity** | **az** | 0.00E+00 | 2.00E-01 | 1.57E-01 | m |
| **Vertical dispersivity** | **ay** | 0.00E+00 | 2.00E-02 | 1.57E-02 | |

**Note values of dispersivity must be > 0**

For calculated value, assumes ax = 0.1 *x, az = 0.01 * x, ay = 0.001 * x

Xu & Eckstein (1995) report ax = $0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed




Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared with the Level 3 remedial target to determine the need for further action.
Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O2, NO3, SO4 etc than an alternative solution should be used

| | |
|---|---|
| Site being assessed: | Glan Llyn |
| Completed by: | Ross Cameron |
| Date: | ####### |
| Version: | 1 |

**Calculated concentrations for distance-concentration graph**

**Domenico - Steady state**
**From calculation sheet**

| Distance | Concentration |
|---|---|
| | mg/l |
| 0 | 2.3E-01 |
| 1.0 | 4.86E-02 |
| 2.0 | 1.02E-02 |
| 3.0 | 2.15E-03 |
| 4.0 | 4.53E-04 |
| 5.0 | 9.52E-05 |
| 6.0 | 2.00E-05 |
| 7.0 | 4.20E-06 |
| 8.0 | 8.80E-07 |
| 9.0 | 1.84E-07 |
| 10.0 | 3.86E-08 |
| 11.0 | 8.06E-09 |
| 12.0 | 1.69E-09 |
| 13.0 | 3.52E-10 |
| 14.0 | 7.35E-11 |
| 15.0 | 1.53E-11 |
| 16.0 | 3.20E-12 |
| 17.0 | 6.67E-13 |
| 18.0 | 1.39E-13 |
| 19.0 | 2.90E-14 |
| 20.0 | 6.05E-15 |

# Porosity Calculator

These results are not carried through to any of the other worksheets

## DRY BULK DENSITY DATA

| Variable | Value | Unit | justification |
|---|---|---|---|
| Natural Moisture Content | 0.00 | % wt | |
| Particle Density | 2.78 | tonnes/m$^3$ | (Change this number only if you have specific information) |
| Dry Bulk Density | 0.00 | tonnes/m$^3$ | |
| *Calculated Parameters* | | | |
| Voids Ratio | #DIV/0! | fraction | |
| Initial Saturation | #DIV/0! | % | |
| **Total porosity** | **1.000** | **fraction** | |
| **Air Filled Porosity** | **#DIV/0!** | **fraction** | |
| **Water Filled Porosity** | **#DIV/0!** | **fraction** | |

## WET BULK DENSITY DATA

| Variable | Value | Unit | |
|---|---|---|---|
| Moisture Content | 0.00 | % wt | |
| Particle Density | 2.78 | tonnes/m$^3$ | (Change this number only if you have specific information) |
| Actual (wet) Bulk Density ( i.e. at natural MC) | 0.00 | tonnes/m$^3$ | |
| *Calculated Parameters* | | | |
| Voids Ratio | #DIV/0! | fraction | |
| dry bulk density | 0.00 | tonnes/m$^3$ | |
| Initial Saturation | #DIV/0! | % | |
| **Total porosity** | **1.000** | **fraction** | **#DIV/0!** |
| **Air Filled Porosity** | **#DIV/0!** | **fraction** | |
| **Water Filled Porosity** | **#DIV/0!** | **fraction** | |

*Analytical solutions provided by David Hall, Golder Associates (UK) Ltd*

# Simple hydrogeological calculations

**(These are not specific to, or required in, the Remedial Targets Methodology)**

| Parameter | symbol | | unit | justification |
|---|---|---|---|---|
| Hydraulic conductivity | K | 0.00E+00 | m/d | |
| Hydraulic gradient | i | 0.00E+00 | unitless | |
| Effective porosity of aquifer | n | 0.00E+00 | fraction | |
| Thickness of saturated aquifer | b | 0.00E+00 | m | |
| Width of aquifer perpendicular to flow | w | 0.00E+00 | m | |
| Distance to receptor | x | 0.00E+00 | m | |
| Bulk density of aquifer materials | ρ | 0.00E+00 | $g/cm^3$ | |
| Soil-water partition co-efficient | Kd | 0.00E+00 | l/kg | |
| Retardation factor of pollutant | R | #DIV/0! | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Groundwater flow velocity | v(GW) | #DIV/0! | m/s | #DIV/0! | m/day | #DIV/0! | m/year |
| Time for groundwater to reach receptor | t(GW) | #DIV/0! | seconds | #DIV/0! | days | #DIV/0! | years |
| Rate of groundwater flow through aquifer | Q | 0.00E+00 | $m^3/s$ | 0.00E+00 | $m^3$/day | 0.00E+00 | $m^3$/year |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Contaminant flow velocity | v(contam) | #DIV/0! | m/s | #DIV/0! | m/day | #DIV/0! | m/year |
| Time for contaminant to reach receptor | t(contam) | #DIV/0! | seconds | #DIV/0! | days | #DIV/0! | years |

## Level 1 Calculation Sheet

**Contaminant** **Naphthalene**

| Parameter | Value | Units |
|---|---|---|
| (carried over from input sheet) | | |
| $C_T$ | 2.00E-03 | mg/l |
| Kd | 1.34E+02 | l/kg |
| foc | | fraction |
| koc | | l/kg |
| $\theta_W$ | 5.00E-01 | fraction |
| $\theta a$ | 3.70E-01 | fraction |
| $\rho$ | 1.36E+00 | g/cm3 |
| H | 1.00E+00 | dimensionless |
| Koc,n | | l/kg |
| Koc,i | | l/kg |
| pH | | pH units |
| pKa | | |
| foc (ionic) | | fraction |

**Calculations (Refer toTable 4.3, R&D Publication 20)**

**Selected option** User specified value for partition coefficient

| | calc | calc | Calc Kd | l/kg |
|---|---|---|---|---|
| Calculation of partition coefficient for ionic organic chemical | | | | |
| Partition coefficient used in Level 1 Assessment | | | 1.34E+02 | l/kg |

**Calculated Remedial Target** **2.69E-01 mg/kg** **for Naphthalene**

Factor (partitioning between soil and water) 1.35E+02

| | |
|---|---|
| Site being assessed: | Glan Llyn |
| Completed by: | Ross Cameron |
| Date: | 24/02/2020 |
| Version: | 1 |

## Level 2 Calculation Sheet

**Contaminant** **Naphthalene**

| Site assessed: | Glan Llyn |
|---|---|
| Date: | 24/02/2020 |
| Version: | 1 |

| Parameter | Value | Units |
|---|---|---|
| (carried over from input sheet) | | |
| Mz | 0.00E+00 | m |
| L | 0.00E+00 | m |
| da | 0.00E+00 | m |
| Inf | 0.00E+00 | m/d |
| K | 0.00E+00 | m/d |
| i | 0.00E+00 | m3/d |
| A | 0.00E+00 | m2 |
| Cc | 0.00E+00 | m3/d mg/l |
| $C_T$ | 2.00E-03 | mg/l |
| Cu | 0.00E+00 | mg/l |
| w | 0.00E+00 | m |

Calculated Dilution Factor

Calculation based on target concentration #DIV/0!

Calculation based on observed contaminant concentration #DIV/0!



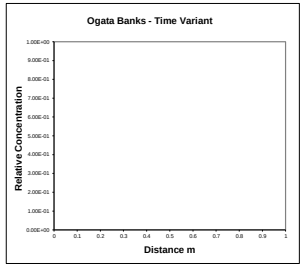
**OGATA BANKS SOLUTION**

**Contaminant** **Naphthalene**

| Input | Value | Units |
|---|---|---|
| $C_T$ | 2.000E-03 | mg/l |
| DF | #DIV/0! | |
| λ | 6.931E-101 | $days^{-1}$ |
| Sz | 0.000E+00 | m |
| Sy | 0.000E+00 | m |
| Kd | 0.000E+00 | l/kg |
| ρ | 0.000E+00 | g/cm3 |
| n | 0.000E+00 | |
| i | #DIV/0! | |
| K | 0.000E+00 | m/d |
| x | 0.000E+00 | m |
| z | 0.000E+00 | m |
| y | 0.000E+00 | m |
| t | 1.000E+99 | days |
| ax | 0.000E+00 | m |
| az | 0.000E+00 | m |
| ay | 0.000E+00 | m |

Calculations for source located in centre of aquifer (ie vertical dispersion in two directions)

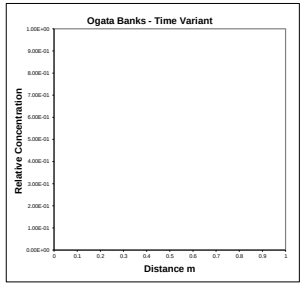
| | X | Term 1 | Term 2 | EXP | Term 3 | ERFC | Term 4 | EXP | Term 5 | ERFC | Term 6a | ERF | Term 6b | ERF | Term 7a | ERF | Term 7b | ERF | Relative Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 2 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 3 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 4 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 5 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 6 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 7 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 8 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 9 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 10 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 11 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 12 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 13 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 14 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 15 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 16 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 17 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 18 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 19 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 20 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |




| Calc | Value | |
|---|---|---|
| v | #DIV/0! | m/d |
| Rc | #DIV/0! | |
| u | #DIV/0! | m/d |

Calculations for source located at top of aquifer (ie vertical dispersion in one direction) -USED FOR LEVEL ASSESSMENT

| | X | Term 1 | Term 2 | EXP | Term 3 | ERFC | Term 4 | EXP | Term 5 | ERFC | Term 6a | ERF | Term 6b | ERF | Term 7a | ERF | Term 7b | ERF | Relative Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 2 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 3 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 4 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 5 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 6 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 7 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 8 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 9 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 10 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 11 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 12 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 13 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 14 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 15 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 16 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 17 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 18 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 19 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 20 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |




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|---|---|
| Date: | 24/02/2020 |
| Version: | 1 |

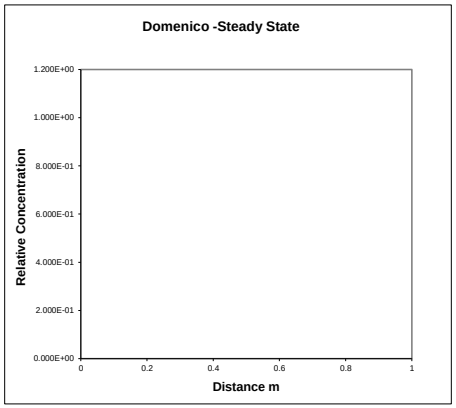
**Contaminant** **Naphthalene**

**DOMENICO (STEADY STATE)**

Calculations for source located in centre of aquifer (ie vertical dispersion in two directions)

| Input | Value | Units |
|---|---|---|
| $C_T$ | 2.000E-03 | mg/l |
| DF | #DIV/0! | |
| | | |
| | | |
| λ | 6.931E-101 | days$^{-1}$ |
| Sz | 0.000E+00 | m |
| Sy | 0.000E+00 | m |
| Kd | 0.000E+00 | l/kg |
| ρ | 0.000E+00 | g/cm3 |
| n | 0.000E+00 | |
| i | #DIV/0! | |
| K | 0.000E+00 | m/d |
| x | 0.000E+00 | m |
| z | 0.000E+00 | m |
| y | 0.000E+00 | m |
| ax | 0.000E+00 | m |
| az | 0.000E+00 | m |
| ay | 0.000E+00 | m |

| | X | Term 1 | Term 2 | EXP | Term 3A | ERF | Term 4B | ERF | Term 4A | ERF | Term 4B | ERF | Relative Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 2 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 3 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 4 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 5 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 6 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 7 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 8 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 9 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 10 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 11 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 12 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 13 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 14 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 15 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 16 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 17 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 18 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 19 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 20 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |



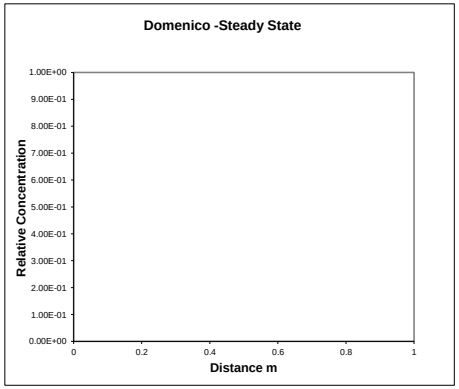

**Calc** **Value**

| | | |
|---|---|---|
| v | #DIV/0! | m/d |
| Rc | #DIV/0! | |
| u | #DIV/0! | m/d |

**DOMENICO (STEADY STATE)**

Calculations for source located at top of aquifer (ie vertical dispersion in one direction) - USED FOR LEVEL ASSESSMENT

| | X | Term 1 | Term 2 | EXP | Term 3A | ERF | Term 4B | ERF | Term 4A | ERF | Term 4B | ERF | Relative Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 2 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 3 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 4 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 5 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 6 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 7 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 8 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 9 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 10 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 11 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 12 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 13 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 14 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 15 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 16 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 17 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 18 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 19 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 20 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |




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| Date: | 24/02/2020 |
| Version: | 1 |

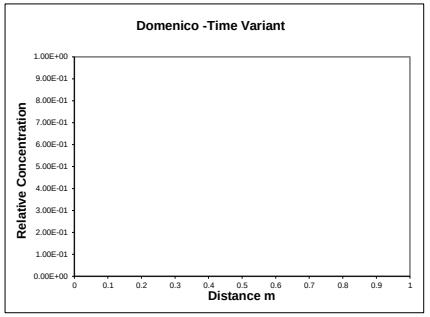
**DOMENICO (TIME VARIANT)**

**Contaminant** **Naphthalene**

| **Input** | **Value** | **Units** |
|---|---|---|
| $C_T$ | 0.002 | mg/l |
| DF | #DIV/0! | |
| λ | 6.931E-101 | days$^{-1}$ |
| Sz | 0.000E+00 | m |
| Sy | 0.000E+00 | m |
| Kd | 0.000E+00 | l/kg |
| ρ | 0.000E+00 | g/cm3 |
| n | 0.000E+00 | |
| i | #DIV/0! | |
| K | 0.000E+00 | m/d |
| x | 0.000E+00 | m |
| z | 0.000E+00 | m |
| y | 0.000E+00 | m |
| t | 1.000E+99 | days |
| ax | 0.000E+00 | m |
| az | 0.000E+00 | m |
| ay | 0.000E+00 | m |

Calculations for source located in centre of aquifer (ie vertical dispersion in two directions)

| | X | Term 1 | Term 2 | EXP | Term 3 | ERFC | Term 4A | ERF | Term 4B | ERF | Term 5A | ERF | Term 5B | ERF | Relative Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | m | | | | | | | | | | | | | | |
| 1 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 2 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 3 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 4 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 5 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 6 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 7 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 8 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 9 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 10 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 11 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 12 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 13 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 14 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 15 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 16 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 17 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 18 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 19 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 20 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |

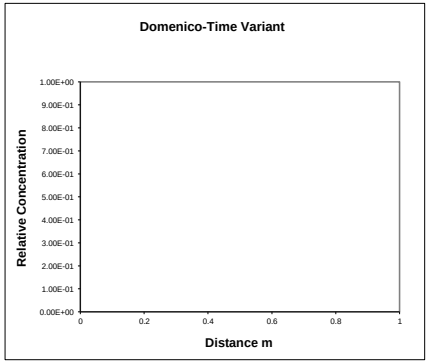



**Calc** **Value**

| | | |
|---|---|---|
| v | #DIV/0! | m/d |
| Rc | #DIV/0! | |
| u | #DIV/0! | m/d |

Calculations for source located at top of aquifer (ie vertical dispersion in one direction only) - USED FOR LEVEL ASSESSMENT

| | X | Term 1 | Term 2 | EXP | Term 3 | ERFC | Term 4A | ERF | Term 4B | ERF | Term 5A | ERF | Term 5B | ERF | Relative Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | m | | | | | | | | | | | | | | |
| 1 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 2 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 3 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 4 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 5 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 6 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 7 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 8 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 9 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 10 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 11 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 12 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 13 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 14 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 15 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 16 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 17 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 18 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 19 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 20 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |




| | |
|---|---|
| Date: | 24/02/2020 |
| Version: | 1 |

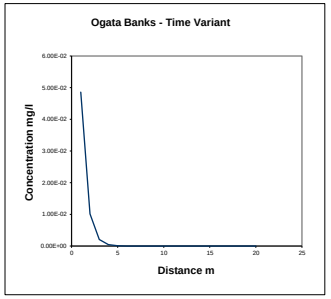
**OGATA BANKS SOLUTION**

**Contaminant** **Naphthalene**

Calculations for source located in centre of aquifer (ie vertical dispersion in two directions)

| Input | Value | Units |
|---|---|---|
| $C_T$ | 0.002 | mg/l |
| Co | 2.31E-01 | mg/l |
| λ | 1.13E-05 | days$^{-1}$ |
| Sz | 5.00E+02 | m |
| Sy | 1.50E+00 | m |
| Kd | 3.60E+01 | l/kg |
| ρ | 1.36E+00 | g/cm3 |
| n | 8.00E-02 | |
| i | 1.00E-02 | |
| K | 8.64E-03 | m/d |
| x | 2.00E+01 | m |
| z | 0.00E+00 | m |
| y | 0.00E+00 | m |
| t | 1.00E+100 | days |
| ax | 2.00E+00 | m |
| az | 2.00E-01 | m |
| ay | 2.00E-02 | m |

| | X | Term 1 | Term 2 | EXP | Term 3 | ERFC | Term 4 | EXP | Term 5 | ERFC | Term 6a | ERF | Term 6b | ERF | Term 7a | ERF | Term 7b | ERF | Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 0.02888 | -1.6E+00 | 2.1E-01 | -3.4E+47 | 2.000 | 2.1E+00 | 7.8E+00 | 3.4E+47 | 0.000 | 2.8E+02 | 1 | -2.8E+02 | -1 | 2.7E+00 | 0.9998 | -2.7E+00 | -0.99982 | 4.86E-02 |
| 2 | 2 | 0.02888 | -3.1E+00 | 4.4E-02 | -3.4E+47 | 2.000 | 4.1E+00 | 6.1E+01 | 3.4E+47 | 0.000 | 2.0E+02 | 1 | -2.0E+02 | -1 | 1.9E+00 | 0.992 | -1.9E+00 | -0.99199 | 1.01E-02 |
| 3 | 3 | 0.02888 | -4.7E+00 | 9.3E-03 | -3.4E+47 | 2.000 | 6.2E+00 | 4.8E+02 | 3.4E+47 | 0.000 | 1.6E+02 | 1 | -1.6E+02 | -1 | 1.5E+00 | 0.9696 | -1.5E+00 | -0.96962 | 2.09E-03 |
| 4 | 4 | 0.02888 | -6.2E+00 | 2.0E-03 | -3.4E+47 | 2.000 | 8.2E+00 | 3.8E+03 | 3.4E+47 | 0.000 | 1.4E+02 | 1 | -1.4E+02 | -1 | 1.3E+00 | 0.9392 | -1.3E+00 | -0.93921 | 4.25E-04 |
| 5 | 5 | 0.02888 | -7.8E+00 | 4.1E-04 | -3.4E+47 | 2.000 | 1.0E+01 | 3.0E+04 | 3.4E+47 | 0.000 | 1.3E+02 | 1 | -1.3E+02 | -1 | 1.2E+00 | 0.9065 | -1.2E+00 | -0.90647 | 8.63E-05 |
| 6 | 6 | 0.02888 | -9.4E+00 | 8.7E-05 | -3.4E+47 | 2.000 | 1.2E+01 | 2.3E+05 | 3.4E+47 | 0.000 | 1.1E+02 | 1 | -1.1E+02 | -1 | 1.1E+00 | 0.8742 | -1.1E+00 | -0.87421 | 1.75E-05 |
| 7 | 7 | 0.02888 | -1.1E+01 | 1.8E-05 | -3.4E+47 | 2.000 | 1.4E+01 | 1.8E+06 | 3.4E+47 | 0.000 | 1.1E+02 | 1 | -1.1E+02 | -1 | 1.0E+00 | 0.8436 | -1.0E+00 | -0.84362 | 3.56E-06 |
| 8 | 8 | 0.02888 | -1.2E+01 | 3.8E-06 | -3.4E+47 | 2.000 | 1.6E+01 | 1.4E+07 | 3.4E+47 | 0.000 | 9.9E+01 | 1 | -9.9E+01 | -1 | 9.4E-01 | 0.8151 | -9.4E-01 | -0.8151 | 7.23E-07 |
| 9 | 9 | 0.02888 | -1.4E+01 | 8.1E-07 | -3.4E+47 | 2.000 | 1.9E+01 | 1.1E+08 | 3.4E+47 | 0.000 | 9.3E+01 | 1 | -9.3E+01 | -1 | 8.8E-01 | 0.7887 | -8.8E-01 | -0.7887 | 1.47E-07 |
| 10 | 10 | 0.02888 | -1.6E+01 | 1.7E-07 | -3.4E+47 | 2.000 | 2.1E+01 | 8.7E+08 | 3.4E+47 | 0.000 | 8.8E+01 | 1 | -8.8E+01 | -1 | 8.4E-01 | 0.7643 | -8.4E-01 | -0.76432 | 3.00E-08 |
| 11 | 11 | 0.02888 | -1.7E+01 | 3.6E-08 | -3.4E+47 | 2.000 | 2.3E+01 | 6.8E+09 | 3.4E+47 | 0.000 | 8.4E+01 | 1 | -8.4E+01 | -1 | 8.0E-01 | 0.7418 | -8.0E-01 | -0.7418 | 6.13E-09 |
| 12 | 12 | 0.02888 | -1.9E+01 | 7.5E-09 | -3.4E+47 | 2.000 | 2.5E+01 | 5.4E+10 | 3.4E+47 | 0.000 | 8.1E+01 | 1 | -8.1E+01 | -1 | 7.7E-01 | 0.721 | -7.7E-01 | -0.72098 | 1.25E-09 |
| 13 | 13 | 0.02888 | -2.0E+01 | 1.6E-09 | -3.4E+47 | 2.000 | 2.7E+01 | 4.2E+11 | 3.4E+47 | 0.000 | 7.8E+01 | 1 | -7.8E+01 | -1 | 7.4E-01 | 0.7017 | -7.4E-01 | -0.70169 | 2.57E-10 |
| 14 | 14 | 0.02888 | -2.2E+01 | 3.3E-10 | -3.4E+47 | 2.000 | 2.9E+01 | 3.3E+12 | 3.4E+47 | 0.000 | 7.5E+01 | 1 | -7.5E+01 | -1 | 7.1E-01 | 0.6838 | -7.1E-01 | -0.68377 | 5.26E-11 |
| 15 | 15 | 0.02888 | -2.3E+01 | 7.0E-11 | -3.4E+47 | 2.000 | 3.1E+01 | 2.6E+13 | 3.4E+47 | 0.000 | 7.2E+01 | 1 | -7.2E+01 | -1 | 6.8E-01 | 0.6671 | -6.8E-01 | -0.66708 | 1.08E-11 |
| 16 | 16 | 0.02888 | -2.5E+01 | 1.5E-11 | -3.4E+47 | 2.000 | 3.3E+01 | 2.0E+14 | 3.4E+47 | 0.000 | 7.0E+01 | 1 | -7.0E+01 | -1 | 6.6E-01 | 0.6515 | -6.6E-01 | -0.6515 | 2.22E-12 |
| 17 | 17 | 0.02888 | -2.6E+01 | 3.1E-12 | -3.4E+47 | 2.000 | 3.5E+01 | 1.6E+15 | 3.4E+47 | 0.000 | 6.8E+01 | 1 | -6.8E+01 | -1 | 6.4E-01 | 0.6369 | -6.4E-01 | -0.63692 | 4.56E-13 |
| 18 | 18 | 0.02888 | -2.8E+01 | 6.5E-13 | -3.4E+47 | 2.000 | 3.7E+01 | 1.2E+16 | 3.4E+47 | 0.000 | 6.6E+01 | 1 | -6.6E+01 | -1 | 6.3E-01 | 0.6232 | -6.3E-01 | -0.62324 | 9.40E-14 |
| 19 | 19 | 0.02888 | -3.0E+01 | 1.4E-13 | -3.4E+47 | 2.000 | 3.9E+01 | 9.7E+16 | 3.4E+47 | 0.000 | 6.4E+01 | 1 | -6.4E+01 | -1 | 6.1E-01 | 0.6104 | -6.1E-01 | -0.61038 | 1.94E-14 |
| 20 | 20 | 0.02888 | -3.1E+01 | 2.9E-14 | -3.4E+47 | 2.000 | 4.1E+01 | 7.6E+17 | 3.4E+47 | 0.000 | 6.3E+01 | 1 | -6.3E+01 | -1 | 5.9E-01 | 0.5983 | -5.9E-01 | -0.59826 | 3.99E-15 |

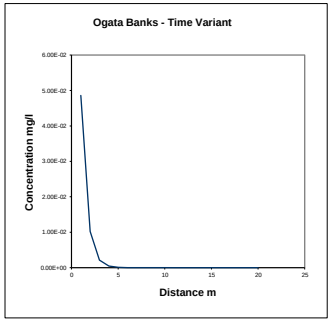



Vertical dispersion option Simulate vertical dispersion in 1 direction

| Calc | Value | |
|---|---|---|
| v | 1.08E-03 | m/d |
| Rc | 6.13E+02 | |
| u | 1.76E-06 | m/d |

Calculations for source located at top of aquifer (ie vertical dispersion in one direction) - USED FOR LEVEL ASSESSMENT

| | X | Term 1 | Term 2 | EXP | Term 3 | ERFC | Term 4 | EXP | Term 5 | ERFC | Term 6a | ERF | Term 6b | ERF | Term 7a | ERF | Term 7b | ERF | Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 0.02888 | -1.6E+00 | 2.1E-01 | -3.4E+47 | 2.000 | 2.1E+00 | 7.8E+00 | 3.4E+47 | 0.000 | 2.8E+02 | 1 | -2.8E+02 | -1 | 5.3E+00 | 1 | -5.3E+00 | -1 | 4.86E-02 |
| 2 | 2 | 0.02888 | -3.1E+00 | 4.4E-02 | -3.4E+47 | 2.000 | 4.1E+00 | 6.1E+01 | 3.4E+47 | 0.000 | 2.0E+02 | 1 | -2.0E+02 | -1 | 3.8E+00 | 1 | -3.8E+00 | -1 | 1.02E-02 |
| 3 | 3 | 0.02888 | -4.7E+00 | 9.3E-03 | -3.4E+47 | 2.000 | 6.2E+00 | 4.8E+02 | 3.4E+47 | 0.000 | 1.6E+02 | 1 | -1.6E+02 | -1 | 3.1E+00 | 1 | -3.1E+00 | -0.99999 | 2.15E-03 |
| 4 | 4 | 0.02888 | -6.2E+00 | 2.0E-03 | -3.4E+47 | 2.000 | 8.2E+00 | 3.8E+03 | 3.4E+47 | 0.000 | 1.4E+02 | 1 | -1.4E+02 | -1 | 2.7E+00 | 0.9998 | -2.7E+00 | -0.99982 | 4.53E-04 |
| 5 | 5 | 0.02888 | -7.8E+00 | 4.1E-04 | -3.4E+47 | 2.000 | 1.0E+01 | 3.0E+04 | 3.4E+47 | 0.000 | 1.3E+02 | 1 | -1.3E+02 | -1 | 2.4E+00 | 0.9992 | -2.4E+00 | -0.9992 | 9.52E-05 |
| 6 | 6 | 0.02888 | -9.4E+00 | 8.7E-05 | -3.4E+47 | 2.000 | 1.2E+01 | 2.3E+05 | 3.4E+47 | 0.000 | 1.1E+02 | 1 | -1.1E+02 | -1 | 2.2E+00 | 0.9978 | -2.2E+00 | -0.9978 | 2.00E-05 |
| 7 | 7 | 0.02888 | -1.1E+01 | 1.8E-05 | -3.4E+47 | 2.000 | 1.4E+01 | 1.8E+06 | 3.4E+47 | 0.000 | 1.1E+02 | 1 | -1.1E+02 | -1 | 2.0E+00 | 0.9954 | -2.0E+00 | -0.99541 | 4.20E-06 |
| 8 | 8 | 0.02888 | -1.2E+01 | 3.8E-06 | -3.4E+47 | 2.000 | 1.6E+01 | 1.4E+07 | 3.4E+47 | 0.000 | 9.9E+01 | 1 | -9.9E+01 | -1 | 1.9E+00 | 0.992 | -1.9E+00 | -0.99199 | 8.80E-07 |
| 9 | 9 | 0.02888 | -1.4E+01 | 8.1E-07 | -3.4E+47 | 2.000 | 1.9E+01 | 1.1E+08 | 3.4E+47 | 0.000 | 9.3E+01 | 1 | -9.3E+01 | -1 | 1.8E+00 | 0.9876 | -1.8E+00 | -0.98758 | 1.84E-07 |
| 10 | 10 | 0.02888 | -1.6E+01 | 1.7E-07 | -3.4E+47 | 2.000 | 2.1E+01 | 8.7E+08 | 3.4E+47 | 0.000 | 8.8E+01 | 1 | -8.8E+01 | -1 | 1.7E+00 | 0.9823 | -1.7E+00 | -0.98229 | 3.86E-08 |
| 11 | 11 | 0.02888 | -1.7E+01 | 3.6E-08 | -3.4E+47 | 2.000 | 2.3E+01 | 6.8E+09 | 3.4E+47 | 0.000 | 8.4E+01 | 1 | -8.4E+01 | -1 | 1.6E+00 | 0.9763 | -1.6E+00 | -0.97626 | 8.06E-09 |
| 12 | 12 | 0.02888 | -1.9E+01 | 7.5E-09 | -3.4E+47 | 2.000 | 2.5E+01 | 5.4E+10 | 3.4E+47 | 0.000 | 8.1E+01 | 1 | -8.1E+01 | -1 | 1.5E+00 | 0.9696 | -1.5E+00 | -0.96962 | 1.69E-09 |
| 13 | 13 | 0.02888 | -2.0E+01 | 1.6E-09 | -3.4E+47 | 2.000 | 2.7E+01 | 4.2E+11 | 3.4E+47 | 0.000 | 7.8E+01 | 1 | -7.8E+01 | -1 | 1.5E+00 | 0.9625 | -1.5E+00 | -0.96249 | 3.52E-10 |
| 14 | 14 | 0.02888 | -2.2E+01 | 3.3E-10 | -3.4E+47 | 2.000 | 2.9E+01 | 3.3E+12 | 3.4E+47 | 0.000 | 7.5E+01 | 1 | -7.5E+01 | -1 | 1.4E+00 | 0.955 | -1.4E+00 | -0.95498 | 7.35E-11 |
| 15 | 15 | 0.02888 | -2.3E+01 | 7.0E-11 | -3.4E+47 | 2.000 | 3.1E+01 | 2.6E+13 | 3.4E+47 | 0.000 | 7.2E+01 | 1 | -7.2E+01 | -1 | 1.4E+00 | 0.9472 | -1.4E+00 | -0.94719 | 1.53E-11 |
| 16 | 16 | 0.02888 | -2.5E+01 | 1.5E-11 | -3.4E+47 | 2.000 | 3.3E+01 | 2.0E+14 | 3.4E+47 | 0.000 | 7.0E+01 | 1 | -7.0E+01 | -1 | 1.3E+00 | 0.9392 | -1.3E+00 | -0.93921 | 3.20E-12 |
| 17 | 17 | 0.02888 | -2.6E+01 | 3.1E-12 | -3.4E+47 | 2.000 | 3.5E+01 | 1.6E+15 | 3.4E+47 | 0.000 | 6.8E+01 | 1 | -6.8E+01 | -1 | 1.3E+00 | 0.9311 | -1.3E+00 | -0.93109 | 6.67E-13 |
| 18 | 18 | 0.02888 | -2.8E+01 | 6.5E-13 | -3.4E+47 | 2.000 | 3.7E+01 | 1.2E+16 | 3.4E+47 | 0.000 | 6.6E+01 | 1 | -6.6E+01 | -1 | 1.3E+00 | 0.9229 | -1.3E+00 | -0.9229 | 1.39E-13 |
| 19 | 19 | 0.02888 | -3.0E+01 | 1.4E-13 | -3.4E+47 | 2.000 | 3.9E+01 | 9.7E+16 | 3.4E+47 | 0.000 | 6.4E+01 | 1 | -6.4E+01 | -1 | 1.2E+00 | 0.9147 | -1.2E+00 | -0.91468 | 2.90E-14 |
| 20 | 20 | 0.02888 | -3.1E+01 | 2.9E-14 | -3.4E+47 | 2.000 | 4.1E+01 | 7.6E+17 | 3.4E+47 | 0.000 | 6.3E+01 | 1 | -6.3E+01 | -1 | 1.2E+00 | 0.9065 | -1.2E+00 | -0.90647 | 6.05E-15 |




| | |
|---|---|
| Date: | 24/02/2020 |
| Version: | 1 |

**Contaminant** **Naphthalene**

| Input | Value | Units |
|---|---|---|
| $C_T$ | 0.002 | mg/l |
| Co | 2.31E-01 | mg/l |
| λ | 1.13E-05 | days$^{-1}$ |
| Sz | 5.00E+02 | m |
| Sy | 1.50E+00 | m |
| Kd | 3.60E+01 | l/kg |
| ρ | 1.36E+00 | g/cm3 |
| n | 8.00E-02 | |
| i | 1.00E-02 | |
| K | 8.64E-03 | m/d |
| x | 2.00E+01 | m |
| z | 0.00E+00 | m |
| y | 0.00E+00 | m |
| ax | 2.00E+00 | m |
| az | 2.00E-01 | m |
| ay | 2.00E-02 | m |

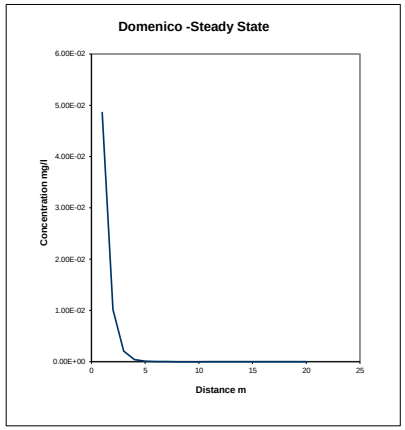
Vertical dispersion optio Simulate vertical dispersion in 1 direction

| Calc | Value | |
|---|---|---|
| v | 1.08E-03 | m/d |
| Rc | 6.13E+02 | |
| u | 1.76E-06 | m/d |

**DOMENICO (STEADY STATE)**

Calculations for source located in centre of aquifer (ie vertical dispersion in two directions)

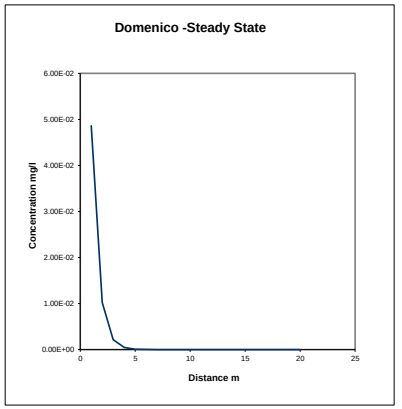
| | X | Term 1 | Term 2 | EXP | Term 3A | ERF | Term 3B | ERF | Term 4A | ERF | Term 4B | ERF | Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 0.05775 | -1.56E+00 | 2.10E-01 | 2.80E+02 | 1 | -2.80E+02 | -1 | 2.65E+00 | 1 | -2.65E+00 | -0.9998 | 4.86E-02 |
| 2 | 2 | 0.05775 | -3.12E+00 | 4.43E-02 | 1.98E+02 | 1 | -1.98E+02 | -1 | 1.88E+00 | 0.992 | -1.88E+00 | -0.992 | 1.01E-02 |
| 3 | 3 | 0.05775 | -4.68E+00 | 9.31E-03 | 1.61E+02 | 1 | -1.61E+02 | -1 | 1.53E+00 | 0.97 | -1.53E+00 | -0.9696 | 2.09E-03 |
| 4 | 4 | 0.05775 | -6.24E+00 | 1.96E-03 | 1.40E+02 | 1 | -1.40E+02 | -1 | 1.33E+00 | 0.939 | -1.33E+00 | -0.9392 | 4.25E-04 |
| 5 | 5 | 0.05775 | -7.79E+00 | 4.12E-04 | 1.25E+02 | 1 | -1.25E+02 | -1 | 1.19E+00 | 0.906 | -1.19E+00 | -0.9065 | 8.63E-05 |
| 6 | 6 | 0.05775 | -9.35E+00 | 8.67E-05 | 1.14E+02 | 1 | -1.14E+02 | -1 | 1.08E+00 | 0.874 | -1.08E+00 | -0.8742 | 1.75E-05 |
| 7 | 7 | 0.05775 | -1.09E+01 | 1.82E-05 | 1.06E+02 | 1 | -1.06E+02 | -1 | 1.00E+00 | 0.844 | -1.00E+00 | -0.8436 | 3.56E-06 |
| 8 | 8 | 0.05775 | -1.25E+01 | 3.84E-06 | 9.88E+01 | 1 | -9.88E+01 | -1 | 9.38E-01 | 0.815 | -9.38E-01 | -0.8151 | 7.23E-07 |
| 9 | 9 | 0.05775 | -1.40E+01 | 8.08E-07 | 9.32E+01 | 1 | -9.32E+01 | -1 | 8.84E-01 | 0.789 | -8.84E-01 | -0.7887 | 1.47E-07 |
| 10 | 10 | 0.05775 | -1.56E+01 | 1.70E-07 | 8.84E+01 | 1 | -8.84E+01 | -1 | 8.39E-01 | 0.764 | -8.39E-01 | -0.7643 | 3.00E-08 |
| 11 | 11 | 0.05775 | -1.71E+01 | 3.58E-08 | 8.43E+01 | 1 | -8.43E+01 | -1 | 8.00E-01 | 0.742 | -8.00E-01 | -0.7418 | 6.13E-09 |
| 12 | 12 | 0.05775 | -1.87E+01 | 7.52E-09 | 8.07E+01 | 1 | -8.07E+01 | -1 | 7.65E-01 | 0.721 | -7.65E-01 | -0.721 | 1.25E-09 |
| 13 | 13 | 0.05775 | -2.03E+01 | 1.58E-09 | 7.75E+01 | 1 | -7.75E+01 | -1 | 7.35E-01 | 0.702 | -7.35E-01 | -0.7017 | 2.57E-10 |
| 14 | 14 | 0.05775 | -2.18E+01 | 3.33E-10 | 7.47E+01 | 1 | -7.47E+01 | -1 | 7.09E-01 | 0.684 | -7.09E-01 | -0.6838 | 5.26E-11 |
| 15 | 15 | 0.05775 | -2.34E+01 | 7.01E-11 | 7.22E+01 | 1 | -7.22E+01 | -1 | 6.85E-01 | 0.667 | -6.85E-01 | -0.6671 | 1.08E-11 |
| 16 | 16 | 0.05775 | -2.49E+01 | 1.47E-11 | 6.99E+01 | 1 | -6.99E+01 | -1 | 6.63E-01 | 0.651 | -6.63E-01 | -0.6515 | 2.22E-12 |
| 17 | 17 | 0.05775 | -2.65E+01 | 3.10E-12 | 6.78E+01 | 1 | -6.78E+01 | -1 | 6.43E-01 | 0.637 | -6.43E-01 | -0.6369 | 4.56E-13 |
| 18 | 18 | 0.05775 | -2.81E+01 | 6.53E-13 | 6.59E+01 | 1 | -6.59E+01 | -1 | 6.25E-01 | 0.623 | -6.25E-01 | -0.6232 | 9.40E-14 |
| 19 | 19 | 0.05775 | -2.96E+01 | 1.37E-13 | 6.41E+01 | 1 | -6.41E+01 | -1 | 6.08E-01 | 0.61 | -6.08E-01 | -0.6104 | 1.94E-14 |
| 20 | 20 | 0.05775 | -3.12E+01 | 2.89E-14 | 6.25E+01 | 1 | -6.25E+01 | -1 | 5.93E-01 | 0.598 | -5.93E-01 | -0.5983 | 3.99E-15 |




**DOMENICO (STEADY STATE)**

Calculations for source located at top of aquifer (ie vertical dispersion in one direction) - USED FOR LEVEL ASSESSMENT

| | X | Term 1 | Term 2 | EXP | Term 3A | ERF | Term 3B | ERF | Term 4A | ERF | Term 4B | ERF | Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 0.05775 | -1.56E+00 | 2.10E-01 | 2.80E+02 | 1 | -2.80E+02 | -1 | 5.30E+00 | 1 | -5.30E+00 | -1 | 4.86E-02 |
| 2 | 2 | 0.05775 | -3.12E+00 | 4.43E-02 | 1.98E+02 | 1 | -1.98E+02 | -1 | 3.75E+00 | 1 | -3.75E+00 | -1 | 1.02E-02 |
| 3 | 3 | 0.05775 | -4.68E+00 | 9.31E-03 | 1.61E+02 | 1 | -1.61E+02 | -1 | 3.06E+00 | 1 | -3.06E+00 | -1 | 2.15E-03 |
| 4 | 4 | 0.05775 | -6.24E+00 | 1.96E-03 | 1.40E+02 | 1 | -1.40E+02 | -1 | 2.65E+00 | 1 | -2.65E+00 | -0.9998 | 4.53E-04 |
| 5 | 5 | 0.05775 | -7.79E+00 | 4.12E-04 | 1.25E+02 | 1 | -1.25E+02 | -1 | 2.37E+00 | 0.999 | -2.37E+00 | -0.9992 | 9.52E-05 |
| 6 | 6 | 0.05775 | -9.35E+00 | 8.67E-05 | 1.14E+02 | 1 | -1.14E+02 | -1 | 2.17E+00 | 0.998 | -2.17E+00 | -0.9978 | 2.00E-05 |
| 7 | 7 | 0.05775 | -1.09E+01 | 1.82E-05 | 1.06E+02 | 1 | -1.06E+02 | -1 | 2.00E+00 | 0.995 | -2.00E+00 | -0.9954 | 4.20E-06 |
| 8 | 8 | 0.05775 | -1.25E+01 | 3.84E-06 | 9.88E+01 | 1 | -9.88E+01 | -1 | 1.88E+00 | 0.992 | -1.88E+00 | -0.992 | 8.80E-07 |
| 9 | 9 | 0.05775 | -1.40E+01 | 8.08E-07 | 9.32E+01 | 1 | -9.32E+01 | -1 | 1.77E+00 | 0.988 | -1.77E+00 | -0.9876 | 1.84E-07 |
| 10 | 10 | 0.05775 | -1.56E+01 | 1.70E-07 | 8.84E+01 | 1 | -8.84E+01 | -1 | 1.68E+00 | 0.982 | -1.68E+00 | -0.9823 | 3.86E-08 |
| 11 | 11 | 0.05775 | -1.71E+01 | 3.58E-08 | 8.43E+01 | 1 | -8.43E+01 | -1 | 1.60E+00 | 0.976 | -1.60E+00 | -0.9763 | 8.06E-09 |
| 12 | 12 | 0.05775 | -1.87E+01 | 7.52E-09 | 8.07E+01 | 1 | -8.07E+01 | -1 | 1.53E+00 | 0.97 | -1.53E+00 | -0.9696 | 1.69E-09 |
| 13 | 13 | 0.05775 | -2.03E+01 | 1.58E-09 | 7.75E+01 | 1 | -7.75E+01 | -1 | 1.47E+00 | 0.962 | -1.47E+00 | -0.9625 | 3.52E-10 |
| 14 | 14 | 0.05775 | -2.18E+01 | 3.33E-10 | 7.47E+01 | 1 | -7.47E+01 | -1 | 1.42E+00 | 0.955 | -1.42E+00 | -0.955 | 7.35E-11 |
| 15 | 15 | 0.05775 | -2.34E+01 | 7.01E-11 | 7.22E+01 | 1 | -7.22E+01 | -1 | 1.37E+00 | 0.947 | -1.37E+00 | -0.9472 | 1.53E-11 |
| 16 | 16 | 0.05775 | -2.49E+01 | 1.47E-11 | 6.99E+01 | 1 | -6.99E+01 | -1 | 1.33E+00 | 0.939 | -1.33E+00 | -0.9392 | 3.20E-12 |
| 17 | 17 | 0.05775 | -2.65E+01 | 3.10E-12 | 6.78E+01 | 1 | -6.78E+01 | -1 | 1.29E+00 | 0.931 | -1.29E+00 | -0.9311 | 6.67E-13 |
| 18 | 18 | 0.05775 | -2.81E+01 | 6.53E-13 | 6.59E+01 | 1 | -6.59E+01 | -1 | 1.25E+00 | 0.923 | -1.25E+00 | -0.9229 | 1.39E-13 |
| 19 | 19 | 0.05775 | -2.96E+01 | 1.37E-13 | 6.41E+01 | 1 | -6.41E+01 | -1 | 1.22E+00 | 0.915 | -1.22E+00 | -0.9147 | 2.90E-14 |
| 20 | 20 | 0.05775 | -3.12E+01 | 2.89E-14 | 6.25E+01 | 1 | -6.25E+01 | -1 | 1.19E+00 | 0.906 | -1.19E+00 | -0.9065 | 6.05E-15 |




| | |
|---|---|
| Date: | 24/02/2020 |
| Version: | 1 |

## DOMENICO (TIME VARIANT)

**Contaminant** **Naphthalene**

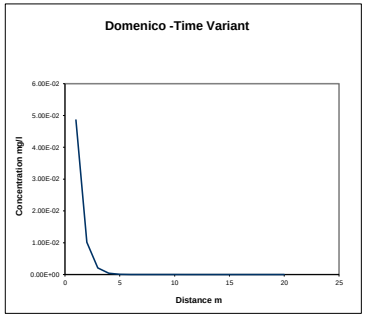
| Input | Value | Units |
|---|---|---|
| $C_T$ | 0.002 | mg/l |
| Co | 2.31E-01 | mg/l |
| λ | 1.13E-05 | days$^{-1}$ |
| Sz | 5.00E+02 | m |
| Sy | 1.50E+00 | m |
| Kd | 3.60E+01 | l/kg |
| ρ | 1.36E+00 | g/cm3 |
| n | 8.00E-02 | |
| i | 1.00E-02 | |
| K | 8.64E-03 | m/d |
| x | 2.00E+01 | m |
| z | 0.00E+00 | m |
| y | 0.00E+00 | m |
| t | 1.00E+100 | days |
| ax | 2.00E+00 | m |
| az | 2.00E-01 | m |
| ay | 2.00E-02 | m |

Vertical dispersion option Simulate vertical dispersion in 1 direction

| Calc | Value | |
|---|---|---|
| v | 1.08E-03 | m/d |
| Rc | 6.13E+02 | |
| u | 1.76E-06 | m/d |

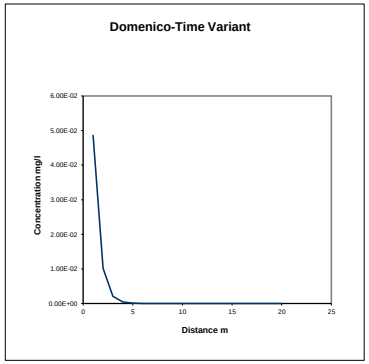
Calculations for source located in centre of aquifer (ie vertical dispersion in two directions)

| | X | Term 1 | Term 2 | EXP | Term 3 | ERFC | Term 4A | ERF | Term 4B | ERF | Term 5A | ERF | Term 5B | ERF | Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | m | | | | | | | | | | | | | | |
| 1 | 1 | 0.02888 | -1.56E+00 | 2.10E-01 | -3.40E+47 | 2 | 2.80E+02 | 1 | -2.80E+02 | -1 | 2.65E+00 | 0.9998 | -2.65E+00 | -1 | 4.86E-02 |
| 2 | 2 | 0.02888 | -3.12E+00 | 4.43E-02 | -3.40E+47 | 2 | 1.98E+02 | 1 | -1.98E+02 | -1 | 1.88E+00 | 0.992 | -1.88E+00 | -0.992 | 1.01E-02 |
| 3 | 3 | 0.02888 | -4.68E+00 | 9.31E-03 | -3.40E+47 | 2 | 1.61E+02 | 1 | -1.61E+02 | -1 | 1.53E+00 | 0.9696 | -1.53E+00 | -0.97 | 2.09E-03 |
| 4 | 4 | 0.02888 | -6.24E+00 | 1.96E-03 | -3.40E+47 | 2 | 1.40E+02 | 1 | -1.40E+02 | -1 | 1.33E+00 | 0.9392 | -1.33E+00 | -0.939 | 4.25E-04 |
| 5 | 5 | 0.02888 | -7.79E+00 | 4.12E-04 | -3.40E+47 | 2 | 1.25E+02 | 1 | -1.25E+02 | -1 | 1.19E+00 | 0.9065 | -1.19E+00 | -0.906 | 8.63E-05 |
| 6 | 6 | 0.02888 | -9.35E+00 | 8.67E-05 | -3.40E+47 | 2 | 1.14E+02 | 1 | -1.14E+02 | -1 | 1.08E+00 | 0.8742 | -1.08E+00 | -0.874 | 1.75E-05 |
| 7 | 7 | 0.02888 | -1.09E+01 | 1.82E-05 | -3.40E+47 | 2 | 1.06E+02 | 1 | -1.06E+02 | -1 | 1.00E+00 | 0.8436 | -1.00E+00 | -0.844 | 3.56E-06 |
| 8 | 8 | 0.02888 | -1.25E+01 | 3.84E-06 | -3.40E+47 | 2 | 9.88E+01 | 1 | -9.88E+01 | -1 | 9.38E-01 | 0.8151 | -9.38E-01 | -0.815 | 7.23E-07 |
| 9 | 9 | 0.02888 | -1.40E+01 | 8.08E-07 | -3.40E+47 | 2 | 9.32E+01 | 1 | -9.32E+01 | -1 | 8.84E-01 | 0.7887 | -8.84E-01 | -0.789 | 1.47E-07 |
| 10 | 10 | 0.02888 | -1.56E+01 | 1.70E-07 | -3.40E+47 | 2 | 8.84E+01 | 1 | -8.84E+01 | -1 | 8.39E-01 | 0.7643 | -8.39E-01 | -0.764 | 3.00E-08 |
| 11 | 11 | 0.02888 | -1.71E+01 | 3.58E-08 | -3.40E+47 | 2 | 8.43E+01 | 1 | -8.43E+01 | -1 | 8.00E-01 | 0.7418 | -8.00E-01 | -0.742 | 6.13E-09 |
| 12 | 12 | 0.02888 | -1.87E+01 | 7.52E-09 | -3.40E+47 | 2 | 8.07E+01 | 1 | -8.07E+01 | -1 | 7.65E-01 | 0.721 | -7.65E-01 | -0.721 | 1.25E-09 |
| 13 | 13 | 0.02888 | -2.03E+01 | 1.58E-09 | -3.40E+47 | 2 | 7.75E+01 | 1 | -7.75E+01 | -1 | 7.35E-01 | 0.7017 | -7.35E-01 | -0.702 | 2.57E-10 |
| 14 | 14 | 0.02888 | -2.18E+01 | 3.33E-10 | -3.40E+47 | 2 | 7.47E+01 | 1 | -7.47E+01 | -1 | 7.09E-01 | 0.6838 | -7.09E-01 | -0.684 | 5.26E-11 |
| 15 | 15 | 0.02888 | -2.34E+01 | 7.01E-11 | -3.40E+47 | 2 | 7.22E+01 | 1 | -7.22E+01 | -1 | 6.85E-01 | 0.6671 | -6.85E-01 | -0.667 | 1.08E-11 |
| 16 | 16 | 0.02888 | -2.49E+01 | 1.47E-11 | -3.40E+47 | 2 | 6.99E+01 | 1 | -6.99E+01 | -1 | 6.63E-01 | 0.6515 | -6.63E-01 | -0.651 | 2.22E-12 |
| 17 | 17 | 0.02888 | -2.65E+01 | 3.10E-12 | -3.40E+47 | 2 | 6.78E+01 | 1 | -6.78E+01 | -1 | 6.43E-01 | 0.6369 | -6.43E-01 | -0.637 | 4.56E-13 |
| 18 | 18 | 0.02888 | -2.81E+01 | 6.53E-13 | -3.40E+47 | 2 | 6.59E+01 | 1 | -6.59E+01 | -1 | 6.25E-01 | 0.6232 | -6.25E-01 | -0.623 | 9.40E-14 |
| 19 | 19 | 0.02888 | -2.96E+01 | 1.37E-13 | -3.40E+47 | 2 | 6.41E+01 | 1 | -6.41E+01 | -1 | 6.08E-01 | 0.6104 | -6.08E-01 | -0.61 | 1.94E-14 |
| 20 | 20 | 0.02888 | -3.12E+01 | 2.89E-14 | -3.40E+47 | 2 | 6.25E+01 | 1 | -6.25E+01 | -1 | 5.93E-01 | 0.5983 | -5.93E-01 | -0.598 | 3.99E-15 |




Calculations for source located at top of aquifer (ie vertical dispersion in one direction only) - USED FOR LEVEL ASSESSMENT

| | X | Term 1 | Term 2 | EXP | Term 3 | ERFC | Term 4A | ERF | Term 4B | ERF | Term 5A | ERF | Term 5B | ERF | Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | m | | | | | | | | | | | | | | |
| 1 | 1 | 0.02888 | -1.56E+00 | 2.10E-01 | -3.40E+47 | 2 | 2.80E+02 | 1 | -2.80E+02 | -1 | 5.30E+00 | 1 | -5.30E+00 | -1 | 4.86E-02 |
| 2 | 2 | 0.02888 | -3.12E+00 | 4.43E-02 | -3.40E+47 | 2 | 1.98E+02 | 1 | -1.98E+02 | -1 | 3.75E+00 | 1 | -3.75E+00 | -1 | 1.02E-02 |
| 3 | 3 | 0.02888 | -4.68E+00 | 9.31E-03 | -3.40E+47 | 2 | 1.61E+02 | 1 | -1.61E+02 | -1 | 3.06E+00 | 1 | -3.06E+00 | -1 | 2.15E-03 |
| 4 | 4 | 0.02888 | -6.24E+00 | 1.96E-03 | -3.40E+47 | 2 | 1.40E+02 | 1 | -1.40E+02 | -1 | 2.65E+00 | 0.9998 | -2.65E+00 | -1 | 4.53E-04 |
| 5 | 5 | 0.02888 | -7.79E+00 | 4.12E-04 | -3.40E+47 | 2 | 1.25E+02 | 1 | -1.25E+02 | -1 | 2.37E+00 | 0.9992 | -2.37E+00 | -0.999 | 9.52E-05 |
| 6 | 6 | 0.02888 | -9.35E+00 | 8.67E-05 | -3.40E+47 | 2 | 1.14E+02 | 1 | -1.14E+02 | -1 | 2.17E+00 | 0.9978 | -2.17E+00 | -0.998 | 2.00E-05 |
| 7 | 7 | 0.02888 | -1.09E+01 | 1.82E-05 | -3.40E+47 | 2 | 1.06E+02 | 1 | -1.06E+02 | -1 | 2.00E+00 | 0.9954 | -2.00E+00 | -0.995 | 4.20E-06 |
| 8 | 8 | 0.02888 | -1.25E+01 | 3.84E-06 | -3.40E+47 | 2 | 9.88E+01 | 1 | -9.88E+01 | -1 | 1.88E+00 | 0.992 | -1.88E+00 | -0.992 | 8.80E-07 |
| 9 | 9 | 0.02888 | -1.40E+01 | 8.08E-07 | -3.40E+47 | 2 | 9.32E+01 | 1 | -9.32E+01 | -1 | 1.77E+00 | 0.9876 | -1.77E+00 | -0.988 | 1.84E-07 |
| 10 | 10 | 0.02888 | -1.56E+01 | 1.70E-07 | -3.40E+47 | 2 | 8.84E+01 | 1 | -8.84E+01 | -1 | 1.68E+00 | 0.9823 | -1.68E+00 | -0.982 | 3.86E-08 |
| 11 | 11 | 0.02888 | -1.71E+01 | 3.58E-08 | -3.40E+47 | 2 | 8.43E+01 | 1 | -8.43E+01 | -1 | 1.60E+00 | 0.9763 | -1.60E+00 | -0.976 | 8.06E-09 |
| 12 | 12 | 0.02888 | -1.87E+01 | 7.52E-09 | -3.40E+47 | 2 | 8.07E+01 | 1 | -8.07E+01 | -1 | 1.53E+00 | 0.9696 | -1.53E+00 | -0.97 | 1.69E-09 |
| 13 | 13 | 0.02888 | -2.03E+01 | 1.58E-09 | -3.40E+47 | 2 | 7.75E+01 | 1 | -7.75E+01 | -1 | 1.47E+00 | 0.9625 | -1.47E+00 | -0.962 | 3.52E-10 |
| 14 | 14 | 0.02888 | -2.18E+01 | 3.33E-10 | -3.40E+47 | 2 | 7.47E+01 | 1 | -7.47E+01 | -1 | 1.42E+00 | 0.955 | -1.42E+00 | -0.955 | 7.35E-11 |
| 15 | 15 | 0.02888 | -2.34E+01 | 7.01E-11 | -3.40E+47 | 2 | 7.22E+01 | 1 | -7.22E+01 | -1 | 1.37E+00 | 0.9472 | -1.37E+00 | -0.947 | 1.53E-11 |
| 16 | 16 | 0.02888 | -2.49E+01 | 1.47E-11 | -3.40E+47 | 2 | 6.99E+01 | 1 | -6.99E+01 | -1 | 1.33E+00 | 0.9392 | -1.33E+00 | -0.939 | 3.20E-12 |
| 17 | 17 | 0.02888 | -2.65E+01 | 3.10E-12 | -3.40E+47 | 2 | 6.78E+01 | 1 | -6.78E+01 | -1 | 1.29E+00 | 0.9311 | -1.29E+00 | -0.931 | 6.67E-13 |
| 18 | 18 | 0.02888 | -2.81E+01 | 6.53E-13 | -3.40E+47 | 2 | 6.59E+01 | 1 | -6.59E+01 | -1 | 1.25E+00 | 0.9229 | -1.25E+00 | -0.923 | 1.39E-13 |
| 19 | 19 | 0.02888 | -2.96E+01 | 1.37E-13 | -3.40E+47 | 2 | 6.41E+01 | 1 | -6.41E+01 | -1 | 1.22E+00 | 0.9147 | -1.22E+00 | -0.915 | 2.90E-14 |
| 20 | 20 | 0.02888 | -3.12E+01 | 2.89E-14 | -3.40E+47 | 2 | 6.25E+01 | 1 | -6.25E+01 | -1 | 1.19E+00 | 0.9065 | -1.19E+00 | -0.906 | 6.05E-15 |




| | |
|---|---|
| Date: | 24/02/2020 |
| Version: | 1 |

# R&D Publication 20 Remedial Targets Worksheet, Release 3.2

## Level 3 - Groundwater

See Note

| Input Parameters (using pull down menu) | Variable | Value | Unit | Source |
|---|---|---|---|---|
| Contaminant | | Vanadium | | from Level 1 |
| Target Concentration | $C_T$ | 2.00E-02 | mg/l | from Level 1 |

**Select analytical solution (click on brown cell below, then on pull-down menu)**

Domenico - Steady state — Equations in HRA publication

Approach for simulating vertical dispersion: Simulate vertical dispersion in 1 direction

**Select nature of decay rate (click on brown cell below, then on pull-down menu)**

Approach for simulating degradation of pollutants: Apply degradation rate to dissolved pollutants only

| | | | | Source of parameter value |
|---|---|---|---|---|
| Initial contaminant concentration in groundwater at plume core | $C_0$ | 9.70E-01 | mg/l | *Based on average soil conc of 206.93mg/kg* |
| Half life for degradation of contaminant in water | $t_{1/2}$ | 9.00E+99 | days | *Estimation* |
| Calculated decay rate | $\lambda$ | 7.70E-101 | $days^{-1}$ | |
| Width of plume in aquifer at source (perpendicular to flow) | Sz | 5.00E+02 | m | *Site data* |
| Plume thickness at source | Sy | 1.50E+00 | m | *Thickness of re-engineered MG* |
| Saturated aquifer thickness | da | 2.00E+00 | m | *Based upon proposed total MG and cappi* |
| Bulk density of aquifer materials | $\rho$ | 1.36E+00 | $g/cm^3$ | *Site data* |
| Effective porosity of aquifer | n | 8.00E-02 | fraction | *Estimate* |
| Hydraulic gradient | i | 1.00E-02 | fraction | |
| Hydraulic conductivity of aquifer | K | 8.64E-03 | m/d | *Proposed best achievable* |
| Distance to compliance point | x | 2.00E+01 | m | *Site data* |
| Distance (lateral) to compliance point perpendicular to flow direction | z | | m | |
| Distance (depth) to compliance point perpendicular to flow direction | y | | m | |
| Time since pollutant entered groundwater | t | 1.00E+100 | days | *time variant options only* |
| *Parameters values determined from options* | | | | |
| Partition coefficient | Kd | 2.13E+02 | l/kg | *see options* |
| Longitudinal dispersivity | ax | 1.57E+00 | m | *see options* |
| Transverse dispersivity | az | 1.57E-01 | m | *see options* |
| Vertical dispersivity | ay | 1.57E-02 | m | *see options* |

**Select Method for deriving Partition Co-efficient (using pull down menu)**

User specified value for partition coefficient

***Entry if specify partition coefficient (option)***

Soil water partition coefficient — Kd — 2.13E+02 — l/kg

***Entry for non-polar organic chemicals (option)***

Fraction of organic carbon in aquifer — foc — fraction

Organic carbon partition coefficient — Koc — l/kg

***Entry for ionic organic chemicals (option)***

Sorption coefficient for related species — $K_{oc,n}$ — l/kg

Sorption coefficient for ionised species — $K_{oc,i}$ — l/kg

pH value — pH

acid dissociation constant — pKa

Fraction of organic carbon in aquifer — foc — fraction

Soil water partition coefficient — Kd — 2.13E+02 — l/kg

**Define dispersivity (click brown cell and use pull down list)**

Dispersivity based on Xu & Eckstein (1995)

| | | Enter value | Calc value Xu & Eckstein | | |
|---|---|---|---|---|---|
| **Longitudinal dispersivity** | **ax** | 0.00E+00 | 2.00E+00 | 1.57E+00 | m |
| **Transverse dispersivity** | **az** | 0.00E+00 | 2.00E-01 | 1.57E-01 | m |
| **Vertical dispersivity** | **ay** | 0.00E+00 | 2.00E-02 | 1.57E-02 | |

**Note values of dispersivity must be > 0**

For calculated value, assumes ax = 0.1 *x, az = 0.01 * x, ay = 0.001 * x

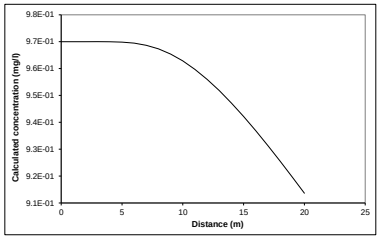
Xu & Eckstein (1995) report ax = $0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed

| Calculated Parameters | Variable | | |
|---|---|---|---|
| Groundwater flow velocity | v | 1.08E-03 | m/d |
| Retardation factor | Rf | 3.62E+03 | fraction |
| Decay rate used | $\lambda$ | 2.13E-104 | $d^{-1}$ |
| Rate of contaminant flow due to retardation | u | 2.98E-07 | m/d |
| Contaminant concentration at distance x, assuming one-way vertical dispersion | $C_{ED}$ | 9.14E-01 | mg/l |
| **Attenuation factor (one way vertical dispersion, CO/CED)** | **AF** | **1.06E+00** | |

## Remedial Targets

| | | | | |
|---|---|---|---|---|
| **Remedial Target** | | **2.12E-02** | **mg/l** | For comparison with measured groundwater concentration. |
| Domenico - Steady state | | | | |
| **Distance to compliance point** | | **20** | **m** | |
| **Concentration of contaminant at compliance point** | **$C_{ED}/C_0$** | **9.14E-01** | **mg/l** | Domenico - Steady state |

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99.




Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared with the Level 3 remedial target to determine the need for further action.
Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O2, NO3, SO4 etc than an alternative solution should be used

| | |
|---|---|
| Site being assessed: | Glan Llyn |
| Completed by: | Ross Cameron |
| Date: | ####### |
| Version: | 1 |

**Calculated concentrations for distance-concentration graph**

**Domenico - Steady state**
**From calculation sheet**

| Distance | Concentration |
|---|---|
| | mg/l |
| 0 | 9.7E-01 |
| 1.0 | 9.70E-01 |
| 2.0 | 9.70E-01 |
| 3.0 | 9.70E-01 |
| 4.0 | 9.70E-01 |
| 5.0 | 9.70E-01 |
| 6.0 | 9.69E-01 |
| 7.0 | 9.69E-01 |
| 8.0 | 9.67E-01 |
| 9.0 | 9.65E-01 |
| 10.0 | 9.63E-01 |
| 11.0 | 9.60E-01 |
| 12.0 | 9.56E-01 |
| 13.0 | 9.52E-01 |
| 14.0 | 9.47E-01 |
| 15.0 | 9.42E-01 |
| 16.0 | 9.37E-01 |
| 17.0 | 9.31E-01 |
| 18.0 | 9.26E-01 |
| 19.0 | 9.20E-01 |
| 20.0 | 9.14E-01 |

# Hydrogeological risk assessment for land contamination

## Remedial Targets Worksheet , Release 3.2

**First released: 2006. Version 3.2: January 2013**

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination ( Environment Agency 2006).

**Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.**

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The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

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IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

| Details to be completed for each assessment | | | | |
|---|---|---|---|---|
| Site Name: | Glan Llyn | | | |
| Site Address: | Llanwern | | | |
| Completed by: | Ross Cameron | | | |
| Date: | 24-Feb-20 | | Version: | 1 |
| Contaminant | Benzo(a)pyrene | | | |
| Target Concentration ($C_T$) | 0.00000017 | mg/l | Origin of $C_T$: | Proposed Water Framework Directive EQS |

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparision with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).
Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.
Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.
Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.
Data carried forward from an earlier worksheet are identified by a light green background
It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

## Remedial Targets Worksheet , Release 3.2

# Level 1 - Soil

**Select the method of calculating the soil water Partition Co-efficient by using the pull down menu below**

**User specified value for partition coefficient**

| | | | | |
|---|---|---|---|---|
| **Contaminant** | | **Benzo(a)pyrene** | | |
| **Target concentration** | $C_T$ | **0.00000017** | **mg/l** | |

| **Input Parameters** | **Variable** | **Value** | **Unit** | **Source of parameter value** |
|---|---|---|---|---|
| ***Standard entry*** | | | | |
| Water filled soil porosity | $\theta_w$ | 5.00E-01 | fraction | 0.5 |
| Air filled soil porosity | $\theta a$ | 3.70E-01 | fraction | 0.0037 |
| Bulk density of soil zone material | $\rho$ | 1.36E+00 | g/cm$^3$ | 1.36 |
| Henry's Law constant | H | 1.00E+00 | dimensionless | *1* |
| ***Entry if specify partition coefficient (option)*** | | | | |
| Soil water partition coefficient | Kd | 1.34E+02 | l/kg | *1.34E+02* |
| ***Entry for non-polar organic chemicals (option)*** | | | | |
| Fraction of organic carbon (in soil) | foc | | fraction | |
| Organic carbon partition coefficient | Koc | | l/kg | |
| ***Entry for ionic organic chemicals (option)*** | | | | |
| Sorption coefficient for neutral species | $K_{oc,n}$ | | l/kg | |
| Sorption coefficient for ionised species | $K_{oc,i}$ | | l/kg | |
| pH value | pH | | pH units | |
| Acid dissociation constant | pKa | | | |
| Fraction of organic carbon (in soil) | foc | | fraction | |

This sheet calculates the Level 1 remedial target for soils(mg/kg) based on a selected target concentration and theoretical calculation of soil water partitioning. Three options are included for determining the partition coefficient.
The measured soil concentration as mg/kg should be compared with the Level 1 remedial target to determine the need for further action.

| | | | | |
|---|---|---|---|---|
| **Soil water partition coefficient used in Level Assessment** | **Kd** | **1.34E+02** | **l/kg** | *Specified value* |

## Level 1 Remedial Target

| | | | |
|---|---|---|---|
| **Level 1 Remedial Target** | **2.29E-05** | **mg/kg** | **(for comparison with soil analyses)** |
| | **or** | | |
| | **0.00000017** | **mg/l** | **(for comparison with leachate test results)** |

| | |
|---|---|
| Site being assessed: | Glan Llyn |
| Completed by: | Ross Cameron |
| Date: | 24-Feb-20 |
| Version: | 1 |

## Remedial Targets Worksheet , Release 3.2

# Level 2 - Soil

| | | | | |
|---|---|---|---|---|
| **Contaminant** | | **Benzo(a)pyrene** | | from Level 1 |
| **Target concentration** | **$C_T$** | **0.00000017** | **mg/l** | from Level 1 |

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamiantion' (Environment Agency 2006)

| **Input Parameters** | **Variable** | **Value** | **Unit** | **Source of parameter value** | |
|---|---|---|---|---|---|
| *Standard entry* | | | | | |
| Infiltration | Inf | 0.00E+00 | m/d | | |
| Area of contaminant source | A | 0.00E+00 | $m^2$ | | Not used in calculation |
| *Entry for groundwater flow below site* | | | | | |
| Length of contaminant source in direction of groundwater flow | L | 0.00E+00 | m | | |
| Saturated aquifer thickness | da | 0.00E+00 | m | | |
| Hydraulic Conductivity of aquifer in which dilution occurs | K | 0.00E+00 | m/d | | |
| Hydraulic gradient of water table | i | 0.00E+00 | fraction | | |
| Width of contaminant source perpendicular to groundwater flow | w | 0.00E+00 | m | | Not used in calculation |
| Background concentration of contaminant in groundwater beneath site | Cu | 0.00E+00 | mg/l | | |
| Define mixing zone depth by specifying or calculating depth (using pull down list) | | **Specify** | | | |
| Enter mixing zone thickness | Mz | 0.00E+00 | m | | |
| Calculated mixing zone thickness | Mz | | m | | |

## Calculated Parameters

| | | | | |
|---|---|---|---|---|
| **Dilution Factor** | **DF** | **#DIV/0!** | | |
| **Level 2 Remedial Target** | | **#DIV/0!** | **mg/l** | **For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentra** |
| | | **or** | | |
| | | **#DIV/0!** | **mg/kg** | **For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water** |

## *Additional option*

**Calculation of impact on receptor**

| | | | | |
|---|---|---|---|---|
| Concentration of contaminant in contaminated discharge (entering receptor) | Cc | 0.00E+00 | mg/l | |
| Calculated concentration within receptor (dilution only) | | #DIV/0! | mg/l | 0 |

| | |
|---|---|
| Site being assessed: | Glan Llyn |
| Completed by: | Ross Cameron |
| Date: | 24-Feb-20 |
| Version: | 1 |

**Remedial Targets Worksheet , Release 3.2**

## Level 3 - Soil

See Note

### Input Parameters

| | Variable | Value | Unit | Source |
|---|---|---|---|---|
| Contaminant | | Benzo(a)pyrene | | from Level 1 |
| Target Concentration | $C_T$ | 0.00000017 | mg/l | from Level 1 |
| Dilution Factor | DF | #DIV/0! | | from Level 2 |

**Select analytical solution (click on brown cell below, then on pull-down menu)**

Ogata Banks — Equations in HRA publication

**Select nature of decay rate (click on brown cell below, then on pull-down menu)**

Approach for simulating degradation of pollutants: Apply degradation rate to pollutants in all phases (e.g. field derived value, lab derived value)

| | Variable | Value | Unit | Source of parameter value |
|---|---|---|---|---|
| Enter source concentration | | Soil concentration as mg/kg | | |
| Enter soil concentration | | 0 | mg/kg | |
| Half life for degradation of contaminant in water | $t_{1/2}$ | 1.00E+100 | days | |
| Calculated decay rate | $\lambda$ | 6.93E-101 | $days^{-1}$ | calculated |
| Width of plume in aquifer at source | Sz | 0.00E+00 | m | from Level 2 |
| Plume thickness in aquifer at source | Sy | 0.00E+00 | m | from Level 2 |
| Bulk density of aquifer materials | $\rho$ | 0.00E+00 | $g/cm^3$ | |
| Effective porosity of aquifer | n | 0.00E+00 | fraction | |
| Hydraulic gradient | i | #DIV/0! | fraction | from Level 2 (adjusted) |
| Hydraulic conductivity of saturated aquifer | K | 0.00E+00 | m/d | from Level 2 |
| Distance to compliance point | x | 0.00E+00 | m | |
| Distance (lateral) to compliance point perpendicular to flow direction | z | | m | |
| Distance (depth) to compliance point perpendicular to flow direction | y | | m | |
| Time since pollutant entered groundwater | t | 1.00E+99 | days | *time variant options only* |
| *Parameters values determined from options* | | | | |
| Partition coefficient | Kd | 0.00E+00 | l/kg | *see options* |
| Longitudinal dispersivity | ax | 0.000 | m | *see options* |
| Transverse dispersivity | az | 0.000 | m | *see options* |
| Vertical dispersivity | av | 0.000 | m | *see options* |

***Parameter values should be checked against Level 1 and 2***

### Calculated Parameters

| | Variable | | |
|---|---|---|---|
| Groundwater flow velocity | v | #DIV/0! | m/d |
| Retardation factor | Rf | #DIV/0! | fraction |
| Decay rate used | $\lambda$ | 6.93E-101 | $d^{-1}$ |
| Hydraulic gradient used in aquifer flow down-gradient | i | #DIV/0! | fraction |
| Rate of contaminant flow due to retardation | u | #DIV/0! | m/d |
| Ratio of Compliance Point to Source Concentration | $C_{ED}/C_0$ | #DIV/0! | fraction |
| **Attenuation factor ($C_0/C_{ED}$)** | **AF** | **#DIV/0!** | **fraction** |
| Calculated soil leachate concentration | Co | 0.00E+00 | mg/l |

### Remedial Targets

| | | | |
|---|---|---|---|
| **Level 3 Remedial Target** | **#DIV/0!** | **mg/l** | For comparison with measured pore water concentration. |
| Ogata Banks | **or** | | This assumes Level 1 Remedial Target is based on Target Concentration. |
| | **#DIV/0!** | **mg/kg** | For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water partitioning equation. |
| **Distance to compliance point** | **0** | **m** | |
| **Ratio of Compliance Point to Source Concentration** | **$C_{ED}/C_0$** | **#DIV/0!** | **fraction** Ogata Banks |

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99

**Enter method of defining partition co-efficient (using pull down list)**

Calculate for ionic organic chemicals (acids)

*Entry if specify partition coefficient (option)*

| | | | |
|---|---|---|---|
| Soil water partition coefficient | Kd | | l/kg |

*Entry for non-polar organic chemicals (option)*

| | | | |
|---|---|---|---|
| Fraction of organic carbon in aquifer | foc | | fraction |
| Organic carbon partition coefficient | Koc | | l/kg |

*Entry for ionic organic chemicals (option)*

| | | | |
|---|---|---|---|
| Sorption coefficient for related species | $K_{oc,n}$ | 0.00E+00 | l/kg |
| Sorption coefficient for ionised species | $K_{oc,i}$ | 0.00E+00 | l/kg |
| pH value | pH | 0.00E+00 | |
| Acid dissociation constant | pKa | 0.00E+00 | |
| Fraction of organic carbon in aquifer | foc | 0.00E+00 | fraction |
| Soil water partition coefficient | Kd | 0.00E+00 | l/kg |

**Define dispersivity (click brown cell and use pull down list)**

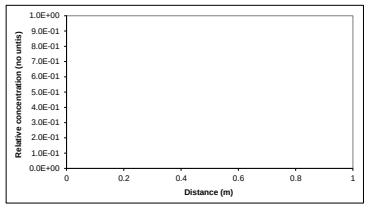
User defined values for dispersivity

| | | Enter value | Calc value | Xu & Eckstein | |
|---|---|---|---|---|---|
| **Longitudinal dispersivity** | **ax** | 0.00E+00 | 0.00E+00 | #NUM! | m |
| **Transverse dispersivity** | **az** | 0.00E+00 | 0.00E+00 | #NUM! | m |
| **Vertical dispersivity** | **ay** | 0.00E+00 | 0.00E+00 | #NUM! | m |

**Note values of dispersivity must be > 0**

Xu & Eckstein (1995) report ax = $0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed

Note
This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by $O_2$, $NO_3$, $SO_4$ etc than an alternative solution should be used




Note: 'Relative concentration' is the ratio of calculated concentation at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

| | |
|---|---|
| Site being assessed: | Glan Llyn |
| Completed by: | Ross Cameron |
| Date: | ######## |
| Version: | 1 |

**Calculated (relative) concentrations for distance-concentration graph**

Ogata Banks
From calculation sheet

| Distance | Relative concentration (No units) | Concentration mg/l |
|---|---|---|
| 0 | 1.0E+00 | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |

# Remedial Targets Worksheet , Release 3.2

## Calculation of contaminant concentration in groundwater from a soil source

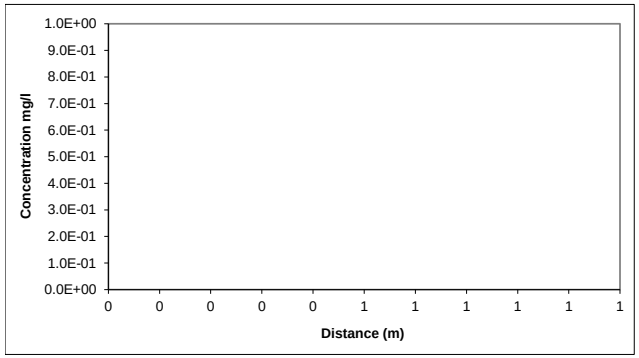
Only input required is Soil Contaminant Concentration

| | | | | |
|---|---|---|---|---|
| | Input Parameters | | | |
| | Soil contaminant concentration | $C_0$ | 0.00E+00 | mg/kg |
| **Level 1 Parameters** | | | | |
| | Water filled soil porosity | $\theta_w$ | 5.00E-01 | fraction |
| | Air filled soil porosity | $\theta a$ | 3.70E-01 | fraction |
| | Bulk density | $\rho$ | 1.36E+00 | g/cm$^3$ |
| | Henry's Law constant | H | 1.00E+00 | dimensionless |
| | Soil water partition coefficient used in Level Assessment | Kd | 1.34E+02 | l/kg |
| | Factor (partitioning between soil and water) | | 1.35E+02 | dimensionless |
| **Level 2 Parameters** | **Dilution Factor** | DF | #DIV/0! | |
| **Level 3 Parameters** | **Attenuation factor ($C_O/C_{ED}$)** | AF | #DIV/0! | |

### Predicted concentrations at compliance point

| | | | | |
|---|---|---|---|---|
| **Level 1** | C | 0.00E+00 | mg/l | No dilution or attenuation |
| **Level 2** | C | #DIV/0! | mg/l | Dilution taken into account |
| **Level 3** | C | #DIV/0! | mg/l | Dilution and attenuation taken into account |

### Predicted concentrations between source and compliance point - Level 3




| Distance m | Concentration mg/l |
|---|---|
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
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| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |

# R&D Publication 20 Remedial Targets Worksheet, Release 3.2

## Level 3 - Groundwater

See Note

**Input Parameters (using pull down menu)** | Variable | Value | Unit | Source

| | | | | |
|---|---|---|---|---|
| Contaminant | | Benzo(a)pyrene | | from Level 1 |
| Target Concentration | $C_T$ | 1.70E-07 | mg/l | from Level 1 |

**Select analytical solution (click on brown cell below, then on pull-down menu)**

Domenico - Steady state — Equations in HRA publication

Approach for simulating vertical dispersion: Simulate vertical dispersion in 1 direction

**Select nature of decay rate (click on brown cell below, then on pull-down menu)**

Approach for simulating degradation of pollutants: Apply degradation rate to dissolved pollutants only

| | | | | Source of parameter value |
|---|---|---|---|---|
| Initial contaminant concentration in groundwater at plume core | $C_0$ | 7.00E-02 | mg/l | *Based on max soil conc of 714mg/kg* |
| Half life for degradation of contaminant in water | $t_{1/2}$ | 3.65E+04 | days | *10 year half life estimation* |
| Calculated decay rate | λ | 1.90E-05 | $days^{-1}$ | |
| Width of plume in aquifer at source (perpendicular to flow) | Sz | 5.00E+02 | m | *Site data* |
| Plume thickness at source | Sy | 1.50E+00 | m | *Thickness of re-engineered MG* |
| Saturated aquifer thickness | da | 2.00E+00 | m | *Based upon proposed total MG and cappi* |
| Bulk density of aquifer materials | ρ | 1.36E+00 | $g/cm^3$ | *Site data* |
| Effective porosity of aquifer | n | 8.00E-02 | fraction | *Estimate* |
| Hydraulic gradient | i | 1.00E-02 | fraction | *Estimate* |
| Hydraulic conductivity of aquifer | K | 8.64E-03 | m/d | *Proposed best achievable* |
| Distance to compliance point | x | 2.00E+01 | m | *Site data* |
| Distance (lateral) to compliance point perpendicular to flow direction | z | | m | |
| Distance (depth) to compliance point perpendicular to flow direction | y | | m | |
| Time since pollutant entered groundwater | t | 1.00E+100 | days | *time variant options only* |
| *Parameters values determined from options* | | | | |
| Partition coefficient | Kd | 1.02E+04 | l/kg | *see options* |
| Longitudinal dispersivity | ax | 2.00E+00 | m | *see options* |
| Transverse dispersivity | az | 2.00E-01 | m | *see options* |
| Vertical dispersivity | ay | 2.00E-02 | m | *see options* |

**Calculated Parameters** | Variable

| | | | |
|---|---|---|---|
| Groundwater flow velocity | v | 1.08E-03 | m/d |
| Retardation factor | Rf | 1.73E+05 | fraction |
| Decay rate used | λ | 1.10E-10 | $d^{-1}$ |
| Rate of contaminant flow due to retardation | u | 6.24E-09 | m/d |
| Contaminant concentration at distance x, assuming one-way vertical dispersion | $C_{ED}$ | 4.52E-02 | mg/l |
| **Attenuation factor (one way vertical dispersion, CO/CED)** | **AF** | **1.55E+00** | |

**Select Method for deriving Partition Co-efficient (using pull down menu)**

User specified value for partition coefficient

***Entry if specify partition coefficient (option)***

| | | | |
|---|---|---|---|
| Soil water partition coefficient | Kd | 1.02E+04 | l/kg |

***Entry for non-polar organic chemicals (option)***

| | | | |
|---|---|---|---|
| Fraction of organic carbon in aquifer | foc | | fraction |
| Organic carbon partition coefficient | Koc | | l/kg |

***Entry for ionic organic chemicals (option)***

| | | | |
|---|---|---|---|
| Sorption coefficient for related species | $K_{oc,n}$ | | l/kg |
| Sorption coefficient for ionised species | $K_{oc,i}$ | | l/kg |
| pH value | pH | | |
| acid dissociation constant | pKa | | |
| Fraction of organic carbon in aquifer | foc | | fraction |
| Soil water partition coefficient | Kd | 1.02E+04 | l/kg |

**Define dispersivity (click brown cell and use pull down list)**

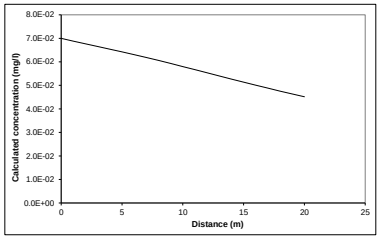
Dispersivities 10%, 1%, 0.1% of pathway length

| | | Enter value | Calc value Xu & Eckstein | | |
|---|---|---|---|---|---|
| **Longitudinal dispersivity** | **ax** | 0.00E+00 | 2.00E+00 | 1.57E+00 | m |
| **Transverse dispersivity** | **az** | 0.00E+00 | 2.00E-01 | 1.57E-01 | m |
| **Vertical dispersivity** | **ay** | 0.00E+00 | 2.00E-02 | 1.57E-02 | |

**Note values of dispersivity must be > 0**

For calculated value, assumes ax = 0.1 *x, az = 0.01 * x, ay = 0.001 * x

Xu & Eckstein (1995) report ax = $0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed




Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared with the Level 3 remedial target to determine the need for further action.
Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O2, NO3, SO4 etc than an alternative solution should be used

**Calculated concentrations for distance-concentration graph**

**Domenico - Steady state**
**From calculation sheet**

| Distance | Concentration |
|---|---|
| | mg/l |
| 0 | 7.0E-02 |
| 1.0 | 6.88E-02 |
| 2.0 | 6.77E-02 |
| 3.0 | 6.65E-02 |
| 4.0 | 6.54E-02 |
| 5.0 | 6.42E-02 |
| 6.0 | 6.31E-02 |
| 7.0 | 6.19E-02 |
| 8.0 | 6.06E-02 |
| 9.0 | 5.93E-02 |
| 10.0 | 5.80E-02 |
| 11.0 | 5.67E-02 |
| 12.0 | 5.53E-02 |
| 13.0 | 5.40E-02 |
| 14.0 | 5.27E-02 |
| 15.0 | 5.14E-02 |
| 16.0 | 5.01E-02 |
| 17.0 | 4.88E-02 |
| 18.0 | 4.76E-02 |
| 19.0 | 4.63E-02 |
| 20.0 | 4.52E-02 |

| | |
|---|---|
| Site being assessed: | Glan Llyn |
| Completed by: | Ross Cameron |
| Date: | ####### |
| Version: | 1 |

**Remedial Targets**

| | | | | |
|---|---|---|---|---|
| **Remedial Target** | | **2.64E-07** | **mg/l** | For comparison with measured groundwater concentration. |
| Domenico - Steady state | | | | |
| **Distance to compliance point** | | **20** | **m** | |
| **Concentration of contaminant at compliance point** | $C_{ED}/C_0$ | **4.52E-02** | **mg/l** | Domenico - Steady state |

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99.

# Porosity Calculator

These results are not carried through to any of the other worksheets

## DRY BULK DENSITY DATA

| Variable | Value | Unit | justification |
|---|---|---|---|
| Natural Moisture Content | 0.00 | % wt | |
| Particle Density | 2.78 | tonnes/m$^3$ | (Change this number only if you have specific information) |
| Dry Bulk Density | 0.00 | tonnes/m$^3$ | |
| *Calculated Parameters* | | | |
| Voids Ratio | #DIV/0! | fraction | |
| Initial Saturation | #DIV/0! | % | |
| **Total porosity** | **1.000** | **fraction** | |
| **Air Filled Porosity** | **#DIV/0!** | **fraction** | |
| **Water Filled Porosity** | **#DIV/0!** | **fraction** | |

## WET BULK DENSITY DATA

| Variable | Value | Unit | |
|---|---|---|---|
| Moisture Content | 0.00 | % wt | |
| Particle Density | 2.78 | tonnes/m$^3$ | (Change this number only if you have specific information) |
| Actual (wet) Bulk Density ( i.e. at natural MC) | 0.00 | tonnes/m$^3$ | |
| *Calculated Parameters* | | | |
| Voids Ratio | #DIV/0! | fraction | |
| dry bulk density | 0.00 | tonnes/m$^3$ | |
| Initial Saturation | #DIV/0! | % | |
| **Total porosity** | **1.000** | **fraction** | **#DIV/0!** |
| **Air Filled Porosity** | **#DIV/0!** | **fraction** | |
| **Water Filled Porosity** | **#DIV/0!** | **fraction** | |

*Analytical solutions provided by David Hall, Golder Associates (UK) Ltd*

# Simple hydrogeological calculations

**(These are not specific to, or required in, the Remedial Targets Methodology)**

| Parameter | symbol | | unit | justification |
|---|---|---|---|---|
| Hydraulic conductivity | K | 0.00E+00 | m/d | |
| Hydraulic gradient | i | 0.00E+00 | unitless | |
| Effective porosity of aquifer | n | 0.00E+00 | fraction | |
| Thickness of saturated aquifer | b | 0.00E+00 | m | |
| Width of aquifer perpendicular to flow | w | 0.00E+00 | m | |
| Distance to receptor | x | 0.00E+00 | m | |
| Bulk density of aquifer materials | ρ | 0.00E+00 | g/cm$^3$ | |
| Soil-water partition co-efficient | Kd | 0.00E+00 | l/kg | |
| Retardation factor of pollutant | R | #DIV/0! | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Groundwater flow velocity | v(GW) | #DIV/0! | m/s | #DIV/0! | m/day | #DIV/0! | m/year |
| Time for groundwater to reach receptor | t(GW) | #DIV/0! | seconds | #DIV/0! | days | #DIV/0! | years |
| Rate of groundwater flow through aquifer | Q | 0.00E+00 | m$^3$/s | 0.00E+00 | m$^3$/day | 0.00E+00 | m$^3$/year |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Contaminant flow velocity | v(contam) | #DIV/0! | m/s | #DIV/0! | m/day | #DIV/0! | m/year |
| Time for contaminant to reach receptor | t(contam) | #DIV/0! | seconds | #DIV/0! | days | #DIV/0! | years |

## Level 1 Calculation Sheet

**Contaminant** **Benzo(a)pyrene**

| **Parameter** (carried over from input sheet) | **Value** | **Units** |
|---|---|---|
| $C_T$ | 1.70E-07 | mg/l |
| Kd | 1.34E+02 | l/kg |
| foc | | fraction |
| koc | | l/kg |
| $\theta_W$ | 5.00E-01 | fraction |
| $\theta a$ | 3.70E-01 | fraction |
| $\rho$ | 1.36E+00 | g/cm3 |
| H | 1.00E+00 | dimensionless |
| Koc,n | | l/kg |
| Koc,i | | l/kg |
| pH | | pH units |
| pKa | | |
| foc (ionic) | | fraction |

**Calculations (Refer toTable 4.3, R&D Publication 20)**

**Selected option** User specified value for partition coefficient

| | calc | calc | Calc Kd | l/kg |
|---|---|---|---|---|
| Calculation of partition coefficient for ionic organic chemical | | | | |
| Partition coefficient used in Level 1 Assessment | | | 1.34E+02 | l/kg |

| **Calculated Remedial Target** | **2.29E-05** | **mg/kg** | **for** | **Benzo(a)pyrene** |
|---|---|---|---|---|

Factor (partitioning between soil and water) 1.35E+02

| | |
|---|---|
| Site being assessed: | Glan Llyn |
| Completed by: | Ross Cameron |
| Date: | 24/02/2020 |
| Version: | 1 |

## Level 2 Calculation Sheet

**Contaminant** **Benzo(a)pyrene**

| | |
|---|---|
| Site assessed: | Glan Llyn |
| Date: | 24/02/2020 |
| Version: | 1 |

| Parameter | Value | Units |
|---|---|---|
| (carried over from input sheet) | | |
| Mz | 0.00E+00 | m |
| L | 0.00E+00 | m |
| da | 0.00E+00 | m |
| Inf | 0.00E+00 | m/d |
| K | 0.00E+00 | m/d |
| i | 0.00E+00 | |
| | | m3/d |
| A | 0.00E+00 | m2 |
| | | m3/d |
| Cc | 0.00E+00 | mg/l |
| $C_T$ | 1.70E-07 | mg/l |
| Cu | 0.00E+00 | mg/l |
| w | 0.00E+00 | m |

Calculated Dilution Factor

Calculation based on target concentration #DIV/0!

Calculation based on observed contaminant concentration #DIV/0!



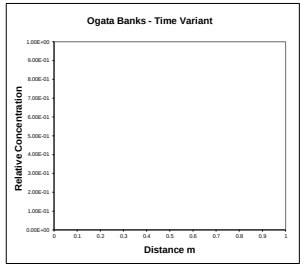
**OGATA BANKS SOLUTION**

**Contaminant** **Benzo(a)pyrene**

| Input | Value | Units |
|---|---|---|
| $C_T$ | 1.700E-07 | mg/l |
| DF | #DIV/0! | |
| | | |
| | | |
| λ | 6.931E-101 | $days^{-1}$ |
| Sz | 0.000E+00 | m |
| Sy | 0.000E+00 | m |
| Kd | 0.000E+00 | l/kg |
| ρ | 0.000E+00 | g/cm3 |
| n | 0.000E+00 | |
| i | #DIV/0! | |
| K | 0.000E+00 | m/d |
| x | 0.000E+00 | m |
| z | 0.000E+00 | m |
| y | 0.000E+00 | m |
| t | 1.000E+99 | days |
| ax | 0.000E+00 | m |
| az | 0.000E+00 | m |
| ay | 0.000E+00 | m |

Calculations for source located in centre of aquifer (ie vertical dispersion in two directions)

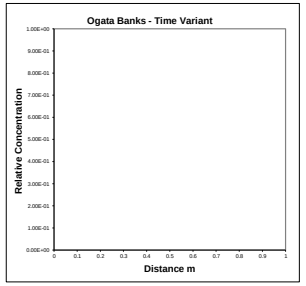
| | X | Term 1 | Term 2 | EXP | Term 3 | ERFC | Term 4 | EXP | Term 5 | ERFC | Term 6a | ERF | Term 6b | ERF | Term 7a | ERF | Term 7b | ERF | Relative Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 2 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 3 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 4 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 5 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 6 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 7 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 8 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 9 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 10 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 11 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 12 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 13 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 14 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 15 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 16 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 17 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 18 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 19 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 20 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |




| Calc | Value | |
|---|---|---|
| v | #DIV/0! | m/d |
| Rc | #DIV/0! | |
| u | #DIV/0! | m/d |

Calculations for source located at top of aquifer (ie vertical dispersion in one direction) -USED FOR LEVEL ASSESSMENT

| | X | Term 1 | Term 2 | EXP | Term 3 | ERFC | Term 4 | EXP | Term 5 | ERFC | Term 6a | ERF | Term 6b | ERF | Term 7a | ERF | Term 7b | ERF | Relative Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 2 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 3 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 4 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 5 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 6 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 7 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 8 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 9 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 10 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 11 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 12 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 13 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 14 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 15 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 16 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 17 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 18 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 19 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 20 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |




| | |
|---|---|
| Date: | 24/02/2020 |
| Version: | 1 |

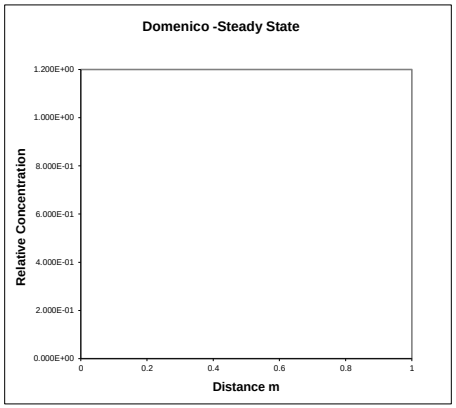
**Contaminant** **enzo(a)pyrene**

**DOMENICO (STEADY STATE)**

Calculations for source located in centre of aquifer (ie vertical dispersion in two directions)

| Input | Value | Units |
|---|---|---|
| $C_T$ | 1.700E-07 | mg/l |
| DF | #DIV/0! | |
| λ | 6.931E-101 | days$^{-1}$ |
| Sz | 0.000E+00 | m |
| Sy | 0.000E+00 | m |
| Kd | 0.000E+00 | l/kg |
| ρ | 0.000E+00 | g/cm3 |
| n | 0.000E+00 | |
| i | #DIV/0! | |
| K | 0.000E+00 | m/d |
| x | 0.000E+00 | m |
| z | 0.000E+00 | m |
| y | 0.000E+00 | m |
| ax | 0.000E+00 | m |
| az | 0.000E+00 | m |
| ay | 0.000E+00 | m |

| | X | Term 1 | Term 2 | EXP | Term 3A | ERF | Term 3B | ERF | Term 4A | ERF | Term 4B | ERF | Relative Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 2 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 3 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 4 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 5 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 6 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 7 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 8 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 9 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 10 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 11 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 12 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 13 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 14 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 15 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 16 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 17 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 18 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 19 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 20 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |



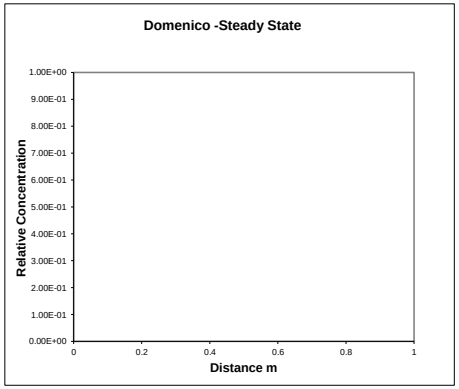

**Calc** **Value**

| | | |
|---|---|---|
| v | #DIV/0! | m/d |
| Rc | #DIV/0! | |
| u | #DIV/0! | m/d |

**DOMENICO (STEADY STATE)**

Calculations for source located at top of aquifer (ie vertical dispersion in one direction) - USED FOR LEVEL ASSESSMENT

| | X | Term 1 | Term 2 | EXP | Term 3A | ERF | Term 3B | ERF | Term 4A | ERF | Term 4B | ERF | Relative Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 2 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 3 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 4 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 5 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 6 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 7 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 8 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 9 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 10 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 11 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 12 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 13 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 14 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 15 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 16 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 17 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 18 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 19 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 20 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |




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|---|---|
| Date: | 24/02/2020 |
| Version: | 1 |

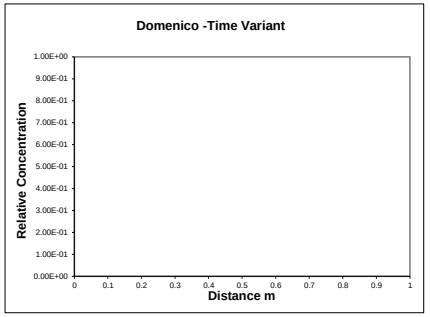
**DOMENICO (TIME VARIANT)**

**Contaminant** Benzo(a)pyrene

Calculations for source located in centre of aquifer (ie vertical dispersion in two directions)

| Input | Value | Units |
|---|---|---|
| $C_T$ | 0.00000017 | mg/l |
| DF | #DIV/0! | |
| λ | 6.931E-101 | days$^{-1}$ |
| Sz | 0.000E+00 | m |
| Sy | 0.000E+00 | m |
| Kd | 0.000E+00 | l/kg |
| ρ | 0.000E+00 | g/cm3 |
| n | 0.000E+00 | |
| i | #DIV/0! | |
| K | 0.000E+00 | m/d |
| x | 0.000E+00 | m |
| z | 0.000E+00 | m |
| y | 0.000E+00 | m |
| t | 1.000E+99 | days |
| ax | 0.000E+00 | m |
| az | 0.000E+00 | m |
| ay | 0.000E+00 | m |

| | X | Term 1 | Term 2 | EXP | Term 3 | ERFC | Term 4A | ERF | Term 4B | ERF | Term 5A | ERF | Term 5B | ERF | Relative Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | m | | | | | | | | | | | | | | |
| 1 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 2 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 3 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 4 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 5 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 6 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 7 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 8 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 9 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 10 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 11 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 12 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 13 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 14 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 15 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 16 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 17 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 18 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 19 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 20 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |

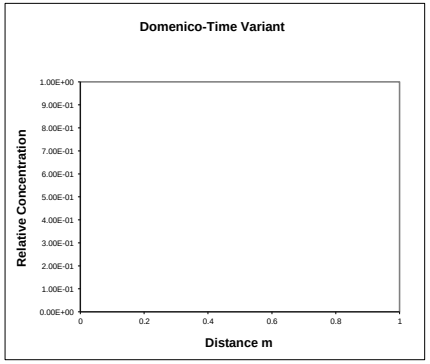



**Calc**

| Value | Value | |
|---|---|---|
| v | #DIV/0! | m/d |
| Rc | #DIV/0! | |
| u | #DIV/0! | m/d |

Calculations for source located at top of aquifer (ie vertical dispersion in one direction only) - USED FOR LEVEL ASSESSMENT

| | X | Term 1 | Term 2 | EXP | Term 3 | ERFC | Term 4A | ERF | Term 4B | ERF | Term 5A | ERF | Term 5B | ERF | Relative Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | m | | | | | | | | | | | | | | |
| 1 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 2 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 3 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 4 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 5 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 6 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 7 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 8 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 9 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 10 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 11 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 12 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 13 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 14 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 15 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 16 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 17 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 18 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 19 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 20 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |




| | |
|---|---|
| Date: | 24/02/2020 |
| Version: | 1 |

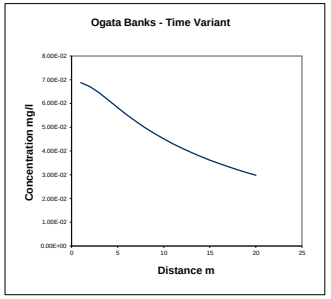
**OGATA BANKS SOLUTION**

**Contaminant** **Benzo(a)pyrene**

Calculations for source located in centre of aquifer (ie vertical dispersion in two directions)

| Input | Value | Units |
|---|---|---|
| $C_T$ | 0.00000017 | mg/l |
| Co | 7.00E-02 | mg/l |
| λ | 1.10E-10 | days$^{-1}$ |
| Sz | 5.00E+02 | m |
| Sy | 1.50E+00 | m |
| Kd | 1.02E+04 | l/kg |
| ρ | 1.36E+00 | g/cm3 |
| n | 8.00E-02 | |
| i | 1.00E-02 | |
| K | 8.64E-03 | m/d |
| x | 2.00E+01 | m |
| z | 0.00E+00 | m |
| y | 0.00E+00 | m |
| t | 1.00E+100 | days |
| ax | 2.00E+00 | m |
| az | 2.00E-01 | m |
| ay | 2.00E-02 | m |

| X | Term 1 | Term 2 | EXP | Term 3 | ERFC | Term 4 | EXP | Term 5 | ERFC | Term 6a | ERF | Term 6b | ERF | Term 7a | ERF | Term 7b | ERF | Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.00875 | -1.7E-02 | 9.8E-01 | -3.0E+45 | 2.000 | 5.2E-01 | 1.7E+00 | 3.0E+45 | 0.000 | 2.8E+02 | 1 | -2.8E+02 | -1 | 2.7E+00 | 0.9998 | -2.7E+00 | -0.99982 | 6.88E-02 |
| 2 | 0.00875 | -3.4E-02 | 9.7E-01 | -3.0E+45 | 2.000 | 1.0E+00 | 2.8E+00 | 3.0E+45 | 0.000 | 2.0E+02 | 1 | -2.0E+02 | -1 | 1.9E+00 | 0.992 | -1.9E+00 | -0.99199 | 6.71E-02 |
| 3 | 0.00875 | -5.1E-02 | 9.5E-01 | -3.0E+45 | 2.000 | 1.6E+00 | 4.7E+00 | 3.0E+45 | 0.000 | 1.6E+02 | 1 | -1.6E+02 | -1 | 1.5E+00 | 0.9696 | -1.5E+00 | -0.96962 | 6.45E-02 |
| 4 | 0.00875 | -6.8E-02 | 9.3E-01 | -3.0E+45 | 2.000 | 2.1E+00 | 7.9E+00 | 3.0E+45 | 0.000 | 1.4E+02 | 1 | -1.4E+02 | -1 | 1.3E+00 | 0.9392 | -1.3E+00 | -0.93921 | 6.14E-02 |
| 5 | 0.00875 | -8.5E-02 | 9.2E-01 | -3.0E+45 | 2.000 | 2.6E+00 | 1.3E+01 | 3.0E+45 | 0.000 | 1.3E+02 | 1 | -1.3E+02 | -1 | 1.2E+00 | 0.9065 | -1.2E+00 | -0.90647 | 5.83E-02 |
| 6 | 0.00875 | -1.0E-01 | 9.0E-01 | -3.0E+45 | 2.000 | 3.1E+00 | 2.2E+01 | 3.0E+45 | 0.000 | 1.1E+02 | 1 | -1.1E+02 | -1 | 1.1E+00 | 0.8742 | -1.1E+00 | -0.87421 | 5.53E-02 |
| 7 | 0.00875 | -1.2E-01 | 8.9E-01 | -3.0E+45 | 2.000 | 3.6E+00 | 3.7E+01 | 3.0E+45 | 0.000 | 1.1E+02 | 1 | -1.1E+02 | -1 | 1.0E+00 | 0.8436 | -1.0E+00 | -0.84362 | 5.24E-02 |
| 8 | 0.00875 | -1.4E-01 | 8.7E-01 | -3.0E+45 | 2.000 | 4.1E+00 | 6.3E+01 | 3.0E+45 | 0.000 | 9.9E+01 | 1 | -9.9E+01 | -1 | 9.4E-01 | 0.8151 | -9.4E-01 | -0.8151 | 4.98E-02 |
| 9 | 0.00875 | -1.5E-01 | 8.6E-01 | -3.0E+45 | 2.000 | 4.7E+00 | 1.0E+02 | 3.0E+45 | 0.000 | 9.3E+01 | 1 | -9.3E+01 | -1 | 8.8E-01 | 0.7887 | -8.8E-01 | -0.7887 | 4.74E-02 |
| 10 | 0.00875 | -1.7E-01 | 8.4E-01 | -3.0E+45 | 2.000 | 5.2E+00 | 1.8E+02 | 3.0E+45 | 0.000 | 8.8E+01 | 1 | -8.8E+01 | -1 | 8.4E-01 | 0.7643 | -8.4E-01 | -0.76432 | 4.51E-02 |
| 11 | 0.00875 | -1.9E-01 | 8.3E-01 | -3.0E+45 | 2.000 | 5.7E+00 | 3.0E+02 | 3.0E+45 | 0.000 | 8.4E+01 | 1 | -8.4E+01 | -1 | 8.0E-01 | 0.7418 | -8.0E-01 | -0.7418 | 4.31E-02 |
| 12 | 0.00875 | -2.0E-01 | 8.2E-01 | -3.0E+45 | 2.000 | 6.2E+00 | 4.9E+02 | 3.0E+45 | 0.000 | 8.1E+01 | 1 | -8.1E+01 | -1 | 7.7E-01 | 0.721 | -7.7E-01 | -0.72098 | 4.12E-02 |
| 13 | 0.00875 | -2.2E-01 | 8.0E-01 | -3.0E+45 | 2.000 | 6.7E+00 | 8.3E+02 | 3.0E+45 | 0.000 | 7.8E+01 | 1 | -7.8E+01 | -1 | 7.4E-01 | 0.7017 | -7.4E-01 | -0.70169 | 3.94E-02 |
| 14 | 0.00875 | -2.4E-01 | 7.9E-01 | -3.0E+45 | 2.000 | 7.2E+00 | 1.4E+03 | 3.0E+45 | 0.000 | 7.5E+01 | 1 | -7.5E+01 | -1 | 7.1E-01 | 0.6838 | -7.1E-01 | -0.68377 | 3.77E-02 |
| 15 | 0.00875 | -2.6E-01 | 7.7E-01 | -3.0E+45 | 2.000 | 7.8E+00 | 2.3E+03 | 3.0E+45 | 0.000 | 7.2E+01 | 1 | -7.2E+01 | -1 | 6.8E-01 | 0.6671 | -6.8E-01 | -0.66708 | 3.62E-02 |
| 16 | 0.00875 | -2.7E-01 | 7.6E-01 | -3.0E+45 | 2.000 | 8.3E+00 | 3.9E+03 | 3.0E+45 | 0.000 | 7.0E+01 | 1 | -7.0E+01 | -1 | 6.6E-01 | 0.6515 | -6.6E-01 | -0.6515 | 3.47E-02 |
| 17 | 0.00875 | -2.9E-01 | 7.5E-01 | -3.0E+45 | 2.000 | 8.8E+00 | 6.6E+03 | 3.0E+45 | 0.000 | 6.8E+01 | 1 | -6.8E+01 | -1 | 6.4E-01 | 0.6369 | -6.4E-01 | -0.63692 | 3.34E-02 |
| 18 | 0.00875 | -3.1E-01 | 7.4E-01 | -3.0E+45 | 2.000 | 9.3E+00 | 1.1E+04 | 3.0E+45 | 0.000 | 6.6E+01 | 1 | -6.6E+01 | -1 | 6.3E-01 | 0.6232 | -6.3E-01 | -0.62324 | 3.21E-02 |
| 19 | 0.00875 | -3.2E-01 | 7.2E-01 | -3.0E+45 | 2.000 | 9.8E+00 | 1.8E+04 | 3.0E+45 | 0.000 | 6.4E+01 | 1 | -6.4E+01 | -1 | 6.1E-01 | 0.6104 | -6.1E-01 | -0.61038 | 3.09E-02 |
| 20 | 0.00875 | -3.4E-01 | 7.1E-01 | -3.0E+45 | 2.000 | 1.0E+01 | 3.1E+04 | 3.0E+45 | 0.000 | 6.3E+01 | 1 | -6.3E+01 | -1 | 5.9E-01 | 0.5983 | -5.9E-01 | -0.59826 | 2.98E-02 |

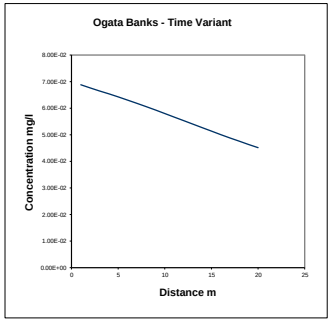



Vertical dispersion option Simulate vertical dispersion in 1 direction

| Calc | Value | |
|---|---|---|
| v | 1.08E-03 | m/d |
| Rc | 1.73E+05 | |
| u | 6.24E-09 | m/d |

Calculations for source located at top of aquifer (ie vertical dispersion in one direction) - USED FOR LEVEL ASSESSMENT

| X | Term 1 | Term 2 | EXP | Term 3 | ERFC | Term 4 | EXP | Term 5 | ERFC | Term 6a | ERF | Term 6b | ERF | Term 7a | ERF | Term 7b | ERF | Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.00875 | -1.7E-02 | 9.8E-01 | -3.0E+45 | 2.000 | 5.2E-01 | 1.7E+00 | 3.0E+45 | 0.000 | 2.8E+02 | 1 | -2.8E+02 | -1 | 5.3E+00 | 1 | -5.3E+00 | -1 | 6.88E-02 |
| 2 | 0.00875 | -3.4E-02 | 9.7E-01 | -3.0E+45 | 2.000 | 1.0E+00 | 2.8E+00 | 3.0E+45 | 0.000 | 2.0E+02 | 1 | -2.0E+02 | -1 | 3.8E+00 | 1 | -3.8E+00 | -1 | 6.77E-02 |
| 3 | 0.00875 | -5.1E-02 | 9.5E-01 | -3.0E+45 | 2.000 | 1.6E+00 | 4.7E+00 | 3.0E+45 | 0.000 | 1.6E+02 | 1 | -1.6E+02 | -1 | 3.1E+00 | 1 | -3.1E+00 | -0.99999 | 6.65E-02 |
| 4 | 0.00875 | -6.8E-02 | 9.3E-01 | -3.0E+45 | 2.000 | 2.1E+00 | 7.9E+00 | 3.0E+45 | 0.000 | 1.4E+02 | 1 | -1.4E+02 | -1 | 2.7E+00 | 0.9998 | -2.7E+00 | -0.99982 | 6.54E-02 |
| 5 | 0.00875 | -8.5E-02 | 9.2E-01 | -3.0E+45 | 2.000 | 2.6E+00 | 1.3E+01 | 3.0E+45 | 0.000 | 1.3E+02 | 1 | -1.3E+02 | -1 | 2.4E+00 | 0.9992 | -2.4E+00 | -0.9992 | 6.42E-02 |
| 6 | 0.00875 | -1.0E-01 | 9.0E-01 | -3.0E+45 | 2.000 | 3.1E+00 | 2.2E+01 | 3.0E+45 | 0.000 | 1.1E+02 | 1 | -1.1E+02 | -1 | 2.2E+00 | 0.9978 | -2.2E+00 | -0.9978 | 6.31E-02 |
| 7 | 0.00875 | -1.2E-01 | 8.9E-01 | -3.0E+45 | 2.000 | 3.6E+00 | 3.7E+01 | 3.0E+45 | 0.000 | 1.1E+02 | 1 | -1.1E+02 | -1 | 2.0E+00 | 0.9954 | -2.0E+00 | -0.99541 | 6.19E-02 |
| 8 | 0.00875 | -1.4E-01 | 8.7E-01 | -3.0E+45 | 2.000 | 4.1E+00 | 6.3E+01 | 3.0E+45 | 0.000 | 9.9E+01 | 1 | -9.9E+01 | -1 | 1.9E+00 | 0.992 | -1.9E+00 | -0.99199 | 6.06E-02 |
| 9 | 0.00875 | -1.5E-01 | 8.6E-01 | -3.0E+45 | 2.000 | 4.7E+00 | 1.0E+02 | 3.0E+45 | 0.000 | 9.3E+01 | 1 | -9.3E+01 | -1 | 1.8E+00 | 0.9876 | -1.8E+00 | -0.98758 | 5.93E-02 |
| 10 | 0.00875 | -1.7E-01 | 8.4E-01 | -3.0E+45 | 2.000 | 5.2E+00 | 1.8E+02 | 3.0E+45 | 0.000 | 8.8E+01 | 1 | -8.8E+01 | -1 | 1.7E+00 | 0.9823 | -1.7E+00 | -0.98229 | 5.80E-02 |
| 11 | 0.00875 | -1.9E-01 | 8.3E-01 | -3.0E+45 | 2.000 | 5.7E+00 | 3.0E+02 | 3.0E+45 | 0.000 | 8.4E+01 | 1 | -8.4E+01 | -1 | 1.6E+00 | 0.9763 | -1.6E+00 | -0.97626 | 5.67E-02 |
| 12 | 0.00875 | -2.0E-01 | 8.2E-01 | -3.0E+45 | 2.000 | 6.2E+00 | 4.9E+02 | 3.0E+45 | 0.000 | 8.1E+01 | 1 | -8.1E+01 | -1 | 1.5E+00 | 0.9696 | -1.5E+00 | -0.96962 | 5.53E-02 |
| 13 | 0.00875 | -2.2E-01 | 8.0E-01 | -3.0E+45 | 2.000 | 6.7E+00 | 8.3E+02 | 3.0E+45 | 0.000 | 7.8E+01 | 1 | -7.8E+01 | -1 | 1.5E+00 | 0.9625 | -1.5E+00 | -0.96249 | 5.40E-02 |
| 14 | 0.00875 | -2.4E-01 | 7.9E-01 | -3.0E+45 | 2.000 | 7.2E+00 | 1.4E+03 | 3.0E+45 | 0.000 | 7.5E+01 | 1 | -7.5E+01 | -1 | 1.4E+00 | 0.955 | -1.4E+00 | -0.95498 | 5.27E-02 |
| 15 | 0.00875 | -2.6E-01 | 7.7E-01 | -3.0E+45 | 2.000 | 7.8E+00 | 2.3E+03 | 3.0E+45 | 0.000 | 7.2E+01 | 1 | -7.2E+01 | -1 | 1.4E+00 | 0.9472 | -1.4E+00 | -0.94719 | 5.14E-02 |
| 16 | 0.00875 | -2.7E-01 | 7.6E-01 | -3.0E+45 | 2.000 | 8.3E+00 | 3.9E+03 | 3.0E+45 | 0.000 | 7.0E+01 | 1 | -7.0E+01 | -1 | 1.3E+00 | 0.9392 | -1.3E+00 | -0.93921 | 5.01E-02 |
| 17 | 0.00875 | -2.9E-01 | 7.5E-01 | -3.0E+45 | 2.000 | 8.8E+00 | 6.6E+03 | 3.0E+45 | 0.000 | 6.8E+01 | 1 | -6.8E+01 | -1 | 1.3E+00 | 0.9311 | -1.3E+00 | -0.93109 | 4.88E-02 |
| 18 | 0.00875 | -3.1E-01 | 7.4E-01 | -3.0E+45 | 2.000 | 9.3E+00 | 1.1E+04 | 3.0E+45 | 0.000 | 6.6E+01 | 1 | -6.6E+01 | -1 | 1.3E+00 | 0.9229 | -1.3E+00 | -0.9229 | 4.76E-02 |
| 19 | 0.00875 | -3.2E-01 | 7.2E-01 | -3.0E+45 | 2.000 | 9.8E+00 | 1.8E+04 | 3.0E+45 | 0.000 | 6.4E+01 | 1 | -6.4E+01 | -1 | 1.2E+00 | 0.9147 | -1.2E+00 | -0.91468 | 4.63E-02 |
| 20 | 0.00875 | -3.4E-01 | 7.1E-01 | -3.0E+45 | 2.000 | 1.0E+01 | 3.1E+04 | 3.0E+45 | 0.000 | 6.3E+01 | 1 | -6.3E+01 | -1 | 1.2E+00 | 0.9065 | -1.2E+00 | -0.90647 | 4.52E-02 |




| | |
|---|---|
| Date: | 24/02/2020 |
| Version: | 1 |

**Contaminant** enzo(a)pyrene

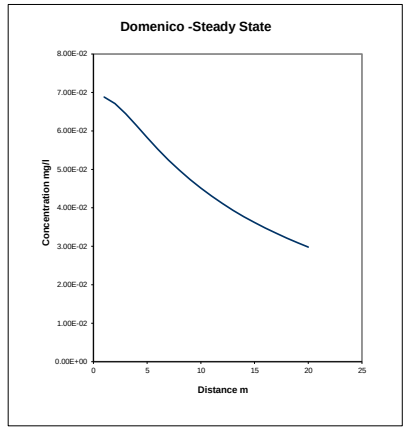
**DOMENICO (STEADY STATE)**

Calculations for source located in centre of aquifer (ie vertical dispersion in two directions)

| Input | Value | Units |
|---|---|---|
| $C_T$ | 0.00000017 | mg/l |
| Co | 7.00E-02 | mg/l |
| λ | 1.10E-10 | days$^{-1}$ |
| Sz | 5.00E+02 | m |
| Sy | 1.50E+00 | m |
| Kd | 1.02E+04 | l/kg |
| ρ | 1.36E+00 | g/cm3 |
| n | 8.00E-02 | |
| i | 1.00E-02 | |
| K | 8.64E-03 | m/d |
| x | 2.00E+01 | m |
| z | 0.00E+00 | m |
| y | 0.00E+00 | m |
| ax | 2.00E+00 | m |
| az | 2.00E-01 | m |
| ay | 2.00E-02 | m |

Vertical dispersion optio Simulate vertical dispersion in 1 direction

| | X | Term 1 | Term 2 | EXP | Term 3A | ERF | Term 3B | ERF | Term 4A | ERF | Term 4B | ERF | Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 0.0175 | -1.70E-02 | 9.83E-01 | 2.80E+02 | 1 | -2.80E+02 | -1 | 2.65E+00 | 1 | -2.65E+00 | -0.9998 | 6.88E-02 |
| 2 | 2 | 0.0175 | -3.40E-02 | 9.67E-01 | 1.98E+02 | 1 | -1.98E+02 | -1 | 1.88E+00 | 0.992 | -1.88E+00 | -0.992 | 6.71E-02 |
| 3 | 3 | 0.0175 | -5.10E-02 | 9.50E-01 | 1.61E+02 | 1 | -1.61E+02 | -1 | 1.53E+00 | 0.97 | -1.53E+00 | -0.9696 | 6.45E-02 |
| 4 | 4 | 0.0175 | -6.80E-02 | 9.34E-01 | 1.40E+02 | 1 | -1.40E+02 | -1 | 1.33E+00 | 0.939 | -1.33E+00 | -0.9392 | 6.14E-02 |
| 5 | 5 | 0.0175 | -8.50E-02 | 9.18E-01 | 1.25E+02 | 1 | -1.25E+02 | -1 | 1.19E+00 | 0.906 | -1.19E+00 | -0.9065 | 5.83E-02 |
| 6 | 6 | 0.0175 | -1.02E-01 | 9.03E-01 | 1.14E+02 | 1 | -1.14E+02 | -1 | 1.08E+00 | 0.874 | -1.08E+00 | -0.8742 | 5.53E-02 |
| 7 | 7 | 0.0175 | -1.19E-01 | 8.88E-01 | 1.06E+02 | 1 | -1.06E+02 | -1 | 1.00E+00 | 0.844 | -1.00E+00 | -0.8436 | 5.24E-02 |
| 8 | 8 | 0.0175 | -1.36E-01 | 8.73E-01 | 9.88E+01 | 1 | -9.88E+01 | -1 | 9.38E-01 | 0.815 | -9.38E-01 | -0.8151 | 4.98E-02 |
| 9 | 9 | 0.0175 | -1.53E-01 | 8.58E-01 | 9.32E+01 | 1 | -9.32E+01 | -1 | 8.84E-01 | 0.789 | -8.84E-01 | -0.7887 | 4.74E-02 |
| 10 | 10 | 0.0175 | -1.70E-01 | 8.44E-01 | 8.84E+01 | 1 | -8.84E+01 | -1 | 8.39E-01 | 0.764 | -8.39E-01 | -0.7643 | 4.51E-02 |
| 11 | 11 | 0.0175 | -1.87E-01 | 8.29E-01 | 8.43E+01 | 1 | -8.43E+01 | -1 | 8.00E-01 | 0.742 | -8.00E-01 | -0.7418 | 4.31E-02 |
| 12 | 12 | 0.0175 | -2.04E-01 | 8.15E-01 | 8.07E+01 | 1 | -8.07E+01 | -1 | 7.65E-01 | 0.721 | -7.65E-01 | -0.721 | 4.12E-02 |
| 13 | 13 | 0.0175 | -2.21E-01 | 8.02E-01 | 7.75E+01 | 1 | -7.75E+01 | -1 | 7.35E-01 | 0.702 | -7.35E-01 | -0.7017 | 3.94E-02 |
| 14 | 14 | 0.0175 | -2.38E-01 | 7.88E-01 | 7.47E+01 | 1 | -7.47E+01 | -1 | 7.09E-01 | 0.684 | -7.09E-01 | -0.6838 | 3.77E-02 |
| 15 | 15 | 0.0175 | -2.55E-01 | 7.75E-01 | 7.22E+01 | 1 | -7.22E+01 | -1 | 6.85E-01 | 0.667 | -6.85E-01 | -0.6671 | 3.62E-02 |
| 16 | 16 | 0.0175 | -2.72E-01 | 7.62E-01 | 6.99E+01 | 1 | -6.99E+01 | -1 | 6.63E-01 | 0.651 | -6.63E-01 | -0.6515 | 3.47E-02 |
| 17 | 17 | 0.0175 | -2.89E-01 | 7.49E-01 | 6.78E+01 | 1 | -6.78E+01 | -1 | 6.43E-01 | 0.637 | -6.43E-01 | -0.6369 | 3.34E-02 |
| 18 | 18 | 0.0175 | -3.06E-01 | 7.36E-01 | 6.59E+01 | 1 | -6.59E+01 | -1 | 6.25E-01 | 0.623 | -6.25E-01 | -0.6232 | 3.21E-02 |
| 19 | 19 | 0.0175 | -3.23E-01 | 7.24E-01 | 6.41E+01 | 1 | -6.41E+01 | -1 | 6.08E-01 | 0.61 | -6.08E-01 | -0.6104 | 3.09E-02 |
| 20 | 20 | 0.0175 | -3.40E-01 | 7.12E-01 | 6.25E+01 | 1 | -6.25E+01 | -1 | 5.93E-01 | 0.598 | -5.93E-01 | -0.5983 | 2.98E-02 |



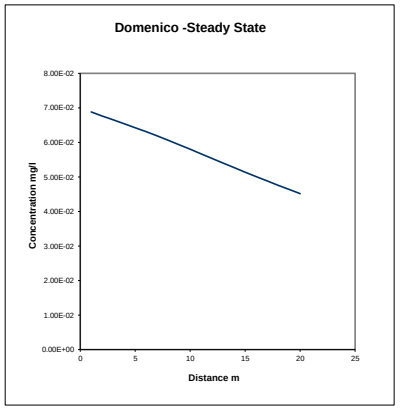

**Calc** **Value**

| | | |
|---|---|---|
| v | 1.08E-03 | m/d |
| Rc | 1.73E+05 | |
| u | 6.24E-09 | m/d |

**DOMENICO (STEADY STATE)**

Calculations for source located at top of aquifer (ie vertical dispersion in one direction) - USED FOR LEVEL ASSESSMENT

| | X | Term 1 | Term 2 | EXP | Term 3A | ERF | Term 3B | ERF | Term 4A | ERF | Term 4B | ERF | Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 0.0175 | -1.70E-02 | 9.83E-01 | 2.80E+02 | 1 | -2.80E+02 | -1 | 5.30E+00 | 1 | -5.30E+00 | -1 | 6.88E-02 |
| 2 | 2 | 0.0175 | -3.40E-02 | 9.67E-01 | 1.98E+02 | 1 | -1.98E+02 | -1 | 3.75E+00 | 1 | -3.75E+00 | -1 | 6.77E-02 |
| 3 | 3 | 0.0175 | -5.10E-02 | 9.50E-01 | 1.61E+02 | 1 | -1.61E+02 | -1 | 3.06E+00 | 1 | -3.06E+00 | -1 | 6.65E-02 |
| 4 | 4 | 0.0175 | -6.80E-02 | 9.34E-01 | 1.40E+02 | 1 | -1.40E+02 | -1 | 2.65E+00 | 1 | -2.65E+00 | -0.9998 | 6.54E-02 |
| 5 | 5 | 0.0175 | -8.50E-02 | 9.18E-01 | 1.25E+02 | 1 | -1.25E+02 | -1 | 2.37E+00 | 0.999 | -2.37E+00 | -0.9992 | 6.42E-02 |
| 6 | 6 | 0.0175 | -1.02E-01 | 9.03E-01 | 1.14E+02 | 1 | -1.14E+02 | -1 | 2.17E+00 | 0.998 | -2.17E+00 | -0.9978 | 6.31E-02 |
| 7 | 7 | 0.0175 | -1.19E-01 | 8.88E-01 | 1.06E+02 | 1 | -1.06E+02 | -1 | 2.00E+00 | 0.995 | -2.00E+00 | -0.9954 | 6.19E-02 |
| 8 | 8 | 0.0175 | -1.36E-01 | 8.73E-01 | 9.88E+01 | 1 | -9.88E+01 | -1 | 1.88E+00 | 0.992 | -1.88E+00 | -0.992 | 6.06E-02 |
| 9 | 9 | 0.0175 | -1.53E-01 | 8.58E-01 | 9.32E+01 | 1 | -9.32E+01 | -1 | 1.77E+00 | 0.988 | -1.77E+00 | -0.9876 | 5.93E-02 |
| 10 | 10 | 0.0175 | -1.70E-01 | 8.44E-01 | 8.84E+01 | 1 | -8.84E+01 | -1 | 1.68E+00 | 0.982 | -1.68E+00 | -0.9823 | 5.80E-02 |
| 11 | 11 | 0.0175 | -1.87E-01 | 8.29E-01 | 8.43E+01 | 1 | -8.43E+01 | -1 | 1.60E+00 | 0.976 | -1.60E+00 | -0.9763 | 5.67E-02 |
| 12 | 12 | 0.0175 | -2.04E-01 | 8.15E-01 | 8.07E+01 | 1 | -8.07E+01 | -1 | 1.53E+00 | 0.97 | -1.53E+00 | -0.9696 | 5.53E-02 |
| 13 | 13 | 0.0175 | -2.21E-01 | 8.02E-01 | 7.75E+01 | 1 | -7.75E+01 | -1 | 1.47E+00 | 0.962 | -1.47E+00 | -0.9625 | 5.40E-02 |
| 14 | 14 | 0.0175 | -2.38E-01 | 7.88E-01 | 7.47E+01 | 1 | -7.47E+01 | -1 | 1.42E+00 | 0.955 | -1.42E+00 | -0.955 | 5.27E-02 |
| 15 | 15 | 0.0175 | -2.55E-01 | 7.75E-01 | 7.22E+01 | 1 | -7.22E+01 | -1 | 1.37E+00 | 0.947 | -1.37E+00 | -0.9472 | 5.14E-02 |
| 16 | 16 | 0.0175 | -2.72E-01 | 7.62E-01 | 6.99E+01 | 1 | -6.99E+01 | -1 | 1.33E+00 | 0.939 | -1.33E+00 | -0.9392 | 5.01E-02 |
| 17 | 17 | 0.0175 | -2.89E-01 | 7.49E-01 | 6.78E+01 | 1 | -6.78E+01 | -1 | 1.29E+00 | 0.931 | -1.29E+00 | -0.9311 | 4.88E-02 |
| 18 | 18 | 0.0175 | -3.06E-01 | 7.36E-01 | 6.59E+01 | 1 | -6.59E+01 | -1 | 1.25E+00 | 0.923 | -1.25E+00 | -0.9229 | 4.76E-02 |
| 19 | 19 | 0.0175 | -3.23E-01 | 7.24E-01 | 6.41E+01 | 1 | -6.41E+01 | -1 | 1.22E+00 | 0.915 | -1.22E+00 | -0.9147 | 4.63E-02 |
| 20 | 20 | 0.0175 | -3.40E-01 | 7.12E-01 | 6.25E+01 | 1 | -6.25E+01 | -1 | 1.19E+00 | 0.906 | -1.19E+00 | -0.9065 | 4.52E-02 |




| | |
|---|---|
| Date: | 24/02/2020 |
| Version: | 1 |

## DOMENICO (TIME VARIANT)

**Contaminant** Benzo(a)pyrene

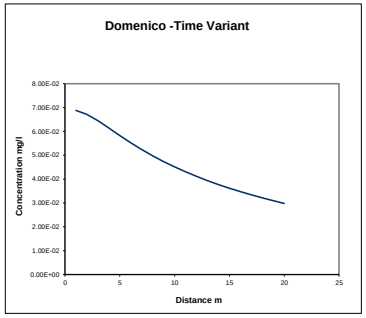
| Input | Value | Units |
|---|---|---|
| $C_T$ | 0.00000017 | mg/l |
| Co | 7.00E-02 | mg/l |
| λ | 1.10E-10 | days$^{-1}$ |
| Sz | 5.00E+02 | m |
| Sy | 1.50E+00 | m |
| Kd | 1.02E+04 | l/kg |
| ρ | 1.36E+00 | g/cm3 |
| n | 8.00E-02 | |
| i | 1.00E-02 | |
| K | 8.64E-03 | m/d |
| x | 2.00E+01 | m |
| z | 0.00E+00 | m |
| y | 0.00E+00 | m |
| t | 1.00E+100 | days |
| ax | 2.00E+00 | m |
| az | 2.00E-01 | m |
| ay | 2.00E-02 | m |

Vertical dispersion option: Simulate vertical dispersion in 1 direction

| Calc | Value | |
|---|---|---|
| v | 1.08E-03 | m/d |
| Rc | 1.73E+05 | |
| u | 6.24E-09 | m/d |

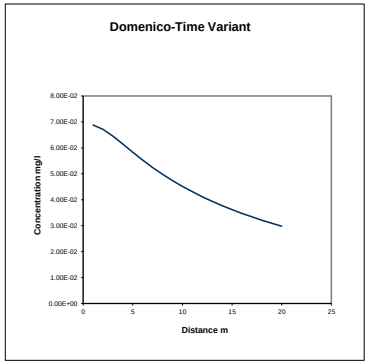
Calculations for source located in centre of aquifer (ie vertical dispersion in two directions)

| | X | Term 1 | Term 2 | EXP | Term 3 | ERFC | Term 4A | ERF | Term 4B | ERF | Term 5A | ERF | Term 5B | ERF | Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | m | | | | | | | | | | | | | | |
| 1 | 1 | 0.00875 | -1.70E-02 | 9.83E-01 | -2.98E+45 | 2 | 2.80E+02 | 1 | -2.80E+02 | -1 | 2.65E+00 | 0.9998 | -2.65E+00 | -1 | 6.88E-02 |
| 2 | 2 | 0.00875 | -3.40E-02 | 9.67E-01 | -2.98E+45 | 2 | 1.98E+02 | 1 | -1.98E+02 | -1 | 1.88E+00 | 0.992 | -1.88E+00 | -0.992 | 6.71E-02 |
| 3 | 3 | 0.00875 | -5.10E-02 | 9.50E-01 | -2.98E+45 | 2 | 1.61E+02 | 1 | -1.61E+02 | -1 | 1.53E+00 | 0.9696 | -1.53E+00 | -0.97 | 6.45E-02 |
| 4 | 4 | 0.00875 | -6.80E-02 | 9.34E-01 | -2.98E+45 | 2 | 1.40E+02 | 1 | -1.40E+02 | -1 | 1.33E+00 | 0.9392 | -1.33E+00 | -0.939 | 6.14E-02 |
| 5 | 5 | 0.00875 | -8.50E-02 | 9.18E-01 | -2.98E+45 | 2 | 1.25E+02 | 1 | -1.25E+02 | -1 | 1.19E+00 | 0.9065 | -1.19E+00 | -0.906 | 5.83E-02 |
| 6 | 6 | 0.00875 | -1.02E-01 | 9.03E-01 | -2.98E+45 | 2 | 1.14E+02 | 1 | -1.14E+02 | -1 | 1.08E+00 | 0.8742 | -1.08E+00 | -0.874 | 5.53E-02 |
| 7 | 7 | 0.00875 | -1.19E-01 | 8.88E-01 | -2.98E+45 | 2 | 1.06E+02 | 1 | -1.06E+02 | -1 | 1.00E+00 | 0.8436 | -1.00E+00 | -0.844 | 5.24E-02 |
| 8 | 8 | 0.00875 | -1.36E-01 | 8.73E-01 | -2.98E+45 | 2 | 9.88E+01 | 1 | -9.88E+01 | -1 | 9.38E-01 | 0.8151 | -9.38E-01 | -0.815 | 4.98E-02 |
| 9 | 9 | 0.00875 | -1.53E-01 | 8.58E-01 | -2.98E+45 | 2 | 9.32E+01 | 1 | -9.32E+01 | -1 | 8.84E-01 | 0.7887 | -8.84E-01 | -0.789 | 4.74E-02 |
| 10 | 10 | 0.00875 | -1.70E-01 | 8.44E-01 | -2.98E+45 | 2 | 8.84E+01 | 1 | -8.84E+01 | -1 | 8.39E-01 | 0.7643 | -8.39E-01 | -0.764 | 4.51E-02 |
| 11 | 11 | 0.00875 | -1.87E-01 | 8.29E-01 | -2.98E+45 | 2 | 8.43E+01 | 1 | -8.43E+01 | -1 | 8.00E-01 | 0.7418 | -8.00E-01 | -0.742 | 4.31E-02 |
| 12 | 12 | 0.00875 | -2.04E-01 | 8.15E-01 | -2.98E+45 | 2 | 8.07E+01 | 1 | -8.07E+01 | -1 | 7.65E-01 | 0.721 | -7.65E-01 | -0.721 | 4.12E-02 |
| 13 | 13 | 0.00875 | -2.21E-01 | 8.02E-01 | -2.98E+45 | 2 | 7.75E+01 | 1 | -7.75E+01 | -1 | 7.35E-01 | 0.7017 | -7.35E-01 | -0.702 | 3.94E-02 |
| 14 | 14 | 0.00875 | -2.38E-01 | 7.88E-01 | -2.98E+45 | 2 | 7.47E+01 | 1 | -7.47E+01 | -1 | 7.09E-01 | 0.6838 | -7.09E-01 | -0.684 | 3.77E-02 |
| 15 | 15 | 0.00875 | -2.55E-01 | 7.75E-01 | -2.98E+45 | 2 | 7.22E+01 | 1 | -7.22E+01 | -1 | 6.85E-01 | 0.6671 | -6.85E-01 | -0.667 | 3.62E-02 |
| 16 | 16 | 0.00875 | -2.72E-01 | 7.62E-01 | -2.98E+45 | 2 | 6.99E+01 | 1 | -6.99E+01 | -1 | 6.63E-01 | 0.6515 | -6.63E-01 | -0.651 | 3.47E-02 |
| 17 | 17 | 0.00875 | -2.89E-01 | 7.49E-01 | -2.98E+45 | 2 | 6.78E+01 | 1 | -6.78E+01 | -1 | 6.43E-01 | 0.6369 | -6.43E-01 | -0.637 | 3.34E-02 |
| 18 | 18 | 0.00875 | -3.06E-01 | 7.36E-01 | -2.98E+45 | 2 | 6.59E+01 | 1 | -6.59E+01 | -1 | 6.25E-01 | 0.6232 | -6.25E-01 | -0.623 | 3.21E-02 |
| 19 | 19 | 0.00875 | -3.23E-01 | 7.24E-01 | -2.98E+45 | 2 | 6.41E+01 | 1 | -6.41E+01 | -1 | 6.08E-01 | 0.6104 | -6.08E-01 | -0.61 | 3.09E-02 |
| 20 | 20 | 0.00875 | -3.40E-01 | 7.12E-01 | -2.98E+45 | 2 | 6.25E+01 | 1 | -6.25E+01 | -1 | 5.93E-01 | 0.5983 | -5.93E-01 | -0.598 | 2.98E-02 |




Calculations for source located at top of aquifer (ie vertical dispersion in one direction only) - USED FOR LEVEL ASSESSMENT

| | X | Term 1 | Term 2 | EXP | Term 3 | ERFC | Term 4A | ERF | Term 4B | ERF | Term 5A | ERF | Term 5B | ERF | Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | m | | | | | | | | | | | | | | |
| 1 | 1 | 0.00875 | -1.70E-02 | 9.83E-01 | -2.98E+45 | 2 | 2.80E+02 | 1 | -2.80E+02 | -1 | 5.30E+00 | 1 | -5.30E+00 | -1 | 6.88E-02 |
| 2 | 2 | 0.00875 | -3.40E-02 | 9.67E-01 | -2.98E+45 | 2 | 1.98E+02 | 1 | -1.98E+02 | -1 | 3.75E+00 | 1 | -3.75E+00 | -1 | 6.77E-02 |
| 3 | 3 | 0.00875 | -5.10E-02 | 9.50E-01 | -2.98E+45 | 2 | 1.61E+02 | 1 | -1.61E+02 | -1 | 3.06E+00 | 1 | -3.06E+00 | -1 | 6.65E-02 |
| 4 | 4 | 0.00875 | -6.80E-02 | 9.34E-01 | -2.98E+45 | 2 | 1.40E+02 | 1 | -1.40E+02 | -1 | 2.65E+00 | 0.9998 | -2.65E+00 | -1 | 6.54E-02 |
| 5 | 5 | 0.00875 | -8.50E-02 | 9.18E-01 | -2.98E+45 | 2 | 1.25E+02 | 1 | -1.25E+02 | -1 | 2.37E+00 | 0.9992 | -2.37E+00 | -0.999 | 6.42E-02 |
| 6 | 6 | 0.00875 | -1.02E-01 | 9.03E-01 | -2.98E+45 | 2 | 1.14E+02 | 1 | -1.14E+02 | -1 | 2.17E+00 | 0.9978 | -2.17E+00 | -0.998 | 6.31E-02 |
| 7 | 7 | 0.00875 | -1.19E-01 | 8.88E-01 | -2.98E+45 | 2 | 1.06E+02 | 1 | -1.06E+02 | -1 | 2.00E+00 | 0.9954 | -2.00E+00 | -0.995 | 6.19E-02 |
| 8 | 8 | 0.00875 | -1.36E-01 | 8.73E-01 | -2.98E+45 | 2 | 9.88E+01 | 1 | -9.88E+01 | -1 | 1.88E+00 | 0.992 | -1.88E+00 | -0.992 | 6.06E-02 |
| 9 | 9 | 0.00875 | -1.53E-01 | 8.58E-01 | -2.98E+45 | 2 | 9.32E+01 | 1 | -9.32E+01 | -1 | 1.77E+00 | 0.9876 | -1.77E+00 | -0.988 | 5.93E-02 |
| 10 | 10 | 0.00875 | -1.70E-01 | 8.44E-01 | -2.98E+45 | 2 | 8.84E+01 | 1 | -8.84E+01 | -1 | 1.68E+00 | 0.9823 | -1.68E+00 | -0.982 | 5.80E-02 |
| 11 | 11 | 0.00875 | -1.87E-01 | 8.29E-01 | -2.98E+45 | 2 | 8.43E+01 | 1 | -8.43E+01 | -1 | 1.60E+00 | 0.9763 | -1.60E+00 | -0.976 | 5.67E-02 |
| 12 | 12 | 0.00875 | -2.04E-01 | 8.15E-01 | -2.98E+45 | 2 | 8.07E+01 | 1 | -8.07E+01 | -1 | 1.53E+00 | 0.9696 | -1.53E+00 | -0.97 | 5.53E-02 |
| 13 | 13 | 0.00875 | -2.21E-01 | 8.02E-01 | -2.98E+45 | 2 | 7.75E+01 | 1 | -7.75E+01 | -1 | 1.47E+00 | 0.9625 | -1.47E+00 | -0.962 | 5.40E-02 |
| 14 | 14 | 0.00875 | -2.38E-01 | 7.88E-01 | -2.98E+45 | 2 | 7.47E+01 | 1 | -7.47E+01 | -1 | 1.42E+00 | 0.955 | -1.42E+00 | -0.955 | 5.27E-02 |
| 15 | 15 | 0.00875 | -2.55E-01 | 7.75E-01 | -2.98E+45 | 2 | 7.22E+01 | 1 | -7.22E+01 | -1 | 1.37E+00 | 0.9472 | -1.37E+00 | -0.947 | 5.14E-02 |
| 16 | 16 | 0.00875 | -2.72E-01 | 7.62E-01 | -2.98E+45 | 2 | 6.99E+01 | 1 | -6.99E+01 | -1 | 1.33E+00 | 0.9392 | -1.33E+00 | -0.939 | 5.01E-02 |
| 17 | 17 | 0.00875 | -2.89E-01 | 7.49E-01 | -2.98E+45 | 2 | 6.78E+01 | 1 | -6.78E+01 | -1 | 1.29E+00 | 0.9311 | -1.29E+00 | -0.931 | 4.88E-02 |
| 18 | 18 | 0.00875 | -3.06E-01 | 7.36E-01 | -2.98E+45 | 2 | 6.59E+01 | 1 | -6.59E+01 | -1 | 1.25E+00 | 0.9229 | -1.25E+00 | -0.923 | 4.76E-02 |
| 19 | 19 | 0.00875 | -3.23E-01 | 7.24E-01 | -2.98E+45 | 2 | 6.41E+01 | 1 | -6.41E+01 | -1 | 1.22E+00 | 0.9147 | -1.22E+00 | -0.915 | 4.63E-02 |
| 20 | 20 | 0.00875 | -3.40E-01 | 7.12E-01 | -2.98E+45 | 2 | 6.25E+01 | 1 | -6.25E+01 | -1 | 1.19E+00 | 0.9065 | -1.19E+00 | -0.906 | 4.52E-02 |




| | |
|---|---|
| Date: | 24/02/2020 |
| Version: | 1 |

# Hydrogeological risk assessment for land contamination

## Remedial Targets Worksheet , Release 3.2

**First released: 2006. Version 3.2: January 2013**

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination ( Environment Agency 2006).

**Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.**

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The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

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IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions)

| **Details to be completed for each assessment** | | | | |
|---|---|---|---|---|
| **Site Name:** | **Glan Llyn** | | | |
| **Site Address:** | **Llanwern** | | | |
| **Completed by:** | **Ross Cameron** | | | |
| **Date:** | **24-Feb-20** | | **Version:** | **1** |
| **Contaminant** | **Benzo(b)fluoranthene** | | | |
| **Target Concentration ($C_T$)** | **0.00000017** | **mg/l** | **Origin of $C_T$:** | **Proposed Water Framework Directive EQS** |

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparision with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).
Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.
Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.
Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.
Data carried forward from an earlier worksheet are identified by a light green background
It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

# Hydrogeological risk assessment for land contamination

## Remedial Targets Worksheet , Release 3.2

**First released: 2006. Version 3.2: January 2013**

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination ( Environment Agency 2006).

**Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.**

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The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

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IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

| Details to be completed for each assessment | | | | |
|---|---|---|---|---|
| Site Name: | Glan Llyn | | | |
| Site Address: | Llanwern | | | |
| Completed by: | Ross Cameron | | | |
| Date: | 20-Feb-20 | | Version: | 1 |
| Contaminant | Iron | | | |
| Target Concentration ($C_T$) | 1 | mg/l | Origin of $C_T$: | Water Framework Directive EQS |

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparision with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).
Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.
Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.
Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.
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It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

## Remedial Targets Worksheet , Release 3.2

# Level 1 - Soil

**Select the method of calculating the soil water Partition Co-efficient by using the pull down menu below**

**User specified value for partition coefficient**

| | | | | |
|---|---|---|---|---|
| **Contaminant** | | **Iron** | | |
| **Target concentration** | **$C_T$** | **1** | **mg/l** | |

| **Input Parameters** | **Variable** | **Value** | **Unit** | **Source of parameter value** |
|---|---|---|---|---|
| ***Standard entry*** | | | | |
| Water filled soil porosity | $\theta_w$ | 5.00E-01 | fraction | 0.5 |
| Air filled soil porosity | θa | 3.70E-01 | fraction | 0.0037 |
| Bulk density of soil zone material | ρ | 1.36E+00 | g/cm$^3$ | 1.36 |
| Henry's Law constant | H | 1.00E+00 | dimensionless | *1* |
| ***Entry if specify partition coefficient (option)*** | | | | |
| Soil water partition coefficient | Kd | 1.34E+02 | l/kg | *1.34E+02* |
| ***Entry for non-polar organic chemicals (option)*** | | | | |
| Fraction of organic carbon (in soil) | foc | | fraction | |
| Organic carbon partition coefficient | Koc | | l/kg | |
| ***Entry for ionic organic chemicals (option)*** | | | | |
| Sorption coefficient for neutral species | $K_{oc,n}$ | | l/kg | |
| Sorption coefficient for ionised species | $K_{oc,i}$ | | l/kg | |
| pH value | pH | | pH units | |
| Acid dissociation constant | pKa | | | |
| Fraction of organic carbon (in soil) | foc | | fraction | |

This sheet calculates the Level 1 remedial target for soils(mg/kg) based on a selected target concentration and theoretical calculation of soil water partitioning. Three options are included for determining the partition coefficient.

The measured soil concentration as mg/kg should be compared with the Level 1 remedial target to determine the need for further action.

| | | | | |
|---|---|---|---|---|
| **Soil water partition coefficient used in Level Assessment** | **Kd** | **1.34E+02** | **l/kg** | *Specified value* |

## Level 1 Remedial Target

| | | | |
|---|---|---|---|
| **Level 1 Remedial Target** | **1.35E+02** | **mg/kg** | **(for comparison with soil analyses)** |
| | **or** | | |
| | **1** | **mg/l** | **(for comparison with leachate test results)** |

| | |
|---|---|
| Site being assessed: | Glan Llyn |
| Completed by: | Ross Cameron |
| Date: | 20-Feb-20 |
| Version: | 1 |

## Remedial Targets Worksheet , Release 3.2

# Level 2 - Soil

| | | | | |
|---|---|---|---|---|
| **Contaminant** | | **Iron** | | from Level 1 |
| **Target concentration** | $C_T$ | **1** | **mg/l** | from Level 1 |

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamiantion' (Environment Agency 2006)

| **Input Parameters** | **Variable** | **Value** | **Unit** | **Source of parameter value** | |
|---|---|---|---|---|---|
| *Standard entry* | | | | | |
| Infiltration | Inf | 0.00E+00 | m/d | | |
| Area of contaminant source | A | 0.00E+00 | $m^2$ | | Not used in calculation |
| *Entry for groundwater flow below site* | | | | | |
| Length of contaminant source in direction of groundwater flow | L | 0.00E+00 | m | | |
| Saturated aquifer thickness | da | 0.00E+00 | m | | |
| Hydraulic Conductivity of aquifer in which dilution occurs | K | 0.00E+00 | m/d | | |
| Hydraulic gradient of water table | i | 0.00E+00 | fraction | | |
| Width of contaminant source perpendicular to groundwater flow | w | 0.00E+00 | m | | Not used in calculation |
| Background concentration of contaminant in groundwater beneath site | Cu | 0.00E+00 | mg/l | | |
| Define mixing zone depth by specifying or calculating depth (using pull down list) | | **Specify** | | | |
| Enter mixing zone thickness | Mz | 0.00E+00 | m | | |
| Calculated mixing zone thickness | Mz | | m | | |

## Calculated Parameters

| | | | | |
|---|---|---|---|---|
| **Dilution Factor** | **DF** | **#DIV/0!** | | |
| **Level 2 Remedial Target** | | **#DIV/0!** | **mg/l** | **For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentra** |
| | | **or** | | |
| | | **#DIV/0!** | **mg/kg** | **For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water** |

## *Additional option*

**Calculation of impact on receptor**

| | | | | |
|---|---|---|---|---|
| Concentration of contaminant in contaminated discharge (entering receptor) | Cc | 0.00E+00 | mg/l | |
| Calculated concentration within receptor (dilution only) | | #DIV/0! | mg/l | 0 |

| | |
|---|---|
| Site being assessed: | Glan Llyn |
| Completed by: | Ross Cameron |
| Date: | 20-Feb-20 |
| Version: | 1 |

**Remedial Targets Worksheet , Release 3.2**

## Level 3 - Soil

See Note

### Input Parameters

| | Variable | Value | Unit | Source |
|---|---|---|---|---|
| Contaminant | | Iron | | from Level 1 |
| Target Concentration | $C_T$ | 1 | mg/l | from Level 1 |
| Dilution Factor | DF | #DIV/0! | | from Level 2 |

**Select analytical solution (click on brown cell below, then on pull-down menu)**

Ogata Banks — Equations in HRA publication

**Select nature of decay rate (click on brown cell below, then on pull-down menu)**

Approach for simulating degradation of pollutants: Apply degradation rate to pollutants in all phases (e.g. field derived value, lab derived value)

| | Variable | Value | Unit | Source of parameter value |
|---|---|---|---|---|
| Enter source concentration | | Soil concentration as mg/kg | | |
| Enter soil concentration | | 0 | mg/kg | |
| Half life for degradation of contaminant in water | $t_{1/2}$ | 1.00E+100 | days | |
| Calculated decay rate | $\lambda$ | 6.93E-101 | $days^{-1}$ | calculated |
| Width of plume in aquifer at source | Sz | 0.00E+00 | m | from Level 2 |
| Plume thickness in aquifer at source | Sy | 0.00E+00 | m | from Level 2 |
| Bulk density of aquifer materials | $\rho$ | 0.00E+00 | $g/cm^3$ | |
| Effective porosity of aquifer | n | 0.00E+00 | fraction | |
| Hydraulic gradient | i | #DIV/0! | fraction | from Level 2 (adjusted) |
| Hydraulic conductivity of saturated aquifer | K | 0.00E+00 | m/d | from Level 2 |
| Distance to compliance point | x | 0.00E+00 | m | |
| Distance (lateral) to compliance point perpendicular to flow direction | z | | m | |
| Distance (depth) to compliance point perpendicular to flow direction | y | | m | |
| Time since pollutant entered groundwater | t | 1.00E+99 | days | *time variant options only* |
| *Parameters values determined from options* | | | | |
| Partition coefficient | Kd | 0.00E+00 | l/kg | *see options* |
| Longitudinal dispersivity | ax | 0.000 | m | *see options* |
| Transverse dispersivity | az | 0.000 | m | *see options* |
| Vertical dispersivity | av | 0.000 | m | *see options* |

***Parameter values should be checked against Level 1 and 2***

### Calculated Parameters

| | Variable | | |
|---|---|---|---|
| Groundwater flow velocity | v | #DIV/0! | m/d |
| Retardation factor | Rf | #DIV/0! | fraction |
| Decay rate used | $\lambda$ | 6.93E-101 | $d^{-1}$ |
| Hydraulic gradient used in aquifer flow down-gradient | i | #DIV/0! | fraction |
| Rate of contaminant flow due to retardation | u | #DIV/0! | m/d |
| Ratio of Compliance Point to Source Concentration | $C_{ED}/C_0$ | #DIV/0! | fraction |
| **Attenuation factor ($C_0/C_{ED}$)** | **AF** | **#DIV/0!** | **fraction** |
| Calculated soil leachate concentration | Co | 0.00E+00 | mg/l |

### Remedial Targets

| | | | |
|---|---|---|---|
| **Level 3 Remedial Target** | **#DIV/0!** | **mg/l** | For comparison with measured pore water concentration. |
| Ogata Banks | **or** | | This assumes Level 1 Remedial Target is based on Target Concentration. |
| | **#DIV/0!** | **mg/kg** | For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water partitioning equation. |
| **Distance to compliance point** | **0** | **m** | |
| **Ratio of Compliance Point to Source Concentration** | **$C_{ED}/C_0$** | **#DIV/0!** | **fraction** Ogata Banks |

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99

**Enter method of defining partition co-efficient (using pull down list)**

Calculate for ionic organic chemicals (acids)

*Entry if specify partition coefficient (option)*

Soil water partition coefficient — Kd — l/kg

*Entry for non-polar organic chemicals (option)*

Fraction of organic carbon in aquifer — foc — fraction
Organic carbon partition coefficient — Koc — l/kg

*Entry for ionic organic chemicals (option)*

| | | | |
|---|---|---|---|
| Sorption coefficient for related species | $K_{oc,n}$ | 0.00E+00 | l/kg |
| Sorption coefficient for ionised species | $K_{oc,i}$ | 0.00E+00 | l/kg |
| pH value | pH | 0.00E+00 | |
| Acid dissociation constant | pKa | 0.00E+00 | |
| Fraction of organic carbon in aquifer | foc | 0.00E+00 | fraction |
| Soil water partition coefficient | Kd | 0.00E+00 | l/kg |

**Define dispersivity (click brown cell and use pull down list)**

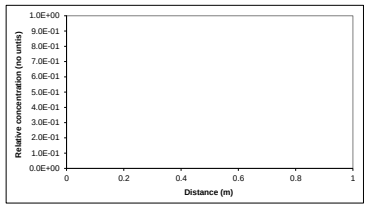
User defined values for dispersivity

| | | Enter value | Calc value | Xu & Eckstein | |
|---|---|---|---|---|---|
| **Longitudinal dispersivity** | **ax** | 0.00E+00 | 0.00E+00 | #NUM! | m |
| **Transverse dispersivity** | **az** | 0.00E+00 | 0.00E+00 | #NUM! | m |
| **Vertical dispersivity** | **ay** | 0.00E+00 | 0.00E+00 | #NUM! | m |

**Note values of dispersivity must be > 0**

Xu & Eckstein (1995) report ax = $0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed

Note
This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by $O_2$, $NO_3$, $SO_4$ etc than an alternative solution should be used




Note: 'Relative concentration' is the ratio of calculated concentation at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

| | |
|---|---|
| Site being assessed: | Glan Llyn |
| Completed by: | Ross Cameron |
| Date: | ######## |
| Version: | 1 |

**Calculated (relative) concentrations for distance-concentration graph**

Ogata Banks
From calculation sheet

| Distance | Relative concentration (No units) | Concentration mg/l |
|---|---|---|
| 0 | 1.0E+00 | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |

# Remedial Targets Worksheet , Release 3.2

## Calculation of contaminant concentration in groundwater from a soil source

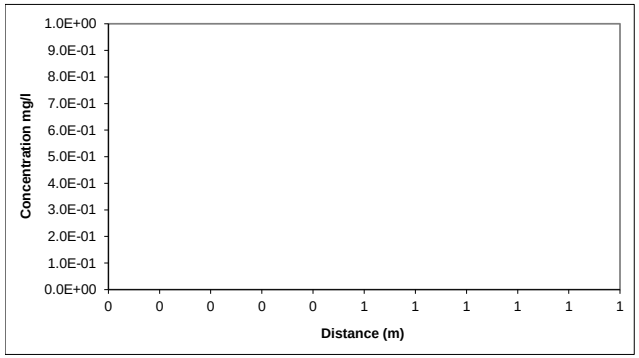
Only input required is Soil Contaminant Concentration

| | | | | |
|---|---|---|---|---|
| | Input Parameters | | | |
| | Soil contaminant concentration | $C_0$ | 0.00E+00 | mg/kg |
| **Level 1 Parameters** | | | | |
| | Water filled soil porosity | $\theta_w$ | 5.00E-01 | fraction |
| | Air filled soil porosity | $\theta a$ | 3.70E-01 | fraction |
| | Bulk density | $\rho$ | 1.36E+00 | g/cm$^3$ |
| | Henry's Law constant | H | 1.00E+00 | dimensionless |
| | Soil water partition coefficient used in Level Assessment | Kd | 1.34E+02 | l/kg |
| | Factor (partitioning between soil and water) | | 1.35E+02 | dimensionless |
| **Level 2 Parameters** | **Dilution Factor** | DF | #DIV/0! | |
| **Level 3 Parameters** | **Attenuation factor ($C_O/C_{ED}$)** | AF | #DIV/0! | |

### Predicted concentrations at compliance point

| | | | | |
|---|---|---|---|---|
| **Level 1** | C | 0.00E+00 | mg/l | No dilution or attenuation |
| **Level 2** | C | #DIV/0! | mg/l | Dilution taken into account |
| **Level 3** | C | #DIV/0! | mg/l | Dilution and attenuation taken into account |

### Predicted concentrations between source and compliance point - Level 3




| Distance m | Concentration mg/l |
|---|---|
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |

# R&D Publication 20 Remedial Targets Worksheet, Release 3.2

## Level 3 - Groundwater

See Note

**Input Parameters (using pull down menu)**

| | Variable | Value | Unit | Source |
|---|---|---|---|---|
| Contaminant | | Iron | | from Level 1 |
| Target Concentration | $C_T$ | 1.00E+00 | mg/l | from Level 1 |

**Select analytical solution (click on brown cell below, then on pull-down menu)**

Domenico - Steady state — Equations in HRA publication

Approach for simulating vertical dispersion: Simulate vertical dispersion in 1 direction

**Select nature of decay rate (click on brown cell below, then on pull-down menu)**

Approach for simulating degradation of pollutants: Apply degradation rate to dissolved pollutants only

| | | | | Source of parameter value |
|---|---|---|---|---|
| Initial contaminant concentration in groundwater at plume core | $C_0$ | 2.95E+03 | mg/l | *Based on maximum soil conc of 2390000mg/kg* |
| Half life for degradation of contaminant in water | $t_{1/2}$ | 9.00E+99 | days | *Estimation* |
| Calculated decay rate | λ | 7.70E-101 | $days^{-1}$ | |
| Width of plume in aquifer at source (perpendicular to flow) | Sz | 5.00E+02 | m | *Site data* |
| Plume thickness at source | Sy | 1.50E+00 | m | *Thickness of re-engineered MG* |
| Saturated aquifer thickness | da | 2.00E+00 | m | *Based upon proposed total MG and cappi* |
| Bulk density of aquifer materials | ρ | 1.36E+00 | $g/cm^3$ | *Site data* |
| Effective porosity of aquifer | n | 8.00E-02 | fraction | *Estimate* |
| Hydraulic gradient | i | 1.00E-02 | fraction | |
| Hydraulic conductivity of aquifer | K | 8.64E-03 | m/d | *Proposed best achievable* |
| Distance to compliance point | x | 2.00E+01 | m | *Site data* |
| Distance (lateral) to compliance point perpendicular to flow direction | z | | m | |
| Distance (depth) to compliance point perpendicular to flow direction | y | | m | |
| Time since pollutant entered groundwater | t | 1.00E+100 | days | *time variant options only* |
| *Parameters values determined from options* | | | | |
| Partition coefficient | Kd | 8.10E+02 | l/kg | *see options* |
| Longitudinal dispersivity | ax | 1.57E+00 | m | *see options* |
| Transverse dispersivity | az | 1.57E-01 | m | *see options* |
| Vertical dispersivity | ay | 1.57E-02 | m | *see options* |

**Calculated Parameters**

| | Variable | | |
|---|---|---|---|
| Groundwater flow velocity | v | 1.08E-03 | m/d |
| Retardation factor | Rf | 1.38E+04 | fraction |
| Decay rate used | λ | 5.59E-105 | $d^{-1}$ |
| Rate of contaminant flow due to retardation | u | 7.84E-08 | m/d |
| Contaminant concentration at distance x, assuming one-way vertical dispersion | $C_{ED}$ | 2.78E+03 | mg/l |
| **Attenuation factor (one way vertical dispersion, CO/CED)** | **AF** | **1.06E+00** | |

**Remedial Targets**

| | | | | |
|---|---|---|---|---|
| **Remedial Target** | | **1.06E+00** | **mg/l** | For comparison with measured groundwater concentration. |
| Domenico - Steady state | | | | |
| **Distance to compliance point** | | **20** | **m** | |
| **Concentration of contaminant at compliance point** | **$C_{ED}/C_0$** | **2.78E+03** | **mg/l** | Domenico - Steady state |

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99.

**Select Method for deriving Partition Co-efficient (using pull down menu)**

User specified value for partition coefficient

***Entry if specify partition coefficient (option)***

Soil water partition coefficient — Kd — 8.10E+02 — l/kg

***Entry for non-polar organic chemicals (option)***

Fraction of organic carbon in aquifer — foc — fraction

Organic carbon partition coefficient — Koc — l/kg

***Entry for ionic organic chemicals (option)***

Sorption coefficient for related species — $K_{oc,n}$ — l/kg

Sorption coefficient for ionised species — $K_{oc,i}$ — l/kg

pH value — pH

acid dissociation constant — pKa

Fraction of organic carbon in aquifer — foc — fraction

Soil water partition coefficient — Kd — 8.10E+02 — l/kg

**Define dispersivity (click brown cell and use pull down list)**

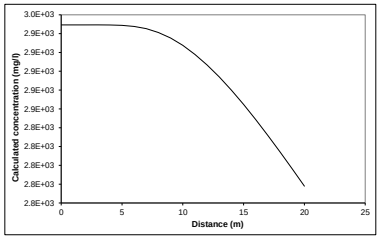
Dispersivity based on Xu & Eckstein (1995)

| | | Enter value | Calc value Xu & Eckstein | | |
|---|---|---|---|---|---|
| **Longitudinal dispersivity** | **ax** | 0.00E+00 | 2.00E+00 | 1.57E+00 | m |
| **Transverse dispersivity** | **az** | 0.00E+00 | 2.00E-01 | 1.57E-01 | m |
| **Vertical dispersivity** | **ay** | 0.00E+00 | 2.00E-02 | 1.57E-02 | |

**Note values of dispersivity must be > 0**

For calculated value, assumes ax = 0.1 *x, az = 0.01 * x, ay = 0.001 * x

Xu & Eckstein (1995) report ax = $0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed




Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared with the Level 3 remedial target to determine the need for further action.
Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O2, NO3, SO4 etc than an alternative solution should be used

| | |
|---|---|
| Site being assessed: | Glan Llyn |
| Completed by: | Ross Cameron |
| Date: | ####### |
| Version: | 1 |

**Calculated concentrations for distance-concentration graph**

**Domenico - Steady state**
**From calculation sheet**

| Distance | Concentration |
|---|---|
| | mg/l |
| 0 | 2.9E+03 |
| 1.0 | 2.95E+03 |
| 2.0 | 2.95E+03 |
| 3.0 | 2.95E+03 |
| 4.0 | 2.95E+03 |
| 5.0 | 2.95E+03 |
| 6.0 | 2.95E+03 |
| 7.0 | 2.95E+03 |
| 8.0 | 2.94E+03 |
| 9.0 | 2.94E+03 |
| 10.0 | 2.93E+03 |
| 11.0 | 2.92E+03 |
| 12.0 | 2.91E+03 |
| 13.0 | 2.89E+03 |
| 14.0 | 2.88E+03 |
| 15.0 | 2.86E+03 |
| 16.0 | 2.85E+03 |
| 17.0 | 2.83E+03 |
| 18.0 | 2.81E+03 |
| 19.0 | 2.80E+03 |
| 20.0 | 2.78E+03 |

# Porosity Calculator

These results are not carried through to any of the other worksheets

## DRY BULK DENSITY DATA

| Variable | Value | Unit | justification |
|---|---|---|---|
| Natural Moisture Content | 0.00 | % wt | |
| Particle Density | 2.78 | tonnes/m$^3$ | (Change this number only if you have specific information) |
| Dry Bulk Density | 0.00 | tonnes/m$^3$ | |
| *Calculated Parameters* | | | |
| Voids Ratio | #DIV/0! | fraction | |
| Initial Saturation | #DIV/0! | % | |
| **Total porosity** | **1.000** | **fraction** | |
| **Air Filled Porosity** | **#DIV/0!** | **fraction** | |
| **Water Filled Porosity** | **#DIV/0!** | **fraction** | |

## WET BULK DENSITY DATA

| Variable | Value | Unit | |
|---|---|---|---|
| Moisture Content | 0.00 | % wt | |
| Particle Density | 2.78 | tonnes/m$^3$ | (Change this number only if you have specific information) |
| Actual (wet) Bulk Density ( i.e. at natural MC) | 0.00 | tonnes/m$^3$ | |
| *Calculated Parameters* | | | |
| Voids Ratio | #DIV/0! | fraction | |
| dry bulk density | 0.00 | tonnes/m$^3$ | |
| Initial Saturation | #DIV/0! | % | |
| **Total porosity** | **1.000** | **fraction** | **#DIV/0!** |
| **Air Filled Porosity** | **#DIV/0!** | **fraction** | |
| **Water Filled Porosity** | **#DIV/0!** | **fraction** | |

*Analytical solutions provided by David Hall, Golder Associates (UK) Ltd*

# Simple hydrogeological calculations

**(These are not specific to, or required in, the Remedial Targets Methodology)**

| Parameter | symbol | | unit | justification |
|---|---|---|---|---|
| Hydraulic conductivity | K | 0.00E+00 | m/d | |
| Hydraulic gradient | i | 0.00E+00 | unitless | |
| Effective porosity of aquifer | n | 0.00E+00 | fraction | |
| Thickness of saturated aquifer | b | 0.00E+00 | m | |
| Width of aquifer perpendicular to flow | w | 0.00E+00 | m | |
| Distance to receptor | x | 0.00E+00 | m | |
| Bulk density of aquifer materials | ρ | 0.00E+00 | $g/cm^3$ | |
| Soil-water partition co-efficient | Kd | 0.00E+00 | l/kg | |
| Retardation factor of pollutant | R | #DIV/0! | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Groundwater flow velocity | v(GW) | #DIV/0! | m/s | #DIV/0! | m/day | #DIV/0! | m/year |
| Time for groundwater to reach receptor | t(GW) | #DIV/0! | seconds | #DIV/0! | days | #DIV/0! | years |
| Rate of groundwater flow through aquifer | Q | 0.00E+00 | $m^3/s$ | 0.00E+00 | $m^3$/day | 0.00E+00 | $m^3$/year |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Contaminant flow velocity | v(contam) | #DIV/0! | m/s | #DIV/0! | m/day | #DIV/0! | m/year |
| Time for contaminant to reach receptor | t(contam) | #DIV/0! | seconds | #DIV/0! | days | #DIV/0! | years |

## Level 1 Calculation Sheet

**Contaminant** **Iron**

| Parameter (carried over from input sheet) | Value | Units |
|---|---|---|
| $C_T$ | 1.00E+00 | mg/l |
| Kd | 1.34E+02 | l/kg |
| foc | | fraction |
| koc | | l/kg |
| $\theta_w$ | 5.00E-01 | fraction |
| $\theta a$ | 3.70E-01 | fraction |
| $\rho$ | 1.36E+00 | g/cm3 |
| H | 1.00E+00 | dimensionless |
| Koc,n | | l/kg |
| Koc,i | | l/kg |
| pH | | pH units |
| pKa | | |
| foc (ionic) | | fraction |

**Calculations (Refer toTable 4.3, R&D Publication 20)**

**Selected option** User specified value for partition coefficient

| | calc | calc | Calc Kd | l/kg |
|---|---|---|---|---|
| Calculation of partition coefficient for ionic organic chemical | | | | |
| Partition coefficient used in Level 1 Assessment | | | 1.34E+02 | l/kg |

**Calculated Remedial Target** **1.35E+02 mg/kg** **for Iron**

Factor (partitioning between soil and water) 1.35E+02

| | |
|---|---|
| Site being assessed: | Glan Llyn |
| Completed by: | Ross Cameron |
| Date: | 20/02/2020 |
| Version: | 1 |

## Level 2 Calculation Sheet

**Contaminant** **Iron**

| Site assessed: | Glan Llyn |
|---|---|
| Date: | 20/02/2020 |
| Version: | 1 |

| Parameter | Value | Units |
|---|---|---|
| (carried over from input sheet) | | |
| Mz | 0.00E+00 | m |
| L | 0.00E+00 | m |
| da | 0.00E+00 | m |
| Inf | 0.00E+00 | m/d |
| K | 0.00E+00 | m/d |
| i | 0.00E+00 | |
| | | m3/d |
| A | 0.00E+00 | m2 |
| | | m3/d |
| Cc | 0.00E+00 | mg/l |
| $C_T$ | 1.00E+00 | mg/l |
| Cu | 0.00E+00 | mg/l |
| w | 0.00E+00 | m |

Calculated Dilution Factor

Calculation based on target concentration #DIV/0!

Calculation based on observed contaminant concentration #DIV/0!

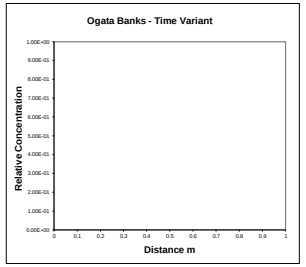


**OGATA BANKS SOLUTION**

| Contaminant | Iron | | |
|---|---|---|---|
| **Input** | **Value** | **Units** | |
| $C_T$ | 1.000E+00 | mg/l | |
| DF | #DIV/0! | | |
| | | | |
| λ | 6.931E-101 | $days^{-1}$ | |
| Sz | 0.000E+00 | m | |
| Sy | 0.000E+00 | m | |
| Kd | 0.000E+00 | l/kg | |
| ρ | 0.000E+00 | g/cm3 | |
| n | 0.000E+00 | | |
| i | #DIV/0! | | |
| K | 0.000E+00 | m/d | |
| x | 0.000E+00 | m | |
| z | 0.000E+00 | m | |
| y | 0.000E+00 | m | |
| t | 1.000E+99 | days | |
| ax | 0.000E+00 | m | |
| az | 0.000E+00 | m | |
| ay | 0.000E+00 | m | |

Calculations for source located in centre of aquifer (ie vertical dispersion in two directions)

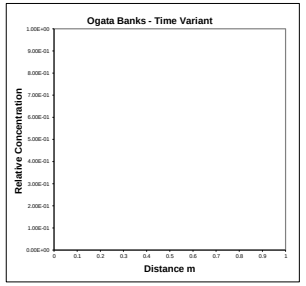
| | X | Term 1 | Term 2 | EXP | Term 3 | ERFC | Term 4 | EXP | Term 5 | ERFC | Term 6a | ERF | Term 6b | ERF | Term 7a | ERF | Term 7b | ERF | Relative Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 2 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 3 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 4 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 5 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 6 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 7 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 8 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 9 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 10 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 11 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 12 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 13 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 14 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 15 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 16 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 17 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 18 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 19 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 20 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |




| Calc | Value | |
|---|---|---|
| v | #DIV/0! | m/d |
| Rc | #DIV/0! | |
| u | #DIV/0! | m/d |

Calculations for source located at top of aquifer (ie vertical dispersion in one direction) -USED FOR LEVEL ASSESSMENT

| | X | Term 1 | Term 2 | EXP | Term 3 | ERFC | Term 4 | EXP | Term 5 | ERFC | Term 6a | ERF | Term 6b | ERF | Term 7a | ERF | Term 7b | ERF | Relative Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 2 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 3 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 4 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 5 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 6 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 7 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 8 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 9 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 10 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 11 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 12 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 13 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 14 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 15 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 16 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 17 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 18 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 19 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 20 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |




| | |
|---|---|
| Date: | 20/02/2020 |
| Version: | 1 |

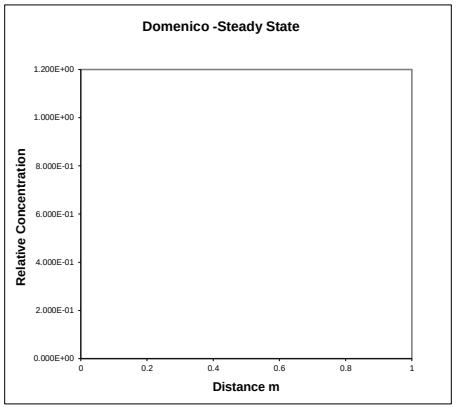
**Contaminant** **Iron**

**DOMENICO (STEADY STATE)**

Calculations for source located in centre of aquifer (ie vertical dispersion in two directions)

| Input | Value | Units |
|---|---|---|
| $C_T$ | 1.000E+00 | mg/l |
| DF | #DIV/0! | |
| | | |
| λ | 6.931E-101 | days$^{-1}$ |
| Sz | 0.000E+00 | m |
| Sy | 0.000E+00 | m |
| Kd | 0.000E+00 | l/kg |
| ρ | 0.000E+00 | g/cm3 |
| n | 0.000E+00 | |
| i | #DIV/0! | |
| K | 0.000E+00 | m/d |
| x | 0.000E+00 | m |
| z | 0.000E+00 | m |
| y | 0.000E+00 | m |
| ax | 0.000E+00 | m |
| az | 0.000E+00 | m |
| ay | 0.000E+00 | m |

| | X | Term 1 | Term 2 | EXP | Term 3A | ERF | Term 4A | ERF | Term 4B | ERF | Relative Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 2 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 3 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 4 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 5 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 6 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 7 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 8 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 9 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 10 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 11 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 12 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 13 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 14 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 15 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 16 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 17 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 18 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 19 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 20 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |



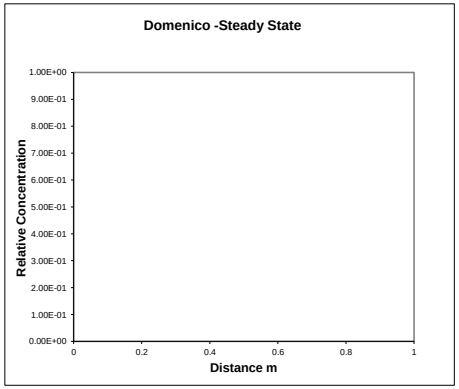

**Calc** **Value**

| | | |
|---|---|---|
| v | #DIV/0! | m/d |
| Rc | #DIV/0! | |
| u | #DIV/0! | m/d |

**DOMENICO (STEADY STATE)**

Calculations for source located at top of aquifer (ie vertical dispersion in one direction) - USED FOR LEVEL ASSESSMENT

| | X | Term 1 | Term 2 | EXP | Term 3A | ERF | Term 4A | ERF | Term 4B | ERF | Relative Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 2 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 3 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 4 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 5 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 6 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 7 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 8 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 9 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 10 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 11 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 12 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 13 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 14 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 15 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 16 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 17 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 18 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 19 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 20 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |




| | |
|---|---|
| Date: | 20/02/2020 |
| Version: | 1 |

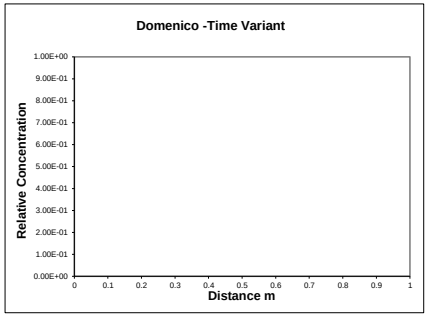
## DOMENICO (TIME VARIANT)

**Contaminant** **Iron**

Calculations for source located in centre of aquifer (ie vertical dispersion in two directions)

| Input | Value | Units |
|---|---|---|
| $C_T$ | 1 | mg/l |
| DF | #DIV/0! | |
| λ | 6.931E-101 | days$^{-1}$ |
| Sz | 0.000E+00 | m |
| Sy | 0.000E+00 | m |
| Kd | 0.000E+00 | l/kg |
| ρ | 0.000E+00 | g/cm3 |
| n | 0.000E+00 | |
| i | #DIV/0! | |
| K | 0.000E+00 | m/d |
| x | 0.000E+00 | m |
| z | 0.000E+00 | m |
| y | 0.000E+00 | m |
| t | 1.000E+99 | days |
| ax | 0.000E+00 | m |
| az | 0.000E+00 | m |
| ay | 0.000E+00 | m |

| | X | Term 1 | Term 2 | EXP | Term 3 | ERFC | Term 4A | ERF | Term 4B | ERF | Term 5A | ERF | Term 5B | ERF | Relative Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | m | | | | | | | | | | | | | | |
| 1 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 2 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 3 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 4 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 5 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 6 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 7 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 8 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 9 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 10 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 11 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 12 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 13 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 14 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 15 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 16 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 17 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 18 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 19 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 20 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |

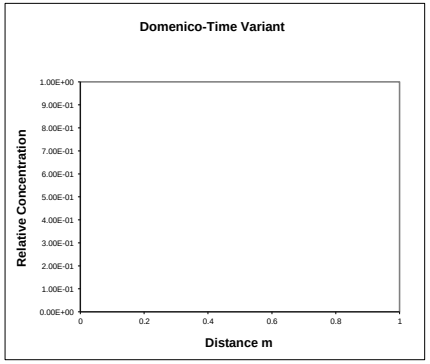



**Calc** **Value**

| | | |
|---|---|---|
| v | #DIV/0! | m/d |
| Rc | #DIV/0! | |
| u | #DIV/0! | m/d |

Calculations for source located at top of aquifer (ie vertical dispersion in one direction only) - USED FOR LEVEL ASSESSMENT

| | X | Term 1 | Term 2 | EXP | Term 3 | ERFC | Term 4A | ERF | Term 4B | ERF | Term 5A | ERF | Term 5B | ERF | Relative Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | m | | | | | | | | | | | | | | |
| 1 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 2 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 3 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 4 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 5 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 6 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 7 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 8 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 9 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 10 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 11 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 12 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 13 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 14 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 15 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 16 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 17 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 18 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 19 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 20 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |



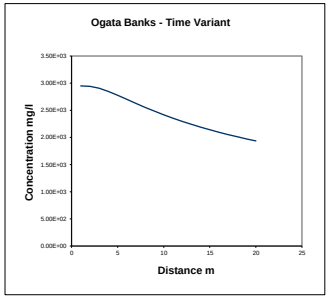

| | |
|---|---|
| Date: | 20/02/2020 |
| Version: | 1 |

**OGATA BANKS SOLUTION**

| Contaminant | Iron | |
|---|---|---|
| **Input** | **Value** | **Units** |
| $C_T$ | 1 | mg/l |
| Co | 2.95E+03 | mg/l |
| λ | 5.59E-105 | $days^{-1}$ |
| Sz | 5.00E+02 | m |
| Sy | 1.50E+00 | m |
| Kd | 8.10E+02 | l/kg |
| ρ | 1.36E+00 | g/cm3 |
| n | 8.00E-02 | |
| i | 1.00E-02 | |
| K | 8.64E-03 | m/d |
| x | 2.00E+01 | m |
| z | 0.00E+00 | m |
| y | 0.00E+00 | m |
| t | 1.00E+100 | days |
| ax | 1.57E+00 | m |
| az | 1.57E-01 | m |
| ay | 1.57E-02 | m |

Calculations for source located in centre of aquifer (ie vertical dispersion in two directions)

| | X | Term 1 | Term 2 | EXP | Term 3 | ERFC | Term 4 | EXP | Term 5 | ERFC | Term 6a | ERF | Term 6b | ERF | Term 7a | ERF | Term 7b | ERF | Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 368.659 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 6.4E-01 | 1.9E+00 | 1.1E+46 | 0.000 | 3.2E+02 | 1 | -3.2E+02 | -1 | 3.0E+00 | 1 | -3.0E+00 | -0.99998 | 2.95E+03 |
| 2 | 2 | 368.659 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 1.3E+00 | 3.6E+00 | 1.1E+46 | 0.000 | 2.2E+02 | 1 | -2.2E+02 | -1 | 2.1E+00 | 0.9973 | -2.1E+00 | -0.99726 | 2.94E+03 |
| 3 | 3 | 368.659 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 1.9E+00 | 6.8E+00 | 1.1E+46 | 0.000 | 1.8E+02 | 1 | -1.8E+02 | -1 | 1.7E+00 | 0.9856 | -1.7E+00 | -0.98557 | 2.91E+03 |
| 4 | 4 | 368.659 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 2.6E+00 | 1.3E+01 | 1.1E+46 | 0.000 | 1.6E+02 | 1 | -1.6E+02 | -1 | 1.5E+00 | 0.9659 | -1.5E+00 | -0.96587 | 2.85E+03 |
| 5 | 5 | 368.659 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 3.2E+00 | 2.4E+01 | 1.1E+46 | 0.000 | 1.4E+02 | 1 | -1.4E+02 | -1 | 1.3E+00 | 0.9419 | -1.3E+00 | -0.94189 | 2.78E+03 |
| 6 | 6 | 368.659 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 3.8E+00 | 4.6E+01 | 1.1E+46 | 0.000 | 1.3E+02 | 1 | -1.3E+02 | -1 | 1.2E+00 | 0.9163 | -1.2E+00 | -0.91633 | 2.70E+03 |
| 7 | 7 | 368.659 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 4.5E+00 | 8.7E+01 | 1.1E+46 | 0.000 | 1.2E+02 | 1 | -1.2E+02 | -1 | 1.1E+00 | 0.8907 | -1.1E+00 | -0.89072 | 2.63E+03 |
| 8 | 8 | 368.659 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 5.1E+00 | 1.7E+02 | 1.1E+46 | 0.000 | 1.1E+02 | 1 | -1.1E+02 | -1 | 1.1E+00 | 0.8659 | -1.1E+00 | -0.86587 | 2.55E+03 |
| 9 | 9 | 368.659 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 5.7E+00 | 3.1E+02 | 1.1E+46 | 0.000 | 1.1E+02 | 1 | -1.1E+02 | -1 | 1.0E+00 | 0.8422 | -1.0E+00 | -0.84215 | 2.48E+03 |
| 10 | 10 | 368.659 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 6.4E+00 | 5.9E+02 | 1.1E+46 | 0.000 | 1.0E+02 | 1 | -1.0E+02 | -1 | 9.5E-01 | 0.8197 | -9.5E-01 | -0.81971 | 2.42E+03 |
| 11 | 11 | 368.659 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 7.0E+00 | 1.1E+03 | 1.1E+46 | 0.000 | 9.5E+01 | 1 | -9.5E+01 | -1 | 9.0E-01 | 0.7986 | -9.0E-01 | -0.79858 | 2.36E+03 |
| 12 | 12 | 368.659 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 7.7E+00 | 2.1E+03 | 1.1E+46 | 0.000 | 9.1E+01 | 1 | -9.1E+01 | -1 | 8.6E-01 | 0.7787 | -8.6E-01 | -0.77872 | 2.30E+03 |
| 13 | 13 | 368.659 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 8.3E+00 | 4.0E+03 | 1.1E+46 | 0.000 | 8.8E+01 | 1 | -8.8E+01 | -1 | 8.3E-01 | 0.7601 | -8.3E-01 | -0.76006 | 2.24E+03 |
| 14 | 14 | 368.659 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 8.9E+00 | 7.6E+03 | 1.1E+46 | 0.000 | 8.4E+01 | 1 | -8.4E+01 | -1 | 8.0E-01 | 0.7425 | -8.0E-01 | -0.74253 | 2.19E+03 |
| 15 | 15 | 368.659 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 9.6E+00 | 1.4E+04 | 1.1E+46 | 0.000 | 8.2E+01 | 1 | -8.2E+01 | -1 | 7.7E-01 | 0.726 | -7.7E-01 | -0.72604 | 2.14E+03 |
| 16 | 16 | 368.659 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 1.0E+01 | 2.7E+04 | 1.1E+46 | 0.000 | 7.9E+01 | 1 | -7.9E+01 | -1 | 7.5E-01 | 0.7105 | -7.5E-01 | -0.71052 | 2.10E+03 |
| 17 | 17 | 368.659 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 1.1E+01 | 5.2E+04 | 1.1E+46 | 0.000 | 7.7E+01 | 1 | -7.7E+01 | -1 | 7.3E-01 | 0.6959 | -7.3E-01 | -0.69588 | 2.05E+03 |
| 18 | 18 | 368.659 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 1.1E+01 | 9.8E+04 | 1.1E+46 | 0.000 | 7.4E+01 | 1 | -7.4E+01 | -1 | 7.1E-01 | 0.6821 | -7.1E-01 | -0.68205 | 2.01E+03 |
| 19 | 19 | 368.659 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 1.2E+01 | 1.8E+05 | 1.1E+46 | 0.000 | 7.2E+01 | 1 | -7.2E+01 | -1 | 6.9E-01 | 0.669 | -6.9E-01 | -0.66897 | 1.97E+03 |
| 20 | 20 | 368.659 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 1.3E+01 | 3.5E+05 | 1.1E+46 | 0.000 | 7.1E+01 | 1 | -7.1E+01 | -1 | 6.7E-01 | 0.6566 | -6.7E-01 | -0.65658 | 1.94E+03 |

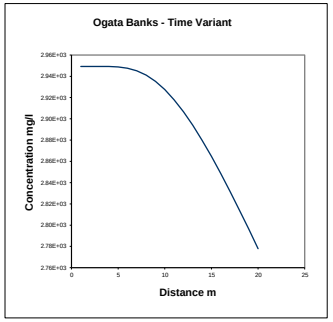



Vertical dispersion option Simulate vertical dispersion in 1 direction

| Calc | Value | |
|---|---|---|
| v | 1.08E-03 | m/d |
| Rc | 1.38E+04 | |
| u | 7.84E-08 | m/d |

Calculations for source located at top of aquifer (ie vertical dispersion in one direction) - USED FOR LEVEL ASSESSMENT

| | X | Term 1 | Term 2 | EXP | Term 3 | ERFC | Term 4 | EXP | Term 5 | ERFC | Term 6a | ERF | Term 6b | ERF | Term 7a | ERF | Term 7b | ERF | Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 368.659 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 6.4E-01 | 1.9E+00 | 1.1E+46 | 0.000 | 3.2E+02 | 1 | -3.2E+02 | -1 | 6.0E+00 | 1 | -6.0E+00 | -1 | 2.95E+03 |
| 2 | 2 | 368.659 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 1.3E+00 | 3.6E+00 | 1.1E+46 | 0.000 | 2.2E+02 | 1 | -2.2E+02 | -1 | 4.2E+00 | 1 | -4.2E+00 | -1 | 2.95E+03 |
| 3 | 3 | 368.659 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 1.9E+00 | 6.8E+00 | 1.1E+46 | 0.000 | 1.8E+02 | 1 | -1.8E+02 | -1 | 3.5E+00 | 1 | -3.5E+00 | -1 | 2.95E+03 |
| 4 | 4 | 368.659 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 2.6E+00 | 1.3E+01 | 1.1E+46 | 0.000 | 1.6E+02 | 1 | -1.6E+02 | -1 | 3.0E+00 | 1 | -3.0E+00 | -0.99998 | 2.95E+03 |
| 5 | 5 | 368.659 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 3.2E+00 | 2.4E+01 | 1.1E+46 | 0.000 | 1.4E+02 | 1 | -1.4E+02 | -1 | 2.7E+00 | 0.9998 | -2.7E+00 | -0.99985 | 2.95E+03 |
| 6 | 6 | 368.659 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 3.8E+00 | 4.6E+01 | 1.1E+46 | 0.000 | 1.3E+02 | 1 | -1.3E+02 | -1 | 2.4E+00 | 0.9995 | -2.4E+00 | -0.99946 | 2.95E+03 |
| 7 | 7 | 368.659 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 4.5E+00 | 8.7E+01 | 1.1E+46 | 0.000 | 1.2E+02 | 1 | -1.2E+02 | -1 | 2.3E+00 | 0.9986 | -2.3E+00 | -0.99864 | 2.95E+03 |
| 8 | 8 | 368.659 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 5.1E+00 | 1.7E+02 | 1.1E+46 | 0.000 | 1.1E+02 | 1 | -1.1E+02 | -1 | 2.1E+00 | 0.9973 | -2.1E+00 | -0.99726 | 2.94E+03 |
| 9 | 9 | 368.659 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 5.7E+00 | 3.1E+02 | 1.1E+46 | 0.000 | 1.1E+02 | 1 | -1.1E+02 | -1 | 2.0E+00 | 0.9953 | -2.0E+00 | -0.99527 | 2.94E+03 |
| 10 | 10 | 368.659 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 6.4E+00 | 5.9E+02 | 1.1E+46 | 0.000 | 1.0E+02 | 1 | -1.0E+02 | -1 | 1.9E+00 | 0.9926 | -1.9E+00 | -0.99263 | 2.93E+03 |
| 11 | 11 | 368.659 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 7.0E+00 | 1.1E+03 | 1.1E+46 | 0.000 | 9.5E+01 | 1 | -9.5E+01 | -1 | 1.8E+00 | 0.9894 | -1.8E+00 | -0.98938 | 2.92E+03 |
| 12 | 12 | 368.659 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 7.7E+00 | 2.1E+03 | 1.1E+46 | 0.000 | 9.1E+01 | 1 | -9.1E+01 | -1 | 1.7E+00 | 0.9856 | -1.7E+00 | -0.98557 | 2.91E+03 |
| 13 | 13 | 368.659 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 8.3E+00 | 4.0E+03 | 1.1E+46 | 0.000 | 8.8E+01 | 1 | -8.8E+01 | -1 | 1.7E+00 | 0.9812 | -1.7E+00 | -0.98124 | 2.89E+03 |
| 14 | 14 | 368.659 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 8.9E+00 | 7.6E+03 | 1.1E+46 | 0.000 | 8.4E+01 | 1 | -8.4E+01 | -1 | 1.6E+00 | 0.9765 | -1.6E+00 | -0.97647 | 2.88E+03 |
| 15 | 15 | 368.659 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 9.6E+00 | 1.4E+04 | 1.1E+46 | 0.000 | 8.2E+01 | 1 | -8.2E+01 | -1 | 1.5E+00 | 0.9713 | -1.5E+00 | -0.97133 | 2.86E+03 |
| 16 | 16 | 368.659 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 1.0E+01 | 2.7E+04 | 1.1E+46 | 0.000 | 7.9E+01 | 1 | -7.9E+01 | -1 | 1.5E+00 | 0.9659 | -1.5E+00 | -0.96587 | 2.85E+03 |
| 17 | 17 | 368.659 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 1.1E+01 | 5.2E+04 | 1.1E+46 | 0.000 | 7.7E+01 | 1 | -7.7E+01 | -1 | 1.5E+00 | 0.9601 | -1.5E+00 | -0.96015 | 2.83E+03 |
| 18 | 18 | 368.659 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 1.1E+01 | 9.8E+04 | 1.1E+46 | 0.000 | 7.4E+01 | 1 | -7.4E+01 | -1 | 1.4E+00 | 0.9542 | -1.4E+00 | -0.95421 | 2.81E+03 |
| 19 | 19 | 368.659 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 1.2E+01 | 1.8E+05 | 1.1E+46 | 0.000 | 7.2E+01 | 1 | -7.2E+01 | -1 | 1.4E+00 | 0.9481 | -1.4E+00 | -0.94812 | 2.80E+03 |
| 20 | 20 | 368.659 | 0.0E+00 | 1.0E+00 | -1.1E+46 | 2.000 | 1.3E+01 | 3.5E+05 | 1.1E+46 | 0.000 | 7.1E+01 | 1 | -7.1E+01 | -1 | 1.3E+00 | 0.9419 | -1.3E+00 | -0.94189 | 2.78E+03 |




| | |
|---|---|
| Date: | 20/02/2020 |
| Version: | 1 |

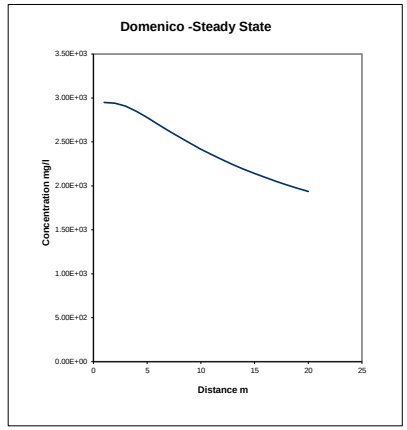
**DOMENICO (STEADY STATE)**

| Contaminant | Iron | |
|---|---|---|
| **Input** | **Value** | **Units** |
| $C_T$ | 1 | mg/l |
| Co | 2.95E+03 | mg/l |
| λ | 5.59E-105 | days$^{-1}$ |
| Sz | 5.00E+02 | m |
| Sy | 1.50E+00 | m |
| Kd | 8.10E+02 | l/kg |
| ρ | 1.36E+00 | g/cm3 |
| n | 8.00E-02 | |
| i | 1.00E-02 | |
| K | 8.64E-03 | m/d |
| x | 2.00E+01 | m |
| z | 0.00E+00 | m |
| y | 0.00E+00 | m |
| ax | 1.57E+00 | m |
| az | 1.57E-01 | m |
| ay | 1.57E-02 | m |

Vertical dispersion optio Simulate vertical dispersion in 1 direction

Calculations for source located in centre of aquifer (ie vertical dispersion in two directions)

| | X | Term 1 | Term 2 | EXP | Term 3A | ERF | Term 3B | ERF | Term 4A | ERF | Term 4B | ERF | Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 737.318 | 0.00E+00 | 1.00E+00 | 3.16E+02 | 1 | -3.16E+02 | -1 | 3.00E+00 | 1 | -3.00E+00 | -1 | 2.95E+03 |
| 2 | 2 | 737.318 | 0.00E+00 | 1.00E+00 | 2.23E+02 | 1 | -2.23E+02 | -1 | 2.12E+00 | 0.997 | -2.12E+00 | -0.9973 | 2.94E+03 |
| 3 | 3 | 737.318 | 0.00E+00 | 1.00E+00 | 1.82E+02 | 1 | -1.82E+02 | -1 | 1.73E+00 | 0.986 | -1.73E+00 | -0.9856 | 2.91E+03 |
| 4 | 4 | 737.318 | 0.00E+00 | 1.00E+00 | 1.58E+02 | 1 | -1.58E+02 | -1 | 1.50E+00 | 0.966 | -1.50E+00 | -0.9659 | 2.85E+03 |
| 5 | 5 | 737.318 | 0.00E+00 | 1.00E+00 | 1.41E+02 | 1 | -1.41E+02 | -1 | 1.34E+00 | 0.942 | -1.34E+00 | -0.9419 | 2.78E+03 |
| 6 | 6 | 737.318 | 0.00E+00 | 1.00E+00 | 1.29E+02 | 1 | -1.29E+02 | -1 | 1.22E+00 | 0.916 | -1.22E+00 | -0.9163 | 2.70E+03 |
| 7 | 7 | 737.318 | 0.00E+00 | 1.00E+00 | 1.19E+02 | 1 | -1.19E+02 | -1 | 1.13E+00 | 0.891 | -1.13E+00 | -0.8907 | 2.63E+03 |
| 8 | 8 | 737.318 | 0.00E+00 | 1.00E+00 | 1.12E+02 | 1 | -1.12E+02 | -1 | 1.06E+00 | 0.866 | -1.06E+00 | -0.8659 | 2.55E+03 |
| 9 | 9 | 737.318 | 0.00E+00 | 1.00E+00 | 1.05E+02 | 1 | -1.05E+02 | -1 | 9.99E-01 | 0.842 | -9.99E-01 | -0.8422 | 2.48E+03 |
| 10 | 10 | 737.318 | 0.00E+00 | 1.00E+00 | 9.99E+01 | 1 | -9.99E+01 | -1 | 9.47E-01 | 0.82 | -9.47E-01 | -0.8197 | 2.42E+03 |
| 11 | 11 | 737.318 | 0.00E+00 | 1.00E+00 | 9.52E+01 | 1 | -9.52E+01 | -1 | 9.03E-01 | 0.799 | -9.03E-01 | -0.7986 | 2.36E+03 |
| 12 | 12 | 737.318 | 0.00E+00 | 1.00E+00 | 9.12E+01 | 1 | -9.12E+01 | -1 | 8.65E-01 | 0.779 | -8.65E-01 | -0.7787 | 2.30E+03 |
| 13 | 13 | 737.318 | 0.00E+00 | 1.00E+00 | 8.76E+01 | 1 | -8.76E+01 | -1 | 8.31E-01 | 0.76 | -8.31E-01 | -0.7601 | 2.24E+03 |
| 14 | 14 | 737.318 | 0.00E+00 | 1.00E+00 | 8.44E+01 | 1 | -8.44E+01 | -1 | 8.01E-01 | 0.743 | -8.01E-01 | -0.7425 | 2.19E+03 |
| 15 | 15 | 737.318 | 0.00E+00 | 1.00E+00 | 8.15E+01 | 1 | -8.15E+01 | -1 | 7.74E-01 | 0.726 | -7.74E-01 | -0.726 | 2.14E+03 |
| 16 | 16 | 737.318 | 0.00E+00 | 1.00E+00 | 7.90E+01 | 1 | -7.90E+01 | -1 | 7.49E-01 | 0.711 | -7.49E-01 | -0.7105 | 2.10E+03 |
| 17 | 17 | 737.318 | 0.00E+00 | 1.00E+00 | 7.66E+01 | 1 | -7.66E+01 | -1 | 7.27E-01 | 0.696 | -7.27E-01 | -0.6959 | 2.05E+03 |
| 18 | 18 | 737.318 | 0.00E+00 | 1.00E+00 | 7.44E+01 | 1 | -7.44E+01 | -1 | 7.06E-01 | 0.682 | -7.06E-01 | -0.6821 | 2.01E+03 |
| 19 | 19 | 737.318 | 0.00E+00 | 1.00E+00 | 7.25E+01 | 1 | -7.25E+01 | -1 | 6.87E-01 | 0.669 | -6.87E-01 | -0.669 | 1.97E+03 |
| 20 | 20 | 737.318 | 0.00E+00 | 1.00E+00 | 7.06E+01 | 1 | -7.06E+01 | -1 | 6.70E-01 | 0.657 | -6.70E-01 | -0.6566 | 1.94E+03 |

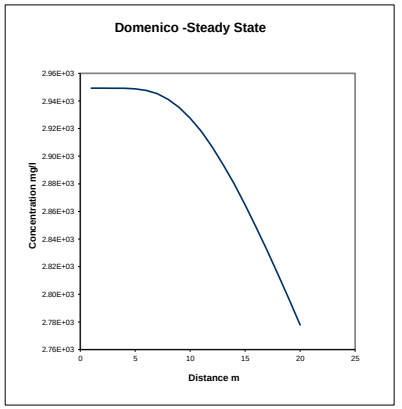



**DOMENICO (STEADY STATE)**

| Calc | Value | |
|---|---|---|
| v | 1.08E-03 | m/d |
| Rc | 1.38E+04 | |
| u | 7.84E-08 | m/d |

Calculations for source located at top of aquifer (ie vertical dispersion in one direction) - USED FOR LEVEL ASSESSMENT

| | X | Term 1 | Term 2 | EXP | Term 3A | ERF | Term 3B | ERF | Term 4A | ERF | Term 4B | ERF | Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 737.318 | 0.00E+00 | 1.00E+00 | 3.16E+02 | 1 | -3.16E+02 | -1 | 5.99E+00 | 1 | -5.99E+00 | -1 | 2.95E+03 |
| 2 | 2 | 737.318 | 0.00E+00 | 1.00E+00 | 2.23E+02 | 1 | -2.23E+02 | -1 | 4.24E+00 | 1 | -4.24E+00 | -1 | 2.95E+03 |
| 3 | 3 | 737.318 | 0.00E+00 | 1.00E+00 | 1.82E+02 | 1 | -1.82E+02 | -1 | 3.46E+00 | 1 | -3.46E+00 | -1 | 2.95E+03 |
| 4 | 4 | 737.318 | 0.00E+00 | 1.00E+00 | 1.58E+02 | 1 | -1.58E+02 | -1 | 3.00E+00 | 1 | -3.00E+00 | -1 | 2.95E+03 |
| 5 | 5 | 737.318 | 0.00E+00 | 1.00E+00 | 1.41E+02 | 1 | -1.41E+02 | -1 | 2.68E+00 | 1 | -2.68E+00 | -0.9998 | 2.95E+03 |
| 6 | 6 | 737.318 | 0.00E+00 | 1.00E+00 | 1.29E+02 | 1 | -1.29E+02 | -1 | 2.45E+00 | 0.999 | -2.45E+00 | -0.9995 | 2.95E+03 |
| 7 | 7 | 737.318 | 0.00E+00 | 1.00E+00 | 1.19E+02 | 1 | -1.19E+02 | -1 | 2.26E+00 | 0.999 | -2.26E+00 | -0.9986 | 2.95E+03 |
| 8 | 8 | 737.318 | 0.00E+00 | 1.00E+00 | 1.12E+02 | 1 | -1.12E+02 | -1 | 2.12E+00 | 0.997 | -2.12E+00 | -0.9973 | 2.94E+03 |
| 9 | 9 | 737.318 | 0.00E+00 | 1.00E+00 | 1.05E+02 | 1 | -1.05E+02 | -1 | 2.00E+00 | 0.995 | -2.00E+00 | -0.9953 | 2.94E+03 |
| 10 | 10 | 737.318 | 0.00E+00 | 1.00E+00 | 9.99E+01 | 1 | -9.99E+01 | -1 | 1.89E+00 | 0.993 | -1.89E+00 | -0.9926 | 2.93E+03 |
| 11 | 11 | 737.318 | 0.00E+00 | 1.00E+00 | 9.52E+01 | 1 | -9.52E+01 | -1 | 1.81E+00 | 0.989 | -1.81E+00 | -0.9894 | 2.92E+03 |
| 12 | 12 | 737.318 | 0.00E+00 | 1.00E+00 | 9.12E+01 | 1 | -9.12E+01 | -1 | 1.73E+00 | 0.986 | -1.73E+00 | -0.9856 | 2.91E+03 |
| 13 | 13 | 737.318 | 0.00E+00 | 1.00E+00 | 8.76E+01 | 1 | -8.76E+01 | -1 | 1.66E+00 | 0.981 | -1.66E+00 | -0.9812 | 2.89E+03 |
| 14 | 14 | 737.318 | 0.00E+00 | 1.00E+00 | 8.44E+01 | 1 | -8.44E+01 | -1 | 1.60E+00 | 0.976 | -1.60E+00 | -0.9765 | 2.88E+03 |
| 15 | 15 | 737.318 | 0.00E+00 | 1.00E+00 | 8.15E+01 | 1 | -8.15E+01 | -1 | 1.55E+00 | 0.971 | -1.55E+00 | -0.9713 | 2.86E+03 |
| 16 | 16 | 737.318 | 0.00E+00 | 1.00E+00 | 7.90E+01 | 1 | -7.90E+01 | -1 | 1.50E+00 | 0.966 | -1.50E+00 | -0.9659 | 2.85E+03 |
| 17 | 17 | 737.318 | 0.00E+00 | 1.00E+00 | 7.66E+01 | 1 | -7.66E+01 | -1 | 1.45E+00 | 0.96 | -1.45E+00 | -0.9601 | 2.83E+03 |
| 18 | 18 | 737.318 | 0.00E+00 | 1.00E+00 | 7.44E+01 | 1 | -7.44E+01 | -1 | 1.41E+00 | 0.954 | -1.41E+00 | -0.9542 | 2.81E+03 |
| 19 | 19 | 737.318 | 0.00E+00 | 1.00E+00 | 7.25E+01 | 1 | -7.25E+01 | -1 | 1.37E+00 | 0.948 | -1.37E+00 | -0.9481 | 2.80E+03 |
| 20 | 20 | 737.318 | 0.00E+00 | 1.00E+00 | 7.06E+01 | 1 | -7.06E+01 | -1 | 1.34E+00 | 0.942 | -1.34E+00 | -0.9419 | 2.78E+03 |




| | |
|---|---|
| Date: | 20/02/2020 |
| Version: | 1 |

## DOMENICO (TIME VARIANT)

**Contaminant** **Iron**

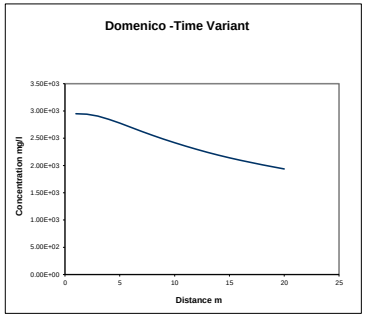
| **Input** | **Value** | **Units** |
|---|---|---|
| $C_T$ | 1 | mg/l |
| Co | 2.95E+03 | mg/l |
| λ | 5.59E-105 | days$^{-1}$ |
| Sz | 5.00E+02 | m |
| Sy | 1.50E+00 | m |
| Kd | 8.10E+02 | l/kg |
| ρ | 1.36E+00 | g/cm3 |
| n | 8.00E-02 | |
| i | 1.00E-02 | |
| K | 8.64E-03 | m/d |
| x | 2.00E+01 | m |
| z | 0.00E+00 | m |
| y | 0.00E+00 | m |
| t | 1.00E+100 | days |
| ax | 1.57E+00 | m |
| az | 1.57E-01 | m |
| ay | 1.57E-02 | m |

Vertical dispersion option: Simulate vertical dispersion in 1 direction

| **Calc** | **Value** | **Units** |
|---|---|---|
| v | 1.08E-03 | m/d |
| Rc | 1.38E+04 | |
| u | 7.84E-08 | m/d |

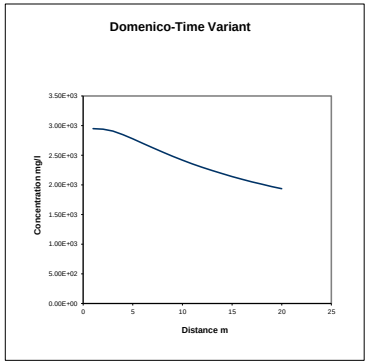
Calculations for source located in centre of aquifer (ie vertical dispersion in two directions)

| | X | Term 1 | Term 2 | EXP | Term 3 | ERFC | Term 4A | ERF | Term 4B | ERF | Term 5A | ERF | Term 5B | ERF | Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | m | | | | | | | | | | | | | | |
| 1 | 1 | 368.659 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 3.16E+02 | 1 | -3.16E+02 | -1 | 3.00E+00 | 1 | -3.00E+00 | -1 | 2.95E+03 |
| 2 | 2 | 368.659 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 2.23E+02 | 1 | -2.23E+02 | -1 | 2.12E+00 | 0.9973 | -2.12E+00 | -0.997 | 2.94E+03 |
| 3 | 3 | 368.659 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 1.82E+02 | 1 | -1.82E+02 | -1 | 1.73E+00 | 0.9856 | -1.73E+00 | -0.986 | 2.91E+03 |
| 4 | 4 | 368.659 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 1.58E+02 | 1 | -1.58E+02 | -1 | 1.50E+00 | 0.9659 | -1.50E+00 | -0.966 | 2.85E+03 |
| 5 | 5 | 368.659 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 1.41E+02 | 1 | -1.41E+02 | -1 | 1.34E+00 | 0.9419 | -1.34E+00 | -0.942 | 2.78E+03 |
| 6 | 6 | 368.659 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 1.29E+02 | 1 | -1.29E+02 | -1 | 1.22E+00 | 0.9163 | -1.22E+00 | -0.916 | 2.70E+03 |
| 7 | 7 | 368.659 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 1.19E+02 | 1 | -1.19E+02 | -1 | 1.13E+00 | 0.8907 | -1.13E+00 | -0.891 | 2.63E+03 |
| 8 | 8 | 368.659 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 1.12E+02 | 1 | -1.12E+02 | -1 | 1.06E+00 | 0.8659 | -1.06E+00 | -0.866 | 2.55E+03 |
| 9 | 9 | 368.659 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 1.05E+02 | 1 | -1.05E+02 | -1 | 9.99E-01 | 0.8422 | -9.99E-01 | -0.842 | 2.48E+03 |
| 10 | 10 | 368.659 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 9.99E+01 | 1 | -9.99E+01 | -1 | 9.47E-01 | 0.8197 | -9.47E-01 | -0.82 | 2.42E+03 |
| 11 | 11 | 368.659 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 9.52E+01 | 1 | -9.52E+01 | -1 | 9.03E-01 | 0.7986 | -9.03E-01 | -0.799 | 2.36E+03 |
| 12 | 12 | 368.659 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 9.12E+01 | 1 | -9.12E+01 | -1 | 8.65E-01 | 0.7787 | -8.65E-01 | -0.779 | 2.30E+03 |
| 13 | 13 | 368.659 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 8.76E+01 | 1 | -8.76E+01 | -1 | 8.31E-01 | 0.7601 | -8.31E-01 | -0.76 | 2.24E+03 |
| 14 | 14 | 368.659 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 8.44E+01 | 1 | -8.44E+01 | -1 | 8.01E-01 | 0.7425 | -8.01E-01 | -0.743 | 2.19E+03 |
| 15 | 15 | 368.659 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 8.15E+01 | 1 | -8.15E+01 | -1 | 7.74E-01 | 0.726 | -7.74E-01 | -0.726 | 2.14E+03 |
| 16 | 16 | 368.659 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 7.90E+01 | 1 | -7.90E+01 | -1 | 7.49E-01 | 0.7105 | -7.49E-01 | -0.711 | 2.10E+03 |
| 17 | 17 | 368.659 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 7.66E+01 | 1 | -7.66E+01 | -1 | 7.27E-01 | 0.6959 | -7.27E-01 | -0.696 | 2.05E+03 |
| 18 | 18 | 368.659 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 7.44E+01 | 1 | -7.44E+01 | -1 | 7.06E-01 | 0.6821 | -7.06E-01 | -0.682 | 2.01E+03 |
| 19 | 19 | 368.659 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 7.25E+01 | 1 | -7.25E+01 | -1 | 6.87E-01 | 0.669 | -6.87E-01 | -0.669 | 1.97E+03 |
| 20 | 20 | 368.659 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 7.06E+01 | 1 | -7.06E+01 | -1 | 6.70E-01 | 0.6566 | -6.70E-01 | -0.657 | 1.94E+03 |




Calculations for source located at top of aquifer (ie vertical dispersion in one direction only) - USED FOR LEVEL ASSESSMENT

| | X | Term 1 | Term 2 | EXP | Term 3 | ERFC | Term 4A | ERF | Term 4B | ERF | Term 5A | ERF | Term 5B | ERF | Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | m | | | | | | | | | | | | | | |
| 1 | 1 | 368.659 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 3.16E+02 | 1 | -3.16E+02 | -1 | 5.99E+00 | 1 | -5.99E+00 | -1 | 2.95E+03 |
| 2 | 2 | 368.659 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 2.23E+02 | 1 | -2.23E+02 | -1 | 4.24E+00 | 1 | -4.24E+00 | -1 | 2.95E+03 |
| 3 | 3 | 368.659 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 1.82E+02 | 1 | -1.82E+02 | -1 | 3.46E+00 | 1 | -3.46E+00 | -1 | 2.95E+03 |
| 4 | 4 | 368.659 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 1.58E+02 | 1 | -1.58E+02 | -1 | 3.00E+00 | 1 | -3.00E+00 | -1 | 2.95E+03 |
| 5 | 5 | 368.659 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 1.41E+02 | 1 | -1.41E+02 | -1 | 2.68E+00 | 0.9998 | -2.68E+00 | -1 | 2.95E+03 |
| 6 | 6 | 368.659 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 1.29E+02 | 1 | -1.29E+02 | -1 | 2.45E+00 | 0.9995 | -2.45E+00 | -0.999 | 2.95E+03 |
| 7 | 7 | 368.659 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 1.19E+02 | 1 | -1.19E+02 | -1 | 2.26E+00 | 0.9986 | -2.26E+00 | -0.999 | 2.95E+03 |
| 8 | 8 | 368.659 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 1.12E+02 | 1 | -1.12E+02 | -1 | 2.12E+00 | 0.9973 | -2.12E+00 | -0.997 | 2.94E+03 |
| 9 | 9 | 368.659 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 1.05E+02 | 1 | -1.05E+02 | -1 | 2.00E+00 | 0.9953 | -2.00E+00 | -0.995 | 2.94E+03 |
| 10 | 10 | 368.659 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 9.99E+01 | 1 | -9.99E+01 | -1 | 1.89E+00 | 0.9926 | -1.89E+00 | -0.993 | 2.93E+03 |
| 11 | 11 | 368.659 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 9.52E+01 | 1 | -9.52E+01 | -1 | 1.81E+00 | 0.9894 | -1.81E+00 | -0.989 | 2.92E+03 |
| 12 | 12 | 368.659 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 9.12E+01 | 1 | -9.12E+01 | -1 | 1.73E+00 | 0.9856 | -1.73E+00 | -0.986 | 2.91E+03 |
| 13 | 13 | 368.659 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 8.76E+01 | 1 | -8.76E+01 | -1 | 1.66E+00 | 0.9812 | -1.66E+00 | -0.981 | 2.89E+03 |
| 14 | 14 | 368.659 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 8.44E+01 | 1 | -8.44E+01 | -1 | 1.60E+00 | 0.9765 | -1.60E+00 | -0.976 | 2.88E+03 |
| 15 | 15 | 368.659 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 8.15E+01 | 1 | -8.15E+01 | -1 | 1.55E+00 | 0.9713 | -1.55E+00 | -0.971 | 2.86E+03 |
| 16 | 16 | 368.659 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 7.90E+01 | 1 | -7.90E+01 | -1 | 1.50E+00 | 0.9659 | -1.50E+00 | -0.966 | 2.85E+03 |
| 17 | 17 | 368.659 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 7.66E+01 | 1 | -7.66E+01 | -1 | 1.45E+00 | 0.9601 | -1.45E+00 | -0.96 | 2.83E+03 |
| 18 | 18 | 368.659 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 7.44E+01 | 1 | -7.44E+01 | -1 | 1.41E+00 | 0.9542 | -1.41E+00 | -0.954 | 2.81E+03 |
| 19 | 19 | 368.659 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 7.25E+01 | 1 | -7.25E+01 | -1 | 1.37E+00 | 0.9481 | -1.37E+00 | -0.948 | 2.80E+03 |
| 20 | 20 | 368.659 | 0.00E+00 | 1.00E+00 | -1.12E+46 | 2 | 7.06E+01 | 1 | -7.06E+01 | -1 | 1.34E+00 | 0.9419 | -1.34E+00 | -0.942 | 2.78E+03 |




| | |
|---|---|
| Date: | 20/02/2020 |
| Version: | 1 |

# R&D Publication 20 Remedial Targets Worksheet, Release 3.2

## Level 3 - Groundwater

See Note

**Input Parameters (using pull down menu)**

| | Variable | Value | Unit | Source |
|---|---|---|---|---|
| Contaminant | | Manganese | | from Level 1 |
| Target Concentration | $C_T$ | 1.23E-01 | mg/l | from Level 1 |

**Select analytical solution (click on brown cell below, then on pull-down menu)**

Domenico - Steady state — Equations in HRA publication

Approach for simulating vertical dispersion: Simulate vertical dispersion in 1 direction

**Select nature of decay rate (click on brown cell below, then on pull-down menu)**

Approach for simulating degradation of pollutants: Apply degradation rate to dissolved pollutants only

| | | | | Source of parameter value |
|---|---|---|---|---|
| Initial contaminant concentration in groundwater at plume core | $C_0$ | 8.99E-01 | mg/l | *Based on maximum soil conc of 408000mg/kg* |
| Half life for degradation of contaminant in water | $t_{1/2}$ | 9.00E+99 | days | *Estimation* |
| Calculated decay rate | $\lambda$ | 7.70E-101 | $days^{-1}$ | |
| Width of plume in aquifer at source (perpendicular to flow) | Sz | 5.00E+02 | m | *Site data* |
| Plume thickness at source | Sy | 1.50E+00 | m | *Thickness of re-engineered MG* |
| Saturated aquifer thickness | da | 2.00E+00 | m | *Based upon proposed total MG and cappi* |
| Bulk density of aquifer materials | ρ | 1.36E+00 | $g/cm^3$ | *Site data* |
| Effective porosity of aquifer | n | 8.00E-02 | fraction | *Estimate* |
| Hydraulic gradient | i | 1.00E-02 | fraction | |
| Hydraulic conductivity of aquifer | K | 8.64E-03 | m/d | *Proposed best achievable* |
| Distance to compliance point | x | 2.00E+01 | m | *Site data* |
| Distance (lateral) to compliance point perpendicular to flow direction | z | | m | |
| Distance (depth) to compliance point perpendicular to flow direction | y | | m | |
| Time since pollutant entered groundwater | t | 1.00E+100 | days | *time variant options only* |
| *Parameters values determined from options* | | | | |
| Partition coefficient | Kd | 7.20E+02 | l/kg | *see options* |
| Longitudinal dispersivity | ax | 1.57E+00 | m | *see options* |
| Transverse dispersivity | az | 1.57E-01 | m | *see options* |
| Vertical dispersivity | ay | 1.57E-02 | m | *see options* |

**Calculated Parameters**

| | Variable | | |
|---|---|---|---|
| Groundwater flow velocity | v | 1.08E-03 | m/d |
| Retardation factor | Rf | 1.22E+04 | fraction |
| Decay rate used | λ | 6.29E-105 | $d^{-1}$ |
| Rate of contaminant flow due to retardation | u | 8.82E-08 | m/d |
| Contaminant concentration at distance x, assuming one-way vertical dispersion | $C_{ED}$ | 8.47E-01 | mg/l |
| **Attenuation factor (one way vertical dispersion, CO/CED)** | **AF** | **1.06E+00** | |

**Select Method for deriving Partition Co-efficient (using pull down menu)**

User specified value for partition coefficient

***Entry if specify partition coefficient (option)***

Soil water partition coefficient — Kd — 7.20E+02 — l/kg

***Entry for non-polar organic chemicals (option)***

Fraction of organic carbon in aquifer — foc — fraction

Organic carbon partition coefficient — Koc — l/kg

***Entry for ionic organic chemicals (option)***

Sorption coefficient for related species — $K_{oc,n}$ — l/kg

Sorption coefficient for ionised species — $K_{oc,i}$ — l/kg

pH value — pH

acid dissociation constant — pKa

Fraction of organic carbon in aquifer — foc — fraction

Soil water partition coefficient — Kd — 7.20E+02 — l/kg

**Define dispersivity (click brown cell and use pull down list)**

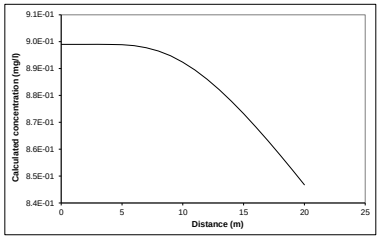
Dispersivity based on Xu & Eckstein (1995)

| | | Enter value | Calc value Xu & Eckstein | | |
|---|---|---|---|---|---|
| **Longitudinal dispersivity** | **ax** | 0.00E+00 | 2.00E+00 | 1.57E+00 | m |
| **Transverse dispersivity** | **az** | 0.00E+00 | 2.00E-01 | 1.57E-01 | m |
| **Vertical dispersivity** | **ay** | 0.00E+00 | 2.00E-02 | 1.57E-02 | |

**Note values of dispersivity must be > 0**

For calculated value, assumes ax = 0.1 *x, az = 0.01 * x, ay = 0.001 * x

Xu & Eckstein (1995) report ax = $0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed




Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared with the Level 3 remedial target to determine the need for further action.
Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O2, NO3, SO4 etc than an alternative solution should be used

**Calculated concentrations for distance-concentration graph**

**Domenico - Steady state**
**From calculation sheet**

| Distance | Concentration |
|---|---|
| | mg/l |
| 0 | 9.0E-01 |
| 1.0 | 8.99E-01 |
| 2.0 | 8.99E-01 |
| 3.0 | 8.99E-01 |
| 4.0 | 8.99E-01 |
| 5.0 | 8.99E-01 |
| 6.0 | 8.99E-01 |
| 7.0 | 8.98E-01 |
| 8.0 | 8.97E-01 |
| 9.0 | 8.95E-01 |
| 10.0 | 8.92E-01 |
| 11.0 | 8.89E-01 |
| 12.0 | 8.86E-01 |
| 13.0 | 8.82E-01 |
| 14.0 | 8.78E-01 |
| 15.0 | 8.73E-01 |
| 16.0 | 8.68E-01 |
| 17.0 | 8.63E-01 |
| 18.0 | 8.58E-01 |
| 19.0 | 8.52E-01 |
| 20.0 | 8.47E-01 |

| | |
|---|---|
| Site being assessed: | Glan Llyn |
| Completed by: | Ross Cameron |
| Date: | ####### |
| Version: | 1 |

**Remedial Targets**

| | | | |
|---|---|---|---|
| **Remedial Target** | | **1.31E-01** | **mg/l** |
| Domenico - Steady state | | | |
| **Distance to compliance point** | | **20** | **m** |
| **Concentration of contaminant at compliance point** | $C_{ED}/C_0$ | **8.47E-01** | **mg/l** |

For comparison with measured groundwater concentration.

Domenico - Steady state

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99.

# Hydrogeological risk assessment for land contamination

## Remedial Targets Worksheet , Release 3.2

**First released: 2006. Version 3.2: January 2013**

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination ( Environment Agency 2006).

**Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.**

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The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

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IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions)

| Details to be completed for each assessment | | | | |
|---|---|---|---|---|
| Site Name: | Glan Llyn | | | |
| Site Address: | Llanwern | | | |
| Completed by: | Ross Cameron | | | |
| Date: | 24-Feb-20 | | Version: | 3 |
| Contaminant | Naphthalene | | | |
| Target Concentration ($C_T$) | 0.002 | mg/l | Origin of $C_T$: | Proposed Water Framework Directive EQS |

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparision with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).
Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.
Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.
Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.
Data carried forward from an earlier worksheet are identified by a light green background
It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

## Remedial Targets Worksheet , Release 3.2

# Level 1 - Soil

**Select the method of calculating the soil water Partition Co-efficient by using the pull down menu below**

**User specified value for partition coefficient**

| | | | | |
|---|---|---|---|---|
| **Contaminant** | | **Naphthalene** | | |
| **Target concentration** | **$C_T$** | **0.002** | **mg/l** | |

| **Input Parameters** | **Variable** | **Value** | **Unit** | **Source of parameter value** |
|---|---|---|---|---|
| ***Standard entry*** | | | | |
| Water filled soil porosity | $\theta_w$ | 5.00E-01 | fraction | 0.5 |
| Air filled soil porosity | θa | 3.70E-01 | fraction | 0.0037 |
| Bulk density of soil zone material | ρ | 1.36E+00 | g/cm$^3$ | 1.36 |
| Henry's Law constant | H | 1.00E+00 | dimensionless | *1* |
| ***Entry if specify partition coefficient (option)*** | | | | |
| Soil water partition coefficient | Kd | 1.34E+02 | l/kg | *1.34E+02* |
| ***Entry for non-polar organic chemicals (option)*** | | | | |
| Fraction of organic carbon (in soil) | foc | | fraction | |
| Organic carbon partition coefficient | Koc | | l/kg | |
| ***Entry for ionic organic chemicals (option)*** | | | | |
| Sorption coefficient for neutral species | $K_{oc,n}$ | | l/kg | |
| Sorption coefficient for ionised species | $K_{oc,i}$ | | l/kg | |
| pH value | pH | | pH units | |
| Acid dissociation constant | pKa | | | |
| Fraction of organic carbon (in soil) | foc | | fraction | |

This sheet calculates the Level 1 remedial target for soils(mg/kg) based on a selected target concentration and theoretical calculation of soil water partitioning. Three options are included for determining the partition coefficient.

The measured soil concentration as mg/kg should be compared with the Level 1 remedial target to determine the need for further action.

| | | | | |
|---|---|---|---|---|
| **Soil water partition coefficient used in Level Assessment** | **Kd** | **1.34E+02** | **l/kg** | *Specified value* |

## Level 1 Remedial Target

| | | | |
|---|---|---|---|
| **Level 1 Remedial Target** | **2.69E-01** | **mg/kg** | **(for comparison with soil analyses)** |
| | **or** | | |
| | **0.002** | **mg/l** | **(for comparison with leachate test results)** |

| | |
|---|---|
| Site being assessed: | Glan Llyn |
| Completed by: | Ross Cameron |
| Date: | 24-Feb-20 |
| Version: | 3 |

## Remedial Targets Worksheet , Release 3.2

# Level 2 - Soil

| | | | | |
|---|---|---|---|---|
| **Contaminant** | | **Naphthalene** | | from Level 1 |
| **Target concentration** | $C_T$ | **0.002** | **mg/l** | from Level 1 |

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamiantion' (Environment Agency 2006)

| **Input Parameters** | **Variable** | **Value** | **Unit** | **Source of parameter value** | |
|---|---|---|---|---|---|
| *Standard entry* | | | | | |
| Infiltration | Inf | 0.00E+00 | m/d | | |
| Area of contaminant source | A | 0.00E+00 | $m^2$ | | Not used in calculation |
| *Entry for groundwater flow below site* | | | | | |
| Length of contaminant source in direction of groundwater flow | L | 0.00E+00 | m | | |
| Saturated aquifer thickness | da | 0.00E+00 | m | | |
| Hydraulic Conductivity of aquifer in which dilution occurs | K | 0.00E+00 | m/d | | |
| Hydraulic gradient of water table | i | 0.00E+00 | fraction | | |
| Width of contaminant source perpendicular to groundwater flow | w | 0.00E+00 | m | | Not used in calculation |
| Background concentration of contaminant in groundwater beneath site | Cu | 0.00E+00 | mg/l | | |
| Define mixing zone depth by specifying or calculating depth (using pull down list) | | **Specify** | | | |
| Enter mixing zone thickness | Mz | 0.00E+00 | m | | |
| Calculated mixing zone thickness | Mz | | m | | |

## Calculated Parameters

| | | | | |
|---|---|---|---|---|
| **Dilution Factor** | **DF** | **#DIV/0!** | | |
| **Level 2 Remedial Target** | | **#DIV/0!** | **mg/l** | **For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentra** |
| | | **or** | | |
| | | **#DIV/0!** | **mg/kg** | **For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water** |

## *Additional option*

**Calculation of impact on receptor**

| | | | | |
|---|---|---|---|---|
| Concentration of contaminant in contaminated discharge (entering receptor) | Cc | 0.00E+00 | mg/l | |
| Calculated concentration within receptor (dilution only) | | #DIV/0! | mg/l | 0 |

| | |
|---|---|
| Site being assessed: | Glan Llyn |
| Completed by: | Ross Cameron |
| Date: | 24-Feb-20 |
| Version: | 3 |

**Remedial Targets Worksheet , Release 3.2**

## Level 3 - Soil

See Note

Environment Agency

### Input Parameters

| | Variable | Value | Unit | Source |
|---|---|---|---|---|
| Contaminant | | Naphthalene | | from Level 1 |
| Target Concentration | $C_T$ | 0.002 | mg/l | from Level 1 |
| Dilution Factor | DF | #DIV/0! | | from Level 2 |

**Select analytical solution (click on brown cell below, then on pull-down menu)**

Ogata Banks — Equations in HRA publication

**Select nature of decay rate (click on brown cell below, then on pull-down menu)**

Approach for simulating degradation of pollutants: Apply degradation rate to pollutants in all phases (e.g. field derived value, lab derived value)

| | Variable | Value | Unit | Source of parameter value |
|---|---|---|---|---|
| Enter source concentration | | Soil concentration as mg/kg | | |
| Enter soil concentration | | 0 | mg/kg | |
| Half life for degradation of contaminant in water | $t_{1/2}$ | 1.00E+100 | days | |
| Calculated decay rate | $\lambda$ | 6.93E-101 | $days^{-1}$ | calculated |
| Width of plume in aquifer at source | Sz | 0.00E+00 | m | from Level 2 |
| Plume thickness in aquifer at source | Sy | 0.00E+00 | m | from Level 2 |
| Bulk density of aquifer materials | $\rho$ | 0.00E+00 | $g/cm^3$ | |
| Effective porosity of aquifer | n | 0.00E+00 | fraction | |
| Hydraulic gradient | i | #DIV/0! | fraction | from Level 2 (adjusted) |
| Hydraulic conductivity of saturated aquifer | K | 0.00E+00 | m/d | from Level 2 |
| Distance to compliance point | x | 0.00E+00 | m | |
| Distance (lateral) to compliance point perpendicular to flow direction | z | | m | |
| Distance (depth) to compliance point perpendicular to flow direction | y | | m | |
| Time since pollutant entered groundwater | t | 1.00E+99 | days | *time variant options only* |
| *Parameters values determined from options* | | | | |
| Partition coefficient | Kd | 0.00E+00 | l/kg | *see options* |
| Longitudinal dispersivity | ax | 0.000 | m | *see options* |
| Transverse dispersivity | az | 0.000 | m | *see options* |
| Vertical dispersivity | av | 0.000 | m | *see options* |

***Parameter values should be checked against Level 1 and 2***

### Calculated Parameters

| | Variable | | |
|---|---|---|---|
| Groundwater flow velocity | v | #DIV/0! | m/d |
| Retardation factor | Rf | #DIV/0! | fraction |
| Decay rate used | $\lambda$ | 6.93E-101 | $d^{-1}$ |
| Hydraulic gradient used in aquifer flow down-gradient | i | #DIV/0! | fraction |
| Rate of contaminant flow due to retardation | u | #DIV/0! | m/d |
| Ratio of Compliance Point to Source Concentration | $C_{ED}/C_0$ | #DIV/0! | fraction |
| **Attenuation factor ($C_0/C_{ED}$)** | **AF** | **#DIV/0!** | **fraction** |
| Calculated soil leachate concentration | Co | 0.00E+00 | mg/l |

### Remedial Targets

| | | | |
|---|---|---|---|
| **Level 3 Remedial Target** | **#DIV/0!** | **mg/l** | For comparison with measured pore water concentration. |
| Ogata Banks | **or** | | This assumes Level 1 Remedial Target is based on Target Concentration. |
| | **#DIV/0!** | **mg/kg** | For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water partitioning equation. |
| **Distance to compliance point** | **0** | **m** | |
| **Ratio of Compliance Point to Source Concentration** | **$C_{ED}/C_0$** | **#DIV/0!** | **fraction** Ogata Banks |

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99

**Enter method of defining partition co-efficient (using pull down list)**

Calculate for ionic organic chemicals (acids)

*Entry if specify partition coefficient (option)*

| | | |
|---|---|---|
| Soil water partition coefficient | Kd | l/kg |

*Entry for non-polar organic chemicals (option)*

| | | |
|---|---|---|
| Fraction of organic carbon in aquifer | foc | fraction |
| Organic carbon partition coefficient | Koc | l/kg |

*Entry for ionic organic chemicals (option)*

| | | | |
|---|---|---|---|
| Sorption coefficient for related species | $K_{oc,n}$ | 0.00E+00 | l/kg |
| Sorption coefficient for ionised species | $K_{oc,i}$ | 0.00E+00 | l/kg |
| pH value | pH | 0.00E+00 | |
| Acid dissociation constant | pKa | 0.00E+00 | |
| Fraction of organic carbon in aquifer | foc | 0.00E+00 | fraction |
| Soil water partition coefficient | Kd | 0.00E+00 | l/kg |

**Define dispersivity (click brown cell and use pull down list)**

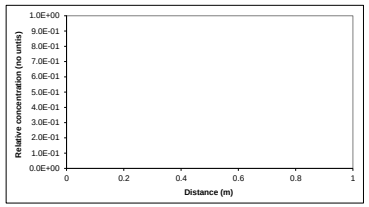
User defined values for dispersivity

| | | Enter value | Calc value | Xu & Eckstein | |
|---|---|---|---|---|---|
| **Longitudinal dispersivity** | **ax** | 0.00E+00 | 0.00E+00 | #NUM! | m |
| **Transverse dispersivity** | **az** | 0.00E+00 | 0.00E+00 | #NUM! | m |
| **Vertical dispersivity** | **ay** | 0.00E+00 | 0.00E+00 | #NUM! | m |

**Note values of dispersivity must be > 0**

Xu & Eckstein (1995) report ax = $0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed

Note
This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by $O_2$, $NO_3$, $SO_4$ etc than an alternative solution should be used




Note: 'Relative concentration' is the ratio of calculated concentation at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

| | |
|---|---|
| Site being assessed: | Glan Llyn |
| Completed by: | Ross Cameron |
| Date: | ######## |
| Version: | 3 |

**Calculated (relative) concentrations for distance-concentration graph**

Ogata Banks
From calculation sheet

| Distance | Relative concentration (No units) | Concentration mg/l |
|---|---|---|
| 0 | 1.0E+00 | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |

# Remedial Targets Worksheet , Release 3.2

## Calculation of contaminant concentration in groundwater from a soil source

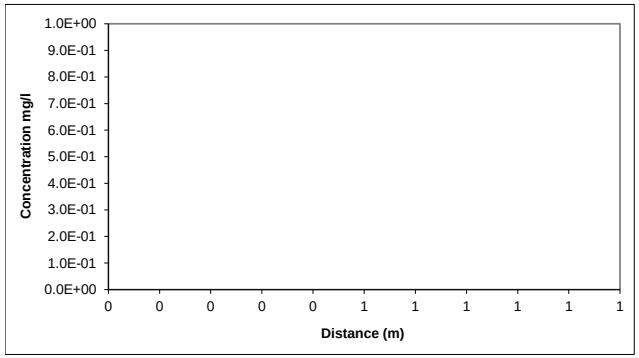
Only input required is Soil Contaminant Concentration

| | | | | |
|---|---|---|---|---|
| | Input Parameters | | | |
| | Soil contaminant concentration | $C_0$ | 0.00E+00 | mg/kg |
| **Level 1 Parameters** | | | | |
| | Water filled soil porosity | $\theta_w$ | 5.00E-01 | fraction |
| | Air filled soil porosity | $\theta a$ | 3.70E-01 | fraction |
| | Bulk density | $\rho$ | 1.36E+00 | g/cm$^3$ |
| | Henry's Law constant | H | 1.00E+00 | dimensionless |
| | Soil water partition coefficient used in Level Assessment | Kd | 1.34E+02 | l/kg |
| | Factor (partitioning between soil and water) | | 1.35E+02 | dimensionless |
| **Level 2 Parameters** | **Dilution Factor** | DF | #DIV/0! | |
| **Level 3 Parameters** | **Attenuation factor ($C_O/C_{ED}$)** | AF | #DIV/0! | |

### Predicted concentrations at compliance point

| | | | | |
|---|---|---|---|---|
| **Level 1** | C | 0.00E+00 | mg/l | No dilution or attenuation |
| **Level 2** | C | #DIV/0! | mg/l | Dilution taken into account |
| **Level 3** | C | #DIV/0! | mg/l | Dilution and attenuation taken into account |

### Predicted concentrations between source and compliance point - Level 3




| Distance m | Concentration mg/l |
|---|---|
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |

# R&D Publication 20 Remedial Targets Worksheet, Release 3.2

## Level 3 - Groundwater

See Note

**Input Parameters (using pull down menu)** | Variable | Value | Unit | Source

| | | | | |
|---|---|---|---|---|
| Contaminant | | Naphthalene | | from Level 1 |
| Target Concentration | $C_T$ | 2.00E-03 | mg/l | from Level 1 |

**Select analytical solution (click on brown cell below, then on pull-down menu)**

Domenico - Steady state — Equations in HRA publication

Approach for simulating vertical dispersion: Simulate vertical dispersion in 1 direction

**Select nature of decay rate (click on brown cell below, then on pull-down menu)**

Approach for simulating degradation of pollutants: Apply degradation rate to dissolved pollutants only

| | | | | Source of parameter value |
|---|---|---|---|---|
| Initial contaminant concentration in groundwater at plume core | $C_0$ | 1.29E+02 | mg/l | *Based on maximum soil conc of 4680mg/kg* |
| Half life for degradation of contaminant in water | $t_{1/2}$ | 1.00E+02 | days | *100 day half life estimation* |
| Calculated decay rate | λ | 6.93E-03 | $days^{-1}$ | |
| Width of plume in aquifer at source (perpendicular to flow) | Sz | 5.00E+02 | m | *Site data* |
| Plume thickness at source | Sy | 1.50E+00 | m | *Thickness of re-engineered MG* |
| Saturated aquifer thickness | da | 2.00E+00 | m | *Based upon proposed total MG and cappir* |
| Bulk density of aquifer materials | ρ | 1.36E+00 | $g/cm^3$ | *Site data* |
| Effective porosity of aquifer | n | 8.00E-02 | fraction | *Estimate* |
| Hydraulic gradient | i | 1.00E-02 | fraction | |
| Hydraulic conductivity of aquifer | K | 8.64E-03 | m/d | *Proposed best achievable* |
| Distance to compliance point | x | 2.00E+01 | m | *Site data* |
| Distance (lateral) to compliance point perpendicular to flow direction | z | | m | |
| Distance (depth) to compliance point perpendicular to flow direction | y | | m | |
| Time since pollutant entered groundwater | t | 1.00E+100 | days | *time variant options only* |
| *Parameters values determined from options* | | | | |
| Partition coefficient | Kd | 3.60E+01 | l/kg | *see options* |
| Longitudinal dispersivity | ax | 2.00E+00 | m | *see options* |
| Transverse dispersivity | az | 2.00E-01 | m | *see options* |
| Vertical dispersivity | ay | 2.00E-02 | m | *see options* |

**Calculated Parameters** | Variable

| | | | |
|---|---|---|---|
| Groundwater flow velocity | v | 1.08E-03 | m/d |
| Retardation factor | Rf | 6.13E+02 | fraction |
| Decay rate used | λ | 1.13E-05 | $d^{-1}$ |
| Rate of contaminant flow due to retardation | u | 1.76E-06 | m/d |
| Contaminant concentration at distance x, assuming one-way vertical dispersion | $C_{ED}$ | 3.37E-12 | mg/l |
| **Attenuation factor (one way vertical dispersion, CO/CED)** | **AF** | **3.82E+13** | |

**Remedial Targets**

| | | | | |
|---|---|---|---|---|
| **Remedial Target** | | **7.64E+10** | **mg/l** | For comparison with measured groundwater concentration. |
| Domenico - Steady state | | | | |
| **Distance to compliance point** | | **20** | **m** | |
| **Concentration of contaminant at compliance point** | **$C_{ED}/C_0$** | **3.37E-12** | **mg/l** | Domenico - Steady state |

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.E+99.

**Select Method for deriving Partition Co-efficient (using pull down menu)**

User specified value for partition coefficient

| | | | |
|---|---|---|---|
| ***Entry if specify partition coefficient (option)*** | | | |
| Soil water partition coefficient | Kd | 3.60E+01 | l/kg |
| ***Entry for non-polar organic chemicals (option)*** | | | |
| Fraction of organic carbon in aquifer | foc | | fraction |
| Organic carbon partition coefficient | Koc | | l/kg |
| ***Entry for ionic organic chemicals (option)*** | | | |
| Sorption coefficient for related species | $K_{oc,n}$ | | l/kg |
| Sorption coefficient for ionised species | $K_{ow\cdot i}$ | | l/kg |
| pH value | pH | | |
| acid dissociation constant | pKa | | |
| Fraction of organic carbon in aquifer | foc | | fraction |
| Soil water partition coefficient | Kd | 3.60E+01 | l/kg |

**Define dispersivity (click brown cell and use pull down list)**

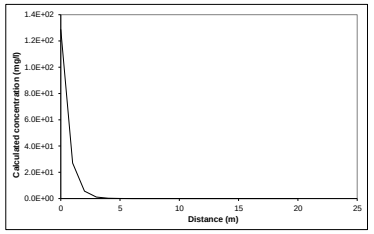
Dispersivities 10%, 1%, 0.1% of pathway length

| | | Enter value | Calc value Xu & Eckstein | m |
|---|---|---|---|---|
| **Longitudinal dispersivity** | **ax** | 0.00E+00 | 2.00E+00 | 1.57E+00 m |
| **Transverse dispersivity** | **az** | 0.00E+00 | 2.00E-01 | 1.57E-01 m |
| **Vertical dispersivity** | **ay** | 0.00E+00 | 2.00E-02 | 1.57E-02 m |

**Note values of dispersivity must be > 0**

For calculated value, assumes ax = 0.1 *x, az = 0.01 * x, ay = 0.001 * x

Xu & Eckstein (1995) report ax = $0.83(\log_{10}x)^{2.414}$ ; az = ax/10, ay = ax/100 are assumed




Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared with the Level 3 remedial target to determine the need for further action.
Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O2, NO3, SO4 etc than an alternative solution should be used

| | |
|---|---|
| Site being assessed: | Glan Llyn |
| Completed by: | Ross Cameron |
| Date: | ######## |
| Version: | 3 |

**Calculated concentrations for distance-concentration graph**

**Domenico - Steady state**
**From calculation sheet**

| Distance | Concentration |
|---|---|
| | mg/l |
| 0 | 1.3E+02 |
| 1.0 | 2.71E+01 |
| 2.0 | 5.70E+00 |
| 3.0 | 1.20E+00 |
| 4.0 | 2.52E-01 |
| 5.0 | 5.30E-02 |
| 6.0 | 1.11E-02 |
| 7.0 | 2.34E-03 |
| 8.0 | 4.90E-04 |
| 9.0 | 1.03E-04 |
| 10.0 | 2.15E-05 |
| 11.0 | 4.49E-06 |
| 12.0 | 9.39E-07 |
| 13.0 | 1.96E-07 |
| 14.0 | 4.09E-08 |
| 15.0 | 8.54E-09 |
| 16.0 | 1.78E-09 |
| 17.0 | 3.72E-10 |
| 18.0 | 7.75E-11 |
| 19.0 | 1.62E-11 |
| 20.0 | 3.37E-12 |

# Porosity Calculator

These results are not carried through to any of the other worksheets

## DRY BULK DENSITY DATA

| Variable | Value | Unit | justification |
|---|---|---|---|
| Natural Moisture Content | 0.00 | % wt | |
| Particle Density | 2.78 | tonnes/m$^3$ | (Change this number only if you have specific information) |
| Dry Bulk Density | 0.00 | tonnes/m$^3$ | |
| *Calculated Parameters* | | | |
| Voids Ratio | #DIV/0! | fraction | |
| Initial Saturation | #DIV/0! | % | |
| **Total porosity** | **1.000** | **fraction** | |
| **Air Filled Porosity** | **#DIV/0!** | **fraction** | |
| **Water Filled Porosity** | **#DIV/0!** | **fraction** | |

## WET BULK DENSITY DATA

| Variable | Value | Unit | |
|---|---|---|---|
| Moisture Content | 0.00 | % wt | |
| Particle Density | 2.78 | tonnes/m$^3$ | (Change this number only if you have specific information) |
| Actual (wet) Bulk Density ( i.e. at natural MC) | 0.00 | tonnes/m$^3$ | |
| *Calculated Parameters* | | | |
| Voids Ratio | #DIV/0! | fraction | |
| dry bulk density | 0.00 | tonnes/m$^3$ | |
| Initial Saturation | #DIV/0! | % | |
| **Total porosity** | **1.000** | **fraction** | **#DIV/0!** |
| **Air Filled Porosity** | **#DIV/0!** | **fraction** | |
| **Water Filled Porosity** | **#DIV/0!** | **fraction** | |

*Analytical solutions provided by David Hall, Golder Associates (UK) Ltd*

# Simple hydrogeological calculations

**(These are not specific to, or required in, the Remedial Targets Methodology)**

| Parameter | symbol | | unit | justification |
|---|---|---|---|---|
| Hydraulic conductivity | K | 0.00E+00 | m/d | |
| Hydraulic gradient | i | 0.00E+00 | unitless | |
| Effective porosity of aquifer | n | 0.00E+00 | fraction | |
| Thickness of saturated aquifer | b | 0.00E+00 | m | |
| Width of aquifer perpendicular to flow | w | 0.00E+00 | m | |
| Distance to receptor | x | 0.00E+00 | m | |
| Bulk density of aquifer materials | ρ | 0.00E+00 | $g/cm^3$ | |
| Soil-water partition co-efficient | Kd | 0.00E+00 | l/kg | |
| Retardation factor of pollutant | R | #DIV/0! | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Groundwater flow velocity | v(GW) | #DIV/0! | m/s | #DIV/0! | m/day | #DIV/0! | m/year |
| Time for groundwater to reach receptor | t(GW) | #DIV/0! | seconds | #DIV/0! | days | #DIV/0! | years |
| Rate of groundwater flow through aquifer | Q | 0.00E+00 | $m^3/s$ | 0.00E+00 | $m^3$/day | 0.00E+00 | $m^3$/year |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Contaminant flow velocity | v(contam) | #DIV/0! | m/s | #DIV/0! | m/day | #DIV/0! | m/year |
| Time for contaminant to reach receptor | t(contam) | #DIV/0! | seconds | #DIV/0! | days | #DIV/0! | years |

## Level 1 Calculation Sheet

**Contaminant** **Naphthalene**

| Parameter | Value | Units |
|---|---|---|
| (carried over from input sheet) | | |
| $C_T$ | 2.00E-03 | mg/l |
| Kd | 1.34E+02 | l/kg |
| foc | | fraction |
| koc | | l/kg |
| $\theta_w$ | 5.00E-01 | fraction |
| $\theta a$ | 3.70E-01 | fraction |
| $\rho$ | 1.36E+00 | g/cm3 |
| H | 1.00E+00 | dimensionless |
| Koc,n | | l/kg |
| Koc,i | | l/kg |
| pH | | pH units |
| pKa | | |
| foc (ionic) | | fraction |

**Calculations (Refer toTable 4.3, R&D Publication 20)**

**Selected option** User specified value for partition coefficient

| | calc | calc | Calc Kd | l/kg |
|---|---|---|---|---|
| Calculation of partition coefficient for ionic organic chemical | | | | |
| Partition coefficient used in Level 1 Assessment | | | 1.34E+02 | l/kg |

**Calculated Remedial Target** **2.69E-01 mg/kg** **for Naphthalene**

Factor (partitioning between soil and water) 1.35E+02

| | |
|---|---|
| Site being assessed: | Glan Llyn |
| Completed by: | Ross Cameron |
| Date: | 24/02/2020 |
| Version: | 3 |

## Level 2 Calculation Sheet

**Contaminant** **Naphthalene**

| Site assessed: | Glan Llyn |
|---|---|
| Date: | 24/02/2020 |
| Version: | 3 |

| Parameter | Value | Units |
|---|---|---|
| (carried over from input sheet) | | |
| Mz | 0.00E+00 | m |
| L | 0.00E+00 | m |
| da | 0.00E+00 | m |
| Inf | 0.00E+00 | m/d |
| K | 0.00E+00 | m/d |
| i | 0.00E+00 | m3/d |
| A | 0.00E+00 | m2 |
| Cc | 0.00E+00 | m3/d mg/l |
| $C_T$ | 2.00E-03 | mg/l |
| Cu | 0.00E+00 | mg/l |
| w | 0.00E+00 | m |

Calculated Dilution Factor

Calculation based on target concentration #DIV/0!

Calculation based on observed contaminant concentration #DIV/0!

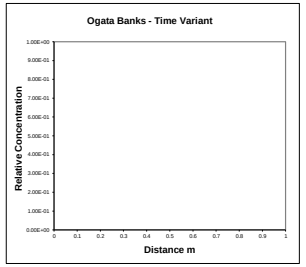


**OGATA BANKS SOLUTION**

| Contaminant | Naphthalene | |
|---|---|---|
| **Input** | **Value** | **Units** |
| $C_T$ | 2.000E-03 | mg/l |
| DF | #DIV/0! | |
| λ | 6.931E-101 | $days^{-1}$ |
| Sz | 0.000E+00 | m |
| Sy | 0.000E+00 | m |
| Kd | 0.000E+00 | l/kg |
| ρ | 0.000E+00 | g/cm3 |
| n | 0.000E+00 | |
| i | #DIV/0! | |
| K | 0.000E+00 | m/d |
| x | 0.000E+00 | m |
| z | 0.000E+00 | m |
| y | 0.000E+00 | m |
| t | 1.000E+99 | days |
| ax | 0.000E+00 | m |
| az | 0.000E+00 | m |
| ay | 0.000E+00 | m |

Calculations for source located in centre of aquifer (ie vertical dispersion in two directions)

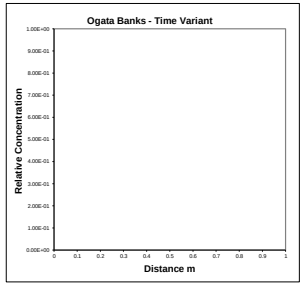
| | X | Term 1 | Term 2 | EXP | Term 3 | ERFC | Term 4 | EXP | Term 5 | ERFC | Term 6a | ERF | Term 6b | ERF | Term 7a | ERF | Term 7b | ERF | Relative Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 2 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 3 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 4 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 5 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 6 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 7 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 8 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 9 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 10 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 11 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 12 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 13 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 14 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 15 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 16 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 17 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 18 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 19 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 20 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |




| Calc | Value | |
|---|---|---|
| v | #DIV/0! | m/d |
| Rc | #DIV/0! | |
| u | #DIV/0! | m/d |

Calculations for source located at top of aquifer (ie vertical dispersion in one direction) -USED FOR LEVEL ASSESSMENT

| | X | Term 1 | Term 2 | EXP | Term 3 | ERFC | Term 4 | EXP | Term 5 | ERFC | Term 6a | ERF | Term 6b | ERF | Term 7a | ERF | Term 7b | ERF | Relative Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
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| 2 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 3 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 4 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 5 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 6 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 7 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 8 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 9 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 10 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 11 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 12 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 13 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 14 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 15 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 16 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 17 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 18 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 19 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 20 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |




| | |
|---|---|
| Date: | 24/02/2020 |
| Version: | 3 |

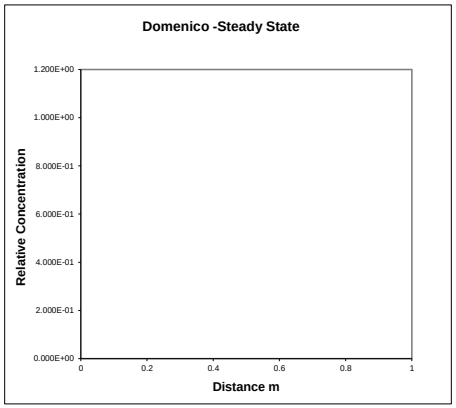
**Contaminant** **Naphthalene**

**DOMENICO (STEADY STATE)**

Calculations for source located in centre of aquifer (ie vertical dispersion in two directions)

| Input | Value | Units |
|---|---|---|
| $C_T$ | 2.000E-03 | mg/l |
| DF | #DIV/0! | |
| λ | 6.931E-101 | days$^{-1}$ |
| Sz | 0.000E+00 | m |
| Sy | 0.000E+00 | m |
| Kd | 0.000E+00 | l/kg |
| ρ | 0.000E+00 | g/cm3 |
| n | 0.000E+00 | |
| i | #DIV/0! | |
| K | 0.000E+00 | m/d |
| x | 0.000E+00 | m |
| z | 0.000E+00 | m |
| y | 0.000E+00 | m |
| ax | 0.000E+00 | m |
| az | 0.000E+00 | m |
| ay | 0.000E+00 | m |

| | X | Term 1 | Term 2 | EXP | Term 3A | ERF | Term 4A | ERF | Term 4B | ERF | Relative Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 2 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 3 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 4 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 5 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 6 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 7 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 8 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 9 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 10 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 11 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 12 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 13 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 14 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 15 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 16 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 17 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 18 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 19 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 20 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |



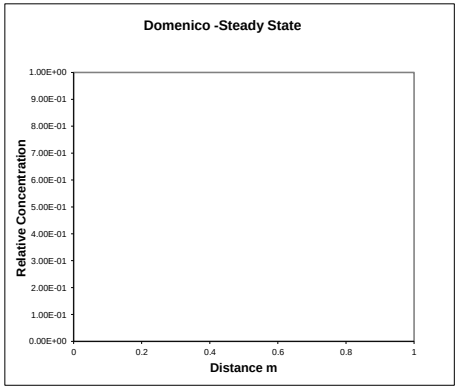

**Calc** **Value**

| | | |
|---|---|---|
| v | #DIV/0! | m/d |
| Rc | #DIV/0! | |
| u | #DIV/0! | m/d |

**DOMENICO (STEADY STATE)**

Calculations for source located at top of aquifer (ie vertical dispersion in one direction) - USED FOR LEVEL ASSESSMENT

| | X | Term 1 | Term 2 | EXP | Term 3A | ERF | Term 4A | ERF | Term 4B | ERF | Relative Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 2 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 3 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 4 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 5 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 6 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 7 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 8 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 9 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 10 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 11 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 12 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 13 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 14 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 15 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 16 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 17 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 18 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 19 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 20 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |




| | |
|---|---|
| Date: | 24/02/2020 |
| Version: | 3 |

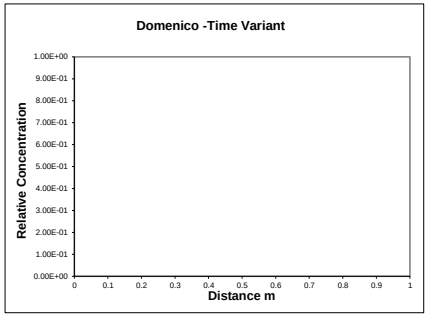
**DOMENICO (TIME VARIANT)**

**Contaminant** **Naphthalene**

Calculations for source located in centre of aquifer (ie vertical dispersion in two directions)

| Input | Value | Units |
|---|---|---|
| $C_T$ | 0.002 | mg/l |
| DF | #DIV/0! | |
| λ | 6.931E-101 | days$^{-1}$ |
| Sz | 0.000E+00 | m |
| Sy | 0.000E+00 | m |
| Kd | 0.000E+00 | l/kg |
| ρ | 0.000E+00 | g/cm3 |
| n | 0.000E+00 | |
| i | #DIV/0! | |
| K | 0.000E+00 | m/d |
| x | 0.000E+00 | m |
| z | 0.000E+00 | m |
| y | 0.000E+00 | m |
| t | 1.000E+99 | days |
| ax | 0.000E+00 | m |
| az | 0.000E+00 | m |
| ay | 0.000E+00 | m |

| | X | Term 1 | Term 2 | EXP | Term 3 | ERFC | Term 4A | ERF | Term 4B | ERF | Term 5A | ERF | Term 5B | ERF | Relative Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | m | | | | | | | | | | | | | | |
| 1 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 2 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 3 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 4 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 5 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 6 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 7 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 8 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 9 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 10 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 11 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 12 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 13 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 14 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 15 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 16 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 17 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 18 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 19 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 20 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |

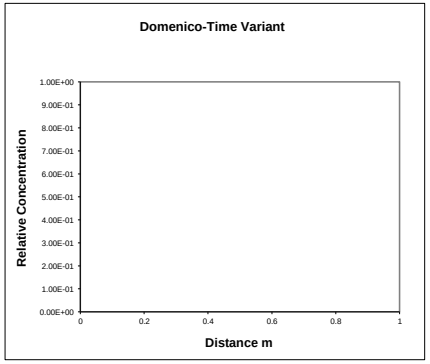



**Calc** **Value**

| | | |
|---|---|---|
| v | #DIV/0! | m/d |
| Rc | #DIV/0! | |
| u | #DIV/0! | m/d |

Calculations for source located at top of aquifer (ie vertical dispersion in one direction only) - USED FOR LEVEL ASSESSMENT

| | X | Term 1 | Term 2 | EXP | Term 3 | ERFC | Term 4A | ERF | Term 4B | ERF | Term 5A | ERF | Term 5B | ERF | Relative Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | m | | | | | | | | | | | | | | |
| 1 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 2 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 3 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 4 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 5 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 6 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 7 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 8 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 9 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 10 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 11 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 12 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 13 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 14 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 15 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 16 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 17 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 18 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 19 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 20 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |



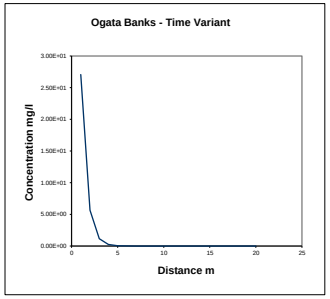

| | |
|---|---|
| Date: | 24/02/2020 |
| Version: | 3 |

**OGATA BANKS SOLUTION**

| Contaminant | Naphthalene | |
|---|---|---|
| **Input** | **Value** | **Units** |
| $C_T$ | 0.002 | mg/l |
| Co | 1.29E+02 | mg/l |
| λ | 1.13E-05 | days$^{-1}$ |
| Sz | 5.00E+02 | m |
| Sy | 1.50E+00 | m |
| Kd | 3.60E+01 | l/kg |
| ρ | 1.36E+00 | g/cm3 |
| n | 8.00E-02 | |
| i | 1.00E-02 | |
| K | 8.64E-03 | m/d |
| x | 2.00E+01 | m |
| z | 0.00E+00 | m |
| y | 0.00E+00 | m |
| t | 1.00E+100 | days |
| ax | 2.00E+00 | m |
| az | 2.00E-01 | m |
| ay | 2.00E-02 | m |

Calculations for source located in centre of aquifer (ie vertical dispersion in two directions)

| | X | Term 1 | Term 2 | EXP | Term 3 | ERFC | Term 4 | EXP | Term 5 | ERFC | Term 6a | ERF | Term 6b | ERF | Term 7a | ERF | Term 7b | ERF | Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 16.085 | -1.6E+00 | 2.1E-01 | -3.4E+47 | 2.000 | 2.1E+00 | 7.8E+00 | 3.4E+47 | 0.000 | 2.8E+02 | 1 | -2.8E+02 | -1 | 2.7E+00 | 0.9998 | -2.7E+00 | -0.99982 | 2.71E+01 |
| 2 | 2 | 16.085 | -3.1E+00 | 4.4E-02 | -3.4E+47 | 2.000 | 4.1E+00 | 6.1E+01 | 3.4E+47 | 0.000 | 2.0E+02 | 1 | -2.0E+02 | -1 | 1.9E+00 | 0.992 | -1.9E+00 | -0.99199 | 5.65E+00 |
| 3 | 3 | 16.085 | -4.7E+00 | 9.3E-03 | -3.4E+47 | 2.000 | 6.2E+00 | 4.8E+02 | 3.4E+47 | 0.000 | 1.6E+02 | 1 | -1.6E+02 | -1 | 1.5E+00 | 0.9696 | -1.5E+00 | -0.96962 | 1.16E+00 |
| 4 | 4 | 16.085 | -6.2E+00 | 2.0E-03 | -3.4E+47 | 2.000 | 8.2E+00 | 3.8E+03 | 3.4E+47 | 0.000 | 1.4E+02 | 1 | -1.4E+02 | -1 | 1.3E+00 | 0.9392 | -1.3E+00 | -0.93921 | 2.37E-01 |
| 5 | 5 | 16.085 | -7.8E+00 | 4.1E-04 | -3.4E+47 | 2.000 | 1.0E+01 | 3.0E+04 | 3.4E+47 | 0.000 | 1.3E+02 | 1 | -1.3E+02 | -1 | 1.2E+00 | 0.9065 | -1.2E+00 | -0.90647 | 4.81E-02 |
| 6 | 6 | 16.085 | -9.4E+00 | 8.7E-05 | -3.4E+47 | 2.000 | 1.2E+01 | 2.3E+05 | 3.4E+47 | 0.000 | 1.1E+02 | 1 | -1.1E+02 | -1 | 1.1E+00 | 0.8742 | -1.1E+00 | -0.87421 | 9.76E-03 |
| 7 | 7 | 16.085 | -1.1E+01 | 1.8E-05 | -3.4E+47 | 2.000 | 1.4E+01 | 1.8E+06 | 3.4E+47 | 0.000 | 1.1E+02 | 1 | -1.1E+02 | -1 | 1.0E+00 | 0.8436 | -1.0E+00 | -0.84362 | 1.98E-03 |
| 8 | 8 | 16.085 | -1.2E+01 | 3.8E-06 | -3.4E+47 | 2.000 | 1.6E+01 | 1.4E+07 | 3.4E+47 | 0.000 | 9.9E+01 | 1 | -9.9E+01 | -1 | 9.4E-01 | 0.8151 | -9.4E-01 | -0.8151 | 4.03E-04 |
| 9 | 9 | 16.085 | -1.4E+01 | 8.1E-07 | -3.4E+47 | 2.000 | 1.9E+01 | 1.1E+08 | 3.4E+47 | 0.000 | 9.3E+01 | 1 | -9.3E+01 | -1 | 8.8E-01 | 0.7887 | -8.8E-01 | -0.7887 | 8.20E-05 |
| 10 | 10 | 16.085 | -1.6E+01 | 1.7E-07 | -3.4E+47 | 2.000 | 2.1E+01 | 8.7E+08 | 3.4E+47 | 0.000 | 8.8E+01 | 1 | -8.8E+01 | -1 | 8.4E-01 | 0.7643 | -8.4E-01 | -0.76432 | 1.67E-05 |
| 11 | 11 | 16.085 | -1.7E+01 | 3.6E-08 | -3.4E+47 | 2.000 | 2.3E+01 | 6.8E+09 | 3.4E+47 | 0.000 | 8.4E+01 | 1 | -8.4E+01 | -1 | 8.0E-01 | 0.7418 | -8.0E-01 | -0.7418 | 3.41E-06 |
| 12 | 12 | 16.085 | -1.9E+01 | 7.5E-09 | -3.4E+47 | 2.000 | 2.5E+01 | 5.4E+10 | 3.4E+47 | 0.000 | 8.1E+01 | 1 | -8.1E+01 | -1 | 7.7E-01 | 0.721 | -7.7E-01 | -0.72098 | 6.98E-07 |
| 13 | 13 | 16.085 | -2.0E+01 | 1.6E-09 | -3.4E+47 | 2.000 | 2.7E+01 | 4.2E+11 | 3.4E+47 | 0.000 | 7.8E+01 | 1 | -7.8E+01 | -1 | 7.4E-01 | 0.7017 | -7.4E-01 | -0.70169 | 1.43E-07 |
| 14 | 14 | 16.085 | -2.2E+01 | 3.3E-10 | -3.4E+47 | 2.000 | 2.9E+01 | 3.3E+12 | 3.4E+47 | 0.000 | 7.5E+01 | 1 | -7.5E+01 | -1 | 7.1E-01 | 0.6838 | -7.1E-01 | -0.68377 | 2.93E-08 |
| 15 | 15 | 16.085 | -2.3E+01 | 7.0E-11 | -3.4E+47 | 2.000 | 3.1E+01 | 2.6E+13 | 3.4E+47 | 0.000 | 7.2E+01 | 1 | -7.2E+01 | -1 | 6.8E-01 | 0.6671 | -6.8E-01 | -0.66708 | 6.01E-09 |
| 16 | 16 | 16.085 | -2.5E+01 | 1.5E-11 | -3.4E+47 | 2.000 | 3.3E+01 | 2.0E+14 | 3.4E+47 | 0.000 | 7.0E+01 | 1 | -7.0E+01 | -1 | 6.6E-01 | 0.6515 | -6.6E-01 | -0.6515 | 1.24E-09 |
| 17 | 17 | 16.085 | -2.6E+01 | 3.1E-12 | -3.4E+47 | 2.000 | 3.5E+01 | 1.6E+15 | 3.4E+47 | 0.000 | 6.8E+01 | 1 | -6.8E+01 | -1 | 6.4E-01 | 0.6369 | -6.4E-01 | -0.63692 | 2.54E-10 |
| 18 | 18 | 16.085 | -2.8E+01 | 6.5E-13 | -3.4E+47 | 2.000 | 3.7E+01 | 1.2E+16 | 3.4E+47 | 0.000 | 6.6E+01 | 1 | -6.6E+01 | -1 | 6.3E-01 | 0.6232 | -6.3E-01 | -0.62324 | 5.23E-11 |
| 19 | 19 | 16.085 | -3.0E+01 | 1.4E-13 | -3.4E+47 | 2.000 | 3.9E+01 | 9.7E+16 | 3.4E+47 | 0.000 | 6.4E+01 | 1 | -6.4E+01 | -1 | 6.1E-01 | 0.6104 | -6.1E-01 | -0.61038 | 1.08E-11 |
| 20 | 20 | 16.085 | -3.1E+01 | 2.9E-14 | -3.4E+47 | 2.000 | 4.1E+01 | 7.6E+17 | 3.4E+47 | 0.000 | 6.3E+01 | 1 | -6.3E+01 | -1 | 5.9E-01 | 0.5983 | -5.9E-01 | -0.59826 | 2.22E-12 |

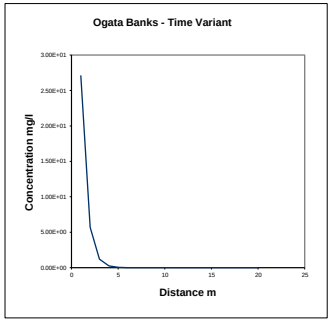



Vertical dispersion option Simulate vertical dispersion in 1 direction

| Calc | Value | |
|---|---|---|
| v | 1.08E-03 | m/d |
| Rc | 6.13E+02 | |
| u | 1.76E-06 | m/d |

Calculations for source located at top of aquifer (ie vertical dispersion in one direction) - USED FOR LEVEL ASSESSMENT

| | X | Term 1 | Term 2 | EXP | Term 3 | ERFC | Term 4 | EXP | Term 5 | ERFC | Term 6a | ERF | Term 6b | ERF | Term 7a | ERF | Term 7b | ERF | Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 16.085 | -1.6E+00 | 2.1E-01 | -3.4E+47 | 2.000 | 2.1E+00 | 7.8E+00 | 3.4E+47 | 0.000 | 2.8E+02 | 1 | -2.8E+02 | -1 | 5.3E+00 | 1 | -5.3E+00 | -1 | 2.71E+01 |
| 2 | 2 | 16.085 | -3.1E+00 | 4.4E-02 | -3.4E+47 | 2.000 | 4.1E+00 | 6.1E+01 | 3.4E+47 | 0.000 | 2.0E+02 | 1 | -2.0E+02 | -1 | 3.8E+00 | 1 | -3.8E+00 | -1 | 5.70E+00 |
| 3 | 3 | 16.085 | -4.7E+00 | 9.3E-03 | -3.4E+47 | 2.000 | 6.2E+00 | 4.8E+02 | 3.4E+47 | 0.000 | 1.6E+02 | 1 | -1.6E+02 | -1 | 3.1E+00 | 1 | -3.1E+00 | -0.99999 | 1.20E+00 |
| 4 | 4 | 16.085 | -6.2E+00 | 2.0E-03 | -3.4E+47 | 2.000 | 8.2E+00 | 3.8E+03 | 3.4E+47 | 0.000 | 1.4E+02 | 1 | -1.4E+02 | -1 | 2.7E+00 | 0.9998 | -2.7E+00 | -0.99982 | 2.52E-01 |
| 5 | 5 | 16.085 | -7.8E+00 | 4.1E-04 | -3.4E+47 | 2.000 | 1.0E+01 | 3.0E+04 | 3.4E+47 | 0.000 | 1.3E+02 | 1 | -1.3E+02 | -1 | 2.4E+00 | 0.9992 | -2.4E+00 | -0.9992 | 5.30E-02 |
| 6 | 6 | 16.085 | -9.4E+00 | 8.7E-05 | -3.4E+47 | 2.000 | 1.2E+01 | 2.3E+05 | 3.4E+47 | 0.000 | 1.1E+02 | 1 | -1.1E+02 | -1 | 2.2E+00 | 0.9978 | -2.2E+00 | -0.9978 | 1.11E-02 |
| 7 | 7 | 16.085 | -1.1E+01 | 1.8E-05 | -3.4E+47 | 2.000 | 1.4E+01 | 1.8E+06 | 3.4E+47 | 0.000 | 1.1E+02 | 1 | -1.1E+02 | -1 | 2.0E+00 | 0.9954 | -2.0E+00 | -0.99541 | 2.34E-03 |
| 8 | 8 | 16.085 | -1.2E+01 | 3.8E-06 | -3.4E+47 | 2.000 | 1.6E+01 | 1.4E+07 | 3.4E+47 | 0.000 | 9.9E+01 | 1 | -9.9E+01 | -1 | 1.9E+00 | 0.992 | -1.9E+00 | -0.99199 | 4.90E-04 |
| 9 | 9 | 16.085 | -1.4E+01 | 8.1E-07 | -3.4E+47 | 2.000 | 1.9E+01 | 1.1E+08 | 3.4E+47 | 0.000 | 9.3E+01 | 1 | -9.3E+01 | -1 | 1.8E+00 | 0.9876 | -1.8E+00 | -0.98758 | 1.03E-04 |
| 10 | 10 | 16.085 | -1.6E+01 | 1.7E-07 | -3.4E+47 | 2.000 | 2.1E+01 | 8.7E+08 | 3.4E+47 | 0.000 | 8.8E+01 | 1 | -8.8E+01 | -1 | 1.7E+00 | 0.9823 | -1.7E+00 | -0.98229 | 2.15E-05 |
| 11 | 11 | 16.085 | -1.7E+01 | 3.6E-08 | -3.4E+47 | 2.000 | 2.3E+01 | 6.8E+09 | 3.4E+47 | 0.000 | 8.4E+01 | 1 | -8.4E+01 | -1 | 1.6E+00 | 0.9763 | -1.6E+00 | -0.97626 | 4.49E-06 |
| 12 | 12 | 16.085 | -1.9E+01 | 7.5E-09 | -3.4E+47 | 2.000 | 2.5E+01 | 5.4E+10 | 3.4E+47 | 0.000 | 8.1E+01 | 1 | -8.1E+01 | -1 | 1.5E+00 | 0.9696 | -1.5E+00 | -0.96962 | 9.39E-07 |
| 13 | 13 | 16.085 | -2.0E+01 | 1.6E-09 | -3.4E+47 | 2.000 | 2.7E+01 | 4.2E+11 | 3.4E+47 | 0.000 | 7.8E+01 | 1 | -7.8E+01 | -1 | 1.5E+00 | 0.9625 | -1.5E+00 | -0.96249 | 1.96E-07 |
| 14 | 14 | 16.085 | -2.2E+01 | 3.3E-10 | -3.4E+47 | 2.000 | 2.9E+01 | 3.3E+12 | 3.4E+47 | 0.000 | 7.5E+01 | 1 | -7.5E+01 | -1 | 1.4E+00 | 0.955 | -1.4E+00 | -0.95498 | 4.09E-08 |
| 15 | 15 | 16.085 | -2.3E+01 | 7.0E-11 | -3.4E+47 | 2.000 | 3.1E+01 | 2.6E+13 | 3.4E+47 | 0.000 | 7.2E+01 | 1 | -7.2E+01 | -1 | 1.4E+00 | 0.9472 | -1.4E+00 | -0.94719 | 8.54E-09 |
| 16 | 16 | 16.085 | -2.5E+01 | 1.5E-11 | -3.4E+47 | 2.000 | 3.3E+01 | 2.0E+14 | 3.4E+47 | 0.000 | 7.0E+01 | 1 | -7.0E+01 | -1 | 1.3E+00 | 0.9392 | -1.3E+00 | -0.93921 | 1.78E-09 |
| 17 | 17 | 16.085 | -2.6E+01 | 3.1E-12 | -3.4E+47 | 2.000 | 3.5E+01 | 1.6E+15 | 3.4E+47 | 0.000 | 6.8E+01 | 1 | -6.8E+01 | -1 | 1.3E+00 | 0.9311 | -1.3E+00 | -0.93109 | 3.72E-10 |
| 18 | 18 | 16.085 | -2.8E+01 | 6.5E-13 | -3.4E+47 | 2.000 | 3.7E+01 | 1.2E+16 | 3.4E+47 | 0.000 | 6.6E+01 | 1 | -6.6E+01 | -1 | 1.3E+00 | 0.9229 | -1.3E+00 | -0.9229 | 7.75E-11 |
| 19 | 19 | 16.085 | -3.0E+01 | 1.4E-13 | -3.4E+47 | 2.000 | 3.9E+01 | 9.7E+16 | 3.4E+47 | 0.000 | 6.4E+01 | 1 | -6.4E+01 | -1 | 1.2E+00 | 0.9147 | -1.2E+00 | -0.91468 | 1.62E-11 |
| 20 | 20 | 16.085 | -3.1E+01 | 2.9E-14 | -3.4E+47 | 2.000 | 4.1E+01 | 7.6E+17 | 3.4E+47 | 0.000 | 6.3E+01 | 1 | -6.3E+01 | -1 | 1.2E+00 | 0.9065 | -1.2E+00 | -0.90647 | 3.37E-12 |




| | |
|---|---|
| Date: | 24/02/2020 |
| Version: | 3 |

**Contaminant** **Naphthalene**

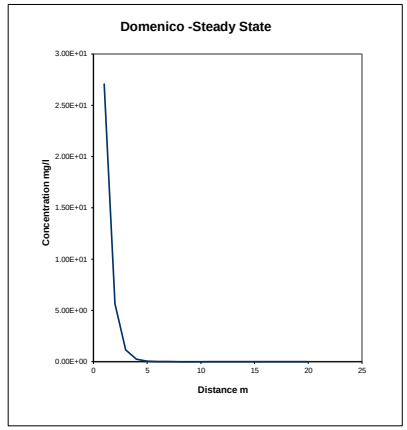
| Input | Value | Units |
|---|---|---|
| $C_T$ | 0.002 | mg/l |
| Co | 1.29E+02 | mg/l |
| λ | 1.13E-05 | days$^{-1}$ |
| Sz | 5.00E+02 | m |
| Sy | 1.50E+00 | m |
| Kd | 3.60E+01 | l/kg |
| ρ | 1.36E+00 | g/cm3 |
| n | 8.00E-02 | |
| i | 1.00E-02 | |
| K | 8.64E-03 | m/d |
| x | 2.00E+01 | m |
| z | 0.00E+00 | m |
| y | 0.00E+00 | m |
| ax | 2.00E+00 | m |
| az | 2.00E-01 | m |
| ay | 2.00E-02 | m |

Vertical dispersion optio Simulate vertical dispersion in 1 direction

**DOMENICO (STEADY STATE)**

Calculations for source located in centre of aquifer (ie vertical dispersion in two directions)

| | X | Term 1 | Term 2 | EXP | Term 3A | ERF | Term 3B | ERF | Term 4A | ERF | Term 4B | ERF | Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 32.17 | -1.56E+00 | 2.10E-01 | 2.80E+02 | 1 | -2.80E+02 | -1 | 2.65E+00 | 1 | -2.65E+00 | -0.9998 | 2.71E+01 |
| 2 | 2 | 32.17 | -3.12E+00 | 4.43E-02 | 1.98E+02 | 1 | -1.98E+02 | -1 | 1.88E+00 | 0.992 | -1.88E+00 | -0.992 | 5.65E+00 |
| 3 | 3 | 32.17 | -4.68E+00 | 9.31E-03 | 1.61E+02 | 1 | -1.61E+02 | -1 | 1.53E+00 | 0.97 | -1.53E+00 | -0.9696 | 1.16E+00 |
| 4 | 4 | 32.17 | -6.24E+00 | 1.96E-03 | 1.40E+02 | 1 | -1.40E+02 | -1 | 1.33E+00 | 0.939 | -1.33E+00 | -0.9392 | 2.37E-01 |
| 5 | 5 | 32.17 | -7.79E+00 | 4.12E-04 | 1.25E+02 | 1 | -1.25E+02 | -1 | 1.19E+00 | 0.906 | -1.19E+00 | -0.9065 | 4.81E-02 |
| 6 | 6 | 32.17 | -9.35E+00 | 8.67E-05 | 1.14E+02 | 1 | -1.14E+02 | -1 | 1.08E+00 | 0.874 | -1.08E+00 | -0.8742 | 9.76E-03 |
| 7 | 7 | 32.17 | -1.09E+01 | 1.82E-05 | 1.06E+02 | 1 | -1.06E+02 | -1 | 1.00E+00 | 0.844 | -1.00E+00 | -0.8436 | 1.98E-03 |
| 8 | 8 | 32.17 | -1.25E+01 | 3.84E-06 | 9.88E+01 | 1 | -9.88E+01 | -1 | 9.38E-01 | 0.815 | -9.38E-01 | -0.8151 | 4.03E-04 |
| 9 | 9 | 32.17 | -1.40E+01 | 8.08E-07 | 9.32E+01 | 1 | -9.32E+01 | -1 | 8.84E-01 | 0.789 | -8.84E-01 | -0.7887 | 8.20E-05 |
| 10 | 10 | 32.17 | -1.56E+01 | 1.70E-07 | 8.84E+01 | 1 | -8.84E+01 | -1 | 8.39E-01 | 0.764 | -8.39E-01 | -0.7643 | 1.67E-05 |
| 11 | 11 | 32.17 | -1.71E+01 | 3.58E-08 | 8.43E+01 | 1 | -8.43E+01 | -1 | 8.00E-01 | 0.742 | -8.00E-01 | -0.7418 | 3.41E-06 |
| 12 | 12 | 32.17 | -1.87E+01 | 7.52E-09 | 8.07E+01 | 1 | -8.07E+01 | -1 | 7.65E-01 | 0.721 | -7.65E-01 | -0.721 | 6.98E-07 |
| 13 | 13 | 32.17 | -2.03E+01 | 1.58E-09 | 7.75E+01 | 1 | -7.75E+01 | -1 | 7.35E-01 | 0.702 | -7.35E-01 | -0.7017 | 1.43E-07 |
| 14 | 14 | 32.17 | -2.18E+01 | 3.33E-10 | 7.47E+01 | 1 | -7.47E+01 | -1 | 7.09E-01 | 0.684 | -7.09E-01 | -0.6838 | 2.93E-08 |
| 15 | 15 | 32.17 | -2.34E+01 | 7.01E-11 | 7.22E+01 | 1 | -7.22E+01 | -1 | 6.85E-01 | 0.667 | -6.85E-01 | -0.6671 | 6.01E-09 |
| 16 | 16 | 32.17 | -2.49E+01 | 1.47E-11 | 6.99E+01 | 1 | -6.99E+01 | -1 | 6.63E-01 | 0.651 | -6.63E-01 | -0.6515 | 1.24E-09 |
| 17 | 17 | 32.17 | -2.65E+01 | 3.10E-12 | 6.78E+01 | 1 | -6.78E+01 | -1 | 6.43E-01 | 0.637 | -6.43E-01 | -0.6369 | 2.54E-10 |
| 18 | 18 | 32.17 | -2.81E+01 | 6.53E-13 | 6.59E+01 | 1 | -6.59E+01 | -1 | 6.25E-01 | 0.623 | -6.25E-01 | -0.6232 | 5.23E-11 |
| 19 | 19 | 32.17 | -2.96E+01 | 1.37E-13 | 6.41E+01 | 1 | -6.41E+01 | -1 | 6.08E-01 | 0.61 | -6.08E-01 | -0.6104 | 1.08E-11 |
| 20 | 20 | 32.17 | -3.12E+01 | 2.89E-14 | 6.25E+01 | 1 | -6.25E+01 | -1 | 5.93E-01 | 0.598 | -5.93E-01 | -0.5983 | 2.22E-12 |



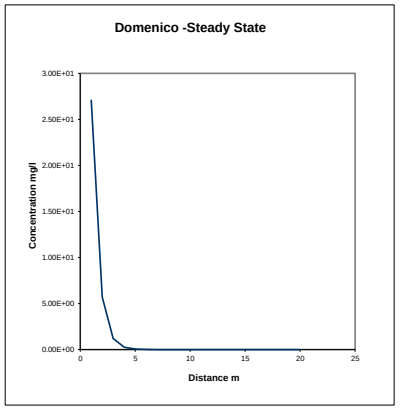

**Calc** **Value**

| | | |
|---|---|---|
| v | 1.08E-03 | m/d |
| Rc | 6.13E+02 | |
| u | 1.76E-06 | m/d |

**DOMENICO (STEADY STATE)**

Calculations for source located at top of aquifer (ie vertical dispersion in one direction) - USED FOR LEVEL ASSESSMENT

| | X | Term 1 | Term 2 | EXP | Term 3A | ERF | Term 3B | ERF | Term 4A | ERF | Term 4B | ERF | Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 32.17 | -1.56E+00 | 2.10E-01 | 2.80E+02 | 1 | -2.80E+02 | -1 | 5.30E+00 | 1 | -5.30E+00 | -1 | 2.71E+01 |
| 2 | 2 | 32.17 | -3.12E+00 | 4.43E-02 | 1.98E+02 | 1 | -1.98E+02 | -1 | 3.75E+00 | 1 | -3.75E+00 | -1 | 5.70E+00 |
| 3 | 3 | 32.17 | -4.68E+00 | 9.31E-03 | 1.61E+02 | 1 | -1.61E+02 | -1 | 3.06E+00 | 1 | -3.06E+00 | -1 | 1.20E+00 |
| 4 | 4 | 32.17 | -6.24E+00 | 1.96E-03 | 1.40E+02 | 1 | -1.40E+02 | -1 | 2.65E+00 | 1 | -2.65E+00 | -0.9998 | 2.52E-01 |
| 5 | 5 | 32.17 | -7.79E+00 | 4.12E-04 | 1.25E+02 | 1 | -1.25E+02 | -1 | 2.37E+00 | 0.999 | -2.37E+00 | -0.9992 | 5.30E-02 |
| 6 | 6 | 32.17 | -9.35E+00 | 8.67E-05 | 1.14E+02 | 1 | -1.14E+02 | -1 | 2.17E+00 | 0.998 | -2.17E+00 | -0.9978 | 1.11E-02 |
| 7 | 7 | 32.17 | -1.09E+01 | 1.82E-05 | 1.06E+02 | 1 | -1.06E+02 | -1 | 2.00E+00 | 0.995 | -2.00E+00 | -0.9954 | 2.34E-03 |
| 8 | 8 | 32.17 | -1.25E+01 | 3.84E-06 | 9.88E+01 | 1 | -9.88E+01 | -1 | 1.88E+00 | 0.992 | -1.88E+00 | -0.992 | 4.90E-04 |
| 9 | 9 | 32.17 | -1.40E+01 | 8.08E-07 | 9.32E+01 | 1 | -9.32E+01 | -1 | 1.77E+00 | 0.988 | -1.77E+00 | -0.9876 | 1.03E-04 |
| 10 | 10 | 32.17 | -1.56E+01 | 1.70E-07 | 8.84E+01 | 1 | -8.84E+01 | -1 | 1.68E+00 | 0.982 | -1.68E+00 | -0.9823 | 2.15E-05 |
| 11 | 11 | 32.17 | -1.71E+01 | 3.58E-08 | 8.43E+01 | 1 | -8.43E+01 | -1 | 1.60E+00 | 0.976 | -1.60E+00 | -0.9763 | 4.49E-06 |
| 12 | 12 | 32.17 | -1.87E+01 | 7.52E-09 | 8.07E+01 | 1 | -8.07E+01 | -1 | 1.53E+00 | 0.97 | -1.53E+00 | -0.9696 | 9.39E-07 |
| 13 | 13 | 32.17 | -2.03E+01 | 1.58E-09 | 7.75E+01 | 1 | -7.75E+01 | -1 | 1.47E+00 | 0.962 | -1.47E+00 | -0.9625 | 1.96E-07 |
| 14 | 14 | 32.17 | -2.18E+01 | 3.33E-10 | 7.47E+01 | 1 | -7.47E+01 | -1 | 1.42E+00 | 0.955 | -1.42E+00 | -0.955 | 4.09E-08 |
| 15 | 15 | 32.17 | -2.34E+01 | 7.01E-11 | 7.22E+01 | 1 | -7.22E+01 | -1 | 1.37E+00 | 0.947 | -1.37E+00 | -0.9472 | 8.54E-09 |
| 16 | 16 | 32.17 | -2.49E+01 | 1.47E-11 | 6.99E+01 | 1 | -6.99E+01 | -1 | 1.33E+00 | 0.939 | -1.33E+00 | -0.9392 | 1.78E-09 |
| 17 | 17 | 32.17 | -2.65E+01 | 3.10E-12 | 6.78E+01 | 1 | -6.78E+01 | -1 | 1.29E+00 | 0.931 | -1.29E+00 | -0.9311 | 3.72E-10 |
| 18 | 18 | 32.17 | -2.81E+01 | 6.53E-13 | 6.59E+01 | 1 | -6.59E+01 | -1 | 1.25E+00 | 0.923 | -1.25E+00 | -0.9229 | 7.75E-11 |
| 19 | 19 | 32.17 | -2.96E+01 | 1.37E-13 | 6.41E+01 | 1 | -6.41E+01 | -1 | 1.22E+00 | 0.915 | -1.22E+00 | -0.9147 | 1.62E-11 |
| 20 | 20 | 32.17 | -3.12E+01 | 2.89E-14 | 6.25E+01 | 1 | -6.25E+01 | -1 | 1.19E+00 | 0.906 | -1.19E+00 | -0.9065 | 3.37E-12 |




| | |
|---|---|
| Date: | 24/02/2020 |
| Version: | 3 |

## DOMENICO (TIME VARIANT)

**Contaminant** **Naphthalene**

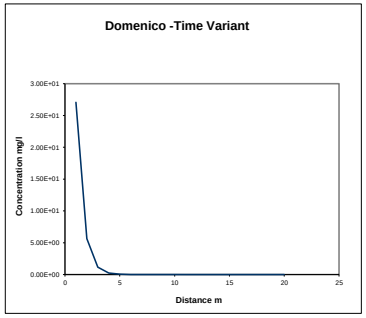
| **Input** | **Value** | **Units** |
|---|---|---|
| $C_T$ | 0.002 | mg/l |
| Co | 1.29E+02 | mg/l |
| λ | 1.13E-05 | days$^{-1}$ |
| Sz | 5.00E+02 | m |
| Sy | 1.50E+00 | m |
| Kd | 3.60E+01 | l/kg |
| ρ | 1.36E+00 | g/cm3 |
| n | 8.00E-02 | |
| i | 1.00E-02 | |
| K | 8.64E-03 | m/d |
| x | 2.00E+01 | m |
| z | 0.00E+00 | m |
| y | 0.00E+00 | m |
| t | 1.00E+100 | days |
| ax | 2.00E+00 | m |
| az | 2.00E-01 | m |
| ay | 2.00E-02 | m |

Vertical dispersion option Simulate vertical dispersion in 1 direction

| **Calc** | **Value** | **Units** |
|---|---|---|
| v | 1.08E-03 | m/d |
| Rc | 6.13E+02 | |
| u | 1.76E-06 | m/d |

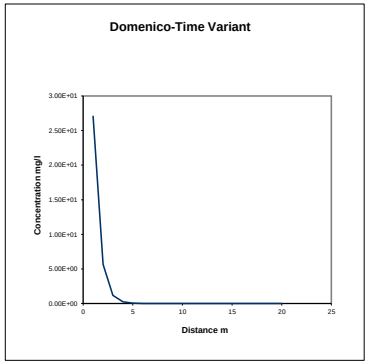
Calculations for source located in centre of aquifer (ie vertical dispersion in two directions)

| | X | Term 1 | Term 2 | EXP | Term 3 | ERFC | Term 4A | ERF | Term 4B | ERF | Term 5A | ERF | Term 5B | ERF | Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | m | | | | | | | | | | | | | | |
| 1 | 1 | 16.085 | -1.56E+00 | 2.10E-01 | -3.40E+47 | 2 | 2.80E+02 | 1 | -2.80E+02 | -1 | 2.65E+00 | 0.9998 | -2.65E+00 | -1 | 2.71E+01 |
| 2 | 2 | 16.085 | -3.12E+00 | 4.43E-02 | -3.40E+47 | 2 | 1.98E+02 | 1 | -1.98E+02 | -1 | 1.88E+00 | 0.992 | -1.88E+00 | -0.992 | 5.65E+00 |
| 3 | 3 | 16.085 | -4.68E+00 | 9.31E-03 | -3.40E+47 | 2 | 1.61E+02 | 1 | -1.61E+02 | -1 | 1.53E+00 | 0.9696 | -1.53E+00 | -0.97 | 1.16E+00 |
| 4 | 4 | 16.085 | -6.24E+00 | 1.96E-03 | -3.40E+47 | 2 | 1.40E+02 | 1 | -1.40E+02 | -1 | 1.33E+00 | 0.9392 | -1.33E+00 | -0.939 | 2.37E-01 |
| 5 | 5 | 16.085 | -7.79E+00 | 4.12E-04 | -3.40E+47 | 2 | 1.25E+02 | 1 | -1.25E+02 | -1 | 1.19E+00 | 0.9065 | -1.19E+00 | -0.906 | 4.81E-02 |
| 6 | 6 | 16.085 | -9.35E+00 | 8.67E-05 | -3.40E+47 | 2 | 1.14E+02 | 1 | -1.14E+02 | -1 | 1.08E+00 | 0.8742 | -1.08E+00 | -0.874 | 9.76E-03 |
| 7 | 7 | 16.085 | -1.09E+01 | 1.82E-05 | -3.40E+47 | 2 | 1.06E+02 | 1 | -1.06E+02 | -1 | 1.00E+00 | 0.8436 | -1.00E+00 | -0.844 | 1.98E-03 |
| 8 | 8 | 16.085 | -1.25E+01 | 3.84E-06 | -3.40E+47 | 2 | 9.88E+01 | 1 | -9.88E+01 | -1 | 9.38E-01 | 0.8151 | -9.38E-01 | -0.815 | 4.03E-04 |
| 9 | 9 | 16.085 | -1.40E+01 | 8.08E-07 | -3.40E+47 | 2 | 9.32E+01 | 1 | -9.32E+01 | -1 | 8.84E-01 | 0.7887 | -8.84E-01 | -0.789 | 8.20E-05 |
| 10 | 10 | 16.085 | -1.56E+01 | 1.70E-07 | -3.40E+47 | 2 | 8.84E+01 | 1 | -8.84E+01 | -1 | 8.39E-01 | 0.7643 | -8.39E-01 | -0.764 | 1.67E-05 |
| 11 | 11 | 16.085 | -1.71E+01 | 3.58E-08 | -3.40E+47 | 2 | 8.43E+01 | 1 | -8.43E+01 | -1 | 8.00E-01 | 0.7418 | -8.00E-01 | -0.742 | 3.41E-06 |
| 12 | 12 | 16.085 | -1.87E+01 | 7.52E-09 | -3.40E+47 | 2 | 8.07E+01 | 1 | -8.07E+01 | -1 | 7.65E-01 | 0.721 | -7.65E-01 | -0.721 | 6.98E-07 |
| 13 | 13 | 16.085 | -2.03E+01 | 1.58E-09 | -3.40E+47 | 2 | 7.75E+01 | 1 | -7.75E+01 | -1 | 7.35E-01 | 0.7017 | -7.35E-01 | -0.702 | 1.43E-07 |
| 14 | 14 | 16.085 | -2.18E+01 | 3.33E-10 | -3.40E+47 | 2 | 7.47E+01 | 1 | -7.47E+01 | -1 | 7.09E-01 | 0.6838 | -7.09E-01 | -0.684 | 2.93E-08 |
| 15 | 15 | 16.085 | -2.34E+01 | 7.01E-11 | -3.40E+47 | 2 | 7.22E+01 | 1 | -7.22E+01 | -1 | 6.85E-01 | 0.6671 | -6.85E-01 | -0.667 | 6.01E-09 |
| 16 | 16 | 16.085 | -2.49E+01 | 1.47E-11 | -3.40E+47 | 2 | 6.99E+01 | 1 | -6.99E+01 | -1 | 6.63E-01 | 0.6515 | -6.63E-01 | -0.651 | 1.24E-09 |
| 17 | 17 | 16.085 | -2.65E+01 | 3.10E-12 | -3.40E+47 | 2 | 6.78E+01 | 1 | -6.78E+01 | -1 | 6.43E-01 | 0.6369 | -6.43E-01 | -0.637 | 2.54E-10 |
| 18 | 18 | 16.085 | -2.81E+01 | 6.53E-13 | -3.40E+47 | 2 | 6.59E+01 | 1 | -6.59E+01 | -1 | 6.25E-01 | 0.6232 | -6.25E-01 | -0.623 | 5.23E-11 |
| 19 | 19 | 16.085 | -2.96E+01 | 1.37E-13 | -3.40E+47 | 2 | 6.41E+01 | 1 | -6.41E+01 | -1 | 6.08E-01 | 0.6104 | -6.08E-01 | -0.61 | 1.08E-11 |
| 20 | 20 | 16.085 | -3.12E+01 | 2.89E-14 | -3.40E+47 | 2 | 6.25E+01 | 1 | -6.25E+01 | -1 | 5.93E-01 | 0.5983 | -5.93E-01 | -0.598 | 2.22E-12 |




Calculations for source located at top of aquifer (ie vertical dispersion in one direction only) - USED FOR LEVEL ASSESSMENT

| | X | Term 1 | Term 2 | EXP | Term 3 | ERFC | Term 4A | ERF | Term 4B | ERF | Term 5A | ERF | Term 5B | ERF | Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | m | | | | | | | | | | | | | | |
| 1 | 1 | 16.085 | -1.56E+00 | 2.10E-01 | -3.40E+47 | 2 | 2.80E+02 | 1 | -2.80E+02 | -1 | 5.30E+00 | 1 | -5.30E+00 | -1 | 2.71E+01 |
| 2 | 2 | 16.085 | -3.12E+00 | 4.43E-02 | -3.40E+47 | 2 | 1.98E+02 | 1 | -1.98E+02 | -1 | 3.75E+00 | 1 | -3.75E+00 | -1 | 5.70E+00 |
| 3 | 3 | 16.085 | -4.68E+00 | 9.31E-03 | -3.40E+47 | 2 | 1.61E+02 | 1 | -1.61E+02 | -1 | 3.06E+00 | 1 | -3.06E+00 | -1 | 1.20E+00 |
| 4 | 4 | 16.085 | -6.24E+00 | 1.96E-03 | -3.40E+47 | 2 | 1.40E+02 | 1 | -1.40E+02 | -1 | 2.65E+00 | 0.9998 | -2.65E+00 | -1 | 2.52E-01 |
| 5 | 5 | 16.085 | -7.79E+00 | 4.12E-04 | -3.40E+47 | 2 | 1.25E+02 | 1 | -1.25E+02 | -1 | 2.37E+00 | 0.9992 | -2.37E+00 | -0.999 | 5.30E-02 |
| 6 | 6 | 16.085 | -9.35E+00 | 8.67E-05 | -3.40E+47 | 2 | 1.14E+02 | 1 | -1.14E+02 | -1 | 2.17E+00 | 0.9978 | -2.17E+00 | -0.998 | 1.11E-02 |
| 7 | 7 | 16.085 | -1.09E+01 | 1.82E-05 | -3.40E+47 | 2 | 1.06E+02 | 1 | -1.06E+02 | -1 | 2.00E+00 | 0.9954 | -2.00E+00 | -0.995 | 2.34E-03 |
| 8 | 8 | 16.085 | -1.25E+01 | 3.84E-06 | -3.40E+47 | 2 | 9.88E+01 | 1 | -9.88E+01 | -1 | 1.88E+00 | 0.992 | -1.88E+00 | -0.992 | 4.90E-04 |
| 9 | 9 | 16.085 | -1.40E+01 | 8.08E-07 | -3.40E+47 | 2 | 9.32E+01 | 1 | -9.32E+01 | -1 | 1.77E+00 | 0.9876 | -1.77E+00 | -0.988 | 1.03E-04 |
| 10 | 10 | 16.085 | -1.56E+01 | 1.70E-07 | -3.40E+47 | 2 | 8.84E+01 | 1 | -8.84E+01 | -1 | 1.68E+00 | 0.9823 | -1.68E+00 | -0.982 | 2.15E-05 |
| 11 | 11 | 16.085 | -1.71E+01 | 3.58E-08 | -3.40E+47 | 2 | 8.43E+01 | 1 | -8.43E+01 | -1 | 1.60E+00 | 0.9763 | -1.60E+00 | -0.976 | 4.49E-06 |
| 12 | 12 | 16.085 | -1.87E+01 | 7.52E-09 | -3.40E+47 | 2 | 8.07E+01 | 1 | -8.07E+01 | -1 | 1.53E+00 | 0.9696 | -1.53E+00 | -0.97 | 9.39E-07 |
| 13 | 13 | 16.085 | -2.03E+01 | 1.58E-09 | -3.40E+47 | 2 | 7.75E+01 | 1 | -7.75E+01 | -1 | 1.47E+00 | 0.9625 | -1.47E+00 | -0.962 | 1.96E-07 |
| 14 | 14 | 16.085 | -2.18E+01 | 3.33E-10 | -3.40E+47 | 2 | 7.47E+01 | 1 | -7.47E+01 | -1 | 1.42E+00 | 0.955 | -1.42E+00 | -0.955 | 4.09E-08 |
| 15 | 15 | 16.085 | -2.34E+01 | 7.01E-11 | -3.40E+47 | 2 | 7.22E+01 | 1 | -7.22E+01 | -1 | 1.37E+00 | 0.9472 | -1.37E+00 | -0.947 | 8.54E-09 |
| 16 | 16 | 16.085 | -2.49E+01 | 1.47E-11 | -3.40E+47 | 2 | 6.99E+01 | 1 | -6.99E+01 | -1 | 1.33E+00 | 0.9392 | -1.33E+00 | -0.939 | 1.78E-09 |
| 17 | 17 | 16.085 | -2.65E+01 | 3.10E-12 | -3.40E+47 | 2 | 6.78E+01 | 1 | -6.78E+01 | -1 | 1.29E+00 | 0.9311 | -1.29E+00 | -0.931 | 3.72E-10 |
| 18 | 18 | 16.085 | -2.81E+01 | 6.53E-13 | -3.40E+47 | 2 | 6.59E+01 | 1 | -6.59E+01 | -1 | 1.25E+00 | 0.9229 | -1.25E+00 | -0.923 | 7.75E-11 |
| 19 | 19 | 16.085 | -2.96E+01 | 1.37E-13 | -3.40E+47 | 2 | 6.41E+01 | 1 | -6.41E+01 | -1 | 1.22E+00 | 0.9147 | -1.22E+00 | -0.915 | 1.62E-11 |
| 20 | 20 | 16.085 | -3.12E+01 | 2.89E-14 | -3.40E+47 | 2 | 6.25E+01 | 1 | -6.25E+01 | -1 | 1.19E+00 | 0.9065 | -1.19E+00 | -0.906 | 3.37E-12 |




| | |
|---|---|
| Date: | 24/02/2020 |
| Version: | 3 |

# Hydrogeological risk assessment for land contamination

## Remedial Targets Worksheet , Release 3.2

**First released: 2006. Version 3.2: January 2013**

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination ( Environment Agency 2006).

**Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.**

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The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

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IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

**Details to be completed for each assessment**

| | | | | |
|---|---|---|---|---|
| **Site Name:** | **Glan Llyn** | | | |
| **Site Address:** | **Llanwern** | | | |
| **Completed by:** | **Ross Cameron** | | | |
| **Date:** | **24-Feb-20** | | **Version:** | **1** |
| **Contaminant** | **Vanadium** | | | |
| **Target Concentration ($C_T$)** | **0.02** | **mg/l** | **Origin of $C_T$:** | **UK Standard (Statutory): Protection of Aquatic Life (Co** |

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparision with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).
Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.
Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.
Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.
Data carried forward from an earlier worksheet are identified by a light green background
It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

## Remedial Targets Worksheet , Release 3.2

# Level 1 - Soil

**Select the method of calculating the soil water Partition Co-efficient by using the pull down menu below**

**User specified value for partition coefficient**

| | | | | |
|---|---|---|---|---|
| **Contaminant** | | **Vanadium** | | |
| **Target concentration** | **$C_T$** | **0.02** | **mg/l** | |

| **Input Parameters** | **Variable** | **Value** | **Unit** | **Source of parameter value** |
|---|---|---|---|---|
| ***Standard entry*** | | | | |
| Water filled soil porosity | $\theta_w$ | 5.00E-01 | fraction | 0.5 |
| Air filled soil porosity | θa | 3.70E-01 | fraction | 0.0037 |
| Bulk density of soil zone material | ρ | 1.36E+00 | g/cm$^3$ | 1.36 |
| Henry's Law constant | H | 1.00E+00 | dimensionless | *1* |
| ***Entry if specify partition coefficient (option)*** | | | | |
| Soil water partition coefficient | Kd | 1.34E+02 | l/kg | *1.34E+02* |
| ***Entry for non-polar organic chemicals (option)*** | | | | |
| Fraction of organic carbon (in soil) | foc | | fraction | |
| Organic carbon partition coefficient | Koc | | l/kg | |
| ***Entry for ionic organic chemicals (option)*** | | | | |
| Sorption coefficient for neutral species | $K_{oc,n}$ | | l/kg | |
| Sorption coefficient for ionised species | $K_{oc,i}$ | | l/kg | |
| pH value | pH | | pH units | |
| Acid dissociation constant | pKa | | | |
| Fraction of organic carbon (in soil) | foc | | fraction | |

This sheet calculates the Level 1 remedial target for soils(mg/kg) based on a selected target concentration and theoretical calculation of soil water partitioning. Three options are included for determining the partition coefficient.

The measured soil concentration as mg/kg should be compared with the Level 1 remedial target to determine the need for further action.

| | | | | |
|---|---|---|---|---|
| **Soil water partition coefficient used in Level Assessment** | **Kd** | **1.34E+02** | **l/kg** | *Specified value* |

## Level 1 Remedial Target

| | | | |
|---|---|---|---|
| **Level 1 Remedial Target** | **2.69E+00** | **mg/kg** | **(for comparison with soil analyses)** |
| | **or** | | |
| | **0.02** | **mg/l** | **(for comparison with leachate test results)** |

| | |
|---|---|
| Site being assessed: | Glan Llyn |
| Completed by: | Ross Cameron |
| Date: | 24-Feb-20 |
| Version: | 1 |

## Remedial Targets Worksheet , Release 3.2

# Level 2 - Soil

| | | | | |
|---|---|---|---|---|
| **Contaminant** | | **Vanadium** | | from Level 1 |
| **Target concentration** | $C_T$ | **0.02** | **mg/l** | from Level 1 |

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamiantion' (Environment Agency 2006)

| **Input Parameters** | **Variable** | **Value** | **Unit** | **Source of parameter value** | |
|---|---|---|---|---|---|
| *Standard entry* | | | | | |
| Infiltration | Inf | 0.00E+00 | m/d | | |
| Area of contaminant source | A | 0.00E+00 | $m^2$ | | Not used in calculation |
| *Entry for groundwater flow below site* | | | | | |
| Length of contaminant source in direction of groundwater flow | L | 0.00E+00 | m | | |
| Saturated aquifer thickness | da | 0.00E+00 | m | | |
| Hydraulic Conductivity of aquifer in which dilution occurs | K | 0.00E+00 | m/d | | |
| Hydraulic gradient of water table | i | 0.00E+00 | fraction | | |
| Width of contaminant source perpendicular to groundwater flow | w | 0.00E+00 | m | | Not used in calculation |
| Background concentration of contaminant in groundwater beneath site | Cu | 0.00E+00 | mg/l | | |
| Define mixing zone depth by specifying or calculating depth (using pull down list) | | **Specify** | | | |
| Enter mixing zone thickness | Mz | 0.00E+00 | m | | |
| Calculated mixing zone thickness | Mz | | m | | |

## Calculated Parameters

| | | | | |
|---|---|---|---|---|
| **Dilution Factor** | **DF** | **#DIV/0!** | | |
| **Level 2 Remedial Target** | | **#DIV/0!** | **mg/l** | **For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentra** |
| | | **or** | | |
| | | **#DIV/0!** | **mg/kg** | **For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water** |

## *Additional option*

**Calculation of impact on receptor**

| | | | | |
|---|---|---|---|---|
| Concentration of contaminant in contaminated discharge (entering receptor) | Cc | 0.00E+00 | mg/l | |
| Calculated concentration within receptor (dilution only) | | #DIV/0! | mg/l | 0 |

| | |
|---|---|
| Site being assessed: | Glan Llyn |
| Completed by: | Ross Cameron |
| Date: | 24-Feb-20 |
| Version: | 1 |

**Remedial Targets Worksheet , Release 3.2**

## Level 3 - Soil

See Note

Environment Agency

### Input Parameters

| | Variable | Value | Unit | Source |
|---|---|---|---|---|
| Contaminant | | Vanadium | | from Level 1 |
| Target Concentration | $C_T$ | 0.02 | mg/l | from Level 1 |
| Dilution Factor | DF | #DIV/0! | | from Level 2 |

**Select analytical solution (click on brown cell below, then on pull-down menu)**

Ogata Banks — Equations in HRA publication

**Select nature of decay rate (click on brown cell below, then on pull-down menu)**

Approach for simulating degradation of pollutants: Apply degradation rate to pollutants in all phases (e.g. field derived value, lab derived value)

| | Variable | Value | Unit | Source of parameter value |
|---|---|---|---|---|
| Enter source concentration | | Soil concentration as mg/kg | | |
| Enter soil concentration | | 0 | mg/kg | |
| Half life for degradation of contaminant in water | $t_{1/2}$ | 1.00E+100 | days | |
| Calculated decay rate | $\lambda$ | 6.93E-101 | $days^{-1}$ | calculated |
| Width of plume in aquifer at source | Sz | 0.00E+00 | m | from Level 2 |
| Plume thickness in aquifer at source | Sy | 0.00E+00 | m | from Level 2 |
| Bulk density of aquifer materials | $\rho$ | 0.00E+00 | $g/cm^3$ | |
| Effective porosity of aquifer | n | 0.00E+00 | fraction | |
| Hydraulic gradient | i | #DIV/0! | fraction | from Level 2 (adjusted) |
| Hydraulic conductivity of saturated aquifer | K | 0.00E+00 | m/d | from Level 2 |
| Distance to compliance point | x | 0.00E+00 | m | |
| Distance (lateral) to compliance point perpendicular to flow direction | z | | m | |
| Distance (depth) to compliance point perpendicular to flow direction | y | | m | |
| Time since pollutant entered groundwater | t | 1.00E+99 | days | *time variant options only* |
| *Parameters values determined from options* | | | | |
| Partition coefficient | Kd | 0.00E+00 | l/kg | *see options* |
| Longitudinal dispersivity | ax | 0.000 | m | *see options* |
| Transverse dispersivity | az | 0.000 | m | *see options* |
| Vertical dispersivity | av | 0.000 | m | *see options* |

***Parameter values should be checked against Level 1 and 2***

### Calculated Parameters

| | Variable | | |
|---|---|---|---|
| Groundwater flow velocity | v | #DIV/0! | m/d |
| Retardation factor | Rf | #DIV/0! | fraction |
| Decay rate used | $\lambda$ | 6.93E-101 | $d^{-1}$ |
| Hydraulic gradient used in aquifer flow down-gradient | i | #DIV/0! | fraction |
| Rate of contaminant flow due to retardation | u | #DIV/0! | m/d |
| Ratio of Compliance Point to Source Concentration | $C_{ED}/C_0$ | #DIV/0! | fraction |
| **Attenuation factor ($C_0/C_{ED}$)** | **AF** | **#DIV/0!** | **fraction** |
| Calculated soil leachate concentration | Co | 0.00E+00 | mg/l |

### Remedial Targets

| | | | |
|---|---|---|---|
| **Level 3 Remedial Target** | **#DIV/0!** | **mg/l** | For comparison with measured pore water concentration. |
| Ogata Banks | **or** | | This assumes Level 1 Remedial Target is based on Target Concentration. |
| | **#DIV/0!** | **mg/kg** | For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water partitioning equation. |
| **Distance to compliance point** | **0** | **m** | |
| **Ratio of Compliance Point to Source Concentration** $C_{ED}/C_0$ | **#DIV/0!** | **fraction** | Ogata Banks |

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99

**Enter method of defining partition co-efficient (using pull down list)**

Calculate for ionic organic chemicals (acids)

***Entry if specify partition coefficient (option)***

Soil water partition coefficient — Kd — l/kg

***Entry for non-polar organic chemicals (option)***

Fraction of organic carbon in aquifer — foc — fraction
Organic carbon partition coefficient — Koc — l/kg

***Entry for ionic organic chemicals (option)***

| | | | |
|---|---|---|---|
| Sorption coefficient for related species | $K_{oc,n}$ | 0.00E+00 | l/kg |
| Sorption coefficient for ionised species | $K_{oc,i}$ | 0.00E+00 | l/kg |
| pH value | pH | 0.00E+00 | |
| Acid dissociation constant | pKa | 0.00E+00 | |
| Fraction of organic carbon in aquifer | foc | 0.00E+00 | fraction |
| Soil water partition coefficient | Kd | 0.00E+00 | l/kg |

**Define dispersivity (click brown cell and use pull down list)**

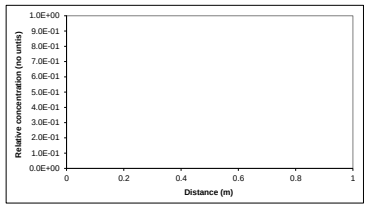
User defined values for dispersivity

| | | Enter value | Calc value | Xu & Eckstein | |
|---|---|---|---|---|---|
| **Longitudinal dispersivity** | **ax** | 0.00E+00 | 0.00E+00 | #NUM! | m |
| **Transverse dispersivity** | **az** | 0.00E+00 | 0.00E+00 | #NUM! | m |
| **Vertical dispersivity** | **ay** | 0.00E+00 | 0.00E+00 | #NUM! | m |

**Note values of dispersivity must be > 0**

Xu & Eckstein (1995) report ax = $0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed

Note
This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by $O_2$, $NO_3$, $SO_4$ etc than an alternative solution should be used




Note: 'Relative concentration' is the ratio of calculated concentation at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

| | |
|---|---|
| Site being assessed: | Glan Llyn |
| Completed by: | Ross Cameron |
| Date: | ######## |
| Version: | 1 |

**Calculated (relative) concentrations for distance-concentration graph**

Ogata Banks
From calculation sheet

| Distance | Relative concentration (No units) | Concentration mg/l |
|---|---|---|
| 0 | 1.0E+00 | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
| 0.0 | #DIV/0! | #DIV/0! |
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# Remedial Targets Worksheet , Release 3.2

## Calculation of contaminant concentration in groundwater from a soil source

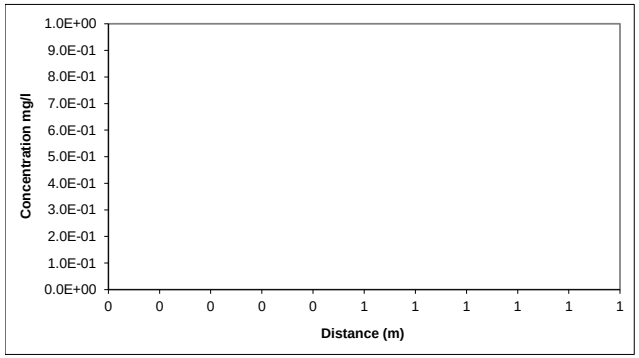
Only input required is Soil Contaminant Concentration

| | | | | |
|---|---|---|---|---|
| | Input Parameters | | | |
| | Soil contaminant concentration | $C_0$ | 0.00E+00 | mg/kg |
| **Level 1 Parameters** | | | | |
| | Water filled soil porosity | $\theta_w$ | 5.00E-01 | fraction |
| | Air filled soil porosity | $\theta a$ | 3.70E-01 | fraction |
| | Bulk density | $\rho$ | 1.36E+00 | g/cm$^3$ |
| | Henry's Law constant | H | 1.00E+00 | dimensionless |
| | Soil water partition coefficient used in Level Assessment | Kd | 1.34E+02 | l/kg |
| | Factor (partitioning between soil and water) | | 1.35E+02 | dimensionless |
| **Level 2 Parameters** | **Dilution Factor** | DF | #DIV/0! | |
| **Level 3 Parameters** | **Attenuation factor ($C_O/C_{ED}$)** | AF | #DIV/0! | |

### Predicted concentrations at compliance point

| | | | | |
|---|---|---|---|---|
| **Level 1** | C | 0.00E+00 | mg/l | No dilution or attenuation |
| **Level 2** | C | #DIV/0! | mg/l | Dilution taken into account |
| **Level 3** | C | #DIV/0! | mg/l | Dilution and attenuation taken into account |

### Predicted concentrations between source and compliance point - Level 3




| Distance m | Concentration mg/l |
|---|---|
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
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| 0.00 | #DIV/0! |
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| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |
| 0.00 | #DIV/0! |

# R&D Publication 20 Remedial Targets Worksheet, Release 3.2

## Level 3 - Groundwater

See Note

**Input Parameters (using pull down menu)**

| | Variable | Value | Unit | Source |
|---|---|---|---|---|
| Contaminant | | Vanadium | | from Level 1 |
| Target Concentration | $C_T$ | 2.00E-02 | mg/l | from Level 1 |

**Select analytical solution (click on brown cell below, then on pull-down menu)**

Domenico - Steady state — Equations in HRA publication

Approach for simulating vertical dispersion: Simulate vertical dispersion in 1 direction

**Select nature of decay rate (click on brown cell below, then on pull-down menu)**

Approach for simulating degradation of pollutants: Apply degradation rate to dissolved pollutants only

| | | | | Source of parameter value |
|---|---|---|---|---|
| Initial contaminant concentration in groundwater at plume core | $C_0$ | 1.35E+01 | mg/l | *Based on maximum soil conc of 2880mg/kg* |
| Half life for degradation of contaminant in water | $t_{1/2}$ | 9.00E+99 | days | *Estimation* |
| Calculated decay rate | $\lambda$ | 7.70E-101 | $days^{-1}$ | |
| Width of plume in aquifer at source (perpendicular to flow) | Sz | 5.00E+02 | m | *Site data* |
| Plume thickness at source | Sy | 1.50E+00 | m | *Thickness of re-engineered MG* |
| Saturated aquifer thickness | da | 2.00E+00 | m | *Based upon proposed total MG and cappi* |
| Bulk density of aquifer materials | ρ | 1.36E+00 | $g/cm^3$ | *Site data* |
| Effective porosity of aquifer | n | 8.00E-02 | fraction | *Estimate* |
| Hydraulic gradient | i | 1.00E-02 | fraction | |
| Hydraulic conductivity of aquifer | K | 8.64E-03 | m/d | *Proposed best achievable* |
| Distance to compliance point | x | 2.00E+01 | m | *Site data* |
| Distance (lateral) to compliance point perpendicular to flow direction | z | | m | |
| Distance (depth) to compliance point perpendicular to flow direction | y | | m | |
| Time since pollutant entered groundwater | t | 1.00E+100 | days | *time variant options only* |
| *Parameters values determined from options* | | | | |
| Partition coefficient | Kd | 2.13E+02 | l/kg | *see options* |
| Longitudinal dispersivity | ax | 1.57E+00 | m | *see options* |
| Transverse dispersivity | az | 1.57E-01 | m | *see options* |
| Vertical dispersivity | ay | 1.57E-02 | m | *see options* |

**Calculated Parameters**

| | Variable | | |
|---|---|---|---|
| Groundwater flow velocity | v | 1.08E-03 | m/d |
| Retardation factor | Rf | 3.62E+03 | fraction |
| Decay rate used | λ | 2.13E-104 | $d^{-1}$ |
| Rate of contaminant flow due to retardation | u | 2.98E-07 | m/d |
| Contaminant concentration at distance x, assuming one-way vertical dispersion | $C_{ED}$ | 1.27E+01 | mg/l |
| **Attenuation factor (one way vertical dispersion, CO/CED)** | **AF** | **1.06E+00** | |

**Remedial Targets**

| | | | | |
|---|---|---|---|---|
| **Remedial Target** | | **2.12E-02** | **mg/l** | For comparison with measured groundwater concentration. |
| Domenico - Steady state | | | | |
| **Distance to compliance point** | | **20** | **m** | |
| **Concentration of contaminant at compliance point** | **$C_{ED}/C_0$** | **1.27E+01** | **mg/l** | Domenico - Steady state |

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99.

**Select Method for deriving Partition Co-efficient (using pull down menu)**

User specified value for partition coefficient

***Entry if specify partition coefficient (option)***

Soil water partition coefficient — Kd — 2.13E+02 — l/kg

***Entry for non-polar organic chemicals (option)***

Fraction of organic carbon in aquifer — foc — fraction

Organic carbon partition coefficient — Koc — l/kg

***Entry for ionic organic chemicals (option)***

Sorption coefficient for related species — $K_{oc,n}$ — l/kg

Sorption coefficient for ionised species — $K_{oc,i}$ — l/kg

pH value — pH

acid dissociation constant — pKa

Fraction of organic carbon in aquifer — foc — fraction

Soil water partition coefficient — Kd — 2.13E+02 — l/kg

**Define dispersivity (click brown cell and use pull down list)**

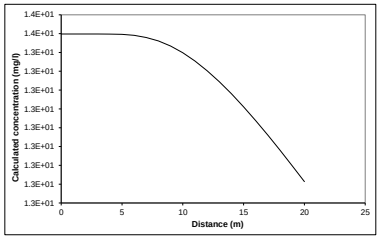
Dispersivity based on Xu & Eckstein (1995)

| | | Enter value | Calc value Xu & Eckstein | | |
|---|---|---|---|---|---|
| **Longitudinal dispersivity** | **ax** | 0.00E+00 | 2.00E+00 | 1.57E+00 | m |
| **Transverse dispersivity** | **az** | 0.00E+00 | 2.00E-01 | 1.57E-01 | m |
| **Vertical dispersivity** | **ay** | 0.00E+00 | 2.00E-02 | 1.57E-02 | |

**Note values of dispersivity must be > 0**

For calculated value, assumes ax = 0.1 *x, az = 0.01 * x, ay = 0.001 * x

Xu & Eckstein (1995) report ax = $0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed




Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared with the Level 3 remedial target to determine the need for further action.
Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O2, NO3, SO4 etc than an alternative solution should be used

| | |
|---|---|
| Site being assessed: | Glan Llyn |
| Completed by: | Ross Cameron |
| Date: | ####### |
| Version: | 1 |

**Calculated concentrations for distance-concentration graph**

**Domenico - Steady state**
**From calculation sheet**

| Distance | Concentration |
|---|---|
| | mg/l |
| 0 | 1.3E+01 |
| 1.0 | 1.35E+01 |
| 2.0 | 1.35E+01 |
| 3.0 | 1.35E+01 |
| 4.0 | 1.35E+01 |
| 5.0 | 1.35E+01 |
| 6.0 | 1.35E+01 |
| 7.0 | 1.35E+01 |
| 8.0 | 1.35E+01 |
| 9.0 | 1.34E+01 |
| 10.0 | 1.34E+01 |
| 11.0 | 1.34E+01 |
| 12.0 | 1.33E+01 |
| 13.0 | 1.32E+01 |
| 14.0 | 1.32E+01 |
| 15.0 | 1.31E+01 |
| 16.0 | 1.30E+01 |
| 17.0 | 1.30E+01 |
| 18.0 | 1.29E+01 |
| 19.0 | 1.28E+01 |
| 20.0 | 1.27E+01 |

# Porosity Calculator

These results are not carried through to any of the other worksheets

## DRY BULK DENSITY DATA

| Variable | Value | Unit | justification |
|---|---|---|---|
| Natural Moisture Content | 0.00 | % wt | |
| Particle Density | 2.78 | tonnes/m$^3$ | (Change this number only if you have specific information) |
| Dry Bulk Density | 0.00 | tonnes/m$^3$ | |
| *Calculated Parameters* | | | |
| Voids Ratio | #DIV/0! | fraction | |
| Initial Saturation | #DIV/0! | % | |
| **Total porosity** | **1.000** | **fraction** | |
| **Air Filled Porosity** | **#DIV/0!** | **fraction** | |
| **Water Filled Porosity** | **#DIV/0!** | **fraction** | |

## WET BULK DENSITY DATA

| Variable | Value | Unit | |
|---|---|---|---|
| Moisture Content | 0.00 | % wt | |
| Particle Density | 2.78 | tonnes/m$^3$ | (Change this number only if you have specific information) |
| Actual (wet) Bulk Density ( i.e. at natural MC) | 0.00 | tonnes/m$^3$ | |
| *Calculated Parameters* | | | |
| Voids Ratio | #DIV/0! | fraction | |
| dry bulk density | 0.00 | tonnes/m$^3$ | |
| Initial Saturation | #DIV/0! | % | |
| **Total porosity** | **1.000** | **fraction** | **#DIV/0!** |
| **Air Filled Porosity** | **#DIV/0!** | **fraction** | |
| **Water Filled Porosity** | **#DIV/0!** | **fraction** | |

*Analytical solutions provided by David Hall, Golder Associates (UK) Ltd*

# Simple hydrogeological calculations

**(These are not specific to, or required in, the Remedial Targets Methodology)**

| Parameter | symbol | | unit | justification |
|---|---|---|---|---|
| Hydraulic conductivity | K | 0.00E+00 | m/d | |
| Hydraulic gradient | i | 0.00E+00 | unitless | |
| Effective porosity of aquifer | n | 0.00E+00 | fraction | |
| Thickness of saturated aquifer | b | 0.00E+00 | m | |
| Width of aquifer perpendicular to flow | w | 0.00E+00 | m | |
| Distance to receptor | x | 0.00E+00 | m | |
| Bulk density of aquifer materials | ρ | 0.00E+00 | $g/cm^3$ | |
| Soil-water partition co-efficient | Kd | 0.00E+00 | l/kg | |
| Retardation factor of pollutant | R | #DIV/0! | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Groundwater flow velocity | v(GW) | #DIV/0! | m/s | #DIV/0! | m/day | #DIV/0! | m/year |
| Time for groundwater to reach receptor | t(GW) | #DIV/0! | seconds | #DIV/0! | days | #DIV/0! | years |
| Rate of groundwater flow through aquifer | Q | 0.00E+00 | $m^3/s$ | 0.00E+00 | $m^3$/day | 0.00E+00 | $m^3$/year |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Contaminant flow velocity | v(contam) | #DIV/0! | m/s | #DIV/0! | m/day | #DIV/0! | m/year |
| Time for contaminant to reach receptor | t(contam) | #DIV/0! | seconds | #DIV/0! | days | #DIV/0! | years |

## Level 1 Calculation Sheet

**Contaminant** **Vanadium**

| **Parameter** (carried over from input sheet) | **Value** | **Units** |
|---|---|---|
| $C_T$ | 2.00E-02 | mg/l |
| Kd | 1.34E+02 | l/kg |
| foc | | fraction |
| koc | | l/kg |
| $\theta_w$ | 5.00E-01 | fraction |
| $\theta a$ | 3.70E-01 | fraction |
| $\rho$ | 1.36E+00 | g/cm3 |
| H | 1.00E+00 | dimensionless |
| Koc,n | | l/kg |
| Koc,i | | l/kg |
| pH | | pH units |
| pKa | | |
| foc (ionic) | | fraction |

**Calculations (Refer toTable 4.3, R&D Publication 20)**

**Selected option** User specified value for partition coefficient

| | calc | calc | Calc Kd | l/kg |
|---|---|---|---|---|
| Calculation of partition coefficient for ionic organic chemical | | | | |
| Partition coefficient used in Level 1 Assessment | | | 1.34E+02 | l/kg |

| **Calculated Remedial Target** | **2.69E+00** | **mg/kg** | **for** | **Vanadium** |
|---|---|---|---|---|

Factor (partitioning between soil and water) 1.35E+02

| | |
|---|---|
| Site being assessed: | Glan Llyn |
| Completed by: | Ross Cameron |
| Date: | 24/02/2020 |
| Version: | 1 |

## Level 2 Calculation Sheet

**Contaminant** **Vanadium**

| Site assessed: | Glan Llyn |
|---|---|
| Date: | 24/02/2020 |
| Version: | 1 |

| Parameter | Value | Units | | |
|---|---|---|---|---|
| (carried over from input sheet) | | | | |
| Mz | 0.00E+00 | m | | |
| L | 0.00E+00 | m | | |
| da | 0.00E+00 | m | | Calculated |
| Inf | 0.00E+00 | m/d | | Dilution Factor |
| K | 0.00E+00 | m/d | | |
| i | 0.00E+00 | | Calculation based on target concentration | #DIV/0! |
| | | m3/d | | |
| A | 0.00E+00 | m2 | Calculation based on observed contaminant concentration | #DIV/0! |
| | | m3/d | | |
| Cc | 0.00E+00 | mg/l | | |
| $C_T$ | 2.00E-02 | mg/l | | |
| Cu | 0.00E+00 | mg/l | | |
| w | 0.00E+00 | m | | |



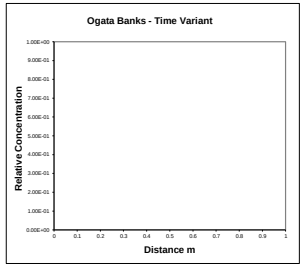
**Contaminant** **Vanadium**

**OGATA BANKS SOLUTION**

Calculations for source located in centre of aquifer (ie vertical dispersion in two directions)

| Input | Value | Units |
|---|---|---|
| $C_T$ | 2.000E-02 | mg/l |
| DF | #DIV/0! | |
| | | |
| λ | 6.931E-101 | $days^{-1}$ |
| Sz | 0.000E+00 | m |
| Sy | 0.000E+00 | m |
| Kd | 0.000E+00 | l/kg |
| ρ | 0.000E+00 | g/cm3 |
| n | 0.000E+00 | |
| i | #DIV/0! | |
| K | 0.000E+00 | m/d |
| x | 0.000E+00 | m |
| z | 0.000E+00 | m |
| y | 0.000E+00 | m |
| t | 1.000E+99 | days |
| ax | 0.000E+00 | m |
| az | 0.000E+00 | m |
| ay | 0.000E+00 | m |

| | X | Term 1 | Term 2 | EXP | Term 3 | ERFC | Term 4 | EXP | Term 5 | ERFC | Term 6a | ERF | Term 6b | ERF | Term 7a | ERF | Term 7b | ERF | Relative Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 2 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 3 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 4 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 5 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 6 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 7 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 8 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 9 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 10 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 11 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 12 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 13 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 14 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 15 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 16 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 17 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 18 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 19 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 20 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |

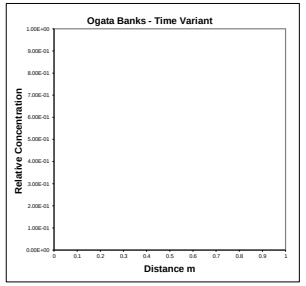



**Calc** **Value**

| | | |
|---|---|---|
| v | #DIV/0! | m/d |
| Rc | #DIV/0! | |
| u | #DIV/0! | m/d |

Calculations for source located at top of aquifer (ie vertical dispersion in one direction) -USED FOR LEVEL ASSESSMENT

| | X | Term 1 | Term 2 | EXP | Term 3 | ERFC | Term 4 | EXP | Term 5 | ERFC | Term 6a | ERF | Term 6b | ERF | Term 7a | ERF | Term 7b | ERF | Relative Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 2 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 3 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 4 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 5 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 6 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 7 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 8 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 9 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 10 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 11 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 12 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 13 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 14 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 15 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 16 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 17 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 18 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 19 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 20 | 0 | 0.13 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |




| | |
|---|---|
| Date: | 24/02/2020 |
| Version: | 1 |

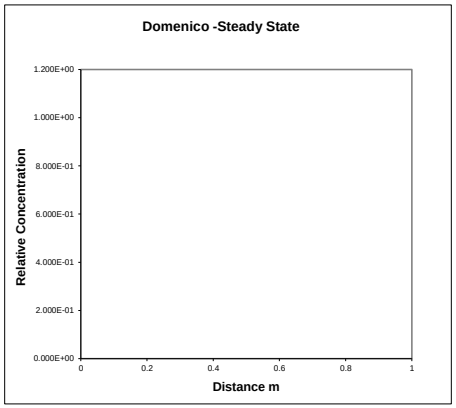
**Contaminant** **Vanadium**

| Input | Value | Units |
|---|---|---|
| $C_T$ | 2.000E-02 | mg/l |
| DF | #DIV/0! | |
| | | |
| λ | 6.931E-101 | days$^{-1}$ |
| Sz | 0.000E+00 | m |
| Sy | 0.000E+00 | m |
| Kd | 0.000E+00 | l/kg |
| ρ | 0.000E+00 | g/cm3 |
| n | 0.000E+00 | |
| i | #DIV/0! | |
| K | 0.000E+00 | m/d |
| x | 0.000E+00 | m |
| z | 0.000E+00 | m |
| y | 0.000E+00 | m |
| ax | 0.000E+00 | m |
| az | 0.000E+00 | m |
| ay | 0.000E+00 | m |

**DOMENICO (STEADY STATE)**

Calculations for source located in centre of aquifer (ie vertical dispersion in two directions)

| | X | Term 1 | Term 2 | EXP | Term 3A | ERF | Term 3B | ERF | Term 4A | ERF | Term 4B | ERF | Relative Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 2 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 3 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 4 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 5 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 6 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 7 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 8 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 9 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 10 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 11 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 12 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 13 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 14 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 15 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 16 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 17 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 18 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 19 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 20 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |



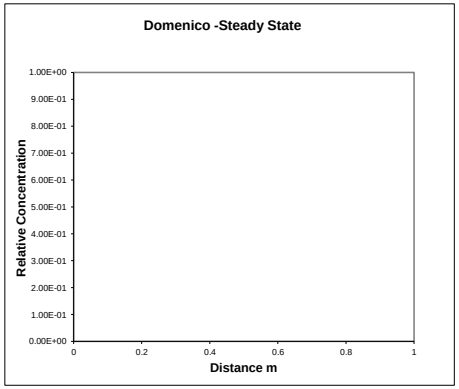

**Calc** **Value**

| | | |
|---|---|---|
| v | #DIV/0! | m/d |
| Rc | #DIV/0! | |
| u | #DIV/0! | m/d |

**DOMENICO (STEADY STATE)**

Calculations for source located at top of aquifer (ie vertical dispersion in one direction) - USED FOR LEVEL ASSESSMENT

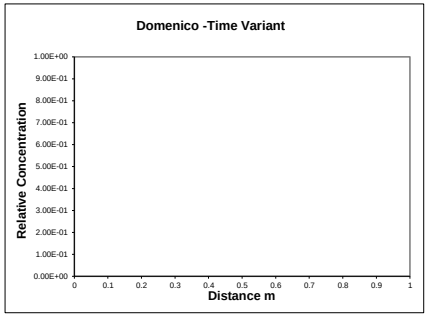
| | X | Term 1 | Term 2 | EXP | Term 3A | ERF | Term 3B | ERF | Term 4A | ERF | Term 4B | ERF | Relative Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 2 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 3 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 4 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 5 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 6 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 7 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 8 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 9 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 10 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 11 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 12 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 13 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 14 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 15 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 16 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 17 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 18 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 19 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |
| 20 | 0 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | ###### | #DIV/0! | #DIV/0! | #DIV/0! |



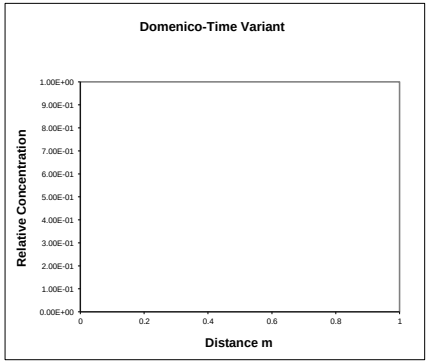

| | |
|---|---|
| Date: | 24/02/2020 |
| Version: | 1 |

**DOMENICO (TIME VARIANT)**

| Contaminant | Vanadium | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Calculations for source located in centre of aquifer (ie vertical dispersion in two directions) | | | | | | | | | | | | | | |
| **Input** | **Value** | **Units** | | X | Term 1 | Term 2 | EXP | Term 3 | ERFC | Term 4A | ERF | Term 4B | ERF | Term 5A | ERF | Term 5B | ERF | Relative Concentration |
| | | | | m | | | | | | | | | | | | | | |
| $C_T$ | 0.02 | mg/l | 1 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| DF | #DIV/0! | | 2 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| | | | 3 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| | | | 4 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| λ | 6.931E-101 | $days^{-1}$ | 5 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| Sz | 0.000E+00 | m | 6 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| Sy | 0.000E+00 | m | 7 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| Kd | 0.000E+00 | l/kg | 8 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| ρ | 0.000E+00 | g/cm3 | 9 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| n | 0.000E+00 | | 10 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| i | #DIV/0! | | 11 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| K | 0.000E+00 | m/d | 12 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| x | 0.000E+00 | m | 13 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| z | 0.000E+00 | m | 14 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| y | 0.000E+00 | m | 15 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| t | 1.000E+99 | days | 16 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| ax | 0.000E+00 | m | 17 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| az | 0.000E+00 | m | 18 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| ay | 0.000E+00 | m | 19 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| | | | 20 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |




| Calc | Value | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Calculations for source located at top of aquifer (ie vertical dispersion in one direction only) - USED FOR LEVEL ASSESSMENT | | | | | | | | | | | | | | |
| | | | | X | Term 1 | Term 2 | EXP | Term 3 | ERFC | Term 4A | ERF | Term 4B | ERF | Term 5A | ERF | Term 5B | ERF | Relative Concentration |
| v | #DIV/0! | m/d | | m | | | | | | | | | | | | | | |
| Rc | #DIV/0! | | 1 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| u | #DIV/0! | m/d | 2 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| | | | 3 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| | | | 4 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| | | | 5 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| | | | 6 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| | | | 7 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| | | | 8 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| | | | 9 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| | | | 10 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| | | | 11 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| | | | 12 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| | | | 13 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| | | | 14 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| | | | 15 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| | | | 16 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| | | | 17 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| | | | 18 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| | | | 19 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| | | | 20 | 0 | 0.125 | #DIV/0! | #DIV/0! | #DIV/0! | ##### | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |



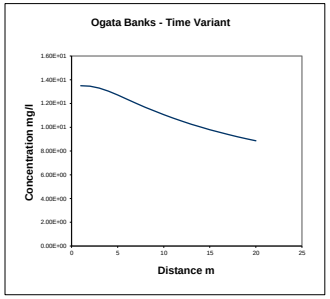

| | |
|---|---|
| Date: | 24/02/2020 |
| Version: | 1 |

**OGATA BANKS SOLUTION**

| Contaminant | Vanadium | |
|---|---|---|
| **Input** | **Value** | **Units** |
| $C_T$ | 0.02 | mg/l |
| Co | 1.35E+01 | mg/l |
| λ | 2.13E-104 | $days^{-1}$ |
| Sz | 5.00E+02 | m |
| Sy | 1.50E+00 | m |
| Kd | 2.13E+02 | l/kg |
| ρ | 1.36E+00 | g/cm3 |
| n | 8.00E-02 | |
| i | 1.00E-02 | |
| K | 8.64E-03 | m/d |
| x | 2.00E+01 | m |
| z | 0.00E+00 | m |
| y | 0.00E+00 | m |
| t | 1.00E+100 | days |
| ax | 1.57E+00 | m |
| az | 1.57E-01 | m |
| ay | 1.57E-02 | m |

Calculations for source located in centre of aquifer (ie vertical dispersion in two directions)

| | X | Term 1 | Term 2 | EXP | Term 3 | ERFC | Term 4 | EXP | Term 5 | ERFC | Term 6a | ERF | Term 6b | ERF | Term 7a | ERF | Term 7b | ERF | Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 1.68725 | 0.0E+00 | 1.0E+00 | -2.2E+46 | 2.000 | 6.4E-01 | 1.9E+00 | 2.2E+46 | 0.000 | 3.2E+02 | 1 | -3.2E+02 | -1 | 3.0E+00 | 1 | -3.0E+00 | -0.99998 | 1.35E+01 |
| 2 | 2 | 1.68725 | 0.0E+00 | 1.0E+00 | -2.2E+46 | 2.000 | 1.3E+00 | 3.6E+00 | 2.2E+46 | 0.000 | 2.2E+02 | 1 | -2.2E+02 | -1 | 2.1E+00 | 0.9973 | -2.1E+00 | -0.99726 | 1.35E+01 |
| 3 | 3 | 1.68725 | 0.0E+00 | 1.0E+00 | -2.2E+46 | 2.000 | 1.9E+00 | 6.8E+00 | 2.2E+46 | 0.000 | 1.8E+02 | 1 | -1.8E+02 | -1 | 1.7E+00 | 0.9856 | -1.7E+00 | -0.98557 | 1.33E+01 |
| 4 | 4 | 1.68725 | 0.0E+00 | 1.0E+00 | -2.2E+46 | 2.000 | 2.6E+00 | 1.3E+01 | 2.2E+46 | 0.000 | 1.6E+02 | 1 | -1.6E+02 | -1 | 1.5E+00 | 0.9659 | -1.5E+00 | -0.96587 | 1.30E+01 |
| 5 | 5 | 1.68725 | 0.0E+00 | 1.0E+00 | -2.2E+46 | 2.000 | 3.2E+00 | 2.4E+01 | 2.2E+46 | 0.000 | 1.4E+02 | 1 | -1.4E+02 | -1 | 1.3E+00 | 0.9419 | -1.3E+00 | -0.94189 | 1.27E+01 |
| 6 | 6 | 1.68725 | 0.0E+00 | 1.0E+00 | -2.2E+46 | 2.000 | 3.8E+00 | 4.6E+01 | 2.2E+46 | 0.000 | 1.3E+02 | 1 | -1.3E+02 | -1 | 1.2E+00 | 0.9163 | -1.2E+00 | -0.91633 | 1.24E+01 |
| 7 | 7 | 1.68725 | 0.0E+00 | 1.0E+00 | -2.2E+46 | 2.000 | 4.5E+00 | 8.7E+01 | 2.2E+46 | 0.000 | 1.2E+02 | 1 | -1.2E+02 | -1 | 1.1E+00 | 0.8907 | -1.1E+00 | -0.89072 | 1.20E+01 |
| 8 | 8 | 1.68725 | 0.0E+00 | 1.0E+00 | -2.2E+46 | 2.000 | 5.1E+00 | 1.7E+02 | 2.2E+46 | 0.000 | 1.1E+02 | 1 | -1.1E+02 | -1 | 1.1E+00 | 0.8659 | -1.1E+00 | -0.86587 | 1.17E+01 |
| 9 | 9 | 1.68725 | 0.0E+00 | 1.0E+00 | -2.2E+46 | 2.000 | 5.7E+00 | 3.1E+02 | 2.2E+46 | 0.000 | 1.1E+02 | 1 | -1.1E+02 | -1 | 1.0E+00 | 0.8422 | -1.0E+00 | -0.84215 | 1.14E+01 |
| 10 | 10 | 1.68725 | 0.0E+00 | 1.0E+00 | -2.2E+46 | 2.000 | 6.4E+00 | 5.9E+02 | 2.2E+46 | 0.000 | 1.0E+02 | 1 | -1.0E+02 | -1 | 9.5E-01 | 0.8197 | -9.5E-01 | -0.81971 | 1.11E+01 |
| 11 | 11 | 1.68725 | 0.0E+00 | 1.0E+00 | -2.2E+46 | 2.000 | 7.0E+00 | 1.1E+03 | 2.2E+46 | 0.000 | 9.5E+01 | 1 | -9.5E+01 | -1 | 9.0E-01 | 0.7986 | -9.0E-01 | -0.79858 | 1.08E+01 |
| 12 | 12 | 1.68725 | 0.0E+00 | 1.0E+00 | -2.2E+46 | 2.000 | 7.7E+00 | 2.1E+03 | 2.2E+46 | 0.000 | 9.1E+01 | 1 | -9.1E+01 | -1 | 8.6E-01 | 0.7787 | -8.6E-01 | -0.77872 | 1.05E+01 |
| 13 | 13 | 1.68725 | 0.0E+00 | 1.0E+00 | -2.2E+46 | 2.000 | 8.3E+00 | 4.0E+03 | 2.2E+46 | 0.000 | 8.8E+01 | 1 | -8.8E+01 | -1 | 8.3E-01 | 0.7601 | -8.3E-01 | -0.76006 | 1.03E+01 |
| 14 | 14 | 1.68725 | 0.0E+00 | 1.0E+00 | -2.2E+46 | 2.000 | 8.9E+00 | 7.6E+03 | 2.2E+46 | 0.000 | 8.4E+01 | 1 | -8.4E+01 | -1 | 8.0E-01 | 0.7425 | -8.0E-01 | -0.74253 | 1.00E+01 |
| 15 | 15 | 1.68725 | 0.0E+00 | 1.0E+00 | -2.2E+46 | 2.000 | 9.6E+00 | 1.4E+04 | 2.2E+46 | 0.000 | 8.2E+01 | 1 | -8.2E+01 | -1 | 7.7E-01 | 0.726 | -7.7E-01 | -0.72604 | 9.80E+00 |
| 16 | 16 | 1.68725 | 0.0E+00 | 1.0E+00 | -2.2E+46 | 2.000 | 1.0E+01 | 2.7E+04 | 2.2E+46 | 0.000 | 7.9E+01 | 1 | -7.9E+01 | -1 | 7.5E-01 | 0.7105 | -7.5E-01 | -0.71052 | 9.59E+00 |
| 17 | 17 | 1.68725 | 0.0E+00 | 1.0E+00 | -2.2E+46 | 2.000 | 1.1E+01 | 5.2E+04 | 2.2E+46 | 0.000 | 7.7E+01 | 1 | -7.7E+01 | -1 | 7.3E-01 | 0.6959 | -7.3E-01 | -0.69588 | 9.39E+00 |
| 18 | 18 | 1.68725 | 0.0E+00 | 1.0E+00 | -2.2E+46 | 2.000 | 1.1E+01 | 9.8E+04 | 2.2E+46 | 0.000 | 7.4E+01 | 1 | -7.4E+01 | -1 | 7.1E-01 | 0.6821 | -7.1E-01 | -0.68205 | 9.21E+00 |
| 19 | 19 | 1.68725 | 0.0E+00 | 1.0E+00 | -2.2E+46 | 2.000 | 1.2E+01 | 1.8E+05 | 2.2E+46 | 0.000 | 7.2E+01 | 1 | -7.2E+01 | -1 | 6.9E-01 | 0.669 | -6.9E-01 | -0.66897 | 9.03E+00 |
| 20 | 20 | 1.68725 | 0.0E+00 | 1.0E+00 | -2.2E+46 | 2.000 | 1.3E+01 | 3.5E+05 | 2.2E+46 | 0.000 | 7.1E+01 | 1 | -7.1E+01 | -1 | 6.7E-01 | 0.6566 | -6.7E-01 | -0.65658 | 8.86E+00 |

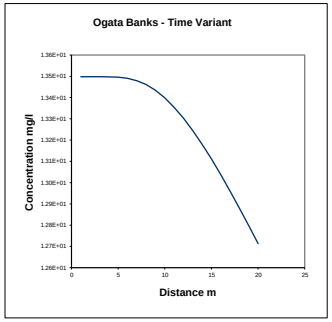



Vertical dispersion option Simulate vertical dispersion in 1 direction

| Calc | Value | |
|---|---|---|
| v | 1.08E-03 | m/d |
| Rc | 3.62E+03 | |
| u | 2.98E-07 | m/d |

Calculations for source located at top of aquifer (ie vertical dispersion in one direction) - USED FOR LEVEL ASSESSMENT

| | X | Term 1 | Term 2 | EXP | Term 3 | ERFC | Term 4 | EXP | Term 5 | ERFC | Term 6a | ERF | Term 6b | ERF | Term 7a | ERF | Term 7b | ERF | Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 1.68725 | 0.0E+00 | 1.0E+00 | -2.2E+46 | 2.000 | 6.4E-01 | 1.9E+00 | 2.2E+46 | 0.000 | 3.2E+02 | 1 | -3.2E+02 | -1 | 6.0E+00 | 1 | -6.0E+00 | -1 | 1.35E+01 |
| 2 | 2 | 1.68725 | 0.0E+00 | 1.0E+00 | -2.2E+46 | 2.000 | 1.3E+00 | 3.6E+00 | 2.2E+46 | 0.000 | 2.2E+02 | 1 | -2.2E+02 | -1 | 4.2E+00 | 1 | -4.2E+00 | -1 | 1.35E+01 |
| 3 | 3 | 1.68725 | 0.0E+00 | 1.0E+00 | -2.2E+46 | 2.000 | 1.9E+00 | 6.8E+00 | 2.2E+46 | 0.000 | 1.8E+02 | 1 | -1.8E+02 | -1 | 3.5E+00 | 1 | -3.5E+00 | -1 | 1.35E+01 |
| 4 | 4 | 1.68725 | 0.0E+00 | 1.0E+00 | -2.2E+46 | 2.000 | 2.6E+00 | 1.3E+01 | 2.2E+46 | 0.000 | 1.6E+02 | 1 | -1.6E+02 | -1 | 3.0E+00 | 1 | -3.0E+00 | -0.99998 | 1.35E+01 |
| 5 | 5 | 1.68725 | 0.0E+00 | 1.0E+00 | -2.2E+46 | 2.000 | 3.2E+00 | 2.4E+01 | 2.2E+46 | 0.000 | 1.4E+02 | 1 | -1.4E+02 | -1 | 2.7E+00 | 0.9998 | -2.7E+00 | -0.99985 | 1.35E+01 |
| 6 | 6 | 1.68725 | 0.0E+00 | 1.0E+00 | -2.2E+46 | 2.000 | 3.8E+00 | 4.6E+01 | 2.2E+46 | 0.000 | 1.3E+02 | 1 | -1.3E+02 | -1 | 2.4E+00 | 0.9995 | -2.4E+00 | -0.99946 | 1.35E+01 |
| 7 | 7 | 1.68725 | 0.0E+00 | 1.0E+00 | -2.2E+46 | 2.000 | 4.5E+00 | 8.7E+01 | 2.2E+46 | 0.000 | 1.2E+02 | 1 | -1.2E+02 | -1 | 2.3E+00 | 0.9986 | -2.3E+00 | -0.99864 | 1.35E+01 |
| 8 | 8 | 1.68725 | 0.0E+00 | 1.0E+00 | -2.2E+46 | 2.000 | 5.1E+00 | 1.7E+02 | 2.2E+46 | 0.000 | 1.1E+02 | 1 | -1.1E+02 | -1 | 2.1E+00 | 0.9973 | -2.1E+00 | -0.99726 | 1.35E+01 |
| 9 | 9 | 1.68725 | 0.0E+00 | 1.0E+00 | -2.2E+46 | 2.000 | 5.7E+00 | 3.1E+02 | 2.2E+46 | 0.000 | 1.1E+02 | 1 | -1.1E+02 | -1 | 2.0E+00 | 0.9953 | -2.0E+00 | -0.99527 | 1.34E+01 |
| 10 | 10 | 1.68725 | 0.0E+00 | 1.0E+00 | -2.2E+46 | 2.000 | 6.4E+00 | 5.9E+02 | 2.2E+46 | 0.000 | 1.0E+02 | 1 | -1.0E+02 | -1 | 1.9E+00 | 0.9926 | -1.9E+00 | -0.99263 | 1.34E+01 |
| 11 | 11 | 1.68725 | 0.0E+00 | 1.0E+00 | -2.2E+46 | 2.000 | 7.0E+00 | 1.1E+03 | 2.2E+46 | 0.000 | 9.5E+01 | 1 | -9.5E+01 | -1 | 1.8E+00 | 0.9894 | -1.8E+00 | -0.98938 | 1.34E+01 |
| 12 | 12 | 1.68725 | 0.0E+00 | 1.0E+00 | -2.2E+46 | 2.000 | 7.7E+00 | 2.1E+03 | 2.2E+46 | 0.000 | 9.1E+01 | 1 | -9.1E+01 | -1 | 1.7E+00 | 0.9856 | -1.7E+00 | -0.98557 | 1.33E+01 |
| 13 | 13 | 1.68725 | 0.0E+00 | 1.0E+00 | -2.2E+46 | 2.000 | 8.3E+00 | 4.0E+03 | 2.2E+46 | 0.000 | 8.8E+01 | 1 | -8.8E+01 | -1 | 1.7E+00 | 0.9812 | -1.7E+00 | -0.98124 | 1.32E+01 |
| 14 | 14 | 1.68725 | 0.0E+00 | 1.0E+00 | -2.2E+46 | 2.000 | 8.9E+00 | 7.6E+03 | 2.2E+46 | 0.000 | 8.4E+01 | 1 | -8.4E+01 | -1 | 1.6E+00 | 0.9765 | -1.6E+00 | -0.97647 | 1.32E+01 |
| 15 | 15 | 1.68725 | 0.0E+00 | 1.0E+00 | -2.2E+46 | 2.000 | 9.6E+00 | 1.4E+04 | 2.2E+46 | 0.000 | 8.2E+01 | 1 | -8.2E+01 | -1 | 1.5E+00 | 0.9713 | -1.5E+00 | -0.97133 | 1.31E+01 |
| 16 | 16 | 1.68725 | 0.0E+00 | 1.0E+00 | -2.2E+46 | 2.000 | 1.0E+01 | 2.7E+04 | 2.2E+46 | 0.000 | 7.9E+01 | 1 | -7.9E+01 | -1 | 1.5E+00 | 0.9659 | -1.5E+00 | -0.96587 | 1.30E+01 |
| 17 | 17 | 1.68725 | 0.0E+00 | 1.0E+00 | -2.2E+46 | 2.000 | 1.1E+01 | 5.2E+04 | 2.2E+46 | 0.000 | 7.7E+01 | 1 | -7.7E+01 | -1 | 1.5E+00 | 0.9601 | -1.5E+00 | -0.96015 | 1.30E+01 |
| 18 | 18 | 1.68725 | 0.0E+00 | 1.0E+00 | -2.2E+46 | 2.000 | 1.1E+01 | 9.8E+04 | 2.2E+46 | 0.000 | 7.4E+01 | 1 | -7.4E+01 | -1 | 1.4E+00 | 0.9542 | -1.4E+00 | -0.95421 | 1.29E+01 |
| 19 | 19 | 1.68725 | 0.0E+00 | 1.0E+00 | -2.2E+46 | 2.000 | 1.2E+01 | 1.8E+05 | 2.2E+46 | 0.000 | 7.2E+01 | 1 | -7.2E+01 | -1 | 1.4E+00 | 0.9481 | -1.4E+00 | -0.94812 | 1.28E+01 |
| 20 | 20 | 1.68725 | 0.0E+00 | 1.0E+00 | -2.2E+46 | 2.000 | 1.3E+01 | 3.5E+05 | 2.2E+46 | 0.000 | 7.1E+01 | 1 | -7.1E+01 | -1 | 1.3E+00 | 0.9419 | -1.3E+00 | -0.94189 | 1.27E+01 |



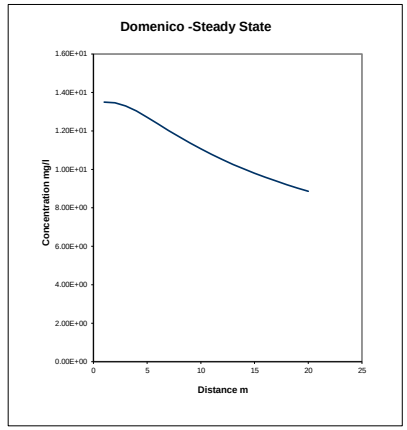

| | |
|---|---|
| Date: | 24/02/2020 |
| Version: | 1 |

**Contaminant** **Vanadium**

**DOMENICO (STEADY STATE)**

Calculations for source located in centre of aquifer (ie vertical dispersion in two directions)

| Input | Value | Units | | X | Term 1 | Term 2 | EXP | Term 3A | ERF | Term 3B | ERF | Term 4A | ERF | Term 4B | ERF | Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $C_T$ | 0.02 | mg/l | 1 | 1 | 3.3745 | 0.00E+00 | 1.00E+00 | 3.16E+02 | 1 | -3.16E+02 | -1 | 3.00E+00 | 1 | -3.00E+00 | -1 | 1.35E+01 |
| | | | 2 | 2 | 3.3745 | 0.00E+00 | 1.00E+00 | 2.23E+02 | 1 | -2.23E+02 | -1 | 2.12E+00 | 0.997 | -2.12E+00 | -0.9973 | 1.35E+01 |
| | | | 3 | 3 | 3.3745 | 0.00E+00 | 1.00E+00 | 1.82E+02 | 1 | -1.82E+02 | -1 | 1.73E+00 | 0.986 | -1.73E+00 | -0.9856 | 1.33E+01 |
| Co | 1.35E+01 | mg/l | 4 | 4 | 3.3745 | 0.00E+00 | 1.00E+00 | 1.58E+02 | 1 | -1.58E+02 | -1 | 1.50E+00 | 0.966 | -1.50E+00 | -0.9659 | 1.30E+01 |
| λ | 2.13E-104 | $days^{-1}$ | 5 | 5 | 3.3745 | 0.00E+00 | 1.00E+00 | 1.41E+02 | 1 | -1.41E+02 | -1 | 1.34E+00 | 0.942 | -1.34E+00 | -0.9419 | 1.27E+01 |
| Sz | 5.00E+02 | m | 6 | 6 | 3.3745 | 0.00E+00 | 1.00E+00 | 1.29E+02 | 1 | -1.29E+02 | -1 | 1.22E+00 | 0.916 | -1.22E+00 | -0.9163 | 1.24E+01 |
| Sy | 1.50E+00 | m | 7 | 7 | 3.3745 | 0.00E+00 | 1.00E+00 | 1.19E+02 | 1 | -1.19E+02 | -1 | 1.13E+00 | 0.891 | -1.13E+00 | -0.8907 | 1.20E+01 |
| Kd | 2.13E+02 | l/kg | 8 | 8 | 3.3745 | 0.00E+00 | 1.00E+00 | 1.12E+02 | 1 | -1.12E+02 | -1 | 1.06E+00 | 0.866 | -1.06E+00 | -0.8659 | 1.17E+01 |
| ρ | 1.36E+00 | g/cm3 | 9 | 9 | 3.3745 | 0.00E+00 | 1.00E+00 | 1.05E+02 | 1 | -1.05E+02 | -1 | 9.99E-01 | 0.842 | -9.99E-01 | -0.8422 | 1.14E+01 |
| n | 8.00E-02 | | 10 | 10 | 3.3745 | 0.00E+00 | 1.00E+00 | 9.99E+01 | 1 | -9.99E+01 | -1 | 9.47E-01 | 0.82 | -9.47E-01 | -0.8197 | 1.11E+01 |
| i | 1.00E-02 | | 11 | 11 | 3.3745 | 0.00E+00 | 1.00E+00 | 9.52E+01 | 1 | -9.52E+01 | -1 | 9.03E-01 | 0.799 | -9.03E-01 | -0.7986 | 1.08E+01 |
| K | 8.64E-03 | m/d | 12 | 12 | 3.3745 | 0.00E+00 | 1.00E+00 | 9.12E+01 | 1 | -9.12E+01 | -1 | 8.65E-01 | 0.779 | -8.65E-01 | -0.7787 | 1.05E+01 |
| x | 2.00E+01 | m | 13 | 13 | 3.3745 | 0.00E+00 | 1.00E+00 | 8.76E+01 | 1 | -8.76E+01 | -1 | 8.31E-01 | 0.76 | -8.31E-01 | -0.7601 | 1.03E+01 |
| z | 0.00E+00 | m | 14 | 14 | 3.3745 | 0.00E+00 | 1.00E+00 | 8.44E+01 | 1 | -8.44E+01 | -1 | 8.01E-01 | 0.743 | -8.01E-01 | -0.7425 | 1.00E+01 |
| y | 0.00E+00 | m | 15 | 15 | 3.3745 | 0.00E+00 | 1.00E+00 | 8.15E+01 | 1 | -8.15E+01 | -1 | 7.74E-01 | 0.726 | -7.74E-01 | -0.726 | 9.80E+00 |
| | | | 16 | 16 | 3.3745 | 0.00E+00 | 1.00E+00 | 7.90E+01 | 1 | -7.90E+01 | -1 | 7.49E-01 | 0.711 | -7.49E-01 | -0.7105 | 9.59E+00 |
| ax | 1.57E+00 | m | 17 | 17 | 3.3745 | 0.00E+00 | 1.00E+00 | 7.66E+01 | 1 | -7.66E+01 | -1 | 7.27E-01 | 0.696 | -7.27E-01 | -0.6959 | 9.39E+00 |
| az | 1.57E-01 | m | 18 | 18 | 3.3745 | 0.00E+00 | 1.00E+00 | 7.44E+01 | 1 | -7.44E+01 | -1 | 7.06E-01 | 0.682 | -7.06E-01 | -0.6821 | 9.21E+00 |
| ay | 1.57E-02 | m | 19 | 19 | 3.3745 | 0.00E+00 | 1.00E+00 | 7.25E+01 | 1 | -7.25E+01 | -1 | 6.87E-01 | 0.669 | -6.87E-01 | -0.669 | 9.03E+00 |
| | | | 20 | 20 | 3.3745 | 0.00E+00 | 1.00E+00 | 7.06E+01 | 1 | -7.06E+01 | -1 | 6.70E-01 | 0.657 | -6.70E-01 | -0.6566 | 8.86E+00 |



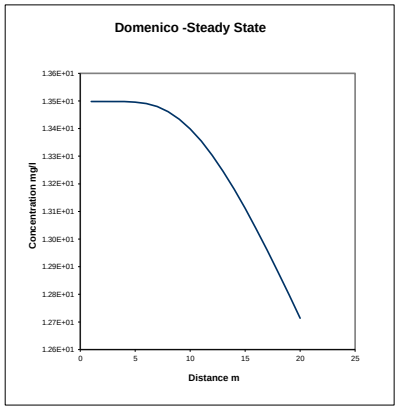

Vertical dispersion optio Simulate vertical dispersion in 1 direction

**Calc** **Value**

**DOMENICO (STEADY STATE)**

Calculations for source located at top of aquifer (ie vertical dispersion in one direction) - USED FOR LEVEL ASSESSMENT

| | | | | X | Term 1 | Term 2 | EXP | Term 3A | ERF | Term 3B | ERF | Term 4A | ERF | Term 4B | ERF | Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| v | 1.08E-03 | m/d | | | | | | | | | | | | | | |
| Rc | 3.62E+03 | | | | | | | | | | | | | | | |
| u | 2.98E-07 | m/d | 1 | 1 | 3.3745 | 0.00E+00 | 1.00E+00 | 3.16E+02 | 1 | -3.16E+02 | -1 | 5.99E+00 | 1 | -5.99E+00 | -1 | 1.35E+01 |
| | | | 2 | 2 | 3.3745 | 0.00E+00 | 1.00E+00 | 2.23E+02 | 1 | -2.23E+02 | -1 | 4.24E+00 | 1 | -4.24E+00 | -1 | 1.35E+01 |
| | | | 3 | 3 | 3.3745 | 0.00E+00 | 1.00E+00 | 1.82E+02 | 1 | -1.82E+02 | -1 | 3.46E+00 | 1 | -3.46E+00 | -1 | 1.35E+01 |
| | | | 4 | 4 | 3.3745 | 0.00E+00 | 1.00E+00 | 1.58E+02 | 1 | -1.58E+02 | -1 | 3.00E+00 | 1 | -3.00E+00 | -1 | 1.35E+01 |
| | | | 5 | 5 | 3.3745 | 0.00E+00 | 1.00E+00 | 1.41E+02 | 1 | -1.41E+02 | -1 | 2.68E+00 | 1 | -2.68E+00 | -0.9998 | 1.35E+01 |
| | | | 6 | 6 | 3.3745 | 0.00E+00 | 1.00E+00 | 1.29E+02 | 1 | -1.29E+02 | -1 | 2.45E+00 | 0.999 | -2.45E+00 | -0.9995 | 1.35E+01 |
| | | | 7 | 7 | 3.3745 | 0.00E+00 | 1.00E+00 | 1.19E+02 | 1 | -1.19E+02 | -1 | 2.26E+00 | 0.999 | -2.26E+00 | -0.9986 | 1.35E+01 |
| | | | 8 | 8 | 3.3745 | 0.00E+00 | 1.00E+00 | 1.12E+02 | 1 | -1.12E+02 | -1 | 2.12E+00 | 0.997 | -2.12E+00 | -0.9973 | 1.35E+01 |
| | | | 9 | 9 | 3.3745 | 0.00E+00 | 1.00E+00 | 1.05E+02 | 1 | -1.05E+02 | -1 | 2.00E+00 | 0.995 | -2.00E+00 | -0.9953 | 1.34E+01 |
| | | | 10 | 10 | 3.3745 | 0.00E+00 | 1.00E+00 | 9.99E+01 | 1 | -9.99E+01 | -1 | 1.89E+00 | 0.993 | -1.89E+00 | -0.9926 | 1.34E+01 |
| | | | 11 | 11 | 3.3745 | 0.00E+00 | 1.00E+00 | 9.52E+01 | 1 | -9.52E+01 | -1 | 1.81E+00 | 0.989 | -1.81E+00 | -0.9894 | 1.34E+01 |
| | | | 12 | 12 | 3.3745 | 0.00E+00 | 1.00E+00 | 9.12E+01 | 1 | -9.12E+01 | -1 | 1.73E+00 | 0.986 | -1.73E+00 | -0.9856 | 1.33E+01 |
| | | | 13 | 13 | 3.3745 | 0.00E+00 | 1.00E+00 | 8.76E+01 | 1 | -8.76E+01 | -1 | 1.66E+00 | 0.981 | -1.66E+00 | -0.9812 | 1.32E+01 |
| | | | 14 | 14 | 3.3745 | 0.00E+00 | 1.00E+00 | 8.44E+01 | 1 | -8.44E+01 | -1 | 1.60E+00 | 0.976 | -1.60E+00 | -0.9765 | 1.32E+01 |
| | | | 15 | 15 | 3.3745 | 0.00E+00 | 1.00E+00 | 8.15E+01 | 1 | -8.15E+01 | -1 | 1.55E+00 | 0.971 | -1.55E+00 | -0.9713 | 1.31E+01 |
| | | | 16 | 16 | 3.3745 | 0.00E+00 | 1.00E+00 | 7.90E+01 | 1 | -7.90E+01 | -1 | 1.50E+00 | 0.966 | -1.50E+00 | -0.9659 | 1.30E+01 |
| | | | 17 | 17 | 3.3745 | 0.00E+00 | 1.00E+00 | 7.66E+01 | 1 | -7.66E+01 | -1 | 1.45E+00 | 0.96 | -1.45E+00 | -0.9601 | 1.30E+01 |
| | | | 18 | 18 | 3.3745 | 0.00E+00 | 1.00E+00 | 7.44E+01 | 1 | -7.44E+01 | -1 | 1.41E+00 | 0.954 | -1.41E+00 | -0.9542 | 1.29E+01 |
| | | | 19 | 19 | 3.3745 | 0.00E+00 | 1.00E+00 | 7.25E+01 | 1 | -7.25E+01 | -1 | 1.37E+00 | 0.948 | -1.37E+00 | -0.9481 | 1.28E+01 |
| | | | 20 | 20 | 3.3745 | 0.00E+00 | 1.00E+00 | 7.06E+01 | 1 | -7.06E+01 | -1 | 1.34E+00 | 0.942 | -1.34E+00 | -0.9419 | 1.27E+01 |




| | |
|---|---|
| Date: | 24/02/2020 |
| Version: | 1 |

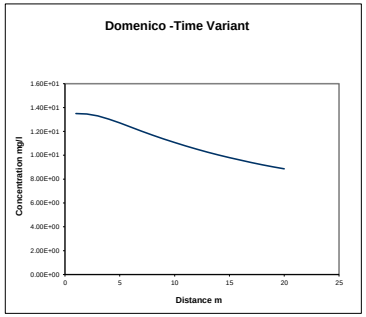
## DOMENICO (TIME VARIANT)

| Contaminant | Vanadium | |
|---|---|---|
| **Input** | **Value** | **Units** |
| $C_T$ | 0.02 | mg/l |
| Co | 1.35E+01 | mg/l |
| λ | 2.13E-104 | days$^{-1}$ |
| Sz | 5.00E+02 | m |
| Sy | 1.50E+00 | m |
| Kd | 2.13E+02 | l/kg |
| ρ | 1.36E+00 | g/cm3 |
| n | 8.00E-02 | |
| i | 1.00E-02 | |
| K | 8.64E-03 | m/d |
| x | 2.00E+01 | m |
| z | 0.00E+00 | m |
| y | 0.00E+00 | m |
| t | 1.00E+100 | days |
| ax | 1.57E+00 | m |
| az | 1.57E-01 | m |
| ay | 1.57E-02 | m |

Vertical dispersion option: Simulate vertical dispersion in 1 direction

Calculations for source located in centre of aquifer (ie vertical dispersion in two directions)

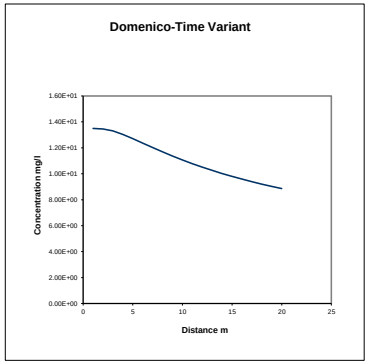
| | X | Term 1 | Term 2 | EXP | Term 3 | ERFC | Term 4A | ERF | Term 4B | ERF | Term 5A | ERF | Term 5B | ERF | Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | m | | | | | | | | | | | | | | |
| 1 | 1 | 1.68725 | 0.00E+00 | 1.00E+00 | -2.18E+46 | 2 | 3.16E+02 | 1 | -3.16E+02 | -1 | 3.00E+00 | 1 | -3.00E+00 | -1 | 1.35E+01 |
| 2 | 2 | 1.68725 | 0.00E+00 | 1.00E+00 | -2.18E+46 | 2 | 2.23E+02 | 1 | -2.23E+02 | -1 | 2.12E+00 | 0.9973 | -2.12E+00 | -0.997 | 1.35E+01 |
| 3 | 3 | 1.68725 | 0.00E+00 | 1.00E+00 | -2.18E+46 | 2 | 1.82E+02 | 1 | -1.82E+02 | -1 | 1.73E+00 | 0.9856 | -1.73E+00 | -0.986 | 1.33E+01 |
| 4 | 4 | 1.68725 | 0.00E+00 | 1.00E+00 | -2.18E+46 | 2 | 1.58E+02 | 1 | -1.58E+02 | -1 | 1.50E+00 | 0.9659 | -1.50E+00 | -0.966 | 1.30E+01 |
| 5 | 5 | 1.68725 | 0.00E+00 | 1.00E+00 | -2.18E+46 | 2 | 1.41E+02 | 1 | -1.41E+02 | -1 | 1.34E+00 | 0.9419 | -1.34E+00 | -0.942 | 1.27E+01 |
| 6 | 6 | 1.68725 | 0.00E+00 | 1.00E+00 | -2.18E+46 | 2 | 1.29E+02 | 1 | -1.29E+02 | -1 | 1.22E+00 | 0.9163 | -1.22E+00 | -0.916 | 1.24E+01 |
| 7 | 7 | 1.68725 | 0.00E+00 | 1.00E+00 | -2.18E+46 | 2 | 1.19E+02 | 1 | -1.19E+02 | -1 | 1.13E+00 | 0.8907 | -1.13E+00 | -0.891 | 1.20E+01 |
| 8 | 8 | 1.68725 | 0.00E+00 | 1.00E+00 | -2.18E+46 | 2 | 1.12E+02 | 1 | -1.12E+02 | -1 | 1.06E+00 | 0.8659 | -1.06E+00 | -0.866 | 1.17E+01 |
| 9 | 9 | 1.68725 | 0.00E+00 | 1.00E+00 | -2.18E+46 | 2 | 1.05E+02 | 1 | -1.05E+02 | -1 | 9.99E-01 | 0.8422 | -9.99E-01 | -0.842 | 1.14E+01 |
| 10 | 10 | 1.68725 | 0.00E+00 | 1.00E+00 | -2.18E+46 | 2 | 9.99E+01 | 1 | -9.99E+01 | -1 | 9.47E-01 | 0.8197 | -9.47E-01 | -0.82 | 1.11E+01 |
| 11 | 11 | 1.68725 | 0.00E+00 | 1.00E+00 | -2.18E+46 | 2 | 9.52E+01 | 1 | -9.52E+01 | -1 | 9.03E-01 | 0.7986 | -9.03E-01 | -0.799 | 1.08E+01 |
| 12 | 12 | 1.68725 | 0.00E+00 | 1.00E+00 | -2.18E+46 | 2 | 9.12E+01 | 1 | -9.12E+01 | -1 | 8.65E-01 | 0.7787 | -8.65E-01 | -0.779 | 1.05E+01 |
| 13 | 13 | 1.68725 | 0.00E+00 | 1.00E+00 | -2.18E+46 | 2 | 8.76E+01 | 1 | -8.76E+01 | -1 | 8.31E-01 | 0.7601 | -8.31E-01 | -0.76 | 1.03E+01 |
| 14 | 14 | 1.68725 | 0.00E+00 | 1.00E+00 | -2.18E+46 | 2 | 8.44E+01 | 1 | -8.44E+01 | -1 | 8.01E-01 | 0.7425 | -8.01E-01 | -0.743 | 1.00E+01 |
| 15 | 15 | 1.68725 | 0.00E+00 | 1.00E+00 | -2.18E+46 | 2 | 8.15E+01 | 1 | -8.15E+01 | -1 | 7.74E-01 | 0.726 | -7.74E-01 | -0.726 | 9.80E+00 |
| 16 | 16 | 1.68725 | 0.00E+00 | 1.00E+00 | -2.18E+46 | 2 | 7.90E+01 | 1 | -7.90E+01 | -1 | 7.49E-01 | 0.7105 | -7.49E-01 | -0.711 | 9.59E+00 |
| 17 | 17 | 1.68725 | 0.00E+00 | 1.00E+00 | -2.18E+46 | 2 | 7.66E+01 | 1 | -7.66E+01 | -1 | 7.27E-01 | 0.6959 | -7.27E-01 | -0.696 | 9.39E+00 |
| 18 | 18 | 1.68725 | 0.00E+00 | 1.00E+00 | -2.18E+46 | 2 | 7.44E+01 | 1 | -7.44E+01 | -1 | 7.06E-01 | 0.6821 | -7.06E-01 | -0.682 | 9.21E+00 |
| 19 | 19 | 1.68725 | 0.00E+00 | 1.00E+00 | -2.18E+46 | 2 | 7.25E+01 | 1 | -7.25E+01 | -1 | 6.87E-01 | 0.669 | -6.87E-01 | -0.669 | 9.03E+00 |
| 20 | 20 | 1.68725 | 0.00E+00 | 1.00E+00 | -2.18E+46 | 2 | 7.06E+01 | 1 | -7.06E+01 | -1 | 6.70E-01 | 0.6566 | -6.70E-01 | -0.657 | 8.86E+00 |




| Calc | Value | |
|---|---|---|
| v | 1.08E-03 | m/d |
| Rc | 3.62E+03 | |
| u | 2.98E-07 | m/d |

Calculations for source located at top of aquifer (ie vertical dispersion in one direction only) - USED FOR LEVEL ASSESSMENT

| | X | Term 1 | Term 2 | EXP | Term 3 | ERFC | Term 4A | ERF | Term 4B | ERF | Term 5A | ERF | Term 5B | ERF | Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | m | | | | | | | | | | | | | | |
| 1 | 1 | 1.68725 | 0.00E+00 | 1.00E+00 | -2.18E+46 | 2 | 3.16E+02 | 1 | -3.16E+02 | -1 | 5.99E+00 | 1 | -5.99E+00 | -1 | 1.35E+01 |
| 2 | 2 | 1.68725 | 0.00E+00 | 1.00E+00 | -2.18E+46 | 2 | 2.23E+02 | 1 | -2.23E+02 | -1 | 4.24E+00 | 1 | -4.24E+00 | -1 | 1.35E+01 |
| 3 | 3 | 1.68725 | 0.00E+00 | 1.00E+00 | -2.18E+46 | 2 | 1.82E+02 | 1 | -1.82E+02 | -1 | 3.46E+00 | 1 | -3.46E+00 | -1 | 1.35E+01 |
| 4 | 4 | 1.68725 | 0.00E+00 | 1.00E+00 | -2.18E+46 | 2 | 1.58E+02 | 1 | -1.58E+02 | -1 | 3.00E+00 | 1 | -3.00E+00 | -1 | 1.35E+01 |
| 5 | 5 | 1.68725 | 0.00E+00 | 1.00E+00 | -2.18E+46 | 2 | 1.41E+02 | 1 | -1.41E+02 | -1 | 2.68E+00 | 0.9998 | -2.68E+00 | -1 | 1.35E+01 |
| 6 | 6 | 1.68725 | 0.00E+00 | 1.00E+00 | -2.18E+46 | 2 | 1.29E+02 | 1 | -1.29E+02 | -1 | 2.45E+00 | 0.9995 | -2.45E+00 | -0.999 | 1.35E+01 |
| 7 | 7 | 1.68725 | 0.00E+00 | 1.00E+00 | -2.18E+46 | 2 | 1.19E+02 | 1 | -1.19E+02 | -1 | 2.26E+00 | 0.9986 | -2.26E+00 | -0.999 | 1.35E+01 |
| 8 | 8 | 1.68725 | 0.00E+00 | 1.00E+00 | -2.18E+46 | 2 | 1.12E+02 | 1 | -1.12E+02 | -1 | 2.12E+00 | 0.9973 | -2.12E+00 | -0.997 | 1.35E+01 |
| 9 | 9 | 1.68725 | 0.00E+00 | 1.00E+00 | -2.18E+46 | 2 | 1.05E+02 | 1 | -1.05E+02 | -1 | 2.00E+00 | 0.9953 | -2.00E+00 | -0.995 | 1.34E+01 |
| 10 | 10 | 1.68725 | 0.00E+00 | 1.00E+00 | -2.18E+46 | 2 | 9.99E+01 | 1 | -9.99E+01 | -1 | 1.89E+00 | 0.9926 | -1.89E+00 | -0.993 | 1.34E+01 |
| 11 | 11 | 1.68725 | 0.00E+00 | 1.00E+00 | -2.18E+46 | 2 | 9.52E+01 | 1 | -9.52E+01 | -1 | 1.81E+00 | 0.9894 | -1.81E+00 | -0.989 | 1.34E+01 |
| 12 | 12 | 1.68725 | 0.00E+00 | 1.00E+00 | -2.18E+46 | 2 | 9.12E+01 | 1 | -9.12E+01 | -1 | 1.73E+00 | 0.9856 | -1.73E+00 | -0.986 | 1.33E+01 |
| 13 | 13 | 1.68725 | 0.00E+00 | 1.00E+00 | -2.18E+46 | 2 | 8.76E+01 | 1 | -8.76E+01 | -1 | 1.66E+00 | 0.9812 | -1.66E+00 | -0.981 | 1.32E+01 |
| 14 | 14 | 1.68725 | 0.00E+00 | 1.00E+00 | -2.18E+46 | 2 | 8.44E+01 | 1 | -8.44E+01 | -1 | 1.60E+00 | 0.9765 | -1.60E+00 | -0.976 | 1.32E+01 |
| 15 | 15 | 1.68725 | 0.00E+00 | 1.00E+00 | -2.18E+46 | 2 | 8.15E+01 | 1 | -8.15E+01 | -1 | 1.55E+00 | 0.9713 | -1.55E+00 | -0.971 | 1.31E+01 |
| 16 | 16 | 1.68725 | 0.00E+00 | 1.00E+00 | -2.18E+46 | 2 | 7.90E+01 | 1 | -7.90E+01 | -1 | 1.50E+00 | 0.9659 | -1.50E+00 | -0.966 | 1.30E+01 |
| 17 | 17 | 1.68725 | 0.00E+00 | 1.00E+00 | -2.18E+46 | 2 | 7.66E+01 | 1 | -7.66E+01 | -1 | 1.45E+00 | 0.9601 | -1.45E+00 | -0.96 | 1.30E+01 |
| 18 | 18 | 1.68725 | 0.00E+00 | 1.00E+00 | -2.18E+46 | 2 | 7.44E+01 | 1 | -7.44E+01 | -1 | 1.41E+00 | 0.9542 | -1.41E+00 | -0.954 | 1.29E+01 |
| 19 | 19 | 1.68725 | 0.00E+00 | 1.00E+00 | -2.18E+46 | 2 | 7.25E+01 | 1 | -7.25E+01 | -1 | 1.37E+00 | 0.9481 | -1.37E+00 | -0.948 | 1.28E+01 |
| 20 | 20 | 1.68725 | 0.00E+00 | 1.00E+00 | -2.18E+46 | 2 | 7.06E+01 | 1 | -7.06E+01 | -1 | 1.34E+00 | 0.9419 | -1.34E+00 | -0.942 | 1.27E+01 |




| | |
|---|---|
| Date: | 24/02/2020 |
| Version: | 1 |

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# Appendix D – Phase 4B & 5D CWDQRA

# Technical Note

| | | | |
|---|---|---|---|
| **Project:** | P18-669 Llanwern – Phase 4B & 5D | | |
| **Subject:** | Phase 4B & 5D Controlled Waters Detailed Quantitative Risk Assessment Addendum | | |
| **Prepared by:** | Aimee Meredith-Smith – Geo-Environmental Consultant | **Date:** | 05/12/2025 |
| **Authorised by:** | Chris Wilson – Principal Geo-Environmental Consultant | **Status:** | S2 - Information |
| **Document Ref:** | 18669-RLL-24-XX-RP-O-0591 | **Revision:** | P04 |

# 1 Introduction

## 1.1 General

Rodgers Leask Ltd (RLL) has been commissioned by Revantage Real Estate Ltd (Revantage) to develop a phase specific addendum Controlled Waters Detailed Quantitative Risk Assessment (CWDQRA) to assess the potential risk to Controlled Waters for Phase 4B & 5D of the Glan Llyn development at Llanwern, Newport (herein referred to as the Site).

In July 2024 the Client, St Modwen Developments were rebranded to be called Revantage Real Estate. Any reference to the previous company name in this report should be referred to accordingly.

## 1.2 Purpose

This report has been prepared to support the discharge of Planning Condition 27 of the Outline Planning Permission Reference 06/0471 for the proposed development of residential development Phase 4B & 5D as part of a wider mixed-use development at Llanwern, Newport.

Planning Condition 27 states the following.

*"(27) Prior to the commencement of each phase of development as defined by Condition 03 (or at such other date or stage in development or for such specified activities or works as may be agreed in writing with the Local Planning Authority), the following components of a scheme to deal with the risks associated with contamination relating to that phase or activity shall each be submitted to and approved, in writing, by the Local Planning Authority:*

*(1) A preliminary risk assessment which has identified:*
- *(a) all previous uses;*
- *(b) potential contaminants associated with those uses;*
- *(c) a conceptual model of the site indicating sources, pathways and receptors;*
- *(d) potentially unacceptable risks arising from contamination at the site.*

*(2) A site investigation scheme, based on (1) to provide information for a detailed assessment of the risk to all receptors that may be affected, including those off site.*

*(3) The site investigation results and the detailed risk assessment (2) and, based on these, an options appraisal and remediation strategy giving full details of the remediation measures required and how they are to be undertaken.*

*(4) A verification plan providing details of the data that will be collected in order to demonstrate that the works set out in (3) are complete and identifying any requirements for longer term monitoring of pollutant linkages, maintenance and arrangements for contingency action. Any changes to these components require the express consent of the Local Planning Authority.*

*Reason: To ensure that the proposed development will not cause pollution of the environment or harm to human health."*

## 1.3 Objectives and Scope

The objectives and scope of this report are to assess the soil chemical testing results obtained during previous ground investigations, within the Site, against the soil re-use criteria presented in H F Consulting's Soils Validation Strategy and to discuss the suitability of the soils for retention as part of the proposed remedial works.

## 1.4 Sources of Information

The following documents have been reviewed in preparation of this technical note, and should be read in conjunction with it:

- RLL, Updated Controlled Waters Detailed Quantitative Risk Assessment, Glan Llyn, ref. 18669-RLE-19-RP-O-0006, dated June 2022
- RLL, Phase 4B & 5D Desk Study & Phase 2 Geo-Environmental Report, ref. 18669-RLL-22-XX-RP-O-0328 _P03, dated June 2025.
- H F Consulting, Glan Llyn: Soils validation strategy for protection of controlled waters (30937 R2), dated December 2024.

# 2 Site Information

## 2.1 Site Setting

The Site is located within the Glan Llyn development at the former Llanwern Steelworks, approximately 4km to the east of Newport City Centre at approximate National Grid Reference 335990E, 186950N. The wider Glan Llyn development covers approximately 250 hectares and is proposed to be redeveloped for residential, commercial and open space use.

The eastern part of Phase 4B & 5D formed part of a separate contract managed by Vertase FLI and approved under planning application references 23/1127 (PC27) and 24/0468 (PC28). This area is not included in this study area.

The Site covers an area of approximately 3.10ha and is located in the approximate centre of the wider Glan Llyn development. The Site historically housed a bag filter plant, conveyors, hoppers and a travelling boom. The Site was partially demolished by 2004 and fully demolished by 2021.

The Site boundary is shown on drawing 18669-RLL-22-X-DR-O-0323-P02, the site masterplan is presented on Drawing ref. 8111-08-A012, both presented in **Appendix A**.

## 2.2 Geology

Information pertaining to the underlying ground conditions at the Site has been obtained via the BGS Onshore Geoindex[1]. The published geological information shows the Site to be void of Made Ground. However, due to the Site's history, Made Ground is likely to be present associated with the previous development and subsequent demolition.

Superficial deposits are shown to comprise Tidal Flat Deposits.

Tidal Flat Deposits are described by the BGS as *'unconsolidated sediment, mainly mud and/ or sand. They may form the top surface of a deltaic deposit. Normally a consolidated soft silty clay, with layers of sand, gravel and peat.'*

The underlying bedrock is shown to be the Mercia Mudstone Group.

The Mercia Mudstone Group is described by the BGS as comprising '*predominantly red, less commonly green-grey, mudstones and subordinate siltstones with thick halite bearing units in some basinal areas. Thin beds of gypsum/anhydrite are widespread; sandstones are also present*'.

[1] http://mapapps2.bgs.ac.uk/geoindex/home.html

There is an inferred fault approximately 500m north-east of the Site which trends roughly north to south and extends northwards away from Site.

## 2.3 Encountered Ground Conditions

One ground investigation has been undertaken by RLL in 2021 which covered the wider Glan Llyn development and included the current Site boundary. As part of this ground investigation 35 trial pits were excavated within the Site area. Detailed information is available in the RLL Phase 4B & 5D Desk Study and Ground Investigation Report (**Appendix C**).

The following table provides a summary of the exploratory holes that were situated within the Site boundary.

| **Table 2.1: Summary of Historical Exploratory Holes within the Site Boundary** | |
|---|---|
| **Report** | **Exploratory Holes** |
| RLL (2021) | 35 Trial Pits (U14, U12, T14, S15, S14, R18, R15, R14, Q17, Q14, P16, P15, P14, V21, V20, V19, V18, V17, V16, V14, V13, V12, V11, V10, U19, U16, U15, U11, U10, T18, T15, T13, T12, T10 and S16) |

The RLL ground investigation found the Site to be underlain by Made Ground overlying Tidal Flat Deposits, encountered from 1.20m to 2.30m depth.

The Made Ground comprised sandy gravelly clay to sandy gravel of slag with occasional to frequent cobbles. Gravel and cobble constituents typically comprised sandstone, mudstone, shale, concrete, brick, and slag, as well as occasional fragments of plastic, timber, iron ore and metal.

Tidal Flat Deposits were generally described as very soft to firm, bluish grey to grey, occasionally mottled black and occasionally peaty clay.

The Mercia Mudstone Group bedrock was not encountered during the intrusive investigation.

## 2.4 Post-construction ground conditions

The following table provides an anticipated post-construction ground model.

| **Post-Development Ground Conditions** | | |
|---|---|---|
| **Unit** | **Approximate Thickness** | **Description** |
| Impermeable Construction Materials/ Housing Sub-base/Permeable Topsoil | 0.6m | Imported clean topsoil/ construction materials |
| Piling Mat* | 0.5m | Imported 6F2 (*may be included |

| | | |
|---|---|---|
| | | within 600mm of construction materials) |
| Made Ground | 1.5 – 2.0m | Excavated and re-compacted Made Ground |
| Tidal Flat Deposits | 7.0 – 10.0m | No change from current conditions |
| Bedrock (Mercia Mudstone Group) | >1,350m | No change from current conditions |

In accordance with the assumptions of the 2019 RLL CWDQRA, further mitigation to promote lateral flow is the provision of a drainage blanket to cap the reengineered material (including piling mat) which will increase the fall from the centre of a plot to periphery.

## 2.5 Historical Groundwater Monitoring and Wider Site Hydrogeology

A summary of pre-reclamation groundwater levels is presented in the Phase 4B & 5D Desk Study & Phase 2 Geo-Environmental Report. Groundwater levels recorded during the pre-reclamation ground investigations across the development suggest that the groundwater is present beneath the wider Glan Llyn development as follows:

- Shallow/ perched groundwater within the Made Ground (shallow boreholes); and
- Groundwater within the Tidal Flat Deposits (confined to the basal sand layers) and Mercia Mudstone (deep boreholes).

The shallow perched groundwater described above was recorded during pre-reclamation conditions. The earthworks on the phase include the reengineering of the Made Ground, this shallow perched groundwater shall no longer be present.

Groundwater monitoring within the deep boreholes was considered to be primarily derived from the bedrock geology, and hydraulic continuity between the upper perched shallow groundwater and 'regional' groundwater was considered likely to be limited. Post-development, the excavation and re-compaction of the Made Ground was recognised as likely to reduce its permeability, lowering still further, the hydraulic continuity.

# 3 Controlled Waters Detailed Quantitative Risk Assessment

## 3.1 Introduction

In 2019 RLL were commissioned by St Modwen to prepare a Controlled Waters Detailed Quantitative Risk Assessment (CWDQRA) for the wider Glan Llyn development, report reference 18669-RLE-19-RP-O-0006, dated June 2022. This assessment was considered to be an update to and further development of Atkins Limited (Atkins), CWDQRA, Document Reference: 5111373-LLA-OUT-0257, Version: 3, dated February 2017.

The principal objectives of the 2019 RLL CWDQRA, as practicably as possible, was to provide compliant future surface water flow contributions from private drainage system on the wider Glan Llyn development (following the redevelopment for mixed residential and commercial end use) upon entry into the Monks' Ditch. It was also to improve sustainability and further limit the amount of material which requires off-site removal by virtue of its contaminative potential towards local Controlled Waters.

With the aim generating a streamlined and consistent process for the Phase-by-Phase reporting process, in 2024 H Fraser Consulting Ltd. were commissioned to build on the findings of the CWDQRA and produce a Soils Validation Strategy for the Protection of Controlled Waters (30937 R2).

A summary of the reporting relating to controlled waters on the development are presented in the following sections.

The area of the development this assessment covers, which includes the Site, are presented on RLL drawing reference 18669-RLE-19-XX-DR-O-0004 in **Appendix A**.

## 3.2 RLL CWDQRA Summary

In 2019 RLL prepared a Controlled Waters Detailed Quantitative Risk Assessment (CWDQRA) for the wider Glan Llyn development site. This assessment incorporated a comprehensive dataset of concentrations of contamination recorded in soils across the development, included data taken from the 2018 investigations within the Site. Screening analysis of soil, soil leachate, groundwater and surface water data revealed potential moderate to low levels of inorganic and organic contamination present onsite in line with contaminants associated with former steelworks sites. Made Ground comprising clayey sandy gravels with local slag, burnt shale, tarmac, concrete, brick and mudstone was found to be a potential source of contamination. Calculation of representative re-use criteria for a commercial end use was undertaken using a dilution assessment methodology based on the site-wide water balance, incorporating site specific permeability and infiltration parameters. No allowance was made for dilution of

discharged waters within Monks' Ditch itself as part of this calculation as, this being the receptor, it is proposed that the water quality in this Controlled Water be maintained (as far as possible) at EQS values.

Comparison of re-use criteria against available soil chemical testing established that the much of the Made Ground was likely to be suitable for re-use onsite, however, localised source materials existed containing higher concentrations of contamination (particularly elevated concentrations of iron, manganese and vanadium), and ammoniacal and cyanide components, may require remediation, or offsite disposal.

Further modelling of these contaminants was undertaken using Remedial Target Methodology (RTM) to assess the potential extent of attenuation of these specific determinands within the ground where these soils may be placed, with the receiving surface waters being assumed to be existing blueways (reens), which were considered as the Compliance Points. The compliance point for the Business Park is at the pumping station and will require an enacted permit for discharge to occur.

Initial modelling was carried out by Atkins (Glan Llyn, Llanwern Controlled Waters Detailed Quantitative Risk Assessment dated February 2017), with this approach being adopted within later revisions of this Report in the Rodgers Leask, Controlled Waters Detailed Quantitative Risk Assessment, Glan Llyn (sitewide) Update (2019), using the Equation presented in the EA Table 5.2 – soil-water partitioning of the EA Remedial Targets Methodology Guidance (2006) where a pore-water concentration (Cp) was determined from soil concentration analyses to derive soil reuse criteria at the site as a whole. Subsequently, and purely to gauge the potential distance that re-engineered Made Ground could be placed from the respective Compliance Point(s), further modelling was carried out for specific determinands using the EA RT Excel Worksheets, based on maximum and average soils concentrations determined within samples of re-engineered Made Ground and available site derived data.

Further modelling was carried out for specific determinands (including specific PAHs) using the EA Remedial Target Excel Worksheets, based on maximum and average soils concentrations did indicate that there was little attenuation of the initial porewater PAH concentrations on migration within the re-engineered Made Ground toward the nearest reen Receptors. However, the presence of elevated porewater PAH concentrations were only theoretical and based on calculated values derived using the Equation presented in the EA Table 5.2 – soil-water partitioning of the EA Remedial Targets Methodology Guidance (2006). Actual PAH concentrations determined more recently in groundwater samples recovered (where sufficient groundwater was available for sampling purposes), were generally lower, and potentially significantly lower, than the calculated values which were derived using soils analyses data. Additionally, as previously mentioned, there was little evidence obtained of hydraulicly continuous groundwater horizon(s) within the re-engineered Made Ground beneath areas proposed for residential and commercial development. Therefore, there have been no proven PAH (or other contaminant) migration pathways towards the reens.

As the data used within the CWDQRA has utilised ground investigation data taken from within the Site, it is therefore considered that the findings of this assessment are representative of the Site and therefore adoption of the calculated re-use criteria and recommendations presented within the CWQRA are appropriate.

### 3.3 HFCL Glan Llyn: Soils Validation Strategy for Protection of Controlled Waters

Following queries from Natural Resources Wales (NRW), H Fraser Consulting Limited (HFCL) were commissioned by RLL to assist with NRW liaison and reporting pursuant to the discharge of PC28. Following discussion with NRW, RLL and the developer, HFCL prepared a revised methodology for the validation of soils in relation to the protection of controlled waters.

The assessment does not rely on groundwater analysis, being dependent rather on soil re-use values. It included distance specific remedial targets that model the attenuation of contaminants in the saturated zone allowing for advection, dispersion, retardation and decay during transport. In addition to the inclusion of distance specific remedial targets, further statistical and spatial analysis was carried out on contaminants of concern.

More detail is provided in the HFC Glan Llyn: Soils Validation Strategy for the Protection of Controlled Waters (30937 R2).

# 4 Comparison of Phase 4B & 5D and CWDQRA Dataset

The dataset utilised in the RLL CWDQRA was taken from soil samples from the wider Glan Llyn development site which did not include the Site area. Therefore, a comparison of the residential CWDQRA dataset with the soil samples taken from within the Site has been undertaken.

The purpose of this comparison is to establish if the residential dataset used in the CWDQRA is representative of concentrations of contamination present within Site and therefore whether the derived re-use criteria and recommendations of this assessment are applicable to the Site or whether further assessment is required.

## 4.1 Phase 4B & 5D Sampling

60 soil samples were collected from the Site during the 2021 RLL ground investigation for contamination testing, all of which were taken from the Made Ground. The works comprised trial pitting to collect soil samples for chemical and geotechnical testing.

The samples were tested for heavy metals, polycyclic aromatic hydrocarbons (PAH), total petroleum hydrocarbon (TPH), gasoline range organics (GROs), BTEX, pH, soil organic matter (SOM), cyanide, phenols, ammoniacal nitrogen and select samples were also tested for asbestos.

## 4.2 Comparison of Results

| Determinand | Samples from Phase 4B & 5D – Residential Area | | | Samples from CWDQRA - Residential Area | | | Considered Representative of CWDQRA data (Yes/No) |
|---|---|---|---|---|---|---|---|
| | Maximum Soil Sample Value* (mg/kg) | Average Soil Sample Value* (mg/kg) | 95th Percentile Soil Sample Value* (mg/kg) | Maximum Soil Sample Value (mg/kg) | Average Soil Sample Value* (mg/kg) | 95th Percentile Soil Sample Value* (mg/kg) | |
| **Inorganic Metals and Metalloids** | | | | | | | |
| Arsenic | 78.60 | 7.75 | 13.46 | 397.00 | 12.18 | 21.89 | Y |
| Cadmium | 2.19 | 0.54 | 1.71 | 31.30 | 0.65 | 2.37 | Y |
| Chromium | 783.00 | 130.81 | 523.20 | 3090.00 | 138.89 | 590.80 | Y |
| Copper | 71.70 | 19.73 | 44.31 | 1790.00 | 25.19 | 52.07 | Y |
| Iron | 232000 | 61542 | 154400 | 2390000 | 103039 | 277000 | Y |
| Lead | 408.00 | 44.67 | 143.15 | 4220.00 | 91.58 | 231.85 | Y |
| Manganese | 93900 | 10324 | 28785 | 408000 | 9574 | 33520 | Y |
| Mercury | 2.13 | 0.94 | 1.40 | 6.24 | 0.68 | 1.40 | Y |
| Nickel | 50.80 | 12.47 | 30.01 | 313.00 | 25.73 | 44.90 | Y |
| Selenium | 71.30 | 10.23 | 15.20 | 51.70 | 6.09 | 16.67 | N |
| Vanadium | 680.00 | 154.81 | 473.10 | 2880.00 | 206.93 | 693.10 | Y |

| Determinand | Samples from Phase 4B & 5D – Residential Area | | | Samples from CWDQRA - Residential Area | | | Considered Representative of CWDQRA data (Yes/No) |
|---|---|---|---|---|---|---|---|
| | Maximum Soil Sample Value* (mg/kg) | Average Soil Sample Value* (mg/kg) | 95th Percentile Soil Sample Value* (mg/kg) | Maximum Soil Sample Value (mg/kg) | Average Soil Sample Value* (mg/kg) | 95th Percentile Soil Sample Value* (mg/kg) | |
| Zinc | 482.00 | 100.19 | 292.60 | 13300.00 | 291.45 | 784.75 | Y |
| **Other Inorganics** | | | | | | | |
| Ammoniacal Nitrogen | 30.60 | 12.37 | 12.00 | 1590.00 | 60.97 | 263.00 | Y |
| Cyanide | 20.90 | 1.69 | 4.44 | 272.00 | 2.32 | 4.05 | Y |
| **Organics** | | | | | | | |
| Benzene | 1.8 | 0.37 | 1.8 | 0.12 | 0.04 | 0.04 | N |
| Toluene | 2.41 | 0.31 | 1.40 | 0.07 | 0.01 | 0.02 | N |
| Ethylbenzene | 0.80 | 0.16 | 0.80 | 0.02 | 0.01 | 0.01 | N |
| Xylene | 2.00 | 0.41 | 2.00 | 0.11 | 0.01 | 0.01 | N |
| Phenol | 1.00 | 0.24 | 1.00 | 1.21 | 0.02 | 0.03 | N |
| **TPH Criteria Working Group** | | | | | | | |
| Aliphatics >C5-C6 | 0.07 | 0.01 | 0.03 | 0.92 | 0.03 | 0.04 | Y |
| Aliphatics >C6-C8 | 0.36 | 0.04 | 0.15 | 3.32 | 0.04 | 0.09 | Y |
| Aliphatics >C8-C10 | 0.30 | 0.04 | 0.16 | 74.20 | 0.20 | 0.12 | Y |
| Aliphatics >C10-C12 | 52.30 | 2.58 | 5.83 | 987.00 | 2.55 | 0.35 | Y |
| Aliphatics >C12-C16 | 186.00 | 9.81 | 26.21 | 514.00 | 5.26 | 16.47 | Y |
| Aliphatics >C16-C21 | 811.00 | 28.78 | 65.05 | 3530.00 | 26.92 | 83.07 | Y |
| Aliphatics >C21-C35 | 778.00 | 49.43 | 126.10 | 2980.00 | 64.53 | 174.70 | Y |
| Aliphatics >C35-C44 | 188.00 | 14.88 | 45.37 | 913.00 | 20.37 | 68.99 | Y |
| Aromatics >EC5-EC7 | 0.09 | 0.01 | 0.02 | 5.26 | 0.03 | 0.04 | Y |
| Aromatics >EC7-EC8 | 0.12 | 0.01 | 0.03 | 20.30 | 0.05 | 0.04 | Y |
| Aromatics >EC8-EC10 | 0.20 | 0.03 | 0.11 | 49.50 | 0.14 | 0.10 | Y |
| Aromatics >EC10-EC12 | 26.80 | 2.14 | 4.74 | 658.00 | 1.71 | 0.24 | N |
| Aromatics >EC12-EC16 | 151.00 | 7.42 | 21.08 | 5280.00 | 13.62 | 24.72 | Y |
| Aromatics >EC16-EC21 | 265.00 | 19.45 | 77.24 | 9800.00 | 56.85 | 165.55 | Y |
| Aromatics >EC21-EC35 | 317.00 | 43.19 | 137.25 | 9010.00 | 122.76 | 440.85 | Y |
| Aromatics >EC35-EC44 | 52.90 | 5.81 | 39.05 | 1580.00 | 40.69 | 150.00 | Y |
| **Polyaromatic Hydrocarbons** | | | | | | | |
| Acenaphthylene | 14.10 | 0.64 | 1.84 | 2100.00 | 3.08 | 3.18 | Y |
| Acenaphthene | 0.88 | 0.10 | 0.67 | 193.00 | 0.47 | 0.41 | Y |
| Anthracene | 20.90 | 1.07 | 2.83 | 1860.00 | 3.608 | 5.48 | Y |
| Benz(a)anthracene | 20.30 | 1.82 | 6.40 | 1150.00 | 4.64 | 1.61 | Y |
| Benzo(a)pyrene | 15.30 | 1.42 | 5.18 | 714.00 | 3.73 | 10.58 | Y |
| Benzo(b)fluoranthene | 20.80 | 2.25 | 9.05 | 1110.00 | 5.28 | 15.87 | Y |
| Benzo(k)fluoranthene | 7.62 | 0.76 | 7.62 | 373.00 | 2.08 | 5.96 | Y |
| Benzo(g,h,i)perylene | 10.00 | 1.02 | 3.60 | 333.00 | 2.51 | 7.27 | Y |
| Chrysene | 16.90 | 1.65 | 5.68 | 1090.00 | 4.22 | 11.47 | Y |
| Dibenzo(a,h)anthracene | 2.12 | 0.26 | 1.02 | 177.00 | 0.74 | 1.86 | Y |
| Indeno(1,2,3-cd)pyrene | 12.20 | 1.20 | 4.25 | 374.00 | 2.61 | 7.46 | Y |
| Fluoranthene | 58.30 | 4.54 | 13.35 | 2940.00 | 11.59 | 29.56 | Y |
| Fluorene | 16.50 | 0.67 | 1.91 | 1890.00 | 2.81 | 2.72 | Y |
| Naphthalene | 24.10 | 1.59 | 7.17 | 4680.00 | 10.98 | 5.66 | Y |
| Phenanthrene | 60.80 | 3.87 | 12.27 | 3810.00 | 9.79 | 18.03 | Y |
| Pyrene | 39.10 | 3.21 | 9.68 | 1.95 | 0.01 | 0.03 | N |

A review of the datasets has shown that the contaminants largely show similar or lower concentration ranges for the Site and for the wider Glan Llyn development site; with the

exception of selenium, benzene, toluene, ethylbenzene, xylene, phenol, aromatics >EC10-EC12 and pyrene.

Selenium shows higher maximum and average concentrations when compared to the CWDQRA dataset, but has a lower 95$^{th}$ percentile concentration and therefore can be considered comparable to the CWDQRA data. Similarly, aromatic >EC10-EC12 TPH shows a higher 95$^{th}$ percentile concentration but lower maximum and average concentrations when compared to the wider site CWDQRA dataset and can be considered comparable. Laboratory concentrations of selenium and aromatic >EC10-EC12 TPH were all below the residential soil re-use criteria for controlled waters.

Benzene, toluene, ethylbenzene, xylene, phenol and pyrene from within the Site present higher maximum, average and 95$^{th}$ percentile concentrations when compared to the wider site CWDQRA dataset. However, the detection limits for these contaminants within the sample pool on the Site have concentrations that are greater than the respective concentrations presented within the wider CWDQRA and this causes a significant skew in the results. The true concentrations for these contaminants are likely to be significantly lower than their respective values. Laboratory concentrations of benzene, toluene, ethylbenzene, xylene, phenol and pyrene were all below the residential soil re-use criteria for controlled waters.

Given the values were lower than the relevant reuse criteria this shouldn't have a detrimental impact on the conclusions of the CWDQRA.

### 4.3 Comparison to RLL CWDQRA Reuse Criteria for 40% Infiltration Rainfall

The samples collected for the Site, as part of the RLL ground investigation, have subsequently been assessed against the RLL CWDQRA Reuse Criteria for 40% Infiltration Rainfall values for a residential end use as outlined in the RLL CWDQRA.

A summary of exceedances is presented in the table below, and the chemical screening results are presented in full in **Appendix B**.

| **Summary of Exceedances of RLL CWDQRA Reuse Criteria for 40% Infiltration Rainfall for Residential End Use** | | | | |
|---|---|---|---|---|
| **Contaminant** | **No. of Exceedances** | **Location of Exceedances (Depth in m)** | **Exceedance Concentration Range** | **Screening Value** |
| Cyanide, Total | 7 | P14-2 (1.80), Q14-1 (0.50), Q17-1 (0.30), U16-1 (1.00), V10-2 (1.50), V12-2 (1.60), V18-1 (0.50) | 2.35 mg/kg – 20.90 mg/kg | 2.313 mg/kg |
| Manganese | 1 | P16-1 (1.30) | 93900.00 mg/kg | 38175.69 mg/kg |
| Phenanthrene | 2 | Q17-2 (1.50), T10-1 (0.30) | 44400.00 µg/kg – 60800.00 µg/kg | 31077.00 µg/kg |

| Summary of Exceedances of RLL CWDQRA Reuse Criteria for 40% Infiltration Rainfall for Residential End Use | | | | |
|---|---|---|---|---|
| **Contaminant** | **No. of Exceedances** | **Location of Exceedances (Depth in m)** | **Exceedance Concentration Range** | **Screening Value** |
| Fluoranthene | 7 | P15-2 (2.20), Q14-1 (0.50), Q17-2 (1.50), R15-2 (1.20), T10-1 (0.30), T10-3 (2.90), V10-1 (0.30) | 7750.00 µg/kg – 58300.00 µg/kg | 7614.00 µg/kg |
| Benzo(b)fluoranthene | 7 | P15-2 (2.20), Q14-1 (0.50), Q17-2 (1.50), R15-2 (1.20), T10-1 (0.30), T10-2 (1.00), V10-1 (0.30) | 4010.00 µg/kg – 20800.00 µg/kg | 3914.00 µg/kg |
| Benzo(k)fluoranthene | 2 | Q14-1 (0.50), Q17-2 (1.50) | 6690.00 µg/kg – 7620.00 µg/kg | 5790.00 µg/kg |

The results show that with the exception of total cyanide, manganese, phenanthrene, fluoranthene, benzo(b)fluoranthene and benzo(k)fluoranthene, there are no exceedances of the RLL reuse criteria recorded during the 2021 ground investigation. The location of exceedances are shown on RLL Drawing 18669-RLL-24-XX-DR-O-0751-P02, **Appendix A**.

The re-use criteria in the above assessment were presented within the RLL CWDQRA, however following review by H F Consulting, slight calculation adjustments were made, and they were updated and re-produced within their Soils Validation Strategy for the Protection of Controlled Waters.

Following this assessment, recorded exceedances shall be managed, via the earthworks operation, in accordance with the HFC Glan Llyn: Soils Validation Strategy for the Protection of Controlled Waters.

Soil chemical testing certificates are presented within the RLL Phase 4B & 5D Desk Study and Ground Investigation Report (18669-RLL-22-XX-RP-O-0328-P03).

## 4.4 Visual and Olfactory Evidence of Contamination

During the 2021 intrusive investigation, visual or olfactory evidence of contamination was recorded in nine locations within the Made Ground, ranging from slight hydrocarbon sheens on water to sulphurous and hydrocarbon odours; and in one location a slight biofilm on water. Given the low number of locations where visual or olfactory evidence of hydrocarbon contamination was identified, the presence of significant gross contamination unsuitable for retention within the wider development is considered unlikely. No further evidence of a source of the visual or olfactory contamination was encountered. During the proposed turnover within Phase 4B & 5D a watching brief will be maintained.

# 5 Conclusion

In 2021 RLL submitted a CWDQRA for the wider Glan Llyn development site. This assessment incorporated a comprehensive dataset of concentrations of contamination recorded in soils across the development. Further assessment has been undertaken comparing soil concentrations recorded within the Site area with those of the wider residential Glan Llyn development site used in the CWDQRA.

This assessment has concluded that the dataset used in the CWDQRA is largely representative of the levels of contamination present within the Site and therefore adoption of the calculated re-use criteria and recommendations presented within the CWDQRA are appropriate for the Site.

Following an assessment of soil chemical testing data from within the Site, exceedances of the reuse criteria for cyanide, manganese, phenanthrene, fluoranthene, benzo(b)fluoranthene and benzo(b)fluoranthene have been identified that may represent a risk to Controlled Waters.

The soil reuse criteria have been conservatively calculated considering only dilution of contamination by intercepted surface water from the finished development. In reality subsurface degradation and attenuation will occur as these contaminants migrate laterally though the ground, further reducing they concentrations prior to dilution within the on-site private drainage system.

It is recommended that further delineation and assessment of the identified exceedances of cyanide, manganese, phenanthrene, fluoranthene, benzo(b)fluoranthene and benzo(k)fluoranthene (as shown on RLL Drawing 18669-RLL-25-XX-RP-O-0751-P03) are undertaken as part of the remediation works, with unsuitable material being removed as necessary, in order to ensure that they do not present a risk to controlled waters.

A Remediation Strategy has been prepared for Phase 4B & 5D (18669-RLL-24-XX-RP-O-0587-P03) outlining required remedial measures for the Site.

# Appendix A: Drawings




## GENERAL NOTES

NO DIMENSIONS TO BE SCALED OFF THIS DRAWING.

THIS DRAWING TO BE READ IN CONJUNCTION WITH ALL RELEVANT ARCHITECT'S AND ENGINEER'S DRAWINGS.

ALL DIMENSIONS ARE IN MILLIMETRES UNLESS NOTED OTHERWISE.

ALL LEVELS ARE IN METRES UNLESS NOTED OTHERWISE.

ANY DISCREPANCIES NOTED ON SITE ARE TO BE REPORTED TO THE ENGINEER IMMEDIATELY.

## KEY:

**Approximate Site Boundary**

| Rev | Date | Amendments | By | Chk |
|---|---|---|---|---|
| P02 | 10/09/2024 | Update to site boundary, excluding Vertase Area | AMS | CW |

Client

St Modwen Developments

Project

P18-669 Llanwern Reclamation

Drawing Title

Phase 4b & 5d
Site Location Plan

INFORMATION

| | Drawn | Checked | Date |
|---|---|---|---|
| 1:1250 @ A1 | SR | CW | 06.09.22 |

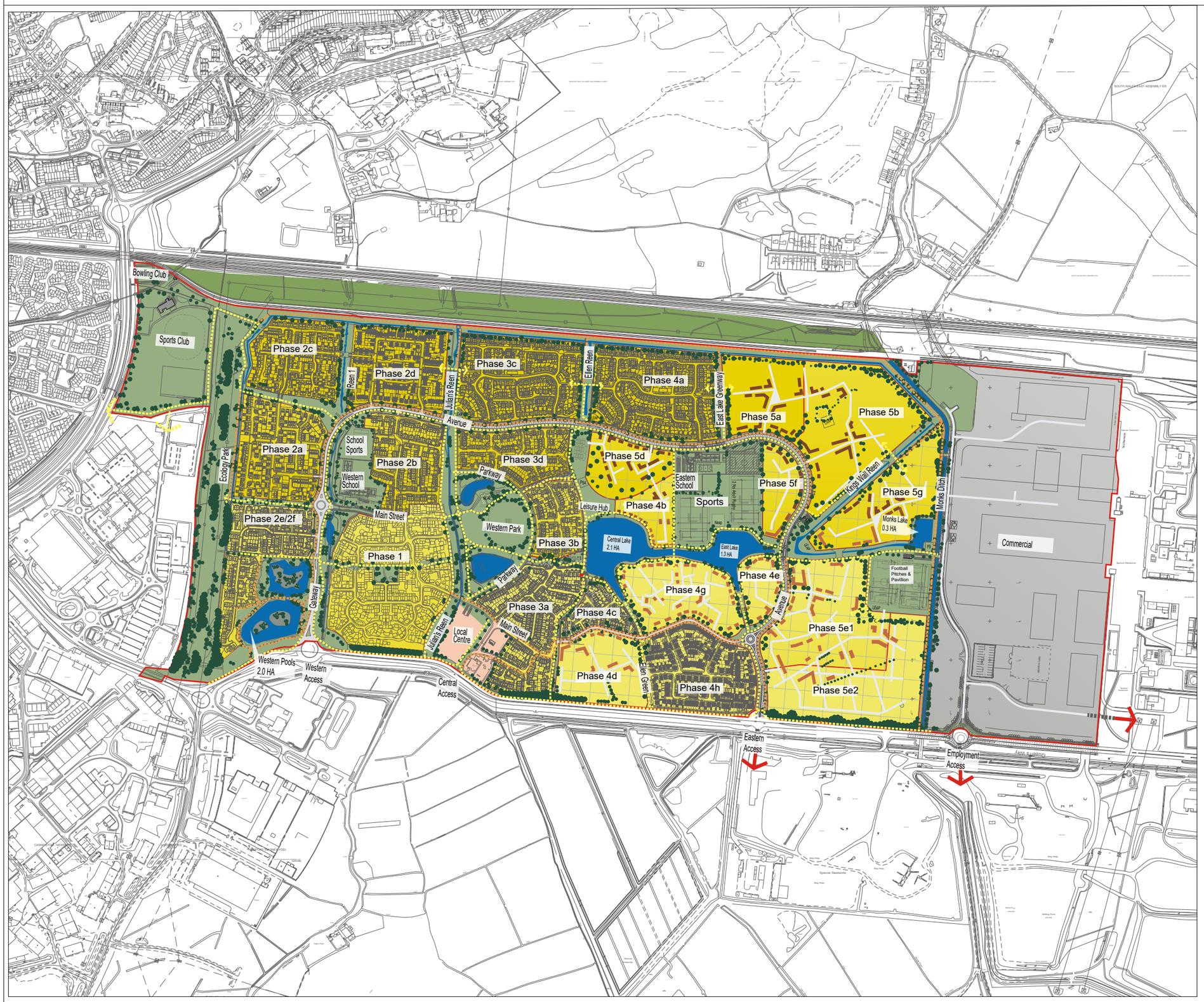
Drawing No. — Rev.

18669-RLL-22-XX-DR-O-0323 P02

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# Glan Llyn -ESAMP Indicative Masterplan




SGP
Architects + Masterplanners


Waterfront House,
2a Smith Way, Grove Park,
Enderby, Leicester,
LE19 1SX
t: +44 (0)116 247 0557
www.stephengeorge.co.uk


| | | | |
|---|---|---|---|
| **SGP File Ref:** | 8111-08-A011 | **Drawing No:** | 8111-08-A012 |
| **Project No:** | 8111-08 | **Rev:** | **Rev P19** |
| **Drawn By:** | NV | **Scale:** | 1:5000 @A1 |
| **Date:** | 10/04/2019 | | |

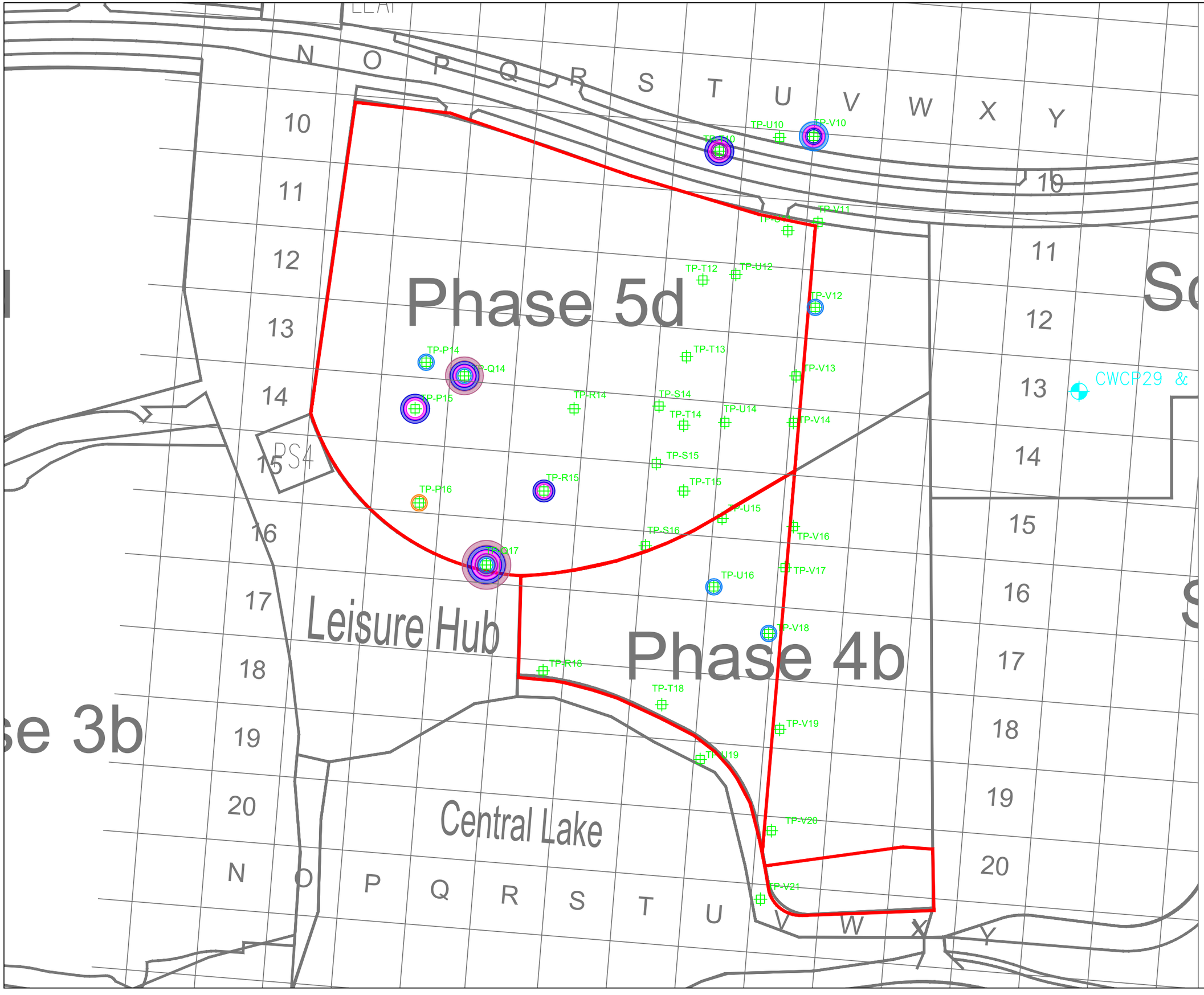
**Notes:**
Residential areas quoted are approximate gross site areas and include Leaps, Laps and on plot road infrastructure

**Notes:**
Residential areas quoted are approximate gross site areas and include Leaps, Laps and on plot road infrastructlayture

0 50 100 200 250 300 400 500
Metres at scale 1:5000

ST.MODWEN


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ANY DISCREPANCIES NOTED ON SITE ARE TO BE REPORTED TO THE ENGINEER IMMEDIATELY.

## KEY:

- Site Boundary
- TP-W32 Rodgers Leask GI 2020/21
- CWCP20 CWRA Borehole
- Cyanide Exceedance Location
- Benzo(b)fluoranthene Exceedance Location
- Benzo(k)fluoranthene Exceedance Location
- Fluoranthene Exceedance Location
- Phenanthracene Exceedance Location
- Manganese Exceedance Location

| Rev | Date | Amendments | By | Chk |
|---|---|---|---|---|
| P02 | 04/12/2025 | Updated screening values | AMS | CW |
| P01 | 09/06/2025 | First Issue | AMS | CW |

Client

Revantage Real Estate

Project

P18-669 Llanwern Reclamation Phase 4B & 5D

Drawing Title

Exceedance Location Plan

RLL CWDQRA Soil Re-Use Values

INFORMATION

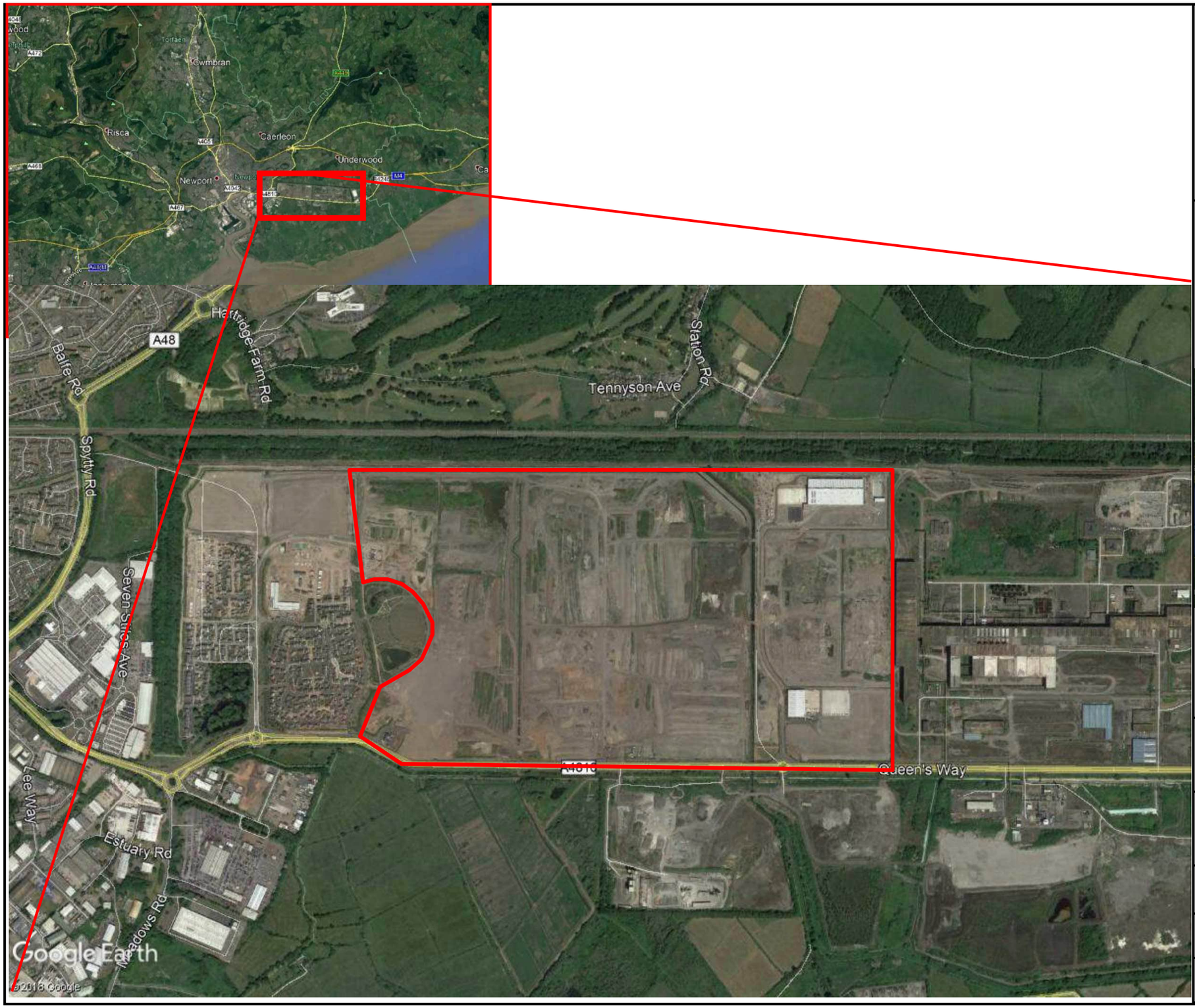
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|---|---|---|---|
| NTS | AMS | CW | 09/06/25 |

Drawing No. Rev.

18669-RLL-25-XX-DR-O-0751 P02

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ANY DISCREPANCIES NOTED ON SITE ARE TO BE REPORTED TO THE ENGINEER IMMEDIATELY

## Key

Redline boundary




RLRE

CLIENT

**ST. MODWEN DEVELOPMENTS**

PROJECT

**LLANWERN SITE LOCATION PLAN**

STATUS

**FOR INFORMATION**

| DRAWN | CHECKED | DATE |
|---|---|---|
| ET | CW | 19/08/2019 |

| PROJECT NUMBER | DRAWING NUMBER | REV. |
|---|---|---|
| P18-669 | 18669-RLE-19-XX-DR-O-0004 | |

# Appendix B: Chemical Screening

| Client: Rodgers Leask Environmental | Customer Sample ID | | | | | | | | | | | P14-1 | P14-2 | P15-1 | P15-2 | P16-1 | P16-2 | Q14-1 | Q14-2 | Q17-1 | Q17-2 | R14-1 | R14-2 | R15-1 | R15-2 | R18-1 | R18-2 | S14-1 | S14-2 | S15-1 | S15-2 | S16-1 | S16-2 | T10-1 | T10-2 | T10-3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Depth | | | | | | | | | | | 0.30-0.30 | 1.80-1.80 | 0.30-0.30 | 2.20-2.20 | 0.30-0.30 | 1.30-1.30 | 0.50-0.50 | 1.60-1.60 | 0.30-0.30 | 1.50-1.50 | 0.10-0.10 | 1.70-1.70 | 0.50-0.50 | 1.20-1.20 | 0.60-0.60 | 1.80-1.80 | 0.50-0.50 | 1.30-1.30 | 0.70-0.70 | 1.40-1.40 | 0.90-0.90 | 2.25-2.25 | 0.30-0.30 | 1.00-1.00 | 2.90-2.90 |
| | Sample Type | | | | | | | | | | | SOLID | SOLID | SOLID | SOLID | SOLID | SOLID | SOLID | SOLID | SOLID | SOLID | SOLID | SOLID | SOLID | SOLID | SOLID | SOLID | SOLID | SOLID | SOLID | SOLID | SOLID | SOLID | SOLID | SOLID | SOLID |
| | Sampled Date | | | | | | | | | | | 28/01/2021 | 28/01/2021 | 28/01/2021 | 28/01/2021 | 28/01/2021 | 28/01/2021 | 28/01/2021 | 28/01/2021 | 28/01/2021 | 28/01/2021 | 28/01/2021 | 28/01/2021 | 28/01/2021 | 28/01/2021 | 27/01/2021 | 27/01/2021 | 28/01/2021 | 28/01/2021 | 27/01/2021 | 27/01/2021 | 04/02/2021 | 04/02/2021 | 03/02/2021 | 03/02/2021 | 03/02/2021 |
| | Sample Received Date | | CWQCRA Reuse Criteria for 40% Infiltration Rainfall (Residential) | | | | | | | | | 28/01/2021 | 28/01/2021 | 28/01/2021 | 28/01/2021 | 27/01/2021 | 27/01/2021 | 28/01/2021 | 28/01/2021 | 27/01/2021 | 27/01/2021 | 28/01/2021 | 28/01/2021 | 28/01/2021 | 28/01/2021 | 27/01/2021 | 27/01/2021 | 28/01/2021 | 28/01/2021 | 27/01/2021 | 27/01/2021 | 04/02/2021 | 04/02/2021 | 04/02/2021 | 04/02/2021 | 04/02/2021 |
| | Final Instruction Date | | | | | | | | | | | 08/02/2021 | 08/02/2021 | 08/02/2021 | 08/02/2021 | 03/02/2021 | 03/02/2021 | 08/02/2021 | 08/02/2021 | 03/02/2021 | 03/02/2021 | 08/02/2021 | 08/02/2021 | 08/02/2021 | 08/02/2021 | 03/02/2021 | 03/02/2021 | 11/02/2021 | 11/02/2021 | 11/02/2021 | 11/02/2021 | 15/02/2021 | 15/02/2021 | 10/02/2021 | 10/02/2021 | 10/02/2021 |
| | Report Completed Date | | | | | | | | | | | | | | | 09/02/2021 | 09/02/2021 | | | 09/02/2021 | 09/02/2021 | | | | | 09/02/2021 | 09/02/2021 | 23/02/2021 | 23/02/2021 | 23/02/2021 | 23/02/2021 | 19/02/2021 | 19/02/2021 | 26/02/2021 | 26/02/2021 | 26/02/2021 |
| | SDG | | | | | | | | | | | 210128-35 | 210128-35 | 210128-35 | 210128-35 | 210127-42 | 210127-42 | 210128-35 | 210128-35 | 210127-42 | 210127-42 | 210128-35 | 210128-35 | 210128-35 | 210128-35 | 210127-42 | 210127-42 | 210205-65 | 210205-65 | 210205-65 | 210205-65 | 210205-39 | 210205-39 | 210204-77 | 210204-77 | 210204-77 |
| | Lab Sample Number | | | | | | | | | | | 23621438 | 23621447 | 23621452 | 23621293 | 23613950 | 23613957 | 23621418 | 23621429 | 23613939 | 23613943 | 23621397 | 23621406 | 23621287 | 23621251 | 23614011 | 23613914 | 23672951 | 23672957 | 23672983 | 23672967 | 23677975 | 23678320 | 23695051 | 23695060 | 23695058 |
| | Sample Temperature | | | | | | | | | | | 10.2 | 10.2 | 10.2 | 10.2 | 5.4 | 5.4 | 10.2 | 10.2 | 10.2 | 10.2 | 5.4 | 5.4 | 10.2 | 10.2 | 5.4 | 5.4 | 9.0 | 9.0 | 9.0 | 9.0 | 8.7 | 8.7 | 8.8 | 8.8 | 8.8 |
| **Determinand** | **Method** | **Units** | **LOD** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Colour | PM024 | No units | | | | | | | | | | Dark Brown | Dark Brown | Dark Brown | Black | Grey | Grey | Black | Black | Grey | Grey | Dark Brown | Dark Brown | Dark Brown | Black | Dark Brown | Dark Brown | Black | Dark Brown | Dark Brown | Dark Brown | Dark Brown | Dark Brown | Black | Black | Black |
| Description | PM024 | No units | | | | | | | | | | Loamy Sand | Loamy Sand | Loamy Sand | Sand | Sand | Sand | Sand | Sand | Sand | Sandy Loam | Loamy Sand | Loamy Sand | Sand | Sand | Loamy Sand | Sand | Sand | Sand | Sand | Sand | Loamy Sand | Sand | Sand | Silt Loam |
| Inclusion 1) | PM024 | No units | | | | | | | | | | Stones | Stones | Stones | Stones | Stones | Stones | None | None | None | None | Stones | Stones | Stones | None | Stones | None | Stones | Stones | Stones | Stones | Stones | Stones | Stones | Stones | None |
| Inclusion 2) | PM024 | No units | | | | | | | | | | None | None | None | None | None | N/A | Stones | Stones | Stones | N/A | Vegetation | None | Vegetation | Stones | Brick | Stones | Vegetation | None | None | Crushed Brick | Vegetation | Vegetation | None | |
| Moisture Content Ratio (% of as received sample) | PM024 | % | | | | | | | | | | 16.00 | 11.00 | 11.00 | 8.50 | 8.60 | 10.00 | 9.10 | 13.00 | 9.80 | 14.00 | 13.00 | 14.00 | 6.30 | 11.00 | 7.70 | 17.00 | 13.00 | 14.00 | 9.90 | 32.00 | 11.00 | 19.00 | 1.10 | 11.00 | 35.00 |
| Asbestos Quantification - Gravimetric - % | TM004 | % | 0.001 | | | | | | | | | | | | | | | | | | | | | | | | | 0.00 | | | | | | | | |
| Date of Analysis | TM046 | No units | | | | | | | | | | 08/02/2021 | - | 05/02/2021 | - | 03/02/2021 | - | 08/02/2021 | - | 03/02/2021 | - | 05/02/2021 | - | 05/02/2021 | - | 03/02/2021 | - | 11/02/2021 | - | 11/02/2021 | - | 15/02/2021 | - | 10/02/2021 | - | 10/02/2021 |
| Analysed By | TM046 | No units | | | | | | | | | | Marcin Magdziarek | - | Paul Poynton | - | Paul Poynton | - | Marcin Magdziarek | - | Paul Poynton | - | James Richards | - | James Richards | - | Paul Poynton | - | Marcin Magdziarek | - | Paul Poynton | - | Marcin Magdziarek | - | Christian Hallam | - | Christian Hallam |
| Asbestos Quantification - PCOM Evaluation - % | TM004 | % | 0.001 | | | | | | | | | | | <0.001 | - | - | - | | | - | - | <0.001 | - | | | | | <0.001 | - | - | - | - | - | <0.001 | - | - |
| Additional Asbestos Components (Using TM046) | TM004 | No units | | | | | | | | | | | | None | - | - | - | | | - | - | None | - | | | | | None | - | - | - | - | - | None | - | - |
| Analysis Comments | TM004 | No units | | | | | | | | | | | | NA | - | - | - | | | - | - | NA | - | | | | | - | - | - | - | - | - | - | - | - |
| Asbestos Quantification - Total - % | TM004 | % | 0.001 | | | | | | | | | | | <0.001 | - | - | - | | | - | - | <0.001 | - | | | | | <0.001 | - | - | - | - | - | <0.001 | - | - |
| Chrysotile (White) Asbestos | TM048 | No units | | | | | | | | | | Not Detected | - | Not Detected | - | Not Detected | - | Not Detected | - | Not Detected | - | Detected | - | Not Detected | - | Not Detected | - | Detected | - | Not Detected | - | Not Detected | - | Detected | - | Not Detected |
| Amosite (Brown) Asbestos | TM048 | No units | | | | | | | | | | Not Detected | - | Detected | - | Not Detected | - | Not Detected | - | Not Detected | - | Not Detected | - | Not Detected | - | Not Detected | - | Not Detected | - | Not Detected | - | Not Detected | - | Not Detected | - | Not Detected |
| Crocidolite (Blue) Asbestos | TM048 | No units | | | | | | | | | | Not Detected | - | Not Detected | - | Not Detected | - | Not Detected | - | Not Detected | - | Not Detected | - | Not Detected | - | Not Detected | - | Not Detected | - | Not Detected | - | Not Detected | - | Not Detected | - | Not Detected |
| Fibrous Anthophyllite | TM048 | No units | | | | | | | | | | Not Detected | - | Not Detected | - | Not Detected | - | Not Detected | - | Not Detected | - | Not Detected | - | Not Detected | - | Not Detected | - | Not Detected | - | Not Detected | - | Not Detected | - | Not Detected | - | Not Detected |
| Fibrous Tremolite | TM048 | No units | | | | | | | | | | Not Detected | - | Not Detected | - | Not Detected | - | Not Detected | - | Not Detected | - | Not Detected | - | Not Detected | - | Not Detected | - | Not Detected | - | Not Detected | - | Not Detected | - | Not Detected | - | Not Detected |
| Fibrous Actinolite | TM048 | No units | | | | | | | | | | Not Detected | - | Not Detected | - | Not Detected | - | Not Detected | - | Not Detected | - | Not Detected | - | Not Detected | - | Not Detected | - | Not Detected | - | Not Detected | - | Not Detected | - | Not Detected | - | Not Detected |
| Non-Asbestos Fibre | TM048 | No units | | | | | | | | | | Not Detected | - | Not Detected | - | Detected | - | Not Detected | - | Not Detected | - | Not Detected | - | Not Detected | - | Not Detected | - | Not Detected | - | Not Detected | - | Not Detected | - | Detected | - | Not Detected |
| Comments | TM048 | No units | | | | | | | | | | - | - | ACM fragment in soil | - | - | - | - | - | - | - | Fibre bundles in soil | - | - | - | - | - | Loose fibres in soil | - | - | - | - | - | Fibre bundles in soil | - | - |
| Soil Organic Matter (SOM) | TM132 | % | 0.35 | | | | | | | | | 49.50 | 6.36 | 3.19 | 1.59 | 18.80 | 2.16 | - | - | 22.80 | 21.90 | 5.97 | 22.60 | 12.40 | 20.50 | 7.29 | 8.69 | 71.20 | 29.30 | 17.10 | 65.90 | 61.70 | 32.10 | 34.80 | 35.00 | - |
| pH | TM133 | pH Units | 1 | | | | | | | | | 11.40 | 11.90 | 12.80 | 12.70 | 12.40 | 12.60 | 8.98 | 8.94 | 12.50 | 12.10 | 8.97 | 11.10 | 10.80 | 11.30 | 11.10 | 10.90 | 9.30 | 10.60 | 10.60 | 8.33 | 11.10 | 8.96 | 10.90 | 11.80 | 11.70 |
| Cyanide, Total | TM153 | mg/kg | 1 | 2.31 | 7 | 20.90 | 2.35 | 4.44 | 4.44 | 20.90 | 1.69 | 1.00 | 1.08 | 6.23 | <1 | <1 | <1 | 6.24 | <1 | 2.35 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| Exchangeable Ammonia as N | TM024 | mg/kg | 12 | 176.98 | 0 | no exc. | 0.00 | 12.00 | no exc. | 30.80 | 12.37 | 12.00 | <12 | <12 | <12 | <12 | <12 | <12 | <12 | <12 | <12 | <12 | <12 | <12 | <12 | <12 | <12 | 15.60 | <12 | <12 | <12 | <12 | <12 | <12 | <12 | 30.80 |
| Arsenic | TM181 | mg/kg | 0.6 | 2902.69 | 0 | no exc. | 0.00 | 13.46 | no exc. | 78.60 | 7.75 | 2.47 | <6 | <6 | 6.85 | <6 | 78.60 | <6 | <6 | 8.89 | <6 | <6 | 13.40 | <6 | 10.60 | <6 | 9.32 | 12.10 | 5.83 | <6 | 9.45 | <6 | <6 | 6.47 | 5.87 | <6 | <6 |
| Cadmium | TM181 | mg/kg | 0.02 | 83.66 | 0 | no exc. | 0.00 | 1.71 | no exc. | 2.19 | 0.54 | 0.09 | 0.91 | 1.56 | 1.71 | 1.75 | <0.2 | 0.63 | 0.54 | 0.64 | <0.2 | 0.69 | 2.19 | 1.00 | 2.14 | 1.11 | 0.40 | 0.22 | 0.33 | 0.48 | 1.59 | <0.2 | <0.2 | <0.2 | 0.78 | <0.2 | 0.32 |
| Chromium | TM181 | mg/kg | 0.9 | 10806.91 | 0 | no exc. | 0.00 | 523.20 | no exc. | 783.00 | 130.81 | 9.00 | 234.00 | 421.00 | 741.00 | 783.00 | 378.00 | 546.00 | 62.30 | 17.50 | 522.00 | 426.00 | 195.00 | 235.00 | 184.00 | 300.00 | 58.10 | 45.80 | 39.20 | 27.40 | 89.90 | 11.90 | 83.60 | 11.70 | 214.00 | 59.90 | 31.40 |
| Copper | TM181 | mg/kg | 1.4 | 516.88 | 0 | no exc. | 0.00 | 44.31 | no exc. | 71.70 | 19.73 | 5.72 | 18.10 | <14 | 36.50 | 22.60 | 54.40 | 22.50 | <14 | 46.40 | 16.30 | 28.90 | 31.30 | 25.80 | 33.60 | 14.50 | 22.10 | 32.40 | 16.20 | <14 | 33.90 | 27.40 | <14 | 22.60 | 15.40 | <14 | 18.80 |
| Iron | TM181 | mg/kg | 1000 | 349148.01 | 0 | no exc. | 0.00 | 154400.00 | no exc. | 232000.00 | 61541.67 | 93000.00 | 103000.00 | 144000.00 | 141000.00 | 152000.00 | 144000.00 | 127000.00 | 29500.00 | 19500.00 | 139000.00 | 114000.00 | 129000.00 | 73100.00 | 93400.00 | 94800.00 | 69600.00 | 33700.00 | 30800.00 | 53800.00 | 171000.00 | 41300.00 | 40100.00 | 24200.00 | 59900.00 | 20900.00 | 17400.00 |
| Lead | TM181 | mg/kg | 0.7 | 18032.07 | 0 | no exc. | 0.00 | 143.15 | no exc. | 408.00 | 44.67 | 1.08 | 23.10 | 28.00 | 16.30 | <7 | 55.20 | 10.10 | 35.30 | 38.80 | 26.40 | 25.00 | 105.00 | 235.00 | 11.50 | 146.00 | 9.90 | 52.20 | 28.80 | 29.90 | 61.70 | 97.30 | 32.00 | 22.20 | 20.20 | 41.10 | 18.20 | 23.90 |
| Manganese | TM181 | mg/kg | 0.13 | 38175.69 | 1 | 93900.00 | 93900.00 | 28785.00 | no exc. | 93900.00 | 10334.45 | 522.00 | 18000.00 | 21400.00 | 32300.00 | 34400.00 | 93900.00 | 27400.00 | 17500.00 | 522.00 | 24900.00 | 28900.00 | 8710.00 | 14100.00 | 10400.00 | 16800.00 | 4170.00 | 2650.00 | 4130.00 | 3230.00 | 8150.00 | 724.00 | 4880.00 | 4100.00 | 13300.00 | 4050.00 | 2810.00 |
| Mercury | TM181 | mg/kg | 0.14 | 150.81 | 0 | no exc. | 0.00 | 1.40 | no exc. | 2.13 | 0.94 | 0.10 | <1.4 | <1.4 | <1.4 | <1.4 | <1.4 | <1.4 | 2.13 | <1.4 | <1.4 | <1.4 | <1.4 | <1.4 | <1.4 | <1.4 | <1.4 | <1.4 | <1.4 | <1.4 | <1.4 | <1.4 | <1.4 | <1.4 | <1.4 | <1.4 | <1.4 |
| Nickel | TM181 | mg/kg | 0.2 | 13188.60 | 0 | no exc. | 0.00 | 30.01 | no exc. | 50.80 | 12.47 | 2.00 | 11.10 | 5.46 | 21.30 | 14.30 | 50.80 | 8.48 | 5.35 | 18.40 | 12.60 | 14.90 | 30.10 | 20.20 | 34.00 | 9.65 | 20.20 | 24.40 | 11.80 | 8.00 | 22.00 | 28.20 | 8.99 | 19.90 | 10.50 | 5.86 | 6.74 |
| Selenium | TM181 | mg/kg | 1 | 804.31 | 0 | no exc. | 0.00 | 15.20 | no exc. | 71.30 | 10.23 | 1.00 | 13.20 | <10 | 15.00 | 19.80 | 71.30 | 12.70 | 14.30 | <10 | 19.00 | 14.70 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <1 | <10 | <10 | <10 | <10 | <10 | 4.52 | <10 | <10 |
| Vanadium | TM181 | mg/kg | 0.2 | 1840.20 | 0 | no exc. | 0.00 | 473.10 | no exc. | 680.00 | 154.81 | 20.30 | 270.00 | 413.00 | 680.00 | 655.00 | 416.00 | 473.00 | 62.80 | 21.40 | 416.00 | 475.00 | 174.00 | 373.00 | 228.00 | 249.00 | 95.30 | 61.30 | 59.50 | 46.40 | 134.00 | 33.80 | 94.10 | 31.10 | 222.00 | 65.90 | 41.80 |
| Zinc | TM181 | mg/kg | 1.9 | 157599.52 | 0 | no exc. | 0.00 | 292.60 | no exc. | 482.00 | 100.19 | 19.00 | 63.00 | 66.70 | 76.90 | 40.80 | 95.30 | 51.70 | 77.70 | 90.40 | 54.80 | 106.00 | 482.00 | 113.00 | 420.00 | 82.50 | 137.00 | 48.60 | 87.00 | 143.00 | 380.00 | 55.90 | 55.30 | 73.80 | 151.00 | 57.60 | 82.80 |
| Phenol | TM802 (S) | mg/kg | 0.01 | 3.50 | 0 | no exc. | 0.00 | 1.00 | no exc. | 1.00 | 0.24 | 0.01 | <0.01 | <0.01 | <0.01 | <0.01 | 0.04 | <0.01 | <0.01 | <0.01 | <0.01 | 0.01 | 0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | 0.01 | <0.01 | <1 | <1 | <1 |
| Cresols | TM802 (S) | mg/kg | 0.01 | | | 0.11 | 0.01 | 1.00 | 1.00 | 1.00 | 0.25 | 0.01 | <0.01 | <0.01 | <0.01 | <0.01 | 0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | 0.02 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | 0.03 | <0.01 | <0.01 | <0.01 | <0.01 | <1 | <1 | <1 |
| Xylenols | TM802 (S) | mg/kg | 0.015 | | | 0.07 | 0.07 | 1.50 | 1.50 | 1.50 | 0.36 | 0.02 | <0.015 | <0.015 | <0.015 | <0.015 | <0.015 | <0.015 | <0.015 | <0.015 | <0.015 | <0.015 | <0.015 | <0.015 | <0.015 | <0.015 | <0.015 | <0.015 | <0.015 | <0.015 | <0.015 | <0.015 | <0.015 | <0.015 | <1.5 | <1.5 | <1.5 |
| Phenols, Total Detected monohydric | TM802 (S) | mg/kg | 0.035 | | | 0.19 | 0.05 | 3.50 | 3.50 | 3.50 | 0.85 | 0.04 | <0.035 | <0.035 | <0.035 | 0.05 | <0.035 | <0.035 | <0.035 | <0.035 | <0.035 | <0.035 | <0.035 | <0.035 | <0.035 | <0.035 | <0.035 | <0.035 | <0.035 | 0.05 | <0.035 | <0.035 | <0.035 | <0.035 | <3.5 | <3.5 | <3.5 |
| Total Aliphatics >C5-C10 | TM069 | µg/kg | 50 | | | 725.00 | 50.60 | 318.45 | 318.45 | 725.00 | 104.19 | 50.00 | 67.80 | <50 | <50 | <50 | 171.00 | 159.00 | <50 | 384.00 | 58.80 | 122.00 | <50 | 259.00 | 53.40 | 86.10 | <50 | 315.00 | <50 | <50 | <50 | 725.00 | 125.00 | 217.00 | 311.00 | 97.00 | |
| Total Aromatics >EC5-EC10 | TM069 | µg/kg | 50 | | | 403.00 | 52.26 | 150.10 | 150.10 | 403.00 | 66.31 | 50.00 | <50 | <50 | <50 | <50 | 61.30 | 52.20 | <50 | 81.70 | <50 | <50 | <50 | 147.00 | <50 | <50 | <50 | 160.00 | <50 | <50 | <50 | 403.00 | 53.30 | 82.90 | 146.00 | <50 | |
| GRO >C5-C10 | TM069 | µg/kg | 20 | | | 1130.00 | 50.60 | 467.95 | 467.95 | 1130.00 | 114.71 | 20.00 | 67.80 | <20 | <20 | <20 | 232.00 | 211.00 | <20 | 466.00 | 58.80 | 122.00 | <20 | 406.00 | 53.40 | 86.10 | <20 | 525.00 | <20 | <20 | <20 | 1130.00 | 179.00 | 300.00 | 459.00 | 97.00 | |
| GRO Surrogate % recovery** | TM069 | % | | | | 134.00 | 0.70 | 107.35 | 107.35 | 134.00 | 55.88 | 0.70 | 92.80 | 73.60 | 90.80 | 77.10 | 102.00 | 61.50 | 11.10 | 31.50 | 9.60 | 77.20 | 71.50 | 24.30 | 78.10 | 29.80 | 11.70 | 80.90 | 3.80 | 13.40 | 17.30 | 5.80 | 14.80 | 134.00 | 16.80 | 13.60 | 0.70 | |
| Aliphatics >C5-C6 | TM409 | µg/kg | 10 | 83664.00 | 0 | no exc. | 0.00 | 32.34 | no exc. | 71.20 | 14.05 | 10.00 | <10 | <10 | <10 | <10 | 35.00 | 32.20 | <10 | 48.30 | 13.30 | 26.70 | <10 | 31.30 | <10 | <10 | <10 | 10.90 | <10 | <10 | <10 | <10 | 71.20 | 14.90 | 17.20 | 22.60 | 10.80 |
| Aliphatics >C6-C8 | TM409 | µg/kg | 10 | 417626.00 | 0 | no exc. | 0.00 | 150.30 | no exc. | 359.00 | 38.98 | 10.00 | 36.50 | <10 | <10 | <10 | 42.70 | 72.20 | <10 | 230.00 | 30.00 | 45.20 | <10 | 150.00 | 24.60 | 42.60 | 10.80 | 52.00 | <10 | <10 | <10 | 359.00 | 45.90 | 95.00 | 134.00 | 58.50 |
| Aliphatics >C8-C10 | TM409 | µg/kg | 10 | 3254980.00 | 0 | no exc. | 0.00 | 157.35 | no exc. | 295.00 | 41.59 | 10.00 | 33.30 | <10 | <10 | <10 | 93.00 | 54.40 | <10 | 106.00 | 15.50 | 49.90 | <10 | 77.70 | 28.80 | 23.50 | <10 | 252.00 | <10 | <10 | <10 | 295.00 | 64.50 | 105.00 | 154.00 | 27.70 | |
| Aliphatics >C10-C12 | TM414 | µg/kg | 1000 | 2583823.00 | 0 | no exc. | 0.00 | 5628.50 | no exc. | 52300.00 | 2584.50 | 1000.00 | 1740.00 | <1000 | <1000 | <1000 | <1000 | <1000 | <1000 | 4080.00 | 1420.00 | <1000 | <1000 | <1000 | <1000 | <1000 | <1000 | 4650.00 | 6370.00 | 1080.00 | <1000 | <1000 | 17000.00 | <1000 | 4740.00 | 5800.00 | 52300.00 |
| Aliphatics >C12-C16 | TM414 | µg/kg | 1000 | 51548680.00 | 0 | no exc. | 0.00 | 26210.00 | no exc. | 185000.00 | 9812.50 | 1000.00 | 2300.00 | <1000 | 1320.00 | <1000 | 1640.00 | <1000 | 7020.00 | 6300.00 | 2100.00 | 2800.00 | <1000 | 4200.00 | <1000 | 4200.00 | <1000 | 3770.00 | 10700.00 | 5430.00 | 1900.00 | <1000 | 77200.00 | 8060.00 | 17500.00 | 20600.00 | 185000.00 |
| Aliphatics >C16-C21 | TM414 | µg/kg | 1000 | 64895263780.00 | 0 | no exc. | 0.00 | 69045.00 | no exc. | 811000.00 | 28777.50 | 1000.00 | 64200.00 | 1220.00 | 5290.00 | 2230.00 | 5250.00 | 3980.00 | 54000.00 | 6450.00 | 11800.00 | 6860.00 | <1000 | 10560.00 | 4370.00 | 2740.00 | 9540.00 | 8110.00 | 18500.00 | 9240.00 | 5490.00 | 2600.00 | 87500.00 | 15800.00 | 26900.00 | 42200.00 | 811000.00 |
| Aliphatics >C21-C35 | TM414 | µg/kg | 1000 | 64895263780.00 | 0 | no exc. | 0.00 | 126100.00 | no exc. | 778000.00 | 49430.33 | 1000.00 | 125000.00 | 5810.00 | 36000.00 | 15300.00 | 38900.00 | 31300.00 | 35200.00 | 10700.00 | 118000.00 | 78500.00 | <1000 | 49300.00 | 26700.00 | 12100.00 | 31000.00 | 24100000.00 | 37300.00 | 18400.00 | 24000.00 | 20500.00 | 60000.00 | 16800.00 | 35500.00 | 79600.00 | 778000.00 |
| Aliphatics >C35-C44 | TM414 | µg/kg | 1000 | 64895263780.00 | 0 | no exc. | 0.00 | 45375.00 | no exc. | 188000.00 | 14883.83 | 1000.00 | 25400.00 | 1760.00 | 12000.00 | 3860.00 | 9520.00 | 6170.00 | 3870.00 | <1000 | 24400.00 | 56300.00 | <1000 | 44200.00 | 5850.00 | 1340.00 | 7110.00 | 34800.00 | 3370.00 | 4800.00 | 6700.00 | 6740.00 | 12000.00 | 3110.00 | 21700.00 | 38500.00 | 188000.00 |
| Total Aliphatics >C10-C44 | TM414 | µg/kg | 1000 | | | 2020000.00 | 5100.00 | 254000.00 | 254000.00 | 2020000.00 | 104833.17 | 5000.00 | 239000.00 | 9190.00 | 57900.00 | 22000.00 | 56000.00 | 42600.00 | 55000.00 | 15500.00 | 25800.00 | 157000.00 | 14000.00 | 95000.00 | 37200.00 | 17300.00 | 52000.00 | 39000.00 | 85100.00 | 39000.00 | 30300.00 | 24400.00 | 126000.00 | 18000.00 | 80000.00 | 188000.00 | 2020000.00 |
| Total Aliphatics & Aromatics >C10-C44 | TM414 | µg/kg | 10000 | | | 2690000.00 | 13200.00 | 431800.00 | 431800.00 | 2690000.00 | 182070.67 | 10000.00 | 301000.00 | 13200.00 | 97200.00 | 53000.00 | 89600.00 | 62700.00 | 48500.00 | 57100.00 | 223000.00 | 391000.00 | <10000 | 145000.00 | 59200.00 | 34000.00 | 92700.00 | 429000.00 | 145000.00 | 98900.00 | 78300.00 | 47400.00 | 323000.00 | 59500.00 | 302000.00 | 323000.00 | 2690000.00 |
| Aromatics >EC5-EC7 | TM069 | µg/kg | 10 | 9752.00 | 0 | no exc. | 0.00 | 17.68 | no exc. | 91.50 | 12.09 | 10.00 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | 36.00 | <10 | <10 | <10 | 10.90 | <10 | <10 | <10 | <10 | 91.50 | <10 | <10 | 19.20 | <10 |
| Aromatics >EC7-EC8 | TM069 | µg/kg | 10 | 202890.00 | 0 | no exc. | 0.00 | 27.15 | no exc. | 115.00 | 13.98 | 10.00 | <10 | <10 | <10 | <10 | <10 | 16.70 | <10 | 11.50 | <10 | <10 | <10 | 59.20 | <10 | 15.70 | <10 | 10.90 | <10 | <10 | <10 | <10 | 115.00 | 11.20 | 13.10 | 26.00 | <10 |
| Aromatics >EC8-EC10 | TM069 | µg/kg | 10 | 164594.00 | 0 | no exc. | 0.00 | 105.20 | no exc. | 197.00 | 29.51 | 10.00 | 21.40 | <10 | <10 | <10 | 61.30 | 35.50 | <10 | 70.20 | <10 | 33.60 | <10 | 52.20 | 19.20 | 15.70 | <10 | 168.00 | <10 | <10 | <10 | <10 | 197.00 | 42.20 | 69.80 | 103.00 | 18.50 |
| Aromatics > EC10-EC12 | TM414 | µg/kg | 1000 | 259633.00 | 0 | no exc. | 0.00 | 4737.00 | no exc. | 25800.00 | 2138.67 | 1000.00 | 1310.00 | <1000 | <1000 | <1000 | 1400.00 | <1000 | 7000.00 | 1900.00 | <1000 | 1760.00 | 2400.00 | <1000 | <1000 | <1000 | <1000 | 6070.00 | <1000 | <1000 | <1000 | <1000 | 4410.00 | <1000 | 4460.00 | 3420.00 | 25800.00 |
| Aromatics > EC12-EC16 | TM414 | µg/kg | 1000 | 517061.00 | 0 | no exc. | 0.00 | 21075.00 | no exc. | 151000.00 | 7421.17 | 1000.00 | 6340.00 | <1000 | <1000 | <1000 | 3020.00 | <1000 | 22500.00 | 6980.00 | 2250.00 | 21000.00 | <1000 | 4100.00 | <1000 | 1050.00 | 3550.00 | 1070.00 | 11500.00 | 5350.00 | 2160.00 | <1000 | 31500.00 | 2420.00 | 13800.00 | 14900.00 | 151000.00 |
| Aromatics > EC16-EC21 | TM414 | µg/kg | 1000 | 1631673.00 | 0 | no exc. | 0.00 | 77235.00 | no exc. | 265000.00 | 19454.67 | 1000.00 | 14700.00 | 1110.00 | 5680.00 | 7270.00 | 13700.00 | 6530.00 | 9880.00 | 8550.00 | 16000.00 | 76100.00 | 1270.00 | 7980.00 | 2170.00 | 4630.00 | 8580.00 | 2380.00 | 11500.00 | 11500.00 | 9310.00 | <1000 | 14500.00 | 2830.00 | 58100.00 | 37200.00 | 265000.00 |
| Aromatics > EC21-EC35 | TM414 | µg/kg | 1000 | 12949875.00 | 0 | no exc. | 0.00 | 137250.00 | no exc. | 317000.00 | 42193.67 | 1000.00 | 35800.00 | 1510.00 | 29800.00 | 21500.00 | 14700.00 | 11700.00 | 21600.00 | 14400.00 | 41900.00 | 126000.00 | 2940.00 | 20100.00 | 18100.00 | 8020.00 | 26100.00 | 41900.00 | 30900.00 | 39600.00 | 27600.00 | 15800.00 | 17200.00 | 9700.00 | 111000.00 | 75000.00 | 224000.00 |
| Aromatics >EC35-EC44 | TM414 | µg/kg | 1000 | 12949875.00 | 0 | no exc. | 0.00 | 39050.00 | no exc. | 52800.00 | 5808.17 | 1000.00 | 3460.00 | <1000 | 3470.00 | 1510.00 | 1400.00 | <1000 | 1000.00 | <1000 | 4940.00 | 13100.00 | <1000 | 2980.00 | 1460.00 | <1000 | 2710.00 | <1000 | 2500.00 | 1400.00 | <1000 | <1000 | <1000 | 8200.00 | 4070.00 | 9970.00 | |
| Aromatics > EC40-EC44 | TM414 | µg/kg | 1000 | 12949875.00 | 0 | no exc. | 0.00 | 7101.00 | no exc. | 19000.00 | 1843.33 | 1000.00 | <1000 | <1000 | <1000 | <1000 | <1000 | <1000 | <1000 | 1580.00 | <1000 | <1000 | <1000 | <1000 | <1000 | <1000 | <1000 | <1000 | <1000 | <1000 | <1000 | <1000 | <1000 | <1000 | <1000 | 1250.00 |
| Total Aromatics > EC10-EC44 | TM414 | µg/kg | 5000 | | | 677000.00 | 5710.00 | 252700.00 | 252700.00 | 677000.00 | 77366.83 | 5000.00 | 61700.00 | <5000 | 36300.00 | 31000.00 | 33800.00 | 20100.00 | 38000.00 | 31300.00 | 65900.00 | 248000.00 | 5710.00 | 35900.00 | 22000.00 | 16800.00 | 40500.00 | 47700.00 | 60100.00 | 59700.00 | 40600.00 | 17100.00 | 69800.00 | 16000.00 | 199000.00 | 138000.00 | 677000.00 |
| Total Aliphatics & Aromatics >C5-C44 | TM414 | µg/kg | 10000 | | | 2690000.00 | 23200.00 | 431800.00 | 431800.00 | 2690000.00 | 182076.67 | 10000.00 | 301000.00 | <10000 | 97200.00 | 53000.00 | 90000.00 | 62900.00 | 48500.00 | 57500.00 | 223000.00 | 391000.00 | <10000 | 145000.00 | 59200.00 | 34100.00 | 92700.00 | 429000.00 | 145000.00 | 98900.00 | 78300.00 | 47400.00 | 324000.00 | 59700.00 | 302000.00 | 324000.00 | 2690000.00 |
| Naphthalene-d8 % recovery** | TM218 | % | | | | 102.00 | 74.82 | 98.93 | 98.93 | 102.00 | 86.08 | 74.82 | 85.30 | 86.00 | 85.20 | 84.20 | 85.40 | 82.50 | 82.60 | 83.40 | 84.70 | 83.10 | 90.00 | 79.10 | 88.20 | 74.00 | 88.30 | 84.50 | 77.50 | 78.50 | 107.00 | 84.80 | 80.60 | 59.30 | 101.00 | 98.20 | 84.80 | 104.00 | 85.80 |
| Acenaphthene-d10 % recovery** | TM218 | % | | | | 108.00 | 71.70 | 102.05 | 102.05 | 108.00 | 87.78 | 71.70 | 86.70 | 85.20 | 86.20 | 84.80 | 87.40 | 83.10 | 82.60 | 82.80 | 83.10 | 90.00 | 79.10 | 88.20 | 74.00 | 88.30 | 84.50 | 77.50 | 78.50 | 107.00 | 84.80 | 80.60 | 59.30 | 101.00 | 98.20 | 84.80 | 104.00 | 85.80 |
| Phenanthrene-d10 % recovery** | TM218 | % | | | | 107.00 | 52.40 | 101.15 | 101.15 | 107.00 | 87.28 | 52.40 | 89.10 | 84.10 | 88.10 | 86.80 | 86.60 | 82.10 | 82.80 | 83.10 | 90.00 | 79.10 | 88.20 | 74.00 | 88.30 | 84.50 | 77.50 | 78.50 | 107.00 | 84.80 | 80.60 | 59.30 | 101.00 | 98.20 | 84.80 | 104.00 | 85.80 |
| Chrysene-d12 % recovery** | TM218 | % | | | | 123.00 | 34.20 | 99.43 | 99.43 | 123.00 | 81.78 | 34.20 | 75.60 | 81.80 | 81.60 | 82.70 | 78.30 | 75.40 | 73.80 | 76.80 | 89.40 | 79.30 | 80.60 | 70.70 | 81.30 | 76.20 | 72.00 | 40.30 | 97.00 | 81.20 | 81.10 | 34.20 | 89.90 | 86.30 | 76.60 | 90.90 | 53.60 | |
| Perylene-d12 % recovery** | TM218 | % | | | | 111.00 | 20.60 | 101.00 | 101.00 | 111.00 | 76.26 | 20.60 | 75.30 | 80.70 | 77.60 | 79.30 | 76.90 | 75.00 | 71.00 | 75.40 | 87.50 | 80.80 | 78.40 | 77.50 | 76.90 | 70.50 | 70.40 | 20.60 | 82.80 | 72.50 | 76.90 | 25.50 | 77.30 | 87.30 | 71.30 | 77.50 | 28.70 | |
| Naphthalene | TM218 | µg/kg | 9 

| Client: Rodgers Leask Environmental | Customer Sample ID | | | T12-1 | T13-1 | T13-2 | T14-1 | T14-2 | T15-1 | U10-1 | U10-2 | U11-1 | U11-2 | U12-1 | U12-2 | U14-1 | U14-2 | U15-1 | U16-1 | U16-2 | U19-1 | V10-1 | V10-2 | V11-1 | V11-2 | V12-1 | V12-2 | V13-1 | V14-1 | V16-1 | V16-2 | V16-3 | V17-1 | V18-1 | V18-2 | V19-1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Depth | | | 0.15-0.15 | 0.40-0.40 | 1.10-1.10 | 0.30-0.30 | 1.40-1.40 | 1.00-1.00 | 1.00-1.00 | 1.50-1.50 | 1.00-1.00 | 1.40-1.40 | 0.60-0.60 | 1.90-1.90 | 0.30-0.30 | 2.00-2.00 | 1.00-1.00 | 1.00-1.00 | 2.00-2.00 | 0.30-0.30 | 0.30-0.30 | 1.50-1.50 | 0.50-0.50 | 1.65-1.65 | 1.00-1.00 | 1.60-1.60 | 1.00-1.00 | 0.30-0.30 | 1.00-1.00 | 1.80-1.80 | 2.30-2.30 | 1.00-1.00 | 0.50-0.50 | 1.50-1.50 | 0.50-0.50 |
| | Sample Type | | | SOLID | SOLID | SOLID | SOLID | SOLID | SOLID | SOLID | SOLID | SOLID | SOLID | SOLID | SOLID | SOLID | SOLID | SOLID | SOLID | SOLID | SOLID | SOLID | SOLID | SOLID | SOLID | SOLID | SOLID | SOLID | SOLID | SOLID | SOLID | SOLID | SOLID | SOLID | SOLID | SOLID |
| | Sampled Date | | | 04/02/2021 | 03/02/2021 | 03/02/2021 | 03/02/2021 | 03/02/2021 | 03/02/2021 | 02/02/2021 | 02/02/2021 | 02/02/2021 | 02/02/2021 | 04/02/2021 | 04/02/2021 | 04/02/2021 | 04/02/2021 | 04/02/2021 | 04/02/2021 | 04/02/2021 | 05/02/2021 | 05/02/2021 | 05/02/2021 | 02/02/2021 | 02/02/2021 | 02/02/2021 | 02/2/2021 | 2/2/2021 | 2/2/2021 | 2/2/2021 | 2/2/2021 | 2/2/2021 | 2/2/2021 | 2/2/2021 | 2/2/2021 | 2/1/2021 |
| | Sample Received Date | CWQCRA Reuse Criteria for 40% Infiltration Rainfall (Residential) | | 05/02/2021 | 04/02/2021 | 04/02/2021 | 04/02/2021 | 04/02/2021 | 05/02/2021 | 04/02/2021 | 04/02/2021 | 04/02/2021 | 04/02/2021 | 05/02/2021 | 05/02/2021 | 05/02/2021 | 05/02/2021 | 05/02/2021 | 05/02/2021 | 05/02/2021 | 06/02/2021 | 04/02/2021 | 04/02/2021 | 04/02/2021 | 04/02/2021 | 04/02/2021 | 2/3/2021 | 2/3/2021 | 2/3/2021 | 2/3/2021 | 2/3/2021 | 2/3/2021 | 2/3/2021 | 2/3/2021 | 2/3/2021 |
| | Final Instruction Date | | | 11/02/2021 | 10/02/2021 | 10/02/2021 | 10/02/2021 | 10/02/2021 | 11/02/2021 | 10/02/2021 | 10/02/2021 | 10/02/2021 | 10/02/2021 | 11/02/2021 | 11/02/2021 | 11/02/2021 | 11/02/2021 | 11/02/2021 | 11/02/2021 | 15/02/2021 | 10/02/2021 | 10/02/2021 | 10/02/2021 | 2/10/2021 | 2/10/2021 | 2/10/2021 | 2/10/2021 | 2/10/2021 | 2/10/2021 | 2/10/2021 | 2/10/2021 | 2/10/2021 | 2/10/2021 | 2/10/2021 | 2/10/2021 |
| | Report Completed Date | | | 23/02/2021 | 26/02/2021 | 26/02/2021 | 26/02/2021 | 26/02/2021 | 23/02/2021 | 26/02/2021 | 26/02/2021 | 26/02/2021 | 26/02/2021 | 23/02/2021 | 23/02/2021 | 23/02/2021 | 23/02/2021 | 23/02/2021 | 23/02/2021 | 19/02/2021 | 26/02/2021 | 26/02/2021 | 26/02/2021 | 2/17/2021 | 2/17/2021 | 2/17/2021 | 2/17/2021 | 2/17/2021 | 2/17/2021 | 2/17/2021 | 2/17/2021 | 2/17/2021 | 2/17/2021 | 2/17/2021 | 2/17/2021 | 2/17/2021 |
| | SDG | | | 210295-65 | 210304-77 | 210304-77 | 210304-77 | 210304-77 | 210305-65 | 210294-77 | 210294-77 | 210294-77 | 210294-77 | 210295-65 | 210295-65 | 210295-65 | 210295-65 | 210295-65 | 210295-65 | 210295-65 | 210295-65 | 210306-39 | 210294-77 | 210294-77 | 210294-77 | 210294-77 | 210303-41 | 210303-41 | 210303-41 | 210303-41 | 210303-41 | 210303-41 | 210303-41 | 210303-41 | 210303-41 | 210303-41 |
| | Lab Sample Number | | | 23672946 | 23666114 | 23665124 | 23666133 | 23666144 | 23672941 | 23666173 | 23666182 | 23666154 | 23666163 | 23673002 | 23673008 | 23672993 | 23672977 | 23672977 | 23672982 | 23672987 | 23678044 | 23666192 | 23665923 | 23665991 | 23665998 | 23656304 | 23656309 | 23656299 | 23656275 | 23655279 | 23656284 | 23656355 | 23656342 | 23656346 | 23656356 |
| | Sample Temperature | | | 9.0 | 8.8 | 8.8 | 8.8 | 8.8 | 9.0 | 8.8 | 8.8 | 8.8 | 8.8 | 9.0 | 9.0 | 9.0 | 9.0 | 9.0 | 9.0 | 9.0 | 9.0 | 8.7 | 8.8 | 8.8 | 8.8 | 8.4 | 8.4 | 8.4 | 8.4 | 8.4 | 8.4 | 8.4 | 8.4 | 8.4 | 8.4 | 8.4 |
| **Determinand** | **Method** | **Units** | **LOD** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Colour | PM024 | No units | | Dark Brown | Black | Dark Brown | Grey | Grey | Dark Brown | Dark Brown | Dark Brown | Dark Brown | Dark Brown | Black | Dark Brown | Black | Dark Brown | Black | Black | Dark Brown | Dark Brown | Dark Brown | Dark Brown | Dark Brown | Dark Brown | Dark Brown | Dark Brown | Dark Brown | Dark Brown | Dark Brown | Dark Brown | Dark Brown | Dark Brown | Dark Brown | Dark Brown | Dark Brown |
| Description | PM024 | No units | | Sand | Sand | Sandy Loam | Sand | Sand | Sand | Sandy Loam | Sand | Sand | Sand | Sand | Sand | Stone/Soil | Sand | Sand | Sandy | Sandy Loam | Sand | Sand | Sandy Loam | Sand | Sand | Gravel | Loamy Sand | Loamy Sand | Sandy Silt Loam | Sand | Sand | Sand | Loamy Sand | Sandy Silt Loam | Loamy Sand | Sandy Loam |
| Inclusion 1) | PM024 | No units | | Stones | None | None | Stones | Stones | Stones | Stones | Stones | Stones | Stones | Stones | Stones | Stones | Stones | None | Stones | Stones | Stones | Stones | Stones | Stones | Stones | Stones | Stones | Stones | Stones | Stones | Stones | Stones | Stones | Stones | Stones | Stones |
| Inclusion 2) | PM024 | No units | | None | Stones | N/A | None | None | Vegetation | Crushed Brick | Vegetation | Vegetation | None | None | Vegetation | None | None | Vegetation | Vegetation | Vegetation | Vegetation | None | None | Vegetation | None | None | None | None | None | None | None | None | None | None | Vegetation | Vegetation | Vegetation |
| Moisture Content Ratio (% of as received sample) | PM024 | % | | 3.00 | 9.70 | 14.00 | 12.00 | 32.00 | 4.10 | 10.00 | 14.00 | 1.60 | 4.40 | 9.90 | 9.70 | 11.00 | 6.60 | 0.00 | 3.60 | 12.00 | 11.00 | 12.00 | 13.00 | 6.38 | 14.00 | 8.60 | 15.00 | 12.00 | 11.00 | 10.00 | 3.50 | 10.00 | 17.00 | 11.00 | 21.00 | 7.80 |
| Asbestos Quantification - Gravimetric - % | TM004 | % | 0.001 | | | | | | | | | | | | | | | 0.0039 | | | | | | | | | | | | | | | | | | |
| Date of Analysis | TM048 | No units | | - | 10/02/2021 | - | 11/02/2021 | - | 10/02/2021 | - | 09/02/2021 | - | - | - | 11/02/2021 | - | 11/02/2021 | 11/02/2021 | - | 11/02/2021 | - | 09/02/2021 | - | 10/02/2021 | - | 09/02/2021 | - | - | 09/02/2021 | - | 09/02/2021 | - | 09/02/2021 | 09/02/2021 | - | - |
| Analysed By | TM048 | No units | | - | Christian Hallam | - | Paul Poynton | - | Christian Hallam | Christian Hallam | - | James Richards | - | - | Christian Hallam | - | Marcin Magdziarek | Paul Poynton | - | Christian Hallam | - | Paul Poynton | - | Christian Hallam | - | Paul Poynton | - | - | Paul Poynton | - | Paul Poynton | - | James Richards | Marcin Magdziarek | - | - |
| Asbestos Quantification - PCOM Evaluation - % | TM004 | % | 0.001 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | <0.001 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Additional Asbestos Components (Using TM048) | TM004 | No units | | - | - | - | - | - | - | - | - | - | - | - | - | - | - | None | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Analysis Comments | TM004 | No units | | - | - | - | - | - | - | - | - | - | - | - | - | - | - | N/A | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Asbestos Quantification - Total - % | TM004 | % | 0.001 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0.0039 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Chrysotile (White) Asbestos | TM048 | No units | | - | Not Detected | - | Not Detected | - | Not Detected | Not Detected | - | Not Detected | - | - | Not Detected | - | Not Detected | Not Detected | - | Not Detected | - | Not Detected | - | Not Detected | - | Not Detected | - | - | Not Detected | - | Not Detected | - | Not Detected | Not Detected | - | - |
| Amosite (Brown) Asbestos | TM048 | No units | | - | Not Detected | - | Not Detected | - | Not Detected | Not Detected | - | Not Detected | - | - | Not Detected | - | Not Detected | Not Detected | - | Not Detected | - | Not Detected | - | Not Detected | - | Not Detected | - | - | Not Detected | - | Not Detected | - | Not Detected | Not Detected | - | - |
| Crocidolite (Blue) Asbestos | TM048 | No units | | - | Not Detected | - | Not Detected | - | Not Detected | Not Detected | - | Not Detected | - | - | Not Detected | - | Not Detected | Not Detected | - | Not Detected | - | Not Detected | - | Not Detected | - | Not Detected | - | - | Not Detected | - | Not Detected | - | Not Detected | Not Detected | - | - |
| Fibrous Anthophyllite | TM048 | No units | | - | Not Detected | - | Not Detected | - | Not Detected | Not Detected | - | Not Detected | - | - | Not Detected | - | Not Detected | Not Detected | - | Not Detected | - | Not Detected | - | Not Detected | - | Not Detected | - | - | Not Detected | - | Not Detected | - | Not Detected | Not Detected | - | - |
| Fibrous Tremolite | TM048 | No units | | - | Not Detected | - | Not Detected | - | Not Detected | Not Detected | - | Not Detected | - | - | Not Detected | - | Not Detected | Not Detected | - | Not Detected | - | Not Detected | - | Not Detected | - | Not Detected | - | - | Not Detected | - | Not Detected | - | Not Detected | Not Detected | - | - |
| Fibrous Actinolite | TM048 | No units | | - | Not Detected | - | Not Detected | - | Not Detected | Not Detected | - | Not Detected | - | - | Not Detected | - | Not Detected | Not Detected | - | Not Detected | - | Not Detected | - | Not Detected | - | Not Detected | - | - | Not Detected | - | Not Detected | - | Not Detected | Not Detected | - | - |
| Non-Asbestos Fibre | TM048 | No units | | - | Not Detected | - | Not Detected | - | Not Detected | Not Detected | - | Not Detected | - | - | Not Detected | - | Not Detected | Not Detected | - | Not Detected | - | Not Detected | - | Not Detected | - | Not Detected | - | - | Not Detected | - | Not Detected | - | Not Detected | Not Detected | - | - |
| Comments | TM048 | No units | | - | - | - | - | - | - | - | - | - | - | - | - | - | - | Degraded textile ACM debris in soil | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Soil Organic Matter (SOM) | TM132 | % | 0.35 | 2.17 | 24.30 | 7.57 | 36.50 | 84.00 | 55.70 | 13.10 | 28.10 | 6.24 | 1.64 | 27.80 | 4.52 | 30.20 | <0.35 | 41.40 | 44.30 | 31.70 | 8.26 | 22.90 | 9.09 | 9.67 | 42.80 | 1.74 | 16.60 | 11.20 | 8.81 | 4.10 | - | 12.50 | 71.90 | 5.90 | 50.70 | 3.43 |
| pH | TM133 | pH Units | 1 | 10.70 | 10.00 | 8.67 | 9.03 | 9.22 | 9.93 | 9.58 | 10.20 | 10.50 | 10.90 | 9.05 | 9.87 | 9.24 | 10.90 | 9.51 | 8.89 | 9.84 | 12.00 | 10.70 | 11.60 | 11.00 | 11.10 | 9.78 | 10.90 | 10.20 | 10.40 | 9.96 | 9.97 | 8.71 | 10.50 | 8.53 | 10.50 | 11.40 |
| Cyanide, Total | TM153 | mg/kg | 1 | 2.31 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | 4.06 | 1.46 | <1 | 1.78 | 2.22 | <1 | 1.16 | <1 | 4.35 | <1 | <1 | <1 | <1 | <1 | <1 | 20.40 | <1 | <1 | <1 |
| Exchangeable Ammonia as N | TM024 | mg/kg | 12 | 176.98 | <12 | <12 | <12 | <12 | <12 | <12 | <12 | <12 | <12 | <12 | <12 | <12 | <12 | <12 | <12 | <12 | <12 | <12 | <12 | <12 | <12 | <12 | <12 | <12 | <12 | <12 | <12 | <12 | <12 | <12 | <12 | <12 | <12 |
| Arsenic | TM181 | mg/kg | 0.6 | 2902.69 | <6 | 2.47 | 6.48 | <6 | 6.93 | 3.72 | 6.33 | 7.37 | 3.37 | <6 | 2.68 | <6 | 2.71 | <6 | 3.49 | <6 | 5.23 | <6 | 8.20 | <6 | 4.94 | <6 | <6 | 4.81 | 6.06 | 6.72 | <6 | <6 | <6 | <6 | 6.22 | 15.50 |
| Cadmium | TM181 | mg/kg | 0.02 | 83.66 | <0.2 | 0.10 | <0.2 | 0.33 | <0.2 | 0.30 | 0.32 | <0.2 | 0.39 | <0.2 | 0.09 | <0.2 | 0.11 | <0.2 | 0.23 | 0.35 | 0.89 | 0.54 | 0.20 | 0.81 | <0.2 | <0.2 | <0.2 | 0.30 | 0.23 | 0.75 | 0.28 | <0.2 | 0.59 | 0.55 | 0.71 | 0.56 |
| Chromium | TM181 | mg/kg | 0.9 | 10806.91 | 29.00 | 20.00 | 42.90 | 10.30 | 12.40 | 22.70 | 42.90 | 95.30 | 144.00 | 302.00 | 36.90 | 11.50 | 9.05 | 46.20 | 14.10 | 93.70 | 25.20 | 476.00 | 94.30 | 82.70 | 127.00 | 56.50 | <9 | 34.10 | 10.50 | 89.20 | 40.90 | 17.10 | 15.40 | 27.80 | <9 | 86.90 | 86.10 |
| Copper | TM181 | mg/kg | 1.4 | 516.88 | <14 | 5.72 | <14 | <14 | 29.00 | 8.49 | 19.70 | 15.80 | 14.80 | <14 | 7.98 | <14 | 6.92 | <14 | 6.65 | 16.70 | 11.90 | <14 | 25.10 | <14 | 13.10 | <14 | <14 | 10.40 | <14 | 14.30 | <14 | <14 | <14 | <14 | <14 | <14 | 44.20 |
| Iron | TM181 | mg/kg | 1000 | 349148.01 | 11200.00 | 12400.00 | 19600.00 | 14700.00 | 14800.00 | 20400.00 | 60300.00 | 47000.00 | 85900.00 | 76300.00 | <10000 | <10000 | <10000 | <10000 | 12000.00 | 49100.00 | 24500.00 | 154000.00 | 74200.00 | 38300.00 | 68300.00 | 44800.00 | <10000 | 22400.00 | 20700.00 | 67200.00 | 41000.00 | 14100.00 | 15300.00 | 23100.00 | 128800.00 | 23800.00 | 96400.00 |
| Lead | TM181 | mg/kg | 0.7 | 18032.07 | <7 | 14.40 | 27.30 | 30.20 | 27.80 | 14.00 | 41.30 | 47.00 | 1.08 | <7 | 27.10 | 8.31 | 3.62 | <7 | 15.90 | 80.40 | 408.00 | 31.20 | 82.30 | 26.50 | 35.30 | 19.40 | <7 | 28.60 | 11.90 | 51.10 | 16.60 | 400.00 | 8.08 | 36.30 | 23.20 | 27.30 | 32.40 |
| Manganese | TM181 | mg/kg | 5.13 | 38175.69 | 5290.00 | 4480.00 | 3430.00 | 2760.00 | 5500.00 | 3200.00 | 5150.00 | 5410.00 | 13000.00 | 11300.00 | 3680.00 | 831.00 | 3530.00 | 4430.00 | 1080.00 | 4560.00 | 2040.00 | 26200.00 | 8280.00 | 5260.00 | 16600.00 | 5360.00 | 5590.00 | 4620.00 | 2950.00 | 7640.00 | 6910.00 | 3220.00 | 3340.00 | 4840.00 | 8720.00 | 10500.00 | 8110.00 |
| Mercury | TM181 | mg/kg | 0.14 | 150.81 | <1 | <0.1 | <1 | <1 | <1 | <1 | <1 | <1 | <0.1 | <1 | <1 | <1 | <0.1 | <1 | <0.1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <0.1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| Nickel | TM181 | mg/kg | 0.2 | 13188.60 | 2.01 | 3.76 | 15.30 | 6.21 | 30.00 | 6.21 | 14.20 | 12.60 | 8.82 | 9.85 | 4.33 | 8.92 | 3.24 | <2 | 4.15 | 10.20 | 10.80 | 10.10 | 17.50 | 8.46 | 8.72 | 8.36 | <2 | 5.65 | 6.82 | 13.80 | 5.54 | 4.98 | 14.30 | 6.64 | 5.69 | 7.15 | 17.40 |
| Selenium | TM181 | mg/kg | 1 | 804.31 | <10 | 3.55 | <10 | <10 | <10 | <10 | 1.59 | <10 | 4.98 | 10.10 | 2.89 | <10 | 2.11 | <10 | <1 | <10 | <1 | 12.00 | <10 | <10 | 4.40 | <10 | <10 | 3.12 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 |
| Vanadium | TM181 | mg/kg | 0.2 | 1840.20 | 47.50 | 39.90 | 98.20 | 25.30 | 28.30 | 32.60 | 90.20 | 138.00 | 277.00 | 265.00 | 32.40 | 24.50 | 20.30 | 29.90 | 31.00 | 56.60 | 23.40 | 409.00 | 234.00 | 184.00 | 443.00 | 128.00 | 21.00 | 73.80 | 24.50 | 159.00 | 53.20 | 50.30 | 44.40 | 40.30 | 21.90 | 87.30 | 131.00 |
| Zinc | TM181 | mg/kg | 1.9 | 157599.52 | <19 | 61.50 | 60.50 | 74.20 | 61.60 | 66.30 | 117.00 | 161.00 | 30.60 | 40.00 | 52.70 | 23.00 | 36.90 | <19 | 33.50 | 207.00 | 107.00 | 86.10 | 288.00 | 207.00 | 177.00 | 83.60 | <19 | 93.20 | 52.70 | 167.00 | 83.20 | 20.20 | 27.60 | 78.70 | 96.10 | 44.80 | 110.00 |
| Phenol | TM802 (S) | mg/kg | 0.01 | 3.50 | <0.01 | <1 | <1 | <1 | <0.1 | <0.01 | <1 | <1 | <1 | <1 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <1 | <1 | <1 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | 0.01 | <0.01 | <0.01 |
| Cresols | TM802 (S) | mg/kg | 0.01 | | <0.01 | <1 | <1 | <1 | <0.1 | <0.01 | <1 | <1 | <1 | <1 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <1 | <1 | <1 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | 0.11 | 0.02 | 0.01 | <0.01 |
| Xylenols | TM802 (S) | mg/kg | 0.015 | | <0.015 | <1.5 | <1.5 | <1.5 | <0.15 | <0.015 | <1.5 | <1.5 | <1.5 | <1.5 | <0.015 | <0.015 | <0.015 | <0.015 | <0.015 | <0.015 | <0.015 | <0.015 | <0.015 | <0.015 | <1.5 | <1.5 | <1.5 | <0.015 | <0.015 | <0.015 | <0.015 | <0.015 | <0.015 | <0.015 | 0.07 | <0.015 | <0.015 | <0.015 |
| Phenols, Total Detected monohydric | TM802 (S) | mg/kg | 0.035 | | <0.035 | <3.5 | <3.5 | <3.5 | <0.35 | <0.035 | <3.5 | <3.5 | <3.5 | <3.5 | <0.035 | <0.035 | <0.035 | <0.035 | <0.035 | <0.035 | <0.035 | <0.035 | <0.035 | <0.035 | <3.5 | <3.5 | <3.5 | <0.035 | <0.035 | <0.035 | <0.035 | <0.035 | <0.035 | <0.035 | 0.19 | <0.035 | <0.035 | <0.035 |
| Total Aliphatics >C5-C10 | TM089 | µg/kg | 50 | | <50 | <50 | <50 | <50 | <50 | <50 | <50 | 53.40 | 128.00 | <50 | <50 | <50 | <50 | <50 | <50 | <50 | <50 | 144.00 | <50 | <50 | 50.80 | 55.20 | 169.00 | <50 | 146.00 | 121.00 | <50 | <50 | <50 | <50 | 101.00 | 402.00 | <50 |
| Total Aromatics >EC5-EC10 | TM089 | µg/kg | 50 | | <50 | <50 | <50 | <50 | <50 | <50 | <50 | <50 | 56.90 | <50 | <50 | <50 | <50 | <50 | <50 | <50 | <50 | <50 | <50 | <50 | <50 | 73.10 | <50 | 82.50 | <50 | <50 | <50 | <50 | <50 | 52.80 | 214.00 | <50 |
| GRO >C5-C10 | TM089 | µg/kg | 20 | | <20 | <20 | <20 | <20 | <20 | <20 | <20 | 53.40 | 185.00 | <20 | <20 | <20 | <20 | <20 | <20 | <20 | <20 | 144.00 | <20 | <20 | 50.80 | 55.20 | 242.00 | <20 | 209.00 | 121.00 | <20 | <20 | <20 | <20 | 153.00 | 616.00 | <20 |
| GRO Surrogate % recovery** | TM089 | % | | | 57.50 | 58.00 | 65.00 | 23.20 | 26.00 | 12.00 | 55.00 | 53.00 | 89.00 | 103.00 | 9.50 | 107.00 | 9.10 | 98.20 | 32.60 | 10.50 | 44.10 | 56.20 | 55.00 | 77.00 | 59.00 | 87.00 | 114.00 | 58.60 | 63.20 | 63.00 | 74.60 | 79.30 | 83.50 | 73.40 | 72.00 | 115.00 | 75.00 |
| Aliphatics >C5-C6 | TM089 | µg/kg | 10 | 83664.00 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | 12.50 | <10 | <10 | <10 | 15.10 | <10 | 14.20 | 11.40 | <10 | <10 | <10 | <10 | <10 | <10 | 25.20 | <10 |
| Aliphatics >C6-C8 | TM089 | µg/kg | 10 | 411626.00 | <10 | 28.90 | <10 | <10 | <10 | <10 | <10 | <10 | 19.70 | 42.70 | 15.70 | <10 | <10 | <10 | <10 | <10 | <10 | 65.00 | 11.30 | <10 | 31.10 | 30.10 | 67.30 | 14.50 | 60.20 | 51.30 | <10 | <10 | <10 | 22.40 | 156.00 | <10 | <10 |
| Aliphatics >C8-C10 | TM089 | µg/kg | 10 | 3254980.00 | <10 | 20.00 | <10 | <10 | <10 | <10 | <10 | <10 | 33.60 | 85.30 | 16.70 | <10 | <10 | <10 | <10 | <10 | <10 | 66.10 | 12.40 | <10 | 19.60 | 25.10 | 87.00 | <10 | 72.00 | 58.10 | <10 | <10 | <10 | <10 | 78.40 | 221.00 | <10 |
| Aliphatics >C10-C12 | TM014 | µg/kg | 1000 | 2583823.00 | <1000 | <1000 | <1000 | >1000 | <1000 | 1250.00 | <1000 | <1000 | <1000 | <1000 | 1190.00 | <1000 | 1270.00 | <1000 | <1000 | 1110.00 | <1000 | <1000 | <1000 | <1000 | <1000 | <1000 | <1000 | <1000 | 1590.00 | <1000 | <1000 | <1000 | <1000 | 1780.00 | 3510.00 | 1610.00 | <1000 |
| Aliphatics >C12-C16 | TM014 | µg/kg | 1000 | 51548680.00 | <1000 | 4360.00 | <1000 | <1000 | 5130.00 | <1000 | 4260.00 | 1440.00 | 1780.00 | 1280.00 | 4240.00 | <1000 | 3720.00 | <1000 | 5130.00 | <1000 | 2400.00 | 3520.00 | 1960.00 | 1500.00 | 3130.00 | 1250.00 | <1000 | 2060.00 | 2240.00 | 2580.00 | 1460.00 | <1000 | <1000 | 1300.00 | 3490.00 | 1870.00 | 4340.00 |
| Aliphatics >C16-C21 | TM014 | µg/kg | 1000 | 64895263780.00 | 3530.00 | 7540.00 | <1000 | 13100.00 | 1360.00 | 11200.00 | 6320.00 | 7410.00 | 4200.00 | <1000 | 8440.00 | <1000 | 13200.00 | <1000 | 9340.00 | 6290.00 | 4310.00 | 5900.00 | 33800.00 | 16000.00 | 2440.00 | 10200.00 | <1000 | 45200.00 | 49500.00 | 6500.00 | 1710.00 | 10100.00 | 3200.00 | 48100.00 | 37900.00 | 31000.00 | 13100.00 |
| Aliphatics >C21-C35 | TM014 | µg/kg | 1000 | 64895263780.00 | 15700.00 | 19800.00 | <1000 | 19600.00 | 10600.00 | 31100.00 | 14800.00 | 17300.00 | 7580.00 | 1670.00 | 11400.00 | 3540.00 | 36500.00 | <1000 | 26100.00 | 18100.00 | 6990.00 | 59600.00 | 30500.00 | 53600.00 | 14900.00 | 42800.00 | 2930.00 | 54100.00 | 84700.00 | 28300.00 | 8380.00 | 9920.00 | 7200.00 | 147000.00 | 48200.00 | 36000.00 | 84200.00 |
| Aliphatics >C35-C44 | TM014 | µg/kg | 1000 | 64895263780.00 | 4270.00 | 3740.00 | <1000 | <1000 | <1000 | <1000 | 4700.00 | 2230.00 | 2690.00 | 1120.00 | <1000 | <1000 | <1000 | <1000 | 5170.00 | <1000 | 2890.00 | 4700.00 | <1000 | 10200.00 | 7460.00 | 13400.00 | 4630.00 | 13800.00 | <1000 | 5900.00 | 20400.00 | 20900.00 | 4790.00 | <1000 | <1000 | 44800.00 | 34700.00 | 25900.00 | 88900.00 |
| Total Aliphatics >C10-C44 | TM014 | µg/kg | 10 | | 24200.00 | 30400.00 | <5000 | 36200.00 | 13400.00 | 52000.00 | 24800.00 | 28200.00 | 14200.00 | <5000 | 23300.00 | 5100.00 | 54200.00 | <5000 | 43000.00 | 41200.00 | 33800.00 | 13400.00 | 77200.00 | 73000.00 | 84400.00 | 22800.00 | 68700.00 | <5000 | 182000.00 | 254000.00 | 57000.00 | 15200.00 | 21000.00 | 11000.00 | 254000.00 | 155800.00 | 113000.00 | 183000.00 |
| Total Aliphatics & Aromatics >C10-C44 | TM014 | µg/kg | 10000 | | 33500.00 | 68200.00 | <10000 | 91400.00 | 23200.00 | 118000.00 | 249000.00 | 101000.00 | 41700.00 | 29700.00 | 75700.00 | 25000.00 | 111000.00 | <10000 | 84200.00 | 80400.00 | 43200.00 | 93000.00 | 58100.00 | 146000.00 | 49000.00 | 98500.00 | <10000 | 169000.00 | 234000.00 | 128000.00 | 42000.00 | 30300.00 | 48000.00 | 401000.00 | 370000.00 | 220000.00 | 327000.00 |
| Aromatics >EC5-EC7 | TM089 | µg/kg | 10 | 9752.00 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | 17.60 | <10 |
| Aromatics >EC7-EC8 | TM089 | µg/kg | 10 | 202890.00 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | 11.00 | 15.10 | <10 | 14.20 | 10.30 | <10 | <10 | <10 | <10 | <10 | 49.10 | <10 |
| Aromatics >EC8-EC10 | TM089 | µg/kg | 10 | 164594.00 | <10 | 13.30 | <10 | <10 | <10 | <10 | <10 | 22.00 | 56.90 | 11.50 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | 44.50 | <10 | <10 | 12.70 | 17.10 | 58.00 | <10 | 48.40 | 38.80 | <10 | <10 | <10 | <10 | 52.60 | 147.00 | <10 |
| Aromatics > EC10-EC12 | TM014 | µg/kg | 1000 | 259933.00 | <1000 | <1000 | <1000 | 1010.00 | <1000 | <1000 | 1140.00 | <1000 | <1000 | <1000 | <1000 | <1000 | <1000 | <1000 | <1000 | <1000 | <1000 | <1000 | <1000 | <1000 | 1600.00 | <1000 | <1000 | <1000 | <1000 | 1190.00 | <1000 | <1000 | <1000 | 2330.00 | 1960.00 | 2400.00 | <1000 |
| Aromatics > EC12-EC16 | TM014 | µg/kg | 1000 | 517061.00 | <1000 | 3470.00 | <1000 | 5070.00 | <1000 | 4030.00 | 9130.00 | 3360.00 | <1000 | <1000 | 3460.00 | <1000 | 3640.00 | <1000 | 2750.00 | 3130.00 | <1000 | <1000 | 13900.00 | 1970.00 | <1000 | 1450.00 | <1000 | 4070.00 | 7590.00 | 3880.00 | <1000 | <1000 | <1000 | 15200.00 | 17400.00 | 10200.00 | 3250.00 |
| Aromatics > EC16-EC21 | TM014 | µg/kg | 1000 | 1631673.00 | 1230.00 | 5080.00 | <1000 | 7270.00 | 1300.00 | 12400.00 | 6860.00 | 16800.00 | 3790.00 | 6950.00 | 8690.00 | 8030.00 | 7650.00 | <1000 | 10500.00 | 8830.00 | 10500.00 | 3890.00 | 24300.00 | 13400.00 | 7020.00 | 6060.00 | 4560.00 | <1000 | 10100.00 | 13000.00 | 15800.00 | 4560.00 | 3290.00 | 9300.00 | 21400.00 | 42900.00 | 12900.00 | 11700.00 |
| Aromatics > EC21-EC35 | TM014 | µg/kg | 1000 | 12949875.00 | 6640.00 | 19000.00 | 1510.00 | 33300.00 | 8160.00 | 44800.00 | 13000.00 | 47100.00 | 21000.00 | 16800.00 | 34200.00 | 10500.00 | 32400.00 | <1000 | 29500.00 | 31300.00 | 21000.00 | 11700.00 | 317000.00 | 47900.00 | 17800.00 | 22500.00 | <1000 | 23600.00 | 29000.00 | 44700.00 | 14900.00 | 4350.00 | 25800.00 | 104000.00 | 95200.00 | 43400.00 | 80100.00 |
| Aromatics >EC35-EC44 | TM014 | µg/kg | 1000 | 12949875.00 | <1000 | 5980.00 | <1000 | <1000 | 5270.00 | <1000 | 3020.00 | 1810.00 | 1650.00 | <1000 | 3760.00 | 2220.00 | 1940.00 | <1000 | 2270.00 | <1000 | 1670.00 | <1000 | 4550.00 | <1000 | 4000.00 | <1000 | <1000 | 1700.00 | <1000 | 2220.00 | 6230.00 | <1000 | 1100.00 | 3540.00 | 5380.00 | 3660.00 | 42500.00 |
| Aromatics > EC40-EC44 | TM014 | µg/kg | 1000 | 12949875.00 | <1000 | <1000 | <1000 | <1000 | <1000 | <1000 | <1000 | 1810.00 | <1000 | <1000 | <1000 | <1000 | <1000 | <1000 | <1000 | <1000 | <1000 | <1000 | <1000 | <1000 | 6880.00 | <1000 | <1000 | <1000 | <1000 | <1000 | 1190.00 | <1000 | 1290.00 | 2690.00 | <1000 | <1000 | 13200.00 | 11300.00 | 19000.00 |
| Total Aromatics > EC10-EC44 | TM014 | µg/kg | 5000 | | 9230.00 | 29800.00 | <5000 | 52200.00 | 10800.00 | 65800.00 | 224000.00 | 71900.00 | 27600.00 | 27300.00 | 52300.00 | 19900.00 | 46300.00 | <5000 | 43000.00 | 46700.00 | 29800.00 | 15800.00 | 509000.00 | 61600.00 | 26200.00 | 29800.00 | <5000 | 40200.00 | 52300.00 | 70800.00 | 26800.00 | 9300.00 | 37000.00 | 147000.00 | 211000.00 | 107000.00 | 138000.00 |
| Total Aliphatics & Aromatics >C5-C44 | TM089 | µg/kg | 10000 | | 33500.00 | 68300.00 | <10000 | 91400.00 | 23200.00 | 118000.00 | 249000.00 | 101000.00 | 41900.00 | 27300.00 | 75700.00 | 25000.00 | 111000.00 | <10000 | 84200.00 | 80400.00 | 43400.00 | 93000.00 | 58100.00 | 146000.00 | 49100.00 | 98800.00 | <10000 | 169000.00 | 235000.00 | 128000.00 | 42000.00 | 30300.00 | 48000.00 | 401000.00 | 370000.00 | 220000.00 | 327000.00 |
| Naphthalene-d8 % recovery** | TM018 | % | | | 78.00 | 93.90 | 88.10 | 85.20 | 75.00 | 80.00 | 96.20 | 82.10 | 85.00 | 79.80 | 98.80 | 79.20 | 102.00 | 81.70 | 79.30 | 76.50 | 77.00 | 98.00 | 86.40 | 79.00 | 93.10 | 96.80 | 83.90 | 91.90 | 81.10 | 74.60 | 87.00 | 88.50 | 85.20 | 90.70 | 84.40 | 91.40 | 81.20 |
| Acenaphthene-d10 % recovery** | TM018 | % | | | 80.70 | 89.10 | 86.70 | 83.90 | 71.70 | 83.80 |

| Client: Rodgers Leask Environmental | Customer Sample ID | | | | V20-1 | V21-1 |
|---|---|---|---|---|---|---|
| | Depth | | | | 1.30-1.30 | 0.50-0.50 |
| | Sample Type | | | | SOLID | SOLID |
| | Sampled Date | | | | 2/1/2021 | 2/1/2021 |
| | Sample Received Date | | | CWDCRA Reuse Criteria for 40% Infiltration Rainfall (Residential) | 2/3/2021 | 2/3/2021 |
| | Final Instruction Date | | | | 2/10/2021 | 2/10/2021 |
| | Report Compleated Date | | | | 2/17/2021 | 2/17/2021 |
| | SDG | | | | 210323-41 | 210323-41 |
| | Lab Sample Number | | | | 2959330 | 2959325 |
| | Sample Temperature | | | | 8.4 | 8.4 |
| **Determinand** | **Method** | **Units** | **LOD** | | | |
| Colour | PM024 | No units | | | Dark Brown | Dark Brown |
| Description | PM024 | No units | | | Sand | Sandy Silt Loam |
| Inclusion 1) | PM024 | No units | | | Stones | Stones |
| Inclusion 2) | PM024 | No units | | | None | None |
| Moisture Content Ratio (% of as received sample) | PM024 | % | | | 12.00 | 10.00 |
| Asbestos Quantification - Gravimetric - % | TM004 | % | 0.001 | | | |
| Date of Analysis | TM048 | No units | | | 09/02/2021 | - |
| Analysed By | TM048 | No units | | | James Richards | - |
| Asbestos Quantification - PCOM Evaluation - % | TM004 | % | 0.001 | | - | - |
| Additional Asbestos Components (Libror TM048) | TM004 | No units | | | - | - |
| Analysts Comments | TM004 | No units | | | - | - |
| Asbestos Quantification - Total - % | TM004 | % | 0.001 | | - | - |
| Chrysotile (White) Asbestos | TM048 | No units | | | Not Detected | - |
| Amosite (Brown) Asbestos | TM048 | No units | | | Not Detected | - |
| Crocidolite (Blue) Asbestos | TM048 | No units | | | Not Detected | - |
| Fibrous Anthophyllite | TM048 | No units | | | Not Detected | - |
| Fibrous Tremolite | TM048 | No units | | | Not Detected | - |
| Fibrous Actinolite | TM048 | No units | | | Not Detected | - |
| Non-Asbestos Fibre | TM048 | No units | | | Not Detected | - |
| Comments | TM048 | No units | | | - | - |
| Soil Organic Matter (SOM) | TM132 | % | 0.35 | | 4.41 | 11.00 |
| pH | TM133 | pH Units | 1 | | 11.10 | 10.10 |
| Cyanide, Total | TM153 | mg/kg | 1 | 2.31 | <1 | <1 |
| Exchangeable Ammonia as N | TM024 | mg/kg | 12 | 176.98 | <12 | <12 |
| Arsenic | TM181 | mg/kg | 0.6 | 2902.69 | <6 | 14.50 |
| Cadmium | TM181 | mg/kg | 0.02 | 83.66 | 0.35 | 0.61 |
| Chromium | TM181 | mg/kg | 0.9 | 10806.91 | 10.50 | <9 |
| Copper | TM181 | mg/kg | 1.4 | 516.88 | 71.70 | <14 |
| Iron | TM181 | mg/kg | 1000 | 349148.01 | 53700.00 | 232000.00 |
| Lead | TM181 | mg/kg | 0.7 | 18032.07 | 12.80 | 41.10 |
| Manganese | TM181 | mg/kg | 0.13 | 38175.69 | 3330.00 | 4580.00 |
| Mercury | TM181 | mg/kg | 0.14 | 150.81 | <1 | <1 |
| Nickel | TM181 | mg/kg | 0.2 | 13188.60 | 6.41 | 22.90 |
| Selenium | TM181 | mg/kg | 1 | 804.31 | <10 | <10 |
| Vanadium | TM181 | mg/kg | 0.2 | 1840.20 | 52.30 | 80.10 |
| Zinc | TM181 | mg/kg | 1.9 | 157599.52 | 44.00 | 87.30 |
| Phenol | TM002 (S) | mg/kg | 0.01 | 3.50 | <0.01 | <0.01 |
| Cresols | TM002 (S) | mg/kg | 0.01 | | <0.01 | <0.01 |
| Xylenols | TM002 (S) | mg/kg | 0.015 | | <0.015 | <0.015 |
| Phenols, Total Detected monohydric | TM002 (S) | mg/kg | 0.035 | | <0.035 | <0.035 |
| Total Aliphatics >C5-C10 | TM089 | µg/kg | 50 | | <50 | <50 |
| Total Aromatics >EC5-EC10 | TM089 | µg/kg | 50 | | <50 | <50 |
| GRO >C5-C10 | TM089 | µg/kg | 20 | | <20 | <20 |
| GRO Surrogate % recovery** | TM089 | % | | | 74.30 | 76.00 |
| Aliphatics >C5-C6 | TM089 | µg/kg | 10 | 83664.00 | <10 | <10 |
| Aliphatics >C6-C8 | TM089 | µg/kg | 10 | 411626.00 | <10 | <10 |
| Aliphatics >C8-C10 | TM089 | µg/kg | 10 | 3254980.00 | <10 | <10 |
| Aliphatics >C10-C12 | TM414 | µg/kg | 1000 | 25838230.00 | <1000 | <1000 |
| Aliphatics >C12-C16 | TM414 | µg/kg | 1000 | 515488681.00 | 2990.00 | 1740.00 |
| Aliphatics >C16-C21 | TM414 | µg/kg | 1000 | 6489526378O.00 | 11000.00 | 12000.00 |
| Aliphatics >C21-C35 | TM414 | µg/kg | 1000 | 6489526378O.00 | 32000.00 | 47500.00 |
| Aliphatics >C35-C44 | TM414 | µg/kg | 1000 | 6489526378O.00 | 7040.00 | 20700.00 |
| Total Aliphatics >C10-C44 | TM414 | µg/kg | 5000 | | 53300.00 | 82200.00 |
| Total Aliphatics & Aromatics >C16-C44 | TM414 | µg/kg | 10000 | | 61500.00 | 112000.00 |
| Aromatics >EC5-EC7 | TM089 | µg/kg | 10 | 9752.00 | <10 | <10 |
| Aromatics >EC7-EC8 | TM089 | µg/kg | 10 | 202890.00 | <10 | <10 |
| Aromatics >EC8-EC10 | TM089 | µg/kg | 10 | 164594.00 | <10 | <10 |
| Aromatics > EC10-EC12 | TM414 | µg/kg | 1000 | 259633.00 | <1000 | <1000 |
| Aromatics > EC12-EC16 | TM414 | µg/kg | 1000 | 517061.00 | <1000 | 1900.00 |
| Aromatics > EC16-EC21 | TM414 | µg/kg | 1000 | 1631673.00 | 1200.00 | 3320.00 |
| Aromatics > EC21-EC35 | TM414 | µg/kg | 1000 | 12949875.00 | 5660.00 | 22100.00 |
| Aromatics >EC35-EC44 | TM414 | µg/kg | 1000 | 12949875.00 | <1000 | 2100.00 |
| Aromatics > EC40-EC44 | TM414 | µg/kg | 1000 | 12949875.00 | <1000 | <1000 |
| Total Aromatics > EC10-EC44 | TM414 | µg/kg | 5000 | | 8170.00 | 29700.00 |
| Total Aliphatics & Aromatics >C5-C44 | TM414 | µg/kg | 10000 | | 61500.00 | 112000.00 |
| Naphthalene-d8 % recovery** | TM218 | % | | | 82.60 | 85.50 |
| Acenaphthene-d10 % recovery** | TM218 | % | | | 88.00 | 86.20 |
| Phenanthrene-d10 % recovery** | TM218 | % | | | 93.00 | 100.00 |
| Chrysene-d12 % recovery** | TM218 | % | | | 88.40 | 123.00 |
| Perylene-d12 % recovery** | TM218 | % | | | 82.70 | 109.00 |
| Naphthalene | TM218 | µg/kg | 9 | 31450.00 | 42.90 | 292.00 |
| Acenaphthylene | TM218 | µg/kg | 12 | 19168.00 | <12 | 82.30 |
| Acenaphthene | TM218 | µg/kg | 8 | 34073.00 | 11.00 | 12.20 |
| Fluorene | TM218 | µg/kg | 10 | 31077.00 | 24.10 | 42.40 |
| Phenanthrene | TM218 | µg/kg | 15 | 31077.00 | 137.00 | 431.00 |
| Anthracene | TM218 | µg/kg | 16 | 39119.00 | 25.00 | 93.30 |
| Fluoranthene | TM218 | µg/kg | 17 | 7614.00 | 126.00 | 503.00 |
| Pyrene | TM218 | µg/kg | 15 | 87557.00 | 100.00 | 397.00 |
| Benz(a)anthracene | TM218 | µg/kg | 14 | 695380.00 | 61.00 | 299.00 |
| Chrysene | TM218 | µg/kg | 10 | 711578.00 | 79.50 | 375.00 |
| Benzo(b)fluoranthene | TM218 | µg/kg | 15 | 3914.00 | 81.90 | 553.00 |
| Benzo(k)fluoranthene | TM218 | µg/kg | 14 | 5790.00 | 23.20 | 165.00 |
| Benzo(a)pyrene | TM218 | µg/kg | 15 | 39489.00 | 41.50 | 276.00 |
| Indeno(1,2,3-cd)pyrene | TM218 | µg/kg | 18 | 29018.00 | 30.90 | 294.00 |
| Dibenz(a,h)anthracene | TM218 | µg/kg | 23 | 959886.00 | <23 | 71.10 |
| Benzo(g,h,i)perylene | TM218 | µg/kg | 24 | 15229.00 | 33.30 | 305.00 |
| PAH, Total Detected USEPA 16 | TM218 | µg/kg | 118 | | 818.00 | 4190.00 |
| Dibromofluoromethane** | TM116 | % | | | 102.00 | 106.00 |
| Toluene-d8** | TM116 | % | | | 97.10 | 98.70 |
| 4-Bromofluorobenzene** | TM116 | % | | | 88.20 | 91.00 |
| Methyl Tertiary Butyl Ether | TM116 | µg/kg | 10 | | <200 | <200 |
| Benzene | TM116 | µg/kg | 9 | 4358.00 | <180 | <180 |
| Toluene | TM116 | µg/kg | 7 | 147182.00 | <140 | <140 |
| Ethylbenzene | TM116 | µg/kg | 4 | 92030.00 | <80 | <80 |
| p/m-Xylene | TM116 | µg/kg | 10 | 84970.00 | <200 | <200 |
| o-Xylene | TM116 | µg/kg | 10 | 84970.00 | <200 | <200 |
| Naphthalene | TM116 | µg/kg | 13 | 31450.00 | <260 | <260 |
| Sum of Detected Xylenes | TM116 | mg/kg | 0.02 | | <0.4 | <0.4 |
| Sum of BTEX | TM116 | µg/kg | 40 | | <800 | <800 |

# Appendix E – H F Consulting  Soild Validation Strategy

H Fraser Consulting
Contaminated Land and Hydrogeology

# Glan Llyn: Soils validation strategy for protection of controlled waters

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Date: 17/12/2024
Status: FINAL
Reference: 30937 R2
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Contaminated Land and Hydrogeology

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Version History

| Version | Author | Approved by | Issue date | Comment |
|---|---|---|---|---|
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**APPENDICES**

Appendix A RTM modelling spreadsheet outputs (electronic)

Appendix B Example RTM spreadsheets (electronic)

# 1. BACKGROUND

Glan Llyn is a major residential and commercial development in Llanwern, South Wales, on the site of a former steelworks. Planning permission for the development includes planning conditions PC27 and PC28, which relate to the remediation strategy for the on-site soils and the validation of the remediation once achieved.

The initial risk assessment and remediation strategy report was produced by Atkins (2017) and this was subsequently updated by Rodgers Leask (2019-22), as described in Section 2. These documents have been accepted as satisfying PC27 for a number of development phases that are already completed or are currently being developed. Recent efforts to satisfy the requirements of PC28, which relate to the validation of the soil quality following remediation, for the protection of controlled waters, have been subject to considerable discussion with the regulator, NRW, and the planning authority, Newport City Council.

Recent meetings and discussion involving H Fraser Consulting Ltd (HFCL) resulted in agreement in principle on a revised approach to validation reporting, with regard to protection of controlled waters.

## 1.1 Objective

The objective of this report is to present the revised approach referred to above. This will provide a standard methodology and reference for all future phase validations and thus enable validation to proceed efficiently for all parties.

## 1.2 Scope of report

The report summarises the remediation work and validation at Glan Llyn to date (Section 2) and presents the updated approach and methodology (Section 3). Section 4 contains reference tables for contaminants of concern, to be applied to validation of soil quality in future validation reporting.

Additional planning conditions related to surface water are not part of the scope of this validation strategy.

This report considers only the elements of the remediation that relate to protection of controlled waters; elements of the remediation strategy that protect human health receptors (for example, placement of vapour membranes) are outside the scope of this report.

# 2 REMEDIATION WORKS AND VALIDATION TO DATE

## 2.1 Remediation strategy

The agreed remediation strategy and risk assessment for controlled waters at the site is detailed in Rodgers Leask (2019-22). The remediation strategy is briefly summarised here.

The remediation comprises excavation of Made Ground materials, removal of materials unsuitable for re-use in the development platform, and re-compaction of suitable Made Ground materials as an engineered fill. A drainage layer, formed as part of the normal construction phase, will then be installed above the engineered fill layer, to reduce infiltration to the Made Ground.

The Site has been divided into two strategies broadly responding to the division of the site between residential use and commercial use, referred to as the 'Full Turnover Specification' and the 'One Metre Turnover Specification'. The Full Turnover Specification comprises the excavation of Made Ground to a depth where the natural underlying Tidal Flat Deposits are exposed before a minimum of 2 m of suitable material is placed and reengineered. The One Meter Turnover Specification requires a trim and chase process excavating material to a depth minimum of 5.3 m aOD before approximately 2 m of suitable material is placed and reengineered to a formation level of 7.25 m aOD. Practical measures to identify, remove and validate the absence of gross contamination and known and potential obstructions extending below 5.3 m aOD shall be undertaken.

Several phases of trial pitting have been undertaken across the Site to assess and characterise the Made Ground for suitability for reuse. Material present within the proposed residential area that exceeds residential soil re-use values shall be transferred and re-used in the commercial phase of the development. Where material is not suitable for either a residential or commercial end use, the material will either be treated to allow re-use on site (at the supervising engineers discretion), or arrangements made for off-site disposal.

The remediation work and development are proceeding in phases as shown in Figure 2.1 for the residential area, and Figure 2.2 for the commercial area.




**Figure 2.1 Residential phases**

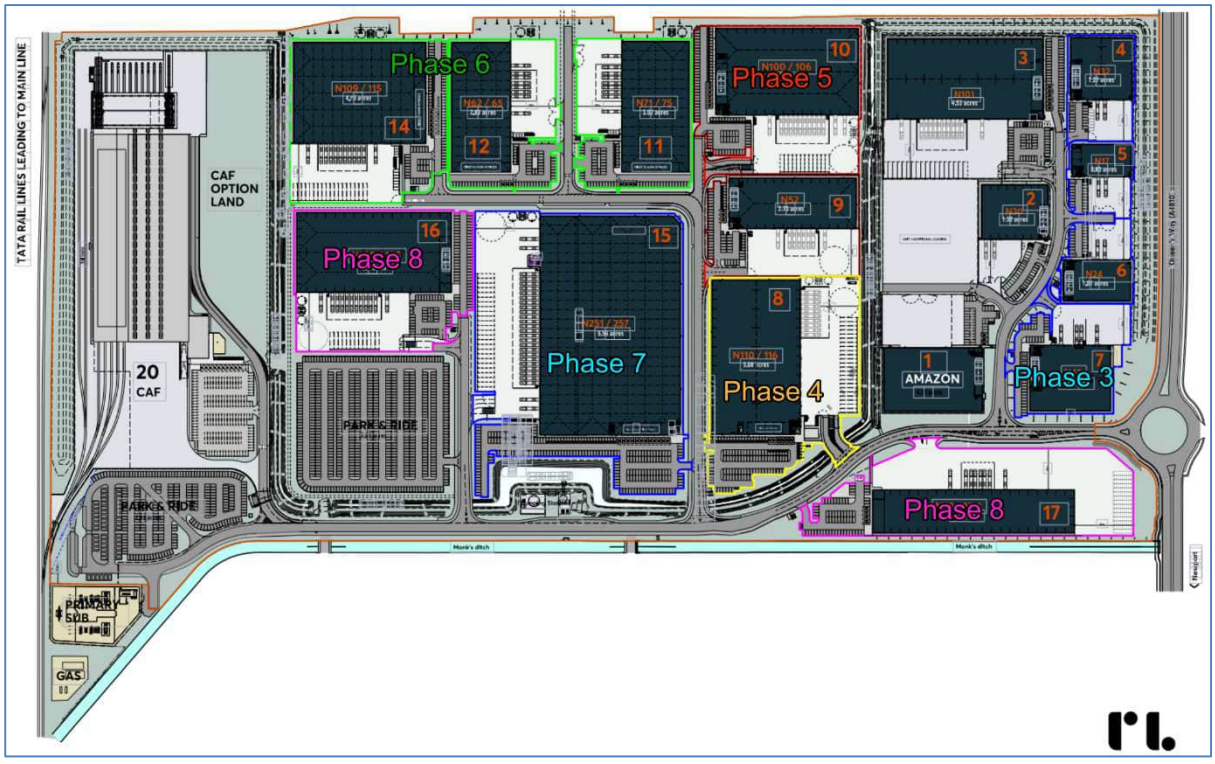



**Figure 2.2 Commercial phases**

Two planning conditions apply to the site remediation work.

- PC27 requires that, prior to commencement of each phase of development, a risk assessment, remediation strategy and verification plan are submitted to and approved in writing by the Local Authority.
- PC28 requires that prior to commencement of each phase of development (excluding works required for the remediation strategy) a verification report is submitted to and approved in writing by the Local Authority, to demonstrate completion of the remediation strategy and the effectiveness of the remediation.

The site is drained by a number of deep drainage ditches, referred to as reens. Soil re-use values (SRVs) for the protection of controlled waters were derived by Atkins and amended by Rodgers Leask, assuming the following conceptual model.

- 60% of the residential site surface and 95% of the commercial site surface is impermeable. 100% of incident rainfall on impermeable areas either evaporates or is routed via the drainage system directly to the reens.
- 40% of the residential site and 5% of the commercial site has soft landscaping. In these areas infiltration was calculated as 12.85 mm/a, by subtracting evapotranspiration and runoff from the total rainfall figure. Runoff from these areas also passes to the reens.
- 12.85 mm/a infiltrates the drainage layer overlying the engineered fill.
- In the soft landscaping areas, 60% of infiltration drains laterally through the drainage layer into a reen and does not enter the engineered fill.
- 40% of infiltration drains into the engineered fill and migrates through the fill to a reen, dissolving potential contaminants from the fill materials.
- The infiltration that travels through the fill is diluted on reaching the reens by runoff and infiltration through the drainage layer. The relative fluxes of water passing through the fill to clean runoff provides the dilution factor.
- SRVs are calculated by multiplying the Environmental Quality Standard (EQS) by the dilution factor and converting this water concentration into a soil concentration using a partition co-efficient.

This approach was set out originally by Atkins (2017), modified by Rogers Leask (2019-22) and approved by the Local Authority under discharge of PC27 for a number of development phases. The commercial area and the residential area have different remedial targets due to the different ratio of soft landscaping to hardstanding.

Soils re-use values (SRVs) were set out in Rogers Leask (2019-22). A minor update to correct an error in calculation for the residential area was provided by HFCL (2024). The SRVs are reproduced here in Table 2.1.

## Table 2.1 Agreed soil re-use values (SRVs)

| Determinand | Soil re-use values (mg/kg) | |
|---|---|---|
| | Commercial area | Residential area[1] |
| **Inorganic Metals and Metalloids** | | |
| Arsenic | 1.15E+4 | 2533 |
| Cadmium | 331 | 73.0 |
| Chromium | 4.27E+4 | 9431 |
| Copper | 2042 | 451 |
| Iron | 1.38E+6 | 3.05E+5 |
| Lead | 7.12E+4 | 1.57E+4 |
| Manganese | 1.51E+5 | 3.33E+4 |
| Mercury | 596 | 132 |
| Nickel | 5.21E+4 | 1.15E+4 |
| Selenium | 3178 | 702 |
| Vanadium | 7271 | 1606 |
| Zinc | 6.23E+5 | 1.38E+5 |
| **Other Inorganics** | | |
| Ammoniacal Nitrogen | 699 | 154 |
| Cyanide | 9.14 | 2.02 |
| **Organics** | | |
| Benzene | 17.2 | 3.80 |
| Toluene | 582 | 128 |
| Ethylbenzene | 364 | 80.0 |
| Xylene | 336 | 74.0 |
| Phenol | 13.8 | 3.05 |
| **TPH Criteria Working Group** | | |
| Aliphatics >C5-C6 | 331 | 73.0 |
| Aliphatics >C6-C8 | 1626 | 359 |
| Aliphatics >C8-C10 | 1.29E+4 | 2841 |
| Aliphatics >C10-C12 | 1.02E+5 | 2.25E+4 |
| Aliphatics >C12-C16 | 2.04E+6 | 4.50E+5 |
| Aliphatics >C16-C21 | 2.56E+8 | 5.66E+7 |
| Aliphatics >C21-C35 | 2.56E+8 | 5.66E+7 |
| Aliphatics >C35-C44 | 2.56E+8 | 5.66E+7 |
| Aromatics >EC5-EC7 | 38.5 | 8.51 |
| Aromatics >EC7-EC8 | 802 | 177 |
| Aromatics >EC8-EC10 | 650 | 144 |
| Aromatics >EC10-EC12 | 1027 | 227 |
| Aromatics >EC12-EC16 | 2043 | 451 |
| Aromatics >EC16-EC21 | 6447 | 1424 |
| Aromatics >EC21-EC35 | 5.12E+4 | 1.13E+4 |
| Aromatics >EC35-EC44 | 5.12E+4 | 1.13E+4 |
| Aromatics >EC40-EC44 | 5.12E+4 | 1.13E+4 |
| **Polyaromatic Hydrocarbons** | | |
| Acenaphthylene | 75.7 | 16.7 |

[1] Updated per H Fraser Consulting 2024; *30937 TN1D1 Glan Llyn, Llanwern: Soil Quality Verification*

| Determinand | Soil re-use values (mg/kg) | |
|---|---|---|
| | Commercial area | Residential area[1] |
| Acenaphthene | 135 | 30.0 |
| Anthracene | 155 | 34.0 |
| Benz(a)anthracene | 2748 | 607 |
| Benzo(a)pyrene | 156 | 34.0 |
| Benzo(b)fluoranthene | 15.5 | 3.42 |
| Benzo(k)fluoranthene | 22.9 | 5.05 |
| Benzo(g,h,i)perylene | 60.2 | 13.0 |
| Chrysene | 2812 | 621 |
| Dibenzo(a,h)anthracene | 3793 | 838 |
| Indeno(1,2,3-cd)pyrene | 115 | 25.0 |
| Fluoranthene | 30.1 | 6.64 |
| Fluorene | 123 | 27.0 |
| Naphthalene | 124 | 27.0 |
| Phenanthrene | 123 | 27.0 |
| Pyrene | 346 | 76.0 |

## 2.2 Remediation

Remediation has taken place in phases as shown in Figure 2.1 (residential) and Figure 2.2 (commercial). As of October 2024, remediation has been completed across the majority of the site. Remediation has been validated and approved for Phases 1 to 3 of the residential development and Phases 1 to 3 of the commercial development. These phases were remediated and validated under the site model, risk assessment and remediation strategy developed by Atkins (2017), and therefore had different validation requirements to Phase 4 onwards.

The remediation and verification work on each of the phases includes the following:

- Complete excavation of Made Ground materials to the underlying Tidal Flat Deposits in the residential areas and to a depth minimum of 5.3 m aOD in the commercial area;
- Screening and stockpiling of the excavated material;
- Sampling of stockpile materials;
- Removal of material unsuitable for use;
- Subdivision of the site into backfill zones, generally in a 25x25 m grid;
- Placement of engineered fill in 300 mm layers, zone by zone;
- Sampling of surface materials, post-placement, to provide additional verification data.

As noted in Section 2.1, material originating from the site that was unsuitable for use in the residential area was to be re-used on the commercial area (where agreed SRVs are higher) or, if necessary, removed from site. In practice, all excavated material was stockpiled and tested, and the above criterion applied. That is, if testing of stockpiled material showed it to be unsuitable for residential area backfill, it was moved to the commercial area or removed from the site, in accordance with the stipulations of the remediation strategy (Rodgers Leask, 2019-22).

Table 2.2 shows a summary of where each phase is in the remediation and verification process. Table 2.2 also indicates whether the planning conditions for each phase have been discharged, and whether this was in accordance with the Atkins remediation strategy (RS) or the Rogers Leask RS. Note that part of the residential area that was formerly a coking works has been remediated by

Vertase FLI Ltd (Vertase); HFCL has not reviewed the remediation strategy or soil re-use values for this part of the site. The coking works area includes parts of Phases 4A, 4B, 5A and 5D, as well as the proposed school.

### Table 2.2 Summary of phase progress

| Phase | Remediation works complete | Discharge of planning conditions * | |
|---|---|---|---|
| | | PC27 | PC28 |
| **Residential** | | | |
| Phase 1 | Yes | Atkins RS | Atkins RS |
| Phase 2 | Yes | Atkins RS | Atkins RS |
| Phase 3 | Yes | Atkins RS | Atkins RS |
| Coking works | Yes | Vertase | Pending |
| Phase 4A (compound) | Yes | RL RS / Vertase | Pending |
| Phase 4B | Yes | Pending | Pending |
| Phase 4C | Yes | RL RS | Pending |
| Phase 4D | Yes | RL RS, parts 1 and 2 | Pending |
| Phase 4E | Yes | Pending | Pending |
| Phase 4G | Yes | Pending | Pending |
| Phase 4H | Yes | RL RS | Pending |
| Phase 5A | Yes | Pending | Pending |
| Phase 5B | Yes | Pending | Pending |
| Phase 5G | Yes | Pending | Pending |
| Phase 5D | Yes | Pending | Pending |
| Phase 5E1 | Yes | RL RS | Pending |
| Phase 5E2 | Yes | Pending | Pending |
| Phase 5F | Ongoing | Pending | Pending |
| **Commercial** | | | |
| Phase 1 (Amazon) | Yes | Atkins RS | Atkins RS |
| Phase 2 (CAF) | Yes | Atkins RS | Atkins RS |
| Phase 3 (Units 4-7 ) | Yes | Atkins RS | Atkins RS |
| Phase 4 (Unit 8) | Yes | RL RS | Pending |
| Phase 5 (Units 9-10) | Yes | RL RS | Pending |
| Phase 6a (Units 11-14) | Yes | RL RS | Pending |
| Phase 6b (Units 15 and 16) | Yes | RL RS | Pending |
| Phase 7 (Park and Ride) | Yes | RL RS | Pending |
| Phase 8 (Unit 17) | Ongoing | Pending | Pending |

* "Pending" indicates that the application has not yet been made.

## 2.3 Soil testing and validation

Soil samples are taken from each stockpile and sent to an accredited laboratory for analysis of the soil re-use determinands as listed in Table 2.1. An average soil concentration is then obtained for each stockpile. During the placement of the engineering fill each 300 mm layer is taken from a specific stockpile. Each stockpile may be used for multiple layers in one backfill zone, or across

multiple zones. Rogers Leask maintains a materials management database, so that there is a record of the soil analytical results for each stockpile and which stockpile was used for each layer in each backfill zone. A variable number of layers is laid down in each zone to achieve the desired ground surface level.

Surface verification samples may be taken upon completion of the engineered fill placement, principally for validation of human health criteria rather than controlled waters.

All samples are sent to an accredited laboratory for analysis of the determinands listed in Table 2.1. It is assumed the surface verification samples are representative of the top 100 mm of soil, since they are taken using a trowel.

Hundreds of soil samples are relevant to each backfill zone, and these can be taken as a group to represent the quality of soils used in the remediation.

A database of all the soil analytical results for each phase is developed. This includes all the surface verification samples taken across the phase, and all soil samples from any stockpiles used in the engineered fill. The 95%ile of all the analytical results is compared to the soil re-use values. Any determinands where the 95%ile exceeds the SRV is taken forward as a Contaminant of Concern (CoC) for that phase.

## 2.4 Issues arising

During the remediation verification for Phase 4H (residential) and Phases 4 and 5 (Units 8-10, commercial) exceedances of the SRVs were identified for certain parameters in specific areas of backfill during the verification process. It was therefore not possible to validate the remediation in those cases. An updated approach was consequently developed which combined a more detailed statistical analysis and enhanced data presentation, supplemented where needed by contaminant transport modelling. Where data presentation was unable to show that a contaminant presented no risk, modelling was applied to predict the concentration that would reach the surface water receptors. This updated approach allows for advection, dispersion, retardation and decay that act to reduce contaminant concentrations along a transport pathway.

The approach was agreed with NRW for Phase 4H and Units 8-10. This report sets out a streamlined approach to applying the same methodology, which involves the derivation of zoned reference values for all identified contaminants of concern across the site. This updated methodology, which will be applied to verification of future phases, is described in detail in Section 3.

As long as a sufficient number of robust sample analyses is available to represent the backfill material in each phase, the updated approach can be used to provide appropriate validation against the agreed soil criteria, without the need for additional consideration of subsurface water quality within the fill.

The updated SRVs derived by Rodgers Leask depend on the existence of a drainage layer above the fill. The drainage layer needs to be composed of appropriate granular material and evidence of its installation layer will form part of the requirement for the discharge of PC28.

# 3 UPDATED APPROACH AND METHODOLOGY

The following methodology is recommended for the future phases going forward. This methodology has been developed following discussion with NRW and agreement on the principles to be followed. An overview of the process is given here first, with further clarification of each stage in the following sub-sections.

Distance-specific reference values have been derived using Remedial Targets Methodology spreadsheets (RTM, see Environment Agency, 2006) to model the attenuation of contaminants during transport in the saturated zone. This allows for advection, dispersion, retardation and decay that act to reduce contaminant concentrations along a transport pathway. Reference values have been tabulated for three different travel distances to the compliance point. Comparison of reference values against measured soil concentrations can then determine whether contaminants are expected to reach the receptors at unacceptable concentrations. Full details of the derivation of the reference tables are provided in Sections 3.1 to 3.3.

For each development phase, a screening exercise will be carried out on all the contaminants of concern identified in the site-wide RL Remediation Strategy, as described in Section 3.4. Contaminants of Concern (CoCs) for that phase will be defined as determinands for which the 95%ile of the analytical results from the fill materials exceeded the SRV. (This maintains consistency with previous validation reporting.) The remaining CoCs will then be moved forward for further assessment.

In this further assessment a thorough statistical and spatial analysis will be carried out on the stockpile verification samples for these contaminants. This will include a calculation of the Upper Confidence Limit of the mean (UCLmean) for each backfill zone across the Phase (see Section 3.4). The UCLmean for each backfill area will then be compared to the tabulated reference values.

## 3.1 Development of reference tables

The agreed SRVs (Rodgers Leask, 2019-22) were calculated assuming that water infiltrates the engineered fill and travels to a reen, where it is then diluted in the volume of runoff across the site. The calculation only allows for dilution in the reen and does not allow for transport processes such as advection, dispersion, retardation and decay that act to reduce contaminant concentrations along a transport pathway. The site drainage strategy (Rodgers Leask, 2017) requires that a minimum depth of 300 mm of water always remains in the reens. This serves various purposes including dilution of groundwater from the Made Ground.

New reference values have now been derived using RTM spreadsheets to model the attenuation of contaminants during transport in the saturated zone. This allows for advection, dispersion, retardation and decay that act to reduce contaminant concentrations along a transport pathway.

Generic modelling reference tables are developed, so that modelling is not required for each individual phase. Instead, the concentration for each CoC in each backfill zone can be checked against the reference tables. Reference values in the tables are given for three specific distances (12.5 m, 37.5 m and 62.5 m)[2].

[2] 12.5 m was selected because it represents the half of the distance across a standard remediation grid square. Grid squares measure 25 m square and were used across most of the Glan Llyn site as backfill zones. 37.5 m represents the distance across one and a half grid squares, i.e. the travel distance from a backfill zone that is one removed from the

The RTM has been used to assess the attenuation of contaminant concentrations through the engineered fill. To do this a 'Level 3' groundwater assessment has been undertaken as follows.

- The target concentration at the compliance point is taken to be the pore water concentration in equilibrium with the previously calculated SRV (Table 2.1). This is representative of the groundwater concentration before dilution at the point of discharge into the reen.
- The source area has been taken as the area of a standard backfill zone (25 m by 25 m).
- A time period of 1,000 years has been used.[3]
- The reference value is calculated as the target soil concentration in equilibrium with the groundwater remedial target taken from the RTM Level 3 groundwater assessment.

Equivalent pore water concentrations for a given soil concentration, and vice versa, are calculated using the equation below.

$$C_p = \frac{C_s}{\left(K_d + \frac{\theta_w + \theta_a H}{\rho}\right)}$$

Where:

$C_s$ = soil concentration (mg/kg)
$C_p$ = pore water concentration (mg/l)
$K_d$ = soil-water partition coefficient (l/kg)
$\theta_w$ = water-filled soil porosity (fraction)
$\theta_a$ = air-filled soil porosity (fraction)
$\rho$ = bulk density (g/cm$^3$)
$H$ = Henry's Law constant (dimensionless)

## 3.2 Input parameters

The model input parameters are shown in Table 3.1 (general parameters) and Table 3.2 (contaminant-specific input parameters). The models were run with no degradation in the sorbed phase (i.e. degradation was only allowed in the dissolved phase), which is a conservative approach.

When considering contaminant degradation, a range of values is usually provided by reference books, dependent on conditions such as the redox state of the environment. In these cases we conservatively assumed the longest given half-life, which usually corresponds to anaerobic conditions.

In general, model input parameters were based on those adopted by Atkins in the earliest derivation of soil re-use values, to provide consistency with previous approaches.

reen. 62.5 m represents the distance across 2 and a half grid squares, i.e. the travel distance from a backfill zone that is two removed from the reen.

[3] One thousand years is considered to represent a reasonably conservative time scale for any impacts to become apparent, and to allow a proportionate approach to contaminants that sorb to the extent that travel times are very long, in accordance with section 5.5 of the Remedial Targets Methodology (Environment Agency, 2006).

### Table 3.1 General model parameters

| Input parameters | symbol | value | Unit | Source |
|---|---|---|---|---|
| Plume thickness at source | Sy | 1.98 | m | Table 2-2 Atkins |
| Saturated aquifer thickness | da | 2.1 | m | Table 2-2 Atkins |
| Bulk density of aquifer materials | r | 1.36 | $g/cm^3$ | Table 5-3 Atkins |
| Effective porosity of aquifer | n | 0.08 | fraction | Table 5.3.1 RL Remediation strategy |
| Water filled porosity | $\theta_w$ | 0.5 | fraction | Table 5-3 Atkins |
| Air filled porosity | $\theta_a$ | 0.0037 | fraction | Table 5-3 Atkins |
| Hydraulic gradient | i | 0.0133 | fraction | Table 5.3.1 RL Remediation strategy |
| Hydraulic conductivity of aquifer | K | 1.00E-06 | m/s | Hydraulic conductivity data given in RL, 2024[4] |
| Width of plume | $S_z$ | 25 | m | Size of backfill zone |
| Distance to compliance point | x | 12.5<br>37.5<br>62.5 | m | |
| Time since pollutant entered groundwater | t | 365,000 | days | 1,000 years |

[4] Rodgers Leask, 2024, Phase 4H, Glan Llyn, Newport, Chemical Validation Report draft. Similar values have been reported from Phase 4A compound and Units 8-10 in the Commercial area.

## Table 3.2 Contaminant-specific model parameters

| Determinand | Commercial RL Soil re-use criteria[1] | Residential RL Soil re-use criteria[2] | Henry's Law Constant (H)[3] | Soil Organic Carbon-Water Partitioning Coefficient (koc)[3] | Solid/Liquid Partition Coefficient (Kd)[3] | Half life[4] | Commercial Compliance Target | Residential Compliance Target |
|---|---|---|---|---|---|---|---|---|
| **Units** | **mg/kg** | **mg/kg** | **($cm^3/cm^3$)** | **(-)** | **l/kg** | **Days** | **mg/l** | **mg/l** |
| **Inorganic Metals and Metalloids** | | | | | | | | |
| Arsenic | 11,469 | 2,533 | 1 | - | 134 | 1.00E+99 | 85.352 | 18.851 |
| Cadmium | 331 | 73 | 1 | - | 776 | 1.00E+99 | 0.426 | 0.094 |
| Chromium | 42,699 | 9,431 | 1 | - | 5,336 | 1.00E+99 | 8.002 | 1.767 |
| Copper | 2,042 | 451 | 1 | - | 1,199 | 1.00E+99 | 1.703 | 0.376 |
| Iron | 1,379,516 | 304,690 | 1 | - | 810 | 1.00E+99 | 1,702.328 | 375.989 |
| Lead | 71,246 | 15,736 | 1 | - | 34,877 | 1.00E+99 | 2.043 | 0.451 |
| Manganese | 150,836 | 33,315 | 1 | - | 720 | 1.00E+99 | 209.386 | 46.247 |
| Mercury | 596 | 132 | 1 | - | 5,000 | 1.00E+99 | 0.119 | 0.026 |
| Nickel | 52,109 | 11,509 | 1 | - | 7,652 | 1.00E+99 | 6.810 | 1.504 |
| Selenium | 3,178 | 702 | 1 | - | 186 | 1.00E+99 | 17.051 | 3.767 |
| Vanadium | 7,271 | 1,606 | 1 | - | 213 | 1.00E+99 | 34.076 | 7.527 |
| Zinc | 622,690 | 137,532 | 1 | - | 33,558 | 1.00E+99 | 18.555 | 4.098 |
| **Other Inorganics** | | | | | | | | |
| Ammoniacal Nitrogen | 699 | 154 | 1 | - | 1 | 1,095[5] | 510.284 | 112.379 |
| Cyanide | 9 | 2 | 1 | - | 5 | 15[6] | 1.702 | 0.372 |
| **Organics** | | | | | | | | |
| Benzene | 17 | 4 | 0.182 | 27 | 1 | 720 | 17.081 | 3.769 |
| Toluene | 582 | 128 | 0.221 | 178 | 4 | 28 | 125.920 | 27.716 |
| Ethylbenzene | 364 | 80 | 0.300 | 432 | 10 | 228 | 34.051 | 7.492 |
| Xylene | 336 | 74 | 0.220 | 260 | 6 | 365 | 51.113 | 11.27 |

| Determinand | Commercial RL Soil re-use criteria[1] | Residential RL Soil re-use criteria[2] | Henry's Law Constant (H)[3] | Soil Organic Carbon-Water Partitioning Coefficient (koc)[3] | Solid/Liquid Partition Coefficient (Kd)[3] | Half life[4] | Commercial Compliance Target | Residential Compliance Target |
|---|---|---|---|---|---|---|---|---|
| **Units** | **mg/kg** | **mg/kg** | **($cm^3/cm^3$)** | **(-)** | **l/kg** | **Days** | **mg/l** | **mg/l** |
| Phenol | 14 | 3 | 0.000068 | 29 | 1 | 28 | 13.063 | 2.836 |
| **TPH Criteria Working Group** | | | | | | | | |
| TPH Aliphatic C5-C6 | 331 | 73 | 33 | 794 | 19 | 8 | 16.989 | 3.752 |
| TPH Aliphatic C6-C8 | 1,626 | 359 | 50 | 3,981 | 95 | 8 | 17.029 | 3.759 |
| TPH Aliphatic C8-C10 | 12,861 | 2,841 | 80 | 31,623 | 755 | 8 | 17.021 | 3.760 |
| TPH Aliphatic C10-C12 | 102,089 | 22,548 | 120 | 25,1189 | 5,996 | 365 | 17.024 | 3.760 |
| TPH Aliphatic C12-C16 | 2,036,743 | 449,851 | 520 | 501,1872 | 119,643 | 730 | 17.023 | 3.760 |
| TPH Aliphatic C16-C21 | 256,407,138 | 56,632,055 | 4,900 | 630,957,344 | 15,062,116 | 1.00E+99 | 17.023 | 3.760 |
| TPH Aliphatic C21-C35 | 256,407,138 | 56,632,055 | 4,900 | 630,957,344 | 15,062,116 | 1.00E+99 | 17.023 | 3.760 |
| TPH Aliphatic C35-C44 | 256,407,138 | 56,632,055 | 4,900 | 630,957,344 | 15,062,116 | 1.00E+99 | 17.023 | 3.760 |
| TPH Aromatic C5-C7 | 39 | 9 | 0.230 | 79 | 2 | 730 | 16.269 | 3.589 |
| TPH Aromatic C7-C8 | 802 | 177 | 0.270 | 251 | 6 | 28 | 125.878 | 27.79 |
| TPH Aromatic C8-C10 | 650 | 144 | 0.480 | 1,585 | 38 | 365 | 16.949 | 3.753 |
| TPH Aromatic C10-C12 | 1,027 | 227 | 0.140 | 2,512 | 60 | 258 | 17.013 | 3.760 |
| TPH Aromatic C12-C16 | 2,043 | 451 | 0.0500 | 5,012 | 120 | 800 | 16.973 | 3.747 |
| TPH Aromatic C16-C21 | 6,447 | 1,424 | 0.0100 | 15,849 | 378 | 120 | 17.039 | 3.764 |
| TPH Aromatic C21-C35 | 51,166 | 11,301 | 0.000670 | 125,893 | 3,005 | 1,059 | 17.025 | 3.760 |
| TPH Aromatic C35-C44 | 51,166 | 11,301 | 0.000670 | 125,893 | 3,005 | 1.00E+99 | 17.025 | 3.760 |
| TPH Aromatic C40-C44 | 51,166 | 11,301 | 0.000670 | 125,893 | 3,005 | 1.00E+99 | 17.025 | 3.760 |
| **Polyaromatic Hydrocarbons** | | | | | | | | |
| Acenaphthene | 76 | 17 | 0.00490 | 18,621 | 445 | 204 | 0.170 | 0.0375 |

| Determinand | Commercial RL Soil re-use criteria[1] | Residential RL Soil re-use criteria[2] | Henry's Law Constant (H)[3] | Soil Organic Carbon-Water Partitioning Coefficient (koc)[3] | Solid/Liquid Partition Coefficient (Kd)[3] | Half life[4] | Commercial Compliance Target | Residential Compliance Target |
|---|---|---|---|---|---|---|---|---|
| Units | mg/kg | mg/kg | ($cm^3/cm^3$) | (-) | l/kg | Days | mg/l | mg/l |
| Acenaphthylene | 135 | 30 | 0.00340 | 33,113 | 791 | 120 | 0.170 | 0.0379 |
| Anthracene | 155 | 34 | 0.00160 | 38,019 | 908 | 920 | 0.170 | 0.0374 |
| Benzo(a)anthracene | 2,748 | 607 | 0.000240 | 676,083 | 16,139 | 1,360 | 0.170 | 0.0376 |
| Benzo(a)pyrene | 156 | 34 | 0.0000190 | 426,580 | 10,183 | 2,120 | 0.0153 | 0.00334 |
| Benzo(b)fluoranthene | 15 | 3 | 0.000200 | 2,238,721 | 53,442 | 1,219 | 0.000289 | 0.0000636 |
| Benzo(k)fluoranthene | 23 | 5 | 0.0000340 | 3,311,311 | 79,047 | 4,280 | 0.000289 | 0.0000645 |
| Benzo(g,h,i)perylene | 60 | 13 | 0.0000300 | 8,709,636 | 207,915 | 1,300 | 0.000289 | 0.0000625 |
| Chrysene | 2,812 | 621 | 0.0000260 | 691,831 | 16,515 | 2,000 | 0.170 | 0.0376 |
| Di-benz(a,h)anthracene | 3,793 | 838 | 0.000000600 | 933,254 | 22,279 | 1,880 | 0.170 | 0.0376 |
| Indeno(1,2,3-cd)pyrene | 115 | 25 | 0.0000660 | 16,595,869 | 396,174 | 1,460 | 0.000289 | 0.0000631 |
| Fluoranthene | 30 | 7 | 0.000420 | 117,490 | 2,805 | 880 | 0.0107 | 0.00235 |
| Fluorene | 123 | 27 | 0.00320 | 30,200 | 721 | 120 | 0.170 | 0.0374 |
| Naphthalene | 124 | 27 | 0.0170 | 1,514 | 36 | 258 | 3.417 | 0.742 |
| Phenanthrene | 123 | 27 | 0.00130 | 30,200 | 721 | 402 | 0.170 | 0.0374 |
| Pyrene | 346 | 76 | 0.000370 | 85,114 | 2,032 | 3,796 | 0.170 | 0.0374 |

[1] Rodgers Leask (2019-22); [2] H Fraser Consulting (2024); [3] Rodgers Leask (2019-22), Appendix; [4] Howard et al. (1991); [5] Buss et al. (2004); [6] WFD UK Technical Advisory Group

## 3.3 Results

The RTM spreadsheet model can be applied to one contaminant and one transport distance at a time. With 59 contaminants and three distances, and different SRVs for the residential and commercial sites, the total number of models that were required for this report is therefore 354. The resulting reference values are given in Section 4. Appendix A provides the summarised outputs of the RTM assessments in more detail.

In both Section 4 and Appendix A, for each contaminant the remedial soil target is given at a distance of 12.5 m, 37.5 m, and 62.5 m from the compliance point. Two reference tables have been produced, one for the commercial site, and one for the residential site.

Some examples of the RTM spreadsheet calculations are provided electronically in Appendix B.

## 3.4 Statistical methodology

A summary of the general statistical methods referred to in the methodology is given here.

Box plots and histograms are used to present the range of data visually. Box plots show the minimum value of the data set, the range of data falling between the 25th and 75th percentile, the mean value and the maximum value. They are useful to visually assess whether the data points are evenly distributed throughout the range. Histograms show the data distributed by the number of data points within specific ranges and are useful for identifying the distribution of data across the range, and for identifying whether higher values are common or rare in the data set.

The 95th percentile of a dataset is the highest value in a set of data after removing the top 5% of values. Referred to in this report as the "95%ile".

For any data set, there is uncertainty associated with the estimate of the mean value; a conservative assessment of the mean value can be made by calculating a 95 % Upper Confidence Limit (UCL) in the mean. This will be done using Student's t-distribution method, which is appropriate for distributions with a small number of samples. The 95% upper confidence limit (UCL) is a probability statement that indicates a 95% confidence that the true population mean is less than or equal to the calculated UCL. This report refers to the 95% upper confidence limit in the mean value as "UCLmean".

For each 25x25 m backfill zone the UCLmean will be calculated by taking the average stockpile value for each 300 mm layer, and the average of any surface verification samples (taken from the top 100 mm) falling within that backfill zone. An overall weighted average and UCLmean will then be calculated for that whole soil profile in each backfill zone, with the layer and surface verification samples weighted by thickness (300 mm for each layer and 100 mm for the surface verification samples).

## 3.5 Summary of the approach

Generic modelling reference tables are developed in the next section, so that modelling is not required for each individual phase – rather the recorded values for each CoC can be checked against the reference tables.

Reference values in the tables are given for specific distances.

For each of the remaining site phases the following methodology will be implemented.

1. The 95%ile of all analytical results across the entire phase area (including stockpile and surface verification samples) will be calculated for all contaminants identified in the site-wide Remediation Strategy. These contaminants are as listed in Table 2.1.
2. The 95%ile value will be screened against the SRVs (Table 2.1). Any exceedances will be shortlisted as Contaminants of Concern (CoCs) for this phase and further assessment will be carried out.
3. Some CoCs are shown by the reference tables to have such slow travel times that they will not travel 12.5 m in the 1,000-year assessment period. These are marked "no impact" in the reference tables and they will be eliminated from the CoC shortlist.
4. For each remaining shortlisted CoC a thorough statistical and spatial analysis will be carried out. This will include the following:
    - Presentation of the entire data set as a box plot;
    - Presentation of the entire data set as a histogram; and
    - Spatial assessment of the data, with an average concentration and UCLmean concentration calculated for each 25x25 m backfill zone.
5. The UCLmean concentration for each 25x25 m backfill zone will be compared to the 12.5 m reference values. If any of the backfill zones exceed the reference values for 12.5 m, the UCLmean will be compared to the 37.5 m and the 62.5 m reference values tables as appropriate given the distance of the backfill zone from the nearest reen.

Table 4.1 and Table 4.2 in the following section set out the reference values for the residential and commercial parts of the site respectively. If any backfill zones are found to fail the relevant reference value checks, contingency actions will be required, as discussed in Section 3.6.

## 3.6 Contingency actions

Failure of backfilled soils to meet the appropriate reference values will require additional contingency action. Any such eventualities would need to be agreed on a case-by-case basis, since the appropriate actions may be different in each case.

The first contingency action would therefore be for the site owner to propose and for NRW to agree the appropriate work, given the specific circumstances of the failure. Appropriate works are likely to include one or more from the following list:

- further monitoring actions and additional soils testing to more closely define the soils in question;
- isolation of a volume of soils deemed to have failed the criteria;
- excavation and replacement of soils deemed to have failed the criteria; and
- installation of flow barriers (such as low permeability clays) to appropriately lengthen the flow pathway from such a source area to the reen system.

## 3.7 Validation of drainage layer

The Rogers Leask SRVs (and hence the new reference values in this report) were derived assuming that 60% of infiltration is intercepted by a drainage layer above the engineered fill. It is therefore important that the presence of a drainage layer comprising clean granular material (e.g. 6F5 or Type 1) is evidenced as follows:

- Materials import receipts including description of the materials
- Photographic evidence of the extent of the materials (e.g. aerial photographs)
- Photographic evidence of the type and depth of the materials on a 75 m x 75 m grid

The sequencing of site works is such that the drainage layer will be placed post-commencement of construction works, and will therefore need to be validated separately from the engineered fill materials.

## 3.8 Validation of hydraulic conductivity

The Rogers Leask SRVs assume that there is a sufficient contrast between the hydraulic conductivity of the drainage layer (high) and the engineered fill (low) that most of the infiltration travels laterally through the drainage layer. The calculations do not however specify a value for hydraulic conductivity. The reference values derived in this report assume a hydraulic conductivity of $1 \times 10^{-6}$ m/d or less for the engineered fill.

It is proposed that the hydraulic conductivity of the fill is validated by taking at least three hydraulic conductivity measurements per phase, with a guide density of one test per 6.25 ha.

## 3.9 Groundwater sampling

Provided that there are sufficient soil samples available to have confidence in the quality of the soils materials, it is not considered necessary to provide groundwater sampling data to support discharge of PC28. [5]

[5] Note that groundwater monitoring may be required to support an application to discharge PC29, or to support an application for an environmental permit to discharge water from the reens to the wider environment. However, that is outside the scope of this report and will be dealt with separately.

# 4 REFERENCE TABLES FOR CONTAMINANTS OF CONCERN

In these tables the reference values shown are for comparison with UCLMean calculated soil concentrations in backfill zones at Glan Llyn.

Where a cell shows "No impact", the RTM spreadsheet predicts that the contaminant will not travel the indicated distance within the modelled time frame. (Where this occurs it results from a combination of the slow groundwater velocity, the degradation of the contaminant and its retardation (sorption) within the fill material.)

Other cell values show the remedial target for soil, calculated by the spreadsheet to meet the agreed soil reuse value at the reen margin. Where a cell shows ">1E+06" this means that the remedial target calculated is greater than $10^6$ mg/kg, which cannot plausibly be reached.

## 4.1 Residential

**Table 4.1 Residential phase reference tables, by distance from reen**

| | Remedial Target (Residential) mg/kg | | |
|---|---|---|---|
| Contaminant | 12.5 m | 37.5 m | 62.5 m |
| **Metals and metalloids** | | | |
| Arsenic | >1E+06 | No impact | No impact |
| Cadmium | No impact | No impact | No impact |
| Chromium | No impact | No impact | No impact |
| Copper | No impact | No impact | No impact |
| Iron | No impact | No impact | No impact |
| Lead | No impact | No impact | No impact |
| Manganese | No impact | No impact | No impact |
| Mercury | No impact | No impact | No impact |
| Nickel | No impact | No impact | No impact |
| Selenium | >1E+06 | No impact | No impact |
| Vanadium | No impact | No impact | No impact |
| Zinc | No impact | No impact | No impact |
| **Other inorganics** | | | |
| Ammoniacal Nitrogen | 260.0 | 872.3 | 3,322 |
| Cyanide | >1E+06 | >1E+06 | >1E+06 |
| **Organics** | | | |
| Benzene | 8.271 | 40.68 | 207.7 |
| Ethylbenzene | 703.5 | 20,947 | 466,939 |
| Phenol | 109,647 | >1E+06 | >1E+06 |
| Toluene | >1E+06 | >1E+06 | >1E+06 |
| Xylene | 313.7 | 3,777 | 38,464 |
| **Petroleum hydrocarbons** | | | |
| TPH Aliphatic C5-C6 | >1E+06 | >1E+06 | >1E+06 |
| TPH Aliphatic C6-C8 | >1E+06 | >1E+06 | >1E+06 |
| TPH Aliphatic C8-C10 | No impact | No impact | No impact |
| TPH Aliphatic C10-C12 | No impact | No impact | No impact |
| TPH Aliphatic C12-C16 | No impact | No impact | No impact |
| TPH Aliphatic C16-C21 | No impact | No impact | No impact |
| TPH Aliphatic C21-C35 | No impact | No impact | No impact |

| Contaminant | Remedial Target (Residential) mg/kg | | |
|---|---|---|---|
| | 12.5 m | 37.5 m | 62.5 m |
| TPH Aliphatic C35-C44 | No impact | No impact | No impact |
| TPH Aromatic C5-C7 | 18.32 | 88.80 | 448.6 |
| TPH Aromatic C7-C8 | >1E+06 | >1E+06 | >1E+06 |
| TPH Aromatic C8-C10 | 1,558 | >1E+06 | >1E+06 |
| TPH Aromatic C10-C12 | 17,730 | >1E+06 | No impact |
| TPH Aromatic C12-C16 | >1E+06 | No impact | No impact |
| TPH Aromatic C16-C21 | No impact | No impact | No impact |
| TPH Aromatic C21-C35 | No impact | No impact | No impact |
| TPH Aromatic C35-C44 | No impact | No impact | No impact |
| TPH Aromatic C40-C44 | No impact | No impact | No impact |
| **Polyaromatic hydrocarbons** | | | |
| Acenaphthene | No impact | No impact | No impact |
| Acenaphthylene | No impact | No impact | No impact |
| Anthracene | No impact | No impact | No impact |
| Benzo(a)anthracene | No impact | No impact | No impact |
| Benzo(a)pyrene | No impact | No impact | No impact |
| Benzo(b)fluoranthene | No impact | No impact | No impact |
| Benzo(g,h,i)perylene | No impact | No impact | No impact |
| Benzo(k)fluoranthene | No impact | No impact | No impact |
| Chrysene | No impact | No impact | No impact |
| Di-benz(a,h)anthracene | No impact | No impact | No impact |
| Fluoranthene | No impact | No impact | No impact |
| Fluorene | No impact | No impact | No impact |
| Indeno(1,2,3-cd)pyrene | No impact | No impact | No impact |
| Naphthalene | 366.6 | 895,675 | >1E+06 |
| Phenanthrene | No impact | No impact | No impact |
| Pyrene | No impact | No impact | No impact |

## 4.2 Commercial

### Table 4.2 Commercial phase reference tables, by distance from reen

| Contaminant | Remedial Target (Commercial) mg/kg | | |
|---|---|---|---|
| | 12.5 m | 37.5 m | 62.5 m |
| **Metals and metalloids** | | | |
| Arsenic | >1E+06 | No impact | No impact |
| Cadmium | No impact | No impact | No impact |
| Chromium | No impact | No impact | No impact |
| Copper | No impact | No impact | No impact |
| Iron | No impact | No impact | No impact |
| Lead | No impact | No impact | No impact |
| Manganese | No impact | No impact | No impact |
| Mercury | No impact | No impact | No impact |
| Nickel | No impact | No impact | No impact |
| Selenium | >1E+06 | No impact | No impact |

| Contaminant | Remedial Target (Commercial) mg/kg | | |
|---|---|---|---|
| | 12.5 m | 37.5 m | 62.5 m |
| Vanadium | No impact | No impact | No impact |
| Zinc | No impact | No impact | No impact |
| **Other inorganics** | | | |
| Ammoniacal Nitrogen | 1,181 | 3,961 | 15,084 |
| Cyanide | >1E+06 | >1E+06 | >1E+06 |
| **Organics** | | | |
| Benzene | 37.48 | 184.3 | 941.3 |
| Toluene | >1E+06 | >1E+06 | >1E+06 |
| Ethylbenzene | 3,197 | 95,209 | >1E+06 |
| Xylene | 1,423 | 17,137 | 174,505 |
| Phenol | 504,959 | >1E+06 | >1E+06 |
| **Petroleum hydrocarbons** | | | |
| TPH Aliphatic C5-C6 | >1E+06 | >1E+06 | >1E+06 |
| TPH Aliphatic C6-C8 | >1E+06 | >1E+06 | >1E+06 |
| TPH Aliphatic C8-C10 | No impact | No impact | No impact |
| TPH Aliphatic C10-C12 | No impact | No impact | No impact |
| TPH Aliphatic C12-C16 | No impact | No impact | No impact |
| TPH Aliphatic C16-C21 | No impact | No impact | No impact |
| TPH Aliphatic C21-C35 | No impact | No impact | No impact |
| TPH Aliphatic C35-C44 | No impact | No impact | No impact |
| TPH Aromatic C5-C7 | 83.04 | 402.5 | 2,034 |
| TPH Aromatic C7-C8 | >1E+06 | >1E+06 | >1E+06 |
| TPH Aromatic C8-C10 | 7,035 | >1E+06 | >1E+06 |
| TPH Aromatic C10-C12 | 80,215 | >1E+06 | No impact |
| TPH Aromatic C12-C16 | >1E+06 | No impact | No impact |
| TPH Aromatic C16-C21 | No impact | No impact | No impact |
| TPH Aromatic C21-C35 | No impact | No impact | No impact |
| TPH Aromatic C35-C44 | No impact | No impact | No impact |
| TPH Aromatic C40-C44 | No impact | No impact | No impact |
| **Polyaromatic hydrocarbons** | | | |
| Acenaphthene | No impact | No impact | No impact |
| Acenaphthylene | No impact | No impact | No impact |
| Anthracene | No impact | No impact | No impact |
| Benzo(a)anthracene | No impact | No impact | No impact |
| Benzo(a)pyrene | No impact | No impact | No impact |
| Benzo(b)fluoranthene | No impact | No impact | No impact |
| Benzo(k)fluoranthene | No impact | No impact | No impact |
| Benzo(g,h,i)perylene | No impact | No impact | No impact |
| Chrysene | No impact | No impact | No impact |
| Di-benz(a,h)anthracene | No impact | No impact | No impact |
| Fluoranthene | No impact | No impact | No impact |
| Fluorene | No impact | No impact | No impact |
| Indeno(1,2,3-cd)pyrene | No impact | No impact | No impact |
| Naphthalene | 1,687 | >1E+06 | >1E+06 |
| Phenanthrene | No impact | No impact | No impact |

| Contaminant | Remedial Target (Commercial) mg/kg | | |
|---|---|---|---|
| | 12.5 m | 37.5 m | 62.5 m |
| Pyrene | No impact | No impact | No impact |

# 5 VALIDATION REPORT AND DISCHARGE OF PLANNING CONDITION 28

It is proposed that, for each Phase, the discharge of PC28 is split into two parts as follows.

## 5.1 Discharge of PC28 Part 1

A validation report is to be submitted to demonstrate the quality of the engineered fill materials to include:

- Description of remediation activities
- Summary of soil movements (tickets for import and export of materials to be provided if relevant)
- Presentation of soils validation data (laboratory certificates and summary tables)
- Screening against RL SRVs to identify CoCs
- Statistical assessment and screening against reference values for CoCs
- Presentation of hydraulic conductivity data for the engineered fill

## 5.2 Discharge of PC28 Part 2

A validation report is to be submitted to demonstrate the presence, thickness and nature of the drainage layer, to include:

- A description of the works undertaken
- Materials import receipts including description of the materials (typically 6F2 or Type 1 materials)
- Photographic evidence of the extent of the materials (e.g. aerial photographs)
- Photographic evidence of the type and depth of the materials on a 75 m x 75 m grid (or finer grid as appropriate for the size of the plot)

# 6 REFERENCES

Atkins, 2017, Glan Llyn, Llanwern: Llanwern Controlled Waters Detailed Quantitative Risk Assessment.

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Howard, PH, Boethling, RS, Jarvis, WF, Meylan, WM and Michalenko, EM, 1991. Handbook of environmental degradation rates.

Rodgers Leask, 2019-2022: Glan Llyn Llanwern Sitewide: Controlled Waters DQRA 2019 Update.

Rodgers Leask, 2017: Glan Llyn surface water drainage strategy.

# APPENDIX A

## RTM modelling spreadsheet outputs (electronic)

# APPENDIX B

## Example RTM spreadsheets (electronic)

# Appendix F – Remediation Strategy Addendum Information

# Technical Note

| | |
|---|---|
| **Project:** | P18-669 Glan Llyn, Newport |
| **Subject:** | CWDQRA Validation Plan |
| **Date:** | June 2022 |
| **Document Reference:** | 18669-RLL-22-XX-RP-O-0260 |
| **Prepared by** | Chris Wilson BSc (Hons) MCIWEM |
| **Reviewed by** | Howel Morris BSc (Hons) MSc CGeol FGS |

A site wide Remediation Strategy was submitted by Rodgers Leask Limited (RLL) in November 2021 for the Glan Llyn development in Newport pursuant to the sitewide discharge of part of condition 27 of the outline planning approval 06/0471. Natural Resources Wales (NRW) reviewed the strategy and the appended updated controlled water detailed quantitative risk assessment (CWDQRA). A meeting was held with NRW on 20th April 2022 and following the meeting RLL has prepared this CWDQRA validation plan to verify that material with contaminants of concern exceeding the criteria are placed at the appropriate distance from a surface water, to assess whether the hydraulic conductivity and the pore water chemical concentrations within the reengineered material are as assumed in the CWDQRA. This note provides the method to collect and assess the CWDQRA validation information as an addendum to the remediation strategy and also presents a number of points as a continency plan.

Contaminants of Concern Validation

The updated CWDQRA identified some exceedances for concentrations of contaminants of concern (CoC) in relation to a 20m compliance distance. A further assessment has shown material recording concentrations exceeding the 20m compliance criteria for the CoC is suitable when placed at a distance of greater than 30m from the compliance point. The phase specific validation report will show that material with CoC exceeding the 20m compliance criteria has been placed at a suitable distance i.e. greater than 30m.

Hydraulic Conductivity Validation

The updated CWDQRA recognises the benefits of excavating and reengineering the made ground on the permeability of the material. The earthworks validation report presents test results characterising the made ground and standard results for compaction and air voids validating that the compaction requirements have been achieved. It is considered helpful, as a line of evidence to support the poor drainage characterisation of the reengineered material, to undertake falling head tests, and where possible rising head tests, upon and within the reengineered material.

The formation falling head tests are to be undertaken using a cylinder to hold a head of water against the formation surface. Approximately 10 falling head tests will be undertaken per phase or a minimum of 1 test per 100m$^2$. Whilst the dimensions of the falling head test are not

complaint with BRE Soakaway test, the monitoring and assessment will be undertaken in accordance with the BRE. The standard dimensions of the BRE Soakaway test would damage the formation and potentially be influenced by the underlying clay.

The falling and rising head tests will be undertaken on the shallow monitoring wells installed, following the earthworks, in the reengineered made ground. Up to 8 shallow monitoring locations will be installed in each phase.

The CWDQRA describes the permeability of piling mat post construction. The validation report shall include, as part of the developer obligations, confirmation or verification of construction material/ piling mat with the suitable permeability characteristics in accordance with the CWDQRA & Remediation Strategy.

Pore Water Concentration Assessment

The updated DQCWRA assumed pore water concentrations as shown in Table 1.

**Table 1. Calculated Pore-water Concentrations for Contaminants of Concern (CoC) Modelled in P20 Remedial Target Worksheets**

| **Determinands** | **Calculated Porewater Concentrations (mg/l) based upon laboratory derived totals soil concentrations (mg/kg) and 1806 (No.) Soil Samples** | | |
|---|---|---|---|
| | Average | Upper 95 % Percentile | Maximum |
| Iron | 113.57 | 314.67 | 2949.27 |
| Manganese | 12.00 | 44.70 | 566.00 |
| Vanadium | 0.97 | 3.01 | 13.498 |
| Benzo(a)pyrene | 2.85E-4 | 0.00113 | 0.07 |
| Benzo(b)fluoranthene | 0.0767 | 0.28 | 20.77 |
| Naphthalene | 0.231 | 0.165 | 128.68 |

It is intended, as part of the validation, to then compare the field chemical concentrations with the pore water concentrations adopted within the CWDQRA. This will only be possible where perched water is encountered. Where water is present within the shallow monitoring wells the sample will be collected using a peristaltic (low flow) pump.

The monitoring locations, the positions of the formation surface tests falling head tests, the results and the assessment of the results will be presented in the validation report for each phase.

Following validation of the earthworks to achieve the formation surface, it is proposed that a limited number of monitoring wells are retained (approximately 30% or 3 per phase) or

installed in landscaping areas. The validation report for each phase will contain specific information on how this will be achieved. This will allow long-term monitoring of the perched water post construction and build on a sitewide dataset of perched water quality.

Contingency Plan

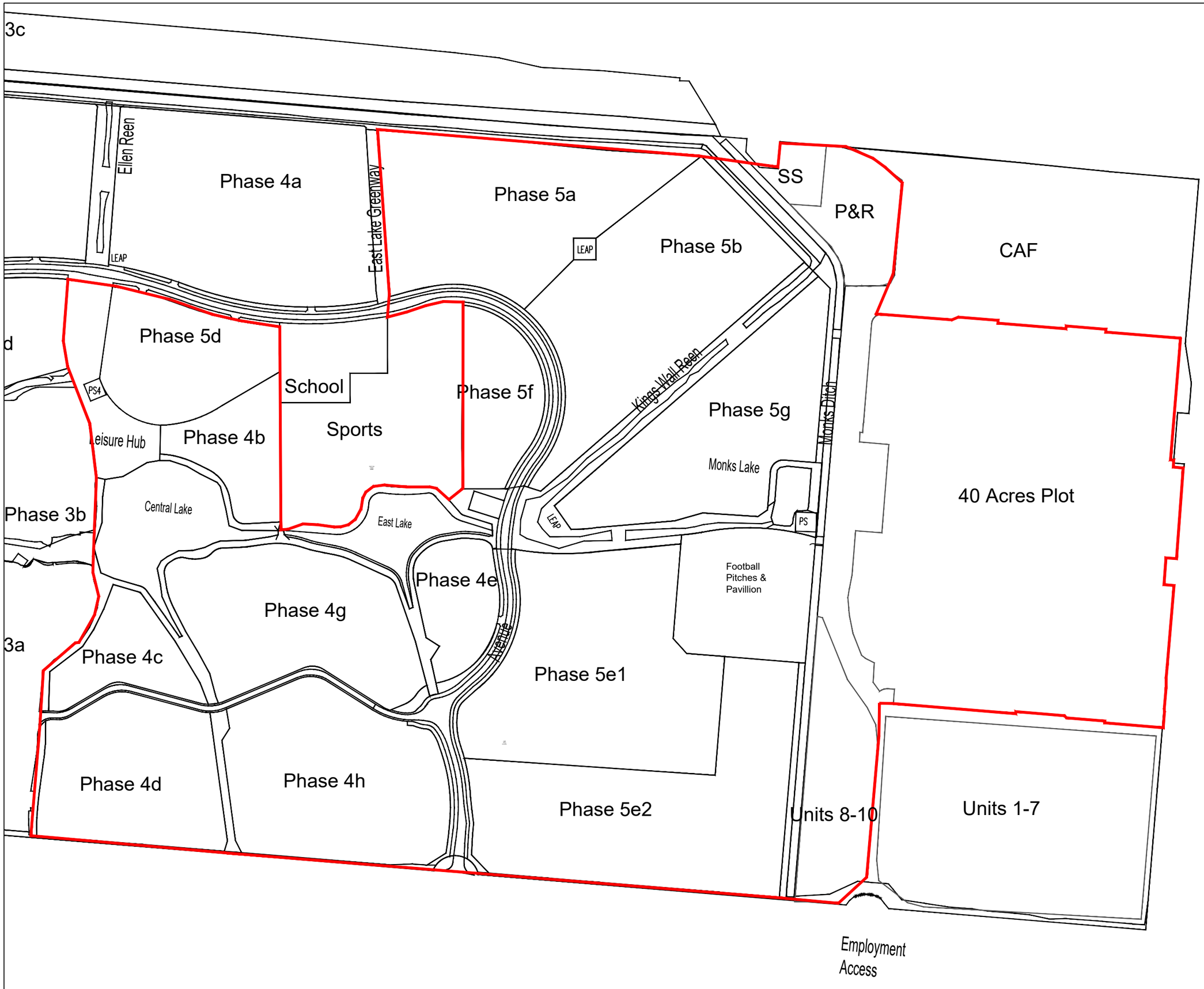
The validation assessment will also, where appropriate, compare results from adjacent phases and site wide monitoring results as part of the validation assessment. The creation of baseline set of data for the site, through the accumulation of results from individual phases, to support the maintenance of suitable site wide surface water quality. The comparison of phase specific information and sitewide information may also be used as contingency where soil concentrations exceed criteria or pore water concentrations exceed modelled parameters but monitoring indicates suitable sitewide conditions.

The CWDQRA also considers that there is a potential for natural attenuation benefits from further improving the existing surface water features on the site, which mainly comprise reens and ponds/small lakes. This is anticipated particularly through:

1. Further establishing the vegetation within the reens which will help reduce the concentrations of organic contaminants and particularly nutrients such as ammoniacal nitrogen. The reens are known to vegetate rapidly and require regular maintenance to remove surplus growth;

2. Undertaking organic matter enrichment of soils along margins of the reens and ponds/lakes into which water penetrating the Made Ground are likely to discharge. This could be undertaken by placement of locally excavated peat (obtained from Alluvial and underlying Tidal Flat Deposits) and other soils containing high concentrations of organic matter. This should enable a further stripping out of low concentrations of PAHs and TPH within these discharge waters. Amendment of these soils with other materials will also be considered, taking into consideration further knowledge of the residual contaminant profile, in order to provide a passive sustainable solution to the long-term remediation of this site.

The preliminary validation plan for Phase 4h is attached to this note as an example of the typical layout of post earthworks validation sampling and monitoring locations for a residential phase.




## GENERAL NOTES

NO DIMENSIONS TO BE SCALED OFF THIS DRAWING.

THIS DRAWING TO BE READ IN CONJUNCTION WITH ALL RELEVANT ARCHITECT'S AND ENGINEER'S DRAWINGS.

ALL DIMENSIONS ARE IN MILLIMETRES UNLESS NOTED OTHERWISE.

ALL LEVELS ARE IN METRES UNLESS NOTED OTHERWISE.

ANY DISCREPANCIES NOTED ON SITE ARE TO BE REPORTED TO THE ENGINEER IMMEDIATELY.

## KEY:

- REMEDIATION STRATEGY BOUNDARY
- PHASE BOUNDARIES

| Rev | Date | Amendments | By | Chk |
|---|---|---|---|---|
| A | 03:05:22 | Updated Boundary | SR | CW |

Client

St Modwen Developments

Project

P18-669 Llanwern Reclamation

Drawing Title

Remediation Strategy Boundary Plan

INFORMATION

| | Drawn | Checked | Date |
|---|---|---|---|
| NTS | SR | CW | 27.04.22 |

Drawing No. — Rev.

18669-RLL-22-XX-DR-O-0262 A

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4H-SV19
4H WS02
4H FH2
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4H WS03
4H-SV13
4H-SV20
4H FH3
4H-SV8
4H-SV21
4H WS08
4H-SV14
4H-SV15
4H FH4
4H WS04
4H WS01
4H-SV11
4H-SV7
4H FH5
4H FH6
4H-SV4
4H-SV3
4H-SV10
4H-SV16
4H-SV18
4H FH7
4H-SV6
4H-SV2
4H WS05
4H FH8
4H-SV1
4H-SV17
4H WS06
4H FH9
BHCP10
4H WS07
4H-SV5
4H-SV9

## GENERAL NOTES

NO DIMENSIONS TO BE SCALED OFF THIS DRAWING.

THIS DRAWING TO BE READ IN CONJUNCTION WITH ALL RELEVANT ARCHITECT'S AND ENGINEER'S DRAWINGS.

ALL DIMENSIONS ARE IN MILLIMETRES UNLESS NOTED OTHERWISE.

ALL LEVELS ARE IN METRES UNLESS NOTED OTHERWISE.

ANY DISCREPANCIES NOTED ON SITE ARE TO BE REPORTED TO THE ENGINEER IMMEDIATELY.

## KEY:

4H-SV **SURFACE VALIDATION CHEMICAL SAMPLE LOCATION**

4H WS08 **WINDOW SAMPLE LOCATION FOR GAS AND PERCHED WATER MONITORING**

4H FH3 **FALLING HEAD TEST LOCATION**

| Rev | Date | Amendments | By | Chk |
|---|---|---|---|---|

RLRE

Client

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Project

P18-669 Llanwern Reclamation

Drawing Title

Phase 4H Validation Plan

INFORMATION

| | Drawn | Checked | Date |
|---|---|---|---|
| NTS | SR | CW | 27.04.22 |

Drawing No. Rev.

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# Technical Note

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| **Project:** | P18-669 Glan Llyn, Newport |
| **Subject:** | Remediation Strategy Addendum Information |
| **Date:** | January 2022 |
| **Document Reference:** | 18669-RLL-22-XX-RP-O-0192 |
| **Prepared by** | Chris Wilson BSc (Hons) MCIWEM |
| **Reviewed by** | Howel Morris BSc (Hons) MSc CGeol FGS |

A site wide Remediation Strategy was submitted by Rodgers Leask Limited (RLL) in November 2021 for the Glan Llyn development in Newport pursuant to the discharge of condition 27 of outline planning approval 06/0471. The Senior Scientific Officer (Steve Manning) at Newport City Council (NCC) reviewed and provided a response. This note provides addendum information to the Remediation Strategy following correspondence with the Senior Scientific Officer. The paragraphs numbered below relate to the points raised by NCC and discussed in the correspondence between NCC and RLL (Technical Note 187), presented in **Appendix A**.

1. Pictorial versions of the earthworks process intended to enhance the conceptual site model (CSM) for the residential and commercial parts of the development have been prepared and are presented in **Drawings**. The Made Ground in the residential areas will be cleared to the natural underlaying clay before placement of suitable material from within the phase and from pre validated stockpiles to achieve the required formation level. Photographs of the process are inserted. The commercial area will undergo an excavation/ trim to 2m below formation level with obstructions and unsuitable material removed to natural clay before suitable material from the trim exercise and the residential site is re-engineered to achieve formation level.

*2.* The removal of unsuitable material from the residential phases and the turnover and placement of retained suitable Made Ground in 300mm layers is intended reduce the contamination risks (Phase 4h – vapour) by thinly spreading and compacting source material to improve consistency and reduce permeability. Monitoring (chemical surface validation sampling, gas monitoring and, where appropriate, vapour monitoring in each residential phase) will be undertaken following the remedial earthworks to assess the remediated condition and the contamination status of the formation surface. The Validation Report (submitted pursuant to the approval of NCC & partial discharge of planning condition 28) will recommended appropriate mitigation measures, if required, in addition to the clean cover as part of the listed developer actions.

3. The post remedial earthworks formation in residential areas will undergo chemical sampling (greater than 1 per 50m$^2$) in addition to the pre-remediation testing to comply with the recommended testing frequency but also provide information to assess the contamination status of the formation surface as recommended by NCC. The surface contamination status,

in addition to earthworks validation, will be assessed to recommend the form of mitigation measures in addition to the clean cover.

4. A clean cover provision of 600mm in landscape areas is accepted. The landscape areas will also undergo formation surface chemical sampling to assess the contamination status and whether mitigation measures are required in addition to 600mm of clean cover.

5. The trim and chase strategy (also referred to as the 1m turnover) within the Remediation Strategy applies only to the central business park. The business park will have the benefit of at least 2m of re-engineered material underlying the construction material before the hardstanding or floor slabs area constructed. This is presented in the commercial area pictorial earthworks CSM (**Drawings**). The re-engineered material will have a reduced permeability in comparison with undisturbed in situ Made Ground and the hydraulic gradient would likely be away from the engineered material towards the undisturbed Made Ground. The hydraulic gradient would protect the engineered profile.

6. The Validation Report for each phase includes a section on the developer actions. The actions typically comprise the provision of clean cover and gas protection measures. The final form of the developer actions are to be confirmed following the post remedial works monitoring and validation sampling.

General Items

It is noted that the LPA and the project team await the comments from Natural Resources Wales (NRW) regarding the controlled waters.

The NRW and NCC have accepted an invite to attend site on 26th January 2022.

It is hoped that a greater understanding of the proposed Remediation Strategy has been provided in the correspondence. It is understood that the potential mitigation measures (to break pathways) will be reviewed following the assessment of the contamination status of the surface formation. This will comprise chemical sampling of the formation surface, shallow gas monitoring of the phase and, where appropriate, vapour monitoring.

# Llanwern Residential Phases, Conceptual Site Model

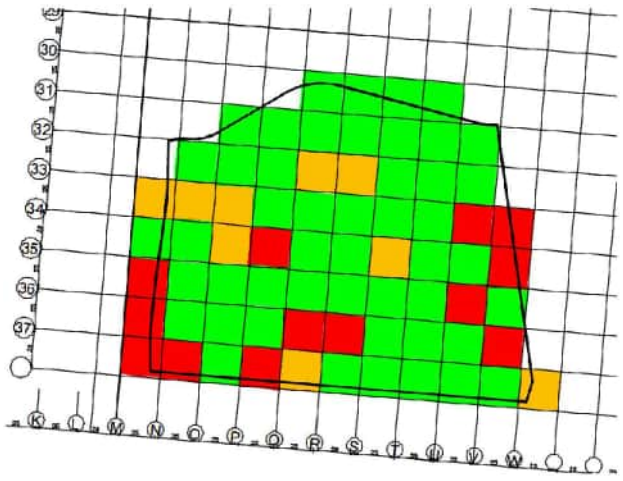
## 1. Pre-Reclamation Sampling Exercise

Chemical assessment undertaken on in-situ made ground and stockpiled material. Sampling across a 25m grid identifies chemically unsuitable material within phase.

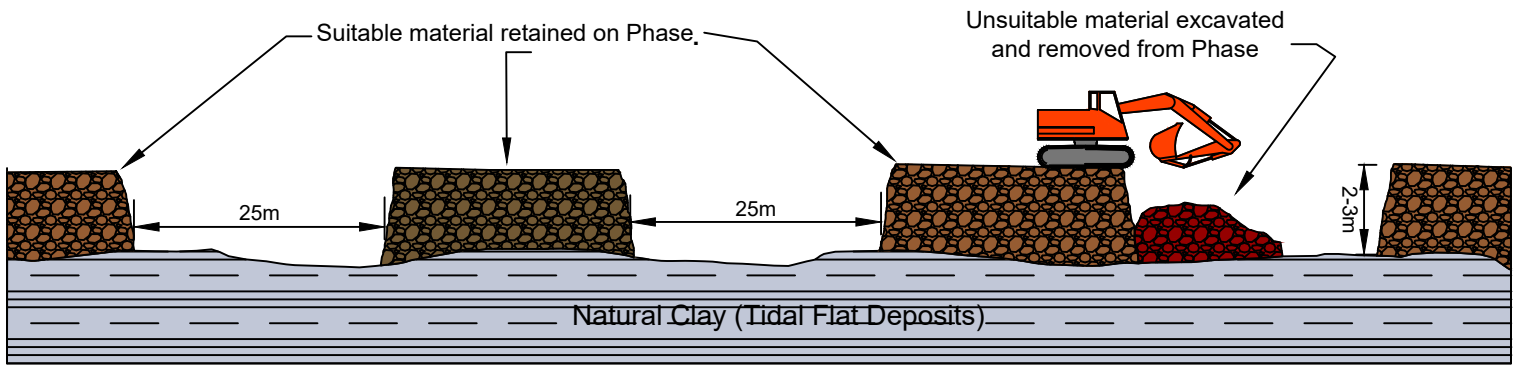
Made Ground to be excavated to natural Clay and removed for treatment or re-use on commercial area.

Potential for re-use within plot following turnover.

Made Ground to be turned over for re use within plot.

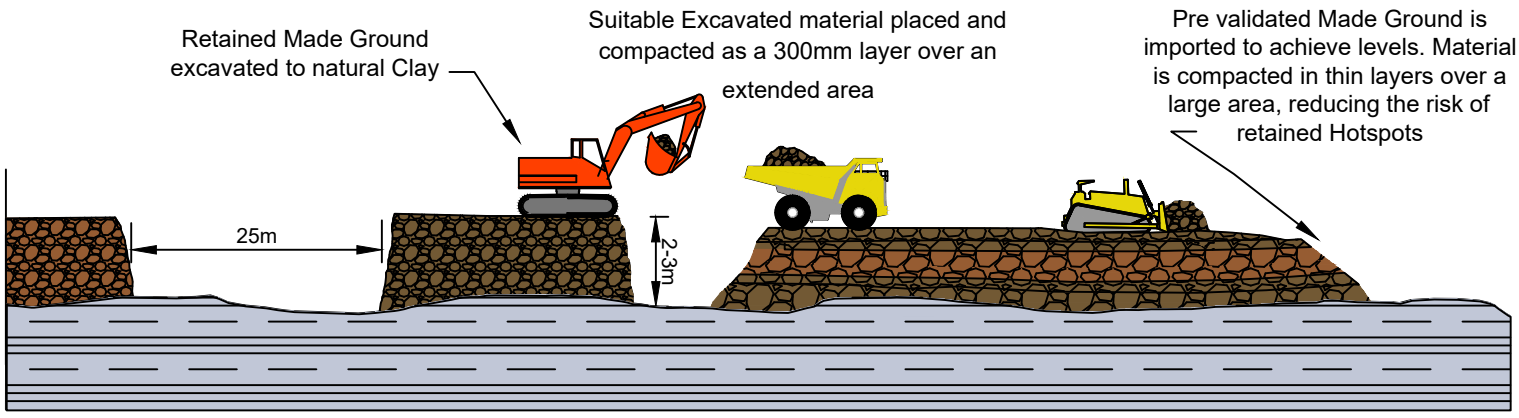


## 2. Unsuitable material removed from Site. Phase ready for turnover.



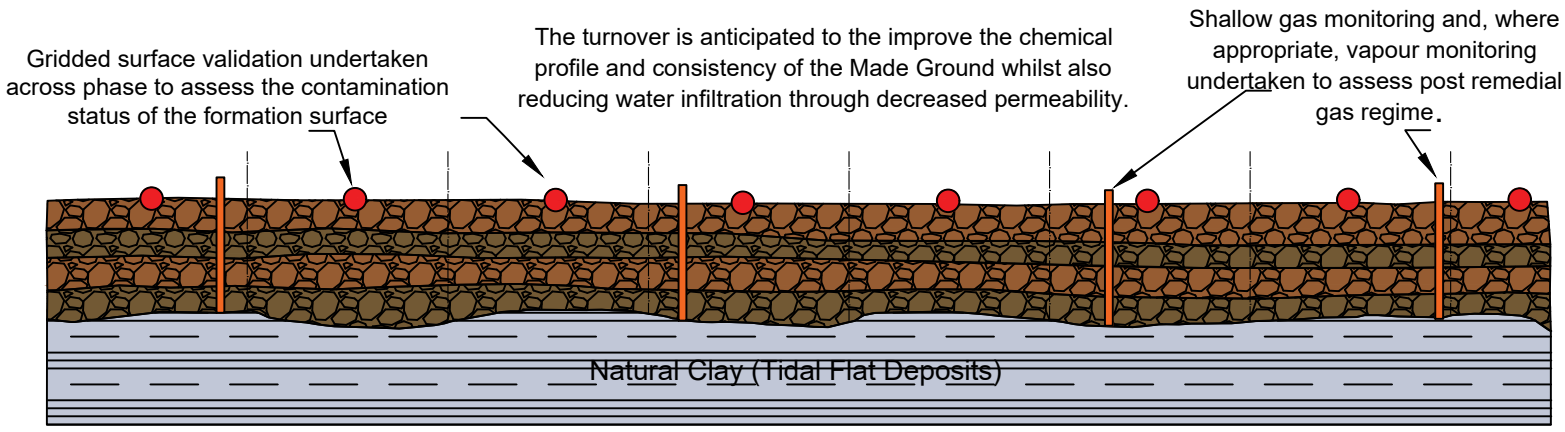



## 3. Turnover Exercise



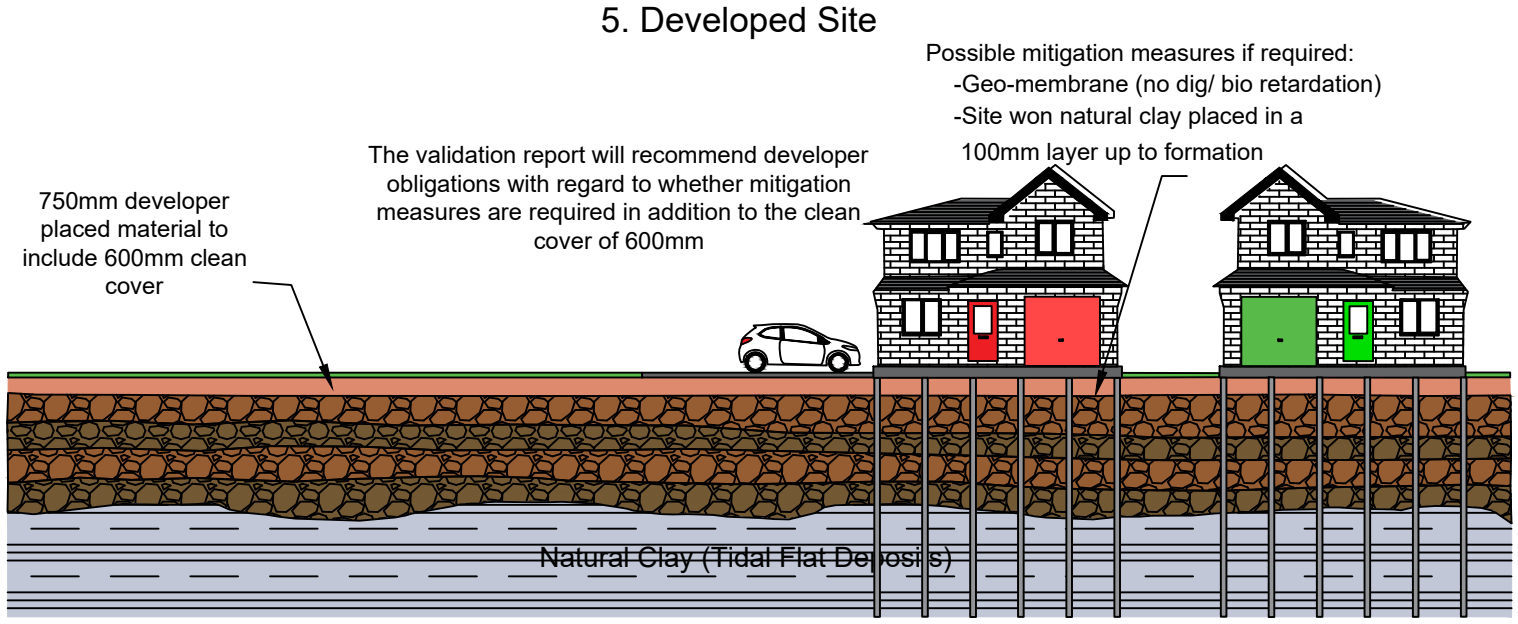



## 4. Post Earthworks Additional Surface Validation





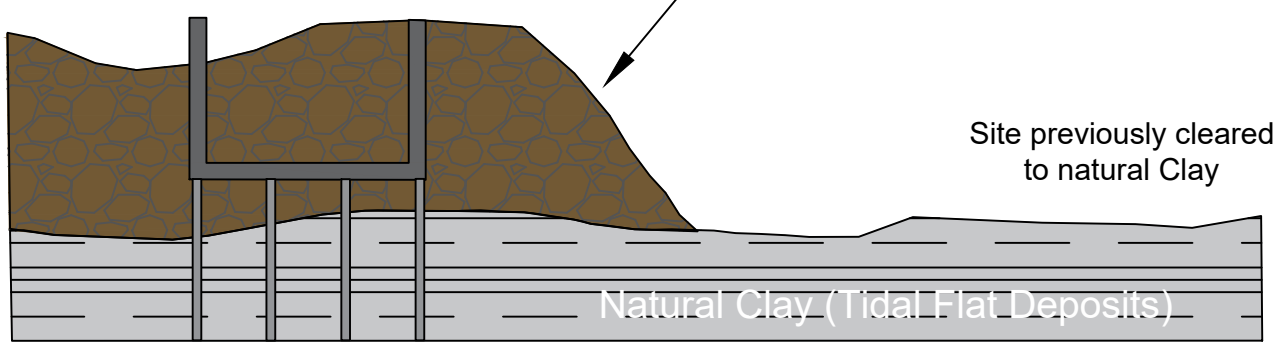

## 5. Developed Site






# Llanwern Business Park, Conceptual Site Model

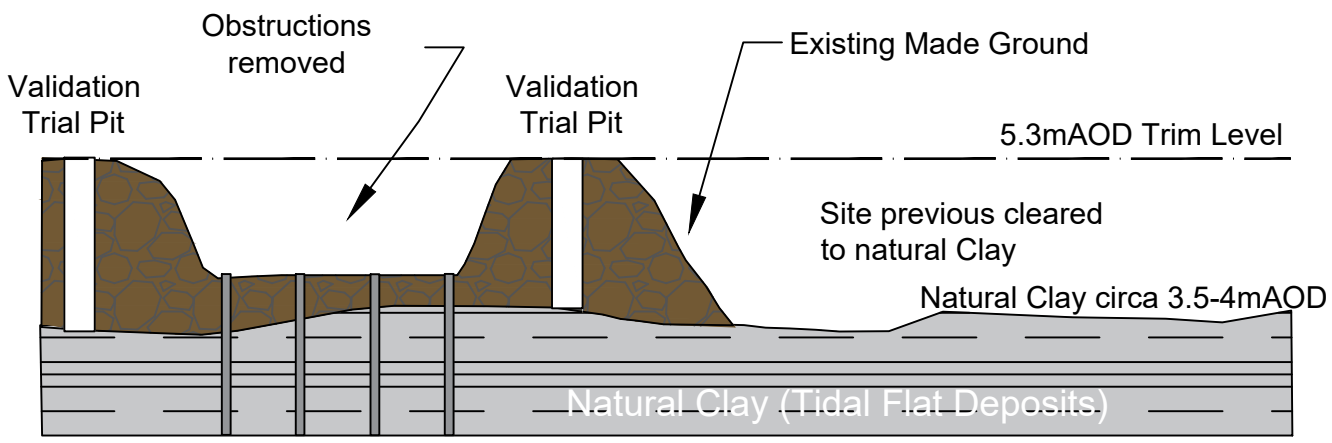
## 1. Site Pre-Trim




Exploratory Hole Location Plan



## 2. Site Trimmed to 5.3mAOD and obstructions removed

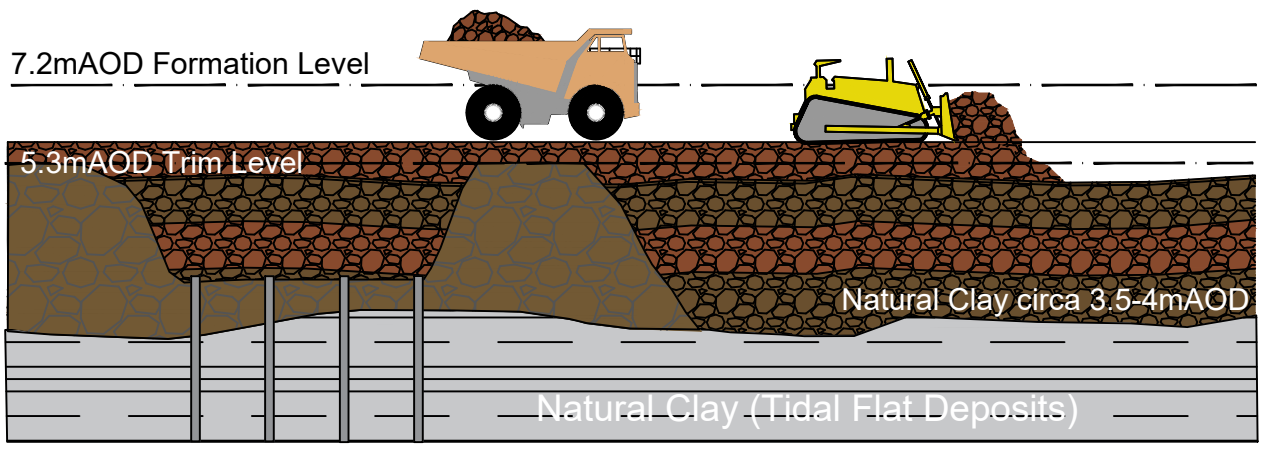





## 3. Fill engineered across site to formation level.

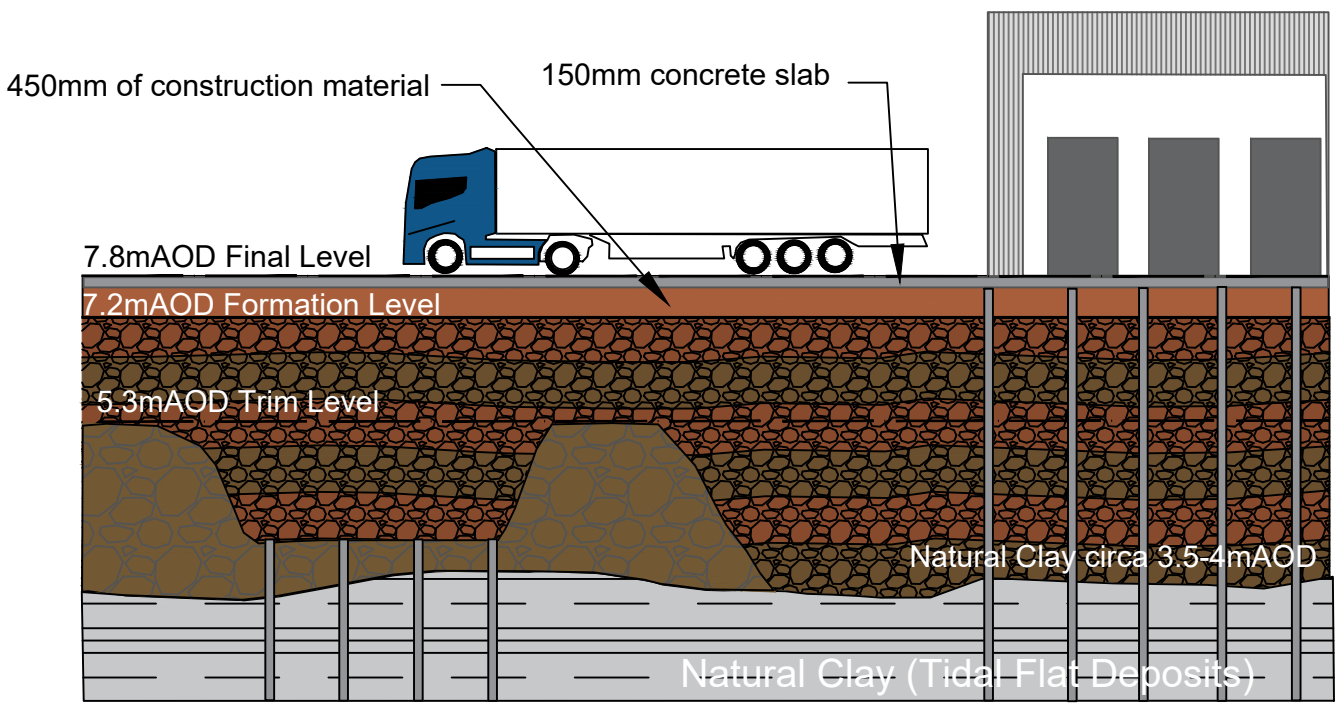
Suitable material from the trim exercise and material from the residential site placed and compacted as a 300mm layer over an extended area

Made Ground is imported to achieve levels. Material is compacted in thin layers over a large area, reducing the risk of retained Hotspots






## 3. Developed Site Including 0.6m of clean cover material






# Appendix A – TN187, LPA Comments

# Technical Note

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| **Project:** | P18-669 Glan Llyn, Newport |
| **Subject:** | Phase 4h Response to LPA Comments |
| **Date:** | December 2021 |
| **Document Reference:** | 18669-RLE-21-XX-RP-O-0187 |
| **Prepared by** | Chris Wilson BSc (Hons) MCIWEM |
| **Reviewed by** | Howel Morris BSc (Hons) MSc CGeol FGS |

It is worth stating that all made ground will be removed and only suitable material will be used in the formation of the plot. The Phase II report for Phase 4h reports the pre remediation conditions and all of the made ground will have been excavated to a validated natural clay. The full turnover of the made ground is exceptional and hugely conservative as it allows for the visual and olfactory assessment of all of the made ground in addition to chemical assessment. Approximately 40% of the made ground from Phase 4h has already been removed and stockpiled for treatment or reuse in the commercial area.

Comments:

*1. Detailed cut and fill/reuse drawings for all areas requiring remediation are sought so that extents and depths can be better understood prior to works.*

*The site will have all unsuitable made ground removed and the remaining made ground assessed as suitable for retention will be turned over to the underlying natural clay. The removal or turnover of all of the made ground is a conservative approach where 100% of the made ground is excavated. A normal ground investigation would cover less than 1% of the material and therefore there is confidence in the consistency and suitability of the material. The natural clay will be sampled as a part of the validation testing. A base of excavation drawing showing the surface of the natural deposits and relevant validation information will be provided within the validation report.* Is there an existing drawing which confirms this conceptually ? it is important NCC has a clear picture of what is intended as well as what is done.

*2. Will the removal of contaminated material be sufficient to remove the vapour pathway for hydrocarbons into dwellings/garden areas ? Yes, although as a precaution we will undertake vapour monitoring post earthworks. The CSM in appendix D makes no reference to this. a vapour pathways will remain after made ground remediation then full protection of dwellings, services and garden areas needs to be considered for the benefit of future developers and the onward developer documentation trail. It is noted that a post remedial vapour assessment is proposed however this pathway needs to be included in the CSM for completeness. Accepted, we will update the CSM as an addendum to the report.* Both items in red text are supported.

*3. The Reuse Criteria for 40% Infiltration of Incident Rainfall into Engineered Made Ground are noted and cause concern given their high levels at a what will be depth of only 600mm below residential gardens. Engineered cover systems appear to be warranted and not simple cover systems; in view of significantly elevated levels that will exist below cover. The*

*earthworks will provide an engineered difficult dig layer of low permeability which will be validated to assess compliance with the earthworks specification. The formation created would prove a difficult dig for a JCB even without the 600mm above.* This aspect is noted however it is the contamination status of the final formations surface that will dictate the degree to which additional separation from domestic digging activity contact is required through engineered cover. *The use of a semi permeable or impermeable membrane incorporating a bright orange geomembrane should be considered as part of engineered cover to deter against digging beneath clean material – a combined anti-dig/capillary break layer should also be considered as part of the remedial approach for final development. This is considered necessary to prevent both the upward migration of any contamination into cover systems and contact with material beneath them. The use of a 'Bentomat' type system (geotextiles with bentonite clay layer) to prevent infiltration may be warranted in this situation given the nature of contaminated material being proposed for reuse beneath cover and proposals regarding this are sought. Although 600mm is specified in the remediation strategy the formation level is set 750mm below the final ground level. Could the proposed developer actions regarding cover be recommended following review of the validation report. It is anticipated that the average concentrations will be well below the proposed thresholds. The remedial criteria is based on an average approach and the complete removal of made ground across the plot with placement of validated site won made ground. The turnover of the made ground will cause improvement of the material, where the organic concentrations are likely to be reduced, from the pre remediated state reported in the phase II report. The post remedial conditions are designed to be much improved and we can provide an isopachyte of concentrations to assist in zoning the site should enhanced protection measure be required.* This appears to be a suitably pragmatic approach to specifying final developer cover and must take the form of an engineered cover system design with detailed drawings so that requirements are clear to all when available.

*4. The proposed cover of only 300mm in landscaped areas does not appear sufficient given the level of contamination that will remain as a result of the proposed Reuse Criteria for 40% Infiltration of Incident Rainfall into Engineered Made Ground. Either the reuse levels are made more conservative given the level of proposed cover ; or the level of cover is increased to a minimum of 600mm. 600mm is likely to be acceptable.* 600mm will be accepted as suggested subject to its engineered nature. *Incorporation of the features in 3 above would be relevant in landscaped areas also for any thickness of cover. The reengineered ground is likely to be provide a sufficient no dig barrier.* This aspect is noted however it is the contamination status of the final formations surface that will dictate the degree to which additional separation from domestic digging activity contact is required through engineered features.

*5. It is not clear whether the one metre turn over specification will prevent any lateral movement of contaminants into regions that have had the full turnover applied of full turn over ? The 1m turnover applies to the central business park where the interception of rainfall is >90% when the site is developed and the proposed levels are to be raised providing at least 2m of low permeability reengineered material above the base of excavation. The remediation strategy proposed by RLE recommends full turnover in the residential areas. Where this meets the remediation strategy proposed by Vertase FLI, the full depth of reengineered made ground would retard migration from the 1m turnover strategy. or what the significance of this would be? Graphical illustration of how this will work between areas of the two specifications is sought. If there is any risk of migration from one meter turnover regions into full turnover regions then an approach where all regions undergo full turnover may be worth considering ? This has been assessed as part of the CWRA, appended to the remediation strategy, the hydraulic gradient would suggest that the direction of migration would be from the engineered material to the non engineered material. Thus protecting the fully engineered profile. However the likely volume of perched water will be reduced due to*

*the reduced permeability of the engineered profile.* This aspect is noted and may require further consideration by NRW – copied in for comment.

*6. Onward developer action documentation needs to be provided in advance of any developers being in the frame; and the format of this is sought at this stage. A general developer actions list can be provided. The actions typically comprise the provision of clean cover and gas protection measures.* Accepted that a draft format may be all that is possible at this stage in view of finalising developer engineered cover design further to validation of this first remedial phase.

*It is important that the LPA obtain comments from NRW in respect of this site as controlled waters are clearly a sensitive receptor and Reuse Criteria for 40% Infiltration of Incident Rainfall into Engineered Made Ground are concerningly high. The strategy is intended to deliver an acceptable water quality into the surface waters by turning over the made ground and creating a consistent low permeability, 2m thick, engineered material. This is intended inhibit the percolation of rainwater into the made ground. The compaction also reduces the ability to disturb the made ground without the use of heavy mechanical means.* This aspect is noted however it is the contamination status of the final formations surface that will dictate the degree to which additional separation from end user digging activity contact is required.

*I am not at present reassured that the human health pathway will be sufficiently mitigated at both made ground remedial and developer remedial stages and as such the above matters need to be addressed before any consideration can be given to support for discharge. We would like to invite the local authority to attend site for a walkover as the benefit and scale of the remediation works are better understood during a site visit.* A site meeting is welcomed and I would suggest NRW are invited to such a meeting also.

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