CONSULTATION RESPONSE re Hinkley Point C Sediment Sampling Plan SP1914
compiled by Tim Deere-Jones (Marine Radioactivity Research & Consultancy)

From: the Senedd Petition Campaign to Stop the Dump of Radioactively Contaminated sediments at the Cardiff Grounds dump site

TO: National Resources Wales

Introduction:
This Consultation submission is a response to the EdF sediment sampling plan: proposed by EdF in advance of their application for a permit to dispose of up to 600.000 cubic metres of sediment to be dredged from Bridgwater Bay in 2021.

This Submission has been compiled on behalf of, and with the support of, the Nuclear Free Local Authorities of Wales and England, CND Cymru, and the Stop Hinkley Campaign Group. This Submission has also been compiled on behalf of the 7,000 signatories to the Senedd Petitions Committee petition of 2017; and the 150,000+ signatories to additional petitions managed by Sum-of-Us and Greenpeace, who objected to the permitting by the then Welsh Environment Minister, of EdF's original proposal to dump up to 300,000 tons of Bridgwater Bay sediments contaminated by radioactivity discharged into the Bay as a result of 50+ years of discharges from the Hinkley Point A and B nuclear stations.

Reference to the "Campaign" in the following text refers to the organisations and signatories referred to in the above paragraph.

It should be noted that the Campaign has been researching and commenting on these issues since 2017, during which time it has engaged with, and represented its concerns to, the National Assembly, Natural Resources Wales (NRW), EdF and the Centre for Environment, Fisheries and Aquaculture Science (CEFAS) via the Senedd Petitions Committee hearings of evidence.

Throughout that engagement the Campaign has posed a number of questions to NRW, about the EdF dredge and dump proposals, which sought to clarify the behaviour and end fate of radioactively contaminated sediments dredged from Bridgwater Bay and dumped at the Cardiff Grounds, and also to elicit fully detailed responses to queries about the effectiveness, and outcomes, of the sampling and analytical techniques employed by EdF and their contractors.
To date none of these questions has been answered by EdF, the proposers of the dredge and dump actions, or by Welsh Government ministers and NRW.

This current Consultation submission is a response to the news that EdF have proposed a second dredge and dump operation (for 2021) which includes plans to dispose of an additional "up to 600.000 cubic metres" of Bridgwater Bay radioactively contaminated sediments at the Cardiff Grounds disposal site. It addresses issues which are relevant to both the EdF current proposed sediment sampling plan and to the outstanding issues which were not clearly answered by EdF and NRW during 2017 and 2018.

The Campaign takes this opportunity to demand full and detailed, scientifically referenced responses to each of the 20 sections set out in this Consultation Submission instead of the partial or non-existent responses it has received throughout its previous engagement with NRW on these issues.

PREAMBLE

Baseline survey issues : This Submission notes that NRW failed to insist that a range of baseline surveys were carried out in order to quantify pre dump concentrations of man-made radioactivity, derived from Bristol Channel and Severn Estuary nuclear power station liquid effluent discharges, in coastal sediments of the south Wales coast and in south Wales coastal zone terrestrial environment

This submission notes that NRW made no attempt to investigate the behaviour and end fate of the radiologically contaminated sediment from the Bridgwater Bay which has been and will, in the future, be dumped at the Cardiff Grounds dispersal site.

This submission contends that this failure of NRW (and by extension the Welsh Government) has created a data black hole such that there is a lack of information on the relevant radiological and environmental parameters, and hence of the impact that the completed and proposed dump has, and will have, on the south Wales coastal zone and its wildlife and human occupants.

In the context of the importance of, and imperative for, baseline surveys and analysis this submission offers scientifically referenced technical details and arguments, and precise recommendations for future action in sections 1 to 10.

Analytical, scientific and technical issues; This submission notes that during the course of 2017 and 2018 the Campaign submitted numerous tranches of evidence to the Senedd Petitions Committee hearings, covering a wide range of scientific and technical issues arising from the EdF and CEFAS sediment sampling and radiological analytical techniques and protocols as promulgated by the IAEA.

The Campaign's contention is that EdF "mis-spoke" when claiming that gamma spectrometry would identify **all** of the man-made radio-nuclides present in the Bridgwater Bay sediments, and that the analytical techniques and protocols commissioned and employed by EdF and CEFAS were incapable of providing fully accurate empirical data about the radioactivity content of the sediments.

This submission notes that although the Senedd Petitions Committee process made this data available to NRW and EdF, and despite the fact that the Campaign's submissions were highly critical of many of the methodologies followed by EdF and CEFAS during their analytical and monitoring work, NRW did not offer any comment on, or engage with any of the issues raised by the Campaign.

In the context of these issues, sections 11 to 17 represent the Campaigns concerns on the following issues including*: EdF's claim that gamma spectrometry could identify **all** the anthropogenic radio nuclides present in Bridgwater Bay sediments, the weaknesses of the gamma spectrometry techniques and protocols commissioned by EdF, the failure to carry out any alpha analysis, and the failure to carry out sediment grain size analysis.*

These sections offer recommendations for the improvement of these methodologies and the acquisition of data capable of generating a full empirical understanding of potential pathways of radiological exposure and relevant dose estimates.

RIO DECLARATION issues, environmental and legal definitions: in sections 18 to 20 inclusive, this submission references and discusses possible breaches of the principles and objectives of the 1972 Rio Declaration, and the lack of clarity and precision of Environmental and Legal definitions of the concepts of "sea", "marine environment" and "estuary", and demands that NRW review these issues and publish its conclusions.

INDEX:

Baseline (pre dump) surveys and analysis of south Wales and Somerset coastal regions

Intro: *the acquisition of baseline data, prior to any action likely to have a deleterious effect on the health of human communities and the environment is a necessary precursor to any such action. Baseline data informs Governments, Regulators, Environmental Protection Agencies and the Public about the current (pre action) status of relevant significant environmental parameters.*

In the case of the current subject of Consultation, one of those parameters is the concentration of multiple radio nuclides historically discharged from the four reactors of the Hinkley A & B stations into the Inner Bristol Channel and the Severn Estuary, and transported into the south Wales coastal environment by well established transport pathways of the regional water body.

1: Radioactive Particles Released from Nuclear Power Stations:
1:1 The Campaign's study of the annual RIFE (Radioactivity in Food and the Environment) reports has raised concerns that there may be "particles" of relatively "enhanced" radioactive material (discharged from Bristol Channel MAGNOX nuclear power stations) in both the sedimentary environment of the south Wales coast **and** in those Hinkley Point contaminated sediments from Bridgwater Bay proposed for dredge and dumping off Cardiff Bay.

1:2 In this context it is relevant to note that the Hinkley A MAGNOX station and the Chapelcross MAGNOX station (southern Scotland) shared not only the same design but also the same purpose, i.e. the manufacture of military grade Plutonium for the UK nuclear weapons programme, over and above electricity generation. Thus the operation and output of these stations was **unlike** that of other Magnox sites.

1:3 The radioactive particles of concern to the Campaign are those reported as found about ten metres from the end of the discharge outfall of the Chapelcross MAGNOX nuclear power station in 1992, and identified as "particles of irradiated uranium".

In the wake of that discovery, follow up sampling reported in RIFE 3 (Radioactivity in Food and the Environment 1998), has found many more "particles" identified by the authors of the RIFE Reports (Environment Agency, Food Standards Agency and Scottish Environmental protection Agency) as **mostly** lime scale **with elevated concentrations of radioactivity attached** and believed to "originate from deposits within the pipeline". At least one of these "particles" was described as **"more active than normal"** and **"likely to have come from degraded fuel ... probably discharged in the late 1970s"**

From this wording, and in the absence of any additional clarification, the Campaign assumes that **some** of the particles found in post 1992 follow up sampling were also "particles of irradiated uranium" which had become attached to the pipeline lining material and then discharged as that material deteriorated.

1:4 This submission can confirm that, to date, despite a search of the available literature, there is **no evidence** that any sampling or analysis for such "particles" has been carried out in the marine/estuarine sedimentary environments either at the pipeline, or downstream of the Hinkley A and B nuclear power stations.

Details of the liquid effluent discharges and the programmes used to analyse them, during the period of weapons grade Plutonium manufacture at Hinkley Point A have been obtained from the Nuclear Decommissioning Authority, the Environment Agency, and Magnox South. It is clear that such “particles” would not have been detected during annual “bulk sample” analysis reportedly carried out at the Hinkley Point A and B reactor sites, as those “bulk samples” are collected from the liquid effluent prior to its discharge, whereas the particles discovered at the Chapelcross site were described as originating “from deposits within the pipeline” and hence outside the scope of the regular annual bulk sample analysis.

1:5 A scientific paper submitted to the 2009 “Radioactive Particles in the Environment” Conference* has further confirmed that “Radioactive particles and colloids are also released via effluents from reprocessing facilities and **civil reactors**, and radioactive particles are identified in sediments in the close vicinity of radioactive waste dumped at sea.”

The 2009 paper further reported that “Radioactive particles in the environment are heterogeneously distributed and can carry substantial amounts of refractory fission products, activation products and transuranics. Samples collected may not be representative, and inert particles can be difficult to dissolve. For particle contaminated areas, the estimated inventories can therefore be underestimated" *(Transuranics, or transuranic elements, include Plutonium, Curium and Americium).*

*** Reference: “Radioactive Particles Released from Different Nuclear Sources”, (pp3-13) Brit Salbu: Conference paper, from “Radioactive Particles in the Environment”: 2009: editors DH Oughton & V. Kashparov. Nato Science for Peace & Security Series. Pub: Springer**

1:6 The 2009 paper also noted that “Radioactive particles in the environment are defined as localised aggregates of radioactive atoms” that give rise to an inhomogeneous distribution of radio nuclides significantly different from that of the matrix background (IAEA CRP, 2001).

In water, “particles are defined as entities having diameters larger than 0.45 μm, which will settle due to gravity, while particles larger than 1 mm are referred to as fragments. Particles less than 10 μm are considered respiratory.” (i.e. easily inhaled).

1:7 The Campaign considers that there is a high probability that, during the 50+ year lifetime of liquid nuclear waste effluent discharges from the Hinkley Point Magnox and AGR reactors, radioactive particles, similar to those discharged from the Chapelcross site, and similar to those described by the 2009 paper, will have been discharged into the Hinkley marine and sedimentary environment.

In the context that Hinkley Point A (Magnox) Station is known to have been engaged in the manufacture of Plutonium for the UK Nuclear Weapons Programme, the Campaign believes that it is possible that some highly radioactive particles, from the same basic sources but possibly contaminated with additional plutonium, may have been released to the Bridgwater Bay receiving sediments during routine operational liquid effluent discharges throughout the weapons Plutonium manufacturing period.

1:8 The Campaign has (to date) found no reporting of searches for this type of "radioactive particles" in the sediments around the Hinkley outfalls, and certainly the CEFAS sediment sampling related to the dredge and dump proposal does not appear to have included any such investigation.

1:9 The Campaign notes that this issue was raised in documentary submissions of evidence to the Senedd Petitions Committee during discussions prior to the 2018 dump of Bridgwater bay sediments at Cardiff Grounds, and that the Welsh Government, NRW and CEFAS, who appear to be NRW's radiation advisors, did not respond to the concerns raised in the that evidence submission.

In the context of the above paragraphs and the absence of any investigation for such particles, the Campaign recommends that the proposed future EdF sampling and analysis of the Bridgwater Bay sediments include analysis for such "radioactive particles" and, if discovered, investigation of their radio nuclide content, activity yield and inhalable/respiratory potential.

..

2: The vital importance of detailed baseline surveys and analysis for Plutonium

2:1 A number of sources confirm that the Hinkley Point A (MAGNOX) station was modified in order to manufacture Plutonium for the UK and US nuclear weapons. The most relevant of these sources is the 1958 statement to the House of Commons, made by Conservative Party MP Reginald Maudling, then Paymaster General and later President of the Board of Trade, who reported that "the Central Electricity Generating Board has agreed to a small modification in the design of Hinkley Point and of the next two stations in its programme so as to enable plutonium suitable for military purposes to be extracted should the need arise."

REF:" Atomic Power Stations (Plutonium production)". Hansard. UK. Parliament HC Deb. 24 June 1958 vol 590. cc246-8

This statement was re-iterated in a second, 1959, debate in the Commons, reported in Hansard Vol 607 col. 849, which confirmed the selection of Hinkley Point A as one of the future sites for weapons grade Plutonium manufacture.

2:2 A bitter debate has subsequently been ongoing about whether or not the Hinkley Point A reactors actually did make Plutonium for UK and US nuclear weapons, with the reactors' owners and operators (the CEGB) and the UK government denying that such activity took place, and CND and others presenting evidence which they said proved that Hinkley Point A did manufacture weapons grade Plutonium. This debate remains open and non-concluded to this day and has been much obscured by the use of the Official Secrets Act and similar "security considerations".

2:3 The Campaign has acquired the liquid effluent discharge record for the Hinkley Point A reactors from 1965 (the commissioning year) through to 1984. These years cover the period in which the reactor was in "start-up mode", and much of the period in which it is claimed that the Hinkley Point A reactors were manufacturing Plutonium for the military programme (see ANNEX 3).

REF source: email (with attachment) from: Nigel Monckton: Corporate Communications Manager: Magnox Limited. 09/03/2020

2:4 The Campaign's analysis of the liquid effluent discharge record shows that for the first four years, after its commissioning/start up in 1965, the Hinkley Point A liquid effluent discharges of Plutonium 239 achieved a yearly average of 1,570 million becquerel (Bqs, or 1.5 giga-becquerel Gbqs) per year.

However, the Campaign's analysis then shows that for the following 16 years (1969-1984 inclusive) the average yearly liquid effluent discharge of Plutonium 239 rose to 16, 987 million Bqs (16.9 GBqs)

It is clear that liquid effluent discharges of Plutonium to the Bridgwater Bay receiving environment were, on average, 10 time higher across the latter 16 years than they were in the first 4 years.

The maximum yearly discharge of Plutonium 239 in liquid effluents (1969 to 1984) occurred in 1977 (22 GBqs), 1981 (34 GBqs) and 1982 (54 GBqs).

2:5 The Campaign has been unable to access or identify any regular or formal marine environmental radioactivity programme prior to the publication of the first Aquatic Environment Monitoring Reports (AEMRs), which was published by the UK Ministry of Agriculture and Fisheries, in 1972. The AEMRs claim to be part of the Ministry's responsibilities under the UK Radioactive Substances Act 1960.

However it is noted that the first published AEMR did not appear until over a decade after the Act and it is assumed by the Campaign that the initiation of the AEMR programme was a response to the insistence of the 1972 Rio Declaration that coastal states had an obligation to collate and publish relevant data on significant marine pollution issues.

2:6 It is notable that annual reporting of discharges from UK nuclear power station sites almost always provides an explanation of variations in liquid effluent discharges from nuclear power station sites if they are a result of operational factors within the site.

The Campaign's review of the available AEMRs, and their more recent successors, the Radioactivity in Food and the Environment (RIFE) reports, has been unable to find an explanation for the 10 fold increase in Hinkley Point A site liquid discharges of Plutonium 239 through the period 1969 to 1984. The Campaign therefore assumes that those reasons are also the subject of "security considerations".

2:7 However, the facts laid out in the liquid effluent discharges record cannot be cannot be disputed and it is clear that substantial quantities of Plutonium 239 were discharged to the Bridgwater Bay sedimentary receiving environment, where it would be expected that, by way of the adsorption mechanism, and sedimentary flocculation and deposition processes, much of that Plutonium 239 would become sequestered in the Bridgwater Bay sedimentary deposits.

2:8 There is a general lack of precise detail about sedimentary deposition rates in the Bridgwater Bay (this issue is discussed further in sections 14 and 15 below). The issue is clearly further complicated by the fact that the first dredge action (2017/2018) carried out by EdF will have generated considerable disturbance and movement of the remaining un-dredged sediments in the Bay, especially those in the vicinity of the previous dredge action.

It is clearly impossible to provide 100% protection of the integrity of dredged areas (trenches etc) on the seabed. There is a wide consensus that all the evidence proves that there is always some degree of slumping at the edge of dredge excavations and some degree of in-filling of dredge cavities after any dredge action. If dredge cavities were not filled with relevant construction relatively soon after the dredge, those cavities excavated during the first dredge action will have been partially refilled as a result of sediment movement.

Such movement of, at least the surface sediments in the near vicinity of the excavations, are likely to have generated additional complexity of the "chronological vertical layering" of historical depositions of radioactive materials.

2:9 In the context of the highly elevated levels of Plutonium 239 discharged, in liquid effluent releases, to the Bridgwater Bay receiving sediments during the years 1969 to at least 1984, and the inevitability of major sediment disturbance and re-distribution following the dredging activity of 2018, the Campaign strongly recommends that core samples from the EdF proposed future sampling and analytical programme should undergo thorough vertical sub-sampling on a 10 to 20 cms basis in order to identify the depths at which the peak Plutonium concentrations are found and also to identify the vertical extent of "bands" of high Plutonium concentration.

2:10 These issues are additionally complicated because there has been no Bridgwater Bay wide study to identify the depths at which the Plutonium and other (time relevant nuclides) from the 1969 -1984 period may now be sequestered.

Since it is widely understood that finer (small grain size) sedimentary material holds higher concentrations of alpha emitters than the coarse sediments, and in the context of the available evidence (discussed in sections 14 and 15 below) about the spatial variability of sediment type and the relationship between these factors and the concentration of alpha emitters, the Campaign contends that there is a pressing need to conduct the vertical sub-sample analysis recommended in 2:9 above.

2:11 The Campaign contends that it was imperative that that EdF should have carried out such work before the first dredge and dump operation.

The Campaign contends that it was equally imperative that the Welsh environmental protection agency, and the Regulator and Permitter of such activities, should have insisted that EdF carry out such work, and notes that its failure to do so has led to a major failure of data acquisition which leaves the Welsh public in a state of ignorance about the impacts of the recent permitted dump.

In the context of the above, the Campaign demands that such work now be undertaken and urges NRW to initiate such action.

3: “De minimis” assessments and assumed pathways of exposure for coastal population

3:1 With regard to the potential exposures of members of the public to radioactivity, the Campaign notes that IAEA protocols advises that that members of the public in the vicinity of a disposal site are considered to be exposed via the following pathways:
1: ingestion of seafood caught in the vicinity of the disposal site,
2: external exposure to radio nuclides deposited on the shore,
3: inadvertent ingestion of beach sediment,
4: inhalation of re-suspended beach sediment,
5: inhalation of sea spray,
and that CEFAS and NRW appear to have uncritically accepted the IAEA position,

3:2 However, the IAEA protocol offers a set of basic and extremely simplistic exposure pathway assumptions for anthropogenic marine radioactivity which have been in place for many years and have not kept pace with the growing scientific evidence from independent empirical research, which now shows them to be outdated, inadequate and incomplete.

3:3 The Campaign challenges the simplistic and outdated assumptions made by the IAEA, and notes that the basis of such assumptions has been reinforced by hypothetical modelling and that there is a significant shortfall of empirical input into the hypothetical models. Accordingly, the Campaign strongly recommends that the IAEA assumptions be re-examined and revised in the context of the new understandings gained from the latest scientific, empirical evidence.

3:4 The Campaign reports that a number of studies have demonstrated additional exposure pathway of significance for sea to land transfer processes. These occur as a result of a number of mechanisms such as coastal inundation events and the production of sea spray, and more importantly, marine aerosols in breaking waves in the surf zone during periods of onshore wind.

These pathways are not addressed by the IAEA protocol nor by the nuclear industry, EdF or by recent commentaries on “de minimis” issued by regulatory and monitoring bodies (NRW and CEFAS) attached to departments of pro-nuclear governments.

It appears that NRW is among those bodies not to give credence to the Campaign’s concerns about these pathways, which were presented as evidence to the Senedd Petition Committee through 2017 and 2018, during the course of which NRW completely failed to address or to comment on the scientifically referenced evidence that the Campaign had submitted.

3:5 Coastal inundation of Urban environments: Coastal inundation is a regular occurrence (more so in the current phase of sea level rise). In 1990, at Towyn, on the North Wales coast, a storm surge caused extensive flooding of the coastal zone, damaging caravan/holiday parks, shops and houses. Many tonnes of near-shore, marine sediment were deposited as a result of the storm surge. 14 samples of this sediment were collected and sent to an independent radiological analyst who carried out laboratory analysis of all 14 samples for both Americium 241 and Caesium 137.

The analysis showed that both Americium 241 and Caesium 137 were present in the marine sediment; Americium levels in most samples exceeded 20 Bq/sq metre, the “Contamination GDL” for Americium, with 8 of the 14 samples exceeded the GDL level by “more than ten times” (i.e. above 200Bqs/sq metre).

NB: GDLs (Generalised Derived Limits) were the concentrations in environmental media that were estimated to result in an annual dose, to members of the public, of 1mSv, the dose limit recommended at the time, by the International Radiological Protection Committee and endorsed by the then UK National Radiological Protection Board. It was recommended that where GDLs were exceeded by 25%, further investigations into the public implications should undertaken. There is no evidence that such further action was taken at Towyn.

3:6 The consultant's report also stated that:
A: the presence of Americium 241 "also implies the presence of the plutonium isotopes Pu238, Pu 239, Pu 240 and Pu 241, and quite probably the GDLs for these will also be exceeded";
B: "contamination due to Americium, and probably also of Plutonium isotopes….. is generally greater than limit set….for further investigations" (i.e. the GDL); and
C: "the values suggest that, when the sediment dries out, there is a possible radiation hazard due to the inhalation of radioactive dust containing the isotopes of Americium and Plutonium".

: Edinburgh Radiation Consultants: "Radiation Survey of Towyn ": March 1990. (copy of report available from Tim Deere-Jones)

3:7 The Campaign comments that the significant evidence from this single (privately funded) analytical research project should have been acted upon by the UK government at the time, and as soon as it was made known to them, both by carrying out the "further investigations" recommended under GDL protocols, and by carrying out ongoing and in depth investigations of the radiological impact of urban coastal inundations.

The failure of both governments to investigate further the very significant outcomes of this study of pathways of exposure of coastal urban communities to marine anthropogenic radioactivity in the event of coastal flooding and to calculate the potential doses to workers and residents is inexplicable, represents a clear failure of duty of care and was of considerable benefit to the pro-nuclear cause, in that it avoided the possibility of negative publicity.

3:8 The Campaign contends that the IAEA's reference to only "external exposure to radio nuclides deposited on the shore" is clearly inadequate because it is obviously **not** the only radiological impact to coastal communities that should be expected following the inundation (from the sea) of coastal communities located in areas where the water column and the marine sediments are known to be contaminated with anthropogenic radioactivity.

3:9 Noting that there is no legal insistence that National Governments must not, or cannot, improve upon the existing inadequate IAEA protocols, the Campaign demands that NRW take note of the evidence from Towyn and insist that EdF commission both baseline (pre second dump) surveys of coastal environments to determine their current radiological status, and post second dump in order to identify any variations in radiological status in the south Wales coastal sedimentary, intertidal and inundation prone terrestrial environments.

3:10 Noting that, in the current context of increasing flooding of estuarine and coastal terrestrial zones in the context of climate change and sea level rise, such inundation events are manifestly on the increase, the Campaign recommends that any community known to have experienced tidal or coastal inundation over recent years (ideally at least 20 years) be given the benefit of such investigation and research prior to any further, large scale (1000s of

cubic metres) dumping of radioactively contaminated sediments into the coastal waters of south Wales

...

4: Coastal Inundation of Salt Marsh grazing land

4:1 Coastal inundation is also an issue having a marked impact on coastal salt marsh grazing land which is usually flooded concurrent with spring tides and/or in association with super tides and storm surges (the latter becoming increasingly numerous due to climate change).

4:2 Hypothetical modelling of the radioactivity dose derived from the potential transfer of anthropogenic radioactivity to "tide washed pastures" has been reported in the RIFE reports from 1997 to the present. Although it does not support or agree with the official dose estimates drawn up as a result of the hypothetical modelling carried out by government agencies and reported by the RIFE reports, the Campaign notes that even these agencies recognise that some degree of radiological contamination of "tide washed pastures" does occur.

4:3 RIFE 3 (1997) provides results of the monitoring of "Radioactivity in Sediment from the Cumbrian coast and further afield". This table focuses principally on clearly intertidal materials such as mud and sand, however it does report analytical results for 6 samples of "turf" and one of "salt marsh". These, particularly those designated as "turf", are clearly definable as terrestrial, but certainly subjected to tidal inundation on occasion. Table 4:6 shows positive results for Caesium 137 and Americium 241 in turf and salt marsh, and also shows positive results for Plutonium 238, 239 and 240 in the salt marsh sample, and in many of the adjacent "mud" and "sand" sediments intertidal samples.

Although the "salt marsh" sample is recorded to have held Plutonium 238 concentrations of 57 Bq/gg and Plutonium 239/240 concentrations of 290 Bq/kg, it is surprising to note that the "turf" samples were not analysed for Plutonium nuclides.

4:4 RIFE 3 (1997) Table 4:14 provides results of radioactivity sampling of "tide washed pasture" at 8 coastal locations relatively close to Sellafield. Tabulated results of this work show positive results for 9 anthropogenic radio nuclides in coastal soil including Americium 241, Caesium 137, Cobalt 60, Technetium 99, Iodine 129, Caesium 134, Ruthenium 106, Antimony 125, and Europium 155.

This table also omits any results for Plutonium 238, 239 and 240 and it is presumed that these nuclides were not analysed for in this study. However, despite the unexplained failure (or refusal) to analyse terrestrial "tide washed" turf for Plutonium nuclides it is also clear that tide washed salt marsh will contain Plutonium as per the "salt marsh" sample.

NB Salt marsh is generally less likely to experience inundation than the standard "intertidal" zone and may be regarded as a transitional zone between the true intertidal and the true terrestrial zone. "Tide washed pasture" or coastal grazing marsh is a specific term applied to land derived from the enclosure of salt marsh, thus the two are virtually identical in all respects except that one has been enclosed.

4:5 The paragraphs above prove that at least 12 radio nuclides are capable of being transferred from the marine environment into coastal urban environments, and terrestrial "tide washed" marshland grazing environments.

4:6 The Campaign contends that it is clear that the nuclides named in preceding paragraphs are readily transferred from marine environments into urban environments where urban populations may be exposed, and onto coastal marshland and tide washed pasture where they may be consumed by grazing animals and provide dietary/ingestion doses to human consumers of animal products (milk, other dairy products, and meat).

4:7 In the context of the evidence above, and given the number and volume of nuclides discharged from the Hinkley Point A and Hinkley Point B sites (and those discharged from the Berkeley and Oldbury sites) over a 50+ year time scale, and the acreage of both urban coastal environments and intertidal and tide washed pastures along the south Wales coast and that of the Somerset and Avon coast, the Campaign concludes that the Welsh government and its environmental regulation agency, NRW, have been deeply remiss in not initiating any form of radiological monitoring of the south Wales coastal urban environments, tide washed pastures and marshland grazing. The failure of regulators and of EdF to carry out similar monitoring and analytical work on the coasts of Avon and Somerset is equally remiss.

4:8 Both the Welsh Government and NRW have signally failed to address the Campaign's 2017/2018 call for pre dump monitoring of coastal urban areas and tide washed pastures in order to establish baseline data against which to measure the impact of the first licensed dump of Bridgwater Bay sediments into the Cardiff Grounds marine disposal site.

That failure means that any impact of the first dump is now un-quantifiable. The Campaign contends that this failure is both scientifically and morally unjustifiable, and must not be repeated in the context of the forthcoming proposal for dredge and dump activity in 2021, and that NRW and the Welsh Government must now insist on appropriate baseline environmental monitoring of these parameters prior to any further consideration of permitting future dumping at Cardiff Grounds marine disposal site.

4:9 Accordingly the Campaign contends that baseline investigation involving the collection of EMPIRICAL field data (not modelled hypothetical data) must now be undertaken into the baseline (pre second dump) concentration of nuclear power station radio nuclides along the intertidal and tide washed (terrestrial) coastal environments of south Wales in order to assess both the potential pathways of exposure and the likely dietary doses arising as a result of occupation of flooded urban environments and the consumption of produce reared on "tide washed" coastal grazing.

4:10 Noting that there is no legal insistence that National Governments must or can not improve upon the existing inadequate IAEA protocols, the Campaign demands that NRW take note of the evidence discussed above and insist that EdF commission both baseline (pre second dump) surveys of coastal environments to determine their current radiological status, and post (second) dump in order to identify any variations in radiological status.

4:11 Noting that, in the current context of increasing flooding of estuarine and coastal terrestrial zones, such inundation events are plainly on the increase, the Campaign recommends that any such environments known to have experienced tidal or coastal

inundation over recent years (ideally at least 20 years) are prioritised and given the benefit of such investigation.

...

5: The imperative for baseline Tritium and Organically Bound Tritium (OBT) analysis

5:1 The Campaign has noted, and previously commented on, the total absence of any reference by EdF or the Welsh environmental protection agency, NRW, to the Tritium content of the Bridgwater Bay sediments which have been dredged and dumped at the Cardiff Grounds.

5:2 There is a massive body of evidence from AEMR and RIFE reports to confirm that annual discharges of Tritium (as tritiated water or HTO), from the 4 reactors of the Hinkley Point A and B sites, into the Bridgwater Bay receiving environment are high. Reports regularly show that the Hinkley Point B station in particular is responsible for annual liquid discharges of several hundred TBq per year.

5:3 The IAEA and nuclear regulators are once again "behind the curve" when it comes to their appreciation of the significance of tritium discharges to the environment. It is clear that historically these organisations have shared a common view that tritium is of low biological significance in marine environments largely based on the assumption that tritium, discharged as tritiated water, would naturally dissolve to infinity and thus present no hazard.

This attitude was typified when in 1985 liquid tritium discharges from the Hinkley Point A station were increased 23 fold following work to clean the coolant circuit, and the regulators commented, through the UK Aquatic Environment Monitoring Report, that "the increased discharges were of negligible radiological significance".

REF: MAFF Aquatic Environment Monitoring Report for 1985 (published 1986) No. 14 section 6:6. Page 36.

5:4 However, through the late 1990 and the early 2000s independent academic research published in peer reviewed journals forced a re-assessment of the significance of tritium discharges to aquatic environments. As early as 1993 academics were reporting that organically bound tritium (OBT) entered the human body on several pathways, either from the primary producers (vegetable food), or at a higher tropic level (animal food), and that animal experiments had shown that the dose due to ingestion of organically bound tritium can be up to twice as high as a comparable intake of tritiated water in gaseous or liquid form.

REF: "Organically bound tritium.". Diabaté S et al' Health Phys. 1993 Dec;65(6):698-712.

5:5: By 1999 even the RIFE reports (which succeeded the AEMRs) were commenting that "Experimental results, suggest that the presence and nature of organic matter is critical to the fate of tritium in the aquatic environment, and that there is also potential for its interaction with and uptake by inorganic phases. Association of tritium with sediment organic matter was corroborated in our studies by its near complete (greater than 95%) digestion in untreated estuarine particles".

REF: RIFE Report 1999 (RIFE-5) (published 2000). Sections 8:2 and 11:2 and Tables 8:2 (a) and 8:2 (c) page 111

5:6 Bridgwater Bay sediments are expected to be relatively highly enriched with organic material derived from inputs from the River Parret, however to date the Campaign has been unable to identify any thorough investigation of organic matter content and distribution across the Bridgewater Bay in general and through the proposed dredge areas in particular.

5:7 OBT is shown to be a significant factor with “relatively high levels of organically bound tritium (OBT) in local fish and shellfish” from the Cardiff area of the Bristol Channel/Severn Estuary (max of 33,000 Bq/Kg in cod and 26,000Bq/Kg in mussel).

It was also reported that additional sampling of tide washed pasture and wildfowl (Curlew, Pintail, Shelduck and “duck”) that feed in the Bristol Channel/Severn Estuary intertidal zone had found elevated levels of tritium in most samples with:

a: lowest wildfowl concentrations at 2,400 Bq/Kg

b: “the highest values found were in Shelduck at about 61,000Bq/Kg total tritium”

c: grass concentrations ranging from less than 3 Bq/kg to 2,000Bq/Kg

d: intertidal sediment concentrations ranging from 18Bq/Kg to 2,500Bq/Kg

while the ambient sea water concentrations of total tritium were reported to range from 9.2 Bq/Kg to 10Bq/Kg; thus representing an extremely high rate/level of biological accumulation of total tritium (assumed to be OBT plus tritiated water)

REF: RIFE Report 1999 (RIFE-5) 2000. Sections 8:2 and 11:2 and Tables 8:2 (a) and 8:2 (c) page 111

5:8 To date there appear to be no relevant studies of tritium and OBT in consolidated, sub-surface, seabed fine sediments.

However a 2015 study of tritium and OBT in terrestrial soils from Canada reported that much of the OBT in soil is tritium incorporated into organic material, and it is thus concluded that because soil acts as a repository for decaying organic matter, the OBT concentration in soil represents a long term tritium reservoir of historical tritium releases.
The study commented that “given that organic matter can reside in soils for decades ... a fraction of the OBT measured in soils may represent tritium incorporated into plants when tritium concentrations were elevated ... due to bomb testing”, i.e. tritium in soil, as OBT, could probably have a life span of decades.

REF:” Levels of tritium in soils and vegetation near Canadian nuclear facilities releasing tritium to the atmosphere: implications for environmental models”: PA Thompson et al’: Journal of Environmental Radioactivity Volume 140, February 2015, Pages 105-11.

5:9 In the absence of any empirical evidence to the contrary, the Campaign postulates that OBT may have a similar life span in consolidated, sub-surface seabed fine sediments.

If this is the case, then the dredge and dump of Bridgwater Bay sediments is highly likely to re-distribute previously sequestered OBT associated with organic materials incorporated into the deposited sediments. Following the 2018 dump activity this will have released OBT into the marine environment of the south Wales coast and there is a potential for a similar, but larger release of OBT following the proposed future 2021 dump.

5:10 Following such releases the OBT attached to fine organic sediment micro-particles is then likely to be biologically available to members of the south Wales coastal zone population via seafood ingestion pathways, and pathways of inhalation and ingestion (of contaminated terrestrial agricultural produce) generated by sea to land transfer mechanisms.

5:11 In the context of the information discussed above, the Campaign demands that NRW initiate analysis of:

a: south Wales coastal fine sediment samples in order to quantify the concentrations of OBT already present there

b: Somerset and coastal fine sediment samples in order to quantify the concentrations of OBT following the construction and dredge activity of 2016, 2017 and 2018

c: the Bridgwater Bay sediments to be dredged and dumped in 2021.

in order to acquire a relevant suite of baseline data against which to compare and contrast the impacts of any further dredge and dump activity.

...

6: Sea to land transfer via marine aerosol processes

6:1 These processes involve the airborne transfer of radio nuclides (entrained in water droplets or attached to fine sediments), in marine aerosols, across the shoreline during periods of onshore wind. The IAEA, CEFAS and EdF have chosen to ignore the issue of sea to land transfer via marine aerosoling mechanisms and to focus instead on "inhalation of re-suspended beach sediment" and "inhalation of sea spray".

6:2 Definitions: beach sediments: coastal geo-morphologists define "beach" thus: "Beaches form through erosion of rock or coral reefs near the edge of the ocean. Rocks are worn away slowly over millions of years into tiny particles, like sand or pebbles. The particles that make up beaches may travel from many miles away in the ocean to reach the beach. Water waves carry the particles and deposit them on the shore.

REF: https://study.com/academy/lesson/what-is-a-beach-definition-formation-characteristics.html

A **beach** is a narrow strip of land separating a body of water from inland areas. **Beaches** are usually made of sand, tiny grains of rocks and minerals that have been worn down by constant pounding by wind and waves.

REF: www.nationalgeographic.org > encyclopaedia

6:3 Clearly neither of the above definitions have any similarity or relevance to the extensive fine sediment / muddy intertidal zone of the shorelines of the Severn estuary, which are composed largely of silts, clay mineral particles and organic particles (micro organisms etc) small and fine enough to be suspended in the Severn estuary water column for relatively prolonged periods of transport before being deposited in the Severn estuary intertidal zone, largely as a result of flocculation processes.

6:4 There is a clear consensus among oceanographers, coastal geomorphologists and other coastal experts that "beach sediments" consist of particles both larger and heavier than silts / clay mineral particles or organic particles. As such, beach sediments are generally most likely to come under the size definition of "sands" and hence are:

a: unlikely to be suspended for very long in the coastal water column,

b: unlikely to be injected into the coastal atmosphere at normal inhalation heights,

c: very unlikely to be of respirable size (i.e. small enough to enter the lung),

d: very unlikely to remain suspended in the coastal airstreams over time scales sufficiently prolonged to permit them to penetrate deep in to the coastal zone (i.e. more than a few score yards.)

6:5 Oceanographers distinguish between sea spray (larger droplets sheared away from the upper surface of cresting and breaking waves) and sea water aerosols (micro-droplets / film droplets / jet drops produced from bubbles bursting within breaking waves)

REF: "The effects of the marine aerosol on infrared propagation over the world oceans". Stuart G. Gathman: Oceanologia 41 (4) 1999. pps 489-513.

6:6 In windy conditions, water droplets are mechanically torn off from crests of breaking waves are defined as "spray". Sea spray droplets generated this way are called "spume droplets" and are typically larger in size than aerosol droplets and therefore have less residence time in air. Impingement of plunging waves on sea surface also generates sea spray in the form of splash droplets which are also larger than aerosol droplets.

Such droplets, as is the case with "sands", are generally too large and too heavy to have significant potential to penetrate deep in to the coastal zone.

6:7 By contrast, in the case of marine aerosols, "film droplets" make up the majority of the smaller particles created by the initial bubble burst, while "jet droplets" (also small) are generated by a collapse of the bubble cavity and are ejected from the sea surface in the form of a vertical jet.

REF: "Ocean Spray". F. Veron Annual Review of Fluid Mechanics. : 2015: 47 (1): 507–538
REF: F. McIntyre.. "Flow patterns in breaking bubbles". Journal of Geophysical Research: 1972: 77 (27): 5211–5228
REF: "The Impact of Sea Spray on Air-Sea Fluxes in Coupled Atmosphere-Ocean Models". Edgar Andreas. 2002. Fort Belvoir, VA

6:8 On behalf of the UK Nuclear Free Local Authorities and others, this author has reviewed a number of nuclear industry and non-aligned independent and academic studies of sea to land transfer issues, some of which have been published in peer reviewed journals, others of which were produced by County Councils and General Medical Practitioners. These studies, universally focussed on the sea to land transfer of only 5 radio nuclides (Caesium 137, Americium 241, Plutonium 238, Plutonium 239 and Plutonium 240), have confirmed that the sea to land transfer of these nuclides does occur by way of sea spray and marine aerosol micro droplets carried inland during periods of onshore winds.

These studies from the fully referenced Technical Briefing published by the Nuclear Free Local Authorities, are summarised below:

6:9 A study by the UK AERE provided **EMPIRICAL** data showing that these nuclides are all enriched by various degrees during the process, with Caesium 137 showing enrichment factors (EFs) of about 2 relative to ambient sea water concentrations. The alpha emitting Plutoniums and Americium were shown to have EFs, relative to filtered ambient seawater, of up to 800. It was noted that the sea spray and aerosols were generated by breaking waves in both the offshore zone and at the surf line. Alpha emitters were found to be associated (by adsorption) with micro particles of sedimentary and organic material suspended in the marine water column and ejected into the atmosphere as aerosol micro droplets by bursting bubbles in breaking waves.

REF: NFLA Radioactive Waste Policy Briefing Number 78: Sea to Land Transfer of Man-made Radioactivity – an update. July 2019 www.nuclearpolicy.infoRad_Waste_Brfg_78_Sea_to_Land_Transfer

6:10 A study from Dyfed County Council provided **EMPIRICAL** data showing that sea to land transferred nuclides penetrate deep inland (sea borne Caesium 137 shown to penetrate at least 10 miles inland into the Welsh coastal zone) and then contaminate pasture grass, thus providing a public dose exposure pathway via the consumption of meat and dairy produce. (*There are no comparable studies for the 4 alpha emitting nuclides of Plutonium and Americium.)*

The reviewed studies have also provided **EMPIRICAL** data showing that in coastal communities, people consuming locally grown produce grown from affected coastal zones have higher radioactivity body burden than those **not** consuming locally grown produce.

REF: NFLA Radioactive Waste Policy Briefing Number 78: Sea to Land Transfer of Man-made Radioactivity – an update. July 2019 www.nuclearpolicy.infoRad_Waste_Brfg_78_Sea_to_Land_Transfer

6:11 A study carried out by a team of GPs (with the assistance of the Scottish Universities Research and Reactor Centre, East Kilbride) has also provided **EMPIRICAL** data showing that individuals from affected coastal zone communities **derive larger dietary doses of marine sourced man made radioactivity, from terrestrial produce grown in the coastal zone, than from sea foods harvested from local waters.**

REF: NFLA Radioactive Waste Policy Briefing Number 78: Sea to Land Transfer of Man-made Radioactivity – an update. July 2019 www.nuclearpolicy.infoRad_Waste_Brfg_78_Sea_to_Land_Transfer

6:12 One of the reviewed studies provided **EMPIRICAL** evidence showing that individuals living next to the Hinkley nuclear power station had **lower** doses of 7 radio nuclides from locally grown produce, than the doses of the same 7 nuclides received by individuals living in a coastal zone "distant" (at least 30kms) from any licensed discharges eating a replica diet. This outcome was attributed to sea to land transfer processes.

REF: NFLA Radioactive Waste Policy Briefing Number 78: Sea to Land Transfer of Man-made Radioactivity – an update. July 2019 www.nuclearpolicy.infoRad_Waste_Brfg_78_Sea_to_Land_Transfer

6:13 In the context of the data presented above, the Campaign contends that sea to land transfer of radio nuclides, via both the inundation and marine aerosol pathway, is EMPIRICALLY demonstrated to be a pathway of significance and that it is at least as important as any of the other parameters referenced by EdF in accord with IAEA protocol (all of which appear to be supported only by hypothetical model outcomes and NOT by EMPIRICAL evidence).

6:14 In this context, the Campaign demands that NRW recognise these phenomena and act upon them, by insisting that EdF commission the monitoring and analytical research advised and recommended in earlier paragraphs in order to establish baseline data on the extent and inland penetration of radiological impacts, arising from both coastal inundation and the sea to land transfer of marine aerosols, in respect of all of the nuclides know to have been discharged in liquid effluents to the Bridgwater Bay from the Hinkley Point A & B stations.

6:15 Additionally the Campaign demands that NRW commission Severn estuary specific studies of the sea to land transfer of radio nuclides in order to confirm whether or not, given that the suspended sediment concentration of Severn estuary water is so much higher than that of the Sellefield waters, it is case that the concentration of plutonium (and other sediment adsorbed radio nuclides) in Severn estuary surf zone sea spray is "proportional to the concentration of sediment in the water".

..

7: Does Sellefield data provide conservative outcomes for Severn estuary assumptions?

7:1 Much of the commentary from the nuclear industry and nuclear regulators has proposed that, because of the high concentrations of radioactivity discharged from BNFL sites, all modelled and hypothetical assumptions about sea to land transfer based on the Sellefield observations are "conservative" (relative to other sea areas) for that reason.

For example CEFAS commentary on the radiological analysis of Bridgwater Bay sediments has, in respect of their hypothetically modelled / calculated Plutonium content of the Bridgwater Bay sediments based on their analysis of Bridgwater Bay Americium 241, used Sellafield parameters to calculate what CEFAS claims are "conservative" figures for the Plutonium concentrations present therein.

7:2 However, the Campaign disputes both this specific assumption, and the wider assumption that any calculations about sea to land transfer (of Americium and the Plutonium nuclides) via aerosoling, because the available data for the suspended sediment loadings of sea water from the Sellafield area shows a marked dis-similarity from that of the Severn estuary water column for a highly relevant parameter.

7:3 A 1998 study of coastal sea water from the estuarine/inshore zone of the north east basin of the Irish Sea (Liverpool Bay) found that the annual mean concentration of water column suspended sediments was approximately 10 mg/litre.

REF: "MEAD-The development of a long term dispersion model for shelf seas" S. Clarke. IAEA-sm-354/94: 1998

7:4 A 1982 study by the UK Atomic Energy Research Establishment noted that the 3 highest concentrations of suspended sediments in seawater samples taken from the surf zone of the Sellafield region of Cumbrian coast (where, due to wave action, the suspended sediment load was at its most concentrated) were 100mg/litre, 560mg/litre and 1,300mg/litre.

Pages 17 and 18 of this study also noted that **"the concentration of plutonium in spray is approximately proportional to the concentration of sediment in the water"** and that microscopic examination of the sedimentary particles showed that the greater majority of the particles were 1 to 2 micrometres or less and consisted of clay minerals and organic detritus.

REF: "Studies of Environmental Radioactivity in Cumbria Part 5: The Magnitude & Mechanism of Enrichment of Seaspray with Actinides in West Cumbria". AERE. Harwell. 1982

7:5 No data has been found for the suspended sediment load in the Severn estuary surf zone waters, however a 1993 study reports that the presence of fine grained material causes the formation of extensive peripheral salt marshes (140 km square in area) and high suspended sediment concentrations in the water column (**20 gms/litre** during spring tides of the Severn Estuary)".

REF: "Sediment Dynamics of the Severn estuary and inner Bristol Channel." P. McLaren et al'. Journal of the Geological Society: London. Vol 150.1993. page 590

7:6 More recent research from 2010 reports that in the Bridgwater Bay, where the adsorption of radio nuclides onto fine sediments of the Bridgwater Bay "sink" takes place, suspended sediment concentrations in the water column may be as high as **100 to 200 gms** per litre at spring tides, and that in the inner, or upper, Severn Estuary suspended sediment concentrations of **5 gms per** litre are recorded.

REF: "A Review of Sediment Dynamics in the Severn Estuary: Influence of Flocculation". A.J. Manning et al'. Marine Pollution Bulletin. 2010. Vol 61. Issues 1-3 (paras 3.2 & 5)

7:7 The Campaign contends that these studies show that sediment loadings become higher in the surf zone, where the action of breaking waves in shallow waters increases the sediment loading of the water column. Noting that offshore (non-surf zone) waters of the north east basin of the Irish Sea have an annual mean of about **10 mg/litre** compared to the offshore (non-surf zone) waters of the Severn estuary which have between **6 and 20 grams per litre**, the Campaign contends that Severn estuary (non-surf zone) waters have suspended sediment concentrations which are up to 2000 higher than those of the N.E. basin of the Irish Sea, relatively close to the Sellafield site.

7:8 The Campaign notes that, from the available evidence, sediments from the surf zone water column of the Sellafield coast (north east basin of the Irish Sea) may be 10 to 130 times enriched with suspended sediments relative to the offshore sediment concentrations. In that context, the Campaign contends (in the absence of evidence to the contrary) that from the available evidence it may be postulated that similar suspended sediment enrichment factors may arise in the Severn estuary surf zones, leading to very high sediment concentration therein.

7:9 The Campaign notes the UK AERE comment that **"the concentration of plutonium in spray is approximately proportional to the concentration of sediment in the water"** and interprets this to mean that elevated suspended sediment concentrations in the water column are closely related to elevated concentrations of Plutonium (and by extension other actinides such as Americium) in spray and marine aerosols.

7:10 The Campaign contends that, because the suspended sediment concentration of Severn estuary water is so much higher than that of the Sellefield waters it may well be case that the concentration of plutonium (and other sediment adsorbed radio nuclides) in Severn estuary surf zone sea spray is similarly "proportional to the concentration of sediment in the water".

7:11 Accordingly, the Campaign demands that NRW insist that EdF commission surveys and analytical studies to investigate the suspended sediment concentrations of the Severn Estuary water columns and marine aerosols in order to obtain baseline data which can clarify whether or not they have a higher suspended sediment load than those of the Sellafield coast and thus to ascertain whether the potential (dietary and inhalation) doses to coastal populations of the Severn estuary are higher than those of the Sellafield coast.

..

8: Fate and behaviour of sediment radioactivity suspended by HPC "dredge" activity at Bridgwater Bay

8:1 Because NRW has refused to insist that CEFAS and EdF undertake any baseline data acquisition there is no information whatsoever about the fate and behaviour of:

a: those sediments in Bridgwater Bay disturbed by dredging activity, nor

b: about the fate and behaviour of sediments dumped at the Cardiff Grounds disposal site,

this has led to a major absence of important information about the effect of the Dredge and Dump activities on both the south coast of Wales and on the Avon and Somerset coast.

8:2 However some indication of the potential impact of such activity may be identified by a review of the radioactivity concentrations in surface sediment samples taken from the intertidal zone of the Somerset coast in the region adjacent to, and downstream of, the Hinkley Point multiple A and B station reactors.

8:3 Many years of data from previous Radioactivity in Food and the Environment (RIFE) reports and their predecessors the Aquatic Environment Monitoring reports (AEMRs) have clearly demonstrated that the much of the radioactivity from the Hinkley liquid effluent discharges becomes adsorbed to fine sediments and is deposited out in downstream (easterly) monitored intertidal fine sediments, with concentrations appearing to generally decrease with distance from the discharge pipeline.

8:4 This is in accord with a consensus that suspended sediments move eastward along the Somerset and Avon coast until reaching the maximum turbidity zone in the Severn estuary, which itself moves east or west in response to the ebb and flood tidal patterns. By various routes the water body "parcels" and their associated suspended sediments are transported into the coastal regions of south Wales where they trend generally west towards the Celtic and Irish Seas.

8:5 Over many years, the RIFE & AEMR reports show an overall steady decline in radioactivity concentrations in downstream sediments. These reports widely comment that this steady decline in the environmental concentrations is the outcome of steady declines in the volume/concentration of radio activity in the liquid effluent discharges from the Hinkley Point A and B stations.

8:6 On the rare occasions when such trends are interrupted, or reversed, it has always been the case that the authors of RIFE and AEMR reports have commented on variations in the internal operational performance of the Hinkley reactors, where they believe those operational performances to be responsible for temporary increases in radioactivity concentrations recorded by the annual marine sampling and analysis programmes at Hinkley.

8:7 Thus, in the case of an increase in Hinkley regional radioactivity concentrations recorded by the RIFE 19 report for 2013, the authors of RIFE 19 specifically noted that liquid discharges to sea were increased in 2013 due to fuel pond cleaning at the HP A station and increased power generation at the HP B station.

8:8 A 2020 a review, carried out by the Campaign, for the years 2013 to 2018 inclusive **(see ANNEX 1)** introduces data from RIFE reports which linked rising concentrations of radioactivity through 2016, 2017 and 2018 in the regional marine environment, to construction activity at Hinkley Point C and proposed that this activity had disturbed Bridgwater Bay sediments and the radioactivity previously sequestered therein and released it to the environment.
The Campaign's review noted that this process was confirmed by rising concentrations reported for intertidal surface sediments reported by the RIFE reports for the relevant years.

8:9 The ANNEX 1 review also introduced evidence from RIFE 22, 23 and 24 showing that over the period covered there were
a: increased concentrations of sediment associated Cobalt 60 and Americium 241 in coastal inter tidal sediments
b: increased gamma readings above intertidal sediments
c: increased total dose to the public ... and that
d: from the data presented in the RIFE reports for 2016, 2017 and 2018 it can be calculated that total dose to the public increased by 215% over the 3 year period

The Campaign's ANNEX 1 review, noting that the RIFE authors un-characteristically offered **no explanation** for the 2016-2018 rise in concentrations, has, in the absence of any information to the contrary, attributed the rise to Hinkley Point C construction and dredge related activity in the intertidal and subtidal zones of the Bridgwater Bay.

8:10 EdFs environment spokesman Chris Fayers responded to the Campaign's review by stating that no dredging took place until **after** the sediment samples were collected.

However, despite Fayer's statement, the Campaign can report that EdF's own PR makes it clear that a whole raft of activities were indeed taking place in the Hinkley Point C intertidal and subtidal zones during 2016, 2017 and 2018, including the construction of a "barrier sea wall", pile driving and seabed drilling into the subtidal sediments prior to the construction of a jetty, and the subsequent construction of the jetty itself.

The Campaign contends that all of these activities would inevitably have disturbed both subtidal and inter-tidal sediments and concludes, in the absence of any other information, that they would undoubtedly have contributed to the observed reported increased concentrations noted by the RIFE reports.

8:11 The Campaign concludes that there is no doubt that the reported intertidal and sub tidal activity relating to the Hinkley Point C construction has been responsible for the re-suspension and re-release, into the marine environment, of previously sequestered sediments and their associated radioactivity. This action subsequently lead to the raising of radioactivity concentrations in coastal sediments in the Hinkley region, and this effect was observed to the limit of the downstream area where sampling and analysis of coastal intertidal sediments was carried out (approx. 12 miles from the activity site)

8:12 In the context of the preceding paragraph the Campaign contends that a similar effect was and is inevitable in the region of the dredge waste disposal site at the Cardiff Deep disposal site when the dredged Hinkley Point sediments have been, and are proposed to be, dumped.

8:13 The Campaign notes that the recorded 12 mile impact reach of the 2016-2018 marine activity at Hinkley Point C is a function of the limits of the Hinkley nuclear power station sampling and analysis programme which does **not** extend beyond Weston super Mare. Had it done so, there is a strong possibility that the recorded elevated concentrations would have been found beyond the 12 mile limit.

8:14 The Campaign contends that the evidence discussed in the preceding paragraphs indicates that sub tidal and intertidal works carried out in the Bridgwater Bay as part of the Hinkley Point C construction process is clearly the causative factor for the increased, and increasing, radioactivity concentrations recorded through 2016, 2017 and 2018 by the annual RIFE reports.

8:15 The Campaign contends that there is no evidence that EdF had carried out, or commissioned any form of study to investigate the Somerset coast implications of their intertidal and subtidal works and demands that, prior to their proposed 2021 activity, EdF carry out, or commission such investigations.

On behalf of its supporters from the communities on the Somerset and Avon coasts, the Campaign demands that EdF carry out or commission such investigations and publicly and widely report the outcome of those investigations.

..

9: Probable impacts on south Wales coastal regions, of the disposal of Bridgwater Bay radiologically contaminated sediments at the Cardiff Grounds disposal site

9:1 In the context of the recorded (at least) 12 mile extent of elevated concentrations of sedimentary radioactivity generated by the intertidal and subtidal work at Hinkley, it is clearly relevant to consider such an impact range in the context of the dumping of Bridgwater bay sediment at the Cardiff Grounds disposal site and the south Wales coast.

9:2 In this context the Campaign notes that a number of studies report extensive movement, and prolonged residence times of "water parcels" and "water particles" in the Bristol Channel and Severn Estuary environments:

"Water parcels can move up to 25 kms during a flood or ebb tide"
REF: "Hydrodynamics of the Bristol Channel", Uncles.J. Marine Pollution Bulletin. 1984. Vol 15 (2) pps 47-53

"Tidal excursion of water particles is extensive (up to 22 km) over a single tidal cycle" and "mean retention times of 20- 90 days" in the outer Severn Estuary
REF: "Sediment Fluxes in the Bristol Channel". MB.Collins. Procs Usher Society. 1989. Vol 7. Pps 107-111

9:3 In the context of the preceding paras it is highly relevant to note that:

a: landfall 25 km east of the Cardiff Deep dump site is on the Gwent Levels approximately south of Redwick village : this distance encompasses the western extent of the Gwent levels including the extensive fine sediment intertidal foreshores of the Cardiff sea front, Wentlooge etc, the estuary of the Usk, the Newport sea front and a significant section of the eastern Gwent levels;

b: landfall 25 km west of the Cardiff Deep disposal site is on the south coast of Glamorgan: this distance encompasses much of the coast of South Glamorgan including the relatively extensive fine sediment enriched intertidal zones of Barry Harbour, Whitmore, Jacksons, Sully, Swanbridge and St Mary's Well bays plus the extensive fine sediment deposits along the Cardiff sea front.

9:4 The Campaign notes that, due to the lack of diligence of successive Welsh Governments and their regulating agencies (currently NRW), there has been no investigation of any nuclear power station radioactivity concentrations along the south Wales coastline despite the fact that it is downstream of no less than three nuclear power station sites containing 8 reactors. Those reactors have been responsible for the discharge of multiple radio nuclides into the Severn estuary and Bristol Channel aquatic environments over the last 58 years.

9:5 Of equal importance for the acquisition of deeply relevant baseline data, following the original 20102/13 application by EdF to dump 3000,000 tonnes of Bridgwater bay radio-actively contaminated sediment at the Cardiff Grounds site, there has been no attempt by Welsh Government or their regulating agency NRW to order or undertake any studies to investigate the end fate of sedimentary material dumped at the Cardiff Grounds site.

This is particularly remiss in the context that the Cardiff Grounds site is specifically referred to as a "dispersal" site, i.e. where sediment will not accumulate and modify the sea bed, but will be dispersed to sites elsewhere.

9:6 Further discussion of these issues was submitted, by the Campaign, in a short Briefing to the Senedd Petitions Committee. Following that submission of evidence, the Senedd Petitions Committee made the following resolution directed at NRW and EdF

"to ask for further details of any sampling or monitoring carried out within the wider Severn Estuary and studies relating to how the sediments would be likely to be dispersed following dumping at the Cardiff Grounds site."

REF: Senedd Petition Committee: Minutes of discussion of previous evidence session. 02/01/18

9:7 The Campaign notes that some months later, after repeated prompting from the Campaign, NRW did eventually provide the required information, which proved to have been constructed and collated by the Westminster government agency CEFAS rather than by the Welsh government agency NRW. Despite queries from the Campaign as to why NRW had not/did not undertake their own research or request assistance from the several Welsh University departments with the relevant Academic expertise, staff and equipment, no specific response was forthcoming.

9:8 Following the April 2018 presentation by NRW of the requested information to the Senedd Petition Committee, in the form of a collection of studies collated, reviewed and commented on by CEFAS (see ANNEX 2) with no apparent input from NRW, the Campaign produced a review of NRW submission.

……………………………………………………………………………………………………

10: Campaign Conclusions on the 2018 NRW submission

10:1 *The papers submitted by NRW provide very little useful or reliable data about the potential fate of radioactively contaminated sediment emplaced into the sea at the Cardiff Grounds disposal site about 2 miles off shore of Cardiff because:*

A: *all the papers are Severn Estuary wide in scope and none report any site specific (Cardiff Grounds) data investigations;*

B: *the main subjects for several papers were commercial issues (sand & aggregate resource, barrage proposal) and fine sediments were of little interest to the research;*

C: *a 1993 paper stated that* ***"the present state of knowledge is still insufficient to understand fully sediment supply and transport within such a complex system";*** *a 2010 paper concludes that* ***"much of the research and data collection was undertaken several decades ago, hence there is a requirement for further investigation";*** *another 2010 paper reports that* ***the study and understanding of Bristol Channel sediments is now additionally "complicated by large scale ecosystem collapse due to climate change";***

D: *the campaign agrees with CEFAS that the papers confirm:*

1: a north and east movement of sediment in the Cardiff sector of the Bristol Channel; ***the Campaign notes that this means from the Cardiff Grounds towards the mudflats to the north east, i.e. Gwent levels/Wentlooge Flats and the estuarine and intertidal mudflats fringing the south Wales coast up to the Wye estuary;***

2: that the sediments are more likely to remain in the sediment cell and to circulate throughout the cell; ***the campaign notes that this is until deposited in sites such as those listed above;***

E: *CEFAS state that the "general trend of sediment behaviour within the intertidal area around Cardiff and the shoreline closest to Cardiff Grounds has been identified as one of erosion. Therefore it is unlikely that any sediment leaving the cell would settle in those areas."* ***CEFAS offer no other comment on the end fate of the sediments. The Campaign believes it unlikely that NO sediment from the dump site would be deposited in a "Cardiff shoreline". The Campaign notes the failure of NRW or CEFAS to bring forward any data related to the wider environmental fate of sediment dumped at Cardiff Grounds.***

F: *the Campaign's concerns about the end fate of material dumped at Cardiff Grounds have always encompassed those of its supporters: that the entire south Wales coast is the issue.* ***The CEFAS commentary above, is plainly inadequate because it comments only on the intertidal area around Cardiff and offers no information on the potential impact on coastlines to the north-east and west;***

G: *CEFAS proposes that any "contamination will be further diluted over time through mixing in the water column".* ***The Campaign disagrees with this claim, because although contamination may be temporarily diluted through mixing in the water immediately post dumping period, over the longer term the re-concentration of radioactivity in sediments is always shown in the Bristol Channel, where annual monitoring of sea water and sediments demonstrates that unfiltered sea water always shows much lower radioactivity concentrations than samples of deposited fine sediments (see RIFE reports);***

H: *from the papers offered by NRW, the Campaign concludes that there is a consensus that extensive inter-tidal sites to the north and east of the Cardiff Grounds (river Usk, Newport Deep, Cardiff Roads, Wentlooge Flats etc.) are depositional and accretion sites where fine sediments entrained in the Severn Estuary water column and transported north and east from the Cardiff Grounds may be deposited out.* ***The campaign notes that NRW, the relevant devolved Welsh Government Agency, appear to not have undertaken any review of, or search for, relevant data and are relying on the UK CEFAS, a Westminster Government agency, for information;***

I: the Campaign states that NRW submission has NOT allayed the concerns expressed in the original petition text and that the submissions have confirmed that radioactively contaminated sediments proposed for dumping at Cardiff Grounds appear most likely to travel north-east towards the mud flat and estuary depositional environments of the east Glamorgan and Gwent coasts where they may deposit out and remain for uncertain time scales. The Campaign notes that had an exhaustive (site and proposal specific) EIA been carried out these issues could have been settled long ago.

10:2 In the Context of the above Review and the clear conclusion to be drawn from the papers cited by CEFAS, the Campaign concludes that there is still no definitive evidence about the likely end fate of the dredge material proposed for the 2021 dump at the Cardiff Grounds.

10:3 In the context of the evidence of demonstrably raised concentrations of radioactivity in intertidal sediments along the Somerset coast, caused by the re-distribution of previously sequestered anthropogenic radioactivity disturbed by subtidal and intertidal construction, drilling and bore holing activity related to the HPC development, the Campaign contends

that similar radiological outcomes may arise as a result of the disposal/dispersal of up to an additional 600,000 cubic metres of those self-same sediments at Cardiff Grounds, added to the sediment already dumped in 2018.

10:4 The Campaign contends that the failure to conduct such baseline studies prior to the 2018 dump has left a yawning data gap about the potential environmental and human health impacts of the 2018 dump. The Campaign contends that the implications of the preceding paras, when applied to the massively enlarged proposed 2021 dump at the Cardiff Grounds, demand that this data gap be removed before the proposed 2021 activity is considered.

10:5 Accordingly, the Campaign contends that the must NRW insist that EdF, CEFAS or preferably some independent academic institution undertake extensive and detailed research in order to ascertain the end fate deposition of sediments dumped at the Cardiff Grounds dispersal site and subsequently make fully public the details and outcomes of that research.

10:6 The Campaign states that such extensive and detailed research could have been carried out and completed PRIOR to any dredge and dump had NRW and the Welsh Government demanded that an EIA be undertaken. The Campaign takes this opportunity to demand that NRW insist upon the initiation of an EIA to be both scoped, and carried out, by independent academics guaranteed to produce an impartial conclusion.

..

"De minimis" assessment: surveying, sampling and technical analytical issues.

11: EdF Statements to Senedd Petition Committee re the radiological analysis of sediments dumped in 2018

11:1 The Welsh Government, through their regulating agency Natural Resources Wales (NRW), and in conjunction with EdF and the rest of the UK Nuclear Industry, and the Westminster Government's Centre for Environment, Fisheries and Aquaculture Science (CEFAS) have always argued that the programmes for the collection of marine environmental samples and the subsequent radiological analysis of those samples is of the highest quality because carried out in accordance with the international protocols issued by the International Atomic Energy Agency.

11:2 Critiquing the Campaigns concerns about the repeated and widely publicised EdF statements (unquestioningly accepted and repeated by NRW and the Welsh Government) that Bridgwater Bay sediments were not radioactive, Chris Fayers of EdF told the Senedd Petitions Committee that the sediment

"has been referred to inaccurately, (by Campaigners) as radioactive, nuclear and toxic waste, and that there may be risks to human health or the environment." (para 137 of evidence to the Senedd Petitions Committee: 5 Dec. 2017 from meeting transcript)

and added that

"We know this because we have tested it independently three times using world-leading equipment to highly conservative standards. These standards are supported by Natural Resources Wales, Public Health Wales, the Environment Agency, the Centre for Environment, Fisheries and Aquaculture Science, the UK Government and the United Nations." (para 138 of evidence to the Senedd Petitions Committee: 5 Dec. 2017 from meeting transcript)

11:3 Note that it was not EdF who carried out the testing, the available documentary evidence confirms that CEFAS were commissioned to carry out all of the analyses on behalf of EdF. It is assumed that this was a commercial agreement and that the surveying, sample recovery and analytical work was scoped, in part at least, by EdF.

The Campaign notes that no details of the funding and scoping arrangements have been made public.

11:4 The position statement (Para 9:1 above) issued by and on the behalf of interested parties, although it may convey the impression that these bodies and agencies are independent, should not be uncritically accepted as such:

NRW (in its own words) is "a **Welsh** Government Sponsored Body". Welsh Government, in light of its recent response to nuclear issues is clearly a pro-nuclear government;

CEFAS (in its own words) "is an executive agency, sponsored by the Department for Environment, Food & Rural Affairs". DEFRA is a department of the avowedly pro-nuclear Westminster Government. CEFAS works according to protocols supported by the pro-nuclear Westminster Government and the IAEA so it is no surprise that it supports the methods that it uses itself.

The **IAEA** in the first clause of its *ARTICLE II: Objectives* of its Statute states that "The Agency shall seek to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world…".

The IAEA in the first paragraph of its *ARTICLE III: Functions* of its Statute states that "A. The Agency is authorized: 1. To encourage and assist research on, and development and practical application of, atomic energy for peaceful uses throughout the world; and, if requested to do so, to act as an intermediary for the purposes of securing the performance of services or the supplying of materials, equipment, or facilities by one member of the Agency for another; and to perform any operation or service useful in research on, or development or practical application of, atomic energy for peaceful purposes.."

11:5: Having ensured that it became an Agency of the UN, and in the context that ÍT is the source of the international standards quoted by EdF's Mr Fayers, it is no surprise that the IAEA supports the methods used in the EdF surveys.

11:6 The commentary in the immediately preceding section is highly relevant to the following discussion of the sampling, monitoring and analytical techniques used by CEFAS and supported by EdF, NRW and the pro nuclear Welsh Government, and explains why the Stop the Mud Dump campaign is not convinced of the "independence" of those permitted to control and manage the analysis of, and commentary on, sedimentary radioactivity in the Bridgwater Bay Dredge/Cardiff Bay dump material.

……………………………………………………………………………………………

12: Review of the analytical techniques used prior to the (pre-2018) dredge and dump.

12:1 EdF representatives have repeatedly proposed, in statements to the Welsh media and in verbal evidence given to the Senedd Petitions Committee evidence sessions, that the Gamma Spectrometry techniques for radiological analysis of the Bridgwater Bay sediments, used during the first three analytical assessments of the sediment to be dredged and dumped, would identify all of the radio nuclides present in the sediment, as shown below:

Neil McEvoy Am

the first question is: how many radionuclides were tested for?

Peter Bryant: EdF

So, basically the testing was done by CEFAS. They would have used something called high-purity germanium detection. It sounds very complicated, but in essence each radionuclide normally emits a gamma ray, which is a byproduct of alpha and beta decay. That's always at a specific energy, and that energy is like a signature that says, 'This particular radionuclide has emitted an emission of radioactivity.' So, the high-purity germanium detection system looks across all the energy range, really, so wherever there's a peak that corresponds to a particular radionuclide. So, you detect actually what's present, and so it will detect way above 50 plus different types of radionuclides that occur in the environment. So, it is very much looking for the signature of radionuclide: rather than just going, 'I'm going to target these three or four'; it goes, 'I look across the entire range of energies and I detect exactly what's present.'

Neil McEvoy AM

***So, in effect, all the man-made radionuclides were tested for through that process**?*

Peter Bryant EdF
***Yes,** ....*

Paras 146, 147, 148 and 149 of session transcript Senedd Petitions Committee Hearing of Evidence 5 Dec 2017

12:2 I have highlighted**, in bold**, the most significant statements in this exchange, from which it is clear that EdF representative Peter Bryant was telling the Senedd Petitions Committee that **all** of the man-made radio nuclides in the Bridgwater Bay sediments had been tested for by the Gamma Spectrometry techniques employed.

However, the three surveys referenced by EdF only recorded 3 anthropogenic/man-made radio nuclides (Caesium 137, Cobalt 60 and Americium 241) whereas there was ample evidence, submitted by the Campaign, to the Senedd Petitions Committee that the existing and historical (55 years) liquid discharges from the Hinkley site into the Bridgwater Bay sedimentary environment had consisted of many more radio nuclides. At no stage during the Committee's hearings of evidence, or at any other time, was this evidence denied or refuted by EdF, NRW or CEFAS.

12:3 It was, and remains, the Campaign's contention that the identification of only 3 man-made radio nuclides is a proof that the use of Gamma Spectrometry alone has failed to record the presence **of all of the nuclides** known to be present in the Bridgwater Bay sediments.

This Campaign position is reinforced by the following statement made, by CEFAS in their reporting of the 2017 survey carried out on the Bridgwater Bay sediments on behalf of EdF *"In addition to the nuclides detected by gamma spectrometry, sediments are also known to contain activities of Pu (Plutonium) radionuclides. The Am 241 data were used to derive estimates for the radio nuclides Pu 239, Pu 240 and Pu 241, assuming their activity was proportional to the ratio in* *the time integrated Sellafield discharges"* which clearly confirms that the Gamma Spectrometry did not, and could not, specifically detect a number of Plutomium nuclides (despite the fact that the sediments were known to contain Plutonium), and that because of the lack of precise measured Plutonium data, CEFAS could only offer "derived estimates", based on debatable conclusions relating to the Sellafield experience (*see Section 7 above*).

Ref: "CEFAS BEEMS Technical Report TR444, HPC intake and outfall location pre-dredge sediment sample analysis results." Page 30 of 36

12:4 Campaign notes that such derivations are not likely to be particularly accurate as neither the Plutonium known to be present in the Bridgwater bay sediments, or the measured Americium are entirely derived from Sellafield, as both are listed as present in the discharges from Magnox and AGR reactors, and the Hinkley Magnox station is believed to have been used to generate Plutonium for the UK nuclear weapons programme.

12:5 The inability of Gamma Spectrometry to detect pure alpha emitting Plutonium nuclides (Pu 238, 239, 240) is caused by the simple and widely known fact that the majority of Plutonium nuclides have no gamma emissions.

Other radio nuclides, such as Tritium (H3), Organically Bound Tritium (OBT), Strontium 90, Plutonium 241, Carbon 14, Technetium 99 and Ruthenium 106 (associated with both nuclear reactor discharges (as at Hinkley Point) or with the Sellafield reprocessor discharges) are Beta emitters, and equally undetectable by the gamma spectrometry employed by CEFAS.

12:6 *NB: it is important to note that the annual Radioactivity in Food and the Environment (RIFE) monitoring reports for the Hinkley Point marine environment always state that "Other contributors to the aquatic environment" (for Hinkley Point) "are Sellafield, and fallout from Chernobyl and nuclear weapons testing."*

It is also relevant to note that the Bridgwater Bay sediments are widely recognised as being a long term "sink" of "sequestered" historical radioactivity.

REF: Liquid waste discharges and aquatic monitoring RIFE REPORT 24 (2018) page 125

12:7 At least 7 of these pure beta and pure alpha emitting radio nuclides are regularly analysed for in marine samples taken from the Hinkley Point marine environment as reported in the annual RIFE reports. In that context, it is hard to understand why they were not analysed for in the radioactivity surveys conducted in 2009, 2013 and 2017 and presumably scoped and paid for by EdF.

REF: "Table 4.7A Concentrations of radionuclides in food and the environment near Hinkley Point" RIFE Report 24 (2018) page144.

However, the fact that these nuclides were NOT analysed for during the dredge sediment analysis, clearly reduces the veracity of the CEFAS and EdF assumption of "**de minimis**" radioactivity in the dredge sediments to be disposed of in the Cardiff Deeps site.

12:8 The Campaign view is that the claim that Gamma Spectrometry can, and did, identify all of the radio nuclides present in the Bridgwater bay sediments prior to their dredge and subsequent dump into Cardiff Deeps, is false and without scientific justification.

....

13: Academic commentary on the capabilities of gamma spectrometry

13:1 The Campaign view is that EdF's claim that gamma spectrometry can identify all of the radio nuclides present in the Bridgwater bay sediments prior to their dredge is false and without scientific justification.

In support of that view the Campaign offers the following brief quotations from relevant academic, technical & scientific literature

13:2 "it's relatively easy (and not terribly expensive – no more than a few tens of thousands of dollars) to perform gamma spectroscopy, but the cheap and easy way of doing it isn't tremendously precise. To do gamma spectroscopy well costs over $100 K and is best done by a radiochemistry laboratory.

Alpha spectroscopy is another kettle of fish entirely – there is (as of now) no quick, easy, or cheap way to do alpha spec – you pretty much have to have a trained chemist and a full-blown laboratory with a few hundred thousand dollars' worth of equipment … there are times that you need to know exactly what types of radioactivity you might (or might not) have and the best way to make this identification is through alpha or gamma spectroscopy.

One caution – gamma spectroscopy is fairly inexpensive, but alpha spectroscopy can cost a few hundred dollars per analysis and a thousand dollars or so to completely analyse a sample. But if the alternative could call for spending hundreds of thousands – or millions – of dollars in cleanup and/or waste disposal, this is money well-spent." **REF: What is Alpha and Gamma Spectroscopy?** www.ntanet.net/what-is-alpha-gamma-spectroscopy

N.B. From the above introduction to the differing types of radio analysis it is clear that there is a major financial incentive supporting the exclusive use of gamma spectrometry and the decision to NOT use alpha analysis.

13:3: "A typical laboratory may be equipped with the following nuclear counting instrumentation:

Gas proportional detectors for alpha and beta-particle counting (GP);

Sodium iodide or **high resolution germanium detectors for gamma detection and spectrometry** [NaI(Tl) and HPGe];

Low-energy gamma- or X-ray detectors [HPGe or Si(Li)];

Solid-state detectors for alpha spectrometry (HPGe); and Contents

It may also have the following equipment, which rely on atom- or ion-counting techniques, molecular methods of analysis, or gamma-ray spectrometry:

Kinetic Phosphorimeter Analysis (KPA)

Mass Spectrometric Analyses

Inductively Coupled Plasma-Mass Spectrometry (ICP-MS)

Thermal Ionization Mass Spectrometry (TIMS)

Accelerator Mass Spectrometry (AMS)

Neutron Activation. "

REF: "Quantification of Radionuclides" US.EPA. July 2004 (pages 15.1 and 15.2)

"Alpha radioactivity normally can be measured by several types of detectors in combination with suitable electronic components. The alpha detection devices most widely used are ionization chambers, proportional counters, solid-state (silicon) semiconductor detectors/spectrometers, and scintillation counters (plastic, ZnS phosphor-photomultiplier tube combination, or a liquid cocktail). The associated electronic components in all cases include high-voltage power supplies, preamplifiers, amplifiers, pulse discrimination, scalers, and recording devices. For spectrometry systems, an analog-to-digital converter (ADC) and a multichannel analyzer (MCA) would be included in the list of components."

REF: https://www.epa.gov/sites/production/files/2015-05/documents/402-b-04-001b-15-final.pdf

N.B. The CEFAS radiological analysis procedures, used to analyse the radioactivity in the sediments to be dumped at Cardiff Grounds, made use of High Resolution Germanium Detectors for gamma detection and spectrometry

N.B. Gamma spectrometry is NOT referenced as an analytical tool for alpha analysis.

13:4 From pages 15.47 & 15.48… "The radiation detectors used for beta-particle measurements include an end window Geiger Mueller tube, gas proportional chamber, liquid scintillation counter, plastic scintillators, and solid-state detectors. Each of these detectors is discussed in subsequent subsections. The end window Geiger-Mueller tube, plastic scintillators, and solid-state detectors have limited laboratory applications for beta-particle detection. Since the end-window Geiger-Mueller tube and gas proportional counters have similar characteristics and operational requirements, these two beta-particle detectors are discussed in the same subsection.

Certain aqueous beta-emitting radionuclide calibration standards and sources are available from NIST or from a radioactive source manufacturer (complies with ANSI N42.22) that supplies NIST-traceable standards. **The long-lived pure beta-emitting radio nuclides available from NIST include: 3H, 14C, 63Ni, 129I, 89Sr, 90Sr, 99Tc, 228Ra, and Pu 241".**

REF: https://www.epa.gov/sites/production/files/2015-05/documents/402-b-04-001b-15-final.pdf

13:5 N.B. Both tritiated water (3H) and its organically bonded form known as OBT (Organically Bonded Tritium) are beta emitters which have been annually sampled for, and recorded in significant quantities (20+Bq/Kg) in aquatic samples from the Hinkley Point site. OBT is well understood to associate with organic particles and lipids such as those found in high concentrations in the Hinkley marine environments. Tritium represents one of the higher volume radionuclide discharges from the both the Hinkley Point A and B stations and, as OBT, is known to have very high bio-accumulation and bio-concentration enrichment factors thus presenting a dose risk for both wildlife and human populations.

13:6 From Page 15:57

"When beta measurements involving pure beta emitters of low energy are required, they are often performed using liquid scintillation spectrometry, because sample preparation is easy and counting efficiencies are relatively high (Herpers, 1986). Although it is the preferred method for measuring low-energy, pure beta-emitting radionuclides, (e.g., 3 H, 14C, 35S, and 63N) it is a well established procedure for measuring numerous other beta-emitting radionuclides, including 45Ca, 32P, 65Zn, 141Ce, 60Co, 89Sr, 55Fe, 87Rb, 147Pm, and 36Cl (Hemingway, 1975).

REF: https://www.epa.gov/sites/production/files/2015-05/documents/402-b-04-001b-15-final.pdf

N.B. Gamma spectrometry is NOT referenced as an analytical tool for beta analysis

13:7 Alpha-particle spectrometry is routinely performed with the aim of measuring absolute activities, activity ratios between different alpha-emitting nuclides or decay data such as branching factors, alpha emission probabilities and relative half-lives. It is most commonly performed with ion-implanted silicon detectors. Strong features of the technique are the low background levels that can be achieved due to low sensitivity to other types of radiation, the intrinsic efficiency close to 1 which reduces the efficiency calculations to a geometrical problem and the uniqueness of the energy spectra for each α-decaying nuclide. The main challenge is the limitation to the attainable energy resolution, even with thin and homogenous sources, which causes alpha energy peaks to be partially unresolved due to their width and low-energy tailing. The spectral deconvolution often requires fitting of analytical functions to each peak in the alpha spectrum. True coincidence effects between alpha particles and subsequently emitted conversion electrons cause distortions of the alpha spectra which lead to significant changes in the apparent peak area ratios. Optimum energy resolution can only be achieved on very thin sources, which puts constraints on the source preparation techniques. Radiochemical separations may be needed to extract the alpha emitters from voluminous matrices and efficiency tracing is performed by adding in another isotope by known amounts. Typical uncertainty components are discussed by means of some hypothetical examples.

REF: " Typical uncertainties in alpha-particle spectrometry" S Pomm: Published 22 May 2015 • © 2015 BIPM & IOP Publishing Ltd

N.B. Gamma spectrometry is NOT referenced as an analytical tool for alpha analysis

13:8 "We measured full energy peak efficiency of High-Purity Germanium detector which is important for gamma-ray spectrometry experiments.

RESULTS AND DISCUSSION

The use of germanium detectors has completely revolutionized gamma spectroscopy."

REF : "High purity germanium detector in gamma-ray spectrometry" Mayeen Uddin Khandaker Department of Physics, University of Malaya, Kuala Lumpur 50603, Malaysia (Received Jan 2011; Published June 2011)

N.B. High Purity Germanium Gamma Spectrometry (HPGe) is the only analytical method used by CEFAS in the Bridgewater analyses to date, but is NOT referenced as an analytical tool for alpha or beta analysis.

13:9 Germanium detectors are semiconductor diodes having a p-i-n structure in which the intrinsic (i**) region is sensitive to ionizing radiation, particularly x rays and gamma rays.**

REF: http://www.canberra.com/products/detectors/pdf/Germanium-Det-SS-C39606.pdf

N.B. (HPGe) Gamma spectrometry is NOT referenced as an analytical tool for alpha or beta analysis

13:10 The Campaign contends that these extracts from various scientific, academic and informative literature support the Campaign's long standing position that Gamma Spectrometry alone will not and has not identified all of the nuclides present in the Bridgwater Bay as a result of the 50 years + of liquid radioactive effluent discharge from the Hinkley A Magnox and the Hinkley B AGR stations.

13:11 In the context of the above paras, the Campaign demands that ALL Bridgewater Bay sediment samples undergo analysis by alpha analysis, beta analysis and gamma analysis in order to identify the presence and concentrations of ALL of the radio nuclides likely to deliver a dose (however small) to both workers (dredger crew) and to coastal populations.

Such a methodology would more effectively calculate the cumulative dose from all man made sources (especially those nuclides discharged from the Hinkley A & B stations over the last 50 years+)

..

14: Gamma spectrometry "Less than" results

14:1 The Campaign is also concerned by the "less than" results given in the tables of radioactivity in Hinkley sediments presented in the three Hinkley sediment CEFAS radiological analysis reports (2009, 2013 and 2017) for the following reasons:

14:2 The Campaign notes the dis-continuity (*wide difference*) between "less than" results for Americium 241 presented in the tables. For example, the 2013 results for 17 samples (Table 1) presents 14 of those results as "less than" and 3 results as definitive positives. The 14 "less than" results vary widely, ranging from "less than" 0.66 Bq/Kg to "less than" 1.71 Bq/Kg, with the maximum "less than" being more than twice as high as the minimum.

14:3 The Campaign states that these "less thans" do not prove the absence of the radionuclide being analysed for, rather they demonstrate the inefficiency and lack of precision of the technique being used to carry out the analysis.

The Campaign observes that of the three **positive** results presented in the 2013 table of Americium results (0.63 Bq/Kg, 0.97 Bq/Kg and 3.16 Bq/Kg), one (the positive 0.63) is lower than **all** of the presented "less thans" and the other (the positive 0.97 Bq/Kg) is lower than 11 of the "less thans". Neither CEFAS nor EDF have offered an explanation for this dichotomy.

14:4 These startling variations in the ability of the methodology to accurately measure the concentrations of Americium 241 raise major concerns about the ability and effectiveness of both methodology and the interpretation of the results, which do nothing to engender confidence.

Similar effects are noted for the tables for the 2009 and 2017 results.

14:5 The Campaign also notes the lack of continuity of Cobalt 60 “less thans” presented in the tables for the three surveys. For example, the 2013 results for 17 samples (Table 1) are all given as “less thans”, but they range from “less than” 0.25 Bq/Kg to “less than” 0.49 Bq/Kg, with the maximum “less than” being nearly twice as great as the minimum “less than”.

The Campaign concludes that these widely varying figures for “less thans”, and the occasional “positives” which are smaller / lower than many of the “less thans”, are a product of truncated count times and the wider relative errors associated with shorter counts (see following paragraph).

14:6 In this context the Campaign re-introduces the issue of the “less than” data from the Hinkley Point A and B liquid effluent monitoring discussed in earlier paragraphs, which pointed out that A and B stations results are quantified in kilo Bqs per cubic metre and that a notable feature of results for those stations is the widely disparate, and very high recorded measurements for “less thans” of the majority of listed radio nuclides and offered the following examples:

“Among the “less thans” reported for 2007 it is notable that:

the Hinkley Point A report recorded <170 kBq/cubic metre for Ruthenium 106, and <110 kBq/cubic metre for Cerium 144,

the Hinkley Point B report recorded <53 kBq/cubic metre for Ruthenium 106, and < 27 kBq/cubic metre for Cerium 144”

14:7 The Campaign notes that 1 cubic metre of liquid = 1,000 litres of liquid, and accordingly deduces that the analytical techniques deployed in 2007 were incapable of:

a: detecting Ruthenium106 in Hinkley Point A liquids at concentrations below170 Bq/litre or

b: detecting Ruthenium 106 in Hinkley Point B liquids at concentrations below 53 Bq/Kg

and that similar dichotomous outcomes can be observed for many of the other “ less than” radio nuclides investigated in the Hinkley liquid effluents.

14:8 In the context of the above, the Campaign concludes that the methodology used by CEFAS has generated confusing and contradictory outcomes. The Campaign is not convinced that the methodologies generating such highly variable less thans are of the highest quality standards and representative of the best available existing techniques.

The Campaign therefore has little faith in the data produced for EdF by CEFAS using methodologies that permit such dichotomous outcomes and such high and variable “less than” measurements. Accordingly it is the Campaign’s conclusion that any future analysis by gamma, beta or alpha methods should be upgraded to the best available existing standards most likely to produce the most accurate representation of total concentrations of the radio nuclides under investigation thus enabling the most precise dose estimates to be calculated.

14:9 The Campaign specifically requests that NRW comment in depth upon the scientific rigour of the application of such imprecise and incoherent analytical techniques and provides a considered opinion on the usefulness of such techniques in the development of dose estimates for the coastal populations of the south Wales coastal region.

..

15: Gamma spectrometry “Counting Times”

15:1 The Campaign has analysed scientific papers undertaking research and review of the methodology of Gamma spectrometry. From these papers the Campaign concludes that because such decay occurs randomly through time, the measurement of decay “events” detected over a given time period is never exact but represents an average value, and that consequently longer “counting” periods will provide more reliable results. In that context the Campaign understands that both unreliability and lack of specificity may be expected when results are presented, especially if the counting times are relatively short.

15:2 Data presented to the Campaign by CEFAS during 2017 and 2018 (machine “translations” of the raw Gamma Spectrometry data) indicate that the CEFAS methodology used for those surveys “counted” the samples for approximately 15 hours or 55,000 seconds. However, many papers indicate or recommend much longer counting times for maximum statistical efficiency.

15:3 Recent (peer reviewed) papers have explained that the 55,000 seconds is regarded as merely the “optimal measurement counting time” (rather than offering the ultimate precision that might be required when investigating the human health potential of radio nuclide concentrations) and that such “optimal” standards are achieved by arriving at the best balance between financial costs and the effectiveness of the Spectrometry results.

15:4 There is now a broad consensus that “Better average values can be obtained by acquiring data over longer time periods” and “ for the analysis of environmental samples with low radioactivity, a relatively long counting time is required e.g. up to 1-2 days to obtain accurate and precise results”.

Ref: UNSCEAR Report to the General Assembly. Annex B: Exposures from Natural Radiation Sources (2000)

Ref: IAEA-TECDOC-1401: “Quantifying Uncertainty in Nuclear Analytical Measurements”, International Atomic Energy Authority (2004)

Ref: Nuclear Forensic International Technical Working Group, Guidelines Task Group, high resolution gamma spectrometry general overview: INFL-GSOV (2013)

15:5 A 2016 paper references counting “for 86,400 seconds (24 hrs) for effective peak area statistics of above 0.1%”

REF: Joel et al’ “Precision measurement of radioactivity in gamma rays spectrometry using two HPGe detectors comparison techniques: Application to the soil measurement”: published online 2016 Dec 31. Doi: 10.1016/j.mex.2016.12.003

15:6 A 2017 paper explains that “Better average values can be obtained by acquiring data over longer time periods” and “for the analysis of environmental samples with low radioactivity, a relatively long counting time is required e.g. up to 1-2 days to obtain accurate and precise results.”

This paper also provides detailed analysis of fourteen consecutive analytical measurements of selected “natural” radio nuclides under the influence of different time measurement and counting statistics using HPGe detectors (similar to those used by CEFAS) for time periods ranging from 5 minutes up to 72 hours (3 days).

This paper shows that only one radio nuclide, Pb (Lead) 212 – a decay product of Uranium-235, was detected after 5 minutes counting, but the related error was greater than 20%, while a longer counting time demonstrably reduced the related error.

After ten minutes counting the radio nuclides Bismuth 212 and Potassium 40 were detected but their related errors were 27% and 33% respectively, again longer counting times reduced the related error.

At the other end of the scale Uranium-235 and Radium-226 required a count of 3 hours before they were initially detected but appropriate statistical results were not achieved until 24 and 36 hours respectively.

REF: "Optimal Measurement Counting Time and Statistics in Gamma Spectrometry Analysis: The Time Balance" Joel et al': American Institute of Physics, Conf Proceedings 1792 100001 (2017); doi: 10.1063/1.4969040

15:7 Figure 1 of the 2017 paper reports (in graph form) the Relative Error (in terms of percentage), related to Specific Activity (Bq/Kg) of nine radio nuclides over the fourteen set count times and confirms that, after approximately 36 hours counting, the Relative Error for all nine radio nuclides is approaching its minimum level and that, as also shown in Table 1, the lowest error is achieved after 72 hours (259,200 seconds).

REF: "Optimal Measurement Counting Time and Statistics in Gamma Spectrometry Analysis: The Time Balance" Joel et al': American Institute of Physics, Conf Proceedings 1792 100001 (2017); doi: 10.1063/1.4969040

15:8 On this basis, the Campaign concludes that greater accuracy and coherence of both positive and "less than" measurements of radioactivity concentrations in the 2017/2018 Hinkley sediments would have been achieved if longer counting times had been used, and that longer counting times were not deployed in the interests of reducing costs to EdF and that this conclusion is supported by the scientific research and reviews reported above.

The Campaign therefore has no faith in the accuracy or veracity of the claims put forward by EdF and apparently supported by NRW (who have confirmed that they do not have any in-house marine environmental radioactivity expertise).

15:9 In the context of the above paragraphs, the Campaign recommends that ALL proposed 2020 sediment samples subjected to future radio analysis should be subject to the most effective extended counting times, at least 3 days, in order to achieve the lowest possible relative errors and provide the most accurate concentration data for each radio nuclide in order to identify the presence and concentrations of ALL of the radio nuclides likely to deliver a dose (however small) to both workers (dredger crew) and to members of the coastal population.

...

16: Alpha analysis of Bridgwater bay sediments proposed for dredge and disposal in 2021

16:1 CEFAS TR502 HPC 2019 proposes that "For one core at one outfall and one core at one intake location, subsamples will be taken from all depths and Alpha spectrometry will be used to determine the plutonium (Pu 239 and 240) and Americium 241 isotopes within these subsamples.

Thus CEFAS TR502 proposes that subsamples from only 2 of 35 (or 45, if "contingency" samples are taken) samples be analysed for alpha emitters.

16:2 Investigation of the broad scale variability of sediment grain size in the Bridgwater Bay noted that the finest sediments occur in the inshore (southern sector) sector of the Bridgewater Bay whilst the coarser sediments are found offshore in the northern area of the Bay.

REF "Sediment dynamics of the Severn Estuary & Inner Bristol Channel": P. McLaren et al': Journal of the geolocal Society. Vol 150. 1993 :p (597)

16:3 In the context of the above, it is noted that of the two core samples selected for alpha analysis only one of 15 numbered samples will be taken from an intake site (offshore) and only one of 3 numbered samples will be taken from an outfall site (inshore).

The Campaign does not believe that 2 of a total of 35 (5.7%), or 2 of a possible total of 45 (4.4%), of samples can possibly construct a representative set of data which adequately describes the alpha nuclide concentrations in the areas where capital and maintenance dredging are to be conducted

REF: "Sediment dynamics of the Severn Estuary & Inner Bristol Channel": P. McLaren et al': Journal of the geolocal Society. Vol 150. 1993 :p (597)

16:4 In the context of the likely spatial variation of sediment grade size discussed in the following section of this Submission, and the well understood mechanisms of nuclide adsorbtion to sediments, particularly in the case of the major alpha emitters (plutonium, americium, etc.), the Campaign notes that, in the context of sediment spatial variability, the proposed future policy is clearly unable to be fully representative of the presence of alpha emitting, sediment adsorbed radio nuclides across the range of Bridgwater Bay sediments to be dredged in 2021.

16:5 Accordingly the Campaign advises a thorough overhaul and review of the current proposed sampling plan in order that all samples (both surface and core) are subjected to, and undergo, full Alpha spectrometry.

This will provide the full and complete data relevant to the entirety of the dredge sediment proposed for disposal into Welsh coastal waters.

Only thus can a genuinely full and complete dose to both dredger workers and the coastal zone public of both the Welsh coast adjacent to the disposal site, and the Somerset coast adjacent to the dredge site, be calculated.

..

17: Sediment sample distribution and grain size.

17:1 CEFAS TR502 HPC 2019 states that it is planned to take 35 samples (plus 10 possible "contingency" samples) spread across the four dredge areas.

17:2 Noting that the four dredge areas are separated from each other by considerable distances and that the individual sample sites within them are (as far as the map presented in TR502 can show) also approx.. 100 to 125 metres apart, the Campaign notes that it is well understood that:

a: sediment grain size is a major factor in the concentration of radio nuclides in marine sediments
b: it is well understood that sediment grain size may be highly spatially variable in marine sediments.

17:3 EdFs own documentation describes a 1985 study of Bridgwater Bay sediment chronology which concluded that, at a site 1.4 km north-west of the Hinkley Point cooling water intakes, approx. 2 metres of sediment had accumulated since the 1950s. *(approx. 66 mm per year).*

The same EdF documentation reported a 2002 study from two Bridgwater Bay sites at a similar distance north-west and north of the cooling water intakes, which concluded that the annual sedimentation rate was 4 mm per year at one site and 18 mm per year at the other.

REF: HPC Pre application Consultation Stage 2. Environmental Appraisal: Vol 2. Chap 16. Hydrodynamics & Coastal Geomorphology (page 14) EdF

Clearly this indicates a wide spatial variation in rates of sedimentation across a relatively narrow sector of the Bridgwater Bay sedimentary environment. It is unfortunate that such work did not report any analysis of sediment grain size variability.

17:4 A 1997 study investigated surface sediment samples collected from the estuary of the River Ribble. Radioactivity concentrations were measured by gamma and alpha-spectrometry and activity concentrations showed significant relationships with sediment grain size with higher levels in finer-grained sediments at upstream/inshore sites, highest activity concentrations were also found at sites with fine-grained sediments.

REF: Radiological assessment of the Ribble estuary—I. Distribution of radionuclides in surface sediments. DJ Assinder et al': Journal of Environmental Radioactivity, Vol 36. Issue 1 : 1997, Pages 1-19

17:5 A study on the spatial variability of both sediments and radio nuclides in near coastal sedimentary environments was carried out in 2001. This study observed that "In a previous study of the radionuclides in the Ribble Estuary, variation in dose rates at the 100 x 12 m scale was investigated. The results indicated a range between 1 and 2 micro Sv h^{-1} ... In unpublished follow up studies, the variation within a one metre square was investigated and significant variation could be seen, perhaps greater than that of the larger scale."

REF: "Micro-Scale Variability of Contaminants in Surface Sediments: The implications for sampling". S.M. Mudge et al'. R&D Technical Report P3-057/TR

17:6: Technical Report P3-057 initially reported that a 66.6% range difference between dose rates from samples at the 100x 12m scale was of significance, the additional reported evidence of variation within a one metre square at perhaps "greater than the than that of the larger scale" significance, clearly implies that the widespread distribution of sampling sites (i.e. fewer sites) may militate against accurate assessment of radio nuclide concentration over the broad spatial scale and that more accurate and precise data may be gathered by initiating the use of a greater number of closer together sample sites.

17:7 A 2006 CEFAS report on the methodology for judging de minimis radioactivity confirms such commentary, reporting that at various sites near Sellafield "activities of artificial radio nuclides (Caesium 137 and Americium 241) were significantly variable ranging from <1 to 400 Bkq/Kg dry weight. The main causes of this variability is likely to be variation in grain size, levels being greatest on fine grained sediments".

REF: Cefas Environment Report RL 05/06: D.McCubbin & C.Vivian. 2006 (page79)

17:8 Many studies have confirmed that the Bridgwater Bay is a sink for fine sediments and their associated pollutants such as adsorbed radio nuclides and heavy metals. There is a wide consensus that the concentrations of many radio nuclides in sedimentary deposits is closely linked to the fineness of the sedimentary particles and that highest concentrations of many such nuclides tend to be found in the finest sediments. Hence, the issue of grain size spatial variability is of the utmost importance when investigating the radioactivity concentration of adsorbed radio nuclides.

17:9 Radio nuclide analysis of Bridgwater Bay sediments has confirmed major spatial variability and proved that proved that there are areas of

a: rapid deposition (up to 130cm in 21 years)
b: areas of apparent erosion since radio isotopes were absent even in the surface layer
c: areas of limited radio isotope enrichment, which were shown by geo-chemical evidence to have had levels which were not recently varied.

REF: "Estuaries and Coasts: Spatial and Temporal Intercomparisons": Eds M. Elliot & JP Ducatoy

17:10 Investigation of the broad scale variability of sediment grain size in the Bridgwater Bay noted that the finest sediments occur in the inshore (southern sector) sector of the Bridgewater Bay whilst the coarser sediments are found offshore in the northern area of the Bay.

REF: "Sediment dynamics of the Severn Estuary & Inner Bristol Channel": P. McLaren et al': Journal of the geolocal Society. Vol 150. 1993 : (p 597)

17:11 The implication of the information discussed above is clearly that, in order to acquire data capable of generating a full and accurate understanding of the distribution of anthropogenic radio nuclides across the Bridgewater Bay dredge sites, the understanding of grain size distribution across the wider Bridgwater Bay environment, and the proposed dredge areas in particular, is a vital parameter for investigation.

17:12 The Campaign therefore demands that NRW insist that the number of sample points within the identified construction areas should be at least doubled (so that sample sites are no more than 50 metres apart) and that both surface and borehole samples undergo a thorough and complete grain size analysis.

17:13 Furthermore the Campaign demands that borehole samples not be analysed on a bulk basis, but should be sub-sampled in relatively short sections, possibly as short as 20 cms, in order to identify those depths with the highest percentage of fine sediments and radioactivity concentrations.

...

Rio Declaration, Environmental definitions, and Legal definitions

18: EdF/CEFAS sampling proposals in the context of the Rio Declaration (from the principle and objectives)

18:1 The principles and objectives of the 1992 Rio Declaration contain a number of clauses of some relevance to the concerns of the Campaign and its sponsors and supporters as set out below.

18:2 the right to a precautionary and anticipatory approach to marine environmental protection: ... which the Campaign believes may have been breached by the Welsh Government and NRW decision to permit and licence and disposal of radiologically contaminated fine sediments from Bridgwater Bay into the Cardiff Grounds site **without** prior appropriate research into marine environmental dynamics and the fate and behaviour of anthropogenic radioactivity in the Severn Estuary marine environment (as explained in earlier sections of this document).

18:3 the right of access for concerned individuals, groups and organisations to relevant information: ... which the Campaign believes may have been breached by the Welsh Government and its environmental protection and regulatory agency NRW, in that it failed to provide "relevant information" to the Welsh public, as a result of its refusal to insist that EdF commission CEFAS to undertake:

a: baseline environmental (empirical) surveys of radio activity concentrations in (intertidal and subtidal) coastal sediments and the coastal water body along the south coast of Wales;
b: baseline environmental (empirical) surveys to indicate and assess the transport fate of sediments deposited into the Cardiff Grounds dump/disposal site;
c: baseline environmental (empirical) investigations of parameters related to the sea to land transfer, by several pathways, of radioactivity dispersed into the Severn estuary water column as a result of the past and proposed Dredge and Dump activity.

18:4 The Campaign contends that (in the context of 18:2 and 18:3 above) the Welsh Government and its agency NRW have denied the communities and individuals of the south Wales coast and coastal zone a suite of information deeply relevant to the psychological and physical health and wellbeing of current and future generations, and have therefore breached the protocols of the Rio Declarataion.

18:5 The Campaign demands that the Welsh Government and its environmental and regulatory agency, NRW, comment on the issues raised above and publishes the opinion of their legal advisors.
..

19: Is the SEVERN ESTUARY a SEA, a MARINE ENVIRONMENT or neither?

19:1: The use of the Cardiff Grounds dispersal site for the dumping of radioactively contaminated sediments dredged from Bridgwater Bay has been justified by EdF and NRW on the basis of protocols developed by the IAEA.

REF: "Determining the Suitability of Materials for disposal at Sea under the London Convention 1972 and London Protocol 1996: A Radiological Assessment Procedure" REF: IAEA. Vienna. 201

19:2 After a review of the available scientific and technical literature the Campaign contends that the Cardiff Grounds disposal site may be situated WITHIN the Severn estuary and NOT in the open sea. The SEA is universally defined by dictionaries of common usage and by oceanographers alike as "the continuous body of salt water covering the greater part of the earth's surface".

19:3 By contrast, oceanographers universally define Estuaries as follows:
"a partially enclosed body of water, and its surrounding coastal habitats, where saltwater from

the **ocean** mixes with fresh water from rivers or streams. ... **Estuaries** are transitional areas that straddle the land and the sea, as well as freshwater and saltwater habitats".

REF: Estuaries - NOAA's National Ocean Service Education oceanservice.noaa.gov › education › kits › estuaries › estuaries

19:4 "An **estuary** is a partially enclosed coastal body of brackish water with one or more rivers or streams flowing into it, and with a free connection to the open sea".

REF: ***Pritchard, D. W. (1967). "What is an estuary: physical viewpoint". In Lauf, G. H. (ed.). Estuaries. A.A.A.S. Publ. 83. Washington, DC. pp. 3–5. hdl:1969.3/24383.***

19:5 "**Estuaries form a transition zone between river environments and maritime environments** known as ecotones. Estuaries are subject both to marine influences such as tides, waves, and the influx of saline water and to riverine influences such as flows of freshwater and sediment. The mixing of seawater and freshwater provides high levels of nutrients both in the water column and in sediment, making estuaries among the most productive natural habitats in the world."

REF: McLusky, D. S.; Elliott, M. (2004). ***The Estuarine Ecosystem: Ecology, Threats and Management*****. New York: Oxford University Press. ISBN 978-0-19-852508-0**

19:6 The UK JNCC concurs with these definitions and states that: "Estuaries are habitat complexes which comprise an interdependent mosaic of subtidal and intertidal habitats, which are closely associated with surrounding terrestrial habitats. Many of these habitats, such as **1140 Mudflats and sandflats not covered by sea water at low tide**, saltmarshes, **1110 Sandbanks which are slightly covered by sea water all the time** and **1170 Reefs**, are identified as Annex I habitat types in their own right.

19:7 Estuaries are defined as the downstream part of a river valley, subject to the tide and extending from the limit of brackish water. There is a gradient of salinity from freshwater in the river to increasingly marine conditions towards the open sea. The input of sediment from the river, the shelter of the estuary from wave action, and the often low current flows typically lead to the presence of extensive intertidal sediment flats and sediment-filled subtidal channels. There is usually only a limited extent of rocky habitat. In contrast, marine inlets where seawater is not significantly diluted by freshwater are considered as Annex I type **1160 Large shallow inlets and bays**."

REF: "JNCC Description and ecological characteristics https://sac.jncc.gov.uk/habitat/H1130/

19:8 The Campaign notes that the majority of these physical characteristics are typical of the area in which the Cardiff Grounds Disposal site is situated and NOT typical of marine environments and thus concludes that the Cardiff Grounds dispersal site is situated within an estuary and not the "sea".

19:9 Such definitions are clearly accepted and used by the Admiralty Chart SC1179 which comments that the Severn estuary extends from Aust, the site of the first Severn bridge crossing, where the Estuary is about 2 miles (3.2 km) wide, down to its seaward extent between Cardiff and Weston-super-Mare where it is about 14km wide.

A narrower definition adopted by some maps is that the river Severn becomes the Severn Estuary below the lower Severn crossing near Severn beach, South Gloucestershire, and extends westwards to a line from Lavernock Point, south west of Cardiff, to Sand Point near Weston-super-Mare

19:10 Under both definitions, the Estuary forms the boundary between Wales and England. On the northern side of the estuary are the Caldicot and Wentloog (Gwent) levels which are very extensive areas of intertidal fine sediment deposits located on either side of the city of Newport; and, to the west, the city of Cardiff together with the resort of Penarth. These wide and extensive intertidal mud flats (some sections of which are exposed for over 1km at low tide) are absolutely typical of estuarine environments and absolutely NOT typical of marine, open sea environments.

19:11 NRW document ”Marine Character Areas. MCA 29. Severn Estuary (Wales)” states that:

“This Marine Character Area (MCA) comprises the Welsh part of the Severn Estuary, stretching from the national border with England to the western fringes of Barry. The marine area is coincident with the majority of the Severn Estuary SAC (Wales) and full extent of the marine plan area. Its south western boundary broadly follows bathymetry, with the aim of excluding the deepest parts of the inshore channel.

The MCA also includes all of the Severn Estuary SPA, Ramsar and SSSI within the inshore and intertidal zones. It meets the coast in the west to be coincident with NLCA 35: Newport, Cardiff and Barry (developed coastline which spreads out from Cardiff Bay). • The MCA is also consistent with how the Estuary is spatially defined for the purposes of coastal navigation (e.g. Imray, 2008). The MCA excludes a small section of ‘Welsh’ waters along and at the mouth of the River Wye, which would be picked up by the adjacent English marine plan area.”

19:12 The Campaign contends that, in the context of the above, it is clear that in ecological, geophysical and geomorphological terms, and in accepted Admiralty etc. definitions, the Cardiff Deeps Dump/Disposal site is WITHIN the Severn Estuary.

The Campaign further contends that the Bridgwater Bay dredge sites are OUTSIDE the Severn estuary and that the current proposal by EdF (2021), and the past licenced activity (2018) involved dredge material being transported from outside the Severn Estuary and subsequently imported and dumped inside the Severn Estuary.

19:13 The Campaign demands that the Welsh Government and its environmental and regulatory agency, NRW, comment on the issues raised above and make public the full and detailed opinion of their legal advisors.

…………………………………………………………………………………………..

20: Legal review of the difference between “estuaries” and the “sea”.

20:1 A review of the legal status of estuaries in the context of the law of the sea notes the following:

Page 128 of the review notes that UNCLOS 1982 nowhere offers a definition of “the sea”, “sea water”, “marine environment” or “estuaries”.

20:2 Page 131 of the review notes that the London Convention on the Dumping of Waste at Sea of 1972 points out that "marine pollution originates in many resources, such as dumping and discharges through the atmosphere, rivers, estuaries, outfalls and pipelines ...": this wording implies a separation between estuaries and the marine environment

20:3 “The "dumping" covered, nonetheless, is confined to disposals "at sea";' "sea" is defined to mean "all marine waters other than the internal waters of States"' and, “therefore, does not include most estuarine zones.”

20:4 “Estuaries are seldom covered by the existing international law of water courses or the law of the sea. In some cases they are explicitly removed; in others they appear to be covered in theory, but are not in reality. The needs of estuaries must be considered and their protection must be ensured under international law so that these critical zones are not lost forever.”

REF: Robert D. Hayton, Reflections on the Estuarine Zone, 31 Nat. Resources J. 123 (1991).

20:5 Despite a literature search for further clarification on the legal definition and/or understanding and status of “Estuary/Estuaries” as opposed to “Sea/Marine Environments”, the Campaign has been unable to discover any final, definitive legal ruling on such issues which has consensual support from national and international competent legal authorities

20:6 In the Context of this, and the previous section, the Campaign notes that the Bridgwater Bay dredge site is clearly outside the area defined (by both definitions) as the Severn Estuary and notes that in this case, material contaminated with radioactivity from the Hinkley A & B sites has been dredged from outside the officially identified estuarine area and then transported INTO the officially designated Severn estuary and dumped therein.

20:7 The Campaign demands that the Welsh Government and its environmental and regulatory agency, NRW, comment on the issues raised above and make public the detailed and full opinion of their legal advisors.

…………………………………………………………………………………………..……

ANNEX 1

A REVIEW of Radioactivity Concentrations in Bridgwater Bay and Somerset coast Intertidal Surface Sediments following construction activity in the HPC subtidal and intertidal zone

Part 1: Radioactivity in Food and the Environment (RIFE) reports show a significant increase in radioactivity levels following construction related disturbance of sub tidal and intertidal fine sediments at the Hinkley Point C site.

Data from the government funded "Radioactivity in Food and the Environment" (RIFE) reports for 2016, 2017 and 2018 show that EdF's dredging of underwater sediment and shoreline construction work at Hinkley Point have resulted in significantly increased radioactivity levels in the environment.

EdF's operations have disturbed and re-distributed radioactive particles from the Hinkley Point A and B nuclear power stations, which had been sequestered and relatively contained for many decades within the sediments, resulting in them now being detected at far higher levels than before the dredging began.

RIFE measured radioactivity at seven locations along the Somerset coast. The results indicate a significant increase in the distribution of radioactive sediments from the Bridgwater Bay and River Parrett Estuary construction activity into the wider regional marine environment.

This environment includes:

- the entire tidal corridor of the River Parrett, reaching 21 km inland and passing through the centre of the region's busiest town, Bridgwater (where concentrations of Cobalt 60 increased by 98% and concentrations of highly radioactive Americium 241 rose by 139%);

- the shoreline at Stolford, where concentrations of Americium 241 increased by 158%, and Cobalt 60 by 209%; *NB this site is approximately the same distance (2 km) from the area dredged, as the Cardiff shoreline is from the Cardiff bay Dumpsite,*

- the shoreline east of Hinkley Point, including Burnham (where concentrations of Americium 241 increased by 46%) and Weston super-Mare, 12 miles from Hinkley Point (where concentrations of Cobalt 60 increased by 17%).

NB: Weston is the most easterly site sampled, and so it is possible that increases in concentrations occurred further along the coast.

The sampling at Stolford also shows significant increases in the amount of Tritium in shellfish – which may give an indication that similar increases in Tritium may be found in shellfish harvested off the south Wales coastline.

These results are the only data available to indicate the likely effects of Edf's dumping of sediment containing radioactive particles dredged from the Hinkley site in the Cardiff Bay marine "dispersal" site.

Marine Radioactivity Consultant Tim Deere-Jones, initiator of the Cardiff Mud Dump Petition to the Senedd Petitions Committee, said:

"Our Campaign urged the Welsh Government to conduct radioactivity measurements along the Welsh shorelines that were likely to be effected by the dumping of Hinkley sediment off Cardiff Bay before and after the dumping took place. The refusal of Welsh Government and Natural Resources Wales to carry out the research advised by the Stop the Dump campaign has left coastal communities in a position of complete ignorance about the impacts of the dump. Although we have no Welsh coastal data, these results from the Somerset coast confirm our worst fears and predictions.

Our supporters are deeply disappointed that the nuclear industry was allowed to proceed with this foolhardy action and that the concerns of the Welsh people were ignored by the Welsh government in favour of unqualified support for the French nuclear industry and their construction of a nuclear power station in England." *NB Petitions in support of the Campaign were signed by over 170,000 people*

………

Tables produced by the Stop the Cardiff Mud Dump campaign from the RIFE reports are presented below. Further background information follows the tables.

Table 1: Cobalt 60 in sediments from Hinkley Point (Becquerels per kilogram)

Site	**2016**	**2017**	**2018**	**Increase since 2016**
Pipeline	<0.41	<0.56	<0.57	39% increase
Stolford	<0.55	<0.79	<1.70	209% increase
Steart Flats	<0.52	<0.66	<0.71	36% increase
River Parrett estuary	<0.99	<0.88	<1.00	1% increase
River Parrett Bridgwater	<0.50	<0.57	<0.99	98% increase
Weston	<0.35	<0.43	<0.41	17% increase
Burnham	<0.36	<0.34	<0.34	

Table 2: Americium 241 in sediments from Hinkley Point (Becquerels per kilogram)

Site	**2016**	**2017**	**2018**	**Increase since 2016**
Pipeline	<0.50	<0.69	<0.78	56% increase
Stolford	<0.66	<0.79	<1.70	158% increase
Steart Flats	<0.52	<0.66	<0.88	69% increase
River Parrett estuary	<1.20	<0.92	<2.00	67% increase
River Parrett Bridgwater	<0.65	<0.78	<1.60	139% increase

Weston	<0.38	<0.48	<0.47	24% increase
Burnham	<0.37	<0.45	<0.54	46% increase

Table 3: Organically Bound Tritium in shellfish at Stolford (Becquerels per kilogram)

Type	**2016**	**2017**	**2018**	**Increase since 2016**
Shrimps	<25	<34	<56	124% increase
Limpets	<25	<25	<47	88% increase

NB: not analysed for at any other sites or in any other media

able 4: Tritium (as tritiated water) in shellfish at Stolford (Becquerels per kilogram)

Type	**2016**	**2017**	**2018**	**Increase since 2016**
Shrimps	<25	<34	<55	120% increase
Limpets	<14	<25	<47	236% increase

NB: not analysed for at any other sites or in any other media

Background information: There is NO data on the impacts of dump activity at the Cardiff Bay marine disposal site.

Due to the long term failure of NRW and the Welsh Government to insist on comprehensive and long term monitoring of south Wales coastal environments for the nuclear wastes discharged by the 8 reactors historically sited on the Severn Estuary/Bristol Channel, there is no pre-existing baseline data for such radio-nuclides along the south Wales coast. Hence any commentary from the Welsh Government or NRW on the risks or impacts of those radioactive wastes on welsh coastal environments, wildlife or human communities has never been based on any form of relevant regional empirical scientific data.

Despite the Campaign's requests for a postponement of the Dump in order for Welsh Government and NRW to gather baseline radioactivity data along the south Wales coast, with a major focus on those nuclides known to be present in the sediment to be dumped (Plutonium and Americium, Cobalt 60, Strontium, organically bound Tritium, etc), the nuclear industry was permitted to carry out the dump without any such information being gathered.

Subsequently no form of radioactivity monitoring has been initiated by Welsh Government or NRW in order to observe what impact the dump has had on adjacent coastal sediments and communities, despite the fact that the dump took place in close proximity to South Wales's most densely populated coast and our capital city.

As the Cardiff Mud Dump Senedd Petition Campaign had warned, this has resulted in a major data gap, especially for the coastlines and communities closest to the dump site.

However RIFE, the UK wide annual marine monitoring programme, which focuses on areas close to existing (active and de-commissioned) nuclear sites has provided relevant information which clearly shows a significant, and time relevant, increase in some of the radioactive species known to be present in the dumped sediment.

The Hinkley Point C dredging and Cardiff Bay Mud dumping

During 2017 and 2018 the French nuclear company EDF began major excavation works in the intertidal zone of Bridgwater Bay (Somerset) in order to facilitate the construction of sub-tidal pipelines for the discharge of liquid radioactive wastes to sea, the intake of cooling water and docking facilities for the proposed double reactor nuclear site at Hinkley Point C.

Along with permission to undertake these works, EDF was also granted permission by the Welsh Government and National Resources Wales to dump up to 300,000 tonnes of radioactive sediment from Bridgwater Bay at sea, in Cardiff Bay, within 2 kms of the Cardiff sea front.

In response, concerned Welsh citizens launched a vigorous protest campaign, through the National Assembly's Senedd Petition process, which was supported by many thousands of Welsh petitioners.

Noting that there was significant absence of baseline data and information about the likely fate of the radioactivity in the sediments and its impact on south Wales coastal environments and communities, the initial intention of the Campaign and its supporters was to seek a delay to the Dump in order to acquire more information.

This view was strongly supported by Assembly Members sitting on the Senedd Petitions Committee (who had the opportunity to hear evidence from marine radioactivity consultant Tim Deere-Jones who had initiated the petition, and from EdF and NRW who opposed it), and concluded that the petitioners request was valid enough to be the subject of a Plenary Debate in the National Assembly.

During the subsequent Plenary Debate in the Senedd , the great majority of Assembly Members who contributed, spoke in support of the Petitioners intentions. However, the then Environment Minister (Leslie Griffith), with the support of the Welsh Government, ignored the expressed wishes of the majority of speakers and the welsh public and permitted the dump to take place.

RIFE reports on the Somerset coast

Annual reporting of the monitoring of marine environmental samples from sites close to and downstream of the Hinkley Point construction site are recorded in the annual UK government-funded RIFE reports which report concentrations of a range of radio nuclides discharged to sea from the site. Many of the radio nuclides recorded by the RIFE reports are also those reported as present in the dredge spoil dumped into Cardiff Bay. This is particularly true of those radio nuclides know to strongly associate with sediments including Cobalt 60, Americium 241, Plutonium and Organically Bound Tritium (OBT)

However, EdF's commissioned analysis of the dredge sediments neglected to analyse for Plutonium, and Organically Bound Tritium, while the RIFE reports fail to analyse for Plutonium.

The method of sample gathering *(surface scrapes usually not more than a few cms deep*) and the nature of the sites (*intertidal with easy access from the shoreline and roadways*) from which sediment samples are taken is consensually agreed to generate results reflective of the most recent annual depositions of radioactivity discharged to sea from the Hinkley nuclear site or released as a result of unusual activity such as dredging and construction.

Since the annual reporting of Hinkley reactor operations indicate nothing unusual, it may be safely concluded that the greatly increased concentrations of radioactivity recorded are the result of the construction and dredging activity discharges initiated and carried out during 2017 and 2018.

Future dredging and dumping ?

EdF's licence to dump sediment in the Cardiff Bay marine disposal site has expired. We believe that EdF may well want to do more dredging off the Hinkley Point C site; however, they have not, to date, applied for a licence to dump any more sediment off the south Wales coast.

Part 2: An additional review of relevant sediment radioactivity concentrations recorded in the RIFE reports 19, 20 &21 (covering the years 2013, 2014 and 2015) and compared to outcomes for 2016, 2017 & 2018

Significant additional conclusions:
RIFE reports have reported raised sedimentary concentrations of radioactivity in 2013 and 2014 and have clearly attributed them to operational activity at the Hinkley A & B stations

RIFE have reported raised sedimentary concentrations of radioactivity in 2017 and 2018, but have not attributed them to any operational discharges at Hinkley A & B

RIFE have reported increased gamma dose (over intertidal sediments) in 2017 and 2018 and NOT attributed this to operational activity discharges from Hinkley A or B

RIFE have reported increasing total dose to the public for 2017 and 2018 (compared to 2016) and have NOT attributed this to any operational activity discharges from Hinkley A or B

From data presented in the RIFE reports for 2016, 2017 and 2018 it can be calculated that total dose to the public increased by 215% over the 3 year period.

In the absence of any contradictory data, the most likely cause for the above recorded increases (in a: radioactivity concentrations in sediment, b: gamma readings above intertidal sediments and c: total dose to the public) is the disturbance of Bridgwater Bay sediments due to intertidal and subtidal boreholing, construction work and dredging carried out by EdF.

....

Concentrations are tabulated below: construction and dredge years are in standard font, *2013 to 2015 year in italic)*

Table 1: Cobolt 60 in sediments Hinkley Point Bq/Kg (2013, 2014 & 2015)

Site	***2013***	***2014***	***2015***
Pipeline	*<0.45*	***<0.96***	*<0.36*
Stolford	*<0.79*	***<1.1***	*<0.53*
Steart Flats	***<0.51***	*<0.39*	*<0.42*
R.Parrett: estuary	***<1.4***	*<1.1*	*<1.2*
Weston	***<0.38***	*<0.35*	*<0.37*
Burnham	*<0.34*	*<0.3*	*<0.34*

NB: highest concs in bold

RIFE19 reports that liquid discharges to sea were increased in 2013 due to fuel pond cleaning at the HP A station and increased power generating from HP B station.
RIFE 20 notes that fuel pond cleaning was completed by 2014, that radioactivity concentrations began to decline again and does not comment on power generation.
RIFE 21 does not report any fluctuation in station operational discharges to sea for 2015.

Table 1: Cobalt 60 in sediments Hinkley Point Bq/Kg (2016, 2017 & 2018)

Site	**2016**	**2017**	**2018**
Pipeline	<0.41	<0.56	**<0.57 (39% increase)**
Stolford	<0.55	<0.79	**<1.7 (209% increase)**
Steart flats	<0.52	< 0.66	**<0.71 (36% increase)**
R.Parrett: estuary	<0.99	<0.88	**<1.0 (1% increase)**
R. Parrett: Bridgwater	<0.5	<0.57	**<0.99 (98% increase)**
Weston	<0.35	**<0.43**	**<0.41 (17% increase)**
Burnham	<0.36	<0.34	<0.34 no overall

See final NB for final comment

Tables 2: Americium 241 in sediments: Hinkley Point Bq/Kg (2013,2014 & 2015)

Site	***2013***	***2014***	***2015***
Pipeline	*<0.65*	***<1.2***	*<0.5*
Stolford	***<1.2***	***<1.2***	*<0.72*
Steart Flats	*<0.71*	***<0.73***	*<0.6*
R.Parrett estuary	***<1.7***	*<1.1*	*<1.2*
Weston	***<0.5***	*<0.48*	*<0.42*
Burnham	*<0.42*	***<0.48***	*<0.39*

NB: highest concs in bold

RIFE19 reports that liquid discharges to sea were increased in 2013 due to fuel pond cleaning at HP A station and increased power generating from HPB.
RIFE 20 notes that fuel pond cleaning was completed by 2014 and does not comment on power generation.
RIFE 21 does not report any further fluctuation in station discharges to sea for 2015 and in fact reports a general decline in radioactivity concentrations in sediments.

Table 2: Americium 241 in sediments: Hinkley Point (Bq/Kg)

Site	**2016**	**2017**	**2018**
Pipeline	<0.5	**<0.69**	**<0.78 (56% increase)**
Stolford	<0.66	**<0.79**	**<1.7 (158% increase)**
Steart Flats	<0.52	**<0.66** `	**<0.88 (69% increase)**
R. Parrett: estuary	<1.2	<0.92	**<2.00 (67% increase)**
R Parrett: Bridgwater	<0.65	**<0.78**	**<1.6 (139% increase)**
Weston	<0.38	**<0.48**	**<0.47 (24% increase)**
Burnham	<0.37	**<0.45**	**<0.54 (46% increase)**

RIFE 22 (2016) does not report any fluctuation in station operational discharges to sea for 2016, and reports that most radioactivity concentration in liquid discharges from the HP stations actually decreased in 2016 compare to 2015.
RIFE 22 (2016) reports that Gamma readings over intertidal sediments remained the same as 2015
RIFE 22 (2016) reports that total dose to the public **was 0.013mSv in 2016**

RIFE 23 (2017) did not report any fluctuation in station operational discharges to sea for 2017,

RIFE 23 (2017) reports that Gamma readings over intertidal sediments increased compared to 2016
RIFE 23 (2017) reports that total dose to the public **rose to 0.032mSv in 2017**

RIFE 24 (2018) did not report any fluctuation in station operational discharges to sea for 2018
RIFE 24 (2018) reports that Gamma readings over intertidal sediments increased compared to 2017
RIFE 24 (2018) reports that total dose to the public rose **to 0.041 mSv in 2018**

From the above data it can be calculated that total dose to the public increased by 215% through the 3 year period.

...

ANNEX 2

Campaign: BRIEFING to Senedd Petitions Committee: April 2018

The Campaign's original petition to the National Assembly expressed concerns relating to the absence of information about the possible impact/effect of the disposal of up to 300,000 tonnes of radioactively contaminated sediment from Hinkley Point.

These concerns were threefold, and all revolved around the issue of "baseline data" which should have been gathered BEFORE the project was approved:

1: the absence of information about the final destination of the radioactively contaminated sediments, post dumping:

2: the absence of information about the pre-dumping radioactivity exposures (dose rates) of the general population of the south Wales coastal zone, despite their long term proximity to the marine and atmospheric discharges from the multiple Bristol Channel nuclear sites.

3: the absence of information about man-made, Hinkley derived, beta and alpha emitting radio nuclides in the Hinkley sediments (see previous briefings).

NRW have recently submitted documentation, to the Petitions Committee, which they have obtained from CEFAS, in support of the EDF/CEFAS/NRW proposition that studies relating to the fate of sediment disposed of at Cardiff Grounds disposal site raise no concerns about the environmental and impact of the proposed dumping of radioactively contaminated sediments at Cardiff Grounds.

1: CEFAS summary of their review of the following papers:

A: Sediment dynamics of the Severn Estuary and Inner Bristol Channel, McLaren et al., 1993

B: Distribution, transport and exchanges of fine sediment, with tidal power implications: Severn Estuary, UK, Kirby, 2010

C: A review of sediment dynamics in the Severn Estuary: Influence of flocculation, Manning et al., 2010

D: The Sediment Regime of the Severn Estuary Literature Review, Phil Cannard (Bristol City Council), 2016

*E: *Sedimentation Processes in the Bristol Channel/Severn Estuary, Dyer, 1984*

*F: *Tidal Lagoon Cardiff: Conceptual Process Model, Tidal Lagoon Power, 2016*

N:B: Copies of the last 2 papers (asterisked) have not been received to date:

The CEFAS Summary Document concludes as follows:

Paragraph 14: CEFAS state that "net transport of sands within the estuary" is "upstream" in the Cardiff sector of the Severn estuary: and that the Cardiff Grounds area is identified as being "in equilibrium" (i.e. the sediments are more likely to remain in the sediment cell)

Paragraph 15: CEFAS state that the "general trend of sediment behaviour within the intertidal area around Cardiff and the shoreline closest to Cardiff Grounds has been identified as one of erosion. Therefore it is unlikely that any sediment leaving the cell would settle in those areas."

Paragraph 16: CEFAS propose that several of the listed studies imply that "sediment within the estuary is highly mobile, with sediment being frequently re-suspended and rarely settling out permanently" and concludes that, as a result any "contamination will be further diluted over time through mixing in the water column".

Paragraph 17: Finally, due to the high turbidity and tidal forcing of the estuary, it is noted within several of the studies listed above that sediment within the estuary is highly mobile, with sediment being frequently resuspended, and rarely settling out permanently. Therefore, if any sediment disposed of to the area is found to contain contaminants (within acceptable levels for disposal), it is likely that this contamination will be further diluted over time through mixing in the water column.

Campaign comments on the papers submitted by NRW:

"Sediment Dynamics of the Severn Estuary and inner Bristol Channel": MacLaren.P. et al': Journal of the Geological Society of London. Vol 150; 1993; pp 589-603

The majority of this 1993 paper principally refers to and discusses the sand resource in the context of its major commercial significance.

However, in the context of fine suspended sediments, the paper does report that the "presence of fine grained material caused the formation of extensive peripheral salt marshes (140 square kms in area) and high suspended sediment concentrations in the water column." in the inner Bristol Channel and Severn estuary sea area. This statement is in direct contradiction of the CEFAS claim that "sediment rarely settles out permanently" *(see note re para 17: top of page*)

Page 601 of the paper identifies the inner Bridgwater Bay, the sub tidal area within Swansea Bay, the area off the River Usk, and the fringing mudflats of the inner Severn Estuary as "major depositional areas".

Page 590 of the paper reports that "the present state of knowledge is still insufficient to understand fully sediment supply and transport within such a complex system."

"Distribution, transport and exchanges of fine sediment, with tidal power implications: Severn Estuary, UK," Kirby, 2010 ; Marine Pollution Bulletin. Vol 61 : 2010: pps 21-36
Although it is focused specifically on the potential impact of a Cardiff/Weston Barrage constructed within the inner Bristol Channel/Severn estuary, this paper has a greater focus on fine suspended sediments than the other papers so far made available.

The paper reports (page 20) that the study and understanding of Bristol Channel sediments is now additionally "complicated by large scale ecosystem collapse due to climate change".

The paper (page 26) reports that the Newport Deep is a "natural fine …. sediment **sink receiving mud from foreshore erosion and reworked dredge material disposal at Cardiff Grounds"** and with reference to the Cardiff Roads (Cardiff Port Approaches) the paper states that " the fact that it engenders high rates of mud maintenance dredging……. makes it likely that it is a sink similar in many ways to the adjacent Newport Deep"**:** *N.B. this paper does not reference these statements*

"A Review of Sediment Dynamics in the Severn Estuary: Influence of Flocculation": Manning AJ et al': Marine Pollution Bulletin. Vol 61: 2010: pps 37-61

This paper (page 49) concludes that "much of the research and data collection was undertaken several decades ago, hence there is a requirement for further investigation"

The paper then catalogues 8 subject areas where such further investigations are recommended., in order to provide better data and permit a more complete understanding of sediment dynamics.

The paper reports that, in the Severn Estuary, 70% of sediments suspended during spring tides settled out during the neap rides and described the Wentlooge Flats (fringing mudflats of Gwent levels) as “accreting” : i.e. areas where fine sediments are deposited.

The paper contains no reference/discussion of the movement of sediments out of the Cardiff Grounds disposal site area

“The Sediment regime of the Severn Estuary: Literature Review” :Bristol City Council: P. Cannard. 29th June 2016. This review reports that Severn Estuary salt marsh and mudflat environments represent “sinks of sediment deposition” (page 9,10)

Also reports that the main sediment sink locations for fine sediments are Newport Deep and Bridgwater Bay, and that “sediment sinks also occur around the estuary’s tributaries including the R. Avon and the R. Usk”

The paper contains no reference/discussion of the movement of sediments out of the Cardiff Grounds disposal site area

Campaign Conclusions on NRW submission:

The papers submitted by NRW provide very little useful or reliable data about the potential fate of radioactively contaminated sediment emplaced into the sea at the Cardiff Grounds disposal site about 2 miles off shore of Cardiff because:

A: all the papers are Severn Estuary wide in scope and none report any site specific (Cardiff Grounds) data investigations.

B: the main subjects for several papers were commercial issues (sand & aggregate resource, barrage proposal) and fine sediments were of little interest to the research.

C: a 1993 paper stated that **“the present state of knowledge is still insufficient to understand fully sediment supply and transport within such a complex system”:** a 2010 paper concludes that **“much of the research and data collection was undertaken several decades ago, hence there is a requirement for further investigation”** : another 2010 paper reports that **the study and understanding of Bristol Channel sediments is now additionally “complicated by large scale ecosystem collapse due to climate change”.**

D: the campaign agrees with CEFAS that the papers confirm:

a: a north and east movement of sediment in the Cardiff sector of the Bristol Channel, ***The Campaign notes that this means from the Cardiff Grounds towards the mudflats to the north east, i.e. Gwent levels/Wentlooge Flats and the estuarine and intertidal mudflats fringing the south Wales coast up to the Wye estuary***

b: that the sediments are more likely to remain in the sediment cell and to circulate throughout the cell ***The campaign notes that this is until deposited in sites such as those listed above***

E: CEFAS state that the “general trend of sediment behaviour within the intertidal area around Cardiff and the shoreline closest to Cardiff Grounds has been identified as one of erosion. Therefore it is unlikely that any sediment leaving the cell would settle in those areas.” ***CEFAS offer no other comment on the end fate of the sediments. The Campaign believes it unlikely that no sediment from the dump site would be deposited in a “Cardiff shoreline” and notes from the CEFAS language that they have no empirical evidence to disprove the Campaign’s contention.***

The Campaign notes the failure of NRW or CEFAS to bring forward any data relate to the fate of sediment dumped at Cardiff Grounds.

F: the Campaign’s concerns about the end fate of material dumped at Cardiff Grounds have always encompassed those of its supporters, and that the entire south Wales coast is the issue. ***The CEFAS commentary above, is plainly inadequate because it comments only on the intertidal area around Cardiff and offers no information on the potential impact on coastlines to the north and east***

G: CEFAS proposes that any “contamination will be further diluted over time through mixing in the water column”. ***The Campaign disagrees with this claim, because although contamination may be diluted through mixing in the water immediately post dumping period, over the longer term the re-concentration of radioactivity in sediments is always shown in the Bristol Channel, where annual monitoring of sea water and sediments demonstrates that unfiltered sea water always shows lower radioactivity concentrations than fine sediment samples. (see RIFE reports)***

H: from the papers offered by NRW, the Campaign concludes that there is a consensus that extensive inter-tidal sites to the north and east of the Cardiff Grounds (R. Usk, Newport Deep, Cardiff Roads, Wentlooge Flats etc..) are depositional and accretion sites where fine sediments entrained in the Severn Estuary water column and transported north and east from the Cardiff Grounds may be deposited out. ***The campaign notes that NRW, the relevant devolved Welsh Government Agency, appear to not have undertaken any review of, or search for, relevant data and are relying on the UK CEFAS, a Westminster Government agency, for information***

I: ***the Campaign concludes that NRW submission has NOT allayed the concerns expressed in the original petition text and that the submissions have confirmed that radioactively contaminated sediments proposed for dumping at Cardiff Grounds appear most likely to travel north-east towards the mud flat and estuary depositional environments of the east Glamorgan and Gwent coasts where they may deposit out and remain for uncertain time scales. The Campaign notes that had an exhaustive (site and proposal specific) EIS been carried out these issues could have been settled long ago.***

Table 34

Discharges from Hinkley Pt A. UK

Nuclide	1965	1966	1967	1968	1969	1970
^{3}H	$6.4\ 10^{12}$	$1.2\ 10^{12}$	0	$1.7\ 10^{12}$	$1.3\ 10^{12}$	$6.9\ 10^{11}$
^{14}C	$7.0\ 10^{7}$	$6.6\ 10^{8}$	$2.9\ 10^{8}$	$1.1\ 10^{9}$	$7.2\ 10^{9}$	$4.7\ 10^{9}$
^{32}P	$9.3\ 10^{7}$	$8.8\ 10^{8}$	$3.8\ 10^{8}$	$1.4\ 10^{9}$	$9.6\ 10^{9}$	$6.2\ 10^{9}$
^{35}S	$2.3\ 10^{9}$	$2.2\ 10^{10}$	$9.7\ 10^{9}$	$3.7\ 10^{10}$	$2.4\ 10^{11}$	$1.5\ 10^{11}$
^{45}Ca	$1.1\ 10^{8}$	$1.1\ 10^{9}$	$4.8\ 10^{8}$	$1.8\ 10^{9}$	$1.2\ 10^{10}$	$7.8\ 10^{9}$
^{51}Cr	$3.7\ 10^{8}$	$3.5\ 10^{9}$	$1.5\ 10^{9}$	$5.8\ 10^{9}$	$3.8\ 10^{10}$	$2.5\ 10^{10}$
^{54}Mn	$4.6\ 10^{7}$	$4.4\ 10^{8}$	$1.9\ 10^{8}$	$7.3\ 10^{8}$	$4.8\ 10^{9}$	$3.1\ 10^{9}$
^{55}Fe	$6.3\ 10^{8}$	$5.9\ 10^{9}$	$2.6\ 10^{9}$	$9.9\ 10^{9}$	$6.4\ 10^{10}$	$4.2\ 10^{10}$
^{58}Co	$5.8\ 10^{7}$	$5.5\ 10^{8}$	$2.4\ 10^{8}$	$9.1\ 10^{8}$	$6.0\ 10^{9}$	$3.9\ 10^{9}$
^{59}Fe	$4.6\ 10^{7}$	$4.4\ 10^{8}$	$1.9\ 10^{8}$	$7.3\ 10^{8}$	$4.8\ 10^{9}$	$3.1\ 10^{9}$
^{60}Co	$7.0\ 10^{7}$	$6.6\ 10^{8}$	$2.9\ 10^{8}$	$1.1\ 10^{9}$	$7.2\ 10^{9}$	$4.7\ 10^{9}$
^{63}Ni	$4.6\ 10^{7}$	$4.4\ 10^{8}$	$1.9\ 10^{8}$	$7.3\ 10^{8}$	$4.8\ 10^{9}$	$3.1\ 10^{9}$
^{65}Zn	$4.6\ 10^{7}$	$4.4\ 10^{8}$	$1.9\ 10^{8}$	$7.3\ 10^{8}$	$4.8\ 10^{9}$	$3.1\ 10^{9}$
^{89}Sr	$1.6\ 10^{9}$	$1.5\ 10^{10}$	$6.8\ 10^{9}$	$2.6\ 10^{10}$	$1.7\ 10^{11}$	$1.1\ 10^{11}$
^{90}Sr	$9.3\ 10^{9}$	$8.8\ 10^{10}$	$3.8\ 10^{10}$	$1.4\ 10^{11}$	$9.6\ 10^{11}$	$6.2\ 10^{11}$
^{90}Y	$9.3\ 10^{9}$	$8.8\ 10^{10}$	$3.8\ 10^{10}$	$1.4\ 10^{11}$	$9.6\ 10^{11}$	$6.2\ 10^{11}$
^{91}Y	$3.2\ 10^{8}$	$3.0\ 10^{9}$	$1.3\ 10^{9}$	$5.1\ 10^{9}$	$3.3\ 10^{10}$	$2.1\ 10^{10}$
^{95}Zr	$4.6\ 10^{7}$	$4.4\ 10^{8}$	$1.9\ 10^{8}$	$7.3\ 10^{8}$	$4.8\ 10^{9}$	$3.1\ 10^{9}$
^{95}Nb	$5.8\ 10^{7}$	$5.5\ 10^{8}$	$2.4\ 10^{8}$	$9.1\ 10^{8}$	$6.0\ 10^{9}$	$3.9\ 10^{9}$
^{106}Ru	$3.0\ 10^{9}$	$2.9\ 10^{10}$	$1.2\ 10^{10}$	$4.8\ 10^{10}$	$3.1\ 10^{11}$	$2.0\ 10^{11}$
^{106}Rh	$3.0\ 10^{9}$	$2.9\ 10^{10}$	$1.2\ 10^{10}$	$4.8\ 10^{10}$	$3.1\ 10^{11}$	$2.0\ 10^{11}$
^{110m}Ag	$4.6\ 10^{7}$	$4.4\ 10^{8}$	$1.9\ 10^{8}$	$7.3\ 10^{8}$	$4.8\ 10^{9}$	$3.1\ 10^{9}$
^{124}Sb	$8.1\ 10^{7}$	$7.7\ 10^{8}$	$3.3\ 10^{8}$	$1.2\ 10^{9}$	$8.4\ 10^{9}$	$5.4\ 10^{9}$
^{125}Sb	$9.5\ 10^{9}$	$8.9\ 10^{10}$	$3.9\ 10^{10}$	$1.5\ 10^{11}$	$9.7\ 10^{11}$	$6.3\ 10^{11}$
^{125m}Te	$2.2\ 10^{9}$	$2.1\ 10^{10}$	$9.3\ 10^{9}$	$3.5\ 10^{10}$	$2.3\ 10^{11}$	$1.5\ 10^{11}$
^{134}Cs	$2.1\ 10^{9}$	$2.0\ 10^{10}$	$9.0\ 10^{9}$	$3.4\ 10^{10}$	$2.2\ 10^{11}$	$1.4\ 10^{11}$
^{137}Cs	$1.9\ 10^{10}$	$1.8\ 10^{11}$	$7.9\ 10^{10}$	$3.0\ 10^{11}$	$1.9\ 10^{12}$	$1.2\ 10^{12}$
^{144}Ce	$1.8\ 10^{9}$	$1.7\ 10^{10}$	$7.5\ 10^{9}$	$2.8\ 10^{10}$	$1.8\ 10^{11}$	$1.2\ 10^{11}$
^{144}Pr	$1.8\ 10^{9}$	$1.7\ 10^{10}$	$7.5\ 10^{9}$	$2.8\ 10^{10}$	$1.8\ 10^{11}$	$1.2\ 10^{11}$
^{147}Pm	$2.8\ 10^{9}$	$2.6\ 10^{10}$	$1.1\ 10^{10}$	$4.4\ 10^{10}$	$2.8\ 10^{11}$	$1.8\ 10^{11}$
^{154}Eu	$7.0\ 10^{7}$	$6.6\ 10^{8}$	$2.9\ 10^{8}$	$1.1\ 10^{9}$	$7.2\ 10^{9}$	$4.7\ 10^{9}$
^{155}Eu	$3.5\ 10^{7}$	$3.3\ 10^{8}$	$1.4\ 10^{8}$	$5.5\ 10^{8}$	$3.6\ 10^{9}$	$2.3\ 10^{9}$
^{239}Pu	$2.1\ 10^{8}$	$1.9\ 10^{9}$	$8.7\ 10^{8}$	$3.3\ 10^{9}$	$2.1\ 10^{10}$	$1.4\ 10^{10}$

Table 34 (continued)

Nuclide	1971	1972	1973	1974	1975	1976	1977
^{3}H	$9.2\ 10^{11}$	$1.4\ 10^{12}$	$1.3\ 10^{12}$	$1.4\ 10^{12}$	$2.0\ 10^{12}$	$8.8\ 10^{11}$	$1.2\ 10^{12}$
^{14}C	$6.0\ 10^{9}$	$5.4\ 10^{9}$	$4.2\ 10^{9}$	$4.6\ 10^{9}$	$5.9\ 10^{9}$	$2.5\ 10^{9}$	$2.2\ 10^{9}$
^{32}P	$8.0\ 10^{9}$	$5.4\ 10^{9}$	$4.2\ 10^{9}$	$9.2\ 10^{9}$	$5.9\ 10^{10}$	$1.0\ 10^{10}$	$4.4\ 10^{9}$
^{35}S	$2.0\ 10^{11}$	$1.0\ 10^{10}$	$2.7\ 10^{11}$	$1.5\ 10^{11}$	$3.8\ 10^{11}$	$1.1\ 10^{11}$	$3.5\ 10^{11}$
^{45}Ca	$1.0\ 10^{10}$	$5.4\ 10^{9}$	$8.4\ 10^{9}$	$9.2\ 10^{9}$	$1.1\ 10^{10}$	$2.5\ 10^{10}$	$1.7\ 10^{10}$
^{51}Cr	$3.2\ 10^{10}$	$2.8\ 10^{10}$	$2.5\ 10^{10}$	$3.6\ 10^{10}$	$1.1\ 10^{10}$	$4.5\ 10^{10}$	$6.6\ 10^{10}$
^{54}Mn	$4.0\ 10^{9}$	$3.6\ 10^{9}$	$4.2\ 10^{9}$	$2.3\ 10^{9}$	$2.9\ 10^{9}$	$2.5\ 10^{9}$	$2.2\ 10^{9}$
^{55}Fe	$5.4\ 10^{10}$	$4.3\ 10^{10}$	$8.4\ 10^{9}$	$7.8\ 10^{10}$	$1.1\ 10^{10}$	$5.1\ 10^{9}$	$8.8\ 10^{9}$
^{58}Co	$5.0\ 10^{9}$	$5.4\ 10^{9}$	$4.2\ 10^{9}$	$2.3\ 10^{9}$	$2.9\ 10^{9}$	$2.5\ 10^{9}$	$2.2\ 10^{9}$
^{59}Fe	$4.0\ 10^{9}$	$3.6\ 10^{9}$	$4.2\ 10^{9}$	$2.3\ 10^{9}$	$2.9\ 10^{9}$	$2.5\ 10^{9}$	$2.2\ 10^{9}$
^{60}Co	$6.0\ 10^{9}$	$5.4\ 10^{9}$	$4.2\ 10^{9}$	$4.6\ 10^{9}$	$5.9\ 10^{9}$	$2.5\ 10^{9}$	$4.4\ 10^{9}$
^{63}Ni	$4.0\ 10^{9}$	$3.6\ 10^{9}$	$4.2\ 10^{9}$	$2.3\ 10^{9}$	$2.9\ 10^{9}$	$2.5\ 10^{9}$	$2.2\ 10^{9}$
^{65}Zn	$4.0\ 10^{9}$	$3.6\ 10^{9}$	$4.2\ 10^{9}$	$2.3\ 10^{9}$	$2.9\ 10^{9}$	$2.5\ 10^{9}$	$2.2\ 10^{9}$
^{89}Sr	$1.4\ 10^{11}$	$2.3\ 10^{11}$	$1.0\ 10^{11}$	$1.3\ 10^{10}$	$6.4\ 10^{10}$	$2.6\ 10^{11}$	$6.1\ 10^{10}$
^{90}Sr	$8.0\ 10^{11}$	$9.9\ 10^{11}$	$6.9\ 10^{11}$	$2.3\ 10^{11}$	$3.0\ 10^{11}$	$1.1\ 10^{12}$	$4.0\ 10^{11}$
^{90}Y	$8.0\ 10^{11}$	$9.9\ 10^{11}$	$6.9\ 10^{11}$	$2.3\ 10^{11}$	$3.0\ 10^{11}$	$1.1\ 10^{12}$	$4.0\ 10^{11}$
^{91}Y	$2.8\ 10^{10}$	$2.5\ 10^{10}$	$4.2\ 10^{9}$	$3.2\ 10^{10}$	$3.5\ 10^{10}$	$3.0\ 10^{10}$	$5.7\ 10^{10}$
^{95}Zr	$4.0\ 10^{9}$	$3.6\ 10^{9}$	$2.1\ 10^{9}$	$2.3\ 10^{9}$	$5.9\ 10^{9}$	$5.1\ 10^{9}$	$8.8\ 10^{9}$
^{95}Nb	$5.0\ 10^{9}$	$4.5\ 10^{9}$	$2.1\ 10^{9}$	$4.6\ 10^{9}$	$5.9\ 10^{9}$	$2.0\ 10^{10}$	$6.6\ 10^{10}$
^{106}Ru	$2.6\ 10^{11}$	$3.3\ 10^{11}$	$1.6\ 10^{11}$	$1.4\ 10^{11}$	$1.0\ 10^{11}$	$8.1\ 10^{10}$	$2.1\ 10^{11}$
^{106}Rh	$2.6\ 10^{11}$	$3.3\ 10^{11}$	$1.6\ 10^{11}$	$1.4\ 10^{11}$	$1.0\ 10^{11}$	$8.1\ 10^{10}$	$2.1\ 10^{11}$
^{110m}Ag	$4.0\ 10^{9}$	$3.6\ 10^{9}$	$4.2\ 10^{9}$	$2.3\ 10^{9}$	$2.9\ 10^{9}$	$2.5\ 10^{9}$	$2.2\ 10^{9}$
^{124}Sb	$7.0\ 10^{9}$	$6.3\ 10^{9}$	$4.9\ 10^{9}$	$5.3\ 10^{9}$	$6.8\ 10^{9}$	$5.9\ 10^{9}$	$5.1\ 10^{9}$
^{125}Sb	$8.1\ 10^{11}$	$4.8\ 10^{11}$	$8.0\ 10^{11}$	$5.8\ 10^{11}$	$4.3\ 10^{11}$	$1.5\ 10^{11}$	$1.3\ 10^{11}$
^{125m}Te	$1.9\ 10^{11}$	$1.7\ 10^{11}$	$1.9\ 10^{11}$	$1.5\ 10^{11}$	$1.0\ 10^{11}$	$3.5\ 10^{10}$	$3.0\ 10^{10}$
^{134}Cs	$1.8\ 10^{11}$	$1.3\ 10^{11}$	$1.0\ 10^{11}$	$2.0\ 10^{11}$	$3.7\ 10^{11}$	$3.3\ 10^{11}$	$2.4\ 10^{11}$
^{137}Cs	$1.6\ 10^{12}$	$7.3\ 10^{11}$	$7.9\ 10^{11}$	$2.2\ 10^{12}$	$3.2\ 10^{12}$	$1.4\ 10^{12}$	$1.0\ 10^{12}$
^{144}Ce	$1.5\ 10^{11}$	$3.0\ 10^{11}$	$4.6\ 10^{10}$	$4.6\ 10^{10}$	$4.7\ 10^{10}$	$4.0\ 10^{10}$	$3.6\ 10^{11}$
^{144}Pr	$1.5\ 10^{11}$	$3.0\ 10^{11}$	$4.6\ 10^{10}$	$4.6\ 10^{10}$	$4.7\ 10^{10}$	$4.0\ 10^{10}$	$3.6\ 10^{11}$
^{147}Pm	$2.4\ 10^{11}$	$3.4\ 10^{11}$	$7.9\ 10^{10}$	$1.7\ 10^{11}$	$2.3\ 10^{11}$	$9.1\ 10^{10}$	$3.2\ 10^{11}$
^{154}Eu	$6.0\ 10^{9}$	$5.4\ 10^{9}$	$4.2\ 10^{9}$	$4.6\ 10^{9}$	$5.9\ 10^{9}$	$2.5\ 10^{9}$	$4.4\ 10^{9}$
^{155}Eu	$3.0\ 10^{9}$	$2.7\ 10^{9}$	$2.1\ 10^{9}$	$2.3\ 10^{9}$	$2.9\ 10^{9}$	$2.5\ 10^{9}$	$2.2\ 10^{9}$
^{239}Pu	$1.8\ 10^{10}$	$1.6\ 10^{10}$	$1.2\ 10^{10}$	$1.3\ 10^{10}$	$1.1\ 10^{10}$	$1.0\ 10^{10}$	$2.2\ 10^{10}$

Table 34 (continued)

Nuclide	1978	1979	1980	1981	1982	1983	1984
^{3}H	$2.0\ 10^{12}$	$3.6\ 10^{12}$	$2.0\ 10^{12}$	$2.0\ 10^{12}$	$6.7\ 10^{11}$	$7.0\ 10^{11}$	$5.2\ 10^{11}$
^{14}C	$2.0\ 10^{9}$	$1.1\ 10^{9}$	$2.5\ 10^{9}$	$1.7\ 10^{9}$	$1.3\ 10^{9}$	$6.5\ 10^{8}$	$1.1\ 10^{9}$
^{32}P	$2.0\ 10^{9}$	$1.1\ 10^{9}$	$2.5\ 10^{9}$	$1.7\ 10^{9}$	$1.3\ 10^{9}$	$6.5\ 10^{8}$	$1.1\ 10^{9}$
^{35}S	$2.7\ 10^{11}$	$1.7\ 10^{11}$	$5.8\ 10^{11}$	$2.0\ 10^{11}$	$2.1\ 10^{11}$	$2.2\ 10^{11}$	$2.8\ 10^{11}$
^{45}Ca	$4.1\ 10^{9}$	$1.6\ 10^{10}$	$5.1\ 10^{9}$	$3.4\ 10^{9}$	$1.3\ 10^{10}$	$6.5\ 10^{9}$	$1.1\ 10^{10}$
^{51}Cr	$2.0\ 10^{9}$	$1.1\ 10^{9}$	$2.5\ 10^{9}$	$5.6\ 10^{8}$	$4.5\ 10^{8}$	0	0
^{54}Mn	$2.0\ 10^{9}$	$1.1\ 10^{9}$	$2.5\ 10^{9}$	$1.7\ 10^{9}$	$1.3\ 10^{9}$	0	$1.1\ 10^{9}$
^{55}Fe	$8.2\ 10^{9}$	$6.9\ 10^{9}$	$5.1\ 10^{9}$	$6.8\ 10^{9}$	$1.3\ 10^{10}$	$6.5\ 10^{9}$	$1.1\ 10^{10}$
^{58}Co	$2.0\ 10^{9}$	$1.1\ 10^{9}$	$2.5\ 10^{9}$	$1.7\ 10^{9}$	$1.3\ 10^{9}$	0	0
^{59}Fe	$2.0\ 10^{9}$	$1.1\ 10^{9}$	$2.5\ 10^{9}$	$3.4\ 10^{9}$	$1.3\ 10^{10}$	0	0
^{60}Co	$2.0\ 10^{9}$	$1.1\ 10^{9}$	$2.5\ 10^{9}$	$3.4\ 10^{9}$	$1.3\ 10^{10}$	$6.5\ 10^{9}$	$1.1\ 10^{10}$
^{63}Ni	$2.0\ 10^{9}$	$1.1\ 10^{9}$	$2.5\ 10^{9}$	$1.7\ 10^{9}$	$1.3\ 10^{9}$	$6.5\ 10^{8}$	$1.1\ 10^{9}$
^{65}Zn	$2.0\ 10^{9}$	$1.1\ 10^{9}$	$2.5\ 10^{9}$	$1.7\ 10^{9}$	$1.3\ 10^{9}$	$6.5\ 10^{8}$	$1.1\ 10^{10}$
^{89}Sr	$4.1\ 10^{9}$	$9.2\ 10^{9}$	$2.0\ 10^{10}$	$3.4\ 10^{10}$	0	0	0
^{90}Sr	$3.1\ 10^{11}$	$2.8\ 10^{11}$	$4.0\ 10^{11}$	$3.3\ 10^{11}$	$2.9\ 10^{11}$	$1.8\ 10^{11}$	$3.3\ 10^{11}$
^{90}Y	$3.1\ 10^{11}$	$2.8\ 10^{11}$	$4.0\ 10^{11}$	$3.3\ 10^{11}$	$2.9\ 10^{11}$	$1.8\ 10^{11}$	$3.3\ 10^{11}$
^{91}Y	$8.2\ 10^{9}$	$1.1\ 10^{10}$	$2.5\ 10^{9}$	0	0	0	0
^{95}Zr	$4.1\ 10^{9}$	$1.1\ 10^{9}$	$1.5\ 10^{10}$	$1.3\ 10^{10}$	$2.7\ 10^{10}$	0	0
^{95}Nb	$2.0\ 10^{10}$	$2.3\ 10^{9}$	$2.0\ 10^{10}$	$3.0\ 10^{10}$	$5.4\ 10^{10}$	$6.5\ 10^{9}$	0
^{106}Ru	$1.4\ 10^{11}$	$5.5\ 10^{10}$	$7.6\ 10^{10}$	$1.2\ 10^{11}$	$1.3\ 10^{11}$	$2.6\ 10^{10}$	$2.2\ 10^{10}$
^{106}Rh	$1.4\ 10^{11}$	$5.5\ 10^{10}$	$7.6\ 10^{10}$	$1.2\ 10^{11}$	$1.3\ 10^{11}$	$2.6\ 10^{10}$	$2.2\ 10^{10}$
^{110m}Ag	$2.0\ 10^{9}$	$1.1\ 10^{9}$	$2.5\ 10^{9}$	$1.7\ 10^{9}$	$1.3\ 10^{9}$	0	0
^{124}Sb	$4.7\ 10^{9}$	$1.1\ 10^{9}$	$5.1\ 10^{9}$	$6.8\ 10^{9}$	$1.3\ 10^{10}$	$6.5\ 10^{9}$	$1.1\ 10^{10}$
^{125}Sb	$3.3\ 10^{11}$	$1.1\ 10^{11}$	$1.7\ 10^{11}$	$1.9\ 10^{11}$	$8.1\ 10^{10}$	$2.6\ 10^{10}$	$2.2\ 10^{10}$
^{125m}Te	$8.2\ 10^{10}$	$2.7\ 10^{10}$	$4.5\ 10^{10}$	$4.7\ 10^{10}$	$2.7\ 10^{10}$	$6.5\ 10^{9}$	$1.1\ 10^{10}$
^{134}Cs	$2.3\ 10^{11}$	$1.2\ 10^{11}$	$4.0\ 10^{11}$	$2.1\ 10^{11}$	$1.0\ 10^{11}$	$3.9\ 10^{10}$	$8.8\ 10^{10}$
^{137}Cs	$1.3\ 10^{12}$	$9.4\ 10^{11}$	$2.5\ 10^{12}$	$1.0\ 10^{12}$	$6.7\ 10^{11}$	$4.8\ 10^{11}$	$1.0\ 10^{12}$
^{144}Ce	$3.8\ 10^{11}$	$5.5\ 10^{10}$	$9.6\ 10^{10}$	$1.8\ 10^{11}$	$1.8\ 10^{11}$	$2.6\ 10^{10}$	$1.1\ 10^{10}$
^{144}Pr	$3.8\ 10^{11}$	$5.5\ 10^{10}$	$9.6\ 10^{10}$	$1.8\ 10^{11}$	$1.8\ 10^{11}$	$2.6\ 10^{10}$	$1.1\ 10^{10}$
^{147}Pm	$1.3\ 10^{11}$	$7.1\ 10^{10}$	$5.1\ 10^{10}$	$2.8\ 10^{11}$	$2.1\ 10^{11}$	$5.2\ 10^{10}$	$2.2\ 10^{10}$
^{154}Eu	$4.1\ 10^{9}$	$2.3\ 10^{9}$	$1.0\ 10^{10}$	$1.0\ 10^{10}$	$1.3\ 10^{10}$	$6.5\ 10^{9}$	$1.1\ 10^{10}$
^{155}Eu	$2.0\ 10^{9}$	$2.3\ 10^{9}$	$5.1\ 10^{9}$	$1.0\ 10^{10}$	$1.3\ 10^{10}$	$6.5\ 10^{9}$	$1.1\ 10^{10}$
^{239}Pu	$8.2\ 10^{9}$	$4.6\ 10^{9}$	$1.0\ 10^{10}$	$3.4\ 10^{10}$	$5.4\ 10^{10}$	$1.3\ 10^{10}$	$1.1\ 10^{10}$