March 17, 2026

RADIATION SAFETY PROGRAM

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1. Purpose

This purpose of this Radiation Protection (Safety) Program is to establish minimum safety standards and ensure compliance with regard to the handling and management of radioactive materials, specifically including Technologically Enhanced Naturally Occurring Radioactive Material (TENORM) and to ensure that all reasonable precautions will be taken to protect workers whose work activities may involve exposure to TENORM-impacted material.

This document, therefore, provides guidelines to ensure employees and workers are fully knowledgeable of the correct procedures to be followed for worker protection, while protecting the environment from potential contamination. Through safe work practices, proper containment, effective monitoring/screening, and due diligence managing radiologically-impacted materials can be done safely and in full compliance with applicable radiation control regulations.

Years of measurement and monitoring of dose rates to workers in North Dakota have shown that radiological exposure rates from oil and gas activities assimilate natural background. Nonetheless, White Owl is committed to documenting procedures, training its staff in safe work practices, and providing 3rd party monitoring to ascertain that their employees can come to work in confidence, knowing they are safe. When employees show good discernment and make wise choices by practicing good hygiene, wearing their personal protective equipment (PPE), and following this safety program and all standard operating procedures they can effectively mitigate risk to themselves and others.

2. Scope

The practices outlined in this Radiation Safety Program apply to all White Owl Energy Services (White Owl) employees, contract employees, contractors and other visiting personnel on White Owl's licensed premises and worksites.

This Radiation Safety Program was developed in support of compliance objectives found in Section 23.1-03-01 through Section 23.1-03-15 of Chapter 23.1-03 of the North Dakota Century Code, and 33.1-10 of the North Dakota Administrative Code. North Dakota has established Radiological Health Rules and licensing and compliance is managed by designated personnel within the North Dakota Department of Environmental Quality. The Radiological Health Rules set minimum standards for radioactive materials management including the following key elements:

- Management control over work practices including supervisory requirements to ensure radiation safety procedures are developed and implemented;
- Personnel qualifications and training;
- Control of occupational and public exposure to radiation;
- External gamma radiation monitoring and protection;
- Contamination monitoring and control;
- Environmental controls; and
- Waste management controls.

In conjunction with these objectives, the Radiation Safety Program (RSP) outlines the appropriate recordkeeping requirements of the above elements as follows:

- Dose Assessments;
- Training records;
- Screening, contamination and radiation surveys;
- Environmental monitoring; and
- Waste management tracking, transport and manifest documentation.

3. Administration

White Owl's management team administers the Radiation Safety Program to ensure:

- Radiation surveys are prioritized and conducted as required to identify potential radiation management issues.
- The company's Standard Operating Procedures (SOPs) for the management of radioactive materials are implemented.
- The Radiation Safety Program is implemented in each operating area where radioactive materials may be present through effective screening procedures and protocol.
- All personnel (employees or subcontractors) who work in TENORM storage or offload areas or who may potentially be exposed to incremental dose from low-level radioactive material understand White Owl's requirements and have received training in radiation safety and protection commensurate with their potential exposure and job function.
- Any support resources required are identified in each area to oversee and control all radiation safety and radioactive material waste management requirements. This support team may consist of trained and experienced employees and/or a network of contractors who specialize in radioactive materials management on an as needed basis. White Owl will leverage a properly trained and qualified Radiation Safety Officer (RSO) to manage its radiation safety program. Its own management team will also support the RSO and implementation of the safety and compliance program.
- Policies and requirements are implemented to maintain the lowest levels of employee exposure possible in support of ALARA (As Low As Reasonably Achievable) objectives.
- Updates to the Radiation Safety Program are completed and implemented as required.
- Audits of the Radiation Safety Program will be performed annually by the RSO.

Organization Structure

The processing facility's organizational structure is designed to maximize accountability and efficiency through clear functional and reporting responsibilities combined with each persons' unique skills and giftedness.

The chain of command is as follows for day-to-day operations:

VP of Engineering/General Manager of North Dakota
Facility Manager
Operators (TENORM/Rad Technicians)
Administrative Staff

Additional support is provided by other key personnel including:

RSO
HSE/Waste Manager

RSO Responsibilities

The RSO is responsible for the development and maintenance of the radiation safety program and SOPs, radioactive materials license compliance, regulatory affairs, radiation safety training and refresher programs, and the dosimetry program. The RSO has the authority to stop work at any time if an unsafe situation occurs or the RSO has reason to believe an unsafe situation may occur.

U.S. General Manager Responsibilities

The U.S. General Manager is responsible for achieving company objectives while running safe and compliant operations at all facilities in the United States. The U.S. General Manager explicitly supports the RSO by ensuring the RSO has the authority from the entire management team to fulfill all compliance and safety objectives related to radiation safety and compliance with the company's radioactive materials license.

Facility Manager Responsibilities

The Facility Manager is responsible for implementation of this Radiation Safety Program and SOPs at the facility they manage. This includes ensuring the proper, consistent use of personal

protective equipment, and proper survey technique and documentation. The facility ensures that all new operators have received 8-hour TENORM Surveyor training and that Refresher is conducted annually. Naturally, the Facility Manager has the authority to stop work at any time if an unsafe situation is anticipated or already exists. They participate in any safety meetings or procedural changes impacting their facility.

Lead Operator Responsibilities

The Lead Operator fully supports the Facility Manager in observing daily on-site activities and is responsible for making sure Operators are wearing PPE, following all SOPs, safety protocol (including but not limited to this RSP), and reinforcing good survey techniques and documentation. The Lead Operator has stop work authority and reinforces to his team that they also have stop work authority any time an unsafe situation is anticipated or already exists.

Operator Responsibilities

Operators fully support the Facility Manager and Lead Operator by always wearing PPE, practicing good hygiene, following all SOPs, safety protocol (including but not limited to this RSP), and practicing good survey techniques and documentation. Operators have stop work authority time an unsafe situation is anticipated or already exists.

4. Training

Training and awareness are a major part of a radiation safety program. All new processing facility employees will receive a safety orientation immediately upon reporting for duty their first day, which will include TENORM Awareness. All employees who will be in contact with or will be surveying waste must take and pass White Owl Energy Services' designated 8-hour TENORM Surveyor training within 90 days of being hired. Refresher training must be attended annually. All training records will be documented and retained by the RSO for at least 3 years. Based on the individual's job title below the core knowledge requirements and training for personnel includes the following:

Operators (TENORM Technicians)

Workers need to be provided TENORM training, which includes the following topics:

- Waste streams and equipment which may contain TENORM
- Hazards of radiation and the necessary controls to mitigate
- The risks associated with radiation to which the worker may be exposed in the course of his or her work
- Comparisons of other radiation sources personnel are exposed to everyday;
- Safe work procedures including selection of Personal Protective Equipment (job-specific as appropriate), radioactive contamination control zones, and personnel decontamination procedures
- Emergency Response
- Radiation fundamentals
- Survey instruments and documentation
- TENORM regulatory requirements including the applicable radiation dose limits for incidentally and occupationally exposed workers
- Sampling operations
- Air sampling
- Types of laboratory analysis
- Area posting and signage requirements
- Radiation monitoring procedures (before working with TENORM-impacted equipment or waste including managing control areas and fixed and removable contamination surveys)
- ALARA and instruction on dose mitigation
- A practical session involving the actual surveys for TENORM

Radiation Safety Officers (RSO)

All TENORM Technician training above **plus** the following:

- Waste management handling and storage procedures
- Surveying plans and schedules
- Record keeping requirements including documentation of dose exposure levels
- Posting and labeling of TENORM and radioactive materials
- Shipping and transportation of radioactive materials
- Dosimetry and Total Effective Dose Equivalents
- Disposal options and management of TENORM-impacted waste and equipment
- Liability minimization
- Formal RSO training and certification that includes:
  - Workplace inspections and audits
  - Biological and health effects of radiation exposure
  - Radiation detection, instrumentation and calibration
  - Transport of radioactive materials
  - Regulatory agencies and standard-setting organizations
  - Licensing of TENORM and other devices with radiation
  - E & P exemption
  - Proper use of a Geiger-Mueller probe vs. a scintillator, depending on waste stream and circumstances
- Detailed knowledge and practical abilities necessary to implement and monitor a Radiation Safety Program
- A complete understanding of all applicable federal, state, local, and company regulatory requirements
- Extensive practical experience with TENORM surveying, worker radiation protection and risk communication.

5. TENORM Formation

Technologically Enhanced Naturally Occurring Radioactive Material (TENORM) has been recognized as a potential hazard in industries that produce our natural resources. These include oil and gas, mining, refractory brick and ceramics manufacture, fertilizer, water treatment, and power generation industries.

The origin of TENORM in the oil and gas industry is primarily through the concentration of Radium (Ra-226 or Ra-228) associated with produced water production and Lead (Pb-210) associated with natural gas production. These radionuclides are daughters of uranium and thorium which are incorporated in the Earth's crust and form part of the earth's natural background radiation.

Generally, NORM (naturally occurring radioactive materials) exist in low concentrations in rock formations and pose little radiological concern. However, as part of industrial activities such as oil and gas production, NORM can be transported to surface and concentrated to levels that may pose a hazard to human health and the environment (TENORM). For example, barium or calcium scale precipitated from oil recovery brine may concentrate radium at much greater concentrations than the original produced water source itself.

While there is potential to exceed allowable external radiation doses as a result of larger accumulated volumes and concentration of TENORM, in most cases, the radiological concern to workers is from the inhalation or ingestion of TENORM materials.

TENORM hazards are easily mitigated and controlled by implementing safe work procedures. As a result, special precautions are needed for handling, storing, transporting, and disposal of material, by-products, end-products or process equipment containing TENORM.

6. Radiation Hazards

Two types of radiation hazards may be encountered: external hazards and internal hazards. The difference is whether the hazard is outside the body (an external hazard) or inside the body as the result of inhalation or ingestion of radioactive material (an internal hazard).

6.1 External Radiation Hazard

External radiation exposure occurs when personnel are exposed to ionizing radiation from sources outside the body. Typically, external TENORM radiation hazards in the oil and gas industry are extremely low. External radiation doses can be maintained ALARA by applying the radiation control principles of time, distance and shielding.

Operations will be conducted so that individual members of the public and incidental workers will not exceed 100 mrem annually. White Owl employees will be monitored for external radiation dose by use of dosimetry.

6.2 Internal Radiation Hazard

Internal radiation exposure occurs when TENORM gets into the body, and could be a far greater concern than external radiation exposure. Some radioactivity may not be eliminated from the body for several decades and a very large cumulative dose could theoretically build up as a result.

Internal contamination is prevented by avoiding the inhalation or ingestion of radioactive materials.

- Inhalation is a common route of entry. All feasible measures must be taken to prevent radioactive particles from becoming airborne and to maintain internal doses ALARA. Industrial operations, such as welding, grinding or cutting can create an inhalation hazard. Accordingly, White Owl requires this work to be outsourced to a licensed radioactive materials contractor. Engineering controls such as using water to prevent materials becoming airborne, using engineered ventilation controls, good hygiene and housekeeping, and closure of emission points are all potentially useful in mitigating exposure risks. If the dust cannot be controlled through these measures, the licensed radioactive materials contractor will use respiratory protection.

- Ingestion of TENORM may occur when contaminants are deposited on personnel, clothing, PPE, or equipment and then transferred into the body. Engineering and administrative controls shall be implemented to maintain internal ingestion ALARA. See Section 8.1 for personal protective equipment and other risk mitigation guidance.

6.3 Summation of External and Internal Doses

Compliance with the dose limits can be demonstrated by summing external and internal doses. The RSO may, at his discretion, pursue measuring the Total Effective Dose Equivalent (TEDE). This would involve the measurement of:

1. *Intake by inhalation*. If the only intake of radionuclides is by inhalation, the total effective dose equivalent limit is not exceeded if the sum of the deep-dose equivalent divided by the total effective dose equivalent limit, and one of the following, does not exceed unity:
    a. The sum of the fractions of the inhalation ALI for each radionuclide, or
    b. The total number of derived air concentration-hours (DAC-hours) for all radionuclides divided by 2,000, or
    c. The sum of the calculated committed effective dose equivalents to all significantly irradiated[1] organs or tissues (T) calculated from bioassay data using appropriate biological models and expressed as a fraction of the annual limit.
2. *Intake by oral ingestion*. If the occupationally exposed individual also receives an intake of radionuclides by oral ingestion greater than 10 percent of the applicable oral ALI, the licensee shall account for this intake and include it in demonstrating compliance with the limits.
3. *Intake through wounds or absorption through skin*. The licensee shall evaluate and, to the extent practical, account for intakes through wounds or skin absorption.

(Note: The dose equivalents for the lens of the eye, the skin, and the extremities are not included in the summation, but are subject to separate limits.)

7. Worker Protection & Exposure Control

7.1 ALARA Principle

The basic philosophy of worker protection from all radioactive materials, including NORM/ TENORM, is to maintain all exposures ALARA. In other words, if it is practical to avoid unnecessary exposures (above natural background levels), that is the preferred objective.

In addition to the principle of ALARA, maximum TENORM exposure or dose limits to workers and members of the public have been developed as outlined in section 7.2. The maximum allowable dose limit for members of the public and incidentally exposed workers is 100 mrem TEDE.

7.2 Radiation Exposure Limits

Doses to members of the public and workers must be estimated by conducting a radiation survey of the work place/worksite or by dosimetry. The radiation surveys should include evaluations of both gamma dose rates and airborne radioactivity if required. Occupationally exposed workers or "radiation workers," are considered to be those who regularly work in an environment with work-related radiation exposures. Properly trained radiation workers may receive doses in excess of 100 mrem/yr though staying below this dose rate is the objective defined by White Owl.

North Dakota Radiological Health Rules and White Owl's Radioactive Materials License requires monitoring and development and implementation of a Radiation Control Plan if workers are potentially subject to elevated radiation levels. Estimates of the effective dose to workers and the public must consider the following exposure pathways:

- External exposure.
- Ingestion of TENORM-containing materials.
- Inhalation of TENORM-containing dust.
- Inhalation of radon gas and its radioactive decay products.

Table 1 outlines radiation exposure limits for different types of workers and the public. These limits are in addition to natural background exposures and include both internal exposures and external exposure pathways.

Incidentally exposed workers are employees whose regular duties do *not* include exposure to TENORM sources of radiation. They are considered members of the public who work in an occupational exposure environment.

The occupational dose to individual adults shall be controlled to the following dose limits:

i. An annual limit, which is the more limiting of:

(1) The total effective dose equivalent being equal to 5 rem; or
(2) The sum of the deep dose equivalent and the committed dose equivalent to any individual organ or tissue other than the lens of the eye being equal to 50 rem.

ii. The annual limits to the lens of the eye, the skin, and extremities are:

(1) A lens dose equivalent of 15 rem;
(2) A shallow dose equivalent of 50 rem to the skin or to any extremity.

The dose equivalent to an embryo/fetus during the entire pregnancy, due to the occupational exposure of a declared pregnant woman, shall be monitored and will not exceed 0.5 rem (5 mSv).

The annual occupational dose limits for minors are 10 percent of the annual occupational dose limits specified for adult workers.

Table 1 Radiation Dose Limits

Affected Group	*Annual Limit*
Occupationally TEDE Limits for Adults	5 rem (50 mSv)
Incidentally Exposed Workers & General Public	100 mrem (1 mSv)

7.3 Derived Working Limits (DWLs)

Derived Working Limits (DWLs) have been determined from the annual radiation dose limits to assist in dose assessments. The DWLs provide an estimate of dose that can be directly measured in the workplace. Table 2 outlines the incremental gamma radiation dose rate in the workplace for each classification group and the steps required to maintain a high level of health and safety for workers and the public.

Table 2 Derived Working Limits – Gamma Dose Rate Thresholds

TENORM CLASSIFICATION	*THRESHOLD DOSE mrem/a*	*DERIVED WORKING LIMIT - (above background)*	*THRESHOLD REQUIREMENTS*
Normal Operations*	≤ 100 mrem/a	≤ 50 µrem/hr for 2,000 exposure hours per annum	- Public and worker access unrestricted. - Workers follow TENORM safe work guidance in Section 8.1 - Workers follow TENORM waste handling, shipping and material management procedures.
TENORM Management Threshold	> 100 mrem/a to 2000 mrem/a	> 50 µrem/hr for 2,000 exposure hours per annum	- Public access and incidentally exposed worker access restricted. - Workers follow TENORM safe work guidance in Section 8.1. - Workers follow TENORM waste handling, shipping and management procedures. - Report levels to employee and look for reasonable mitigation measures to further limit dose and maintain ALARA.
Radiation Protection Management Threshold	> 2000 mrem/a	> 2500 µrem/hr for 2,000 exposure hours per annum	- Public access and incidentally exposed worker access restricted. - Workers follow TENORM safe work guidance in Section 8.1. - Workers follow TENORM waste handling, shipping and management procedures. - Report levels to employee and look for reasonable mitigation measures to further limit dose and maintain ALARA. - Ensure workers do not exceed a five-year average occupational effective dose of 2000 mrem/a

Investigative threshold when DWL reaches 50 µrem/hr based on monthly surveys.

7.4 Action Levels

To ensure that the public and incidentally exposed workers do not exceed the targeted annual dose threshold of 100 mrem, an action level of 25 mrem/quarter has been established.

If a dosimeter exceeds 25 mrem/quarter, the following action items may be taken by the RSO:

a. the employee will be interviewed by the RSO to investigate further to see if any sources or explanations are readily available; and
b. if protocol for wearing or storing the dosimeter has not been followed by the employee, the employee will be coached (again) on the appropriate wearing and storage of their dosimeter;
c. the employee's immediate supervisor will be notified to assist in supervision of the employee with regard to the wearing and storage of the dosimeter. Additional attention will be paid to their assigned work activities and their work schedule.
d. Radiological surveys may be performed of the area at the RSO's discretion to see if elevated levels (or existing survey data from the quarter) may offer additional insight and help narrow the cause; and
e. time/motion studies may be performed at the discretion of the RSO.
f. Findings, corrective actions, and any changes in protocol will be documented anytime an investigation is warranted, including dating of documents and write-up along with any supporting documents (e.g., new SOPs, performance improvement plans, new policies, etc.). All investigative reports and documents created to memorialize the investigation, findings, and outcomes will be retained for a minimum of 3 years in TENORM license compliance folders for record retention purposes, as well as review and inspection by ND DEQ regulators.

Subject to RSO discretion and good judgment, items #d and #e above may not be required at the first occurrence of an exceedance by a single employee. If there is an exceedance for the same employee in the following quarter, additional investigative activities should be taken as well as performance of the last two action items above (#d and #e). Finally, if exceedances continue, the RSO and management will meet to make a determination on potential additional action items, which may things such as altering work activities, cleaning out high-level tank bottoms, isolating or moving or disposing of any material(s) that are contributing to incremental dose,

Members of the public (non-workers), including truck drivers, will not be allowed in controlled areas of the facility where contamination or significant exposure to higher levels of TENORM may be present.

7.5 Equipment Maintenance

Workers may be directly be exposed to TENORM-impacted material in tanks (when confined space entry is required), pigs, impacted pipe, filter socks and filter pods, and heavy equipment, all of which may become impacted (contaminated) with TENORM. Accordingly, workers should check with the RSO if they have questions about safe work practices, PPE, additional screening criteria, sampling requirements, or compliance implications. The RSO may also consult with a health physicist with questions or additional means of dose monitoring where TENORM impact and worker safety is concerned.

8. Worker Dose Mitigation

The mechanisms for worker dose commitment are via external gamma radiation, inhalation of radioactive dust during work activities, and, to a lesser extent, inadvertent ingestion of TENORM. The following procedures will be implemented to mitigate worker exposure levels.

- To the extent practical, process or other engineering controls, such as, containment, decontamination or ventilation will be used to control the concentrations of radioactive material in air.
- When it is not practicable to apply process or other engineering controls to control the concentrations of radioactive material in air to values below those that define an airborne radioactivity area, a control area must be created in the immediate area where work on TENORM contaminated materials is performed. Signs shall be erected around the perimeter of the contaminated work area to notify personnel of the TENORM hazard and to restrict access to unauthorized personnel.
- All personnel who may come into contact with TENORM contamination must wear appropriate PPE and be advised of the hazards associated with the TENORM contaminated materials.
- Seal open ends of pipes or equipment with plastic, welded plates, or, at a minimum, duct tape, to prevent undue spreading of TENORM.
- Where possible, keep material damp, but not wet, to prevent dust generation while minimizing the volume of contaminated wastewater.

- Contaminated gloves, respirators, coveralls, boots, cleaning rags and tools shall have surface contamination surveys conducted and shall be decontaminated as necessary prior to disposal. If decontamination on site is not possible, the material must be sealed, labeled, and sent to a licensed decontamination facility. All contaminated equipment or material must be properly contained and sealed for storage or disposal.
- TENORM contaminated waste shall be placed in storage bins that are suitable to contain all TENORM waste such metal waste boxes, filter bins or heavy gauge polyurethane hazmat drums. All containers should be placed in a suitable monitored and secure TENORM storage area. The container shall be tagged with TENORM warning labels, contents, origin, date, dose rates and activity levels if possible.
- Eating, drinking, chewing, and smoking are not permitted in TENORM contaminated areas.
- All personnel shall observe good personal hygiene practices, washing their face and hands to prevent any possible ingestion of TENORM contaminated material. Any personnel coming into direct contact with TENORM contamination should be surveyed (frisked out) prior to leaving the TENORM controlled work area.

8.1 Personal Protective Equipment

During routine operations where TENORM-impacted material may be present and direct contact is possible, safety glasses and disposable gloves must be worn in addition to the normal requirement for fire-resistant (FR) clothing and steel-toed boots. It is recommended that workers survey/frisk their boots (and any soiled FRs) for contamination prior to leaving the facility. If contamination is found, they should return to the offload pad to have their boots sprayed off/decontaminated. Boots should then be resurveyed to verify that contamination has been removed.

As a last resort, when the first 4 control measures cannot be implemented to control dust or other emissions as outlined in Section 7.5, a properly fit-tested respirator must be worn to mitigate the risks associated with inhalation of TENORM-impacted dust or other airborne particulate.

TENORM concentrations can present both an external and internal exposure hazard. Due to the type of ionizing radiation involved with Oil and Gas production TENORM, inhalation is the primary pathway of any exposure concerns.

Generally, filter cake and sludges are moist and do not pose an immediate inhalation risk. If there is the potential for airborne contamination and inhalation, respirators equipped with cartridges approved for radionuclide dust must be worn. A high protection factor can only be obtained if there is an effective respirator selection, service and fitting program.

If hazards exist that required fitted face masks or confined space entry, White Owl policy requires outsourcing this work to compliant contractors with complete respiratory protection programs.

Wear protective boots, gloves and coveralls to minimize contact with TENORM contaminated material or equipment. Whenever possible use easily washable or disposable PPE such as Tyvek if significant direct contact with TENORM-impacted material is anticipated. However, be aware of heat stress and other safety considerations when using Tyvek. These other risk factors may be higher on a risk hierarchy than TENORM!

Modifications to the PPE requirements may be made by the RSO or another safety person depending on local circumstances and conditions. Typically, the determination to increase the amount of protection is determined by safety personnel or management. However, a decision to reduce PPE level requirements, proper survey documentation and environmental conditions must be justified. For example, if the material being excavated is found to be wet and poses no airborne hazard, the requirement for respirators may be waived.

For some work, the RSO (or their designee) may determine that a TENORM Technician be available to assist with the proper donning and doffing of PPE, provide radiation and contamination monitoring, and free release surveys.

8.2 Contamination Control Areas

Of primary importance in the prevention and spread of contamination is the identification and maintenance of defined and secure work areas. Work involving the handling of TENORM shall be confined to these designated areas, which include the offload pad, the solids pad, temporary storage bins, the tank battery, the pump house/filter cartridge area and the approved filter disposal bin. These controlled areas will be delineated and access to and egress from the areas will be carefully monitored and controlled.

The RSO and all White Owl staff will ensure unauthorized access to these areas is prevented and must be diligent to control traffic by means of prescribed access points. Management must also make sure all employees working in contamination control areas have received appropriate instructions about the nature of any radiation hazards in the area.

Impacted equipment within the contamination control area must be washed and/or wiped down or otherwise decontaminated prior to removal from the designated TENORM work area. Equipment will be surveyed by a trained TENORM Technician and the survey documented (and copy of the survey retained) to ensure that there is no TENORM radioactivity greater than two times (2x) local background. If equipment is being sold or transferred to an unlicensed entity for repairs or maintenance, the survey will be reviewed and approved by the RSO and the DEQ prior to releasing it to another party.

If the disposable PPE is found to have contamination, placed it in the designated, labeled filter sock/cartridge bin or suitable containment device for decontamination or TENORM waste disposal. The TENORM rules require the container not be leaking, be properly labeled, and only transported by a TENORM transporter.

Records of the results of the radiation and contamination monitoring of contamination control areas shall be kept by the Facility Manager and/or the RSO.

8.3 Personal Hygiene

Good housekeeping and good personal hygiene are basic expectations of all employees. Eating, drinking, or smoking in TENORM work areas where contamination may be present is not allowed.

Implementation of good work practices (such as washing hands and face when exiting work areas and before eating and drinking) will eliminate the ingestion pathway.

Where direct contact with TENORM-impacted material has occurred, the following procedure may be used for decontamination of skin. Continue with each step of the procedure until no contamination is detected:

- Monitor skin carefully to determine contamination level and location;
- Wash with tepid soap and water. Leave soap lather on for two to three minutes before rinsing (waterless hand cleaner has proved to be extremely effective at removing loose contamination from the skin);
- Re-monitor; do not use harsh cleansers or abrasive techniques for washing.
- Wash skin with a mild detergent. Scrub carefully with a soft bristly brush, soap, and water. Stop if skin reddens. Re-monitor.
- If contamination persists, consult the RSO immediately.
- The removed material (along with any wash water) will be placed into a container and will be labeled, inventoried and deposited into the onsite TENORM waste storage area.
- The normal PPE required during active cleanup work will include disposable clothing such as Tyvek® suits and gloves. Disposable clothing will be removed prior to leaving designated TENORM work areas and bagged for disposal in the closest onsite waste storage area.

8.4 Dosimetry Requirements

Employees working at the processing facility who may be exposed to TENORM will be assigned their own dosimeter, which must be worn while on-duty at the facility. A NVLAP-approved dosimetry service will be used to measure personnel radiation doses for all facility staff and management. Quarterly evaluation of each badge and dose will be performed by the RSO to ensure safety, noting and investigating as necessary any significant variations. The RSO may, at his discretion, also place dosimeters in any area(s) of the facility that has the potential for high levels of radioactivity and/or in areas with longer occupancy periods or potential dose to visitors.

Badges will be collected at the end of each calendar quarter and sent to the vendor to be "read." After review of the dosimetry results each quarter, the RSO will initial and date each report; then file the reports in a permanent file.

Each quarter, the dosimeters will be replaced with new units and any unused dosimeters will be returned by the RSO to the licensed dosimetry company for measurement.

A lost or missing dosimeter is to be reported immediately to the RSO and a replacement will be provided as quickly as possible.

The RSO investigate within 30 days of the receipt of a quarterly dosimetry report the cause of any exposure that is anomalous or which exceeds the applicable derived working limit. If warranted, the RSO will take corrective actions to ensure that unnecessary exposures are halted and recurrence is prevented. A report of each investigation and the actions taken, if any, will be recorded and maintained for inspection purposes.

If a derived working limit (shown in Table 2) is exceeded, the RSO will:

- conduct an investigation to establish the cause for reaching the action level;
- identify and take action to restore the effectiveness of the implemented radiation protection program; and
- notify senior management.

If appropriate, an ALARA review will be performed.

If a regulatory dose limit is exceeded on any personnel dosimeter, the following will be performed:

- conduct an investigation to determine the magnitude of the dose and to establish the causes of the exposure;
- identify and take any action required to prevent the occurrence of a similar incident; and
- immediately report the results of the investigation to senior management.

8.5 Declaration of Pregnancy and Notification to Female Worker

At the time of their initial TENORM Surveyor training, every female worker at the licensed facility will be informed in writing, of:

- The risks associated with the exposure of embryos/unborn babies to radiation and the risks to breast fed infants from the intake of radioactive substances/material;
- The importance of informing the licensee, as soon as feasible and in writing, that the female worker is pregnant or breastfeeding;
- The rights of a pregnant worker and the rights of a breastfeeding worker; and
- The applicable effective dose regulatory dose limits for pregnant workers.

This notification will be documented via Appendix C, Notification to Female Workers. A copy of this written acknowledgement from each female worker will be kept in the records by the RSO.

Should a female worker inform the RSO in writing of a pregnancy (see Appendix D), her work will be assessed by the RSO. Should her work require her to work near radioactive material, a fetal dosimeter will be issued, and her radiation dose will be restricted to an effective dose of 500 mrem for the balance of the pregnancy, as measured by her dosimetry. If necessary and justified (as assessed by the RSO in consultation with the worker), the worker's job may be modified to minimize her radiation exposure for the duration of the pregnancy.

Similarly, should a female worker inform the RSO in writing that she is breastfeeding an infant, her work will be assessed by the RSO. If necessary and justified (as assessed by the RSO in consultation with the worker), the worker's job may be modified to minimize her risk of intake of radioactive material for the duration of the breastfeeding. Modification of a worker's duties due to breastfeeding is not expected to be required, as the intake of any radioactive material is highly unlikely.

9. Radiation Monitoring Equipment

Gamma survey meters, typically NaI scintillation types, will be used for monitoring gamma radiation fields. The exact type and make will be determined by the Radiation Safety Officer (RSO) prior to the commencement of any TENORM work and the personnel using the instrumentation will be provided appropriate training. At least two survey meters will be maintained at any licensed facility.

All instruments must be calibrated annually according to the manufacturer's specification. A battery check and source check shall be performed each morning. Source check readings will be documented in *u*R/hr.

Note: Use of an intrinsically safe survey meter is recommended, but not required.

10. TENORM Surveys

10.1 TENORM Survey Requirements

Only personnel who are adequately trained in the hazards of TENORM and use of radiation monitoring equipment may conduct surveys for TENORM. Poor survey techniques and/or improper training or familiarity with detection equipment may lead to improper waste management, safety issues, and/or the spread of contamination.

The testing equipment must be a radiation survey meter capable of operating in either rate meter or scalar mode with the ability to accurately measure gamma radiation dose rates in micro-Roentgen per hour (µR/hr) or equivalent and contamination levels in counts per minute (CPM). The survey meter should have both a gamma scintillation probe and pancake (Geiger-Mueller) contamination probe.

Survey equipment must be calibrated annually according to the manufacturer's specifications. A copy of the current calibration documentation must be kept with the equipment.

In addition to verifying the equipment's regular calibration, the survey meter must be checked against a known source, verified to be in good operating condition, and have sufficient battery life before each survey to ensure the equipment is in proper working order.

All survey data should be recorded. Background levels have to be determined before each survey. Background measurements should be performed away from any potential sources or impacted material. If monitoring results are inconsistent with normal background levels at the facility, take additional background readings further away from any potential sources and/or potential shielding agents. Readings may be averaged if multiple readings are taken. If observed levels are still not consistent with anticipated levels, the backup instrument should be employed to check all readings. The RSO should be contacted if any unusual readings or equipment malfunctions are observed.

10.2 TENORM Gamma Radiation Surveys

Monitoring equipment that can detect gamma radiation must be used and the results should be recorded as a dose rate in µR/hr.

Dose rate measurements taken on the outside surfaces of suspect equipment shall be managed as potentially TENORM contaminated if the dose rate exceeds 2x background radiation levels.

Dose rate measurements should be taken within ½ inch (1 cm) of the subject equipment surface at locations where TENORM scale or sludge are suspected to build up. Consideration should be given to equipment wall thickness and the distance of the survey meter from the suspected TENORM contamination.

All inbound and outbound loads must be surveyed and documented. Monthly off-pad surveys and tank and bin inspection forms shall also be performed by staff and approved by the facility manager or lead operator. Roadways into the facility will be surveyed quarterly. If a spill occurs anywhere at the facility, the RSO will be immediately notified and, minimally, radiological surveys will be conducted and documented to verify the absence of TENORM contamination. ***All survey and inspection forms shall be forwarded to the RSO for review and recordkeeping.***

10.3 TENORM Contamination Surveys

Documented surveys will be performed utilizing a NaI probe (recorded in *u*R/hr) for free release of any heavy equipment or processing plant components. Free release criterion of 2x background will be used. All free release surveys must be forwarded to the RSO who will review and approve free release surveys before equipment may be released/transferred. Survey documents must be retained for inspection by the NDDEQ.

11. Regulatory

This practice is subject to the following regulatory requirements:

11.1 Federal

Wastes containing naturally occurring radioactive materials (TENORM) are generally not regulated by federal agencies. However, one area in which TENORM-containing wastes are regulated at the federal level is transportation.

TENORM-containing wastes that have a specific activity greater than 270 pCi/g are subject to the U.S. Department of Transportation (DOT) regulations governing transport of radioactive materials. These regulations are contained in the Code of Federal Regulations, Title 49, Chapter 1, Part 173, Subpart I, "Class 7 (Radioactive) Materials," § 173.401 - 173.476.

In addition, TENORM management activities may be subject to regulations promulgated by the Occupational Safety & Health Administration (OSHA).

11.1.1 North Dakota

TENORM-Specific Regulations:
Subject to the state's TENORM rules and regulations as outlined in the North Dakota Administrative Code, Chapter 33.1-10-23, "Regulation and Licensing of Technologically Enhanced Naturally Occurring Radioactive Material" as well as rules in Article 33.1-20, "Solid Waste and Land Protection."

12. TENORM Waste Management

The management of TENORM wastes encompasses all aspects of initial characterization, handling, storage, transportation, processing, treatment, and disposal practices from the point of generation to the final disposition.

This practice provides recommendations based on the radiological properties of TENORM. In determining an acceptable material management option, other hazardous properties such as chemical toxicity must be considered. In some cases, the non-radiological hazardous properties of TENORM materials are the critical selection criteria for the preferred TENORM material management option.

This practice outlines Unconditional Derived Release Limits (UDRL) for discrete TENORM wastes. All TENORM impacted materials at or above UDRL limits must be stored in a designated and signed TENORM storage area in appropriate containers until the TENORM Supervisor arranges for transfer to a licensed disposal site.

12.1 Diffuse TENORM Sources

Table 3 – Unconditional Derived Release Limits (UDRL's) Diffuse TENORM Sources

TENORM RADIONUCLIDES	*SOLID*
North Dakota (combined Ra-226 and -228)	5.0 pCi/g

12.2 Discrete TENORM Sources

Limits for surface contamination on equipment, tools and scrap surfaces intended for unconditional release are listed in Table 4. These limits are applicable to fixed surface contamination. Loose surface contamination must be completely removed or all accessible surfaces cleaned prior to release to levels less than 1,000 dpm/100 cm^2. This work is beyond the scope and capabilities of White Owl and, if required, would be performed by a licensed 3rd party radioactive materials contractor.

Table 4 – Unconditional Derived Release Limits (UDRL's) Discrete TENORM Sources

Property	*Limit*
Dose Rate (metal recycling)	2x background
Fixed Surface Contamination	22.43 pCi/cm^2 averaged over a 100 cm^2

Labeling of TENORM Impacted Equipment

All equipment identified as TENORM contaminated by testing for TENORM on the equipment's outside surfaces, shall be tagged or labeled as:

Caution: "Technologically Enhanced Naturally Occurring Radioactive Material" or Caution: TENORM"

Special precautions are required before the equipment is opened for repair, maintenance or inspection. Contact the RSO or Facility Manager prior to initiating work on equipment labeled as TENORM.

12.3 Storage of TENORM Impacted Materials

Outdoor storage areas should have appropriate security fencing or other barricades such as concrete barriers or walls, positioned such that the annual exposure to members of the public does not exceed 25 mrem/a at the perimeter. Access to the storage area should be restricted and work practices established so that the annual exposure to incidentally exposed workers does not exceed 100 mrem/a. In addition, TENORM impacted materials must be stored under the following requirements:

- Containers and equipment in storage containing TENORM shall be stored in a fenced, signed, monitored and secure area with limited access.
- TENORM materials should be stored on a controlled concrete pad or in an approved, leak-proof container (with appropriate signage affixed).
- Provisions must be in place for secondary containment (e.g., an impervious barrier or liner) where liquid TENORM wastes are being stored.
- Wherever possible, materials with higher radiation levels should be stored near the center of the area to reduce radiation levels at the storage area perimeter. The facility may also isolate higher level material in shale bins off the pad and removed from the core operating areas.
- Containers and equipment containing TENORM material must be recorded and secured against unauthorized removal from the storage area.
- An accurate inventory of materials must be maintained including originating location, date, activity levels and package contents, including measurement in tons, yards, or barrels. Inventories must be conducted and documented on a ticket for each inbound load received at the licensed facility. Dose levels within the storage area must be recorded monthly and inspections shall be performed to identify leaking or corroded containers, which must be immediately repacked or sealed.
- Outbound loads will be properly manifested on an NRC-540 form (if activity levels exceed 270 pCi/g) or put on a Bill of Lading (BOL), both with compliant certification language per ND regulations.
- TENORM contaminated PPE, rags, etc. should be placed into a filter sock/cartridge disposal bin.
- Personnel who enter TENORM storage areas shall be informed of the presence of radioactive materials, the safety hazards associated with the material and the methods of controlling exposures.

- The boundary and all entrances to TENORM storage areas shall be identified with a sign with the words “CAUTION, TENORM STORAGE AREA”.
- If the storage area has a dose rate of greater than 2,000 µR/hr must contact their supervisor for a review of the area.
- Any containerized waste records shall document at least the following information:
    - Generator information – location, address and contact.
    - Container identification code.
    - The storage location.
    - Type of material in storage (scale, sludge, PPE, etc.).
    - The date the material entered storage.
    - The original location of material or equipment and type of service.
    - Measurement data that reflects the radioactivity of each container (gamma dose in µR/hour and activity in pCi/g.

12.4 Sampling Procedures

The purpose of this sampling procedure is to provide a safe and documented standard for preparing and shipping of TENORM samples for laboratory analysis. Proper personal protective equipment (PPE) should be used while taking samples to prevent inhalation or ingestion of TENORM contaminated materials. Specifically, the employee should be wearing safety glasses, FR clothing, steel-toed boots, and disposable gloves. Additional PPE may be dictated by the RSO or EHS manager as circumstances or conditions dictate.

A TENORM survey meter is essential at the time of sampling in order to take a representative TENORM sample and to record the external radiation dose levels of the sample for shipping and laboratory purposes. A composite sample may be required if the waste stream is not homogeneous. All samples of waste materials taken for analysis must be sampled prior to adding any drying agents for any material that would stay in-state.

In general, TENORM sampling should be conducted in conjunction with a TENORM survey conducted by qualified personnel. This will ensure that subsequent laboratory analysis is meaningful and will provide the most value in regards to having an integrated approach for handling any potential TENORM contamination problems. Currently, composite samples are required to be taken every six loads (200 tons) for any impacted materials (</= 50 pCi/g) that will be disposed of at Oaks Disposal in Lindsay, MT. Any residuals or waste in excess of 50

pCi/g will require analytical to establish a waste profile and waste acceptance at facilities such as Republic's Grand View, ID or Clean Harbors' Deer Trail, CO landfills). These facilities currently accept waste at concentrations > 50 pCi/g. These facilities may only require new analytical for conforming waste annually, provided that processes and concentration levels remain static. Note: Waste acceptance criteria may change from time to time. Consult the RSO for additional guidance on waste disposal options.

- TENORM samples must be put into strong plastic containers (i.e., Nalgene Sample Bottles) with screw-on lids. The lids should be sealed shut with duct tape after filling.
- The recommended minimum quantity for solid sample analysis is 200 grams (150 ml). The recommended minimum quantity for a liquid sample is 1.0 liters.
- TENORM samples of limited quantities are shipped as exempted packages under transport regulations. Consequently, samples may be shipped using regular parcel post provided the samples are properly labeled and packaged.
- All TENORM samples should be properly labeled with company name, location, contact name and phone number, description of contents, and sample dose rate.
- A Warning label should be attached to the sample container which states the following: "Caution – TENORM."
- Samples should be packaged so as to prevent the escape of odors or the package contents. No warning signs are to be put on the exterior of the package.

12.5 Transport of TENORM

Transportation of TENORM-impacted materials must be completed by a licensed and permitted TENORM Transporter/Hauler.

The majority of transported oilfield TENORM-impacted material/waste exhibits radioactivity below 270 pCi/g and is not subject to federal transportation regulations – i.e., a Bill of Lading is permissible. For transportation of higher level TENORM, consult the table in 49 CFR 173.436 to verify that the concentration and total consignment activity levels are safe for transport and that it has been properly labeled and packaged (with placarding as required). In this case, an authorized/certified radioactive materials shipper is required to prepare and sign the manifests (typically an NRC-540 Form is used).

Regardless of levels, all transporters of TENORM-impacted material and SCO equipment are required to hold a TENORM Transporter's License, issued by the North Dakota Department

of Environmental Quality (DEQ), **regardless of activity levels.** Accordingly, all TENORM falls under the jurisdiction of North Dakota's Radiation Control Program, and all inbound and outbound waste must be transported by a licensed TENORM Transporter.

Shipments of oilfield TENORM (Ra-226, Ra-228 and Pb-210) with activity above 270 pCi/g fall under the federal jurisdiction and are, therefore, subject to the requirements of federal regulations, including U.S. Department of Transportation (DOT) regulations (as well as ND rules/regulations).

All personnel are to obtain approval from the Radiation Safety Officer prior to shipping materials that falls under federal jurisdiction. The RSO must be an authorized radioactive materials shipper.

Surface contaminated objects (SCO), including pipe and equipment impacted by TENORM should be appropriately packaged or sealed to prevent the release of radioactive material during transportation. All openings where potential TENORM contamination could escape must be sealed prior to transport, using heavy polyurethane wrap, duct tape and other materials as necessary to prevent the inadvertent spread of contamination.

The objective is to seal the TENORM contamination within equipment ensuring that there are no leaks or spills during loading, unloading and transport of the TENORM contaminated objects. Tubing and pipe should have pipe protectors (end caps) installed or the ends sealed. The shipment should also be tarped to provide secondary containment and in case the ends get knocked off during loading, unloading or transport.

12.6 Disposal

As noted above, North Dakota regulations define what materials must be managed as regulated TENORM and sent to appropriate TENORM-licensed disposal facilities.

Any decontamination activities beyond spraying off heavy equipment or boots on the pad must be coordinated with the RSO to ensure proper safety procedures and containment of TENORM are in place. The RSO will be responsible for overseeing waste profiling and acceptance, regulatory interface related to TENORM, and proper documentation and supervision of transportation and disposal of any TENORM contaminated wastes and equipment.

Disposal options for TENORM waste will be reviewed by the RSO in coordination White Owl's HSE/Waste Manager.

13. Emergency Response and Spills

13.1 Emergency Response

The first priority is preservation of human life and ensuring employees are attended to. Their health and safety are the top priorities. **TENORM does <u>not</u> pose a significant short-term health risk.** As a result, all emergency response plans must address immediate health and safety concerns as a first priority.

The Emergency Response Plan (ERP) addresses potential emergencies, such as fires, spills, gas releases, injuries, suspicious packages, severe weather including tornados, and the steps to be implemented along with chain of command during the emergency. A copy of the ERP is kept in the Operations Building and the Facility Manager's Office.

13.2 Environmental Control Measures

TENORM spills or other potential contamination-producing events should be prevented whenever possible by using appropriate containment, such as shale bins, roll-offs, drip trays, tarps, sealing of equipment openings, and secondary containment. If a spill occurs, the site must be secured and the Facility Manager and the RSO notified as appropriate. If it is safe to do so, all reasonable attempts should be made to control and contain the spill. Refer to White Owl's Emergency Response Plan for additional information. Site safety meetings must be conducted and documented with control areas (exclusion zones) clearly established through use of safety cones, caution tape, and good signage and communication.

TENORM-related spills may be cleaned up by White Owl personnel who are trained in TENORM work procedures under the supervision of the RSO or their designee, or a licensed TENORM contractor such as Rad Pros may be used. All appropriate safe work procedures must be followed, and dosimeters and personal protective equipment must be worn as outlined in this Radiation Safety Program.

Note: Significant spills or events, or off-site management of TENORM-impacted equipment or material requires the use of a <u>licensed</u> decommissioning/decontamination TENORM contractor, (not just a TENORM transporter or hydrovac company).

For small spills, hazmat drums or polyethylene containers can be used to collect the waste. Larger spills may require sealed roll-off containers or a shale bin. All containers and waste materials must be appropriately labeled and inventoried prior to being stored or sent for

TENORM disposal. TENORM-impacted areas and any containers used will need to be confirmed cleaned (free released) through TENORM radiation surveys and/or radiological sampling. **The free release of equipment requires approval by the RSO**. Free release surveys must be performed when *any* equipment that may have come into contact with TENORM-impacted waste/residuals, (such as loaders, skidsteers, tanks, centrifuge components, and/or other process equipment), is going to leave the site or be transferred to untrained individuals or unlicensed companies (i.e., companies without a current NDDEQ decommissioning/decontamination license). It's important to not expose untrained workers to TENORM or to risk the spread of contamination beyond the licensed processing facility.

14.0 Definitions

Activity (Radioactivity): The number of nuclear transformations that occur in a quantity of material per unit of time. Unit: Curie (Ci) = 3.7×10^{10} Becquerel (Bq), 1 Bq = 1 disintegration per second.

ALARA: A principle of risk management according to which exposures are kept as low as reasonably achievable, economic and social factors being taken into consideration. ALARA is a guiding principle of radiation protection and the principle must be taught to all workers.

Alpha Radiation (Alpha Decay): A high-energy positively charged particle ejected from the nucleus of an unstable (radioactive) atom, consisting of two protons and two neutrons. An alpha particle is a helium nucleus.

Annual Limit on Intake (ALI): The intake by inhalation, ingestion or through the skin of a given radionuclide in a year by a reference man which would result in a committed dose equal to the relevant dose limit. The ALI is expressed in units of activity.

Atomic Number: The number of protons contained in the nucleus of an atom. This number gives each atom its distinct chemical identity.

Atomic Mass (Mass Number): The total mass of protons and neutrons contained in the nucleus of an atom.

Background Radiation: The radiation to which an individual is exposed arising from natural radiation sources such as terrestrial radiation from radionuclides in the soil, cosmic radiation from space, and naturally occurring radionuclides deposited in the body from foods, etc.

Becquerel (Bq): An SI unit of radioactivity, equivalent to 1 nuclear transformation per second. Used as a measurement of the quantity of a radionuclide since the number of radioactive transformations (disintegrations) is directly proportional to the number of atoms of the radionuclide present. Replaces an earlier unit, the curie (Ci).

Beta Radiation (Beta Decay): The ejection of a high-energy negatively charged subatomic particle from the nucleus of an unstable atom. A beta particle is identical in mass and charge to an electron.

Contamination (Radioactive Contamination): Radioactive material present in excess of natural background quantities in a place it is not wanted.

Committed Dose: The total dose received from a radioactive substance in the body during the remainder of a person's life (assumed as 50 years for adults, 70 years for children) following the intake of the radionuclide.

Decay (Radioactive Decay): A process followed by an unstable nucleus to gain stability by the release of energy in the form of particles and/or electromagnetic radiation. NORM materials decay with the release of alpha particles, beta particles and/or gamma photons.

Decay Series (Radioactive Decay Series): A succession of radionuclides, each member of which transforms by radioactive decay into the next member until a stable nuclide results. The first member is called the "parent", the intermediate members are called "progeny" and the final stable member is called the "end product". In the two TENORM decay series; uranium-238 and thorium-232 are the "parents," and lead-206 and lead-208 are the "end products".

Derived Working Limit (DWL): A practical working limit derived from regulatory limits. Derived Working Limits can be compared to measured values at the work site to assess compliance with regulatory limits.

Diffuse TENORM: TENORM-contaminated material in which the radioactive concentration is uniformly dispersed. It is generally low in radioactive concentration, and relatively large in volume.

Discrete TENORM: TENORM-contaminated material in which radioactive substances are concentrated, or not uniformly dispersed throughout the material.

Dose Constraint: An upper bound on the annual dose that members of the public or incidentally exposed workers should receive from a planned operation or single source.

Dosimeter: A device for measuring a dose of radiation that is worn or carried by an individual

Equilibrium (Radioactive): In a radioactive decay series, the state that prevails when the rate at which progeny are produced is equal to the rate at which they are decaying. This form of equilibrium may be attained only if the precursor is very long-lived relative to any member of the decay chain. All members of a TENORM radioactive decay series in equilibrium have the same radioactivity.

Exclusion Zone: A work area where:

1. Access is limited to those persons who are required to work or perform any duty in the area.
2. The boundaries of the area are clearly delineated and are made known to employees.
3. Any person entering the area has received appropriate instructions about the nature of the radiation hazards in the area.

Gamma Radiation (Gamma Rays or Gamma Photons): Electromagnetic radiation or photon energy emitted from an unstable nucleus in the process of ridding itself of excess energy. Highly penetrating, gamma rays lose energy as they pass through atoms of matter.

Half-life, Radioactive: The time required for a radioactive material to lose half of its activity through radioactive decay.

IAEA: International Atomic Energy Agency.

ICRP: International Commission on Radiological Protection.

Incidentally Exposed Workers: Employees whose regular duties are not expected to result in exposure to TENORM radiation. The public annual dose limit of 100 mrem applies to this category of workers in an occupational exposure environment – the occupational domain.

NORM (Naturally Occurring Radioactive Materials): NORM is an acronym for naturally occurring radioactive materials comprising radioactive elements found in the environment. Long-lived radioactive elements of interest include uranium, thorium and potassium and any of their respective radioactive decay products such as radium and radon. Some of these elements have always been present in the earth's crust and within the tissues of all living beings. Although the concentration of NORM in most natural substances is low, higher

concentrations may arise as the result of human activities. NORM is not regulated in the State of North Dakota. Please also review the TENORM definition in this section for additional, related information.

One-year Dosimetry Period: The period of one calendar year beginning on January 1 of the year following the year in which the Radiation Safety Program is started, and every period of one calendar year thereafter.

Occupationally Exposed Workers (TENORM Workers): Employees who expect to receive exposure to sources of TENORM radiation as a result of their regular duties. The annual occupational dose limit of 2,000 mrem applies to this category of workers in an occupational exposure environment.

Personal Dosimetry Threshold: The annual effective dose above which radiation dosimetry of individual workers is required.

Radiochemical Analysis: Analysis of the radioactive content of a NORM/TENORM sample. Radiochemical analysis will identify and quantify the concentration of various radionuclides in the TENORM sample (Ra-226, Ra-228, Pb-210, and Po-210). Note: North Dakota does not currently require analysis for Pb-210 or Po-210 though these isotopes are present in oil and gas exploration and production (and midstream) activities. These 4 isotopes are generally considered the "TENORM isotopes."

Radionuclide or Radioisotope: A particular form of an element, characterized by a specific atomic mass and atomic number, whose atomic nucleus is unstable and decays or disintegrates with a statistical probability characterized by its physical half-life.

Radium-226: A radioactive element with a half-life of 1620 years. It is a particularly hazardous decay product of natural uranium and is frequently the dominant TENORM nuclide. It decays into the radioactive gas Radon-222.

Radon: The only radioactive gas generated during natural radioactive decay processes. Two radioisotopes of radon are present – radon and thoron – each a decay product of radium. Radon (Rn-222) is found in the uranium decay series while thoron (Rn-220) is found in the thorium decay series.

Radon Progeny: The products of radon (radon-222) or thoron (radon-220) decay with short half-lives. Radon decay products include; Polonium-218 (RaA), Lead-214 (RaB), Bismuth-214 (RaC), and Polonium-214 (RaC'). Thoron decay products include; Polonium-216 (ThA), Lead-212 (ThB), Bismuth-212 (ThC), Polonium-212 (ThC'), and Thallium-208 (ThC").

Rem: A historical unit of human dose equivalent. Rem is an acronym for roentgen equivalent man and was replaced in 1977 by the sievert in the international system of units.

Roentgen (R): The classical unit of radiation ionization in air, frequently misapplied as a unit of exposure in humans. Replaced in international system of units by the "coulomb per kg in air."

Shielding: The reduction of radiation beam intensity by interposing, between the source and an object or person that might be exposed, a substance that absorbs.

SI (International System of Units): The "metric" system of units generally based on the meter/kilogram/ second units. Special quantities for radiation include the Becquerel, gray and sievert.

Specific Activity (Radioactive Concentration): The number of picoCuries per unit of mass of a material. Units: pCi/g.

Technologically Enhanced Naturally Occurring Radioactive Material (TENORM): Naturally occurring radioactive material whose radionuclide concentrations are increased by or as a result of past or present human practices. TENORM does not include background radiation or the natural radioactivity of rocks or soils. TENORM does not include "source material" and "byproduct material" as both are defined in the Atomic Energy Act of 1954, as amended (AEA 42 USC §2011 et seq.) and relevant regulations implemented by the NRC. TENORM is regulated by the NDDEQ.

Total Effective Dose Equivalent (TEDE): The sum of effective dose equivalent from external exposure and committed effective dose equivalent from internal exposure, thereby taking into account all known exposures.

15. References

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Canadian NORM Working Group of the Federal Provincial Territorial Radiation Protection Committee, “Canadian Guidelines for the Management of Naturally Occurring Radioactive materials (NORM”; First Edition, October 2000.

Grey, P.R.; “NORM Contamination in the Petroleum Industry”, Presented at the 16th Annual Technical Conference and Exhibition of the Society of Petroleum Engineers, Dallas, Oct. 6-9, 1991.

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Radiation Protection and the Management of Radioactive Waste in the Oil and Gas Industry, IAEA Safety Reports Series No. 34, Vienna 2003.

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16. Appendices

Appendix A

State Government Agencies

North Dakota

Oil and Gas Agency
North Dakota Industrial Commission
Department of Mineral Resources
Oil and Gas Division
600 East Boulevard Ave., Dept. 474
Bismarck, ND 58505-0614
Phone: (701) 328-8020

Radiation Control Agency
Division of Waste Management
Radiation Control Program
4201 Normandy Street
Bismarck, ND 58503-1324
Phone: (701) 328-5166
State Radio: (1-800) 472-2121

Appendix B

ALARA Review

If a regulatory dose limit is exceeded, the following will be performed:

- Immediate notification of the dose levels to the individual as well as to the North Dakota Department of Environmental Quality (DEQ);
- Removal of the person from any work that is likely to add to the dose;
- Assessment of the YTD dose received;
- an investigation will be conducted to determine the magnitude of the dose and to establish the potential cause(s) of the elevated exposure;
- Delineating and taking any action required to prevent the occurrence of a similar incident;
- Documentation will be created of the potential cause(s) and any corrective measures. The documentation will be retained for future reference and audit; and
- The investigation results will be shared with senior management and the Department of Environmental Quality.

Appendix C

Notification to Female Workers

Name:	
Date of Notification:	

As required by the North Dakota Radiological Health Rules, I have been informed in writing of:

a) The risks associated with the exposure of embryos and unborn babies to radiation and the risks to breast fed infants from the intake of radioactive substances/material;
b) The importance of informing the company (the licensee) as soon as feasible, in writing, should I become pregnant or be breast feeding;
c) The rights of a pregnant worker and the rights of a breastfeeding worker; and
d) The applicable effective and regulatory dose limits for a pregnant worker.

I acknowledge that I have received the above information:

_____ _____
Employee Signature *Date*

_____ _____
Radiation Safety Officer *Date*

Appendix D

Declaration of Pregnancy Form

Name:	
Date of Notification:	
Declaration Details:	

Declaration of Pregnancy

I, _____ (print full name), have read the United States Nuclear Regulatory Commission Regulatory Guide 8.13 and understand my rights. I have been advised on radiation risks to an embryo/fetus and on radiation protection measures. I am voluntarily declaring my pregnancy in writing with the understanding that I can withdraw this declaration at any time. I understand that the fetus/unborn baby exposure limit for the remainder of my pregnancy will be 500 mrem. To track this exposure, I will wear a fetal dosimetry badge for the remainder of my pregnancy.

My estimated date of conception: _____

_____ _____

Employee Signature *Date*

_____ _____

Radiation Safety Officer *Date*

Appendix E

Standard Operating Procedures

Standard Operating Procedure

Dose Evaluations
SOP #1

1.0 Purpose:

This SOP describes the methodology that will be used by White Owl to evaluate and record the radiation dose received by all White Owl and contractor personnel who may be exposed to radioactive materials or radiation above ambient local backgrounds in the course of any work activities performed on behalf of White Owl.

2.0 Scope:

This SOP applies to all White Owl and contractor personnel whose work activities may reasonably be expected to result in potential exposure to radioactive materials or radiation in excess of local ambient background values. Other personnel, at White Owl's option, may also receive dose evaluations in conformance to this standard operating procedure.

3.0 Equipment and Supplies:

Dose evaluations will consider both internal and external exposures. Equipment and supplies for this evaluation may consist of any of the following:

- Thermoluminescent (TLD) or Optically Stimulated Luminescence (OSL) dosimeters for measuring external radiation exposure (personal or area as applicable);
- Alpha Track (or other passive dosimeters) and air sampling as may be necessary to assess exposure to radon and/or radon progeny;
- Personal sampling pumps and suitable filters for evaluating exposure to airborne radioactivity;
- Work area sampling pumps and suitable filters for evaluating general area exposure to airborne radioactivity; and
- Other exposure monitoring devices as specified by the White Owl Radiation Safety Officer (RSO).

4.0 Special Conditions or Requirements

In the event that special radiation exposure hazards may exist for a specific project or work activity, the RSO may specify additional exposure monitoring or calculation procedures beyond those specified in this standard operating procedure (SOP).

5.0 Procedure

Workers at the licensed facility will be limited to potential exposure to naturally occurring radioactive materials derived from oil and gas production wastes and other similar activities. As such, the likely exposure scenarios are limited to whole-body exposure to elevated gamma radiation fields and internal exposure by way of inhalation of dust containing radioactive materials. Elevated radon and radon daughter concentrations as a result of the decay of naturally occurring radioactive materials may also be a possible route of exposure.

This SOP addresses these possible exposure routes. If other project activities present additional exposure routes and will be amended or supplemented by additional material to address other exposure pathways.

5.1 External Exposure to Ionizing Radiation

External exposure to ionizing radiation will be measured using a program of external dosimetry. Each White Owl employee whose regular work activities may lead to exposure to external radiation in excess of local ambient background will be issued a thermoluminescent (or OSL) dosimeter provided through a qualified vendor of dosimetry service. These dosimeters will be evaluated on a schedule determined by the RSO based on reasonably anticipated exposure rates. Dosimeters and any results of air sampling programs (and bioassay if applicable) will be evaluated at least quarterly, and more frequently if anticipated doses may be in excess of 10% of any annual exposure limit (e.g., 5000 mrem, 2000 DAC hrs, one ALI per year).

Dosimetry results will be recorded for each potentially exposed worker. Dosimetry results will be provided to employees as they are received. The White Owl RSO (or a qualified health physicist) will be available to explain the meaning and significance of these exposure results to employees.

5.2. Internal Exposure to Ionizing Radiation

Any internal exposure to ionizing radiation for White Owl and contractor employees would come through inhalation of radon and radon progeny and inhalation of airborne particulates containing radioactive materials. At outdoor sites or facilities, radon and progeny exposure will be considered negligible unless data or specific site considerations dictate otherwise.

If the radiation hazard indicates the likelihood of measurable radon or radon daughter exposure above the expected range of background, Alpha Track, other acceptable passive radon monitoring devices, and/or Kusnetz method-based air sampling programs may be used and results will be included in the overall dose assessment for all site or project personnel.

Other internal exposures, principally through inhalation of airborne particulates containing radionuclides, may be evaluated through a regular program of personal and work area air monitoring. This program is described in SOP #1. The results of the personal and work area exposure monitoring program will be used to calculate a committed effective dose equivalent (CEDE) value based on the concentrations of specific radionuclides detected in the airborne particulates, in combination with exposure time and other factors effecting intake, (e.g., breathing rates, respiratory protection factors, etc.).

The value of the CEDE will be calculated using Derived Air Concentrations (DAC) and /or Annual Limits on Intake (ALIs) for the applicable solubility classes (D,W,Y) from the United States Nuclear Regulatory Commission (USNRC) in 10CFR20, Appendix B (or F,S,M absorption types in subsequent ICRP guidance). If the solubility class of the nuclide compound is unknown, the most insoluble category (Y or S) will be used (except for natural or low enriched uranium where chemotoxicity may be limiting – see intake limits for soluble uranium in 10CFR20).

CEDE values for each employee will be calculated at least quarterly, and more frequently at the discretion of the RSO. CEDE values will be incorporated in each employee's total equivalent dose exposure (TEDE) on a quarterly basis or *pro rata* in the event of termination regardless of reason in advance of a calendar quarter.

External dose (Dose Equivalent = DE), CEDE, and TEDE values will be presented to each employee on a quarterly basis or upon termination regardless of reason if requested by the employee; the meaning and significance of the individual components of the TEDE and the method of calculation would then be explained

and results will be provided to future employers (if requested) as part of the individual's lifetime exposure record.

In the event that an individual airborne radiation exposure sample indicates that an employee may have been exposed to airborne radioactivity in excess of 25% of the applicable derived air concentration (DAC), bioassay sampling (e.g., urinalysis) will be required. The affected employee will be notified as soon as practicable. Upon receipt of laboratory analytical results, verification of bioassay results and of intake and performance of calculations of employee's actual exposure, if necessary, these results will be transmitted to the employee together with any additional explanatory material that may be appropriate.

6.0 Quality Assurance/Quality Control

Quality assurance/quality control (QA/QC) of the dosimetry program will be ensured by using vendors who are certified through the National Voluntary Laboratory Assessment Program (NVLAP). Dosimetry vendors must submit NVLAP certification as a condition for use as a vendor to White Owl.

Laboratory analysis of air samples will only be performed by organizations with a recognized radiological quality control system (e.g., per NELAP). The RSO will evaluate potential vendors of laboratory radiological monitoring services to determine the acceptability of their internal QA/QC system.

As part of the annual ALARA and license compliance audit to be performed by the RSO, the dose evaluation program will be reviewed. A written report to White Owl management will be performed as a result of this audit presenting findings, shortcomings, and recommendations for future action.

TEDE calculations will be subject to external audit upon request by the client, competent oversight agency, individual employee, or White Owl management. All data and calculations used to determine the TEDE will be subject to this audit and oversight.

7.0 Documentation

Exposure records will be maintained for each employee. Records will include the results of individual dosimetry, individual airborne exposure monitoring, bioassay results and other exposure monitoring results assigned to the employee by proximity or similar work activities. All individual dose calculations will be included in the employee's record.

In addition to individual employee exposure records, overall records of the dose assessment activity will be retained by White Owl, including all vendor assessments, performance reviews, air sampling records, original laboratory data from individual or work area samples including bioassay results generated during the project.