UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

MAR 16 2011

OFFICE OF
AIR AND RADIATION

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Dear Dr. Oliver:

Thank you for the opportunity to review and comment on your draft report. Attached please find detailed comments from me and members of my staff. Note that these comments reflect our opinions only and not necessarily those of our Agency.

As part of our review, we obtained and carefully read through all of your supporting references, as well as several other relevant peer-reviewed papers regarding wildfires in the Chernobyl Exclusion Zone (CEZ). In addition, we constructed spreadsheets containing the equations and parameter values you specify in your report and in IAEA SRS 19, and used these to check your calculations. Finally, we used the health physics computer code HotSpot (Version 2.07.1) (https://narac.llnl.gov/HotSpot/HotSpot.html) to cross check Gaussian plume projections, estimated airborne and ground surface activity concentrations, and predicted pathway-specific and total doses.

Overall, we believe that your screening level calculations based on the IAEA models and parameter values result in plausible first-order approximations of the potential upper-bound doses and risks to children (1 y) and adults at distances 25-150 km downwind from a catastrophic wildfire in the CEZ that releases large quantities of radionuclides from burning contaminated grasslands and forests. During our review of your analyses, we did, however, discover a number of calculation errors and missing exposure pathways that may result in underestimated doses and risks. We point these out in our detailed comments and suggest alternative values and approaches. Moreover, it is important to acknowledge that the neither the IAEA nor the HotSpot models are designed to estimate radiological impacts at distances greater than ~20 km, and that the IAEA models assume continuous discharges of radionuclides into the environment over several years, not episodic releases such as those caused by wildfires. While it is likely that these limitations in both models will result in overestimates of doses and risks for short-term events impacting individuals at far distances downwind, we recommend that you discuss and possibly validate whether or not the IAEA models and parameter values are appropriate for your scenario.

Our primary recommendations are summarized as follows:

- Include scale maps showing the locations and areal extent of: (1) the source term/release point; (2) surface contamination contours for all radionuclides of concern; (3) contaminated grasslands and forests; (4) concentric rings centered on the source term at distances of 25, 30, 50, 75, 100, and 125 km; (5) projected plume deposition contours; and (6) potentially impacted population centers, crop lands, and surface water bodies. (See Graphics A and B for examples).

- Recalculate all estimated doses and risks at distances of 25, 30, 50, 75, 100, and 125 km in order to: (1) account for revised combustible inventories based on corrected concentration factors; (2) include a resuspension/inhalation exposure pathway; (3) include a surface water exposure pathway; (4) account for direct deposition in the computation of food ingestion doses; and (5) correct for revised dose conversion factors.

- If possible, find an actual wildfire event involving contaminated grasslands and forests in or surrounding the CEZ and evaluate its radiological impact on exposed populations in order to gauge the degree of conservatism inherent in your screening level assessments. We found one example mentioned in Hao et al. (2009) (http://www.fs.fed.us/rm/pubs_other/rmrs_2009_hao_w001.pdf). (See Graphic C). Unfortunately, this paper does not include details on the nature and impact of the wildfire event that occurred in western Ukraine on May 8, 2003, but we encourage you to seek these details, along with any radiological measurements and dose estimates made during the event, especially in Kiev.

We hope you find our comments and recommendations helpful.

Sincerely,

Jerome S. Puskin

Jerome S. Puskin, PhD
Director, Center for Science and Technology
Radiation Protection Division

<table>
<tr><th>Page(s)</th><th>Line(s)</th><th>Comment</th></tr>
<tr><td>All</td><td>All</td><td>The following comments refer to the entire document:</td></tr>
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Check to ensure that all equations and tables referenced in the text are numbered and cited properly.
Search for and replace all instances of the following terms:

<table>
<tr><th>Replace this</th><th>With this</th></tr>
<tr><td>• radioisotopes</td><td>• radionuclides</td></tr>
<tr><td>• isotopes</td><td>• nuclides</td></tr>
<tr><td>• dosage</td><td>• dose</td></tr>
<tr><td>• infant</td><td>• child (1 y)</td></tr>
<tr><td>• ^{90}Sr or Sr-90</td><td>• $^{90}Sr/^{90}Y$ or Sr-90/Y-90</td></tr>
<tr><td>• ^{137}Cs or Cs-137</td><td>• $^{137}Cs/^{137M}Ba$ or Cs-137/Ba-137m</td></tr>
</table>

There are several occurrences where the term dose is used incorrectly. Strictly speaking, the results of the inhalation and ingestion exposure assessments should be presented as committed effective doses, because they are calculated using the age- and radionuclide-specific inhalation and ingestion committed effective dose coefficients listed in Table 2. Committed effective dose refers to an effective (summed ICRP tissue-weighted) total body dose committed over a 50-y period after intake by adults and to age 70 y after intake by a pre-adult age. For external exposures via cloud immersion and groundshine, the results should be presented as effective doses. Both committed effective doses and effective doses are expressed using the SI unit Sievert (Sv) (or multiples thereof). The doses are additive, and the sum is simply the dose in Sv.
Inhalation and ingestion dose coefficients listed under "Infant" in Table 2 actually correspond to IAEA/ICRP values for a 1-y old child. For this reason, all references to infant doses should be changed to child (1 y) doses
All doses should be expressed in units of Sv, not Sv/a, because exposures times are included explicitly in the calculations and cancel out. As you know, these are first year doses comprising: (1) the committed effective dose from inhaled radionuclides during 5-day plume passage, (2) the effective dose due to cloud immersion during plume passage, (3) the effective dose from groundshine over the first year, and (4) the committed effective doses from ingestion of contaminated food (vegetation, meat, and milk) over the first year. The sum of the pathway-specific doses should be referred to as the total dose in Sv.

</td></tr>
<tr><td>4</td><td>47-49</td><td>Rewrite the sentence starting on line 47 to read: "The exposure model was used to estimate adult and child (1 y) intakes,</td></tr>
</table>

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		external exposures, and doses via the five exposure pathways: (1) external irradiation due to immersion in a radioactive cloud during plume passage; (2) inhalation of radionuclides during plume passage; (3) external irradiation due to deposited radionuclides on soil during the first year after the wildfire; (4) ingestion of radionuclides in contaminated foods during the first year after the wildfire , and; (5) inhalation of resuspended radionuclides during the first year after the wildfire." For completeness and because our calculations indicate that it is a significant exposure pathway during the first and subsequent years after the wildfire, we recommend including resuspension/inhalation exposures in your dose and risk calculations.
4	49-50	Rewrite the sentence starting on line 49 to read: "Estimates of radionuclide releases, transport, exposures, and doses were based on conservative assumptions and consequently are likely to overestimate potential exposures to members of the general public during an actual wildfire event."
4	50-52	Rewrite the sentence starting on line 50 to read: "Excluding the food ingestion pathways, calculated doses to populations at distances 25 km or greater from the release point are less than Ukrainian radiation protection limits [provide a reference]." Note that this statement needs to be revisited after exposures and doses are recalculated according to additional comments that follow.
5	69-70	Change "potential implications of a catastrophic wildfire" to "potential adverse health effects due to releases of radionuclides during a catastrophic wildfire".
5	72-73	Change "Chernigiv (population 2.7 million) is located approximately 100 km north west of Chernobyl" to "Chernigiv (population 2.7 million) is located approximately 100 km northeast of Chernobyl"
5	76-78	After reviewing other relevant literature, we think your scenario would be more meaningful if it included all of the contaminated forests and grasslands on both sides of the border, especially within 10 km of the source term/release point where most of the activity is deposited– i.e., immediately surrounding the ChNNP. While we recognize that radioactivity contamination isn't as well characterized within the CEZ in Belarus, including only the Ukrainian contamination represents a potentially significant underestimation of doses and risks.
5	79	Change "extremely" to "very conservative". Not all parameter values used in the assessments are extremely conservative, i.e., high-end values.
5	80-82	Rewrite the sentence starting on line 80 to read: "The results of the exposure assessment are reported as the pathway-specific and total doses in Sieverts (Sv) to an adult and child (1 y) during plume passage and for the first year after the event." Note: As pointed out in an earlier comment, all doses should be expressed as Sv, not Sv/a, because the time unit is cancelled out in all the dose equations – i.e., 5 days of inhalation and immersion during plume passage and one year of direct exposure and plant, meat and milk ingestion. Also, it is incorrect to refer to the doses as "average doses" since they are based on high-end values for release, transport, and exposure. More correctly, they are worst-case or upper-bound dose estimates.
6	85-86	Change "the highest levels of effective dose" to "the highest total doses", and on line 86, change "radiation" to

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		"radioactivity".
6	86-88	Rewrite the sentence starting on line 86 to read: "Individuals who are not in the direct centerline of the projected plume of radioactivity or who are impacted by fewer exposure pathways will likely receive lower doses."
6	88-89	Change "the average annual dose" to "the total dose". Note: The total dose in the first year will be higher than doses in subsequent years partly because it includes contributions to dose from the immersion and inhalation pathways during plume passage. That said, in the U.S., we calculate the doses in the second year, third year, and the 50-yr interval after the event to compare with protective action guidelines regarding relocation and cleanup. While it is not incorrect to consider only the first year dose for emergency response purposes, it is our opinion that risk estimates should be based lifetime exposures.
6	91-93	Line 91, change "primarily" to "exclusively". No other reference was used for the screening calculations. This would be a good place to explain why the equations and assumption in IAEA SRS 19 may not be appropriate for modeling the impacts from a wildfire in the CEZ. As stated in several locations in the IAEA report: "The approaches described here [IAEA SRS 19] are not intended for application to instantaneous or short period releases such as might occur in uncontrolled or accident situations. " The report also states: "It should also be noted that the Gaussian plume model is not generally applicable at [distances] $x > 20$ km."
6	95-96	Delete "reporting risk for cases that involve maximum exposure potential." The IAEA generic screening models are used to estimate doses, not risks.
6	99	As pointed out in an earlier comment, we recommend including a fifth exposure pathway to account for resuspension and inhalation of deposited radionuclides in the first year after the event. This is a significant and typically-assessed pathway. In our opinion, its omission is a significant oversight that will result in an underestimation of total dose and risk.
6	Footnote2	Correct typographical error
7	104-106	Change "conservative" to "conventional", and delete the remainder of the sentence after "but". Summing dose contributions from individual exposure pathways is the typical or conventional approach for radiation dose assessments. Better language is provided in the IAEA report, as follows: "The recommended approach to account for exposures from multiple pathways is by simple summation over those pathways. In reality, it is unlikely that a member of the 'true' critical group would be in the most exposed group for all exposure pathways. However, the significance of this potential compounding of pessimistic assumptions is somewhat lessened by the fact that the total dose is seldom dominated by more than a few radionuclides and exposure pathways."
7-9	119-152	The following comments refer to the **Source Model section and Table 1**
		1. Provide a scale map(s) showing: a. the location and size of the source term/release point; b. soil activity concentration contours for Cs-137/Ba-137m, Sr-90/Y-90, Eu-154, Pu-238, Pu-239/240, and Am-241;

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		c. the locations and sizes of radioactively contaminated grasslands and forests, both within and outside the 30-km CEZ; d. concentric circles around the source term/release point representing distances of 25, 30, 50, 75, 100, and 125 km; and e. the locations of major towns and cities, forests, croplands, and surface water bodies in the predominant wind direction assumed in the transport and exposure scenarios.
		2. Correct values in **Table 1**, for the following reasons: a. As presented, the combustible inventories for Sr-90 and Cs-137 (column 3) are calculated incorrectly. b. The concentration factors (i.e., ratios of combustible/soil concentrations) for Sr-90/Y-90, Cs-137/Ba-137m, Pu-238, and Pu-239/240 in forest and grassland (columns 4 and 5) also appear to be miscalculated. Using the data from Yoshenko et al. (2006a), we recalculated ratios and compared them (below) to the current values in Table 2. In addition, we adjusted values for Eu-154 (assumed to be equal to the Pu-239/240 value) and for Am-241 (assumed to be twice that for Pu-239/240):

Radionuclide	Current Ratios in Table 1		Corrected Ratios Based on Mean Values		Corrected Ratios Based on Upper 95th Percentiles**	
	Forest	Grassland	Forest	Grassland*	Forest	Grassland*
Sr-90/Y-90	0.351	0.023	0.542	0.038	1.0	0.11
Cs-137/Ba-137m	0.101	0.037	0.121	0.024	0.22	0.07
Eu-154	0.032	0.005	0.033	0.016	0.06	0.2
Pu-238	0.03	0.004	0.031	0.014	0.06	0.04
Pu-239/240	0.031	0.005	0.033	0.016	0.06	0.05
Am-241	0.062	0.01	0.066	0.032	0.12	0.1

*Higher of the two values reported for Plots #1 and #2

**Based on propagated error terms for the computed ratios

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		3. Recalculate radionuclide inventories (Bq) for all radionuclides in Table 1, column 4 (Combustible in 2010) using the corrected ratios (above) based on the mean or upper 95th percentile values. Assuming a worst case scenario, we suggest using the upper-bound values.
		4. Recalculate all dose and risk estimates based on the revised source term inventories at distances of 25, 30, 50, 75, 100, and 125 km downwind.
9-12	153-204	1. (Line 160) What is the basis for assuming the wildfire would burn over a five day period?
		2. (Footnote #2) Please provide a reference for this discussion. It appears to based on data from Table 4 of

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		Yoshenko et al. (2006a).
		3. (Line 164 and Footnote #3) The scenario assumes a point source located at the center of the CEZ. It might be useful to explore alternate assumptions as to the location and extent of the source to better understand the degree of conservatism in your calculations.
		4. (Line 165) What was the basis for selecting a wind speed of 2m/s and a predominate wind direction frequency of 90%? Why not 5 m/s and 100%, for example?
		5. (Equation 3, line 168) In order to compute C_A, please include the IAEA SRS 19 equations for calculating values for F (IAEA equation #3) and sigma z (in footnote a to Eq. #3).
		6. (Footnote #6) Using the IAEA formulas for F and sigma z, calculations of C_A of the release heights of 0-60 m, we computed result identical air concentrations (to those that assumed a release height of 0 m) at distances equal to or greater than 25 km downwind. For this reason, the statement that a release height of 0 m is conservative is not true.
		7. (Footnote #8) For comparison, default deposition velocity values used in the HotSpot computer code (https://narac.llnl.gov/HotSpot/Hotspot.html) are 260 m/d (0.3 cm/s) for respirable size particles (= or < 10 microns) and 6900 m/d (8 cm/s) for non-respirable size particles (> 10 microns). The IAEA default deposition velocity value of 1000 m/s falls in between the Hotspot values and is not overly conservative.
		8. (Lines 197-204) Based on our literature search, the Kiev Reservoir is a current source of municipal drinking water for several million people, as well as a source for crop irrigation (see, for example, Sansone et al. (1996), Sci. Tot. Env., **186**: 257-271). Based on our HotSpot modeling, we found that the projected plume intersects several surface water bodies, including the lower part of the Kiev Reservoir (see Graphic B). For this reason, we recommend that you calculate the doses and risks contributed by the surface/drinking water pathway before you dismiss it as being insignificant.
		9. Provide a scale map showing the projected plume soil activity deposition contours for the radionuclide of concerns and the locations of crop lands, towns, and cities intersected by the plume.
12-17	205-307	The following comments refer to the **Exposure Model section**
		1. (Line 217) Change the sentence to read: "The ICRP inhalation dose coefficients assume a 50-y dose commitment for adults and 70-y dose commitment for infants/children."
		2. (Line 221) Change "effective dose" to "committed effective dose"
		3. (Line 223) Renumber equation [9] as equation [6]
		4. (Line 225) Change "periodic effective dose" to "committed effective dose" and change (Sv/a)" to "(Sv)". Note: Because the wildfire scenario specifies an exposure time of 5 hours which corresponds to the plume passage, the inhalation pathway dose is calculated as a committed effective dose in SV, not an annual dose rate in Sv/a.
		5. (Line 227) Change "inhalation rate" to "inhalation volume" and change "(m^3/a)" to "(m^3)".

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		6. (Line 229) Change "R_{inh} is 115 m^3/a" to "R_{inh} is 115 m^3" and Change "R_{inh} is 19 m^3/a" to "R_{inh} is 19 m^3"
		7. (Line 228) In Table 2, the units for the inhalation dose coefficients and the ingestion dose coefficients are incorrectly expressed as Sv/a per Bq/m^3 and Sv/a per Bq/kg, respectively. They should be expressed in units of Sv/Bq.
		8. (Line 240) Contrary to what is stated here, the ambient air concentration will not return to normal immediately following the event due to resuspension of deposited activity.
		9. (Line 244) Renumber equation [10] as equation [7]
		10. (Line 246) Change "(Sv/a)" to "(Sv)".
		11. (Line 248) Change "(Sv/a per Bq/m)" to "(Sv/a per Bq/m^3)".
		12. (Line 250) Add the following: "$O_f = 0.014\ a^{-1}$ or 5 d/365 d/a"
		13. (Line 258) Renumber equation [11] as equation [8]
		14. (Line 260) Change "(Sv/a)" to "(Sv)".
		15. (Line 263) Add the following: "$O_f = 1\ a^{-1}$ or 365 d/365 d/a"
		16. (Line 264) Change "Equation [3]" to "Equation [4]"
		17. (Line 269) Change "normal" to "annual"
		18. (Line 271) Change "periodic effective dose" to "committed effective dose"
		19. (Line 272) Renumber equation [12] as equation [9]
		20. (Line 274) Change "effective dose" to "committed effective dose", and change "(Sv/a)" to "(Sv)".
		21. (Line 275) Rewrite the sentence as follows: "Hp is the total amount of an individual foodstuff consumed in the first year following the wildfire event (kg), calculated as the product of the consumption rate (kg/a; Table 3) and one year of intake (a)."
		22. (Line 290, footnote 10) This assumption is counterintuitive, especially given that the wildfire scenario is supposed to represent the "worst case". Given the short-term, one-time nature of this event, direct deposition on crops will be the primary mode of contamination, by a wide margin, compared to contamination occurring by root uptake and soil adhesion. While it is possible that some radioactivity may be lost from directly contaminated fruits and vegetables during preparation, screening models are designed to be conservative and assume no loss. Dairy cows and cattle will consume large quantities of directly contaminated pasture grass/forage and will yield contaminated milk and meat. For these reasons, we recommend recalculating the doses contributed by the ingestion pathways based on both direct and indirect (root uptake) deposition, as directed by the IAEA SRS 19 guidance and formulas. Based on calculations performed using the IAEA equations, we calculated vegetation, meat, and milk ingestion doses that are at least 100 times higher the comparable values listed in Table 8.
		23. (Line 302) As noted in several earlier comments, we recommend adding a fifth exposure pathway to account for the inhalation of resuspensed radionuclides in the first year following a wildfire event. This a commonly included

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		pathway in radiological exposure assessments, and preliminary calculations we performed using HotSpot indicated that the first-year resuspension/inhalation doses were comparable to the inhalation doses computed for the 5 days during plume passage. Add an Equation 10 for resuspension/inhalation.
		24. (Line 304) Change "Equations [4, 5, 6, and 9]" to "Equations [6, 7, 8, 9, and 10, for resuspension/inhalation)]"
		25. (Line 305) Add a term for resuspension/inhalation and number it Equation [10]
		26. (Line 307) Renumber equation [11] as equation [12]
17	308-324	The following comments refer to the **Cancer Incidence and Mortality Model section**
		1. (Line 309) After "exposure", add "to the radionuclides of concern released during the wildfire"
		2. (Line 318) Renumber equation [11] as equation [12]
		3. (Line 324) Change "D is the expected dose" to "D is the estimated total dose from all exposure pathways"
18-19	325-360	The following comments refer to the **Results section**
		1. All results reported in this section and in relevant Tables should be checked and revised, as necessary, after recalculation of all estimates according to our previous recommendations.
		2. (Line 327) Change "release radioactive materials into the population living in the vicinity of the CEZ" to "release airborne radioactive materials that may adversely impact the health of people living downwind of the contaminated smoke plume"
		3. (Line 328) Change "estimated quantities of radioactive materials" to "estimated inventories (in Bq) of Sr-90/Y-90, Cs-137/Ba-137m, Eu-154, Pu-238, Pu-239/240, and Am-241"
		4. (Lines 329-330) Change "The total amount of radioactive material that could be mobilized to an ionized state…" to "The total amount of radioactivity released into the environment…"
		5. (Line 331) Check/revise the value 2.1E14 Bq after recalculation per our recommendations.
		6. (Line 333) Change "discharge of ionized radioactive material" to "release of radioactivity", and check/revise the value 2.1E14 Bq/s after recalculation per our recommendations.
		7. (Lines 334-336) Rewrite the sentence to read: "Table 4 presents the estimated activity concentrations of Sr-90/Y-90, Cs-137/Ba-137m, Eu-154, Pu-238, Pu-239/240, and Am-241 in air, on ground surfaces, and incorporated into vegetation, meat, and milk at 25, 30, 50, 75, 100, and 125 km downwind of the release point." As noted previously, we recommend calculating activity concentrations, doses, and risks at distances of 25, 30, 50, 75, 100, and 125 km.
		8. (Lines 336-338) Rewrite the sentence to read: "As shown in Table 4, and as expected based on the Gaussian plume model, the estimated activity concentrations of all radionuclides at the plume centerline decrease proportionally with increasing downwind distances."
		9. (Lines 338-341) Rewrite the sentence to read: "Table 7 presents estimates of the radionuclide-specific activity concentrations in contaminated crops as a function of downwind distance. It shows that, for all radionuclides at

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		all distances, direct deposition of airborne radionuclides is the primary mode of crop (and forage) contamination by a very large margin."
		10. (Lines 341-342) We recommend including both direct deposition and root uptake/soil adhesion in calculations of all ingestion pathway concentrations and doses, regardless of whether or not the Ukrainian government prohibits consumption of contaminated crops, milk, and milk.
		11. (Line 343-346) Combine and rewrite the first two sentences to read: "Table 8 presents the pathway-specific and total doses (in Sv) contributed by the radionuclides of concern, individually and collectively, at plume centerline distances of 25, 30, 50, 75, 100, and 125 km downwind of the source."
		12. (Lines 346-360) All numerical values given and statements made in the Results section should be checked and corrected, as necessary, after the exposure, dose, and risk estimates have been recalculated per our recommendations. Report doses in Sv, not Sv/a.
19-22	361-433	The following comments refer to the **Discussion section**:
		1. (Line 363) After "screening model" add "for estimating the release, transport, exposure, and doses from radionuclides released into the environment."
		2. (Lines 365-366) Change "over-estimate the dosage that is likely to be received" to "overestimate the total dose to a given member of the critical population." And change, "If the estimated dosages still fall below the level of concern..." to "If the estimated total dose contributed by all radionuclides through all exposure pathways is less than the acceptable numerical dose limit established by the official radiological protection agency, one may conclude that the actual total dose will likely be lower."
		3. (Line 367) Change "if the estimated dosages are" to "if the estimated total dose is"
		4. (Line 368) Change "actual dosages are" to "actual total dose is"
		5. (Lines 373-375) Rewrite the two sentences to read: "The International Commission on Radiological Protection's current dose limits for occupational and public exposures for application to regulated sources in planned exposure situations are 20 mSv/a, when averaged over five years, and 1 mSv/a, respectively (ICRP, 2007)." Note that the correct reference is: The 2007 Recommendations of the International Commission on Radiological Protection, ICRP Publication 103, Ann. ICRP 37 (2-4), 2007.
		6. (Lines 376-384) It would be clearer to the reader if the Ukrainian limits were presented in a table rather than discussed in the text.
		7. (Line 385) Change "The combined estimated dosages..." to "As shown in Table 8, the estimated total doses..."
		8. (Lines 386-389) All doses should be expressed as Sv, not Sv/a, and all values may be subject to revision following recalculation.
		9. (Line 388) Delete "(calculated from Table 8)" and change "equivalent" to "comparable"
		10. (Lines 391-392) Change "exceed the dosage limits set by in the Radiological & Protection 60 for the general

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		public" to "both exceed the ICRP public dose limit."
		11. (Lines 392-433) All dose and risk estimates (and comparisons to limits) may be subject to revision following recalculations.
23	434-444	The following comments refer to the **Conclusion section**:
		1. (Line 437) Recalculate the total estimate for Combustible in 2010 presented in Table 1. We found errors in the calculations of the Sr-90 and Cs-137 estimates and in the combustible/soil ratios for all radionuclides (as pointed out in our earlier comments)
		2. (Lines 438-439) Starting at "ground exposure", change the sentence to read, "groundshine, resuspension/inhalation, and food ingestion in the first year following the wildfire."
		3. (Lines 439-441) Rewrite the sentence to read: "The estimated total doses to a child (1 y) and adult from all exposure pathways, except food ingestion, 25 km or greater downwind from the wildfire, were below the evacuation limits established by the Ukrainian government." Note that this conclusion may need to be revised after recalculation of the dose and risk estimates.
		4. (Lines 441-442) Rewrite the sentence to read: "Since the estimated total ingestion doses to a child (1 y) and adult were found to exceed acceptable levels, it is likely that the Ukrainian government would restrict intakes of contaminated vegetation, meat, and milk indefinitely."
		5. (Lines 442-444) Rewrite the sentence to read: "Although uncalculated, it is likely that doses to people living and working in the CEZ would likely exceed acceptable levels."
24	453-460	The following comments refer to **Table 1:**
		1. The values listed in column #1 are taken from Kashparov et al. (2003) correctly.
		2. The values listed in column #2 are decay corrected correctly.
		3. The values listed in column #3 for Sr-90/Y-90 and Cs-137/Ba-137m are calculated incorrectly.
		4. To correct these errors and to use the revised concentration factors we provided earlier (page 4), we recommend that you recalculate the combustible inventories for all radionuclides and revise Table 1 accordingly.
25	461-463	The following comments refer to **Table 2**:
		1. All values are taken from the IAEA SRS 19 Tables XV-XVII correctly
		2. However, the inhalation and ingestion dose coefficients should be expressed in units of Sv/Bq
		3. We also checked the values in Table 2 against current ICRP references and found a few instances where the IAEA dose coefficients were inconsistent. For example, the IAEA adult and child (1 y) inhalation and ingestion DCFs for Sr-90 do not appear to include the contribution from the Y-90 daughter. Immersion DCFs for Sr-90/Y-90, Pu-238, Pu-239/240, and Am-241 do not correspond to the comparable ICRP values. Finally, we noted that the adult and inhalation DCFs for Sr-90 are the maximum dose per unit intake values (Type S), whereas the corresponding DCFs for Cs-137/Ba-137m (Type F) is the lowest dose per unit intake coefficient. For these reasons, we compiled the

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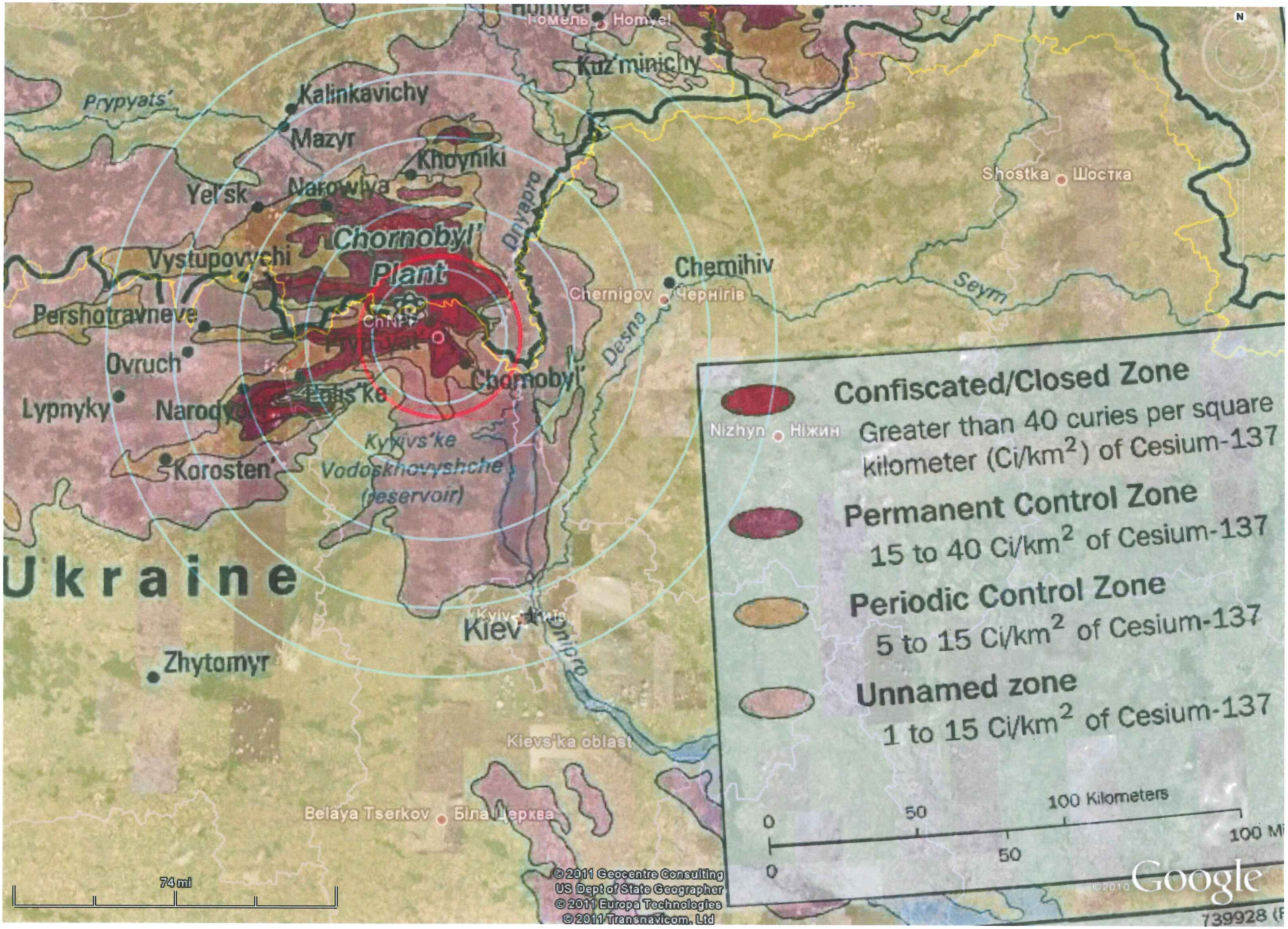
		table of DCFs (below) from current ICRP sources (DCFPAK 2.2, Eckerman and Leggett (2010)) and suggest that you use them to replace the IAEA values listed in your Table 2. Assuming a worst case scenario, we suggest using the maximum inhalation DCFs for the child (1 y) and adult.
		4. Finally, recalculate all dose and risk estimates based on the revised source term inventories and DCFs.

Recommended Replacement Dose Coefficients for Table 2

	Air		Inhalation (Sv/Bq)							
	Submersion	Surface	Adult			Child (1 y)			Ingestion (Sv/Bq)	
Radionuclide	(Sv/a per Bq/m3)	(Sv/a per Bq/m2)	Type F	Type M	Type S	Type F	Type M	Type S	Adult	Child (1 y)
Sr-90/Y-90	2.81E-08	3.52E-09	2.43E-08	3.68E-08	1.57E-07	5.66E-08	1.14E-07	4.04E-07	3.04E-08	9.24E-08
Cs-137/Ba-137m	8.52E-07	1.83E-08	4.65E-09	9.61E-09	3.88E-08	5.39E-09	2.91E-08	1.03E-07	1.36E-08	1.24E-08
Eu-154	1.82E-06	3.69E-08	1.10E-07	5.28E-08	4.72E-08	3.58E-07	1.48E-07	1.31E-07	2.04E-09	1.23E-08
Pu-238	1.06E-10	1.89E-11	1.08E-04	4.60E-05	1.60E-05	1.89E-04	7.39E-05	4.00E-05	2.28E-07	4.00E-07
Pu-239/240	1.19E-10	1.79E-11	1.19E-04	4.99E-05	1.59E-05	2.02E-04	7.70E-05	3.86E-05	2.51E-07	4.22E-07
Am-241	2.12E-08	6.88E-10	9.59E-05	4.15E-05	1.59E-05	1.74E-04	6.90E-05	4.02E-05	2.04E-07	3.75E-07

Page(s)	Line(s)	Comment
26	464-465	All of the values and units listed in **Table 3** are taken correctly from Table XIV (p.78) of IAEA SRS 19.
27	466-469	All of the values and units listed in **Table 4** are taken correctly from Table XI (p.67) of IAEA SRS 19.
28	470-472	All of the values and units listed in **Table 5** are taken correctly from the Tables 12D-1 and 12D-2 (p.311) of the NAS BEIR VII Report.
29	474-476	The following comments refer to **Table 6**:
		1. Column #3: Air concentrations are calculated correctly for all radionuclides at all distances, except for Eu-154 at 25 km. The value should be 2.2E-02 Bq/m^3. However, all values should be recalculated using revised source terms (i.e., Combustible in 2010 inventories), as recommended in our previous comments.
		2. Column #4: Ground concentrations are calculated correctly for all radionuclides at all distances. However, all values should be recalculated using revised source terms (i.e., Combustible in 2010 inventories), as recommended in our previous comments.
		3. Columns #5, #6 and #7: Food concentrations should be recalculated using Eqs. 30-37 in IAEA SRS 19, including the direct deposition pathway model. In addition, all values should be recalculated using revised source terms (i.e., Combustible in 2010 inventories), as recommended in our previous comments.
30	477-481	**Table 7**: Crop contamination concentrations should be recalculated for all radionuclides using the revised source terms

Page(s)	Line(s)	Comment
		(i.e., Combustible in 2010 inventories), as recommended in our previous comments.
31-32	482-483	**Table 8**: Pathway-specific and total doses should be recalculated for all radionuclides using the revised source terms (i.e., Combustible in 2010 inventories), revised air and ground concentration values, and revised dose conversion factors, as recommended in our previous comments. In addition, the table should include a column showing the resuspension/inhalation exposure pathway and the food ingestion values should include the contributed doses from contaminated vegetation, meat and milk due to direct deposition. All doses should be expressed as Sv, not Sv/a, and all values may be subject to revision following recalculation.
33	484-485	**Table 9**: Lifetime attributable cancer risk estimates should be recalculated for all radionuclides using revised dose estimates based on the revised source terms (i.e., Combustible in 2010 inventories), revised air and ground concentration values, and revised dose conversion factors, as recommended in our previous comments.
END		



Kalinkavichy
Prypyats'
Mazyr
Khoyniki
Yel'sk
Narowlya
Chornobyl' Plant
Vystupovychi
Pershotravneve
ChNPP
Ovruch
Lypnyky
Korosten'
Kyyivs'ke Vodoskhovyshche (reservoir)
Chornobyl'
Dnyapro
Chernihiv
Chernigov Чернігів
Desna
Seym
Shostka Шостка
Kuz'minichy
Homyel
Ukraine
Zhytomyr
Kiev
Kyiv Київ
Kievs'ka oblast
Belaya Tserkov Біла Церква
Nizhyn Ніжин
Confiscated/Closed Zone
Greater than 40 curies per square kilometer (Ci/km²) of Cesium-137
Permanent Control Zone
15 to 40 Ci/km² of Cesium-137
Periodic Control Zone
5 to 15 Ci/km² of Cesium-137
Unnamed zone
1 to 15 Ci/km² of Cesium-137
0 50 100 Kilometers
0 50 100 Mi
74 mi
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US Dept of State Geographer
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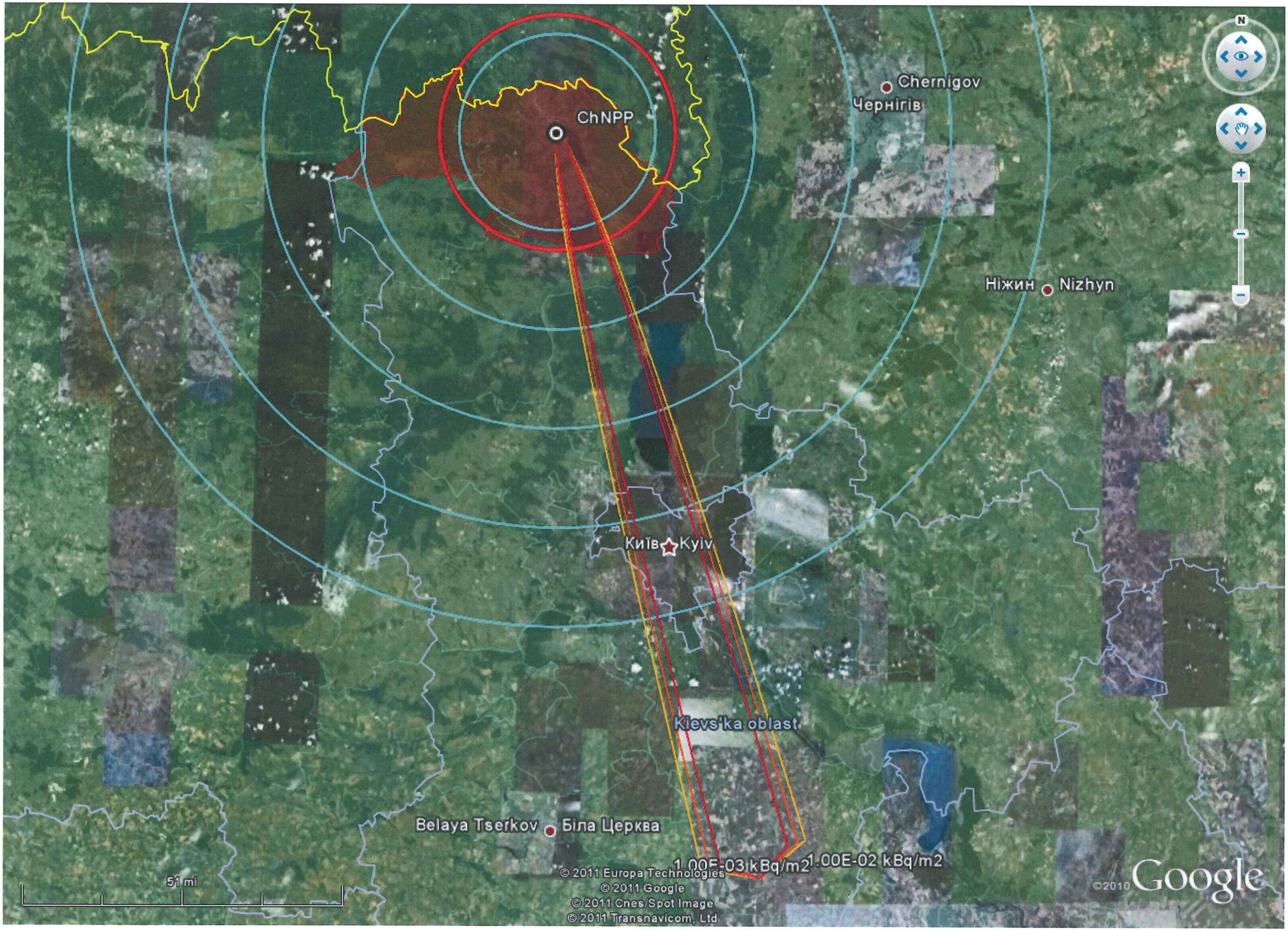
739928


ChNPP
Chernigov
Чернігів
Ніжин
Nizhyn
Київ
Kyiv
Kievs'ka oblast
Belaya Tserkov
Біла Церква
1.00E-03 kBq/m2
1.00E-02 kBq/m2
51 mi
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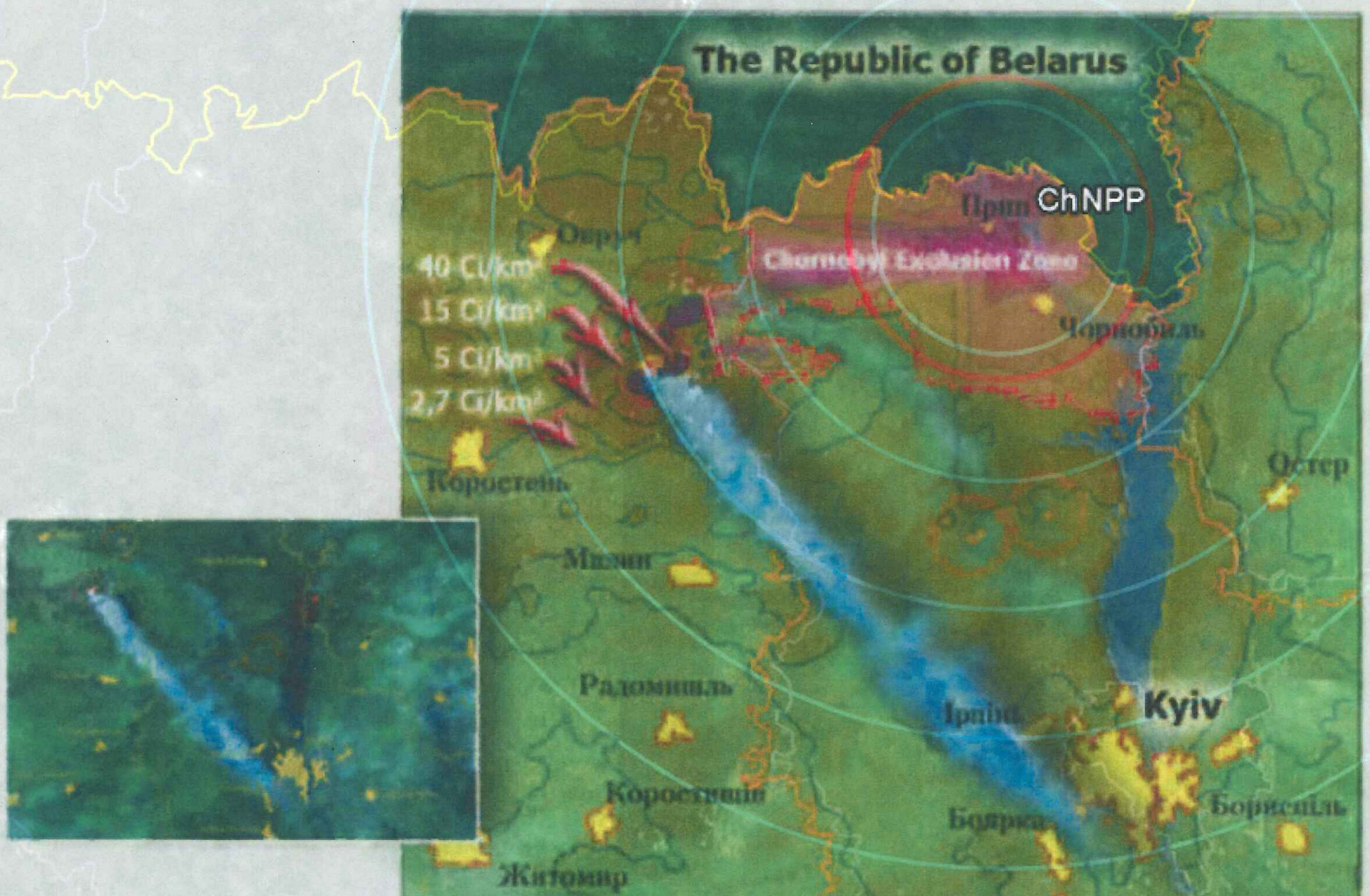

Figure 12.5. The NOAA Advanced Very High Resolution Radiometer (AVHRR) satellite image (small figure) of a smoke plume in western Ukraine, May 8, 2003, overlaid on a land cover map (large picture) (courtesy of the Ukrainian Land and Resource Management Center).