The Intrinsic Danger of Siting Utility Scale Lithium Based Energy Storage Systems In Densely Populated Areas:

Such Danger Would Be Magnified In Nassau and Suffolk Counties

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January 21, 2026

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Executive Summary

This report was written at the request of the Hauppauge Fire Department because of their concerns about a proposed large Battery Energy Storage System (BESS) facility at 220 Rabro Drive. This would be located within 3500 feet of an elementary school, a much less than ideal siting for such a volatile and potentially dangerous facility. Research on that issue revealed, in addition, that the proposed location is close to streams and has a high water table. In a location with these characteristics, a lithium-ion battery fire, of the type that frequently has occurred at BESS facilities, could produce long-term, catastrophic environmental damage. This is in addition to the more immediate, very serious threat to people and structures at the school and in nearby neighborhoods from heat and toxic gases in the event of a fire. The body of this report explains these threats in detail and also provides background that shows why the occurrence of fire at a BESS facility, like the one proposed, presents such a high level of risk. The readers should be aware in reading this report, that the author received no compensation or payment in kind for the research and writing, but willingly invested the hundreds of hours of work required for its preparation strictly as a result of his great concern for the Hauppauge community, Nassau and Suffolk Counties, the downstate region, and the State of New York in general, inspired by the high level of threat and risk arising from the proposed BESS facility. The report is designed to be read on a network connected device and is arranged with hyperlinks providing backup documentation for each issue should readers wish to learn more about the statements made within.

Introduction

Utility scale electrical energy storage has been a recognized need in the New York Metropolitan Area for over sixty years. For example, Con Ed first proposed the Storm King Mountain Pumped Storage facility in the early 1960's to address this. However, that facility was never built because of potentially negative environmental impacts and community opposition. However, the need for energy storage has not gone away and has recently been exacerbated by a growing trend toward electrification to reduce carbon emissions, along with several years of state energy policies that have left the New York state critically short of electric generation.

The New York Independent System Operator (NYISO) recently released their 2025 – 2034 Reliability Study that determined that electric generation capacity margins could go below zero as early as 2027 with the risk increasing even more each year through 2034. Figure 1 from page 10 of that document clearly shows the problem.

This crisis has resulted from state policies, many associated with New York's Climate Leadership & Community Protection Act (CLCPA), that have blocked the construction or retooling of new gas generation plants for the past seven years, while simultaneously closing a 2 Gigawatt nuclear plant without having a viable operating alternative to replace the lost energy. As a result, NY State officials are moving hastily to find solutions to bridge the gaps. Among these hasty measures, the consequences of which do not seem to have been carefully thought out, is the proposed development and addition to its electrical grid of a number of lithium-ion-battery-based electrical energy storage facilities. To expedite this process, these officials have been attempting to override local zoning laws and their own Department of Environmental Conservation, via the six-year-old Office of Renewable Energy Siting (ORES).

One of these hastily conceived and poorly thought through BESS facilities is proposed for Long Island, within the town of Islip, in Suffolk County. This siting of an intrinsically dangerous BESS facility, in such a densely populated and environmentally sensitive area, having a high water table and close proximity to many streams and the ocean, would seem to defy logic. This is especially true given the very recent catastrophic history of a similar BESS siting at Moss Landing, near Monterey Bay in California.

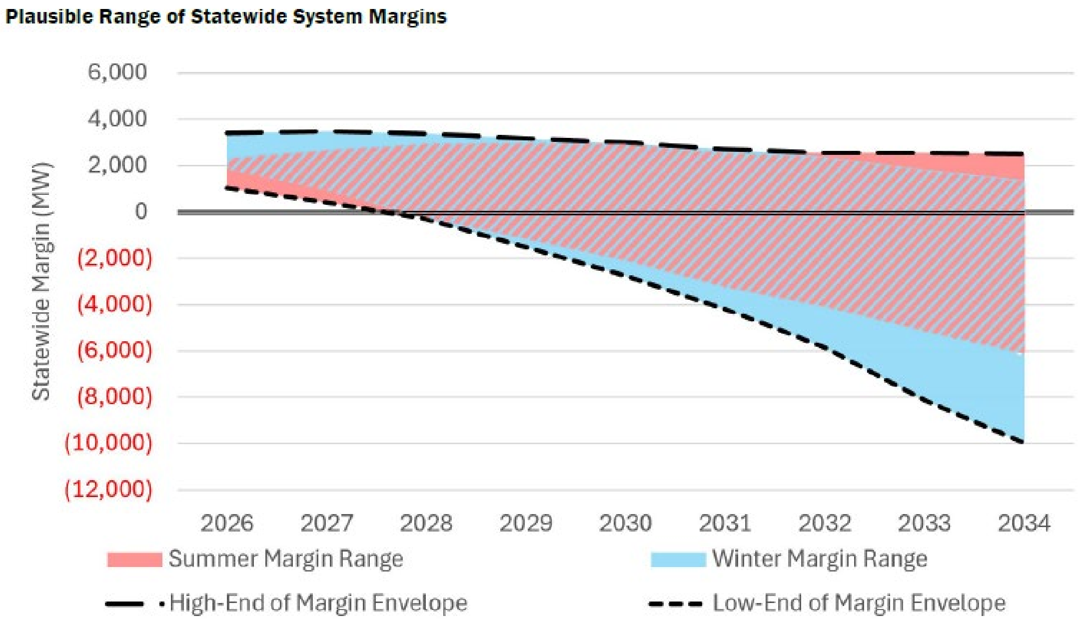

Figure 1

Plausible Range of Statewide System Generation Margins 2025 – 2034. Source: NYISO 11/2025

Whatever help a BESS facility in Islip might promise for the NY state electrical grid is certainly offset by the risks of such a move and the likelihood of accidents with long-term very negative consequences that would impact millions of people and large geographic areas of the state and its waters. These risks follow from three categories of intrinsic dangerous characteristics of lithium ion batteries and the large number of them housed within a BESS facility. These categories of risks are as follows:

- Lithium metal, when brought into contact with any water, creates an exothermic reaction that generates a great deal of heat which can drive the batteries into a state of thermal runaway. So Li-ion batteries and BESS facilities that contain them are very subject to fires, especially if they are located near large bodies of water and exposed to significant humidity or moisture. Lithium Batteries can also burst into flame if they overheat and enter thermal runaway under heavy load.

- Li-ion battery fires are very hot and damaging. They burn at temperatures between 2600 – 5000 degrees-F making these fires, even small ones, very difficult and costly to put out, even if a fire department is well-prepared, which most are not. These fires spread rapidly within a BESS facility, quickly resulting in a conflagration. In addition to the great heat from them, there is release of toxic gases during the fires.

- In the aftermath of large-scale Li-ion battery fires, there is significant, nearly impossible to remediate environmental pollution of land and water with heavy metals and other toxins. This will be particularly damaging in areas with surface water or a high water table, and particularly on Long Island which has a history of water issues and highly permeable soil..

The following sections of this report will explain in detail, with reference to each of these risk categories, why siting utility-scale lithium battery facilities in densely populated areas, like Nassau and Suffolk Counties, is a problem, in general. Also, it will be detailed why this is made especially problematic in coastal areas because of the hydrology and soil composition in this part of Long Island, as well as its proximity to the ocean.

THE ISSUES – LITHIUM IS VOLATILE IN THE PRESENCE OF WATER, LITHIUM BATTERIES CAN OVERHEAT AND ENTER THERMAL RUNAWAY, AND ONCE STARTED THE FIRES ARE DIFFICULT TO EXTINGUISH

> Li-ion batteries and BESS facilities that contain them are very subject to fires, especially if they are located near large bodies of water and exposed to significant moisture.
> Li-ion battery fires are very hot, damaging, and hard to put out, even if a fire department is well-prepared, which most are not. In addition to the heat, there is release of toxic gases during the fires. In the aftermath of Li-ion battery fires, there is significant environmental pollution of land and water with heavy metals and other toxins.

All high energy electric equipment can burn. Even lower energy electric equipment can burn. Transformer fires are not that uncommon. However, transformers are not overly sensitive to moisture and transformer fires can be easily extinguished. In 2023 there were two battery fires in Warwick NY on June 26 and June 27 that occurred nearly simultaneously. It was determined that water penetration during a bad storm caused both of the fires. The owners of the facility claimed to have corrected the issue and the facility was restarted. In December, 2025 there was another fire at the same facility again, apparently because of water penetration. A .csv list of Global Utility Scale Battery Fires can be found here. Appendix 1 has a list of the fires, locations, and dates along with a link to the EPRI Battery Storage Fire Database.

The problem with Lithium battery fires is that after they start, they are not easy to put out. The guidance from the US EPA, available at this EPA link, directs fire crews to let the fires burn themselves out and to use water to prevent the spread of fire to neighboring batteries or buildings. At the 2023 fires in Warwick, they just had to burn themselves out over the course of more than three days. Nearby schools and offices were closed for a week until July 3 due to concerns about toxins. The issues raised by the 2025 Warwick fire can be found here. First responders followed EPA guidelines for fighting Lithium BESS fires.

At the EPA link, the following statements in italics can be found. Of particular note are the bold, underlined sections.

Comply with state and local siting, zoning, marking, and permitting requirements to ensure site suitability.

Incident Response Considerations

Consider the following when developing an incident response plan for BESS:

- *Ensure use of Personal Protective Equipment (PPE) including self-contained breathing apparatuses to protect against hazardous air emissions.*
- *Set an isolation zone for large commercial BESS that is at least 330 feet, depending on the site.*
- *Position responders upwind and uphill.*
- *Evaluate the need for community shelter-in-place or evacuation, depending on the incident and site.*
- *Current guidance is to focus the response on preventing the spread of fire.*
  - ***Direct fire crews to let the fire burn itself out and to use water to prevent the spread of fire to neighboring batteries or other structures. Research is ongoing into the most effective method of water application to prevent spread.***
- *Assess hazardous air emissions:*
  - *Use modeling to guide on-site decision making and initially monitor for hydrogen, carbon monoxide, hydrogen fluoride, hydrogen cyanide, and hydrogen chloride.*
  - *As an incident extends, sample air for metals and other combustion byproducts of burning plastics.*
- ***Minimize, contain, and/or redirect runoff from water application, to the extent possible.***
- *Package contents safely for transport and disposal after the event, considering Department of Transportation and EPA requirements.*

First responders are extremely concerned about these fires because they have no good way of suppressing them. They are basically bystanders watching a 2600 – 5000 degree-F inferno that is spreading contaminants in a rising hot air column.

As bad as that sounds, recent research has shown that the negative effects can be far worse than what has been previously documented. The fire at Moss Landing showed what the worst case scenario can be and researchers are still discovering the negative impacts.

THE AFTERMATH - MOSS LANDING AND ITS LONG TERM AFFECTS ON MONTERREY COUNTY AND THE MARINE WETLANDS

Moss Landing is an area on the Pacific Coast of California between San Jose and Monterrey marked by the red stickpin in the map below in Figure 2.

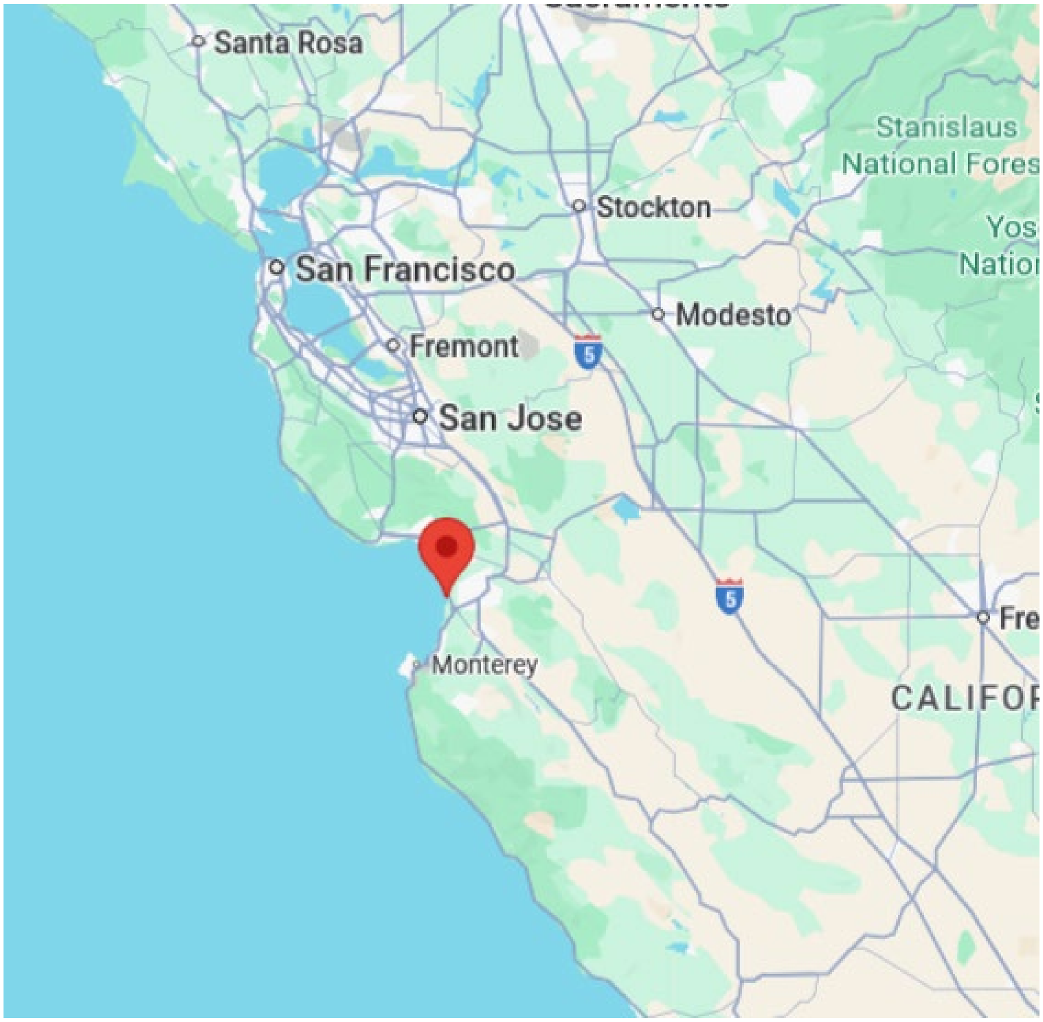

Figure 2 – Moss Landing

There are multiple storage facilities located at the power plant as well as a natural gas generating plant located along a marine estuary as can be seen in the map in Figure 3.

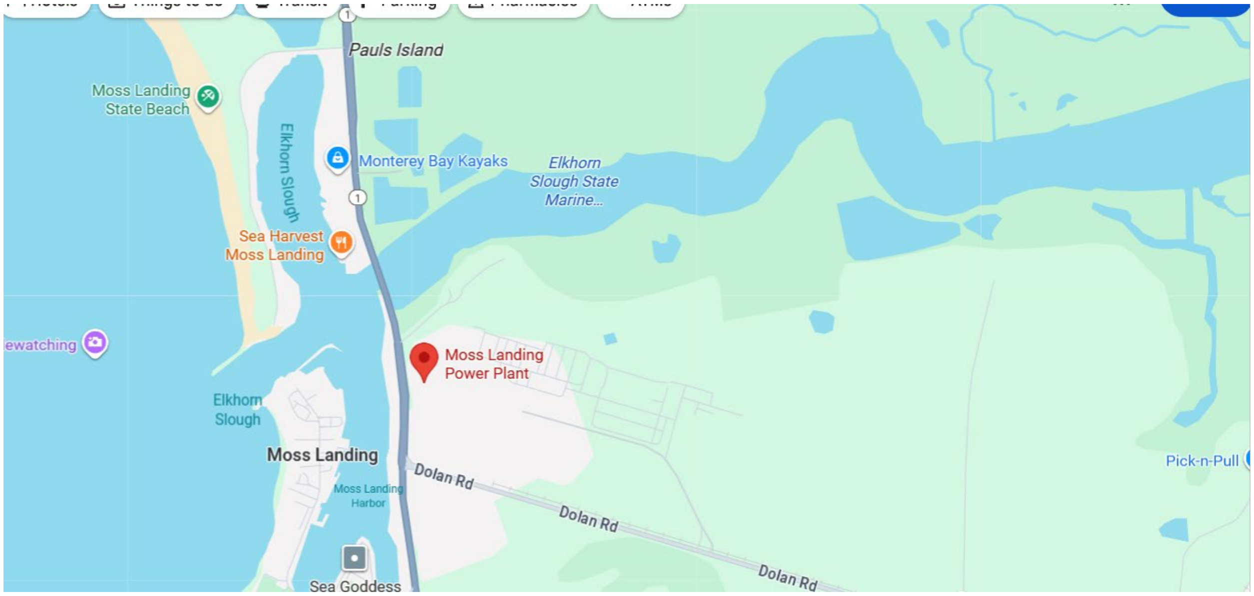

Figure 3 – Moss Landing Power Plant

On January 16, 2025, the 300 Megawatt – 1200 Megawatt-Hour Vistra BESS facility caught fire. Over the course of two days, 80% of the facility burned. A description of the fire and its aftermath are at this NY Times article from February 2025. It also appears in Appendix 2. The discussion of the toxins released into the local environment will be discussed in detail.

At Moss Landing, 1250 people were evacuated over a 2.75 mile radius, a significant portion of which included the Pacific Ocean. That is an area of twenty-four square miles. Smaller fires have required evacuation zones with a radius of a half mile to a mile. A similar sized storage center has been planned at the site of the Ravenswood Generating plant on the East River near Roosevelt Island and Cornell Tech. A document written by Richard Ellenbogen and Roger Caiazza for Case 15-E-0302 for the NY State Department of Public Services documents what a Moss Landing type fire would do within the confines of NY City, starting on page 5 of the document. A twenty-four square mile evacuation zone would require evacuating close to 1.5 million people over some of the most heavily traveled roads in the United States that are nearly parking lots on a normal day. Even a ½ mile radius evacuation zone would include Roosevelt

Island. The paper for 15-E-0302 documents the impossibility of achieving that evacuation within 24 hours.

This past December, researchers at San Jose State released a report that partially documents the aftermath of Moss Landing. The air was not the problem. It was the ground and the water near the plant that has suffered over the past twelve months.

Lithium Battery fires release large amounts of heavy metals, in particular Nickel, Cobalt, and Manganese. Coincidentally, researchers from San Jose State had been working in the marshes around Moss Landing since 2018 and had measurements of the levels of certain chemicals in the ground and water around the BESS Site for at least two years prior to the battery fire. Their research on the effects of the fire on the ground and marshes around the BESS Site appear in the document Coastal wetland deposition of cathode metals from the world's largest lithium-ion battery fire. It is also attached as Appendix 3. From the research paper on page 7 is the following, in italics:

The sharp increase in (Ni, Mn, Co) metal concentrations detected in the surface soils of Hester Marsh between late January and early February 2025 is clearly attributable to the deposition of particulate matter from the smoke plume generated by the nearby battery storage facility fire at Moss Landing just days earlier. This interpretation is supported by multiple lines of evidence, including visible ash residues and soot, the presence of cathode-derived microparticles in surface soils, and distinctive geochemical patterns.

The key to early detection of cathode metal fallout immediately after the Moss Landing battery fire was the use of FpXRF[1]*. While field measurements were not as accurate as lab measurements, they played a pivotal role in rapidly observing that maximum concentrations of the three metals increased by an* ***order of magnitude*** *after the fire….*

An order of magnitude is ten times greater after the fire than before the fire.

Estimates of the release of heavy metals into the environment approach 55,000 pounds. A summary of the findings are as follows in italics.

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1 - Field Portable X-ray Fluorescence (FPXRF) devices are handheld or portable instruments used for rapid, non-destructive, in-situ chemical analysis of materials, measuring elements from Magnesium to Uranium at the ppm level. Weighing under 1.5 kg, they utilize X-ray tubes to emit energy, causing samples to emit characteristic fluorescent X-rays for instant identification, ideal for soil screening, mining, and alloy analysis.

The 2025 fire at the Moss Landing, California, battery energy storage system (BESS)—the world's largest—released approximately 55,000 pounds (25 metric tons) of toxic cathode metals ***(nickel, manganese, cobalt****) into surrounding Elkhorn Slough coastal wetlands. This airborne particulate matter formed a thin, widespread layer (<<5 mm) in surface soils, creating a "fingerprint" of the NMC-type batteries.*

- ***Environmental Impact:*** *The metals, particularly cobalt and manganese, are toxic to aquatic and terrestrial organisms. They pose risks to the ecosystem by potentially bioaccumulating through the food chain, from small invertebrates to shellfish, crabs, and top predators like sea otters.*
- ***Fate of Contaminants:*** *While initially settling in the soil, heavy metals have been mobilized into the estuary through tidal action and rain, spreading the risk beyond the initial deposition zone.*
- ***Detection and Monitoring:*** *Researchers from San Jose State University's Moss Landing Marine Laboratories utilized field-portable X-ray fluorescence (FpXRF) to map the contamination.*
- ***Long-Term Concerns:*** *The long-term impacts on the restored tidal marsh ecosystem are under investigation, as the contaminants may cause lasting, subtle damage to the food web.*

The event highlights the significant environmental risks associated with lithium-ion battery storage fires and the need for rapid assessment of contaminant dispersion

NEGATIVE IMPACTS OF INGESTING HEAVY METALS CONTAINED IN LITHIUM-ION BATTERIES

An AI search on the negative health impacts of the previously listed Cathode metals yielded the following results in italics. The specificity of the question will become clear with further reading.

Which health effects are linked to nickel manganese and cobalt exposure in soil and water from Battery fire runoff over extremely porous soil with a shallow aquifer

Exposure to nickel, manganese, and cobalt from battery fire runoff in porous soil and shallow aquifers heightens risks due to rapid leaching into groundwater, amplifying ingestion and *dermal contact pathways. These metals, common in lithium-ion batteries, can contaminate drinking water and crops, leading to bioaccumulation in the food chain. Health agencies like ATSDR note that such scenarios mirror industrial pollution patterns where soil pH and redox conditions accelerate mobility.*

Nickel Effects

Nickel primarily triggers allergic dermatitis and respiratory issues like asthma upon inhalation or skin contact, with chronic exposure linked to lung cancer and nasal sinus issues in high-dose occupational settings. In water and soil contamination, oral intake causes gastrointestinal distress and potential kidney damage. Porous soil exacerbates dermal absorption during activities like farming.

Manganese Effects

Manganese neurotoxicity manifests as manganism, resembling Parkinson's with tremors, cognitive deficits, and mood changes from chronic overexposure via water or food. ***High runoff levels in shallow aquifers pose risks to children,*** *correlating with ADHD-like symptoms and developmental delays. Soil ingestion by toddlers amplifies vulnerability in contaminated areas.*

Cobalt Effects

Cobalt exposure induces cardiomyopathy, thyroid disruption, and polycythemia from prolonged intake, alongside respiratory irritation from particulates. In battery runoff contexts, it binds to sediments but mobilizes in low-pH soils, raising concerns for reproductive toxicity and fetal development issues. Bioaccumulation in plants adds dietary exposure risks.

Combined Risks

Synergistic effects from nickel-manganese-cobalt mixtures may intensify oxidative stress, organ damage, and carcinogenicity, as seen in battery fire fallout studies showing elevated soil levels near sloughs. Shallow aquifers in porous soils like those in coastal zones facilitate widespread plume migration, urging monitoring for vulnerable populations. Regulatory screening levels often exceed background post-incident.

WHY IS THE GROUNDWATER LEACHING OF THE CATHODE MATERIALS A MUCH LARGER ISSUE ON LONG ISLAND?

Long Island has a long history of water quality issues due to its porous soils and its shallow aquifer which is used to provide its drinking water. In the 1970's, it was phosphates from laundry detergent that was an issue and those are now banned for use on Long Island. In the present day, it is the PFAs or "Forever Chemicals" that are showing up in the dinking water. In fact, several chemical bans have been initiated on Long Island that were later expanded to the entire state and then to the entire country. DDT was the first of those. A history of Long Island environmental advocacy, initiated by water quality concerns, appears here. NY Senate Bill 2021-S393 bans the sale or use of Nitrogen fertilizer in Nassau and Suffolk Counties. There are numerous instances of specialized treatment being given to Long Island with regard to chemicals that can leach into the aquifer. A history of chemical bans on Long Island can be found in Appendix 4. It was created by an AI search and correlates with other publicly available information.

In the prior statement about Manganese Effects, the sentence "**High runoff levels in shallow aquifers pose risks to children**" explains the water situation on Long Island very clearly. Figure 4 is a groundwater map of the area around the proposed Rabro Drive BESS facility. Figure 5 is a Google Earth image of the same area. The battery site is marked on both maps and several locations near the battery site are marked with the depth to the aquifer and the distance from the BESS site in parenthesis. Directly below the BESS Facility, it is only 33 feet down to the aquifer but 300 feet away, it is only 6 feet down to the aquifer, based upon USGS Data. The pumping station for the Suffolk County Water Department is only 4200 feet away, 19 feet above the aquifer.

If one reads the EPA suggested Fire control technique, it states to "***Minimize, contain, and/or redirect runoff from water application, to the extent possible.***" That will be next to impossible to do with porous soil that is going to carry the heavy metals directly to the aquifer only 6 to 33 feet down. There are also large amounts of surface water just over a half mile away, well within the evacuation zones for these fires where the hot thermal air column will carry heavy metal particulates and deposit them into the water. That includes the Nissequogue River, 1200 feet

Figure 4 – Aquifer Depths (Distance from BESS Site)

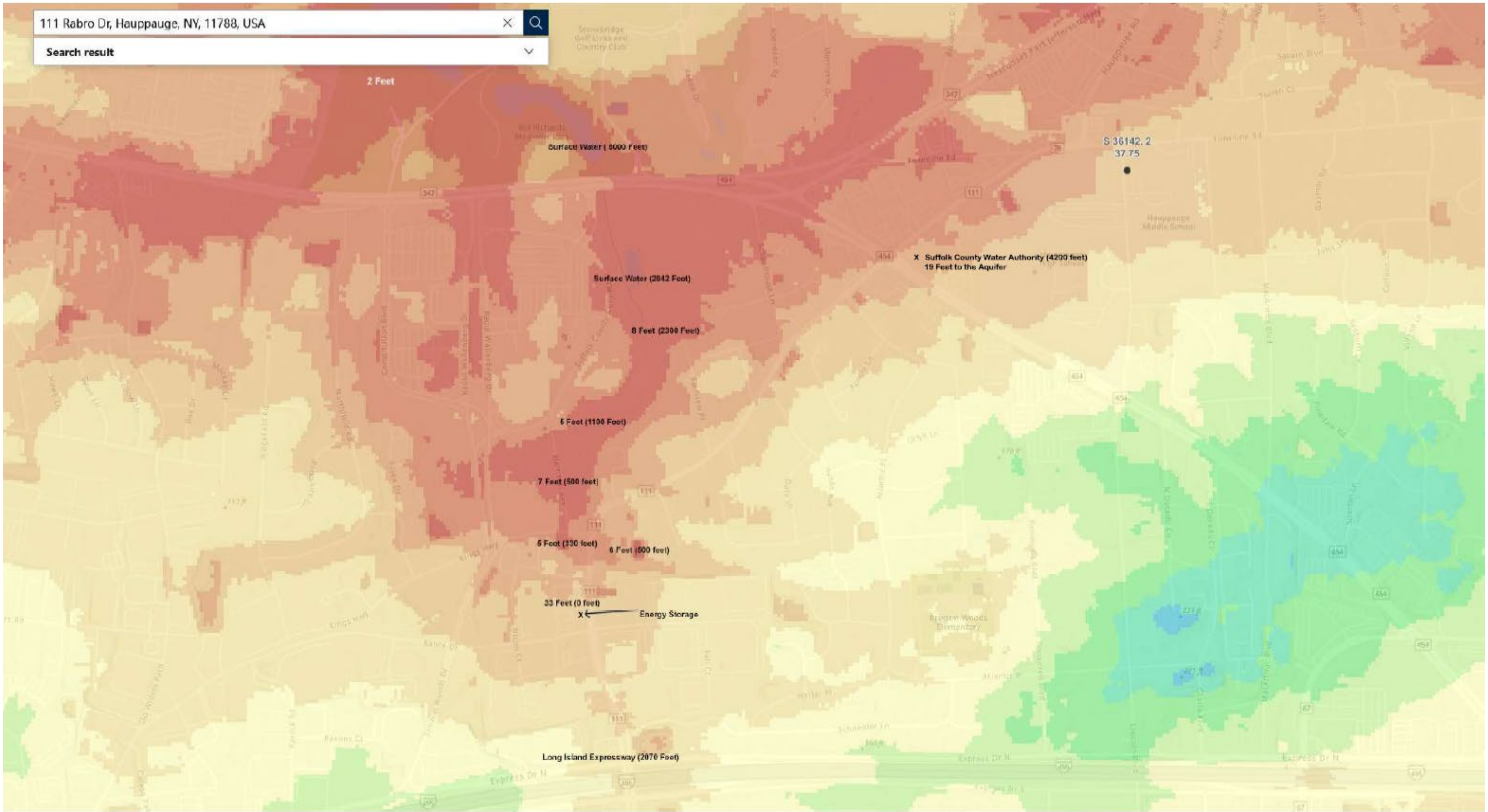
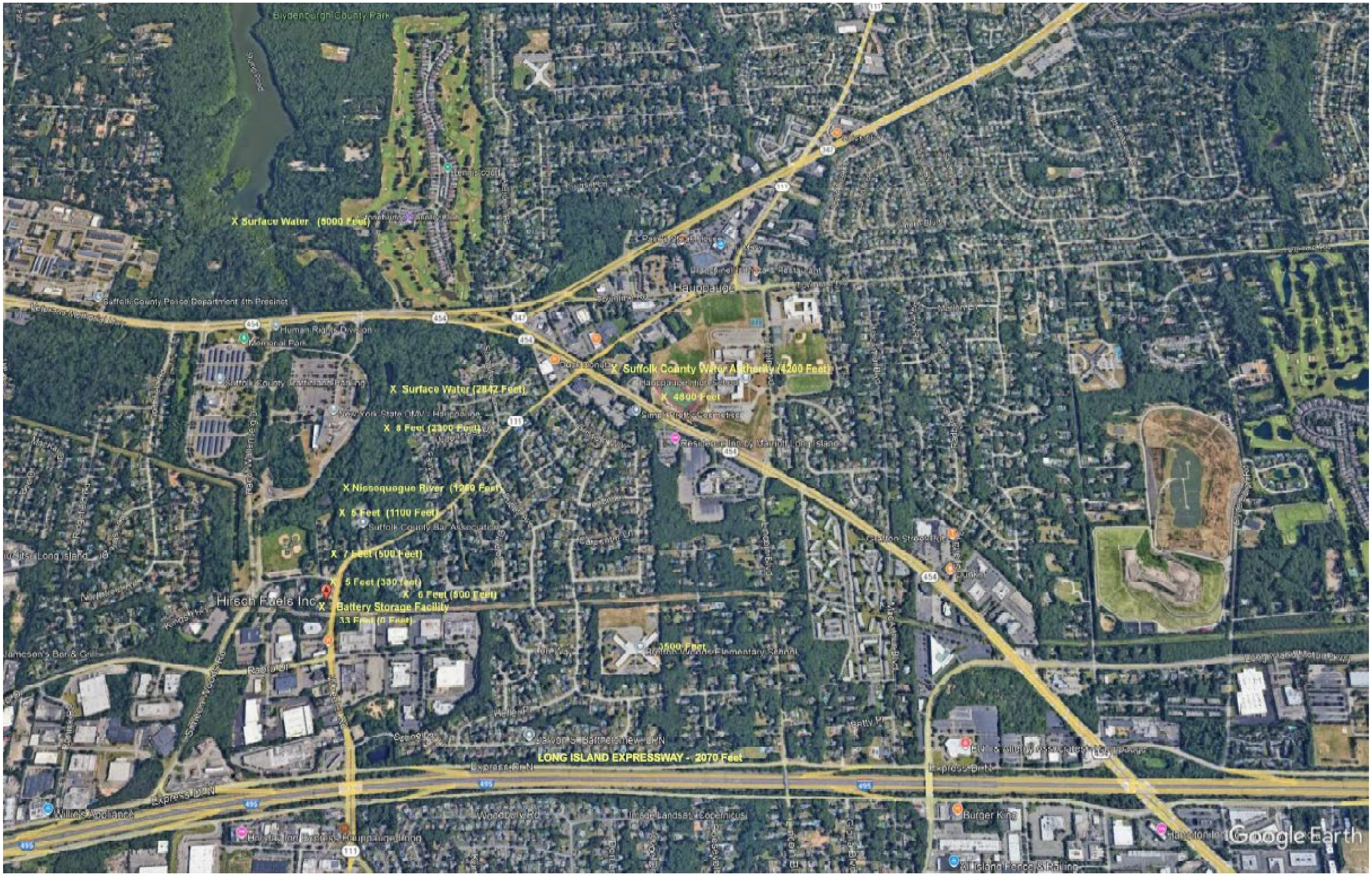


Figure 5 – Google Earth Image of Hydrology Map



away (1/4 mile) which feeds into the Long Island Sound near Sunken Meadows. It will be a repeat of Moss Landing except it will likely contaminate the Hauppauge and Suffolk County Water Supply and possibly the Long Island Sound if there is a large enough fire event.

Further, if fires caused by water penetration into BESS systems during a storm is an issue as it was in Warwick, that will be more likely to occur on Long Island where Category 3 Hurricanes are a distinct possibility.

As per discussions with the Hauppauge Fire Department, many roads in Hauppauge were impassible after Superstorm Sandy for nearly a week. If there is a fire during a major storm and the first responders cannot access it because of blocked roadways, it will burn and the rain will carry all of the heavy metals into the aquifer, even without spraying water onto the surrounding storage units.

The very technique of pumping water onto nearby batteries or structures will increase the likelihood that heavy metals will be carried into the soil and reach the aquifer within about 4 to 7 days. Without the ability to spray water onto nearby batteries, there is no way to mitigate fire spread and there will be even more heavy metals released into the environment which will then be carried into the aquifer by rain runoff. The first responders will be in a no-win situation.

Beyond the water issues, even a 1 mile (5280 feet) evacuation zone would affect Breton Woods Elementary School 3500 feet away, Hauppauge High School 4800 feet away, and it would close the Long Island Expressway which is only 2070 feet away and shut down the main evacuation route. That would be extremely problematic if it happened during a large storm and people were trying to escape coastal flooding on Eastern Long Island. While that is a worst-case scenario, it is not beyond the realm of possibility based upon recent events.

A one-mile evacuation zone around 220 Rabro Drive would also include between 20,000 and 40,000 people as opposed to the only 1250 people in the 2.75 mile evacuation zone at Moss Landing.

CONCLUSION

The author of this document has no monetary interest either way in Lithium Storage technologies. He views the issue entirely from a perspective of, "Would he want one of these facilities near him based upon what he knows, and if not, why not?" That question was answered very clearly in the preceding pages. He has been looking into an Energy Storage system for his factory for over three years. He looked at Lithium based storage and discarded the concept after about a day of research, even before he uncovered the large amount of information in this document. The significant likelihood of a fire, despite the improved technologies, and the lack of a satisfactory way to suppress the fire was the deciding factor for him.

If you combine that with the hazardous emissions and the potential environmental damage, it becomes apparent that the suitable locations for these types of systems have to be restricted to areas where there are very few people and no surface water or ground water. Anything less than that will lead to a high probability of increased public health issues.

Rectifying self-inflicted generation issues by inserting science projects into densely populated areas, especially those with high levels of moisture, a large amount of surface water, or a high water table is a disaster waiting to happen. That is especially true if the ground water is used for human consumption as it is on Long Island. The ramifications of such an event would take years to clean up and leave millions of people with a compromised water supply.

APPENDICES

APPENDIX 1

In Appendix 1 and at the following link are a list of global BESS fires that include thermal runaway incidents and explosions.

EPRI's Battery Energy Storage System Failure Incident Database

About the BESS Failure Incident Database

The BESS Failure Incident Database[1] was initiated in 2021 as part of a wider suite of BESS safety research after the concentration of lithium ion BESS fires in South Korea and the Surprise, AZ, incident in the US. The database was created to inform energy storage industry stakeholders and the public on BESS failures.

Tracking information about systems that have experienced an incident, including age, manufacturer, chemistry, and application, could inform R&D actions taken by the industry to improve storage safety. The focus of the database is on incidents that had a wider public health and safety impact, rather than on operational failures. Some helpful definitions follow:

- BESS: A stationary energy storage system using battery technology. The focus of the database is on lithium ion technologies, but other battery technology failure incidents are included.
- Failure incident: An occurrence caused by a BESS system or component failure which resulted in increased safety risk. **For lithium ion BESS, this is typically a thermal risk such as fire or explosion.**
- Utility-scale: This refers to systems and projects that are interconnected to the grid.
- C&I: This includes systems and projects that are behind-the-meter installations. Residential system failures are not currently tracked. Note that the Stationary Energy Storage Failure Incidents table tracks both utility-scale and C&I system failures.

	Location	Capacity (MWh)	Event Date	System Age (yr)
1	Japan, Ibaraki Prefecture		9/21/2011	
2	US, HI, Kahuku	10	8/1/2012	1.5
3	US, AZ, Flagstaff	1.5	11/26/2012	1.5
4	US, WA, Port Angeles		7/3/2013	
5	US, WI, Franklin		8/10/2016	0
6	China, Shanxi		3/7/2017	
7	South Korea, North Jeolla, Gochang	1.46	8/2/2017	0
8	Belgium, Drogenbos		11/11/2017	
9	China, Shanxi		12/21/2017	
10	South Korea, North Gyeongsang, Gyeongsan	8.6	5/2/2018	1.83
11	South Korea, South Jeolla, Yeongam	14	6/2/2018	2.41
12	South Korea, North Jeolla, Gunsan	18.965	6/15/2018	0.5
13	South Korea, South Jeolla, Haenam	2.99	7/12/2018	0.58
14	South Korea, South Gyeongsang, Geochang	9.7	7/21/2018	1.58
15	South Korea, Sejong	18	7/28/2018	0
16	South Korea, Chungcheongbuk-do, Yeongdong	5.989	9/1/2018	0.66
17	South Korea, Chungcheongnam, Taean	6	9/7/2018	0
18	South Korea, Jeju	0.18	9/14/2018	4
19	South Korea, Gyeonggi, Yongin	17.7	10/18/2018	2.58
20	South Korea, North Gyeongsang, Yeongju	3.66	11/12/2018	0.75
21	South Korea, South Chungcheong, Cheonan	1.22	11/12/2018	0.92
22	South Korea, Gyeongsangbuk-do, Mungyeong	4.16	11/21/2018	0.92
23	South Korea, South Gyeongsang, Geochang	1.331	11/22/2018	0.58
24	South Korea, North Chungcheong, Jecheon	9.316	12/17/2018	1
25	South Korea, Gangwon, Samcheok	2.662	12/22/2018	1
26	South Korea, South Gyeongsangnam, Yangsan	3.289	1/14/2019	0.83
27	South Korea, South Jeolla, Wando	5.22	1/14/2019	1.17
28	South Korea, North Jeolla, Jangsu	2.496	1/15/2019	0.75
29	South Korea, Ulsan	46.757	1/21/2019	0.58
30	US, OR, Tualatin		4/11/2019	0
31	US, AZ, Surprise	2	4/19/2019	2.08
32	South Korea, North Gyeongsang, Chilgok	3.66	5/4/2019	2.25
33	South Korea, North Jeolla, Jangsu	1.027	5/26/2019	1
34	South Korea, Yesan	1.5	8/30/2019	1.66
35	France, Vitry-sur-Seine		9/16/2019	
36	South Korea, Pyeongchang	21	9/24/2019	2.66
37	South Korea, Gunwi	1.5	9/29/2019	1.75
38	South Korea, Hadong	1.3	10/21/2019	1.25
39	South Korea, Gimhae	2.2	10/27/2019	1.5
40	Australia, Brisbane		3/17/2020	6.7
41	South Korea, Haenam		5/27/2020	2.2
42	UK, Liverpool	10	9/15/2020	1.5
43	France, Ariege, Perles-et-Castelet	0.5	12/1/2020	0
44	Gogyeong-myeon, Gyeongsangbuk-do, South	4	3/11/2021	
45	South Korea, YoungCheon City	8.4	3/11/2021	
46	South Korea, Hongseong		4/6/2021	3
47	Australia, Bohle Plains	8	4/7/2021	1.25
48	China, Beijing	25	4/16/2021	2

	Location	Capacity (MWh)	Event Date	System Age (yr)
49	US, MI, Standish		4/19/2021	
50	France, New Caledonia, Boulouparis		7/13/2021	
51	Germany, Neuhardenberg	5	7/18/2021	5
52	US, IL, LaSalle	36	7/19/2021	1.6
53	Australia, Victoria, Moorabool	450	7/30/2021	0
54	US, CA, Moss Landing	1200	9/4/2021	0.8
55	South Korea, Nam-gu, Ulsan	50	1/12/2022	2
56	South Korea, Gunwi-gun, Gyeongsangbuk-do	1.5	1/17/2022	3
57	US, CA, Moss Landing	400	2/13/2022	1
58	Taiwan, Taichung City, Longjing District	1	3/30/2022	2
59	US, CA, Valley Center	560	4/5/2022	0.2
60	US, AZ, Chandler	40	4/18/2022	3
61	South Korea, Jangseong-gun		5/2/2022	
62	France, Corsica, Poggio-di-Nazza	4	6/3/2022	1.75
63	US, CA, Rio Dell		8/3/2022	4
64	South Korea, Incheon		9/6/2022	
65	USA, Wyoming, Yellowstone National Park		9/6/2022	
66	US, CA, Moss Landing	730	9/20/2022	0.5
67	China, Hainan	50	10/20/2022	0
68	South Korea, Jeollanam-do, Damyang-gun, Mu	9.1	12/8/2022	5.5
69	South Korea, Jeollanam-do, Yeongam-gun, Ge	251	12/27/2022	1.75
70	US, PA, Millvale		1/30/2023	
71	France, Saint-Trivier-sur-Moignans		3/28/2023	
72	France, Corsica, Aghione		4/6/2023	
73	Sweden, Gothenburg, Vastra Frolunda	0.875	4/26/2023	0
74	US, NY, East Hampton	40	5/31/2023	4.8
75	US, NY, Warwick	36	6/26/2023	0.1
76	US, NY, Warwick	17.9	6/27/2023	0.1
77	Taiwan, Taichung City, Longjing District		7/4/2023	
78	US, NY, Chaumont	15	7/27/2023	0.4
79	China, Xiangzhou District, Zuhai City		8/19/2023	
80	France, Saucats, Barban	98	8/22/2023	0
81	US, CA, Valley Center	560	9/18/2023	1.6
82	Australia, Queensland, Bouldercombe	100	9/26/2023	0.1
83	France, Martinique, Saint-Esprit		9/29/2023	
84	USA, ID, Melba	8	10/2/2023	0
85	Taiwan, Lanyu		12/28/2023	
86	Japan, Kagoshima, Isa		3/27/2024	
87	US, CA, Kearny Mesa	80	4/29/2024	2.1
88	USA, CA, San Diego	250	5/15/2024	3.7
89	US, CA, Santa Ana		7/17/2024	
90	US, CA, Escondido	120	9/5/2024	7.6
91	Singapore		9/10/2024	
92	Canada, ON, Brantford		9/12/2024	3
93	South Africa, Table Mountain		10/25/2024	
94	Spain, Valencia, Port of Gandia		1/5/2025	
95	US, CA, Moss Landing	1200	1/16/2025	4.1
96	England, Essex, Tilbury	600	2/19/2025	0

	Location	Capacity (MWh)	Event Date	System Age (yr)
97	England, Gloucestershire, Cirencester	51	3/28/2025	2.5
98	US, OR, Hillsboro		5/22/2025	
99	South Korea, Gyeongsangbuk-do, Songdong-ri		6/16/2025	
100	South Korea, Gyeongsangbuk-do, Pohang City		6/16/2025	
101	Netherlands, Almelo		8/4/2025	
102	US, CA, Parkfield	240	8/30/2025	4
103	US, NV, Boulder City	360	9/23/2025	3.75
104	US, AZ, Peoria	100	10/1/2025	4
105	US, NY, Warwick		12/19/2025	

APPENDIX 2

https://www.nytimes.com/2025/02/10/us/california-battery-plant-fire.html

The Moss Landing Power Plant has stood over the community in Moss Landing, Calif., since 1950.Credit...Ian C. Bates for The New York Times

A California Battery Plant Burned. Residents Have Gotten Sick, and Anxious.

Heavy metals detected in the soil have also created health implications for Monterey County's agriculture industry, and the workers who pick the produce.

The Moss Landing Power Plant has stood over the community in Moss Landing, Calif., since 1950.Credit...Ian C. Bates for The New York Times

By Orlando Mayorquín

Reporting from northern Monterey County, Calif.

- Feb. 10, 2025

The vast farmlands just off the coast of California's Monterey Bay are usually quiet during the winter, when there are no crops to pick.

This winter, a different kind of stillness has taken hold. First, fears of immigration raids paralyzed the immigrant communities that make up the agricultural work force. And now, anxiety has spread over what some in the region believe is a sprawling and silent environmental disaster.

Last month, a battery-storage plant went up in flames and burned for days, prompting the evacuation of more than 1,000 residents and shutting down local schools. The plant, located in Moss Landing, an unincorporated community in Monterey County, is the largest facility in the world that uses lithium-ion batteries to store energy. Residents have reported feeling ill, and many of them worry that the fire polluted the air, soil and water with toxins.

"Now you don't see anybody walking outside because it's terrifying, everything that's going on," said Esmeralda Ortiz, who had to evacuate from her home in Moss Landing after the plant began burning on Jan. 16.

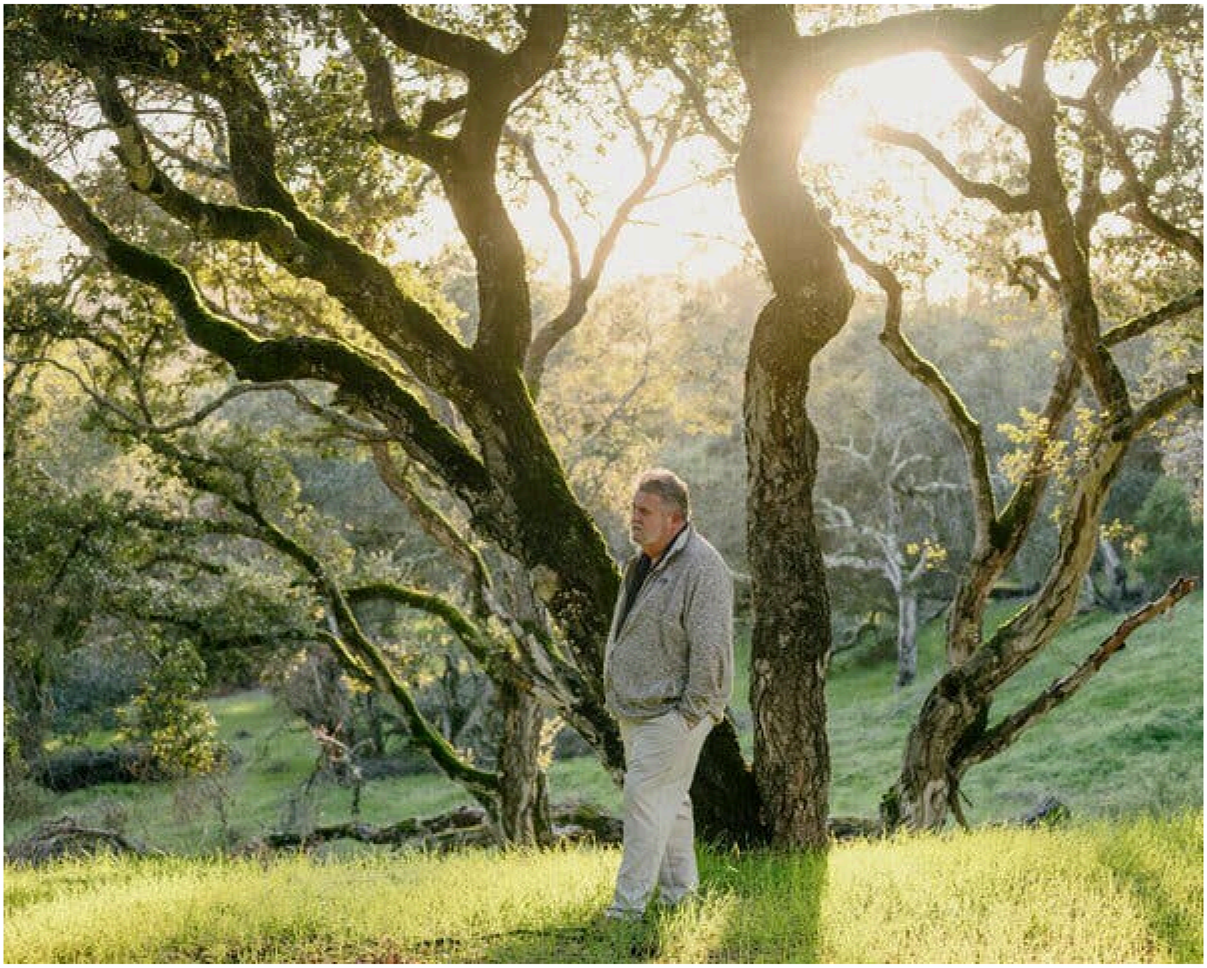
She noticed an odd metallic odor as she and her two young children fled. She said she later took her children to the doctor after they complained of headaches and sore throats, symptoms she also had. Eventually, her children felt better, but Ms. Ortiz said she worries about the potential long-term health effects and whether the strawberry fields where she and her husband plan to work during the harvest have been contaminated.

No homes were damaged in the fire, which unfolded more than 300 miles north of the devastating Palisades and Eaton fires in the Los Angeles area. For weeks, residents, officials, researchers and environmental and public-health experts have been trying to understand the scale of damage, but so far there have been few answers. What was unleashed by the plumes of smoke from thousands of burning lithium-ion batteries? And where did it go?

“A lot of people are concerned about the ingestion of heavy metals,” said Brian Roeder, who moved his family into a rental home for the next month after they felt ill at their home in Prunedale, about eight miles southeast of the fire.

“Most people can’t do that,” Mr. Roeder, 62, said of temporarily relocating. “But we have a 7-year-old and we’re like, ‘We got to get him out of here.’”

Image



Brian Roeder at his home in Prunedale, Calif., about eight miles southeast of the Moss Landing battery-storage plant.Credit...Ian C. Bates for The New York Times

Vistra, the Texas-based energy company that operates the plant, said there were approximately 100,000 lithium ion battery modules inside the storage facility and that most of them had burned. The company said an exact accounting had yet to be done, because crews were still prohibited from entering the facility to do a visual inspection.

Tests conducted by a state agency, the Department of Toxic Substances Control, detected cobalt, nickel, copper and manganese — heavy metals found in lithium ion batteries — at wide-ranging levels in soil sampled at eight sites near the plant and up to roughly five miles away from it. Officials said the data was preliminary and still needed to be thoroughly analyzed. Tests of the local drinking water found the presence of the metals but at safe levels. Air quality monitoring has not detected heavy metal particles or hydrogen fluoride, a gas associated with the batteries, county officials said.

In a separate study, researchers at San Jose State University's Moss Landing Marine Laboratories in the Elkhorn Slough Reserve, an estuary next to the battery facility, found that the levels of cobalt, nickel and manganese had significantly increased in topsoil samples in the area compared to levels from studies conducted before the fire.

The results of soil testing by the state agency and the university lab were cited in a lawsuit filed on behalf of four residents by a legal team that includes the environmental activist Erin Brockovich.

The suit alleged that the amount of cobalt, manganese, nickel and copper in the preliminary state data exceeded federal Environmental Protection Agency risk levels for residential soil, including for children. The lawsuit claimed the facility's fire-suppression system was deficient. It was filed against Vistra as well as other defendants, including the state's largest utility company, Pacific Gas & Electric, which operates another energy storage facility at the Moss Landing plant.

Vistra declined to comment on the lawsuit. The company said in a statement that it was working closely with local officials and community partners. "We have and will continue to do everything we can to do right by our community and are working in concert with federal, state and local agencies to ensure public health and safety," Vistra's statement read.

PG&E said it was reviewing the complaint. In a statement, the utility said the fire was not a PG&E incident. "The Moss Landing power plant is located adjacent to — but walled off and separate from — PG&E's Moss Landing electric substation," the statement read.

Many residents worry that the fire polluted the air, soil and water.Credit...Ian C. Bates for The New York Times

Mr. Roeder has helped lead residents in collecting more than 100 of their own soil samples for testing. The preliminary results detected varying concentrations of lithium, cobalt, nickel or manganese as far as 46 miles away.

Haakon Faste, 47, who lives in Ben Lomond, a mountain community roughly 25 miles northwest of the plant, recalled a metallic taste in the air in the days after the fire broke out on Jan. 16. He and his wife experienced a number of symptoms: sore throat, headaches, bloody noses.

“It feels like you’re breathing — I don’t know if it’s like breathing acid or it’s like the air is so incredibly dry that it burns deep down into your lungs, so it hurts to swallow,” Mr. Faste said.

Soil samples from land surrounding the power plant revealed heavy metals found in lithium ion batteries.Credit...Ian C. Bates for The New York Times

The couple evacuated and moved to a short-term rental. Trips to urgent care have yielded few answers about what may have sickened them.

People who inhale high concentrations of heavy metals experience profound health effects, said Dr. Justin Colacino, an associate professor of environmental health science at the University of Michigan School of Public Health. Throat irritation, lung inflammation and difficulty breathing can occur with heavy-metal inhalation, and manganese can have neurological effects if inhaled at high levels.

“If people in the community are reporting these, that would be consistent with what we know from folks that breathe in metals like this in an occupational setting where the levels tend to be high,” Dr. Colacino said.

Even without a full understanding of the environmental and health effects, the fire has raised questions about the safety of energy storage technology that California is relying on to meet its ambitious timeline for a clean-energy future. The Moss Landing Power Plant has stood tall over the region since 1950, generating gas-powered electricity for the state’s grid. Vistra’s lithium-ion battery facility went online at the site in 2020, in an expansion approved by the California Public Utilities Commission.

Facilities like the one in Moss Landing store excess energy collected during the day and release it as electricity into the grid at night. Presented as a step toward a carbon-free future, the expansion received little attention or resistance from the public or from interest groups, said Glenn Church, a county supervisor who represents northern Monterey County.

“We are right now in a place where government does not have the knowledge to regulate this technology and industry does not have the know-how to control it,” Mr. Church said.

When a lithium-ion battery catches fire, industry best practice is to let it burn. Dousing it with water is ineffective and can cause a chemical reaction.

“I know of no other industry that does that,” Mr. Church said of letting the material burn.

He is pushing to keep the facility off line until there is a full accounting of the cause of the fire and its fallout. In addition, Dawn Addis, the state assembly member who represents the central coast, has introduced a bill to require local input in the permitting process and new regulations for new energy storage facilities. And the utilities commission has proposed the implementation of new safety rules.

More than 1,000 residents had to evacuate when the battery-storage plant went up in flames.
Credit...Ian C. Bates for The New York Times

The depositing of heavy metals onto soil carries added implications for a region known for growing strawberries and other produce, and for the workers who pick the fruit.

At a forum on immigrant rights hosted by the local school district in nearby Castroville in late January, many hands shot up when the presenter asked how many farmworkers were in the room.

“People are in a such big moment of stress that they say it’s one thing and another,” Maria Tarelo, who works packing berries, said of the fears of federal raids and the battery plant fire.

Ms. Tarelo has advised her fellow workers to take precautions by wearing masks and gloves, as they face the potential of working land that could turn out to be hazardous to their health. For many men and women who labor in the fields, the pressing concern is that contaminated crops could result in less work.

“Then we don’t have anything to pay for food or rent,” Ms. Tarelo said. “Sometimes, no matter the state of the environment, we have to go work.”

Orlando Mayorquín is a Times reporter covering California. He is based in Los Angeles.

A version of this article appears in print on Feb. 12, 2025, Section A, Page 10 of the New York edition with the headline: A Battery Plant Burned, And Residents Grew Sick.

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Coastal wetland deposition of cathode metals from the world's largest lithium-ion battery fire

Ivano W. Aiello[1]✉, Charlie Endris[1], Steven Cunningham[1], Monique Fountain[2], Maxime M. Grand[1], Wesley Heim[1], Amanda S. Kahn[1] & Kerstin Wasson[2]

Fires at lithium-ion battery storage facilities pose emerging environmental risks that remain largely undocumented under real-world conditions. Following a major fire at the world's largest Battery Energy Storage System (BESS) in Moss Landing, California, we conducted rapid, high-resolution soil surveys to quantify metal fallout in adjacent estuarine wetlands. Field-portable X-ray fluorescence (FpXRF), validated by SEM/EDS, laboratory XRF, and ICP-MS, revealed a significant but transient surface enrichment of nickel (Ni), manganese (Mn), and cobalt (Co). This enrichment had Ni: Co mass ratios near 2:1 serving as a geochemical fingerprint of NMC-type cathode materials. The metals were confined to a shallow surface layer (< 5 mm). Surface concentrations declined rapidly following precipitation and tidal inundation. The fallout's thin, transient and patchy distribution would have eluded standard coring methods but was detected through spatially intensive FpXRF sampling, highlighting the importance of rapid detection and the mobilization of metals into wetland ecosystems. These findings underscore the need for adaptive environmental monitoring following battery fires and raise critical considerations for ecosystem protection and infrastructure as energy storage systems expand.

Rapid growth of distributed energy storage systems in recent years reflects the global need to store power from renewable energy sources and to regulate electrical systems[1–3]. Lithium-ion batteries (LIBs) are the most widely used type of electrochemical energy storage, as they offer high energy and power density compared to other battery technologies[4]. However, electrochemical energy storage and the use and disposal of LIBs involves inherent risks, such as thermal runaway[5] which can lead to the release of potentially toxic compounds from battery materials[6], and localized deposition of battery-associated metals in adjacent ecosystems[7], with, potentially, long-term implications for terrestrial, aquatic, and human health.

Establishing robust environmental baselines in areas surrounding energy storage systems and achieving adequate spatial and temporal coverage to identify contamination after emergency release are both logistically difficult and often cost-prohibitive. In this context, portable and cost-effective technology such as X-ray fluorescence (FpXRF) offers a means of collecting high-density data, serving as a valuable complement to traditional laboratory-based analytical methods.

On 16 January 2025, a large fire engulfed the largest lithium-ion battery (LIB) Battery Energy Storage System (BESS) in the world, burning actively for at least 2 days. This was followed by a smaller reignition on 18 February 2025. Owned by Vistra Corporation, the BESS is in Moss Landing, California, immediately adjacent to Elkhorn Slough, a Ramsar site recognized as a wetland of international importance[8]. The fire affected the core of the facility (Phase 1) which had a capacity of 300 MW/1200 megawatt-hours (MWh) and was equipped with LG Energy Solution's TR1300 battery rack systems[9]. The fire destroyed approximately 75% of the facility[10] and produced a smoke plume visible from tens of kilometers away, depositing ash and soot across the surrounding area (Fig. 1a). Due to potential toxicity, including possible exposure to hydrogen fluoride, evacuation orders and road closures were issued. Residents were permitted to return 2 days after the fire began[11].

Controlled experiments show Li-ion battery fires emit metal-bearing aerosols (notably Ni–Co–Mn) and other toxicants, which can deposit downwind[6]. Three days after the fire, we rapidly mobilized to assess whether surface soils at Hester Marsh, a wetland restoration area within the Elkhorn Slough National Estuarine Research Reserve (ESNERR), only a few km from the Moss Landing facility had been affected by the fallout material from the smoke plume. Coincidentally, we had collected baseline surface soil elemental data in the same area for other research purposes with an FpXRF in 2023 (Fig. 2).

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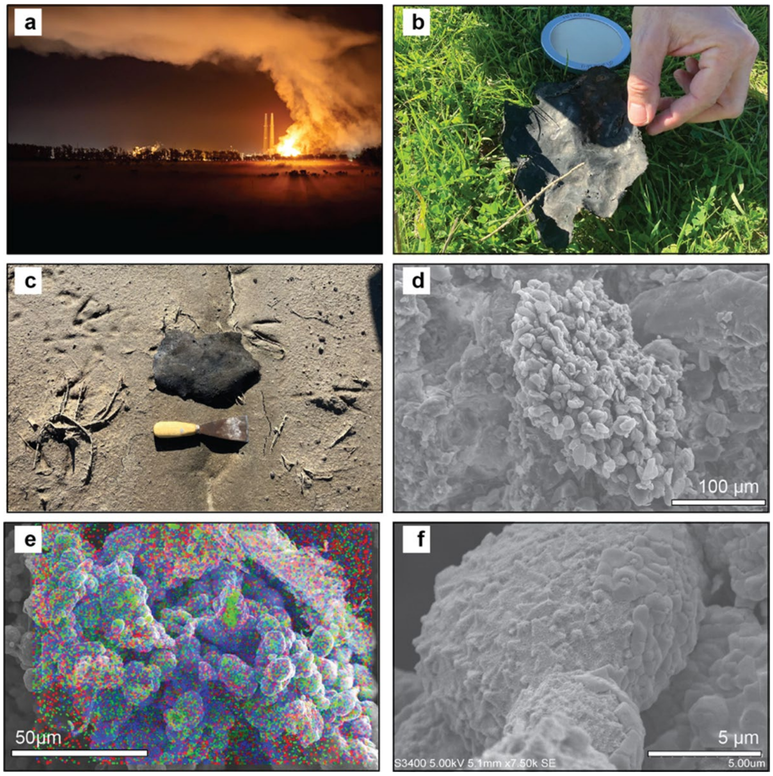

Fig. 1. (**a**) Photo of the battery fire and the smoke plume on January 16th, 2025. The picture is looking south towards the smokestacks of the old Moss Landing power plant and shows the smoke plume hovering Elkhorn Slough and Hester marsh to the east (Photo credit: Mike Takaki). (**b**–**c**) Field photographs showing burned battery fragments from the Vistra battery facility fire collected near transect T12 (B) and transect T8 (C). (**d**) Scanning electron microscope (SEM) images of cathode material aggregate composed of multiple Nickel Manganese Cobalt (NMC) microparticles; (**e**) Energy-dispersive X-ray spectroscopy (EDS) elemental map highlighting the spatial distribution of nickel (Ni, red), manganese (Mn, blue), and cobalt (Co, green). (**f**) A SEM close-up of a single NMC particle.

The Moss Landing battery facility is located within a complex and vulnerable landscape. It sits adjacent to Elkhorn Slough, one of California's largest estuaries, near the town of Moss Landing, and is surrounded by intensively farmed agricultural land. The fallout from the fire's smoke plume raises serious concerns about contamination of soils, water, and vegetation in this region.

Here, we report on the extent and dynamics of cathode metal contamination in estuarine soils immediately following the world's largest lithium-ion battery fire. By combining rapid, high-resolution field surveys with laboratory validation, we tracked the deposition and short-term fate of battery-derived metals in a sensitive wetland ecosystem. Our findings provide rare real-world evidence of the environmental footprint of large-scale battery fires, underscore the value of having a baseline near industrial sites that pose contamination risks, and demonstrate the utility of FpXRF as a practical tool for rapid and spatially intensive environmental monitoring.

Specifically, we test whether the Moss Landing fire deposited a thin surface veneer of battery-associated metals in adjacent wetlands that differ relative to 2023 baseline conditions and whether composition is consistent with NMC cathode material, using a high-density FpXRF survey validated with SEM/EDS, LpXRF, and ICP-MS.

Study area and methodology

Elkhorn Slough is a tide-dominated estuary that in the past 150 years has lost significant vegetated marsh area[12]. At Hester Marsh, extensive diking and draining caused the area to subside and degrade to unvegetated mudflat. In 2018, ESNERR initiated a restoration project to reestablish healthy marsh ecosystems through soil addition, creating a high elevation marsh plain that is only inundated by the highest tides.

To assess relationships between marsh plant health and soil composition, soil property analyses including elemental analysis with a portable Hitachi XMET 8000 XRF (pXRF), were conducted in 2023 along ten permanent transects also monitored for vegetation. These compositional data serve as a baseline for elemental concentrations in soils prior to the 2025 battery fire (Table 1). Following the 16 January 2025 fire at the Moss Landing battery storage facility, three of the original transects were resampled at high spatial and temporal resolution between 21 January and 23 February 2025 (Tables S1 and S2).

During the 2023 survey, surface and subsurface (~ 5–10 mm depth) samples were collected to compare elemental concentrations above and below the shallow redox boundary characteristic of these tidal marsh soils.

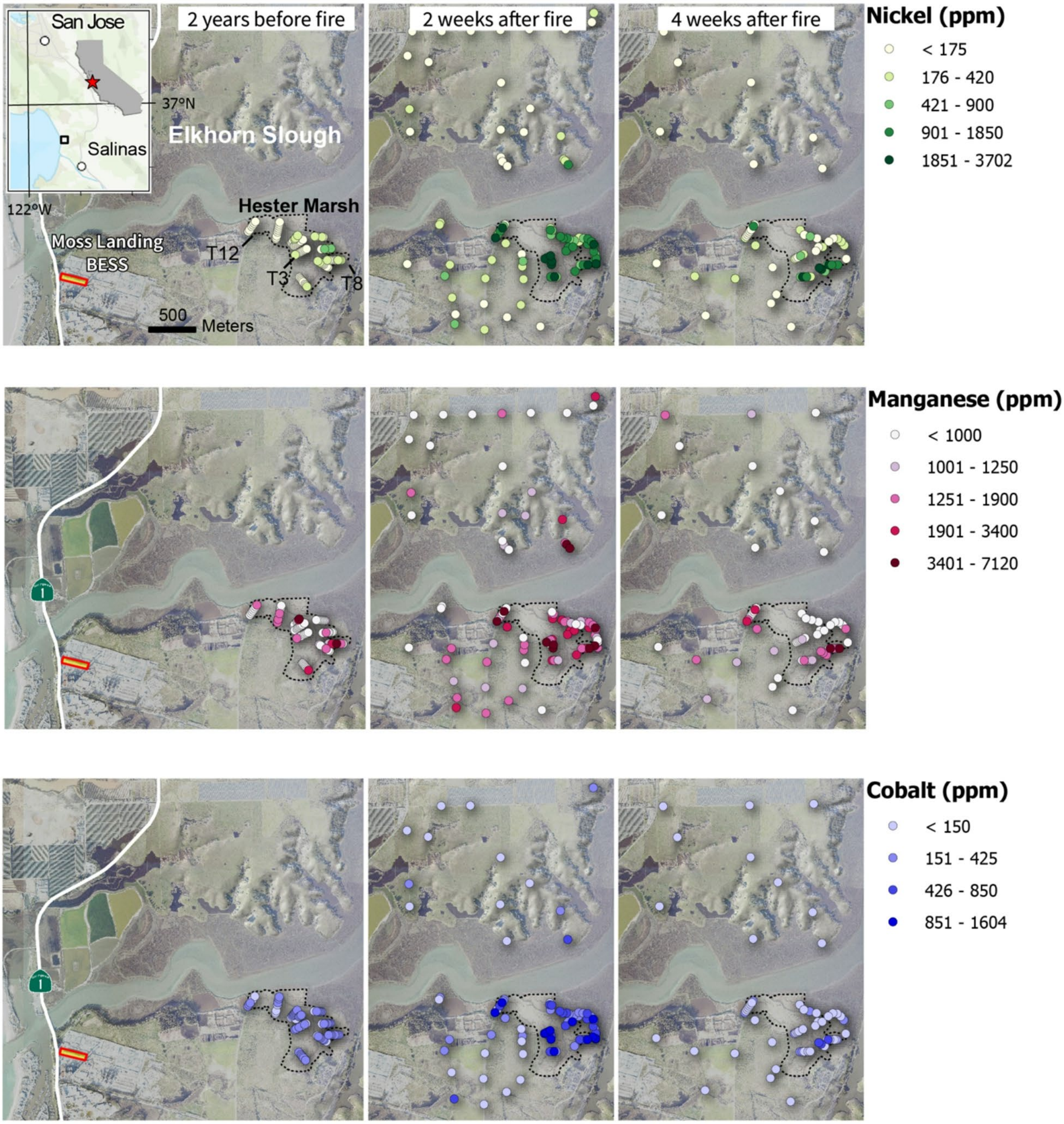

Fig. 2. Spatial distribution of nickel (Ni), cobalt (Co), and manganese (Mn) concentrations (ppm) in soils across three survey periods. The Hester Marsh restoration area is outlined with a dashed line and includes the locations of transects T12, T3, and T8. Peak concentrations were detected within this zone, approximately 1–3 km downwind of the Moss Landing battery facility. Color scales are consistent across all time points for each element to allow temporal comparison. Point classification for each element was done using the "Natural Breaks" (Jenks) method. The map was generated using ArcGIS Pro v3.4.2 (https://pro.arcgis.com/en/pro-app/latest/get-started/download-arcgis-pro.htm).

Additional measurements were taken both outside the transects and beyond the boundaries of Hester Marsh during two post-fire survey periods: post-fire#1 (21 January–12 February 2025) and post-fire#2 (18 February–27 March 2025) (see Supplementary Sect. 1). These post-fire surveys encompassed a broader area, including nearby grasslands within the surrounding watershed (Fig. 2). This approach incidentally enabled differentiation of recent fire-related metal deposition from background levels and allowed detection of a transient, spatially patchy signal. All FpXRF measurements across all surveys have been conducted on bare, relatively dry soils to minimize moisture-related biases.

			Surface												Subsurface†											
			Ni (ppm)				Mn (ppm)				Co (ppm)				Ni (ppm)				Mn (ppm)				Co (ppm)			
Survey period	**Sites (*n*)**	**Area (km^2)**	**min**	**max**	**median**	**MAD**	**min**	**max**	**median**	**MAD**	**min**	**max**	**median**	**MAD**	**min**	**max**	**median**	**MAD**	**min**	**max**	**median**	**MAD**	**min**	**max**	**median**	**MAD**
Pre-fire (2023)	97	0.4	52	246	109	47	228	2193	713	315	72	298	183	59	52	232	116	43	324	2378	834	303	59	214	107	43
Post-fire#1 2025*	135	5.6	52	3702	441	517	386	7119	1488	783	40	1604	309	296	50	303	93	44	264	2119	926	435	40	218	91	49
Post-fire#2 2025^	64	5.6	52	339	100	49	45	3207	871	551	8	833	107	68	1	329	100	49	45	3207	871	551	8	265	97	56

Table . Summary statistics including minimum and maximum values, median, and median absolute deviation (MAD) of nickel (Ni), manganese (Mn), and Cobalt (Co) concentrations (ppm) in surface and subsurface soils measured by field-portable XRF (FpXRF) across three survey periods. Values represent minimum, maximum, and mean concentrations for each metal. †Subsurface measurements are from a few mm below the surface; *Post-fire#1 survey conducted Jan 21–Feb 12; ^Post-fire#2: Feb 18–Mar 27 (surface samples were measured in triplicate during Post-fire#2).

Soil samples collected in the field were analyzed using the pXRF in the lab (LpXRF) and with inductively coupled plasma mass spectrometry (ICP-MS) (Table S3).

Detailed laboratory procedures, including sample preparation, organic carbon analysis, and instrument protocols, environmental data, as well as statistical methods used for data analysis (non-parametric pairwise tests and regression analysis) and interpretation are provided in Supplementary Sect. 2.

Rain and tide data were retrieved from the Moss Landing weather station operated by Moss Landing Marine Laboratories and wind data from the ESNERR meteorological station (Tables S4 and S5).

Results

Detection and mapping of the cathode metals

Fragments of ash and burned or charred material were found scattered across Hester Marsh soils (Fig. 1b, c) in the days to weeks after the fire, providing clear physical evidence of fallout from the battery fire. The comparison between the 2023 and the 2025 post-fire data revealed a marked increase in concentrations of three metals: nickel (Ni), manganese (Mn), and cobalt (Co).

Notably, surface Ni and Co co-varied on log–log axes, with post-fire Ni: Co ratios averaging 2:1, consistent with NMC532 cathode chemistry. This fingerprint supports attribution of the (Ni, Mn, Co) metal spike to battery fire fallout.

Further analysis of selected samples using scanning electron microscopy (SEM) and energy-dispersive X-ray spectrometry (EDS) indicated that the elevated concentrations of Ni, Mn, and Co were linked to the presence of micron-sized metallic particles like those used as cathode materials in Nickel Manganese Cobalt (NMC) batteries. At finer scales, cathode-derived NMC microparticles were identified and elementally mapped in surface soil samples using SEM/EDS (Fig. 1d, e, f), consistent with the fracture and ejection of individual grains from NMC cathodes, a behavior previously observed in laboratory combustion tests[6]. These findings confirm the presence of fire-related battery material on the soil surface of nearby wetlands.

Geochemical evidence from FpXRF further supports the extent and magnitude of contamination. Although Ni, Mn, and Co displayed high spatial variability during the post-fire#1 survey, concentrations increased significantly relative to pre-fire values, with maximum Ni rising by an order of magnitude and Co by a factor of five (Table 1).

Overall, by the time the post-fire#2 survey was conducted, about 1 month after the battery fire, the median concentrations had decreased. The post-fire#1 subsurface data were statistically indistinguishable from the surface and subsurface 2023 pre-fire data. In contrast, surface concentrations of (Ni, Mn, Co) measured during the post-fire#1 survey were significantly elevated compared to pre-fire levels ($p < 0.001$, Mann–Whitney U test; Table S6), clearly indicating that the deposition associated with the fire was initially confined to the top layer of soil.

Figure 2 show that the post-fire#1 increase in metal concentrations (Ni, Mn, Co) in surface measurements was not uniform but clustered in distinct hotspots within Hester Marsh. Hester Marsh was also the area where the post-fire#2 survey recorded the most substantial decrease in metal concentrations. However, a few locations continued to show elevated levels, which explains why the maximum values of Ni and Co in the post-fire#2 survey remained high (Table 1). In contrast to the surface measurements, subsurface data showed no significant changes in either mean or maximum concentrations between the pre- and post-fire surveys. This further confirms that the sharp post-fire increase in cathode metal concentrations was confined to the topmost layer of the soil.

Although the FpXRF measurement along three permanent transects included the concentrations of all three cathode elements: Ni, Mn, and Co, we focused primarily on Ni as a tracer of battery fire fallout, as Ni is dominated by a single oxidation state (Ni^{2+}) across a broad range of redox and pH conditions. This makes it less sensitive to post-depositional remobilization compared to Mn and Co, both of which exhibit variable redox behavior in estuarine settings[13].

Mn is strongly influenced by fluctuations in redox potential and organic matter, and its concentrations often vary independently of anthropogenic inputs[14]. Co also exhibited substantial redox sensitivity and, notably, a large proportion of Co measurements were non-detects, especially in pre-fire and subsurface samples (Table S7), due to concentrations below the portable XRF instrument's relatively high detection limit (Ni ≈ 50 ppm, Mn ≈ 45 ppm, Co ≈ 40 ppm). Box plots depicting the temporal trends of surface Ni concentrations at three permanent transects show that, following the fire, the median Ni concentration increased by two to threefold compared to pre-fire levels (Fig. 3). Over the month-long survey period, both the median and interquartile range of concentrations declined, with a substantial drop to near pre-fire values observed in early February coincident with rainfall in the area. Notably, Ni concentrations rose again at all transects during the surveys conducted in the second half of February.

On log–log axes (Fig. 4a), surface Ni and Co show clear bivariate associations. The distribution of $\log_{10}(Ni/Co)$ (Fig. 4b) shows that post-fire values average near the 2:1 reference (0.301), while pre-fire values average < 0 indicating a substantial change in surface soil metal composition following the fire.

Comparative elemental analysis: field versus lab

To compare FpXRF results with laboratory measurements, we collected 51 samples (24 subsurface and 27 surface) from soils that had previously been analyzed in the field with FpXRF after the battery fire. Aliquots of these samples were analyzed for moisture content, organic carbon content, and elemental composition using LpXRF (5–6 g) and ICP-MS (~ 0.25 g). The water content of the samples ranged from approximately 7 to 43% by weight, while organic carbon concentrations varied between 0.1% and 2.4% by weight.

Because regressions of XRF against the ICPMS reference had non-zero intercepts and modest R^2, we quantified method bias as the geometric mean of the per-sample ratios (i.e., FpXRF/ICPMS, LpXRF/ICPMS, and for completeness FpXRF/LpXRF, see Table S8). In subsurface samples, both XRF methods overestimated Ni

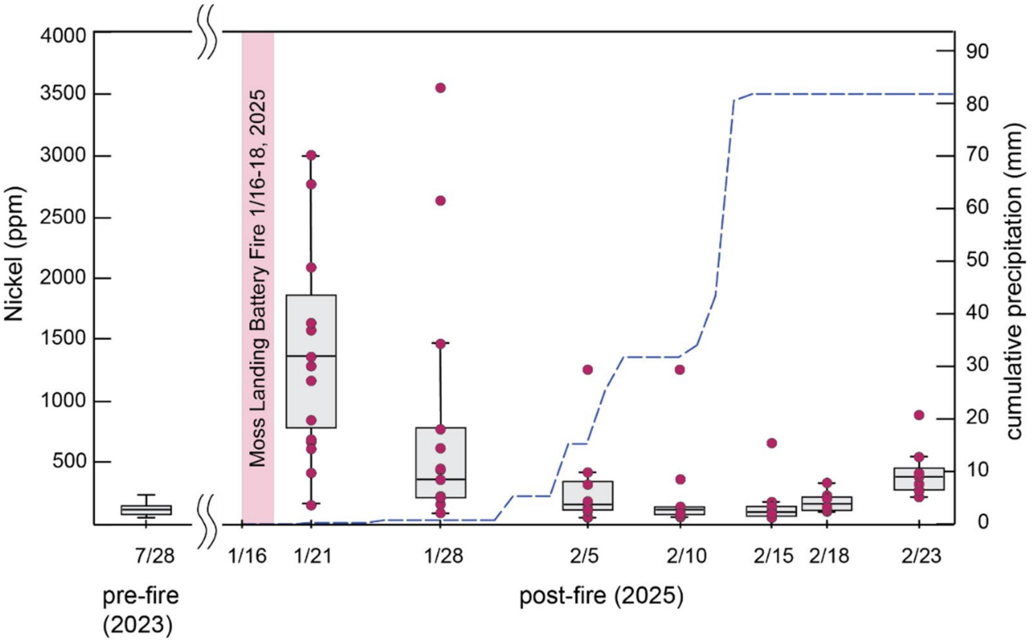

Fig. 3. Temporal variability in surface nickel (Ni) concentrations (ppm) along three permanent transects measured before the battery fire in 2023, and between January and February 2025 using field-portable X-ray fluorescence (FpXRF). Box plots represent the distribution of Ni concentrations at the benchmarks along each transect measured during each sampling date. The datapoints are represented with red circles (the pre-fire survey data were not included because they were indistinguishable and overlapping given their low values). The dashed line shows cumulative precipitation data recorded at the Moss Landing Marine Laboratories weather station (Latitude: 36.80040° N, Longitude: 121.78842° W). A transient spike in Ni concentrations occurred immediately after the 16 January 2025 battery fire, followed by a rapid decline, likely associated with rainfall and tidal flushing in early February. A smaller secondary increase was observed in late February, coinciding with the 18 February 2025 reignition event.

relative to ICPMS by roughly threefold (FpXRF/ICPMS = 3.09, 95% CI 2.74–3.48; LpXRF/ICPMS = 2.81, 95% CI 2.61–3.02), while the two types of XRF measurements were in reasonable agreement (FpXRF/LpXRF = 1.10, 95% CI 0.97–1.25). In surface samples, both FpXRF and LpXRF exhibited a larger positive bias (FpXRF/ICP-MS = 5.40, 95% CI 4.18–6.99; LpXRF/ICP-MS = 2.33, 95% CI 1.93–2.81). As we describe below, the stronger disagreement between FpXRF and laboratory measurements at the surface is best explained by dilution of a thin, metal-rich veneer during laboratory homogenization (which mixes surface material with underlying soil), whereas in-situ FpXRF interrogates the veneer more directly.

As observed with FpXRF data, LpXRF measurements of subsurface samples showed no significant linear association between Co and Ni. In contrast, surface samples showed coherent Ni–Co covariation across methods; Ni: Co ratios were near 2:1, consistent with Fig. 4b and the Ni-to-Co ratio observed in the post-fire#1 FpXRF survey data (Table S9).

Depth distribution of cathode metals

The NMC microparticles primarily occurred as aggregates of varying shape and size, often ~ 100 µm or larger (Fig. 1d, f). This suggests a minimum thickness for the deposition layer of approximately 100 µm, comparable to the critical detection depths for Ni, Mn, and Co in XRF analysis, defined as the depth beyond which less than 1% of the original fluorescent signal reaches the detector.

A rough estimate of the thickness of this contaminated layer can be derived by comparing FpXRF measurements with LpXRF results from sliced surface samples for which lab-based measurements using both LpXRF and ICP-MS yielded lower concentrations of Ni, Mn, and Co compared to those obtained via FpXRF.

Our hypothesis was that FpXRF and LpXRF should approximately yield similar concentrations (i.e., FpXRF/LpXRF ≈ 1) only when the thickness of the lab-analyzed sample approaches the depth of the metal-enriched layer. If the sample is thicker, it will include subsoil not affected by the fire, diluting the signal and resulting in FpXRF/LpXRF > 1.

A regression analysis of sample thickness versus the FpXRF/LpXRF ratio revealed a moderate positive linear association ($R^2 = 0.30$, $p = 0.0129$) that should be interpreted with caution. However, the ratio approaches one for samples between ~ 2 and 5 mm thick, which we interpret as the approximate depth to which fire-related cathode metals were initially incorporated into the soil (Figure S3).

This finding is consistent with our surface method comparison against the ICPMS reference: as the effective field sampling depth increases, the measured signal is increasingly diluted by pre-fire baseline material, leading

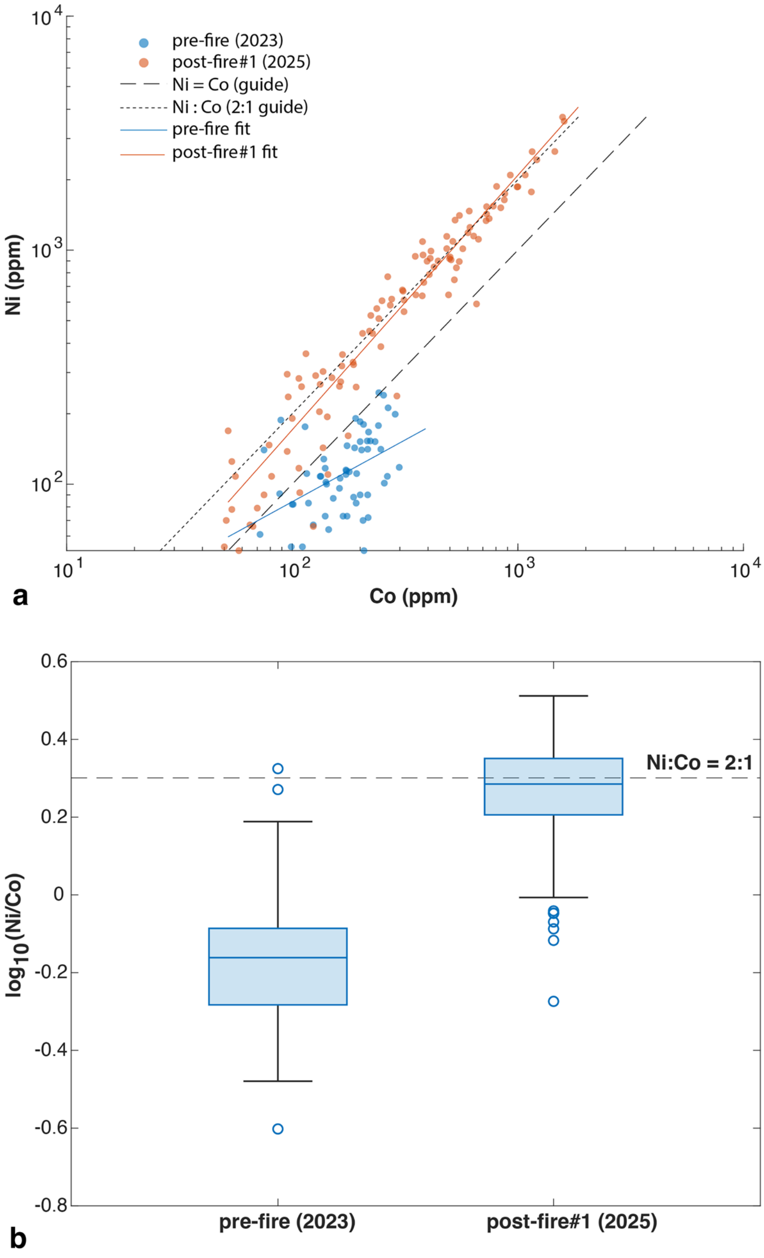

Fig. 4. (**a**) Log–log scatter of Co versus Ni (ppm; FpXRF) for pre-fire (2023, blue) and post-fire#1 (Jan–Feb 2025, orange). Guidelines show Ni = Co (1:1) and Ni: Co = 2:1. Robust log–log fits: pre b = 0.45 (95% CI 0.25–0.65); post b = 0.85 (0.80–0.89). (**b**) Distributions of $\log_{10}$(Ni/Co) for the same samples; dashed line at 0.301 marks Ni: Co = 2:1. Post-fire medians lie near 2:1, whereas pre-fire values are < 0.

to underestimation of battery fire-related surface contamination (see Supplementary Sect. 2 for a detailed discussion of pXRF detection depth and matrix effects).

Discussion

Rapid detection of cathode metals with FpXRF

The sharp increase in (Ni, Mn, Co) metal concentrations detected in the surface soils of Hester Marsh between late January and early February 2025 is clearly attributable to the deposition of particulate matter from the smoke plume generated by the nearby battery storage facility fire at Moss Landing just days earlier. This interpretation is supported by multiple lines of evidence, including visible ash residues and soot, the presence of cathode-derived microparticles in surface soils, and distinctive geochemical patterns.

The key to early detection of cathode metal fallout immediately after the Moss Landing battery fire was the use of FpXRF. While field measurements were not as accurate as lab measurements, they played a pivotal role in rapidly observing that maximum concentrations of the three metals increased by an order of magnitude after the fire, monitoring how quickly they decreased, and assessing how patchy the battery metal fallout was across the landscape. This key information could have been completely missed if we had relied only on a handful of samples taken in space and time. Metal co-variation patterns were consistent across methods (FpXRF, LpXRF, ICP-MS), while absolute levels differed.

While the use of FpXRF offers substantial advantages in responding quickly to environmental emergencies like battery fires, it also comes with limitations. These are especially pronounced in wetland soils, where moisture content, organic matter, and textural variability can significantly influence the accuracy of XRF readings. Light elements such as Ni, Mn, and Co are particularly susceptible to overestimation when measured with XRF, compared to more precise ICP-based methods[15–18]. Our comparison of field and laboratory measurements confirms this pattern: both FpXRF and LpXRF overestimated Ni concentrations by more threefold relative to ICP-MS in the subsurface where samples do not include the fallout deposit.

Nevertheless, the methods showed an acceptable level of reproducibility, supporting the reliability of XRF for rapid environmental assessment. Importantly, although absolute concentrations may be overestimated, the change in surface concentrations before and after the fire was evaluated using the same FpXRF method, allowing for robust spatial comparison and comparison of relative differences over time.

A fingerprint for the cathode material

On log–log axes, Ni scales with Co in surface soils (Fig. 4a). Using ordinary least squares (OLS), the pre-fire fit yields $b = 0.4750b$ and $a = 0.9913$ ($R^2 = 0.175$), indicating a heterogeneous pre-fire ambient signal. The post-fire (survey 1) yields $b = 1.1023$ and $a = 0.0061$ ($R^2 = 0.912$); the point cloud and fitted line lie close to the $Ni = 2 \cdot Co$ guideline across the observed range, motivating a ratio view.

Figure 4b shows that the distribution of $\log_{10}(Ni/Co)$ shifts from pre-fire values < 0 (Ni: Co < 1) to post-fire values near the 2:1 reference ($\log_{10}2 = 0.301$). This composition is consistent with the NMC532 cathode chemistry used in lithium-ion batteries[19].

Subsurface samples remained near pre-fire levels and did not exhibit the post-fire ratio shift, indicating enrichment confined to a surface veneer. Notably, maximum surface concentrations of all three metals increased by several fold relative to pre-fire levels (Table 1). Most post-fire#1 surface samples analyzed with ICP-MS had Ni concentrations above 50 ppm, values that exceed thresholds associated with toxicity risks to plants and aquatic organisms[20].

The observed changes in surface concentrations of Ni, Mn, and Co across Hester Marsh and surrounding areas over time indicate the potential for rapid remobilization of these transition metals into estuarine soils and downstream waters (Fig. 2). FpXRF transect data from February–March 2025 show that surface Ni concentrations dropped to near baseline within weeks of the fire, following early February rain and tidal inundation (Fig. 3).

While variability in Ni concentrations declined over time, indicating redistribution of the cathode metals, at the higher elevation transect T12 (~ 1 km from the fire), higher Ni levels persisted for about 10 days before declining, while the lower elevation transects T3 and T8 showed an earlier decrease, likely due to January tidal flooding that immersed only the areas with the lowest relief.

The transect data and a simple comparison between columns 2 and 3 in Fig. 2 illustrate that had FpXRF sampling been delayed by even a few days, most of the early evidence for surface deposition in Elkhorn Slough would likely have been lost. Timely field deployment was essential for capturing the initial contamination signal before environmental processes such as rainfall and tidal flushing remobilized the metals.

Our results emphasize the high degree of spatial variability in the distribution of battery-associated metals on the soil surface. The highest concentrations observed after the fire were within the unvegetated portions at Hester Marsh (Fig. 2). Concentrations were also highly variable at finer spatial scales, between samples collected 10–20 m apart along the transects.

Boxplots of Ni concentrations over time along three transects (Fig. 3) show that the interquartile range, a measure of variability excluding outliers, increases with the median concentration. This relationship suggests that spatial heterogeneity is greatest where concentrations are highest, a pattern we interpret as evidence of the clumped distribution of cathode metal-bearing particles or ash. At the microscale, this clumping is represented by aggregates of NMC microparticles (Fig. 1d–f); at the macroscale, it is reflected in the scattering of ash and burned material fragments observed throughout the study area, up to approximately 3 km from the battery storage facility (Fig. 1b, c). Larger clumps result in higher localized concentrations and contribute to measurement variability, reinforcing the importance of repeated sampling at multiple spatial scales. This multi-scale capability is one of the key advantages of FpXRF over conventional discrete sampling and ensuing analysis via ICP-MS.

The relationship between the FpXRF/LpXRF concentration ratio and sample thickness used to estimate the critical depth of Ni enrichment following the battery fire shows that the ratio approaches 1.0 when sample thicknesses range between ~ 2 and 5 mm, suggesting that most of the deposited Ni was confined to the uppermost few millimeters of soil. Thicker samples diluted this surface signal, consistent with a sharp depositional pulse and limited vertical mixing. This interpretation aligns with both SEM imaging of NMC microparticle aggregates and the shallow critical escape depth of Ni in soil matrices.

Tracking the environmental footprint of cathode material

The cathode material detected in Elkhorn Slough soils following the battery fire was, at least initially, airborne. As a first approximation, the spatial distribution of cathode metals observed in surface soils during the post-fire#1 survey reflects the deposition pattern of battery-derived particulates that settled from the smoke plume. However, this interpretation likely oversimplifies the dynamics. Prior studies show that ground-level deposition often diverges from the plume's direction due to complex atmospheric behavior, as additional factors might be influencing spatial variability including plume height, particle size and shape, and sorptive properties of the soil surface[21,22].

Our reconstruction of the (Ni, Mn, Co) metal distribution from the post-fire#1 survey reveals that surface concentrations of contaminants do not increase with proximity to the battery fire site. Instead, concentrations peak in the Hester Marsh wetland, located approximately 1–3 km east of the facility (Fig. 2). This offset may be explained by westerly surface winds on the day of the fire, which prevailed for approximately 40% of the time, likely directing the smoke plume eastward over Hester Marsh (Fig. 1a). In addition to wind direction, local soil characteristics may have played a role in the retention of the metal particles following deposition. Hester Marsh soils are predominantly fine-grained and clay-rich, with high sorptive capacity, and higher potential for retention of transition metals that can increase their persistence in surface layers[23,24].

Regardless of the factors that controlled the initial distribution and retention of material deposited from the battery fire, the spike in transition metal concentrations at the surface of the wetland was short-lived. By the time the post-fire#2 survey was conducted, most of the cathode metals accumulated on the surface soils had been remobilized, except for a few persistent hotspots in some of the depressional salt pans within Hester Marsh (Fig. 2).

Natural processes such as rainfall and tidal inundation likely played a major role in the resuspension and remobilization of the contaminants. Precipitation was relatively intense during the first 2 weeks of February 2025 (Fig. 3), and the lower portions of Hester Marsh experienced repeated inundation during high-tide events, facilitating the physical transport and dispersal of deposited cathode metals. Percolation through the soils appears to have been limited since the post-fire#2 and post-fire#1 subsurface concentrations were statistically indistinguishable.

The drop in surface concentration of cathode metals resulting from the battery fire strongly suggests that the metals have been washed into downstream portions of the estuarine ecosystem. Their transport and fate throughout the estuary and potentially into adjacent open coastal ecosystems remain unknown. They may have settled in tidal channels, become buried in sediments, or undergone chemical transformations driven by redox cycling[25].

These processes could affect both metal mobility and, over time, pose a threat to higher trophic levels through bioaccumulation. Ni, Mn, and Co are all known to be toxic to humans as well as to aquatic and terrestrial organisms[20], and Mn toxicity is a major constraint limiting plant growth and production[16]. Co can have lethal or sublethal effects on reproduction in fish and crustaceans and has some bioaccumulation potential through adsorption to plant roots[26]. These risks are particularly acute at Hester Marsh, where an $18 M investment to restore tidal wetlands through soil augmentation raised marsh platforms to elevations intended to sustain native plant growth and survival under future flooding[27].

Mass budget for cathode metal deposition at Hester Marsh

The initial mass of Ni, Mn, and Co originating from the burned batteries that settled on Hester Marsh can be estimated based on the difference between metal concentrations measured at the surface during the pre-fire and the post-fire#1 surveys (see Table S10 for full calculations). To calculate the mass budget, the Hester Marsh area (1200,000 m^2) was overlain with a 200 × 200 m grid composed of 30 cells, each covering a 40,000 m^2 area. For 10 of the 30 cells that contained both pre-fire and post-fire#1 FpXRF measurements, we computed the paired mean difference (post-fire#1—pre-fire) and the standard errors. The concentrations of the three metals were then converted to mass assuming a surface contamination depth of approximately 0.1 mm (which approximates the critical detection depth for these metals) and a dry density of 1500 kg/m^3 for consolidated clay.

We estimate that the minimum deposited mass of cathode metals within the upper 100 µm is ~ 17 kg ± 4 kg per 200 × 200 m cell. However, as discussed earlier, the actual thickness of the soil layer containing the deposited metals is likely greater than the effective depth, and can be ~ 5 mm thick, which corresponds to a mass of cathode metals of ~ 855 kg ± 199 kg per cell. Extrapolation to the entire Hester Marsh area yields an estimated total mass of cathode metals of ~ 25 metric tons (25676 kg ± 5981 kg).

This estimate should be interpreted with caution. First, FpXRF measurements overestimate Ni concentrations by a factor of ~ 3, and the metal concentrations are expected to decline with depth due to dilution and limited vertical mixing. However, the values are also conservative, as they only include deposition on bare soil and exclude potential accumulation on vegetation, which may represent a larger surface area in marsh and upland settings than the exposed soil itself.

To put these figures in perspective, a 1 MW industrial lithium-ion battery manufactured by LG weighs 1.6 metric tons, with cathode materials accounting for approximately 35% of the total mass. This equates to roughly 1900 metric tons for the entire 1200 MWh storage capacity of the Moss Landing facility. If, as reported by Monterey County officials[10], approximately 75% of the batteries were destroyed in the fire, then an estimated ~ 1400 metric tons of cathode material could have been involved in the event and potentially entrained into the smoke plume. Therefore, our estimates of the total mass of (Ni, Mn, Co) metals deposited on the soils of the Hester Marsh extrapolated to a 5 mm cathode metal deposit accounts only for < ~ 2% of the total battery material that may have been released during the Moss Landing battery fire.

Conclusions and implications for future battery fire response

To our knowledge, this study represents the first field-based documentation of battery-associated metal fallout following a large-scale lithium-ion battery fire and offers a framework for assessing future events of this kind. Use of field instrumentation enabled immediate collection of hundreds of measurements, critical given the spatial patchiness of battery metal aggregates in an extensive fallout layer in the vicinity of the fire and given the rapidity with which the metals were transported downstream by tides and rain. As battery energy storage systems continue to expand in scale and density, the risk of both localized and widespread contamination will increase even as safety protocols improve.

This incident also calls attention to the limitations of standard environmental sampling protocols. Conventional soil sampling depths, such as the commonly used top ~ 6 cm of soil[28], may fail to detect thin, spatially heterogeneous deposition layers. The patchy nature of ash deposition observed in this study suggests that sampling strategies must be adaptive and designed to capture contamination at multiple spatial scales and depths. This is especially critical in the first few days following an event, since, over time, rainfall, tides, and wind can rapidly redistribute surface-bound contaminants.

Environmental response frameworks must also consider the potential offset between fire origin and deposition zones. In this case, the most significant contamination occurred not adjacent to the site of the fire, but several kilometers downwind. This spatial offset highlights the need for evacuation protocols and monitoring networks that integrate plume dispersion models, meteorological data, air quality monitoring and ground-based measurements of deposition.

Finally, findings from controlled laboratory battery burns provide additional context for interpreting field observations. Previous experiments have demonstrated that thermal decomposition of cathode materials can release substantial quantities of (Ni, Mn, Co) metals and other toxicants[6]. These studies confirm that NMC-based batteries, when subjected to fire conditions, can emit airborne particles capable of traveling significant distances before settling onto the landscape. Field studies such as this one are essential to understanding how such deposition events unfold under real-world conditions.

Together, these results emphasize the need for proactive planning, site-specific risk assessment, and rapid, multi-scale environmental monitoring in the aftermath of battery fires. As battery technologies evolve, so too must the frameworks we use to track and mitigate their potential environmental impacts.

Data availability

All data used to generate the figures are available through Figshare at https://figshare.com/s/32fb2899e519353f923b **.**.

Received: 14 August 2025; Accepted: 27 October 2025

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Acknowledgements

We are deeply grateful to Julie Packard, Nancy Burnett, and Louise Stephens for their generous support and long-standing commitment to environmental research and conservation. We also thank the Monterey Bay Aquarium and the Simpkin Family for their crucial contributions, which made this work possible. Their support has been instrumental in enabling rapid response science and advancing our understanding of environmental risks in estuarine ecosystems. A grant from NOAA's Office for Coastal Management in support of the Elkhorn Slough National Estuarine Research Reserve (ESNERR) provided funding for KW and CE. The fortuitous pre-fire baseline was made possible due to ESNERR's heavy investment in restoration monitoring at Hester Marsh with grants from the California Department of Fish and Wildlife Greenhouse Gas Reduction Program, Ocean Protection Council and USFW National Coastal Wetland Program. The majority of data for this study come from ESNERR, a partnership between California Department of Fish and Wildlife and NOAA, and we are grateful for ESNERR's support of the study. We acknowledge MLML/Marine Pollutions Study Lab staff members Autumn Bonnema, Adam Newman, and April Sjoboen Guimaraes for ICP-MS sample digestions and analysis. Two anonymous reviewers provided thoughtful suggestions that improved the presentation of data and the clarity of writing.

Author contributions

I.W.A conceived the study, led the writing and contributed to all aspects of this work; CE performed field work, data collection and geospatial interpretations; SC performed lab analyses; MF contributed to study design, site access and data collection; MG contributed to data interpretation; WH performed lab analysis and data interpretation; AK contributed to data interpretation; KW contributed to study design, site access and data interpretation. All authors contributed to manuscript revisions and approved the final version.

Declarations

Competing interests

The authors declare no competing interests.

Additional information

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1038/s41598-025-25972-8.

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APPENDIX 4

What is the history of chemical bans in Nassau and Suffolk Counties

Nassau and Suffolk Counties on Long Island have a 50-plus year history of local action to restrict or eliminate chemicals seen as threats to their sole-source aquifer, with Suffolk generally moving earlier and more aggressively than Nassau. Much of the local activity helped drive later state-level bans and federal restrictions on pesticides and industrial solvents affecting Long Island's drinking water.

Early pesticide battles (1960s–1970s)

- In the mid-1960s, Long Island activists, including Suffolk County residents who later founded the Environmental Defense Fund, used litigation to stop Suffolk's mosquito control program from spraying DDT on salt marshes, one of the first successful local crackdowns on a modern pesticide program.

⍰

⍰ New York State followed by banning DDT statewide in 1971, building on pressure that included Long Island's mosquito-control controversy and broader national concern about wildlife and human health.

-

Suffolk's phosphate detergent ban (1971)

- In 1971 Suffolk County enacted a **phosphate detergent ban**, prohibiting high-phosphate household detergents because slow-degrading surfactants and nutrients were recirculating from cesspools into the shallow groundwater used for drinking water, creating foam and algae problems in surface and tap water.

⍰

⍰ This local ban pre-dated and helped pave the way for broader New York State restrictions on phosphorus in cleaning products adopted later in the 1970s.

Pesticide phase-out on county property (Suffolk)

- Suffolk County passed Local Law No. 34-1999, requiring the **phase-out of pesticide use on county-owned properties by 2003**, with only narrow "special use" exemptions overseen by a Pesticide Community Advisory Committee and an Integrated Pest Management (IPM) program.

⍰

⍰ The IPM program administers this prohibition, ensuring that county facilities default to non-chemical controls and that any pesticide use is scrutinized for necessity and risk.

-

Neighbor notification and state preemption issues

- In the early 1990s, Long Island incidents, including a Farmingville case where drifting lawn-care pesticides sickened a baby, spurred Nassau–Suffolk environmental groups to push for laws requiring neighbor notification before commercial pesticide applications.

⍰

⍰ Advocacy by Nassau–Suffolk groups and legislators ultimately produced New York’s statewide pesticide neighbor-notification law around 2000, rather than a permanent patchwork of separate county bans or rules.

-

Solvents, microbeads, and emerging contaminants

- Long-standing contamination from industrial solvents such as TCE and PCE has been a major groundwater issue in Nassau County, especially at sites like the former Grumman facility in Bethpage, where high TCE concentrations were documented in the late 1970s and 1980s.

⍰

⍰ Federal and state actions have since moved to ban or sharply restrict TCE and PCE uses—building on decades of concern about their role in Long Island groundwater contamination—culminating in recent EPA rules phasing out most uses of TCE and tightening controls on PCE.

-

More recent Suffolk product bans

- Suffolk County has periodically moved ahead of the state on product-specific bans; for example, in 2015 it became the largest New York municipality to adopt a **microbead ban** in personal-care products, a precursor to broader New York State and federal microbead restrictions.

⍰

⍰ These county-level product bans follow the same pattern as earlier Suffolk actions: targeting chemicals that persist in water, accumulate in the environment, and are not effectively removed by conventional wastewater systems.

If you want, a follow-up can map these milestones into a timeline and differentiate clearly between county, state, and federal authorities for specific chemical classes or statutes.

Key chemicals banned in Suffolk County since 1970s

Since the early 1970s, Suffolk County has targeted several groups of chemicals through product-specific bans and a broad phase-out of pesticides on county property. Most of these actions are framed as sale or use prohibitions within the county rather than classic “substance bans” across all sectors.

1971 detergent and phosphate ban

- In 1971 the Suffolk County Legislature banned the sale of synthetic detergents, including phosphate detergents, because slow-degrading, foam-producing surfactants were recycling from cesspools into the shallow drinking-water aquifer and surface waters.

▯ For roughly two years Suffolk allowed only soaps, not detergents, to be sold in the county, going beyond the later statewide phosphate-content limits adopted by New York in the early 1970s.

Pesticides on county property (Local Law 34-1999)

- Local Law No. 34-1999 established a staged prohibition on pesticide use on county-owned or -leased land: as of January 1, 2000, Suffolk banned use on county property of any pesticide in EPA Toxicity Category I or any pesticide classified by EPA as a known, likely, or possible carcinogen.

▯

▯ As of January 1, 2001, the county extended the ban to EPA Category II pesticides and most restricted-use pesticides on county property, and by July 1, 2003, it prohibited application of **any** pesticide on county property, except under narrowly defined exemptions reviewed under Chapter 647 and implemented through the Integrated Pest Management (IPM) program.

Microbeads in personal care products

- In 2015 the Suffolk County Legislature adopted a local law to ban the sale of personal care products containing plastic microbeads, citing their role as persistent microplastics that sorb PCBs, DDT, flame retardants, and other pollutants and then move through wastewater into Long Island’s coastal and inland waters.

▯ The law prohibits, effective January 1, 2018, the sale or offer for sale of any personal care product with microbeads within Suffolk County, with enforcement via random inspections of retailers and ingredient checks for specified plastic bead components.

Scope: “key chemicals” versus regulatory form

- The detergent ban effectively targeted synthetic surfactants and phosphate-containing formulations in household cleaning products sold in Suffolk County.

▯ The pesticide phase-out is framed in functional regulatory categories—EPA toxicity categories, carcinogenicity, and restricted-use status—rather than naming individual active ingredients, so it sweeps in many organophosphates, carbamates, phenoxy herbicides, and other pesticide classes on county land.

Items largely handled at state/federal level

- Other contaminants of concern in Suffolk (e.g., TCE, PCE, 1,4-dioxane, PFAS) have been addressed primarily through state and federal regulation and site-specific enforcement rather than countywide “bans,” so they do not appear as Suffolk-only prohibitions in the county code.

⍰ Suffolk’s strategy has been to use local bans or phase-outs where product sales or county operations can be directly controlled, while relying on state and federal authorities for industrial chemicals and widespread groundwater contaminants.

If helpful, a follow-up can map these actions into a timeline with citations to specific Suffolk County Code chapters and local law numbers for each chemical group.

Key chemicals banned in Suffolk County since 1970s

Since the 1970s, Suffolk County has not “listed” many individual chemicals, but it has effectively banned several major classes of chemicals in specific products and on county property. The most important are synthetic household detergents (including phosphate formulations), most conventional pesticides on county land, and plastic microbeads in personal care products.

Detergent surfactants and phosphates (1971)

- In 1971 Suffolk County banned the sale of virtually all synthetic detergents used for household cleaning, targeting the slow-degrading, foam-producing **surfactants** that were entering and persisting in the shallow groundwater aquifer.

⍰ The county’s detergent law also made it the first U.S. government to ban phosphate-containing laundry detergents countywide (with narrow exceptions like dishwashing products where no alternatives then existed).

Pesticides on county property (Local Law 34-1999)

- Effective January 1, 2000, Suffolk prohibited county departments and their contractors from applying on county property any pesticide classified by EPA as Toxicity Category I or any pesticide EPA classed as a known, likely, or possible carcinogen.

⍰ Effective January 1, 2001, the prohibition expanded to include Toxicity Category II pesticides and all restricted-use pesticides on county property, leading to a practical phase-out of most organophosphate, carbamate, phenoxy, and other conventional pesticide actives on county-owned or-leased land, subject only to narrow exemptions.

Microbeads in personal care products (2015)

- Suffolk’s Article IV of Chapter 446 (“Personal Care Products Containing Microbeads”) bans the sale of personal care products containing plastic **microbeads** (solid plastic particles less than 5 millimeters intended for exfoliation or cleansing) within the county.

□ Legislative findings stress that these polyethylene and similar plastic beads act as persistent microplastics that can adsorb PCBs, DDT, flame retardants, and other pollutants, then pass through wastewater treatment into Long Island’s waters.

How “key chemicals” are defined in practice

- For detergents and microbeads, Suffolk uses product definitions that functionally ban particular chemical types (synthetic surfactant detergents and plastic bead polymers) from the retail market in the county.

□ For pesticides, the law relies on EPA toxicity category, carcinogenicity, and restricted-use status instead of enumerating specific active ingredients, so the “banned” chemicals are all products falling into those regulatory classes when used on county property.

If useful, a follow-up can turn this into a table listing approximate chemical families (e.g., alkylbenzene sulfonate surfactants, polyethylene microbeads, organophosphate insecticides) and the Suffolk code provisions that restrict them.

List Suffolk County local laws banning specific chemicals by year

Suffolk County has adopted a number of local laws that either directly ban or effectively phase out specific chemicals or chemical families, but assembling a complete, by-year list requires pulling each year's compiled local laws and then filtering by subject (pesticides, plastics, toxic toys, latex, fertilizers, etc.). The information below highlights key laws that clearly target specific chemicals or classes; for regulatory or litigation work, this should be treated as a starting point rather than a definitive list.

Key laws targeting specific chemicals

- **Local Law 10-1996 / Ch. 380 (Pesticide Phase-Out)**
    - Phases out the use of pesticides on County property, starting with EPA Toxicity Category I and carcinogens as of January 1, 2000, then Category II and restricted-use pesticides as of January 1, 2001, and eventually all pesticides on County property by January 1, 2003, subject to narrow exceptions.

⍰

⍰ This is a broad **pesticide** phase-out rather than a single-chemical ban, but it effectively prohibits many active ingredients (including various organophosphates, carbamates, and other toxic chemistries) for routine County use.

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⍰ **Plastics "Foam and PVC" law (Local Law 10-1988 and successors)**

- Suffolk's "Plastics Law" in 1988 banned certain plastic food packaging, notably polystyrene and polyvinyl chloride (PVC) food containers and related foam products in many food-service applications.

⍰ While expressed as a product/material ban, it indirectly eliminates exposure to residual monomers and additives associated with those polymers (e.g., styrene, vinyl chloride, certain plasticizers).

Fertilizer near surface waters (Local Law 5-2009)

- 2009 Local Law 5-2009 "to reduce the use of fertilizer near surface waters" restricts fertilizer application in proximity to water bodies in Suffolk County.

⍰

⍰ The law regulates **fertilizers** as a class (driven primarily by nitrogen and phosphorus pollution concerns) rather than individual chemical names, but it effectively limits use of common synthetic nutrient formulations near surface waters.

- ⍰

⍰ **Toxin-Free Toddlers / Toxic-Free Toys Act (children's products)**

- Suffolk adopted local law provisions (later codified in Chapter 704/717 equivalents) that ban the sale of children's products and toys containing lead, mercury, antimony, arsenic, cadmium, and cobalt above specified parts-per-million thresholds.

⍰ Current limits include, for example:

- Lead: 100 ppm in accessible parts, 90 ppm in paint or surface coatings.
- Cadmium: 75 ppm in accessible content.
- Mercury, antimony, arsenic, cobalt: limits on the order of 40–60 ppm per chemical (depending on version/enforcement updates).

⍰ The "Toxic-Free Toys Act" was passed in 2015 and signed in June 2015; enforcement dates and technical standards were later refined and codified as L.L. No. 26-2017, effective November 1, 2017.

Latex in food establishments (Local Law 7-2021)

- Local Law 7-2021 prohibits food establishments in Suffolk County from using products containing **latex** (such as gloves, utensils, and food packaging) in the normal course of business as of July 1, 2021.

⍰

⍰ The law also requires other businesses that still use latex products to post conspicuous notices stating that products containing latex are used on the premises.

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    ○

Why a complete year-by-year list is non-trivial

- Suffolk's chemical-focused local laws are scattered across different chapters (e.g., pesticides in Ch. 380, toxic children's products, plastics and latex rules, fertilizer near surface waters) and often framed as product or use bans rather than naming individual chemical substances in the title.

To build a comprehensive, year-by-year list of all laws "banning specific chemicals," one would need to systematically review each year's compiled local laws (e.g., the Legislature's "Local Laws [year]" PDFs) and the County Code, then catalog: law number, year, code chapter, targeted chemical(s)/class, and effective date.

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Practical path to a full list

If you need a complete, legally reliable table of “Suffolk County local laws banning specific chemicals by year” for work:

- Pull each annual “Local Laws” compilation (e.g., 1990-present) from the Suffolk County Legislature site and keyword-search for terms such as “pesticide,” “fertilizer,” “toxic,” “toy,” “latex,” “plastic,” “polystyrene,” and specific chemical names (lead, mercury, PFOS, etc.).

⍰

⍰ Cross-reference each candidate law in the Suffolk County Code (eCode360) to confirm chemical thresholds, enforcement dates, and whether the law is still in effect, repealed, or superseded.

If you describe the level of detail you need (e.g., just children’s products vs. all media; only explicit CAS-number bans; or inclusion of use-phase restrictions on County property), a more tailored schema or draft table format can be outlined for you to fill out with primary sources.

What chemicals have been banned in Suffolk County to protect the aquifer

Suffolk County has adopted several local laws aimed at protecting its sole-source groundwater aquifer, but the bans tend to target *categories* of products and specific uses rather than issuing a single, comprehensive “aquifer chemicals banned” list. The main examples are below.

Wastewater and sewage additives

- Suffolk County law prohibits the sale of sanitary waste holding tank additives that contain **formaldehyde**, formaldehyde derivatives, and similar bacteria-damaging chemicals, in order to prevent harm to groundwater and sewage treatment processes.

▯

▯ Cesspool and individual sewage disposal system additives must be pre-approved by the County Health Commissioner, who can reject products that would adversely affect groundwater quality.

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Hydraulic fracturing wastes

- The County Legislature passed an “aquifer protection” bill banning the sale and use of **liquid waste from hydraulic fracturing** (fracking) in Suffolk County.

▯

▯ The intent is to prevent fracking brines and associated chemical mixtures from being used or disposed of in ways that could infiltrate the sole-source aquifer.

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Pesticides and related chemicals

At the county level, pesticides are more regulated than flat-out banned, but several chemicals have been the focus of phase-outs, restrictions, or calls for Long Island–specific bans:

- **Atrazine** (herbicide), **metalaxyl** (fungicide), and **imidacloprid** (insecticide) are repeatedly detected in Suffolk groundwater and were targeted in the Long Island Pesticide Pollution Prevention Strategy, which explores restrictions and alternatives to protect the aquifer.

▯ Environmental groups have specifically urged a ban on atrazine, metalaxyl, and imidacloprid for use on Long Island due to frequent detections in the aquifer, though these bans would be implemented primarily through New York State DEC regulatory action rather than county law alone.

Other contaminants of concern (regulated, not necessarily “banned”)

Some chemicals are not locally “banned,” but are treated as priority threats to the aquifer through monitoring and treatment:

- **PFAS compounds** (especially PFOA and PFOS) are widespread in Long Island’s aquifer; the Suffolk County Water Authority has installed granular activated carbon systems to meet strict federal and state limits well ahead of deadlines.

- **1,4-Dioxane**, a solvent stabilizer and component of various industrial and household products, is treated as a contaminant of particular concern in Suffolk due to historic plumes in the sandy sole-source aquifer and is subject to targeted monitoring and advanced oxidation treatment proposals.