TECHNICAL EVALUATION REPORT
U.S. DEPARTMENT OF ENERGY
REQUESTS TO REVISE LAKEVIEW LONG-TERM
SURVEILLANCE PLAN

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LICENSE:	10 CFR 40.27
FACILITY:	Lakeview, Oregon Disposal Site
PROJECT MANAGER:	Richard Chang
TECHNICAL REVIEWERS:	Doug Mandeville, Ted Johnson

1.0 SUMMARY AND CONCLUSIONS

By letter dated August 23, 2002, the U.S. Department of Energy (DOE) submitted a request to the U.S. Nuclear Regulatory Commission (NRC) staff to modify the Long-Term Surveillance Plan (LTSP) for the Lakeview, Oregon, Disposal Site (Lakeview). Lakeview is an UMTRCA Title I disposal site and has been licensed under the NRC general license (10 CFR 40.27) since 1995. Degradation of the riprap has been observed since completion of the final cover system. As shown on Figure 1, attached, the median riprap diameter (D_{50}) has decreased to approximately 2.4 inches, based on the 2008 measurement of 2.33 inches and the 2009 measurement of 2.47 inches. A riprap size of 2.4 inches is less than the original design D_{50} of 2.7 inches. In the 2002 submittal, DOE requested that the required D_{50} be decreased to 1.8 inches. In addition, by letter dated June 10, 2008, DOE submitted a request to further lower the required riprap size to 1.4 inches.

The observed decrease in D_{50} has raised two issues related to the cover system at Lakeview: (1) determination of the minimum acceptable D_{50} for the riprap to resist design rainfall events; and (2) determination of the rate of degradation and decrease in the D_{50} of the riprap.

To address the first issue, DOE prepared the 2002 revised LTSP identified above. In this submittal, DOE re-evaluated the hydrologic conditions at Lakeview to account for soil infiltration and surface roughness. The analysis was based on information included in the original 1997 design. This re-evaluation indicated that the required D_{50} of the in-place riprap could be lowered to 1.8 inches from the original design D_{50} of 2.7 inches. To evaluate this request, the staff visited the site and observed DOE's annual inspections. During these visits, the staff noted that some changes had occurred to the rock cover and that additional degradation had occurred. Further, staff observed some areas where smaller rock had been segregated into areas where smaller rock was concentrated (streak areas). In addition, during these visits, DOE discussed the rock degradation issue with the staff and solicited NRC staff opinions on whether there might some other ways to justify the adequacy of the existing rock size. The staff informed DOE that a different approach to determining the Probable Maximum Precipitation (PMP) rainfall amounts could possibly be examined, since a new report on the PMP determination for California had recently been developed (U.S. Department of Commerce, 1998). DOE submitted a revised analysis in 2008, indicating that the required D_{50} rock size could be further lowered to 1.4 inches.

To address the second issue of the speed of riprap degradation, DOE has been measuring the median riprap diameter at a number of random locations on the side slope on an annual basis. In 2000, the staff approved DOE's procedure for measuring the rock size. The staff observed the field measurements on several occasions and reached a preliminary conclusion that the procedure would likely produce rock measurements that were generally conservative. It should be emphasized that the NRC staff has accepted the field procedure, because it produces a conservative rock size, although it is not necessarily an accurate procedure. DOE has been following this simplified field procedure since that time. As indicated above, this simplified procedure may not yield an accurate D_{50}, because it is not based on the weight of the riprap. Results available through the 2008-2009 inspections (See Figure 1) indicate that the median riprap diameter is currently approximately 2.4 inches. The field measured D_{50} value in 1997 was 2.88 inches.

Although the measurement procedure may be conservative, NRC staff review of DOE's submittals indicates that the calculation methods and the revised calculations and analyses do not have adequate conservatisms and margins of safety, in light of current conditions at the site and staff evaluation of the new 1998 HMR-58 PMP report.

The rate of riprap degradation may still be an important issue, and the true D_{50} of the in-place riprap has not been measured since the early- to mid-1990's. NRC staff considers that sometime in the near future (during the annual inspections), DOE should collect a series of bulk samples of riprap from various locations on the side slope and perform a laboratory gradation test to determine the true D_{50} of the in-place material. Based on the outcome of this sampling and testing, remedial actions may be required. Examples of additional action could include: (i) more frequent inspection and testing of the in-place riprap; (ii) placement of additional riprap on the side slope of the cover system; (iii) conducting a risk assessment to determine the consequences of a potential release; (iv) re-grading to lower the slope angle; or (v) placement of a riprap apron or additional riprap at locations where the top slope meets the side slope to reduce the potential for flow concentrations.

It should be noted that DOE has implemented a new rock durability characterization procedure that could help determine the cause of rock degradation and estimate future rock degradation for each rock type. Such degradation would further decrease the D_{50} of the existing in-place material. The new procedure was implemented during the July 2009 inspection and included identifying the rock types and their durability classes. Representative samples were also collected for future laboratory durability testing and petrographic analysis. This information should also be important to deciding what remedial actions may be required.

2.0 BACKGROUND

2.1 Site Description and History

The Lakeview disposal site is approximately 7 miles northwest of the town of Lakeview, Oregon. Between 1986 and 1989, approximately 926,000 cubic yards of material were relocated from the former Lakeview mill site to the disposal site. The site covers an area of approximately 39.6 acres on a westward facing hill. The area around the disposal cell is covered with a combination of sagebrush, grass, and bushy plants.

The disposal cell covers an area of 16.05 acres and contains 736,000 dry tons of mill tailings. The cell is roughly rectangular with a north to south dimension of 1,100 feet and an east to west dimension of 800 feet. The top slope of the disposal cell was designed to drain storm water runoff to the west with a grade between 2 and 4 percent. The west sideslope has a grade of 5 horizontal to 1 vertical (5H:1V). The disposal cell was excavated into the side of a hill, so nearly all of the runoff from the disposal cell flows to the west. A drainage channel was constructed around the northern edge of the cell to divert runoff from nearby Augur Hill to Camp Creek on the western side of the site.

Construction of the disposal cell was completed in 1988. Beginning in 1995, degradation of the riprap component of the final cover system was observed. This degradation of the riprap is likely the result of physical and chemical weathering. A reduction in riprap size may result in an inadequate level of erosion protection for the final cover system and ultimately the tailings contained in the disposal cell. Since 1997, DOE has been using a gradation testing procedure to evaluate any changes in the D_{50} of the riprap. This procedure involves measuring the diameter of the in-place riprap at ten randomly selected locations each year during the annual inspection. The measurement locations are not necessarily the same from year to year. Between 1997 and 2009, the D_{50} decreased from 2.88 inches to approximately 2.4 inches. Figure 1 shows the annual D_{50} measurements through 2009 (DOE, 2009). The data shows some variation from year to year, which reflects the random selection of the measurement locations. However, there does appear to be a continual decrease in the D_{50}. This procedure was approved by the staff in 2000 and has been observed during several site visits. The staff continues to conclude that the measurement procedure is acceptable, because it is likely to produce conservative results (even though it may not be extremely accurate).

DOE continues to monitor the D_{50} during the annual inspections and submitted a revised LTSP (2002) and additional requests (2008) to resolve the required minimum D_{50} issue. The 2002 LTSP request and the 2008 request formed the basis for this review.

3.0 SURFACE WATER HYDROLOGY AND EROSION PROTECTION

3.1 Introduction

This section of the Technical Evaluation Report (TER) describes the staff's review of surface water hydrology and erosion protection issues as they relate to the long-term stability of the final cover system at Lakeview. In this section, the staff provides the technical basis for the acceptability of DOE's proposed revisions to the LTSP (DOE, 2002, 2008). The revised calculations were compared to the design procedures of erosion protection for long-term stabilization outlined in NUREG-1623 (NRC, 2002).

3.2 Existing Erosion Protection

The cover system over the side slopes at the site consists of the following components from top to bottom:

- a 1.0 ft thick layer of riprap,
- a 0.5 ft thick layer of sand, and
- a 1.5 ft thick layer of clay with a hydraulic conductivity of less than 1 x 10^{-7} cm/sec.

The cover system over the top slope at the site consists of the following components from top to bottom:

- a 4 to 6 in thick layer of soil,
- a 1.0 ft thick layer of riprap,
- a 0.5 ft thick layer of sand, and
- a 1.5 ft thick layer of clay with a hydraulic conductivity of less than 1 x 10^{-7} cm/sec.

As indicated above, the cover system on the side and top slopes is nearly identical. The minor difference is the 4 to 6 inch layer of topsoil placed on the top slopes in an effort to aid in the erosion resistance performance and to promote vegetation growth on the top slope (DOE, 2002). The presence of the topsoil layer, combined with the underlying riprap and shallow 2 to 4 percent slope, provides the required level of erosion protection for the top slope of the disposal cell.

As previously discussed, the issue of riprap degradation has been observed and documented in the erosion protection layer of the side slope cover system. The side slope of the disposal cell has a slope of 5H:1V (20 percent) and generally drains to the west (a small portion drains to the north). In the original design (MK-ES, 1986), the riprap layer was designed to prevent erosion from a PMP event using the Rational Method to estimate runoff and the Stephenson method to calculate the required D_{50}. The appropriate design D_{50} was determined to be 2.7 inches. During the 2009 annual inspection, the D_{50} of the riprap had decreased to approximately 2.47 inches. As indicated by the data in Figure 1, the rate of degradation does not appear to be decreasing.

3.3 Design of Erosion Protection

3.3.1 Original Design Calculations

The required size of the riprap serving as erosion protection is based primarily on the amount of storm water runoff at a particular site. The amount of storm water runoff at a particular site is a function of the drainage area size, the characteristics of the drainage area (slope angle and length), and the magnitude of the rainfall event. The following parameters were used in the original design calculation:

Description	Top Slope Value	Side Slope Value
Drainage Area (ac)	6.67	6.20
Slope length (ft)	500	270
Slope grade (percent)	3	20
PMP (in/hr)	8.5	

The amount of runoff was calculated using the Rational Method. The Rational Method generally overestimates the amount of runoff as it is based on several conservative assumptions related to the return period of the rain event and the consistency of the runoff coefficient over the duration of a storm (Veissman and Lewis, 1996). Despite these assumptions, the Rational Method is an accepted analysis tool for estimating surface runoff. Once the amount of runoff was calculated, the required D_{50} for the riprap was calculated using the Stephenson method.

3.3.2 Revised Design Calculations

In the revised 2002 analysis, DOE used the HEC-HMS program (U.S. Army Corps of Engineers, version 2.01) to calculate surface runoff. While the Rational Method is the simplest way to calculate surface runoff, HEC-HMS is an acceptable method. To maintain consistency with the original design, DOE developed a "calibrated PMP." The calibrated PMP represents the rainfall amount that when used in the HEC-HMS program results in the same surface runoff as the PMP generated using the Rational Method. By using a calibrated PMP in this manner, a change in the required D_{50} will not be the result of reducing the estimated surface runoff with a different analysis technique. With the calibrated PMP, the revised calculation accounts for infiltration into the ground and surface roughness when computing surface runoff. During a significant rain event such as a PMP, the amount of water that falls is significantly more than the amount that can infiltrate into the soil. Additionally, the depth of water is great enough to prevent surface roughness from slowing the runoff. Therefore, accounting for the infiltration and surface roughness has very little impact in reducing the amount of runoff from a PMP event.

After the amount of runoff was computed, DOE used the Abt-Johnson method discussed in NUREG-1623 to calculate the required D_{50} to prevent erosion of the riprap layer. The required D_{50} by this method is 1.8 inches. For comparison purposes, the required D_{50} using the Stephenson method was 2.7 inches. The difference in the required D_{50} from these two methods primarily results from the definition of "failure." In the Abt-Johnson method, failure is defined as the occurrence of erosion or gullying of the entire riprap layer. In the Stephenson method, failure is defined as the occurrence of movement of a riprap particle. Because the initiation of movement occurs before complete failure, the Abt-Johnson method results in a smaller required D_{50} for a given amount of runoff.

In the revised 2008 analyses, DOE calculated the required rock size using rainfall intensities from HMR-58, using the Abt-Johnson Method to calculate the required rock size, and using no flow concentrations in the analyses.

The staff has reviewed the submittals, and concludes that DOE has not provided an adequate technical basis for reducing the rock size required to resist erosion at the Lakeview site. This conclusion is based on the following analyses, calculations, and observations.

1. Use of Abt-Johnson method. The staff considers that the use of Abt-Johnson method to calculate rock sizes may not be appropriate for this site. Although the method used to calculate the required D_{50} follows the calculation guidance provided in NUREG-1623, the DOE analyses do not take account the recommendations in NUREG-1623 that the method be used only for rock layers where the placement is very good. At this site, the staff considers that the placement as it currently exists does not meet the general guidelines outlined in NUREG-1623 for good rock placement. Although the placement was considered to be acceptable after the rock was initially placed, the staff has observed the rock placement during several site visits (most recently, the 2008 and 2009 site visits) and concludes that: (1) the in-place gradations of the rock layer do not now meet gradation specifications in many areas of the side slope of the cell; (2) there are significant voids now present in the rock layer where relatively large rocks have degraded (rubbleized) to the extent that rock of adequate size is not now present in the degraded area, (3) that a uniform well-graded layer of rock does not now exist in many locations on the cell; and (4) that use of the Abt-Johnson method is therefore not appropriate for this specific site, due the current condition of the riprap layers where gradation specifications are no longer met.

2. Rainfall intensity used by DOE. The rainfall intensity derived from HMR-58 is not considered to be appropriately conservative. At the suggestion of the NRC staff, DOE used updated values of the PMP rainfall provided in the 1998 version of HMR-58. In that reference, the minimum rainfall duration is presented as 15 minutes. The rainfall values, as a percentage of the one-hour PMP are provided in Table 2.10 and Figure 2.23 of HMR-58, and the 15-minute rainfall is about 55 percent of the one-hour PMP. Using this percentage, and a computed time of concentration of about 4.7 minutes (for the slope configuration at the Lakeview site), DOE determined that the rainfall for a 4.7-minute duration should be about 17 percent of the one-hour PMP, using straight line interpolation.

Although a straight-line is drawn in Figure 2.23 in HMR-58, it is generally not usual practice to determine the intermediate times of concentration using straight-line interpolation. In its applications in past years, DOE has constructed curves for determining intermediate times of concentrations (MK-ES, 1986), and the staff considers that such an approach should have been used for the current calculations. Staff evaluations of the data indicate that the 4.7-minute rainfall intensity should be increased.

3. Flow concentrations. The staff notes that DOE did not include flow concentrations in the revised analyses. Based on staff review of the calculations and site visits in 2008 and 2009, the staff concludes the following related to flow concentrations:

a. The D_{50} of erosion protection layer has been reduced. The lower D_{50} value may make the erosion protection layer more susceptible to gully development from concentrated flows. The impact of flow concentrations may be particularly significant at the transition of flow from the soil top slope to the rock side slope. By lowering the D_{50}, there is less of a safety factor to account for uncertainty associated with this issue.

b. Staff observations indicate that vegetation is growing on the top slope, as expected. The presence of vegetation reduces the probability that sheet flow will occur and increases the probability of flow concentrations.

Based on staff review and observations, the staff concludes that an increased flow concentration factor should have been used. Unless DOE can provide further justification, the staff recommends that an increased flow concentration should be used to account for the phenomena discussed above and the variability in the placement of the rock. If a flow concentration factor is not included in the calculations, DOE would need to provide energy dissipation and flow spreading measures, such as the construction of a rock apron at the side slope / top slope interface to reduce the effects of the expected flow concentrations.

4. Overall conservatism in the analysis. The discussions provided in Items 1-3, above indicate that the analyses provided by DOE to reduce the required rock size to 1.8 or 1.4 inches may not be conservative. For the purpose of determining the amount of conservatism in DOE's proposed rock size reduction, the staff performed independent reviews and calculations. For example, if the Abt-Johnson equation is used along with a flow concentration of 2 and a 5-minute rainfall intensity that is based on 31% of the one-hour PMP of 8.5 inches, the required D_{50} rock size would need to be about 2.2 inches. Without further justification by DOE, the staff concludes that the minimum required rock size could be much larger than DOE's proposed value of 1.4 inches.

The staff is aware that there are some conservatism associated with use of the Rational Formula and use of some other assumed parameters. In fact, each of the assumptions discussed in Items 1-3 above would not necessarily form the basis for the staff's conclusions regarding the lack of conservatism in DOE's analyses; however, all of the values taken together form the basis for the staff's conclusion that the required D_{50} could be significantly larger than the values of 1.8 or 1.4 inches proposed by DOE.

3.4 Measurement of Median Riprap Diameter

To quantify the rate of riprap degradation, DOE has been measuring median riprap diameter on an annual basis since 1997. This measurement is performed during the annual site inspection and the results are included in the annual report. The procedure used to measure D_{50} is included in Appendix D to the 2002 revised TSP. The procedure consists of the following steps:

- selecting 20 random locations on the side slope, as of 2001
- marking 25 rocks within a 2-ft by 2-ft square around the randomly selected location
- counting the number of rocks that are retained on various sieves with 4-in., 3-in., 2.5-in., and 1.5-in. openings; and
- performing a calculation using the number of rocks retained on each sieve to determine D_{50}.

This procedure was developed to provide an easy method for determining the D_{50} in the field and has proven useful since first used in 1997. However, this method does not provide a true D_{50} value. In a typical grain size test, such as the procedure identified in ASTM D5519 (ASTM, 2007), the D_{50} is based on the weight of the particles retained on each sieve. The D_{50} calculated in the revised design is also based on a weight component, not the number of particles retained on each sieve. At this time, NRC staff notes it could be worthwhile to obtain riprap samples from the erosion protection layer from ten locations on the side slope cover system and measuring the D_{50} in a laboratory setting using the procedures identified in ASTM D5519. At each location, two samples should be obtained: one from the upper six inches of riprap and one from the lower six inches of riprap. A total of 20 riprap samples would be obtained.

This would serve several purposes: the actual D_{50} of the riprap would be known, a comparison between the laboratory and field methods for measuring D_{50} could be made, and it may be possible to identify variations in D_{50} with depth. The NRC staff notes that the samples could easily be obtained during the next annual inspection and does not envision the laboratory testing becoming part of the annual inspection process.

Once again, it should be emphasized that although the D_{50} test method used in the field by DOE is acceptable and is likely to produce conservative results, it is not a true gradation test as there is no weight component in the evaluation. The method provides a reasonable method to estimate D_{50} in the field, but a test method such as ASTM D5519 should be used to verify the actual D_{50} value. DOE should measure the true D_{50} using a generally accepted technique such as ASTM D5519 for comparison with the field measurement results obtained since 1997. It appears from the data presented that the measured D_{50} continues to decrease with time. Accordingly, the development of the revised D_{50} value may represent only a temporary solution to the riprap degradation problem at the site. This solution does not appear to be consistent with the 1000/200 year requirement in 40 CFR 192.

3.5 Conclusions

NRC staff has reviewed DOE's submittals and concludes that the proposed reductions in required rock sizes do not adequately meet the requirements of 40 CFR 192. The staff concludes that DOE's revised analyses do not have adequate conservatisms and margins of safety, in light of current conditions at the site and staff evaluation of the new 1998 PMP report.

Issue #1 - The revised calculations use the Abt-Johnson method to compute the required minimum rock size. The staff concludes that use of this method is not appropriate for this site, due to the degraded condition of the rock layers and the lack of good rock placement.

Issue #2 – The revised calculations discuss both the PMP used in the original design calculation and the PMP used to calculate the lowered D_{50} value. DOE should provide additional information and justification for the reduced PMP value, particularly the use of a straight-line interpolation of the PMP values in HMR-58.

Issue #3 – The revised calculation does not take into account the impact of concentrated flows on the performance of the cover system. The impact of flow concentrations may be significant at the transition of flow from the soil top slope to the rock side slope. By lowering the D_{50}, there is less of a safety factor to account for uncertainty associated with this issue. DOE should provide additional information that justifies the use of no flow concentrations. Alternately, DOE could possibly provide additional protective measures, such as the construction of a rock apron at the intersection of the side slope and top slope to reduce the flow concentrations and justify their use.

Issue #4 – It appears that the measured D_{50} continues to decrease with time. Accordingly, the development of a revised D_{50} value may represent only a temporary solution to the riprap degradation problem at the site. This solution does not appear to be consistent with the requirements of 40 CFR 192. DOE should provide further justification of the proposed solution in the revised LTSP. Additionally, the D_{50} test method used in the field by DOE since 1997 is not a true gradation test, as there is no weight component in the calculation. Therefore, the true D_{50} of the in-place riprap is not currently known (it could possibly be larger than currently assumed or calculated). DOE should measure the true D_{50} using a generally accepted technique such as ASTM D5519 for comparison with the field measurement results obtained since 1997.

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Figure 1
Change in D_{50} over Time
Lakeview, OR Disposal Site