CHAPTER 10 RADIOACTIVE WASTE HANDLING AND DISPOSAL

1.0 RADIOACTIVE WASTE REDUCTION

1.1 Limiting Waste Production

Whenever practical, limit the production of radioactive waste. Some ways to limit waste production include:

- Training personnel in proper handling and disposal of waste.
- Using the safe work practices and containment devices described in Chapter 9, Laboratory Procedures.
- Avoiding the use or storage of non-essential items or excess packaging materials in locations where they may become contaminated.

1.2 Segregation of Radiological and Non-Radiological Waste

- Radioactive waste should be limited to non-useable radioactive materials or to materials that are known or likely to be contaminated with radioactive materials.
- Never dispose of non-radioactive waste in radioactive waste containers.
- When appropriate to reduce waste volumes, perform radiological surveys of potentially contaminated dry solid materials to verify that the materials are suitable for non-radioactive disposal or release to unrestricted use.
- Potentially-contaminated liquids or dry bulk materials (powders, granulated materials, etc.) may be sampled and analyzed for release as described elsewhere in this chapter.
- Always keep radioactive waste containers closed and properly labeled to reduce the likelihood of spills or improper disposals.

1.3 Re-Use and Transfer of Materials

- Properly label and store contaminated items or equipment for re-use.
- When appropriate, decontaminate items instead of disposing of them.
- Items contaminated with short half-life isotopes may be packaged, labeled, and stored for radioactive decay. After being allowed to decay for 10 half-lives, the materials may be surveyed or analyzed for release to unrestricted use.

Radioisotopes or contaminated equipment may be transferred from one Authorized User to another instead of becoming waste. Always contact Radiation Safety prior to initiating a transfer.

2.0 DRY SOLID RADIOACTIVE WASTE HANDLING

2.1 Segregation of Dry Solid Waste

Segregate dry solid radioactive waste according the following categories:

1) Long-lived waste (half-life >120 days)

2) Short-lived waste (half-life <120 days)

3) Long-lived mixed waste

4) Short-lived mixed waste

5) Sealed radioactive sources

Long-lived waste will normally be stored by Radiation Safety pending disposal via a commercial radioactive waste disposal vendor. Please limit the production of this type of waste since commercial disposal is expensive. Long-lived dry waste may be mechanically compacted to achieve volume reduction or incinerated by a licensed vendor. Non-compactable materials and materials that cannot be incinerated should not be put into containers of long-lived dry radioactive waste. Non-compactable and non-incinerable materials include, but are not limited to, metal objects, aerosol cans, and lead shielding materials.

Short-lived waste will normally be held for radioactive decay by Radiation Safety. Following decay for a time period of 10 radioactive half-lives, the waste will be monitored for the presence of residual radioactivity. If no residual radioactivity is detected the waste will be disposed of as non-radioactive. Containers used to store short-lived waste will be returned to the Authorized User after disposal of the contents.

Mixed waste is any combination of a hazardous waste and a radioactive waste. Handling and disposal of mixed waste is expensive. A hazardous waste is any material listed as hazardous by the EPA (refer to the MSDS for this information). Consult with Radiation Safety prior to generating mixed waste. If the estimated cost of disposal of a quantity of long-lived dry mixed waste exceeds the average cost of disposal of a similar quantity of long-lived dry radioactive waste by more than 10%, this will trigger a review by the Radiation Safety Committee. The RSC may then require the Authorized User who generated the waste to arrange for funding to pay for all or part of the disposal costs beyond the average disposal cost for a drum of long-lived dry waste. Short-lived mixed waste will be held for radioactive decay and disposed of as hazardous waste.

Sealed radioactive sources consist of radioactive material that is permanently bonded or constructed in such a manner as to prevent the release or dispersal of the radioactive material under normal use conditions. Certain instruments and manufactured articles contain sealed radioactive sources such as gas chromatographs and liquid scintillation counters. Contact Radiation Safety for specific instructions regarding disposal of sealed sources or surplus equipment that contains radioactive material. If the estimated cost of disposal of one or more sealed radioactive sources submitted for disposal by an Authorized User exceeds the average cost of disposal of a standard size drum of long-lived dry radioactive waste by more than 10%, this will trigger a review by the Radiation Safety Committee. The RSC may then require the Authorized User who generated the waste to arrange for funding to pay for all or part of the disposal costs beyond the average disposal cost for a drum of long-lived dry waste.

The above listed categories should be additionally sub-divided into separate containers when appropriate. For example, different types of hazardous (mixed) waste should not be combined into one container.

Note: Dry radioactive waste materials that are in process will be referred to as **dry active waste (DAW)**. "In process" means that the materials have not officially been classified as radioactive waste for purposes of transportation and final disposal. Treatment options, such as decay in storage, compaction, and incineration, may be used prior to the final classification of this material as low level radioactive waste.

2.2 Dry Active Waste (DAW) Containers

1) The standard container for DAW is a 30-gallon fiber drum with a reinforced metal lock-rim closure lid.

2) Alternative approved containers include 5-gallon plastic pails with secure screw top lids and 10 to 20-gallon capacity all fiber drums. All fiber drums are preferred for use with long-lived DAW because they are completely incinerable, although they may be used any time a smaller container is more practical. Smaller containers should be used only in laboratories that generate small quantities of DAW, so that the need for waste pick-ups will not be excessive.

3) Other special use containers may be approved by the RSO/RSC on a case by case basis.

4) Authorized Users that use more than one of the categories listed in section 2.1 must have separate containers for each category.

5) Procurement of waste containers is the responsibility of the Authorized User.

6) Clearly label the containers and train laboratory personnel to prevent the possibility of mixing the different categories of waste.

7) All radioactive waste containers must be marked with the standard radiation symbol and the words “Caution, Radioactive Materials.” Labeling should also include the isotope(s) and the estimated maximum activity (mCi) in the container. A minimum of two labels should be used with each label placed on opposite sides of the container.

8) Empty waste containers should be marked with an “Empty” label in addition to the radioactive materials label.

9) Temporary collection containers for waste may be used to improve efficiency and reduce the risk of spills. The physical construction of the container must be appropriate for the type of waste. Temporary collection containers should remain closed when not in active use and must not be allowed to overflow. Temporary collection containers should be labeled in the same manner as other waste containers.

10) All DAW containers must be lined with a removable polyethylene liner bag (or bags) to achieve a minimum thickness of 4 millimeters. Liner bags should not have radioactive materials markings and should not be closed or labeled with radiological warning tape.

11) Used waste containers that are no longer needed must be turned over to Radiation Safety for disposal or reuse on campus.

2.3 DAW Packaging

1) No free standing (visible) liquids of any kind may be placed in a DAW container.

2) Small amounts of liquid may be added to absorbent materials and then placed in the container. Ensure that a sufficient quantity of absorbent material is used when absorbing liquids for disposal as DAW.

3) Empty liquid containers may be placed in the dry waste container, but they must not contain any free-standing liquid. Empty liquid containers should have the lids removed prior to disposal to prevent moisture condensation during storage.

4) Empty scintillation vials that were used for analysis of H-3 or C-14 may be disposed of in regular (non-radioactive) trash. Empty scintillation vials that were used for analysis of other isotopes may be disposed of in regular (non-radioactive) trash, IF the count rate of the samples was <

twice the background rate. This value is based on the fact that only a small percentage of the original activity in the scintillation cocktail will remain on the surface of the empty vial as contamination. If the counting results exceed this value, the empty vials must be rinsed with water. According to industry standards a triple rinse will remove >90% of the residual activity. The rinse should be disposed of in an appropriate liquid-waste carboy. The rinsed vials may then be disposed of as non-radioactive.

5) Items that have a high moisture content require special handling. When appropriate, dry these items under low heat in a fume hood prior to disposal. If this is not practical, you must surround these items with a sufficient quantity of absorbent materials to eliminate all free standing liquids that are present or likely to develop during storage.

6) Destroy and/or deface all radiological markings and radiation symbols prior to disposal of items in DAW containers used for short-lived radioisotopes.

7) Sharp objects such as hypodermics, broken glass, and other sharp items must be packaged to avoid injury to persons who must handle the waste. Place such objects in an industry standard "sharps" container or in a plastic jar and secure with tape before placing in the dry waste container. (Label as sharp objects). Do not use radiological warning tape to secure the container if it is to be disposed of in a DAW container used for short-lived radioisotopes.

8) Other than the obvious exceptions of sharp objects (Pasteur pipettes, syringes and hypodermic needles), un-damaged glassware should not be placed into a radioactive sharps container. Most glass items (test tubes, vials, etc.) can be decontaminated by washing with an industrial strength detergent. The percentage of the glass content within the DAW container must be noted on the container.

9) Aerosol containers such as spray cans must not be disposed of as dry radioactive waste. Aerosol containers are hazardous when waste is being mechanically compacted. If the can is sealed and the contents are not radioactive, survey (and if necessary decontaminate) the outside of the container and dispose of as non-radioactive.

10) Lead (Pb) shielding materials must not be placed into a dry waste container. Lead waste is considered hazardous waste. If suspected to be contaminated, lead shielding should be surveyed for contamination in accordance with Chapter 6, *Radiological Surveys*. Contact Radiation Safety for specific information regarding disposal or decontamination of contaminated lead. Do not attempt to decontaminate lead by cutting, heating, or abrasive methods due to the risk of inhalation and ingestion of this hazardous material.

11) The maximum acceptable weight limit for an individual DAW container is 50 pounds.

12) Sealed radioactive sources shall not be put in DAW containers without specific approval from Radiation Safety.

13) DAW containers used for short-lived waste may be returned to the Authorized User after disposal of waste. In order to facilitate the return of used containers, label the container with the name of the Authorized User and ensure that liner bags are used in such a manner that the container does not become contaminated. Since containers will be held for radioactive decay, extra containers should be purchased for use while full containers are being stored by Radiation Safety pending disposal.

14) If early return of containers is desired, very short-lived waste such as Phosphorous-32 (half-life = 14 days) may be collected separately from other short-lived waste such as Sulfur-35 (half-life = 88 days). Containers with both isotopes must be stored for 880 days based on the half-life of Sulfur-35. Phosphorous-32 containers must be stored for only 143 days.

15) DAW containers will be checked for content and activity after pick-up. If radioactive materials

are discovered to have been improperly packaged or labeled, the Authorized User will be held responsible for repackaging the waste.

2.4 Method for Determining the Amount of Radioactivity in DAW

The contents of a typical dry active waste container consist of 2 primary components: associated waste and known additions. This section describes the methodology for determining the amount of radioactivity that each of these components contributes to the total activity of the container.

Associated Waste

The majority of the volume of most DAW is associated waste. Associated waste consists of general laboratory waste that has been in contact with radioactive materials and is therefore potentially contaminated. Associated waste includes such items as used gloves, paper towels, disposable pipette tips, etc. Associated waste may be subdivided into two types: secondary contact waste and direct contact waste.

1) Secondary Contact Waste

   The bulk of associated waste is secondary contact waste. Secondary contact waste consists of materials that have been in limited contact with radioactive materials or have only been in contact with diluted radioactive materials. Based on standard models of transferable contamination, secondary contact waste is calculated to be contaminated to a maximum level of 1% of the original activity with which it was used.

2) Direct Contact Waste

   The other component of associated waste is direct contact waste. Direct contact waste is waste that has been in direct contact with un-diluted radioactive materials (stock solutions). Based on standard models of transferable contamination, direct contact waste is calculated to be contaminated to a maximum level of 10% of the original activity with which it was used.

Associated Waste Contamination Factor

Based on these criteria, the activity of the associated waste in a DAW container may be calculated as follows:

% Secondary Contact Waste x 1% = Secondary Contact Waste Contamination Factor (SCWCF)

% Direct Contact Waste x 10% = Direct Contact Waste Contamination Factor (DCWCF)

SCWCF + DCWCF = Associated Waste Contamination Factor (AWCF)

Based on a standard model of 80% secondary contact waste and 20% direct contact waste, the Associated Waste Contamination Factor for use at UGA is 3%. Therefore, 3% of the total radioactivity that was used during the time period from the initial date the container was put in service to the date of closure is the calculated activity of the associated waste in the container.

In the event that a laboratory's associated waste does not meet this standard model, Radiation Safety will develop a revised Associated Waste Contamination Factor (AWCF) based on input from laboratory personnel regarding the characteristics of waste generated.

Known Additions

When radioactive materials of a known isotope and activity are added to the container, these materials should be listed separately from associated waste and added to the total activity of the container. Known additions include any media suitable for the dry waste container that contains measured or calculated quantities of radioisotopes. If there are no known additions to a waste container the total activity of the contents will be determined exclusively by use of the associated waste contamination factor.

2.5 Use of the DAW Container Log

- Initiate a *DAW Container Log* when a dry active waste container is put into service. A *DAW Container Log* may be printed and attached to the container with the start date and isotope(s) listed on the form. Known additions and the B Numbers of completely used radioisotope orders may be written on the form in the spaces provided as waste is being added to the container. The *DAW Container Log* may also be maintained exclusively in an electronic format as long as the container is labeled with the standard radiation markings, the isotope(s), and the estimated total activity that the container is likely to hold.
- Use separate containers and log sheets for each category of waste, as described in section 2.1 of this chapter.
- If more than one container is in use at any one time, special care must be taken not to mix up the data from one log sheet to another.

When a DAW container is full or when you are ready to have the container picked up by Radiation Safety, the following tasks must be performed:

1) The final copy of the *DAW Container Log* should be completed in an electronic format for increased efficiency. The electronic format must be approved by the RSO and obtained from Radiation Safety. After the electronic form is completed, it must be printed and signed. A signed copy is required for labeling the container.

2) If the electronic format *DAW Container Log* is unavailable or is not being used for any reason, the data may be entered by hand on the form. Radioactivity calculations will have to be performed manually. Contact Radiation Safety for assistance if needed.

3) Record the required data in support of the associated waste calculation to account for non-specific waste in the container.

4) Record the addition of known quantities of radioactive materials in the space provided.

5) The total amount of radioactivity in the container is the total of the associated waste calculation and the known additions. The electronic version of the form will perform the required mathematical calculations automatically.

6) Perform a contamination survey of the exterior of each container and record the results in the space provided on the form. Contamination levels on containers must not exceed 1000 dpm/100 cm^2. Contaminated containers should be decontaminated and resurveyed as described in the *Laboratory Procedures* chapter of this manual.

7) Perform a radiation dose rate survey of the exterior surface of the waste container and record the results in the space provided on the form. If the contact dose rate exceeds 0.5 mrem/hr, notify Radiation Safety of the dose rate on the container when you request a pick-up. The Radiation Safety staff will verify the radiation dose rates and provide appropriate labeling for

the container at the time of pick-up.

8) Sign and date the form in the space provided. Waste container paperwork should only be completed by, or under the supervision of, an Authorized User or Advanced Radworker.

9) Attach the completed *DAW Container Log* to the container and notify Radiation Safety that the container is ready for pick-up.

3.0 ANIMAL CARCASSES AND BIOHAZARDOUS WASTE

Note:	Refer to the University's Biosafety Manual for specific information about biohazardous waste.

1) Notify Radiation Safety prior to initiating any new projects resulting in the generation of animal carcasses or biohazardous waste contaminated with radioactive materials.

2) Animal carcasses and biohazardous waste may be disposed of as if it were not radioactive IF the disposal is documented and approved by Radiation Safety, the disposal method is appropriate for the physical and biohazardous properties of the material, and the material consists of one or more of the following:

   - Animal tissue that does not contain more than 0.05 µCi of H-3 or C-14 per gram.
   - Waste that contains radioisotopes in concentrations that do not exceed the appropriate effluent limit specified in 10 CFR 20 Appendix B, Table 2.
   - Waste that contains short-lived radioisotopes that has been held for radioactive decay for a minimum duration of 10 half-lives and when monitored with an appropriate portable instrument shows no detectable activity.

3) Animal carcasses and biohazardous waste must be properly labeled and safely stored pending disposal.

4) Any radioactive biohazardous waste will NOT be picked up for storage or disposal by Radiation Safety unless the Authorized User has verified that the waste has been deactivated, decontaminated, or sterilized.

5) Waste that has been deactivated, decontaminated, or sterilized should not be labeled as biohazardous. Radioactive waste in bags or containers with biohazard labels will not be picked up for disposal by Radiation Safety.

4.0 LIQUID RADIOACTIVE WASTE HANDLING

4.1 Segregation of Liquid Waste

Segregate liquid radioactive waste according the following categories:

1) Long-lived waste (half-life >120 days)

2) Short-lived waste (half-life <120 days)

3) Long-lived mixed waste

4) Short-lived mixed waste

5) Non-biodegradable liquid scintillation counting fluid containing exclusively H-3 and/or C-14 in concentrations not to exceed 0.05 µCi/gram

Note: Segregation by isotope is always preferred with liquids when possible. For best results when performing radioactive analysis of liquids, use separate containers for each radioisotope.

Disposal of liquid waste is typically performed using the following methods as appropriate for the isotopes, concentration, and form.

- Consolidate compatible materials,
- Sample and analyze for isotope/quantity,
- Release liquids with radioactivity levels below the ALARA action levels,
- Hold materials for radioactive decay,
- Perform disposal by sewer discharge in accordance with the limits of 10 CFR 20, Appendix B and the State of Georgia *Rules and Regulations for Radioactive Materials*; or
- Perform disposal by off-site shipment to an approved waste disposal vendor.

The production of long-lived liquid mixed waste should be kept to a minimum. If the estimated cost of disposal of a quantity of long-lived liquid mixed waste exceeds the average cost of disposal of a standard size drum of long-lived dry radioactive waste by more than 10%, this will trigger a review by the Radiation Safety Committee. The RSC may then require the Authorized User who generated the waste to arrange for funding to pay for all or part of the disposal costs beyond the average disposal cost for a drum of long-lived dry waste.

Short-lived liquid mixed waste will be held for radioactive decay by Radiation Safety and disposed of as hazardous waste.

State of Georgia regulations permit disposal of 0.05 µCi or less of H-3 or C-14 per gram of medium used for liquid scintillation counting as it were not radioactive. Also, scintillation fluid that contains other radioisotopes in concentrations below the ALARA action levels may be released. However, regulations require that appropriate records are kept for all waste disposals. Therefore, liquid scintillation fluid should be segregated by half-life and hazardous waste considerations, and consolidated into waste containers with other similar liquids for sampling and disposal. See section 4.2 for additional information about liquid scintillation fluid.

The above listed categories of waste should be additionally sub-divided into separate containers when appropriate. For example, different types of hazardous (mixed) waste should not be combined into one container. Liquids with low specific activity (i.e. buffers, dilutions, or rinse with low concentrations of radioactivity) may be segregated into separate containers from liquids with higher specific activity. Liquids should always be segregated by isotope. This will facilitate sampling and analysis for release in accordance with the unrestricted area action levels described below.

The ALARA action levels for release of liquids represent 20% of the liquid effluent release values permitted by the Nuclear Regulatory Commission (NRC) in accordance with 10 CFR 20, Appendix B, Table 2, Column 2. These values are based solely on the concentration (µCi/ml) of radioactivity in the liquid. Each individual radioisotope has its own limit. Since some limits are much lower than others these

action levels will be limited to the radioisotopes commonly used on campus that have release limits easily detected by conventional sample counting equipment. These very low levels of radioactivity are considered safe for release. See section 5.3 for additional information.

Disposal of waste by radioactive decay is performed by the Radiation Safety staff. Although some radioactive decay does occur while waste is being accumulated in authorized use locations, the tracking, storage, monitoring, and disposal of waste via the radioactive decay process is performed in a designated facility by Radiation Safety.

Sewer disposal involves the discharge of carefully measured and tracked quantities of radioactive liquids into the sanitary sewer system. These disposals may only be performed in accordance with specific regulatory limits on both the concentration of radioactivity in a liquid and the total amount of radioactivity that the University may release on a monthly and annual basis. Due to the large volume of water in a municipal sanitary sewerage system, these disposals become diluted and therefore do not contribute significantly to environmental radioactivity levels. The vast majority of sewer disposal at UGA is performed by the Radiation Safety staff. Short-lived radioisotopes are typically held for radioactive decay prior to disposal. Specific approval for sewer disposal may be granted to Authorized Users by the RSC on an individual basis. Adding or terminating sewer disposal approval is handled via the Radioactive Materials Permit amendment process.

Note: No hazardous chemicals are to be put down the drain. If in doubt concerning non-radioactive substances, contact Lab Safety.

Radioactive waste disposal by off-site shipment to an approved waste disposal vendor is performed exclusively at UGA by the Radiation Safety staff. Such shipments are strictly regulated and expensive operations.

4.2 Disposal of Used Liquid Scintillation Counting Fluid

1) LSC fluid should be verified biodegradable by checking the manufacturer's specifications prior to purchase.

2) Biodegradable liquid scintillation fluid should be consolidated into a liquid waste carboy and segregated by isotope. **Segregation by isotope is always preferred with liquids when possible.**

3) Non-biodegradable liquid scintillation fluid or any scintillation fluid that contains hazardous chemicals must be controlled as hazardous or mixed waste. Refer to Material Safety Data Sheets (MSDS) to determine if a material is listed as hazardous by the EPA. However, hazardous wastes that contain radioactive materials in concentrations below the effluent release limits of 10 CFR 20 will be considered hazardous waste and not mixed (radioactive) waste. Consolidate these liquids into a separate carboy for analysis by Radiation Safety prior to disposal.

4) Non-biodegradable liquid scintillation fluid or any scintillation fluid that contains hazardous chemicals containing exclusively H-3 or C-14 in concentrations below 0.05 µCi per ml will be considered hazardous waste and not mixed (radioactive) waste. Consolidate these liquids into a separate carboy for analysis by Radiation Safety prior to disposal.

5) If you are counting wipe test samples for surface contamination measurements, you may dispose of any wipe samples, the associated scintillation fluid, and the vials as non-radioactive IF the wipe test results are <200 dpm.

6) If any individual sample counting results are less than 2 standard deviations above the counting instrument's background, the scintillation fluid and sample vial may be disposed of as if it is not

radioactive.

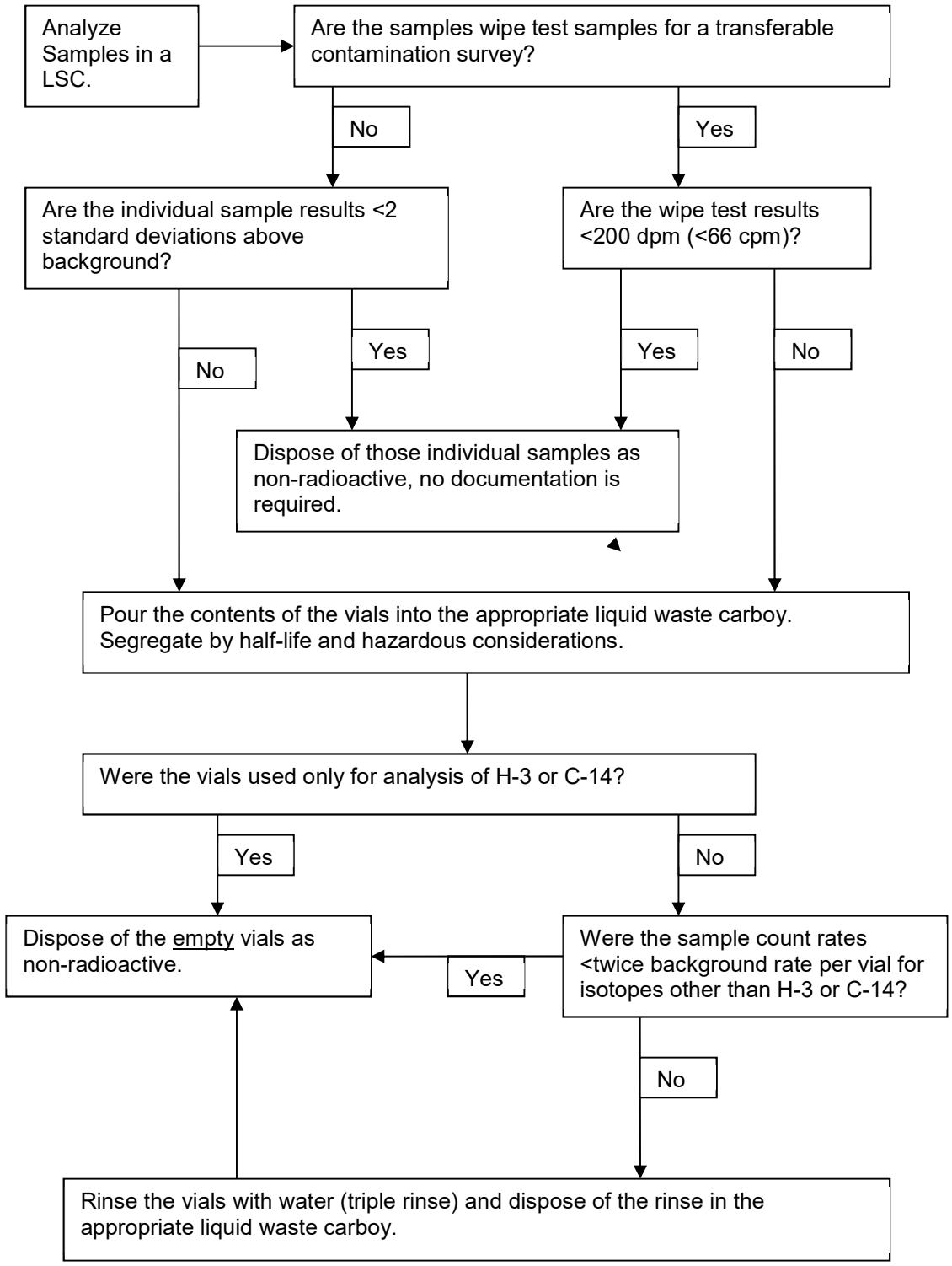
Example: A 1-minute background results in 25 counts. This equals a background count rate of 25 counts per minute (cpm). The square root of 25 cpm is 5, and 5 x 2 = 10. Therefore, if a sample does not exceed a gross result of 35 cpm, or a net result of 10 cpm (gross cpm – background cpm = net cpm), the sample is considered non-radioactive. Both the vial and its contents may be disposed of without regard to radiological concerns.

7) If the individual sample results are greater than 2 standard deviations above background (excluding wipe tests), the contents of the vials should be poured into an appropriate waste carboy. Segregate waste by half-life and hazardous characteristics as described in section 4.1.

8) Empty scintillation vials that were used for analysis of H-3 or C-14 may be disposed of in regular (non-radioactive) trash. Empty scintillation vials that were used for analysis of other isotopes may be disposed of in regular (non-radioactive) trash, IF the count rate of the samples was < twice the background rate. This value is based on the fact that only a small percentage of the original activity in the scintillation cocktail will remain on the surface of the empty vial as contamination. If the counting results exceed this value, the empty vials must be rinsed with water. According to industry standards a triple rinse will remove >90% of the residual activity. The rinse should be disposed of in an appropriate liquid-waste carboy. The rinsed vials may then be disposed of as non-radioactive.

9) If disposal of liquid scintillation fluid and vials will not occur promptly after counting, segregate and label the vials while disposal is pending. Used vials of liquid with counting results <2 standard deviations above background should be separated from radioactive materials while disposal is pending. Used vials of liquids pending packaging for disposal as radioactive materials must be labeled, or kept in suitable containers (i.e. plastic bins) labeled with the standard radiation symbol, the words “Caution, Radioactive Materials”, and the isotope, amount (µCi or mCi), and date. Storage of excessive quantities of used vials is not an acceptable practice. Also, Radiation Safety will not accept any waste containers that contain vials of scintillation fluid.

Flow Chart for Disposal of Used Liquid Scintillation Fluid & Vials



4.3 Liquid Radioactive Waste Containers

1) The standard approved container for liquid radioactive waste is a 2.5-gallon polyethylene "Jerry can". Other containers may be approved by the RSO/RSC on a case by case basis.

2) Authorized Users that are approved for use of more than one of the categories listed in section 4.1 must have separate containers for each category.

3) Clearly label the containers and train laboratory personnel to prevent the possibility of mixing the different categories of waste.

4) Radioactive waste containers must be marked with the standard radiation symbol and the words “Caution, Radioactive Materials.” Labeling should also include the isotope(s) and the estimated maximum activity (mCi). A minimum of two labels should be used with each label placed on opposite sides of the container.

5) Empty waste containers should be marked with an “Empty” label in addition to the radioactive materials label.

6) Temporary collection containers for waste may be used to improve efficiency and reduce the risk of spills. The physical construction of the container must be appropriate for the type of waste. Temporary collection containers should remain closed when not in active use and must not be allowed to overflow. Temporary collection containers should be labeled in the same manner as other waste containers.

7) Used waste containers that are no longer needed must be turned over to Radiation Safety for disposal or reuse on campus.

4.4 Liquid Radioactive Waste Packaging

1) Do not place any solid materials in liquid waste carboys. Filter papers, glass objects, and plant materials are prohibited. Materials too viscous to pour readily through a 20-mesh sieve cannot be accepted. Precipitates must be filtered out.

2) Materials that are insoluble in water, organic solvents, non-biodegradable scintillation fluid, and hazardous chemicals (mixed waste) must be segregated into separate containers by half-life (long- or short-lived) and by the individual type of hazardous waste. Segregation by isotope is always preferable when possible.

3) Do not overfill carboys. The liquid level must not exceed the 2.5 gallon (10 L) mark.

4) Viable bacteria, yeast, or other biological materials are not permitted. Liquid chlorine bleach (sufficient to achieve a 10% solution) or other appropriate material may be added to liquid waste carboys to ensure that no active microorganisms are present.

5) Isotopes with half-lives greater than 120 days should not be mixed with isotopes having half-lives less than 120 days.

6) When practical, carboys will be returned to the Authorized User after disposal of waste. Carboys should be labeled with the name of the Authorized User to facilitate return. Since carboys may have to be held for decay or for scheduling of disposal, extra carboys should be purchased for use while the full container is pending disposal.

7) Liquid radioactive materials will be analyzed for content and activity after pick-up. If radioactive materials are discovered to have been improperly packaged or labeled after pick-up, the Authorized User will be held responsible for repackaging the waste

5.0 SAMPLING, ANALYSIS, EVALUATION, AND DISPOSAL OF LIQUIDS

When a liquid waste container is full, or if disposal of the contents is desired, collect and analyze a representative sample of the contents of the container.

The method of analysis and documentation will be one of the following three options:

- If the liquid contains exclusively H-3, C-14, P-32, P-33, and/or S-35 in concentrations likely to be less than the ALARA action levels of Table 5.3 the liquid may be evaluated for release. Perform and document an analysis and evaluation for release in accordance with section 5.3, *Evaluation of Liquids for Release.*
- If the liquid does not meet the criteria described above, perform and document analysis for pick-up by Radiation Safety in accordance with section 5.4, *Liquid Radioactivity Analysis for a Waste Pick-Up.*
- If your Radioactive Materials Permit (license) authorizes sewer disposal, perform and document analysis in accordance with section 5.5, *Sewer Disposal Permits.*

5.1 Counting Instrument Considerations for Liquid Analysis

1) Instruments used for liquid waste disposal evaluations should have performance checks and routine maintenance performed as recommended by the manufacturer. Instruments that are not in good working order or properly maintained must not to be used to evaluate samples for release to unrestricted areas. For assistance with instrument performance checks, contact Radiation Safety. Instrument repair needs should be directed to the campus electronics shop, qualified vendors, or the instrument manufacturer.

2) The counting equipment used must be capable of meeting the desired release limit. Therefore, the counters minimum detectable activity (MDA) value must be less than the release limit. In some cases, counting times may have to be extended to enable an MDA value to be reached. Calculate the MDA by use of the formula:

$$\text{MDA in } \mu\text{Ci/ml} = \frac{2.71 + 4.66\sqrt{\text{bkg cpm} \times \text{count time}}}{(\text{efficiency})(\text{count time})(2.22\text{ E }6)(\text{sample vol})}$$

Example: A 1 minute counting time, 50 cpm background (bkg), LSC efficiency for H-3 of 0.35, and sample volume of 2 milliliters would give a MDA of 2.29 E-5 µCi/ml. Therefore, it would be appropriate to count a 2 ml sample for 1 minute for H-3 at this background level (or less) because the ALARA action level for release of H-3 is 2 E -4 µCi/ml. If the calculated MDA is less than the action level, the variable parameters of counting time and background are suitable for the release analysis.

3) If a counting instrument's background is high (i.e. >50 cpm), the sample counting time may have to be increased in accordance with an MDA calculation. A high background should be investigated, possible causes include contamination of the counting instrument or the placement of radiation sources (waste containers, stored isotopes, etc.) nearby.

4) Liquids that contain significant quantities of known quenching agents that are likely to contain radioactive material should be considered radioactive waste and not evaluated for release. Analyze samples of these liquids for pick-up by Radiation Safety as described in section 5.4. Coloring agents, non-homogenous samples, and certain chemicals will interfere with liquid

scintillation counting. To ensure accurate counting, samples should have visible clarity (lack of coloration) and homogeneity.

5.2 Procedure for Sampling and Analysis of Liquids

1) Sampling must be representative. Liquids should be uniformly mixed (shaken, stirred, etc.) prior to sampling.
2) Collect and pipette a sample of the liquid waste into a sample counting vial. The minimum sample volume to use is 1 milliliter, with 2 milliliters recommended. When performing sample analysis for release evaluations the sample volume must be adequate to ensure that the required minimum detectable activity (see section 5.1) is met.
3) Add the appropriate amount of scintillation fluid for use with your liquid scintillation counting instrument to the vial (i.e. 7, 10, or 20 ml of scintillation fluid).
4) If you are analyzing samples exclusively for P-32 and would like to perform Cerenkov counting, contact Radiation Safety for assistance. Cerenkov counting cannot be used for liquid release analysis and the counting efficiencies must be adjusted on the *Sewer Disposal Log* and *Liquid Radioactivity Analysis* forms.
5) If you are using a gamma counter, follow the standard counting protocols for that instrument.
6) Set-up the instrument to count in the spectrum of the isotope known or suspected to be present. Multiple isotopes must have distinct energy spectrums to permit differentiation. Segregate liquids by radioisotope to facilitate analysis.
7) If a liquid waste carboy contains multiple isotopes that are not easily differentiated by analysis, the sample should be analyzed by full spectrum counting. The analysis sheet should list all the isotopes in the container and the total activity.
8) Count a background sample and the prepared sample for the appropriate minimum counting time. A minimum counting time of 1 minute should be used for radioactivity analysis or sewer disposal. Liquid release evaluations require longer counting times, see section 5.3 for details.
9) Perform radioactivity calculations as described on the analysis form or as automatically provided by the electronic application.

5.3 Evaluation of Liquids for Release

If you generate liquids that contain very low concentrations of certain radioisotopes you may evaluate these liquids for release in accordance with the regulations for liquid effluents. Each individual radioisotope has its own release limit. The action levels provided only include those radioisotopes commonly used on campus that have release limits easily detected by liquid scintillation counting.

The UGA ALARA action levels for release of liquids represent 20% of the liquid effluent release values permitted by the Nuclear Regulatory Commission (NRC) in accordance with 10 CFR 20, Appendix B, Table 2, Column 2. These values on based solely on the concentration (µCi/ml) of radioactivity in the liquid. This very low level of radioactivity is considered safe for release as a liquid effluent. NRC models show that if a person were continually exposed to this level of radioactivity their annual exposure would only increase by 10 mrem in an entire year.

These effluent releases may be performed by sink disposal if the liquid is non-hazardous, aqueous, and biodegradable. Liquid effluents released at these very low concentrations of radioactivity are not required to be discharged directly into the sanitary sewer system or tracked in the same manner as

sewer disposals (see Section 5.5). Unlike specifically permitted sewer disposal, all Authorized Users are eligible to perform these releases.

Appropriate records must be kept to provide verification that the releases are performed in accordance with the regulations. **If you have any doubt about whether or not a liquid is suitable for release, you should consider the liquid to be radioactive, perform analysis as described in section 5.4, and arrange for a pick-up by Radiation Safety.** In addition, if Radiation Safety determines that liquid releases are not being performed properly by an Authorized User, the option to use this disposal method may be revoked at the discretion of the RSO.

Table 5.3 provides a list of some typically used isotopes and their respective liquid release ALARA action levels in units of µCi/ml and in dpm/ml. These values should be used to evaluate the proper disposal route for liquid waste.

Table 5.3
Liquid Release ALARA Action Levels

Isotope	Liquid Release ALARA Action Level (µCi/ml)	Liquid Release ALARA Action Level (dpm/ml)	Counting Method	Standard Counting Efficiency	Liquid Release ALARA Action Level (cpm/ml)
H-3	2.00E-4	444 dpm/ml	LSC	0.35	155 cpm/ml
C-14	6.00E-6	13 dpm/ml	LSC	0.85	11 cpm/ml
S-35	2.00E-5	44 dpm/ml	LSC	0.85	37 cpm/ml
P-33	1.60E-5	35 dpm/ml	LSC	0.85	30 cpm/ml
P-32	1.80E-6	4 dpm/ml	LSC	0.98	4 cpm/ml

The isotopes I-125 and I-131 are not suitable for release in this manner, due to the very low limits for release of these isotopes. Release limits for other radioisotopes not listed in Table 5.3 may only be approved by the RSO on a case by case basis.

Liquid Release Evaluation Procedure

1) The *Liquid Release Evaluation* form must be completed in an electronic format to ensure consistent performance and eliminate the need to check for mathematical errors. The electronic format must be approved by the RSO and obtained from Radiation Safety. After the electronic form is completed, it must be printed and signed. A signed copy is required as a record of disposal.

2) If the electronic format *Liquid Release Evaluation* form is not available for use, sample analysis should be performed and documented on the form *Liquid Radioactivity Analysis.* This version of the form includes the same analysis information but excludes the ALARA action level comparison and does not allow for disposal by release. To use this method, see section 5.4.

3) Collect a representative sample of the liquid waste in accordance with section 5.2. The sample volume must be adequate to ensure that the required minimum detectable activity is met, as shown in the table below.

4) Add the appropriate amount of scintillation fluid for use with your counting instrument to the vial containing the liquid waste sample.

5) Analyze a background sample and the prepared liquid waste sample for a counting time that is adequate to meet the required minimum detectable activity. Examples of suitable sample volumes, instrument background levels, and minimum counting times are specified in the following table.

Radioisotope	Sample Volume	Maximum Background	Minimum Counting Time
H-3, S-35, P-33	1 ml	50 cpm	5 minutes
H-3, S-35, P-33	2 ml	50 cpm	1 minute
C-14	1 ml	50 cpm	20 minutes
C-14	2 ml	50 cpm	10 minutes
P-32	2 ml	75 cpm	30 minutes
P-32	3 ml	75 cpm	15 minutes

6) Complete the required data on the *Liquid Release Evaluation* form. The form will automatically calculate the sample activity. An automatic comparison of sample results to the ALARA action levels for release will also be performed. One of the following 2 options will be indicated on the form:

- If the sample results are less than the ALARA action levels for release of liquids, the electronic form will indicate that the liquid in the container is suitable for release. The liquid may be disposed of as appropriate for its physical and chemical properties. This will typically be sink disposal if the liquid is biodegradable, aqueous, and non-hazardous. If the liquid has hazardous or other constituents that make it inappropriate for sink disposal, it may be disposed of via the normal (non-radioactive) disposal route for that liquid.
- If the sample results exceed the ALARA action levels for release, the electronic form will indicate that the liquid is NOT suitable for release. Use the *Liquid Release Evaluation* form to label the container and store it until a pick-up is scheduled with Radiation Safety. See section 7.0 for waste pick-up information.

7) If the liquid is not suitable for release, the following actions are required:

- Perform a contamination survey of the exterior of the container and record the results in the space provided on the form. Contamination levels on containers must not exceed 1000 dpm/100 cm^2. Contaminated containers should be decontaminated and resurveyed as described in the *Laboratory Procedures* chapter of this manual.
- Perform a radiation dose rate survey of the exterior surface of the waste container and record the results in the space provided on the form. If the contact dose rate exceeds 0.5 mrem/hr, notify Radiation Safety of the dose rate on the container when you request a pick-up. The Radiation Safety staff will verify the radiation dose rates and provide appropriate labeling for the container at the time of pick-up.

8) Sign and date the form in the space provided. Release evaluation paperwork should only be completed by, or under the supervision of, an Authorized User or Advanced Radworker.

9) Notify Radiation Safety when a container is ready for pick-up and attach the *Liquid Release Evaluation* form to the container.

10) **If disposal is performed by release, you must provide a copy of the completed *Liquid Release Evaluation* form to Radiation Safety.** When used, *Liquid Release Evaluation* forms should be sent to Radiation Safety in conjunction with monthly Radiation Surveys.

5.4 Liquid Radioactivity Analysis for a Waste Pick-up

Use the *Liquid Radioactivity Analysis* form to document the analysis of a liquid waste sample. The results of this analysis will be used to label the container in order to facilitate proper transportation, storage, and disposal of the liquid by Radiation Safety.

1) The *Liquid Radioactivity Analysis* form should be completed in an electronic format for increased efficiency. The electronic format must be approved by the RSO and obtained from Radiation Safety. After the electronic form is completed, it must be printed and signed. A signed copy is required for labeling the container.

2) If the electronic format *Liquid Radioactivity Analysis* is un-available or is not being used for any reason, sample analysis may still be performed and documented on the form. Radioactivity calculations will have to be performed manually. Contact Radiation Safety for assistance if needed.

3) Collect a representative 1 ml sample of the liquid as described in section 5.2.

4) Count a background sample and the prepared liquid waste sample for a minimum of 1 minute in an appropriate counter.

5) Complete the required data on the *Liquid Radioactivity Analysis* form. The electronic version of the form will perform the required mathematical calculations automatically.

6) Perform a contamination survey of the exterior of each container and record the results in the space provided on the form. Contamination levels on containers must not exceed 1000 dpm/100 cm^2. Contaminated containers should be decontaminated and resurveyed as described in the *Laboratory Procedures* chapter of this manual.

7) Perform a radiation dose rate survey of the exterior surface of the waste container and record the results in the space provided on the form. If the contact dose rate exceeds 0.5 mrem/hr, notify Radiation Safety of the dose rate on the container when you request a pick-up. The Radiation Safety staff will verify the radiation dose rates and provide appropriate labeling for the container at the time of pick-up.

8) Sign and date the form in the space provided. Waste container paperwork should only be completed by, or under the supervision of, an Authorized User or Advanced Radworker.

9) Notify Radiation Safety when a container is ready for pick-up and attach the *Liquid Radioactivity Analysis* form to the container.

5.5 Sewer Disposal Permits

1) Sewer disposal permits allow the controlled release of low levels of liquid radioactive materials in concentrations that are higher than the limits of Table 5.3. Sewer disposal permits will be limited to Authorized Users who show the need to conduct these releases.

2) Sewer discharge is only allowed into public sanitary sewerage systems. Private systems, septic tanks, or leach fields shall not be used for disposal of radioactivity at these levels.

3) Except as listed in section 5.3, no radioactive materials may be disposed of by sewer disposal without specific approval in the Radioactive Materials Permit of the Authorized User. When such disposal is approved, records must be maintained listing the isotope, amount, and date of disposal.

4) When approved for a sewer disposal permit, sewer disposal records must be submitted to Radiation Safety <u>every</u> month. Since sewer disposals are tracked on a monthly basis, sewer

disposal records are required to be submitted regardless of the amount of disposal that occurred. Even if the sewer disposal value is zero, monthly reporting is required.

5) Approved concentrations for disposal will generally not exceed 0.05 microcuries per milliliter. The standard activity limits are as follows: 500 µCi for H-3, 100 µCi for C-14, and 100 µCi for all other isotopes combined. Sewer disposal of radioactive iodine (I-125/131) or other isotopes in toxicity groups 1 or 2 (see Chapter 4, Table 3.1) is generally prohibited. In the event that sewer disposal of a non-standard isotope or quantity is requested the RSO and RSC will evaluate the request on a case by case basis.

6) Liquids pending disposal in accordance with a sewer disposal permit should be consolidated in a standard liquid waste container (carboy) or equivalent.

Sewer Disposal Procedure

1) The *Sewer Disposal Log* should be completed in an electronic format for increased efficiency. The electronic format must be approved by the RSO and obtained from Radiation Safety.

2) If the electronic format *Sewer Disposal Log* is un-available or is not being used for any reason, sample analysis may still be performed and documented on the form. Radioactivity calculations will have to be performed manually. Contact Radiation Safety for assistance if needed.

3) Collect a representative 2 ml sample of the liquid as described in section 5.2.

4) Count a background sample and the prepared liquid waste sample for a minimum of 1 minute in an appropriate counter.

5) Enter the required data on the *Sewer Disposal Log.* The electronic version of the form will perform the required mathematical calculations automatically.

6) If the sample results exceed the limits in your sewer discharge permit (either the µCi/ml or total µCi), do not proceed with sewer discharge. Delete the entry from your *Sewer Disposal Log* and use the *Liquid Radioactivity Analysis* form to document the analysis. Complete all the information on the *Liquid Radioactivity Analysis* form as described in section 5.4. Use the *Liquid Radioactivity Analysis* form to label the container and schedule a waste pick-up with Radiation Safety.

7) When all sewer disposals for the month are completed, the electronic form must be printed and signed. A signed copy is required as a record of disposal. Laboratory copies may be maintained in either electronic or hard-copy format.

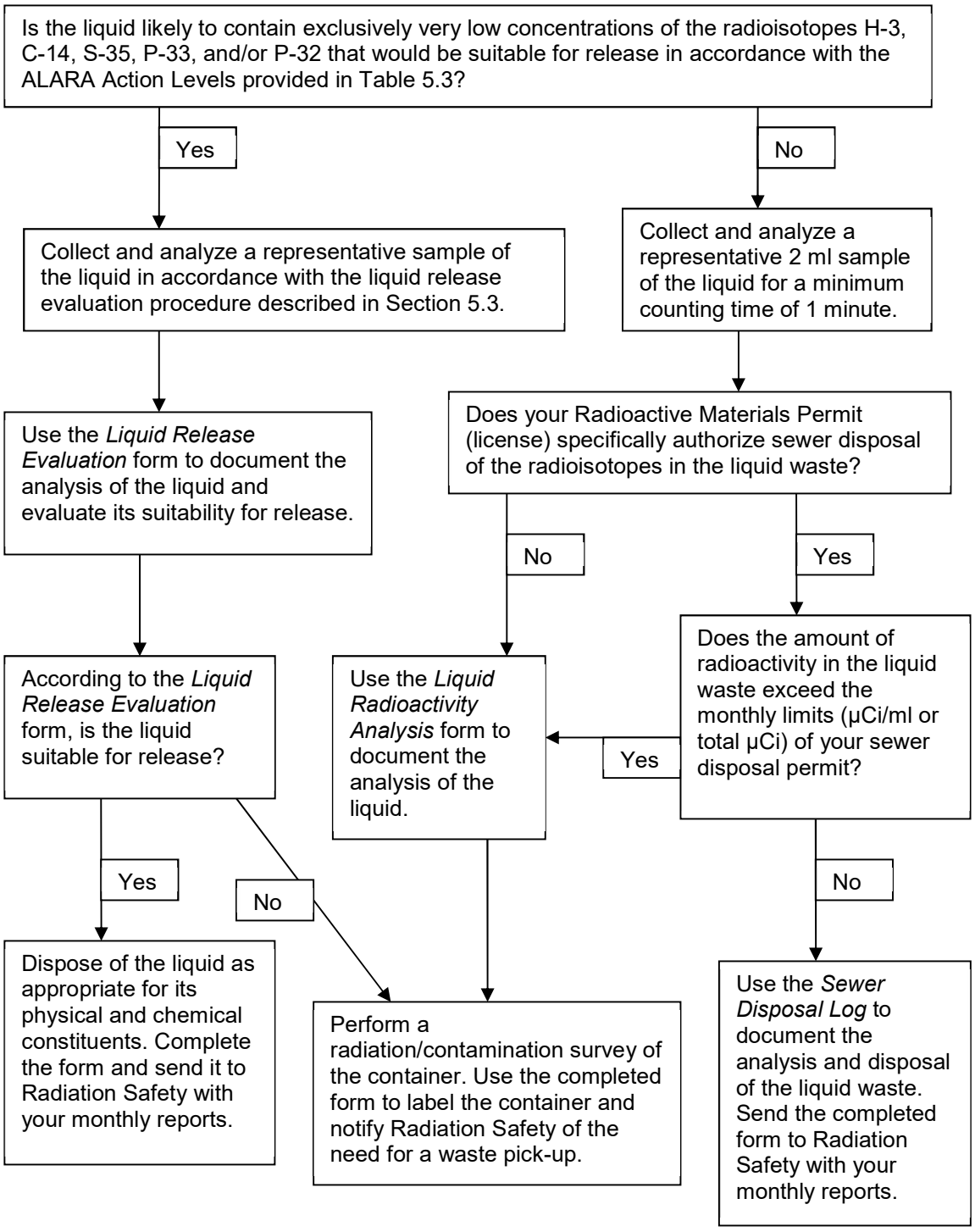
8) Send the completed *Sewer Disposal Log* to Radiation Safety in conjunction with your monthly radiological survey. If no sewer disposal is performed for the current month this should be noted in the space provided on the *Radiological Survey Form*.

9) Sewer disposal shall be performed only at designated locations in posted Radioactive Materials Areas.

10) Discharge liquid waste slowly to minimize splashing with water running to be sure that the material moves out of the sink and into the sewer system.

11) Survey the sink and surrounding work surfaces to confirm that no residual material or contamination remains in the sink or on the work surfaces. Decontaminate as appropriate.

Flow Chart for Evaluation and Disposal of Liquid Waste



6.0 WASTE PICK-UPS

Used radioactive materials collected from University laboratories are taken to the UGA Hazardous Materials Treatment Facility (HMTF). There they are classified and placed in one of several channels for disposal. **Used radioactive materials are not officially designated as radioactive waste until they have been received at HMTF and classified**. Channels of disposal include storage for decay, evaporation, solidification, incineration, sewer, and compaction for shipment to a commercial disposal site.

Full radioactive waste containers are not allowed to accumulate in a laboratory. Contact Radiation Safety and schedule waste pick-ups to prevent accumulation of full containers in work locations.

6.1 Preparing for Pick-Up

- Verify that each individual container has either a *DAW Container Log,* a *Liquid Radioactivity Analysis* form, or a *Liquid Release Evaluation* form attached.
- Make sure that the paperwork contains all required information. Complete each section of the forms.
- Perform a contamination survey of the exterior of each container. Contamination levels on containers should be less than 200 dpm/100 cm^2 and must not exceed 1000 dpm/100 cm^2. Contaminated containers should be decontaminated and resurveyed as described in the *Laboratory Procedures* chapter of this manual.
- Perform a radiation dose rate survey of the exterior surface of the waste container. If the contact dose rate exceeds 0.5 mrem/hr, notify Radiation Safety of the dose rate on the container when you request a pick-up. The Radiation Safety staff will verify the radiation dose rates and provide appropriate labeling for the container at the time of pick-up.
- Sign and date the forms in the space provided. Waste container paperwork should only be completed by, or under the supervision of, an Authorized User or Advanced Radworker.

6.2 Scheduling and Performance of Waste Pick-Ups

- Notify Radiation Safety of your need for a waste pick-up. You will need to specify the isotopes, type of material, and number of containers.
- Radioactive materials pick-ups will generally be on the Thursday following your call. The date and time of pick-up will be provided when you request the pick-up.
- Escort packaged materials to the loading dock of your building. **Do not leave radioactive materials un-attended**.
- Improperly packaged materials will not be picked up. If radioactive materials are discovered to have been improperly packaged or labeled after pick-up, the Authorized User will be responsible for repackaging the waste.

7.0 ATTACHMENTS

DAW Container Log (example)

Liquid Release Evaluation (example)

Liquid Radioactivity Analysis (example)

Sewer Disposal Log (example)