STATE OF DELAWARE

Guidance for Feasibility Studies (FS) under the Hazardous Substance Cleanup Act (HSCA)

Final

State of Delaware
Department on Natural Resources and Environmental Control (DNREC)
Division of Waste & Hazardous Substances
Remediation Section
391 Lukens Drive
New Castle, DE 19720
(302) 395-2600
(302) 395-2601 FAX
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1.0 INTRODUCTION

This Guidance describes the steps that should be followed to perform a Feasibility Study (FS) and a Focused Feasibility Study (FFS) at Sites being addressed under the Hazardous Substance Cleanup Act (HSCA). This guidance supersedes where applicable, the HSCA Guidance (1994), and Presumptive Remedy Policy (2007). Prior written approval by DNREC should be acquired before deviating from this Guidance.

A FS or FFS is performed after a Risk Assessment has determined that contamination on a Site poses an unacceptable risk to human health or the environment and there is a complete pathway from the source to a receptor (present or future). The purpose of the FS or FFS is to identify and screen remedial technologies, develop, and evaluate each Remedial Action alternative using technologies carried through the initial screening, and recommend the Remedial Action most appropriate for the Site based on the Remedial Action Objectives. The submitted report should include, at a minimum, the sections detailed in Appendix A. Additional details for each section can be found in the corresponding section in this guidance.

2.0 FEASIBILITY STUDIES AND FOCUSED FEASIBILITY STUDIES

A Feasibility Study (FS) means an evaluation to identify the potential remedial alternatives that are applicable to satisfy the remedial action objectives for the site. A FS evaluates multiple remedial alternatives, and the scope is dependent upon the complexity of the remedial action needed at the site.

A Focused Feasibility Study (FFS) is a scaled-down version of a FS. A FFS must evaluate a minimum of three different remedial alternatives including the no action alternative and two alternatives involving two different technologies for each impacted media.

All Sites, regardless of program, are going to submit either a FS or FFS in order to justify any recommended remedial action. A FS or FFS is not anticipated to be submitted if there is an acceptable risk for all media under a residential use scenario. DNREC recommends submitting the RI/BFI Report up to the completed risk assessment prior to beginning the FS/FFS portion of the report.

2.1 DETERMINATION OF FFS OR FS

For most of the sites under HSCA, a FFS may be sufficient. A full FS should be considered for sites with extensive contamination in multiple environmental media, where multiple remedial technologies are feasible, and a detailed evaluation is recommended for the selection of the preferred remedial alternative (which may be a remedial technology or a combination of multiple technologies.) DNREC-RS will consider these on a site-specific basis.

3.0 REPORT FORMAT

The FS/FFS can be incorporated into the RI/BFI Report and approved as one document which is DNREC's preference. DNREC also recommends submitting the RI/BFI Report up to the completed risk assessment prior to beginning the FS/FFS portion of the report. Separating the RI/FS into two documents should be based on the complexity of the Site and needs prior approval from the DNREC Project Officer.

4.0 REPORT INTRODUCTION

The information in this section should be summarized from the previous investigations. If the FS is submitted as a standalone document, at a minimum include the following described below in the introduction. If FS is submitted in the BFI or RI Report, this section refers to where the information is located in the BFI or RI Report.

Site Description

The Site description includes, but is not limited to, the following information: address, county, approximate acreage, number of parcels, tax parcel identification numbers, number/locations of buildings, surrounding property uses, and identification of any nearby regulated properties regulated under HSCA, RCRA, etc.

Site History

This section should provide a complete history, including, but not limited to, previous types of operations on the Site and identified sources of past contamination.

Previous Investigations

This section includes, but is not limited to, name, date, and summary of the findings of all significant previous investigations. The text should reference the previous report(s) for full details of the previous investigations.

Nature and Extent of Contamination

This section summarizes the location, impacted media, contaminants of concern and include maps from the previous investigations that show the extent of the contamination for all the impacted media. In addition, the updated and revised conceptual Site Model (CSM) for the site needs to be discussed.

Risk Summary

This section includes a discussion of the exposure pathways that were evaluated, risk populations, current property usage, expected future use and identified unacceptable risk that is requiring remediation.

5.0 REMEDIAL ACTION OBJECTIVES

Remedial Action Objectives (RAOs) are developed to meet the objective of protecting human health and the environment with consideration to the current and future use of the site. This includes potential ecological receptors.

Both qualitative and quantitative RAOs must be established specific to each Site medium and should address both chemical concentrations and potential exposure pathways. Protection can be achieved by reducing the mass, volume, toxicity, or mobility of COCs; by reducing or preventing potential exposures; or by a combination of these approaches.

The RAOs for the Site shall consider:

- Protection of public health, welfare, and the environment,
- Compliance with applicable, relevant, and appropriate requirements (local, state, and federal),
- Use and level of contamination of surrounding properties,
- Site specific human and ecological risk assessment,
- Cost-effective remediation of the Site consistent with planned future land use,
- Remedial Action which limits or eliminates LTS whenever practicable, cost-effective, and consistent with planned future land use, and
- Removal or reduction of source areas of contamination at sites with actual or potential offsite migration of contaminants that may impact potential receptors.

Qualitative Objectives

Describes the remedial action objectives that cannot be quantitatively defined. Future use of the Site and specific threats to public health, welfare, and the environment should be addressed in non-quantifiable terms (e.g., prevention of exposure to trespassers or restoration of habitat).

Quantitative Objectives

Describes the remedial objectives where performance measures may be a targeted percentage or numerical value. Quantitative objectives arise from the risk assessment or post-Remedial Action acceptable risk levels.

DNREC may determine whether performance measures for the defined objectives are appropriate for evaluating the proposed remedial technology's performance in achieving those objectives. Performance measures may be appropriate when developing and evaluating alternatives as described in Section 7.0.

The presentation of the differences between alternatives can be measured qualitatively or quantitatively. Substantive differences between the alternatives should be identified (e.g., greater short term effectiveness concerns, greater cost, etc.) when evaluating alternatives as described in Section 7.0.

6.0 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARs) AND PERMIT REQUIREMENTS

HSCA regulations require that RAOs are developed by considering, among other things, Applicable or Relevant and Appropriate Requirements ("ARARs") which include permit requirements and must be evaluated as part of the FS. The list of possible ARARs should be identified in investigations including Remedial Investigations (RI), Certified Brownfield Investigation (BFI), etc. The DNREC requirement to follow ARARs are based on EPA legal requirements. The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), Section 121(d), requires that on-Site Remedial Actions attain or waive federal environmental ARARs, or more stringent state environmental ARARs, upon completion of the Remedial Action. The 1990 National Oil and Hazardous Substances Pollution Contingency Plan (NCP) also requires compliance with ARARs during removal and Remedial Actions to the extent practicable.

Applicable Requirements: Cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under local, state, or federal environmental laws that specifically address a hazardous substance, pollutant, contaminant, Remedial Action, location, or other circumstance found at a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Site.

Relevant and Appropriate Requirements: Cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under local, state, or federal environmental laws that, while not applicable to a hazardous substance, pollutant, contaminant, Remedial Action, location, or other circumstance at CERCLA Site, addresses problems or situations sufficiently similar to those encountered at the Site that their use is well-suited to the particular Site.

ARARs typically are separated into three categories:

1. Chemical-specific ARARs: These are health-based or risk-based standards that define the allowable limits of specific chemical concentrations found in or discharged to the environment for each medium. They can provide cleanup, exposure, and discharge levels that can determine Site remedial goals. Most chemical specific ARARs are applicable to water sources potentially used for drinking water; few are available for ambient air or soil. MCLs for drinking water are examples of potential chemical specific ARARs.
2. Location-specific ARARs: These requirements can apply to natural Site features, such as wetlands, flood plains, or the presence of endangered species, and to man-made features and institutional factors, including landfills, zoning, and places of historical or archaeological significance. Location-specific ARARs restrict the types of Remedial Actions implemented based on Site-specific characteristics, applicable siting laws, or location. Location specific requirements must be addressed during the formulation and evaluation of potential location specific remedies.
3. Action-specific ARARs: These ARARs are technology-based or activity-based limitations that can set performance and design restrictions. They specify permit requirements and engineering controls that must be instituted during Site activities or restrict particular activities.

The ARAR evaluation is used to determine whether each alternative can meet all its Federal and State ARARs (as defined in CERCLA Section 121) that have been identified in previous stages of the RI/FS process. The detailed analysis should summarize which requirements are applicable or relevant and appropriate to an alternative and describe how the alternative meets these requirements. When an ARAR is not met, the basis for justifying the waivers allowed under HSCA should be discussed. EPA identifies six different waivers (see Section 1.2.1.1 of the EPA CERCLA) for ARARs. DNREC accepts four (4) different waivers which require DNREC pre-approval. These waivers are identified below.

1. The Remedial Action selected is only a part of a total Remedial Action (interim Remedial Action) and the final Remedial Action will attain the ARAR upon its completion.
2. Compliance with the ARAR will result in a greater risk to human health and the environment than alternative options.
3. Compliance with the ARAR is technically impracticable from an engineering perspective.
4. An alternative Remedial Action will attain an equivalent standard of performance through the use of another method or approach.

DNREC recognizes the ARARs, and Permits listed in the section below. This list is not intended to be exhaustive. Other ARARs may apply that are not listed below. The HSCA consultant is responsible for determining applicable ARARs or Permits. The ARARs below should be considered, and a summary table should be included in the report identifying which do and do not apply with rationale. An example table is located in Appendix C.

1. Federal ARARs
    a. RCRA- Resource Conservation and Recovery Act of 1976. (42 U.S.C. §6901 et seq.)
    b. TSCA- Toxic Substances Control Act of 1976 (15 U.S.C. §2601 et seq.)
    c. Clean Air Act- 42 U.S.C. 7401 et seq. (1970)
    d. Clean Water Act. -33 U.S.C. § 1251 et seq. (1972)
        i. Total Maximum Daily Load (TMDL)
    e. OSHA- Contaminated Material Management Plans must conform to OSHA regulations- 29 U.S.C. §651 et seq. (1970)
    f. Wetlands
    g. Other
2. State of Delaware ARARs
    a. Hazardous Waste Regulations. Permits may be necessary for soil and groundwater disposal. (7 DE Admin. Code 1302)
    b. UST/AST Regulations- (7 DE Admin. Code 1351, 7 DE Admin. Code 1352)
    c. Stormwater Regulations - Permits may be required for discharges. E&S requirements for soil disturbing more than 1 acre. Examples include · Sediment and Stormwater Permit (DE 2011-012) (7 DE Admin. Code 5101)
    d. State Water Regulations- Possible permits include-Underground Injection for adding chemicals into the ground, Discharge permit for dewatering or after treatment, permit for installing wells, groundwater grab samples, and any borings

including MIP-HPT, LIF, etc. that penetrate the water table. (7 DE Admin. Code 7102)

e. Drinking Water Regulations (16 DE Admin. Code 4462)
f. Surface Water Regulations- Subaqueous Land Permits may be required for any disturbance in a river (sediment remediation and/or dredging) (7 DE Admin. Code 7504). Surface water discharge permits may be required for dewatering or other water removal exercise (large industrial sumps and other subsurface structures, pits, basements, etc.). (7 DE Admin. Code 7303)
g. State Air Regulations-Permits may be required for treated air such as from Soil Vapor Extraction Systems, Vapor Intrusion Vent Risers, or any discharge to the air. (7 DE Admin. Code 1100)
h. Department of Health- Pre-Authorization may be required for treating public water.
i. Wetlands – Permit required to construct, expand, or extend in a regulated wetland (7 DE Admin. Code 6604, (7 DE Admin. Code 6605)
j. Subaqueous Lands Permit - SP-462/15 (7 DE Admin. Code 7205)
k. Critical Habitats/Endangered Species - (7 DE Admin. Code 601)
l. DelDOT- Typically require a permit for work in rights-of-way.

3. Local ARARs- City or County may require Wastewater Permits for discharges to storm or sanitary sewers. Construction on any floodplain may require a permit for example· Floodplain Permit NCC Application #20150476
4. Other

7.0 DESCRIPTION AND DETAILED ANALYSIS OF ALTERNATIVES BY MEDIA

Provide DNREC with the identified and screened remedial technologies and consult with DNREC prior to selecting alternatives for analysis. Remedial Actions will be warranted for those media identified in a Remedial or Brownfield Investigation report as containing releases of hazardous substances, the exposure to which poses an unacceptable human health and/or environmental risk. Typically, there are multiple Remedial Action alternatives that will mitigate the unacceptable risk(s). This section must include a detailed description of each Remedial Action alternative under consideration, as well as a detailed evaluation as to what extent each alternative meets the Threshold and Balancing Criteria. Prior to proceeding with the evaluation, consult with DNREC regarding the proposed remedial alternatives.

7.1 DESCRIPTION OF ALTERNATIVES

The section should include a description of the technological and administrative components of each Remedial Action alternative, as well as a discussion of the scientific basis for inclusion as a consideration. This section should be included for all alternatives being evaluated. Each alternative description should include the basis for the component (i.e., area to be treated, volume to be treated, depth of treatment, thickness of capping, flow rate, etc.) that inform cost development.

7.2 THRESHOLD CRITERIA

Threshold criteria are requirements that each alternative must meet in order to be eligible for evaluation under balancing criteria. If the alternative, including the no action alternative, does not meet all threshold criteria, it will not be considered further. The criteria are to address whether the alternative is adequately protective in the long and short term; as well as address the elimination, reduction, and/or control of risks for each alternative pathway.

Threshold criteria are:

1. Protection of public health, welfare, and the environment
2. Attainment of Remedial Action objectives (RAO)
3. Control sources of contamination

Feasibility studies performed in accordance with CERCLA have typically required a no action alternative be evaluated through the entire process. DNREC recommends eliminating this alternative from further evaluation after evaluating the threshold criteria if applicable.

7.2.1 PROTECTION OF PUBLIC HEALTH, WELFARE, AND THE ENVIRONMENT

Remedial alternatives should include protection against environmental factors that may adversely impact public health, ecological balances essential to long term public health, and environmental quality, whether in the natural or human-made environment. Factors include but are not limited to soil; air; water contaminants, chemicals, wastes, and habitat alterations.

Remedial alternatives should consider ecological/welfare impacts in addition to human health impacts and consider the following: loss of critical habitat or ecosystem, reduced quality of an environmental resource, potential adverse economic impacts, social nuisances, or decreased human utility.

For more information regarding ecology and welfare impacts, please review the EPA's Appendix A of The Report of Ecology and Welfare Subcommittee Relative Risk Reduction Project (Sept. 1990) found at: https://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=P100L4CE.txt

7.2.2. ATTAINMENT OF REMEDIAL ACTION OBJECTIVES

The ultimate goal of the Remedial Action is one that is protective of public health, welfare, and the environment, that maintains protection over time, and that minimizes the generation of additional Hazardous Waste. To determine if attainment has been achieved, many questions will need to be addressed including: Will the implementation of the defined RAOs be able to attain the medium-specific or Site-specific goals for cleanup? Use statements to describe expected timeframes and the extent of cleanup that will be attained or likely be attained for the following:

1. Media of interest (soil, groundwater, etc.)
2. Types of contaminants (chemical constituents)
3. Potential receptors (human, ecological, current, future)
4. Exposure pathways (direct contact, ingestion, inhalation, etc.)

The RAO must take into consideration any applicable, relevant, and appropriate local, state, and federal laws.

7.2.3. CONTROL SOURCES OF CONTAMINATION

Controlling sources of contamination refers to the preference for a Remedial Action that provides protection by reducing mass, volume, toxicity, or mobility of contamination, by reducing potential exposure, or by a combination of approaches. As applicable, for each alternative evaluate:

- The type and quantity of contaminants treated, removed, or destroyed by volume.
- The type and quantity of contaminant residuals remaining after treatment
- The degree to which treatment is irreversible.
- The movement or control of contaminants through and/or between media.
- Any changes in toxicity. Provide models to demonstrate effectiveness.

7.3. BALANCING CRITERIA

Balancing criteria provide a way to compare alternatives based on criteria deemed appropriate by DNREC. Each alternative should be compared against each balancing criterion. Based on this evaluation, some ranking should be assigned for each alternative with regards to that balancing criterion. Those balancing criteria include:

1. Incorporation of sustainability principles
2. Reduction of contaminant toxicity, mobility, or volume
3. Comments or input from the community in which the facility is located
4. Ease of implementation
5. Short-term effectiveness
6. Long term effectiveness
7. Life-cycle costs

While it is DNREC's preference that a numeric system is utilized for this ranking, DNREC can allow, with prior approval, other ranking systems as long as they are internally consistent and clearly defined in the FS report.

The current DNREC recommendation regarding a numeric system is to assign each alternative an integer score of 0, 1, 2, or 3 for each of the seven balancing criteria. The score should consider how well the alternative meets the balancing criteria, in addition to how it compares to other alternatives. If the alternative does not meet the criterion, a 0 should be assigned. If the alternative does meet the criterion in its entirety, a 3 should be assigned. Within a criterion, multiple alternatives may receive the same score if applicable. For example, assume a situation where, Alternative A meets the criterion in its entirety, Alternative B/Alternative C meet the criterion to a lesser degree but comparatively the same to each other, and Alternative D fails to meet the criterion. In this case an appropriate score may be A is 3, B is 2, C is 2, and D is 0. An example table depicting the balancing criteria evaluation process is included below.

Balancing Criteria	Alternative A	Alternative B	Alternative C	Alternative D
Incorporation of Sustainability Principles	3	2	2	0
Reduction of Toxicity, Mobility, Volume	3	3	2	0
Comments or Input From the Commmunity	3	3	2	0
Ease of Implementation	3	3	2	0
Short-term Effectiveness	3	3	2	0
Long-term Effectiveness	3	3	2	0
Life Cycle Costs	3	3	2	0
Summation	21	20	14	0

Once all alternatives have been evaluated and scored for each criterion, the scores for each alternative should be summed. Any alternatives that have a total number within 10% of the maximum summed score will be considered equally effective. Alternatives below 10% of the maximum summed score are considered not as effective and should be eliminated. For example, if the maximum summed score is 21, 10% is 2.1, and any alternatives with summed scores below 18.9 should be eliminated.

7.3.1 INCORPORATION OF SUSTAINABILITY PRINCIPLES

Sustainability principles as they relate to evaluation of alternatives are those that allow for more efficient use of resources or minimize waste of resources. Examples include but are not limited to low energy inputs, restoration of habitats, preservation of cultural resources, land reuse, materials recycling, infrastructure reuse, reduce runoff, and permanence and protectiveness without an environmental covenant.

For each remedial alternative, the impact on its surrounding environment, including natural habitats and cultural resources must be evaluated. See the sustainability guidance from the Interstate Technology Regulatory Council (ITRC), Sustainable Resilient Remediation (April 2021) for a framework and tools that may be used to perform this evaluation. Remedial alternatives that have a net positive benefit to their surroundings (more sustainable) are to be considered more favorably to those with a detrimental impact or no impact. For example, the incorporation of native plants in Site restoration would be more favorable than the use of non-native plants and Remedial Actions which utilize native plants would be ranked higher than those which do not. In addition, those alternatives with a lower impact with respect to sustainability will be favored over those with a high impact. For example, those alternatives that use less energy are favored, and those than generate less emissions are favored. Minimizing emissions, notably of greenhouse gases, is consistent with the State of Delaware's expressed commitment to making strides in planning for climate change impacts as documented in the Climate Action Plan issued in November 2021. Some alternatives by nature will not have a net positive and as a result, the minimizing of negatives is preferred. The potential for the reuse and recycling of land, infrastructure, and materials should also be made a priority in Remedial Action implementation. If any of these are an option, they are to be considered more favorably than implementation that requires gross consumption of raw materials, maintains, or expands the footprint of the Site contamination, or requires the construction of new infrastructure.

When contamination is left in place such that exposure to it could cause an unacceptable risk, there are long-term stewardship (LTS) obligations associated with ensuring the continued integrity of the implemented Remedial Action(s) such that it remains protective of public health, welfare, and the environment. One of those obligations includes the implementation of institutional controls. For example, the environmental covenant outlines the Site use and/or activity restrictions in effect, often in perpetuity, due either to the contaminant concentrations, and extent of the contamination remaining in place. Preference will be given to those Remedial Action alternatives with the fewest LTS obligations so that the Site can be utilized with as few restrictions as possible, e.g., onsite destruction of contamination may be more favorable than capping it in place based on the reduction of LTS obligations and its permanence/protectiveness without an environmental covenant.

7.3.2 REDUCTION OF CONTAMINANT TOXICITY, MOBILITY, OR VOLUME

Alternatives are preferred if they reduce the toxicity, mobility, or volume of a hazardous substance released into the environment. This includes reducing the toxicity of a hazardous substance by mixing it with an additive which will transform the substance to a less toxic or non-toxic form or render it immobile. It also includes physically reducing the quantity of a hazardous substance release.

This section of the FS should also consider how certain remedial technologies can result in detrimental transformation which may make an alternative a less favorable option. For example, some remedial technologies can impact Per-and Polyfluoroalkyl Substance (PFAS) contaminated groundwater and cause negative effects. Oxidative technologies such as in situ chemical oxidation may transform polyfluorinated precursors into more mobile PFAS compounds such as PFOS and PFOA (Merino et al 2016). Air stripping, which is often applied to remove chlorinated solvents from extracted groundwater, may result in PFAS being released as aerosols (Oliaei et a. 2013). Please see www.clu-in.org for additional information on remedial technologies.

7.3.3 COMMENTS OR INPUT FROM THE COMMUNITY IN WHICH THE FACILITY IS LOCATED

Community concerns and input shall be considered regarding the advantages and disadvantages of various remedial approaches while proposing the remedial alternatives. If no input is provided at the time of the FS, then all alternatives should be weighted the same and DNREC recommends assigning each alternative a value of 2 (or ranking equivalent). If input is provided, the score assigned should include justification based on input. The community will have the opportunity to comment during the Proposed Plan of Remedial Action comment period and these comments should be addressed regarding the remedial alternatives.

7.3.4 EASE OF IMPLEMENTATION

When discussing the ease of implementation, the technical feasibility should be discussed. This includes a discussion of unknowns or issues with implementing the alternative. It also should discuss if the technology has a demonstrated history of effective use and if the alternative needs to be modified, how easily this could be done, if applicable. Please refer to the ARAR section for

details on waivers. Finally, a discussion of how easily the impacts of the alternative could be monitored and the methods used to monitor the implementation should be included.

The administrative feasibility should also be discussed. For example, identifying any permits that would be required or any access related issue both on and off Site that may be encountered. Please see the ARAR section above for more details on possible permits that may be required. The administrative feasibility should also include the availability of required materials. An example of something to include would be if a necessary piece of equipment must be brought in from out of state. This also applies to services. The availability of specialists or facilities required to implement the alternative should be included. The exact pieces of information required will be dependent on the alternative being evaluated.

7.3.5 SHORT-TERM EFFECTIVENESS

The short-term effectiveness evaluation criteria address the effects of the alternative during the completion of a short-term remedial action (like excavation) or the initial establishment of a long-term remedial action (such as installing an SVE system, installing a pump and treat system, installing a surface cap, etc.) .

Alternatives should be evaluated with respect to their impact on public health, welfare, and the environment during Remedial Actions.

As appropriate, the following factors should be addressed for each alternative:

- Protection of the community during Remedial Actions
- Protection of workers during Remedial Actions
- Environmental impacts
- Time until remedial response objectives are achieved

7.3.6 LONG-TERM EFFECTIVENESS

The long-term effectiveness is the ability of the alternative to maintain the desired level of protection over time after the Remedial Action is implemented. Evaluation of this criterion should consider resiliency, or changes in Site or area conditions over time, e.g., due to the anticipated effects of climate change. For example, implementation of an alternative may be considered effective for an area because it is currently not impacted by flooding, however, the alternative may not be an appropriate choice if it is projected to be more susceptible to flooding in the future due to sea level rise. See the guidance from ITRC, Sustainable Resilient Remediation (April 2021), for a framework and tools that may be used to perform this evaluation. Resiliency maximization is consistent with the State of Delaware's expressed commitment to making strides in planning for climate change impacts as documented in the Climate Action Plan issued in November 2021.

Alternatives that best meet this criterion would eliminate the risk without the need for Long-term Stewardship. An example of a Remedial Action for the soil media not requiring long-term stewardship is excavation which removes all of the soil contamination at a Site. In addition, the

ability of the Remedial Action to contain and manage the treatment residuals, minimize Long Term Stewardship (LTS), and maintain established cleanup objectives over time will be a major consideration.

7.3.7 LIFE-CYCLE COSTS

This section details how to calculate the Life Cycle Cost (LCC) of an alternative. The purpose of the LCC is to provide the total anticipated cost of each alternative in order to assist in selecting the most appropriate alternative for the Site. The LCC is not the same as the cost effectiveness of a Remedial Action, which is described in the Section below, and should be used in conjunction with the other balancing criteria to select the most appropriate Remedial Action for the Site.

When calculating the LCC one should consider capital costs, LTS costs, and periodic costs. The sum of these costs is the LCC. Appropriate costs in each category are addressed below.

Capital costs:

The labor, equipment, and material costs associated with mobilization, short-term monitoring/system operation verification, Site work, installation, disposal, planning, or other activities related to the construction of a Remedial Action are considered capital costs. The professional/technical services necessary to support construction of the alternative are included as well. These costs are typically assumed to occur during the first year; however, for multi-year construction projects this should be adjusted as appropriate.

Annual LTS Costs:

Annual LTS Costs are those incurred while verifying the continued effectiveness of a Remedial Action and are post-construction costs. The costs may include but are not limited to the following:

- Labor, equipment, and material costs
- Contractor markups such as overhead and profit
- Monitoring activities
- Operating and maintaining extraction
- Containment
- Treatment systems
- Disposal
- Professional/technical services necessary to support the LTS activities are included as well.
- Oversight activities by the state regarding LTS.

Periodic Costs:

If a cost occurs once or less frequently than annually during the remedial timeframe/LTS period, it can be considered a periodic cost. Both capital and LTS costs can qualify as a periodic cost. These costs are separated as it is more practical for estimating costs.

In order to assist in accounting for all associated elements making up the capital, annual LTS, and periodic costs, it is recommended that a Cost Element Checklist be created. This checklist can vary in appearance; however, it should include a cost element section, an associated description section, and an associated sub-elements section. An example checklist can be found in *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study* (USEPA, 2000).

The accuracy of the LCC is expected to become more exact as the Site moves through the process. When performing a detailed analysis of alternatives an accuracy of +50%/-30% is expected.

All costs incurred are to be presented as a present value. Present value is expressed as:

$$PV = \sum_{t=0}^{n} \left(\frac{x_t}{(1+i)^t} \right)$$

Where,

$$t = Year\ of\ payment$$

$$n = Final\ Year$$

$$x_t = Total\ Payment\ for\ Year\ t$$

$$i = Discount\ Rate$$

Please note: Initial costs are typically first year costs for which t=0. Post first year LTS costs are expressed as t=1 through t=n. Selection of an appropriate n is detailed below. Discount rate (i) is based on the 30 Year Real Interest Rates on Treasury Notes and Bonds of Specified Maturities found in OMB Circular A-94 Appendix C. This circular is updated annually.

For the majority of Sites, the final year to be used is based on when the Remedial Action goals are anticipated to be met. Some Sites may require a different end year than the anticipated one being used for calculating the LCC.

For these Sites the process is as follows: 1) A written request, email is appropriate, is submitted to DNREC providing the anticipated year to achieve the Remedial Action goal, 2) the proposed end year to be used in calculating the LCC, and the 3) Site-specific justification for the use of the proposed end year. Changing the end year used is entirely at DNREC's discretion and an approval may be issued, if deemed appropriate. DNREC reserves the right to rescind this approval at any time.

DNREC recognizes some Sites may require LTS in perpetuity. To calculate the LCC for this alternative use either a default 30-year period (n=30) or the largest final year (n) used for other alternatives. The larger of the two time periods should be used. For example, if the proposed alternatives which do not require LTS have a final year (n) of 5, 10, 20, and 35, then a period of 35 years should be assumed for all alternatives requiring LTS instead of 30.

7.4 COST EFFECTIVENESS

Once the remedial alternatives that meet the threshold criteria and other balancing criteria are determined, those options should be evaluated for cost effectiveness by being compared against each other. Consistent with the EPA, DNREC considers an alternative to be cost-effective if its "costs are proportional to its overall effectiveness". With regards to the numeric system detailed in this document, alternatives within 10% of the maximum summed ranking are considered by DNREC to be comparable, therefore, the lowest cost alternative of those is the most cost effective.

7.5 TABLE SUMMARY

A summary table should be included in the FS. An example is provided below assuming a numeric system, which is DNREC's preference, is used when considering the balancing criteria during the detailed analysis of alternatives.

Table Summary Template	
Threshold Criteria	Alternative 1
PROTECTION OF PUBLIC HEALTH OR WELFARE OR THE ENVIRONMENT	(Y/N)
ATTAINMENT OF REMEDIAL ACTION OBJECTIVES	(Y/N)
CONTROL SOURCES OF CONTAMINATION	(Y/N)
Balancing Criteria	
INCORPORATION OF SUSTAINABILITY PRINCIPLES INCLUDING LOW ENERGY INPUTS, RESTORATION OF HABITAT, PRESERVATION OF CULTURAL RESOURCES, LAND REUSE, MATERIALS RECYCLING, INFRASTRUCTURE REUSE, REDUCED RUN-OFF, PERMANENCE AND PROTECTIVENESS WITHOUT AN ENVIRONMENTAL COVENANT	(0-3)
REDUCTION OF CONTAMINANT TOXICITY, MOBILITY, OR VOLUME	(0-3)
COMMENTS OR INPUT FROM THE COMMUNITY IN WHICH THE FACILITY IS LOCATED	(0-3)
EASE OF IMPLEMENTATION	(0-3)
SHORT-TERM EFFECTIVENESS	(0-3)
LONG-TERM EFFECTIVENESS	(0-3)
LIFE-CYCLE COSTS	####, (0-3)
SUMMATION	(0-21)

Regardless of format, all good tables should:

- Identify each evaluated alternative.
- Identify if each alternative meets the Threshold Criteria
- Identify how effectively each Balancing Criteria is met by each alternative

8.0 CONCLUSIONS AND RECOMMENDATIONS

The purpose of the Conclusion and Recommendation Section is to summarize the remedial alternatives, summarize the results of the comparative analysis (balancing criteria), and present the rationale for the proposed remedial alternative. The comparative analysis of each Remedial Action provides guidance for the Remedial Action selection.

While the FS provides the basis for the Proposed Plan of Remedial Action, DNREC has final discretion on Remedial Action selection. Site specific factors not captured by the FS may result

in deviation from the recommendations of the FS. DNREC should provide documentation to the file detailing the reasons for deviating from the recommended remedial action.

REFERENCES

USEPA, 1988. Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA.

USEPA, 1996. The Role of Cost in the Superfund Remedy Selection Process.

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Merino, N., et al. 2016. Degradation and removal methods for perfluoroalkyl and polyfluoroalkyl substances in water. Environmental Engineering Science 33(9):615-649.

Oliaei, F., D. Kriens, R. Weber, and A. Watson. 2013. PFOS and PFC releases and associated pollution from a PFC production plant in Minnesota (USA). Environmental Science and Pollution Research 20(4): 1977-1992.

APPENDIX A

FEASIBILITY STUDY REPORT OUTLINE

I. Introduction
II. Remedial Action Objectives
III. Applicable or Relevant and Appropriate Requirements (ARARs) and Permit Requirements
IV. Description and Detailed Analysis of Alternatives by media
    i. Threshold Criteria
        1. Protection of public health or welfare or the environment
        2. Attainment of Remedial Action objectives
        3. Control sources of Contamination
    ii. Balancing Criteria
        1. Incorporation of sustainability principles
        2. Reduction of contaminant toxicity, mobility, or volume
        3. Comments or input from the community in which the facility is located
        4. Ease of Implementation
        5. Short-term effectiveness
        6. Long-Term effectiveness
        7. Life-cycle costs (30 Years)
    iii. Cost Effectiveness
    iv. Table Summary
V. Conclusions and Recommendations
VI. References
VII. Appendices
    i. Technology Screening
VIII. Figures
IX. Tables

APPENDIX B

ARAR CHECKLIST

	DNREC FEASIBILITY STUDY APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARAR) CHECKLIST	**Rev. 1**

- For each ARAR, check if applicable or relevant and appropriate and briefly explain any "Yes".

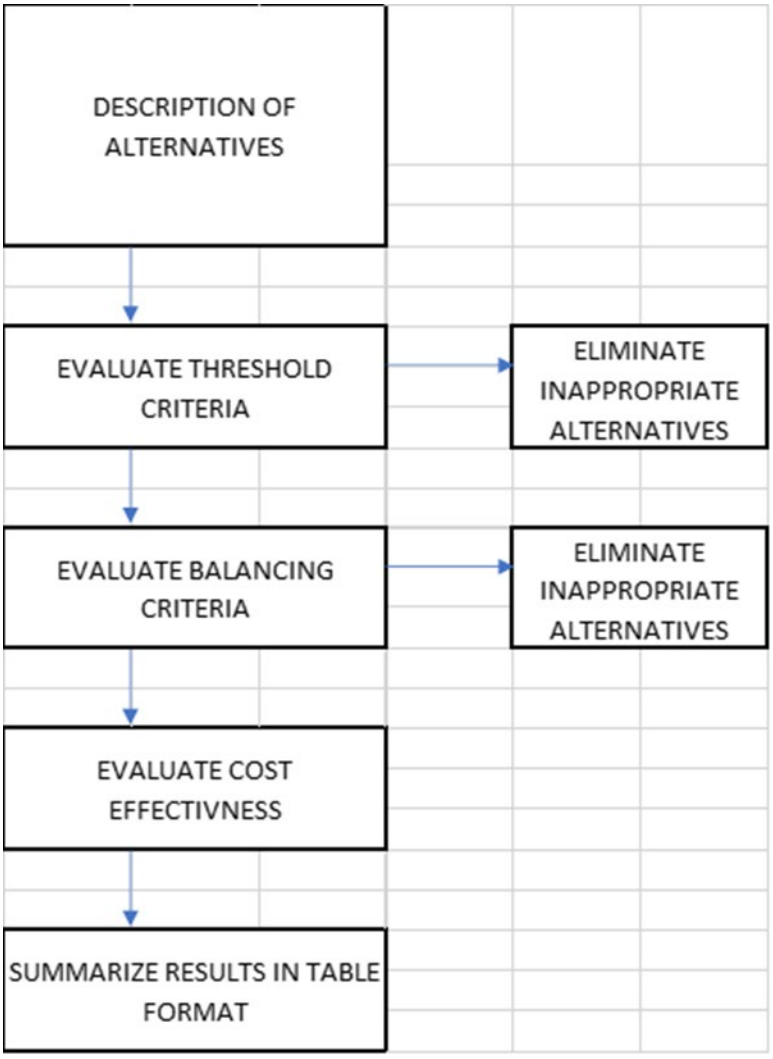
Federal ARARs	Applicable or Relevant and Appropriate		Briefly explain any applicable "Yes"
Resource Conservation and Recovery Act (RCRA)	0 Yes	0 No	
Toxic Substances Control Act (TSCA)	0 Yes	0 No	
Clean Air Act (CAA)	0 Yes	0 No	
Clean Water Act (CWA)	0 Yes	0 No	
Occupational Safety and Health (OSHA)	0 Yes	0 No	
Wetlands	0 Yes	No	
Other	0 Yes	0 No	
	0 Yes	0 No	
Delaware ARARs			
Hazardous Waste Regulations	0 Yes	0 No	
- Soil disposal	0 Yes	0 No	
- Groundwater disposal	0 Yes	0 No	
UST/AST Regulations	0 Yes	0 No	
Stormwater Regulations	0 Yes	0 No	
- Discharge Permit	0 Yes	0 No	
- Soil disturbing E&S Permit	0 Yes	0 No	
State Water Regulations	0 Yes	0 No	

- Underground Injection Permit	0 Yes	0 No	
- Dewatering Discharge Permit	0 Yes	0 No	
- Well Installation Permit	0 Yes	0 No	
- Soil borings -MIP-HPT, LIF, etc. Permit	0 Yes	0 No	
- Drinking Water Treatment	0 Yes	0 No	
Surface Water Regulations	0 Yes	0 No	
- Subaqueous Land Permits	0 Yes	0 No	
- Dewatering Discharge Permit	0 Yes	0 No	
Air Regulations	0 Yes	0 No	
- Soil Vapor Extraction System Permit	0 Yes	0 No	
- Vapor Intrusion Vent Riser Permit	0 Yes	0 No	
Drinking Water Regulations	0 Yes	0 No	
Wetlands-Subaqueous Lands	0 Yes	0 No	
Critical Habitats and/or Endangered Species	0 Yes	0 No	
DelDOT Permits	0 Yes	0 No	
- Right-of-Way Permit	0 Yes	0 No	
Other	0 Yes	0 No	
County ARARs			
- Stormwater or Sanitary Sewer Discharge Permit	0 Yes	0 No	
- Floodplain Construction Permit	0 Yes	0 No	
Other	0 Yes	0 No	
Local Municipal ARARs			

- Stormwater or Sanitary Sewer Discharge Permit	0 Yes	0 No	
- Floodplain Construction Permit	0 Yes	0 No	
Other	0 Yes	0 No	
	0 Yes	0 No	

APPENDIX C

Process Overview


DESCRIPTION OF ALTERNATIVES
EVALUATE THRESHOLD CRITERIA
ELIMINATE INAPPROPRIATE ALTERNATIVES
EVALUATE BALANCING CRITERIA
ELIMINATE INAPPROPRIATE ALTERNATIVES
EVALUATE COST EFFECTIVNESS
SUMMARIZE RESULTS IN TABLE FORMAT