April 18, 1997

Petrotomics Company
ATTN: Mr. Ron A. Juday, Supervisor
P.O. Box 8509
Shirley Basin, WY 82615

SUBJECT: ALTERNATE CONCENTRATION LIMIT APPLICATION FOR PETROTOMICS COMPANY SHIRLEY BASIN WYOMING URANIUM MILL TAILINGS SITE, LICENSE SUA-551

Dear Mr. Juday:

The U.S. Nuclear Regulatory Commission staff has completed its review of Petrotomics Company's application for Alternate Concentration Limits (ACLs) for its Shirley Basin, Wyoming uranium mill site submitted by your letter dated September 20, 1996. Based on its review, the staff has identified several issues that need additional information. These issues are described in the enclosure.

In order to support a timely review of the ACL application, please provide within 30 days of this letter the additional information needed to resolve the issues identified in the enclosure. If you have any questions, please contact the NRC Project Manager, Mohammad Haque at (301) 415-6640.

Sincerely,

(Original signed by)

Charles L. Cain, Acting Chief
Uranium Recovery Branch
Division of Waste Management
Office of Nuclear Material Safety
and Safeguards

Docket No.: 40-6659
TAC No.: L51509

Enclosure: As stated

cc: D. Finley, DEQ, WY
J. Hough, RCPD, WY
WDEQ-LQD, WY

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NRC STAFF REVIEW COMMENTS ON
ALTERNATE CONCENTRATION LIMITS APPLICATION FOR
PETROTOMICS COMPANY SHIRLEY BASIN, WYOMING URANIUM MILL SITE
SOURCE MATERIAL LICENSE SUA-551

In its acceptance review dated October 8, 1996, of Petrotomics Company's (Petrotomics') Alternate Concentration Limit (ACL) application for the Shirley Basin, Wyoming uranium mill tailings site, the U.S. Nuclear Regulatory Commission staff identified six issues that required additional information/documentation. In response, by its letter dated December 20, 1996, Petrotomics submitted Addendum No. 1 to address Acceptance Review Open Issues No. 1 through 5; and Addendum No. 2 to address Issue No. 6. Based on its review, the staff found the information presented in Addenda 1 and 2, sufficient to allow detailed review of Petrotomics' ACL application, and closure of issues 1 through 4.

The information provided in response to Issues No. 5 and 6 is appropriate. However, additional questions related to issue 5 remain to be addressed as discussed in detail in comment 5, below. Issue 6 can not be closed at this time, and will remain open until receipt of written confirmation from U.S. Department of Energy of its willingness to accept the site for its custody and long-term care.

The staff has completed its detailed review of Petrotomics' ACL application package, and has identified a need for additional information as discussed below. The package included ACL application submitted by letter dated September 10, 1996 (Shepherd Miller, Inc., 1996a); addenda 1 and 2 to the ACL application by letter dated December 20, 1996 (Shepherd Miller, Inc., 1996b,c); and a report on assessment of background groundwater monitoring data by letter dated September 20, 1996, (Huber, 1996). The review was conducted in accordance with guidelines and criteria provided in the NRC Staff Technical Position Alternate Concentration Limits for Title II Uranium Mills (NRC, 1996), referred to hereafter as the STP.

1. **COMMENT:** Proposed ACLs are not consistent with "As Low As Reasonably Achievable" (ALARA) requirements. Consequences of enhanced pumping of the Main Sand aquifer and fresh water injection need to be addressed with respect to the ALARA requirements.

   **DISCUSSION:** Pursuant to Criterion 5B(6) of Appendix A to 10 CFR Part 40, the NRC can establish site-specific ACLs for hazardous constituents if it finds that the proposed values are "as low as reasonably achievable," after considering practicable corrective actions.

   In section 4.1 of the ACL application, Petrotomics proposes ACLs for the combined Upper Sand and Main Sand aquifers for the hazardous constituents of concern at the site. The hazardous constituents include cadmium, chromium, lead, nickel, radium-226, radium-228, selenium, thorium-230, and uranium. The 95th percentile of the distribution representing historic monitoring data from two Upper Sand aquifer wells and two Main Sand aquifer wells were proposed as the ACLs. This means

that 95 percent of the historic values are below the proposed ACLs. The two Upper Sand wells (5SC and 51SC) and one of the Main Sand wells (5DC) are the proposed ACL point of compliance (POC) locations for the Upper and Main Sand aquifers, respectively. The other Main Sand well (12DC) is located within the tailings impoundment and does not meet criteria for selection as a POC (section 1.4 of the STP). The proposed ACL values selected from these wells do not appear to represent the lowest reasonable values that could be achieved, considering values that have already been achieved at the site.

In section 1.3 of the ACL application, Petrotomics indicates that there has been a steady decline in constituent concentrations over the last few years as a result of the existing corrective action program (CAP). For many of the hazardous constituents (e.g., cadmium, lead, selenium, thorium-230, and uranium) the proposed ACL values are higher than concentrations measured during 1995 and 1996 in the proposed POC wells (see appendix G of the ACL application). In the case of radium-226 and radium-228, the proposed ACL values are based on monitoring data from well 12DC. Constituent concentrations from this well, which is located within the tailings impoundment, should not be used to select ACL values.

In section 4.1 of the ACL application, Petrotomics estimates that future constituent concentrations will fall below present concentrations. These estimates are based on constituent fate and transport modeling conducted by Petrotomics as part of the ACL application (section 2.2.4). However, by using only historic monitoring data (which dates back to 1985 for the Upper Sand wells) to select ACL values, Petrotomics has not taken into consideration such future declines in concentrations.

Section 3.3.3.2 of the STP requires a demonstration that the proposed ACLs are ALARA considering practicable corrective actions. In section 3.2.2 of the corrective action assessment, Petrotomics rejects the option to pump the Main Sand aquifer at increased rates by completing and pumping additional seepage recovery wells based on the argument that additional recovery from the Main Sand aquifer would result in higher concentrations of constituents in the aquifer sooner and would prolong the time required to affect site closure. However, the application does not discuss the effects of such a corrective action with respect to ALARA requirements.

In appendix E of the ACL application, constituent concentration contour maps for the Main Sand aquifer indicate that contamination is concentrated in an area at the north end of the tailings impoundment. This has been identified by Petrotomics as an area where the Upper and Main Sand aquifers are hydraulically connected. Tailings seepage is currently being recovered from several Main Sand wells in and around this location. Examination of table 3-8 indicates that significant quantities of hazardous constituents, including uranium, radium-226, radium-228, thorium-230, sulfate, and nickel, are currently being extracted from the Main Sand recovery wells. Even though enhanced pumping of the Main Sand aquifer would result in greater concentrations

of constituents, it is also likely that these constituents would be recovered at a faster rate.

In section 3.2.6.1 of the application, Petrotomics rejects fresh water injection as a corrective action alternative by arguing that, over time, acceptable water quality levels will be reached naturally. However, the application does not discuss the effects that this corrective action would have on the ALARA requirements. Fresh water injection would dilute constituent concentrations in the contaminated site aquifers and force groundwater to flow, thus reducing the contaminant load on the downgradient side of the site. Fresh water injection would also raise groundwater pH and cause hazardous constituents to precipitate and adsorb.

By rejecting the above corrective action options without evaluating the effects such actions will have on constituent concentrations at the POCs, the licensee has not demonstrated that the proposed ACLs will meet ALARA requirements.

**ACTION NEEDED:** Petrotomics should propose reasonable (low) ACL values for the hazardous constituents of concern based on an assessment of constituent concentration levels achieved to date or, preferably, on estimated constituent concentrations from fate and transport modeling. Only data from wells outside the tailings impoundment should be used in the assessment. Furthermore, Petrotomics should assess the effects that pumping the Main Sand aquifer and fresh water injection would have on constituent concentrations at the proposed POCs and should demonstrate that the proposed ACLs meet ALARA requirements.

2. **COMMENT:** Data for determining historic and future tailings leakage rates need additional evaluation and documentation.

**DISCUSSION:** In evaluating the potential transport of hazardous constituents between the POC and point of exposure (POE), Petrotomics should provide conservative and defensible estimates of release rates for those hazardous constituents that have been or are anticipated to be released from the source (section 3.3.3.1.1 of STP). These release rate estimates are used in later analyses to predict the mass of constituents released to the groundwater for transport.

In section 2.1.2.1 of the ACL application, Petrotomics presents a log normal regression of estimated historic leakage rates from the tailings impoundment and uses the linear regression equation produced by this analysis to estimate future leakage rates from the impoundment. Review of the data used to produce the regression equation indicates that the analysis may not be conservative.

In the ACL application, historic tailings leakage rates are estimated using three sources of information: (1) a mass balance of tailings liquids calculated from historic data (appendix B-4), (2) historic leakage rates estimated by numerical modeling (appendix F), and (3) a

leakage estimate calculated using simple flux calculations from Darcy's Law (Hydro-Engineering, 1988). The data used in the analyses and the regression equation are presented in figure 2-1 of the ACL application. These data indicate that the tailings impoundment leakage rate peaked in 1980; however, no mass balance of tailings liquids for 1980 was provided to confirm this conclusion.

The modeled historic tailings leakage rates were based on estimates made using mill operational data (appendix F). Although modeled leakage rates compare well with leakage rates calculated from the mass balance of tailings liquids from 1983 to 1985, the modeled tailings leakage rates in 1981 and 1982 are much greater than those calculated from the mass balance of tailing liquids. Modeled tailings leakage rates were approximately 390 gpm and 260 gpm in 1981 and 1982, respectively; whereas leakage rates calculated from the mass balance of tailings liquids were 200 and 99 gpm in 1981 and 1982.

Since the regression equation obtained using the historic tailings leakage rates is used to estimate future tailings leakage rates, the large differences between the measured and modeled leakage rates in 1981 and 1982 raise concerns regarding the validation of the regression analysis, in particular when actual data are available. Using the numerically modeled values to extrapolate future leakage rates may underestimate tailings leakage in the future (i.e., the length of time it takes the leakage rate to reach steady-state may be underestimated).

**ACTION NEEDED:** Petrotomics should re-evaluate the data used to estimate historic leakage rates and demonstrate that the data will provide a conservative estimate of tailings leakage. Petrotomics should also provide data to confirm the leakage rate for 1980.

3. **COMMENT:** Data used to estimate chemical mass loading rates need additional evaluation and documentation. Basis for subtracting mass of constituents in recycled tailings solutions from the mass balance calculations is required.

**DISCUSSION:** Section 3.3.3.1.1 of the STP requires Petrotomics to provide conservative and defensible estimates of release rates for hazardous constituents that have been or are anticipated to be released from the tailings impoundment.

In section 2.1.2.3 of the ACL application, Petrotomics estimates historic and future chemical loading rates using estimated historic and future tailings leakage rates and the concentration of constituents in the tailings waters as calculated from well monitoring of tailings water quality. Review of the data provided by Petrotomics on constituent concentrations in the tailings water raises additional concerns regarding whether chemical loading rate estimates are conservative.

The concentrations of constituents used to calculate chemical mass loading rates in tailings waters are shown in table 2-7 of the ACL

application. The application indicates that the water quality samples from the tailings monitoring wells listed in table 2-7 are representative of water quality data collected since 1988, when monitoring of tailings water quality began. Ideally, historic data from monitoring wells located throughout the tailings impoundment should provide a representative measure of constituent concentrations. Examination of the data in table 2-7 indicates that most analyses are from two wells. Data for 1988 through 1995 are provided from well TW4, which is located at the easternmost edge of the tailings impoundment. Data for 1990 through 1995 are provided from well TW21, which is located in the south-central portion of the tailings impoundment. Single analyses from 1988 were provided for wells PT3, TW6, TW7, and TW10. From this limited data set, it is not possible to determine if these results are representative of water quality throughout the impoundment.

The chemical loading rates were calculated using the average constituent concentrations in the tailings monitoring wells in table 2-7. The calculations assumed no change in tailings water composition with time. Petrotomics provides no technical basis for this assumption. It is probable that constituent concentrations in tailings waters will increase in the future. For example, predicted tailings liquids volume decreases should result in increased constituent concentrations in the tailings waters. For example, concentrations of constituents in well TW4 show an increase from 1988 to 1995. In conclusion, the use of average constituent concentrations from historic tailings water quality data in calculations of future chemical mass loading rates is not conservative and could significantly underestimate the mass of constituents that could be released to the groundwater system.

Section 3.3.3.1 of the STP requires a characterization of the hazardous constituent source term. In section 2.1.1.3 of the application, Petrotomics presents a mass balance for chemical and radiological constituents in the tailings impoundment. From 1980 through 1985, tailings pond liquids were recycled to the mill to replace fresh water supplies. The mass of constituents in these recycled liquids was estimated and subtracted in the mass balance calculations. However, since the recycled tailings liquids were eventually discharged into the tailings impoundment, the constituents in these liquids were never removed from the system.

**ACTION NEEDED:** Petrotomics should recalculate chemical mass loading rates using conservative estimates of tailings liquid constituent concentrations that take into consideration processes such as evaporation that may work to increase future constituent concentrations. Petrotomics should also provide additional documentation on tailings water quality to demonstrate that the constituent concentrations used in chemical mass loading rate calculations are representative of concentrations over the tailings impoundment. In addition, Petrotomics should provide a technical basis for subtracting the mass of constituents in the recycled tailings liquids from the mass balance calculations.

4. **COMMENT:** Uncertainties in relating pH to sulfate concentrations need to be addressed.

**DISCUSSION:** Section 3.3.3.1.2 of the STP requires Petrotomics to evaluate the geochemical characteristics of soils and geologic formations that may affect the attenuation of hazardous constituents and also to address uncertainties associated with attenuation mechanisms.

In section 2.2.2 of the ACL application, Petrotomics concludes that hazardous constituent concentrations in site groundwaters are generally low if the pH is greater than 4 and the sulfate concentration is less than 6,000 mg/l. Groundwater monitoring data from 1995 were used to establish this relationship. This relationship is critical to the ACL application because it is used to establish health-based values for all hazardous constituents at the POE; values that the licensee is required to demonstrate will be protective of human health and the environment.

With the exception of uranium whose transport was modeled separately, Petrotomics uses sulfate transport modeling as a representation of constituent transport at the site. A key assumption of this modeling approach is that pH will always be greater than 4 in site groundwaters with sulfate concentrations less than 6,000 mg/l. Therefore, health-based values established for hazardous constituent concentrations at the POEs will not be exceeded so long as sulfate concentrations at the POEs do not exceed 6,000 mg/l. Petrotomics argues that since sulfuric acid is the primary acid in the site tailings, pH and sulfate values are directly related at the site, and it is possible to set limits on groundwater pH from observed and predicted sulfate concentrations. Although current site chemistry supports this argument, the applicant does not adequately establish that pH and sulfate will retain the same relationship over the period of regulatory concern. The applicant provides only an empirical model for the pH-sulfate relationship based on monitoring data rather than a process-oriented model supporting the pH-sulfate linkage.

The migration of the pH front at the site is controlled by the acid neutralizing capacity of minerals in the site aquifer, chiefly calcite. This buffering capacity has been effective in restricting the migration of the pH front to inside the Petrotomics property boundary. However, as calcite in the site aquifer is consumed by acidic seepage from the tailings impoundment, the buffering capacity of the aquifer may be inadequate to further limit the migration of low pH groundwaters. If the acid neutralizing capacity of the site aquifer is diminished, the relationship between pH and sulfate may change, affecting hazardous constituent concentrations at the POEs. Petrotomics has not addressed these uncertainties.

In section 2.2.3.2.1.2 of the ACL application, Petrotomics indicates that migration of the pH front can be approximated from measurements of the acid neutralizing capacity of aquifer materials. This approximation was not performed, citing difficulty in selecting samples for laboratory

testing that would be representative of the aquifer considering its heterogeneous nature. However, literature-based data on the mineralogy of the Wind River Formation and uranium ore deposits hosted by the Wind River Formation (Harshman, 1972) are available and should be adequate to perform a conservative approximation. Some limited site-derived mineralogical data may be available to support this approximation.

**ACTION NEEDED:** Petrotomics should address uncertainties in the relationship between pH and sulfate concentrations for the period of regulatory interest. Petrotomics is requested to provide a process-oriented model for the pH-sulfate linkage. Petrotomics is requested to demonstrate that the buffering capacity of the site aquifer is adequate to restrict the migration of low pH (i.e., pH 4 or lower) groundwater to inside the Petrotomics property boundary. If Petrotomics is unable to demonstrate this buffering capacity, constituent transport modeling similar to that conducted for uranium (i.e., using conservative retardation factors) should be performed to predict health-based constituent concentrations at the POEs.

5. **COMMENT**: Groundwater flow modeling results require additional verification.

**DISCUSSION**: Section 2.2.4.1 and appendix F of the ACL application discuss the conceptual framework for groundwater flow modeling using MODFLOW. Information concerning the model, model calibration, and modeling results is insufficient.

MODFLOW calibration is based upon estimated rather than measured values. Therefore, calibration of the model could not be adequately evaluated. Furthermore, since the calibrated model was adjusted to address the consequences of backfilling Pit 4 and the altered geometries of other pits on the neighboring Pathfinder site, the validity of model results is uncertain. For example, the NRC expects that backfilling Pit 4 will change the groundwater flow pattern in the area.

The ACL application provides insufficient description of the MODFLOW calibration. For example, in appendix F it is stated that the hydraulic conductivity adjustment "..did not exceed 10 ft/day." In addition, no initial value for the hydraulic conductivity was mentioned in appendix F. There is no sample input file listing model parameters and values.

In descriptions of the transport modeling, the difference between the tailings seepage and recharge due to infiltration was not clearly established for the tailings impoundment. The ACL application refers to an estimated long term tailings seepage rate of 0.7 gpm in section 2.1.2.1. However, in section 2.1.2.2 it is inferred that this seepage rate is due to areal recharge. Also, in the discussion of the transport simulation it was not clearly indicated whether the same long-term seepage rate was used for every year starting in 1996 or whether a variable rate was used up to year 2025.

In section 2.2.4.1.4 of the ACL application, Petrotomics concludes that the total discharge from the Upper Sand aquifer into Pathfinder Pit 33 will not exceed 2 percent (5 gpm in 205 gpm) at steady-state flow. The licensee also concludes that baseflow to the Little Medicine Bow River will increase from less than 2 cfs to more than 3 cfs at steady state. These rates could not be verified from the information and data provided in discussions of the flow model or procedures used for its calibration. In addition, the source of the remainder of the flow into Pit 33 was not defined.

**ACTION NEEDED**: Petrotomics should demonstrate that the model, as calibrated, would produce similar results if Pit 4 is backfilled. The calibration process should also include comparison of results for modified dimensions and levels of the various pits. A detailed model grid, a list of parameters in tabular form, and a sample input file for the model should be included. Petrotomics should also clarify the annual seepage and recharge rates for the model simulation period and should provide documentation to verify flow into Pit 33 and the increase in baseflow to the Little Medicine Bow River.

6. **COMMENT**: Lack of a current geologic section based on well logs.

**DISCUSSION**: Section 3.3.3.1.2 of the STP requires site-specific and regional information to document the physical and hydrogeologic characteristics of groundwater and surface water systems.

The Petrotomics ACL application includes numerous references to the hydraulic connectivity of various groundwater and surface water sources on and in the immediate vicinity of the site, such as Pit 4 and Pathfinder Pit 33. However, Petrotomics has not provided a detailed geologic cross-section of the site so that the hydrogeologic properties and hydraulic connections can be visualized.

**ACTION NEEDED**: Petrotomics should provide a detailed geologic section that demonstrates any hydraulic connections between groundwater and surface water bodies at the site.

7. **COMMENT:** Inconsistencies in predicted constituent concentrations at the POEs used in risk assessments need to be addressed.

**DISCUSSION:** Section 3.3.3.1.3 of the STP requires a demonstration that measured or predicted constituent concentrations at the POEs will be protective of human health and the environment.

In section 2.2.3.3, Petrotomics performs a statistical analysis to predict constituent concentrations at the POEs based on data from monitoring wells in which the pH is greater than 4 and sulfate concentrations are less than 6,000 mg/l. These predicted constituent concentrations are then used to determine adverse effects to humans, livestock, and wildlife in subsequent risk assessments. The ACL application argues that these predicted POE concentrations will not be

exceeded if pH is greater than 4 and sulfate concentrations do not exceed 6,000 mg/l in the site groundwater. Uncertainties regarding the relationship between pH and sulfate concentrations are discussed in comment 4. The staff is concerned that some of the data used in the statistical analysis are from wells that have not been affected by tailings-derived contamination, and their inclusion in the analysis may not provide a conservative prediction of constituent concentrations at the POEs.

In appendix A, Petrotomics uses the predicted POE constituent concentrations to evaluate risk scenarios that include livestock and wildlife drinking from stock watering tanks and humans consuming the affected animals. In this risk assessment, predicted POE constituent concentrations are based on the 95 percent upper confidence limits ($UCL_{95}$) of the normal distribution for the monitoring well data (table A-3 and table 2-14). The application states that using the $UCL_{95}$ for the normal distribution provides a conservative estimate of predicted constituent concentrations at the POEs.

In response to issue 5 of addendum I to the ACL application, the risk from routine and occasional ingestion of groundwater to humans, livestock, and wildlife is evaluated using predicted POE constituent concentrations. In this risk assessment, the applicant uses predicted POE constituent concentrations that were calculated from the $UCL_{95}$ limits of the arithmetic mean for the monitoring well data (table 9 of addendum I).

Comparison of predicted POE constituent concentrations based on the $UCL_{95}$ of the arithmetic mean and the $UCL_{95}$ for the normal distribution indicates that concentrations based on the $UCL_{95}$ for the normal distribution are more conservative (table 8 of addendum I). For example, the $UCL_{95}$ of radium-226 is 106 pCi/L when based on the arithmetic mean, whereas it is 272 pCi/l when based on the normal distribution. The application provides no justification for using the less conservative concentrations in the risk assessments presented in addendum I. Uncertainties in the method by which health-based constituent concentrations at the POEs are determined (i.e., the pH greater than 4 and sulfate concentration less than 6,000 mg/l relationship) would seem to require that the more conservative predictions (those based on the $UCL_{95}$ for the normal distribution) should be used in all risk assessment evaluations. By using the less conservative predicted values for the $UCL_{95}$ of the arithmetic mean, Petrotomics has not demonstrated that predicted constituent concentrations at the POEs are protective of human health and the environment.

**ACTION NEEDED**: Petrotomics should re-evaluate risk due to routine and occasional ingestion of water from the Upper Sand and Main Sand aquifers using conservative predictions of constituent concentrations at the POEs (i.e., those based on the $UCL_{95}$ on the normal distribution). Petrotomics should also provide a justification for including monitoring data from

wells that have not been affected by site-derived contamination in the statistical analysis for predicting constituent concentrations at POE.

8. **COMMENT:** Documentation of sampling, analysis, and quality control/ quality assurance procedures used in the site monitoring program is required.

   **DISCUSSION:** Section 3.2.3.1.1 of the STP requires documentation of the sampling, analyses, and quality control/quality assurance programs used in the site monitoring program. This information is not included in the application and is necessary to assess the reliability of the site water quality monitoring data.

   **ACTION NEEDED:** Petrotomics should provide documentation of sampling, analysis, and quality control/quality assurance procedures. This documentation should include examples of sample, analysis, and quality control records.

REFERENCES:

NRC, 1996, "Staff Technical Position Alternate Concentration Limits for Title II Uranium Mills - Standard Format and Content Guide and Standard Review Plan for Alternate Concentration Limit Applications."

Harshman, E.N., 1972, "Geology and Uranium Deposits, Shirley Basin Area, Wyoming," U.S. Geological Survey, Professional Paper 745.

Huber, W.A., Dames and Moore, Inc., 1996, "Identification and Evaluation of Background Water Monitoring Data and Proposed Concentration Limits for the Petrotomics Company Tailings Area."

Hydro-Engineering, 1988, "Tailings Water Collection System," prepared for Petrotomics Company, Shirley Basin, WY.

Shepherd Miller, Inc., 1996a, "Petrotomics Tailings Facility Application for Alternate Concentration Limits to Amend Source Material License SUA-551," prepared for Petrotomics Company, Shirley Basin, WY

Shepherd Miller, Inc., 1996b, "Petrotomics Tailings Facility Application for Alternate Concentration Limits Source Material License SUA-551," Addendum I, Acceptance Review Issues 1-5, prepared for Petrotomics Company, Shirley Basin, WY.

Shepherd Miller, Inc., 1996c, "Petrotomics Tailings Facility Application for Alternate Concentration Limits Source Material License SUA-551," Addendum No. 2, Land Transfer Commitment Acceptance Review Issue 6, prepared for Petrotomics Company, Shirley Basin, WY.