



Public Health  
England

# Disposal of titanium dioxide industry waste to landfill – radiation exposures

*Models v site-specific measurements*

Kelly Jones and Peter Shaw



Public Health  
England

# Background

More than 100 000 tonnes/y of calcium-based waste produced from titanium dioxide production plant

Waste contains Th-232 decay series with smaller amount of U-238 decay series

Currently no options for re-use or recycling so disposed of to non-hazardous landfill



Public Health  
England

# UK Legislation

STATUTORY INSTRUMENTS

**2012 No. 630**

**ENVIRONMENTAL PROTECTION, ENGLAND AND WALES**

The Environmental Permitting (England and Wales)  
(Amendment) Regulations 2012

*Made* . . . . . 28th February 2012

*Laid before Parliament* 5th March 2012

*Laid before the National Assembly for Wales* 5th March 2012

*Coming into force* . . . . . 6th April 2012



## Radioactive Substances Act 1993

CHAPTER 12

SCOTTISH STATUTORY INSTRUMENTS

**2011 No. 147**

**ATOMIC ENERGY AND RADIOACTIVE SUBSTANCES**

The Radioactive Substances Exemption (Scotland) Order 2011

*Made* - - - - . . . . . 21st February 2011

*Laid before the Scottish Parliament* 23rd February 2011

*Coming into force* - - . . . . . 1st October 2011



# NORM waste activity concentration

Defined as

the sum of the concentrations of the single radionuclide with the highest concentration in each of the natural decay chains beginning with U-238; U-235; and Th-232

Waste being considered in assessment

1 to 3 Bq/g (assumed 2 Bq/g)

100 000 t/a of NORM waste co-disposed with 50 000 t/a of non-radioactive waste

$6 \times 10^{11}$  Bq/a



## Two-tier process

### 1) In or out of scope of legislation?

Raw materials, intermediates or final products not radioactive for purposes of licensing.

In scope of the legislation if wastes arises from a defined list of NORM industries (including titanium dioxide pigment manufacture) and greater than specified activity concentration (eg 0.5 Bq/g for U-238 and Th-232 assumed to be in secular equilibriums with progeny)

Exemption without any conditions from regulatory requirements.



## Two-tier process

2) If in scope of legislation is the waste exempt from some requirements ?

Conditional exemption where solid NORM wastes may be disposed without licencing. However waste still subject to some requirements, such as recording keeping



## Exempt NORM waste

Type 1 – if activity concentration  $< 5$  Bq/g

**a generic assessment** has demonstrated that

Doses to landfill workers  $< 1$  mSv/a

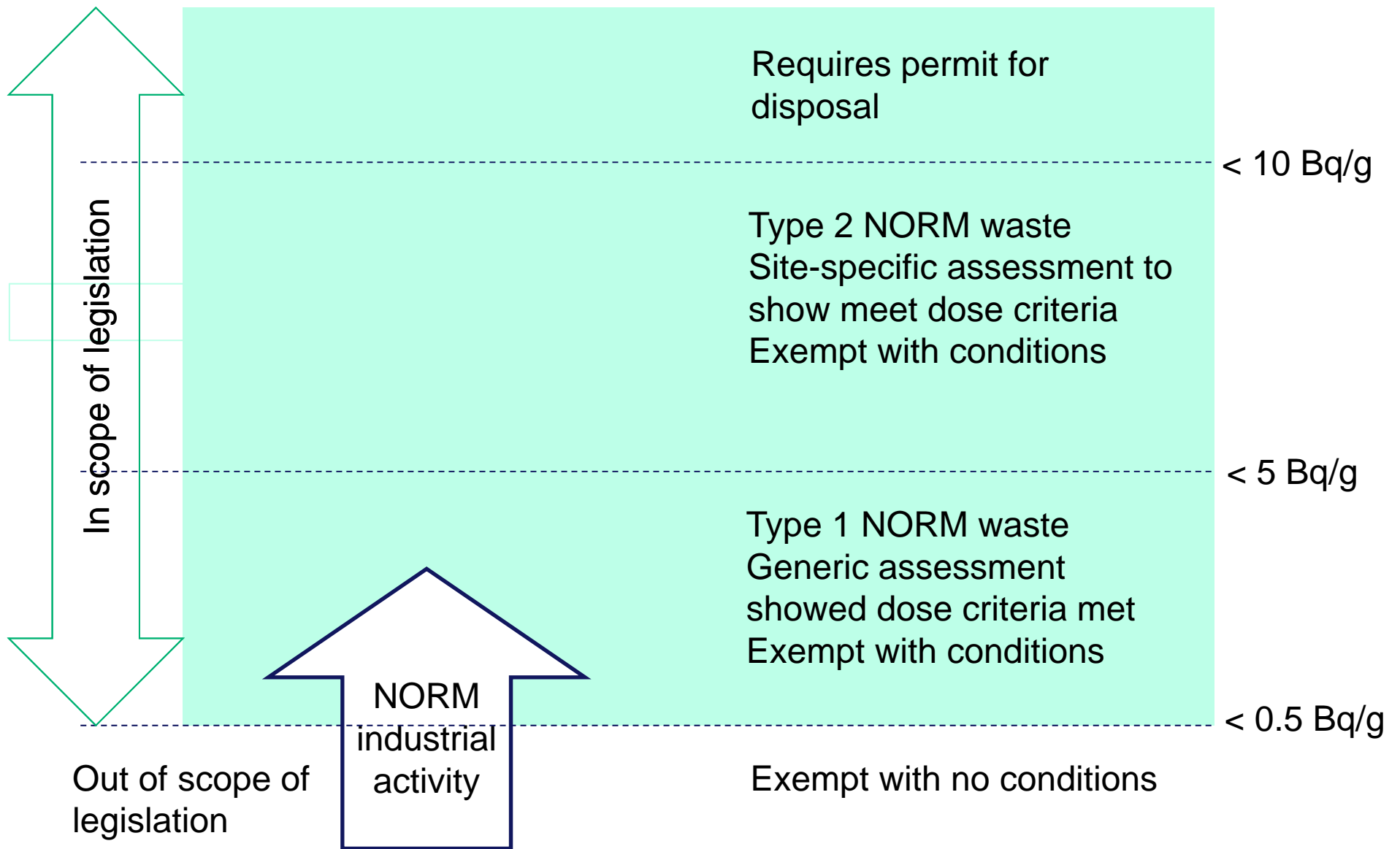
Doses to public  $< 0.3$  mSv/a

Doses to public from inadvertent intrusion  $< 3$  mSv/a

Type 2 – if waste activity concentration  $> 5$  Bq/g but  $< 10$  Bq/g

or activity disposed of  $> 5 \times 10^{10}$  Bq

then **site-specific** assessment required to demonstrate that dose criteria above are met











# Assessment

Regulators specify 27 potential scenarios

Operational phase (to about 60 years)

Worker exposure eg dust, leachate spray, sewage worker

Public exposure eg groundwater migration, leachate and sewage management, fire, flooding

Post closure (60 to 500 years)

Public exposure eg groundwater migration, inadvertent intrusion

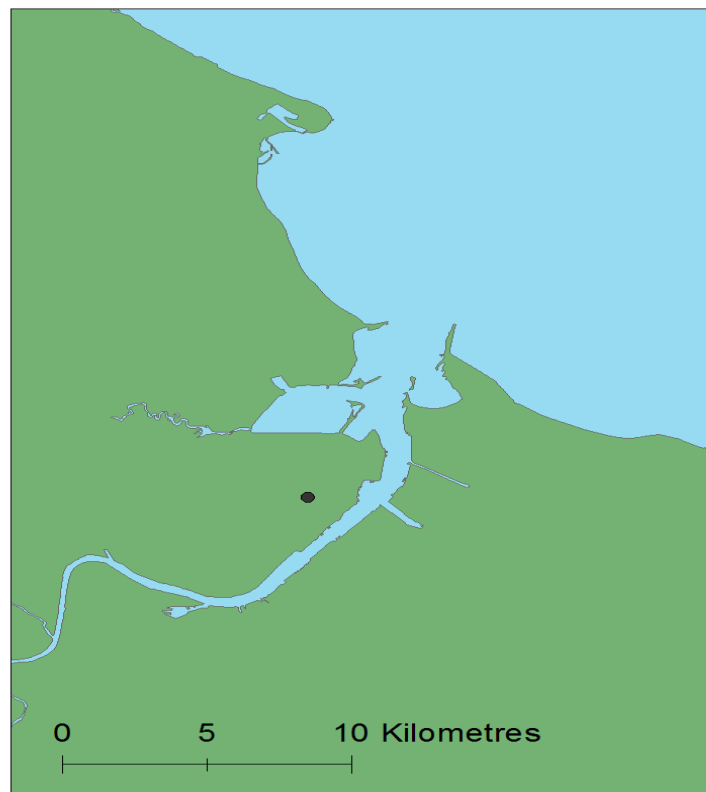
Post closure (> 500 years)

Public exposure eg groundwater migration, inadvertent intrusion, flooding, tidal inundation, coastal erosion



Public Health  
England

# Location of site





# Public exposures

Discharge of leachate to nearby estuary

Flooding of site

Coastal erosion

Modelled using PC-CREAM 08 – software implementation of EU methodology to assess the radiological impact of discharges

Inadvertent intrusion - assumed site restored for housing after closure

Highest dose calculated for inadvertent intrusion – 1.3 mSv/a (65% being inhalation of radon)

Dose criterion from regulators 3 mSv/a



## Worker exposures

Handling of waste – 2000 h/a over uncovered waste

**External irradiation** – calculated using Microshield

Inhalation of dust

Skin contamination – assumed no gloves worn

Inadvertent ingestion

Doses to landfill workers estimated to be 1.9 mSv/a (85% due to external irradiation)

Dose criterion from regulators 1 mSv/a





Public Health  
England

# Site-specific monitoring

On-site gamma-dose rate measurements

Individual external doses

- Electronic dosimeters worn for 2 weeks

- TLDs worn for 3 months

Information on working patterns







Public Health  
England

# Working practices

Waste delivered by lorry

Lorry waste tipped onto landfill

Layered and covered by mechanical excavator and bulldozer

**No direct handling of waste**



## Gamma dose rates and doses

Varied from background to  $1.5 \mu\text{Sv/h}$  in close contact with bulk waste piles

Reading in cabs of excavator and bulldozer  $0.3 - 0.4 \mu\text{Sv/h}$

Based on these readings and working 2000 h/a gives an effective dose of  $0.6$  to  $0.8 \text{ mSv/a}$



# Dosemeters and doses

## **Electronic personal dosemeters**

2 week wear period

Highest estimated dose (excavator operator) 0.6 mSv/a

## **Passive personal dosemeters**

3 month wear period

Estimated dose of 0.4 mSv/a



## Conclusions

Modelled dose to landfill worker – 1.9 mSv/a

Dose assessed using gamma dose rates – 0.6-0.8 mSv/a

Electronic personal dosimeter (2 week wear period) – 0.6 mSv/a

Passive personal dosimeters (3 month wear period) 0.4 mSv/a

Demonstrates the value of on-site measurements where possible

Use of individual dosimeters provided:

- Reassurance to workers

- Direct evidence to the regulatory authority that exemption criterion being met