Radioactive Waste Management Program

Sherwood Uranium Mill Project TECHNICAL EVALUATION REPORT

Monitoring and Stabilization Plan Supplement

February 2000

Washington State Department of Health

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ABSTRACT

The Washington State Department of Health has regulatory authority for uranium and thorium mill operations and closure (WDOH 1997b). Western Nuclear, Inc. operated the Sherwood Project site, located north of Spokane, Washington on the Spokane Indian Reservation (STI 1989).

This Technical Evaluation Report (TER) is designed to supplement the 1998 Sherwood Project TER. This report addresses licensing and closure activities and regulatory compliance issues completed since the 1998 TER (WDOH 1998) was prepared. It specifically covers the monitoring and stabilization period since construction completion in 1996.

KEY WORDS: uranium, mill, radiation, radioactive material, tailings, closure, reclamation, regulations, structural stability, vegetation productivity, ground water, Monitoring and Stabilization Plan (MSP), Spokane Tribe of Indians, license termination.

Sherwood Uranium Mill Project Site – 1999

INTRODUCTION

The Monitoring and Stabilization Plan (MSP) (WNI 1997e) is the primary reference defining licensing and site performance requirements for Western Nuclear, Inc.'s Sherwood Project uranium millsite after reclamation construction activities were completed in 1996. The department prepared a Technical Evaluation Report (TER) (WDOH 1998) that evaluated all millsite activities prior to, during, and immediately after reclamation construction. The MSP evaluates the post-reclamation construction period for reliable performance of the construction design elements and environmental factors at the site. There are three primary factors evaluated by the MSP. They are (1) structural stability, (2) vegetative productivity, and (3) ground water.

STRUCTURAL STABILITY

Structural stability monitoring evaluates the (1) tailing impoundment surface cover, (2) drainage diversion channel, (3) tailing impoundment margins, (4) tailing impoundment embankment, (5) additional areas of disturbance, and (6) watershed drainage basin surrounding the reclaimed tailing impoundment. Performance evaluation issues include (1) rill development, (2) settlement, (3) gullying, (4) head-cutting, (5) slumping, (6) erosion and deposition, (7) loss of erosion protection materials, and (8) manmade or animal impacts which may adversely affect erosion protection performance or compromise the stability and integrity of the reclamation design elements.

Western Nuclear, Inc. contracted with Sheila Pachernegg, P.E., an independent Professional Engineer licensed in the state of Washington and experienced with the design, construction, and performance evaluation of geo-technical engineering, surface water hydrology, and erosion protection practices. Ms. Pachernegg performed semi-annual inspections and prepared reports which were submitted to the department for evaluation (Pachernegg 1998a, 1998b, 1999a, 199b, 1999c). In addition to her reports, the department visited the site several times during each year to evaluate structural stability and prepared its own annual structural stability report (WDOH 1997a).

In the summer of 1999, several Department of Health inspections were performed to evaluate structural stability of the site in preparation for license termination. The department also consulted with professional engineers in the Dam Safety Section at the Department of Ecology (WDOE 1999a). Jerald LaVassar, P.E. provided recommendations to the department regarding (1) erosion at the outfall of the reclaimed impoundment area, (2) small void areas in the riprap lining of the diversion channel floor, and (3) erosion of the swale up-slope from the northwest section of the diversion channel. Jerald LaVassar is an experienced geo-technical engineer, has been the lead engineer at the WNI Sherwood Project site for structural stability compliance under Dam Safety regulations, and has inspected the Sherwood Project site extensively over several years.

As a result of inspections and consultations during the 1999 summer inspection season, the department requested response to 12 structural stability issues from WNI (WNI 1999d). The response resulted in three reconstruction activities: (1) rework and placement of additional rock in void areas in the diversion channel, (2) regrading of a small drainage area near the access roadway, and (3) spreading of soil deposited in the diversion channel and re-construction of the upgradient side-slope. The remaining nine issues were addressed by reporting additional analysis justifying adequacy of the site status and conditions (WDOH 1999f, 1999g).

Dorothy Stoffel, M.S., Hydrogeologist, performed several inspections and evaluations of rock durability and adequacy based on a geological evaluation in the field and review of construction records and petrographic analysis. Ms. Stoffel found that rock (riprap) protection materials fully complied with construction plans and specifications and the NRC Final Staff Technical Position for Design of Erosion Protection Covers for Stabilization of Uranium Mill Tailings Sites (WDOH 1996, 1999a) (NCR 1990).

Earl Fordham, P.E., inspected the site on several occasions and evaluated rock placement, in-place gradation, and rock field status and adequacy. As a result of department inspections, WNI chose to perform minor reconstruction to place additional rock to fill in small void areas and spaces. Follow-up inspections verified by Earl Fordham that the work was performed according to plans and specifications and that the rock (riprap) placement fully complied with the construction plans and specifications and NRC guidance (WDOH 1999b, 1999e, 1999j, 1999l) (WDOE 2000) (NRC 1990).

John R. Blacklaw, P.E., inspected the site on several occasions and evaluated soil erosion and deposition, and site structural stability field status and adequacy. As a result of department inspections, WNI chose to perform minor reconstruction activities. Two areas were reworked. A small drainage area near the access road was re-graded to improve and assure local drainage. The northwest section of the diversion channel was found to contain a small soil deposition fan from adjacent side-slope erosion. The deposition soil was spread to limit diversion channel capacity reduction. The upgradient slope was re-graded to remove a developing gully and a constructed bench. The disturbed area was stabilized with straw mats, and re-seeded. Lou Miller, P.E. (Shepherd Miller, Inc.) prepared the design plans. WNI performed the minor reconstruction work. Sheila Pachernegg performed an as-built inspection and verified construction was performed per plan. A follow-up inspection by John Blacklaw verified that the rework was adequate and that the site fully complies with the reclamation construction plans and specifications as expressed in WNI's Construction Completion Report (WDOH 1999a, 1999c, 1999d, 2000a) (WNI 1996b, 1997d).

In addition to the onsite inspections by department staff, they also reviewed reported analysis and justification on all remaining issues (WNI 1999d) and found the site status and condition regarding structural stability to be adequate and to comply with NRC guidance (NRC 1990) (WDOH 2000a). The department also consulted with Jerald LaVassar from the Dam Safety Section of the Department of Ecology regarding department inspection reports, reports of reconstruction work performed by WNI, and WNI reports with analysis and justifications, and he concluded that his concerns have been satisfactorily addressed (WDOE 2000a).

VEGETATION PRODUCTIVITY

Vegetation productivity monitoring evaluates (1) overall tailing impoundment surface cover and (2) overall tailing impoundment margins, using performance measures of (1) percent cover for total vegetation, and (2) percent cover for perennials. Some areas of the margins were found to be stable without vegetation because they have demonstrated sub-surface stability afforded by competent quartz monzonite.

The tailing impoundment surface cover is the area of the soil cover directly above the placed tailings. The tailing impoundment margin is the area between the relatively flat tailing impoundment cover and the top of the berm that forms the inside structural barrier of the diversion channel. The margins are about 8,000 feet in total length by about 150 feet wide. The slope varies by design from 3h:1v (33%) to 5v:1h (20%). There is a 10 foot wide rock toe at the outside base of the margins. The top of the berm is about 20 feet wide with a slightly crowned top slope (WDOH 1998).

Percent cover is an indirect measure for site performance. The purpose of percent cover monitoring is to assure adequate vegetation has been established on disturbed surfaces and that it is self-sustaining. Undisturbed surfaces in the area have adequate vegetation and do not experience excess erosion effects.

Although the 1% slope of the cover was found to be structurally stable for the short-term with or without vegetation, the vegetation provides erosional protection and removes moisture from the soil through transpiration.

For the margins, where competent monzonite was not found, the reclamation design relies on vegetation and structural stability of the diversion channel berm soils.

Criteria for performance acceptance is based on percent cover monitoring. WNI prepared erosion protection analysis, monitoring methodology and statistical criteria. Department staff, with assistance from Steven Link, Ph.D., a botanist from the University of Washington, reviewed, verified, and approved the criteria and methodology during the reclamation design and construction phase (Link 1997). The specific criterion is based on a conservative erosion protection analysis. The cover requirement is 36% coverage at the lower 80% confidence interval. The margin's requirement is 39% coverage at the lower 80% confidence interval. The criterion applies to perennial species initially and defaults to total vegetation in the third year of monitoring (WNI 1997e).

Since 1997, vegetation monitoring has been performed by WNI staff, and independent verification monitoring has been done by WDOH contractors and WDOH staff. Vegetation productivity has increase steadily since reclamation construction was completed in the fall of 1996. The 1997 vegetation performance was in the range of 10% cover. In 1998, vegetation performance jumped into the 40% range due in large part to proliferation of sweet clover and improvement in perennial species performance. In 1999, vegetation percent cover was 2% less than the 1998 season. The reduction was primarily due to sweet clover performance reduction and drought conditions. Sweet clover is a perennial (biennial) and has a cyclic performance during re-vegetation, peaking in the second, fourth, and even years, until evening out. The department's logarithmic fit curve of vegetation performance indicates that the total percent cover for vegetation during the 1999 season meets the performance criteria. Projections for the 2000 season are in the range of 50% cover for total vegetation (Link 1998a, 1998b, 1999a, 1999b) (WDOH 2000c).

In addition, the department requested that WNI perform justification for short-term performance requirements. Engineers from the Dam Safety Section of the Department of Ecology prepared site-specific detailed estimates of precipitation intensity and hyetographs for several storm recurrence intervals for use in runoff and erosion protection analyses (WDOE 1999b). WNI's analysis indicates that 34% cover is adequate to protect the site for a 10,000-year precipitation event (WNI 1999e). The department's independent verification indicates that a 35% vegetative cover would be adequate, using conservative assumptions (WDOH 2000d). Monitored vegetation productivity performance in 1999 exceeds this short-term criteria and indicates that potential impacts from storm events that may occur during the next few years of vegetation succession are unlikely (WDOH 2000c).

Based on the above information, department staff believe that the Sherwood Project vegetation productivity satisfactorily complies with construction plans and specifications, license conditions, regulatory performance requirements, and provides adequate short-term and long-term site stability.

GROUND WATER

Ground water monitoring evaluates monitoring well water quality immediately downgradient of the tailings pile at the point of compliance (POC). Monitoring wells are also located on the three upgradient sides of the tailings impoundment to evaluate local background water quality. Performance evaluation components include (1) monitoring for hazardous and radioactive constituents in the tailing pore fluid, (2) monitoring for indicator constituents in ground water that promptly indicate water quality excursions due to tailings pore fluid releases, and (3) monitoring for standard water quality measures and monitoring well static water level (WDOH 1998).

Three levels of monitoring are included in the ground water monitoring protocol, based on monitoring results. The three levels include increased frequency in the monitoring schedule and inclusion of additional constituents in ground water analysis, based on an increased incidence of detects above certain action criteria limits. The monitoring level trigger point criteria are set very conservatively to allow prompt evaluation of monitoring excursions before they become exceedances of ground water standards (WNI 1997e).

One of the downgradient point-of-compliance wells, MW-4, has seasonal variation in water quality, represented by late spring and summer peaks, that are consistent with annual infiltration and the rise in static water levels. This seasonal trend has been evaluated closely, and ground water monitoring increased as established by the MSP.

After careful review of all data, the static water levels and indicator parameter concentrations are within normal ranges consistent with expectations and concentrations remain well below regulatory limits (WDOH 1999h, 1999k).

In addition to the ground water monitoring protocol established in the MSP, a final ground water monitoring sample was taken, analyzed for all major constituents, and evaluated for compliance with regulatory requirements. This final ground water evaluation is required by step two of the License Termination Procedure, SA-900, as directed by the U.S. Nuclear Regulatory Commission (WDOH 2000b).

Dorothy Stoffel is an experience hydrogeologist and has directed the department's ground water evaluation at WNI's Sherwood Project site since 1989. Dorothy's responsibilities include review and approval of the site closure plan, reclamation plan design and specifications, monitoring well locations and configuration, well abandonment, ground water monitoring plans, and ground water report evaluations.

Ground water monitoring results have never exceeded ground water standards (WDOH 1999h, 1999k). After department review of required licensee monitoring data and department split samples evaluated in Washington's analytical laboratory, the department has determined that no further ground water monitoring is required at the site and that the site has met ground water monitoring criteria of the MSP (WDOH 1999h, 1999k).

REFERENCES

Link, Steven, and Bonnie Knight, 1997, *Comparison of Vegetative Cover Measurement Methods for Sparce and Newly Restored Native Communities*, December 14, 1997.

Link, Steven, 1998a, *The Effect of the Observer on Surface Cover Estimates at the Sherwood Mine*, March 5, 1998.

Link, Steven, 1998b, *Review of the Sherwood Monitoring and Stabilization Plan Post-Reclamation Construction Monitoring 1997 Vegetation Monitoring Program*, March 22, 1998.

Link, Steven, 1999a, *Review of the Sherwood Monitoring and Stabilization Plan Post-Reclamation Construction Monitoring 1998 Vegetation Monitoring Program*, February 22, 1999.

Link, Steven, 1999b, *Adequacy of the Western Nuclear, Inc. Vegetative Cover: Areas at Risk and Methods for Revegetation*, June 29, 1999.

NRC, 1990, Final Staff Technical Position, Design of Erosion Protection Covers for Stabilization of Uranium Mill Tailings Sites, U.S. Nuclear Regulatory Commission. August 1990.

NRC, 1999, Office of State Programs, Termination of Uranium Mill Licenses in Agreement States, Procedure Number SA-900, April 20, 1999.

Pachernegg, Sheila, 1998a, Fall 1997 Inspection Report, February 12, 1998.

Pachernegg, Sheila, 1998b, Spring 1998 Inspection Report October 6, 1998.

Pachernegg, Sheila, 1999a, Fall 1998 Inspection Report, January 5, 1999.

Pachernegg, Sheila, 1999b, Spring 1999 Inspection Report, June 16, 1999.

Pachernegg, Sheila, 1999c, Final Monitoring and Stabilization Plan Report, November 15, 1999.

Spokane Tribe of Indians (STI), 1989, *Centennial Accord between the Federally Recognized Indian Tribes in Washington State and the State of Washington*, August 4, 1989.

WDOE, 1999a, Letter from Jerald LaVassar to John Blacklaw, *Comments on Riprapped Elements of the Reclaimed Impoundment and Diversion Channel*, July 19, 1999.

WDOE, 1999b, Letter from Martin Walther to John Blacklaw, *Sherwood Uranium Mill, Spokane Indian Reservation Hydrologic Computations for Extreme Precipitation Events* (with attachments), December 16, 1999.

WDOE, 2000, Letter from Jerald LaVassar to John Blacklaw, *Sherwood Project – 1/12/2000 DOH Soil Erosion Stability Inspection Report*, January 19, 2000.

WDOH, 1996, letters from John Blacklaw to Stephanie Baker (WNI) with attached memorandum from Dorothy Stoffel to John Blacklaw and Earl Fordham, *Completion of WNI Petrographic Analysis Review* (with attachments), April 10 and 12, 1996.

WDOH, 1997a, Memorandum from John Blacklaw to Gary Robertson, *Photo Reconnaissance of Sherwood Uranium Mill Site, Conducted May 27-28, 1997*, June 10, 1997.

WDOH, 1997b, Chapter 246-252 WAC (Washington Administrative Code), Radiation Protection – Uranium and/or Thorium Milling, July 17, 1997.

WDOH, 1998, Sherwood Uranium Mill Project Technical Evaluation Report, June 1998.

WDOH, 1999a, Memorandum from Dorothy Stoffel to Gary Robertson, John Blacklaw, and Earl Fordham, *Western Nuclear, Inc. Monitoring and Stabilization 1999 Field Inspection*, August 9, 1999.

WDOH, 1999b. Memorandum from Earl Fordham to Gary Robertson, John Blacklaw, and Dorothy Stoffel, *Western Nuclear, Inc. Monitoring and Stabilization Field Inspection*, August 11, 1999.

WDOH, 1999c, Memorandum from John Blacklaw to Gary Robertson, Dorothy Stoffel, and Earl Fordham, *Western Nuclear, Inc. Monitoring and Stabilization 1999 Field Inspection*, August 11, 1999.

WDOH, 1999d, Letter from Gary Robertson to Brad DeWaard (WNI), August 20, 1999.

WDOH, 1999e, Memorandum from Earl Fordham to Gary Robertson, John Blacklaw, and Dorothy Stoffel, *Structural Stability Inspection at WNI*, August 24, 1999.

WDOH, 1999f, Letter from Gary Robertson to WNI, September 21, 1999.

WDOH, 1999g, Letter from Gary Robertson to WNI, September 21, 1999.

WDOH, 1999h, Memorandum from Dorothy Stoffel to Gary Robertson and John Blacklaw, *Review of Western Nuclear, Inc. Ground Water Monitoring Program, January 1998 to June 1999*, September 22, 1999.

WDOH, 1999i, Letter from Gary Robertson to WNI, September 27, 1999.

WDOH, 1999j, Memorandum from Earl Fordham to Gary Robertson, *Rock Remediation at WNI's Sherwood Site*, October 27, 1999.

WDOH, 1999k, Memorandum from Dorothy Stoffel to Gary Robertson and John Blacklaw, *WNI Monitoring and Stabilization Completion Report (Tab 3), submitted with "Request for License Termination Final Data Submittal," November 1999*, December 2, 1999.

WDOH, 1999l, Memorandum from John Blacklaw to Gary Robertson, *Peer Review of Rock Remediation at WNI's Sherwood Site*, December 20, 1999.

WDOH, 2000a, Memorandum from John Blacklaw to Gary Robertson, *Soil Erosion Stability Inspection and Review at WNI's Sherwood Project*, January 12, 2000.

WDOH, 2000b, Memorandum from Dorothy Stoffel to Gary Robertson and John Blacklaw, *Final Ground Water Sample at Western Nuclear, Inc., Sherwood*, January 24, 2000.

WDOH, 2000c, Memorandum from John Blacklaw to Gary Robertson, *Vegetation Productivity Monitoring and Document Review for WNI's Sherwood Project*, January 28, 2000.

WDOH, 2000d, Memorandum from Earl Fordham to Gary Robertson, *Vegetation Productivity Analysis for WNI's Sherwood Project*, February 1, 2000.

WNI, 1992, Sherwood Mill Decommissioning Plan, April 27, 1992.

WNI, 1993, *1992 Annual Environmental Monitoring Report*, May 3, 1993.

WNI, 1994a, *1993 Annual Environmental Monitoring Report*, May 2, 1994.

WNI, 1994b, Sherwood Project Radiological Verification Program, October 31, 1994.

WNI, 1994c, Sherwood Project Tailings Reclamation Plan, December 22, 1994

WNI, 1995a, Sherwood Project Revegetation System Evaluation, September 15, 1995.

WNI, 1995b, Sherwood Project Ground Water Protection Plan, Technical Integration Report, December 4, 1995.

WNI, 1996a, Sherwood Project Monitoring and Stabilization Plan, February 28,1996.

WNI, 1996b, Revised Technical Specifications, Construction Component Quality Plan, March 13, 1996.

WNI, 1996cc *Sherwood Project Radiological Verification Completion Report*, July 31, 1996.

WNI, 1997a, *1996 Annual Ground Water Report*, May 1, 1997.

WNI, 1997b, *Sherwood Project Mill Decommissioning Construction Completion Report*, May 15, 1997.

WNI, 1997c, Transmitting Results of Confirmation Sampling, May 20, 1997.

WNI, 1997d, *Sherwood Project Tailing Reclamation Construction Completion Report*, June 27, 1997.

WNI, 1997e, Sherwood Project Monitoring and Stabilization Plan, September 24, 1997.

WNI, 1997f, Compliance Monitoring Notification, October 22, 1997.

WNI, 1998a, Vegetation Monitoring and Success Evaluation, February 12, 1998.

WNI, 1998b, *1997 Annual Ground Water Report*, May 1, 1998.

WNI, 1998c, Evaluation of Anomalous Ground Water Quality Data, July 31, 1998.

WNI, 1998d, 1998 Vegetation Monitoring Program, October 6, 1998.

WNI, 1998e, Evaluation of Anomalous Ground Water Quality Data, July 31, 1998.

WNI, 1999a, *1998 Annual Ground Water Report with Data from First Half of 1999*, August 31, 1999.

WNI, 1999b, 1999 Vegetation Monitoring Program, October 22, 1999.

WNI, 1999c, Final Monitoring and Stabilization Plan Report, November 15, 1999.

WNI, 1999d, Request for License Termination; Final Data Submittal, November 15, 1999.

WNI, 1999e, *Response to Washington Department of Health Verbal Questions of December 6*, December 17, 1999.

TER Supplement Selected References

Link, Steven, and Bonnie Knight, 1997, *Comparison of Vegetative Cover Measurement Methods for Sparce and Newly Restored Native Communities*, December 14, 1997.

Link, Steven, 1998a, *The Effect of the Observer on Surface Cover Estimates at the Sherwood Mine*, March 5, 1998.

Link, Steven, 1998b, *Review of the Sherwood Monitoring and Stabilization Plan Post-Reclamation Construction Monitoring 1997 Vegetation Monitoring Program*, March 22, 1998.

Link, Steven, 1999a, *Review of the Sherwood Monitoring and Stabilization Plan Post-Reclamation Construction Monitoring 1998 Vegetation Monitoring Program*, February 22, 1999.

Link, Steven, 1999b, *Adequacy of the Western Nuclear, Inc. Vegetative Cover: Areas at Risk and Methods for Revegetation*, June 29, 1999.

Spokane Tribe of Indians (STI), 1989, *Centennial Accord between the Federally Recognized Indian Tribes in Washington State and the State of Washington*, August 4, 1989.

WDOE, 1999a, Letter from Jerald LaVassar to John Blacklaw, *Comments on Riprapped Elements of the Reclaimed Impoundment and Diversion Channel*, July 19, 1999.

WDOE, 1999b, Letter from Martin Walther to John Blacklaw, *Sherwood Uranium Mill, Spokane Indian Reservation Hydrologic Computations for Extreme Precipitation Events* (with attachments), December 16, 1999.

WDOE, 2000, Letter from Jerald LaVassar to John Blacklaw, *Sherwood Project – 1/12/2000 DOH Soil Erosion Stability Inspection Report*, January 19, 2000.

WDOH, 1996, letters from John Blacklaw to Stephanie Baker (WNI) with attached memorandum from Dorothy Stoffel to John Blacklaw and Earl Fordham, *Completion of WNI Petrographic Analysis Review* (with attachments), April 10 and 12, 1996.

WDOH, 1997a, Memorandum from John Blacklaw to Gary Robertson, *Photo Reconnaissance of Sherwood Uranium Mill Site, Conducted May 27-28, 1997*, June 10, 1997.

WDOH, 1999a, Memorandum from Dorothy Stoffel to Gary Robertson, John Blacklaw, and Earl Fordham, *Western Nuclear, Inc. Monitoring and Stabilization 1999 Field Inspection*, August 9, 1999.

WDOH, 1999b. Memorandum from Earl Fordham to Gary Robertson, John Blacklaw, and Dorothy Stoffel, *Western Nuclear, Inc. Monitoring and Stabilization Field Inspection*, August 11, 1999.

WDOH, 1999c, Memorandum from John Blacklaw to Gary Robertson, Dorothy Stoffel, and Earl Fordham, *Western Nuclear, Inc. Monitoring and Stabilization 1999 Field Inspection*, August 11, 1999.

WDOH, 1999d, Letter from Gary Robertson to Brad DeWaard (WNI), August 20, 1999.

WDOH, 1999e, Memorandum from Earl Fordham to Gary Robertson, John Blacklaw, and Dorothy Stoffel, *Structural Stability Inspection at WNI*, August 24, 1999.

WDOH, 1999f, letter from Gary Robertson to WNI, with attachments, September 21, 1999.

WDOH, 1999g, letter from Gary Robertson to WNI, with attachments, September 21, 1999.

WDOH, 1999h, Memorandum from Dorothy Stoffel to Gary Robertson and John Blacklaw, *Review of Western Nuclear, Inc. Ground Water Monitoring Program, January 1998 to June 1999*, September 22, 1999.

WDOH, 1999i, Letter from Gary Robertson to WNI, September 27, 1999.

WDOH, 1999j, Memorandum from Earl Fordham to Gary Robertson, *Rock Remediation at WNI's Sherwood Site*, October 27, 1999.

WDOH, 1999k, Memorandum from Dorothy Stoffel to Gary Robertson and John Blacklaw, *WNI Monitoring and Stabilization Completion Report (Tab 3), submitted with "Request for License Termination Final Data Submittal," November 1999*, December 2, 1999.

WDOH, 1999l, Memorandum from John Blacklaw to Gary Robertson, *Peer Review of Rock Remediation at WNI's Sherwood Site*, December 20, 1999.

WDOH, 2000a, Memorandum from John Blacklaw to Gary Robertson, *Soil Erosion Stability Inspection and Review at WNI's Sherwood Project*, January 12, 2000.

WDOH, 2000b, Memorandum from Dorothy Stoffel to Gary Robertson and John Blacklaw, *Final Ground Water Sample at Western Nuclear, Inc., Sherwood*, January 24, 2000.

WDOH, 2000c, Memorandum from John Blacklaw to Gary Robertson, *Vegetation Productivity Monitoring and Document Review for WNI's Sherwood Project*, January 28, 2000.

WDOH, 2000d, Memorandum from Earl Fordham to Gary Robertson, *Vegetation Productivity Analysis for WNI's Sherwood Project*, February 1, 2000.

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Comparison of vegetative cover measurement methods for sparse and newly restored native communities

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Abstract

The accurate measurement of percentage cover of vegetation is required when the risk of erosion is high. A test was conducted to determine if the variability of cover estimates obtained using a two dimensional grid quadrat frame with double cross hairs for objective sighting on the ground was lower than estimates obtained using a linear tape. Test data were gathered to compare the techniques with the conclusion that the two methods have equivalent variances. The linear tape method is the favored technique because of simplicity and greater spatial coverage.

Introduction

The measurement of vegetative cover is required in certain applications to meet Washington State Department of Health (WDOH) regulations. These regulations pertain to erosional characteristics of landfill covers. At the Sherwood Mine it has been determined that vegetative cover must exceed 36 percent on the flat surface and 39 percent on the surrounding slopes. These critical cover values were arrived at by examination of the work of Temple *et. al* (1987). Values less than these can lead to erosion that can lead to compromizing the landfill cover placed over radioactive wastes at the mine.

The tool used to measure vegetative cover becomes a critical issue that industry and WDOH must agree upon. Tools under consideration are the linear tape and the two dimensional grid quadrat frame. These tools have been reviewed by Bonham (1989) who concludes that, under certain circumstances, the grid quadrat frame is the more accurate tool.

The linear tape method consists of laying a tape on the ground and then viewing what cover class component intersects with tape hash marks. This is done by the observer looking directly down over the tape and recording the cover class component. The linear tape technique has been criticized as subject to observer bias Bonham (1989). The bias has to do with parallax. The hash mark is a single point. The intersection of the hash mark and the cover class above or below it depends on where the observer stands.

The grid quadrat frame method is two dimensional and makes use of cross hairs to unambiguously focus on a point on the ground. The point frame tested has two sets of strings woven into a wooden frame that can be placed at varying levels above the ground. The strings are crossed making a screen. Two sets of such screens are aligned one above the other. The distance between the screens is 1.2 dm. The screen size is 1 x 1 dm. The frame is a size that allows for 36 points that are 1 dm apart. There are 9 points by 4 points in the rectangular frame.

If the linear tape method is less accurate than the grid quadrat method then cover estimates obtained with the linear tape will more variable than those obtained with the grid quadrat. The objective of this work was to test the hypothesis that the grid quadrat method yields less variable cover estimates than does the linear tape method.

Methods

The comparison of the linear tape and grid quadrat methods was conducted on the grounds of Washington State University at Tri-Cities campus in late October 1997.

The tools were positioned next to each other on ground that appeared to be composed of a homogeneous mixture of plants, soil, rocks, and litter.

The linear tape was placed on the ground and weighed down with large rocks to keep it stationary. A 36 decimeter length of tape was used for data collection with data obtained at each of the 36 decimeter marks on the tape.

The grid quadrat frame was placed on the ground and lowered so that the bottom set of crossed strings were about 3 decimeters above the ground. The height was chosen because it was the most comfortable position for viewing through the two sets of crossed strings to the ground. Data were collected at each of the 36 points on the frame.

The cover classes identified at each point were grass, forb, litter, soil or rock. Any rock less than 1 cm in diameter was classed as soil.

Each tool was examined by ten people producing ten replicate observations of the same surface. Observers were allowed to examine only one tool to avoid any learning that might bias readings on the other tool.

Data were analyzed to compare mean percentage cover and variability of each class for the tools. Variability of each class for the tools was compared to determine if variance was less for the grid quadrat frame than for the linear tape. The test was constructed as:

$$H1: \sigma^2_g < \sigma^2_l \quad \text{If } s^2_g/s^2_l < F(\alpha; n_g\text{-}1, n_l\text{-}1),$$

where s^2 is the sample variance, "g" represents the grid quadrat frame and "l" represents the linear tape.

Hypotheses were tested using Student's t-test for mean comparisons and F tests for variance comparisons (Neter *et al.*, 1985). All decisions were controlled at $\alpha = 0.05$. Analyses were done using JMP version 2.0.2 software (Sall *et al.*, 1991).

Results

Mean values of each cover class were compared for the tools. This was done to determine if the cover characteristics of the test surfaces were comparable. Mean cover values ranged from 40 to 50% for soil and 0 to 10% for rock for both tools (Fig. 1). Mean cover values for all classes except rock were not significantly ($P > 0.05$) different between the two test surfaces (Fig. 1). Significantly more rock was observed on the grid frame test surface. Similar cover between the test areas confirms our assumption that the test areas were comparable.

The hypothesis that the grid quadrat method yields less variable cover estimates than does the linear tape method was tested for all five cover classes. In no case was the variance of the grid quadrat method less than that of the linear tape method (Fig. 2). This conclusion is drawn by noting in figure 2 that all sample variances were not less than the F-test control limit of 0.314. A two-tailed test that the variances are equal was also true for all cover classes. We conclude that the variability of the two measurement tools is the same under the conditions of the test. The grid quadrat method is not less variable than the linear tape method.

Discussion

The variability of cover estimates produced by the grid quadrat and linear tape methods were the same. This implies that either method can be used to estimate cover on surfaces similar to that tested in this study. The linear tape method is favored because of the method's simplicity and, because of a long linear dimension, it is likely to include more spatial variability in the estimates it produces. The tape is a simpler method because all that is required is the tape and weights to hold it down. The grid quadrat technique as tested in this study uses a physically larger tool than the tape and therefore more difficult to work with under field conditions. It is also likely that it takes longer to determine what is between the cross hairs because the bottom grid was about 30 cm above the ground. The tape lies on the ground making it easier to determine what the hash mark was above. We conclude that the draw back associated with parallax bias for the linear tape was not significant under the conditions of the test.

Increased variability with the linear tape method compared with the grid quadrat method as described in Bonham (1989) may be associated with the height above ground of the tape. In an area with high percentage cover of vegetation it is likely that it would be difficult to place the tape directly on the ground. If the tape is held above ground then the distance between the tape and the amount of variability in cover estimates are probably correlated. We hypothesize that variability is positively correlated with the distance above the surface the tape is held at.

In the work at the Sherwood Mine the linear tape method is appropriate until the vegetative cover becomes much higher. At high cover values the accuracy of the measurement tool becomes less important so we conclude that the linear tape method is appropriate under all conditions likely to be encountered at the mine site.

Acknowledgements

This work was supported by the Washington State Department of Health under a contract with Washington State University. Discussions with Earl Fordham, John Blacklaw, Gary Robertson and Dr. Terry McLendon are appreciated.

Literature cited

Bonham, C. D. 1989. Measurements for Terrestrial Vegetation. John Wiley & Sons, New York. Pp. 338.

Neter, J., W. Wasserman, and M. H. Kutner. 1985. Applied Linear Statistical Models. R. D. Irwin, Inc., Homewood, Ill., Pp. 1127.

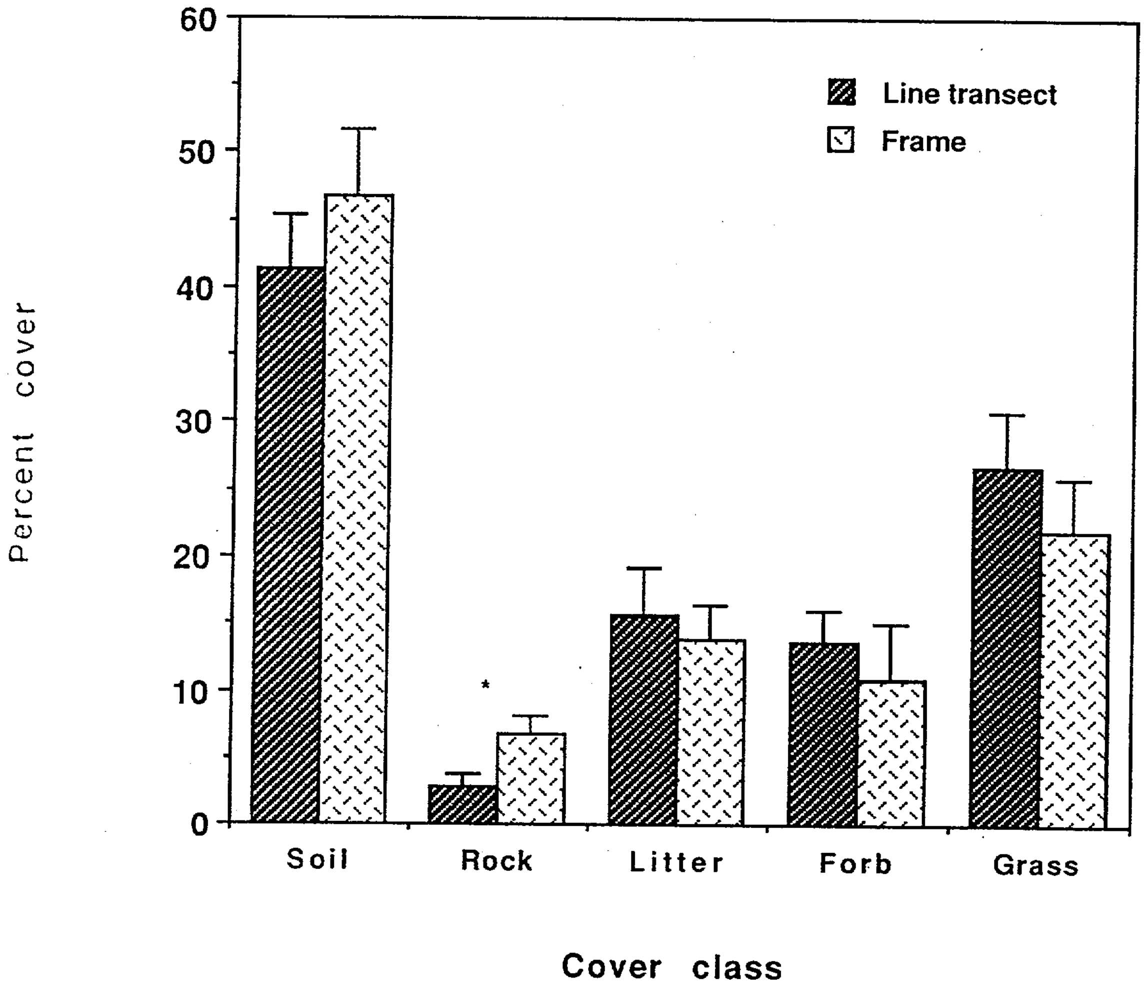
Sall, J., Ng, K., and Hecht, M. 1991. Statistical Visualization for the Macintosh (JMP). SAS Institution, Inc., Cary, NC.

Temple, D. M., K. M. Robinson, R. M. Ahring, and A. G. Davis. 1987. Stability design of grass lined open channels. US Department of Agriculture, Agriculture Handbook Number 667.

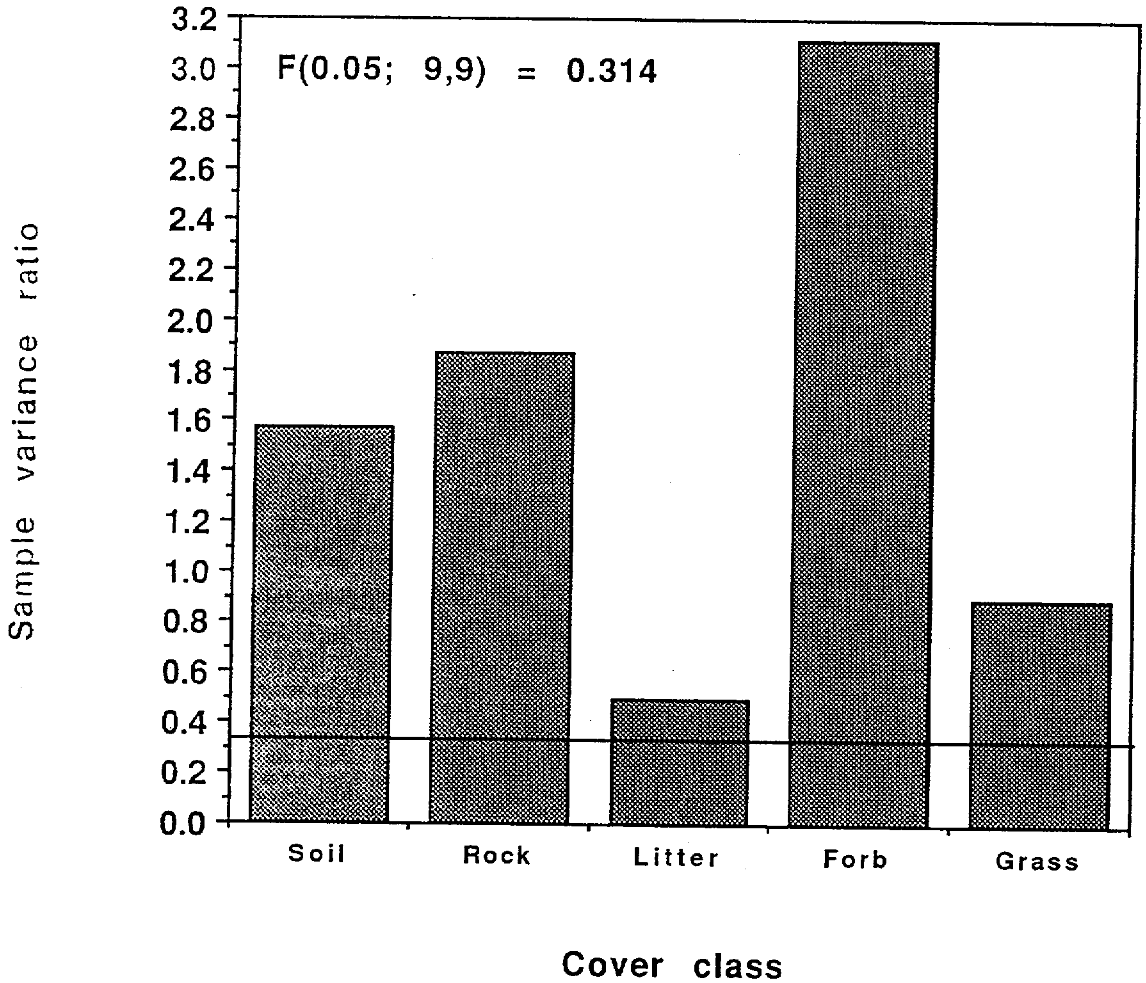
Figures

Figure 1. Mean cover for each of the five cover classes for the linear tape and grid quadrat frame. Error bars are one standard error of the mean. Significant differences are denoted with an asterisk.

Figure 2. Sample variance ratio (grid quadrat/linear tape) for the five cover classes. The control limit given by the F-test score determines the ratio where the variance of the grid quadrat method is significantly ($\alpha = 0.05$) less than that for the linear tape method. This was never true.



60
50
40
30
20
10
0
Percent cover
Line transect
Frame
*
Soil
Rock
Litter
Forb
Grass
Cover class



3.2
3.0
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
F(0.05; 9,9) = 0.314
Sample variance ratio
Soil
Rock
Litter
Forb
Grass
Cover class

March 5, 1998

The Effect of the Observer on Surface Cover Estimates at the Sherwood Mine

by

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Abstract

The accurate measurement of percentage cover of vegetation is required when the risk of erosion is high. The possibility of observer bias can reduce accuracy of cover measurements. A test was conducted to determine if cover values gathered by two observers were different and if the side of the tape used to make the observations had an effect on cover values. The measurement of cover at the Sherwood Mine was independent of the observer and of the side of the tape used to measure cover under the conditions of the test.

Introduction

The measurement of vegetative cover is required in certain applications to meet Washington State Department of Health (WDOH) regulations. These regulations pertain to erosional characteristics of landfill covers. At the Sherwood Mine it has been determined that vegetative cover must exceed 36 percent on the flat surface and 39 percent on the surrounding slopes. These critical cover values were arrived at by examination of the work of Temple *et. al* (1987). Values less than these can lead to erosion that can lead to compromising the landfill cover placed over radioactive wastes at the mine.

Accurate measurement of vegetative cover are required for decisions regarding erosional stability of the surfaces and for changes in the licensing of the Sherwood Mine. The tool used to measure vegetative cover is the line transect (Bonham 1989). Cover is assessed by examining the intersection of hash marks with surface just below the hash mark.

This tool is subject to bias associated with the observer and the side of the tape on which the observer stands during the assessment. An observer may interpret intersections differently than another observer. The problem of which side of the tape the observer stands on while examining the surface is another potential source of bias. Given that the hash marks are on only one edge of the tape it is possible that cover estimates made are dependent on which side of the tape the observer makes the observation.

An effort to determine if these effects are significant was conducted on July 25, 1997 at the Sherwood Mine. The analyses presented in this document are a companion to those presented by DeWaard (1998).

Two hypotheses were tested. These are:

H0a: There is no difference in cover estimates between observers.

H0b: There is no difference in cover estimates between sides of the tape.

The objective of this study was to determine if the observer (Steven O. Link representing WDOH and Brad K. DeWaard of Western Nuclear, Inc.) and if the side of the tape used to measure cover had significant effects on vegetative cover estimates. In addition to testing the two hypotheses i compare cover between the surface and slope study areas.

Methods

The study areas were located on the revegetated portions of the Sherwood Mine cap. Data were acquired on the surface and on the margin slope of the cap. Five line transects were examined on both the surface and on the slope. The physical location of the transects is noted in DeWaard (1998). Data were collected on July 25, 1997 by both observers working together. Each line transect was 10 m long.

At each transect a tape was laid on the ground and anchored at the ends and with rocks at various locations on top of the tape. In each of the ten, one meter sections of the tape, observations were taken at each centimeter mark. This resulted in a total of 1000 observations on each transect. In each meter section observations were taken on the presence or absence of bare ground, rocks, litter, perennials (grass, forb, tree) and annuals (grass, forb). If a rock was at least one centimeter in diameter it was recorded as present. If the rock was smaller it was considered bare ground. Each observer collected data starting on opposite ends of the tape. The side of the tape the observer was standing on to record data was also noted.

The model used to test for effects was:

$$Y = S + O + S^*O + E, \qquad (1)$$

where Y is percent cover of the cover catagories, S is the side of the tape (graduated or unmarked), O is the observer (Link or DeWaard), and E is the random error term for the analysis of variance model (ANOVA).

Comparisons between the two study areas were assessed based on the mean of both observer's data. This yields five observations for each area.

Hypotheses were tested using ANOVA and Student's t-test for mean comparisons (Neter *et al.*, 1985). All decisions were controlled at $\alpha = 0.05$. Analyses were done using JMP version 2.0.2 software (Sall *et al.*, 1991).

Results

Results are presented for the test of the significance of the observer and the side of the tape used for observation and cover comparisons between the two areas.

There were no significant effects of the observer (Figs. 1 and 2) or the side of the tape (data not shown) used for observations on cover values ($p > 0.05$) except for litter cover on the slope. Any differences in litter cover estimates caused by the observer are not considered important because the mean values were less than 1%.

A comparison of cover values between the surface and slope areas reveals that annual grass cover was greater on the slope than on the surface (Fig. 3). Litter cover was much greater on the surface than on the slope while bare ground cover was greater on the slope than on the surface. Total vegetative cover was not significantly *different* between the areas ranging between 10 and 15% (Fig. 3).

Discussion

The major findings of this study were that cover estimation was independent of the observer and that the side of the tape used to estimate cover was immaterial. These findings are in agreement with those of DeWaard (1998).

Total vegetative cover was between 10 and 15% and is only one quarter to one third required to meet WDOH requirements. These low values are because the area had been replanted only a few months before. It is expected that vegetative cover will increase with time as has been noted on covers at the Hanford Reservation (Ward et al. 1997).

Annual grass cover was greater on the slope than on the surface which may be related to some factor favoring annual growth on the slope. The slope faces west and the extra warmth may have improved germination and growth compared with the surface.

Litter was much greater on the surface compared with the slope. This is because straw mulch was not applied on the slope. The lack of straw on the slope is also the cause of greater bare area coverage values than on the surface.

Conclusion

The measurement of cover at the Sherwood Mine is independent of the observer under the conditions of the test. The side of the tape used to measure cover was unimportant.

Acknowledgments

This work was supported by the Washington State Department of Health under a contract with Washington State University. Discussions with Earl Fordham, John Blacklaw, Brad DeWaard and Gary Robertson are appreciated. One half the data was provided by Brad DeWaard.

Literature cited

Bonham, C. D. 1989. Measurements for Terrestrial Vegetation. John Wiley & Sons, New York. Pp. 338.

DeWaard, B. K. 1998. Sherwood monitoring and stabilization plan: Post-reclamation construction monitoring, 1997 vegetation monitoring program. Western Nuclear, Inc., Wellpinit, WA.

Neter, J., W. Wasserman, and M. H. Kutner. 1985. Applied Linear Statistical Models. R. D. Irwin, Inc., Homewood, Ill., Pp. 1127.

Sall, J., Ng, K., and Hecht, M. 1991. Statistical Visualization for the Macintosh (JMP). SAS Institution, Inc., Cary, NC.

Temple, D. M., K. M. Robinson, R. M. Ahring, and A. G. Davis. 1987. Stability design of grass lined open channels. US Department of Agriculture, Agriculture Handbook Number 667.

Ward, A. L., G. W. Gee, and S. O. Link. 1997. Hanford Prototype-Barrier Status Report: FY 1997. PNNL-11789, Pacific Northwest National Laboratory, Richland, Washington.

Figures

Fig. 1. Comparison between observers from the Washington State Department of Health (WDOH) and Western Nuclear Inc. (WNI) of cover measurements on the Sherwood Mine cap surface. Error bars are one standard error of the mean.

Fig. 2. Comparison between observers from the Washington State Department of Health (WDOH) and Western Nuclear Inc. (WNI) of cover measurements on the Sherwood Mine cap slope. Error bars are one standard error of the mean.

Fig. 3. Comparison between study areas of cover measurements at the Sherwood Mine. Error bars are one standard error of the mean. Asterisks indicate significant differences.

Fig.

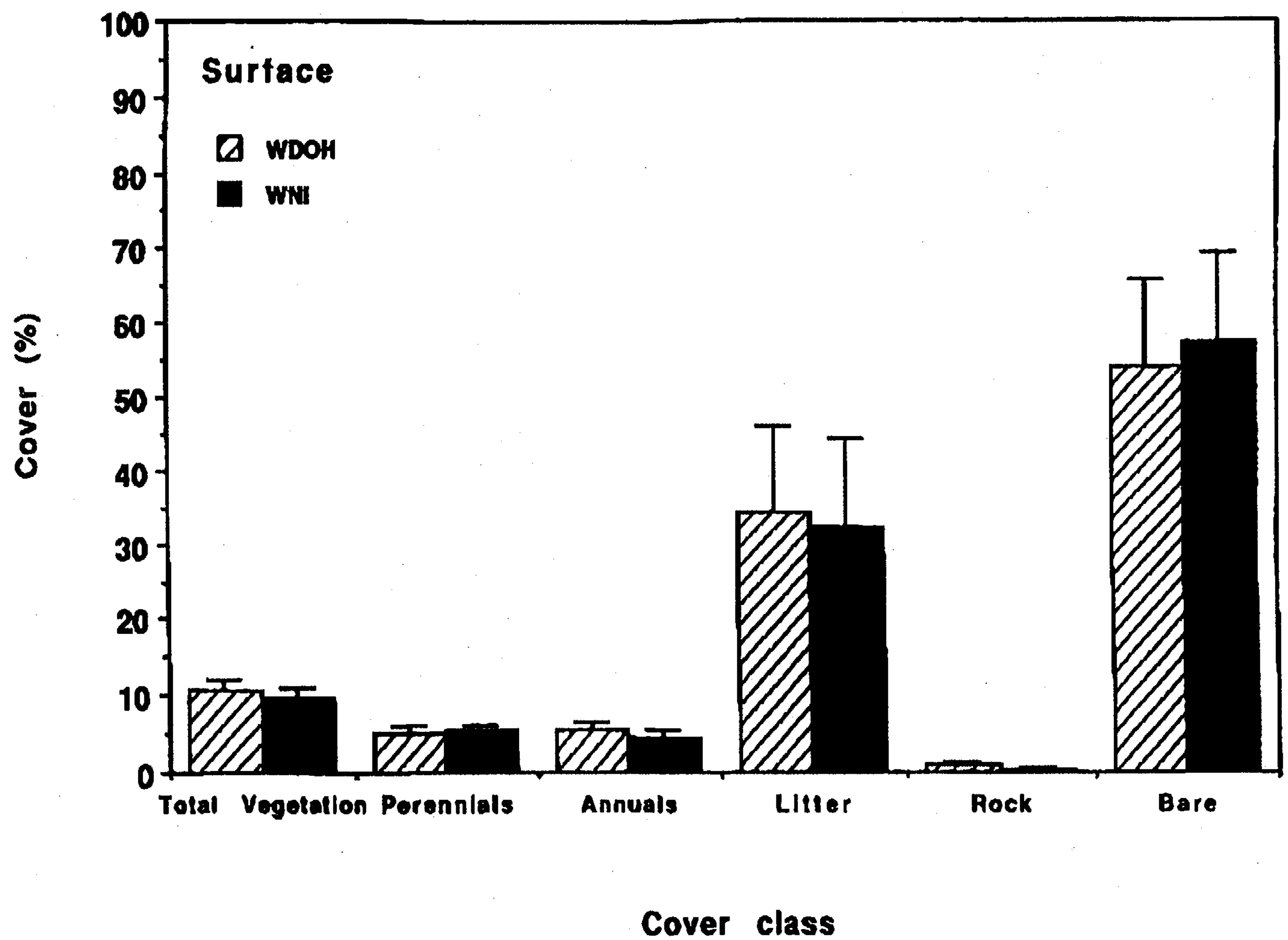

Surface
WDOH
WNI
Cover (%)
0
10
20
30
40
50
60
70
80
90
100
Total Vegetation
Perennials
Annuals
Litter
Rock
Bare
Cover class

Fig 2

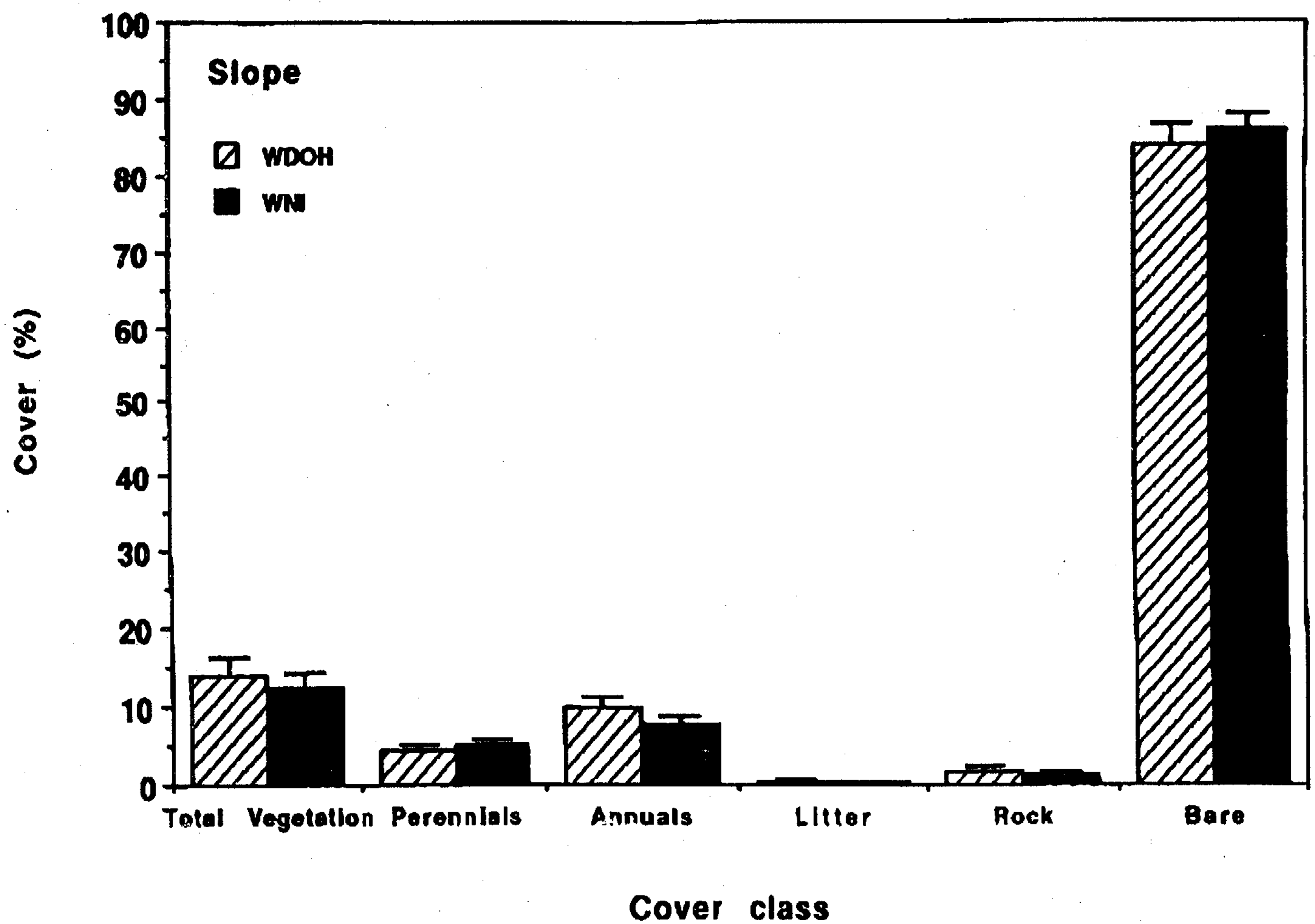
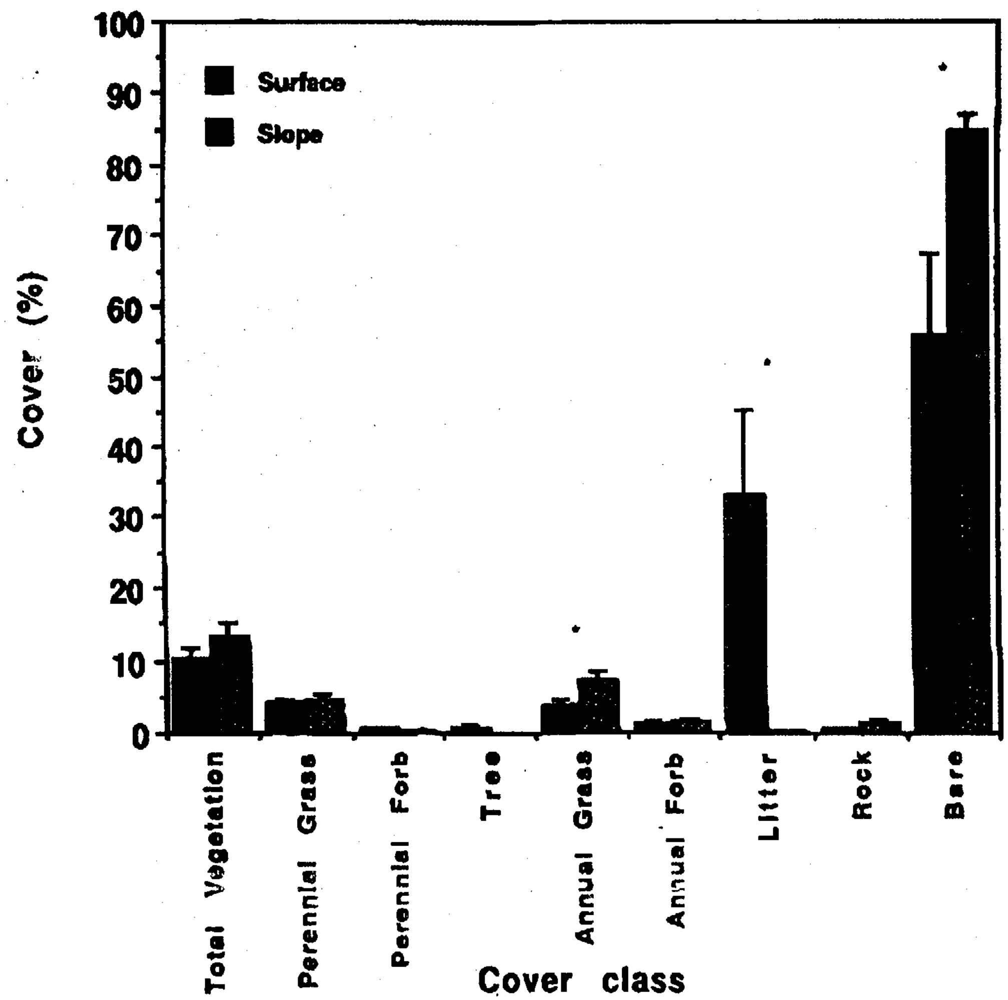

Slope
WDOH
WNI
Cover (%)
100
90
80
70
60
50
40
30
20
10
0
Total Vegetation
Perennials
Annuals
Litter
Rock
Bare
Cover class

Fig 7.


Surface
Slope
Cover (%)
100
90
80
70
60
50
40
30
20
10
0
Total Vegetation
Perennial Grass
Perennial Forb
Tree
Annual Grass
Annual Forb
Litter
Rock
Bare
Cover class

March 22, 1998

Review of the SHERWOOD MONITORING AND STABILIZATION PLAN Post-reclamation Construction Monitoring 1997 VEGETATION MONITORING PROGRAM

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Introduction

The Washington State Department of Health is required to certify that regulations are complied with by the licensee for the Sherwood Reclamation Tailings Pile. The material presented in this document is a review of the SHERWOOD MONITORING AND STABILIZATION PLAN Post-reclamation Construction Monitoring: 1997 VEGETATION MONITORING PROGRAM (DeWaard, B. K. 1998). The plan was written by Western Nuclear, Inc. dated February, 1998. The review supports the Washington State Department of Health in this certification process.

The Sherwood Reclamation Tailings Pile is located near Wellpinit, WA. The tailing's pile is a consequence of the uranium mine's milling process. The pile has been covered by a landfill cover cap. Among the purposes of the cap are the prevention of erosion and the minimization of drainage of precipitation into the waste form. Erosion is controlled by vegetation and rock covers. The beneficial effects of vegetation for landfill cover cap stability have been recognized (Link et al. 1994). The document under review addresses the vegetative cover measurements obtained in 1997.

Review

Title page

Word "stablization" is spelled stabilization

Page 12 Table 2

I noted a few miscalculations and rounding errors in the table. For example with transect ID # 10 perennials WDOH = 3.1 and ANNUALS = 5.3 while the TOTAL is 9.9. The true total is for table 2 is 8.4. The recomputation of the statistics with the correct value did not change the conclusions of the test. Rounding errors also do not lead to changes in conclusions therefore these inconsistencies are not important. Also "perrenial" is correctly spelled as perennial.

Page 5 second paragraph

The WNI estimates ......

If there is no significant difference then any statement suggesting otherwise is misleading and should be dropped. Dropping the comment will not influence the conclusions of DeWaard (1998).

Page 6 second paragraph

The QA/QC sampling .....

I agree (Link 1998).

Table 5

Footnote 2. "k=0.20 (a 20% confidence interval about the mean)" This is incorrect. It should read as "k=0.20 (the average level should accurately represent the true cover average to within ± 20% at the 95% confidence level)". See page 8.15 in Attachment G of Western Nuclear, Inc. (1997). A 20% confidence interval about the mean is less confident than a throw of the dice (50%) so this statement is not really correct here.

Page 7 second paragraph and Table 5

"An additional year of monitoring will be required."

This is wishful thinking. There is no way this supposition can be supported. If cover is not at least as great as 39% in the second year then I suspect at least another year of monitoring will be required. I see this idea stated at the bottom of page 7. OK

Page 7 third paragraph

"The second criteria was not satisfied because no individual transect attained the required 36% cover on all transects ...."

This sentence does not make sense. Reword.

Conclusion

DeWaard (1998) is basically acceptable after the few above comments are addressed.

Literature cited

DeWaard, B. K. 1998. Sherwood monitoring and stabilization plan: Post-reclamation construction monitoring, 1997 vegetation monitoring program. Western Nuclear, Inc., Wellpinit, WA.

Link, S. O. 1998. The Effect of the Observer on Surface Cover Estimates at the Sherwood Mine. (A letter report submitted from WSU-TC to WDOH)

Western Nuclear, Inc. 1997. Sherwood project tailing impoundment monitoring and stabilization plan. Shepherd Miller, Inc., Ft. Collins. September 1997.

*****"The lower limit of the 80% confidence interval about the mean for perennial species cover was 4.5% compared to the 39% cover requirement." 5.1-0.6 = 4.5

Based on this analysis the requirement has not been reached. When the lower limit of the 80% confidence interval about the mean for perennial species cover is greater than 39% then the requirement will have been met. If the standard deviation is independent of the magnitude of the mean then the mean would have to be 39.6 to pass the requirement. 39.6-0.6=39

February 22, 1999

Review of the SHERWOOD MONITORING AND STABILIZATION PLAN Post-reclamation Construction Monitoring 1998 VEGETATION MONITORING PROGRAM

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Introduction

The Washington State Department of Health is required to certify that regulations are complied with by the licensee for the Sherwood Reclamation Tailings Pile. The material presented is a review of DeWaard (1998) entitled "SHERWOOD MONITORING AND STABILIZATION PLAN Post-reclamation Construction Monitoring: 1998 VEGETATION MONITORING PROGRAM". The document was written by Western Nuclear, Inc. and dated October, 1998. This review supports the Washington State Department of Health in the certification process.

The Sherwood Reclamation Tailings Pile is located near Wellpinit, WA. The tailing's pile is a consequence of the uranium mine's milling process. The pile has been covered by a landfill cover cap. Among the purposes of the cap are the prevention of erosion and the minimization of drainage of precipitation into the waste form. Erosion is controlled by vegetation and rock covers. The beneficial effects of vegetation for landfill cover cap stability have been recognized (Link et al. 1994). The document under review addresses the vegetative cover measurements obtained in 1998.

Review

Page 18 Table 2

The row entry third from the bottom of the table is referred to as "t = mean/std.err." This ratio is not used in the body of the text and is superfluous. It is potentially confusing to use "t" for something other than Students t-test. Dropping the row will not influence the conclusions of DeWaard (1998).

Page 7 starting at the second line from the top

QA/QC sampling ..... confidence.

No bias can exist among the samplers if there were no differences among them based on statistical testing. I would suggest changing the first sentence to read, "QA/QC sampling was performed during 1998 and demonstrated that no observer biases exist within the data set." The second sentence can be dropped. If there is no significant difference then any statement suggesting otherwise is misleading.

Page 23 and 24

Footnote 2. "k=0.20 (a 20% confidence interval about the mean)" This is incorrect. It should read as "k=0.20 (the average level should accurately represent the true cover average to within ± 20% at the 95% confidence level)". See page 8.15 in Attachment G of Western Nuclear, Inc. (1997). A 20% confidence interval about the mean is less confident than a throw of the dice (50%) so this statement is not really correct here. My comment here is a repeat of last years comment (Link 1998).

Page 8 last paragraph

"These visuals demonstrate that no specific pattern exists to failed transect values."

The low cover values in the wetland/pond area defined on the map demonstrate a clear and specific pattern of failed transect values. This area is described latter in the document as an area in need of remediation. The statement should be changed to, "These visuals demonstrate that a specific pattern exists to failed transect values." A statement on the pond should follow.

Page 9 third paragraph and Table 7

Statements about comparisons of variances using the F-test would be more informative if the computation of the variance ratios plus the F-test limits were provided.

Conclusion

DeWaard (1998) is basically acceptable after the few above comments are addressed.

Literature cited

DeWaard, B. K. 1998. Sherwood monitoring and stabilization plan: Post-reclamation construction monitoring, 1998 vegetation monitoring program. Western Nuclear, Inc., Wellpinit, WA.

Link, S. O. 1998. Review of the SHERWOOD MONITORING AND STABILIZATION PLAN Post-reclamation Construction Monitoring 1997

VEGETATION MONITORING PROGRAM. Washington State University, Richland, WA., Letter report to the Washington State Department of Health, Olympia, WA, 3 pages.

Western Nuclear, Inc. 1997. Sherwood project tailing impoundment monitoring and stabilization plan. Shepherd Miller, Inc., Ft. Collins. September 1997.

June 29, 1999

Adequacy of the Western Nuclear, Inc. vegetative cover: Areas at risk and methods for revegetation

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Abstract

The objective of this report is to describe areas at risk on the cap and to suggest methods to revegetate those areas. Two areas are considered to be at risk because of difficulty in establishing vegetation. These areas are a ponded depression on the cap surface and scattered areas of monzonite soils on the surface and on the margins. Simple restoration efforts are suggested to establish more vegetation on these sites.

Introduction

The cover cap placed over the Sherwood Mine Tailings area is designed to minimize erosion and infiltration of water to the waste form. The ability of the cap to minimize erosion and the infiltration of water into the waste form depends strongly on the condition of vegetation on the cover. High cover will result in minimal erosion and minimal infiltration. It is important that adequate vegetative cover be maintained on the cap.

The restoration of the cap occurred in 1996 and vegetative cover has been monitored in 1997 and 1998. Adequate vegetative cover has not yet been attained. During the course of my involvement in the monitoring of the cover I have been asked to assess the adequacy of the vegetative cover. A consideration that I have consistently presented is the significance of variation in vegetative cover on the cap. Vegetative cover that is homogeneous (scale dependent) over the entire area of the cap is the desired condition. A homogeneous cover condition would minimize erosion and the risk of infiltration as long as the percent cover is greater than the minimum allowed by the Washington State Department of Health. Areas with less than adequate vegetative cover present a risk for erosion and infiltration. The level of risk is scale dependent. A large area with inadequate cover presents a greater risk than a small area with inadequate cover.

Unfortunately, a homogeneous vegetative cover has not been attained. There is significant variation in vegetative cover across the cap. The appearance of a depression that has become a pond on the surface of the cover has potentially compromised the function of the cover. It has been suggested that the pond presents no risk to the function of the cover because there is a impervious layer beneath the pond. Unfortunately, imperviousness is a fallible characteristic over time. In time water may find a route through the layer and drain to the ground water. Other areas with monzonite soil at the surface have relatively little vegetative cover, but do remain dry during the year.

When I was at the site on July 28, 1998 I expended a small amount of labor to make a cursory survey of the vegetative cover on the cap. The survey occurred after spending most of the time collecting transect data with Brad DeWaard and Nancy Darling. The purpose of the survey was to describe areas at risk.

The objective of this report is to describe areas at risk on the cap and to suggest methods to revegetate those areas.

Areas at risk

On the flat surface two types of areas at risk were recognized. These areas had low vegetative cover. Areas with low vegetative cover were where monzonite soil was at the surface and where there has been an apparent slump on the surface resulting in a large depression and pond.

Areas with monzonite soil at the surface were in small patches located intermittently across the surface examined. The patches were small which means that the area was perhaps on the scale of 10 m^2. This area estimate is based on my recollection. We did not attempt to measure the size of the monzonite patches. We (myself, Brad DeWaard, and Nancy Darling) only walked across a small portion of the cover to examine areas at risk because of monzonite soils. I have to assume that such areas can be found throughout the surface.

The apparent depression on the surface had been a pond earlier in the year 1998. When we examined the area there was no water although the soil was wet. There was very little vegetative material in the depression area. Vegetation around the edge of the depression was relatively lush compared with the rest of the vegetation on the surface.

On the margins there were areas that had some erosion and areas that had monzonite soils at the surface with relatively little vegetation. Areas with erosion had relatively little vegetation.

The vegetative cover and areas at risk were more heterogeneous on the margins than on the flat area.

The areas with monzonite soils at the surface had relatively poor vegetative cover compared with other areas. As we examined these areas we considered reasons for the poor condition of the vegetation. The monzonite soils appeared to me to be a degraded granite that have become a clay. Brad DeWaard remarked that the reason for the poor condition of the vegetation was poor nutritional condition of the monzonite soils. Nancy Darling suggested that these areas suffered from compaction during construction. High compaction can result in surface runoff with little infiltration especially if these soils have a high clay percentage. These conditions alone or in combination can be responsible for poor plant growth. Clays can hold large amounts of water, but much of it is unavailable to plants therefore clay soils can be a water stressed media for plants. Compacted soils are also poor for plant growth because roots have a hard time penetrating dense soils.

The ponded area on the surface had little vegetative cover. This is a result of the stressful conditions that the ephemeral pond creates for plants. The primary reason for the lack of plants in the area is the choice of plants used to revegetate the cover. Plants used to revegetate the cover were those that do well in dryland conditions. I do not think the depression and resulting pond were anticipated by those conducting the revegetation task.

Methods to revegetate areas at risk

I will present a simple approach to revegetate areas at risk. The presentation may be used to compare with the approaches used to revegetate the cover to date.

Ponded depression

It has been recognized that the pond should be minimized. This can be done by adding as much vegetation as possible to use the water and dry the pond. Without effective vegetation the water in the pond will likely remain longer than with effective vegetation. An effort to increase the vegetation in the wetland was initiated by applying seed of various rushes, sedges and shrubs to the area (Brad DeWaard, personal communication). Seeds were applied after July, 1998. Observations indicate that the rushes have established well, the sedges are emerging and there has been little emergence of shrubs to date. It was also noted that a variety of shrubs and trees have established naturally. These include willows and cottonwoods. Given that the pond is still present suggests that more vegetation is needed in the area. There is no guarantee that maximal vegetation in the area will prevent a pond from forming, but it will extract as much water as possible from the area. I suggest that a significant amount of work is required to rapidly and significantly increase vegetative cover in the wetland area.

The steps required to revegetate the ponded area include an initial survey of the similar wetlands near the mine to determine the endpoint of the restoration effort, seed collection, propagation of seedlings for transplantation, site preparation, seed application, planting seedlings, watering, weeding, predator control, and monitoring.

The initial survey of similar ponded areas is needed to determine the structure of a natural area is so that the restoration effort can be designed to match the natural condition. Such a survey includes a species list of vascular plants and a quantification of their numbers. I am not aware of a species list or a quantification of their numbers for similar ponded areas near the site. It may exist. A list (Table 1) of potential species from the Okanogan Highlands for restoration in the ponded area was derived from Stevens and Vanbianchi (1993). Stevens and Vanbianchi (1993) describes restoration of wetlands in Washington.

Table 1. A selection of vascular plant species that may be useful in the ponded area. Plants are of the Okanogan Highlands and are classed by growing condition from wet to dry. The conditions are obligate wetland plants (OBL), facultative wetland plants usually occurring in wetlands (FACW), facultative wetland plants equally likely to occur in wetlands (FAC) and facultative wetland plants that usually occur on dryland, but occasionally occur in wetlands (FACU).

Species	Common name	Growing condition
Trees		
Alnus incana	speckled alder	FACW
Betula occidentalis	water birch	FACW
Crataegus douglasii	black hawthorne	FAC
Populus trichocarpa	black cottonwood	FAC
Populus tremuloides	quaking aspen	FAC
Salix lasiandra	Pacific willow	FACW
Shrubs		
Cornus stolonifera	red osier dogwood	FACW
Physocarpus capitatus	ninebark	FAC
Sambucus cerulea	blue elderberry	FAC
Salix exigua	sandbar willow	OBL
Sambucus racemosa	red elderberry	FACU
Herbs		
Athyrium filix-femina	lady fern	FAC
Carex aperta	Columbia sedge	FACW
Carex nebrascensis	Nebraska sedge	OBL
Carex rostrata	beaked sedge	OBL
Deschampsia caespitosa	tufted hairgrass	FACW
Eleocharis palustris	common spikerush	OBL
Equisetum hyemale	common scouringrush	FACW
Heracleum lanatum	cow parsnip	FAC
Juncus balticus	Baltic rush	OBL
Juncus ensifolius	dagger-leaf rush	FACW
Polygonum spp.	smartweed	FAC-OBL
Sagittaria latifolia	wapato	OBL
Scirpus acutus	hardstem bulrush	OBL
Scirpus validus	hardstem bulrush	OBL
Scirpus cyperinus	wool grass	OBL
Sparaganium eurycarpum	broad-fruited burreed	OBL
Typha latifolia	common cattail	OBL

Local seed needs to collected to retain the local genetic nature of the ecosystem. Once the species to be restored is determined then seed collection can be timed. Native species will ripen at differing times. Adequate local seed may not be available for all desired plants in the amounts needed therefore some seed will need to be purchased.

Propagation of native species depends on the value of seed. If seed is difficult to obtain in number then growing plants to a transplantable size is an efficient use of the seed resource.

There is probably little site surface work required to prepare the area. To apply seed will necessitate roughing the surface in dry areas.

Seed can be applied by hydroseeding in dry areas. Wetland plants can be directly seeded into the water by hand as one walks the edge of the pond. Seed composition should be changed as one moves from wet to dry areas. A significant overlap of dry species should be seeded towards the water. As the size of the pond is reduced dry land species should take over. The seeding effort may have to continue for a few years depending on the success of the restoration effort.

Planting seedlings does not require site preparation here. Planting should be done in the fall to late winter depending on the weather.

Watering can be ignored if the seed and seedlings are in place early in the year.

Weeding can be ignored as long as a sufficient growth is observed for desired plants.

Predator control may be needed to obtain the desired results. There is sufficient browse available in the wetland area to satisfy grazing animals (Brad DeWaard, personal communication). Predator control may be needed for some trees. This can be done with fencing for each tree.

Monitoring is needed to track the development of the restoration effort, to determine when it is done and to recognize problems that need attention. Monitoring for cover of growth forms is sufficient as has been done on the rest of the cover.

Monzonite surface soil patches

Efforts to increase the vegetative cover on the monzonite surface soil patches have included planting bitterbrush. Planting was done after July 1998. Bitterbrush has established well (Brad DeWaard, personal communication). Other vegetation remains sparse.

The steps required to increase vegetative cover on such monzonite soils is similar to that for the ponded area. The steps include an initial survey of the similar monzonite soils, if they exist, near the mine, seed collection, propagation of seedlings for transplantation, site preparation, seed application, planting seedlings, watering, weeding, predator control, and monitoring.

An examination of similar soils with well developed vegetation near the mine will serve to provide a goal for the restoration effort. The survey with a documentation of species and their relative abundance is needed to determine what is likely to grow successfully on monzonite soils on the cap. I have to assume that this has been done or that such soils are not found within reasonable distance from the mine. If such information is not available then plants that can do well on dry land in nutrient poor clays may be the choice. A standard mix of wheatgrasses and clovers has been suggested for bentonite clay soils found in bentonite clay mines (Munshower 1994).

Local seed needs to collected to retain the local genetic nature of the ecosystem. Once the species to be restored is determined then seed collection can be timed. Native species will ripen at differing times. Adequate local seed may not be available for all desired plants in the amounts needed therefore some seed will need to be purchased.

Propagation of native species depends on the value of seed. If seed is difficult to obtain in number then growing plants to a transplantable size is an efficient use of the seed resource.

The soil surface should be roughened to provide a good seed bed before hydroseeding. The soils should also be tested for clay content, bulk density and nutrient levels. If soils are severely compacted then they should be loosened before planting.

Hydroseeding with a nutrient mix will assist plant establishment if the soils are nutrient poor. The seeding effort may have to continue for a few years depending on the success of the restoration effort. Such a hydroseeding effort should be done using a mobile unit on a truck. I believe the existing vegetation will not be severely damaged by this traffic.

Planting seedlings does not require site preparation. Planting should be done in the fall to late winter depending on the weather.

Watering can be ignored if the seed and seedlings are in place early in the year and the year is wet. As the season develops and the soils dry it may be necessary to provide water. This can also be done with a truck.

Weeding can be ignored.

Predator control will not be needed given that there is plentiful vegetation elsewhere on the cap.

Monitoring is needed to track the development of the restoration effort, to determine when it is done and to recognize problems that need attention. Monitoring for cover of growth forms is sufficient as has been done on the rest of the cover.

Literature cited

Munshower, F. F. 1994. Practical Handbook of Disturbed Land Revegetation. Lewis Publishers, Boca Raton, Pp. 265.

Stevens, M. L and R. Vanbianchi. 1993. Restoring wetlands in Washington. A guidebook for wetland restoration, planning and implementation. Washington State Department of Ecology. Publication #93-17.

CENTENNIAL ACCORD
between the
FEDERALLY RECOGNIZED INDIAN TRIBES
in
WASHINGTON STATE
and the
STATE OF WASHINGTON

I. PREAMBLE AND GUIDING PRINCIPLES

This ACCORD dated August 4, 1989, is executed between the federally recognized Indian tribes of Washington signatory to this ACCORD and the State of Washington, through its governor, in order to better achieve mutual goals through an improved relationship between their sovereign governments. This ACCORD provides a framework for that government-to-government relationship and implementation procedures to assure execution of that relationship.

Each Party to this ACCORD respects the sovereignty of the other. The respective sovereignty of the state and each federally recognized tribe provide paramount authority for that party to exist and to govern. The parties share in their relationship particular respect for the values and culture represented by tribal governments. Further, the parties share a desire for a complete accord between the State of Washington and the federally recognized tribes in Washington reflecting a full government-to-government relationship and will work with all elements of state and tribal governments to achieve such an accord.

II. PARTIES

There are twenty-six federally recognized Indian tribes in the state of Washington. Each sovereign tribe has an independent relationship with each other and the state. This ACCORD, provides the framework for that relationship between the state of Washington, through its governor, and the signatory tribes.

The parties recognize that the state of Washington is governed in part by independent state officials. Therefore, although, this ACCORD has been initiated by the signatory tribes and the governor, it welcomes the participation of, inclusion in and execution by chief representatives of all elements of state government so that the government-to-government relationship described herein is completely and broadly implemented between the state and the tribes.

III. PURPOSES AND OBJECTIVES

This ACCORD illustrates the commitment by the parties to implementation of the government-to-government relationship, a relationship reaffirmed as state policy by gubernatorial proclamation January 3, 1989. This relationship respects the sovereign status of the parties, enhances and improves communications between them, and facilitates the resolution of issues.

This ACCORD is intended to build confidence among the parties in the government-to-government relationship by outlining the process for implementing the policy. Not only is this process intended to implement the relationship, but also it is intended to institutionalize it within the organizations represented by the parties. The parties will continue to strive for complete institutionalization of the government-to-government relationship by seeking an accord among all the tribes and all elements of state government.

This ACCORD also commits the parties to the initial tasks that will translate the government-to-government relationship into more-efficient, improved and beneficial services to Indian and non-Indian people. This ACCORD encourages and provides the foundation and framework for specific agreements among the parties outlining specific tasks to address or resolve specific issues.

The parties recognize that implementation of this ACCORD will require a comprehensive educational effort to promote understanding of the government-to-government relationship within their own governmental organizations and with the public.

IV. IMPLEMENTATION PROCESS AND RESPONSIBILITIES

While this ACCORD addresses the relationship between the parties, its ultimate purpose is to improve the services deliv-

ered to people by the parties. Immediately and periodically, the parties shall establish goals for improved services and identify the obstacles to the achievement of those goals. At an annual meeting, the parties will develop joint strategies and specific agreements to outline tasks, overcome obstacles and achieve specific goals.

The parties recognize that a key principle of their relationship is a requirement that individuals working to resolve issues of mutual concern are accountable to act in a manner consistent with this ACCORD.

The state of Washington is organized into a variety of large but separate departments under its governor, other independently elected officials and a variety of boards and commissions. Each tribe, on the other hand, is a unique government organization with different management and decision-making structures.

The chief of staff of the governor of the state of Washington is accountable to the governor for implementation of this ACCORD. State agency directors are accountable to the governor through the chief of staff for the related activities of their agencies. Each director will initiate a procedure within his/her agency by which the government-to-government policy will be implemented. Among other things, these procedures will require persons responsible for dealing with issues of mutual concern to respect the government-to-government relationship within which the issue must be addressed. Each agency will establish a documented plan of accountability and may establish more detailed implementation procedures in subsequent agreements between tribes and the particular agency.

The parties recognize that their relationship will successfully address issues of mutual concern when communication is clear, direct and between persons responsible for addressing the concern. The parties recognize that in state government, accountability is best achieved when this responsibility rests solely within each state agency. Therefore, it is the objective of the state that each particular agency be directly accountable for implementation of the government-to-government relationship in dealing with issues of concern to the parties. Each agency will facilitate this objective by identifying individuals directly responsible for issues of mutual concern.

Each tribe also recognizes that a system of accountability within its organization is critical to successful implementation of the relationship. Therefore, tribal officials will direct their staff to communicate within the spirit of this ACCORD with the particular agency which, under the organization of state government, has the authority and responsibility to deal with the particular issue of concern to the tribe.

In order to accomplish these objectives, each tribe must ensure that its current tribal organization, decision-making process and relevant tribal personnel is known to each state agency with which the tribe is addressing an issue of mutual concern. Further, each tribe may establish a more detailed organizational structure, decision-making process, system of accountability, and other procedures for implementing the government-to-government relationship in subsequent agreements with various state agencies. Finally, each tribe will establish a documented system of accountability.

As a component of the system of accountability within state and tribal governments, the parties will review and evaluate at the annual meeting the implementation of the government-to-government relationship. A management report will be issued summarizing this evaluation and will include joint strategies and specific agreements to outline tasks, overcome obstacles, and achieve specific goals.

The chief of staff also will use his/her organizational discretion to help implement the government-to-government relationship. The Office of Indian Affairs will assist the chief of staff in implementing the government-to-government relationship by providing state agency directors information with which to educate employees and constituent groups as defined in the accountability plan about the requirement of the government-to-government relationship. The Office of Indian Affairs shall also perform other duties as defined by the chief of staff.

V. SOVEREIGNTY and DISCLAIMERS

Each of the parties respects the sovereignty of each other party. In executing this ACCORD, no party waives any rights, including treaty rights, immunities, including sovereign immunities, or jurisdiction. Neither does this ACCORD diminish any rights or protections afforded other Indian persons or entities under state or federal law. Through this ACCORD parties strengthen their collective ability to successfully resolve issues of mutual concern.

While the relationship described by this ACCORD provides increased ability to solve problems, it likely will not result in a resolution of all issues. Therefore, inherent in their relationship is the right of each of the parties to elevate an issue of importance to any decision-making authority of another party, including, where appropriate, that party's executive office.

Signatory parties have executed this ACCORD on the date of August 4, 1989, and agreed to be duly bound by its commitments:

JUL 2 3 1999

DIV. OF RADIATION PROTECTION

STATE OF WASHINGTON

DEPARTMENT OF ECOLOGY

P.O. Box 47600 • Olympia, Washington 98504-7600
(360) 407-6000 • TDD Only (Hearing Impaired) (360) 407-6006

July 19, 1999

Mr. John Blacklaw
Washington Department of Health
Division of Radiation Protection
Airdustrial Park, Building 5
P. O. Box 47827
Olympia, WA 98504-7827

Re: Comments on Riprapped Elements of the Reclaimed Impoundment and Diversion Channel

Dear Mr. Blacklaw:

On June 14, 1999 I met with you and Mr. Earl Fordham to discuss isolated defects in the riprap lining of elements of the reclaimed project. I was shown photographs of three defects:

> Erosion of the cover soil on the riprap lining for the outfall of the reclaimed impoundment area,
>
> Gaps in the riprap lining of the diversion channel floor, and
>
> Erosion of a swale in the northwest corner of the diversion channel that has infilled a portion of the channel base.

My recommendations on addressing those defects are as follows:

Erosion of the cover soil cap on the outfall of the reclaimed impoundment area – The plans called for terminating the downstream end of the riprap armor a maximum of 4.5 feet below finished grade. This involved steepening the slope of the last 30 feet of the armoring layer to provide a maximum burial of 4.5 feet below finished grade. This segment of the riprap was covered with a relatively fine grained soil that was then seeded. The expectation was that the root mass associated with a mature vegetative cover would provide an erosion resistant cap to the fine grained soil. Unfortunately, heavy runoff from the abnormally wet winter immediately following construction occurred before the root system of the vegetative cover had a chance to develop and armor the subgrade. Lacking a protective cover, the fine grained soil layer suffered the creation of a network of erosion channels. The eroded soils were variously washed into the underlying relatively large interstices between pieces of riprap or were transported and deposited in the swale at the toe of the riprap lined segment of the spillway.

It should be understood that this erosion of the cover soil does not pose a threat to the integrity of the underlying riprap layer. It is rather an unsightly situation that gives the appearance of a problem. Thus, your agency faces a decision as to whether other administrative concerns warrant treatment of this "cosmetic damage".

Should your agency elect to minimize further erosion damage, the fine grained soil cover will have to be removed to expose the more erosion resistant riprap layer. This addresses the erosion concern. Unfortunately, exposing the toe of the riprap layer poses an additional concern in that the underlying rock is subject to increased rates of degradation given the greater exposure to extremes of freeze-thaw and wet-dry cycles. These natural processes allow the surficial zone of rock to weather to a soil like medium over time. Eventually, this process could deprive the riprap of its present toe support. If there is actual loss of toe support, the riprap could experience raveling and headward erosion when subjected to intense runoff. To address this issue, it would be prudent to construct a concrete toe support for the downstream end of the riprap. We can assist your agency with conceptual details on such a concrete toe support if topographic and subsurface data are provided of the outfall area of the channel.

Gaps in the riprap lining of the diversion channel – Photos revealed a few isolated areas where the riprap did not form a dense protective blanket. Typically the defects consisted of a few square feet where the blanket was a single rock thick and the rocks were poorly nested together. The lack of intermediate size rocks left relatively large interstitial voids where the underlying filter layer could be seen. In one extreme case, reportedly some 50 square feet of the riprap armoring layer was absent. This situation increases the potential in the immediate area around the poorly graded segments of the lining of increased erosion of the underlying filter and movement of the adjacent riprap. These areas should be reworked to comply with the original specifications for the channel armoring.

Erosion of a swale in the northwest corner of the diversion channel – A swale was cut into the sidewall slope of the diversion channel in the northern end of the "recovery pond area". Reportedly, this swale was not graded appropriately to conduct intercepted runoff from upland areas to a suitable discharge point. Consequently, the swale ponds water during the spring melt. Apparently last spring the ponded water overtopped or breached the sidewall of the swale in one area. The concentrated flow discharged through the breach cut an erosion gully down the sidewall of the channel and dumped appreciable sediments onto the channel floor.

All parties have to recognize that there will be local erosion of the channel sidewalls given the sandy nature of the overburden. To minimize the magnitude of this erosion it is prudent to eliminate any ponding of water on channel sideslopes. Swales that pond water dramatically increase the frequency and erosive power of discharges down the slope over that of sheet flow. Accordingly, it is recommended that the present swale in the northern portion of the diversion channel sidewall be removed. The area should be regraded to eliminate the depression. Unfortunately, regrading the swale area will disturb the developing vegetative cover. To accelerate the "healing" of disturbed areas, it would be prudent to hydroseed all bare soil areas left by the construction. Finally, it would be prudent to remove the accumulation of eroded sediments from within the channel floor. While this is not essential, it would remove one more potential concern that the Nuclear Regulatory Commission might have in reviewing the condition of the facility.

If you have any questions or comments, please call me at (360) 407-6625.

Sincerely,

Jerald LaVassar

Jerald LaVassar, M.S., P.E.
Water Resources Program
Dam Safety Office

JL:jl

cc: Earl Fordham, DOH, Radiation Control Section

John

DEC 2 1 1999

DIV OF RADIATION PROTECTION

STATE OF WASHINGTON

DEPARTMENT OF ECOLOGY

P.O. Box 47600 • Olympia, Washington 98504-7600
(360) 407-6000 • TDD Only (Hearing Impaired) (360) 407-6006

December 16, 1999

John Blacklaw, P.E.
Washington State Department of Health
Division of Radiation Protection
7171 Cleanwater Lane, Bldg. 5
P.O. Box 47827
Olympia, WA 98504-7827

Re: Sherwood Uranium Mill, Spokane Indian Reservation
Hydrologic computations for extreme precipitation events

Dear Mr. Blacklaw:

Attached is a paper copy of my hydrologic computations for the Sherwood project located on the Spokane Indian Reservation northwest of Spokane, Washington. The computations were done on an Excel 97 spreadsheet. Electronic copies were previously transmitted to you on December 6, 1999, for you to forward to the uranium mine's consulting engineers for this project.

These computations follow the procedures described in our Dam Safety Guidelines, Technical Note 3, Design Storm Construction (Schaefer, 1993). The theoretical basis for these procedures is described in Characteristics of Extreme Precipitation Events in Washington State (Schaefer, 1989). Copies of these documents are available from the Dam Safety Office on request. The specific citations for these reference documents are:

Schaefer, M.G. ***Characteristics of Extreme Precipitation Events in Washington State.*** Washington State Department of Ecology Publication No. 89-51. October 1989.

Schaefer, M.G. ***Dam Safety Guidelines, Technical Note 3: Design Storm Construction.*** Washington State Department of Ecology Publication No. 92-55G. April 1993.

Unit hyetographs for our dam safety design storms are given in Technical Note 3. These unit hyetographs are also available in electronic format from the Dam Safety Office. To obtain a specific design storm hyetograph, the procedure is to multiply the unit hyetograph ordinates by the total rainfall depth for the storm of interest. This is typically done within a hydrologic computer model such as HEC-1.

The computations follow Dam Safety's standard procedures for estimating rainfall depths for extreme precipitation events. This information is used in rainfall-runoff computer models to determine the inflow design flood for reservoirs and dams. We typically examine four storm scenarios: short duration, intermediate duration, long duration (intensity focus), and long duration (volume focus). At the same design step, each scenario is equally probable, so our standard practice is to examine all four scenarios to determine which one results in highest water levels in the reservoir and most stress on the dam.

This methodology develops the entire storm hyetograph, so it can be used to determine the entire runoff hydrograph. This methodology should also allow computation of any specific parameter of interest such as total runoff volume, peak runoff discharge, peak rainfall intensity, average rainfall intensity over several time steps, etc. We recommend comparison of all four storm scenarios to determine which one is most critical for the specific criteria to be met.

These documents and computation procedures are fairly specific to Washington State, and may not be commonly used in other states. I have occasion to do these calculations quite frequently for dam safety analyses, and I'm pleased to share them with you and with the mine's engineering consultants to facilitate their hydrologic analyses of the site.

I hope this information is helpful to you and to the mine's consultants. If you or they have any questions, please feel free to call me at (360) 407-6420 or E-mail to mwal461@ecy.wa.gov.

Sincerely,

Martin D. Walther

Martin D. Walther, P.E.
Dam Safety Engineer
Water Resources Program

Enclosures

cc: Doug Johnson, Dam Safety Office

Sherwood Uranium Mill; Spokane Indian Reservation

Worksheet for Computation of 24-hour Precipitation Magnitude-Frequency Curve
Reference: Technical Note 3, worksheet from page B-10
MDW, 12/06/99

Project data:

Location: T 27 N, R 37 E, Section 1
Lat/Long: 47.88 deg. N 118.1 deg. W in Eastern Washington
Climatic Region: 1 (Figure 4 on page 12)
Mean Annual Precip: 20 inches (Isopluvial maps, App. A)
Duration of interest: 24 hours
Design Step: 2 (Worksheet from Tech Note 2)
Drainage area: 1 sq.miles. (Compare to small watershed < 10 sq.miles.)

Parameters for Computation of At-Site Mean:

24-hour, 2-year Partial Duration Value, X_{24} (in.) = 1.4 (Isopluvial maps, App. A)
Regional value of Coefficient of Variation, C_v = 0.33 (Figure 5 on page 13)
Regional value of L-Skewness, T_3 = 0.21 (Figure 6 on page 14)
Frequency factor for 2-year event, K_2 = -0.187 (Table B2, App. B)

Key equations:

At-Site Mean, $X_M = (0.88 * X_{2p}) / [(1 + (K_2 * C_v)]$
where: X_{2p} = 2-year Partial Duration Value (= X_{24} from above)

Quantile estimates: $X_i = X_M * [1 + (K_i * C_v)]$
where: X_i = estimated 24-hour precipitation for selected frequency, inches
K_i = frequency factor for selected frequency (Table B1 or B2, App.B)

Typical precipitation, $P_t = X_{ds}$
where: X_{ds} = quantile estimate X_i for selected design step, inches

Total storm precip = (design precip for 24-hr storm) x (multiplier from mass curve for 72-hr storm)
multiplier for 72-hr intensity storm = 1.3136
multiplier for 72-hr volume storm = 1.5070

At-Site Mean, X_M (inches) = 1.31

Frequency / design step :	2 yr	10 yr	25 yr	100 yr	500 yr	**1000 yr**
Frequency factor, K_i (--) :	-0.187	1.23	2.04	3.39	5.21	6.10
Quantile estimate, X_i (inches) :	1.23	1.85	2.20	2.78	3.57	3.96
Typical precipitation, P_t (in.) :	1.23	1.85	2.20	2.78	3.57	**3.96**
Total precip for intensity storm :	1.62	2.42	2.89	3.65	4.69	**5.20**
Total precip for volume storm :	1.86	2.78	3.31	4.19	5.38	**5.96**

Frequency / design step :	Step 3	Step 4	Step 5	Step 6	Step 7	Step 8
Frequency factor, K_i (--) :	7.72	9.55	11.62	13.96	16.61	19.60
Quantile estimate, X_i (inches) :	4.66	5.45	6.35	7.36	8.51	9.81
Typical precipitation, P_t (in.) :	4.66	5.45	6.35	7.36	8.51	9.81
Total precip for intensity storm :	6.12	7.16	8.34	9.67	11.18	12.88
Total precip for volume storm :	7.02	8.21	9.57	11.09	12.82	14.78

Sherwood Uranium Mill; Spokane Indian Reservation

Worksheet for Computation of 6-hour Precipitation Magnitude-Frequency Curve

Reference: Technical Note 3, worksheet from page B-10

MDW, 12/06/99

Project data:

Location:	T 27 N, R 37 E, Section 1		
Lat/Long:	47.88 deg. N	118.1 deg. W	in Eastern Washington
Climatic Region:	1		(Figure 4 on page 12)
Mean Annual Precip:	20 inches		(Isopluvial maps, App. A)
Duration of interest:	6 hours		
Design Step:	2		(Worksheet from Tech Note 2)
Drainage area:	1 sq.miles.		(Compare to small watershed < 10 sq.miles.)

Parameters for Computation of At-Site Mean:

6-hour, 2-year Partial Duration Value, X_6 (in.)	=	0.8	(Isopluvial maps, App. A)
Regional value of Coefficient of Variation, C_v	=	0.335	(Figure 5 on page 13)
Regional value of L-Skewness, T_3	=	0.210	(Figure 6 on page 14)
Frequency factor for 2-year event, K_2	=	-0.187	(Table B2, App. B)

Key equations:

At-Site Mean, $X_M = (0.88 * X_{2p}) / [(1 + (K_2 * C_v)]$

where: X_{2p} = 2-year Partial Duration Value (= X_6 from above)

Quantile estimates: $X_i = X_M * [1 + (K_i * C_v)]$

where: X_i = estimated 6-hour precipitation for selected frequency, inches

K_i = frequency factor for selected frequency (Table B1 or B2, App.B)

Typical precipitation, $P_t = X_{ds}$

where: X_{ds} = quantile estimate X_i for selected design step, inches

Total storm precip = (design precip for 6-hr storm) x (multiplier from mass curve for 18-hr storm)

multiplier for 18-hr design storm = 1.3680

At-Site Mean, X_M (inches) = 0.75

Frequency / design step :	2 yr	10 yr	25 yr	100 yr	500 yr	**1000 yr**
Frequency factor, K_i (--) :	-0.187	1.23	2.04	3.39	5.21	6.10
Quantile estimate, X_i (inches) :	0.70	1.06	1.26	1.60	2.06	2.29
Typical precipitation, P_t (in.) :	0.70	1.06	1.26	1.60	2.06	**2.29**
Total precip for design storm :	0.96	1.45	1.73	2.19	2.82	**3.13**

Frequency / design step :	Step 3	Step 4	Step 5	Step 6	Step 7	Step 8
Frequency factor, K_i (--) :	7.72	9.55	11.62	13.96	16.61	19.60
Quantile estimate, X_i (inches) :	2.69	3.15	3.67	4.26	4.93	5.68
Typical precipitation, P_t (in.) :	2.69	3.15	3.67	4.26	4.93	5.68
Total precip for design storm :	3.68	4.31	5.03	5.83	6.74	7.77

Sherwood Uranium Mill; Spokane Indian Reservation

Worksheet for Computation of 2-hour Precipitation Magnitude-Frequency Curve
Reference: Technical Note 3, page 11 and worksheet from page B-10

MDW, 12/06/99

Project data:

Location:	T 27 N, R 37 E, Section 1		
Lat/Long:	47.88 deg. N	118.1 deg. W	in Eastern Washington
Basin elevation :	2000 feet		
Climatic Region:	1		(Figure 4 on page 12)
Mean Annual Precip:	20 inches		(Isopluvial maps, App. A)
Duration of interest:	2 hours		
Design Step:	2		(Worksheet from Tech Note 2)
Drainage area:	1 sq.miles.		(Compare to small watershed < 1 sq.mile.)

Parameters for Computation of At-Site Mean:

6-hour, 2-year Partial Duration Value, X_6 (in.) =	0.8	(Isopluvial maps, App. A)
24-hour, 2-year Partial Duration Value, X_{24} (in.) =	1.4	(Isopluvial maps, App. A)
Regional value of Coefficient of Variation, C_v =	0.410	(Figure 5 on page 13)
Regional value of L-Skewness, T_3 =	0.280	(Figure 6 on page 14)
Frequency factor for 2-year event, K_2 =	-0.224	(Table B2, App. B)

Latitude Index, L_1 =	7.88		
Longitude Index L_2 =	18.1		
Elevation Index, Z =	20		
Estimated 2-hour, 2-year Partial Duration Value =		0.45	(Isopluvial maps, App. A)

Key equations :

2-hour, 2-year Partial Duration Value, X_2 :

$$X_2 = A + B*X_6 + C*X_{24} + D*(X_6\text{^}2/X_{24}) + E*Z - F*L_1*L_2$$

where values for A, B, C, D, E and F vary by climatic region as follows:

Region	A	B	C	D	E	F
1	0.014	0.250	0	0.533	0.0008	0
2	0.056	0.278	0.245	0	0	0.0003
3	0.119	0.240	0	0.390	0	0
4	0.122	0.240	0	0.395	0	0
5	0.119	0.240	0	0.390	0	0

At-Site Mean, $X_M = (0.88 * X_{2p}) / [(1 + (K_2 * C_v)]$

where: X_{2p} = 2-year Partial Duration Value (= X_2 from above calculation)

Quantile estimates: $X_i = X_M * [1 + (K_i * C_v)]$

where: X_i = estimated 2-hour precipitation for selected frequency, inches

K_i = frequency factor for selected frequency (Table B1 or B2, App.B)

Typical precipitation, $P_t = X_{ds}$

where: X_{ds} = quantile estimate X_i for selected design step, inches

Sherwood Uranium Mill; Spokane Indian Reservation

Worksheet for Computation of 2-hour Precipitation Magnitude-Frequency Curve
Reference: Technical Note 3, page 11 and worksheet from page B-10

MDW, 12/06/99

Key equations (cont.) :

Total storm precip = (design precip for 2-hr storm) x (multiplier from mass curve for 6-hr storm)

multiplier for 6-hr design storm = 1.0752

2-hour, 2-year Partial Duration Value, X_2 (in.) :

Region	A	B	C	D	E	F
1	0.014	0.250	0	0.533	0.0008	0

X_2 (inches) = 0.47 compares with 0.45 inches estimated from isopluvial map

At-Site Mean, X_M (inches) = 0.46

Frequency / design step :	2 yr	10 yr	25 yr	100 yr	500 yr	**1000 yr**
Frequency factor, K_i (--) :	-0.224	1.11	1.99	3.62	6.16	7.53
Quantile estimate, X_i (inches) :	0.42	0.67	0.83	1.14	1.62	1.88
Typical precipitation, P_t (in.) :	0.42	0.67	0.83	1.14	1.62	**1.88**
Total precip for design storm :	0.45	0.72	0.90	1.23	1.74	**2.02**

Frequency / design step :	Step 3	Step 4	Step 5	Step 6	Step 7	Step 8
Frequency factor, K_i (--) :	10.27	13.71	18.05	23.51	30.38	39.03
Quantile estimate, X_i (inches) :	2.39	3.04	3.86	4.88	6.18	7.80
Typical precipitation, P_t (in.) :	2.39	3.04	3.86	4.88	6.18	7.80
Total precip for design storm :	2.57	3.27	4.15	5.25	6.64	8.39

[End]

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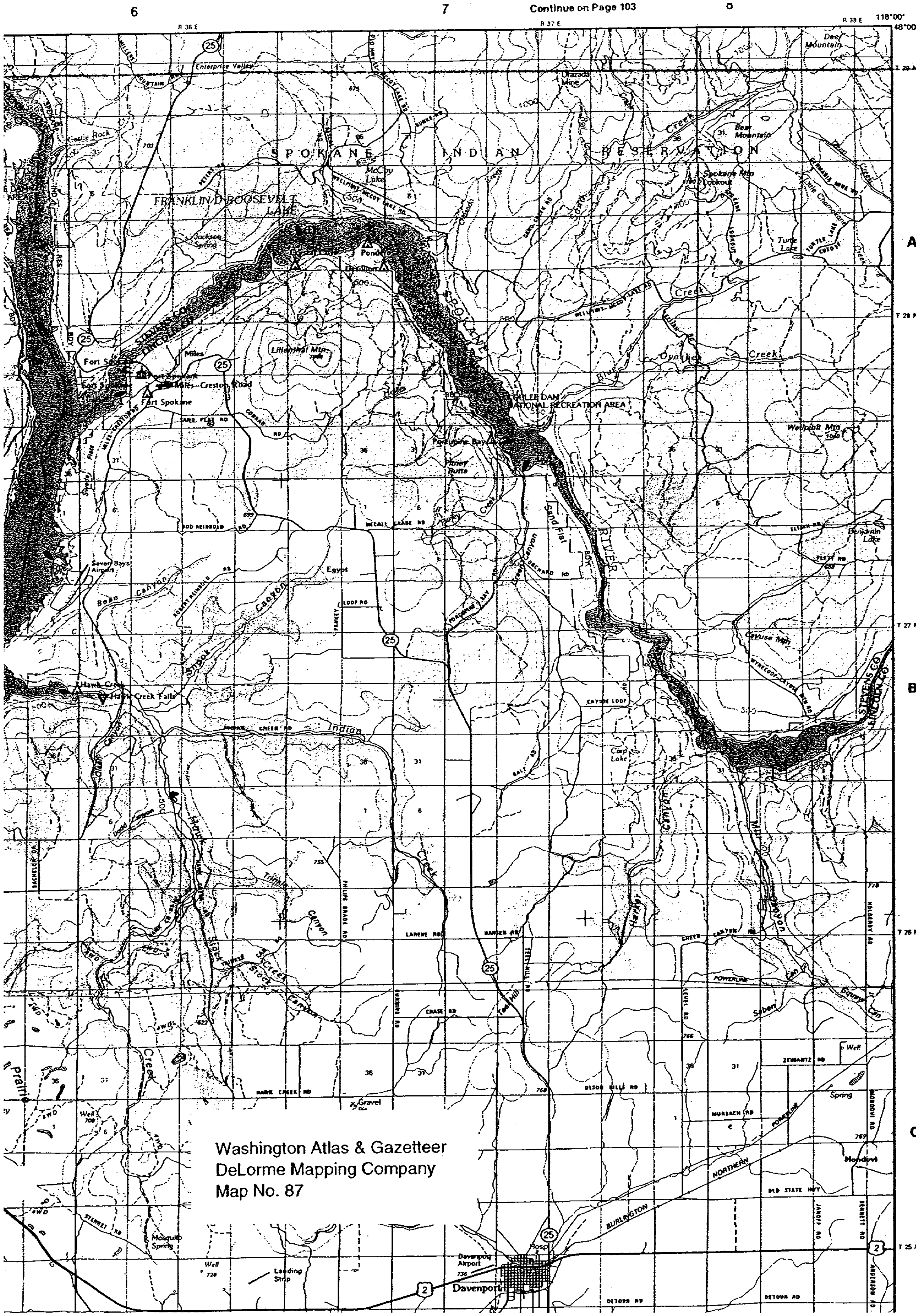

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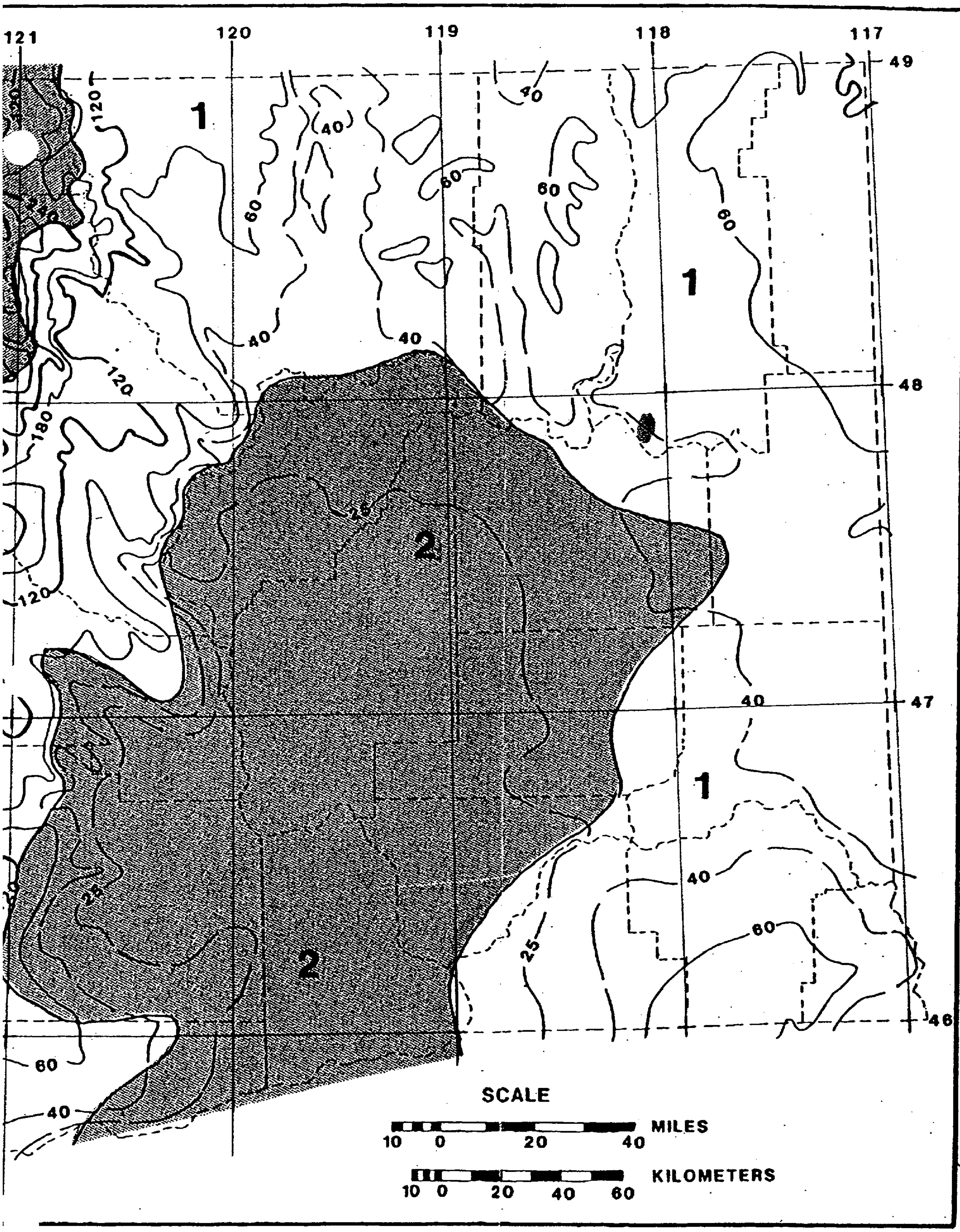

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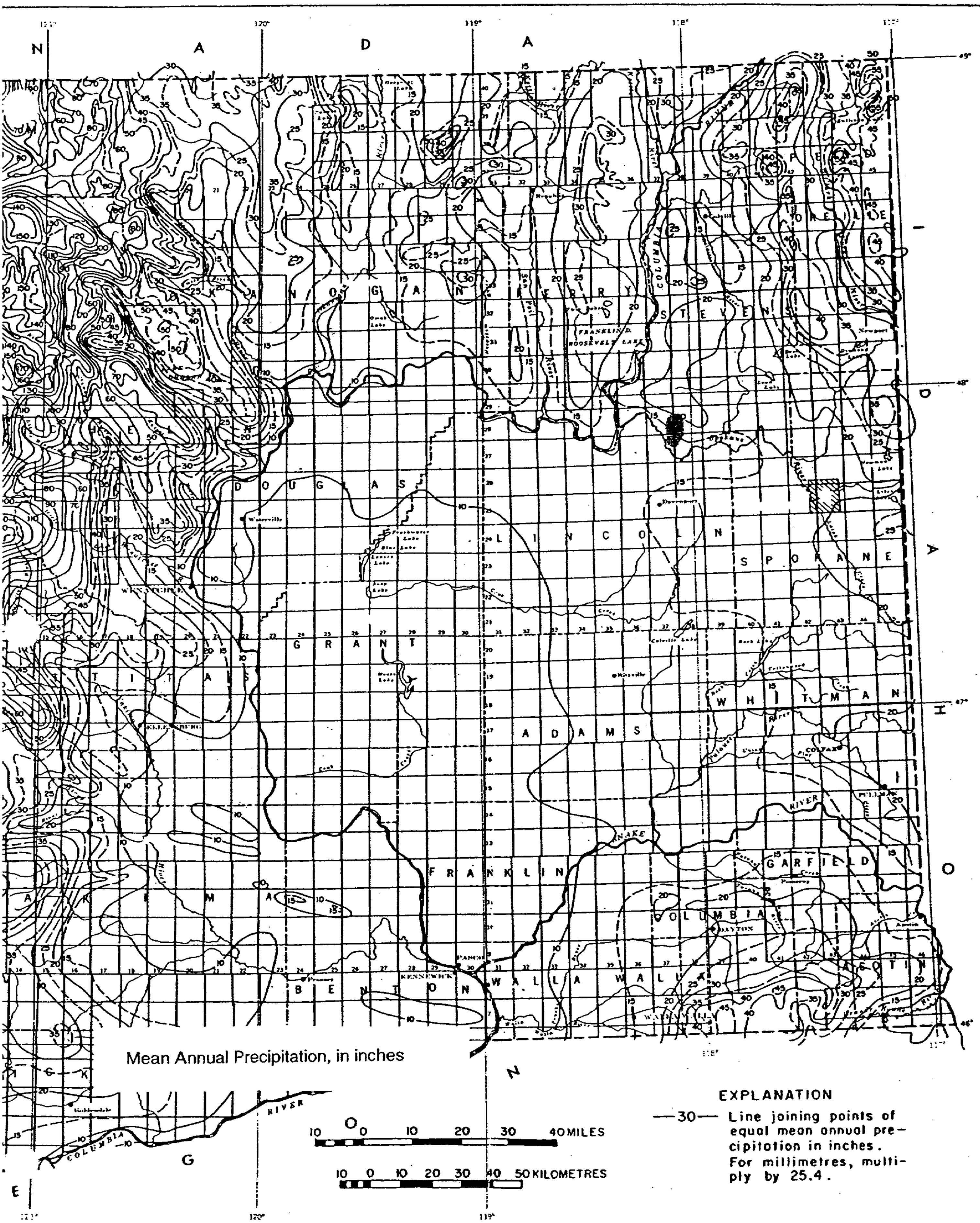

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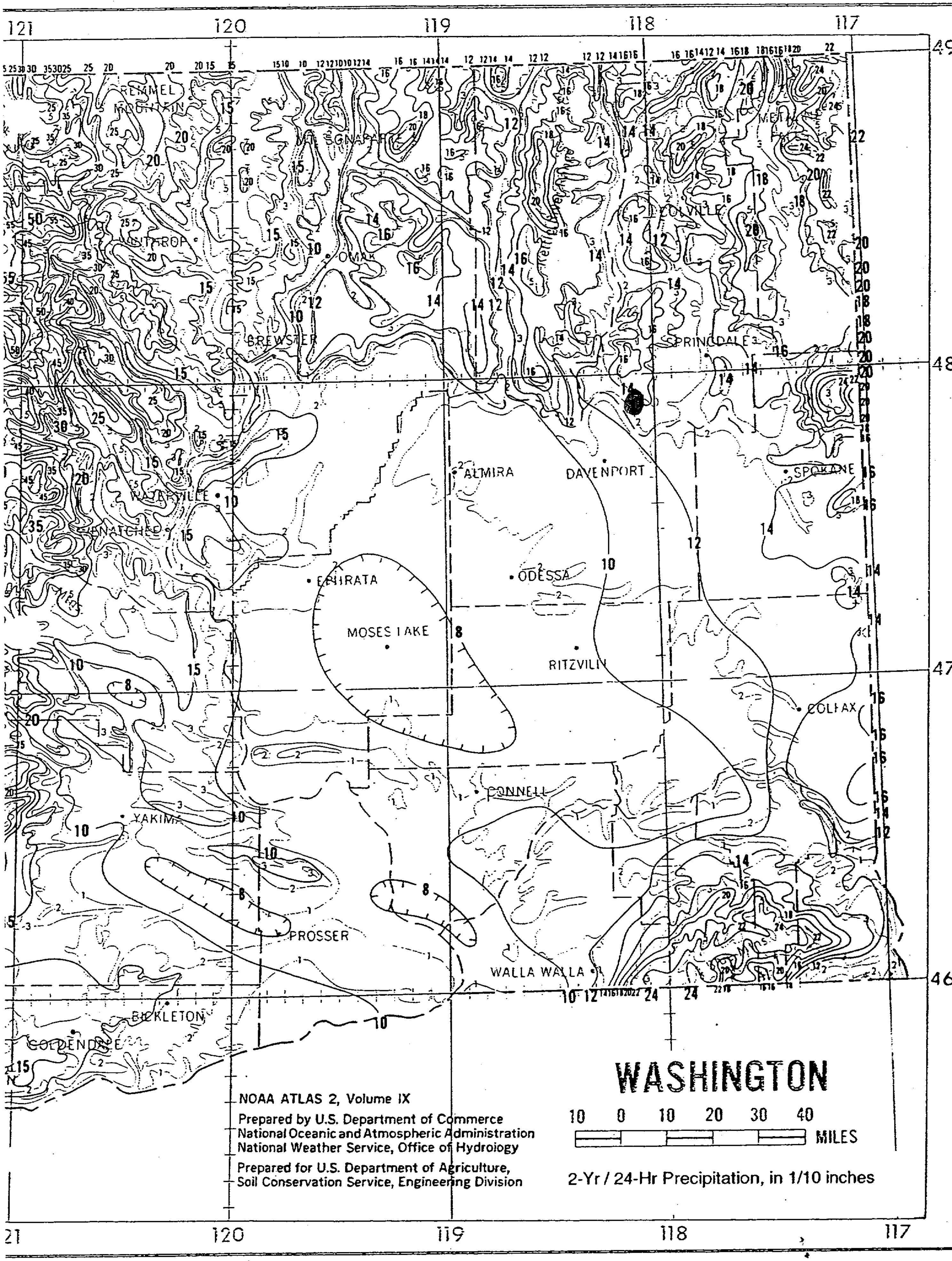

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REMMEL MOUNTAIN
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WALLA WALLA
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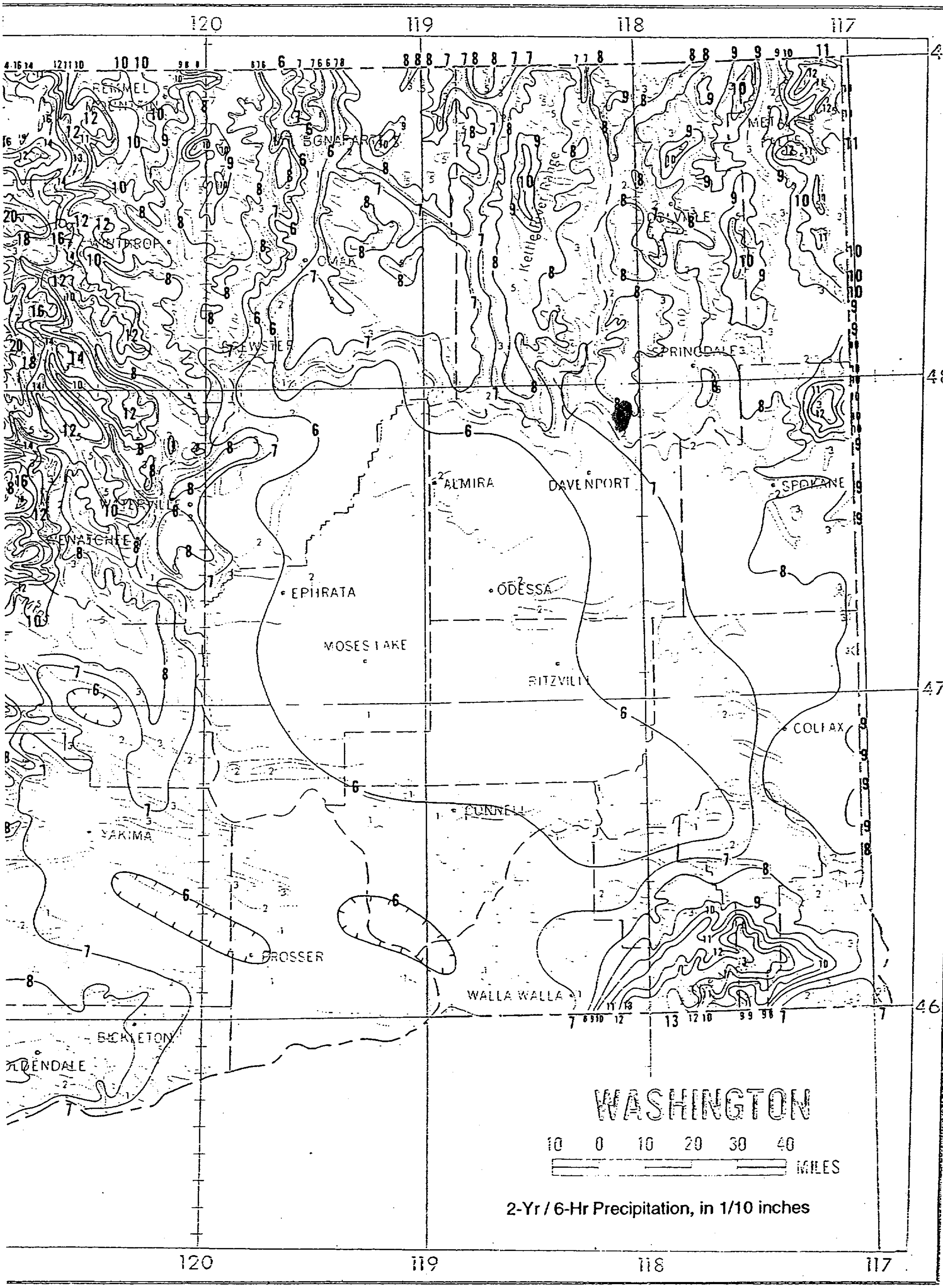
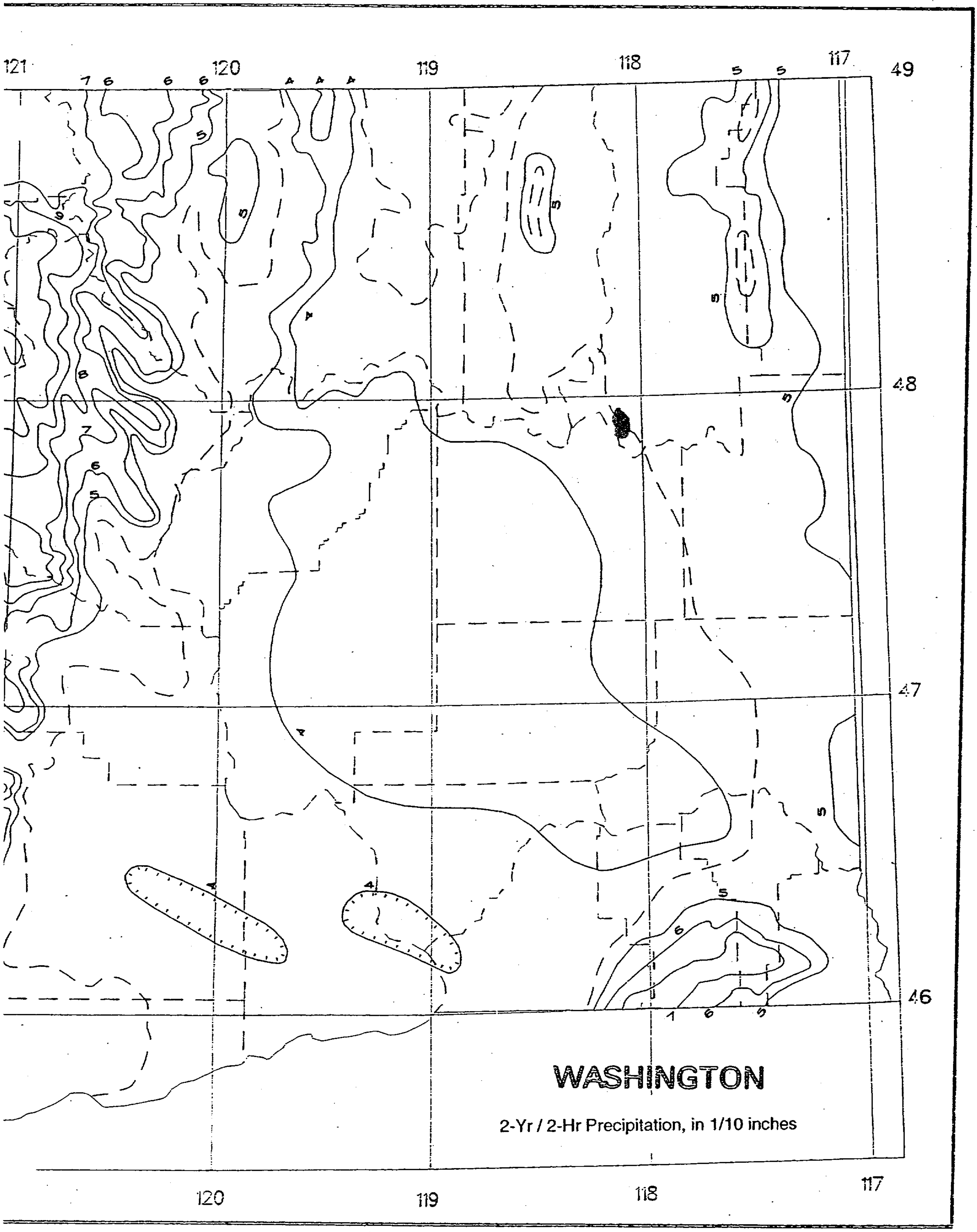
MILES
NOAA ATLAS 2, Volume IX
Prepared by U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service, Office of Hydrology
Prepared for U.S. Department of Agriculture,
Soil Conservation Service, Engineering Division
2-Yr / 24-Hr Precipitation, in 1/10 inches



2-Yr / 6-Hr Precipitation, in 1/10 inches


WASHINGTON
2-Yr / 2-Hr Precipitation, in 1/10 inches
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STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
P.O. Box 47600 • Olympia, Washington 98504-7600
(360) 407-6000 • TDD Only (Hearing Impaired) (360) 407-6006

January 19, 2000

Mr. John Blacklaw, P.E.
Washington State Department of Health
Division of Radiation Protection
7171 Cleanwater Lane, Bldg. 5
P.O. Box 47827
Olympia, WA 98504-7827

Re: Sherwood Project – 1/12/2000 DOH Soil Erosion Stability Inspection Report

Dear Mr. Blacklaw,

Your January 12, 2000 memorandum details the manner in which concerns with the lining of the diversion channel and the outfall of the reclaimed impoundment were addressed. I did not observe the remedial work but, your description of the work is consistent with the engineering recommendations expressed in my July 19, 1999 letter. There were three issues of note.

Erosion of the cover soil cap on the outfall of the reclaimed impoundment– As noted in my July 19th memorandum, this erosion was unsightly but not a threat to the structural integrity of the buried riprap lining. Thus, while actions could be taken to dress the area; no reworking of the area was necessary. The owner elected to forego reworking the area.

Gaps in the riprap lining of the diversion channel – Locally, the lining had small deficiencies. These included the absence or inadequate thickness of riprap, undersized rock and improperly placed rock. In the latter case the rock particles were not placed in a manner to yield a dense, erosion resistant lining. These deficiencies were reported reworked to bring the lining into uniform compliance with the original specifications.

Erosion associated with a swale in the northwest corner of the diversion channel - A swale on the diversion channel sideslope intercepted runoff and channeled that runoff to a depression on the slope. This depression lacked a suitable outfall. The depression reportedly overtopped, eroded the channel slope and dumped the eroded sediments onto the diversion channel floor. The problem has been addressed by eliminating the swale to facilitate sheet flow of runoff.

The recent remedial work satisfactorily addressed concerns with the diversion channel and reclaimed pond outfall. If you have any comments, please call me at (360) 407-6625.

Sincerely,

Jerald LaVassar, M.S., P.E.
Water Resources Program
Dam Safety Office

JL:jl

STATE OF WASHINGTON
DEPARTMENT OF HEALTH
DIVISION OF RADIATION PROTECTION
Airdustrial Center, Bldg. 5 • P.O. Box 47827 • Olympia, Washington 98504-7827

w.D.8.e

FILE COPY

April 10, 1996

Stephanie J. Baker
Manager, Environmental Services
Western Nuclear, Inc.
200 Union Blvd., Suite 300
Lakewood, Colorado 80228

Dear Ms. Baker:

The department has completed staff review of the petrographic analyses, samples, and evaluations you provided in support of construction rock qualification. The department concurs that the quarry source for quartz monzonite from the mine face provides a "fair" and passing qualification based on NRC evaluation methodology. Please see the enclosed memorandum and review comments and/or call Dorothy Stoffel at (509) 456-3166, if you have questions.

When available, please provide rock durability test results for the department's final review and approval of the rock source. Earl Fordham at (509) 377-3869 is our staff lead for this review. Please contact him directly if you have questions.

Sincerely,

John R. Blacklaw

John R. Blacklaw, P.E.
Environmental Engineer

Enclosure

cc: Warren Seyler, Spokane Tribal Business Council
Alfred Peone, BIA, WA
Stanley Speaks, BIA, OR
Gerald LaVassar, WDOE
Lou Miller, SMI
Gary Robertson

DEPARTMENT OF HEALTH
Environmental Health Programs
Division of Radiation Protection

April 9, 1996

TO: John Blacklaw
Earl Fordham

FROM: Dorothy B. Stoffel

SUBJECT: COMPLETION OF WNI PETROGRAPHIC ANALYSES REVIEW

I have completed my review of the Petrographic Analyses of three quartz monzonite samples, prepared by Theodore P. Paster and dated January 11, 1996. The three quartz monzonite samples were taken from the proposed rock quarry site, located at the mine. I have also reviewed the evaluation of the petrographic analyses prepared by Shepherd Miller, Inc., dated February 6, 1996. My review of the petrographic analyses and evaluation was supplemented with review of pertinent sections from the following documents:

- Best, Myron G., Igneous and Metamorphic Petrology, W.H. Freeman and Company, New York.

- Deer, W. A., R.A. Howie, J. Zussman, An Introduction to the Rock Forming Minerals, John Wiley and Sons Inc., New York.

- U.S. Nuclear Regulatory Commission, Staff Technical Position on Testing and Inspection Plans During Construction of DOE's Remedial Action at Inactive Uranium Mill Tailing Sites, Revision 2, January 1989.

- U.S. Nuclear Regulatory Commission, Final Staff Technical Position Design of Erosion Protection Covers for Stabilization of Uranium Mill Tailings Sites, August 1990.

After detailed review of the text and photo micrographs prepared by Dr. Paster, I concur with the evaluation submitted by Shepherd Miller that the rock samples score at least "fair" according to the U.S. NRC procedures. The petrographic analyses also indicate an absence of smectites or expanding lattice clays, which is consistent with what is known about quartz monzonite. According to NUREG 4620, the rock quality score associated with these quartz monzonite samples is "fair", and therefore, pass the petrographic requirements of the rock quality criteria for use as rip rap.

In order to more fully evaluate the suitability of the proposed rock for use as rip rap, I examined the rock outcrop at the proposed quarry site on March 11, 1996 (WDOH Construction Inspection Report, March 11, 1996). In general, the quartz monzonite is very competent and uniform in appearance (i.e., lack of dikes, biotite rich zones, clay weathering, or other fracture zone weathering features.

STATE OF WASHINGTON
DEPARTMENT OF HEALTH
DIVISION OF RADIATION PROTECTION
Airdustrial Center, Bldg. 5 • P.O. Box 47827 • Olympia, Washington 98504-7827

April 12, 1996

Stephanie J. Baker
Manager, Environmental Services
Western Nuclear, Inc.
200 Union Blvd., Suite 300
Lakewood, Colorado 80228

Dear Ms. Baker:

As a result of an electronic error, Dorothy Stoffel's Petrographic Analysis review memorandum enclosed with our April 10 letter to you was truncated. Therefore, disregard that memo in favor of the one enclosed with this letter. The complete memo more fully justifies the department evaluation and conclusions.

If you have questions, please contact Dorothy Stoffel at (509) 456-3166.

Sincerely,

John R. Blacklaw, P.E.
Environmental Engineer

Enclosure

cc: Warren Seyler, Spokane Tribal Business Council
Alfred Peone, BIA, WA
Stanley Speaks, BIA, OR
Gerald LaVassar, WDOE
Lou Miller, SMI
Gary Robertson

DEPARTMENT OF HEALTH
Environmental Health Programs
Division of Radiation Protection

April 12, 1996

TO: John Blacklaw
Earl Fordham

FROM: Dorothy B. Stoffel

SUBJECT: COMPLETION OF WNI PETROGRAPHIC ANALYSES REVIEW

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In order to more fully evaluate the suitability of the proposed rock for use as rip rap, I examined the rock outcrop at the proposed quarry site on March 11, 1996 (WDOH Construction Inspection Report, March 11, 1996). In general, the quartz monzonite is very competent and uniform in appearance (i.e., lack of dikes, biotite rich zones, clay weathering, or other fracture zone weathering features). I pounded on the rock outcrop, as well as boulders that are present as talus at the toe of the rock face, with a small sledge hammer. The rock did not break with the sledge. The rock appears to have crystals that are well cemented, with biotite or muscovite (i.e., sheet silicates) not being a factor in the matrix that influences rock competency.

I did observe some areas of the rock face that display intense areas of jointing. Rock hand specimens from this area did exhibit a high degree of fracturing that would influence the competency of the rock to make the required larger rock sizes. However, I believe that this rock will segregate from the suitable rock during blasting. I anticipate that there may be a significant amount of waste rock generated in the more fractured zones of the proposed quarry. I discussed the issue of sufficient rock volume with Corn Abeyta. He has evaluated the projected volume requirements and has determined that there is sufficient volume at the proposed rock quarry site for their riprap needs.

It is my understanding that additional rock durability test data have not been submitted yet for our review. Because the rating associated with the petrographic analyses is "fair", it is my recommendation that the final determination of the suitability of this quarry not be made until all of the rock durability test results have been submitted and evaluated. A determination related to the need for rock oversizing can best be made when the additional test results have been submitted and evaluated.

DBS:krf

WESTERN NUCLEAR, INC.

UNION PLAZA SUITE 300, 200 UNION BOULEVARD, LAKEWOOD, COLORADO 80228
TELECOPIER (303) 989-8993 TELEPHONE (303) 989-8675

RECEIVED

FEB 0 7 1996

DIV. OF RADIATION PROTECTION

February 5, 1996

Mr. Gary Robertson, Head
Waste Management Section
Washington Department of Health
Division of Radiation Protection
Airdustrial Park, Bldg. 5
P.O. Box 47827
Olympia, WA 98504-7827

RE: WN-I0133-1, SHERWOOD PROJECT, TAILING RECLAMATION PLAN, ROCK PETROGRAPHIC ANALYSIS

Dear Mr. Robertson:

As discussed during our January 24-25, 1996 meeting, please find attached the petrographic analysis and associated engineering evaluation regarding the rock from the proposed rock quarry, situated in the Western Nuclear, Inc. Sherwood mine area, that will be used for erosional stability during the forthcoming 1996 tailing reclamation construction.

In accordance with our July 20-21, 1995 and other recent discussions, seven [7] copies of this submittal are being transmitted to you in Olympia. We would appreciate if you would transmit the copies as you previously indicated, as listed below:

- Spokane Tribe of Indians (1 copy)
- Bureau of Indian Affairs (1 copy)
- Nuclear Regulatory Commission (1 copy)
- Clean file copy (1 copy)
- WDOH [Olympia, WA] (3 copies)

In addition, copies are being transmitted directly to the following parties:

o Two copies of this particular submittal are being sent by WNI directly to Ms. Stoffel [WDOH; Spokane, WA].

o One [1] copy is being sent directly to Mr. Fordham [WDOH; Richland, WA].

We request your prompt review and approval of the attached information, so that permitting and quarrying of the rock borrow source may be completed as soon as possible in support of the forthcoming reclamation construction season.

Should you have any questions, please contact us at your earliest convenience.

Sincerely,

Stephanie J. Baker
Manager of Environmental Services
SJB/tic doh\rockpetr.f96

w/enclosures

cc: CA [w/ attach.]
KCB [w/o attach.]
MAP [w/o attach.]
L. Pruett, Esq. [w/ attach.]
LLM [SMI; w/ attach.]
D. Stoffel [WDOH; w/ attach.]
E. Fordham [WDOH; w/ attach.]

SHEPHERD MILLER
INCORPORATED

February 6, 1996

SMI #03-317

Ms. Stephanie Baker
Western Nuclear, Inc.
Union Plaza
200 Union Boulevard, Suite 300
Lakewood, Colorado 80228

Dear Stephanie:

Enclosed you will find the results of petrographic analysis performed on the three rock samples Corn Abeyta collected from the proposed quartz monzonite quarry near the mine. These analyses, performed by Dr. Theodore Pastor, provided the data necessary to evaluate the rock samples durability relative to NRC guidance. The analyses did not indicate any smectite or expanding lattice clays in any of the samples.

These results have been evaluated relative to the guidelines presented in the NRC "Staff Technical Position - Design of Erosion Protection for Stabilization of Uranium Mill Tailings Sites," August, 1990 and NUREG 4620 "Methodologies for Evaluating Long-Term Stability of Uranium Mill Tailing Impoundments," 1986.

Based upon Dr. Pastor's analyses we found the following:

1) The quartz monzonite samples would be classified in group 2 according to Table 6.1 from NUREG 4620 since they are coarser grained felsic granites.

2) The samples would be classified as fair according to Table 6.4 from NUREG 4620 as they are in group 2, exhibit no significant weathering, and only have trace amounts of clay.

The Staff Technical Position indicates that rock must score at least "fair" according to the procedures presented in NUREG 4620. The appropriate pages from both the STP and NUREG 4620 are attached.

Since the analyses did not identify any smectites or expanding lattice clays and the rock quality score is "fair" (Table 6.4 from NUREG 4620), the quartz monzonite samples pass the petrographic requirements of the rock quality criteria for use as riprap.

Consulting Environmental & Geotechnical Engineers & Scientists

1600 Specht Point Dr., Suite F
Fort Collins, CO 80525
Phone (970) 484-4414
Fax (970) 484-7540

If you have any question or need additional information, please contact me at your convenience.

Sincerely,

SHEPHERD MILLER, INC.

Louis Miller/mp

Louis L. Miller, P.E.
Vice President

LLM:mmp
Enclosures

cc: Corn Abeyta w/enclosures

THEODORE P. PASTER, Ph.D.
Consultant
11425 East Cimmarron Drive
Englewood, Colorado 80111
(303) 771-8219

January 11, 1996

Lawrence E. Fiske
Shepherd Miller, Incorporated
1600 Specht Point Drive, Ste. F.
Fort Collins, CO. 80525

RE: Petrography of Three Quartz Monzonite Samples.

SUMMARY

Rock Type and Composition
The three samples are fresh quartz monzonite with the same mineralogy and composition (**TABLE 1**). They differ in grain size. A complete description is given in **APPENDIX I**.

Weathering
The samples are unweathered.

Secondary Alteration
Some minor (up to 15%) disseminated white mica alteration occurs in the plagioclase (Pl). Carbonate occurs as disseminations and in fractures in Pl in sample C. The magnetite (Mt) in the rocks is partially replaced by hematite. All of this alteration is minor.

Fractures
Some moderately spaced micro-fractures are present in the larger Pl crystals. Through-going fractures were not seen in the oversized thin sections.

Respectfully submitted:

INTRODUCTION

Three rock samples were sent to this laboratory by Shepherd Miller, Incorporated (SMI) for petrographic analyses.

The samples were selected by SMI as being representative of degree of weathering and alteration of the rock to be used as rip rap. The primary focus of this description is to include:

1) Bulk composition.
2) Secondary minerals and weathering.

SAMPLES

The three samples from SMI are labeled: SM-A, SM-B and SM-C. One double-fisted-sized hand specimen of each sample was received. The samples are uniform (Except for their porphyritictexture.) and non-fractured megascopically. They contain 2.5- 6.0" - spaced joints which are not visibly weathered either megascopically or microscopically.

An over-sized thin section measuring 2" x 2" was cut from each sample to minimize the effect of the coarse crystal size of the rock.

RESULTS

TABLE 1 gives the mineralogy and composition of the rocks. **APPENDIX** I gives a detailed petrographic description of the samples. Inasmuch as the three samples are the same rock, the description applies to all samples.

TABLE 1
MINERALOGY OF 3 QUARTZ MONZONITE SAMPLES
(for SMI)

	percent of mineral			
mineral	SM-A	SM-B	SM-C	average
Quartz	35.9 ±3.6	34.5 ±3.9	32.3 ±4.0	34.4 ±6.6
Plagioclase (Pl)	34.5 ±3.6	31.7 ±3.8	32.9 ±4.0	33.1 ±6.6
Carbonate in Pl	0.7 ±0.7	0	0	-
Microperthite	24.8 ±3.2	29.0 ±3.7	26.6 ±3.7	26.7 ±6.1
Biotite (Bt)	3.6 ±1.4	2.4 ±1.3	3.4 ±1.5	
Chlorite from Bt	0.8 ±0.7	0.7 ±0.7	2.3 ±1.3	4.8 ±3.2
Muscovite from Bt	0.3 ±0.3	1.0 ±0.8	0.5 ±0.5	
Magnetite	0.1 ±0.1	0.7 ±0.7	1.6 ±1.1	-
Hematite	-	-	0.4 ±0.4	-
totals	100.0	100.0	100.0	99.0

****

Rock Type

All samples are quartz monzonite as indicated in the average column of the table. The samples have the same mineralogy within counting statistics.

Grain Size
There is some variability in grain size among the samples. From coarsest to finest average grain size the samples are; B, C and A.

Weathering
There is no significant weathering in the samples.

Alteration
Sample C contains a trace of clay in short, discontinuous fractures in Pl. This clay appears to be a deuteric rather than a weathering product. Hematite does not stain the rocks and whatever is present is a partial deuteric oxidation product of Mt. A small amount of carbonate occurs as disseminated patches in Pl in sample A.

Fractures
Fracturing in thin section is mostly healed except for that in Pl where it is moderate. In other words, fracturing is not continuous across mineral grain boundaries.

APPENDIX I
PETROGRAPHIC DESCRIPTION

SM-A, B, and C; Fresh Quartz Monzonite.

34.4%	Quartz (Q)	0.6-8.0mm	Commonly in clumps of equant anhedra. Non-strained but commonly with mutual sutured boundaries. Contain discontinuous, partly healed occasional fractures spaced 1-3mm. Rarely contain small inclusions of biotite which is partly altered to chlorite or muscovite.
33.1%	Plagioclase (Pl, An_{36})	0.4-7.0mm	Subhedra and smaller euhedra as inclusions in K-spar. Larger crystals are fractured. Fractures contain clay in C and carbonate in A. Many contain up to 15% muscovite alteration in disseminated patches.
26.7%	Microperthite (K-spar)	0.6-20mm	Poikilitic, fresh anhedra with 3-10%, 0.06-1.5mm, inclusions of anhedral Q, magnetite, biotite and euhedral crystals of Pl. Occasionally 5% altered to disseminated flakes of white mica. Non-fractured. Often contains incipient alteration.
4.8%	Biotite (Bt)	0.04-1.6mm	Anhedral blocky books. 20-30% replaced by chlorite >> muscovite.
tr	Magnetite (Mt)	0.02-0.5mm	An-Subhedra in clusters. Interstitial to silicates and occasionally included in perthite. Partly altered to Ht.

The rock has a porphyritic texture with larger crystals of K-spar and clumps of Q surrounded by smaller groundmass crystals of all minerals. Pl is occasionally as phenos.

a & b) SM-A; a is plane polarized light (pl) and b is crossed polarized light (xpl); Same view in both photos. Note pencil-lined 8mm grid used in counting which is evident in all photos. Quartz (Q) is colorless in a and polycrystalline as shown in b. Note mostly healed fractures in Q. In "a" plagioclase (Pl) is moderately fractured with sharp to fuzzy lines and patches. Perthite (K) is variably colored with fuzzy brown to tan patches of incipient alteration. Biotite (Bt) is small brown to black subhedral books interstitial to other minerals. Pink mineral in NE corner of b is secondary muscovite (Ms) after Bt.

c & d) SM-A; a is pl and b is xpl; same view in both photos. Non-homogeneity of section in a is shown here where field of view mostly large crystals of colorless Q and K-spar. Small euhedral Pl inclusions are in K-spar and some are marked with arrows in c.

a & b) SM-B; a is pl and b is xpl; same view in both photos. In contrast to a and K-spar in c & d, p. 6. This set of photos shows predominately Q and Pl. Black Bt and magnetite (Mt) are concentrated in center E quarter of photo a.

c & d) SM-C; c is pl and d is xpl; same view in both photos upper portion of photo affords excellent view of white microperthitic inclusions of Pl in K-spar. Below the K-spar is finer-grained cluster of silicate/Mt+Ht which more or less represents the fine-grained portion of the porphyry.

PETROGRAPHIC ABBREVIATIONS

Ab = albite
Act = actinolite
Ad = adularia
Amph = amphibole
An = anorthite
Ap = apatite
Aspy = arsenopyrite
Ba = barite
Bn = bornite
Bt = biotite
Cal = calcite
Car = carrollite
Carb = carbonate
Ch = chrysocolla
Chl = chlorite
Cv = covellite
Di = diopside
Dm = dumortierite
Dol = dolomite
Ep = epidote
F = feldspar
FM = ferromagnesian
Ga = galena
Gn = gneiss
Gp = graphite
Gr = garnet
Gt = goethite
Hb = hornblende
Ht = hematite
Il = illite
Ilm = ilmenite
K-spar = potassium feldspar
Lm = limonite
Lx = leucoxene
Mo = molybdenite
Mont = montmorillonite
Ms = muscovite
Mt = magnetite
pl = plane polarized light
Pl = plagioclase
Po = pyrrhotite
pts = polished thin section
Px = pyroxene
Py = pyrite
Q = quartz
Rt = rutile
Sp = sphalerite
Sph = sphene
Tm = tourmaline
ts = thin section
u = micron
WM = white mica
xpl = crossed polarized light
Zr = zircon

FINAL

STAFF TECHNICAL POSITION

DESIGN OF EROSION PROTECTION COVERS FOR STABILIZATION OF URANIUM MILL TAILINGS SITES

U. S. Nuclear Regulatory Commission

August 1990

6.3 Recommendations

Based on the performance histories of various rock types and the overall intent of achieving long-term stability, the following recommendations should be considered in assessing rock quality and determining riprap requirements for a particular design.

1. The rock that is to be used should first be qualitatively rated at least "fair" in a petrographic examination conducted by a geologist or engineer experienced in petrographic analysis. See NUREG/CR-4620, Table 6.4 (see Ref. D2), for general guidance on qualitative petrographic ratings. In addition, if a rock contains smectites or expanding lattice clay minerals, it will not be acceptable.

2. An occasionally-saturated area is defined as an area with underlying filter blankets and slopes that provide good drainage and are steep enough to preclude ponding, considering differential settlement, and are located well above normal groundwater levels; otherwise, the area is classified as frequently-saturated. Natural channels and relatively flat man-made diversion channels should be classified as frequently-saturated. Generally, any toe or apron located below grade should be classified as frequently-saturated; such toes and aprons are considered to be poorly-drained in most cases.

3. Using the scoring criteria given in Table D1, the results of a durability test determines the score; this score is then multiplied by the weighting factor for the particular rock type. The final rating should be calculated as the percentage of the maximum possible score for all durability tests that were performed. See example of procedure application for additional guidance on determining final rating.

4. For final selection and oversizing, the rating may be based on the durability tests indicated in the scoring criteria. Other tests may also

NUREG/CR-4620
ORNL/TM-10067

Methodologies for Evaluating Long-Term Stabilization Designs of Uranium Mill Tailings Impoundments

Manuscript Completed: May 1986
Date Published: June 1986

Prepared by
J. D. Nelson, S. R. Abt, R. L. Volpe, D. van Zyl, Colorado State University
N. E. Hinkle, W. P. Staub, Oak Ridge National Laboratory

Colorado State University
Fort Collins, CO 80523

Under Contract to:
Oak Ridge National Laboratory
Oak Ridge, TN 37831

Prepared for
Division of Waste Management
Office of Nuclear Material Safety and Safeguards
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555
NRC FIN B0279

relatively resistant to weathering. Table 6.1 lists these rocks in three priority groupings. Groups 1 and 2 are igneous and metamorphic rocks of preferred and acceptable rank, respectively. Group 3 rocks are carbonates which are vulnerable to decomposition in an acidic environment and are not generally recommended for frequently saturated areas.

Table 6.1 Rock Priority Groupings for External Use as Building Stone

Group	Type
1	Quartzites, noncalcareous slates, fine- to medium-grained felsic granites or granitic gneisses
2	Coarser grained granites or gneisses, dense basalts/or diabases
3	Marbles, limestones, dolomites

Source: Jahns, 1982

6.3.1.1 Prospecting

Extensive data files are available for locating suitable and accessible igneous and metamorphic rock quarries in the western United States. Among them are the open-file data of the U.S. Army Corps of Engineers and the U.S. Bureau of Reclamation (USBR). A limited amount of data may also be available from various state highway departments. These data provide quarry location, petrographic analyses, results of various durability tests, and intended uses for the rock. Also, Esmiol (1968) provides an analysis of performance of riprap at 149 USBR dams. It should be possible to identify several candidate sources of durable riprap within 100 km of a mill tailings site.

It may not be practical to open a new quarry closer than an existing quarry in cases where relatively small quantities of riprap are required. Exploration and development costs would likely exceed the savings in transportation costs that might be achieved from hauling a relatively small volume of rock.

6.3.1.2 Selection

Foley's slake-abrasion test should be used to qualify rock for more extensive testing for long-term durability. Candidate sources of riprap can then be compared with one another by examining the results of standard durability tests. At the present time the USBR routinely performs petrographic analysis, specific gravity, absorption, the sulfate soundness, freeze-thaw, and Los Angeles abrasion tests (see Appendix B for details). Table 6.2 is a list of acceptance criteria for USBR routine tests (DePuy and Ensign, 1965). The Corps of Engineers also performs the above tests

Table 6.4 Additional Petrographic Analysis Acceptance Criteria

Criteria	Quality: Poor (N=1)[a]	Fair (N=2)	Good (N=3)
Bulk composition[b]	Group 3, other	Group 2	Group 1
Secondary minerals and weathering	Smectites and thick weathering rinds[c]	Other clays and thin weathering rinds	No clays no weathering rinds

[a]Quality scores
[b]Groups 1, 2, and 3 rocks, see Table 6.1
[c]Greater than 1 cm thick

Acceptance criteria are tentative at this time. The maximum test score for the complete set of seven tests in Tables 6.2 to 6.4 is 17.25. It is suggested that if a riprap source has a test score exceeding 80% of the maximum possible score, it would be considered conditionally acceptable for use on frequently saturated areas. To be accepted, a sample would be required to score higher than 16.2 for the complete set of tests in Tables 6.2 to 6.4. A sample calculation is presented in Appendix C.

X-ray diffraction analysis should be performed on all candidate sources of riprap being seriously considered for use in frequently saturated environments. If smectite clay minerals or carbonate minerals are identified by X-ray diffraction analysis, further chemical tests may be necessary. The ethylene glycol test is used in many Corps of Engineer districts when the presence of smectites is suspected (Lutton et al, 1981). Joints in rocks are often sealed by secondary mineralization. Carbonate mineralization is the second most common form of secondary mineralization (quartz veins being most common). Their presence could be ascertained by placing fairly large rock specimens in a strongly acidic solution. Reaction to either ethylene glycol or acid and marginally acceptable performance in physical durability tests should result in exclusion from frequently saturated areas.

6.3.1.3 Design Modifications

For frequently saturated areas, project design modifications are sometimes possible to make use of rock containing carbonates or rock that is marginally acceptable as indicated by physical durability tests. Table 6.5 lists design modifications for various test results.

W.D. 12.e

Washington State Department of Health
Division of Radiation Protection
Waste Management Section

JOHN ROLAND BLACKLAW
STATE OF WASHINGTON
30030
REGISTERED
PROFESSIONAL ENGINEER
EXPIRES 2/3/98

June 10, 1997

To: Gary Robertson

From: John Blacklaw, P.E.

Subject: **Photo Reconnaissance of Sherwood Uranium Mill site, conducted May 27 - 28, 1997.**

On May 27 and 28, 1997, a walking inspection of the Sherwood Uranium Mill site was conducted. Photographs were taken to document the condition of the site at the time. A soil sample was taken.

The site was recently reclaimed by placement in excess of 13 feet of native soils over uranium tailings ponds, construction of a flood diversion channel, revegetation of all disturbed surfaces and other features in a large construction project. Construction activities were completed November 1, 1996.

After winter weather, the vegetation has recently begun to develop. The generally unprotected soil surface has experienced some erosion from the winter and spring runoff. Some of the larger erosion features were repaired by minor cat work of the areas affected and reseeded. The technique generally used was to traverse the area with the cat in a pattern to work down local erosion and rills, thus compacting the surface and leaving the cat tracks (lug pattern) in opposition to the natural flow of runoff. This method has been generally effective and although it disturbs the new vegetation, it is only partially destruction and leaves a pattern of depressions that enhances seedling development. Since early spring rework, some local and minor erosion remains evident. The photo reconnaissance indicates the location and extent of the vegetation and erosion at the time of the inspection.

Vegetation is in an early spring development stage as a result of unusually wet and cool spring weather. Soil moisture is good and should sustain the vegetation well into maturity, assuming normal summer weather prevails.

Areas that appear to need evaluation and may need erosion protection and/or rework are at the diversion channel outfall, at the South~~east~~west margin between the impoundment and truck shop access road, and on the inside curve of the ~~east~~ west margin. Other areas may also need review and/or rework, since the walking inspection did not encompass the entire site or in sufficient detail to identify all potential areas of special interest. Also, the site is expected to develop with time and will generally improve as the vegetation develops. This inspection is a "snap shot" of the conditions at the time.

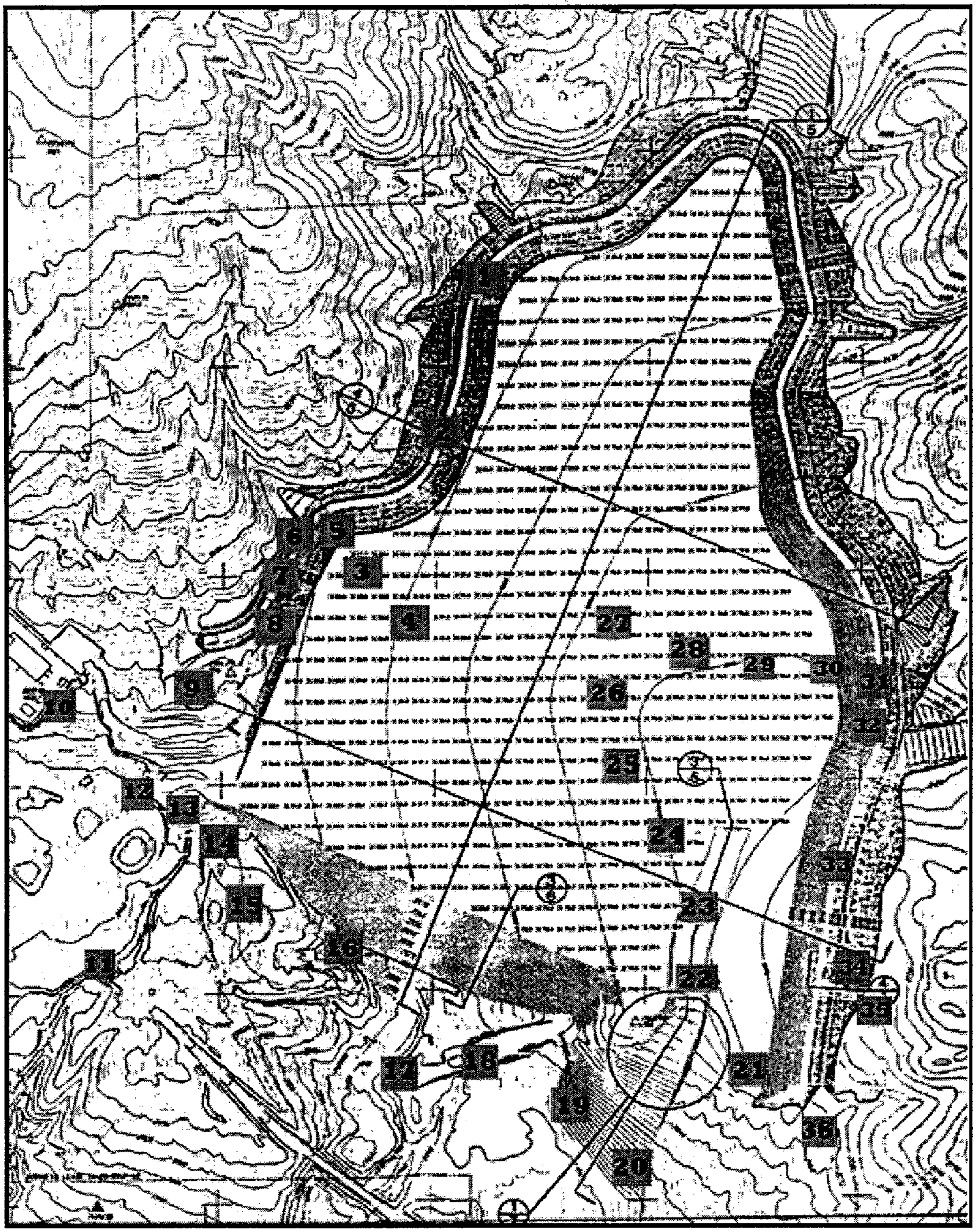
During the inspection, it was evident that there is considerable activity at the site to review and evaluate site performance and to take any actions necessary to assure performance. Sheila Pachernegg, P.E., an engineering consultant for Western Nuclear, Inc., was on-site performing an inspection for structural integrity. Earl Fordham from our office reviewed the rock protection and evaluated vegetation performance at the site. Brad DeWaard and Corn Abeyta, from Western Nuclear, Inc., were on-site and available for review and clarification of Western Nuclear, Inc. activities and plans.

The soil sample was taken on the inside curvature of the east margin at about midslope. The sample was taken about 6 inches deep in an area that showed appreciable erosion and rill cutting in narrow but deep patterns. The soil appears to be composed of very fine sands to fine sands with little silts and no clays. A small protion of litter is evident. The fine nature of the soil and lack of a cohesive component (no clays) makes the soil susceptible to erosion. The location is in an area of 3H:1V slope on an inside curve with a slight flow concentration. The erosion is evident from top to bottom of slope and appears to start at relatively minor concentration features at the top of the slope. This area needs to be watched closely and may need to have enhances stabilizing features applied.

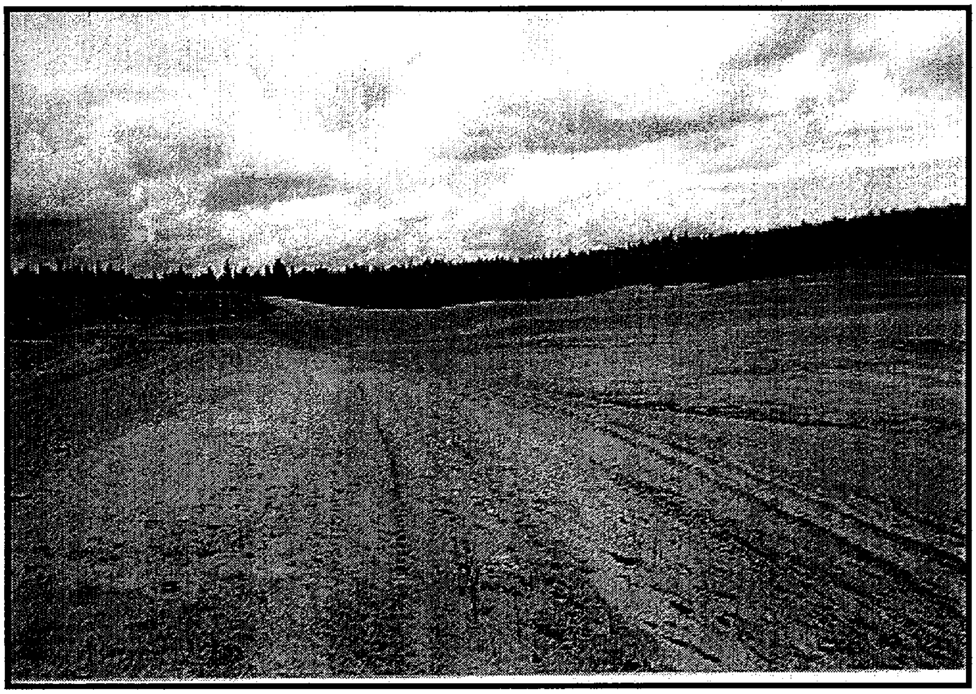
See the attached topographic map with location identifiers and the photo image printouts for the locations shown. Photo captions describe photo image content. The soil sample was taken at location 5, as identified on the topographic map and shown in the photographic images.

Management Review by: Gary Robertson

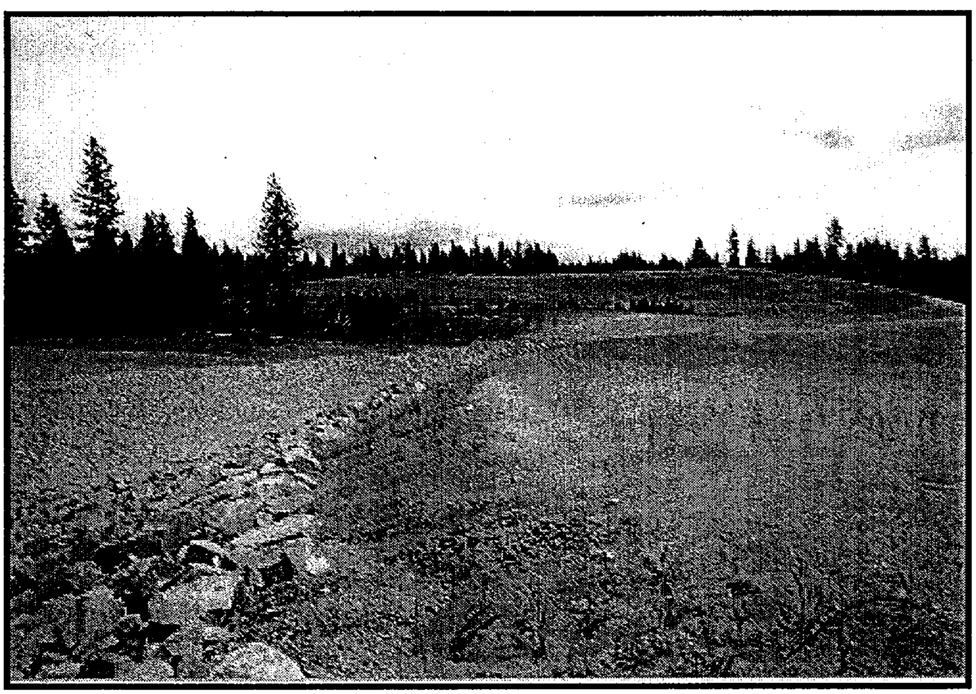
Gary Robertson, Head, Waste Management Section



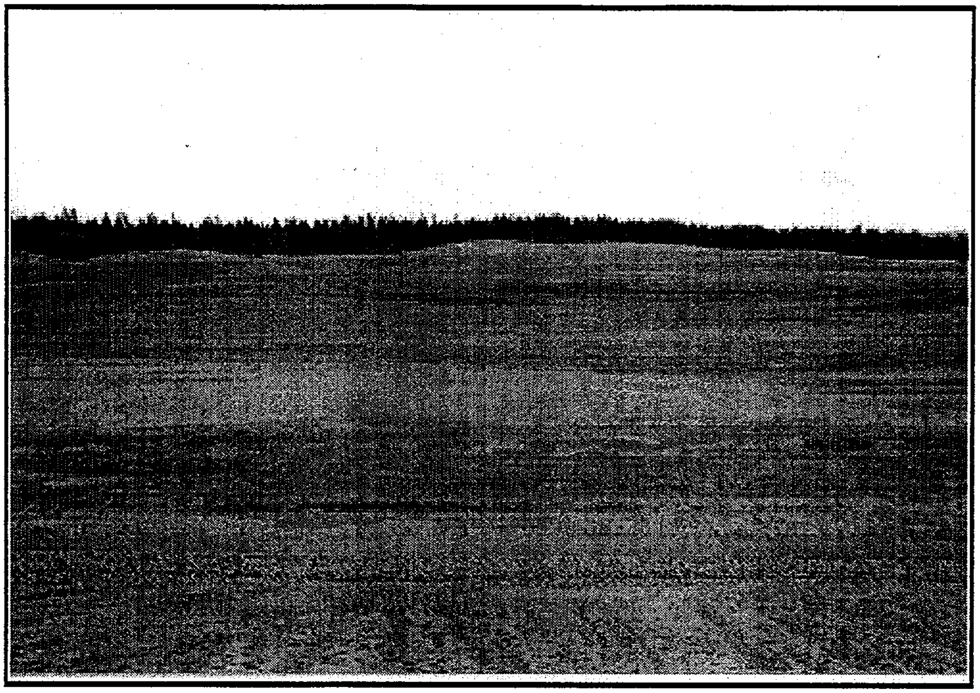
Sherwood Uranium Mill Site
Photo Reconnaissance
May 27 - 28, 1997



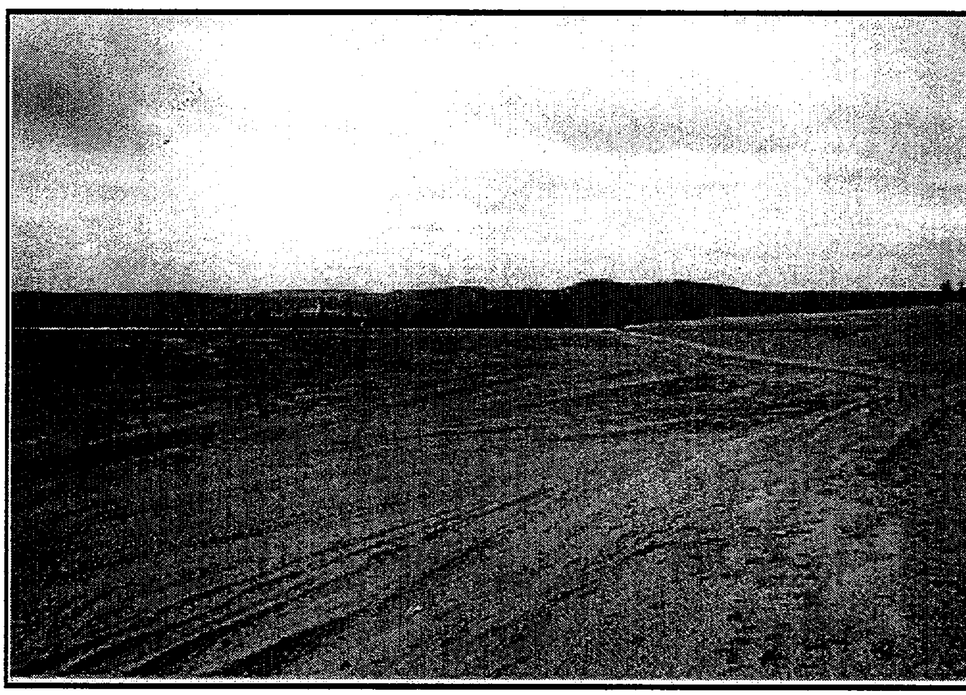
Location 1, looking N from top of dike.



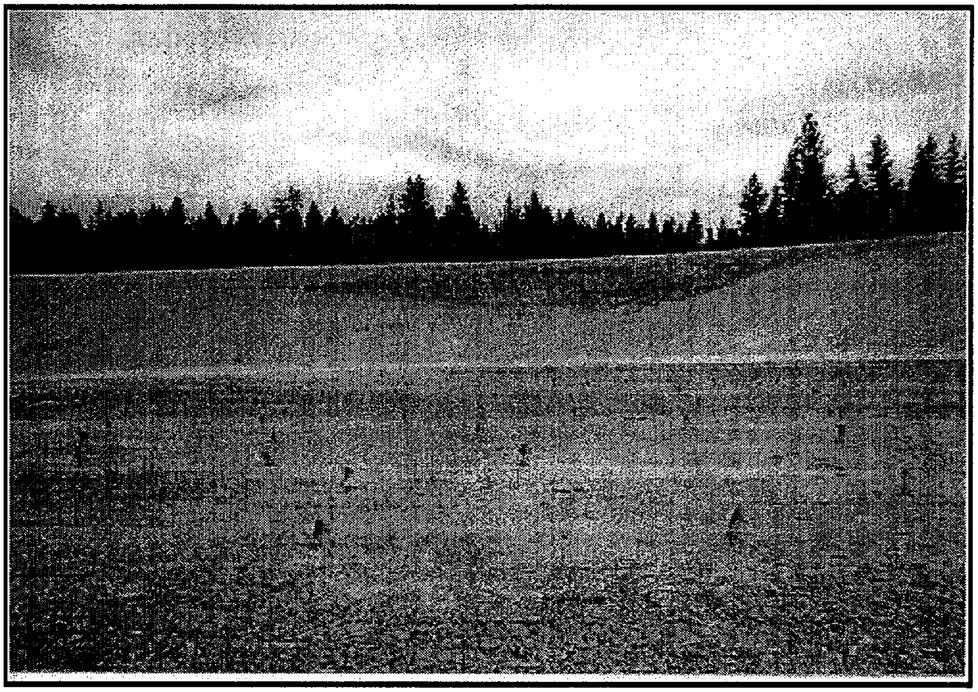
Location 2, looking N from E side of top of dike, diversion channel on left side.



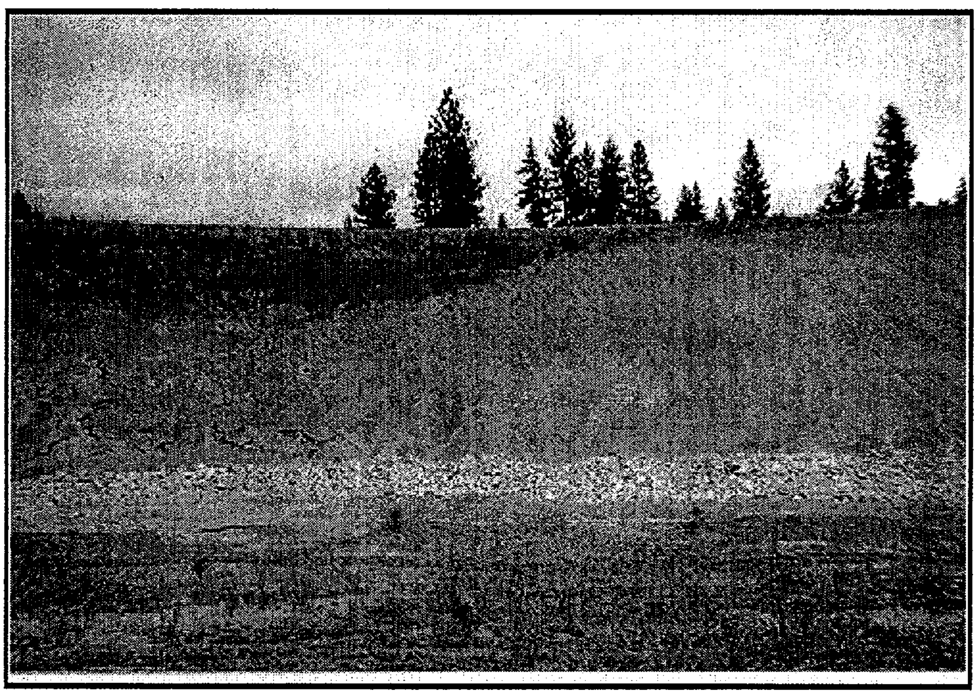
Location 2, looking SW from top of dike.



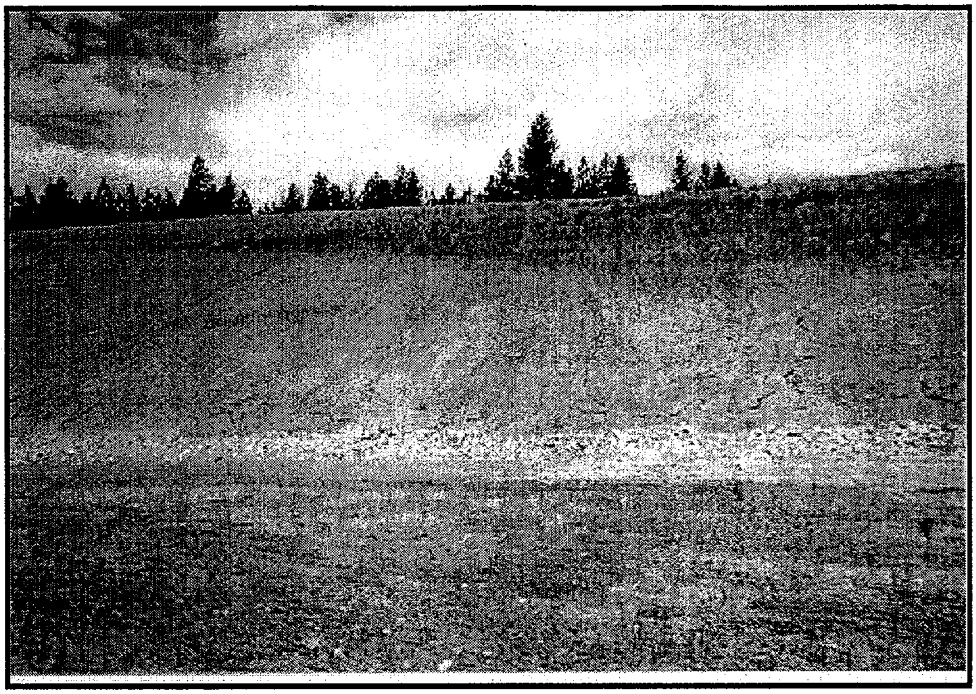
Location 2, looking S from top of dike.



Location 3, looking NW from impoundment about 100 m. from margin slope.

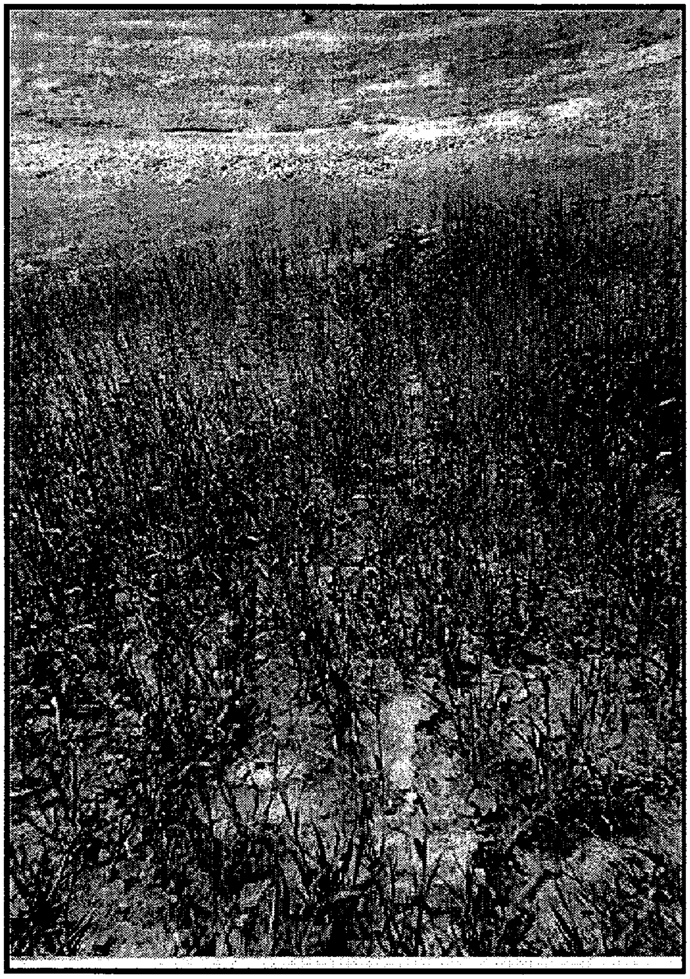


Location 4, looking N from impoundment about 30 m. from margin slope.



Top: Location 4, looking W from impoundment about 30 m. from margin slope.

Left: Location 5, Looking SE from midway of margin slope (down slope), erosion in rills, with local depth to approximately 2 feet. (location of soil sample).

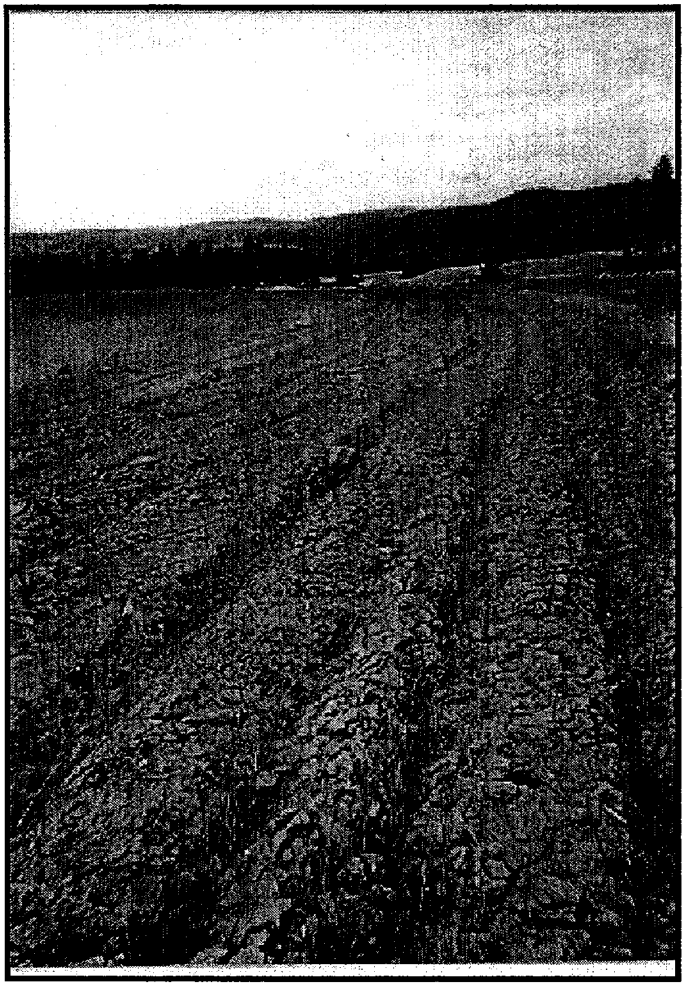


Left: Location 6, looking SE from top of margin slope (down slope), erosion in rills with local depth to 6 inches, consistent from top of slope to bottom, significant vegetation from top of slope to midslope.

Bottom: Location 6, looking ~~E~~ W from top of dike, monitoring well in background.

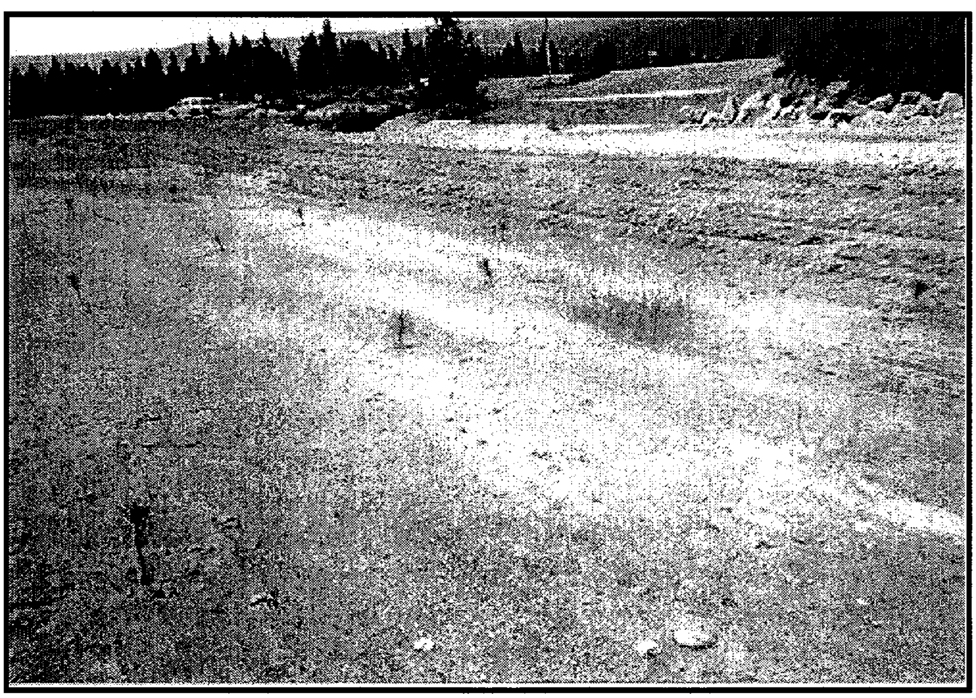
Top: Location 6, looking E from top of margin (down slope), erosion in rills with local depth to 6 inches, erosion starting at slope transition from top of dike, significant vegetation.

Bottom: Location 7, looking E from top of margin (down slope), erosion in rills about every 6 to 12 feet along slope to 6 inches.



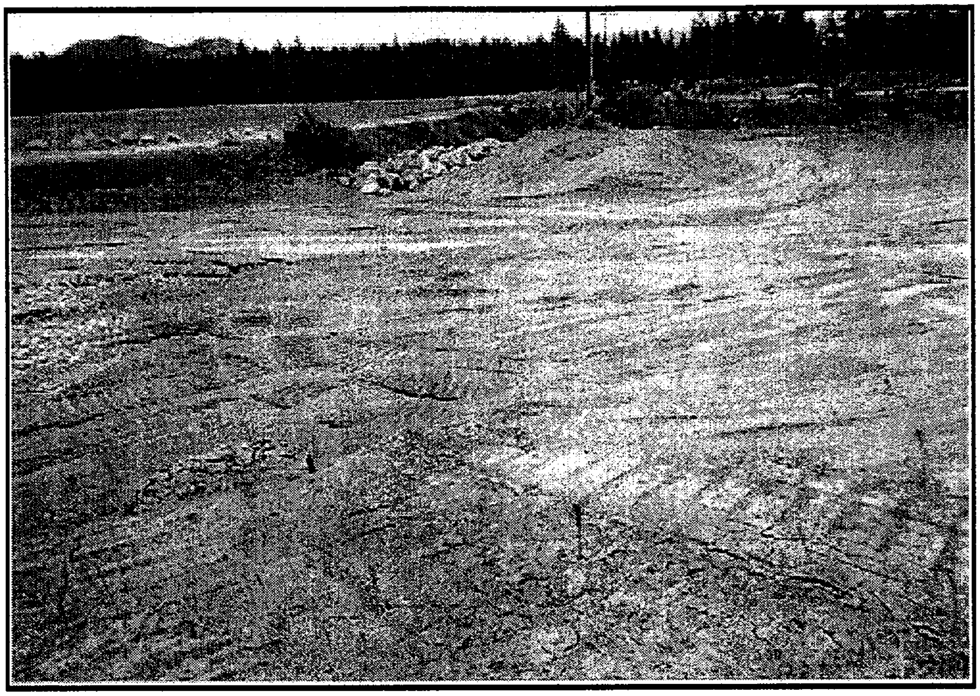
Left: Location 8, looking SE from transition of top of dike to bench above impoundment, erosion in-line with pattern from apparent ripping operation (previous vehicle access road).

Bottom: Location 9, looking SW from bench and previous vehicle access from NW borrow source, erosion protection and culvert for truck shop vehicle access road, in background.

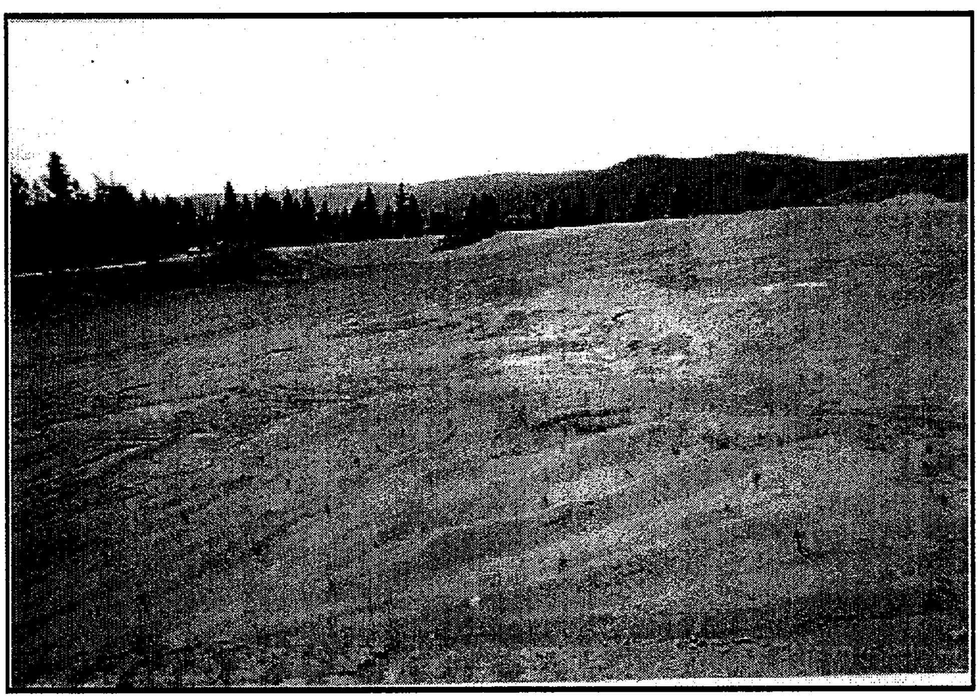


Location 10, looking S from high bench at truck shop (Mill Site).

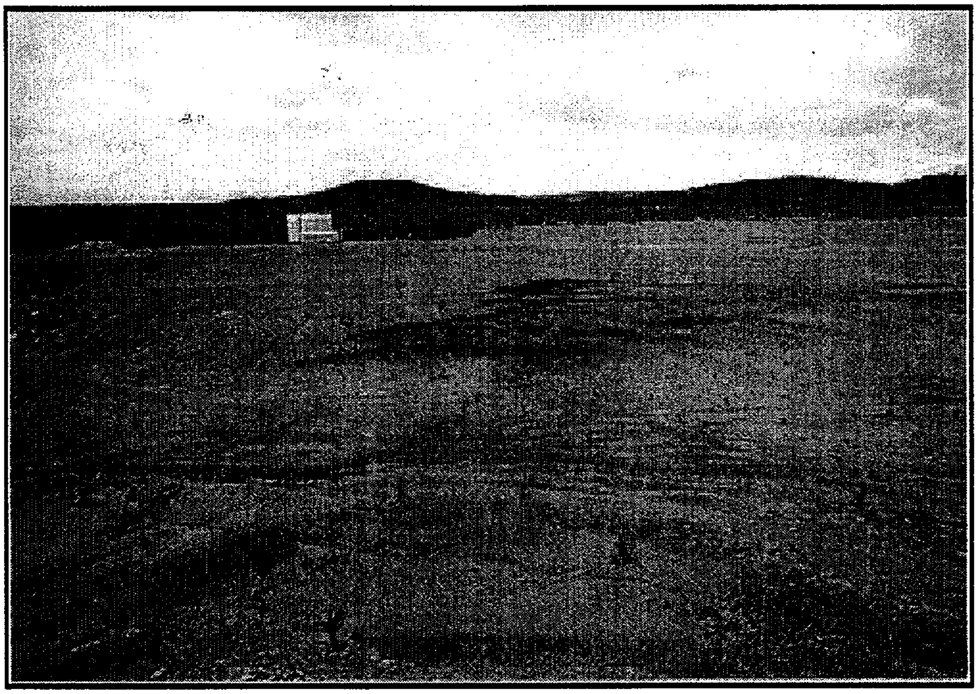
Location 11, looking N from site access guard station (Mill Site).



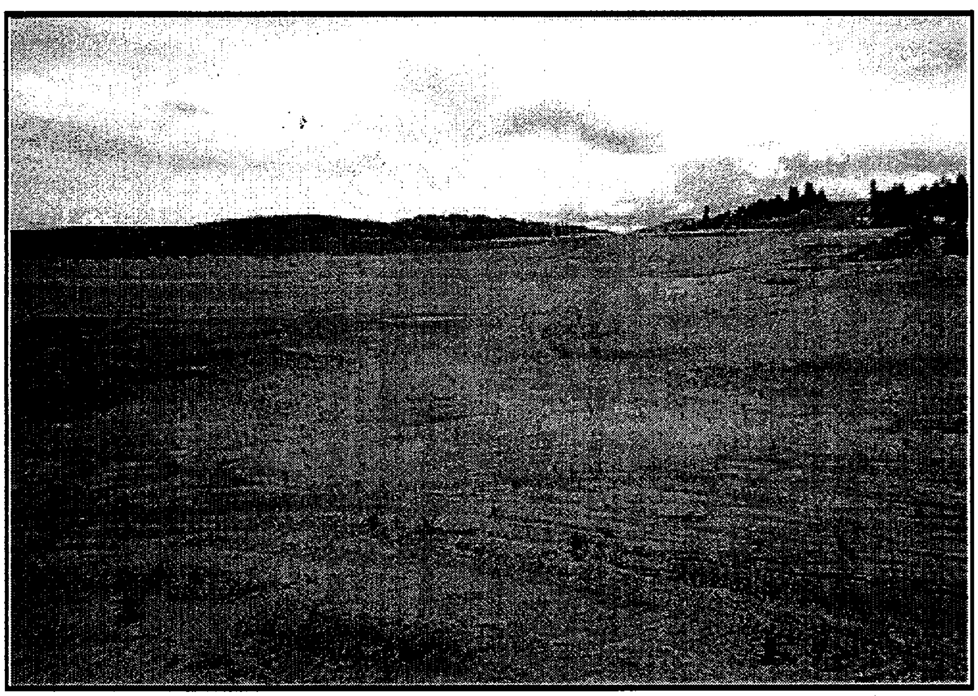
Location 12, looking S from power pole near truck shop vehicle access road culvert (mill site).



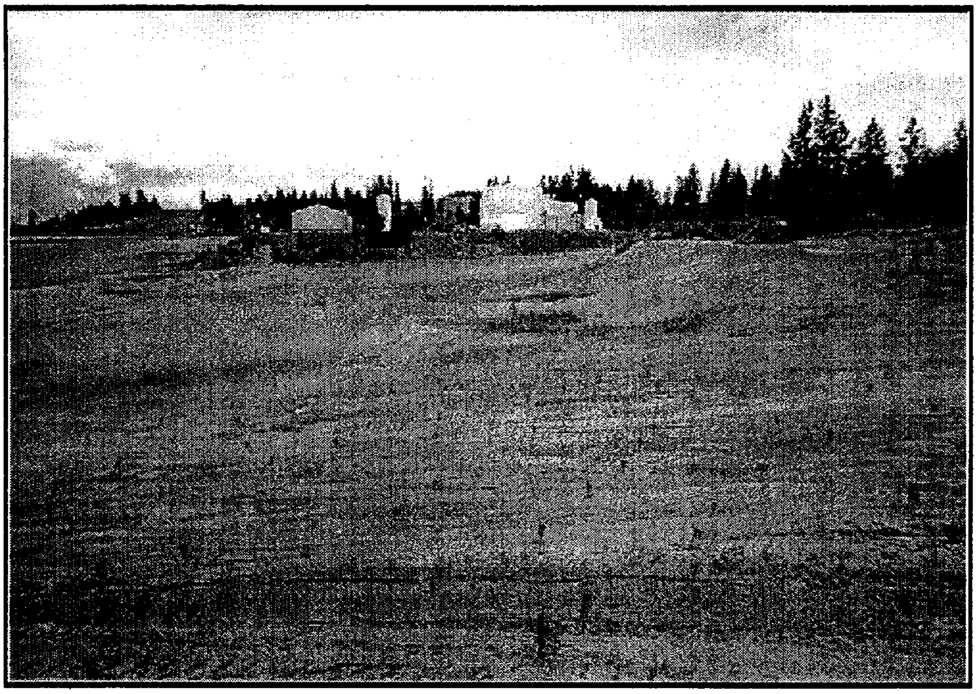
Location 12, looking SW from power pole near truck shop vehicle access road culvert (mill site).



Location 12, looking [redacted] WSW from power pole near truck shop vehicle access road culvert, water tank in background (mill site).

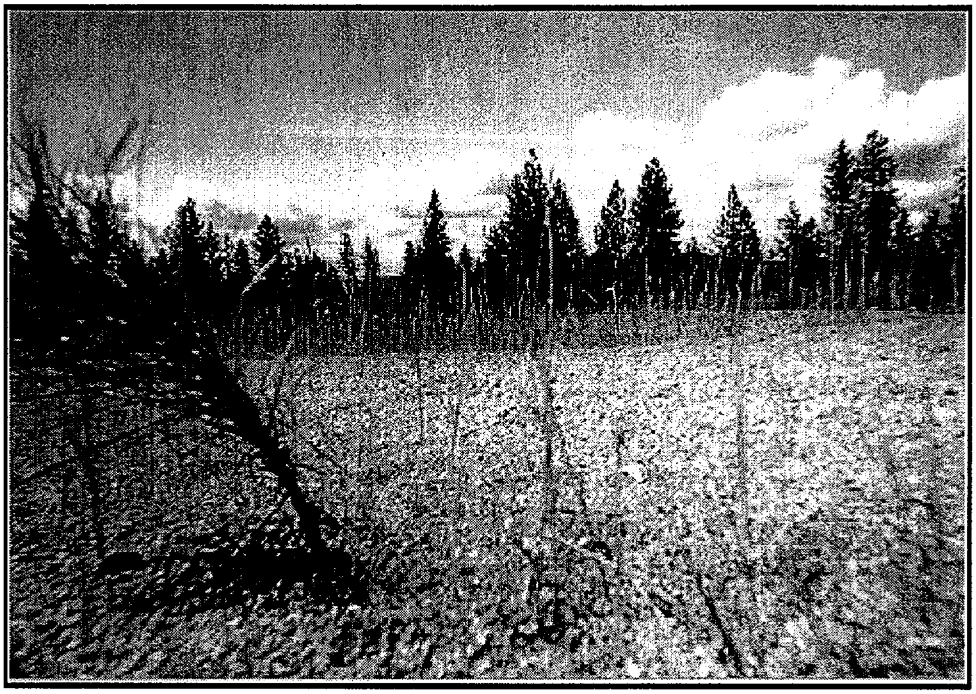


Location 12, looking [redacted] W from power pole near truck shop vehicle access road culvert (mill site).

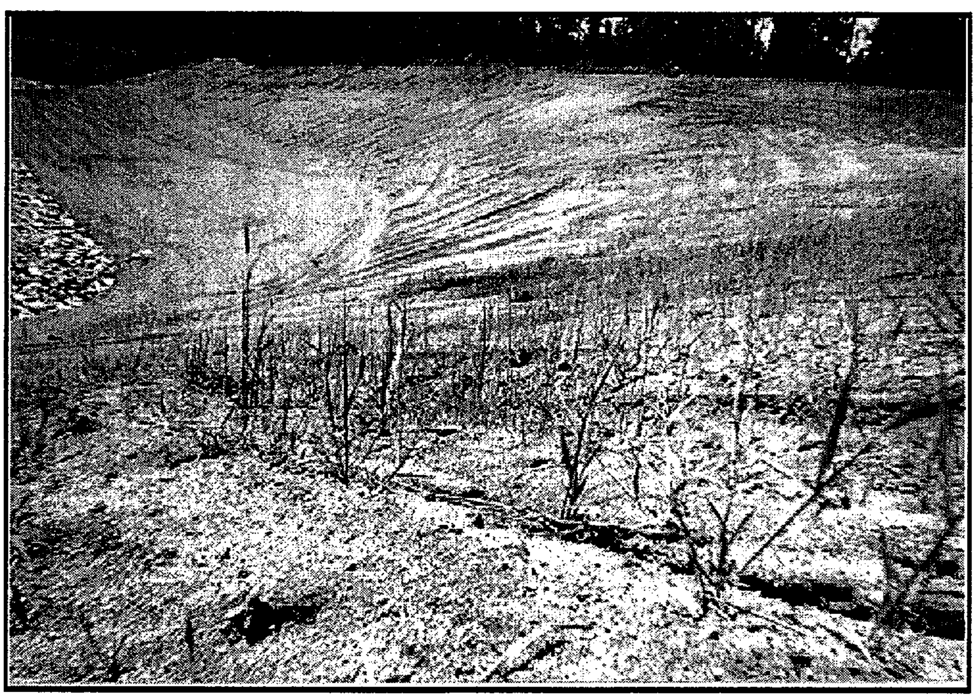


Location 12, looking NW from power pole near truck shop vehicle access road culvert, truck shop in background (mill site).

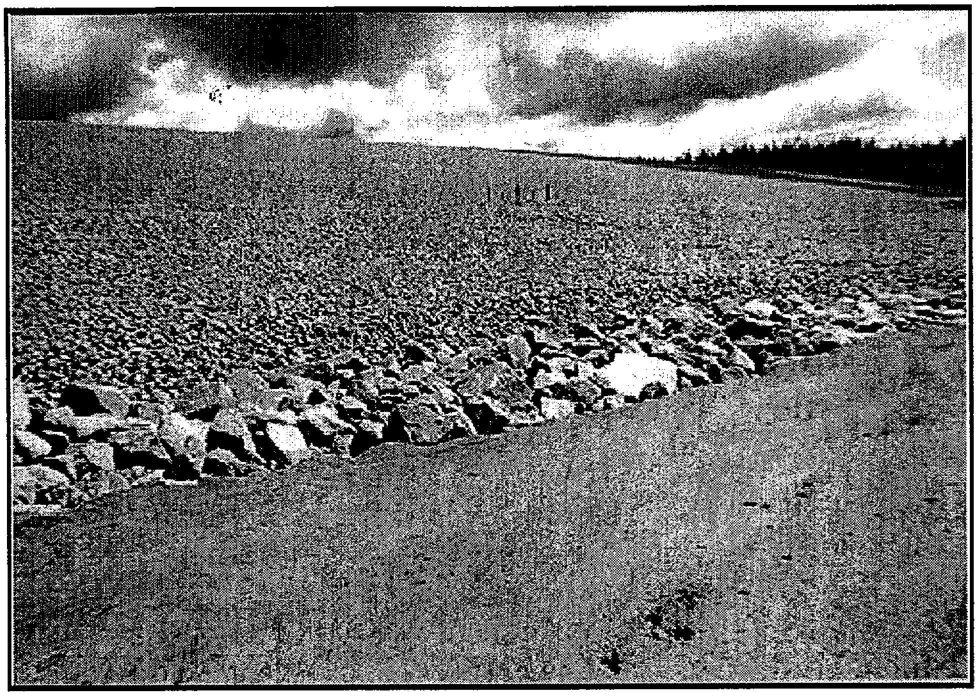
Location 13, looking S from W end of impoundment dam, dam slope rock erosion protection in foreground, east groin of dam in background.



Location 14, looking S from a height of 6 inches, vegetation and pine tree seedling.

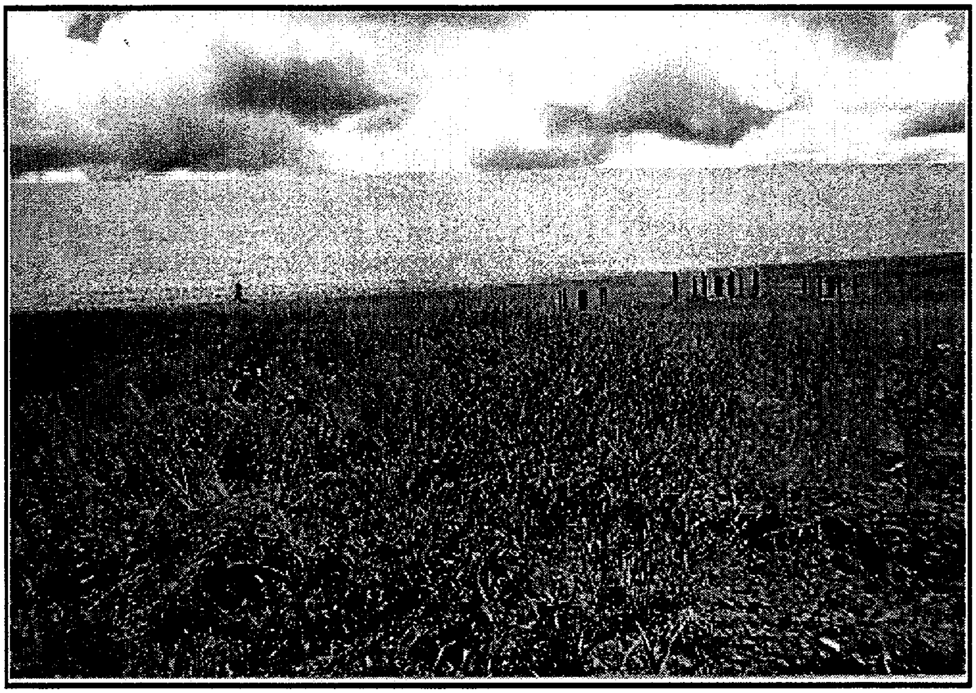


Location 15, looking SE from dam east groin outside margin, vegetation on right, groin rock protection on left.

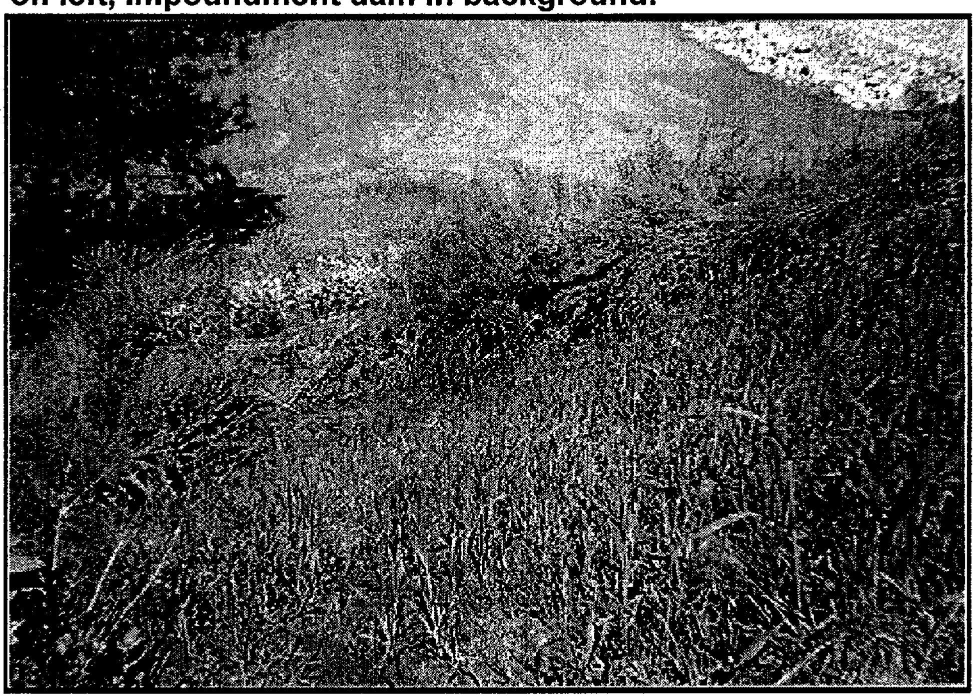


Location 16, looking NE from impoundment dam east groin (up slope), monitoring well 4 at midslope.

Location 17, looking NE from watershed natural drainage toward bottom of impoundment dam (on left), rock protection and monitoring well bench outslope.

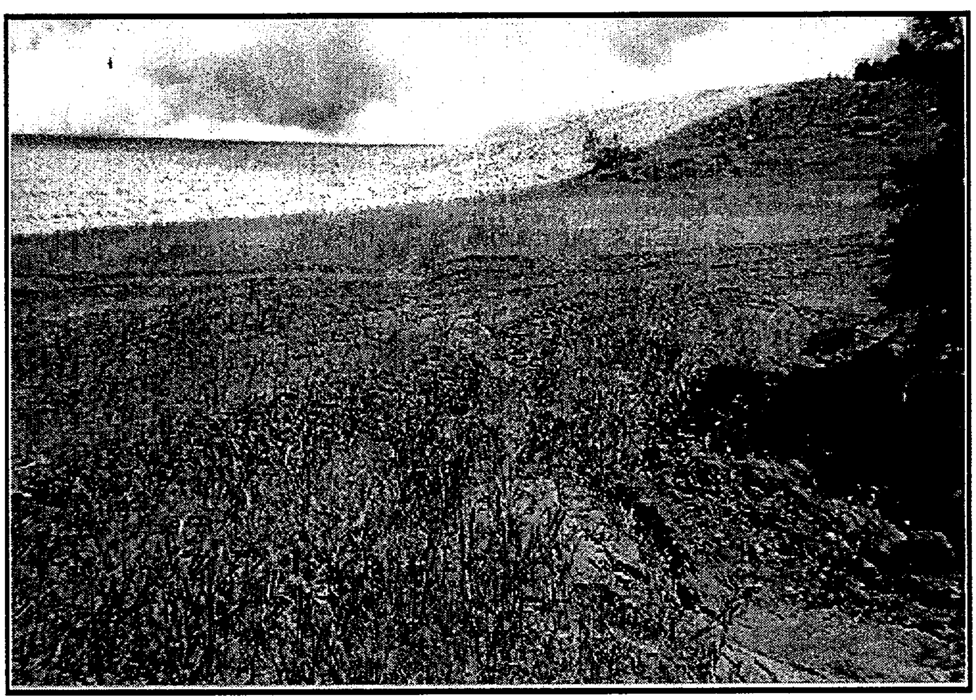


Location 17, looking NE from monitoring well bench, downslope on left, Impoundment dam in background.



Location 17, looking NW from monitoring well bench toward downslope in foreground, bottom of Impoundment dam outslope and natural drainage.

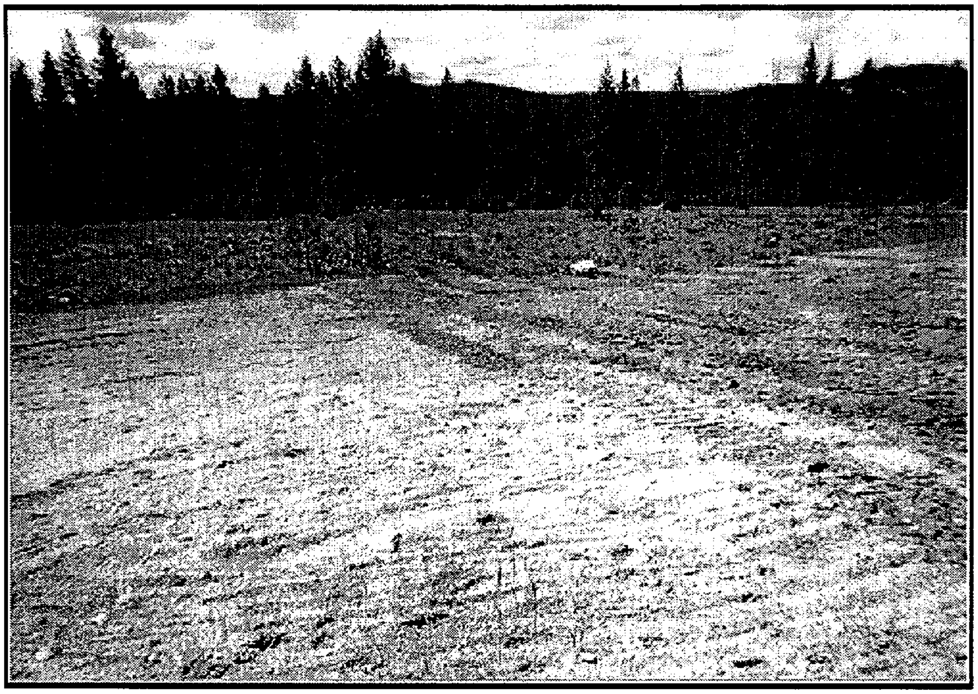
Location 18, looking NW from monitoring well bench, shallow erosion in foreground, wells and impoundment dam in background.



Location 18, looking NE from monitoring well bench, shallow erosion in foreground, impoundment dam in background.

Location 19, looking NW from NE portion of impoundment swale toward dam face, rolling benches in foreground, showing rework from early spring erosion.

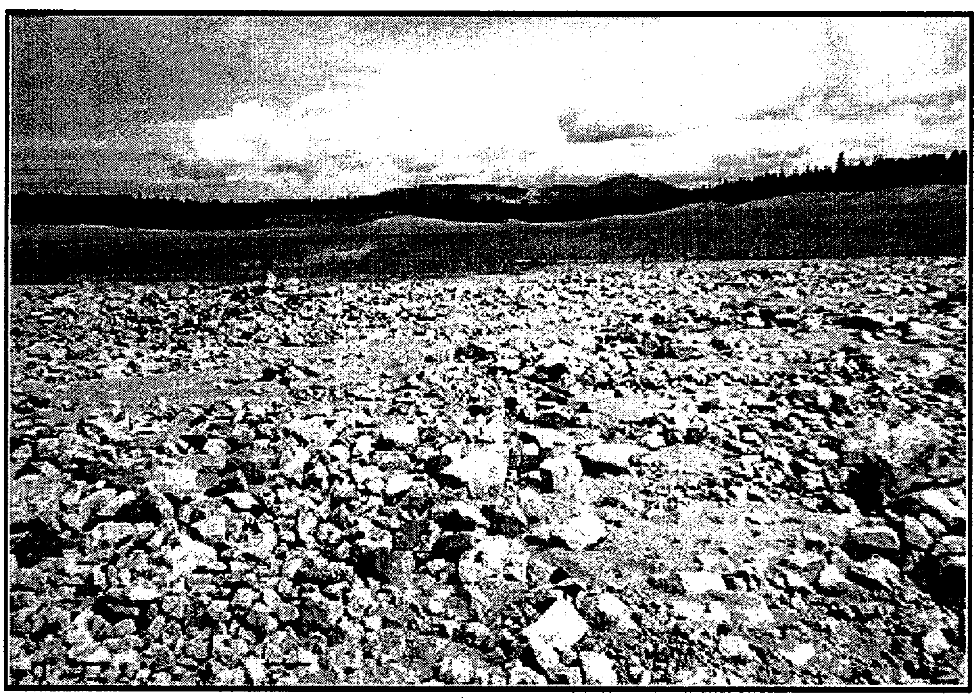
Location 20, looking down at cat tracks showing rework from early spring erosion and vegetation recovery.



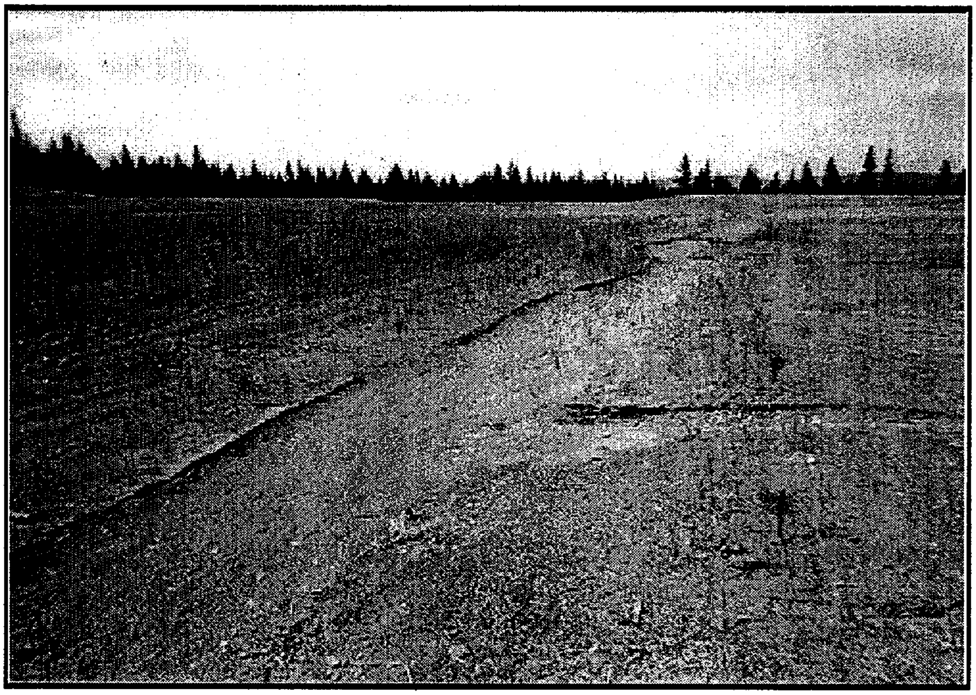
Location 21, looking S showing rework from early spring erosion and transition to natural vegetation.

Location 21, looking N showing ending section of diversion dike and margin toe rock protection. Some erosion is evident parallel to toe.

Location 22, looking N from swale outfall (up slope) showing erosion to about 1 foot and local underlying rock and bedrock outcrops.

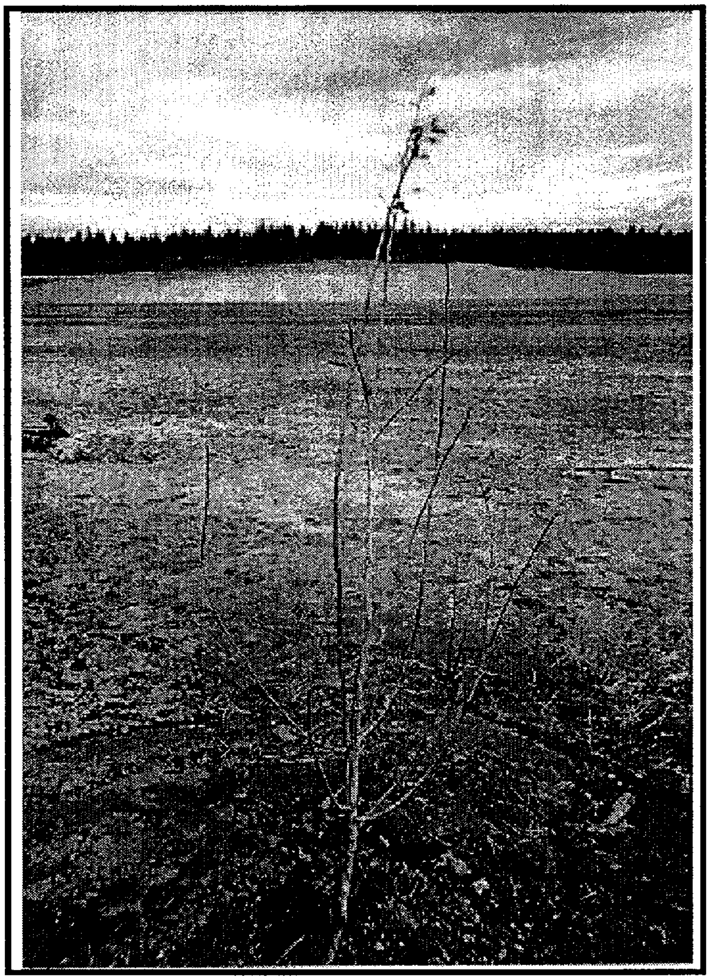


Location 22, looking S toward swale rock protection, showing soil deposition from upstream erosion (see photo above).



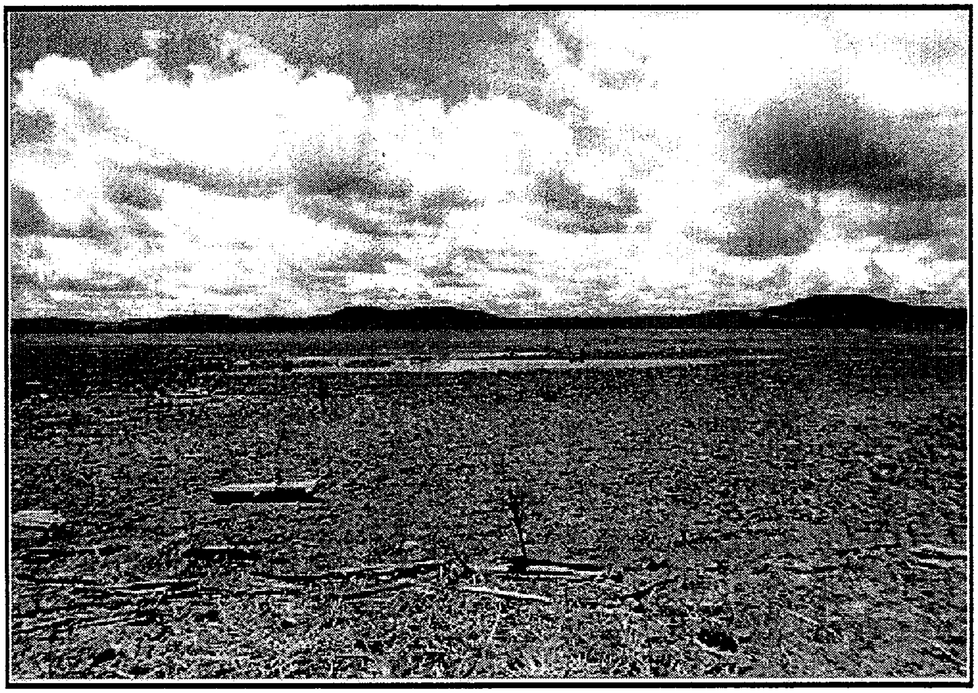
Location 23, looking S showing erosion from upstream of swale. Main channel is from N., side channel is from E (impoundment surface), depths to 4 inches.

Location 24, looking down at impoundment surface, showing vegetation and straw litter placed prior to planting.

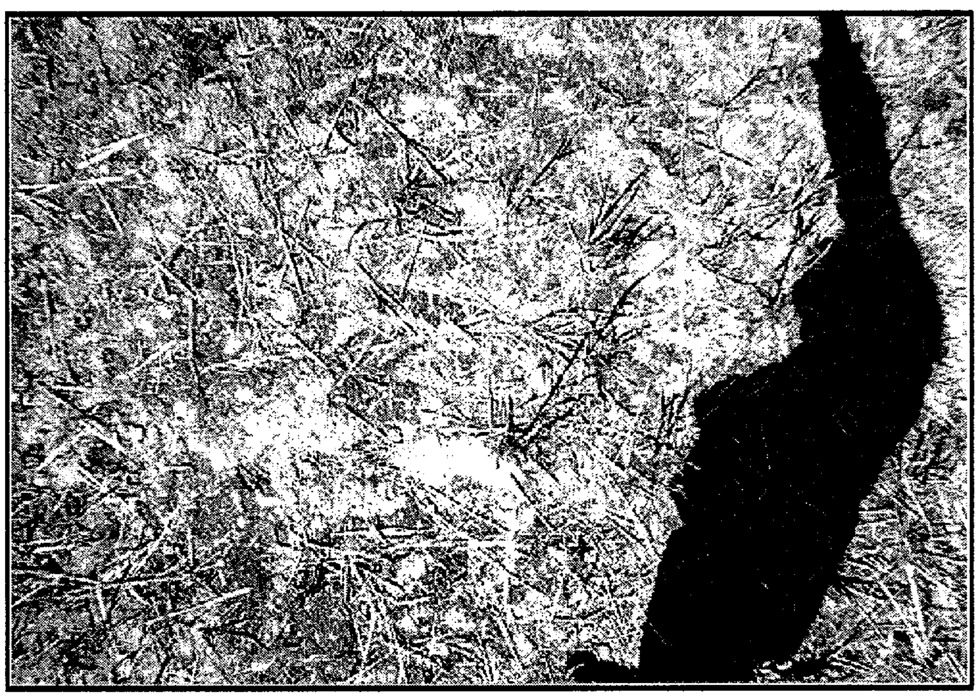


Left: Location 25, looking N, planting of larger (6 foot tall) trees in foreground, background is ponded area recently drying, little vegetation showing.

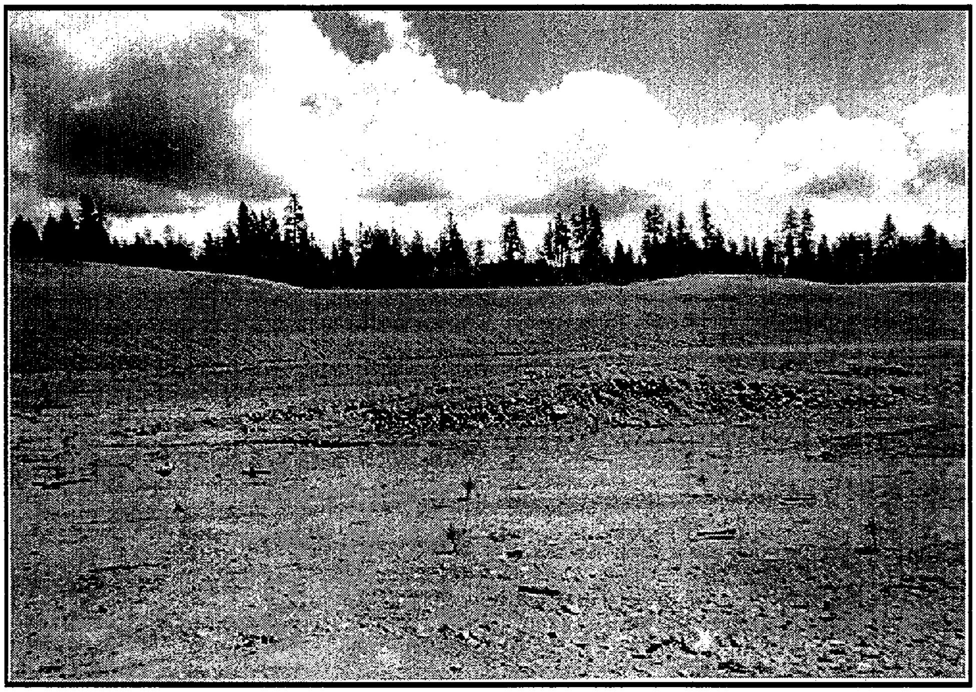
Bottom: Location 26, looking N, small (about 1 acre total) ponded area, soft soil with deer and elk tracks, little vegetation, tadpoles in water.



Location 27, looking WNW showing small pond, pine tree plantings and prior placed litter, little vegetation near pond.



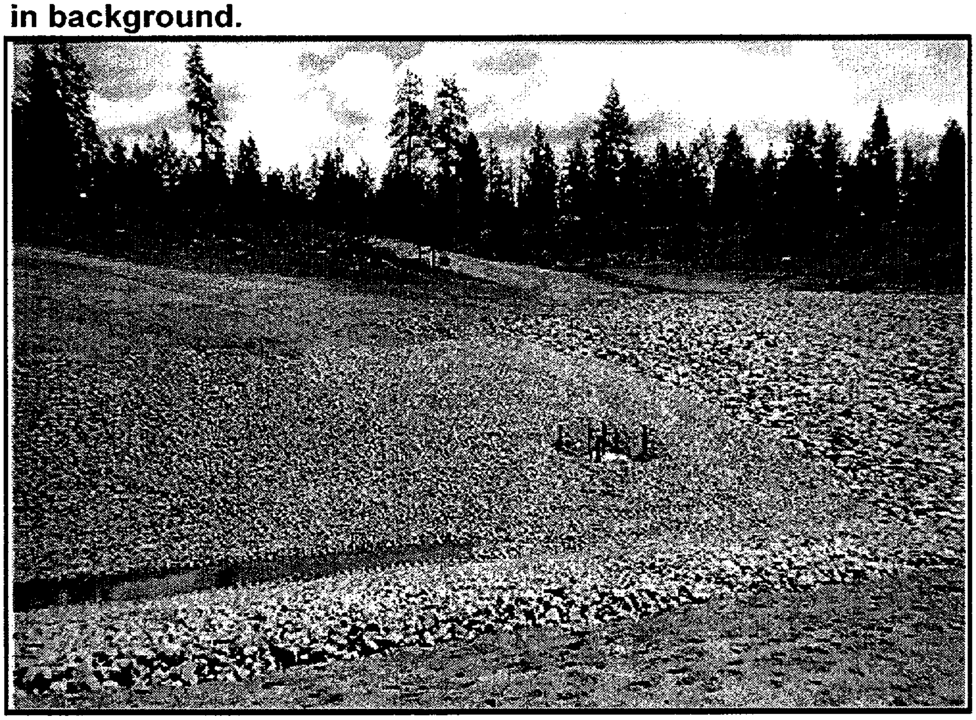
Location 28, looking down, showing vegetation on impoundment surface in area adjacent to pond.



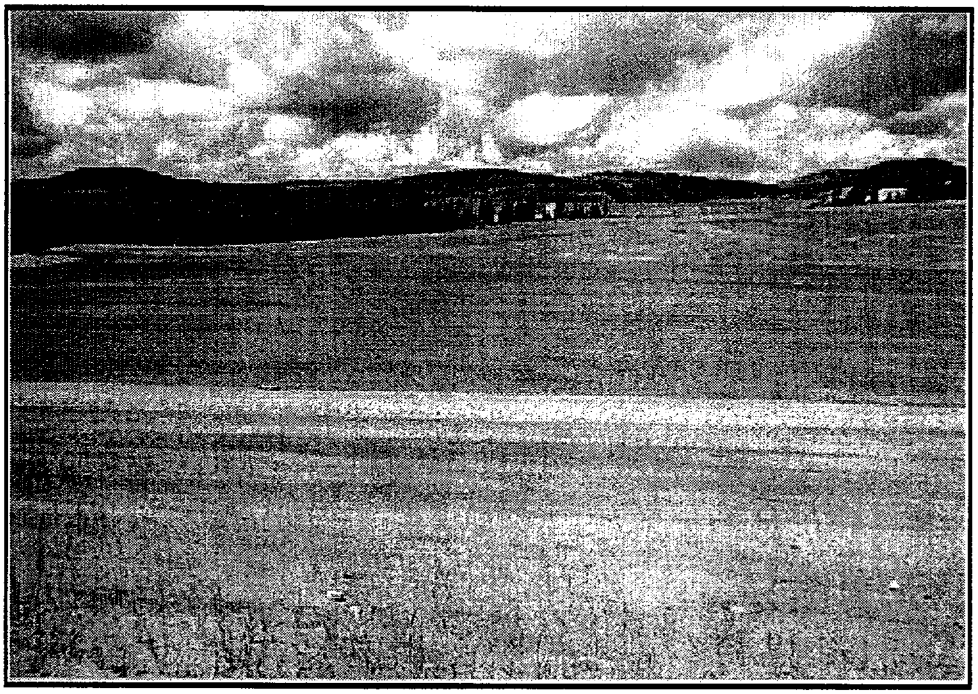
Location 29, looking ESE showing rock area (bedrock) in foreground and east dike margin in background (notice small rills).

Location 30, looking E from base of dike margin (up slope) showing small rills, to 4 inches deep.

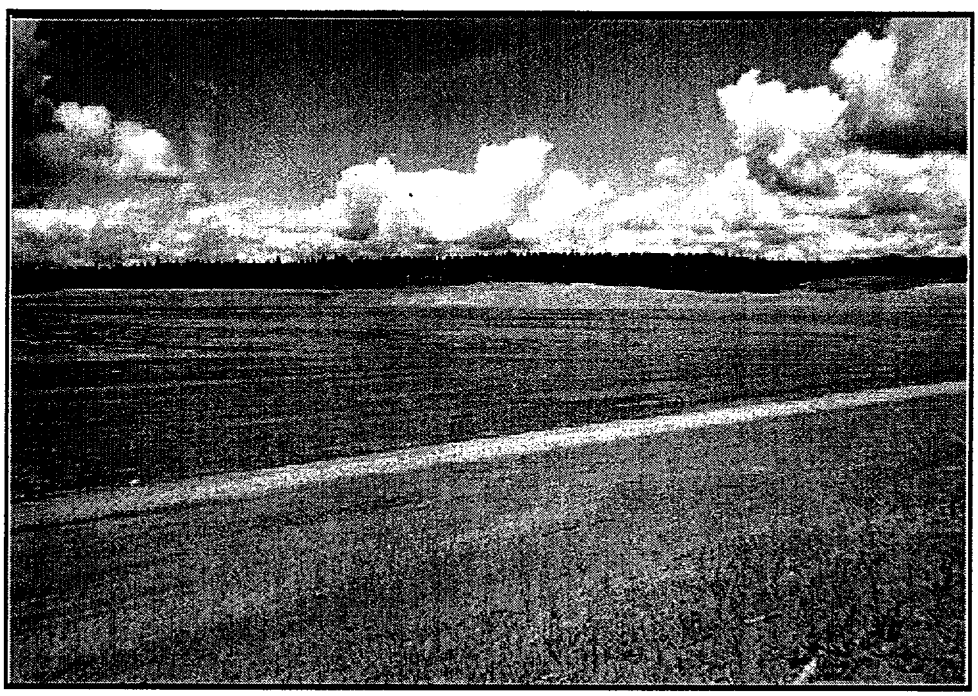
Location 31, looking NE from top of dike, across diversion channel, small pond in channel in foreground, reworked area in background.



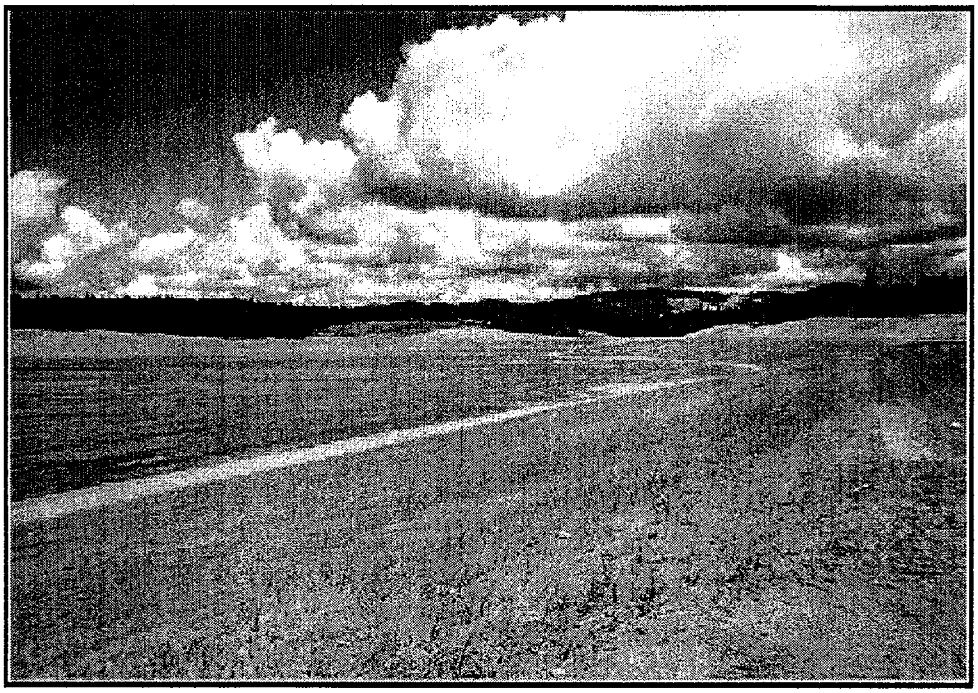
Location 32, looking E from top of dike, across diversion channel, monitoring well, small pond and deer and elk tracks in foreground, reworked area in background.



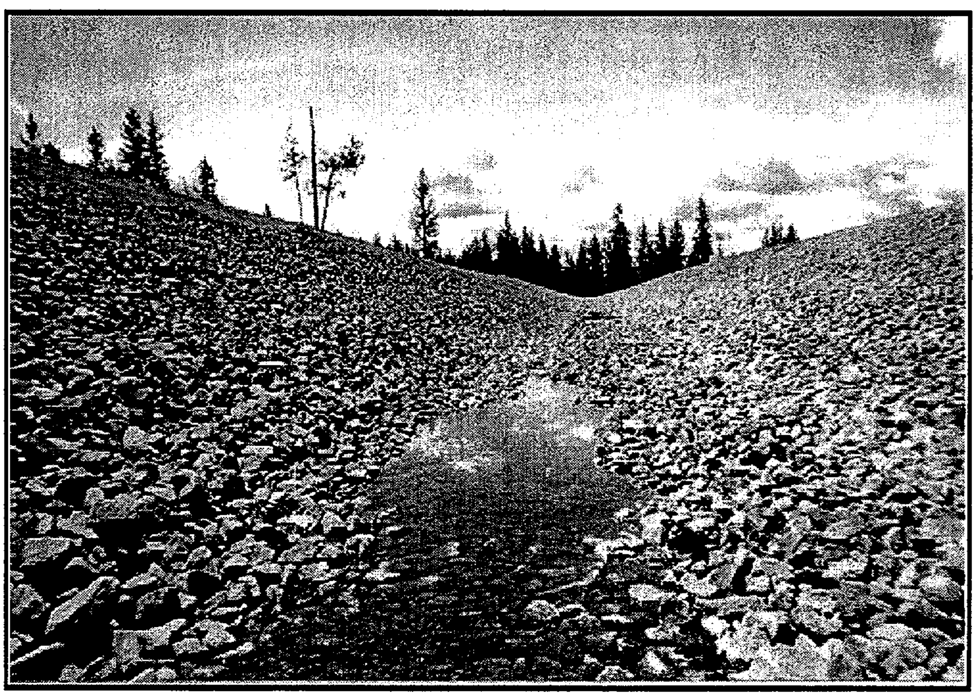
Location 33, (survey station) looking SW from top of dike toward impoundment and dam.



Location 33, (survey station) looking NW from top of dike toward impoundment.



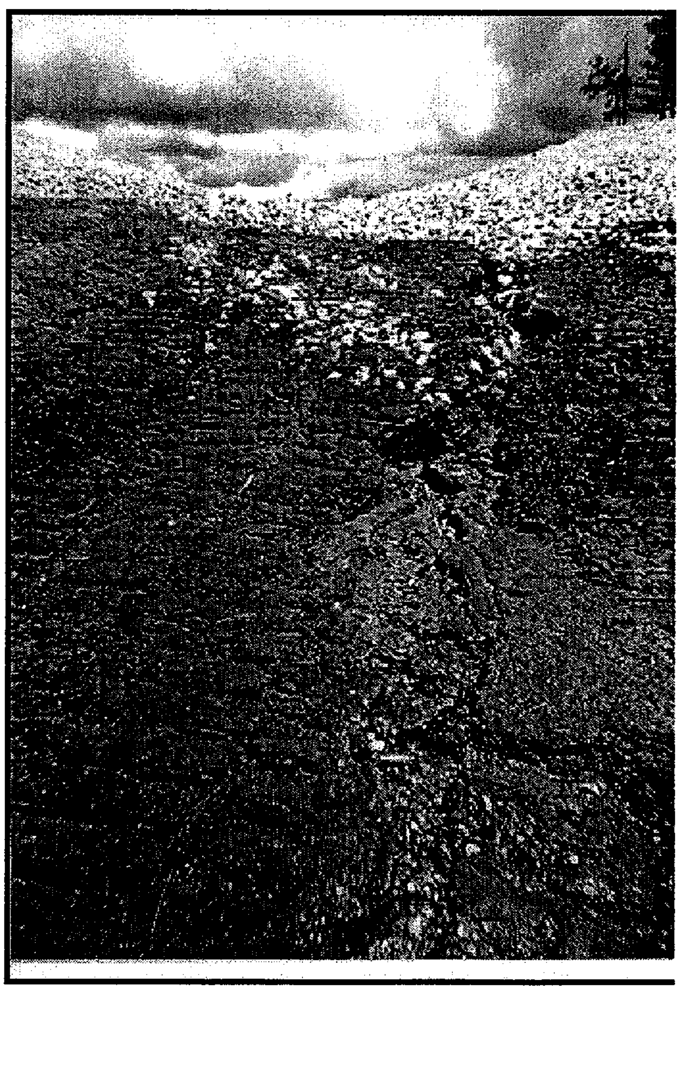
Location 33, (survey station) looking N from top of dike toward upper impoundment and east dike.



Location 34, looking S from 1 foot height, showing bottom of diversion channel (toward outfall).

Top: Location 35, looking N from east up slope side of diversion channel showing diversion channel, dike and impoundment in background. Soil lacks fines content, little vegetation.

Left: Location 36, looking S from end of diversion channel (outfall) at rock protection to natural soil transition, showing rework and erosion to 1 foot at rock transition.



Top: Location 36, looking N from diversion channel outfall natural transition showing erosion and deposition as slope diminishes.

Left: Location 36, looking N from diversion channel outfall transition, showing erosion at rock transition, to 1 foot depth. Slope of about 1H:5V at transition.

MEMORANDUM

August 9, 1999

TO: Gary Robertson
John Blacklaw
Earl Fordham

FROM: Dorothy B. Stoffel

SUBJECT: Western Nuclear, Inc. Monitoring and Stabilization 1999 Field Inspection

I have completed my Western Nuclear, Inc. Monitoring and Stabilization 1999 Field Inspection. The report for the inspection is attached. I have developed the following questions for Western Nuclear pertaining to the elements of the site that are a result of my 1999 inspection.

- Two major gullies have developed at the toe of the outlet swale. The silty topsoil has eroded and the undelying quartz monzonite bedrock is exposed. Some of the quartz monzonite bedrock in the tailings impoundment area weathers quite readily when exposed, and other areas of the quartz monzonite are quite resistent to weathering. The distinction between the two types of quartz monzonite was apparent during construction of the diversion channel because some quartz monzonite was readily ripped and some areas of quartz monzonite required blasting. Has the nature of the quartz monzonite underlying the toe of the outlet swale been characterized and documented? What construction features of the outlet swale would prevent shifting of the riprap if the exposed quartz monzonite significantly weathers over time?

- There is a fifty square foot area which lacks placement of the 15 inch riprap at the southern margin of the last confluence on the east side. The filter material appears to be overlying quartz monzonite. Is the underliying quartz monzonite adequate to provide longterm stability to the riprap in this confluence in the event of a PMP?

These are the extent of my questions for Western Nuclear at this time.

1999 MONITORING AND STABILIZATION INSPECTION REPORT

I have completed my review of rock durability of the riprap in the diversion ditch, tailings dam outslope, and cover swale outfall at Western Nuclear, Inc. as part of the Monitoring and Stabilization annual inspection program. The scope of the review included two days in the field inspecting riprap, review of the April 9, 1996 memo documenting Petrographic Analyses Review, Rock Durability Summary (Shepherd Miller, 1996) as well as related sections of the Construction Completion Report, 1997, prepared by Shepherd Miller, Inc. The previous rock durability review in 1996 was supplemented with review of the following references: Best Myron G., *Igneous and Metamorphic Petrology;* Deer, W.A., R.A. Howie, J Zussman,*An Introduction to the Rock Forming Minerals;* U.S. Nuclear Regulatory Commission, *Staff Techincal Position on Testing and Inspection Plans During Construction of DOE's Remedial Action at Inactive Uranium Mill Tailing Sites, Revision 2;* and U.S. Nuclear Regulatory Commission, *Final Staff Technical Position Design of Erosion Protection Covers for Stabilization of Uranium Mill Tailings Sites.* The findings from my 1999 review of rock durability are summarized below.

May 27, 1999 Field Inspection Summary

On May 27, 1999 I inspected the riprap of the west side of the diversion ditch and the outslope of the tailings dam. My review of the rock included visual inspection and hammering rocks with a small field sledge hammer. John Blacklaw wrote field notes at my request and took photos with a digital camera of rock features.

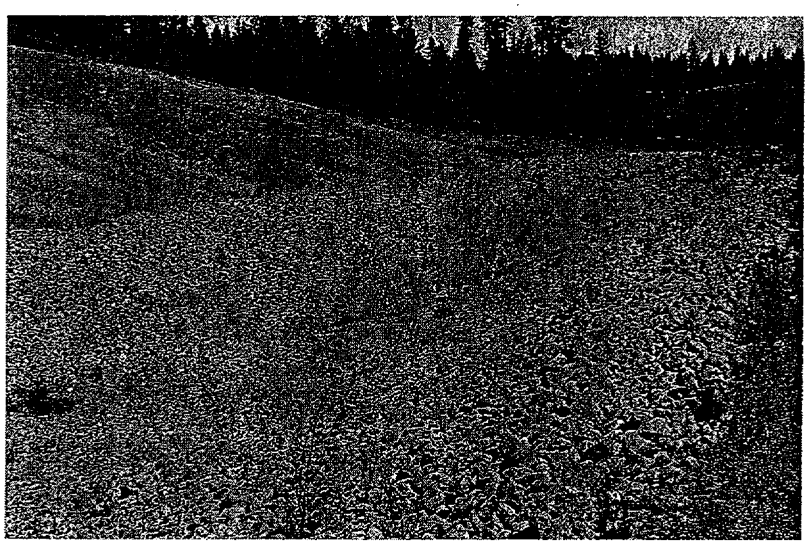


Photo 1.

The riprap associated with diversion ditch is largely made up of competent quartz monzonite. Photo taken of eastside of the diversion ditch.

Most of the riprap is composed of competent quartz monzonite with a small fraction of basalt mixed in. The amount of basalt varies from place to place, and estimated to be less than ten per cent of the total placed rock. (Photo 1.) Only a very minor fraction of the rock showed visual deterioration and did not break with repeated blows by the sledge hammer. The quartz monzonite rocks that showed deterioration by crumbling or fracturing were rocks containing a higher fraction of sheet silicates, notably biotite and sericite/muscovite. Only a minor fraction of the quartz monzonite rocks displayed a greenish alteration product on outer surfaces or fracture surfaces, probably resulting from weathering. Most quartz monzonite rocks did not fracture by repeated hammer blows to the rock or by dropping rocks against riprap. (Photo2.)

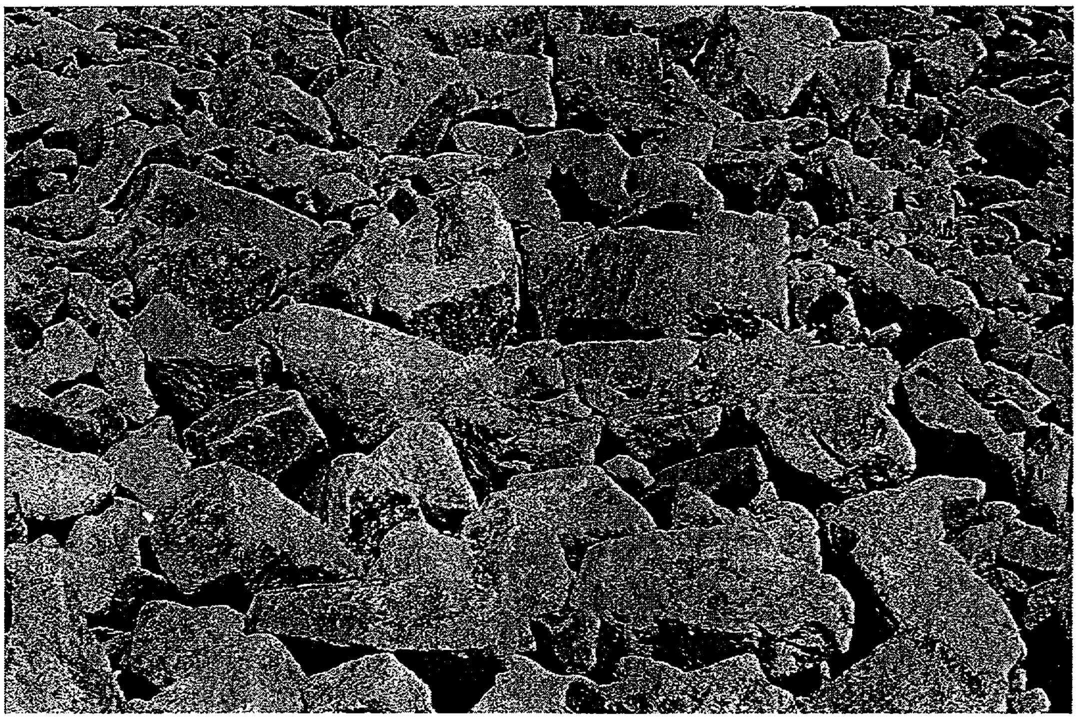


Photo 2.

A typical section of riprap that is mostly competent quartz monzonite with the small percentage of basalt mixed in (less than 5%).

Virtually all of the basalt is dense and uniform, with absence of vesicles, and remained in tact to hammer blows and dropping. A very few of the basalt rocks broke. The breaks were typically associated with basalt rocks that appear to be "zoned". These few rocks often appeared rounded and perhaps could be fragments of pillow basalts.

There were very sparse dark volcanic rocks, less than 10 total, and even fewer light volcanic rocks, encountered over the two miles of riprap that were traversed. The volcanic rocks probably represent Tertiary andecites and dacites that have been mapped in the area of the basalt stockpile. The few volcanic rocks were probably inadvertently incorporated into the riprap when heavy equipment moved the basalt stockpile. These few volcanic rocks have largely crumbled. (Photo 3.)

Photo 3.

Photo shows the occasional dacite at lower left corner, the zoned basalt that fractured at the toe, and the weathered surface of quartz monzonite right of the foot.

June 10, 1999 Field Inspection Summary

The focus of the June 10, 1999 Field Inspection was the riprap associated with the cover outlet swale and the east side of the diversion ditch. I took field notes. John Blacklaw took field notes and photos with a digital camera.

Cover Outlet Swale

The riprap associated with the cover outlet swale was reviewed. (Photo 4.) The southwest portion of the swale does show an increased percentage of quartz monzonite that has deteriorated at this time. However, the percentage remains small. Traversing the swale, the amount of deteriorated rock diminished and the rock was found to be consistent with the rock that was observed in the west side of the diversion ditch.

Photo 4.

Overview of the cover outlet swale. The darker patches of the riprap were evaluated for adequate rock placement. The large riprap fraction is present underneath the smaller riprap fraction.

An area approximately 50 feet by 30 feet in the middle of the swale has patches where the big rocks (15 inch rock) appear to be concealed underneath a layer of smaller rocks that are 2-3 inches in size. The smaller rocks are not fragments of rock that has deteriorated, but represent the initial smaller rock fraction that was placed. This area appears to be more of a gradation question than a rock durability question. John Blacklaw dug a hole by hand, approximately 5 inches deep, until digging became too hard to proceed. John dug a second hole approximately 4 feet away from the first which did uncover the large rock. (Photos 5 and 6)

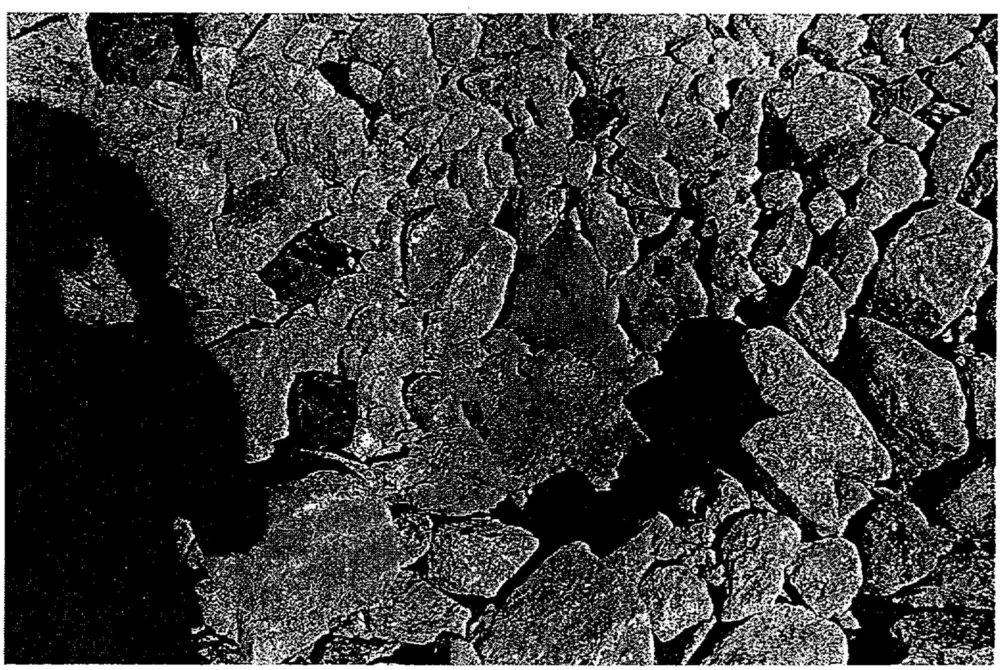


Photo 5.

Area of swale where smaller riprap fraction on the surface conceals the larger riprap. Note the larger rock size surrounding the hole and in the bottom of the hole.

There is an area of the riprap at the top of the swale where fines have washed in from the cover surface since construction was completed. The fines conceal the rock underneath that was placed during construction. (Photos 6 and 7)

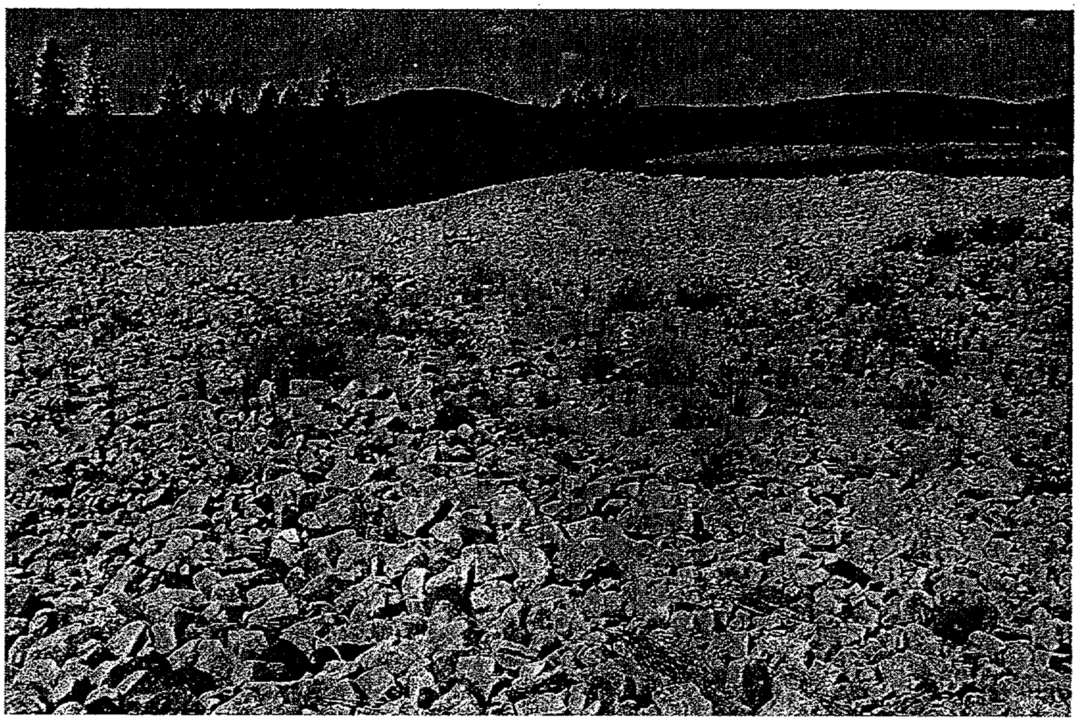


Photo 6.

View of the top of the outlet swale (taken from the east, looking west) where fines have washed into the riprap from the cover surface. The riprap has not been disturbed.

Photo 7.

View from edge of cover surface (looking south) showing extent of fines that have washed onto the swale. The riprap has not been disturbed underneath.

The entire cover outlet swale is underlain by quartz monzonite bedrock. Approximately one foot of topsoil was placed on top of the bedrock at the toe of the riprap. Two major gullies are present at the toe. (Photo 8.)

Photo 8.

Toe of the outlet swale where gullies have developed. The photo was taken on the west side looking toward the east along the toe.

The topsoil has been removed by erosion in the gullies exposing the quartz monzonite bedrock underneath. (Photo 9 and 10.)

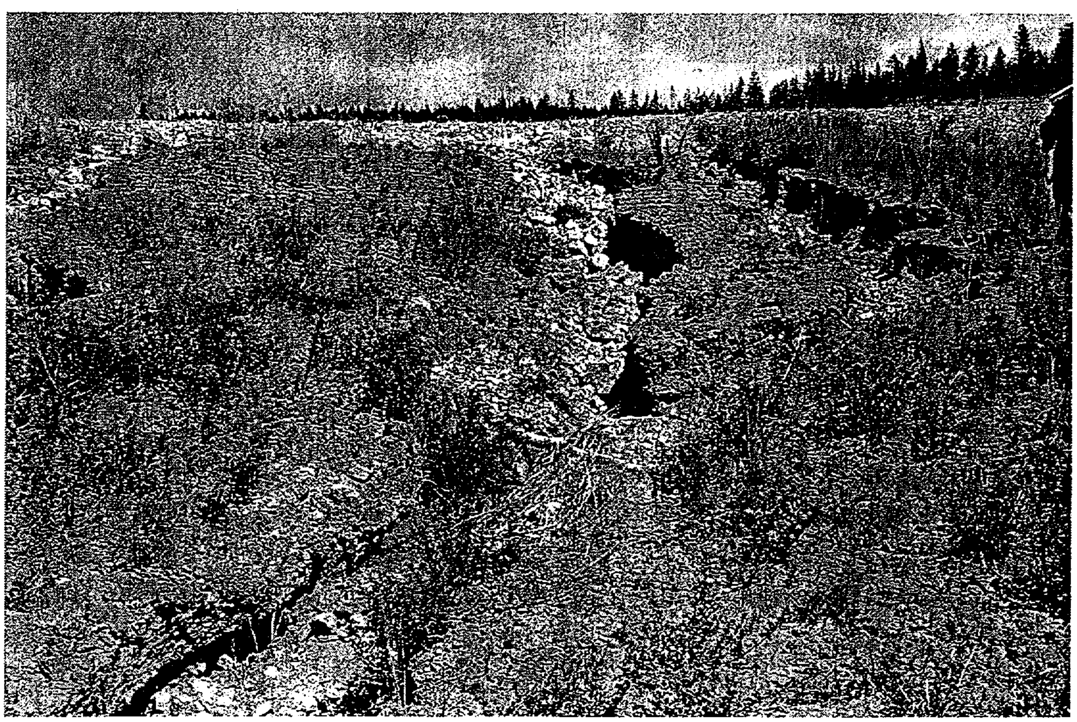


Photo 9.

Photo shows where silty topsoil has been eroded away, exposing the quartz monzonite bedrock underneath.

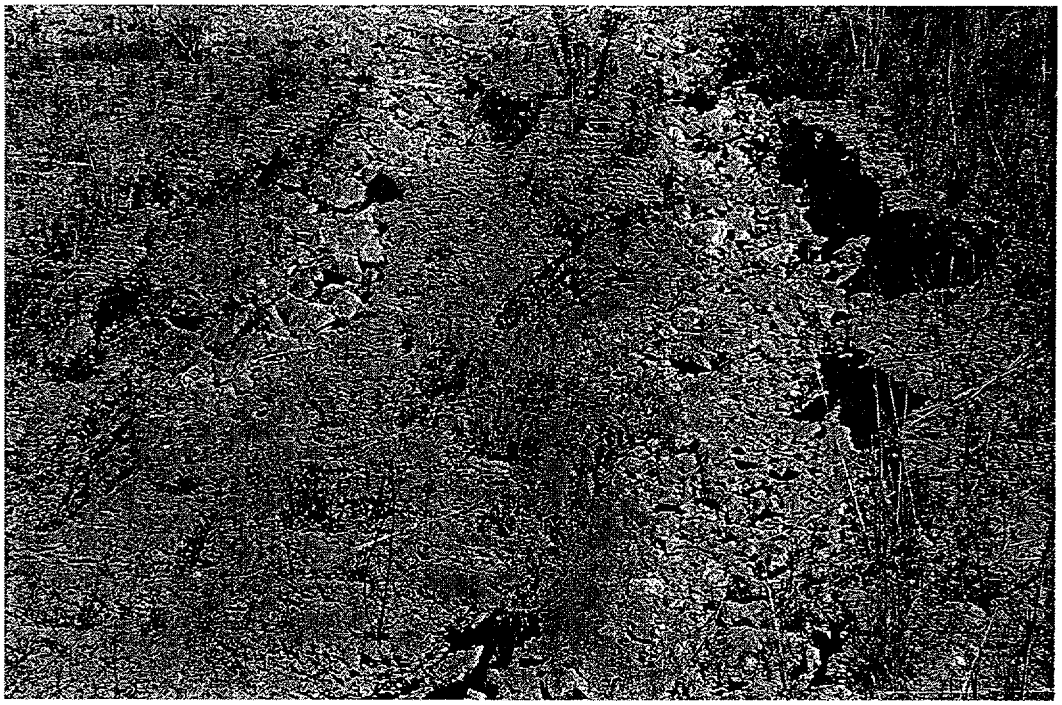


Photo 10.

Close-up view of the eroded topsoil and exposed quartz monzonite bedrock at the toe of the outlet swale.

There are more resistant quartz veins exposed within the quartz monzonite.

Eastside Surface Water Diversion Ditch

I walked the surface water diversion ditch, beginning at the eastern outfall and proceeding up the eastside until I reached the area where I had concluded on the May 27, 1999 inspection. Therefore, rock competency was evaluated for the entire ditch. No areas were identified where the concentration of deteriorating rock appeared to be of concern.

A few oversized rocks were observed that were intentionally fractured during construction. These rocks fractured along distinct planar surfaces. In general, the fracture surfaces remain smooth without evidence of weathering or decomposition.

A location, approximately five feet by ten feet, at the southern edge of the first confluence from the outfall appears to not have 15-inch rock placed. Two holes were dug by John Blacklaw by shovel to determine whether 15-inch rock is present at depth. The excavated material appeared to be Filter #2 material. The holes were dug approximately 18 inches deep and appeared to be dug to the quartz monzonite bedrock. I evaluated the exposed quartz monzonite outcrops of the ditch margin and hillside. Based upon the dip observed on the bedrock surface it is likely that quartz monzonite does underlie the filter material at this location.

Pond on Cover Surface

There is a pond located in a depression on the cover surface in the area where the tailing material was dominated by slimes. The differential settlement of the cover and development of a pond was predicted during the design phase of the reclamation surface. (*Revised Executive Summary and Technical Specifications, November 1995)* The issue of the pond and maximum possible differential settlement (*Revegetation Reclamation System Evaluation Report, September 15, 1995)* was evaluated by Department of Health engineers and hydrogeologists prior to construction of the impoundment cover. As a result of the detailed evaluation, it has been determined that the settlement and pond does not adversely impact the performance of the cover for radon attenuation, structural stability or ground water quality.

1999 Monitoring and Stabilization Rock Inspection Conclusions

In my professional opinion, the riprap associated with the surface water diversion ditch, tailings dam outslope and the cover outlet swale remains largely intact. (Photo 11.)

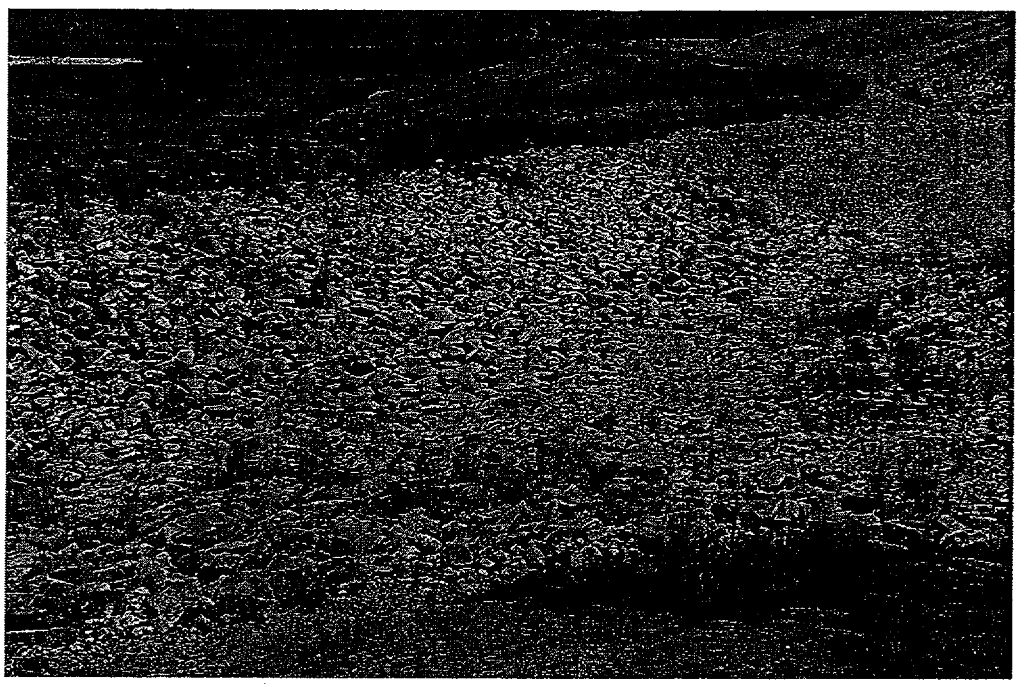


Photo 11.

Northeast confluence of the diversion channel. Note Earl Fordham as scale on the 15 inch riprap.

Field inspection of the rock indicates that rock durability remains consistent with rock testing and field inspection that occurred during the quarry evaluation and riprap production. The riprap production quality assurance and quality control was provided by a third party licensed engineer associated with RZA Agra Engineers. Only a very minor fraction of total rock placed shows deterioration at this time.

As predicted in the tailings reclamation plan, vegetation is encroaching into the rock. The design basis of the ditch, cover, and tailings dam included the vegetation encroachment as part of the long-term stabilization process. The function of the rock is to provide stability until the site reverts to the Ponderosa Pine forest ecological system.

References Cited for the 1999 Monitoring and Stabilization Review

Shepherd Miller, Inc., 1995a., *Revised Executive Summary and Technical Specifications,* prepared for Western Nuclear, Inc.

Shepherd Miller, Inc., 1995b., *Sherwood Project Revegetation Reclamation System Evaluation,* prepared for Western Nuclear, Inc.

Shepherd Miller, Inc., 1996, *Rock Durability Summary, Redesign of Main Embank,ment Outslope Groin Area, Revision #1 to the April 1996 Technical Specifications,* prepared for Western Nuclear, Inc.

Shepherd Miller, Inc., 1997, *Sherwood Tailing Reclamation Construction Completion Report*, Prepared for Western Nuclear, Inc.

Stoffel, Dorothy B., 1996, Internal Memorandum, Completion of WNI Petrographic Analyses Review, April 9, 1996.

MEMORANDUM

August 11, 1999

TO: Gary Robertson, Head
John Blacklaw, PE
Dorothy Stoffel

FROM: Earl Fordham, PE *Earl W. Fordham*

SUBJECT: WESTERN NUCLEAR, INC. MONITORING AND STABILATION FIELD INSPECTION

On June 2nd and 3rd, I conducted a portion of a structural stability inspection of the diversion channel, swale, and main embankment at Western Nuclear Inc.'s Sherwood site in eastern Washington (northwest of Spokane, Washington). I was accompanied on both days of this inspection by John Blacklaw, PE and by Gary Robertson on the second day.

The purpose of my inspection was to determine whether the riprap placement (e.g., coverage and thickness) would provide structural stability required by the Monitoring & Stabilization Plan. After being reclaimed in 1996 under a state approved tailings reclamation plan (TRP), the site is currently in the Monitoring and Stabilization phase of the reclamation. In this phase, the site is being monitored for structural stability, revegetation performance, and ground water compliance.

I have developed the following questions for Western Nuclear regarding the placement and gradation of the riprap that I saw during my inspection.

- There is an area approximately 10 feet by 15 feet at the downstream transition zone of Confluence G that is apparently missing the larger riprap (i.e., 10" D_{50}). Since only filter material is currently visible in this ~150 ft^2 zone, is this zone structural stable without the riprap? Analysis, including calculations, will be needed to substantiate an affirmative answer. Alternatively, corrective action may be proposed.

- In all confluences, except Confluence A, there are several random areas in which the large riprap is thin and segregated (not well-graded) (i.e., not touching adjacent riprap, thus resulting in voids in the riprap layer, and less than 100% coverage) with the filter layer visible. While most of these random areas are 1 to 2 ft^2, some were noted as large as 5 to 6 ft^2. Are these areas in the confluences structural stable? Analysis, including calculations, will be needed to substantiate an affirmative answer. Alternatively, corrective action may be proposed.

- There is scarring (from equipment gouging) and compaction (rock imbedded into the filter) in small rock (i.e., 3" D_{50}) placement areas, predominantly in the smaller portion of the diversion channel on the west side of the impoundment. Are these areas structural stable? Analysis, including calculations, will be needed to substantiate an affirmative answer. Alternatively, corrective action may be proposed.

If I develop further questions at some future date, I will forward them to you at that time.

MEMORANDUM

August 11, 1999

TO: Gary Robertson
Dorothy Stoffel
Earl Fordham, P.E.

FROM: John R. Blacklaw, P.E.

SUBJECT: **Western Nuclear, Inc. Monitoring and Stabilization 1999 Field Inspection**

I have completed my Western Nuclear, Inc. Monitoring and Stabilization Plan (MSP) field inspections for surface soil erosional stability. This inspection is in coordination with inspections by Dorothy Stoffel on rock durability and by Earl Fordham, PE on rock placement and gradation.

I have developed the following inspection findings and questions for Western Nuclear, Inc. It will be necessary for Western Nuclear, Inc. to adequately address these question(s) to assure long-term stability of surface soils.

FINDINGS:

- Ponded surface water on the impoundment surface area is due to settlement since construction completion. The ponding affect was predicted during design and analysis of the site and found to be acceptable and not to adversely affect long-term site performance. (Technical Evaluation Report, June 1998). Evaluation of near surface soils indicates that topsoil placement in the area of the pond has established a low-permeability layer and low infiltration rates. Re-vegetation (seeding) of the pond area took place in the fall of 1998 and is progressing well.

- Site surface stability is protected and assured by either placement of rock (rip rap), establishment of adequate vegetation, inherent stability of the surface soils and/or sub-grade materials, or favorable upstream topography (watershed characteristics).

- Since construction was completed in the fall of 1996, the site has been re-vegetating naturally as expected and remains in the early stages of vegetation progression.

- Some amount of soil erosion (lack of structural stability) is expected, particularly in the early phases of re-vegetation. It may be several years before the site vegetation is mature and climax species have successfully established and stabilized the site.

- Experience to date indicates that soil erosion continues to occur at rates that must diminish to assure long-term performance. Some of the observed soil erosion is on soils that contain significant small particle size content (topsoils). Other erosional areas appear to be due to concentrated flow affects from the contour and topography of upstream watersheds.

- There has been deposition of silty soil at one location in the northwest potion of the diversion channel that could potentially reduce the channel flow capacity if it were allowed to continue.

- On July 17, 1999, a moderate precipitation event (thunderstorm) occurred that caused increased soil erosion (rills, gullying and silt deposition).

- Adjacent land surfaces that have un-disturbed naturally vegetated soils remain structurally stable (Gully and rill formation is absent).

- Rock has been placed during construction in critical areas expected to require protection from surface water runoff events. To date, rock placed during construction has not moved or shown any potential structural instabilities.

QUESTIONS:

Will soil erosion potential continue to diminish and be limited to amounts that will not adversely affect long-term site performance? This question needs to be answered for several site-specific locations identified in the attached inspection report. See noted areas below and in the inspection report:

- Area west of the impoundment near the dam outslope and the site access road where some surface water flow and soil erosion is occurring away from the constructed channel and culvert due to local ditching from construction effects.

- Northwest section of the diversion channel where silty soil has been deposited in the channel.

- Area of gully soil erosion up-gradient of the silt collection point in the diversion channel.

- Areas of rill soil erosion in the diversion channel (both sides) up-gradient from the rock-covered slopes.

- Areas of rill soil erosion on margin slopes between the diversion channel and the impoundment surface.

- Area west (about 200 feet) of the impoundment outfall swale where gully soil erosion and deposition is occurring from southerly surface water flow.

- Area immediately south and southwest of the impoundment outfall swale showing gully soil erosion and deposition from surface water flow from the swale.

1999 MONITORING AND STABILIZATION INSPECTION REPORT
SURFACE SOIL EROSIONAL STABILITY

I have completed my review of surface soil erosional stability at the Western Nuclear, Inc. Sherwood Project site as part of Monitoring and Stabilization Plan (MSP) review requirements. This review and inspection is coordinated with inspections by Dorothy Stoffel for rock durability and by Earl Fordham for rock placement and gradation.

The MSP has been in effect since construction completion in 1996 and has been reviewed periodically by Western Nuclear, Inc. and by department staff for verification. Sheila Pachernegg, P.E. has provided twice annual inspections for structural stability of the Sherwood site since 1996. Department staff have inspected annually for structural stability. Inspection reports are available for review of past findings.

To date, no MSP related erosional stability inspection results have resulting in any re-construction of site features.

The area down-stream of the swale was re-contoured and revegetated and the area down-stream of the diversion channel was repaired and rock added in the spring of 1997. The ponded area was seeded in the fall of 1998 with an appropriate seed mixture approved by the Spokane Tribe of Indians.

Previous site inspections, groundwater reports and trends in re-vegetation results indicate that the site is nearing license termination criteria acceptance, as defined in the MSP. Therefore, the Western Nuclear, Inc. Sherwood Project site has been thoroughly inspected and reviewed in 1999. All specific MSP criteria components are being addressed.

Several inspections have been performed at the Western Nuclear, Inc. Sherwood Project site since April 1999 (after winter weather conditions ended).

- On April 21, an inspection occurred to evaluate results of over-winter effects at the site and for planning of summer inspections.

- May 20, DOE and NRC staff visited the site as part of their tour of several uranium mill reclamation facilities in the long-term stewardship program. (The Sherwood Project will enter this program upon license termination by the state.) DOE staff requested to visit and tour the site on May 20, 1999, before meeting with the Spokane Tribe of Indians on post-license termination issues the next day. DOE staff requested to bring an observer from the NRC who was part of their nation-wide tour. The Department of Health and Western Nuclear, Inc. invited DOE and NRC staff to visit and tour the Western Nuclear, Inc. Sherwood site. The NRC observer was provided a copy of the Department's Technical Evaluation Report, prior to the visit. DOE and NRC staff met with Department of Health and Western Nuclear, Inc. technical review staff and also toured of the reclaimed site. Although the NRC has been repeatedly invited to visit the Sherwood site, this is the first such visit since construction completion in 1996.

- Several detailed inspections for structural stability have occurred for rock durability, rock gradation and placement, and soil erosional stability on May 27, June 2-3, June 10, July 27 and August 5, 1999.

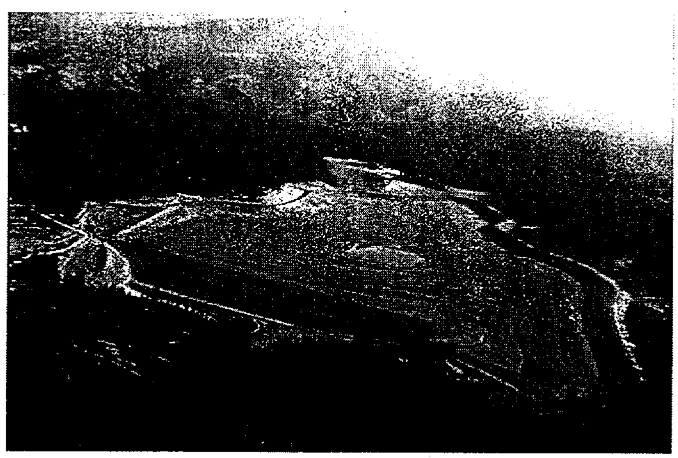
- On June 14, a technical review meeting was held in Olympia with Department of Health engineering review staff and Department of Ecology, Dam Safety Section engineering staff to review inspection findings. (See letter from Department of Ecology sent July 19, 1999.)

- Inspection of the site for vegetation productivity occurred July 21-23, 1999.

- Groundwater sampling, and TLD (thermo-luminescent device) collection has continued, as required by license conditions.

FINDINGS: INSPECTION CONCLUSIONS

Specific review and inspection results have been segregated into findings and questions. Findings are those areas of review where results are documented, but where no response or action is required by the licensee. The purpose of findings is to communicate conclusions. See photograph below for an aerial photo of the site.



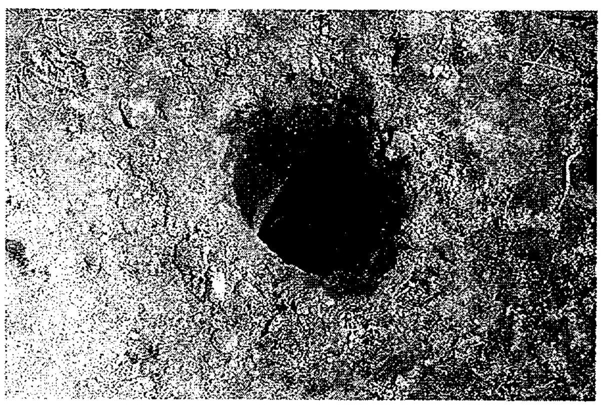
Aerial Photo of the Western Nuclear, Inc. Sherwood Project site near Wellpinit, WA. View is looking north at the mill tailing impoundment surrounded on the east and west by a diversion channel and the dam outslope on the south. A small pond is apparent in the middle. Ponderosa Pine forest surrounds the site.

FINDING 1: SURFACE WATER PONDING

Ponded surface water on the impoundment surface area is due to settlement since construction completion. The ponding affect was predicted during design and analysis of the site and found to be acceptable and not to adversely affect long-term site performance. (Technical Evaluation Report (TER), June 1998).

Evaluation of the near surface soils indicates that topsoil placement in the area of the pond has established a low-permeability layer and low infiltration rates. See photographs below for soil excavation and view of down hole.

Photograph shows Earl Fordham, PE digging a hole in the surface soil near the ponded area of the impoundment cover.

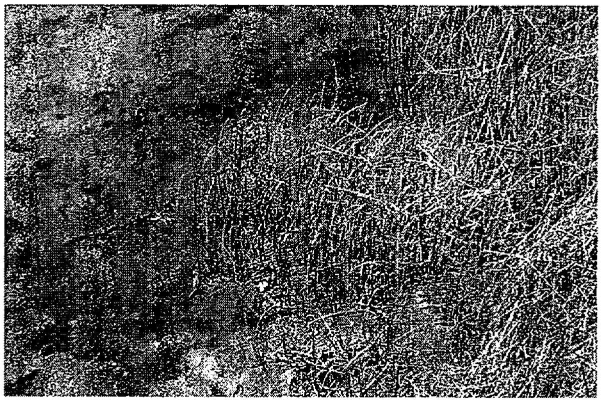


Photograph shows the dug hole after several days. The top portion of the hole (about 12 inches) is dark silty soil difficult to dig when dry (topsoil). Below is tan granular site soil. Water in the hole is approximately at the level of the pond surface.

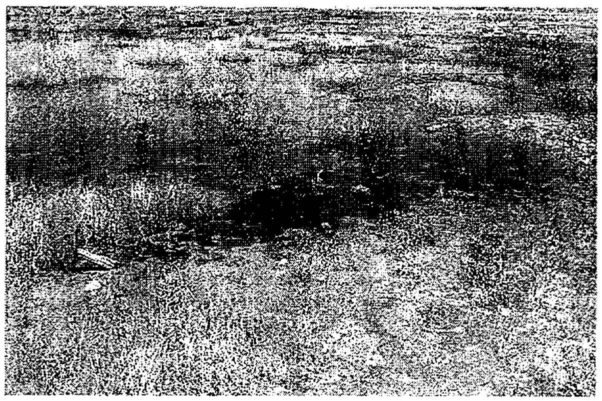
Water balance for the pond favors accumulation in fall and winter periods and evaporation from the surface and evapo-transpiration from plants in the spring and summer. Winter accumulation is due to storm precipitation and snowfall, subsequent run-off from the surrounding watershed (about 20 acres, mostly to the west of the pond) into the pond area, and high humidity preventing loss. Summer losses are due to pond evaporation and plant evapo-transpiration due to high water temperatures and water vapor pressure gradients due to low humidity and light wind conditions.

The pond depth and area fluctuates from about 5 acres at maximum in early spring to dry (none) in late summer and fall. The maximum pond depth is 2 to 3 feet based on topographic survey data. Overflow from the pond is to the east away from impoundment surface and then south through the rock-protected outfall swale.

Re-vegetation (seeding) of the pond area occurred in the fall of 1998 and is progressing well, showing an estimated 20 to 40 percent vegetation coverage of the pond surface by the beginning of August 1999. See photographs of pond vegetation.



Close up of pond vegetation. Photograph taken August 5, 1999.



Pond vegetation showing soil transition to pond water and algae growth. Vegetation productivity is estimated at 20 to 40 percent coverage.

The pond area in early August had diminished about 50 percent since June 1999. Considerable evidence indicates deer and elk drinking at the pond and browsing the cover vegetation. Birds are prevalent. Frogs are found in pollywog and mature stages. Insects are present.

Distant photograph of the ponded area. Deer were browsing and drinking on the near side of the pond when this photograph was taken.

FINDING 2: ROCK PLACEMENT AREAS ARE STABLE

Site surface stability is protected and assured by either placement of rock (rip rap), establishment of adequate vegetation, inherent stability of the surface soils and/or sub-grade materials, or favorable upstream topography (watershed characteristics).

Rock has been placed in critical areas expected to require protection from surface water storm or flood events. (Stability from wind is assured at the Western Nuclear site by requirements for stability from surface water flow.)

To date, rock placed during construction has not moved or shown any potential structural instabilities. (Insert P-60, 78, 86, 99, 108)

Some deposition of silty soils has encroached into the rock covers. However, the rock has not moved.

FINDING 3: UNDISTURBED NATURALLY VEGETATED SOILS ARE STABLE

Adjacent land surfaces, that have undisturbed, naturally-vegetated soils, remain structurally stable. Gully and rill formation is absent in these areas. See the following photographs, showing sites typical of the Sherwood site area.

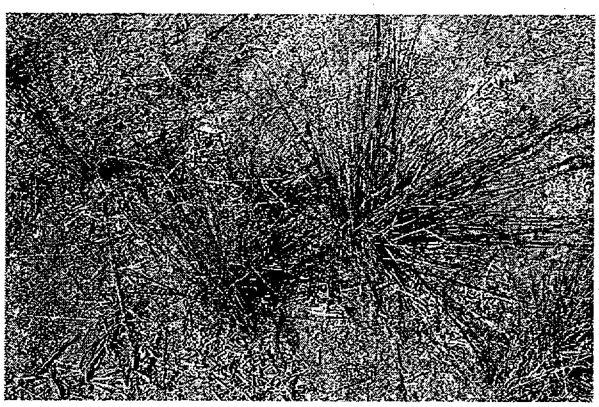
This photgraph was taken in an undisturbed area adjacent to the Sherwood site. The Ponderosa Pine forest is typical of the general area.

This photgraph is taken a few miles south of the Sherwood site showing the hills north of the Spokane River.

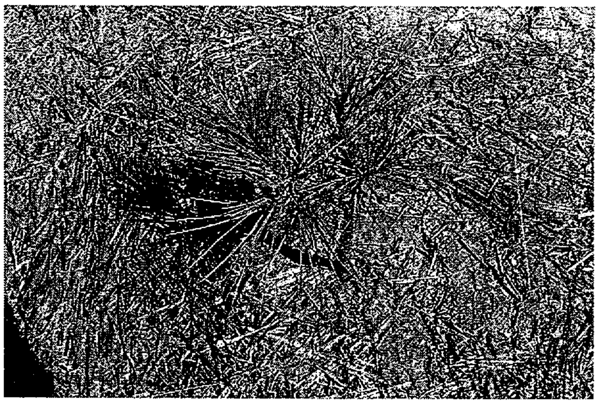
FINDING 4: RE-VEGETATION IS PROGRESSING AS EXPECTED

Since construction was completed in the fall of 1996, the site has been re-vegetating naturally as expected and remains in the early stages of vegetation progression. Vegetation has been monitored using a percent cover criteria and method. The MSP requires annual vegetation monitoring inspections.

In previous years (1997 and 1998), Western Nuclear, Inc. has performed these inspections with Department of Health consultants and/or staff performing QA/QC verification monitoring. In 1999, Department of Health inspection of vegetation has evaluated WNI inspections by QA/QC verification and also by independently monitoring using an adequate sample size. Results of vegetation monitoring are pending completion and will be reported separately from this report.



Photograph of bunch grass clumps typical at the Sherwood site.



Photograph of Ponderosa Pine tree approximately 3 years after planting as a seedling. Straw cover is remaining litter from initial placement in the fall of 1996.

Photograph of large perennial forb found on the Sherwood site.

Photograph is of perennial forb in flower stage (middle), grasses (right and left) and alfalfa (upper right).

Photograph is of natural vegetation with white and red flowers (white is on left, red is in center)

Photograph is from west side of site toward the east. Trees in the background are approximately one half mile away. Pond is seen in the middle. Foreground is margin slope.

FINDING 5: SOIL EROSION IS EXPECTED TO CONTINUE UNTIL ESTABLISHMENT OF MATURE VEGETATION

Some amount of soil erosion (lack of structural stability) is expected, particularly in the early phases of re-vegetation. It may be several years before site vegetation is mature and climax species have successfully stabilized site soils. During that time, the extent of erosional effects should diminish as vegetation becomes more established and soil surfaces adjust through a natural process of re-establishment of structurally stability. The reclamation plan design implemented at the Sherwood site requires this period of stability and therefore the MSP program and criteria.

Experience to date indicates that soil erosion continues to occur in some locations at rates that must diminish to assure long-term site performance. Some of these observed soil erosion area contain soils with significant silt content (topsoils). Other soil erosional areas appear to be due to concentrated flow affects from the contour and topography of upstream watersheds. See question(s) to address these specific erosional areas.

FINDING 6: SOIL DEPOSITION IS OCCURRING IN THE DIVERSION CHANNEL

There has been deposition of silty soils in the diversion channel that could potentially reduce the channel flow capacity, if allowed to continue. At one location in the northwest portion of the diversion channel, a large (more than 25 acres) re-vegetating disturbed area outside the diversion channel has produced rills and a gully erosion and resulting silty soil deposition in the diversion channel. Soil slopes up-gradient of rock-placement surfaces in the diversion channel have produced rills and deposited silt over the rock surfaces. A characteristic deposition fan has developed about 3 feet deep by about 100 feet long and 30 feet wide.

In addition to the large area of silty soil deposition, there is a general low-level encroachment of erosive soils from both sides of the diversion channel, above the rock-covered slopes. This accumulation is due to rilling of the generally un-vegetated upper side slopes. This low-rate depositional effect continues unabated, due to the lack of vegetation to stabilize these surfaces. No topsoil placement,or vegetation (seeding) program was performed during the construction period.

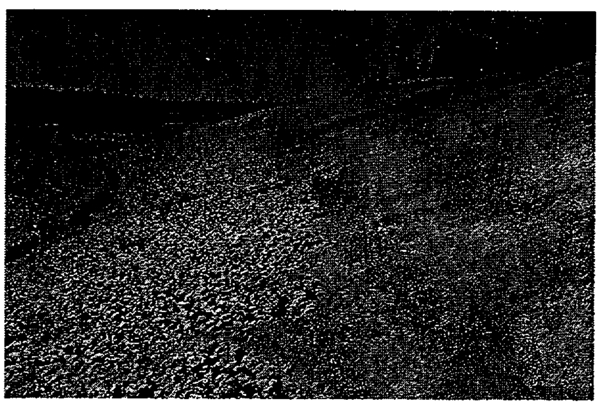
Silty soil that deposits within the rock void space actually increases the structural stability of the rock surfaces by filling the interstices thus precluding flowing water, by enhancing vegetation and by locking the rock pieces together. However, excess silt deposition, above the surface of the rock, may reduce the flow capacity of the channel, if it is allowed to continue accumulation over time.

FINDING 7: A JULY 17, 1999 STORM CAUSED RILLING AND SOIL DEPOSITION IN THE DIVERSION CHANNEL

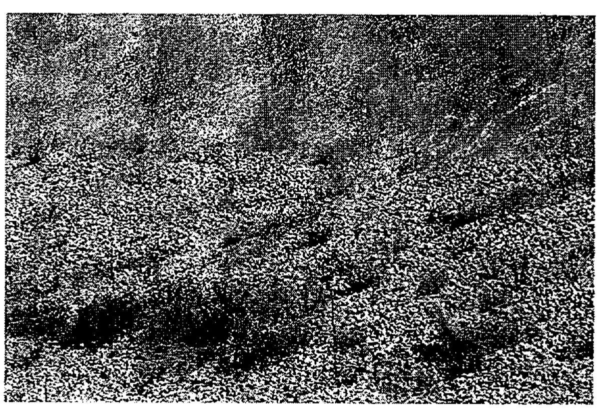
Erosional effects observed during inspections performed between construction completion and this storm versus erosional features seen after this storm indicate that a local thunderstorm of moderate intensity has caused additional rilling and soil deposition.

An hourly-reporting hydrograph, located just east of the reclamation site, indicated a peak intensity of 0.43 inches per hour for an 11-hour storm of 0.86 inches total accumulation.

Whether the amount of additional rilling and deposition is significant or indicative of long-term performance must be addressed by questions that follow. See photographs below for a comparison.



Photograph is taken prior to July 17, 1999 thunderstorm event. Area shown is the east diversion channel looking north. Notice some erosion of soils and deposition in the rock.



Photograph is of the same general area, taken after the thunderstorm. Notice the increase in soil erosion and deposition in the rock.

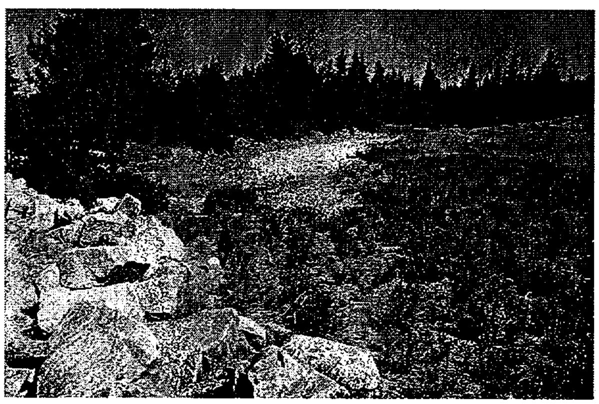
QUESTIONS: WILL SOIL EROSION CONTINUE AND ADVERSELY AFFECT LONG-TERM PERFORMANCE?

Questions require a response or action by the licensee to determine if an acceptable condition exists or is likely to occur in the long-term future. If a written response is inadequate to resolve the question, some action must be taken to correct the situation.

The general question is: Will soil erosion continue, or diminish and limit erosional and depositional effects to amounts that will not adversely affect long-term site performance? This question needs to be answered for several site-specific locations identified below.

QUESTION 1: AREA WEST OF IMPOUNDMENT NEAR ACCESS ROADWAY

The area west of the impoundment near the dam outslope and the site access road has some indication of ditching and channeling along the slope, rather than allowing sheet flow down-gradient. See photographs below of the general area and the ditch and channel effect remnant from contruction.



Photograph is taken from the access roadway up the rock protected drainage channel, looking northwest. Large rock in the foreground is adjacent to the road. A culvert (not seen at middle left of photograph) allows runoff to cross under the road.

Photograph is taken about 50 feet to the east of the photograph above showing the ditching and channeling in the area. Ditches have eroded slightly in alignment with the ripping operation performed during construction. Channels direct runoff away from the drainage and culvert.

Surface water flow and soil erosion are occurring away from the constructed channel and culvert due to local ditching from construction effects. During construction, the area was compacted due to construction traffic and was subsequently ripped with a CAT-mounted deep ripping tool. Surface water flow has since followed this ripping pattern and not flowed into the channel and culvert as expected.

There is a narrow divide between this watershed and the dam outslope western groin watershed that should not be breached. It would be preferred that the area is recontoured or ditches and channels removed to force surface water flow into the designed channel and away from the dam outslope and west groin.

QUESTION 2: AREA OF GULLY SOIL EROSION UPSTREAM OF THE SILT COLLECTION POINT IN THE DIVERSION CHANNEL.

The northwest section of the diversion channel is down-gradient from a disturbed and re-vegetating area located to the north. This area was a borrow source during construction and was re-vegetated (seeded) in 1996. Surface soils in the area have a high silt content and have been eroding slowly in rills. Near the base of this hill area, a bench about 25 feet wide was constructed across the natural (sheet flow) surface water run-off pathways. The bench has very little water-holding capacity and slopes generally toward the south. However, the slope of the bench is nearly level and slightly sloped to the north on the north end of the bench. Surface water and sediment has accumulated on the bench and overflowed at the north end, producing a gully. This gully has expanded over the past 2 years and has now deposited considerable silty soil in the diversion channel. See photographs below of rill on hillside and gully near the bench.

Photograph is of hillside north of the northwest section of the diversion channel. Notice the extent of re-vegetation and the rill formation.

Photograph is of the gully formed at the base of the hillsite north of the northwest section of the diversion channel. The gully has formed where the bench overflowed and eventually cut a gully. Silt from the hillside rills and the gully area have deposited in the diversion channel.

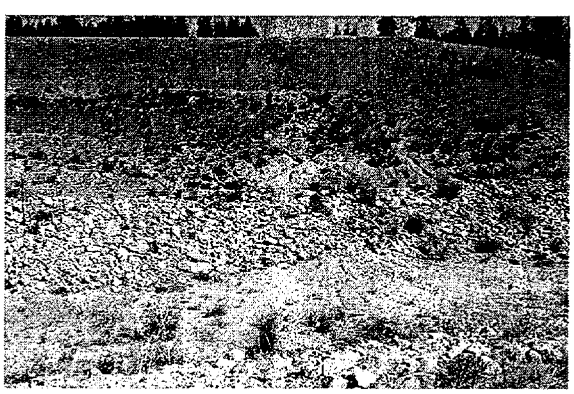
The constructed bench has had the effect of concentrating the surface water flow from the hillside, thus inducing the production of a gully and silty soil deposition in the diversion channel.

To stabilize the local area of the bench, it may be possible that recontouring of the bench, re-sloping of the bench, or removal of the bench may be warranted to eliminate the concentrated flow path. If the area is disturbed by some form of re-construction, it may also be warranted to install stabilization matting to assist erosional stability in the short-term, or rock placement for a more permanent solution.

QUESTION 3. NORTHWEST SECTION OF THE DIVERSION CHANNEL WHERE SILTY SOIL HAS ACCUMULATED.

Silty soil has accumulated in the diversion channel. The accumulation has increased over the past two years, including the July 17th thunderstorm event. This accumulation is likely to continue until the up-gradient soils are stabilized. (See Question 2.)

There is some question that, if the accumulated soil is allowed to remain or continue to accumulate in the channel, it may interfere with the required flow capacity of the diversion channel. It may therefore be warranted that the accumulation of silty soil is removed, or re-distributed, to no longer interfere. It may also be necessary to address Question 2 to limit or eliminate the source of silty soil accumulation. See photograph below of soil deposition in the northwest section of the diversion channel.



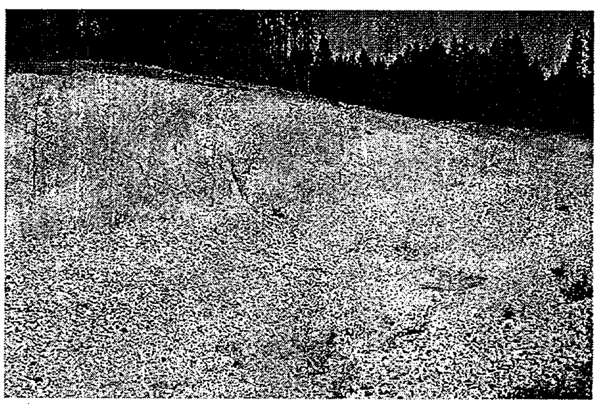
Photograph shows soil deposition in the diversion channel in the foreground and gully in the upper middle of the frame. The background shows the re-vegetated hillside producing the runoff. Note the area of the diversion channel covered with soil. Soil is approximately 3 feet deep at the deepest location.

QUESTION 4: AREAS OF RILL SOIL EROSION IN THE DIVERSION CHANNEL (BOTH SIDES) UP-GRADIENT FROM THE ROCK-COVERED SLOPES.

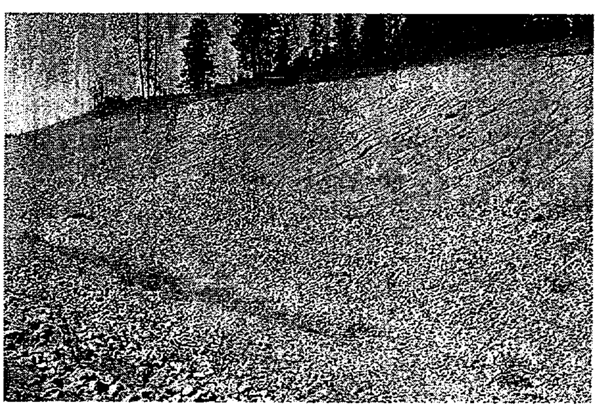
Observation during site inspections indicates a slow-rate rill erosion effect on the soil slopes up-gradient of rock-covered slopes in the diversion channel. This effect is not uniform in all areas, but is seen on both sides and adversely influences by flow concentration features.

These areas are not vegetating because no topsoil was placed in these areas and vegetation (seeding) was not provided during construction. The natural soils are generally void of soil properties conducive to vegetation. Some areas are located on weathered monzonite that remains rather hard with very little small particle fraction (silts and clays).

Natural progression of vegetation has been expected and is likely over the long-term. However, since it has not been evident in three years, there is a question of how long might it take to naturally re-vegetate, and how much accumulation of soil may occur in the diversion channel as a result. See the following photographs of the diversion channel soil slopes at different locations and sides of the channel.

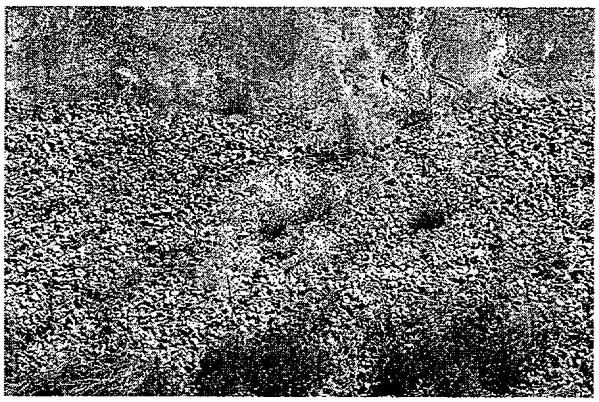


Photograph of the west side of the diversion channel. A sub-soil geological interface has produces a flow concentration effect. This in turn has caused a rill to form and increased soil deposition in the channel at this location.



This photograph is on the east side of the diversion channel showing rilling in the soil area and deposition in the rock slope.

This photograph is of the area between the diversion channel rock slope and the margin. This area is only about 20 feet in length, but shows rilling in spots.



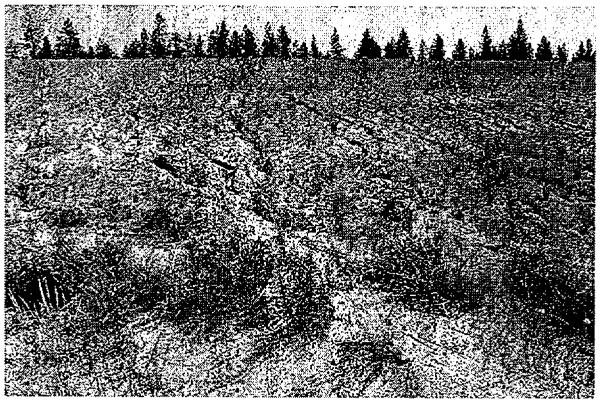
This photograph is of the east diversion area showing soil rills and soil deposition encroaching into the rock slope. Vegetation is establishing in the diversion channel rock slopes and bottom. Vegetation is generally absent on soil slopes.

QUESTION 5: AREAS OF RILL SOIL EROSION ON MARGIN SLOPES BETWEEN THE DIVERSION CHANNEL AND THE IMPOUNDMENT SURFACES.
The margin is the sloped surface area between the diversion channel and the impoundment. The margin slope is generally 5H:1V on the east side of the impoundment and 3H:1V on the west side. The elevation difference, crest to tow, is about 50 vertical feet. The margin area was covered with topsoil approximately 12 inches deep during construction. A rock toe apron 10 feet wide was also placed at the base of the margin.

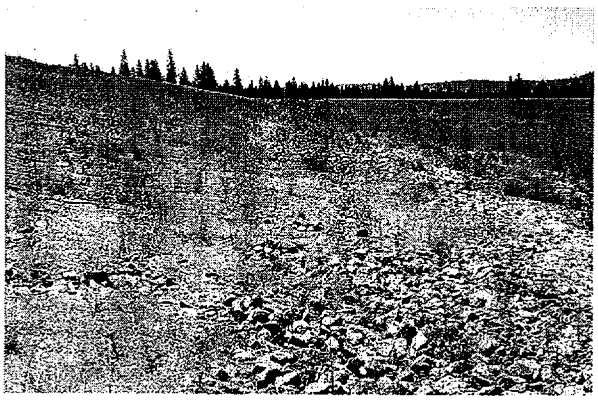
The silty soil (topsoil) layer is comprised of erosive material in some areas and has shown a variable pattern of erosion, deposition and self-healing over time as the margin surface has re-vegetated.

The recent thunderstorm event has caused additional erosion that indicates that the area is not yet stable. Past experience indicates that the recent rill production may self-heal.

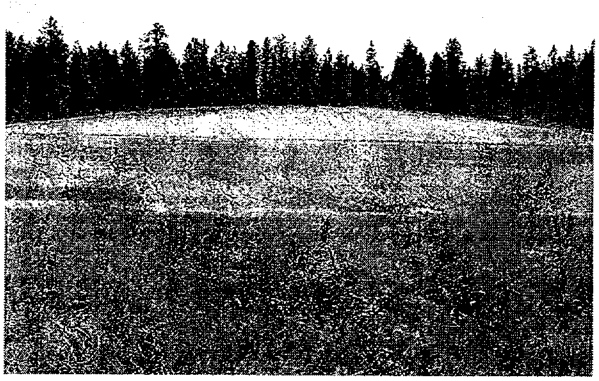
The question of long-term stability needs to be addressed. How long might it take to vegetate sufficiently, and how much erosion of margin soils may occur as a result? In some areas there may be sub-grade soils that are stable without vegetation. In other areas there may not be. This question needs to address specific areas of the margin. See photographs below that are representative of rill erosion on the margins and soil deposition into the rock toe.



Photograph of the east margin surface showing rills on the upper portion of the slope. Some deposition is shown around the larger vegetation in the foreground.



Photograph is of the same general area as above, showing the tow of the margin slope and the soil deposition into the rock toe.



Photograph is on the east margin in the distance. Rills are evident in the margin slope surface. Foreground shows the impoundment cover vegetation.

QUESTION 6: AREA WEST (ABOUT 200 FEET) OF THE IMPOUNDMENT OUTFALL SWALE WHERE GULLY SOIL EROSION AND DEPOSITION IS OCCURRING FROM SOUTHERLY SURFACE WATER FLOW.

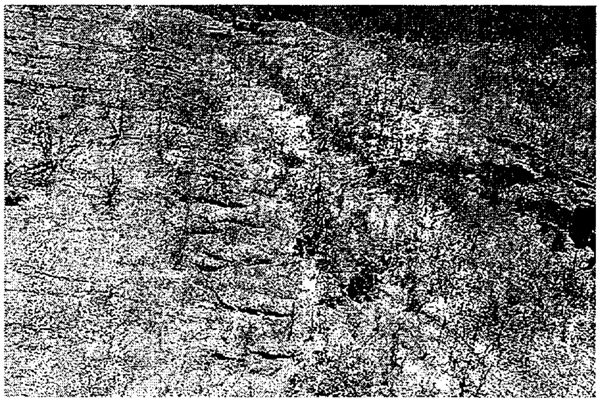
An approximately 5-acre area between the margin slope and the impoundment outfall swale is relatively flat. Construction slopes must have produces a gentle slope toward the south for this small area. It is expected that this area would flow to the outfall swale and that the swale rock apron would mitigate any erosional effects. However, since the surface water flow is toward the south, it must flow south between the impoundment outfall swale and the east margin slope. This area is not protected by rock.

There is a construction bench on the southern extent of this area that concentrates flow toward the south and east (away from the impoundment swale). This bench has a limited water holding capacity and has overflowed producing a progressing gully. The inlet to this bench has also concentrated flow and produced another gully. The bench has received some deposition and may overflow along its length under moderate stormwater flows.

To stabilize the local area of the bench, it may be possible that recontouring of the bench, re-sloping of the bench, or removal of the bench may be warranted to eliminate the concentrated flow path. Although it is desirable that this area produces surface water flow to the outfall swale, this may require a considerable addition of soil fill and may not be warranted. Photographs below show the gully at the south edge of the constructed surface, the bench and the gully at the end of the bench.

Photograph is of gully formed at the south end of the impoundment surface, between the swale and east margin. Runoff from this general area toward the south has cause this gully.

Photograph is of the south end of the impoundment where the gully flows into bench. Bench shows deposition and little capacity prior to breaching.



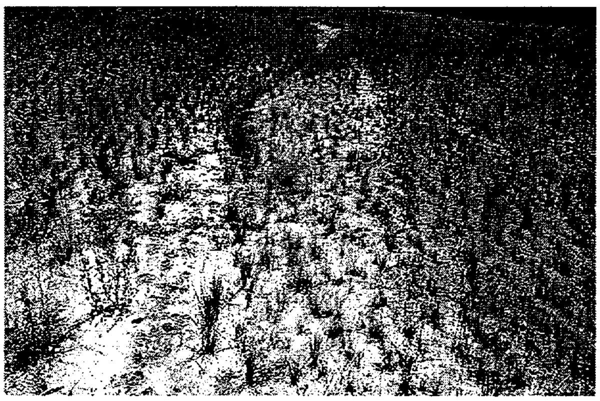
Photograph is of the southeastern extent of the bench shown above. A gully formed at the end of this bench. The bench has recently overflowed and begun cutting a second gully.

QUESTION 7: AREA IMMEDIATELY SOUTH AND SOUTHWEST OF THE IMPOUNDMENT OUTFALL SWALE SHOWING GULLY SOIL EROSION AND DEPOSITION FROM SURFACE WATER FLOW FROM THE SWALE.

The impoundment outfall swale is a primary structural feature of the Sherwood site. Proper functioning of the swale will preclude excessive erosional headcutting upstream from the swale onto the impoundment surface that might expose tailings. The swale rock protection elevation is higher that the tailings elevation. More than 13.5 feet of site soil covers tailings, further protecting the tailings from potential release.

The impoundment swale has seen surface water flow and erosional effects upstream and downstream each year since construction completion. In the first year after construction completion (spring of 1997), the area down-stream was re-contoured and re-vegetated due to swale outflows and erosion of the surface soils. Re-contouring of the area produced a sloped soil apron one to two feet deep and 30 feet long and two successive benches across the down-stream flow path. The soil apron overlays natural rock surfaces of quartz monzonite. The benches have little water holding capacity and are sloped gradually toward the southeast and away from the dam outslope. The soil apron has eroded deeply to expose quartz monzonite sub-grade rock in gullies. The gullies are one to two feet deep by one to three feet wide at several locations across the width of the swale outfall. Silts from the eroding soil apron have accumulated in the first bench and reduced the bench capacity to control and direct surface runoff flow. See photographs below of the area down-stream of the impoundment swale.

Photograph is of soil apron erosion down-stream of the impoundment swale. Soil apron material has high silt content in this area and is highly erosional. Gully shown is approximately 2 feet deep to quartz monzonite sub-grade by approximately 2 to 3 feet wide.



Photograph is of bench just down-stream of the soil apron, shown above. The bench has received some deposition in the foreground. In the background, the bench has begun cutting approximately one foot deep by one to two feet wide.

With moderate runoff from the swale, the first bench is likely to be breached; thus producing concentrated flow, gullying, and deposition of silt in the shallow capacity of the second bench. This would then repeat in due course and produce a gully effect down-slope from the swale through the two benches.

The past two springs have seen some surface water runoff down-stream from the swale and production of erosional effects on the soil apron. The erosion of this soil apron may not be significant to the structural aspects of the swale outfall since there is a quartz monzonite sub-grade. However, soil apron erosion produces silt deposition down-gradient.

In the Jerald LaVassar, PE technical review (Department of Ecology letter of July 19, 1999), the question of quartz monzonite weathering potential was raised. There is concern that exposed quartz monzonite in some instances at the Sherwood site "is subject to increased rates of degradation given the greater exposure of extremes of freeze-thaw and wet-dry cycles…."

It is notable that quartz monzonite structural quality is quite variable at the Sherwood site and that properly qualified quartz monzonite rock was used for rock protection materials during construction. The natural quartz monzonite sub-grade located just at the swale tow should be specifically characterized for its long-term structural capability.

It is important that the swale outfall area retains long-term structural stability to protect this area from potential headcutting and breakdown in the swale function due to gradual weathering of the rock sub-grade and raveling of the swale rock. This is certainly a long-term process, but it needs to be evaluated for longevity.

The present flow path away from the outfall swale follows the slope of the first bench toward the southeast. This path is presently stable for over 100 feet, before the path turns down-gradient, steepens, and begins to cut a small gully. The flow path stabilizes again after crossing a short distance of undisturbed soil. As previously stated, however, the bench(es) itself may not be stable for more than a few years.

The entire area down-stream of the swale requires a technical review, evaluation of performance over the last three years, and an estimate of expected performance over the long-term. Special emphasis must be addressed to the structural stability of exposed quartz monzonite subgrade, the benefit or detriments of the current configuration of benches, and any alternatives that may be required to improve or correct this area. See the Jerald LaVassar, PE letter for some suggested alternatives, if needed.

STATE OF WASHINGTON
DEPARTMENT OF HEALTH
DIVISION OF RADIATION PROTECTION
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August 20, 1999

Brad K. DeWaard, Resident Agent
Western Nuclear, Inc.
Sherwood Project
P.O. Box 392
Wellpinit, Washington 99049

Dear Mr. DeWaard:

As we discussed by phone on August 19, 1999, the department has completed a portion of the monitoring and stabilization review (soil erosion and rock durability, placement, and gradation) of the WNI Sherwood facility. I have enclosed the field inspection reports written by Dorothy Stoffel and John Blacklaw (Earl Fordham's will be forwarded to you by September 7). The inspectors' questions have been summarized below. Please address each point, demonstrating that long-term structural stability requirements will be met. Justify your conclusions with calculations and analysis, if needed. Should any of these areas require correction, please propose remedial actions for the department's review and approval.

<u>SOIL EROSIONAL STABILITY</u>

1. Area west of the impoundment near the dam outslope and the site access road where some surface water flow and soil erosion is occurring away from the constructed channel and culvert due to local ditching from construction effects.

2. Northwest section of the diversion channel where silty soil has been deposited in the channel.

3. Area of gully soil erosion up-gradient of the silt collection point in the diversion channel.

4. Areas of rill soil erosion in the diversion channel (both sides) up-gradient from the rock-covered slopes.

5. Areas of rill soil erosion on margin slopes between the diversion channel and the impoundment surface.

6. Area west (about 200 feet) of the impoundment outfall swale where gully soil erosion and deposition is occurring from southerly stormwater flow.

7. Area immediately south and southwest of the impoundment outfall swale showing gully soil erosion and deposition from stormwater flow across the swale.

ROCK DURABILITY

8. Gullies have developed at the toe of the outlet swale. In these areas, silty topsoil has eroded away and underlying quartz monzonite bedrock is exposed. Some of the quartz monzonite bedrock in the tailings impoundment area weathers quite readily when exposed, and other areas are quite resistant to weathering. The distinction between the two types of quartz monzonite was apparent during construction of the diversion channel because some quartz monzonite was readily ripped and some areas of quartz monzonite required blasting. Has the nature of the quartz monzonite underlying the toe of the outlet swale been characterized and documented? What construction features of the outlet swale would prevent shifting of the riprap (raveling), if the exposed quartz monzonite significantly weathers over time?

9. There is a 150 ft^2 area at the southern transition from Confluence G, which lacks placement of large riprap. Geologic evaluation appears to indicate that visible filter material overlies quartz monzonite. Has the underlying quartz monzonite been characterized, and is it adequate to provide long-term stability to the riprap in this confluence?

ROCK GRADATION AND PLACEMENT

10. There is an area approximately 10 feet by 15 feet at the downstream transition zone of Confluence G that is missing larger riprap (i.e., 10" D_{50}), and only filter material is visible.

11. In all confluences, except Confluence A, there are several random areas in which the large riprap is thin and segregated (not well-graded) (i.e., not touching adjacent riprap, thus resulting in voids in the riprap layer, and less than 100% coverage) with the filter layer visible. While most of these random areas are 1 to 2 ft^2, some were noted as large as 5 to 6 ft^2.

12. There is scarring (from equipment gouging) and compaction (rock imbedded into the filter) in small rock (i.e., 3" D_{50}) placement areas, predominantly in the smaller portion of the diversion channel on the west side of the impoundment.

If it would be helpful, we will meet with you onsite to discuss each area noted above and in the field inspection reports.

You may contact me at (360) 236-3241, John Blacklaw at (360) 236-3243, or Dorothy Stoffel at (509) 456-3166 if you have any questions.

Sincerely,

Gary Robertson

Gary Robertson, Head
Waste Management Section

Enclosure

cc: Bruce Wynne, Spokane Tribe
Mary Verner, Spokane Tribe
Sharon Yepa, BIA, WA
Stanley Speaks, BIA, OR
Shannon Work, Spokane Tribe
Donna Bruce, BIA, WA
Dennis Sollenberger, NRC
Jerald LaVassar, WDOE
Russel Edge, WDOE

Department of Health
Division of Radiation Protection
Waste Management Section

August 24, 1999

TO: Gary Robertson, Head
John Blacklaw, PE
Dorothy Stoffel

FROM: Earl Fordham, PE

SUBJECT: STRUCTURAL STABILITY INSPECTION AT WNI

On June 2nd and 3rd, I conducted a portion of a structural stability inspection of the diversion channel, swale, and main embankment at Western Nuclear Inc.'s Sherwood site in eastern Washington (northwest of Spokane, Washington). I was accompanied on both days of this inspection by John Blacklaw, PE and by Gary Robertson on the second day.

The purpose of my inspection was to determine whether the riprap placement (e.g., coverage and thickness) would provide structural stability required by the Monitoring & Stabilization Plan. After being reclaimed in 1996 under a state approved tailings reclamation plan (TRP), the site is currently in the Monitoring and Stabilization phase of the reclamation. In this phase, the site is being monitored for structural stability, revegetation performance, and ground water compliance.

The structural stability inspection commenced at the upstream end of the diversion channel (station 90+00). The diversion channel is 9000 feet long. Riprap provides approximately 700,000 ft^2 of structural stability. Its upstream end is in the southwestern quadrant of the tailing reclamation area. The purpose of the diversion channel is to capture the runoff water from the surrounding drainage basins and direct it away from the impoundment cover. The cover was constructed a top the tailings pond that was in operations during mill operations. As such, the cover is surrounded by the natural drainage basin. This configuration results in the diversion channel being at a higher elevation that the surface of the cover.

The purpose of the riprap is to protect the channel from eroding, which would result from large quantities of fast moving water flow in the channel if unprotected. Vegetation in the channel is beneficial for securing the soil matrix in place. Additionally, the analysis performed for the TRP took into account the natural encroachment of vegetation and trees in the channel and sized the channel accordingly.

The inspection commenced at the highest portion of the diversion channel. The D_{50} rock size at this location is 3 inch. The thickness of the layer was found to be at least 6 inches. The rock at this location was found to be adequately sized and well graded (e.g., no areas/bands of smaller rock). The picture below shows this uppermost point of the diversion channel.

Picture 1: Looking downstream at the uppermost end of diversion channel

Picture 2: Ridges and valleys from construction

Ridges and valleys were noted on the sloped walls of the diversion channel. The bulldozer used to push the rock up the walls of the diversion channel apparently causes these "waves". The valleys resulted from the compaction offered by the tracks of the bulldozer. The ridges were apparently caused by the lack of any compaction. This ridging and valley effect is called "construction traffic effects" in this report. This effect was noted most often where smaller rock (D_{50} = 3 inch) was placed. While the ridges were generally found to be parallel to the channel centerline in the western portion of the diversion channel, in the eastern sections of the channel the ridges were found to be perpendicular to the channel centerline. Picture 2 (above) and other pictures elsewhere in this report attempt to show the ridges and valleys.

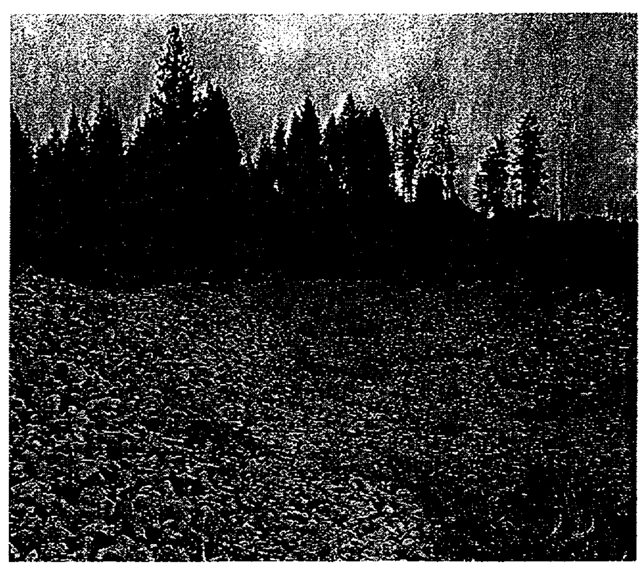
As the inspection proceeded down the diversion channel, small areas (area $\approx 8\ ft^2 = 2' \times 4'$) were noted where the rock was not as thick as adjacent rock. These thin areas, however, had some riprap. Additionally, in these thinner areas, vegetation was visible.

In order to simplify construction, most of the riprap used was oversized. The oversizing ranged from 25% to approximately 100 % (e.g., use 15 inch rock where 8 inch rock was called for in the design). The D_{50} rock sizes that were seen during the inspection were 3 inch, 6 inch, and 15 inch. Beneath the riprap was placed a filter layer of rock. The filters used beneath the riprap had D_{50} sizes of approximately 0.75 inches and 1 inch. Filter material is placed to prevent high water velocities in the within the voids of the riprap.

Picture 3: Vegetation in thin riprap

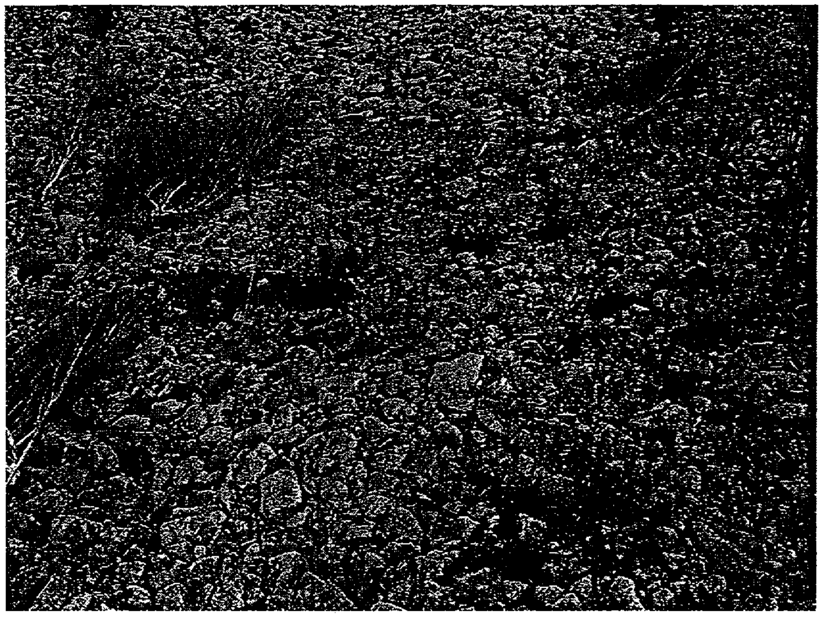
At Station 86+00, a thin area of riprap was noted (see picture 4). Station 86+00 corresponds to the first bend encountered during the inspection. The bend is approximately 30° to the left. Due to the channel width at this point, an apparent thin area was left in the outer diversion channel wall by the equipment used to excavate and build the diversion channel (e.g., scarring the wall). Again, vegetation has taken root where the thickness of the riprap is not uniform. Detailed investigation of this volunteer vegetation indicates that the roots are pervasive. It was with difficulty that the thickness of the riprap in these areas was determined.

Picture 4: Scarring in the channel walls



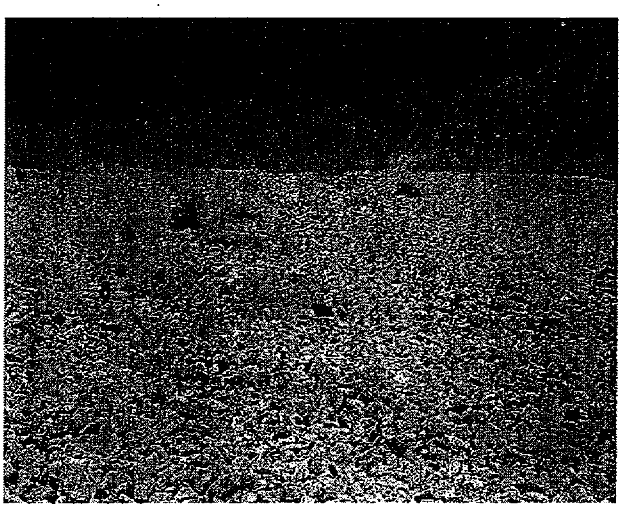
Picture 5: Diversion channel layout

From the first bend, picture 5 shows the channel layout. At Station 83+28 (approximately 100 feet upstream of Confluence A), some uneven rock placement was noted as shown in picture 6.


Picture 6: apparent uneven rock placement

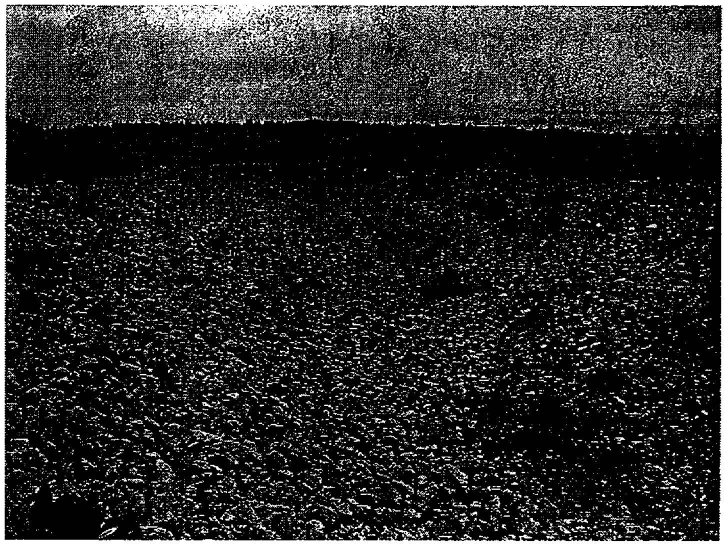
In several spots that were investigated, the effects of post-placement traffic (e.g., driving over the riprap after placement) was apparent. When areas, such as shown in picture 6, were excavated to determine the actual thickness of the riprap for structural stability evaluation, the larger rock sizes were embedded into the filter material under the riprap creating rock mulch. This embedding of the larger riprap into the filter layer was prominent in places where the channel was narrow and there was evidence of traffic.

Picture 7 shows Confluence A with the construction traffic effects. Picture 8, showing the inner wall upper edge, documents vegetation pioneering a spot of riprap.


Picture 7: Confluence A with ridges


Picture 8: inner wall at Confluence A

After Confluence A, the channel bends 30° back to the northeast as shown in picture 9. While construction traffic effects were noted, the channel was well graded.

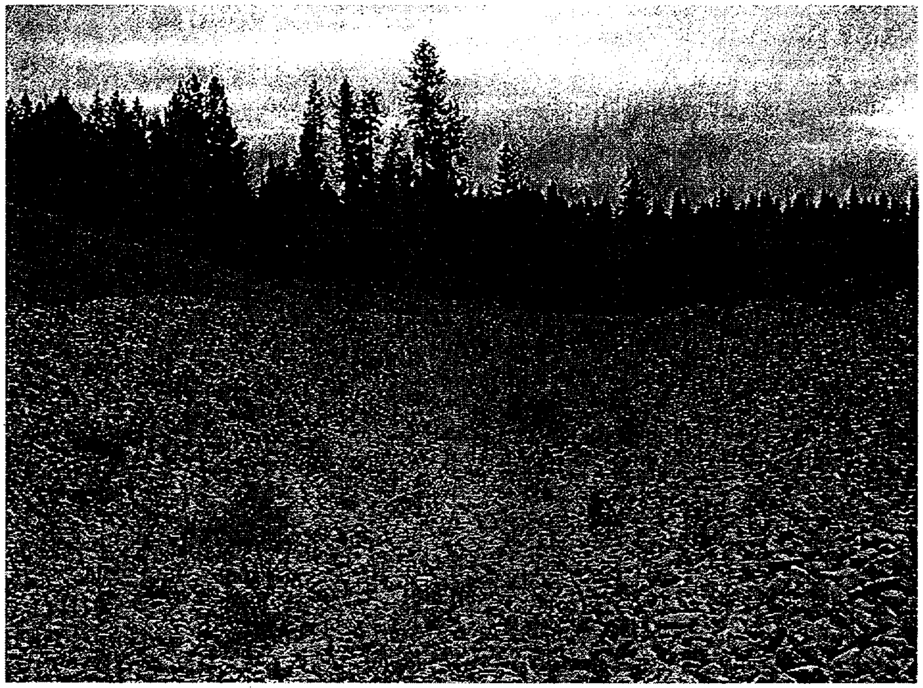


Picture 9: downstream of Confluence A

Picture 10 shows the channel after the bend that is visible in picture 9. In this portion of the diversion channel, the mixing of the various rock sizes was good (e.g., no segregation or banding of riprap). Traffic effects were minimal. Apparent thin areas were found to be structural stable by digging exploratory holes into the riprap layer.

Picture 10: channel between Confluences A and B

In the leg immediately upstream of Confluence B, construction traffic effects were noted on the outer bank of the channel as well as the effects of driving on the riprap at the bottom of the channel. Vegetation was also noted.



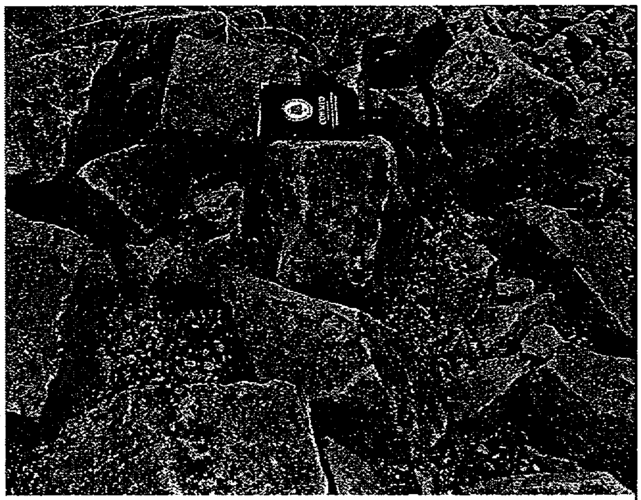
Picture 11

Some construction traffic effects as well as vegetation taking root.

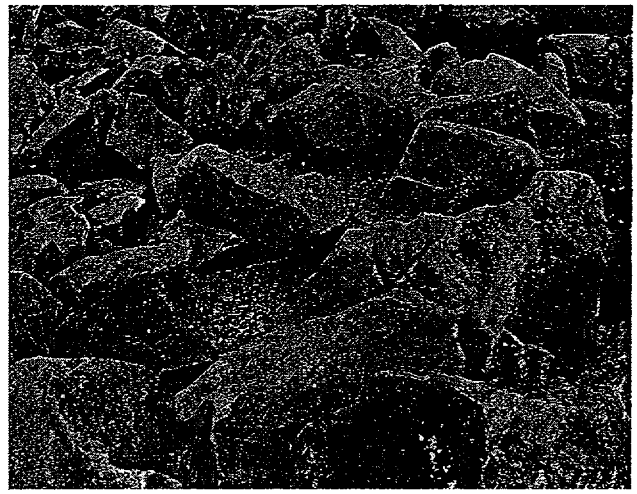
Picture 12 is taken from the upstream transition of Confluence B. Vegetation is easily visible. Construction traffic effects were absent. The area where traffic had traversed the confluence was visible, due to the weight compaction of the equipment moving in this area, but adverse effects did not occur. This absence of construction traffic effects may be due to the wider channel at the confluence.

Picture 12: Confluence B with vegetation

In Confluence B, there were spots, limited to about 1-2 ft^2, where the filter layer was visible. Additionally, as noted before, opportunistic vegetation had pioneered these spots. Pictures 13, 14 and 15 document these spots and surrounding area.



Picture 13: filter visible through riprap
Size of "COHMED" notebook is 9.5 in x 12 in



Picture 14: Filter visible through the riprap at Confluence B

Picture 15: area surrounding picture 13

Examination of Confluence B found exposed spots of filter (i.e., <100% riprap coverage), and construction traffic effects.

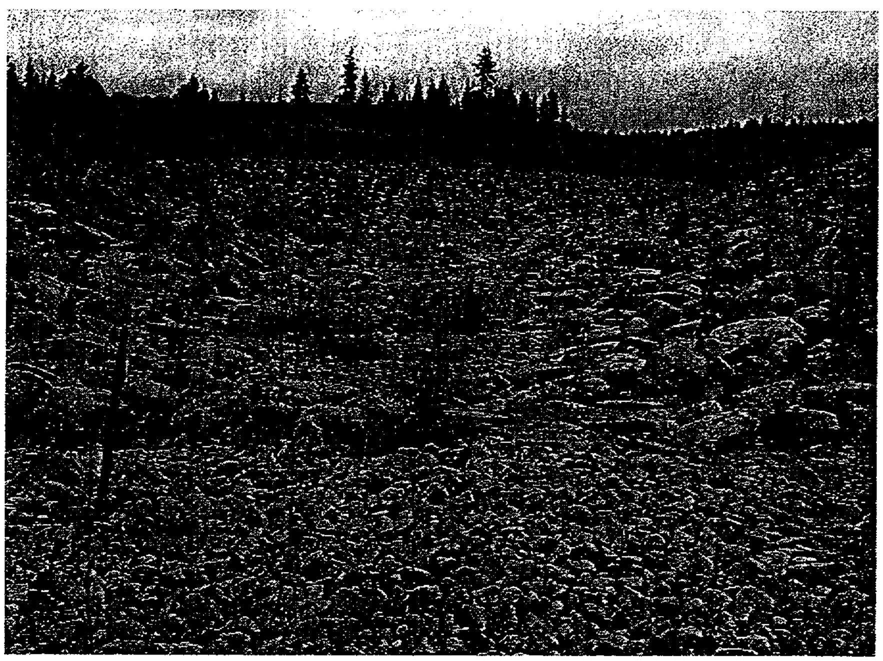
Continuing downstream from Confluence B to Confluence C, construction traffic effects were noted, but the thickness was found to be consistent with adjacent areas. Picture 16 shows the diversion channel immediately downstream of Confluence B.

Picture 16

Taken at the downstream transition at Confluence B.

Ridges and valleys are visible on both slopes of the diversion. While not uniform, the thickness in the valleys was found to be acceptable.

During the inspection, it was noted that the smaller riprap showed the effects of the construction traffic more readily than the larger rock sizes. The predominant impact seen was the compaction of the angular rock into itself and the filter below it.



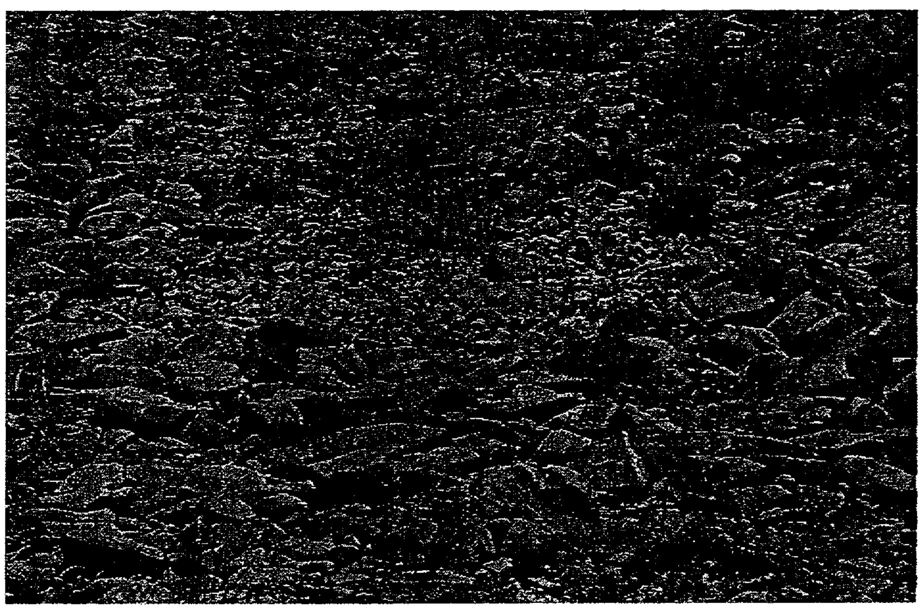
Picture 17: upstream edge of Confluence C

Perhaps the primary reason that construction traffic effects were not noted in the larger rock areas was the size of the rock. As seen in picture 17, there is a substantial difference in the rock size used in the confluence areas versus the rock size used elsewhere in the diversion channel. The confluences were the likely location for voids in the large riprap layer to be found, as in the pictures below.

Picture 18: filter visible through void in riprap layer on inner slope at Confluence C

Picture 19: looking up Confluence C

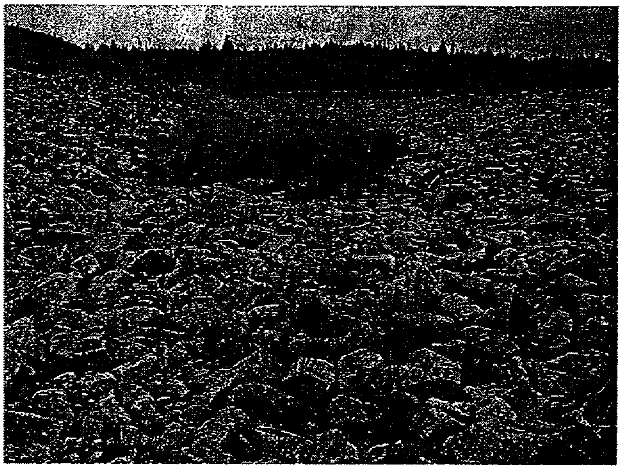
Picture 19 is taken looking up Confluence C. Many different sizes of riprap are also visible. Near the center of picture 19, it appears that there is an area of only small rock. This area was investigated and recorded in picture 20 (below).



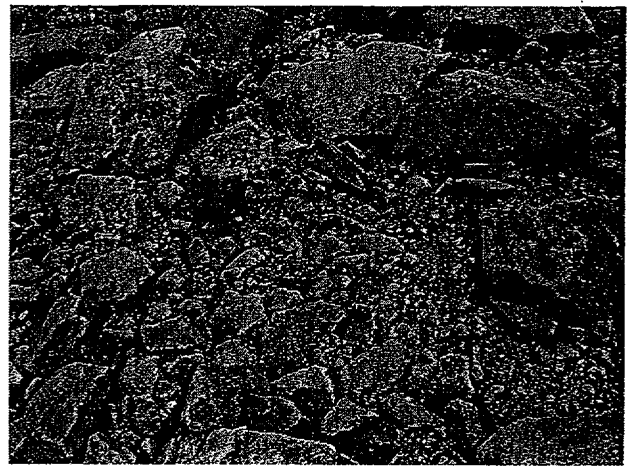
Picture 20: smaller rock area on confluence centerline

Upon initial discovery, this area (shown in picture 20) appears to be a poorly graded area of riprap. However, when the upper layer of smaller riprap (D_{50} = 4-6 inches) is removed, larger rock is found underneath.

Continuing the inspection downstream from Confluence C, silting and riprap voids were visible as shown in pictures 21 and 22. In over 90% of the void areas, vegetation is growing.



Picture 21: silting in channel from erosion



Picture 22: voids in rip-rap layer

As shown in picture 21, beyond the silt area is a bend in the channel to the left. Picture 23 shows the diversion channel layout after that bend. Construction traffic effects are minimal and the riprap is larger (e.g., D_{50} = 6 inch).

Picture 23: diversion upstream of Confluence D

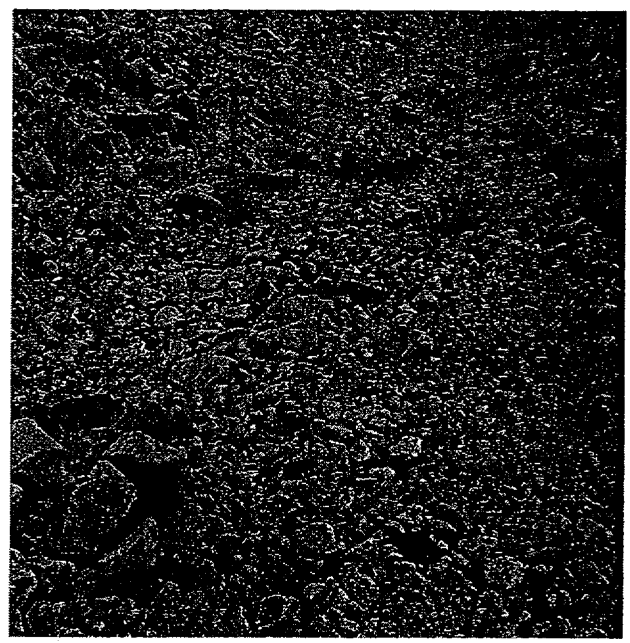
Near the far end of the leg shown in picture 23, a valley of smaller rock sitting atop bigger rock was found. The surface is uneven which corresponds to the bottom of the channel. This area of the channel was blasted during construction due to heavy equipment being unable to excavate the hillside. Picture 24 shows the valley of smaller rock.

Picture 24: about 200 feet upstream of Confluence D

Valley of smaller rock atop bigger rock

At Station 53+00 (about 150 feet upstream of Confluence D), a diversion channel low spot was characterized. The area was approximately 10 ft^2. Picture 25 shows the spot. Vegetation was also seen in this area.

Picture 25: low spot in diversion channel



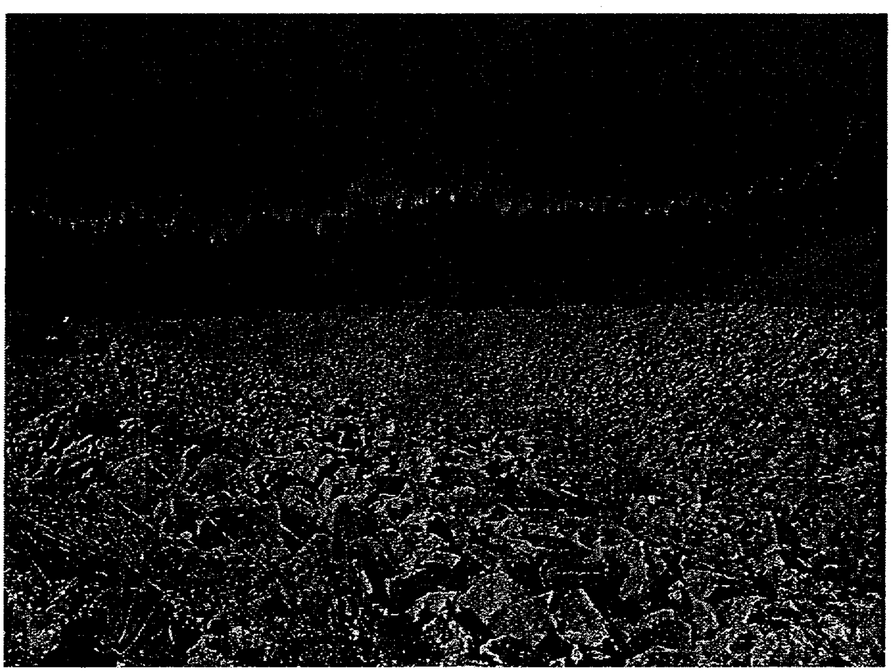
Picture 26: segregation area

In picture 26, a smaller (50 ft^2) area of rock segregation was found. Rock segregation is the placement of rock by discrete size (e.g., band of 6 inch rock) instead of the various rock sizes being mixed together to meet gradation requirements. In other areas construction traffic effects caused larger rock to become embedded into the filter layer giving the impression of poor grading, but in this area no larger rock was found laying below the smaller rock.

As can be seen in the distance of picture 25, Confluence D was the next major portion of the diversion channel reviewed. Confluence D was found to have construction traffic effects

Picture 27: Confluence D (taken from SW corner of confluence)

From this point onward downstream the diversion channel runs in a southerly direction along the eastern edge of the reclaimed tailings area. The next picture, #28, shows the portion of the diversion channel looking upstream from Confluence E.

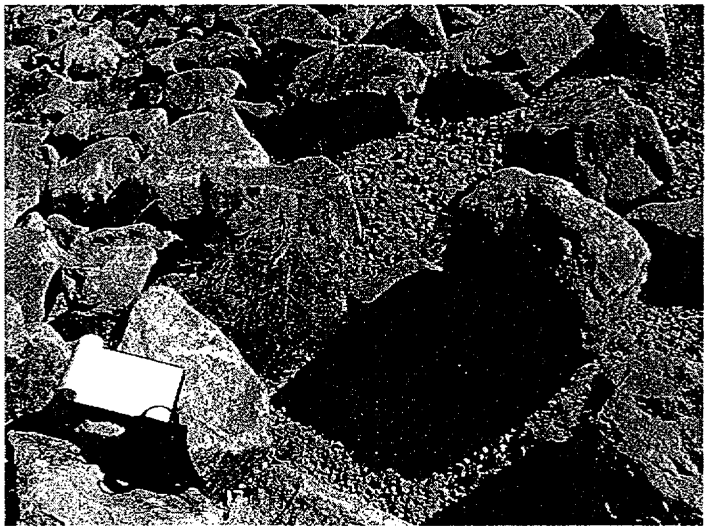


Picture 28

Looking back upstream from Confluence E

Note the vegetation that has pioneered the bottom of the diversion channel.

While the inspection revealed only minor rock placement irregularities when looking at the small 3-inch rock, the larger rock had some voids as is shown in picture 29. The voids were intermittent in the placement of the larger (e.g., 15-inch) rock and characteristically lacked the smaller rock sizes.

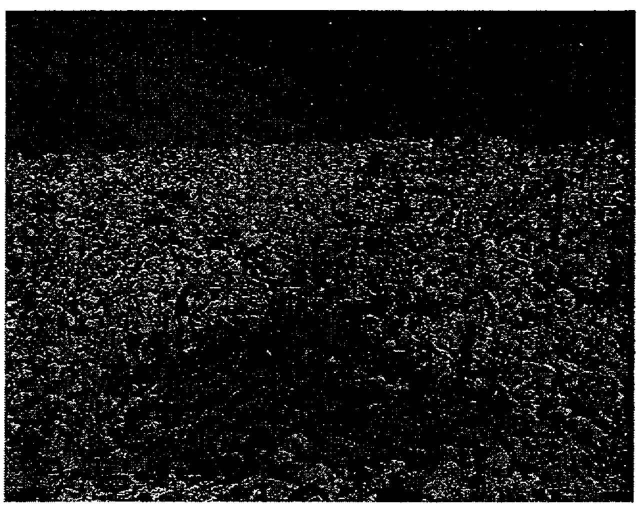


Picture 29: upper riprap edge of inner diversion channel wall at Confluence E.

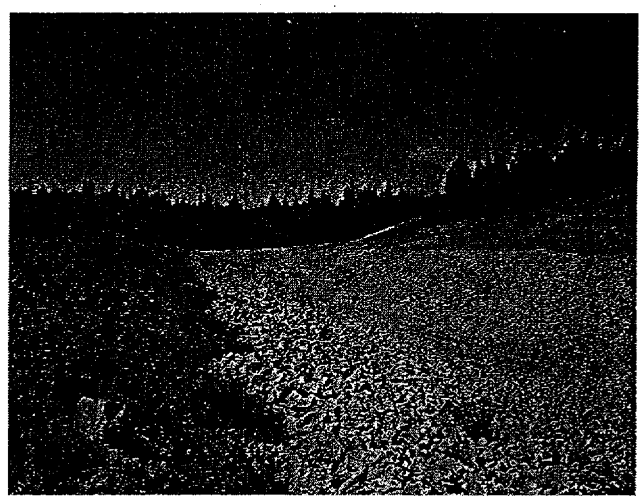
Filter material is clearly visible through the voids in riprap layer.

Notebook visible in lower left corner is about 0.75 ft^2.

The next portion of the diversion channel was Confluence E. Picture 30 shows Confluence E.



Picture 30: Riprap voids being filled with silt at Confluence E



Picture 31: diversion channel between Confluences E and E1

Note the size of the channel by comparing the size of the people standing in the pictures

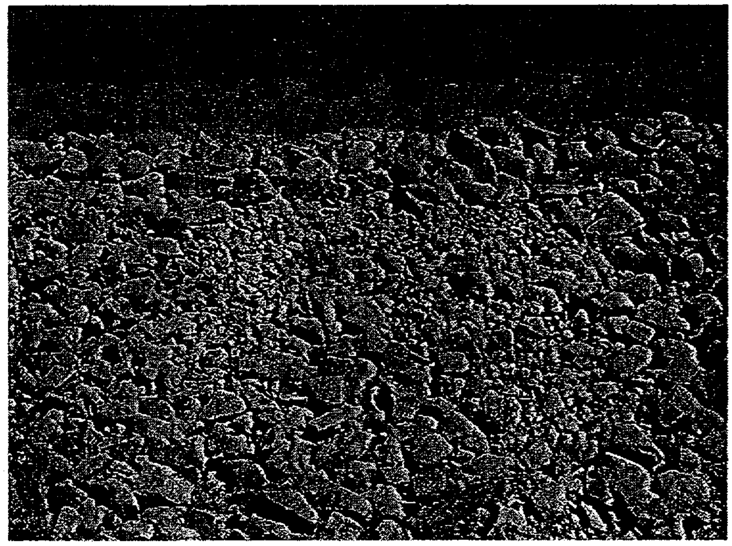
Picture 31 shows the leg of the diversion channel between Confluences E and E1. The construction traffic effects were found at random angles to the diversion channel centerline. At the upper portions of the diversion channel (e.g., western side), construction traffic effects were found to be parallel to the diversion channel centerline.

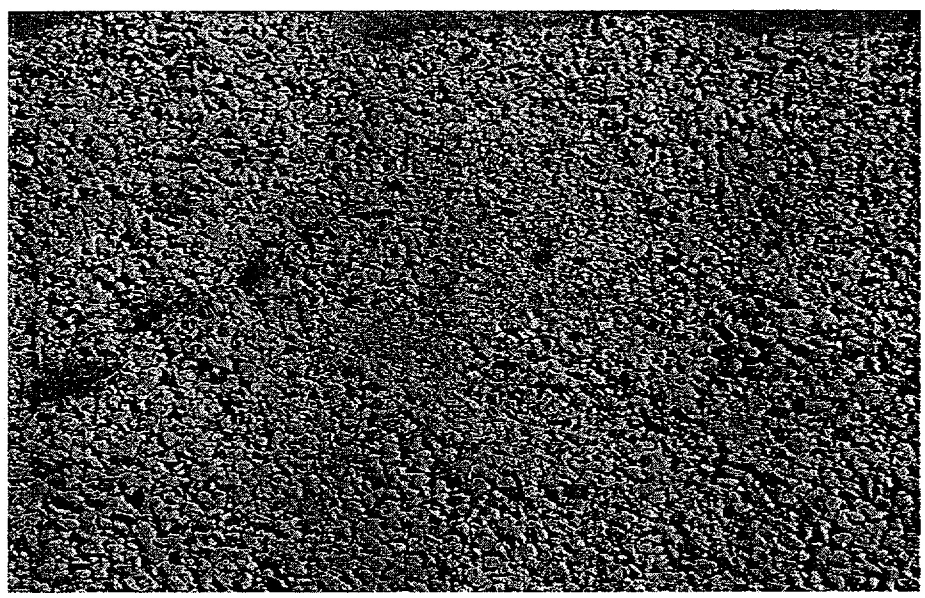
Picture 31 is characteristic of the diversion channel outside of the confluences. Rock was placed in the required thickness and without any segregation of rock sizes. On several occasions during the inspection, an apparent area of poor grading (e.g., rock segregation) was found to be due to construction traffic effects. An example is illustrated in the picture below.

Picture 32: downstream edge of Confluence E1

An area of about 40 ft^2 where rock segregation is apparently occurring.

Upon examination, larger rock was found mixed in and under the surface collection of smaller rock.





Picture 33: illusory area of poor grading

Picture 33 shows how these areas with segregated rock sizes may be misleading. The affected area (center top of picture) appears to be the result of the bulldozer catching some of the filter layer beneath the riprap and mixing the filter with the riprap during placement.

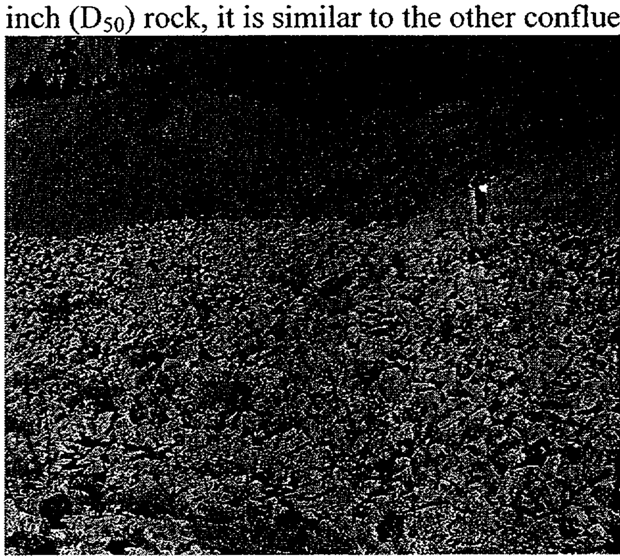
Picture 34 shows the diversion channel between Confluence E1 and Confluence F. It is apparent that a bulldozer was used to move the rock up the slope of the diversion channel walls. In the picture below, ridges can be seen on the outer (left-hand) wall. In most cases, the ridges in the eastern legs of the diversion channel are perpendicular to the channel centerline, but there are occasional stretches where rock was pushed up the slope at angles less than 90° to centerline.

Picture 34: Looking downstream towards Confluence F.

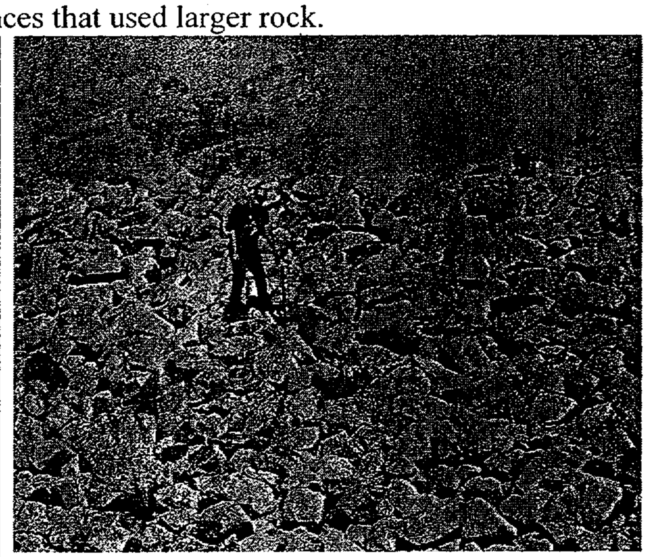
The water in the channel is from a spring intersected during construction.

Confluence F is located at the far end of the leg after the shallow bend show in picture 39. Close examination of the channel bottom revealed much more vegetation than is indicated in the pictures. While the vegetation is easily seen around the areâs where there is or has been standing water, the vegetation is also pioneering areas further away from these wet areas. Examination of the soil riprap interface near these areas often yields very small plants working their way through the riprap layer.

Picture 35 below shows Confluence F. Designed to need 10-inch rock (D_{50}) and built with 15-inch (D_{50}) rock, it is similar to the other confluences that used larger rock.



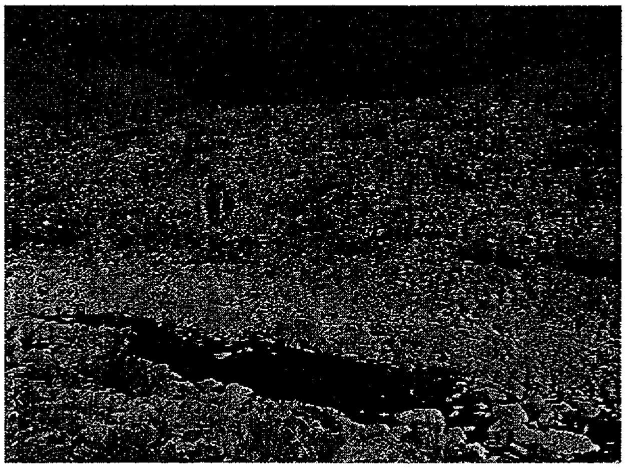
Picture 35: Confluence F



Picture 36: Voids in Confluence F riprap

Picture 36 shows the larger riprap sizes used in the confluences. The filter layer was visible in a few small (< 5 ft^2) areas. Voiding is a small percentage of the total area of the confluence.

Picture 37 shows the general layout of Confluence F2. Very little construction traffic effects were noted. Riprap gradation and placement was found to be excellent.


Picture 37: looking up Confluence F2


Picture 38: upstream edge of Confluence F2

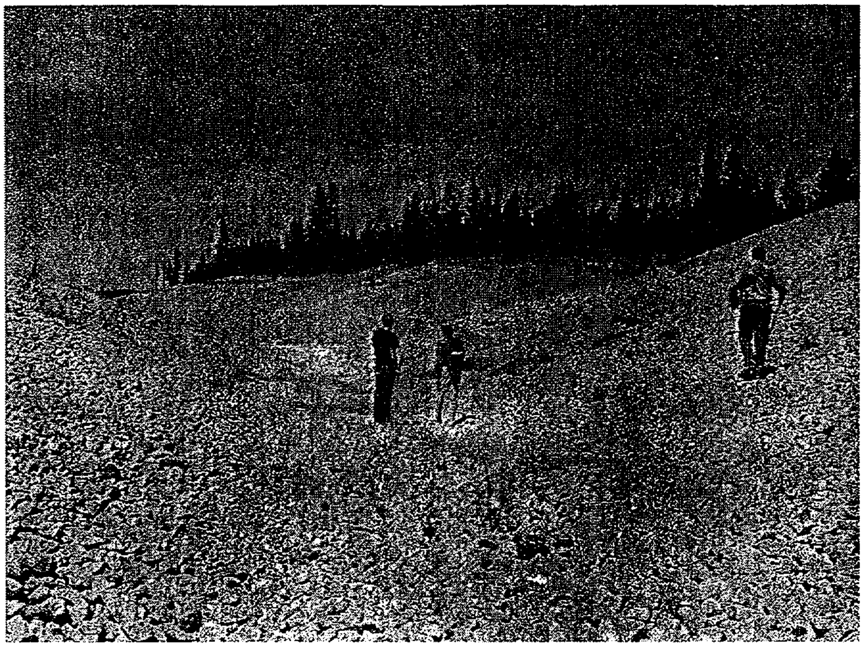
Areas with riprap voids allowing the filter to be easily seen within the boundaries of Confluence F2 were examined. In one area shown in picture 39 (below), where filter is visible, larger (e.g., 10 inch) rock was found underneath.


Picture 39: larger rock found under apparent filter layer


Picture 40: filter layer visible in Confluence F2 riprap

However, one small area (≈ 15-20 ft^2) within Confluence F2 was found with voiding in the riprap layer. This spot was located near a construction-marking stake labeled 21+00. Picture 40 illustrates the voids in the larger riprap that permits the filter layer material to be visible.

At station 19+36 (upstream edge of Confluence G), well-graded 3-inch rock was evident. Construction traffic effects were noted on the slopes of the diversion channel. The ridges prominent in the traffic effects were perpendicular to the centerline of the channel. Picture 41 shows the channel from this point looking upstream to Confluence F2.



Picture 41: looking up the channel from station 19+36 toward Confluence F2.

Well graded 3 inch rock is characteristic of the rock in the diversion channel.

The last major intersection within the diversion channel is Confluence G. Picture 42 and 43 show the layout within the boundaries of Confluence G.

Picture 42: Confluence G

Picture 43: 15 ft^2 area with filter visible

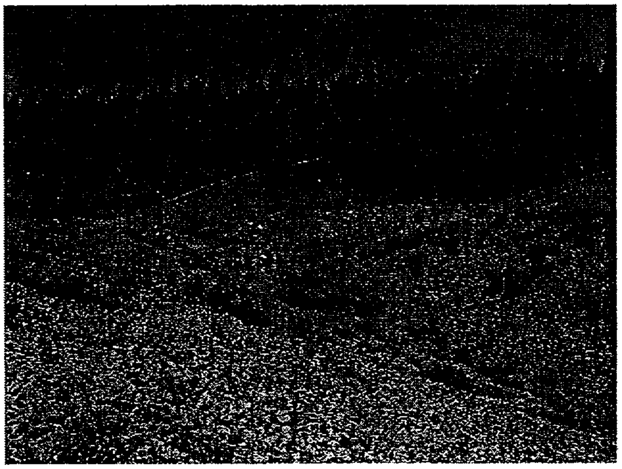
Areas that appeared to be lacking in the requirements for riprap were investigated. Picture 43 is an example of a suspect area. Upon examination, this area was found to be at least 23 inches deep of various size rock surrounding some large ($D_{50} \approx 15$ inch) rock. In essence, the area had developed into a rock mulch layer. Technical literature (e.g., NUREG-1623) has documented that a rock/soil matrix (riprap layer with the rock voids filled with soil) has similar stability characteristics as the riprap layer alone.

Picture 44: approximately 10 ft^2 of voiding in the riprap layer in an otherwise good placement area at Station 15+79.

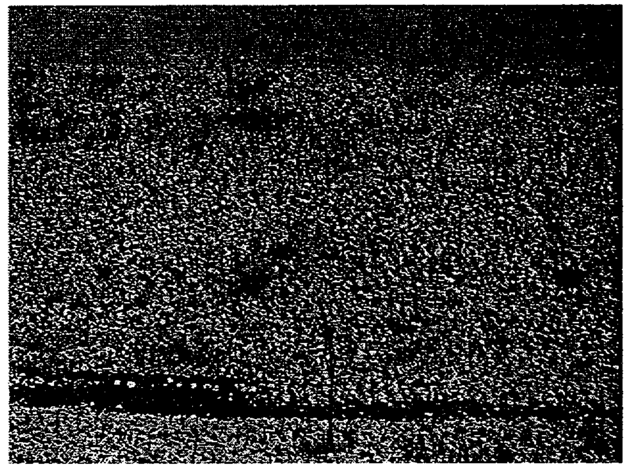
At Station 15+79 a 10 foot by 15 foot area found void of riprap. This area is located along the centerline of the diversion channel at the downstream transition from large (D_{50} =15 inch) riprap used in Confluence G to the smaller (D_{50} =3 inch) riprap used for most of the diversion channel. Picture 45 shows this area.

Picture 45: Confluence G downstream transition found void of riprap.

The next set of three pictures show the diversion channel from about 250 feet downstream of Confluence G. Picture 46 is looking back upstream towards Confluence G.



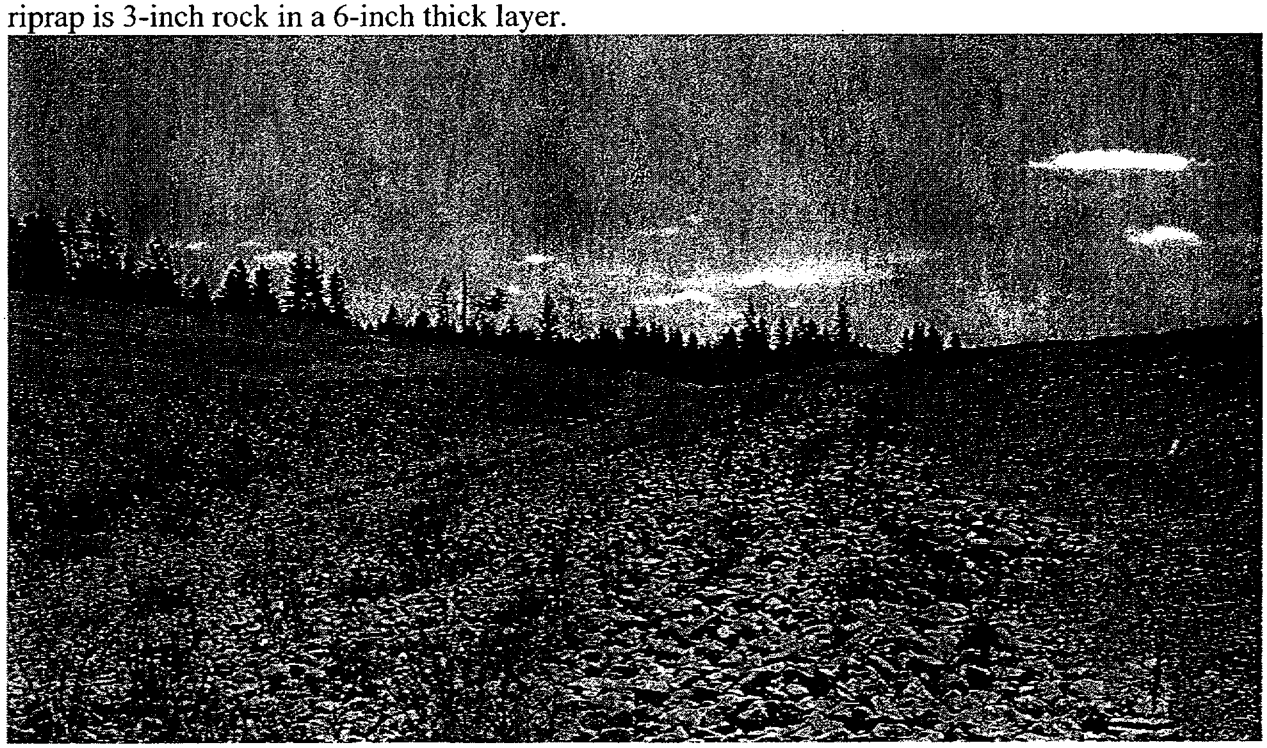
Picture 46: looking upstream to Confluence G



Picture 47: looking across channel

Picture 47 shows the diversion channel bottom and outer wall. The riprap is well graded without any banding of smaller rock next to larger rock or pockets of smaller rock. Construction traffic effects are minimal in this area.

Picture 48, taken from the top of the inner wall, shows the remaining portion of the diversion channel to the outlet. The outlet is approximately 1100 feet downstream from the point where this picture was taken. There are no remaining confluences in this portion of the channel. The riprap is 3-inch rock in a 6-inch thick layer.



Picture 48: looking toward the diversion channel outlet

At the time of this inspection, the diversion channel was less than three (3) years old. In this short time vegetation has pioneered the diversion channel. Along with the various grass species that have become established in the diversion channel, several species of trees can be seen.

Construction traffic effects were noted in the diversion channel between Confluence G and the channel outlet. An example is the embedding of riprap into the filter material underneath. See picture 49 for an illustration.

Picture 49

Riprap embedded into filter layer

Picture 49 shows an area where post-construction remediation efforts have caused the embedding of the riprap into the filter layer. The 2-foot by 20-foot area has soil fines visible. Vegetation has pioneered the area.

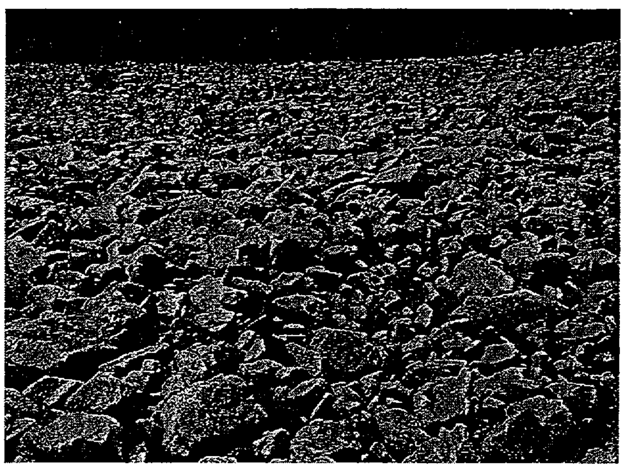
Near the end of the diversion channel outlet, ridges and valleys were found to be prominent. In other portions of the diversion channel, the differential height as measured from the bottom of the valley to the top of the adjacent ridge was approximately 4-6 inches. However, in this area, the differential height approached 1 foot. Picture 50 attempts to illustrate the differential height. The thickness of the riprap in the valleys was examined and found to be at least 6 inches deep.

Picture 50: construction traffic effects creating ridges and valleys

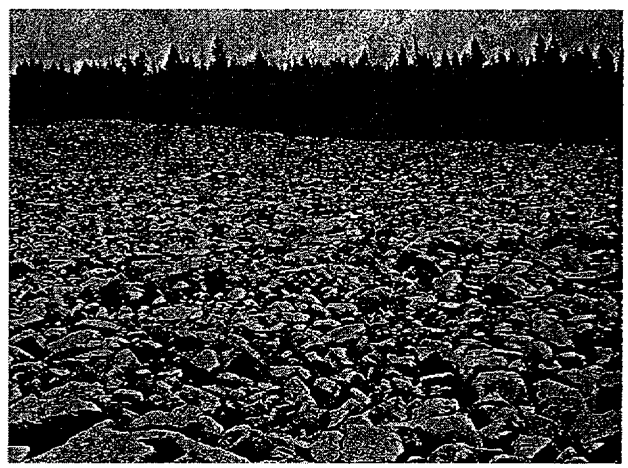
In this area near the channel outlet, the ridges and valleys are prominent.

The ridges are perpendicular to the channel centerline.

The next portion of the inspection was to review the swale for rock placement and thickness. The swale is that portion of the tailings reclamation plan designed to handle the flow of water from the cover surface itself. Conversely, the diversion channel directs water flow from the surrounding drainage basins around the cover to prevent erosion.

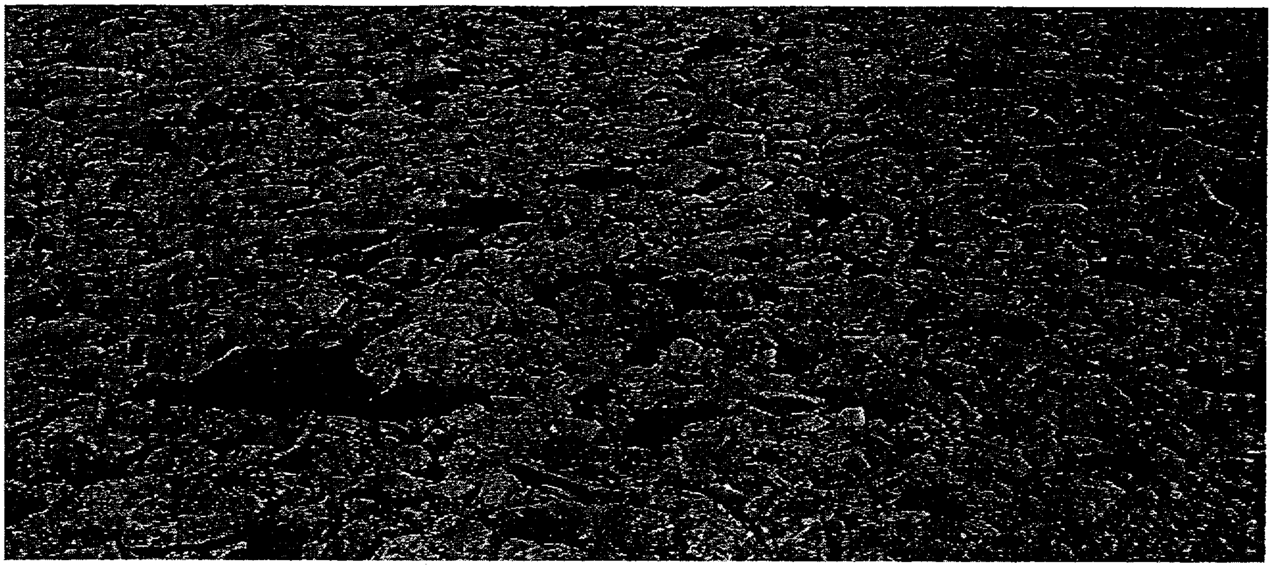


Picture 51: looking south across swale



Picture 52: looking easterly across the swale

As is indicated in pictures 51 and 52, the swale is generally well graded riprap with some basalt visible. Several areas were examined for thickness and found to be acceptable. In one area of apparent segregation of riprap (picture 53, below), only 3 inch rock is visible. However, when the area was dug out, larger rock was discovered beneath. In essence the voids created by using large rock are being filled with the smaller rocks that are part of the gradation requirements. The interlocking feature of the various rock sizes serves to enhance the structural stability of the surface.



Picture 53: smaller rock covering larger riprap

The final portion of the inspection dealt with the riprap slope of the main embankment. Construction traffic effects were seen on the surface of the main embankment. The surface is covered with 3-inch (D_{50}) rock placed in a 6 inch layer throughout. In the pictures that follow, vegetation is visible. In areas affected by construction traffic (e.g., scars and riprap embedding), vegetation has pioneered the area.

Picture 54 shows John Blacklaw pointing to an apparent thin spot of riprap that was caused by construction traffic effects. Upon examination and measurement, the thickness of the riprap was found to be greater than 6 inches.

Picture 54: ridges and valleys from construction traffic are visible on the main embankment.

Note the amount of vegetation that has pioneered the main embankment.

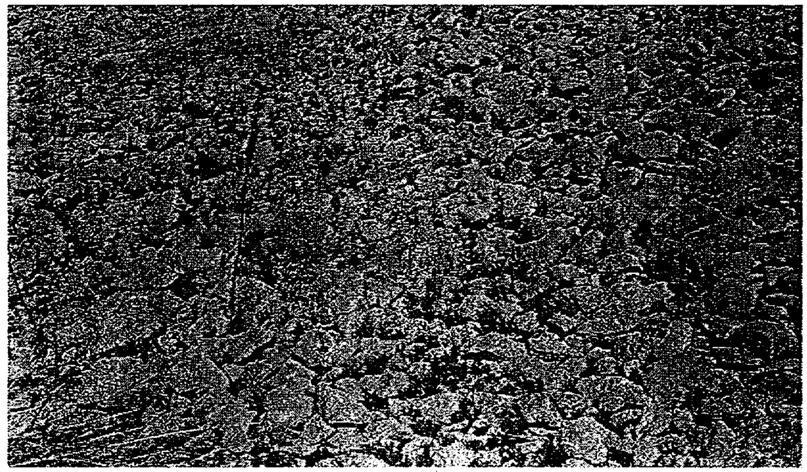
A stick or twig, placed across two nearby rocks, represented the average local riprap surface. During the inspection process, riprap thickness was measured perpendicular to the surface.

Areas were found where larger riprap was embedded into the filter. Such cases were examined to determine the riprap layer thickness. In most cases the riprap thickness was uniform. In fact, this compaction of the various rock sizes created a rock mulch as described earlier. In the few cases that the rock mulch thickness was not at least 6 inches, vegetation was established and expanding. The typical size involved was about 50 ft^2 (= 2 feet by 20-30 feet).

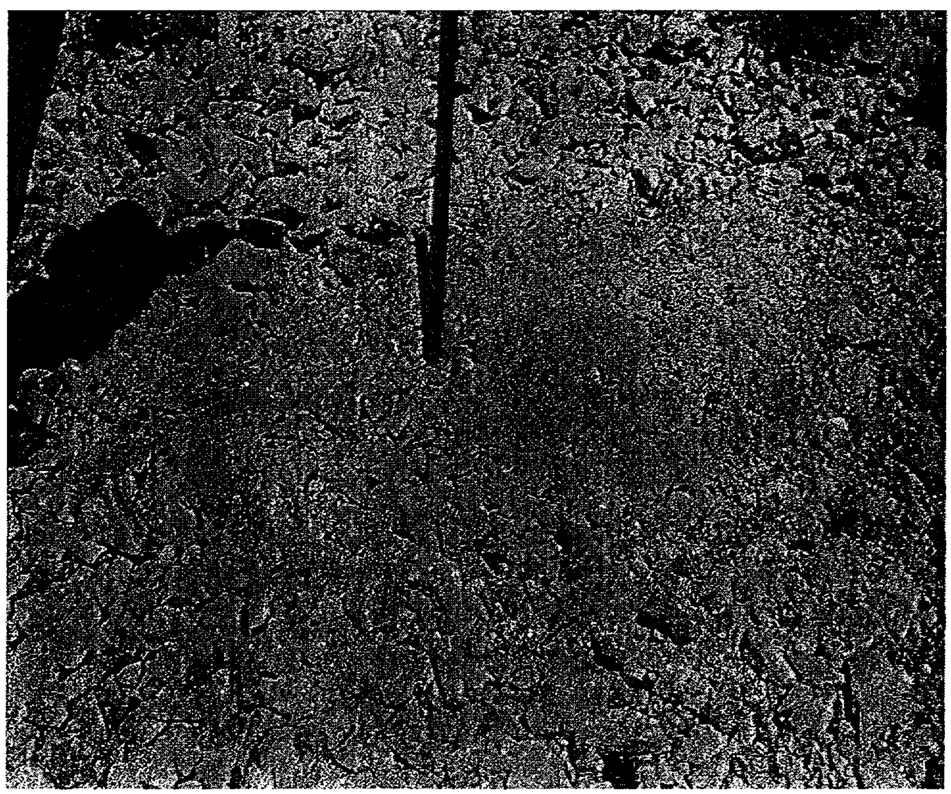
Picture 55: construction traffic effect. (2 feet by 30 feet area where the riprap is embedded into the filter layer)

Note the vegetation that has pioneered the thin areas.

In other areas on the main embankment, small trees were found to be growing.



During the inspection one 18 ft^2 area was found with much smaller (D_{50} = 1 inch) rock overlaid 3-inch rock. Picture 56 below shows the examination hole dug to characterize the riprap layer.



Picture 56: small rock atop larger rock

In summary, the detailed inspections of the diversion channel, swale and main embankment for rock placement, coverage, and thickness revealed only very limited areas potentially requiring remedial efforts. These areas are randomly located generally in the confluences using large 15" riprap. The extent of these areas is less than 0.1% (700 ft^2) of the total riprap coverage. Other effects noted during the inspection included ridges and valleys on the side walls of the diversion channel, the embedding of the larger riprap into the filter layer, and the scarring of the channel wall.

STATE OF WASHINGTON
DEPARTMENT OF HEALTH
DIVISION OF RADIATION PROTECTION
7171 Cleanwater Lane, Bldg. 5 • P.O. Box 47827 • Olympia, Washington 98504-7827
TDD Relay 1-800-833-6388

September 21, 1999

Brad DeWaard, Resident Agent
Western Nuclear, Inc.
P.O. Box 392
Wellpinit, Washington 99049

Dear Mr. DeWaard:

The department has performed several inspections and reviews in an effort to provide reclamation, monitoring and stabilization, and license termination support for Western Nuclear, Inc. projects.

Monitoring and Stabilization Plan verification inspections for the Structural Stability component have been completed recently and provided to your company by separate letter. We have received your initial response with proposed resolution of department findings. The department will continue to support these activities with document review, field inspection, and eventual performance acceptance of this component, when the site has met applicable requirements of license conditions and the Monitoring and Stabilization Plan.

There are several other pending issues that remain, based on department review letters, and several Western Nuclear, Inc. responses and requests for license amendment. These issues must be resolved prior to license termination. These issues are described in the attached List of Issues and Recommended Resolution. Please respond, clarify, or correct, as appropriate to the issue.

In addition, the license has been administratively amended to address some of these issues, and for maintenance purposes to modify or eliminate license requirements that have been satisfied. Please see the attached Radioactive Materials License WN-I0133-1, Amendment No. 32.

If you would wish to discuss the license amendments or the list of issues and the recommended resolution, please contact John Blacklaw at (360) 236-3243, or me at (360) 236-3241.

Sincerely,

John R Blacklaw, for

Gary Robertson, Head
Waste Management Section

GLR/JRB:krf

cc: Lou Miller, P.E., SMI
Jerald LaVassar, P.E., WDOE
Steve Link, WSU
Russell Edge, USDOE GJO
Dennis Sollenberger, NRC
Bruce Wynne, Spokane Tribe
Mary Verner, Spokane Tribe
Sharon Yepa, BIA, WA
Stanley Speaks, BIA, OR
Shannon Work, Spokane Tribe

Attachments: (1) List of Issues and Recommended Resolution
(2) Radioactive Materials License WN-I0133-1, Amendment No. 32

List of Issues and Recommended Resolution

Please refer to department letter of March 12, 1998 and attachments, "Department Comments and Requests for Clarification Based on Final Review of the TRP CCR," and Western Nuclear, Inc. "Response to WDOH Comments on the Sherwood Project Construction Completion Report."

Question 5. AutoCAD drawing data was requested. The response report indicated the data in a table. The department wishes to receive the AutoCAD data in electronic format for spot checking the completion report survey data and for the record.

> *Please provide AutoCAD electronic files to the department that indicate the Tailings Reclamation Plan plans and specifications, as officially approved and revised by your licensed engineer, and as documented in the as-build report (for the northern alignment of the diversion channel). Please provide 5 copies of these files on PC readable CD format.*

Question 17. There were no inspection data included in the Construction Completion Report to justify the location of diversion channel transition points from larger to smaller rock 50 feet upstream and downstream of stream confluences. Your response report provided Appendix H with this data, as requested. However, recent inspections of the downstream transition of Confluence G have indicated that there is a 150 square foot void area where no rock is present. Inspection work to identify the location of these transition points should have identified this void area deficiency.

> *Please explain how this void area deficiency was overlooked during construction, and quality assurance inspections, including your preparation of Appendix H of your response report.*

Construction Completion Reports have been filed with the department, the department has requested clarification, which has also been received and reviewed by the department.

> *Although questions 5 and 17 remain, the department is satisfied that mill decommissioning and tailings reclamation activities at the Sherwood Project site are complete and acceptable in meeting regulatory and license requirements. Therefore, the department is deleting License Condition 34.*

> *Because the deleted License Condition 34 includes the engineering protocol requirements needed for the Monitoring and Stabilization Plan activities, a new license condition (number 37) is added.*

Please refer to Western Nuclear, Inc. letter of December 22, 1998, and Radioactive Materials License WN-I0133-1, License Condition 22, regarding the scope of structural stability inspections in the Monitoring and Stabilization Plan.

> *The department has agreed to, and continues to support your request for specific scope reduction recommendations as described in your December 22, 1998 letter. The license has been revised accordingly.*

Please refer to Western Nuclear, Inc. letter of November 16, 1998, Radioactive Materials License WN-I0133-1, and US Nuclear Regulatory Commission letter of April 20, 1999 from Paul Lohaus with attached OSP Procedure SA-900, Termination of Uranium Mill Licenses in Agreement States.

Your letter requests deletion of License Condition 13 regarding your maintenance of calibrated and operable radiation detection meters. Your letter also requests deletion of License Condition 29 regarding License Termination. In addition, your letter provides formal notification to the department of your interest in promptly terminating your radioactive materials license with the department. The U.S. NRC letter provides recommended guidance for terminating radioactive material licenses at uranium mill sites in Agreement States.

> *License Condition 13 will be retained until license termination is completed. The department believes that it is prudent to retain this requirement in the unexpected but important circumstance that radioactive materials are encountered and an appropriately calibrated and maintained detector is needed.*
>
> *License Condition 29 is modified to delete the requirement for final closure, including tailings recontouring and stabilization, radon barrier, and erosion protection cover by December 31, 1998. This requirement has been accomplished by completion of construction in the fall of 1996, and by your submission and the department's acceptance of your Construction Completion Reports for Mill Decommissioning and Tailings Reclamation. License Condition 29 is further modified to include License Termination requirements and protocol derived from state and federal regulations and recent US Nuclear Regulatory Commission Guidance. See License Amendment 32 for specific requirements.*
>
> *The department acknowledges your formal request for license termination and receipt of your required completed form, "Disposition of Radioactive Materials Certification." The department will continue to assist you in your demonstrated efforts toward prompt license termination. When all technical, performance-based license requirements have been met, the department will recommend license termination for U.S. Nuclear Regulatory Commission concurrence and will prepare applicable documents and follow necessary procedural protocol requirements, as soon as reasonably possible. Continued communication between the parties is needed to accomplish your request.*

Please refer to Western Nuclear, Inc. letter of April 15, 1999. Your letter requests reduction in the surety amount for closure and long-term maintenance and stabilization at Western Nuclear, Inc.'s Sherwood Project Site.

> *The department has not acted on your request for reduction in surety at the Sherwood Project site because of pressing priorities to evaluate the site for structural stability under Monitoring and Stabilization Plan requirements, and because the surety has been reduced substantially from the pre-construction period. Until structural stability issues are resolved, there remains considerable unresolved uncertainty in potential costs to stabilize the site. The current surety amount is approximately in line with the current level of uncertainty. Therefore, your request for reduction in surety amount is placed on hold pending resolution of structural stability issues.*

Please refer to Western Nuclear, Inc. letter of May 20, 1999. Your letter requests reduction in the vegetation component of the Monitoring and Stabilization Plan requirements to reduce the areas of consideration for vegetation monitoring. Specifically, your letter requests that the ponded area on the impoundment surface and areas of the margin with identified quartz monzonite sub-grade are eliminated from vegetation productivity (percent cover) sampling and monitoring procedures.

The department has reviewed your request and has found that an alternative approach is preferred to address your request. The department does not wish to reduce the surface areas sampled and monitored at this time. Instead, the department would allow that you report your vegetation results, as required by the Monitoring and Stabilization Plan, and that sub-sets of the data may also be reported.

As you wish, you may provide additional reporting and analysis to indicate performance in the ponded area of the impoundment, the quartz monzonite sub-grade areas of the margin, all the areas specified by the MSP, and the net area (as specified, less the ponded and quartz monzonite sub-grade margin areas). By this approach, the department has the full set of data for evaluation against established MSP criteria, and your company has the means to justify that the site is erosionally stable by a site- and area-specific approach, if desired.

State of Washington

Radioactive Materials License

License Number WN-I0133-1

Amendment No. 32

Western Nuclear, Inc.
P.O. Box 398
Wellpinit, Washington 99049

Attention: Brad DeWaard
Radiation Safety Officer

Washington State Radioactive Materials License WN-I0133-1 is amended as follows:

License Conditions 22 and 29 are amended to read:

22. **Monitoring and Stabilization Plan (MSP):** the licensee shall maintain an environmental monitoring program following the requirements established in reference documents specified in License Condition 36. A.

    A final Monitoring and Stabilization Plan report, indicating the relative success of post-construction site reclamation, shall be provided to the department at least 90 days prior to license termination.

29. **License Termination:** the licensee shall expedite license termination and follow the US Nuclear Regulatory Commission Procedure SA-900, as specifically identified in Appendix B (a).

License Condition 32 is deleted.

The following is added to License Condition 36.A:

> Letter and enclosure dated December 22, 1998, *WN-I0133-1, License Condition No. 22 – Environmental Monitoring and Stabilization Program*, signed by Lawrence J. Corte, Manager, Western Nuclear, Inc.

License Condition 37 is added:

37. **Engineering:** the licensee shall provide engineering support to any Monitoring and Stabilization Plan activities that constitute the Practice of Engineering, as defined in RCW 18.43.020.

State of Washington

Radioactive Materials License

License Number WN-I0133-1

Amendment No. 32

The department requires that licensed engineer support is provided for any re-construction of the reclaimed site that may be necessary to assure site performance and compliance with applicable regulatory requirements. Such plans and specifications (including sketches) shall be reviewed (and stamped) by a licensed engineer, and submitted to the department for approval, prior to commencement of construction.

Appropriate quality assurance requirements shall be followed, and as-built construction completion reports filed with the department to assure that completed construction activities conform to approved plans and specifications.

FOR THE STATE OF WASHINGTON DEPARTMENT OF HEALTH

Date September 27, 1999

By John R Blacklaw, for
Gary L. Robertson, Head
Waste Management Section

STATE OF WASHINGTON

DEPARTMENT OF HEALTH

DIVISION OF RADIATION PROTECTION

7171 Cleanwater Lane, Bldg. 5 • P.O. Box 47827 • Olympia, Washington 98504-7827

TDD Relay 1-800-833-6388

September 21, 1999

Brad DeWaard, Resident Agent
Western Nuclear, Inc.
P.O. Box 392
Wellpinit, Washington 99049

Dear Mr. DeWaard:

The department has reviewed your letter dated September 16, 1999, regarding surface stability inspection issues from the Monitoring and Stabilization Plan review performed by the department this summer. We appreciated meeting you on September 7, 1999 at the Sherwood Project site to walk around and view the areas of our concerns and discuss resolution of our issues. We continue to support your interest in prompt license termination, as long as all license conditions are satisfied.

Our understanding of your letter is that you propose two actions. A re-construction effort is proposed for rock placement issues and for regrading two areas of the site (northwest corner of the site where gullying is occurring, and southwest area near the roadway). An analysis and written justification is pending final preparation and submittal to the department for all other structural stability issues. In addition, you are proposing that vegetation productivity criteria have not been met in recent sampling and monitoring evaluations and that alternative analytical, field evaluation, and written justification of vegetation success is being planned this fall to address this MSP component and to complement structural stability issue resolution.

During a recent telephone discussion between Lou Miller and John Blacklaw, it was agreed that the department will provide engineering field review and concurrence for all re-construction activities. Additionally, Brad indicated that WNI does not plan to support such activities with engineering designs.

The department agrees that the rock placement re-construction activities should not require any engineering design, since the rock placement proposal is to bring site conditions to the already-approved plans and specifications design condition. This type of work is considered maintenance. However, the department believes the re-contouring of site features will require some engineering design support in the form of a design drawing or sketch and a brief write-up, describing the work completed, since the configurations proposed do not have approved plans and specifications.

Department Review of Listed Issues

ISSUE 1: The department concurs with your approach to this issue. The design configuration for this area will be adjusted to provide a more distinct surface water flow path away from the west groin of the dam outslope. The department also expects that minor rill adjustments will be made on the small watershed slope to direct surface water flow toward the west and the roadway culvert. A design drawing or sketch is required to define this re-construction task.

ISSUE 2: The department concurs with your approach to this issue. Redistributing the silt previously deposited in the channel in this area is a practical approach to limiting the impact on channel flow capacity. The department will provide field inspection support to assist with review of this maintenance task.

ISSUE 3: The gully formed in the northwest area of the diversion channel has produced the silt deposit from issue 2. The gully is not presently stable and must be repaired and corrected. Western Nuclear, Inc.'s approach is to provide a more robust bench to divert the disturbed and re-vegetated northwest borrow area runoff toward the southwest and upstream of the local confluence and therefore to not affect the diversion channel directly. If adequately designed and constructed, this approach would provide short-term erosion control in this area. However, the long-term effect of using such a bench diversion approach is in question.

The department prefers that a long-term solution is proposed that does not introduce the concentrated surface water flow inherent in your proposed bench diversion proposal. Such a proposal would rely on sheet flow, even and continuous slopes, re-construction of the area of the gully and existing bench, and re-vegetation and/or other surface stabilization methods. A design drawing or sketch is required to define this re-construction task.

ISSUE 4: The department awaits your written response to this issue, and does not necessarily concur that this area will not require re-construction.

ISSUE 5: The department awaits your written response to this issue, and does not necessarily concur that this area will not require re-construction.

ISSUE 6: The department awaits your written response to this issue, and does not necessarily concur that this area will not require re-construction.

ISSUE 7 and 8: The department awaits your written response to this issue, and does not necessarily concur that this area will not require re-construction.

ISSUE 9 and 10: The department concurs with your approach to fill the 150 square foot void area with appropriately sized rock according to the approved plans and specifications. Department staff will provide inspection support for this maintenance task.

ISSUE 11: The department concurs with your approach to add appropriately sized rock to areas that have been identified to have less than the required amount or thickness of rock placement to conform to the original plans and specifications. Department staff will provide inspection support for this maintenance task.

MEMORANDUM

September 22, 1999

TO: Gary Robertson
John Blacklaw

FROM: Dorothy B. Stoffel

SUBJECT: Review of Western Nuclear, Inc. Ground Water Monitoring Program, January 1998 to June 1999

I have completed my review of Western Nuclear, Inc. ground water monitoring program, January 1998 to June 1999. The report documenting the data for this timeframe was submitted by Western Nuclear to the department for review on August 31, 1999. The most recent ground water quality analytical and static water level data provided in the report are from May 1999. Trends are plotted for all ground water static water level, total dissolved solids, sulfate, chloride, and uranium data associated with each well.

Monitoring Well 2B ground water quality data show very low values sulfate, chloride and uranium. Total Dissolved Solids have increased since 1996 when the well was installed, however, remain at levels consistent with good ground water quality. The static water levels rose approximately five feet in the spring of 1999, but declined two feet by May 1999.

The data associated with Monitoring Well 4 reflect the spring "peak" in static water level and ground water quality parameters that have been observed in previous years. The May 1999 peak values are significantly higher than 1998 peak values and, in general, approach the high values that were observed in the spring of 1997. It should be noted, however, that the water quality data for all parameters does not exceed, or even approach, established drinking water limits or Corrective Action Levels. The report states that the May 1999 values represent a seasonal peak and are consistent with the seasonal pattern that has previously been observed for this well.

Static water level data for Monitoring Well 10 remains constant, showing no seasonal variation, since the well was installed in 1993.The well is screened in the alluvium above the bedrock and the water derived from the well consistently has a high fine-grained material content. The well has consistently had high Total Dissolved Solids, reflective of the fine-grained material in the water. Sulfate and chloride data are quite low and uranium is significantly below the Corrective Action Level.

Because the most recent data provided in the report are from May 1999 when the water quality for Monitoring Well 4 has "peak" values higher than those observed in 1998, I have the following recommendations:

- It is premature to stop ground water monitoring for monitoring wells MW-2B, MW-4 and MW-10. The quarterly monitoring samples were obtained September 15, 1999. I recommend that an additional round of quarterly sampling should occur in December 1999 so that there are two samples that document the seasonal trend of a water quality peak for MW-4 this year.

- NRC guidance requires a "final" round of ground water analyses for all hazardous constituents in the point of compliance wells prior to license termination. It is my understanding that Western Nuclear obtained samples for these analyses as part of the September 15, 1999 sampling event. I recommend Western Nuclear submit a report to the department documenting all analytical data through December 1999, and include updated plots of water quality trends for each well. Static water levels should continue to be measured and the most current levels provided in the report.

- Monitoring wells 1A and 3 may be abandoned using abandonment procedures consistent with Chapter 173 – 160 WAC. I am not opposed to the abandonment of monitoring well MW-10 at this time. I can not make a decision about the abandonment of monitoring wells MW-2B and MW-4 until the analytical data through December 1999, including the hazardous constituent data consistent with NRC guidance, have been submitted to the department for review.

STATE OF WASHINGTON
DEPARTMENT OF HEALTH
DIVISION OF RADIATION PROTECTION
7171 Cleanwater Lane, Bldg. 5 • P.O. Box 47827 • Olympia, Washington 98504-7827
TDD Relay 1-800-833-6388

September 27, 1999

Mr. Brad DeWaard
Resident Agent
Western Nuclear, Inc.
P.O. Box 392
Wellpinit, Washington 99049

Dear Mr. DeWaard,

Our hydrogeologist, Dorothy Stoffel, has completed her review of the Ground Water Monitoring Report, January 1998 to June 1999, submitted by Western Nuclear, Inc. on August 31, 1999. As a result of her review, the department is providing the following direction to you at this time.

- It is premature to stop ground water monitoring for monitoring wells MW-2B, MW-4 and MW-10. Quarterly ground water sampling should occur again in December 1999 consistent with Western Nuclear's Compliance Monitoring defined in the Monitoring and Stabilization Plan. This sampling event is necessary in order document the 1999 seasonal trend of a water quality peak in MW-4.

- Western Nuclear should submit a report to the department documenting all analytical data through December 1999, and include updated plots of water quality trends for MW-2B, MW-4 and MW-10. The reported analytical data should also include the analyses that have been performed consistent with NRC Guidance of measuring all hazardous constituents of concern in the Point of Compliance wells prior to License Termination. Static water levels should continue to be measured and the most current levels provided in the report.

Dorothy Stoffel has reviewed the issue of well abandonment for all wells. She recommends that wells MW-1B and MW-3 be abandoned using procedures consistent with Chapter 173-160 WAC. She is not opposed to the abandonment of monitoring well MW-10 after all data through December 1999 have been reviewed by the department. Data through December 1999 for monitoring wells MW-2B and MW-4 will have to be reviewed before Dorothy can make a recommendation about their possible abandonment. The department recommends that you consult with the Department of Energy about their desire to keep monitoring wells accessible for their sampling after license termination. The Spokane Tribe may desire certain wells to remain accessible also.

You may contact Dorothy Stoffel at (509) 456-3166, or me at (360) 236-3241 if you have any questions.

Sincerely,

John R Blacklaw, for

Gary Robertson, Head
Waste Management Section

cc: Lou Miller, P.E., SMI
Jerald LaVassar, P.E., WDOE
Steve Link, WSU
Russell Edge, USDOE GJO
Dennis Sollenberger, NRC
Bruce Wynne, Spokane Tribe
Mary Verner, Spokane Tribe
Sharon Yepa, BIA, WA
Stanley Speaks, BIA, OR
Shannon Work, Spokane Tribe

STATE OF WASHINGTON

DEPARTMENT OF HEALTH

DIVISION OF RADIATION PROTECTION

7171 Cleanwater Lane, Bldg. 5 • P.O. Box 47827 • Olympia, Washington 98504-78

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EARL W. FORDHAM STATE OF WASHINGTON REGISTERED PROFESSIONAL ENGINEER

EXPIRES 12/28/99

October 27, 1999

TO: Gary Robertson, Head
Waste Management Section

FROM: Earl Fordham, P.E.
Waste Management Section

SUBJECT: ROCK REMEDIATION AT WNI'S SHERWOOD SITE

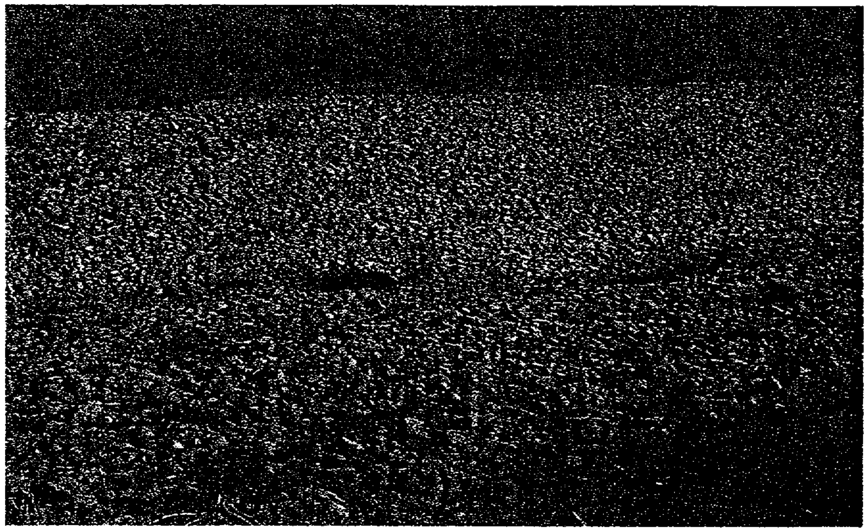
EXECUTIVE SUMMARY

On September 27 and 28, 1999 I witnessed the placement of additional rock at areas that were identified in my earlier report dated August 24, 1999 and during a WNI site inspection conducted on September 7, 1999. Earlier identified sites were marked with yellow flags. A coordinated placement and verification program was utilized to remediate the potentially deficient areas of rock placement that primarily consisted of inadequate rock placement (i.e., voids between large rock exposing the filter layer). The initial estimate of the deficient rock placement was less than 700 ft^2 in a channel that covers over 750,000 ft^2 (<0.1%). The results of this remediation effort reduced this percentage even further. The size of the rock placed was approximately $d_{50} = 3$ inch.

Listing of events

Upon arrival at the Sherwood site on September 27, 1999 Brad Dewaard (WNI's Resident Agent) had already prepared the site for overland travel of a front-end loader with a 7.5 cubic yard bucket. The rock to be placed was extra rock that had been stockpiled after construction of the cover in 1996. Rock qualification and durability tests performed during the construction phase of the tailing reclamation plan (TRP) were deemed to be sufficient for use of this extra rock.

The remediation effort started at SW corner of the diversion channel (high point of the channel). This portion of the channel is relatively narrow and suffered some "scarring" of the channel wall and floor. These scars were remediated with additional rock.



Remediation of channel scarring between Confluence A and Confluence B.

The portions of the channel that required the most intensive effort were the confluences. Of particular concern was the downstream edge of Confluence "G" where apparently only filter was placed in an area about 10 ft by 15 ft.

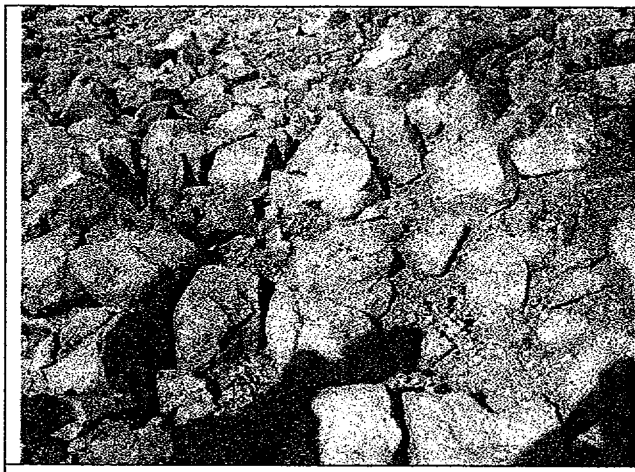
Confluence "A" was found to have satisfactory rock placement. Additional rock was not placed in this confluence.

There were several areas in Confluence "B" that had visible filter. These areas are small 1-2 ft^2 areas that were generally found on the walls of the confluence. These areas were filled with rock from the stockpile. Suspect areas found on the floor of the confluence were found to have filled in with fines from nearby unstabilized slopes (e.g., erosion of these nearby slopes).

At Confluence "C" there were areas, similar to Confluence "B", that had visible filter among the large (d_{50} = 15 inch) rocks. Several front-end loader buckets were placed in this confluence to fill in the voids. During the work at this confluence, Brad and I investigated several areas in the upper half of the inner wall of the confluence. While it initially appeared that additional rock would be needed, when the surrounding rock was moved away, larger rock (3-6 inch d_{50}) was discovered with filter intermingled.

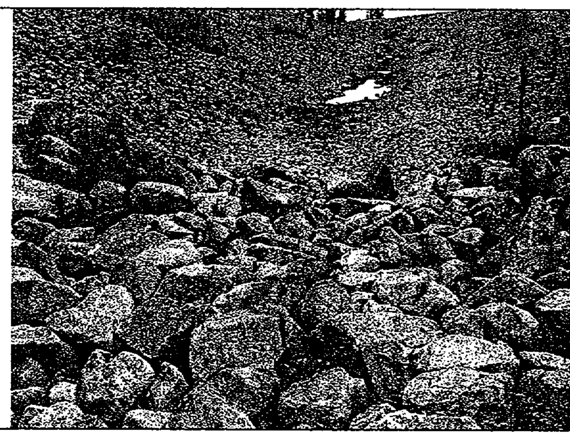
While Confluence "D" did not require any additional rock, one thin spot (2 ft by 20 ft) approximately 50-100 feet upstream of this confluence did receive addition rock to ensure the depth of rock was adequate.

At Confluences "E", "E1", "F", and "F2" rock was placed into the riprap voids via the front-end loader. The front-end loader was able to reach placement voids approximately 3/4 way up the 3:1 diversion channel walls. In areas that the front-end loader could not reach without causing excessive damage to the channel walls, rock was hand-moved from nearby areas that had appropriate sized rock and excess quantities. This technique proved most efficient at the seams of the confluence and the upper edge of the confluence walls.

Confluence F2 before additional rock is added	Confluence F2 after additional rock is placed

At Confluence "G", the voids with filter material visible received additional rock to cover the filter to the proper depth. At the downstream edge of this confluence, large (d_{50}= 10-15 inch) rock was placed at this location. Since the stockpile rock was only 3 inch,, the rock used for this 150-ft^2 area was scavenged from other locations within the channel that had excess rock. Over half of the rock necessary to remediate this location was obtained just upstream of Confluence "E". (See pictures below)

Confluence G edge before remediation	Confluence G edge after remediation

On September 7, 1999 Gary Robertson, John Blacklaw P.E., Dorothy Stoffel, and myself of WDOH's Waste Management Section, Lou Miller, P.E. of Shepherd-Miller, and WNI personnel inspected the diversion channel. During this tour, suspect areas were identified as described above. However, in addition to the obvious areas that had visible filter among the large riprap, several areas in a number of confluences were "flagged" for further investigation. The typical reason for these investigations was to determine if areas had proper mix of rock (i.e., gradation). Usually, such spots had the voids filled with filter material. Upon excavation of these areas, proper rock mix was verified. These areas were typically on the floor of the channel and exhibited equipment causing the larger rock to become embedded into the filter layer creating in essence, rock mulch.

Summary

Approximately 20 bucket loads of rock was placed or moved during this remedial effort. Since no bucket was full when it reached the areas of concern, only an upper limit of rock volume that was placed can be estimated. Using a bucket capacity of 7.5 yd^3, the resultant volume is 150 yd^3, which equates to 4,050 ft^3. My estimate is that the bucket was typically 75% full. This reduces the rock volume to about 3,000 ft^3. With an average void depth of nearly 2 feet, the coverage area was approximately 1,500 ft^2.

It is my professional judgement that the placement of the additional rock in the areas previously identified as not having the required thickness and in the areas of apparent "scarring" satisfies the department's concerns as stated in Issues 9, 10, 11 and 12 in the department's letter to Western Nuclear, Inc. dated September 21, 1999.

Washington State Department of Health
Environmental Health Programs
Division of Radiation Protection
Waste Management Section

December 20, 1999

To: Gary Robertson

From: John R. Blacklaw, P.E.

Subject: **Peer Review of ROCK REMEDIATION AT WNI'S SHERWOOD SITE**

This is a peer review of an engineering report prepared, signed and sealed by Earl Fordham, P.E., titled as above and dated October 27, 1999. This report relates to four issues (Issues 9 – 12) of concern based on department inspections in the summer of 1999. These issues relate in particular to the current condition of rock (riprap) placed during tailings reclamation construction in 1996. The issues were identified during evaluations of monitoring and stabilization plan criteria.

I have observed Earl as an active reviewer and inspector for rock issues during significant project phases during the design, construction, and monitoring and stabilization period. I have also performed other peer reviews of Earl's work, and my own independent technical reviews and inspection of rock placement issues over this entire period for this site.

I have reviewed Earl's preparation, field inspection activities and his referenced engineering report. I was present during some of the inspection activities Earl used to reach his conclusions and evaluate the site. I have independently observed the rock on the site myself during the period of Earl's inspections, while performing other inspection duties for performance status for site monitoring and stabilization plan criteria. Earl and I have discussed our separate and independent conclusions regarding rock issues, in relation to other site issues, and for site performance as a whole.

I concur with Earl's findings in his inspection report and consider them accurate, reasonable, and reflective of conclusions that would be found be an experienced professional engineer under the circumstances that he witnessed. Earl evaluated the circumstances to a reasonable level of inspection and review in coming to his conclusions.

MEMORANDUM

December 2, 1999

TO: Gary Robertson
John Blacklaw

FROM: Dorothy B. Stoffel

SUBJECT: WNI Monitoring and Stabilization Completion Report (Tab 3), submitted with *Request for License Termination Final Data Submittal,* November 1999

I have completed my review of Western Nuclear's *Request for License Termination Final Data Submittal,* November 1999, prepared by Shepherd Miller, Inc. The Monitoring and Stabilization Completion Report (Tab 3), and ground water quality data for all wells, are included in this document. The ground water quality data are through September 1999.
These ground water quality data show that the seasonal peak values in static water level and indicator parameters associated with well MW-4 have declined consistent with the seasonal pattern observed for this well since reclamation was completed in 1997.

Ground water data were submitted to the department in accordance with the Monitoring and Stabilization Plan and License Conditions 22 and 36A:

1. April 22, 1997
2. May 1, 1997 (1996 Annual Ground Water Report)
3. May 20, 1997 (Transmitting results of confirmation sampling)
4. October 22, 1997 (Compliance Monitoring Notification)
5. May 1, 1998 (1997 Annual Ground Water Report)
6. July 31, 1998 (Evaluation of anomalous ground water quality data)
7. August 31, 1999 (1998 Annual Ground Water Report with data from first half of 1999)

In addition to the data developed by Western Nuclear through their ground water monitoring program, the department has split ground water samples with WNI for monitoring wells MW-2B, MW-4, and MW-10 semi-annually. The ground water samples obtained by the department were analyzed by the Department of Health Radiation Laboratory in Seattle.

After review of all of the data, it is my professional opinion that the data demonstrate that all hazardous constituent concentrations in ground water are stable within the range of natural variability and remain below regulatory levels. The observed fluctuations in static water levels and indicator parameter values are consistent with anticipated trends. Therefore, it is my professional opinion that the ground water monitoring requirements dictated by the Monitoring and Stabilization Plan have been satisfied and the monitoring may be suspended.

A one-time final confirmation ground water sample was obtained in November from the Point of Compliance wells. The samples will be analyzed for hazardous constituents consistent with NRC guidance for License Termination. A report of the analytical results is expected in January.

Washington State Department of Health
Environmental Health Programs
Division of Radiation Protection
Waste Management Section

JOHN ROLAND BLACKLAW
STATE OF WASHINGTON
REGISTERED
PROFESSIONAL ENGINEER
EXPIRES 2/3/00

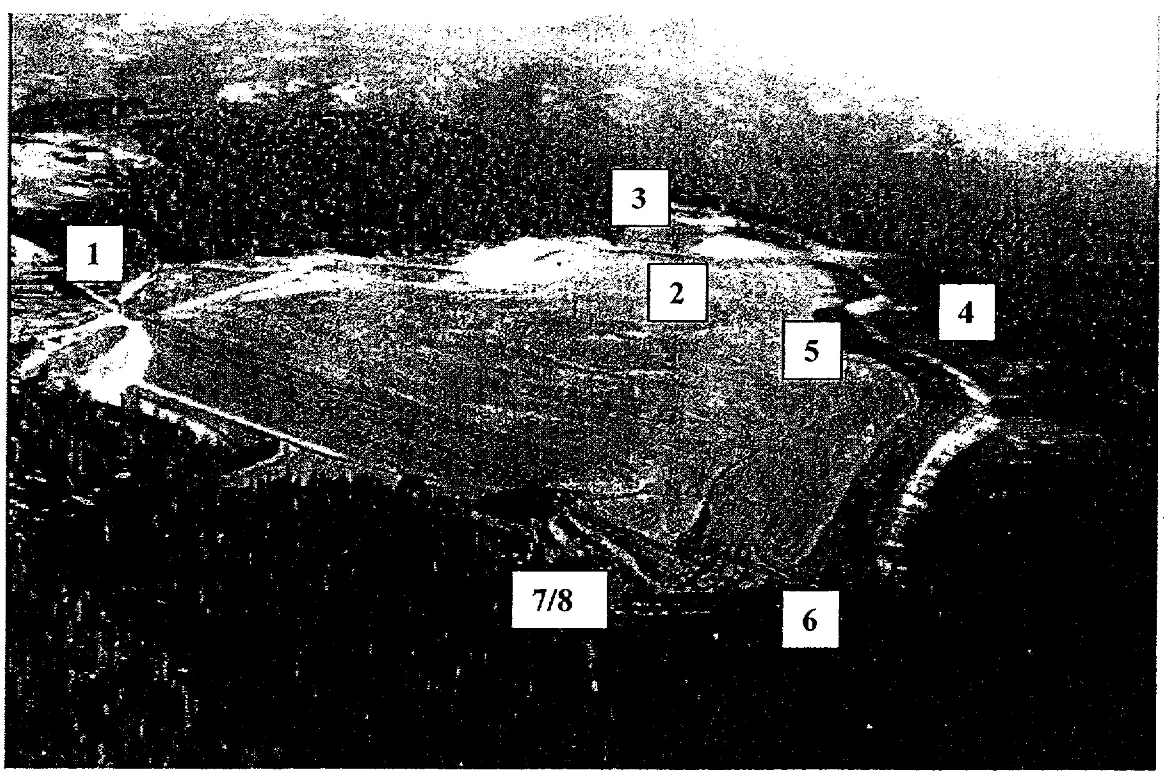
January 12, 2000

To: Gary Robertson

From: John R. Blacklaw, P.E.

Subject: **Soil Erosion Stability Inspection and Review at WNI' Sherwood Project**

On October 13, 18, and 22, 1999 I performed field inspections of Western Nuclear, Inc.'s Sherwood Project site to review minor field corrections performed by Western. These field corrections are in response to earlier field inspections by department staff and a department letter report indicating 12 issues of concern. Issue items 1 through 8 (See locations below on 1999 aerial photo of Western Nuclear's Sherwood uranium millsite) are soil erosion issues addressed by this report. Issues 9 through 12 are rock (riprap) erosion protection issues addressed by Earl Fordham, P.E. by separate report.

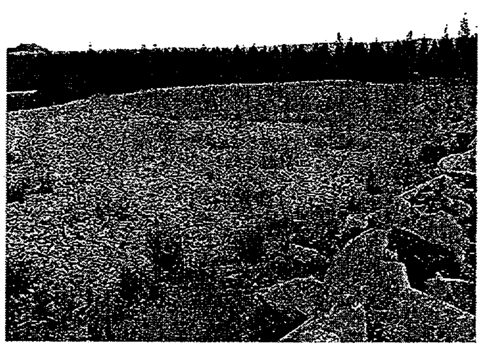


Field Correction Issues

Of the first 8 issues, Western Nuclear, Inc. has addressed issues 1 through 3 by performing field corrections. For these three issues, a licensed engineer designed the field corrections (Lou Miller, P.E. of Shepherd Miller, Inc., Western Nuclear, Inc.'s design engineering consultant), Western Nuclear performed the field corrections, and a licensed engineer inspected the reworked areas and provided an as-build report indicating the work was performed per approved design (Sheila Pachernegg, P.E., Western Nuclear Inc.'s field engineering consultant).[1] Department staff inspected each site during construction. This review was assisted by personal communication with professional staff from several organizations thus providing a multi-disciplinary perspective.[2]

Issue 1 is an area near the access roadway that is collecting runoff from a small watershed (about an acre) that has produced some small rills. Construction in this area is to direct the surface water flow down an existing channel area. Work in the area opened up the channel to about 1 foot deep by 8 feet wide. See photos for before and after conditions. This work enhances the surface water flow path away from a potential for surface water flow into and possible erosion of the west groin area of the dam. Work performed met design requirements.[1]

Before



After

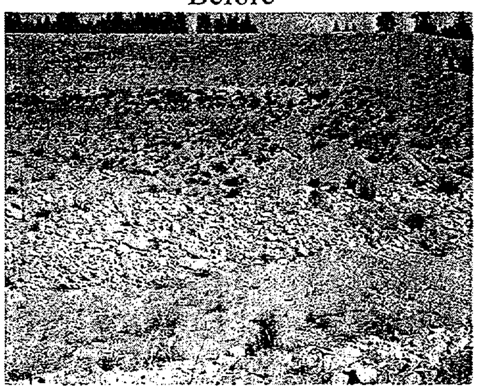
Issues 2 and 3 are in the northwest section of the diversion channel where silt has encroached into the channel from an up-gradient re-vegetated slope. This up-gradient slope area contained a source of borrow top soils. The area was reclaimed, re-contoured and re-vegetated in 1996. The up-gradient slope still shows some rill erosion and produces some silt during storm events.

Near the bottom of the slope, but above the channel, there was a constructed bench directing surface water flow to the south and away from the diversion channel. This bench filled with sediment, overflowed, produced a small gully (Issue 3), and deposited silt in the channel. This gully and the silt from the slope have produced concentrated silt deposition in the channel (Issue 2). This silt has deposited in a classic fan pattern where the surface water encountered rock (riprap) on the side of the channel, and the channel bottom with it's shallow gradient slope.

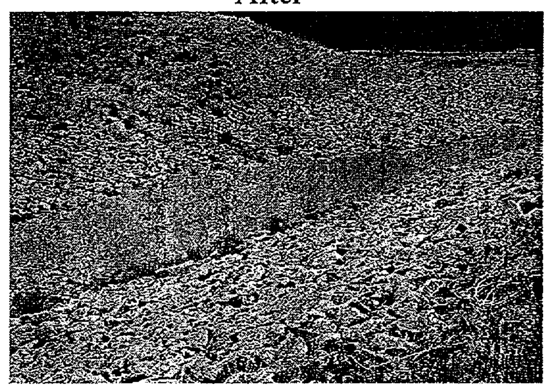
Approximately 3 feet (maximum depth) of silt was found in the diversion channel bottom. The department's interest was to stabilize the area, and reduce the long-term potential for silt deposition accumulation that might reduce the diversion channel flow capacity.

Issue 2 correction was to re-distribute silt in the channel to about 1 foot or less thickness above the rock, thus reducing the amount of diversion channel flow capacity reduction. This was accomplished by moving the accumulated silt down stream reducing silt deposition thickness. This work was defined by memo instruction and inspected in the as-built condition. See photos showing the before and after condition. Work performed met design requirements.[1]

Before

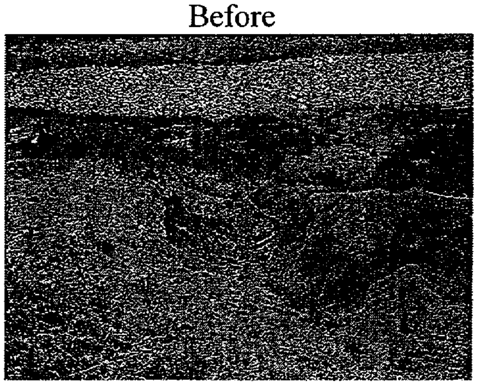


After

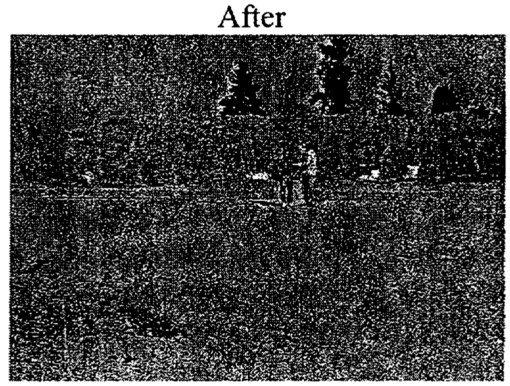


Issue 3 correction was to remove the bench by re-grading and re-contouring the up-gradient slope (at the location of the bench and down-slope), seeding and placement of straw mat, thus reducing the concentrated flow path, gully formation potential and long-term concentrated silt deposition in the channel. This work was defined by memo instruction and inspected in the as-built condition. See photos showing the before and after condition. Work performed met design requirements.[1]

Before



After



Issues 4 through 8 have been addressed using analytical evaluations and professional judgement.[1] These issues are regarding soil erosion from rill formation around the margins and diversion channel and gully erosion on two areas on the southeast end of the site.

Rill Erosion Issues

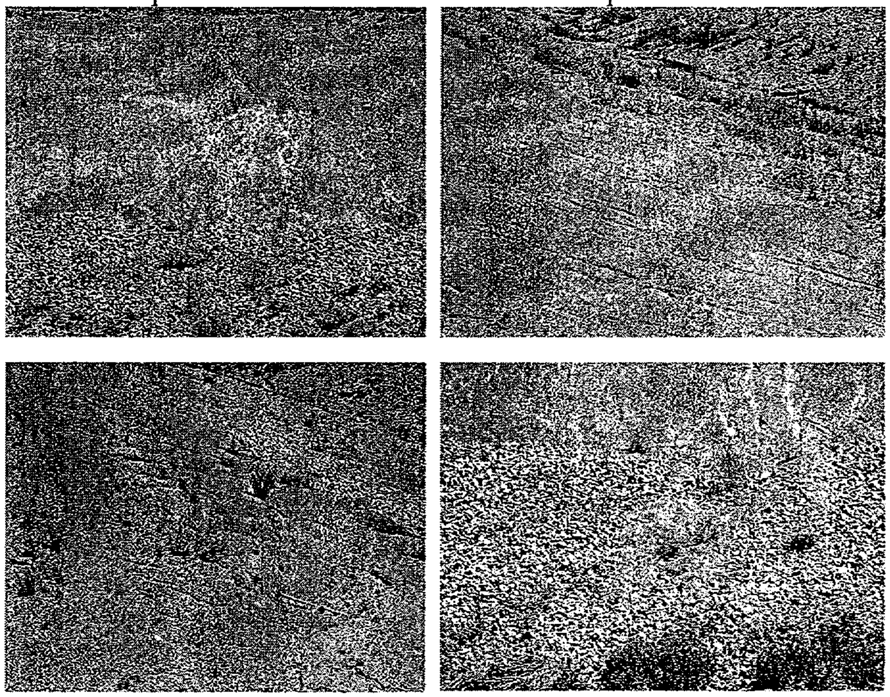
Issue 4 addresses the area of the diversion channel above the rock protection. These areas have experienced rill erosion both on the inside and outside side slopes of the channel.

The inside side slopes are short (10 to 20 feet) slopes between the diversion channel rock placement and the top of the margin berm. This inside slope area shows some rill erosion in finer erodible topsoils. The inside slope erosion is only present on the steeper slope section and does not encroach upon the top surface of the margin berm. The margin berm was constructed by cuts on each side leaving an undisturbed structural cross-section. Topsoil was placed over the margin berm cross-section about 6 to 12 inches thick. Inside slope erosion seems to be present only in finer topsoils present and not extending into the more structurally stable sub-grade material below.

The outside side slopes are longer (20 to 100 feet) slopes between the diversion channel rock placement and the outside, undisturbed area of the site. This area shows longer and wider rills and has caused more silt deposition in the channel (compared with the inside slopes). Outside slopes were not enhanced with topsoil placement or seeding. They are therefore showing slow re-vegetation. The erosion is in rills of depth from 2 to 6 inches in places and widths of a few inches. The rills are parallel to each other and separated by a few feet. The rills appear to be limited in depth by the greater structural capacity of the sub-surface soils, thus flaring in width, rather than depth as they progress down-slope.

Soil erosion and diversion channel capacity analysis[1] prepared by Western Nuclear Inc.'s engineering consultant indicates that the constructed diversion channel geometry is capable of accepting large amounts of soil sedimentation without interfering with the design flow of the diversion channel. Although re-vegetation is slow on the side slopes, and rill erosion is still occurring, side slopes are expected to stabilize like the surrounding terrain over time and before large amounts of silt could accumulate in the diversion channel to cause interference of design flow capacity. Silt accumulation is observable but very much less than the design allowance. See photos below for a general indication of the existing conditions. See the referenced analysis for a quantification of the allowance for sedimentation in the diversion channel.[1]

Examples of Diversion Channel Side Slope Rill Erosion

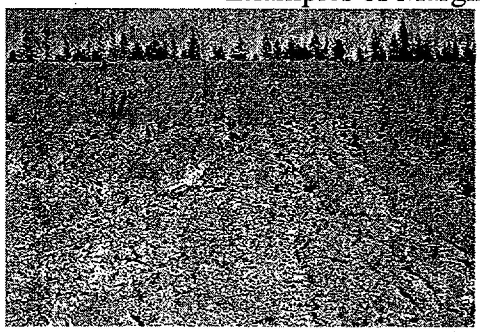


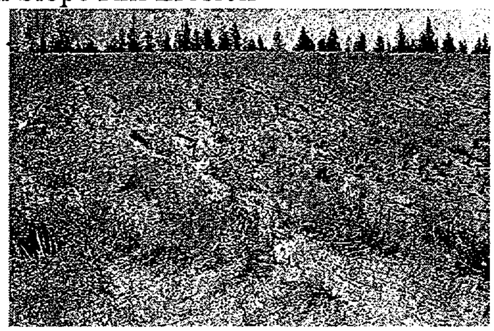
Issue 5 relates to rill erosion potential on the margins between the margin berm and the impoundment. This area is about 75 to 150 feet long down-slope with slopes from 3H:1V (33%) to 5H:1V (20%). The area is covered with placed topsoil 6 to 12 inches thick over the cut constructed margin berm. Most of the sub-grade is weathered monzonite. Some sub-grade material is alluvial soil generally located adjacent to diversion channel confluences. Rills are present in some margin areas and are typically 2 to 6 inches deep. Re-vegetation of the margins has progressed and produced vegetation that has stabilized many of the early (just after construction) erosion areas. Many rills remain and re-vegetation has not completely stabilized the margin slopes.

Vegetation remains in the early succession stage with good growth of grasses. Shrub plants are now present in small size and will improve the erosion protection of these slopes over time. There is still a potential for rill erosion to expand and for sedimentation to continue, especially during major storm events. Over time, the erosion protection afforded by vegetation and natural weather hardening of the exposed surfaces will increase surface stability. Soon, margin side slopes will be stable for expected (high probability) storm events. Rill erosion may then be expected only during major (low probability) storm events. Later, margin side slopes will further stabilize so that rill erosion will be minimized even for major storm events.

Observation of natural side slopes in undisturbed areas adjacent to post-construction areas shows very little erosion or potential for sedimentation. Therefore, the long-term expectation is for rill erosion and sedimentation to cease.

Examples of Margin Slope Rill Erosion



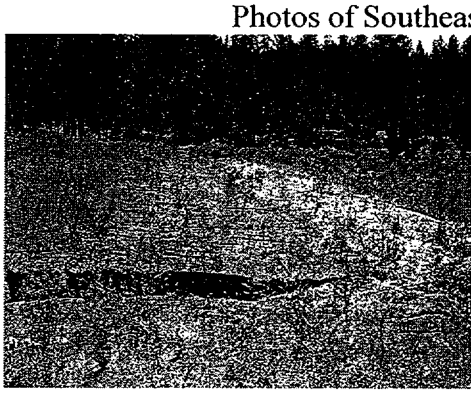


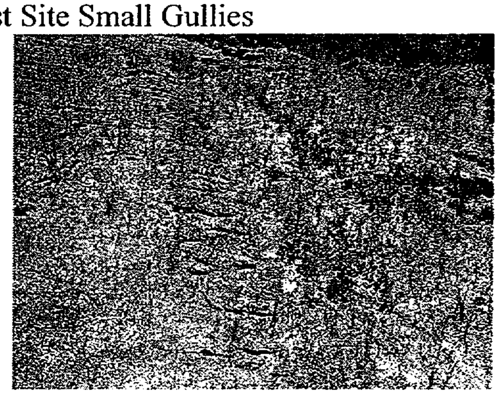
Gully Erosion Issue

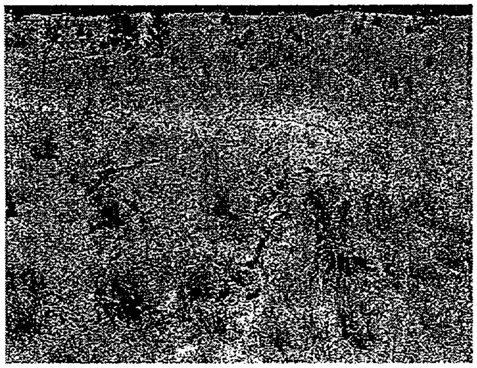
Issue 6 is an area on the southeast edge of the impoundment site. It is quite distant from impounded tailings (several hundred feet). There is a small watershed area (less than 5 acres) of the disturbed area between the swale outfall and the diversion channel outfall that slopes toward the south. This area has produced some concentrated surface water flow to the south and formation of small gullies. There is a constructed bench at the southern extent of this disturbed area that has further concentrated the surface water flow. This bench has filled with sediment, overtopped and produced small gullies.

The total effect, especially considering the distance to impounded tailings or significant structures, and the small size of the gullies, is not significant to performance of the site. See photo of area described.

Photos of Southeast Site Small Gullies







Swale Outfall Gully Erosion Issues

Issues 7 and 8 are concerned with the outfall area of the swale. These issues have been expressed separately as the erosion potential and existing erosion effect on surface soils just down-gradient of the swale rock protection (Issue 7), and as the weathering potential of the sub-grade materials supporting the foot of the swale outfall structure (Issue 8). The cause and circumstances related to these issues are discussed together. Resolution of these issues is then discussed for each issue separately.

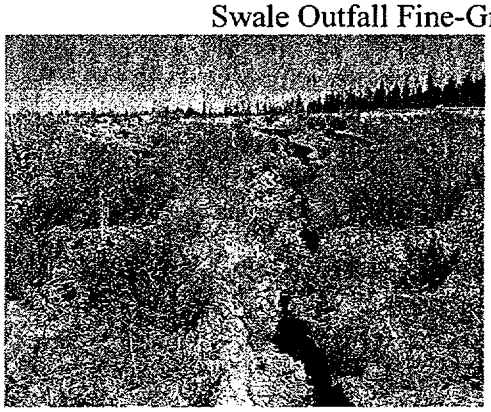
The swale outfall has experienced surface water flow each spring season and during significant storm events. Runoff is produced from the impoundment surface and adjacent watershed areas inside the diversion channel margin. This flow has not been monitored for flow rate but the effect has been noted in inspection reports since construction was completed in the fall of 1996. The erosion effect has decreased over time, as the impoundment and surrounding watershed has re-vegetated. Re-construction work at the swale outfall after the spring 1997 runoff included re-contouring and reseeding of the area after significant erosion removed surface soils and produced gullies. The re-contouring was in the form of two (parallel) swale (shallow/wide) benches directing swale outfall surface water flow toward the southeast. The approximately 20 feet of surface between the swall outfall rock (riprap) and the first bench was covered with 1 to 2 feet of fine-grained soils and re-vegetated. These swale benches have now seen more surface water flow runoff that has resulted in erosion of fine-grained soils, deposition of silts in the beginning 100 feet of the first swale and gully erosion for another 100 or so before turning south onto undisturbed ground. The undisturbed ground past the swale area has shown little erosional impact.

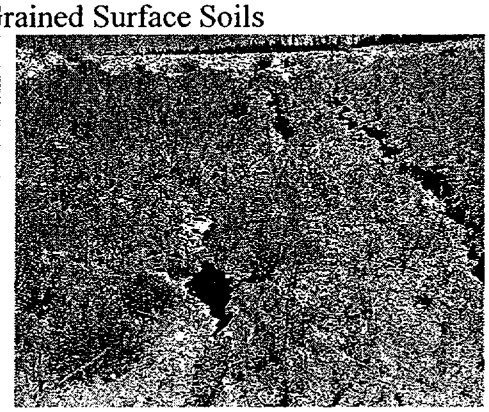
The beginning section of the first swale bench is silted nearly full and will overtop with significant surface water flow from the swall outfall. This potential occurrence would likely produce concentrated flow and formation of a gully. The flow would then pass to the second bench (located about 100 feet to the south, down-slope, and parallel to the first bench) where the flow would be collected and slowed again causing silt deposition. The second swale bench would progress in a similar manner to the first swale bench until it fills with silt, overtops, produces a concentrated flow path and forms gullies further down stream. This would continue until a relatively stable configuration and flow pattern is eventually produced after a few years. Eventually, these gullies may cut back through the fine-grained surface soils to the swale outfall structure.

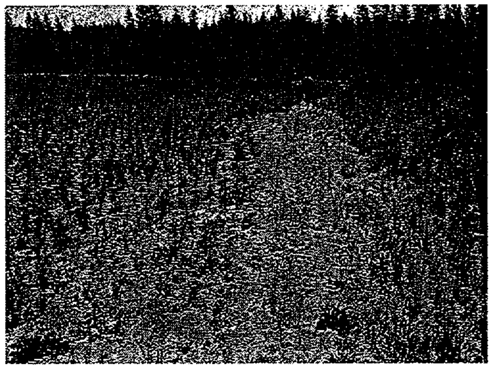
The issue for this area is long-term structural stability performance. Will the site remain stable for the long-term under the postulated outcomes predicted? The analysis[1] provided by WNI and their engineering consultants indicates that the swale outfall is stable. This analysis is based on the constructed swall outfall toe design and a conservative analysis of erosion of site sandy soil that predicts limited downstream scour during a maximum flood event. The swale outfall toe is designed and constructed with a substantial quantity of rock placed and anchored into the natural sub-grade rock. See design and as-built documentation for specific configuration. In addition, actual site conditions, as verified by department staff inspections, indicate that the site material configuration is more inherently stable than the site sand soil assumed in the scour analysis. The as-built condition just down-gradient of the swale outfall is a 1 to 2 foot layer of fine-grain soil covering a substantial weathered monzonite sub-grade mass. The fine-grained soil has eroded sacrificially leaving exposed weathered monzonite. Geophysical data indicates that the monzonite rock sub-grade underlies the entire area between the swale outfall and the area of impounded tailings, several hundred feet away. This massive rock structure is a significant erosion-limiting feature protecting the site from potential release of tailings to the environment. This rock mass, although weatherable, when exposed, has very substantial durability for a long period of time.

Issue 7 is related to surface soils immediately down-gradient of the swall outfall. These soils are fine-grained, imported to the area during construction and re-vegetated, and cover the monzonite sub-grade. These soils are still stabilizing with vegetation, but are not capable of sustaining significant swale outfall concentrated surface water flows. Therefore, these soils are sacrificial. The presence of several small gullies of up to 2 feet deep (down to the monzonite sub-grade) by 2 feet wide or more in this area attests to this effect. However, presence of these fine-grained soils in this area represents an aesthetic aspect of the design and not a performance aspect. Erosion of fine-grained soils in this area is not a performance consideration. See photos below.

Swale Outfall Fine-Grained Surface Soils





Issue 8 relates to the potential for gully formation at the swale outfall toe. Gullies might form in the future and head cut back into the swale outfall area. These gullies would likely stabilize when they encounter the structural capacity of the monzonite sub-grade and riprap from the constructed swale outfall. Weathered monzonite could be exposed locally in the bottom of these gullies. (The monzonite sub-grade, as seen in field inspections, has not eroded at this time, although there is some surface rock that is loose that may eventually move during heavy seasonal swale outfall flows.)

Monzonite sub-grade rock was evaluated (prior to construction) for extent and permeability using geophysical methods. This rock underlies the entire site with a relatively thin layer of fractured rock (more permeable) over a nearly impermeable rock base. Outcrops of the monzonite have been observed during field inspections during operations, construction and since. Observation of outcrops and cuts, and review of geo-technical characterization data by professionally trained staff over the past few years has shown that monzonite sub-grade material in the area is slowly weatherable, when exposed, but structurally sound at depth.[2] Therefore, the potential long-term outcome is that exposed monzonite sub-grade (due to erosion of surface soils) would weather slowly with time, and displace down-stream during heavy storm events. After a long weathering period, the swale outfall area may produce gullies into the monzonite sub-grade and migration into the swale outfall. Durable rock (quartz monzonite riprap) that was placed at the swale outfall during construction could fall into any gully that might head cuts into the structure. Durable rock lying in these gullies may eventually reduce monzonite sub-grade weathering action, stabilize gully formation and reduce the rate of gully migration. It would therefore take a very long time to unravel or degrade the structural integrity of the swale outfall to any extent.

A great mass of monzonite rock underlies the swale outfall and the area between the swale and impounded tailings. There is also a great distance (several hundred feet) from the swale outfall to the impounded tailings. These factors provide additional structural stability based on long-term monzonite sub-grade durability and extent of the monzonite sub-grade mass. Impounded tailings are therefore protected from potential for release to the environment by runoff erosion at the swale outfall.

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[1] Request for License Termination Final Data Submittal, Prepared for Western Nuclear, Inc. by Shepherd Miller Inc., November 1999.

[2]Personal Communication during this inspection and technical review has contributed to the opinions expressed by the author. Special thanks to: Jerald LaVassar, P.E. (Washington Department of Ecology, Dam Safety), Martin D. Walther, P.E. (Washington Department of Ecology, Dam Safety), Terry McLendon, Ph.D. (Shepherd Miller, Inc. and Colorado State University), Steven Link, Ph.D. (Washington State University), Dorothy Stoffel (Department of Health), and Earl Fordham, P.E. (Department of Health).

Cc: Jerald LaVasser, P.E., WDOE

MEMORANDUM

January 24, 2000

TO: Gary Robertson
John Blacklaw

FROM: Dorothy B. Stoffel

SUBJECT: Final Ground Water Sample at Western Nuclear, Inc., Sherwood

Western Nuclear has submitted the analytical results of their final ground water quality sampling event in a report, January 13, 2000. This final sampling event is consistent with NRC SA-900 Guidance for License termination Step 2: Submittal of final ground water sampling results. Ground water was analyzed for constituents previously identified in the tailing liquor. In addition to the analytical results for hazardous constituents, the report contains all of the ground water quality and static water level chronological and graphical trend data for monitoring wells MW-2B, MW-4 and MW-10. After review of the data, I concur that the data confirm that static water levels and indicator parameter concentrations are within normal ranges consistent with expectations, and concentrations of constituents are well below regulatory limits.

A letter report documenting the final abandonment of monitoring wells MW-1A, MW-2, MW-2A and MW-3 was submitted to the department December 16, 1999. This report fulfills the reporting requirements specified in license condition 35A of Radioactive Material License #WN-I0133-1. Abandonment procedures followed requirements of WAC 173-160-560 and original documents have been filed at Washington Department of Ecology's Water Resource Program.

WNI has fulfilled all requirements for ground water monitoring as delineated in the Monitoring and Stabilization Plan, radioactive materials license and NRC Guidance for License Termination. Ground water monitoring for the Department of Health may be terminated in monitoring wells MW-2B, MW-4 and MW-10. The US Department of Energy (US DOE) has requested that the remaining wells be transferred to US DOE for future monitoring availability under the US DOE's long-term surveillance program. WNI will transfer registration of the wells to the US DOE as part of the license termination process.

Washington State Department of Health
Environmental Health Programs
Division of Radiation Protection
Waste Management Section

January 28, 2000

To: Gary Robertson

From: John R. Blacklaw, P.E.

Subject: **Vegetation Productivity Monitoring and Document Review for WNI's Sherwood Project**

Vegetation productivity is one of the three primary measures used to evaluate the Sherwood Project site for post-reclamation construction performance and qualification for radioactive material license termination. The need for vegetation productivity is based on the reclamation design in relation to regulatory requirements to isolate uranium mill tailings from the environment. For the area covering the tailings (cover), vegetation productivity performs a dual purpose of : (1) providing evapo-transpiration of surface water and near-surface soil moisture to prevent or limit infiltration of water from entering into the waste pile, and (2) limiting erosion of surface soils. For the area between the cover and the surrounding diversion channel (margins), vegetation productivity is expected to limit soil erosion potential.

The Monitoring and Stabilization Plan (MSP)[1] documents the vegetation productivity monitoring method (line intercept method), statistical sampling approach, and criterion for acceptance to performance-based criteria. The acceptance criterion for vegetation productivity is 39% vegetative cover on the margins and 36% on the cover. The statistical limit is that the sample mean, less the 80% confidence interval (standard error of the mean), exceeds the vegetative productivity requirement.

The department requested that Western Nuclear, Inc. provide additional information on the inherent factor of safety for the calculation of the vegetation productivity limits of 39 and 36 percent cover. This information is included in the MSP[1] document, Attachment D, Margin Stability Level of Conservatism. There are 7 separate factors that work together to provide a factor of safety of approximate 120. These factors are (1). Probable Maximum Precipitation (PMP), (2). Rainfall Distribution, (3). Soil Moisture Conditions, (4). Longest Steepest Slope, (5). Bottom of Margin, (6). Soil Parameters, and (7). Vegetation Parameters. See discussion in the MSP[1] document.

The department has also made a recent request to Western Nuclear, Inc. technical staff for clarification of short-term vegetation productivity requirements. Assurance is needed at the site to provide adequately erosional and structural stability during the re-vegetation establishment period to allow for unimpeded progress toward longer-term site stability without the concern for re-construction due to likely, or expected, precipitation events. The department requested that a percent cover criterion is prepared for a 10,000-year event and for a 100-year event. The 10,000-year event is considered unlikely for short-term periods and conservative. The 100-year event is considered possible (likely) for short-term periods. Results of recent erosion protection analysis indicate that margin vegetation requirements of 34 percent cover is adequate for a 10,000-year event and that 33 percent cover is adequate for a 100-year event. In addition, the 10,000-yr and 100-yr precipitation events on the cover require no vegetation for erosional stability[3]. See table below.

Table of Margin Vegetation Productivity Acceptance Criteria

Percent Cover by Flood Event Probability	Probable Maximum Flood (PMF) (1 in 1,000,000 yrs.)	Short-Term Unlikely Flood Event (1 in 10,000 yrs.)	Short-Term Possible Flood Event (1 in 100 yrs.)
Percent Vegetal Coverage (Line Intercept Method)	39%	34%	33%

Therefore, the department believes that a margin area that meets or exceeds 34 percent cover is adequate for the short-term while vegetation succession takes place. The 39 percent cover requirement remains valid for the 1,000-year design and regulation-based longevity requirement. The cover area has exceed short-term criteria.

Results of vegetation monitoring are reported[2] by Western Nuclear, Inc. for the 1999 season. Both Western Nuclear, Inc. staff and Department of Health staff performed vegetation productivity sampling using the established protocol. First a qualification sample was performed comparing results of all evaluators for 5 sampling points. Then, Western Nuclear, Inc. evaluated the full sample (50 samples on the margins and 50 samples on the cover) prescribed in the MSP[1]. Department of Health staff followed the same protocol but evaluated only a sub-set of the full sample (15 samples on the margins and 20 samples on the cover). The Department of Health sample is considered a minimum representative sample for determining the sample mean and to check Western Nuclear's sample data. However, since the sample size is small, the confidence interval portion of the criterion is not applicable to evaluate the statistical aspect of the criteria, based on Department of Health samples.

Western Nuclear, Inc. and the Department of Health have long recognized that a portion of the margin area has a stable sub-grade structure that limits erosion potential, even without the requirement for vegetation productivity. These areas were delineated by field evaluation by Western Nuclear's technical consultant, verified by Department of Health staff, and shown on a map identified as Appendix II. Soil Cover Map. Quartz Monzonite

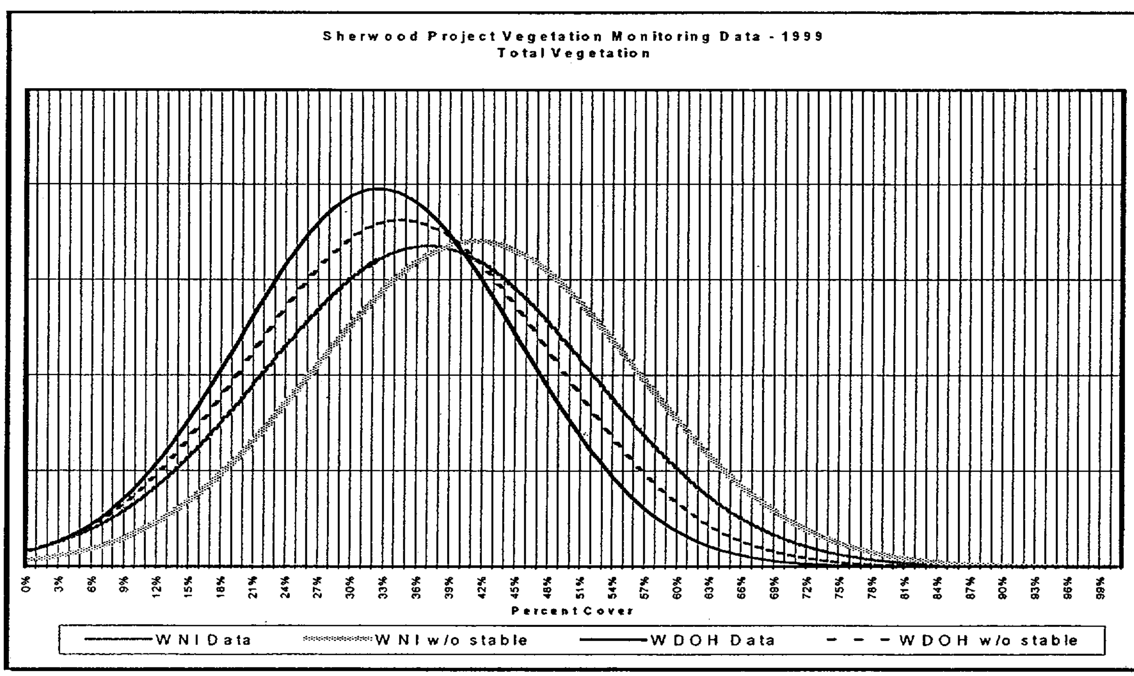
Bedrock. Page 3/3 in the 1999 Vegetation Monitoring Report[2]. Based on this evaluation, a sub-sets of vegetation monitoring sample location was identified for Deep Soils and for Quartz Monzonite less than 1 foot deep. Results were evaluated for WNI's full sample set (50 samples) and Deep Soils sample set (34 samples), and for WDOH's full sample (15 samples) and Deep Soils sample set (9 samples). See the table below for vegetation productivity results for Western Nuclear, Inc. and Department of Health evaluations. Results are tabulated for the Sample Mean, for the 80% Confidence Interval and for the 95% Confidence Interval.

Table of Total Vegetation Productivity Monitoring Results – 1999

Percent Cover Statistics for WNI and WDOH Data	Sample Mean	80% Confidence Interval*	95% Confidence Interval*
WNI Full Sample Data	36.5%	+/- 2.7%	+/- 4.1%
WNI Deep Soils Data	40.9%	+/- 3.2%	+/- 4.9%
WDOH Full Sample Data	32.0%		
WDOH Deep Soils Data	34.1%		

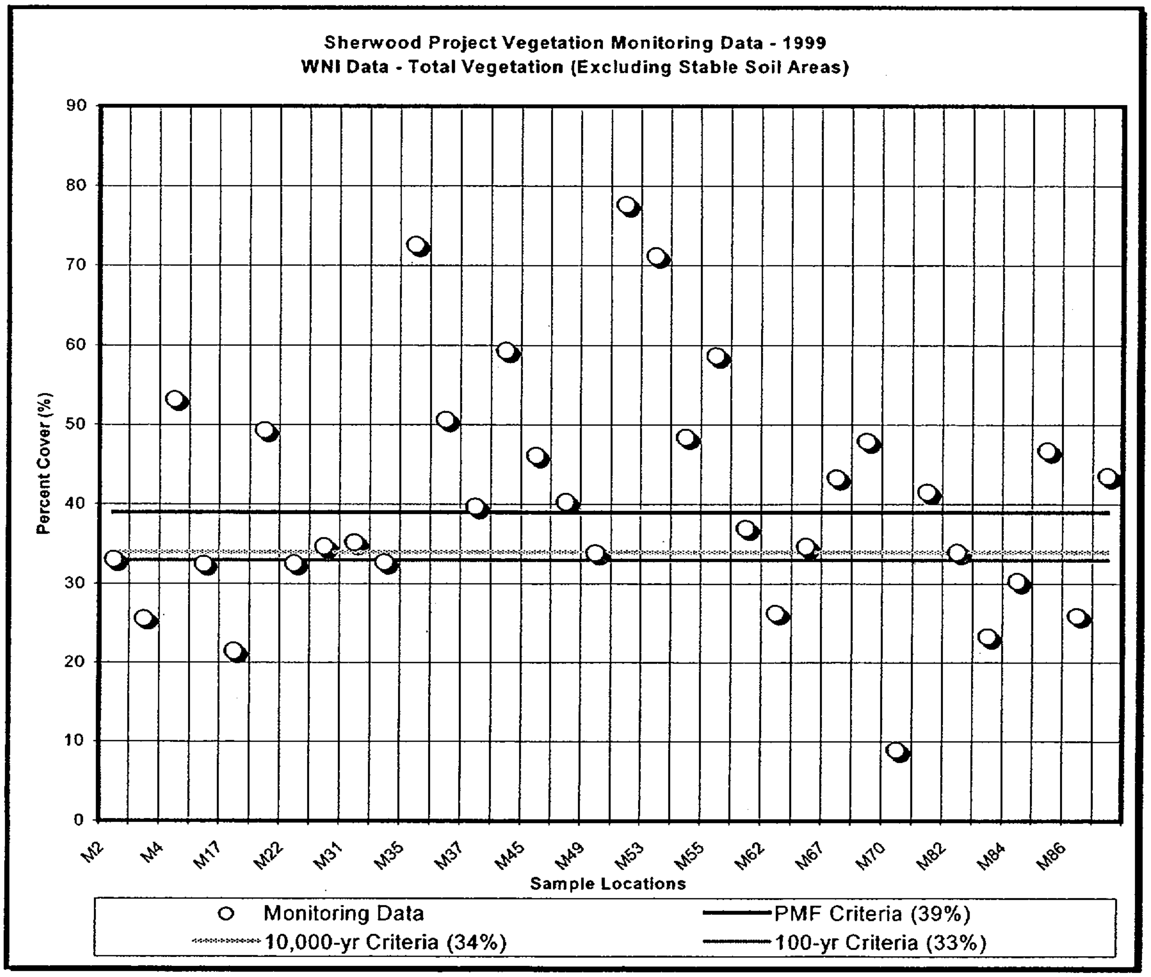
* Confidence Interval is statistically the "Standard Error of the Mean".

Comparison of the sample data for the four cases indicates that the results for the four cases are not statistically different at approximately the 95% confidence interval. In addition, the Deep Soils data indicates better performance than the Full Sample data, but not markedly. Evaluation of individual sample data points shows that considerable vegetation prevails on the areas of the margin where quartz monzonite bedrock is found. See the probability distribution below for the four samples for a visual representation of the individual sample data.



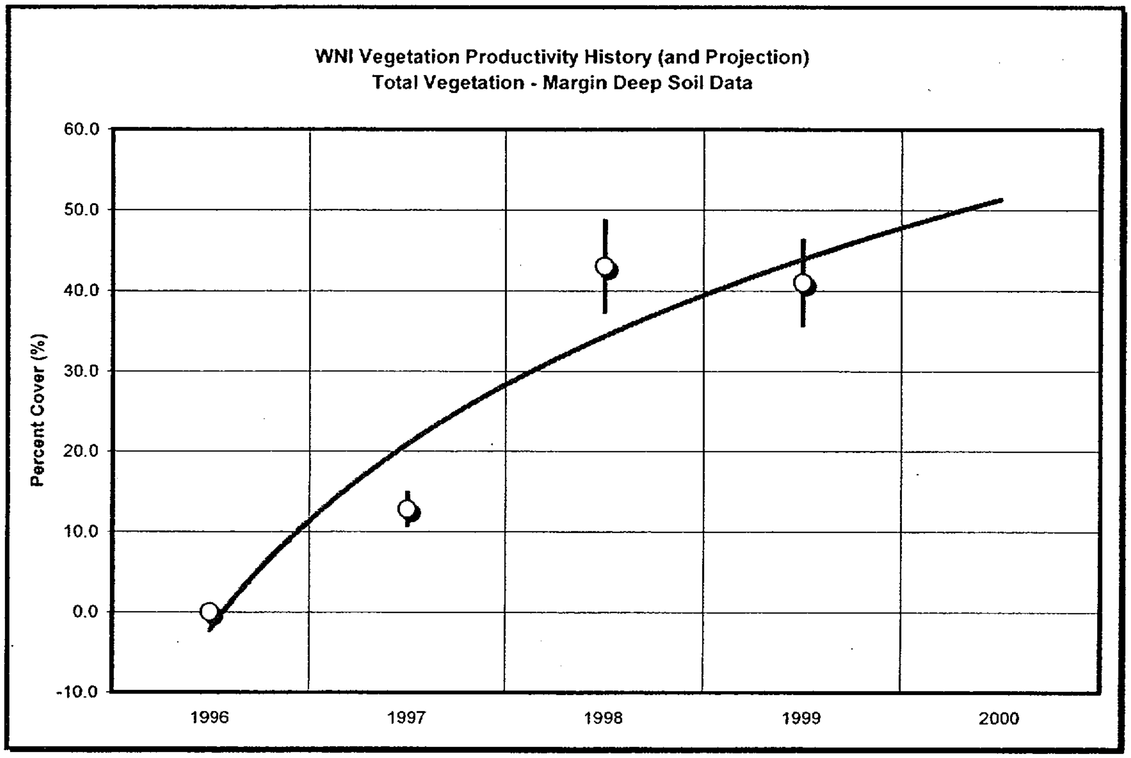
Sample data for Western Nuclear, Inc.'s Deep Soil sample set has been charted for percent cover indicated at each sample location. In addition, the 39% (PMF – 1 in 1,000,000-year storm event criteria), the 34% (1 in 10,000-year storm event criteria) and the 33% (1 in 100-year storm event criteria) criterion bars are also shown. As can be seen below, most sample points exceed the 33% and 34% cover criteria, and a majority of sampling points exceeds the 39% cover criteria.

While it may be apparent by viewing the chart that there may be some likelihood that some erosion may occur, it is not likely to be widespread, cover large areas, or be of a concern for causing major damage that would require re-construction. (There is considerable vegetation productivity variability by sample location.) Only unlikely events (greater than 1 in 10,0000-yr storm events) are likely to cause major damage.



It is also significant to note that sample data was taken for both Total Vegetation and for Perennial Vegetation. Perennial vegetation averaged 79% of total vegetation for the WNI full sample data set. Large portions of perennial vegetation is indicative of vegetative progression past the initial stages of re-vegetation where annual species predominate.

In the longer-term, the site is expected to increase in vegetation productivity and attain relative structural stability from erosion similar to the surrounding areas of the site. In the following chart, the historical data is plotted over the past 4 years for total vegetation on the margin areas for deep soil samples. The mean and 95% confidence interval are shown for each year, as well as a logarithmic fit line that projects vegetation productivity progression into the 2000 season. (Reclamation construction occurred in 1996 indicating a 0 percent cover for that year.) See the following chart for a visual presentation of the history and projections for vegetation productivity.



Although there is variation in vegetative cover from year to year, the trend is for continued improvement and projections of percent cover in the range of 50 percent by the summer of 2000.

There is an apparent higher performance in 1998 compared to 1999 data. It appears that a predominance of sweet clover (a biennial species) has skewed the results somewhat. Sweet clover has a peak performance in the second, fourth, and even years after planting. The odd years will eventually fill in. Therefore, it is expected that year 2000 results will again increase. WNI and department staff observed this affect.

Conclusions

Vegetation productivity performance has increased since reclamation construction. Performance to date is adequate to provide erosional stability for likely short-term precipitation events. Vegetation is expected to continue to increase in a natural progression and eventually approximate the vegetation productivity of adjacent undisturbed local sites that show very minimal erosional affects. Vegetation productivity performance at the Sherwood Project site meets the Monitoring and Stablization Plan performance and regulatory requirements. Therefore, the Sherwood Project site radioactive materials license may be terminated without concern for vegetation productivity.

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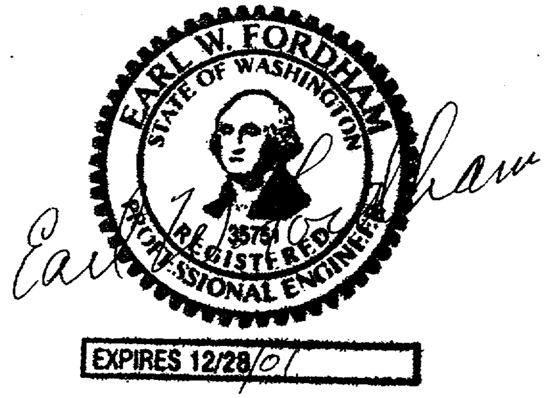
[1]Sherwood Project Tailings Impoundment Monitoring and Stabilization Plan, prepared by Shepherd Miller, Inc. for Western Nuclear, Inc., September 1997.

[2]Sherwood Monitoring and Stabilization Plan, Post-reclamation Construction Monitoring, 1999, Vegetation Monitoring Program, prepared by Western Nuclear, Inc., October 1999.

[3]Response to Washiington Department of Health Verbal Questions of December 6, 1999, prepared by Shepherd Miller, Inc. for Western Nuclear, Inc., December 1999.

Washington State Department of Health
Environmental Health Programs
Division of Radiation Protection
Waste Management Section

February 1, 2000



To: Gary Robertson

From: Earl W. Fordham, P.E.

Subject: **Vegetation Productivity Analysis for WNI's Sherwood Project**

Vegetation productivity is one of the three primary measures used to evaluate the Sherwood Project site for post-reclamation construction performance and qualification for radioactive material license termination. The need for vegetation is based on the regulatory requirements to isolate uranium mill tailings from the environment. For the area covering the tailings (cover), vegetation performs a dual purpose of: (1) providing evapo-transpiration of surface water and near-surface soil moisture to prevent or limit infiltration of water from entering into the buried waste pile, and (2) limiting erosion of surface soils. For the area (i.e., margins) between the cover and the surrounding diversion channel, vegetation and the corresponding subsurface biomass is needed to limit soil erosion.

The Monitoring and Stabilization Plan (MSP)[1] documents the vegetation productivity monitoring method (line intercept method), statistical sampling approach, and criterion for acceptance to performance-based criteria. The acceptance criterion for vegetation productivity is 39% vegetative cover on the margins and 36% vegetation atop the cover. The statistical limit is that the sample mean, less the 80% confidence interval (standard error of the mean), exceeds the vegetative productivity requirement.

In the analysis performed to determine whether the vegetative cover was adequate to ensure minimal soil erosion in the short term, several factors are reviewed. Environmental factors included the rain intensity (up to and including the 10,000-year storm), height and density of the vegetation, the length and slope of the region of interest, and type of soils involved. In addition to these environmental factors, values for three engineering factors were selected: Manning's "n" number (roughness coefficient), run-off coefficient (C) and flow concentration factor (F). Values for the run-off coefficient and flow concentration factor were chosen at the conservative end of their respective ranges. The value of Manning's "n" number (0.035) was chosen from a review of literature.[2, 3]

In addition to the conservatism assumed above, the calculation of the vegetation productivity limits of 39% (margin) and 36% cover included several factors of safety. This information is included in the MSP[1] document, Attachment D, Margin Stability Level of Conservatism. There are 6 factors, in addition to the vegetative factors documented above, that work together to provide a factor of safety of approximate 120. This level of conservatism is reasonable given the level of uncertainty in some of the quantities used, such as rainfall intensity for a certain storm periodicity.

As a result of a recent WDOH request to Western Nuclear, Inc. (WNI) for clarification of short-term (e.g., 1-3 years) vegetation productivity requirements, further analysis by WNI's contractor was initiated. A reasonable expectation is needed that the site will not undergo an erosion event during the re-vegetation establishment period. The department requested that a percent cover criterion be prepared for a 10,000-year event and for a 100-year event. The 10,000-year event is considered unlikely for short-term periods and conservative. The 100-year event is considered possible (likely) for short-term periods. Erosion protection results prepared by WNI's contractor indicate that margin vegetation requirements of 34 percent cover is adequate for a 10,000-year event (maximum rainfall intensity of 6.75 inches per year)[4] and that 33 percent cover is adequate for a 100-year event. In addition, contractor analysis indicated the 10,000-yr and 100-yr precipitation events on the cover require no vegetation for erosional stability[5]. Departmental analysis, using slightly more conservative values (height and density of vegetation), indicates that the site is stable with 35% cover on the margin. WDOH analysis confirms the assessment that no vegetation is needed on the relatively flat cover that is directly above the reclaimed tailings pile.

Therefore, my analysis indicates that a margin area that meets or exceeds 35 percent cover is adequate for the short-term while vegetation succession takes place. The 39 percent cover requirement remains valid for the 1,000-year design utilizing the Probable Maximum Precipitation (PMP) event that results in the Probable Maximum Flood (PMF) and regulation-based longevity requirement. The cover area has exceeded the short-term criteria.

Conclusions

Since the completion of reclamation construction and seeded in 1996, vegetation productivity performance has increased from 0% to approximately 37-38%. Performance to date is adequate to provide erosional stability for precipitation events up to and including the theoretical 10,000-year as described by WDOE documentation.[4]

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[1] Sherwood Project Tailings Impoundment Monitoring and Stabilization Plan, prepared by Shepherd Miller, Inc. for Western Nuclear, Inc., September 1997.

[2] Hydrology For Engineers, 3rd Edition, Ray K. Linsley Jr., Max Kohler, and Joseph H. Paulhus, McGraw-Hill, Inc., New York, 1986.

[3] HANDBOOK OF HYDROLOGY, David R. Maidment, McGraw-Hill, Inc., New York, 1993.

[4] Letter (with enclosures) from Martin D. Walther, PE, State of Washington, Department of Ecology to John Blacklaw, PE dated December 16, 1999, RE: Sherwood Uranium Mill, Spokane Indian Reservation Hydrologic computations for extreme precipitation events.

[5] Response to Washington Department of Health Verbal Questions of December 6, 1999, prepared by Shepherd Miller, Inc. for Western Nuclear, Inc., December 1999.

TO Paul Lohaus 3/1/00

This cd was supposed to accompany the package we sent you yesterday, but was inadvertently left out. my apologies.

Kristin Felip, Secretary
Waste Mgmt. Section