# Adrian Montenegro

SUSTAINABILITY • DESIGN • WATER SYSTEMS

---

## ENGINEERING PORTFOLIO

Civil & Environmental Engineering
Honors College, UNLV
montea12@unlv.edu

December 2025

## About This Portfolio

---

This report illustrates my time spent at UNLV and the work that shaped me as an engineering student. Every section exists because I was fortunate enough to be part of unique opportunities and to work alongside talented classmates, mentors, and faculty. What began as individual projects slowly became moments that defined my curiosity, confidence, and direction in this field.

More than a portfolio, this is a snapshot of how fun, challenging, and meaningful my undergraduate experience truly was—ranging from water research and fieldwork to design competitions, humanitarian engineering, and even creative sound design. Each project reflects the momentum and growth that I'm excited to carry forward into graduate study.

# 1. Waste to Watts: Repurposing Perched Groundwater for Data-Center Cooling

**Role:** Treatment concept design, C-1 water-quality analysis, IX/RO modeling, column testing support, construction estimating, and scheduling.

**Abstract**— This study evaluates the feasibility of diverting perched groundwater from the C-1 channel as a supplemental cooling-water source for Google's Henderson data centers. The project integrates water-quality characterization, treatment-train development, IX/RO modeling, and constructability analysis. Additional testing explores the use of high-TDS groundwater for dust suppression in construction operations.

## Background

Data centers in arid regions depend heavily on potable water for evaporative cooling, placing additional demand on municipal supplies. Perched groundwater in the Las Vegas Valley—captured within engineered channels such as the C-1—offers an underused, high-TDS resource. The Waste to Watts concept evaluates whether treated C-1 water can satisfy cooling-tower and dust-suppression requirements while reducing reliance on potable water.

Perched groundwater samples were collected along the C-1 channel and analyzed for total dissolved solids (TDS), chloride, sulfate, hardness, silica, and metals. Typical TDS values ranged from 1,800–2,200 mg/L, confirming that treatment is required before use in hyperscale cooling systems.

## Water-Quality Characterization

Table **??** summarizes representative results from one sampling event. Chloride and sulfate concentrations are elevated relative to potable water and drive both treatment design and corrosion considerations.

## Treatment Concept Overview

The proposed treatment train includes: (1) media pre-filtration, (2) ion exchange (IX), (3) optional reverse osmosis (RO), and (4) final blending with potable water to meet the target of $< 1000\,\mathrm{mg/L}$ TDS.

A simplified mass balance estimated post-treatment TDS:

$$C_f = (1-R)C_0, \qquad C_{\text{blend}} = x\,C_f + (1-x)\,C_{\text{potable}}$$

where $R$ is IX removal efficiency, $C_0$ is raw-water TDS, and $x$ is the blend fraction. Initial modeling showed that IX alone, coupled with moderate blending, can satisfy the TDS constraint for cooling-tower makeup.

## Treatment Design Details

The final concept refines the core ion exchange (IX) and reverse osmosis (RO) systems into skidded units that can be integrated with well discharge, storage, and the existing cooling-water infrastructure. Figures 2 and 3 summarize the process layout and major design criteria.

### Ion Exchange System

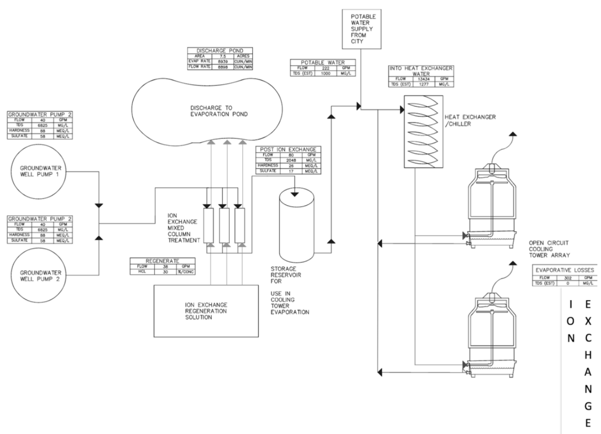



Figure 2: Conceptual ion exchange (IX) skid for C-1 groundwater (placeholder).

The IX system is configured as parallel lead–lag vessels to maintain continuous operation during resin regeneration. Design flow is based on peak cooling-tower makeup with a safety factor to accommodate seasonal variation. Empty bed contact time (EBCT), resin capacity, and breakthrough curves from column testing were used to size vessel diameter and bed depth. Regeneration brine is routed to a dedicated storage tank for off-site disposal or potential future recovery. Instrumentation includes influent/effluent conductivity, flow pacing, and differential-pressure monitoring across each vessel.

### Reverse Osmosis System

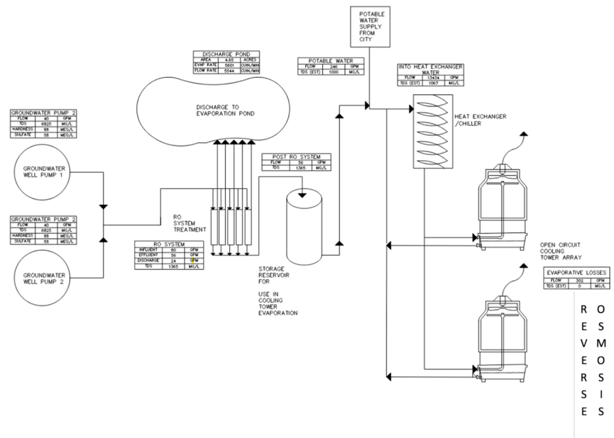



Figure 3: Conceptual reverse osmosis (RO) system downstream of IX (placeholder).

RO is treated as an optional polishing step when lower TDS or specific ion removal is required. The model assumes 50–75% recovery with staged pressure vessels to limit flux and scaling risk. Antiscalant dosing and pH control are provided upstream, and a clean-in-place (CIP) loop allows membrane maintenance without extended downtime. Permeate is blended with IX-treated water and potable water to meet cooling-tower setpoints, while concentrate is combined with IX brine for managed disposal. The layout was evaluated for footprint, tie-in locations, and constructability within the data-center utility yard.

## 2. Fieldwork: C-1 Channel Groundwater Sampling

### Purpose and Field Story

To verify online SNWA reports, our team collected perched groundwater samples along the C-1 channel. The goal was to confirm total dissolved solids (TDS) levels and gather data needed to design ion-exchange (IX) treatment columns that could later be scaled up for full-site application.

Figure 4: Collecting perched groundwater samples from the C-1 channel.

### Verified Water Quality

| Parameter | Measured Value |
| --- | --- |
| TDS (mg/L) | 5,870 |
| Target TDS after Treatment (mg/L) | 1,000 |
| Hardness as $CaCO_3$ (mg/L) | 300 |
| SAC Ion-Exchange Capacity (eq/L) | 1.9 |
| SBA Ion-Exchange Capacity (eq/L) | 1.2 |
| Usable Resin Fraction (-) | 0.8 |

Table 2: Confirmed C-1 channel water-quality inputs used for IX column design.

### Why This Verification Matters

These measured values confirmed that C-1 channel water contains high-TDS levels consistent with SNWA estimates. This ground-truth data ensured that the IX column design reflected real field conditions and informed removal efficiency, resin loading, and scale-up potential.

## 3. C-1 Channel Laboratory Water-Quality Analysis

**Role:** Field sampling support, lab coordination, data processing, and preliminary analysis.

**Purpose.** Groundwater collected from the C-1 channel was transported to the UNLV Water-Quality Laboratory to verify chloride, sulfate, hardness, and TDS levels needed for IX/RO design validation. These measurements ensure accurate model alignment with SNWA-reported values and realistic scale-up potential.

| Parameter | Value (mg/L) |
|---|---|
| TDS | 5870 |
| Chloride | 1200 |
| Sulfate | 350 |
| Hardness | 300 |

*Table 3: Laboratory Water Quality Analysis*

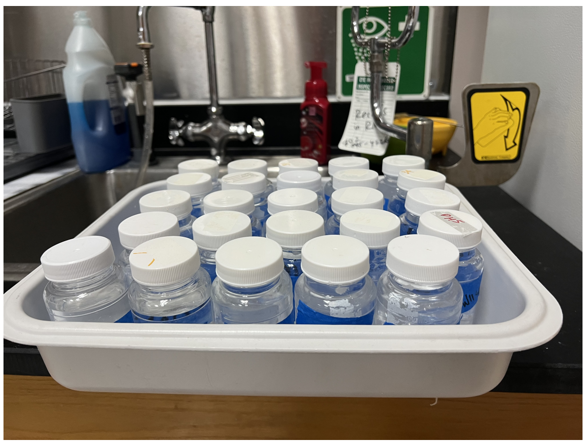


*Figure 5: Prepared C-1 samples for laboratory testing.*

### Representative Results

[leftmargin=1em,itemsep=0.1em]

- TDS, chloride, sulfate, and hardness levels
- Resin loading estimates (SAC/SBA)
- Breakthrough behavior for both resins

### Why This Matters

Bench-scale testing provides critical validation for full-scale IX/RO system design, ensuring resin selection and column sizing align with actual water chemistry rather than theoretical models alone. This verification also builds confidence that laboratory removal performance will translate to reliable operation when the process is scaled to well-field and plant conditions.

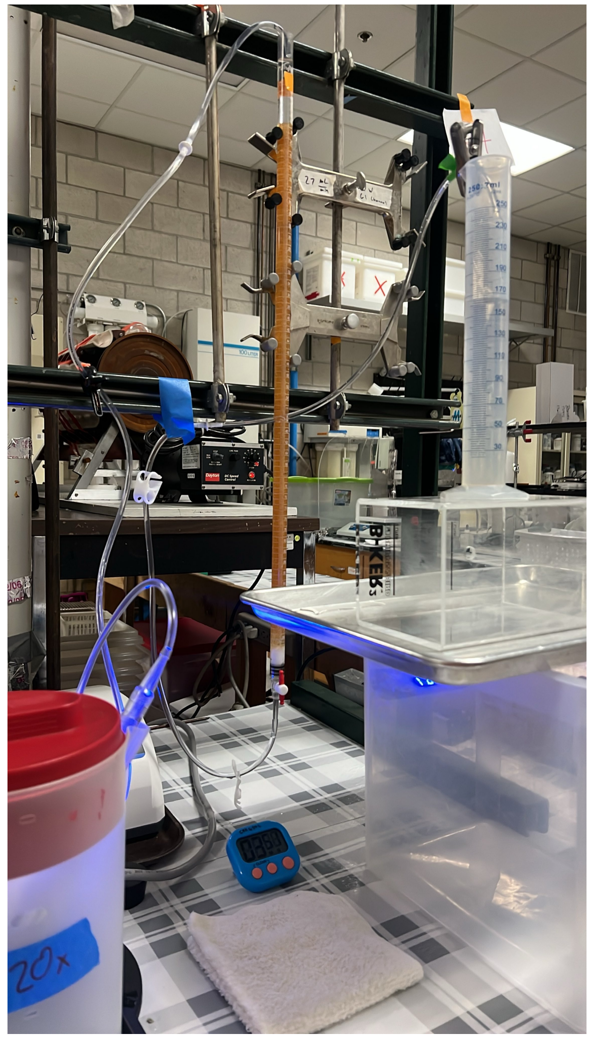



*Figure 6: Bench-scale IX column used for resin loading tests.*

### Design Impact

Laboratory verification confirms high-TDS water consistent with SNWA estimates. Ground-truth data allows accurate IX column sizing, resin-capacity selection, and validation that bench-scale removal performance can realistically scale to a full treatment system.

# 4. Construction Cost Estimating and Gantt Scheduling

## Bid Structure and Scope

Using HeavyBid, I developed a construction estimate and schedule for the Waste to Watts concept. Bid items were grouped by major work packages: 10-series (mobilization), 20-series (well drilling and testing), 30-series (treatment process installation), 40-series (pump / conduit), 50-series (storage tank and final tie-in), and 60-series (demobilization). The estimate includes direct labor, materials, subcontractor costs, equipment time, and indirects (overhead, insurance, and bonding).

## Bid Item Cost Summary

| Bid # | Description | Direct Cost [$] | Indirect/Markup [$] | Total [$] |
|---|---|---|---|---|
| 10 | Mobilization | – | – | Included in total |
| 20 | Drilling & Casing | 61,414 | 3,936 | 65,350 |
| 30 | Water Treatment Process | 67,180 | 4,306 | 71,486 |
| 40 | Pump / Conduit | 110,941 | 7,111 | 118,052 |
| 50 | Storage Tank Setup | 82,944 | 5,316 | 88,260 |
| 60 | Demobilization | – | – | Included in total |
| **Total** | **All Bid Items** | **322,478** | **20,669** | **343,147** |

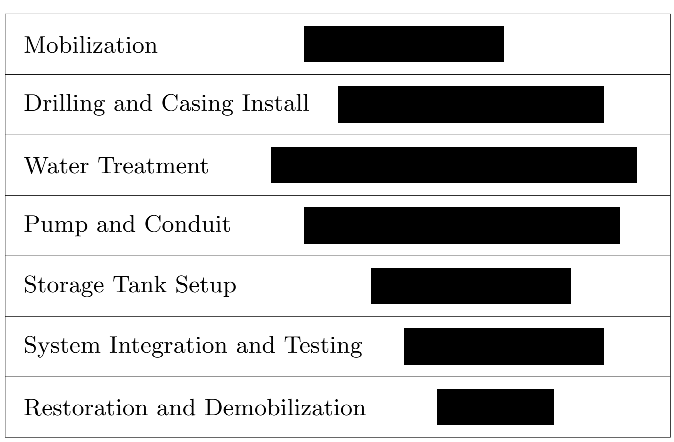
Table 3: Summary of bid items and rolled-up costs (rounded to nearest dollar).

The final construction value for the project was approximately $343k, based on 340 estimated crew manhours. Profits, insurance, overhead, and bonding were applied as percentage markups on total cost.

## Construction Schedule Overview

The schedule maps each work package from site setup to closeout. The critical path moves through drilling and casing, treatment installation, pump and conduit work, tank setup, system integration, and final restoration.

*Critical path of major tasks*



# 5. Comparative Life Cycle Assessment of Indoor Dining vs. Delivery Meals

**Authors:** Maya Arce, Adrian Montenegro, Dariz Rossetti-Busa
**Role:** Lead analyst (emissions modeling, material balances, sensitivity analysis)

### Study Goal
Quantify per-meal emissions, water use, and packaging impacts for dine-in vs. delivery systems.

### System Boundary
Gate-to-grave LCA including transport (ICE/EV), dishwashing, packaging, and disposal.

### Functional Unit
One meal delivered or served under Las Vegas regional conditions.

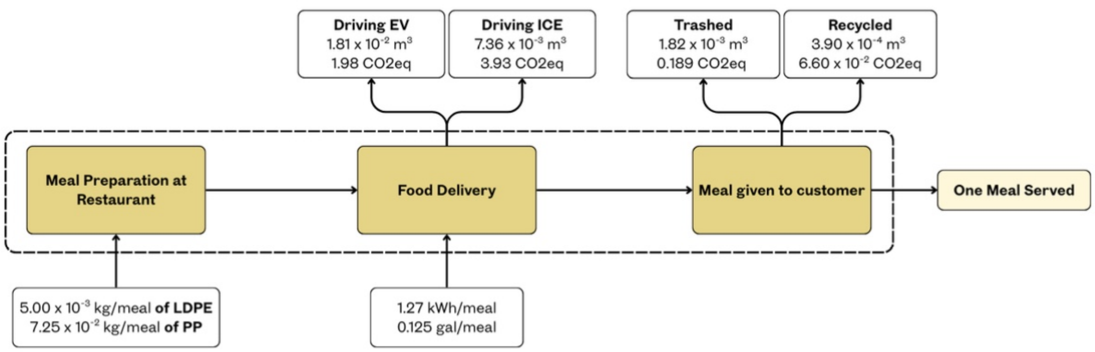



Figure 5: Dine-in system pathway.

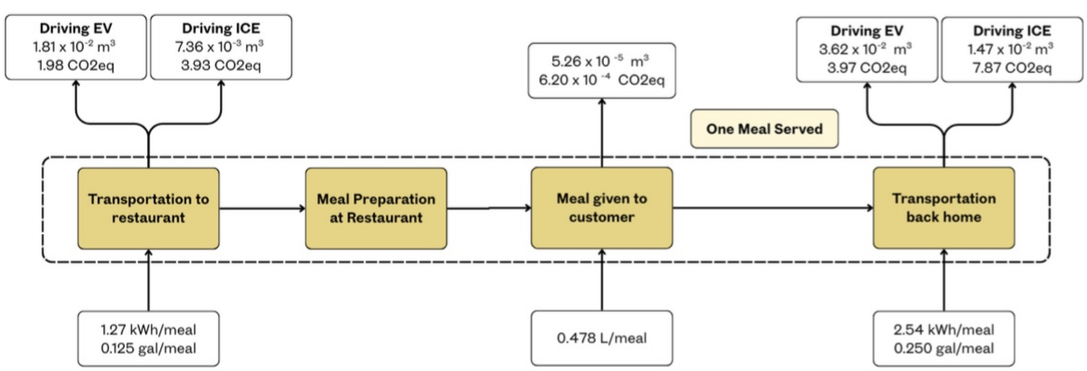



Figure 6: Delivery system pathway.

### Key Results
Driving behavior was the dominant contributor to emissions. Reducing vehicle fuel efficiency from 33.3 to 25 mpg increased dine-in emissions from 3.41 to 4.54 kg $CO_2$e per meal ($\sim$ 33% higher). Charging EVs from the U.S. grid produced 1.06 kg $CO_2$e per meal, while rooftop-solar charging reduced this to just 0.14 kg $CO_2$e per meal ($\sim$ 87% reduction). Packaging selection also played a significant role: switching from plastic to paper/wood lowered disposal emissions from 0.00845 to 0.00409 kg $CO_2$e per meal ($\sim$ 52% reduction). Overall, results show that transportation, electricity source, and packaging choices collectively shape the carbon footprint of both dine-in and delivery meals.

# 6. Humanitarian Design: EWB Challenge – Lobitos & Piedritas, Peru

## Project Context

Lobitos and Piedritas face unreliable water access, failing sanitation, expensive energy, and weak building durability. Tourism is growing, but infrastructure has not kept pace. Many homes rely on thin plywood walls and roofs that degrade rapidly under coastal sun, salt, and El Niño storms.

## Built Environment Problem

Our work focused on improving structural resilience. The core issue was the lack of affordable, thermally efficient, storm-resistant materials suitable for housing and community facilities.

## Proposed Solution

We evaluated locally available materials and proposed structures using corrugated galvanized steel paired with passive-cooling layers (air gap + local insulation). Steel offered superior durability, weather resistance, and lifecycle performance.

| **LCA Category** | **Plywood (20mm)** | **Galv. Steel (0.4mm)** | **Alu-Zinc Steel (0.4mm)** |
|---|---|---|---|
| Initial Cost (S/m²) | 40–50 | 60–75 | 80–100 |
| Service Life (yrs) | 7–12 | 25–40 | 40–60+ |
| 30-yr Lifecycle Cost (S/m²) | 120–160 | 65–80 | 80–100 |
| Embodied Carbon (kg COe/m²) | 15–20 | 30–40 | 35–45 |
| Recyclability | Low | Very High | Very High |
| Wind Resistance | Moderate | High | Very High |
| Moisture/Pest Resistance | Low | Very High | Very High |
| Local Availability | High | High | Moderate |
| Maintenance Needs | High | Low | Very Low |

Table 4: *
LCA functional unit: 1 m² cladding over 30 years. Values adapted for Lobitos' coastal context.

## Engineering Takeaways

- **Long-term cost:** Corrugated steel costs more upfront but less than half over 30 years.
- **Lifecycle carbon:** Plywood's repeated replacement increases its true carbon footprint.
- **Durability:** Steel withstands wind, moisture, pests, and storms—critical in a coastal setting.
- **Local fit:** Steel aligns with existing supply chains and is familiar to the community.

## Community Impact

- durable community facilities (multi-use hall in Piedritas),
- retrofits for existing homes in Lobitos,
- integration with solar and rainwater systems,
- long-term resilience for a tourism-supported economy.

## 7. Honors Research: Campus Security Engineering Analysis

**Title:** *Lethal Learning: Systems Engineering Analysis of Campus Security Infrastructure*
**Context:** UNLV Honors Symposium Research (2022)
**Method:** Mixed-Methods (Structured Interviews + Systems Modeling)


### Abstract

This systems-engineering study modeled campus safety as a socio-technical system. Interview data and infrastructure analysis revealed that surveillance, access control, and staffing shape both safety metrics and learning outcomes through interacting feedback loops.


Table 5: *
**Participant Demographics**

| Role | Count | Edu. Level |
|---|---|---|
| Administrators | 8 | M+ |
| Teachers | 15 | M+ |
| Security Staff | 5 | B+ |
| Students | 22 | UG |
| **Total** | **50** | |

### Key Findings

Table 6: *
**Security Intervention Analysis**

| Measure | Cost | Safety | Learning |
|---|---|---|---|
| Panic Badges | $11k | Med | Neutral |
| Single-Entry Access | $45k | Low | Neg |
| Surveillance Upgrades | $125k | Med | Neg |
| Armed Officers | $180k | Mixed | – |
| Mental Health Staff | $85k | High | ++ |

Table 7: *
**Student Outcomes vs. Security Strategy**

| Metric | High-Sec. | Mod. | MH-Focused |
|---|---|---|---|
| Math Scores | –12% | Base | +8% |
| College Attendance | –15% | Base | +11% |
| Suspensions | +28% | Base | –22% |
| Teacher Retention | –18% | Base | +14% |

### Engineering Recommendations

**System Priorities:**

[leftmargin=1em]

- Universal badge access with minimal intrusion.
- Target 25:1 student-teacher ratio (current: 38:1).
- 1 counselor per 250 students (currently 1:450).
- Surveillance used sparingly to reduce psychological load.

**Cost–Benefit Summary:**

[leftmargin=1em]

- Security hardware shows diminishing returns past $150k.
- Every $1 in mental health returns $3.20 in academic gains.
- Teacher salary investment provides highest long-term ROI.

### Conclusion

Balanced investment across staffing, mental health, and unobtrusive physical controls yields the highest combined safety–learning performance. Over-securitized campuses create negative feedback loops that undermine both instructional quality and psychological safety.

## 8. Sound Design and Audio Engineering

**Project Roles**
Sound Designer & Audio Engineer — UNLV Film Teams

**Overview**
Designed audio for *Into the Darkness* (2022), an award-winning short film exploring 9/11's impact through music. The project became my first engineering lab—transforming raw audio signals into narrative tools using systematic processing and human-centered design.

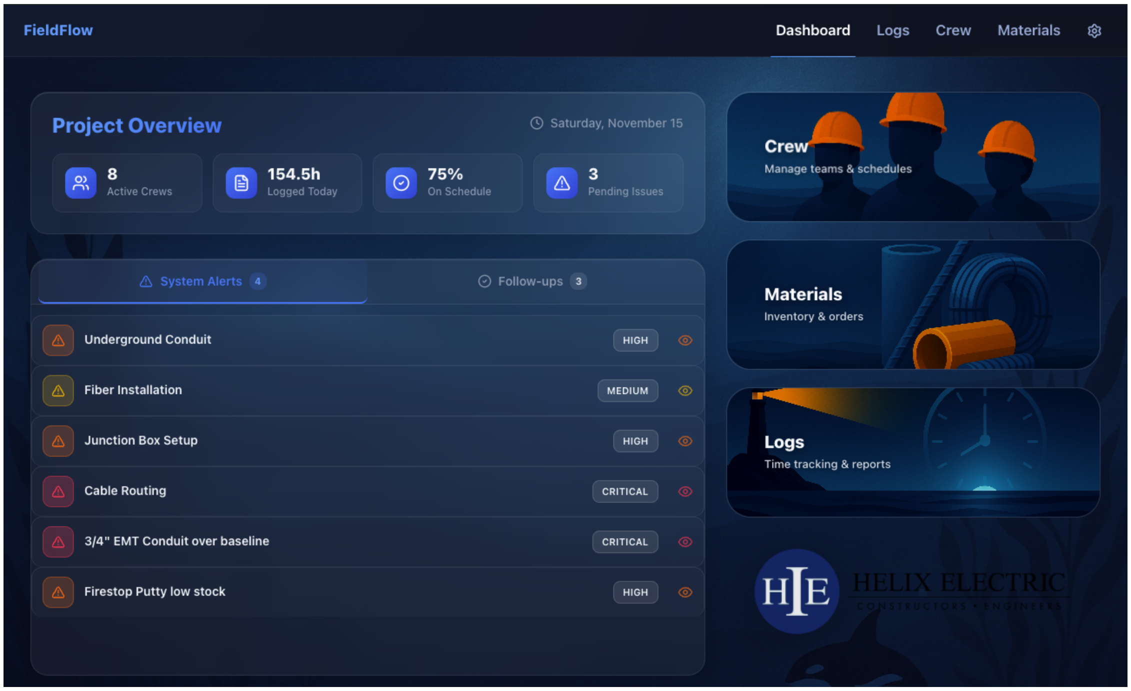
**Engineering Integration**

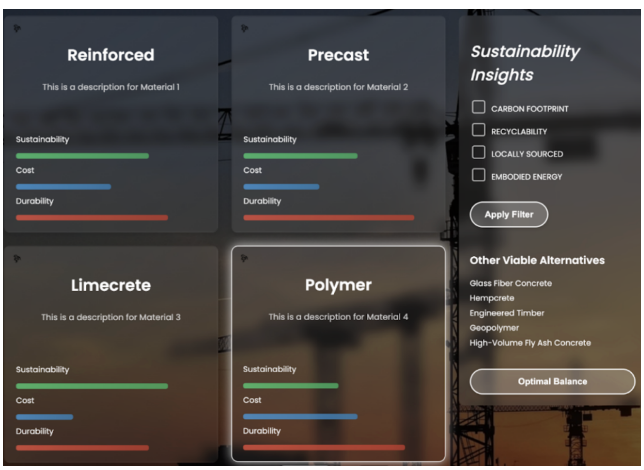
- **Signal Processing:** Sampled a deceased musician's work, applying tempo reduction and frequency filtering to create a haunting motif—engineering emotional impact through waveform manipulation.
- **Systems Thinking:** Built complete soundscapes from limited field recordings, diagnosing acoustic issues and optimizing within technical constraints.
- **Human-Centered Design:** Crafted audio cues that guided emotional perception, directly parallel to user-experience engineering.

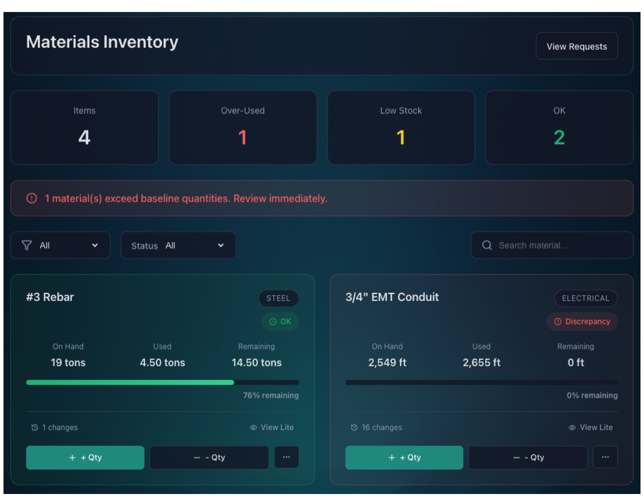
**Key Achievement**
Delivered the award-winning sound design for *Into the Darkness*, using technical audio processing to support a sensitive historical narrative. This creative work cemented my analytical approach to system design and problem-solving.

**Takeaway**
Sound design taught me to see technical constraints as creative opportunities—a mindset I now apply directly to engineering challenges, building systems that are both functionally robust and human-centered.

# 9. Software/UI Projects: OptoMat and FieldFlow




**OptoMat – Materials Scoring Platform.** I built OptoMat to score concrete mixes on cost, carbon impact, and durability. It began as a full-stack engine for evaluating mix designs side-by-side and became the foundation for the material-scoring logic I now use across newer tools. This led me to build my thoughts into reality.

**FieldFlow – Construction Scheduling Dashboard.** FieldFlow grew from working with field engineers who needed something fast, lightweight, and tied directly to daily job-site workflow. It distills OptoMat's scoring logic into a real-time scheduling dashboard for coordinating crews, materials, tasks, and on-site decisions. Now Iam currently working hand-in-hand with a client.

## 10. Awards & Recognition

**Academic Distinction**

- **Dean's Honors List, UNLV** — Multiple–semester academic excellence in Civil & Environmental Engineering.
- **Honors College Graduate (Thesis + Symposium)** — Completed peer-reviewed research and presented at the UNLV Honors Symposium.

**Engineering & Technical Achievement**

- **Waste to Watts: Senior Design Finalist (2025)** — Led LCA modeling, groundwater treatment analysis, and construction estimating for a data-center cooling innovation evaluated by faculty and industry judges.
- **Engineers Without Borders USA — Nationalist & Scholarship Recipient** — Recognized for national-level humanitarian engineering design work.
- **CyberSecurity Excellence Award, GenCyber Camp Challenge — 1st Place** — Awarded top performance during an intensive cybersecurity engineering competition.
- **CEE 472 Heavy-Bid Competency Recognition** — Completed full construction cost model, bid item structuring, and CPM schedule logic comparable to entry-level construction engineers.

**Research & Scholarly Recognition**

- **UNLV Library Publication — "Lethal Learning"** — Archival publication of Honors research on school infrastructure, safety design, and equity impacts.
- **OUR Fall Research Symposium Presenter** — Presented research on school-shooting systemic design and educational outcomes.

  **Engineering Leadership & Service**

  - **UNLV Engineering Student Ambassador** — Represented the College of Engineering through campus tours, outreach events, recruitment, and student engagement; delivered multi-hour engineering building tours.
  - **Team Leader / Election Operations Specialist (Clark County)** — Supervised election teams, authored procedural manuals, and trained personnel during high-volume operations.

    **Interdisciplinary & Creative Work**

    * **Sound Designer, UNLV Film — "Into the Darkness"** — Created the intro soundscape and contributed to full-project audio engineering.
    * **Super Bowl LVIII Halftime Team Member** — Selected performer supporting live-field coordination for a national broadcast event.
    * **OptoMat Founder** — Built early-stage materials-evaluation platform that evolved into **FieldFlow**, a construction-productivity SaaS tool.