Appendix B:
Economic Analysis

Proposed Amendments to the Regulation on Methane Emissions from Municipal Solid Waste Landfills

Release Date: September 23, 2025

I. Introduction

Chapter VIII of the Initial Statement of Reasons (ISOR) provides an overview of the costs of the Proposed Amendments. This appendix contains the detailed inputs and methods used to calculate the estimated incremental costs to regulated parties that will result from each change in the Proposed Amendments. The analysis covers a three-year period beginning with the year that the Proposed Amendments are expected to go into effect. All costs are presented in 2023$. This appendix also includes apportionment of government landfill costs between state-owned and local-owned landfills, estimated costs to local air districts that implement and enforce the Regulation, and cost estimates for alternatives to the Proposed Amendments.

II. Summary Cost Tables for the Proposed Amendments

Costs were estimated separately for each new provision or change in the Proposed Amendments that staff expects to have cost impacts. These costs represent only the incremental costs for proposed new provisions and requirements. Table 1 in Chapter VIII of the ISOR summarizes the estimated costs by summary category. Tables B-1 and B-2 show these same costs for private and government regulated entities, respectively, at the more resolved "provision" level.[1]

Table B-1. Annual Estimated Costs by Provision for Private Sector Regulated Entities

Summary Category	**Provision**	**First Year Cost**	**Annual Ongoing Costs in Subsequent Years**
Remotely Detected Plumes	Investigation and repair of remotely detected emission plumes	$44,658	$44,658
Surface Emissions Monitoring	Monitoring of currently excluded areas on the landfill surface	$425,727	$425,727
Surface Emissions Monitoring	Surface emissions monitoring (SEM) spacing relaxation limited to areas with final cover	$165,922	$165,922
Surface Emissions Monitoring	Every-three-quarters SEM replacing annual SEM	$4,836	$4,836
Surface Emissions Monitoring	Confirmatory re-monitoring one month after initial surface exceedances	$195,910	$195,910

[1] Landfills are owned or operated by both private and government entities. The same calculation approaches were used for both types of entities.

Surface Emissions Monitoring	Monitoring of full extent of surface emissions exceedances	$19,604	$19,604
Surface Emissions Monitoring	Reversion of relaxed SEM frequency/spacing upon initial exceedance	$57,776	$57,776
Recurring Exceedances	Increased monitoring and analysis at landfills with recurring surface exceedances	$224,613	$224,613
Gas Collection System Monitoring	Additional wellhead monitoring	$708,770	$708,770
Early Gas Collection Infrastructure	Early gas collection in new waste areas	$4,006,392	$4,006,392
GCCS Downtime	Limiting collection system downtime	$93,697	$93,697
Third-party Gas Control Systems	Adjusting definitions of gas control system owners and operators	$241,400	$241,400
Component Leak Monitoring	Preparation and maintenance of component leak monitoring plans	$98,116	$9,812
Total	*Total*	*$6,287,421*	*$6,199,116*

Table B-2. Annual Estimated Costs by Provision for Government Sector Regulated Entities

Summary Category	**Provision**	**First Year Cost**	**Annual Ongoing Costs in Subsequent Years**
Remotely Detected Plumes	Investigation and repair of remotely detected emission plumes	$43,074	$43,074
Surface Emissions Monitoring	Monitoring of currently excluded areas on the landfill surface	$515,837	$515,837
Surface Emissions Monitoring	SEM spacing relaxation limited to areas with final cover	$400,026	$400,026
Surface Emissions Monitoring	Every-three-quarters SEM replacing annual SEM	$28,170	$28,170

Surface Emissions Monitoring	Confirmatory re-monitoring one month after initial surface exceedances	$127,136	$127,136
Surface Emissions Monitoring	Monitoring of full extent of surface emissions exceedances	$13,246	$13,246
Surface Emissions Monitoring	Reversion of relaxed SEM frequency/spacing upon initial exceedance	$111,225	$111,225
Recurring Exceedances	Increased monitoring and analysis at landfills with recurring surface exceedances	$363,784	$363,784
Gas Collection System Monitoring	Additional wellhead monitoring	$1,345,446	$1,345,446
Early Gas Collection Infrastructure	Early gas collection in new waste areas	$2,945,009	$2,945,009
GCCS Downtime	Limiting collection system downtime	$170,663	$170,663
Third-party Gas Control Systems	Adjusting definitions of gas control system owners and operators	$0	$0
Component Leak Monitoring	Preparation and maintenance of component leak monitoring plans	$130,004	$13,000
Total	*Total*	*$6,193,619*	*$6,076,615*

Note that the Landfill Methane Regulation (LMR) imposes requirements on the "owner or operator" of facilities and equipment subject to the Regulation. Throughout this appendix, "operator" is often used for simplicity to collectively refer to the "owner or operator" when describing obligations under the Proposed Amendments.

Staff does not expect operators to incur costs or achieve cost savings for the following proposed changes:

- *Changes to action timelines*. The same work will need to be completed and doing so sooner can be achieved by more efficient scheduling.
- *Specifying criteria for low gas management at closed landfills*. For semi-continuous gas collection and control system (GCCS) operation, the changes only standardize and clarify the process that is currently at the discretion of the Executive Officer. For permanent GCCS shutdown, the changes increase regulator oversight, clarify currently ambiguous surface emissions monitoring requirements, add a gas collection threshold, ensure that low gas collection is the result of low gas generation, and ensure that

shutting down the GCCS does not interfere with compliance with other regulations. Staff does not expect that any landfills currently operating a GCCS would have been able to permanently shut down their GCCS under the current Regulation within the analysis timeframe because of the need to continue operating these systems for other rules and regulations (e.g., from California State Water Resources Control Board and local air districts).

- *Changes in annual reporting:* New reporting parameters are added and the format in which data is reported is changed (standardization and digitization). Staff expects that the same personnel at regulated entities (or their contractors) assemble and report the data. Digital reporting is significantly more streamlined than the lengthy PDF reports that CARB typically receives under the current Regulation. Therefore, staff expects that the overall time needed to prepare annual reports (and the associated recordkeeping) will not change considering the impacts of both new reporting parameters and improved streamlining of the reporting format.
- *Gas collection system pressure monitoring*: Based on conversations with experts and operators, and a landfill gas energy project development handbook (LMOP 2024), staff expects that landfills already have the necessary sensors to record gas collection system pressure and already re-tune wells after making adjustments to system pressure.

Staff did not calculate changes in costs or cost savings that could result from operators using alternative technologies under the alternative monitoring procedure approval process because operators are not required to adopt an alternative monitoring technology. Operators who choose to use an approved alternative may incur additional costs or achieve cost savings.

Throughout this analysis, staff calculated costs for private and government facilities separately. To the extent feasible, staff used data specific to the facilities in each category. However, in various cases where there was insufficient data to support such calculations, staff apportioned total costs to private and government landfills based on their relative surface areas or waste-in-place. Staff believes these are the best proxies for apportioning likely costs between private and government landfills.

III. Data, Calculations, and Assumptions used throughout the Cost Analysis

A. Landfill characteristics

Staff frequently used the number of landfills or surface area of landfills to scale up estimates of costs from a per-landfill or per-surface area basis to total costs of all subject landfills. Additionally, staff used ratios in various calculations to apportion costs based on sub-categorizations (e.g., the surface area of landfills on different surface emissions monitoring frequencies or the number of landfills by ownership type). These data are presented here along with their sources and referred to in the subsequent calculations. Landfill characteristics data from LMR reporting were from data year 2022.

The ownership type (i.e., private vs. government) of each landfill was determined based on the owner's name reported under the LMR. Staff used these categorizations throughout the rest of the analysis to separate costs between private and government landfills.

The control status (i.e., whether the landfill has a gas collection and control system) of each landfill was determined based on data reported under the LMR. In two cases, landfills that are currently uncontrolled were categorized as controlled for purposes of this cost analysis because staff anticipates those landfills will install and operate a GCCS during the timeframe of this analysis.

Data on surface area for each landfill was obtained mainly from two sources. Surface areas reported under the LMR for 2022 were used in all cases where these data were reported. In cases where surface area was not reported, data from CARB's version 2024 greenhouse gas emissions inventory (CARB, 2025c) were used instead (representing the maximum waste footprint). In one instance, data was not available from either source; in this case, staff estimated the area by manually tracing in geographic information system software the waste boundary shown in a topographic map reported under the LMR (CARB, 2025d).

Data on waste-in-place (WIP) was obtained primarily from LMR reporting. For the several landfills that did not report WIP under the LMR, WIP data from the U.S. Environmental Protection Agency's (U.S. EPA) Landfill Methane Outreach Program was used (U.S. EPA, 2024h).

For controlled landfills, data on surface emissions monitoring (SEM) frequency and spacing were obtained from LMR reporting. Possible SEM frequencies include quarterly, annually, and mixed (i.e., some of the landfill surface is monitored quarterly and some annually, in which case staff assumed that half of the landfill surface is monitored on each frequency). Possible spacings include 25-feet (ft), 100-ft, and mixed (i.e., some of the landfill surface is monitored with 25-ft spacing and some with 100-ft spacing, in which case staff assumed that half of the landfill surface is monitored with each spacing). Data on frequency was available for all landfills that were performing SEM in 2022. Landfills that became newly subject (or were newly identified as subject) and landfills that staff anticipates will be adding a GCCS were assigned quarterly SEM frequency for purposes of this analysis. Data on spacing was available for approximately 60% of landfills. For the remaining landfills, the frequency was used as a surrogate to estimate the spacing, with those on an annual SEM schedule assigned 100-ft spacing[2] and all others assigned 25-ft spacing.[3]

Tables B-3 through B-8 summarize various combinations of the above data that were used in the cost analysis and represents staff's best estimate of these data for the purposes of this cost analysis.

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[2] The conditions that allow relaxed spacing are similar to those to relaxed frequency (except that the landfill or area must be closed in order to relax frequency).

[3] This assumption is conservative as active landfills have the potential to relax spacing without having the potential to relax frequency, and because landfills with mixed frequency were assigned to quarterly spacing.

Table B-3. Number of Landfills by Ownership Type, Landfill Status, and Control Status

Owner Type – Status	Controlled	Uncontrolled	Total
Private – active	28	0	28
Private – closed (or inactive)	19	1	20
Government – active	51	33	84
Government – closed (or inactive)	55	1	56
Total	153	35	188

Table B-4. Waste-in-Place at Active, Controlled Landfills

Owner Type	Waste-in-Place (tons)
Private	667,977,010
Government	644,284,432
Total	1,312,261,442

Table B-5. Landfill Surface Area by Ownership Type, Landfill Status, and Control Status

Owner Type – Status	Controlled (acres)	Uncontrolled (acres)	Total (acres)
Private – active	5,794	0	5,794
Private – closed (or inactive)	2,215	29	2,244
Government – active	9,384	1,098	10,482
Government – closed (or inactive)	5,616	83	5,699
Total	23,009	1,210	24,219

Note: Totals may be different from sum of column or row due to rounding.

Table B-6. Controlled Landfill Surface Area by Ownership Type, SEM Frequency, and SEM Spacing

Owner Type – Frequency	25 ft spacing (acres)	100 ft spacing (acres)	Mixed spacing (acres)	Total (acres)
Private – quarterly*	5,201	895	898	6,993
Private – annual	0	867	0	867
Private – mixed frequency	31	109	0	140
Government – quarterly*	7,400	1,260	1,649	10,309
Government – annual	325	3,405	54	3,784
Government – mixed frequency	0	266	605	871
Total	12,957	6,801	3,205	22,964

*Includes landfills operating on an alternate schedule per an alternative compliance option (ACO).
Notes: A small amount of controlled surface area is excluded from this table based on reported data.
Totals may be different from sum of column or row due to rounding.

Table B-7. Active Landfills - Controlled Landfill Surface Area by Ownership Type, SEM Frequency, and SEM Spacing

Owner Type – Frequency	25 ft spacing (acres)	100 ft spacing (acres)	Mixed spacing (acres)	Total (acres)
Private – quarterly*	4,383	467	805	5,654
Private – annual	0	0	0	0
Private – mixed frequency	31	109	0	140
Government – quarterly*	5,552	1,012	1,649	8,212
Government – annual	0	247	54	301
Government – mixed frequency	0	266	605	871
Total	9,965	2,101	3,112	15,178

*Includes landfills operating on an alternate schedule per an ACO.
Notes: A small amount of controlled surface area is excluded from this table based on reported data. Totals may be different from sum of column or row due to rounding.

Table B-8. Closed/Inactive Landfills - Controlled Landfill Surface Area by Ownership Type, SEM Frequency, and SEM Spacing

Owner Type – Frequency	25 ft spacing (acres)	100 ft spacing (acres)	Mixed spacing (acres)	Total (acres)
Private – quarterly*	818	428	93	1,339
Private – annual	0	867	0	867
Private – mixed frequency	0	0	0	0
Government – quarterly*	1,849	248	0	2,097
Government – annual	325	3,158	0	3,483
Government – mixed frequency	0	0	0	0
Total	2,992	4,701	93	7,786

*Includes landfills operating on an alternate schedule per an ACO.
Notes: A small amount of controlled surface area is excluded from this table based on reported data. Totals may be different from sum of column or row due to rounding.

B. Inflation adjustments

The costs in this analysis are presented in 2023$. Cost data from prior to 2023 was adjusted based on the change in the California Consumer Price Index (CPI) for “All Urban Consumers” from the California Department of Industrial Relations (DIR, 2025). To make these inflation adjustments, the original cost was multiplied by the appropriate adjustment factor from Table B-9.

Table B-9. California Consumer Price Index and Inflation Adjustment Factors

Year	California Consumer Price Index, All Urban Consumers	Adjustment Factor (to adjust to 2023$)*
2023	331.804	1
2021	297.371	1.116
2018	272.51	1.218
2014	246.055	1.348
2013	241.623	1.373
2009	224.11	1.481

*Adjustment factor is the ratio of the California CPI in 2023 to the California CPI in the year identified in the row.

Note: Only includes the years for which adjustment factors were used in the cost analysis.

C. Labor cost rates

Labor cost rates for new tasks required by the Proposed Amendments were estimated based on the type of personnel who would perform the task. In this analysis, three types of labor tasks were considered, each with a different cost: administrative, technician, and engineering. In each case, staff used the California average (mean) labor rate of a representative job category from the U.S. Bureau of Labor Statistics for 2023 (U.S. BLS, 2024). These labor rates were increased to account for wages and benefits by dividing the wage-only rate reported by U.S. BLS by 0.6615.[4] The resulting labor rates that were used throughout this analysis are as follows:

- Administrative:[5] $38.99/hour
- Technician (civil engineering technician):[6] $59.00/hour
- Engineering (civil engineer):[7] $83.66/hour

[4] 0.6615 is the average of the private and government sector shares of employer costs attributable to wages and salaries (U.S. BLS, 2025).
[5] Represented by the job title “Secretaries and Administrative Assistants, Except Legal, Medical, and Executive.”
[6] Represented by the job title “Civil Engineering Technologists and Technicians.”
[7] Represented by the job title “Civil Engineers.”

D. Surface emissions monitoring and component leak monitoring cost rates

Several of the proposed changes would result in additional SEM and component leak monitoring (CLM). Staff estimated the costs of additional SEM based on one hour of technician labor time per acre of landfill surface per survey at a 25-foot spacing interval (matching the estimated labor time and personnel type used in the cost analysis for the original LMR adoption; CARB, 2009b). For CLM, staff estimated the cost per additional component monitored using an estimated number of components that can be monitored per hour by one technician (CARB, 2016) and the technician labor rate.

The estimated labor time per acre for SEM includes the average time needed for travel and setup. In cases where additional monitoring due to a proposed change is limited but would require an additional visit by monitoring personnel, staff adjusted the costs to account for only active monitoring time and then separately added the estimated time needed for travel and setup. The calculations for both SEM and CLM are shown below with results in Table B-10.

Table B-10. Cost of SEM and CLM per Monitoring Event

Indicator	**Cost, accounting for travel and setup[a]**	**Cost, accounting for monitoring time only[b]**
Cost of SEM per acre at 25 foot spacing	$59.00/acre	$51.63/acre
Cost of SEM per acre at 100 foot spacing	$14.75/acre	$12.91/acre
Cost of CLM per component	$1.74/component	$1.52/component

[a] Calculated in equations 1-3.

[b] Calculated assuming that cost accounting for travel and setup includes one hour of travel and setup time per eight-hour workday: Monitoring-only cost = cost accounting for travel and setup x (8-1)/8.

Equation 1:

$$C_{SEM,pa,25ft,ts} = LT_{SEM,pa,25ft,ts} \times LR_T$$

where,

$C_{SEM,pa,25ft,ts}$ is the cost of SEM per acre at 25-ft spacing including travel and setup ($/acre)

$LT_{SEM,pa,25ft,ts}$ is the labor time for SEM per acre at 25-ft spacing including travel and setup: 1 hr/acre (CARB, 2009b)

LR_T is the labor rate for a technician: 59.00 $/hr

Equation 2:

$$C_{SEM,pa,100ft,ts} = \frac{C_{SEM,pa,25ft,ts}}{4}$$

where,

$C_{SEM,pa,100ft,ts}$ is the cost of SEM per acre at 100-ft spacing including travel and setup ($/acre)

4 is the ratio of spacing interval distance (i.e., 100 ft / 25 ft)

Equation 3:

$$C_{CLM,pc,ts} = \frac{LR_T}{CR}$$

where,

$C_{CLM,pc,ts}$ is the cost of CLM per component including travel and setup ($/component)

CR is the rate of components that one person can monitor per hour accounting for travel and setup: 34 components/hr (CARB, 2016)

E. Re-monitoring and repair

Some of the proposed changes are expected to result in additional instances of re-monitoring or additional repairs. The cost of each additional instantaneous re-monitoring event was estimated based on one hour of travel/setup time and 30 minutes of monitoring time (to account for both the measurement and walking to and from the monitoring location) at the technician labor rate, resulting in an additional cost of $88.50 per additional instantaneous re-monitoring event. The cost of each additional integrated re-monitoring event was estimated based on one hour of travel/setup time at the technician labor rate and the cost of monitoring 1.15 acres (surface area of a monitoring grid) at 25 foot spacing (Table B-10, monitoring time only) resulting in an additional cost of $118.26 per additional integrated re-monitoring event. By including the one hour of travel/setup time, staff is implicitly assuming that each additional re-monitoring event will result in an additional call-out of monitoring personnel. To the extent that re-monitoring events are performed simultaneously, the actual costs may be lower. Additionally, staff only applied these costs in instances where the additional re-monitoring is required in the absence of additional initial monitoring because the labor time for additional initial monitoring includes allowance for re-monitoring.

The cost of each additional surface emissions exceedance repair due to the Proposed Amendments was estimated based on an average of one hour of additional technician labor per repair, resulting in an estimated cost of $59.00 per repair. Staff's understanding is that most repairs consist of simple actions like tuning gas collection wells or adding/compacting soil that would typically take less than one hour to complete. In some cases, the Regulation requires a new or replacement well to be installed. Staff estimated the cost to add a new or replacement well as $30,726, which includes drilling, wellhead, piping, engineering, permitting,

and surveying (US EPA, 2023f).[8] For purposes of calculating estimated tax revenues, staff assumed that 50% of the costs labeled "installed cost of wellhead and pipe gathering system" is for materials/parts, resulting in an estimated 38% of total well installation costs being attributed to materials/parts.

Throughout this analysis, staff only applied additional repair and well installation costs in cases where new areas of the landfill surface would be monitored. This is because proposed changes that increase the frequency of monitoring or add new one-time monitoring events will find and mitigate leaks sooner, but those leaks likely would have been found later and incurred the same repair and well installation costs under the current Regulation.

F. Data reported under the LMR

Staff used data reported by operators under the LMR to aid in estimating various costs. Unless otherwise stated, 2022 data was used.

G. Rounding

Throughout this analysis, the values shown in this appendix are rounded, however, the underlying calculations were generally performed without rounding. Therefore, if a reader attempts to reproduce the calculations of this analysis using rounded intermediate values shown in this appendix, it may produce slightly different results.

IV. Cost Data and Calculations by Provision for the Proposed Amendments

A. Investigation and repair of remotely detected emission plumes

The Proposed Amendments require operators of controlled landfills to respond to CARB notifications of remotely-detected emission plumes by performing a field inspection, repairing leaks discovered in the inspection, and reporting certain information to CARB.

The number of notifications that will be sent will likely depend on the eventual frequency and spatial coverage of satellite overpasses and deployment of other remote sensing technologies approved for this provision, which is not precisely known at this time. For purposes of this cost analysis, staff estimated that 100 notifications would be sent per year. This estimate was based on approximately tripling[9] the number of landfills where plumes were observed in a multi-year flight campaign (Duren et al., 2019). The factor of three was used to account for the potential of a landfill having more than one plume notification per year or more landfills being identified with plumes (e.g., due to the expected increased observation frequency that satellites can provide versus the more periodic flights used in Duren et al., 2019).

[8] Adjusted for inflation from 2013$ to 2023$.

[9] Plumes were observed at 30 landfills. Staff first adjusted this count by multiplying by the "sectoral factor" of 1.11 provided in Duren et al. (2019), and then multiplying the result by three.

The follow-up monitoring area in the Proposed Amendments is 600 ft by 600 ft (360,000 square feet or 8.26 acres). This area was paired with the monitoring-only SEM cost per acre at 25 ft spacing (Table B-10; $51.63/acre) and two hours[10] of travel and setup time at the technician labor rate. Staff estimated how many components would need to be monitored on average per notification separately for gas control systems and for gas collection systems. For gas control systems, staff used an estimated count of 100 components per system based on the highest component count that staff found reported in a sample of LMR annual reports from 2022. Using this data, the monitoring area size (8.26 acres), and the average size of an active controlled landfill from reporting data (192 acres), staff estimated that on average, four gas control system components would be monitored per notification (8.26 acres / 192 acres/landfill x 100 control system components/landfill). For gas collection systems, staff estimated that 83 components would be monitored per notification, based on an estimated 10 components per well, an estimated 1 well per acre of landfill surface (U.S. EPA, 2023f), and the monitoring area of 8.26 acres (8.26 acres x 1 well/acre x 10 components/well). CLM labor costs were estimated using the monitoring-only rate ($1.52/component) because the monitoring personnel are already onsite for SEM and the full monitoring is expected to be completed in a single trip. Thus, the total SEM and CLM monitoring costs to respond to one notification are estimated as $677 (8.26 acres x $51.63/acre + [4 + 83 components] x $1.52/component + 2 hr x $59.00/hr).

Staff apportioned this estimated 100 remote plume detection notifications between private and government facilities proportional to the waste-in-place at active, controlled private and government landfills (see Table B-4). This resulted in an estimated 51 notifications at private facilities and 49 notifications at government facilities. Thus, the total annual monitoring costs were estimated as $34,446 and $33,224 for private and government landfills, respectively (e.g., for private: $677/notification x 51 notifications).

The cost of recordkeeping and reporting resulting from each notification was estimated based on three hours of administrative labor time and one hour of engineer labor time, which staff estimated based on the volume of information that would need to be collected and sent, and how much of that information might need input from an engineer. This resulted in a recordkeeping and reporting cost per notification of $201, with total annual costs of $10,212 and $9,850 for private and government landfills, respectively.

B. Monitoring of currently excluded areas on the landfill surface

The current Regulation allows certain areas on the landfill surface to be excluded from SEM due to safety considerations for personnel performing walking SEM. The Proposed Amendments require that in these areas, operators perform walking SEM at some other point in the monitoring period (e.g., within each quarter at a facility on a quarterly SEM schedule), or if they cannot do so, use a different monitoring technology instead that enables screening from a safe area (e.g., a remote technology).

[10] Staff estimated two hours here (versus one hour for other situations in which monitoring personnel must be called out) because the more limited timeline for performing these measurements may require monitoring personnel to come from farther away.

Staff estimated the area of landfill surface that is currently being excluded from SEM by analyzing a sample of LMR annual reports that showed walking paths on maps. This sample included five active landfills and five closed landfills that represented various sizes. Within the waste boundary at each landfill, staff counted the number of grids excluded and the number of total grids in each monitoring period. At active landfills included in the sample, 717 grids were excluded out of a total of 2,870 grids, which equals an exclusion rate of 25%.[11] At closed landfills, 15 grids were excluded out of a total of 299 grids, which equals an exclusion rate of 5%.

Staff used these exclusion rates and the total surface areas of active and closed (or inactive) landfills to estimate how much additional surface area would be newly monitored. Staff applied monitoring labor costs per acre equivalent to the current walking SEM at each landfill's SEM frequency and spacing.[12] Table B-7 and Table B-8 show the landfill surface area of private and government landfills with each combination of SEM frequency and spacing. Table B-11 shows the estimated annual monitoring costs (including transportation and setup) per acre for each combination of SEM frequency and spacing. The total costs were calculated by scaling the entries for acres in Table B-7 and Table B-8 by the appropriate exclusion rate (i.e., multiplied by 0.25 for active landfills and 0.05 for closed/inactive landfills), multiplying those areas by the corresponding cost entries in Table B-11, and summing the results of each multiplication. This resulted in total annual costs of $309,371 and $446,709 for private and government landfills, respectively.

Table B-11. Annual SEM Costs Per Acre for Each Combination of Frequency and Spacing

Frequency	**25 ft spacing ($/acre-yr)**	**100 ft spacing ($/acre-yr)**	**Mixed spacing ($/acre-yr)**
Quarterly	236.01[a]	59.00[b]	147.51[c]
Annual	59.00[d]	14.75[e]	36.88[f]
Mixed frequency	147.51[g]	36.88[h]	92.19[i]

[a] SEM cost per acre at 25ft spacing x 4 events per year
[b] SEM cost per acre at 100ft spacing x 4 events per year
[c] (0.5 x SEM cost per acre at 25ft spacing + 0.5 x SEM cost per acre at 100ft spacing) x 4 events per year
[d] SEM cost per acre at 25ft spacing x 1 event per year
[e] SEM cost per acre at 100ft spacing x 1 event per year
[f] (0.5 x SEM cost per acre at 25ft spacing + 0.5 x SEM cost per acre at 100ft spacing) x 1 event per year

[11] These counts represent the total number of grid-monitoring events.
[12] Staff expects that some of the currently excluded area would be monitored by walking SEM at a different point in the monitoring period and that for the remaining areas the costs to perform SEM with alternative instruments would be similar.

[g] SEM cost per acre at 25ft spacing x 2.5 events per year
[h] SEM cost per acre at 100ft spacing x 2.5 events per year
[i] (0.5 x SEM cost per acre at 25ft spacing + 0.5 x SEM cost per acre at 100ft spacing) x 2.5 events per year

Notes: SEM costs per acre are from Table B-10 and include transportation and setup. 0.5 factors represent the assumption that 50% of surface area is under each 25ft and 100ft spacing at mixed spacing landfills. 2.5 events per year at mixed frequency landfills derived from assumption that 50% of landfills surface area is under each quarterly and annual schedules (0.5 x 1 event/yr + 0.5 x 4 events/yr).

Staff also estimated costs for corrective actions and well drilling resulting from new exceedances in currently excluded areas. Staff first assumed that these areas have the same spatial density of exceedances as areas currently monitored. Then, Equation 4 was used to estimate the average fraction of total landfill surface currently being excluded at private and government landfills as 19.5% and 17.5%, respectively.

Equation 4:

$$fSA_{ex} = \frac{fSA_{ex,act} \times SA_{act,cont} + fSA_{ex,closed} \times SA_{closed,cont}}{SA_{act,cont} + SA_{closed,cont}}$$

where,

fSA_{ex} is the estimated fraction of surface area currently excluded from monitoring

$fSA_{ex,act}$ is the estimated fraction of surface area excluded from monitoring for active landfills: 0.25 (as derived above)

$fSA_{ex,closed}$ is the estimated fraction of surface area excluded from monitoring for closed landfills: 0.05 (as derived above)

$SA_{act,cont}$ is the surface area of active, controlled landfills: 5,794 acres for private landfills and 9,384 acres for government landfills (Table B-5)

$SA_{closed,cont}$ is the surface area of closed, controlled landfills: 2,215 acres for private landfills and 5,616 acres for government landfills (Table B-5)

Equation 5 was used to estimate that an additional 321 and 191 initial exceedances would be detected in the currently excluded areas for private and government landfills, respectively.

Equation 5:

$$Ex_{new} = \frac{Ex_{current}}{1 - fSA_{ex}} \times fSA_{ex}$$

where,

Ex_{new} is the number of initial exceedances expected in currently excluded areas

$Ex_{current}$ is the number of initial exceedances in currently monitored: 1,329 for private landfills and 898 for public landfills (2020 LMR reporting data)[13]

fSA_{ex} is the fraction of surface area currently excluded from monitoring: 0.195 for private landfills and 0.175 for public landfills, as derived above

Staff estimated that 1% of initial exceedances will result in a new/replacement well being drilled based on assuming half of the third exceedances[14] in 2020 LMR reporting data would result in a new/replacement well being drilled (0.5 wells drilled/third exceedance x (44 third exceedances / 2227 initial exceedances)). Finally, the estimated number of additional initial exceedances in currently excluded areas was multiplied by the 1% factor and by the cost per well drilled from section III.E ($30,726/well). Therefore, annual costs for well drilling were estimated as $97,576 and $57,970 for private and public landfills, respectively (e.g., for private landfills: 321 initial exceedances x 0.01 wells drilled/initial exceedance x $30,726/well drilled). Based on the calculations in section III.E, the materials/parts costs for these well installations, which are a subset of the costs shown above (not additional), are estimated as $59,090 total across both private and government landfills (0.38 fraction of installation costs for parts/materials x [$97,576 + $57,970]).

The remaining 99% of initial exceedances would incur corrective actions other than well installation. Using the same calculation approach as for well installation, except using the cost of a repair action from section III.E ($59.00), staff estimated annual repair costs of $18,780 and $11,157 for private and government landfills, respectively (e.g., for private landfills: 321 initial exceedances x 0.99 non-well corrective actions x $59.00/corrective action).

C. SEM spacing relaxation limited to areas with final cover

The current Regulation allows landfills to relax the spacing interval for SEM from 25 feet to 100 feet when certain conditions are met and maintained.[15] The Proposed Amendments make this relaxation available only in areas closed with final cover. Staff used the operational status of

[13] 2020 data were used because extensive quality control efforts had previously been undertaken on that data to ensure high data quality.

[14] For this calculation, staff assumed that 50% of these new third exceedances would be addressed by an owner or operator submitted alternative that would have associated costs similar to those of other corrective actions.

[15] See sections 95471(c)(1)(B)1. and 2. of the current Regulation.

landfills and data reported regarding the SEM frequency and spacing intervals to estimate how much landfill surface area would be affected by this change.

Staff estimated the increased monitoring costs based on the surface areas of active landfills currently being monitored on each SEM frequency and spacing intervals of either 100 ft or mixed (Table B-7), the cost of monitoring per acre for each SEM spacing, and the frequency of monitoring. Although closed areas (with final cover) of active landfills would maintain the ability to use 100 ft spacing, staff lacks the necessary data to determine those surface areas. For simplicity, staff assumed that all surface area of active landfills using a 100 ft spacing interval would revert to a 25 ft spacing interval and that 50% of the surface area[16] on a mixed spacing interval would revert to a 25 ft spacing interval.

The incremental cost per monitoring event was estimated as $44.25/acre, based on the difference between the cost per monitoring event at spacing intervals of 25 ft and 100 ft in Table B-10 (including travel and setup). For each frequency, staff multiplied the additional cost per monitoring event by the number of annual monitoring events (i.e., 4 for quarterly, 1 for annual, and 2.5 for mixed) and by the surface area reverting from 100 ft to 25 ft spacing.[17] Staff then summed the results for each monitoring frequency resulting in annual costs of $165,922 and $400,026 for private and government landfills, respectively.

D. Every-three-quarters SEM in all areas currently on an annual schedule

The current Regulation allows closed/inactive landfills and closed/inactive areas of active landfills to relax to annual SEM frequency when certain conditions are met and maintained.[18] The Proposed Amendments change that relaxed frequency to performing SEM every three quarters.[19]

Staff estimated increased monitoring costs based on the surface area currently being monitored on each SEM frequency and spacing (Table B-6), and the cost of monitoring per acre for each SEM spacing (Table B-10; cost accounting for travel and setup). Staff assumed that landfills on a mixed SEM frequency are currently performing SEM annually on 50% of their surface area. The resulting total area currently on an annual SEM schedule (i.e., all of the area categorized as annual and 50% of the area categorized as mixed frequency in Table B-6) for each spacing was multiplied by the monitoring cost for that SEM spacing,[20] and all resulting values were summed to calculate the estimated cost for each additional survey needed. That total cost per survey was multiplied by 0.333 to estimate the annual average cost increase to change from annual to every-three-quarters SEM (i.e., four monitoring events every three

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[16] Assuming 50% of this surface area is on a 100 ft spacing interval, and all of that area will revert to 25 ft.

[17] E.g., for private active landfills on a quarterly schedule and 100 ft spacing: 467 acres * $44.25/acre-event * 4 events/yr.

[18] See sections 95469(a)(1)(C), (2)(C), and (3) of the current Regulation.

[19] The Proposed Amendments also adjust the areas that qualify to those closed with final cover, however, staff estimates that this will have little impact on the areas eligible for this relaxation and lack the data for a quantitative estimate.

[20] Staff assumed areas on mixed spacing have 50% of the area on each 25 ft and 100 ft spacing, thus resulting in SEM costs per acre that is the average of the cost per acre for 25 ft and 100 ft spacing.

years rather than three monitoring events every three years). This resulted in total annual costs of $4,836 and $28,170 for private and government landfill, respectively.

E. Confirmatory re-monitoring one month after initial surface exceedances

The Proposed Amendments add an additional re-monitoring event one month after each initial surface emissions exceedance to ensure the repair was durable. Staff estimated an additional 1,329 and 898 instantaneous re-monitoring events per year for private and government landfills, respectively, based on one re-monitoring event for each initial instantaneous exceedance in 2020 LMR reporting data. Similarly, staff estimated an additional 662 and 403 integrated re-monitoring events per year for private and government landfills, respectively (again, one for each initial integrated exceedance from 2020 LMR reporting).

Staff multiplied the costs per instantaneous and integrated re-monitoring event (calculated in section III.E) by the total number of events. This resulted in total 1-month re-monitoring costs of $195,910 and $127,136 for private and government landfills, respectively (e.g., for private landfills: 1,329 inst. re-mon. x $88.50/inst. re-mon. + 662 int. re-mon. x $118.26/int. re-mon.).

F. Monitoring of full extent of surface emissions exceedances

The Proposed Amendments include a requirement to determine the full extent of each instantaneous surface emissions exceedance. Staff estimated the additional costs for this change based on 15 minutes (0.25 hours) of additional monitoring time per initial instantaneous exceedance,[21] the technician labor rate, and the number of annually detected initial instantaneous exceedances in 2020 LMR reporting data (1,329 and 898 for private and government landfills, respectively). This resulted in costs of $19,604 for private landfills and $13,246 for government landfills (e.g., for private landfills: 0.25 hr/initial exceedance x $59.00/hr x 1,329 initial exceedances).

G. Reversion of relaxed SEM frequency and spacing upon initial exceedance

The current Regulation allows a landfill or area of a landfill that was performing SEM at an annual frequency and/or at a 100-ft spacing interval to maintain those relaxed parameters after discovering a surface emissions exceedance so long as it is corrected within 10 days. The Proposed Amendments require reversion (from every-three-quarters frequency and/or 100-ft spacing) to the more stringent frequency (quarterly) and spacing (25-ft) upon finding an exceedance, regardless of how quickly it is repaired.

Staff analyzed LMR reporting data from 2022 to estimate the acres of closed or inactive landfills (as a proxy for areas closed with final cover) using 100-ft spacing and/or an annual schedule that had any exceedances (instantaneous or integrated) over the course of a calendar year. Staff reasoned that this area should be representative of the area that will no longer be on the relaxed spacing or frequency over the course of one year because if the

[21] Staff expects the full extent of most instantaneous surface emissions to be relatively small and easily identifiable in most instances.

landfill does not have an exceedance for four quarters (i.e., one year), it is eligible to return to the relaxed spacing/frequency. The analysis showed the relevant areas to be 267 acres of private landfills and 514 acres of government landfills. Equation 6 was used to calculate the increased cost of this change as $57,776 and $111,225 for private and government landfills, respectively.

Equation 6:

$$C_{SEM\ relax\ revert} = A_{c/i\ relax} \times (C_{SEM,pa,25ft,ts} \times 4 - C_{SEM,pa,100ft,ts} \times 1.33)$$

where,

$C_{SEM\ relax\ revert}$ is the cost to revert SEM spacing and frequency relaxation upon finding an initial exceedance

$A_{c/i\ relax}$ is the surface area of closed/inactive landfills on relaxed frequency and/or spacing in 2022: 267 acres and 514 acres for private and government landfills, respectively

$C_{SEM,pa,25ft,ts}$ is the cost of SEM per acre at 25-ft spacing including travel and setup: $59.00/acre (see Table B-10).

4 is the number of SEM events per year at an annual frequency

$C_{SEM,pa,100ft,ts}$ is the cost of SEM per acre at 100-ft spacing including travel and setup: $14.75/acre (see Table B-10).

1.33 is the average number of SEM events per year at an every-three-quarters frequency

H. Increased monitoring and analysis at landfills with recurring surface exceedances

The Proposed Amendments require operators at landfills with recurring surface emissions exceedances to perform assessments (a cover integrity assessment and gas collection system assessment) and more frequent SEM. This provision is invoked when 5 or more instantaneous exceedances or 3 or more integrated exceedances are found in a single monitoring grid (a 50,000 square foot parcel of the landfill surface) in a 12-month period and the resulting assessments and increased monitoring frequency apply to the grid that exceeded the threshold and all adjacent grids.

Staff performed an analysis of data reported under the LMR from 2020-2022 to estimate how many landfills would be expected to exceed the recurring surface emissions standard based on reported leaks by monitoring grid. This resulted in an estimated 65 and 48 grids exceeding the recurring standard for instantaneous and integrated exceedances, respectively.

Staff estimated that the cover integrity assessment and gas collection system assessment would require a combined total of 15 hours of engineer labor time and 5 hours of technician

labor time at each landfill exceeding the recurring surface emissions standard.[22] Based on the number of grids expected to exceed the standard, these labor time estimates, and the labor rates in section III.C, staff estimated an annual cost of $175,137 ([15 hr engineer x $83.66/hr engineer + 5 hr technician x $59.00/hr technician] x [65 inst. exceed + 48 int. exceed]). These total costs were allocated to private and government landfills based on the relative surface area of active controlled landfills with each ownership type (Table B-5) to arrive at estimated costs of $66,856 and $108,281 for private and government landfills, respectively.

For increasing the SEM frequency, staff started with a baseline assumption that landfills invoking this provision would be on a quarterly schedule with 25-ft spacing. Equation 7 was used to calculate costs for increasing the frequency:

Equation 7:

$$TC_{SEM,RE} = R_g \times SA_g \times 9 \times C_{SEM,pa,25ft,ts} \times AM \times Y$$

where,

$TC_{SEM,RE}$ is the total annual cost of increased frequency SEM at all landfills meeting either recurring exceedance standard

R_g is number of grids triggering increased monitoring due to recurring exceedances in a single grid each year: 113 (65 instantaneous and 48 integrated)

SA_g is the surface area of a single grid (acres): 1.15 (converted from 50,000 square feet)

9 is the estimated number of surrounding grids in which the increased monitoring frequency applies

$C_{SEM,pa,25ft,ts}$ is the cost of SEM per acre at 25 ft spacing including travel and setup ($/acre): 59.00 (see Table B-10)

AM is the additional monitoring events per year per landfill: 8 (the difference between 12 per year for monthly monitoring and 4 per year for quarterly monitoring)

Y is the number of years that the increased frequency is in effect: 0.75 yr (the Proposed Amendments require 6 monthly SEM events without exceedances to return to quarterly frequency, and staff estimated here that increased monitoring will continue for 9 months based on an average of 3 initial months with exceedances and 6 additional months without)

Costs were then apportioned between private and government landfills based on the relative total surface area at active, controlled landfills from Table B-5. This resulted in annual costs of $157,756 and $255,503 for increased monitoring at private and government landfills, respectively.

[22] These labor time estimates are based on the elements required for each analysis, where staff expects that a civil engineer will perform most of data analysis and report writing, while a civil engineering technician will collect any field data necessary for the analyses (such as measurements of the cover thickness).

I. Additional wellhead monitoring

The current Regulation requires monthly monitoring of gas collection wellheads for pressure (wellheads are required to be operated under vacuum, and positive pressure requires corrective action). The federal plan issued pursuant to U.S. EPA's Emission Guidelines requires monthly monitoring of wellhead temperature and either oxygen or nitrogen concentration, as well as corrective action requirements for wellhead pressure and temperatures over a threshold. The Proposed Amendments add wellhead temperature and oxygen concentration monitoring, as well as additional wellhead monitoring parameters, monitoring value analyses, and response actions. These additional parameters include monthly measurement of the landfill gas flow rate, methane content, and carbon dioxide content, as well semi-annual measurement of the liquid level in wells. These additions are intended to identify and respond to early and recurring signs of issues with the gas collection and control system.

Staff did not estimate any new monitoring costs for temperature and oxygen because those are already required to be monitored pursuant to the Emission Guidelines federal plan. Monitoring of methane content, carbon dioxide content, and gas flow rate are new additional requirements. Staff's understanding is that most, if not all, landfills already monitor these parameters at least monthly as industry-standard practice, and have the instruments necessary to do so. These parameters are typically measured though a sampling port during each monitoring event. Landfills that do not already routinely monitor these parameters can do so with minimal additional technician labor time during the already required monthly monitoring. Staff estimated an additional labor time of five minutes per well per month on average, taking into account the expected amount of time to perform the measurements and the assumption that many landfills already measure these parameters. Similarly, staff estimated an additional five minutes of technician labor per well per semi-annual liquid level measurement. Using an assumption of one well per acre (U.S. EPA, 2023f), the area of controlled landfills in Table B-5, five minutes per well per month for gas parameters, 5 minutes per well twice per year for liquid level, and the technician labor rate, staff estimated annual added monitoring costs of $551,322 and $1,032,527 for private and government landfills, respectively (e.g., for private landfills: 8,009 acres x 1 well/acre x [5 minutes/well-month x 12 months/yr + 5 minutes/well-semi-annually x 2 months/yr] x 1 hr/60 minutes x $59.00/hr).

The analysis of wellhead monitoring data required is simple to perform in a database or spreadsheet as it consists of comparing the measured value to a limit value, tracking how many times in the prior 12 months that limit was exceeded, and comparing the current value to either the prior month's value or the 12-month rolling average value. Many landfills already contract with a consulting firm that provides this service and/or the software to facilitate such analysis. Therefore, while the analysis is likely to require no additional time at many sites, staff conservatively estimated an additional 12 hours per year of civil engineer labor time to perform this data analysis at each landfill (1 hour per monthly monitoring event). This resulted in an estimated cost of $47,183 and $106,413 for private and government landfills, respectively (e.g., for private landfills: 47 landfills x 12 hr/landfill-yr x $83.66/hr).

Additionally, recordkeeping and reporting costs were estimated based on 1 minute per wellhead monitoring event (i.e., 12 minutes per well per year for gas parameters and 2 minutes

per well per year for liquid level). Using the technician labor rate, an assumption of one well per acre, and the area of controlled landfills in Table B-5, staff estimated annual recordkeeping and reporting costs of $110,264 and $206,505 for private and government landfills, respectively (e.g., for private landfills: 8,009 acres x 1 well/acre x [12 minutes + 2 minutes] x 1 hr/60 minutes x $59.00/hr)

No costs were added for response to out-of-range parameters because it is expected that one of the following apply to all cases: 1) the monitoring will alert operators to issues sooner that would otherwise need to be addressed later (e.g., a watered-in well will eventually result in surface emissions exceedances); 2) the corrective action is already required under an existing federal, state, or local rule; or 3) that operators already take similar actions in response to such wellhead monitoring data in accordance with their existing standard operating procedures and approved GCCS design plans.

J. Early gas collection in new waste areas

The Proposed Amendments require operators to install early gas collection infrastructure in areas of new waste placement at landfills that received at least 200,000 tons of waste in any of the prior three calendar years. The gas collection infrastructure can be either horizontal collectors or caisson wells (a type of vertical well) and must be put into service when certain conditions are met.

According to operators, horizontal collectors are sometimes designed to be temporary (replaced with vertical wells later) while caisson wells have greater longevity. For purposes of this analysis, only horizontal collectors are considered to be an additional cost because caisson wells are likely to simply remain in place and offset the costs of installing permanent wells later. In the absence of available data, staff assume that temporary horizontal collectors newly added due to the Proposed Amendments will be used to control 50% of incoming waste to landfills subject to this requirement.[23]

The average annual waste acceptance from 2021-2023 for landfills with at least 200,000 tons of waste acceptance in any of those years was 22,963,864 tons at private landfills and 16,329,347 tons at government landfills based on LMR reporting data. Staff estimated that horizontal collectors are typically spaced at 45 ft vertically and 200 ft horizontally based on the midpoints of ranges provided in a technical presentation (Cornerstone, n.d.). Based on a rulemaking analysis from the Colorado Department of Public Health and Environment (CDPHE, 2025), staff estimated that horizontal collectors cost approximately $7,500 per 100 feet of length. Using on Equation 8, staff estimated annual costs of installing horizontal collectors of $4,006,392 and $2,945,009 for private and government landfills, respectively.

[23] Some large landfills already install early gas collection infrastructure voluntarily or due to other requirements and staff assumed some of the waste will be controlled by caisson wells or non-temporary horizontal collectors.

Equation 8:

$$TC_{HC} = \frac{\frac{WA}{RD} \times 27}{HS \times VS \times L} \times C_{HC} \times F_{HC}$$

where,

TC_{HC} is the annual cost of installing horizontal collectors at all landfills newly adding horizontal collectors as a result of the Proposed Amendments

WA is the waste acceptance rate in tons for landfills subject to the early gas collection infrastructure requirements: 23,148,043 at private landfills and 17,015,608 at government landfills

RD is the refuse density in tons per cubic yard: 0.65 (see Proposed Amendments Section 95475(a)(41))

27 is the conversion factor from cubic yards to cubic feet

HS is the typical horizontal spacing of horizontal collectors: 200 feet (Cornerstone, n.d.)

VS is the typical vertical spacing of horizontal collectors: 45 feet (Cornerstone, n.d.)

L is the length of horizontal collector corresponding to the cost estimate: 100 feet

C_{HC} is the cost of a horizontal collector per 100 feet of length: $7,500 (CDPHE, 2025)

F_{HC} is the fraction of incoming waste assumed to be newly controlled by horizontal collectors as a result of the Proposed Amendments: 0.5

For purposes of the sales tax revenue estimation, staff also estimated the subset of the horizontal collector installation costs that are for materials/parts (these are not additional to the costs calculated above). Staff used the same 38% factor derived for traditional wells in section III.E, resulting in total estimated annual materials/parts costs of $2,640,756 total across both private and government landfills (0.38 fraction of installation costs for parts/materials x [$4,006,392 + $2,945,009]).

K. Limiting collection system downtime

The Proposed Amendments require operators to limit the number of wells simultaneously offline and limit downtime of wells and other GCCS components. Staff believes that costs associated with these requirements would consist mainly of improved planning and coordination of activities. Therefore, staff estimated additional costs based on labor time for that planning and coordination.

Staff estimated additional costs based on 40 hours of engineering labor time annually per landfill for planning and coordination. Based on that labor time, the engineering labor rate, and the number of active, controlled private and government landfills (Table B-3; 28 and 51,

respectively),[24] annual costs were estimated as $93,697 and $170,663 for private and government landfills, respectively (e.g., for private landfills: 40 hr/landfill-yr x 28 landfills x $83.66/hr).

L. Adjusting definitions of gas control system owners and operators

The Proposed Amendments make explicit through adjustments to the definitions of "owner" and "operator" that owners or operators of landfill gas control systems that "receive" landfill gas are responsible for compliance with all requirements in the Proposed Amendments that are applicable to the components they own or operate. This ensures that all control systems combusting or treating landfill gas (collectively referred to here as "gas control systems") are following the performance, monitoring, testing, recordkeeping, and reporting requirements.

Under the current Regulation, staff do not have a means of determining whether a third-party gas control system owner (i.e., a system not owned or operated by the landfill owner or operator) is currently purchasing the gas or is also controlling the collection system as described in the current definitions of "owner" or "operator."[25] Therefore, for purposes of this cost analysis, staff conservatively assumed that all third-party landfill gas control system owners would incur additional responsibilities and compliance costs under the Proposed Amendments. Staff used recipient information reported under the LMR for gas supplied to a third party[26] to estimate that there are 33 third-party gas control systems, which staff assumed to be all be owned by private entities based on the available recipient information. Each owner or operator of a third-party gas control system needs to comply with operational requirements for control devices, perform certain monitoring, conduct source testing (i.e., measuring the destruction efficiency of combustion devices), and perform recordkeeping and reporting.

Staff consulted Annual Reports submitted under the LMR to estimate the number of components subject to CLM per control system. Staff used the highest value provided in a sample of reports (100 components) because third-party control systems are likely to be more complex than the typical landfill control system (all current third-party systems are landfill gas-to-energy systems). To estimate the total cost of performing CLM, staff assumed one hour of round-trip travel and setup time per monitoring event at the technician labor rate and the cost per component for monitoring-only CLM from Table B-10. With four monitoring events per year and 33 facilities, total annual costs were estimated as $27,832 (33 facilities x 4 events/yr x [100 components/facility-event x $1.52/component + 1 hr x $59.00/hr]).

Staff estimated that a source tests costs $11,402 based on a cost estimate in a publicly posted contract for landfill gas collection and control system services (County of San Diego, 2016). [27]

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[24] Only active landfills are estimated to incur these expenses because those are the landfills that have active filling, frequent construction, and site dynamics.

[25] For example, revenue sharing contracts may be used wherein the landfill gas may not be purchased by the control system owner/operator, and the control system owner/operator sometimes also controls the blower (blowers are part of the gas collection system, so the entity that controls the blower meets the definition of an owner/operator).

[26] Pursuant to section 95470(b)(3)(H) of the current LMR.

[27] Adjusted for inflation from 2014$ to 2023$.

To estimate the number of control devices at third-party gas control systems, staff calculated the average volume of landfill gas combusted in each energy recovery control device for facilities that reported that data under the LMR and multiplied that by the total gas supplied to a third-party (as reported by landfill owners/operators in LMR reporting data). This resulted in an estimated 67 third-party control devices (some control systems have more than one control device). To inform an estimate of how many additional source tests would be required for these control devices, staff consulted permits for a sample of these control devices and observed that many are already required to be source tested annually, while some are currently required to be source tested every other year. On that basis, staff assumed that 50% of devices would need an additional source test every other year. This resulted in annual estimated source testing costs of $193,826 (67 devices x 0.25 additional sources tests/device-yr x $11,402/source test.

Finally, staff estimated recordkeeping and reporting costs based on one hour of recordkeeping by the technician performing CLM for each quarterly event (i.e., four hours annually), five hours of annual administrative labor time to input data into the reporting template, and two hours of annual civil engineer labor time to add any explanatory information that requires engineering analysis and to review the final product before submission. This resulted in estimated annual costs of $19,743 for recordkeeping and reporting ([4 hr/facility-yr x $59.00/hr + 5 hr/facility x $38.99/hr + 2 hr/facility x $83.66/hr] x 33 facilities).

M. Preparation and maintenance of component leak monitoring plans

The Proposed Amendments require operators to prepare and maintain component leak monitoring plans consisting of procedures, timelines, a sitemap/diagram, and a list of components to be monitored. Based on the required contents of the plan, staff estimated labor time for development at 10 hours each for administrative and engineering labor. The administrative time covers writing non-technical portions of the plan, proofreading, and formatting. The engineering time covers writing technical portions of the plan and reviewing the final plan. Annual updates are required only when changes are made to the equipment or procedures that would affect the accuracy of the plan. Therefore, staff estimated that on average each facility will incur annual labor needs of one hour each for administrative and engineering labor to make plan updates (starting in the second year).

Using the above labor time estimates, the labor rates from section III.C, the number of controlled private and government landfills from Table B-3, and the number of third-party gas control systems (see section IV.L), staff estimated first year costs of $57,643, $130,004, and $40,473 for private landfills, government landfills, and third-party control systems, respectively (e.g., for private landfills: [10 hr/landfill x $38.99/hr + 10 hr/landfill x $83.66/hr] x 47 landfills]). Using the same data sources, staff estimated annual ongoing costs starting in the second year of $5,764, $13,000, and $4,047 for private landfills, government landfills, and third-party control systems, respectively.

V. Apportioning Government Costs between State, Local, and Military Landfills

The majority of landfills subject to the LMR are owned or operated by government entities. Most of those are local government entities such as cities and counties. These entities will incur additional costs to manage their controlled landfills due to the Proposed Amendments. The total costs for all government-owned landfills is shown in Table B-2 as $6,193,619 in the first year and $6,076,615 annually in subsequent years.

State government entities own two landfills subject to the LMR, both of which are controlled and closed. Staff estimated the proportion of costs that would be borne by these two landfills based on the combined surface area of these landfills relative to the surface area of all government landfills, and the total costs for all government landfills. These landfills comprise 226 acres while in total there are 15,000 acres of controlled government landfills subject to the LMR. Because these landfills are closed, they are not expected to experience increased costs from the provisions to limit SEM spacing relaxation or for early gas collection installation. The total costs to government landfills excluding these two provisions are $2,848,584 in the first year and $2,731,581 in subsequent years. Applying the surface area fraction above, this results in estimated state costs for direct regulatory compliance of $42,919 in the first year and $41,156 annually in subsequent years (e.g., for the first year: 226 acres / 15,000 acres x $2,848,584), or $125,232 over the three-year analysis period.

The United States military owns one controlled landfill subject to the LMR. That landfill is active and using 25-foot spacing and quarterly frequency for SEM, according to LMR reporting. The landfill has an estimated surface area of 89 acres. Based on these data and same methods used for apportioning government landfill costs to state-owned landfills, staff estimated costs for this military landfill as $16,845 in the first year and $16,153 annually in subsequent years (e.g., for the first year: 89 acres / 15,000 acres x $2,848,584), or $49,151 over the three-year analysis period.

Staff estimated the local government-owned landfills costs by subtracting the state and military landfill costs from the total government landfill costs. This results in local government landfill costs of $6,133,855 in the first year and $6,019,306 annually in subsequent year (e.g., for the first year: $6,193,619 - $42,919 - $16,845), or $18,172,467 over the three-year analysis period.

VI. Estimated Local Air District Implementation Costs

Under the LMR, local air districts can enter into agreements with CARB to primarily implement and enforce the Regulation in their districts. Currently, 22 local air districts have entered into memoranda of understanding with CARB for this purpose. Staff estimated that implementing air districts would incur labor time increases as follows:

- Four hours to review each request for an alternative remedy of third surface emission exceedances
- Thirty minutes to review each notification of a third surface exceedance where an alternative remedy is not requested

- Ten hours per year per landfill for reviewing component downtime notifications (when downtime exceeds 5 calendar days) and requests to extend timelines for concentration measurements in unsafe-to-walk areas

Staff used a labor rate of $89.55/hr for air district staff costs based on the salary of a civil engineer (U.S. BLS, 2024) accounting for benefits at the average public sector rate (U.S. BLS, 2025) ($55.34/hr / 0.618). In Section IV.B, staff estimated 22 requests of an alternative remedy for a third surface emission exceedance and 22 notifications of a third surface emission exceedance without an alternative remedy.[28] Additionally, according to LMR reporting data, there are 153 controlled landfills subject to the LMR, of which 146 are in MOU districts. Assuming the above air district costs are applicable at the 146 controlled landfills in MOU districts, staff estimated total annual air district costs of $139,198 ($89.55/hr x [22 requests/yr x 4 hr/request + 22 notifications/yr x 0.5 hr/notification + 153 landfills x 10 hr/landfill-yr] x [146 controlled MOU landfills / 153 controlled landfills]), or $417,594 over the three-year analysis period.

VII. Cost Data and Calculations for Alternatives to the Proposed Amendments

A. Alternative 1

Alternative 1 is to exclude the requirements related to remotely detected emission plumes in section 95469(b) of the Proposed Amendments. Specifically, under this alternative, owners or operators would not be required to perform monitoring, make repairs, and report information to CARB when notified of a remotely-detected methane emission plume. The costs of Alternative 1 are the costs of the Proposed Amendments less the cost of the remotely detected emission plumes provision, resulting in annual cost reductions compared to the Proposed Amendments of $44,658 and $43,074 for private and government sectors, respectively, or $87,732 annually across both sectors.

This results in three-year total cost reductions of $133,973 and $129,221 for private and government sectors, respectively, or $263,195 total across both sectors. Thus, the total estimated three-year cost of Alternative 1 is $18,551,680 and $18,217,628 for the private and government sectors, respectively, or $36,769,308 total across both sectors.

B. Alternative 2

Alternative 2 is to add to the Proposed Amendments a requirement to install and operate continuous wellhead monitoring with automated well tuning at all wells on landfills that use an energy recovery control device (e.g., an engine, gas turbine, or boiler that produces heat or electricity). The costs of Alternative 2 are the costs of the Proposed Amendments plus additional costs for continuous wellhead monitoring and automated well tuning systems at the 45 landfills using an energy recovery control device. The costs of the additional continuous

[28] 50% of the 44 third exceedances addressed by each type of action.

wellhead monitoring and tuning systems are estimated as $7,306[29] per well (Bingham & Britton, n.d.). The density of wells is estimated as one well per acre of landfill surface (U.S. EPA, 2023f) and the number of acres on which to install these systems (the surface area of landfills that use energy recovery control devices) is 4,181 and 6,819 acres for private and government landfills, respectively, based on LMR reporting data. Based on these data, staff estimated the additional annual costs as $30,544,329 and $49,816,259 for private and government landfills, respectively (e.g., for private landfills: $7,306/well-yr x 1 well/acre x 4,181 acres), or $80,360,589 annually across both sectors.

This results in additional three-year costs of $91,632,988 and $149,448,778 for private and government landfills, respectively, or $241,081,766 total across both sectors. The total estimated three-year costs of Alternative 2 (including the cost of the Proposed Amendments) is therefore $110,318,641 and $167,795,628 for private and government sectors, respectively, or $278,114,269 total across both sectors.

VIII. References

Bingham, B. & Britton, P. (n.d.). *Automated Landfill Gas Collection Increases Landfill Gas Flow and Quality at Oklahoma City Landfill*. White Paper. *https://locicontrols.com/hubfs/22041406/PDFs/Aria%20Technical%20Paper.pdf?hsLang=en*

California Air Resources Board (CARB). (2025c). *Spreadsheet of CARB Greenhouse Gas Inventory Maximum Waste Footprints of Landfills*.

CARB. (2025d). *North Miramar Boundary Approximated in Google Earth.*

CARB. (2016, May). *Public Hearing to Consider the Proposed Regulation for Greenhouse Gas Emission Standards for Crude Oil and Natural Gas Facilities – Initial Statement of Reasons – Appendix B: Economic Analysis.* Posted May 31, 2016. *https://www.arb.ca.gov/regact/2016/oilandgas2016/oilgasappb.pdf*

CARB. (2009b, May). *Staff Report: Initial Statement of Reasons for the Proposed Regulation to Reduce Methane Emissions from Municipal Solid Waste Landfills – Appendix F: Economic Impact Analysis Methodology.* Posted May 8, 2009. *https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2009/landfills09/appf.pdf*

Colorado Department of Public Health and Environment (CDPHE). (2025). *Economic Impact Analysis (Initial Analysis), Regulation Number 31: Control of Methane Emissions from Municipal Solid Waste Landfills*. Retrieved May 14, 2025, from *https://drive.google.com/drive/folders/1oUQ6xyMl5ejJTyIYvmaVF_ijWRqbvjIV*

Cornerstone. (n.d.). *Back to Basics Landfill Gas Management*. Presentation to the Engineering Society of Detroit. Retrieved May 14, 2025, from *https://www.esd.org/wp-content/uploads/2016/06/SW2019-Sowa.pdf*

[29] Adjusted for inflation from 2018$ to 2023$.

County of San Deigo. (2016). *County Contract Number 553542: Agreement with Stearns, Conrad and Schmidt, Consulting Engineers, Inc. DBA SCS Field Services for Monitoring Operation and Maintenance of County of San Diego Landfill Gas Control and Related Systems.*

Department of Industrial Relations, State of California (DIR). (2025). *California Consumer Price Index (1955-2024).* Retrieved April 2, 2025, from *https://www.dir.ca.gov/oprl/CPI/EntireCCPI.PDF*

Duren, R. M., Thorpe, A. K., Foster, K. T., Rafiq, T., Hopkins, F. M., Yadav, V., ... & Miller, C. E. (2019). California's methane super-emitters. *Nature, 575*(7781), 180-184.

U.S. Bureau of Labor Statistics (U.S. BLS). (2024, April 3). *Occupational Employment and Wage Statistics – May 2023 State Occupational Employment and Wage Estimates – California.* Retrieved March 4, 2025, from *https://www.bls.gov/oes/2023/may/oes_ca.htm*

U.S. BLS. (2025, March 14). *Employer Costs for Employee Compensation – December 2024.* USDL-25-0335.

U.S. Environmental Protection Agency (U.S. EPA). (2024h, September). *LMOP Database*. Landfill Methane Outreach Program. Retrieved January 13, 2025, from *https://www.epa.gov/system/files/documents/2024-09/lmopdataca.xlsx*

U.S. EPA. (2023f, September). *LFGcost-Web Model (Version 3.6)*. Landfill Methane Outreach Program.