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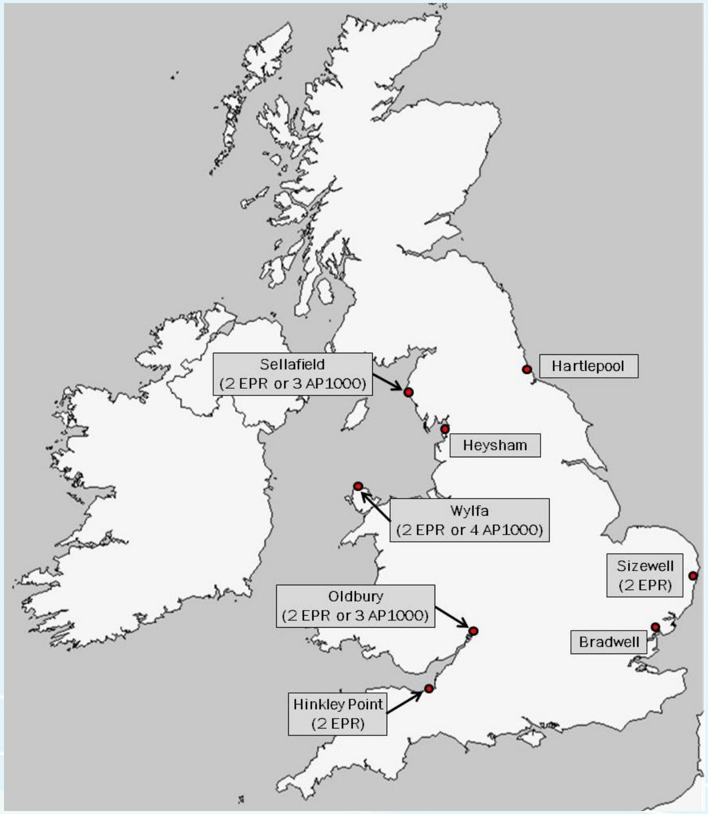
# Assessment of the Impact on the Irish Public Arising from Liquid Discharges from Potential New Build Power Plants in the UK

# Overview

- New Build in the UK
- Source Term for this work
- Routine discharges – Methodology and Results
- Non-routine discharges – Methodology and Results
- Conclusions

# New Build in the UK

- 8 Sites Identified as being suitable for new nuclear development
- 5 sites on West Coast of UK investigated



# Liquid Discharges

| Radionuclide | Routine Discharge (GBq yr$^{-1}$) | Radionuclide | Routine Discharge (GBq yr$^{-1}$) | Radionuclide | Routine Discharge (GBq yr$^{-1}$) |
|---|---|---|---|---|---|
| H-3 | 75,000 | I-135 | 0.0525 | Am-243 | 0.000037 |
| C-14 | 95 | I-131 | 0.05 | As-76 | 0.000037 |
| Co-60 | 3 | I-132 | 0.0438 | Br-82 | 0.000037 |
| Co-58 | 2.07 | Mo-99 | 0.0416 | Cl-36 | 0.000037 |
| Ni-63 | 1.14 | La-140 | 0.0394 | Cm-242 | 0.000037 |
| Fe-55 | 1.06 | Tc-99m | 0.0394 | Cm-244 | 0.000037 |
| Cs-137 | 0.945 | Ba-140 | 0.0306 | Nb-94 | 0.000037 |
| Sb-125 | 0.815 | Zn-65 | 0.0219 | Np-237 | 0.000037 |
| Ag110m | 0.57 | Cs-136 | 0.0203 | Pu-238 | 0.000037 |
| Cs-134 | 0.56 | Zr-95 | 0.0151 | Pu-239 | 0.000037 |
| Sb-124 | 0.49 | I-134 | 0.0129 | Pu-240 | 0.000037 |
| Mn-54 | 0.27 | Fe-59 | 0.0109 | Pu-242 | 0.000037 |
| Ru-103 | 0.263 | W-187 | 0.00656 | Rb-86 | 0.000037 |
| Te-123m | 0.26 | Sr-89 | 0.00525 | Ru-106 | 0.000037 |
| Ce-144 | 0.175 | Rb-88 | 0.000853 | Sb-122 | 0.000037 |
| Pr-144 | 0.175 | Sr-90 | 0.000535 | Sn-117m | 0.000037 |
| Cr-51 | 0.101 | Y-91 | 0.000199 | U-234 | 0.000037 |
| Na-24 | 0.0831 | Pu-241 | 0.000178 | U-235 | 0.000037 |
| I-133 | 0.0634 | I-129 | 0.000037 | U-238 | 0.000037 |
| Nb-95 | 0.06 | Am-241 | 0.000037 | | |

# Routine Discharges Methodology

- CREAM – Consequences of Releases to the Environment: Assessment Methodology
- PC-CREAM-08 software
  - Evaluates radiological consequences of discharges
  - DORIS – To model dispersion of radionuclides
  - MARINE ASSESSOR – To determine dose to Irish population based on outputs from DORIS

# Routine Discharges Methodology

- Activity concentrations in 50th year in:
  - Seawater
  - Sediment
  - Biota
- DORIS compartments –
  - Irish Sea West (Blue)
  - Irish Sea South (Red)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# Routine Discharges Dose Calculation

- Exposure pathways
  - Ingestion of seafood: fish, crustaceans, molluscs
  - Inhalation of seaspray
  - External irradiation: beach sediments, fishing gear (gamma and beta)
- Adult seafood consumer groups:
  - Consumer Group A
  - Consumer Group B
  - Typical Seafood Consumer – IUNA 2011

} RPII Habits Survey

# Routine Discharges: Habits

| Exposure Pathway | Group A | | Group B | | Typical Consumer | |
|---|---|---|---|---|---|---|
| Seafood Consumption (kg $yr^{-1}$) | Fish | 26 | Mussels | 20 | Fish | 8.4 |
| | Crustaceans | 10 | Oysters | 5 | Crustaceans | 0.5 |
| | | | | | Molluscs | 0.1 |
| Time on beach (h $yr^{-1}$) | - | | 410 | | 410 | |
| Handing Fishing Equipment (h $yr^{-1}$) | 2500 | | 730 | | - | |

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# Routine Discharges: Doses

| Discharge Location | Group A Irish Sea West | Group A Irish Sea South | Group B Irish Sea West | Group B Irish Sea South | Typical Consumer Irish Sea West | Typical Consumer Irish Sea South |
|---|---|---|---|---|---|---|
| Sellafield | 1.85E-02 | 6.97E-03 | 1.33E-02 | 4.98E-03 | 5.03E-03 | 1.87E-03 |
| Heysham | 1.85E-02 | 7.17E-03 | 1.33E-02 | 5.12E-03 | 5.02E-03 | 1.92E-03 |
| Wylfa | 3.81E-02 | 1.26E-02 | 2.73E-02 | 9.02E-03 | 1.04E-02 | 3.41E-03 |
| Oldbury | 1.90E-04 | 2.08E-04 | 1.35E-04 | 1.48E-04 | 5.06E-05 | 5.56E-05 |
| Hinkley Point | 1.91E-04 | 2.10E-04 | 1.36E-04 | 1.50E-04 | 5.08E-05 | 5.61E-05 |

Individual effective dose ($\mu Sv.yr^{-1}$) after 50 years of routine releases

- **Largest Doses:**
  - **From Wylfa Site**
  - **From consumption of seafood (95%)**
  - **C-14 most significant contributor (90%)**

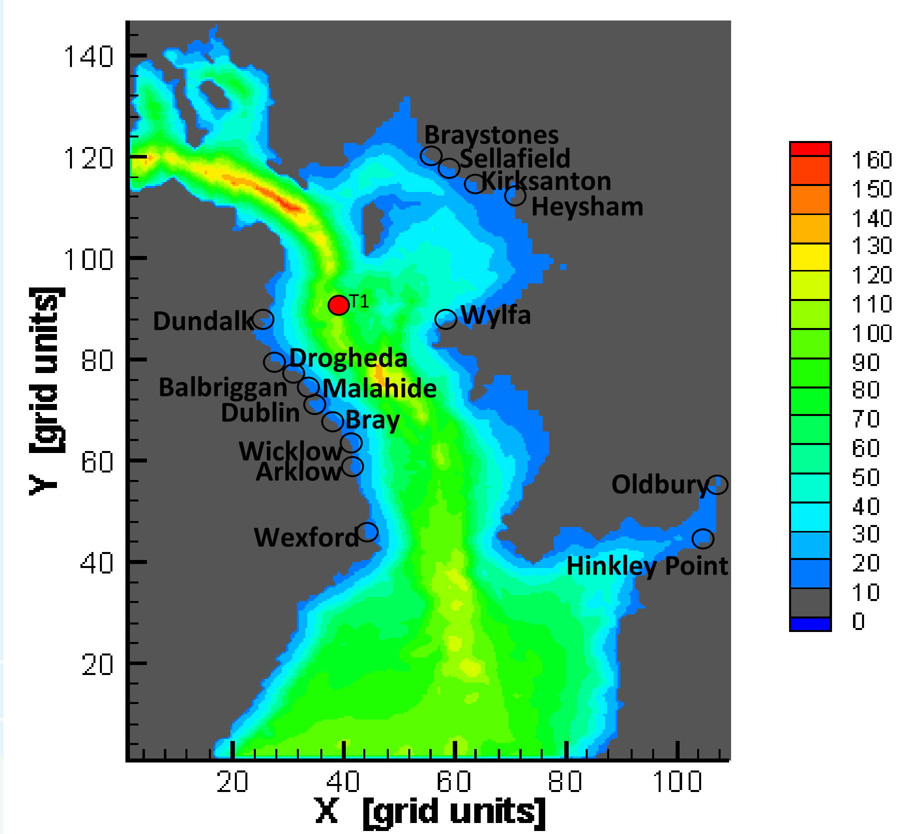
# Non-routine Discharges

- Source Terms
  - Scenario 1: One year of routine discharges released in one week
  - Scenario 2: Total volume of reactor coolant discharged in one week

| Radionuclide | Total Activity (GBq) | Radionuclide | Total Activity (GBq) |
|---|---|---|---|
| **I-133** | 63,000 | **Ni-63** | 930 |
| **I-135** | 42,000 | **Sr-89** | 900 |
| **I-131** | 33,000 | **Ag110m** | 510 |
| **Cs-138** | 30,000 | **Mn-54** | 420 |
| **I-132** | 24,600 | **Sb-122** | 330 |
| **H-3** | 11,100 | **Co-60** | 174 |
| **Cs-136** | 11,100 | **Sb-124** | 168 |
| **Cs-134** | 10,200 | **Fe-59** | 108 |
| **I-134** | 9,000 | **Sb-125** | 30 |
| **Cs-137** | 7,500 | **Sr-90** | 5.7 |
| **Co-58** | 3,000 | **C-14** | 3.9 |
| **Cr-51** | 2,850 | | |

# Non-routine Discharges: Dispersion Modelling

- Estimate activity concentrations and transit times of radionuclide discharges from the proposed sites to selected locations on the east coast of Ireland.
- Conservative behaviour
- Simulates tides, winds, density gradients on currents
- Interseasonal & interannual effects

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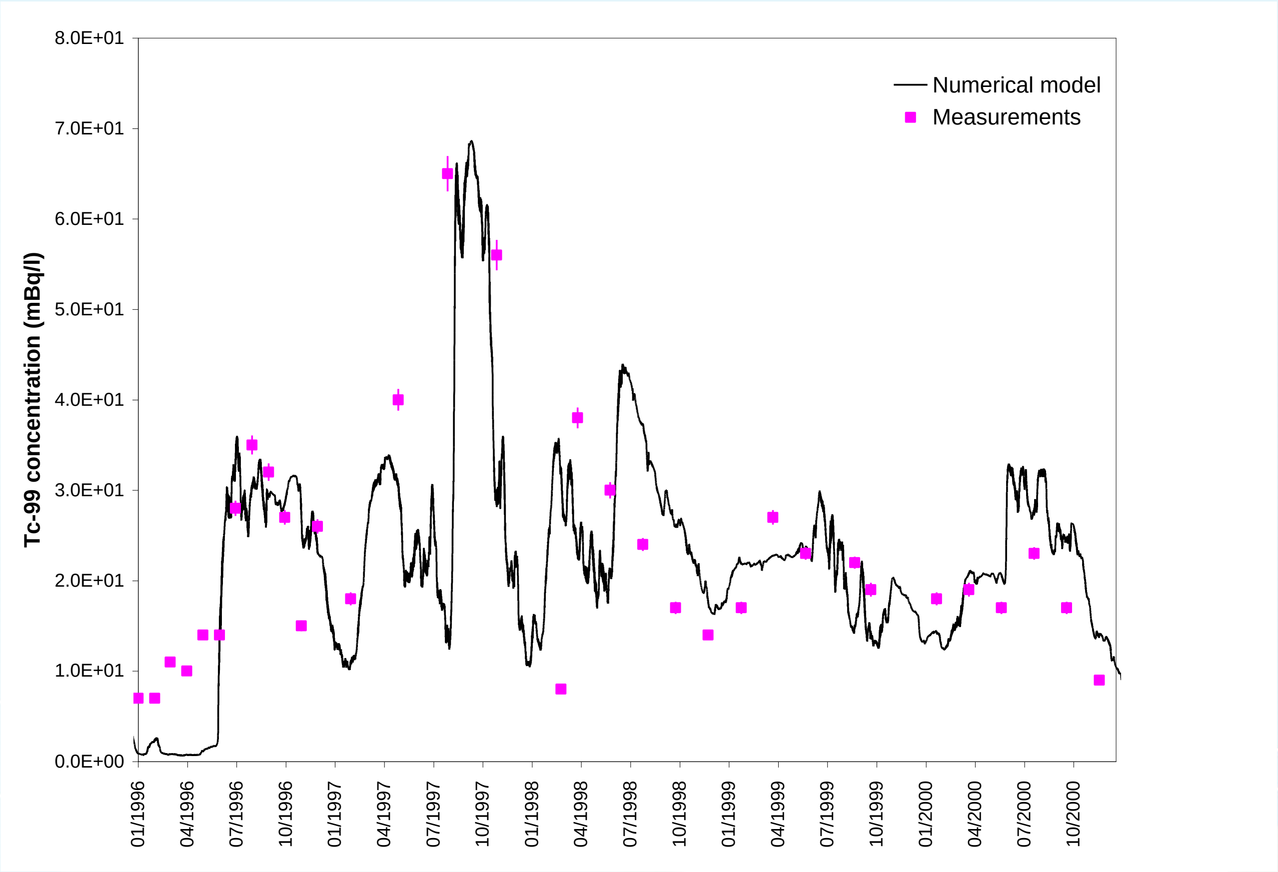
# Historic and Model Time series at Balbriggan



# Non-routine Discharges

- Highest seawater activity observed for Springtime release from Wylfa
- A 604.8 TBq discharge results in a seawater activity concentration of 191 mBq $l^{-1}$ in Dundalk 161 days later
- Dilution factor, based on outcome from NUIG model:

$$DF = \frac{191 \times 10^{-3}\, Bq/l}{604.8 \times 10^{3}\, Gbq} = 3.1581 \times 10^{-7} \left( \frac{Bq/l}{GBq} \right)$$

# Non-routine Discharges: Peak Seawater Activity Concentration

$$C^{i}_{Seawater} = D_i \times DF \times e^{-\lambda_i t}$$

| | |
|---|---|
| $C^{i}_{Seawater}$ | is the peak seawater activity concentration for radionuclide *i* |
| $D_i$ | is the total activity discharged for radionuclide *i* (GBq) |
| DF | is the dilution factor ($3.1581 \times 10^{-7}$ Bq $l^{-1}$/GBq) |
| $\lambda_i$ | is the decay constant for radionuclide *i* (days$^{-1}$) |
| t | is the time taken to reach the peak seawater activity at Greenore i.e. 161 days |

# Non-routine Discharges: Activity Concentrations in Biota and Sediment

- Radioactivity concentrations in biota and sediment:
  - Determined using appropriate concentration factors (CF) and sediment concentration factor ($k_d$)
  - Determined using same factors in the PC-CREAM-08 software for consistency

# Non-routine Discharges: Dose Assessment

- Using CREAM methodology in MS Excel based on PC-CREAM-08 documentation
- Same exposure pathways and consumer groups as routine discharges

# Non-routine Discharges: Dose Assessment

| Total Dose (μSv) | | |
|---|---|---|
| Group A | Group B | Typical Consumer |
| $1.31 \times 10^{-2}$ | $1.03 \times 10^{-2}$ | $4.09 \times 10^{-3}$ |

- Scenario 1
  - Largest dose to consumer group A
  - Ingestion of seafood the dominant exposure pathway (99%)
  - C-14 the radionuclide of most importance

# Non-routine Discharges: Dose Assessment

| Total Dose (µSv) | | |
|---|---|---|
| Group A | Group B | Typical Consumer |
| $3.45 \times 10^{-1}$ | $9.41 \times 10^{-1}$ | $7.45 \times 10^{-1}$ |

- **Scenario 2**
  - **Largest dose calculated is to consumer group B.**
  - **Principal exposure pathway is exposure to beach sediment (gamma)**
  - **Radionuclide of most importance is Mn-54**

# Conclusions

- Routine:
  - Negligible impact on Irish public
- Non-routine:
  - Even with a very conservative dose assessment, impact on Irish public is negligible
- Both
  - For all scenarios outlined doses similar to those received from current inventory in Irish Sea

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# Routine Discharges: Doses