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STATE OF TENNESSEE
DEPARTMENT OF ENVIRONMENT AND CONSERVATION
DOE OVERSIGHT DIVISION
761 EMORY VALLEY ROAD
OAK RIDGE, TENNESSEE 37830-7072

September 9, 2013

Mr. John Michael Japp
Federal Facility Agreement Manager
U.S. Department of Energy
Oak Ridge Operations Office
P.O. Box 2001
Oak Ridge, TN 37831

Dear Mr. Japp

Re: Remedial Investigation/Feasibility Study for Comprehensive Environmental Response, Compensation, and Liability Act Oak Ridge Reservation Waste Disposal, Oak Ridge, TN DOE/OR/01-2535&D2 June 2013

The Tennessee Department of Environment and Conservation (TDEC) previously notified the Department of Energy (DOE) in a letter dated July 15, 2013 that the DOE Response to TDEC comments required more discussion and TDEC placed the Remedial Investigation and Feasibility Study and Response to Comments for Environmental Management Disposal Facility (EMDF) in informal dispute. TDEC's response to DOE's Response to Comments is attached.

Subsequent to initiating informal dispute, DOE hosted a workshop on the Environmental Management Waste Management Facility (EMWMF) and the EMDF. That workshop brought together a number of experts and provided a good overview of the facilities. From those discussions there are several topics that need highlighting:

1. It is common practice to perform a hydrogeologic evaluation prior to siting a waste management facility to verify the site meets siting criteria and as part of assessing alternative sites. This was not done and the schedule proposes selecting the site and then performing a hydrogeologic evaluation. This is backwards. There are ongoing questions with groundwater levels and potential implications on EMWMF and EMDF is in a similar area with potentially similar groundwater issues. This landfill is proposed for placement of radioisotopes, mercury, and other constituents that will be present through geologic time. Landfill stability is of paramount importance and it is preferable to not rely on engineering controls as it is reasonable to assume engineering controls will fail over geologic time.

2. The siting of EMDF was apparently based on siting of EMWMF. With questions as to the hydrogeologic environment, reevaluating siting EMDF in the proposed location is needed.

3. DOE presented a discussion at the workshop that DOE is running out of time to site, design, and construct EMDF before EMWMF is at capacity. EMWMF is being filled with an estimated 30 to 50 percent clean material. DOE should begin volume reduction, waste segregation, and size reduction now to reduce amount of material and space needed in EMWMF thereby extending life of EMWMF to allow time for better evaluation of potential EMDF sites.

4. EMDF previously included building a treatment plant to treat contact water and leachate. Response to Comments on the Remedial Investigation/Feasibility Study removed the treatment plant and specified ARARS that did not include all designated uses. The response to comments also specified EMDF would treat leachate and contact water in the same manner as at EMWMF. At the workshop, handling of leachate and contact water was discussed. It is TDEC's understanding that:

    a. DOE will continue to treat leachate.

    b. If DOE develops a plan and schedule acceptable to TDEC to address contact water, then TDEC will work with DOE to implement the plan. Without an acceptable plan, TDEC will expect DOE treat Contact Water. Timing for developing the plan was not discussed and should be discussed in the informal dispute.

    c. TDEC will expect DOE radiological waste control, treatment and discharge requirements for contact water to be equivalent to the Division of Radiological Health regulations.

    d. If DOE constructs another waste disposal facility in Bear Creek, it should include a water treatment plant to treat leachate and contact water, piping leachate and contact water to a treatment facility or other action so there will be not direct discharge of either leachate or contact water. (A rigorous feasibility study should be performed and a remedy may be implemented prior to construction of a new waste disposal facility as part of the plan referenced above.)

    e. Water management on existing EMWMF is a problem for the operators and practical items should be implemented to better manage water to reduce the volume of contact water.

Questions or comments concerning the contents of this letter should be directed to me at the above address or by phone at (865) 481-0995.

Sincerely

Roger Petrie, FFA Project Manager
Environmental Restoration Program

xc Pat Halsey, DOE
David Adler, DOE
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CERCLA D1 RI/FS COMMENT AND RESPONSE SUMMARY

Comments by: **TDEC Division of DOE Oversight**
Comments Received: February 19, 2013
Title of Document: Remedial Investigation/Feasibility Study for Comprehensive Environmental Response, Compensation, and Liability Act Oak Ridge Reservation Waste Disposal Oak Ridge, Tennessee
Revision No.: D1
Document No: DOE/OR/01-2535&D1
Date: September 2012

No.	Reference	TDEC Comment	DOE Response Approach/Comment	TDEC Approve/Rebuttal
1)	General	The approach to development of a preliminary WAC taken in this document does not address cumulative effects due to the EMWMF and the proposed EMDF, as required by DOE M 435.1-1 (Radioactive Waste Management Manual). TDEC has concerns as to whether the proposed approach is adequate for WAC development or to assure future compliance with the performance objectives required by DOE Order 435.1 and TN Rule 0400-20-11-.16. Below are listed concerns TDEC has with the risk based modeling employed in this document.	DOE Order 435.1 Chg 1 requirements are To Be Considered materials subject to review and approval by the DOE Low-Level Waste Disposal Facility Federal Review Group (LFRG). A Performance Assessment and Composite Analysis will be prepared under separate cover and submitted to LFRG at a later date. The PA, CA and a PA/CA Maintenance Plan are among the requirements for LFRG to approve a Disposal Authorization Statement pursuant to O435.1. A brief explanation of the mission and purpose of LFRG has been added to RI/FS Section 7.2.2.6. A more formal definition of To Be Considered materials has been added to Section 1 of Appendix E.	NUREG guidance should be used for establishing performance under TN Rule 0400-20-11-.16. Compliance with DOE Order 435.1 does not assure performance under state statutes. The composite analysis, LFRG and state review are required before this approval. This is necessary to assure that EMDF performance parameters are properly developed and supported. The state can only approve EMDF once the cumulative impacts of relevant sources in Bear Creek Valley are understood.
		a. Sites on the ORR underlain by carbonate rocks fail a key technical requirement for siting facilities for land disposal of radioactive waste in Tennessee [TN Rule 0400-20-11-.17 (1) (b)]. Consequently, sites on the ORR underlain by carbonate rocks should not be candidate sites for CERCLA land disposal of radioactive wastes.	The commenter's reference to carbonate is apparently meant to imply that delineation of flow paths in karst terrain is usually not possible. The EMDF site is not underlain by the pure carbonate rocks in which karst is best formed. There is no evidence of karst at the site or at similarly positioned sites in Bear Creek Valley, e.g., EMWMF. The EMDF site is expected to be fully capable of being characterized, modeled, analyzed, and monitored. **Text stating that the site can meet the TDEC criteria has been added to Section 7.2.2.6.**	Models cannot be adequately assessed prior to site characterization. TDEC agrees that the EMDF site is expected to be fully capable of being characterized, modeled, and analyzed, but this site must pass this key technical requirement for siting facilities prior to approval of the RI/FS.

		b. Risk modeling is ultimately based on the inventory of contaminant mass or Curies disposed. Using a volume weighted sum of fractions rather than a limit on total mass or curie content (or a mass/Curie weighted SOF) adds an extra and unnecessary step between the calculation of risk and waste acceptance. A less complex and more transparent WAC attainment process than that currently used at the EMWMF would be a goal for any new ORR CERCLA disposal facility, although impacts to the conclusions of this RI/FS might not be significant.	The SOF method used in meeting final WAC is beyond the scope of this RI/FS. The final methodology for WAC attainment will be developed and submitted for regulator and LFRG approval at a later date. WAC approval by LFRG is a required element for obtaining a Disposal Authorization Statement.	The costs and benefits of on-site waste disposal cannot be assessed without agreement on preliminary waste acceptance criteria. WAC must be adequate to assure long-term performance under both DOE Orders and TDEC rules.
		c. The list of waste types proposed for the EMDF (section 2.1.2 of the RI/FS) includes a range of demolition material, but it is not apparent that this has been reflected in the choice of solid-liquid partition coefficients used in modeling.	Please see Appendix F, Section 5.1, 3rd paragraph for more detail on the reasons that K_d for soil-like materials are considered appropriate. This paragraph has been revised to improve clarity.	The soil-like material wastes in the EMWMF do not support the assumptions listed in Section 5.1.
		d. The cell design, waste forms, hydrologic setting, and operations proposed for the EMDF is not sufficient to assure that a 1 centimeter per year infiltration rate through the cell represents a plausible worst case.	This comment lacks specificity, but can be addressed by stating that the design contained within the RI/FS is conceptual. Infiltration rates of 1 cm/yr [i.e., 0.38 in/yr (Partially Functional Stage) and 0.42 in/yr (Long- Term performance Stage)] were calculated by the Hydrologic Evaluation of Landfill Performance (HELP) model using input parameters based on the conceptual landfill design (please see Table F-2 in Appendix F). This approach is conservative because it assumes partial and then total failure of synthetic liners and drainage diversion layers, relying instead on the long-term stability of the compacted clay layers to limit infiltration. No revisions have been made to the RI/FS with regard to this comment.	It is not possible to verify that the assumptions and input parameters used in HELP modeling are conservative. An infiltration rate of 1 cm/yr without benefit of a geomembrane is very low. Differential settling will result in perching of water on this interface, increasing infiltration through the barrier layer and likely causing some deterioration of the barrier layer due to shrink and swell in areas where perched water changes saturation levels significantly. The "worst case scenarios" do not include leachate outbreaks on side slopes. This seems possible in the EMWMF design due to perching or bathtubbing of leachate in wastes with significant voids placed on relatively impermeable wastes. The scenarios do not include effects of ground water intrusion into the clay liner despite the artesian conditions that exist. The cell design, waste forms, hydrologic setting, and operations proposed for the EMDF are similar to those at the EMWMF, and the modeling presented in this document would not assure that a 1 centimeter per year infiltration rate through the cell represents a plausible worst case.

		e. There is little rationale provided for the scenarios used to establish long-term performance of the proposed facility. Other than a proposed three foot thick layer of 4 inch to 12 inch diameter rip-rap in the final cap design, there is nothing to address the performance objective limiting the risk to inadvertent intruders in TN Rule 0400-20-11-.16 (3), or satisfy the similar requirement in Chapter IV, paragraph (P) (2) (h) of DOE M 435.1. The RI should evaluate long term facility performance in accordance with TN Rule 0400-20-11-.16 and DOE Orders, or should provide sufficient justification to demonstrate an equivalent standard of performance under the requirements for formal waiver of ARARS, given in 40 CFR 300.430 (f)(1)(ii)(c)(4).	The biointrusion layer and the cap thickness work to discourage inadvertent intrusion, such as construction of a house basement or drilling a water well. Further, the steep side slopes will discourage construction. Penetration of the cap's layers, especially the biointrusion layer, would require heavy equipment and would therefore be intentional intrusion. Analyses of acute- and chronic-exposure inadvertent human intruder scenarios will be contained in the Performance Assessment (PA) required by O 435.1. The intruder analyses are expected to conform to Manual 435.1, Chapter IV requirements. Additional protective measures could be incorporated into the final design should the PA indicate the need for additional measure to protect from inadvertent intrusion. Revisions have been made to RI/FS Section7.2.2.3 to clarify the expectations regarding inadvertent intrusion.	The scenarios here ignores the possibility of long-term geotechnical problems that might lead to liner or side slope failures, as well as a potential bathtub effect and leachate outbreaks on side slopes.
		f. It also appears that the placement of the well (pages F- 5 to F-9 of the RI/FS) to establish risks through groundwater pathways does not achieve the stated goal of determining a point of compliance at the point of highest projected dose or concentration beyond a 100 meter buffer zone surrounding the disposed waste, per DOE M 435.1 (P) (2) (b). In order to be consistent with both DOE requirements the withdrawal well should not be far outside the 100 meter buffer. A sensitivity analysis should be performed to show that the dilution factor achieved by the hypothetical location and construction of a withdrawal well is at least typical of worst case scenarios.	The location of the hypothetical receptor well for modeling purposes was analogous to the approach approved for EMWMF by the regulators. This location was used to calculate the preliminary WAC, based on the assumption that this is the nearest reasonable location for a resident farmer with a well, watering livestock and crops from Bear Creek. It is not intended to comply with O 435.1 Performance Assessment requirements, which will be addressed in a Performance Assessment and Composite Analysis to be prepared at a later date. No revisions have been made.	Design and input parameters for EMWMF are not a precedent for EMDF. The hypothetical receptor must be put in the most conservative location. Any preferential contaminant pathways, either natural or constructed, must be considered in placing the hypothetical receptor. The transport footprints of EMWMF and EMDF will overlap and should be included in a composite analysis per O 435.1 Performance Assessment and Composite Analysis. This is a requirement prior to state approval.
2)	General	A more thorough consideration of all state and federal laws and regulations than that given in Appendix E will be required before establishing a list of ARARs. Some specific examples relative to siting, design, and operations requirements for the proposed facility considered by TDEC to be most significant are discussed below:	Development of ARARs is an iterative process; and includes incorporation of some regulator comments. The ARARs list will continue to evolve as the remedial design is completed. Additional responses to this multi-part comment are provided below.	All state laws are ARARs unless they are waived via written permission.

		a. The discussion in Chapter 3 of Appendix E (pages E-3 and E-4) of this document is not adequate to provide a basis for the waiver of ARARs, specifically TSCA requirement 40 CFR 761.75(b) (3) or TDEC Rule 1200- 2-11-.17(1)(h) (now TN 400-20 11-.17(1)(h)). The intent of both of these rules is the long term hydrologic isolation of the disposal facility liner from the water table.	40 CFR 761.75(b)(3) requirements will be met, except for the 50 ft buffer requirement between the liner and the historic high water table. A waiver is requested for this requirement on the basis that the landfill liner design provides equivalent protection. Citations to 40 CFR 300.430 (f)(ii)(B)(1) and (C)(4) have been added to Sections 1 and 3 of Appendix E, and additional rationale for the waiver has been added to Section 3. TDEC Rule 0400-2-11-.17(1)(h) would also require a waiver. This waiver would be requested based on the use of an underdrain and packed soil base under the landfill liner to lower the water table sufficient to prevent any springs or seeps to the landfill floor after cell construction is complete. The underdrain system would eliminate the discharge of groundwater to the ground surface. This waiver is requested on the grounds of equivalent protection, per 40 CFR 300.430 (f)(ii)(B)(1) and (C)(4). Additional discussion is presented in Section 3 of Appendix E.	Waiver of TDEC Rule 0400-2-11-.17(1)(h) will require written authorization of the TDEC Division of Solid Waste Management Relocation of stream channel will also require fulfillment of the substantive requirements of TDEC Rule 1200-4-7 (Aquatic Resource Alteration Permits)

		b. Perimeter drains and stormwater diversion channels are required to hydrologically isolate the proposed facility from surface water discharge and ground water recharge along Pine Ridge. There is no evaluation of the potential for these constructed features to fail after the closure of the facility. A record of surface water discharge and hydraulic head and water table fluctuations at the proposed site should be done to demonstrate long term performance and compliance with ARARs listed on pages E-38 and E-39 of the RI/FS (now TN Rule 0400- 02-11-.17, subparagraphs (e), (f), (g), and (i), as well as the monitoring requirements of TN Rule TN Rule 0400- 02-11-.17, paragraph (4).	1) The text in Section 6.2.2.4 of the RI/FS has been modified to indicate a design requirement will be to evaluate the possibility that the upgradient shallow French drain, storm water diversion ditches, and/or underdrain fail after closure of the disposal facility and demonstrate the landfill remains protective of the environment in the event one or more of these engineered features are no longer functional. 2) An extensive site characterization study is currently in the planning process and is expected to begin in FY2014. Characterization is expected to involve continuous ground water level monitoring in multiple wells for one year, continuous surface water flow monitoring in NT-2 and NT-3 for one year, quarterly water quality monitoring and geological and geotechnical testing of soils and bedrock. The results of this study will be used in performance assessment and as a basis for landfill designs. A surface water and groundwater monitoring program will be instituted during operation and after closure of the landfill to demonstrate long-term performance and compliance with ARARs, in accordance with TDEC Rule 0400-20-11-.17(4)(a).	This response is not adequate. The site must be characterized prior to TDEC's approval of the RI/FS.

		c. TN Rule 0400-02-11-.17, subparagraph (2)(d). These requirements should be met through proper cap design and void space reduction measures.	Text was added to Section 6.2.2.4 of the RI/FS stating the landfill cap would be designed to meet the requirements of TN Rule 0400-20-11-.17, subparagraph (2)(d): "Covers must be designed to minimize to the extent practicable water infiltration, to direct percolating or surface water away from the disposed waste and to resist degradation by surface geologic processes and biotic activity" (Note this TDEC Rule is listed in the ARARs table in Appendix E.) The following wording was added to Section 6.2.5: "A goal of the waste placement and compaction operations will be to minimize the void space within the waste, which will lessen the potential for long-term settlement/subsidence of the waste and enhance the long-term stability of the final cover system."	TDEC expects DOE to commit to doing an assessment and estimation of potential for void formation and cap analysis to verify that voids will not compromise the cap prior to approval of the RI/FS.
		d. TN Rule 0400-02-11-.17, subparagraph (2)(f). The requirements would not allow for the current proposal of a low permeability protective layer (modeled in the RI/FS as 1 foot of native soils – hydraulic conductivity of approximately 10^{-6} cm/s on page F-18) above the cell drainage layer and leachate collection system.	TN Rule 0400-02-11-.17, subparagraph (2)(f) states: "The disposal site must be designed to minimize to the extent practicable the contact of water with waste during storage, the contact of standing water with waste during disposal and the contact of percolating or standing water with wastes after disposal." The use of the protective soil layer, as described in this RI/FS, does not violate the requirements of TN Rule 0400-02-11-.17 stated above. Similar to the process being performed at EMWMF, contact water would be collected in the lower portion of the landfill cell away from the waste. Temporary berms would be constructed to contain the contact water and separate it from the waste. Contact water would be removed promptly from the landfill cell after collection to prevent it from standing within the waste during and after disposal. Thus, to the extent practicable the contact of water with waste during storage, the contact of standing water with waste during disposal, and the contact of percolating or standing water with wastes after disposal would be minimized.	Waiver of TDEC Rule 0400-2-11-.17(1)(h) will require written authorization of the TDEC Division of Solid Waste Management

		e. Wastewater treatment is described in section 6.2.2.7 of the RI/FS. ARARs specific to treatment and discharge of leachate and contaminated storm water cited in this document are listed on pages E-40 and E-60 of the document. Subpart A of 40 CFR 445 for point source discharges of wastewater from landfills subject to the provisions of 40 CFR part 264, Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities, Subpart N–(Landfills) is applicable to wastewater discharges from the proposed facility. TN Rule 1200-04-05-.04 (1) (b), which prohibits the discharge of radioactive waste into waters, should be considered relevant and appropriate.	Leachate treatment has been removed from the RI/FS. Contact water and leachate will be handled in the same manner as for EMWMF.	Recreational water quality criteria are ARARs because Bear Creek is classified for recreational use as per TDEC Rule 1200-04-04. The state has not agreed to the same alterations to standard operating procedures and design (i.e. low permeability protective layer) that caused the creation of contact water. Assumptions regarding generation of contact water and leachate will be evaluated with regards to appropriate state laws and regulations.
3)	General	DOE concluded in 2004 (BJC/OR-1908) that the expenditure of 7 to 10 million dollars on volume reduction technologies would save 60,000 to 90,000 cubic yards of landfill capacity under the assumption that void space reduction of wastes generated from scrapyards and large buildings would translate directly into 1:1 clean fill savings requirements. Experience has shown that clean fill savings are likely to be much more significant, since ratios of over 2 to 1 clean fill:waste are required to get proper compaction for a variety of waste materials. The following comments concern the use of volume reduction techniques.	See responses below:	

		a. Appendix B seems to demonstrate the cost effectiveness of volume reduction methods. There are, however, inconsistencies in discussion of unit cost. In comparing disposal costs for on-site and off-site options, cost per unit volume of on-site disposal was made with a basis that includes clean fill in the total disposed volume. The feasibility of processing equipment, structural steel, piping, and other items requiring a high clean fill to void ratio for off-site disposal while disposing of materials not as suitable for volume reduction such as soil or concrete on-site should be evaluated.	Table B-9 provides a comparison of unit costs for on-site and off-site disposal both with and without volume reduction. The cost for on-site disposal has to be based on the amount of air space occupied by the waste material along with the required quantity of clean feel required for the particular material. The cost of the landfill air space was divided by the as-generated volume of the material to obtain $/As-G vol, which is the same basis as the cost for off-site disposal. As shown in Table B-9, the cost of off-site disposal for equipment and structural steel, even with VR, is far greater than the cost of on-site disposal, therefore using a combination of off-site disposal for equipment and on-site disposal for soil will always be more expensive than disposing of all the materials on-site.	The state does not disagree with the cost comparison provided in Table B-9. It is noted that Appendix B shows under scenario B, the cost of aggressive volume reduction does result in a cost savings of over $65M and more importantly a volume savings of over 830,000 cubic yards. Maximizing waste segregation to allow clean material to be disposed in existing onsite landfills will increase the volume of high activity waste that requires off-site disposal. Minimizing the need for clean fill will further reduce the disposal capacity needed to complete the cleanup of the Oak Ridge Reservation. All of this will reduce the area needing characterization for the facility, the area impacted by the facility, and possibly whether there is a need to cross a stream to construct the facility. In addition, in a letter from DOE to the SSAB (July 19, 02013), "RESPONSE TO YOUR LETTER DATED MAY 09, 2013, RECOMMENDATION 215: RECOMMENDATION ON REMAINING LEGACY MATERIALS ON THE OAK RIDGE RESERVATION" DOE states "OREM has established a hierarchy for dispositioning the inventory to minimize disposition costs that includes: • Reuse or recycle of waste or material • Use of onsite Subtitle D landfills for final disposal • Use of the Environmental Management Waste Management Facility for disposal • Use of offsite disposal facilities" This hierarchy is also suitable for minimizing dilution of radiological waste in general and associated costs. This hierarchy would reduce radiological waste volume and the need for oversized capacity in EMDF.

		b. The conceptual design, and presumably, operational costs, of wastewater treatment are based on the assumption that the characteristics of leachate and contaminated stormwater will be similar to the characteristics of wastewater currently generated at the EMWMF. The projected waste stream for EMDF disposal is, however, to be generated from somewhat different sources than waste disposed at EMWMF, and may contain contaminants that will be more expensive to treat to water quality standards. Water handling and wastewater treatment options for the proposed facility should be described in greater detail, including costs associated with possible wastewater treatment at the ORNL process waste treatment plant.	The treatment facility has been removed from the estimate, however the ORNL PWTC uses a very robust system that can accommodate a wide variety of contaminants. All costs for handling leachate and contact water are included in the estimated annual operating cost, which is taken directly from the actual EMWMF operating costs (includes their management of leachate and contact water).	DOE must incorporate any additional ORNL PWTC costs required for treating mercury in the leachate and contact water into the RI/FS.
I)	Executive Summary, Page ES-2, Paragraph 3	**"RI/FS Approach"** Risk assessments on individual remedial sites may not be in the scope of this document, but a risk assessment of this new proposed disposal facility on the EMWMF receptor is required. Our preliminary evaluation indicates that the dose from the new facility close to the EMWMF receptor would be cumulative and could approximately double the dose with the same waste acceptance criteria. This situation requires a composite analysis of the two disposal facilities on the EMWMF receptor. Furthermore, a composite analysis should also incrementally include other sources in Bear Creek Valley, such as S3 ponds, Bear Creek Burial Ground, Bone Yard Burn Yard and so forth, even to consider the Spallation Neutron Source groundwater pathway into spring SS5. It could be that this proposed facility only reduces totaled risk if other sources in Bear Creek Valley are removed, remediated, or consolidated.	A risk assessment was conducted using coupled ground water – surface water models to determine if a receptor located near the confluence of NT-3 with Bear Creek. Modeling results were then used to calculate waste acceptance criteria for specific constituents expected to be present in the waste placed in the EMDF only. A Composite Analysis (CA) will be prepared to meet the requirements of DOE Order 435.1, which includes consideration of the cumulative impacts of all low-level radioactive and chemical waste disposal areas in EBCV. The CA, reviewed and approved by LFRG (see response to comment 1, above), is an element of the Disposal Authorization Statement required by DOE prior to placing waste.	A Composite Analysis is a prerequisite for deciding and siting a new waste management facility that can incrementally contribute risk to on and off site receptors.

2)	Executive Summary, Page ES-5, Top of Page	Waste Control Specialists (WCS) should be included in this discussion or explained why they are not available. Especially since DOE has anticipated capability at the site that may be beneficial. WCS also has rail access. In general, the discussion should include more sorting alternatives for the purpose of disposing non-rad waste in RCRA permitted facilities. "Cradle to cradle" reuse/recycling of metal and other valuable material should also be discussed up front. Please state current and anticipated contract rates for each commercial facility. The discussion, as is, seems to have unsubstantiated cost estimates.	WCS is addressed in some detail as a process modification in Section 6.3.3.8.1, but is not included in the Executive Summary since it is not a primary component of the Off-Site Alternative. DOE recently entered into a contract with WCS. The RIFS addresses only the waste materials that are LLW or LLW/mixed and the WGF basis assumes all non-rad materials have been segregated and properly dispositioned elsewhere. There is no basis for estimating the volume of additional materials for segregation or recycle. Anticipated contract rates for ES disposal are given in the detailed discussion of the Off-Site alternative in Section 6.	Since DOE has a contract with WCS, it should be considered a primary component of the Off-Site Alternative.
		Subsequent pages through about 2-9, including figure 2-2 should include diversion of more debris into non- rad disposal. Some demolition buildings (Table A-2) will not produce all rad waste unless they are mixed with radioactive wastes (dilution). It was not our intent to allow clean waste to be mixed with concentrated rad waste to get higher volume lower activity rad waste (dilution).	Waste that is disposed in the EMDF will only be that generated by CERCLA actions. Clean soils and soil-like materials may be used as void fill necessary to maintain structural stability and prevent cap subsidence. This is not dilution. It is worth noting, however that addition of clean fill in and around radioactive wastes acts as shielding and therefore helps to reduce exposure and risk.	Evaluation of the EMWMF WAC shows that clean fill is being used to reduce the VWSF. The mixing of clean material with rad waste is defined as dilution. In addition, in the event of containment failure any additional "clean" fill material added to EMDF will effectively and proportionally increase the amount of contaminated material to be handled due to cross contamination. In essence all clean material added to EMDF becomes additional waste to be dealt with if a containment failure occurs.
3)	Executive Summary, Page ES-4	"The estimated total project cost for implementing the Off- site Disposal Alternative is $1.992 billion (B [2012 dollars]) or $1.408B (present worth)." Is the EMDF cost estimate a fixed price "turn-key" bid where DOE closes the facility upon depletion of the proposed funding cost? The Off-site Disposal Alternative of $1.992 billion should be based on hard bids from off-site disposal facilities.	The contracting approach (i.e., turn-key, fixed price, design-build, incremental, etc.) has not been decided and is not germane to this document. It is assumed that DOE will fund landfill construction, operation, closure, and post-closure to the extent required to achieve remedial goals and ROD requirements. The cost estimates presented in this RI/FS are based on commonly available commercial rate tables (e.g., R.S. Means), material quotes (if available), available disposal rate tables, experience, and labor rate tables for the ORR. Hard bids are not appropriate at this stage because the design is conceptual, not for construction.	When onsite disposal costs are used and thusly compared to alternatives to justify onsite disposal, then all alternatives are germane to this document. If it can be assumed that DOE will fund all construction, operation, and remediation; then it needs to be clearly stated in the document Were volume negotiated price negotiations used for off-site disposal and rail transportation?

4)	Page 5-2, Table 5-1	Table 5-1 does not evaluate waste classification. Disposal of clean wastes into non-rad RCRA permitted facilities is not mentioned. This infers dilution will be practiced.	Table 5-1 is intended to evaluate effectiveness, implementability, and relative cost only; waste characteristics and classification are discussed in Section 2 of the RI/FS. Table 5-1 has been extensively revised in response to EPA General Comment 10 and TDEC Specific Comment 5. Please also see response to the second part of Specific Comment 2, above.	Clean material and dirty wastes should be kept separate. Mixing separate clean material with waste is avoidable and is called "dilution". Mixing coincident wastes contaminated to various degrees is unavoidable and is called "blending". Dilution increases radioactive waste volume and blending does not. See 46FR51100 for original rational on this to conserve disposal volume. See 76FR50500 for updated considerations.
5)	Page 5-3, Table 5-1	Waste Control Specialists (WCS) is a viable alternative that is not listed. Include WCS.	WCS has been added to Table 5-1. Additionally, note that WCS is addressed in Section 6 as a process modification. Please also see response to Specific Comment 2, above.	No further comment
6)	Section 6.2.2.4, Page 6-15	**"Disposal Facility"** "The geologic buffer could be comprised of compacted native soil or in-situ fine-grained native soil, saprolite, bedrock, or combinations of these geologic materials, depending on measured in situ hydraulic conductivity and layer thickness." There is some concern with the geologic material used in the buffer. The use of saprolite or bedrock may not be accurately measured in determining hydraulic conductivity. Saprolite and bedrock contains rock pieces that make it difficult to compact and meet the hydraulic conductivity criteria uniformly. The native soils should be sieved before use.	In-situ fine-grained native soil, saprolite, and bedrock refers to these materials in their natural undisturbed (i.e., unexcavated) positions. The hydraulic conductivity of these undisturbed materials would be measured using standard field and/or laboratory testing methods, as appropriate for these various materials during the site investigation program. Excavated bedrock and rocky saprolite materials would not be used to construct the geologic buffer layer. DOE concurs large pieces of rock would not be allowed in compacted soil used to construct the geologic buffer layer. The text in Section 6.2.2.4 was revised to clarify native soil used to construct the geologic buffer layer (i.e., compacted native soil) would be sieved in the borrow area, as required, to remove large pieces of rock that could make it difficult to compact and meet hydraulic conductivity criteria, prior to placement and compaction beneath the landfill.	No further comment

		"A lesson learned from the EMWMF construction is that a landfill can be successfully constructed over a tributary in BCV. An underdrain is necessary within the tributary channel to provide a flow path for groundwater immediately below the landfill and prevent upwelling, since tributaries are natural discharge areas for groundwater." A concern using an underdrain is for physical and chemical weathering of the No. 57 stone (limestone). Eventually the underdrain will fail.	As shown on Figure 6-9, the underdrain would be constructed of siliceous rock and not limestone to avoid weathering issues. Wording was added to the text in section 6.2.2.4 stating the underdrain will be constructed of siliceous rock to avoid weathering issues.	It is too early to declare victory on the EMWMF underdrain. DOE must demonstrate the underdrain will be effective for the duration of the risk.
7)	Section 6.2.2.7, Page 6-28	**"Leachate/Contact Water Treatment Facility"** "The portion of precipitation that falls within an open, active cell potentially coming in contact with the waste materials and collecting on the floor of the cell (referred to as "contact water") would be pumped out of the active cells and stored temporarily in lined basins located near the landfill. While in the basin, the contact water would be sampled and tested to determine whether it is contaminated. If the results of the analytical tests indicate the contact water is free of contamination, it would be released to the storm water detention basin. If contaminated, the contact water could not be released as storm water and would be transferred to the treatment facility via a dedicated piping system." The term "Contact Water" as used here is a term invented as a matter of convenience for the EMWMF. It has no basis in TN Rules and Regulations. The state's position is that the protective soil layer should be engineered with permeability such that water entering the active cells will be collected as leachate as much as possible.	The term "contact water" as used in this RI/FS is the same term as used in EMWMF regulatory documents. Based on EMWMF experience, the volume of contact water generated in a given year of landfill operation is approximately three times the volume of leachate removed from the leachate collection and removal system. Since testing of the contact water at EMWMF has demonstrated this fluid is typically not contaminated above environmental release criteria and typically can be released to surface water without treatment, this RI/FS describes managing this fluid separately from leachate to reduce the volume of leachate potentially requiring treatment and disposal. Section 6.2.2.9 of the RI/FS has been revised to include the process option of making "windows" in the protective soil layer and collecting contact water as leachate. The pros and cons of collecting contact water as leachate are discussed in Section 6.2.2.9.	TDEC will require compliance with TN Rule 0400-02-11-.17, subparagraph (2)(f) to assure the disposal site is designed to minimize to the extent practicable the contact of water with waste during storage, the contact of standing water with waste during disposal and the contact of percolating or standing water with wastes after disposal.
8)	Page 6-52	**"Process Modifications"** Volume reduction prior to rail shipment should be a given and not a Process Modification?	The value of VR for off-site shipments depends on the quantities processed and the manner in which VR is executed. As stated in Appendix B, VR would be cost effective if implemented programmatically and/or for large volumes of material. If implemented at a project level for small quantities, the cost effectiveness is not clear.	Consider to implement volume reduction programmatically.

9)	Appendix C, Page C-4, First Paragraph, Lines 2-3	From available maps it appears that the proposed EMDF lies in the Anderson County and not the Roane County Census Tract 9801. Please explain this discrepancy.	The text erroneously identified the county as Roane; the error has been corrected to show that EMDF site is in Anderson County.	No further comment
10)	Appendix C, Page C-20, Figure C-10	Faults that are referred to in the text in section 3.2.3 should be labeled in Figure C-10.	According to Lemiszki (2000, Geologic Map of the Bethel Valley Quadrangle. USGS Draft Open-File Map GM 130-NE.) the White Oak Mountain Thrust fault is more than 2,000 ft below land surface at Bear Creek Valley, more than 1,000 ft below the base of the cross-section. No change was made.	No further comment
11)	Appendix C, Section 3.2.2.2.2, Page C-21	**"Rutledge Limestone"** This formation appears to be labeled **"Friendship Formation"** in Figures C-9 and C-10 (maps) on pages C-19 and C-20, respectively. As the nomenclature **"Friendship Formation"** seems limited to only the Oak Ridge Reservation it is suggested that the designations on the two maps be changed to reflect the commonly accepted formation name Rutledge Limestone.	Figures C-9 and C-10 have been revised.	No further comment
12)	Appendix C, Section 3.2.2.2.4, Page C-21	**"Maryville Limestone"** This formation appears to be labeled **"Dismal Gap Formation"** in Figures C-9 and C-10 (maps) on pages C-19 and C-20, respectively. As the nomenclature **"Dismal Gap Formation"** seems limited to only the Oak Ridge Reservation it is suggested that the designations on the two maps be changed to reflect the commonly accepted formation name Maryville Limestone.	Figures C-9 and C-10 have been revised.	No further comment
13)	Appendix C, Page C-22	"...weathers to for a strongly weathered saprolite..." What is a strongly weathered saprolite? Is it not still a saprolite?	Sentence has been revised to omit the words "strongly weathered".	No further comment

14)	Appendix C, Page C-24	Section 3.2.3 1st sentence, reference to the Whiteoak Mountain thrust fault- the fault needs to be labeled on the figure (C-10)	Figure has been revised.	No further comment
15)	Appendix C, Section 3.2.3, Page C-25	**"Geologic Structure"** Moore (1988) noted the presence of a few high angle faults near ORNL, but tentatively concluded that ". . .groundwater conduits can occur along and near faults . ..but that such features are uncommon and may be rare." So, what is being said is that faults as conduits are uncommon or rare, unless drilling or other data support that?	That is correct. Coring is expected to be included in the site characterization study to help evaluate the presence of fractures and evidence of faulting.	No further comment
16)	Appendix C, Page C-25	"There is no evidence of active, seismically capable faults in the Valley and Ridge physiographic province or within the rocks under where the ORR is located." The wording in this document should not be so dismissive about possible seismic hazards nearer to the facility. The USGS estimate that an earthquake as large as magnitude 7.5 (Richter) are possible in the ETSZ (East Tennessee Seismic Zone) and events of magnitude 5 – 6 are possible every 200-300 years. The largest event measured (magnitude 4.6) occurred near Knoxville in 1973.	Agreed. This paragraph has been moved to a new subsection 3.2.4 entitled Seismicity, which discusses earthquake history and probability of future earthquakes in more detail.	The state does not agree with the implicit assumptions of the seismic activity in the Oak Ridge area.
17)	Appendix C, Page C-25 & C-26	The extensive discussion about fractures in this section, although useful and fascinating, should be taken within the context that it is dissolution along bedding planes that is more important. Although tributary flow must occur along fractures, convergent regional flow occurs along conduits or macrofissures to discharge locations that maybe springs far downgradient or conduits inadvertently intercepted by wells (probably domestic or industrial) at depth.	This is the premise of the site conceptual flow model. Please also note that bedding planes are considered to be a type of fracture. The sentence "It is possible that flow converges in one or more master fractures, including bedding planes, which discharge to springs outside the EMDF area." has been added to the discussion of flow presented in subsection 3.3.3.2.1, 3rd paragraph. Additional supporting text has been added to Sections 3.2.3, 3.3.1.2, and 3.5.	The explanations given in 3.3.1.3 appear to contradict themselves as far as cavity occurrence in the shaly limestones of EBCV. This demonstrates the point that modeling of ground water in this area is extremely challenging.

18)	Appendix C, Page C-26, Third Paragraph, Last Sentence	"Further, they corroborate the notion that the most conductive zone is near the water table." The nature of flow in carbonates and probably in fractured rocks like shales associated with carbonates is one of vertical tiers of conduits that initially form deep below the water table. Tiers are formed during initial development of a setting/aquifer (Worthington, 1991). There is evidence that there is continuous discharge via conduits from settings/aquifers through many millions of years (Worthington, 2004) despite base level lowering. Lower tiers discharge base flow where higher tiers discharge near the water table. Geologically recent changes to the landscape would not affect flow in deeper tiers, when sea level was 130 m lower than at present during the last glacial maximum this further deepened flow systems.	It is a misconception to view the ground water flow system on the flank of Pine Ridge in terms of a classical karst. A review of available borehole data suggests that few if any conduits are to be found in Conasauga Group units, except for the Maynardville Limestone, where they are relatively abundant. Tiers, in the classical karst sense, are unlikely to form in the shaley rocks under the EMDF site, although there is evidence that there may be a deeper tier in the Maynardville Limestone. Worthington (1991) notes that even in classical karst terrains, many cave/conduit systems do not have tiers. Where tiers exist, they develop in response to decreases in water table elevation as a result of lowered base level or uplift. It is unlikely that Pleistocene glacial sea level change greatly affected areas as far inland as eastern Tennessee. See added text in Sections 3.3.1.3, 3.3.3, and 3.3.3.2.1.	The comment does not refer to "karst". The lack of deep monitoring does not allow for the conclusion that ground water flow in this area is shallow and discharges to surface water. In contrast, there are numerous wells in the region that produce high flows at depth.

19)	Appendix C, Section 3.3, Page C-27, Second Paragraph	**"Groundwater"** The quote and reference that follows summarizes the use of the term aquitard in Oak Ridge. "Contaminant migration through aquitards is often erroneously believed to depend only on bulk hydraulic properties of aquitards, without regard to preferential flowpaths in the aquitard or different contaminant types. Actual rates of contaminant transport through aquitards can be very different from those based on estimates of bulk flow rates. Using a two-dimensional, discrete-fracture model, Harrison, Sudicky, and Cherry (1992) showed even though the volumetric flow rates (i.e., Darcy flux) from an aquitard to an aquifer can be very low, contaminant transport through aquitards may be relatively rapid because of fractures, even very small fractures, if they fully penetrate the aquitard. Basic hydrogeologic techniques designed for aquifers, such as pumping and slug tests, commonly need modification to be appropriate for assessment of low permeability geologic media (Novakowski and Bickerton 1997, Shapiro and Greene 1995, van der Kamp 2001)."	No change has been made to the text of Section 3.3. Aquitard is a comparative term used primarily to convey a difference in relative permeability, and by extension, transmissivity and yield, between two or more hydrologic units. It does not, and is not intended to, indicate that groundwater does not occur in rock units identified as aquitards, nor does it indicate that these units will not also transmit contaminants. In the Oak Ridge Reservation, aquifers are those high-flow units, such as the Maynardville Limestone and Copper Ridge Dolomite, and aquitard refers to those units that are less productive, like the Nolichucky Shale. The USGS defines an aquitard as "A saturated, but poorly permeable, geologic unit that impedes ground-water movement and does not yield water freely to wells, but which may transmit appreciable water to and from adjacent aquifers and, where sufficiently thick, may constitute an important groundwater storage unit. Aquitards are characterized by values of leakage that may range from relatively low to relatively high. Areally extensive aquitards of relatively low leakage may function regionally as confining units within aquifer systems." (USGS Water Supply Paper 2025).	Recent papers on units referred to as aquitards show them not to be related to lithology but rather to changes in vertical hydraulic conductivity. Harrison, Sudicky, and Cherry (1992) The response to comments further demonstrates that the term aquitard has numerous interpretations that can lead to confusion therefore, use of this term is very misleading and should be discontinued.

		There are also other recent references that show it is not appropriate to describe settings as aquitards simply based upon lithology, where rather than lithological changes, what is observed are sharp changes in hydraulic head profiles in boreholes, not related to lithological changes in stratigraphy (Meyer at al, 2010, 2012). The use of the term aquitard for lithologies in Oak Ridge should be abandoned, they are shelf sequences and in variably contain both shale and carbonate, by their nature, shales in such sequences are also most commonly discontinuous laterally. In one case an Oak Ridge aquitard has a significant spring that discharges from it, in another an Oak Ridge aquitard is, in an adjacent state a karst preserve, and overall, many domestic wells produce from what are allegedly the aquitards. Use of this term is very misleading and should be discontinued.	The term aquitard does not refer to lithology, but to aquifer properties, particularly the inability to transmit water at high rates. In East TN, poorly transmissive water bearing units are typically shales, clayey limestones, silts, and tightly cemented sandstones and are therefore correlated to lithology. The reviewer is correct that the rock units under Bear Creek Valley were deposited on continental shelf environments and that individual layers can be discontinuous or exhibit lithologic and facies changes across an area. However, such discontinuities are not significant at the at the scale of the EBCV. The Warsaw and Ft. Payne Limestones of south-central Kentucky (Mammoth Cave area) provide an example of a similar lithologic assemblage that produces water at low volumes and does not contain highly evolved conduit systems (Brown, 1966). **No revision has been made.**	Recent papers on units referred to as aquitards show them not to be related to lithology but rather to changes in vertical hydraulic conductivity. Harrison, Sudicky, and Cherry (1992) It is obvious that the term aquitard is being used to describe less pure carbonates or shaly limestones on the ORR. The response to comments further demonstrates that the term aquitard has numerous interpretations that can lead to confusion therefore, use of this term is very misleading and should be discontinued.
20)	Appendix C, Section 3.3.1, Page C-27	**"Aquifer Characteristics"** The use of the term cavities implies that these features are closed. This is theoretically almost impossible to conceive of unless within the framework of the initial deposition of the sediments. Cavities as they are often referred to are simply fragments of sinuous conduits that are intersected by borings. It is known in carbonates in many locations that most of the flux (> 99%, for Oak Ridge; Davies, 2008,) is in conduits with most of the storage in the rock matrix. 94% flux is in conduits regardless of the age of the carbonate rock or the location.	A cavity is a void in the rock, and there is no genetic implication as to its size, shape, or connectivity with other openings. The word cavity is a good general term for use on borehole logs because of the very small area accessed by the boring. It must be recognized that, while the Maryville and Rutledge formations are nominally limestones, in the vicinity of the proposed EMDF these units are dominated by shales and siltstones that are far less susceptible to dissolution than are more purely calcium carbonate limestones. As a result, conduits are unlikely to carry as great a proportion of the ground water flux as purer limestones. Evidence for the lack of strongly developed conduit flow is found in the lack of karst landforms. Revisions have been made to first and second paragraphs of Section 3.3.1.3.	This response underestimates the significance of ground water flux in anything other than pure limestone.

21)	Appendix C, Section 3.3.1.2, Page C-29	**"Fractures"** "Further, they found that fracture aperture is more important than fracture spacing, and that fractures will dominate flow if apertures approach 1 cm or if gradient is very low so that no preferred pathway develops." It should be noted that low gradients also can indicate that a preferred pathway has developed.	Comment accepted and text in Section 3.3.1.2 has been revised.	No further comment
22)	Appendix C, Section 3.3.2, Page C-30	**"Hydraulic Conductivity and Results of Tracer Tests"** "Tracer tests offer one means of direct groundwater flow rate measurement, although they require either a large number of sampling points, or knowledge of or good predictions of flow patterns." Actually the way tracing is done using injected tracers, is that a hydrogeological conceptual model of flow is made and then tested by using injected tracers.	Agreed. It is anticipated that tracer tests will be conducted as part of the site characterization effort to test the conceptual model. No revision required.	Agree, if actual tracer tests are conducted.
23)	Appendix C, Page C-32, Last Paragraph	It has been established that in all measured carbonate aquifers in geological old or relatively young rocks, > 94% of the discharge is in conduits, with only a small fraction in the fractures and an insignificant amount in the rock matrix (Davies, 2008; Worthington et al, 2000a, 2000b). This paragraph sets the case for an equivalent porous medium or a continuum approach. However, in the second to last sentence, beginning "Worthington, (2003, p. 30)......" reference is made to using MODFLOW to simulate flow in carbonates. This is not the complete discussion from the reference, and is misleading. The complete discussion in (Worthington, 1999, incorrectly cited as 2003) does not endorse using MODFLOW as is implied.	This statement may be true of more or less pure carbonate limestones, but is not applicable to shaley limestones and shales such as those occurring on the flank of Pine Ridge. Please see White and White (2001)[1] who note that extensive conduit/cave systems form mainly in relatively pure limestones, while shaley limestones tend to act as aquicludes. Changes have been made in Sections 3.3.1.3 and 3.3.2.1 to clarify this relationship. A review of available well data suggests that conduits are rare or non-existent in the stratigraphic units underlying the proposed EMDF site (see App. C, Sect. 3.3.1.3. The correct reference is Worthington, S.R.H., 2003[2]. Worthington notes that three approaches are commonly used to model flow in fractured aquifers, and while he does not make a value judgment, he does favor a more complex, more representative approach that uses multiple inputs. However, there are, in this case, insufficient data available to employ the method Worthington suggests.	The original reference is Worthington 1999 page 30. If insufficient data is available to employ the method established by Worthington (1999), then proper data needs to be collected, or an alternative model needs to be utilized to simulate ground water flow.

24)	Appendix C, Page C-34, Table C-9	Evans, et al. 1996 applied a particle tracking model and inverse modeling to get an anisotropic ratio of 10:1 for BCV.	The 10:1 ratio was in fact used in the model presented in Appendix F. This reference has been added to Table C-9. Note that one of the authors of this article actually performed the modeling discussed in Appendix F. Text was also added to Section 3.3.2.1, paragraph 5 to further discuss anisotropy.	No further comment
25)	Appendix C, Section 3.3.2.2, Page C-35	**"Results of Tracer Tests"** "Tracer tests are commonly used in fractured and karstic aquifers because they are strongly anisotropic and flow paths are difficult to determine." Since > 94% of the discharge/flow is in conduits and conduits are known to connect sinking streams and springs, with lengths sometimes of several tens of kilometers, one would know the possible extent of the flow path if the spring was the base flow spring.	No revision is required. Please see answer to Specific Comment 24 above. The aquifer at the proposed EMDF site is primarily fractured, not karstic, and conduits are unlikely to be present under the site.	Conduits could be upwards of a few millimeters in hydraulic radius, these cannot be eliminated as pathways. There are springs at these locations that are being fed by conduits.
26)	Appendix C, Page C-36	"Both of these types of behavior indicate a high degree of longitudinal dispersion, which is typical of systems in which matrix diffusion is dominant." The reasons for a high value for longitudinal dispersivity in contaminant or tracer transport is also hydraulic complexity and the nature of the release of the substance.	Agreed. One purpose of the test was to determine if gas tracers would be effective in hydraulically complex fractured rock, i.e., the matrix. Text in paragraph 6 of Appendix C Section 3.3.2.2 has been slightly revised.	Investigations in other settings suggest a minimal role for the matrix with regards to ground water velocities in conduits are with hydraulic radii upwards of a few millimeters.

[1] White, W.B. and White, E.L., 2001. "Conduit fragmentation, cave patterns, and the localization of karst ground water basin: the Appalachians as a test case", Theoretical and Applied Karstology, vol. 13-14, pp. 9-24.
[2] Worthington, S.R.H., 2003[2]. "A comprehensive strategy for understanding flow in carbonate aquifers", in Palmer, A.N., Palmer, M.V., and Sasowsky, I.D. (eds.), Karst Modeling: Special Publication 5. Charles Town, WV: The Karst Waters Institute, pp. 30-37

No.	Reference	Comment	Response Approach/Comment	Approve/Rebuttal
		"Matrix diffusion retarded tracer movement by uptake in small blind fractures and pores, and maintained high tracer concentrations by diffusing back into the flowing groundwater in fractures over time." Velocities in conduits are known to be rapid (geometric mean = 0.022 m/s, n = 3,077) and therefore mostly turbulent (Worthington et al, 2000a, 2000b). How would matrix diffusion work if flow is turbulent?	This questions presupposes the existence of highly evolved and integrated conduit systems under the proposed EMDF footprint; there is little evidence of such conduit systems in Conasauga units outside of the Maynardville Limestone. The conceptual model for the rock units underlying the EMDF area is that groundwater flows in highly and complexly fractured rock, not conduits, and hence, matrix diffusion is not only possible, but likely.	The anisotropy value determined in the Bear Creek Valley system's tracer tests assumes that there is more flow along strike (see comment #24) which assumes no integrated conduit system. Complex hydraulic interaction in fissures can cause high longitudinal dispersion values and is more likely than matrix diffusion. With velocities higher than 0.001 m/s in fissures with hydraulic radii greater than a few mm (Quinlan et al, 1997), turbulent flow is likely and matrix diffusion less likely.
		"It is not the arrival time, but the peak concentration, that is of interest, since this represents the greatest risk." The determination of an accurate peak concentration is dependent upon sampling frequency to avoid aliasing. Most current sampling done under State, Federal, or any other protocols do not sample often enough, so the values obtained are the minimum that could be passing a monitoring point. If the monitoring location is a well there could be other complications to interpreting the results.	The quoted statement refers to modeling results, not actual sampling. However, the point is taken, and will be considered in designing the site characterization study.	The peak concentration can only be modeled or sampled at the Nyquist rate.
27)	Appendix C, Page C-37	The discussion of the storm-flow zone in the second paragraph implies that this is how recharge works in karst terrane in any climate or landscape. The reference used is for **"semi-arid karst shrublands...."** which would not be automatically appropriate for a temperate region like Oak Ridge. There are data from the ORR that refute the general thesis of the storm flow zone that must be cited.	That is not the intended implication; it is rather that storm flow occurs in many environments. Storm-flow is well documented for steep forested slopes in humid climates, and has been documented in many other areas as well. The author of Appendix C is not aware of data that refute the storm-flow thesis for the Oak Ridge Reservation. The text of the 2[nd] paragraph of Appendix C Section 3.3.3.1.1 has been slightly revised.	See following references: Luxmoore, R.J., and Huff, D.D., 1989 Chapter 5: Water (in) Johnson, D.W., Van Hook, R.I., and Ragan, A.L., (eds) Analysis of Biogeochemical Cycling Processess in Walker Branch Watershed, Springer-Verlag New York, p 164 – 195. Clapp, R.B., 1988 Water Balance Modeling (in) Huff, D., Environmental Sciences Division Groundwater Program Office Report of Fiscal Years 1995-1997, Environmental Sciences Division Publication No. 4751, ORNL/GWPO, p. 13-14.

28)	Appendix C, Page C-38, Figure C-13	**"Conceptual Model of Groundwater Zones in BCV"** This figure lists water flux in the storm flow and vadose zone as 90%, estimates of storm flow were obtained from very steeply sloping sites. It is extremely unlikely that 90% of water flux is retained in storm flow or vadose on the moderately sloping portions of the ORR.	Much of the site is steep, and the moderately sloped areas also appear to be unaffected by overland flow. Surface flow occurs rapidly in response to heavy or prolonged precipitation in zero and first order basins. The clayey soils beneath the root zone are of too low permeability to absorb more than a small fraction of storm precipitation. Water balance calculations indicate that most precipitation is lost to stream flow and evapotranspiration. The portion that rapidly enters streams must be due to shallow transport. No revisions have been made.	Soil, root zones, residuum or saprolite contain macropores which can transmit recharge rapidly downwards but are of limited volumetric capacity which when exceeded results in surface flow.
		Further this figure shows what is referred to as an aquiclude at >500 ft. BGS. Based on the definition of the aquiclude on page C-43. Contaminants are reported from these depths on the ORR (OREIS). Domestic wells emplaced within the Conasauga Group Formations offsite in the area offsite of Melton Valley were reported to be completed at depths that would be within the "aquiclude". The presence of contaminants and the use of this interval for domestic water production suggest that the term aquiclude is inappropriate.	Solomon, et al. (1992) note that the saline aquiclude in Melton Valley began with brackish water at about 120 m (~395 ft) and became saline below 180 m (~590 ft). In Bear Creek Valley, brackish water is encountered at about 150 m to 300 m (492 ft – 985 ft) range, but saline water was not encountered. This indicates that the aquiclude is deeper in Bear Creek Valley than in Melton Valley. Note that brackish and saline water is not potable.	It is problematic to assume saline waters are immobile, migration of brines formed the deep flow system deep in the Knox aquifer. Drilling in the valley and ridge encounters both saline and fresh waters at great depths.
29)	Appendix C, Section 3.3.3.2.2 Pages C-42 & C-43	**"Intermediate and Deep Aquifer Zones"** This discussion and table C-10 suggests that elevated pH in the deeper briny groundwaters of Oak Ridge are normal. Most deep wells (not affected by contamination) encountering brines in the Valley and Ridge are somewhat acidic not caustic as presented in ESD publication 2863. Elevated pH is unlikely to be a normal condition of groundwater beneath the ORR.	Schreiber (1995)[3] reported that only two of 55 samples of formation waters from 3 shallow wells in the Nolichucky Shale of East Bear Creek Valley exhibited a pH of < 6.0 S.U.; the remaining 53 ranged from a low of 7.8 S.U. to 8.3 S.U. Similarly, Drier, et al. reported a pH range of 7.0 to 9.6 for samples from multiple depths in 3 deep wells in the Conasauga Group near the S-3 Ponds.	Information in this response is from the ORR. It can be assumed that these waters are contaminated and would therefore have a higher pH. This does not address the original comment.

30)	Appendix C, Section 3.3.4, Page C-44	**"Groundwater Contaminants"** According to the Final Report End Use Working Group 1998, chemicals of concern at the integrator plane are uranium, nitrate, boron and fluoride. Nitrate and gross alpha in groundwater exceed legal requirements. Boron and fluoride are not included.	Site Specific Advisory Board Recommendations are advisory, not requirements. Boron and fluoride limits are not remedial action objectives or primary contaminants as identified in the ROD, and are therefore not monitored at the Integration Point (Bear Creek kilometer 9.2). For comparison only, the Safe Drinking Water Act maximum contaminant limit (MCL) for fluoride in drinking water is 4.0 mg/L; the Bear Creek Valley Remedial Investigation reported that fluoride did not exceed 2.0 mg/L in either NT-1 or at the BCK 12.71 sampling point. There is no MCL for boron.	No further comment
31)	Appendix C, Section 3.4.2.4, Page C-50	**"Tributary Contaminants"** "Water in NT-3 currently meets ambient water quality criteria (AWQC)." Is the referred AWQC, ambient water quality criteria, the State of Tennessee General Water Quality Criteria, listed within the TDEC Water Pollution Control document, General Water Quality Criteria, chapter 1200-04-03?	This does refer to the TDEC ambient water quality criteria. However, the statement was in error. The NT-3 monitoring station had one exceedance for a PCB in 2011. Annualized uranium flux continues to exceed the NT-3 goal of 4.3 kg/yr. The second paragraph of Section 3.4.2.4 has been revised accordingly.	No further comment
32)	Appendix C, Section 3.6.2, page C-56	**"Aquatic Resources"** There is considerably more information relating to species in Bear Creek than is presented for NT-2 and NT-3. The ORNL Biological Monitoring and Abatement Program collect annual samples of macroinvertebrates in NT-3; why is this information not presented?	Text in Appendix C, Section 3.6.2, Aquatic Resources has been substantially revised to include biologic monitoring data and interpretations from recent DOE and TDEC reports. A new Section 3.6.3 has been added to discuss recent conditions on NT-3. Additionally, minor updates were made in Sections 3.3.4 Groundwater Contaminants, 3.4.2.4, Tributary Contaminants, and 3.4.3.4, Bear Creek Contaminants to reflect the 2012 Remediation Effectiveness Report that available after the D1 RI/FS was issued.	No further comment

33)	Appendix F, Section 4.1.1, Page F-16	**"Conceptual Design of Disposal Facility"** "The waste layer is assumed to consist of contaminated soil, cement stabilized soil-like materials, cement-solidified waste, and debris (rubble)." Cement rubble and related material has the potential to induce a hyper-alkaline plume in groundwater (See http://www.grimsel.com/gts-phase-v/hpf/hpf-introduction). Hyper-alkaline conditions in and of themselves may pose a risk to end receptors, hyper-alkaline conditions may mobilize inorganics within wastes and country rock so as to cause groundwater to exceed drinking water limits. Hyper- alkaline conditions may alter the absorptive capacity of matrix materials so as to enhance contaminant transport. This model does not seem to address the potential for cement waste material emplaced in the waste cell to alter pH of liquids leaching through the waste cell and to alter basic groundwater geochemistry.	We agree that geochemical conditions within the cell and along the flow/transport pathway have various impacts on leaching rates and migration of contaminants. However, the impacts are contaminant- specific and geochemical conditions within the waste may either reduce or enhance contaminant mobility. Numerous studies have been conducted to derive the relationship of Kd to geochemical conditions (EPA, 1999a, 1999b). Data from EMWMF leachate indicate that its pH is near neutral, at about 7.3 S.U. The waste release model used to support WAC development is based on a partition (Kd) mass release model and an assumed uniform waste source. Wastes consist of contaminated soil, cement stabilized soil-like materials, cement-solidified waste, and concrete and other debris (rubble). Void spaces are typically filled with soils, and the waste mass itself is encased in soils compacted to the required density. Thus, even though the leachate solution from the concrete debris may be alkaline, it will be buffered by the pH of surrounding soil before it starts its migration to the undisturbed vadose zone. It is also expected that the waste zone will not be fully saturated after final cover is placed. Since the waste zone is assumed to be a constant leaching source with fixed leaching characteristics for each contaminant through the duration of the model (>100,000 yr), using a Kd for a neutral pH condition is the most representative approach. Experience with EMWMF operational leachate indicates a consistently near-neutral pH, which supports the approach used in the model. **See changes to text on pp. F-11, F-16, and F-48.**	No further comment

[3] Schreiber, M. E., 1995. Spatial Variation in Groundwater Chemistry in Fractured Rock: Nolichucky Shale, Oak Ridge, TN. Master's Thesis: University. of Wisconsin-Madison.

No.	Reference	Comment	Response Approach/Comment	Approve/Rebuttal
		The modeling assumptions are not explicitly spelled out, explain what they are.	The model suites used in pWAC development are discussed in Section 3 of Appendix F and a visualization of their interrelationship is presented in Figure F-4. As discussed in the appendix, the HELP model provides water mass input into the waste and out of the cell liner. **No revisions have been made.**	Disagree. All assumptions and limitations for the referenced models should be listed and discussed.
		What assumptions from the various model types overlap and have compound effects?	MODFLOW/MODPATH models predict the groundwater flow field, direction, and velocity. The MT3D model, even though it is a complete fate-transport model, is only used to derive the dilution factor between the well water and leachate into the water table directly beneath the cell caused by advection process (water mixing only in the flow field and applied to all contaminants). All of the other fate-transport processes, such as contaminant specific dispersion, retardation due to absorption, and degradation (radioactive decay), are considered during PATHRAE model application. Therefore, there are no overlap or compound effects from any of the fate-transport processes. As discussed in EMWMF WAC development (Page E-52 of DOE, 1998) and confirmed by this analysis, majority of the water travel time occurs in the vadose zone, and the travel time to surface water through bedrock pathways is very fast. Thus the disposal design cell design is the primary element in attaining long-term environmental isolation of the waste. The natural geochemical properties of the site aquifer play a relatively minor role in reducing potential impacts from contaminant release. **No revisions have been made.**	Disagree. All assumptions and limitations for the referenced models should be listed and discussed.

		What are the assumptions about the waste cell with regards to rapid groundwater flow and transport that should be expected for the terrane beneath the site?	All the fate-transport processes downgradient from the cells in the groundwater zone, such as advection, contaminant specific dispersion, retardation due to absorption, and degradation (radioactive decay), are considered either in the MT3D model or PATHRAE model. As stated in the appendix, different parameters are used as these of vadose zone that leachate properties are used. **No revisions have been made.**	Disagree. All assumptions and limitations for the referenced models should be listed and discussed.
		What is the assumption for leachate far down gradient of the cell?	A steady state flow condition in a constant physiochemical system is assumed for the duration of the modeling period. Geochemical reaction and transport parameters remain constant. This is a generally accepted approach because of the many uncertainties associated with these processes. In this particular application for the EMDF, the impact will be likely minimal as the WAC was developed using the assumption that the worst case leaching scenario started as soon as disposal cell closed. In reality, it will take up to thousands of years before the worst case developed after the cell closure with system function of the cell design.	Disagree. Worst case scenario would occur while the cell is still active and receiving inputs from the environment.

34)	Appendix F, Section 2.1, Page F-3, Fourth Paragraph	*"Small-scale geologic features, such as fractures and solution features are a major factor in groundwater movement through the formations underlying the BCV."* These features rarely have a major role in groundwater movement because they will only be tributary pathways to major large-scale features. Unfortunately these maybe be missed by drilling, even though the small-scale features may be encountered by drilling.	Studies conducted on Oak Ridge Reservation weathered bedrock zones suggest that small-scale geologic features, such as fractures, joints, bedding planes, and solution features, are in the primary pathways for groundwater movement through the in the weathered and competent bedrock. These features are the only void spaces available that are widely distributed, sufficiently open, and interconnected to accommodate ground water flow. A sentence has been added to Section 2.1, paragraph 4, to make this distinction more clearly. We do agree that large scale features, such as a major fracture, karst zone, or a fault zone, will impact or control groundwater flow if they are present in the area. Karst-like conditions, while not present under the proposed EMDF site, do exist in the Maynardville Limestone on the floor of Bear Creek Valley and together with Bear Creek, provide the exit path for waters in the basin. However fractures, bedding planes, and to a lesser extent, conduits carry the majority of ground water flow in and near the proposed EMDF footprint. **No revisions have been made.**	Disagree. Fissures with hydraulic radii of a few mm can sustain turbulent flow and rapid velocities (0.001 m/s) (Quinlan et al, 1997). This suggests that small-scale features could be as influential as large-scale features.

35)	Appendix F, Page F-5, First Paragraph	The majority of flow in only the upper 100 ft of bedrock is not supported by data. The problem is that if enough deeper wells were not drilled then it is flawed logic that leads to this conclusion, especially when conduits are difficult to intercept when drilling. For example, there are many deep wells in every valley on the ORR that exhibit meteoric water signatures and often contaminants. Would this not be evidence that probably a considerable amount of groundwater circulates much deeper than 100 ft below the land surface? The true nature of groundwater circulation at depth should be revisited, because it has been inadequately addressed in this document and others. The potential depth of circulation in the carbonates could well in excess of 400m or even deeper (Brahana and Bradley, 1985). For a basin length of 12 kilometers, (approximately from S3 ponds to the Clinch River) the calculated depth of circulation is 170 m below the present water table, circulation along the whole length of the projected basin (~80 km). This is far deeper than the river, which has been claimed to be a barrier to groundwater flow. The 170 m depth is not extreme, in fact, it was predicted in early and recent models constructed in Bear Creek Valley and such a circulation depth has been openly discussed in other documents. The fact that deep circulation has been predicted and documented on the ORR (Nativ et al., 1997) should mean that caution should be exercised when dealing with eventualities involving accidental waste releases. This would be of particular concern in Bear Creek Valley because it is known that there are sections of Bear Creek that sink into the ground downstream and down gradient of the proposed new waste cell. As of yet there has not been a quantitative assessment made of how much groundwater, tracers, or contaminants flow in shallow, intermediate or deep groundwater zones (deeper than 120 m, 400 ft) as determined by Bailey and Lee (1991) from both potentiometric and geochemical data. It should be noted that the hydraulic conductivity value used in the digital model constructed by Bailey and Lee (1991) of 3E-10 m/s is extremely low when it is known that contamination and evidence of meteoric water circulation is documented at greater depths (Nativ et al., 1997). Evidence of deep flow in the Cambrian and Ordovician carbonates, that extend across the mid-continent and that underlie the ORR is well known and well documented (Graven et al., 1993; Brahana and Bradley, 1985; Brahana et al., 1986). In several locations near the proposed site there are losing reaches of Bear Creek. Most models constructed in the past for Bear Creek Valley assumed that groundwater could circulate at various depths below the current water table. These depths were assumed from early investigations. This is a reasonable assumption and follows the documented nature of flow in carbonates worldwide (Worthington, 1991; 2004). The losing reaches of Bear Creek recharge groundwater and thus recharge regional flow paths. Davies et al. (2012) show that regional groundwater flow in the Valley and Ridge province is related to brine migration and Mississippi Valley type ore emplacement between 380 and 100 Ma, across the US Midcontinent as originally conceived and measured by Graven et al., (1993) and Leech at al., (2001). The issue of regional migration of groundwater and contaminants from the ORR along regional pathways has not been addressed.	Numerous studies conducted on the ORR have indicated that the majority of groundwater flow occurs in relatively shallow saturated zone of bedrock. These studies have included water balance analysis, aquifer tests, core-hole geophysical observations, core description of fracture and porosity distribution with depth, ground water geochemistry, and observed behavior of contaminant plumes. Some of these conclusions are summarized below: As Brahana and Bradley (1985, p. 2) point out, "The Knox Group in the Valley and Ridge of East Tennessee is . . . complexly folded and faulted and hydrologically distinct from the Knox in the remainder of the State." The structure of the valley and Ridge thus limits development of a regional aquifer with regional flow. Regional flow that resulted in MVT-type ore deposits Evidence that the majority of ground water flow occurs in the shallow zone is discussed in Appendix C and summarized below: • Surface water budget analysis included the USGS study for the Bear Creek Valley (Robinson, J.A. and Johnson, G.C. 1995) and site specific studies (DOE, 1997; Shevenell, 1994; Dreier, et al. 1993; Solomon, 1992; Moore and Toran, 1992; Bailey and Lee, 1991; Haase, 1991; Haase, et al., 1987) that concluded that most of the surface water and ground water interactions occur within the shallow intervals. Appendix C discusses this in greater detail. • Bear Creek is a shallow stream exhibiting seasonally variable flow, reflecting the interaction between surface water and ground water flow. The existence of short gaining and losing segments suggests active interaction between surface water and shallow groundwater. Shevenell, 1994 showed that the Maynardville Limestone underlying Bear Creek responds rapidly to precipitation events. This is further discussed in Appendix C. • The majority of the contaminant plumes in east Bear Creek Valley are within relatively shallow (<500 ft) intervals (S3 and BG/BY plumes) and have migrated in ground water a relatively short distance from the sources. SAIC (1997) identified nitrate contaminants from the S-3 Ponds to depths of approximately 500 ft below grade in EBCV. The S-3 plume surfaces to the lower reaches of NT-3 and Bear Creek, and does not appear to extend the length of Bear Creek Valley. • Several studies conducted on the ORR found that fracture density, aperture, and porosity decrease with depth, with concomitant reductions in bulk permeability and flow. (Solomon, et al., 1992; Moore and Young, 1992). Numerous aquifer tests demonstrate that hydraulic conductivity is highest in the shallow zone and decreases with depth (Moore and Young, 1992); see Appendix C. Any number of studies from many different aquifers and petroleum reservoirs lend support to these conclusions. • The shallow zone (<100 ft. below the water table) is characterized by Ca, Mg-HCO3 geochemistry, indicating strong meteoritic influence. Water chemistry data from the deeper zone (~800 ft) is dominantly saline (NaCl), an indication of long residence time, A poorly defined zone of NaCl – $NaHCO_3$ ground water has been documented in EBCV (Bailey and Lee, 1991; Haase, 1991); this may be the result of diffusive mixing. Please see Appendix C for further discussion. The shallow ground water flow regime within the east Bear Creek watershed is confined by the surrounding ridges, and is not apparently part of a reservation-wide regional flow system. A potential contaminant plume exiting the EMDF is not expected to extend any great distance before it discharges into Maynardville Limestone conduits and Bear Creek. The conclusion is supported by the geometries of contaminant plumes from those from Bear Creek Burial Grounds, the S3 Ponds, and the BY/BG. Further, the Bear Creek passes through a water gap in Pine Ridge, separating the lower basin from the upper basin. The basin length in the upper Bear Creek catchment is about 8.3 km, and based on Worthington (1991), the maximum flow depth would be estimated at about 150 m, which is consonant with the depth of contamination in the S-3 nitrate plume in the Maynardville limestone. However, using Worthington's (1991, Eq. 7.4) approach to calculating mean flow depth, $D_m = 0.061(L_x \sin\Theta + 0.034L_x \sin\Phi)^{0.87}$, where $\Theta = 45°$ (dip), $\Phi = 60°$ (angle of flow vector parallel to NT-3 relative to strike), and Lx = 0.91 km (flow length from top of Pine Ridge to confluence of NT-3 and Bear Creek), the mean flow depth is about 43 m (~140 ft) for the EMDF area. Regarding MVT ores, please see the response to Comment 41B, below.	The data on deep flow on the reservation is limited and quantitative hydrogeology has not been done to an extent that supports this response.

36)	Appendix F, Page F-48, Table F-5	The table contains values that require some discussion.	See responses below.	See below.
		Groundwater zone: horizontal velocity, the value of 14 ft/ y (0.012 m/y) is far too slow for the terrane underlying the proposed facility. The geometric mean groundwater velocity in conduits in carbonates is 1,700 m/day (Worthington et al., 2000a; 2000b). In general between wells, most of which do not often intersect conduits traced velocities are in the range of 100 - 500 m/day. The reviewer understands the modeling limitations with regards to MODFLOW not being compatible with settings with high velocities and aspects of turbulent flow that should be expected even in small-sized openings. Knowledge of the limits of such models should eliminate their choice early on in the design process.	Reasoning from the general to the specific does not provide accuracy; at the EMDF site, the carbonates are shaley and do not contain extensive conduit systems. . The values provided in the table are the average flow velocity for an assumed aquifer system in which all connected void spaces, including matrix pores, fractures, and conduits, contribute to steady-state flow. It does not represent fracture flow only, where high ground water velocities may exist during a storm event but which contributes a relatively small amount of contaminant mass movement on an annual basis. High velocity flow during storm event is generally short in duration and extremely diluted in terms of contaminant concentration. To calculate a risk, all pathways and the total available contaminant mass have to be considered. The final footprint of a contaminant plume is determined by groundwater interacting with all aquifer rocks and conditions that host ground water storage and flow. Use of an average flow velocity for the whole aquifer matrix in the model actually provides the most conservative risk estimation in term of peak contaminant concentrations. The travel time within the aquifer zone is much shorter than the travel time in the unsaturated zone from the bottom of the waste to the water table. Also, since the risk is based on peak concentrations, rather than travel time within the ground water zone, small changes in travel time will have minimal impact on overall risk.	A more in-depth discussion for the assumptions needs to be included in the text. Based on this explanation, it appears that actual data would have provided a more accurate estimate of average flow velocities.

		Migration of deep brines and groundwater related to the formation of MVT (Mississippi Valley Type) ore deposits in early Paleozoic sediments (mostly carbonates) over great distances across the mid continent is a concept that has been discussed for decades and is well accepted (Graven et al., 1993). Modeling and dating show that the deep flow system was in place before the extensive folding and faulting in the Valley and Ridge province. This would mean that any recharge or water associated with the waste cell that was lost to the ground could enter this regionally large flow system.	MVT ore bodies that formed as the result of large deep regional ground water flows that occurred after the tectonic deformations that formed the Appalachian Mountains. According to Garven (1993), these flow were driven by gravity from distant highlands, such that velocities declined to essentially zero as topographic relief in the source areas was reduced. These flow systems were hypothesized as occurring at depths of several kilometers, well below the aquifers of the ORR. Further, the structural faulting and folding of the Valley and Ridge Province interrupts possible regional flow paths that might once have been present. This migration route is not credible. Further, it is doubtful that sufficient contaminant mass could reach and be transported by any very deep regional aquifer without dilution to undetectable levels. No revisions have been made.	Disagree. The "distant highlands" were among others the Appalachians and folding and faulting, according to Leach et al. (2001), occurred after pathways were developed. Faulting of carbonates against carbonates could cause cross-formational flow. Response on dilution and dispersion is appropriate.
37)	Appendix G, Section 4.1, Page G-8	***"On-Site Disposal Alternative Cost-Estimate Assumptions"*** *"The long-term monitoring and maintenance for the EMDF would continue after closure of the facility. A perpetual care fee of $1M per year for each year of operation of the EMDF would be paid into an escrow account to be used for long-term monitoring and maintenance."* The state has not agreed to the use of a perpetual care fund for long term maintenance post closure of the EMDF.	Consistent with the agreement reached with the State of Tennessee regarding perpetual care and surveillance and maintenance of the EMWMF, DOE anticipates some residual annual costs associated with long-term monitoring and maintenance similar to those agreed upon for EMWMF. A perpetual care fee of $1M per year of operation is accounted for in the EMDF cost estimate to cover the expected costs of long-term monitoring and maintenance. However, no assumptions have been made to address the performer of those actions, since that is beyond the scope of this document.	No further comment