

GUIDANCE TO DEVELOPING SOLAR ON RHODE ISLAND CLOSED LANDFILLS

The Rhode Island Department of Environmental Management (RIDEM) Office of Land Revitalization and Sustainable Materials Management (LRSMM) encourages post-closure use of landfills provided that the use will not compromise the environmental protection afforded by the landfill cap and closure. Although capped and closed landfills may not be appropriate sites for residential or commercial development, they are more suitable for the installation of a photovoltaic (PV) solar array, which generate renewable energy and may provide income for landfill owners. This guidance describes LRSMM's requirements and the process for approving these activities.

I. Intent

In January of 2021 LRSMM revised the Solid Waste Regulation No. 2 ([250-RICR-140-05-2](#)). This guidance provides expectations and clarifications relative to Section 2.1.9(J) - Installation of Solar Panels on Landfills. In the effort to provide a streamlined process for approving solar on landfills, the following sections provide a summary of the regulations as well as the permitting process and design considerations when choosing solar.

This document provides general information and guidance regarding siting solar PV facilities on Municipal Solid Waste (MSW) landfills. It does not address all information, factors, or considerations that may be relevant in every particular situation.

Closed and capped landfills have the capability to provide land serviceable for PV solar arrays. Given that capped landfills are mostly unhindered by surrounding trees or buildings, they provide optimal solar exposure. Around the country, municipalities, utilities, and landfill owners have found that solar can be the ideal fit for capped landfills. This reuse can effectively provide new economic generation, decrease the reliance on fossil fuels and reduce greenhouse gas emissions.

SECTIONS

I. Intent

II. Solar Regulations and Design Considerations

1. Feasibility Study
2. Gas Monitoring
3. Erosion and Stormwater Controls
 - A. Office of LRSMM Pre-Approved Stormwater and Erosion Mitigation Standards
 - i. SESC Plan
 - ii. Drainage Report
 - iii. O&M Plan

III. Best Practices

IV. Permitting Process

1. Installing Solar on Inactive Landfill
2. Modifications to Closed and Capped Landfills with DEM

V. DEM Contacts

VI. Citations and Additional Resources





II. Solar Regulations and Design Considerations

Solar can be installed on the footprint of a landfill if the panels are approved as part of the overall cap design. Approval by the Landfill Closure Program (LCP) is required, and the design shall be in conformance with the relevant sections of the Solid Waste Regulations. [Section 2.1.9\(J\)](#) of the Solid Waste Regulations requires plans for the solar array to include a feasibility study and to consider landfill gas build-up and erosion and stormwater controls, which are further outlined below.

1. Feasibility Study - [Section \(2.1.9\(J\)\(2\)\(b\)\)](#)

Since there are various important elements of permitting, construction, and maintenance that are unique to landfill solar projects, Section 2.1.9(J)(2)(b) identifies the required information that must be included in the submittal for review and approval of these projects. The feasibility of siting a PV solar array system on a landfill depends on numerous site-specific characteristics which shall address:

A. Details of Anchoring System - [Section 2.1.9\(J\)\(2\)\(b\)\(1-2\)](#)

Penetrations of the landfill cap are prohibited in order to ensure that there is no increase in potential threat to human health and the environment. Posts, ground screws or any other penetrating anchors on the landfill cap are not allowed. Ground mounted systems that are not driven into the cap are essential to avoid creation of preferential pathways for landfill gases and stormwater infiltration.

Ballasted racking systems are the traditional choice when installing solar on landfills. Concrete blocks are positioned on the ground to allow for a structure to be built that holds the solar panels while not having to install anything below the ground surface. Specific details of the anchoring system and all components must be submitted to LRSMM for review and approval.

B. Analysis of Weight Bearing Capacities - [Section 2.1.9\(J\)\(2\)\(b\)\(3\)](#)

The weight of the solar array will likely be affected by the load limit of the cap. This weight capacity will likely also affect construction, and could prevent high weight trucks, cranes, and related equipment from accessing portions of a site, creating additional logistics considerations. If heavy machinery is necessary on site, then access roads shall be designed in a manner that cap components and any gas or leachate lines shall withstand the weight of the equipment.

Therefore, an analysis of the weight bearing capacity of the existing cap and related structures (i.e., gas and leachate controls) is required and must include calculations of the maximum anticipated load from the solar array system. This including loads placed on the cap during construction from equipment, snow and wind loads, and the weight of the solar panels and foundation system. The report must also include wind uplift calculations to confirm the solar panel ballast design will prevent components from blowing over and damaging the final cover system. Please refer to [Table 1608.1](#) in Chapter 16 - *Structural Design* of the RI State Building Code (510-RICR-00-00-1) for design snow loading and wind speeds as defined by Municipality, in accordance with Section 7 of ASCE 7 - *Minimum Design Loads and Associated Criteria for Buildings and Other Structures*.



The depth and materials used for cap components designed for specific hydraulic conductivity (e.g., barrier and drainage layers) may limit the bearing capacity to prevent compression and loss of function. This analysis must include a discussion of construction techniques and specifications for equipment used during construction to ensure that loads do not exceed the weight bearing capacity.

C. Potential for Increased Settlement - [Section 2.1.9\(J\)\(2\)\(b\)\(4\)](#)

Since every landfill is prone to settlement, the type and magnitude of the settlement needs to be investigated during the feasibility assessment phase of the project. Differential settlement is a major concern and will place uneven stresses on the mounting systems/foundations, can cause damage or failure of liner systems and engineered components, and increase the chance of ponding on the landfill cap. If settlement causes ponding, settled areas must be repaired. A plan must be in place for annual inspections of the landfill cap to detect these issues.

When considering differential settlement, the analysis must focus on waste composition, age of the landfill, the effects of additional weight from the solar panels/construction equipment, and the predicted future settlement magnitude. Different designs can be considered when planning for settlement including systems that minimize and distribute weight, adjustable supports for the panels, flexible connections, and lighter weight anchoring systems. Ballasted platforms will be lighter weight than a slab poured foundation.

D. Slope and Stability Analysis - [Section 2.1.9\(J\)\(2\)\(b\)\(5\)](#)

The increase of weight placed on the landfill from the solar array as well as construction equipment can increase settlement and also jeopardize slope stability at the site. Installing solar arrays on steep slopes can also lead to design challenges relating to wind loading, erosion control, stormwater management issues, and foundation stability problems. These challenges also often lead to increased system costs. While the sides of closed landfills generally have steep slopes, the plateau or top of the landfill may provide sufficient acreage and is often the best location for solar placement on the site.

E. Vegetative Cover - [Section 2.1.9\(J\)\(2\)\(b\)\(6\)](#)

Different factors associated with installing solar can disturb the existing vegetative cover on the site. It is essential to plan for construction equipment including using rubber tracked equipment and erosion control measures to minimize cover damage.

There is also the risk of shading from the panels themselves, causing the underlying vegetation to die. In general the higher the tilt angles, the higher the height of the array will need to be and the longer shadow it will cast. Depending on the resilience of the underlying vegetation, reseeded, placing erosion controls, or placing crushed stone underneath the panels will be necessary. Crushed stone underneath the panels and near conduits should be considered to reduce maintenance efforts in mowing and trimming vegetative growth.

To achieve compliance with this section, a discussion of construction techniques which will be utilized to protect the vegetative cover is required.



F. Existing or Proposed Gas or Leachate Management Systems - [Section 2.1.9\(J\)\(2\)\(b\)\(7\)](#)

The placement of a solar array system on a landfill can interfere with the design of existing gas or leachate management systems. The weight bearing capacity of these systems need to be determined and compared to the live and dead loads of the solar array system and construction equipment to prevent damage or failure.

The location of existing or proposed gas systems, including monitoring points, also need to be considered. It is required that both passive and active gas vents must setback at least 10 feet away from all PV panels, transformers, and other equipment capable of generating a spark.

G. Stormwater Control and Impact on Wetlands and/or Surface Waters - [Section 2.1.9\(J\)\(2\)\(b\)\(8\)](#)

Three different plans, as outlined below, are required as part of this Section to address stormwater control, soil erosion, sedimentation and potential impacts to wetlands and or surface waters. More information on these plans can be found in [Section II.3](#) of this document.

i) Soil Erosion and Sediment Control Plan (SESC Plan)

The SESC Plan includes temporary measures to utilized during the construction phase and any land disturbing activities.

ii) Drainage Report

The Drainage Report includes a stormwater runoff drainage analysis to address how the project design functions on a long-term/post construction basis in controlling hydrologic changes as peak runoff discharge rates and permanent soil erosion/sediment controls.

iii) Operation and Maintenance Plan (O&M Plan)

The O&M Plan must address all structural stormwater controls, conveyances and long-term soil erosion and sediment control to ensure that they continue to function as designed for long term use.

H. Minimum Spacing for Maintenance and Emergency Events - [Section 2.1.9\(J\)\(2\)\(b\)\(9\)](#)

There must be adequate spacing between rows of solar panels to allow for the access of repair, mowing and emergency equipment. This spacing shall be no less than ten (10) feet. The spacing underneath the panels also needs to be considered to allow access for repairs and mowing of the vegetative cover, if present. The spacing shall also be enough to prevent inter-panel shading which can affect the presence and function of vegetative cover. If vegetative cover cannot be established beneath the panels and in any other areas due to the impacts of shading or lack of access to rainfall, the design needs to use the best alternative practice of establishing a crushed stone surface.

I. Access Roads and Access Restrictions to the site - [Section 2.1.9\(J\)\(2\)\(b\)\(10\)](#)

As site preparation could remove vegetation and expose soil prior to final stabilization of the area, both temporary and permanent access roads need to be considered in the designing phase of the project. Construction of temporary roads and staging areas is necessary for the solar materials and equipment, construction vehicles, and other construction equipment. The staging areas and access roads must be located and constructed in a way that does not interfere with landfill operation, inspection/monitoring, and maintenance activities. Access roads must also be designed to avoid impacts to the functioning of the landfill cap and other systems by limiting the



travel of heavy equipment to specifically designated areas. If heavy machinery is necessary on site, then access roads shall be designed in a manner that the cap components and any gas or leachate lines shall withstand the weight of the equipment.

In addition to the need for temporary access roads, a more permanent access road may need to be constructed to facilitate normal operations, maintenance and to prevent erosion. All roadways must be clearly designated to limit the movement of construction vehicles and equipment to certain areas. Both temporary and permanent site access roads shall prevent dirt tracking from construction equipment and vehicles onto public roadways.

Security measures must be taken to prevent unauthorized access to the site, protect against theft/vandalism, and protect against potential exposures during the construction phase. The most common security measure is perimeter fencing. Design criteria of fencing systems include type, height, and required set back distances from the solar arrays. Fencing posts shall not be driven into the landfill area. The design of the fencing shall also allow wildlife access underneath by having 6 inches of spacing from the ground.

J. Electrical Plans and Specifications - [Section 2.1.9\(J\)\(2\)\(b\)\(11\)](#)

All electrical plans and specifications showing electrical lines and related equipment must be provided to LRSMM. This includes the location and connections between the PV modules, combiner box, inverter, transformer, meter and utility grid. The location of grounding rods must also be provided. In landfill applications especially, proper grounding techniques must be employed and follow relevant National Electrical Codes. Grounding must be located in an area that is sufficient enough to dissipate the electrical charge while avoiding areas with increased landfill gas and unknown waste materials. Vertical grounding into the landfill footprint is not allowed to avoid penetrating the cap and protruding into unknown waste materials and landfill gas, as this poses a fire and explosion hazard. Trenching is also prohibited on the landfill footprint, including placing any conduits below grade.

K. Health and Safety Plan - [Section 2.1.9\(J\)\(2\)\(b\)\(12\)](#)

LRSMM requires a robust Health and Safety Plan compliant with OSHA standards to ensure protection of human health and the environment from the construction, installation, and operation and maintenance of the development, for site workers, neighbors, and other people who may be affected by the project. The plan must contain specific details to prevent explosions, fires, odors and the release of toxic compounds into ambient air. The plan must also include all emergency contact information.

During construction of the solar array system hazardous situations must be avoided, including potential sparking near landfill gas and exposure to landfilled waste. Any temporary enclosed structures installed at the site must be monitored for explosive levels of landfill gas. In addition, clearly designated access roads must be established to limit the movement of construction vehicles and equipment.



2. Gas Monitoring - [Section 2.1.9\(J\)\(2\)\(c\)](#)

Section 2.1.9(J)(2)(c) of the Solid Waste Regulations states that gas monitoring and alarms will be in place for any controlled structure or other confined space. Buildings, confined spaces, electrical equipment, and utility conduits in close proximity to the landfill become landfill gas receptors and create a safety (explosion/fire) hazard and as such shall be above grade and designed to prevent the accumulation of gas within the structure. When feasible avoid constructing buildings and structures on the landfill cap. Gas monitoring and alarms, vapor barriers, venting systems and any other controls approved by LRSMM are required for this equipment.

3. Soil Erosion & Sediment Control, and Stormwater Management- [Section 2.1.9\(J\)\(3\)](#)

As part of Section 2.1.9(J)(3) of the Solid Waste Regulations, landfills proposing solar array systems to be installed on the capped footprint of filled areas shall be considered an integral part of the final remedy for the purpose of review and approval under this Rule. Therefore, to provide a streamlined approach to activities that may affect freshwater wetlands and surface waters, LRSMM has the authority to approve such activities, but may consult with the Office of Water Resources as necessary. Please note that the solar project must not impact the quality of groundwater, surface water and/or wetlands.

As outlined in Section 2.1.9(J)(3)(a) of the Solid Waste Regulations, applicants have two options when submitting plans and designs for both erosion and stormwater controls. One option is going through the typical permitting with the Office of Water Resources, which includes obtaining a Rhode Island Pollutant Discharge Elimination System General Permit for Stormwater Discharge Associated with Construction Activity (Construction General Permit). The second option provides a streamlined approach by having applicants comply with the following pre-approved standards established by LRSMM. This alternative only applies to landfills that have a total area of 50 acres or less, and landfills that are not in the watershed of the Pocasset River. The information below summarizes current standards that must be addressed to obtain approval solely through the office of LRSMM.

A. LRSMM Pre-Approved Soil Erosion & Sediment Control (SESC), and Stormwater Management Standards - [Section 2.1.9\(J\)\(3\)\(a\)\(2\)](#)

The intent of this section is to provide temporary and permanent SESC measures to prevent migration of sediment to and from the limits of the cap, and to control stormwater run-off from both pre/post-construction from negatively impacting areas within and surrounding the landfill, including adjacent wetlands and water bodies. The plans must give a detailed description in order to design, install, and maintain effective SESC and stormwater controls throughout the life of the project.

The Engineer/designer shall comply with all applicable federal, state, and local regulations concerning both SESC and stormwater management controls, as well as employing Engineering Standards and Best Management Practices (BMPs).



The following sections describe the pre-approved standards in relation to obtaining permitting through LRSMM:

i) Soil Erosion and Sediment Control (SESC)

The following SESC measures must be utilized during the construction phase and any land disturbing activities:

- Fresh water wetlands and surface water must be delineated on site plans, to provide appropriate buffer zones;
- Minimizing areas of disturbance and clearly mark all Limits of Disturbance (LOD) on plans;
- Minimizing slope grades to the extent possible;
- Grading to direct water into stormwater collection areas;
- Construction of a stabilized entrance to the subject site and access roads;
- Providing disturbed areas that are vulnerable to erosion with temporary vegetative cover, mulch, erosion blankets or biodegradable netting. The stabilization of disturbed areas must, at a minimum, be initiated immediately whenever any clearing, grading, excavating or other earth disturbance activities have permanently ceased on any portion of the site, or temporarily ceased on any portion of the site and will not resume for a period exceeding 14 calendar days.
- Prior to construction activities, sediment control measures must be installed along the perimeter areas of the site that will receive stormwater from earth disturbing activities;
- Sediment traps (typically for < 5 acres of contributing area);
- Sediment basins (typically for > 5 acres of contributing drainage area);
- Protect Storm Drain Inlets and Outlets;
- Temporary measures shall be installed to protect permanent or long-term stormwater control and treatment measures as they are installed and throughout the construction phase of the project so that they will function properly when they are brought online;

Please also reference the Performance Criteria as listed in Section 8.16D of the Office of Water Resources Stormwater Management, Design and Installations Rules ([250-RICR-150-10-8](#)). Also, any runoff and sediment controls must also be consistent with the specifications in the [Rhode Island Soil Erosion and Sediment Control Handbook \(RISESCH\)](#).

ii) Stormwater Management – Drainage Report

The Drainage Report must include a stormwater runoff drainage analysis to address how the project design functions on a long-term/post construction basis in controlling hydrologic changes as peak runoff discharge rates and permanent soil erosion/sediment controls. This must take into account the pre and post project peak discharge rates. Stormwater runoff calculations should be included for all runoff control and conveyance features including drainage channels, swales and detention/infiltration ponds. Calculations must be provided to demonstrate that the proposed stormwater management controls have the capacity to effectively direct and contain the runoff and



to prevent long term erosion. Please note that stormwater infiltration is not allowed on the landfill footprint into the waste material. Below are the preapproved permanent design requirements for long term stormwater drainage and soil erosion/sediment control:

- Fresh water wetlands and surface water must be delineated on site plans to provide appropriate buffer zones;
- Permanent vegetation;
- Cap construction which utilizes a drainage layer over low permeability soils to direct stormwater to suitable containment locations;
- Construction of a stabilized entrance to the subject site and access roads;
- Grading to direct water into approved stormwater collection areas;
- Installation of runoff control and conveyance features to prevent ponding, erosion, and an increase in peak runoff discharge rates. Features should include drainage channels, swales, rip-rap and detention/infiltration ponds;
- The design will need to avoid increases in peak runoff discharge rates in the 10-year and 100-year 24-hour Type III design storm events from pre-project to post-project conditions. This can be best accomplished using infiltration and/or detention basins properly designed to achieve these peak flow rate reductions.

The drainage report must also include a discussion of any changes in stormwater management practices as a result of solar panel construction. Since panels will generally channel the flow of stormwater over their flat surface, it may cause more erosion underneath. The use of rain gutters on PV arrays and crushed stone underneath the panels will help to channel stormwater runoff to swales and detention ponds and prevent erosion from panel runoff. Please reference the RI Stormwater Design and Installations Standards Regulations.

iii) Operation and Maintenance Plan (O&M Plan)

The O&M Plan must address all structural stormwater controls, conveyances and long-term soil erosion and sediment control to ensure that they continue to function as designed for long term use. It is the responsibility of the applicant to inspect and maintain all stormwater and erosion controls on-site and make sure they are in good condition and working order. Yearly inspections are required as part of the approved ELUR. Records of the inspection shall be kept on-site and be available for LRSMM upon request.

The O&M Plan must include, at a minimum, the details as listed below:

- Ensure that grass has established; if not, replace with an alternative seed mix;
- Yearly inspections;
- Sediment build-up shall be removed to ensure stormwater controls and sediment controls function as designed;
- Mowing and litter and debris removal; and
- As-needed remedy of any erosion issues that may develop over time



B. Submittals

The applicant shall submit the SESC, Drainage Report and O&M Plan with associated drawings and calculations to LRSMM for its review and approval. Consultation between LRSMM and the Office of Water Resources may occur as necessary throughout the project. The submittals must be stamped by a Professional Engineer registered in the State of Rhode Island. The applicant shall not commence any construction activities prior to obtaining said approval.

III. Best Practices

In addition to the information already listed in this document, *Table 8-1: Summary of Best Practices For Siting Solar PV Projects on Landfills* from the EPA document titled "[Best Practices for Siting Solar Photovoltaics on MSW Landfills](#)", should be referenced. As this is not an exhaustive list of best practices, in fulfillment of their professional duties, engineers shall hold paramount the safety, health and welfare of the public. Services shall only be performed in areas of their competence.

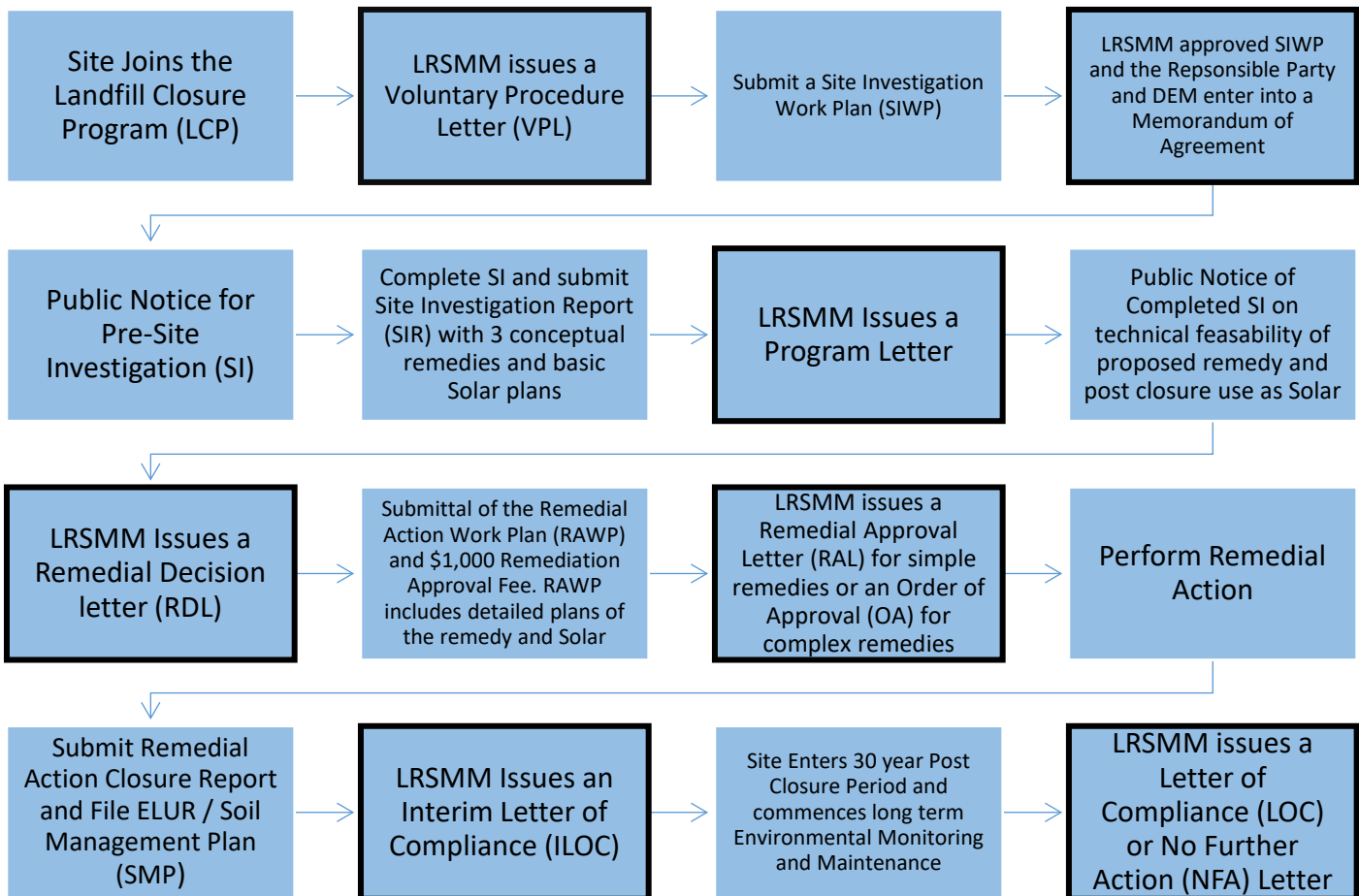
IV. Permitting Process

Plans for solar can be included as part of the permitting process for closure of licensed landfills, during assessment/remediation/closure of inactive or abandoned landfills, or can be a modification to the existing plans if closure has already occurred. The regulatory process for the latter two scenarios for closure are outlined below.

Also, as described in [Section II.3](#) of this document, if solar is included in the closure, then permitting for erosion and stormwater controls may be approved by LRSMM without the need for a wetlands permit.



1. Installing Solar on Inactive Landfills



** Outlined boxes indicate steps taken by LRSMM, while non-outlined boxes are steps taken by the responsible parties/owner*

In addition to the typical requirements of a regular landfill closure, the RAWP for a solar included closure must include how the solar array will interact with existing site conditions, requirements from Section 2.1.9(J) of the Solid Waste Regulations, and specific construction details. The RAWP must also include maintenance details of the vegetative cover especially around all PV solar array structures. This includes measures for replacement of the vegetative cover should the PV solar array cause erosion or damage due to shading or concentrated water flow from PV solar array panels. The RAWP must also include a plan for maintenance of the PV solar array itself.

2. Modifications to Previously Closed and Capped Landfills with DEM

Landfills that have already undergone closure per LRSMM standards may choose to modify the post closure reuse of the landfill site. Modification to address any necessary or desired changes to the reuse of the landfill site resulting from construction of the PV solar array system must submit a modified RAWP. The modified RAWP must consider the already in place final cover system, existing site conditions, [Section 2.1.9\(J\) of the Solid Waste Regulations](#), and specific construction details. The modification must also detail how maintenance of the cap will be addressed, including any vegetation around all PV solar array structures and measures for replacement of vegetative cover should the PV



solar array cause erosion or damage due to shading or concentrated water flow from PV solar array panels. The modified RAWP must also include a plan for maintenance of the PV solar array itself.

Since the proposed reuse of the property will have significantly changed since the original approval, before a Remedial Decision Letter Addendum is issued for the modification, a new public notice period will be required.

V. DEM Contacts

For installation of solar array systems on landfills, applications must be filed directly with the DEM Office of Land Revitalization and Sustainable Materials Management, Landfill Closure Program. Said projects go through an expedited review process as per Solid Waste Regulation No 2 (250-RICR-140-05-2.1.9(J) - Installation of Solar Panels on Landfills).

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VI. Citations and Additional Resources

- United States EPA and the National Renewable Energy Laboratory. Best Practices for Siting Solar Photovoltaics on Municipal Solid Waste Landfills. 2022.
- Rhode Island Department of Environmental Management. *Solid Waste Regulation No. 2 Solid Waste Landfills (250-RICR-140-05-2)*. Office of Land Revitalization and Sustainable Materials Management, 2021.
- Rhode Island Department of Environmental Management. *Site Remediation Rules and Regulations for the Investigation and Remediation of Hazardous Material Releases*. Office of Land Revitalization and Sustainable Materials Management, 2020.
- Rhode Island Department of Environmental Management. *Closure Policy for Inactive or Abandoned Solid Waste Landfills*. Office of Waste Management, 2001.
- Massachusetts Department of Energy Resources and Massachusetts Department of Environmental Protection. *The Guide to Developing Solar Photovoltaics at Massachusetts Landfills*.
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- Rhode Island State Conservation Committee. *Rhode Island Soil Erosion and Sediment Control Handbook, 2014*.