Inglewood Oil Field Remediation and Restoration

School for Environment and Sustainability

University of Michigan

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Executive Summary

It is apparent now more than ever that fossil fuel extraction is a primary cause of warming the Earth's atmosphere which has impacted the environment in a multitude of ways. Since the mid 19th century oil extraction has dominated the energy sector making the transition from fossil fuels to renewable energy a complicated process. However, as carbon neutrality is gaining acceptance, the state of California has decided to phase out oil extraction within the next twenty years. In order to accomplish these goals, the largest urban oil field in Los Angeles, the Inglewood Oil Field, will be decommissioned in phases over the next decade and transitioned to a sustainable, mixed-use community. Encompassing approximately 1,000 acres in Los Angeles County, including areas such as Culver City, Baldwin Hills, Ladera Heights, and View Park, this field has been a significant player in the region's oil industry since the discovery of oil and gas in 1924. Sentinel Peak Resources operates the Inglewood Oil Field, overseeing the largest urban oil field in the United States. Remarkably, more than one million people reside within a five-mile radius of the site, highlighting the complex interplay between industrial activity and densely populated urban areas (Los Angeles Chapter of the Sierra Club).

The Inglewood Oil Field has led to fragmentation of the land, which has disproportionately affected the surrounding communities through health risks and environmental degradation, all of which may pose challenges to incorporating the site back into the community. The goal is to determine how this site can be transitioned to a more sustainable landscape which incorporates and engages the surrounding community, in addition to having a net zero impact. In order to develop the recommendations for the site, the team traveled to Los Angeles to engage in community outreach with the surrounding community of the Inglewood Oil Field. The survey aimed to gauge the community's awareness and expectations of residing near an urban oil field, as well as to discern their preferences for the future use of the remediated site. Key insights from the survey include a strong awareness of the Inglewood Oil Field, but a weak knowledge of the decommissioning of the field. Additionally, the majority of the community residents would like the site to have natural areas with green space and opportunities for walking and biking trails.

Based on the insights derived from the survey and extensive research on land remediation techniques, the recommendations for the Inglewood Oil Field were formulated. The redeveloped site will focus on harnessing long-term sustainability, and our recommendations are a reflection of that idea. The most effective way to measure long term sustainability is by creating a circular system on the site. The recommendations can be grouped into four different categories: soil remediation, urban biodiversity, energy suitability and community well-being. The report goes on to assess the methods needed to measure the success of these recommendations and some limitations that may arise during this process. In conclusion, the Inglewood Oil Field remediation recommendations provide an inclusive approach, prioritizing sustainability.

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Introduction

Revitalizing Urban Oil Fields: A Guidebook for Sustainable Landscape Transition

Impacts & Prospects: Oil Extraction in California

It is apparent now more than ever that fossil fuel extraction is a primary cause of warming the Earth's atmosphere which has impacted the environment in a multitude of ways. Since the mid 19th century oil extraction has dominated the energy sector making the transition from fossil fuels to renewable energy a complicated process. One of the first main hubs of oil extraction in the United States was the reservoir-filled state of California, with the first oil well discovered in 1892 (Witt, *The end of oil drilling in L.A*). After this discovery, wells began to pop up all over the city of Los Angeles quickly leading to rapid development and an increase in population. With the haphazard development of oil fields across the city, many Angelenos found themselves living in close proximity to toxic chemicals and air pollutants that were not heavily regulated. Today, the effects of oil drilling are camouflaged by fences and palm trees to disguise the extraction that is taking place on a daily basis. The city "has a long tradition of hiding its environmentally destructive ontology in winter sunshine and personal wellness" (Witt). However, as carbon neutrality is gaining acceptance, the state of California has decided to phase out oil extraction within the next twenty years.

History

Los Angeles County has over 20,000 active, idle, or abandoned wells spread across a population of 10 million people. About one-third of residents live less than a mile from an active well site, some right next door (Viloria, 2022). One prominent site in this legacy is the Inglewood Oil Field, established in the early 20th century due to its abundant oil and gas resources (Jack, 2023). Encompassing approximately 1,000 acres in Los Angeles County, including areas such as Culver City, Baldwin Hills, Ladera Heights, and View Park, this field has been a significant player in the region's oil industry since the discovery of oil and gas in 1924. Currently, there are around 900 active or idle wells within the field, with an annual production averaging 2.5 – 3.1 million barrels of oil (Los Angeles Chapter of Sierra Club). Sentinel Peak Resources operates the Inglewood Oil Field, overseeing the largest urban oil field in the United States. Remarkably, more than one million people reside within a five-mile radius of the site, highlighting the complex interplay between industrial activity and densely populated urban areas (Los Angeles Chapter of the Sierra Club). Unfortunately, this proximity has raised concerns about the health impacts on neighboring communities. Residents living near active oil wells have reported higher respiratory symptoms, including wheezing and irritation. Studies have also shown lower lung function among those closest to oil operations, particularly those living downwind and within 200 meters of the site (Johnston, Jill E., et al.). These findings underscore the potential respiratory health risks associated with urban oil and gas development, especially in densely populated, low-income communities of color. Furthermore, the environmental impact of oil operations extends beyond human health concerns. Oil spills, for instance, can harm local flora, fauna, and surrounding communities. In this context, it's essential to acknowledge the area's rich cultural heritage. The native tribe associated with the region around Inglewood, Southern California, is the Tongva tribe, also known as the Gabrielino-Tongva Tribe. As the indigenous people of the Los Angeles Basin and the Southern Channel Islands, including the area where Inglewood is situated, their presence serves as a reminder of the deep connection between land, culture, and history (gabrielinotribe.org 2024).

A Framework for Inglewood Oil Field Remediation

This project will focus on the Inglewood Oil Field, the largest oil field in Los Angeles spanning more than two miles long and 1,000 acres, which will be decommissioned within the next decade. This field in particular has led to fragmentation of the land, which has disproportionately affected the surrounding communities through health risks and environmental degradation, all of which may pose challenges to incorporating the site back into the community. Our goal is to determine how this site can be transitioned to a more sustainable landscape which incorporates and engages the surrounding community, in addition to having a net zero impact. The final deliverables will include a comprehensive final report and a guidebook. There will also be a short case study examining applicable remediation strategies and lessons learned from the redevelopment of the nearby Montebello Oil Field (See Appendix D). The intended audience of these deliverables is Sasaki, local governments and other stakeholders with interests in urban oil fields throughout the US and remediating these sites to ecologically sound states.

Hidden Oil Wells and Infrastructure

As part of a site visit to the Inglewood Oil Field in August of 2023, the team visited and made observations on infrastructure that the city of Los Angeles has designed to hide active and inactive oil wells and infrastructure across the city.

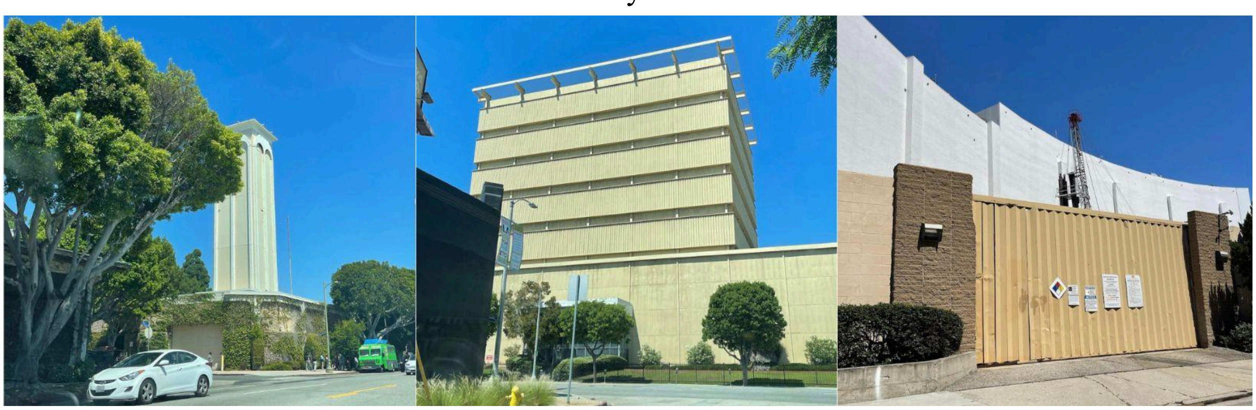


Figure 1. First image Packard Well Site, middle West Pico Drill Site and last photo of the Beverly Center.

The team visited seven sites across the city of Los Angeles: Packard Well Site, West Pico Drill Site, the Beverly Center, Cedar Sinai Hospital, Tower of Hope Beverly Hills, Montebello, and La Brea Tar Pits. Three sites had oil and gas infrastructure hidden in buildings or other structures: Packard Well Site, West Pico Drill Site, and the Beverly Center, all about five miles from Inglewood Oil Field (Figure 1). At the Beverly Center, oil infrastructure is visible from the street corner adjacent to the shopping mall and Cedars-Sinai Hospital. The Tower of Hope Beverly Hills has been demolished and redeveloped. Montebello is an inactive extraction site twenty miles from Inglewood Oil Field; the site is now in the process of being redeveloped into a housing project.

Figure 2. La Brea Tar Pits located in Hancock Park–summer season.

Additionally, our team took the opportunity to learn about the La Brea Tar Pits (Figure 2), which is an active urban paleontological research area in Los Angeles. Located in the Hancock Park area, it was formed around a group of tar pits where natural asphalt has been seeping up from the ground below for tens of thousands of years. The La Brea Tar Pits are related to the Salt Lake oil field and are adjacent to the Beverly Center site.

Community Outreach

Surveying in Los Angeles

Understanding Awareness and Expectations of Residents

Our research project focuses on providing a framework to professionals and stakeholders as a pilot initiative for how to transition an urban oil field into a more sustainable landscape within the context of the Inglewood Oil Field. For this survey, our goal was to engage with community residents to understand their awareness and expectation of living around an urban oil field.

Figure 3. Our prepared toolkit for the on-site survey

Our target population consisted of residents from selected communities around the Inglewood Oil Field. This allowed us to ensure our research accessibility within a limited timeframe while gathering a sufficient number of responses. Through online research and personal knowledge regarding where we can have a significant number of chances to approach residents, we made a daily engagement agenda including three types of survey locations (Park/Trail/Recreational Center, Shopping Mall/Store, Library/College).

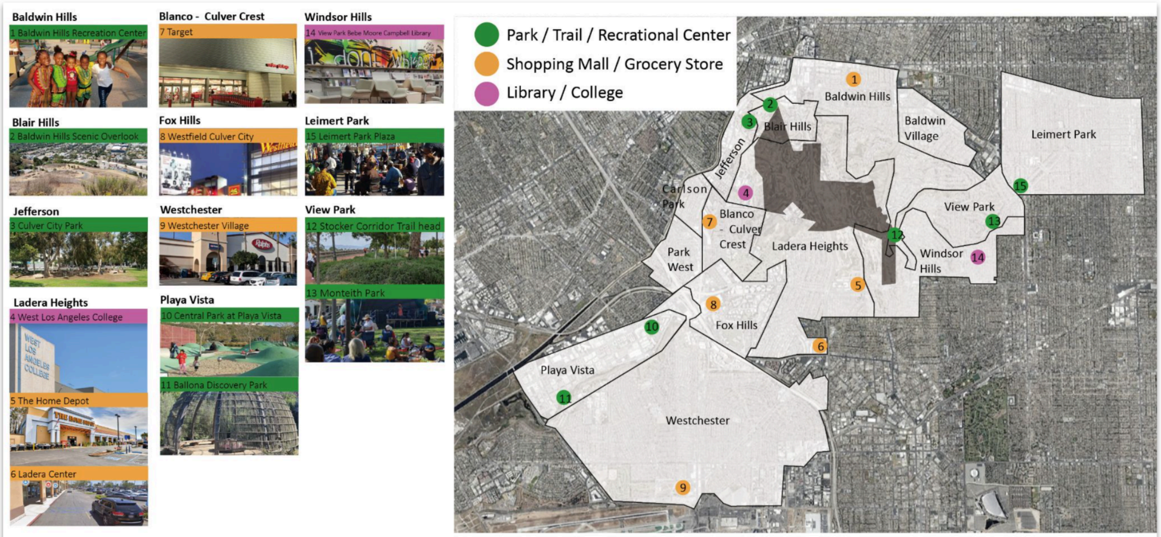


Figure 4. Diagram depicting the three types of planned outreach locations

Qualitative and Quantitative Methods for Surveying

We conducted the community outreach through various approaches, including qualitative methods like distributing surveys (see Figure 3), discussing the Inglewood Oil Field in person, and quantitative methods such as online/offline promotion with retailers or schools.

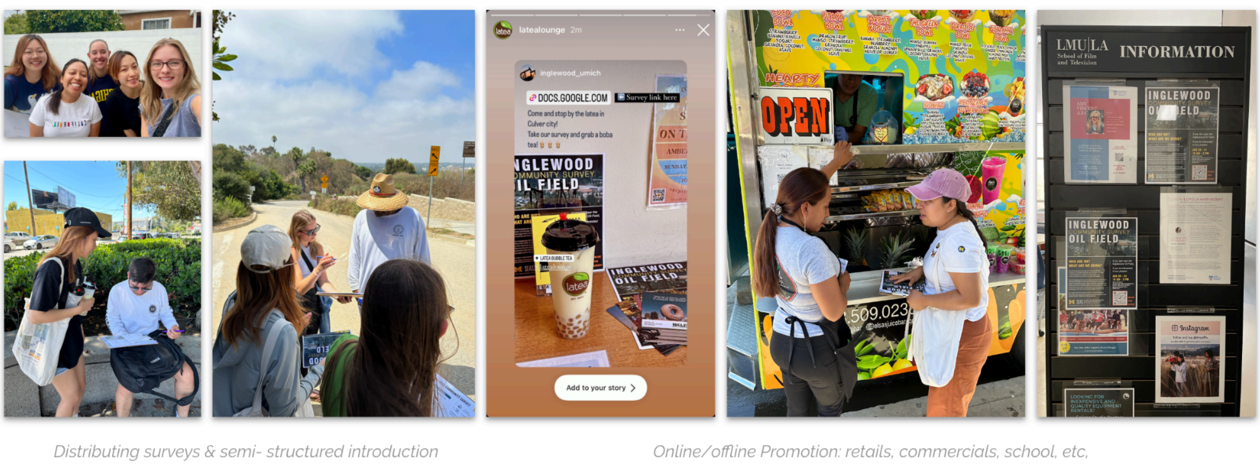


Figure 5. Community outreach execution

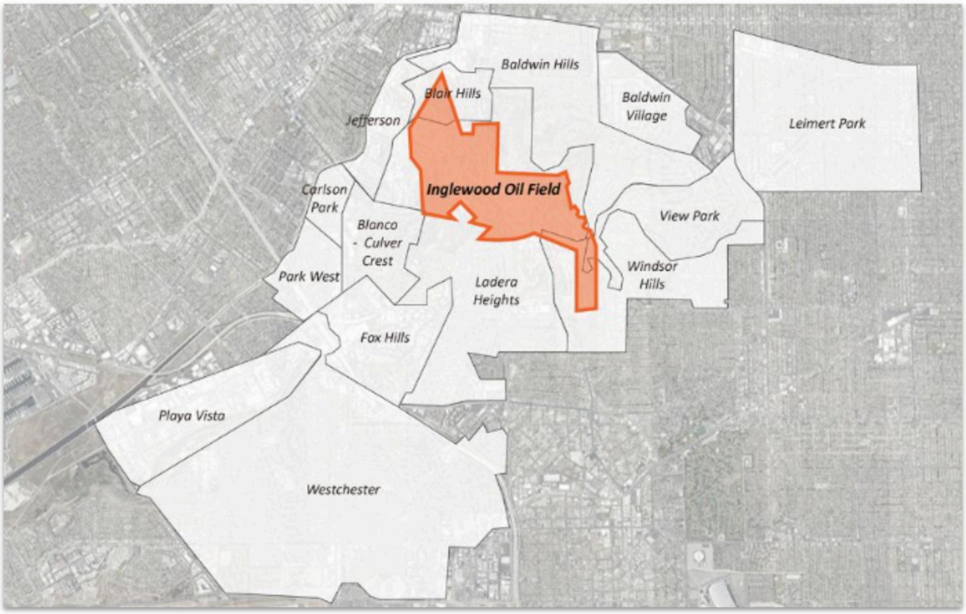


Figure 6. Surrounding communities of the Inglewood Oil Field.

Pilot Study for Inglewood Oil Field Area

The survey method used both hard-copy and online formats. The initial survey was organized into three sections: Sense of The Inglewood Oil Field, Nature Observation, and Demographics. During the first day of our trip, we conducted a pilot survey at Westfield Shopping Mall in Culver City. We distributed 5 hard-copy surveys to residents who met the potential participant criteria to ensure that the survey could be taken in less than three minutes, find any potential errors with the survey, and any other feedback. For the pilot study survey protocol, please see the Appendix.

Based on the pilot test there were several findings, as well as adjustments made to the final survey:

1. The survey could be a little overwhelming since most participants could not complete it within three minutes. To streamline the survey, we reduced its length by removing some Nature Observation questions and the Demographics section while still ensuring our goal of understanding residents' awareness and expectations near the urban oil field.
2. During the pilot survey, we noticed that some of the participants were from outside our selected communities or faced language barriers of only speaking Spanish. Therefore, we expanded our survey area to encompass all of Los Angeles City given its cultural diversity- the Inglewood Oil Field is an important part of Los Angeles City. Therefore, if possible in the future, we should also include a version of the survey in Spanish since there are many Spanish-speaking populations in the surrounding communities.
3. Although commercial interiors can attract large crowds, securing permissions and adhering to mall rules for interior surveys can be complex. Disrupting shoppers'

schedules may also impact response validity. Open spaces like parks, trails, or recreational centers might be more helpful to find participants that align better with our focus on urban oil field remediation expectations. Thus, we adjusted our engagement agenda to include fewer malls or stores and more open spaces for the rest of the trip.

4. For the pilot survey, we aimed for ten participants but received only 5 responses. To improve clarity, we decided to be more direct and clear about our intentions and incentives when introducing ourselves, avoiding assumptions about participants' understanding and patience.

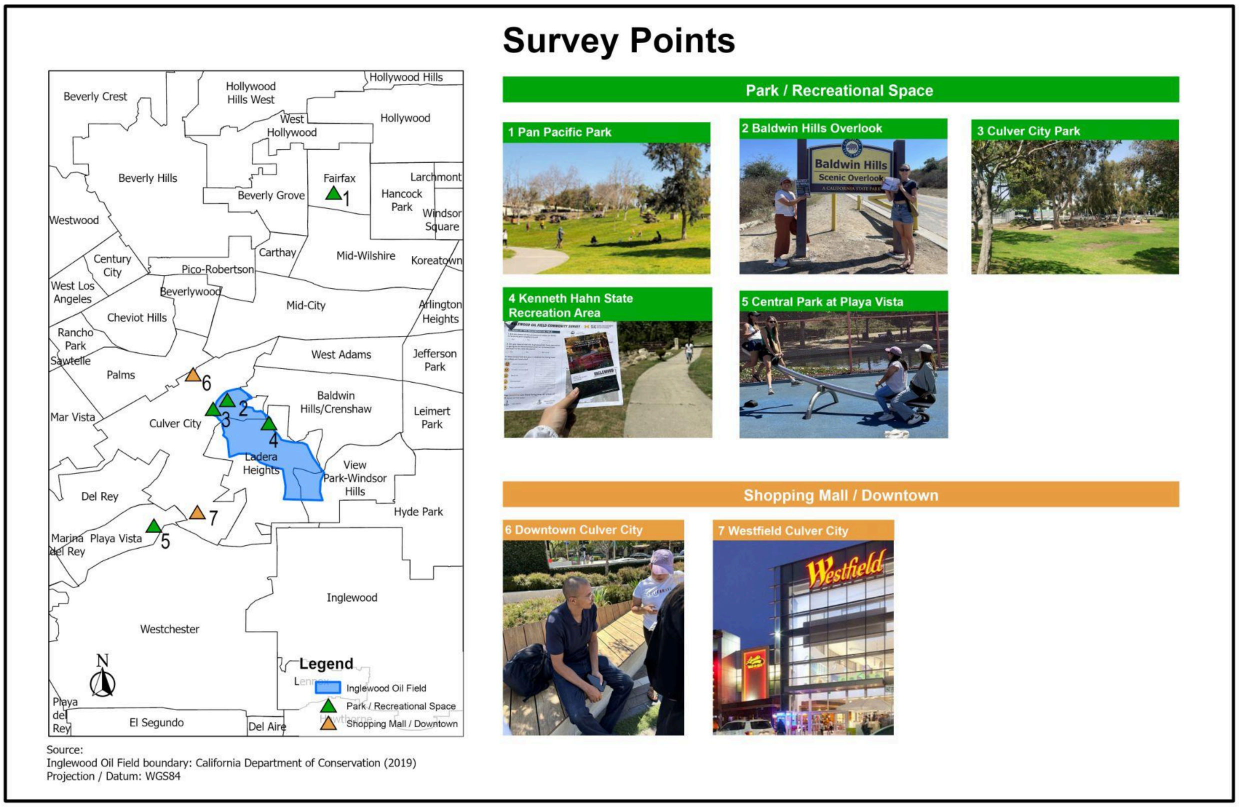


Figure 7. Modified survey locations.

The survey remained open until we started data analysis, and the final metrics revealed that we received a total of 100 responses. To analyze our data, we used Google Forms to tabulate survey responses and performed a qualitative analysis in Google Sheets for open-ended questions. Lastly, we visualized the key insights to support our subsequent recommendations.

Insights from Community Survey

While analyzing the community survey data, we summarized the key findings of the impact of the urban oilfield on the surrounding community through data visualization. The concluded findings are specifically for the urban context of Inglewood Oil Field.

Figure 8. Strategy to address residents' worries and aspirations when planning for the future of urban oil fields.

- ***Strong awareness of Urban Oil Fields, but weak knowledge of decommissioning***

  The majority of the community residents are aware of the presence of an urban oil field in or around their neighborhood, but most of them are not informed about the city's plan to decommission the Inglewood Oil Field operation in the next decade.

- ***Worries about proximity and perceptions of risk***

  The residents have a high level of concern and anxiety about living near an urban oil field site, as they perceive various environmental and health risks associated with it, such as potential oil spills, air pollution, and water pollution. They also experience some negative impacts on their quality of life, such as noise, light pollution, and traffic congestion.

- ***Mixed opinions about the benefits***

  The residents have mixed opinions about the benefits of living near an urban oil field, with half of them seeing no benefits at all, and the other half acknowledging some benefits like job creation and revenue for the city and state. However, these benefits do not seem to outweigh the risks and costs for most of the residents.

- ***Clear desire for the remediation to focus on naturalization***

  The residents have a strong preference for transforming the remediated site from an urban oil field to a more natural and green space that can offer them various recreational and social opportunities, such as hiking trails, parks, nature and wildlife, bird watching, picnic, sports, community gardens, and farmers' markets. They also express a desire for more spaces for leisure and relaxation in their neighborhood.

- ***Long-term attachment to their neighborhood***

  A substantial portion of residents, almost 90%, have lived in their neighborhood for an extended period, with half of them residing there for over 10 years. This suggests a stable and established community that has a vested interest in the future development of their neighborhood and the remediated site.

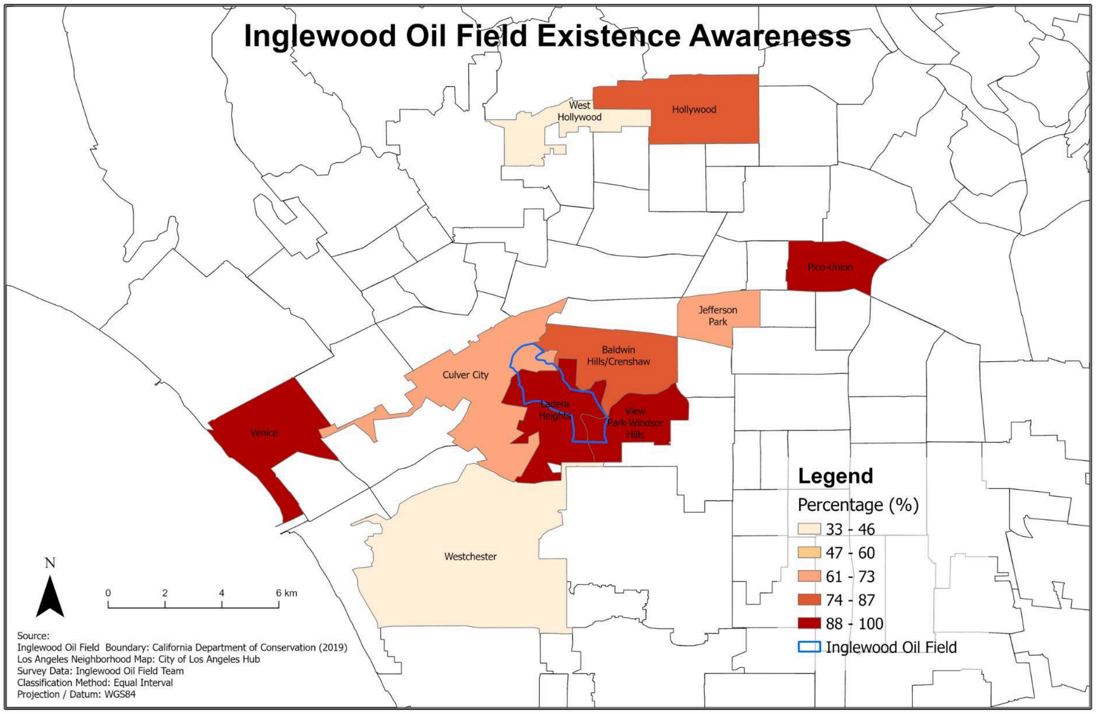
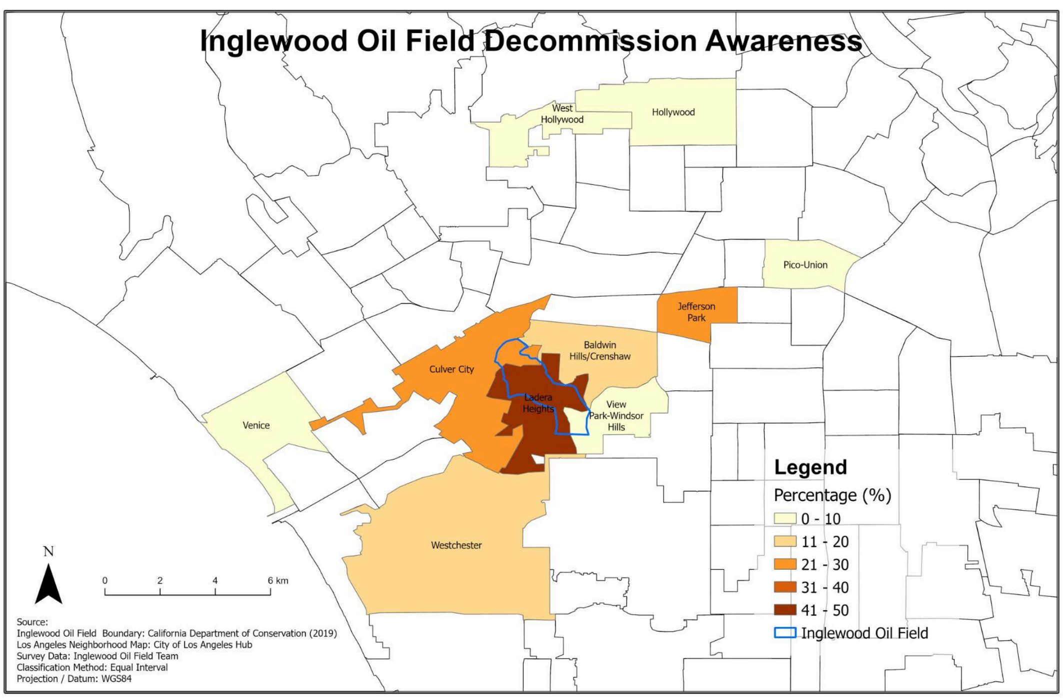


Figure 9. Awareness of the existence of the Inglewood Oil Field is not directly correlated with people's proximity to it.



it.

Figure 10. The closer the community is to Inglewood Oil Field the higher percentage of people know it will be decommissioned in the future.

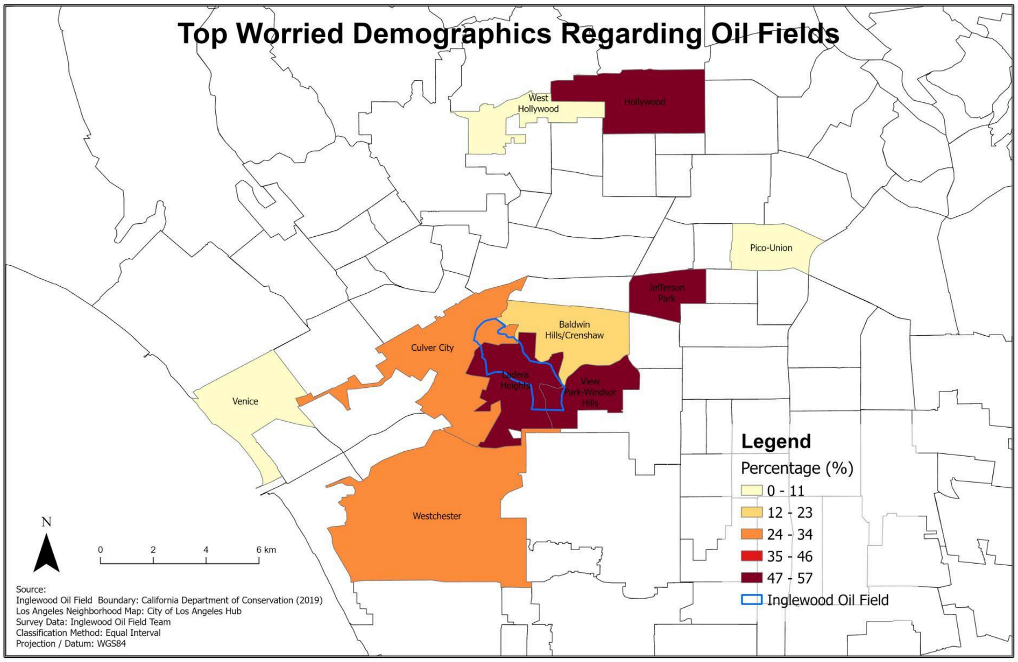


Figure 11. As communities draw nearer to the Inglewood Oil Field, the percentage of individuals expressing the highest level of concern about the negative impacts of the oil fields on their lives gradually increases.

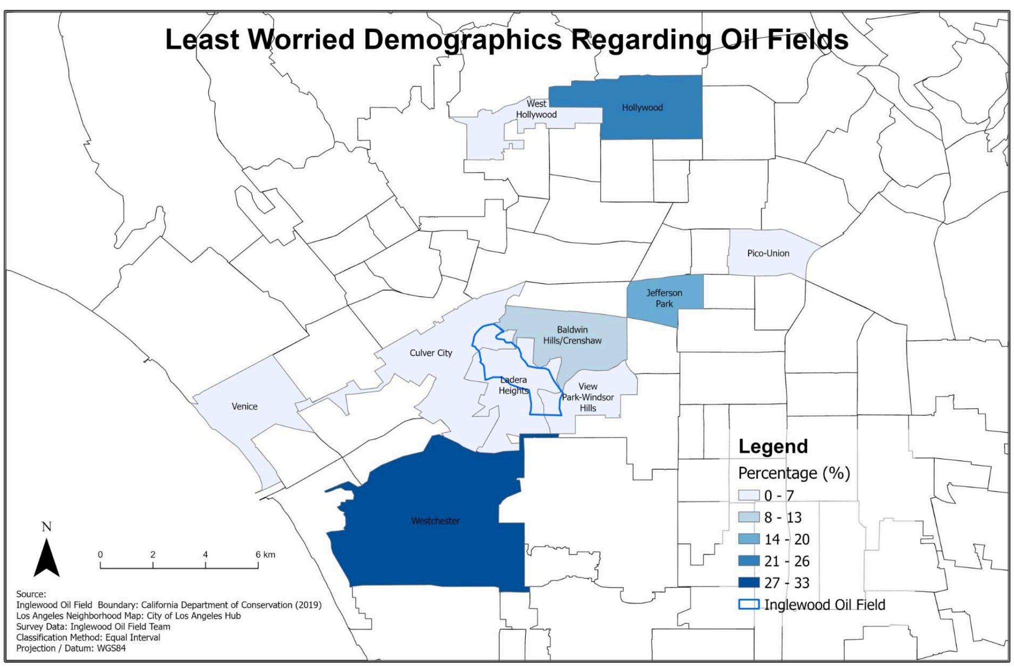


Figure 12. As communities move away from the Inglewood Oil Field, the percentage of individuals expressing the slightest concern about the negative impacts of the oil fields on their lives gradually increases.

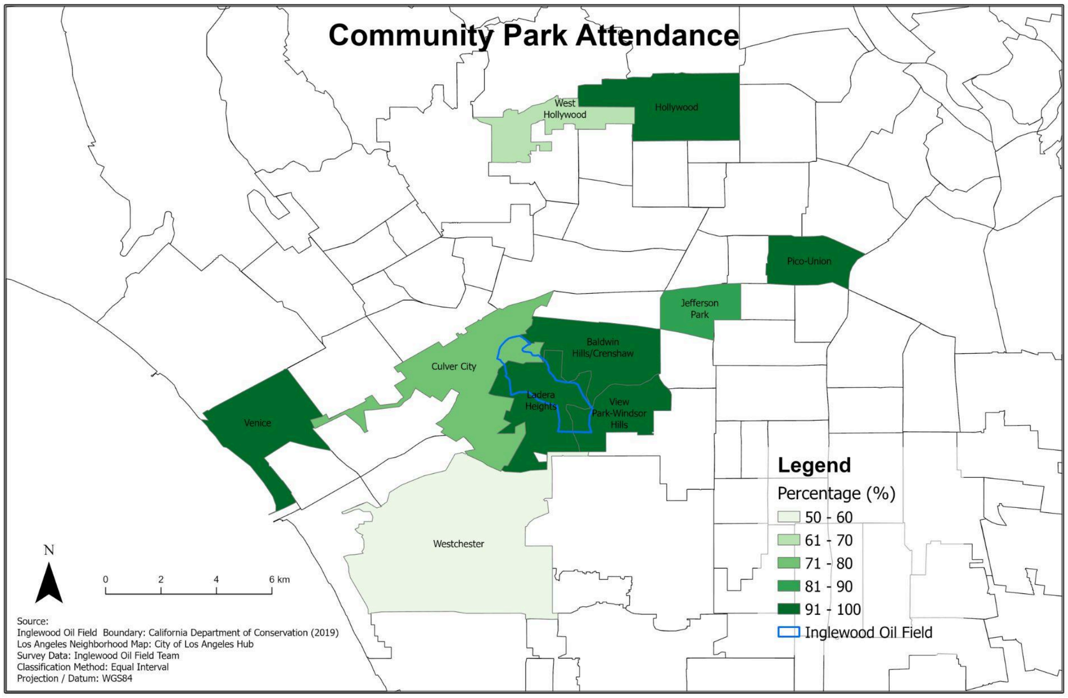


Figure 13. Most people surveyed have visited parks near their communities, with over 50% of respondents in all communities, and many close to 100%.

Air Quality

Methods

Air quality was recorded at 8 locations; Inglewood Oil Field, downtown Culver City, Culver City Park, La Brea Tar Pits, Pan Pacific Park, Baldwin Hills Scenic Overlook, Central Park at Playa Vista, and Whittier Narrows Recreational Area. Sample sites fell into three categories; public spaces or parks where the group canvasses for survey results (downtown Culver City, Culver City Park, La Brea Tar Pits, Pan Pacific Park, Baldwin Hills Scenic Overlook, Central Park at Playa Vista), active extraction sites (Inglewood Oil Field), and near former extraction sites (Whittier Narrows Recreational Area). Air quality was measured for at least 3 minutes at each site using a PocketLab Air sensor. The PocketAir Sensor collected data on time, location (latitude and longitude), PM 10 (ug/m^3), PM 2.5 (ug/m^3), carbon dioxide (ppm), ozone (ppb), Air Quality Index (AQI), barometric pressure (mBar), internal temperature (°C), humidity (%RH), and light intensity (lx). Parameters such as ozone, PM 2.5, and PM 10 were compared to primary federal and state ambient air quality standards. The goal of collecting air quality data was to determine whether air quality varied across sites in Los Angeles and how findings compared to federal and state standards.

Results

Table 1. Ozone (ppm) concentrations from 8 survey locations in August compared to state and federal standards.

Survey Location	*Ozone*	*Within EPA Standard for Ozone? (0.070 ppm)*	*Within CA Standard for Ozone? (0.070 ppm)*
Baldwin Hills Scenic Overlook	0.00038	Yes	Yes
Culver City Park	0.00033	Yes	Yes
Downtown Culver City	0.00036	Yes	Yes
Inglewood Oil Field	0.00023	Yes	Yes
La Brea Tar Pits	0.00035	Yes	Yes
Pan Pacific Park	0.00029	Yes	Yes
Playa Vista	0.00029	Yes	Yes
Whittier Narrows Rec Area	0.00028	Yes	Yes

Table 2. PM 2.5 (μg/m³) concentrations from 8 survey locations in August compared to state and federal standards.

Survey Location	*PM 2.5*	*Within EPA standard for PM 2.5? (12 μg/m³)*	*Within CA Standard for PM 2.5? (12 μg/m³)*
Baldwin Hills Scenic Overlook	26.093	No	No
Culver City Park	25.563	No	No
Downtown Culver City	4.269	Yes	Yes
Inglewood Oil Field	3.309	Yes	Yes
La Brea Tar Pits	15.444	No	No
Pan Pacific Park	13.196	No	No
Playa Vista	13.312	No	No
Whittier Narrows Rec Area	3.532	Yes	Yes

Table 3. PM 10 (μg/m³) concentrations from 8 survey locations in August compared to state and federal standards.

Survey Location	*PM 10*	*Within EPA Standard for PM 10? (150 μg/m³)*	*Within CA Standards for PM 10? (50 μg/m³)*
Baldwin Hills Scenic Overlook	31.668	Yes	Yes
Culver City Park	39.427	Yes	Yes
Downtown Culver City	4.904	Yes	Yes
Inglewood Oil Field	3.827	Yes	Yes
La Brea Tar Pits	18.606	Yes	Yes
Pan Pacific Park	15.429	Yes	Yes
Playa Vista	16.169	Yes	Yes
Whittier Narrows Rec Area	14.721	Yes	Yes

Table 4. U.S. EPA Daily Air Quality Index (AQI) of 8 survey locations in August; color corresponds to level of concern, green (good) or yellow (moderate).

Survey Location	*AQI*
Baldwin Hills Scenic Overlook	80
Culver City Park	79
Downtown Culver City	18
Inglewood Oil Field	14
La Brea Tar Pits	58
Pan Pacific Park	52
Playa Vista	52
Whittier Narrows Rec Area	15

In August, all sites sampled were in compliance with state and federal standards for ozone (ppm) and PM 10 ($\mu g/m^3$). There was more variation among sites for PM 2.5 ($\mu g/m^3$) and Air Quality Index (AQI). Only three sites, downtown Culver City, Inglewood Oil Field, and Whittier Narrows Recreational Area, were within standards for PM 2.5. This was surprising as we expected sites near roads, like downtown Culver City, to have higher concentrations of particulate matter as one major source of PM 2.5 in outside air is the combustion of gasoline, oil, and diesel fuel (CARB). Further, oil and gas operations are one of the largest sources of volatile organic compounds; these compounds can react to form ground level ozone (EPA, *Oil and Natural Gas Air Pollution Standards*). This pattern was seen again with AQI; out of all the sites sampled only downtown Culver City, Inglewood Oil Field, and Whittier Narrows Recreational Area had AQI values in the lowest level of concern. However, this result is likely correlated with PM 2.5 values as particulate matter, along with ground-level ozone, carbon monoxide, sulfur dioxide, and nitrogen dioxide, is one of the major pollutants considered when calculating AQI values (AirNow)

Comparison: Winter Air Quality Observations

Air quality data was recollected in December to determine if there were differences in air quality between summer (August) and winter (December). During winter data collection, weather conditions at La Brea Tar Pits and Pan Pacific Park were comparable. The sky was clear, and the temperature was roughly in the low 50s, with slightly cold air. Additionally, birds were present in the area at both locations. However, in December, there were fewer pollinators such as bees present in the area. The rain ceased two days after the data was collected and one day before the Christmas celebration. In contrast, more pollinators, such as bees, appeared to be more present in summer (August), possibly due to the higher temperatures. In December, temperatures were lower, ranging from around 50 to high 60s degrees, whereas in August, temperatures were higher, ranging from 60s to 70’s degrees. Something to note for winter is that data was collected in two days. Part one of the data collection was before the Christmas celebration. The remainder of the data was collected the day after the Christmas celebration, and the data could have reflected something different in the levels of air quality but during the days that data was collected the sites had clear skies.

Figure 14. La Brea Tar Pits and data collection with the PocketLab Air in winter.

Table 5. Ozone (ppm) concentrations from 8 survey locations in December compared to state and federal standards.

Location	*Ozone*	*Within EPA Standard for Ozone? (0.070 ppm)*	*Within CA Standard for Ozone? (0.070 ppm)*
Baldwin Hills Scenic Overlook	0.00029	Yes	Yes
Culver City Park	0.00033	Yes	Yes
Downtown Culver City	0.00029	Yes	Yes
Inglewood Oil Field	0.00024	Yes	Yes
La Brea Tar Pits	0.00025	Yes	Yes
Pan Pacific Park	0.00037	Yes	Yes
Playa Vista	0.00028	Yes	Yes
Whittier Narrows Rec Area	0.00028	Yes	Yes

Table 6. Change in ozone concentrations (ppm) from August to December.

Survey Location	*Change in Ozone (ppm)*
Baldwin Hills Scenic Overlook	-0.00009
Culver City Park	0.00000
Downtown Culver City	-0.00007
Inglewood Oil Field	0.00001
La Brea Tar Pits	-0.00010
Pan Pacific Park	0.00008
Playa Vista	-0.00001
Whittier Narrows Rec Area	0.00000

Table 7. PM 2.5 (ug/m^3) concentrations from 8 survey locations in December compared to state and federal standards.

Location	*PM 2.5*	*Within EPA standard for PM 2.5? (12 µg/m^3)*	*Within CA Standard for PM 2.5? (12 µg/m^3)*
Baldwin Hills Scenic Overlook	36.306	No	No
Culver City Park	35.452	No	No
Downtown Culver City	36.046	No	No
Inglewood Oil Field	36.016	No	No
La Brea Tar Pits	7.016	Yes	Yes
Pan Pacific Park	5.081	Yes	Yes
Playa Vista	32.860	No	No
Whittier Narrows Rec Area	36.436	No	No

Table 8. Change in PM 2.5 (µg/m^3) from August to December.

Survey Location	*Change in PM 2.5*
Baldwin Hills Scenic Overlook	10.213
Culver City Park	9.889
Downtown Culver City	31.777
Inglewood Oil Field	32.707
La Brea Tar Pits	-8.428
Pan Pacific Park	-8.115
Playa Vista	19.548
Whittier Narrows Rec Area	32.904

Table 9. PM 10 (ug/m^3) concentrations from 8 survey locations in December compared to state and federal standards.

Location	*PM 10*	*Within EPA Standard for PM 10? (150 µg/m^3)*	*Within CA Standards for PM 10? (50 µg/m^3)*
Baldwin Hills Scenic Overlook	45.941	Yes	Yes
Culver City Park	43.935	Yes	Yes
Downtown Culver City	44.371	Yes	Yes
Inglewood	44.172	Yes	Yes
La Brea Tar Pits	8.414	Yes	Yes
Pan Pacific Park	6.756	Yes	Yes
Playa Vista	38.627	Yes	Yes
Whittier Narrows Rec Area	44.107	Yes	Yes

Table 10. Change in PM 10 (µg/m^3) from August to December

Survey Location	*Change in PM 10*
Baldwin Hills Scenic Overlook	14.273
Culver City Park	4.508
Downtown Culver City	39.467
Inglewood Oil Field	40.345
La Brea Tar Pits	-10.192
Pan Pacific Park	-8.673
Playa Vista	22.458
Whittier Narrows Rec Area	29.386

Table 11. U.S. EPA Daily Air Quality Index (AQI) of 8 survey locations in December; color corresponds to level of concern, green (good) or orange (unhealthy for sensitive groups).

Location	*AQI*
Baldwin Hills Scenic Overlook	103
Culver City Park	101
Downtown Culver City	102
Inglewood	102
La Brea Tar Pits	29
Pan Pacific Park	21
Playa Vista	95
Whittier Narrows Rec Area	103

There was no overarching trend when comparing air quality parameters in August and December. For ozone, with the exception of Pan Pacific Park, concentrations of ozone decreased or did not change significantly between August and December. For PM 2.5, concentrations increased by various amounts at six out of eight sites; at two sites, La Brea Tar Pits and Pan Pacific Park, concentrations decreased from August to December by about 8 $\mu g/m^3$. However, changes in PM 10 mirrored those seen in PM 2.5; all sites except for La Brea Tar Pits and Pan Pacific Park saw an increase of various amounts in PM 10 between August and December. The one significant change in air quality parameters between August and December was changes in the AQI values. In August, all values across all sites either fell in the “good” or “moderate” levels of concern. However in December, half of the sites fell into “unhealthy for sensitive groups”. This level of concern indicates that air quality poses a risk for sensitive groups like children, older adults, and those with asthma; members of these groups may experience health effects.

Influences on Air Quality

Many factors influence air quality including temperature, wind, precipitation, solar radiation, and pollutants. Precipitation, especially rain, is known to influence concentrations of pollutants in the air. As raindrops fall through the atmosphere they attract aerosol particles to their surface before hitting the ground. This process by which droplets and aerosols attract is called coagulation (Chu). Coagulation reduces the amount of pollutants in the air like soot, sulfates, and organic particles (Chu). Precipitation is especially influential on particulate matter. One long term study on the effect of wind and precipitation on particulate matter found that although rainfall captured both PM 2.5 and PM 10 in the atmosphere, the effect is greater on PM 10 (Z. Liu et al., 11). Further, how much PM 10 was captured was related to initial concentrations; the higher initial concentrations of PM 10, the more PM 10 was removed (Z. Liu et al., 11). These results are significant because PM 10 is known to cause respiratory issues and is linked to premature death and heart disease.

The scavenging effect of rainfall of atmospheric pollutants is significant to analysis of air quality around Inglewood Oil Field because during the week-long site visit, Los Angeles experienced an extreme precipitation event. Early on during the visit, Tropical Storm Hilary made landfall in Southern California. Hilary brought an immense amount of rainfall to the area; many daily rainfall records were broken across Southern California. For example, downtown Los Angeles received 2.99 inches- far surpassing its previous daily record of 0.03 inch (Pinho). Culver City, where the team was based for the week, received 3.65 inches of rain in one day (Pinho). This could have influenced our results; a massive rainfall event such as Tropical Storm Hilary could have significantly reduced the amount of pollutants in the atmosphere.

Urban Biodiversity

During our site visit, we investigated the following locations: The Inglewood Oil Field, Kenneth Hahn State Recreation Area, Baldwin Hills Scenic Overlook, Culver City Park, Ballona Discovery Park, Playa Vista, and Whittier Narrows Recreation Area.

Figure 15. Sites visited during the summer (August).

Methods

We conducted nature observations at all sites for about five to ten minutes. Photos were taken with a Canon camera, iPhone and Samsung smartphone cameras at each site. The Cornell Lab's Merlin app and iNaturalist app were used to identify species.

Summer Urban Wildlife Observation

Kenneth Hahn State Recreation Area adjoins the Inglewood Oil Field. A wire fence and eucalyptus trees set a boundary that divides the park from the oil field.

Figure 16. Fenceline in between Inglewood Oil Field and Kenneth Hahn State Recreation Area.

The following species were observed at Kenneth Hahn State Recreation Area: Canada goose (*Branta canadensis),* red-tailed hawk (*Buteo jamaicensis),* red-eared slider turtle (*Trachemys scripta elegans),* spiders (*Araneae)*, Western honey bee (*Apis mellifera Linnaeus),* dark-eyed junco *(Junco hyemalis)* and hummingbirds such as the Anna's Hummingbird *(Calypte anna)* in addition to plants and fungi like mushrooms (*Basidiomycota)*, and eucalyptus (*Eucalyptus sp)*.

Figure 17. Species observed at Kenneth Hahn State Recreation Area, from left to right: Canada goose (Branta canadensis) and California brittlebush (Encelia californica)

Baldwin Hills Scenic Overlook is also near the oil field, and is home to diverse species of flora and fauna. Due to its proximity to the field, oil pump jacks can be seen from a distance. At Baldwin Hills, wildlife species that were observed were the Red-tailed hawk (*Buteo jamaicensis),* lizards, snakes, spiders (*Araneae)*, squirrels, and other bird species. During our four-day observations, there was significant bird and pollinator activity. Baldwin Hills Scenic Overlook is a predominately open space with coastal sage brush *(Artemisia californica),* coyote bush *(Baccharis pilularis)*, and bush sunflower *(Encelia californica).* There is also infrastructure such as walking trails, paved roads, and a visitor's center.

Figure 18. Baldwin Hills Scenic Overlook and a bee pollinating a flower.

Culver City Park is adjacent to Baldwin Hills Scenic Overlook and is also in close proximity to the oil field. At Culver City Park, birds like Anna's Hummingbird *(Calypte anna)* and red-tailed hawk (*Buteo jamaicensis)* were seen, in addition to plant species such as palm trees and toyon*(Heteromeles arbutifolia).* At Ballona Discovery Park, we observed the presence of birds like the Dark-eyed junco (*Junco hyemalis*) and plant species like California sagebrush (*Artemisia californica*), coyote brush (*Baccharis pilularis*) and mulefat (accharis salicifolia).

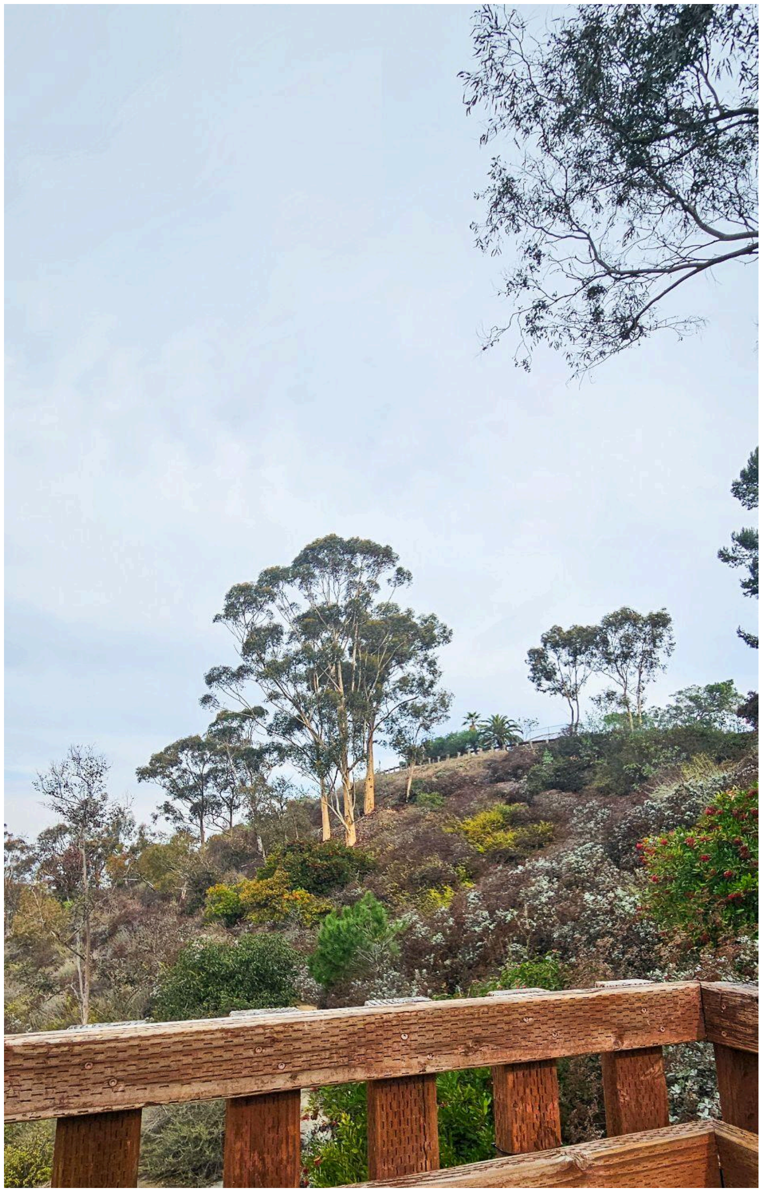


Figure 19. Culver City Park looking toward Baldwin Hills Scenic Overlook.

Whittier Narrows is a large park adjacent to a former extraction site in Montebello. Bird species such as the Canada goose (*Branta canadensis)* and small mammals such as squirrels were observed at this site.

Figure 20. Whittier Narrows Recreation Area looking towards the lake.

The Whittier Narrows Natural Area is a riparian woodland that features a lake. This site is home to plants and animals, and the lake provides a winter sanctuary for migrating waterfowl. Another characteristic of this site is its various trees offer cover. The Whittier Narrows Natural Area is located next to a major freeway. During the time of our survey, the weather for this area was overcast with clouds and slightly due to the rain the night before.

Type	Common name	Scientific name
Birds	Red-tailed hawk Canada geese Dark-eyed junco Barn swallows Anna's Hummingbird	Buteo jamaicensis Branta canadensis Junco hyemalis Hirundo rustica Calypte anna
Rodents	Squirrels	
Reptiles	Red-eared slider turtle Lizards	Trachemys scripta elegans
Arachnids	Spiders	Araneae
Pollinator	Western Honey Bee	Apis mellifera Linnaeus
Mushrooms	Mushrooms	basidiomycota
Trees	Eucalyptus Palm Tree	*Eucalyptus sp*
Grasses	Grasses	

Figure 21. List of species found in summer (August).

Comparison: Winter Urban Wildlife Observation

Along with air quality data, urban wildlife observations were again noted in winter (December) at La Brea Tar Pits, Pan Pacific Park, Whittier Narrows Recreational Area, Central Park at Playa Vista, Kenneth Hahn State Recreation Area, Inglewood Oil Field, Culver City Park, Baldwin Hills Scenic Overlook, and Downtown Culver City. Vegetation at the sites was very green. Note that a few days passed before we did winter observations, and LA received rain, which might have to do with the greenery these locations hold. The temperature was about 67 degrees, sunny with no winds but quite smoggy. La Brea Tar Pits had slight winds and was cloudy with slight sunshine. Meanwhile, at Pan Pacific Park, it was sunny and windy.

Figure 22. Pan Pacific Park, located in the Fairfax District and Anna's Hummingbird (Calypte anna).

Figure 23. Whittier Narrows Recreation Area featuring the domestic goose(Anser anser), and American Coot (Fulica americana).

During our field observations for Playa Vista, data was collected on the same date as the Whittier Narrows Recreation Area, just two days after December 24, 2023. Playa Vista exhibited a lush abundance of greenery compared to Whittier Narrows. The temperature for this site was 67 degrees, but it felt much colder due to the number of trees compared to the Whittier Narrows Recreation Area. It is essential to note the day here since in some locations of LA, on December 24, fireworks are used for celebration.

Figure 24. Double-crested cormorant Phalacrocorax auritus and Anna's hummingbird Calypte anna at Playa vista.

Urban wildlife observations for Inglewood Oil Field, Culver City Park, Baldwin Hills Scenic Overlook, and downtown Culver City were recorded on the same day. It was sunny, slightly cold, and with a high of 66 degrees.

Figure 25. Culver City Park

Inglewood Oil Field, Culver City Park, Baldwin Hills Scenic Overlook, and downtown Culver City were very diverse in terms of the flora and fauna of the area. Species seen here were red-tailed hawk (*Buteo jamaicensis), squirrels,* eucalyptus (*Eucalyptus sp.*), palm trees, and other bushes. These sites were also very green due to recent rain in December.

Figure 26. Baldwin Hills Scenic Overlook and California brittlebush (Encelia californica)

Lastly, in December, at Kenneth Hahn State Recreation Area, we observed birds, such as Canada geese *(Branta canadensis*), flying from the Inglewood Oil Field to Kenneth Hahn State Recreation Area. Canada geese would rest in the grass field, about 100 feet from an Inglewood oil field.

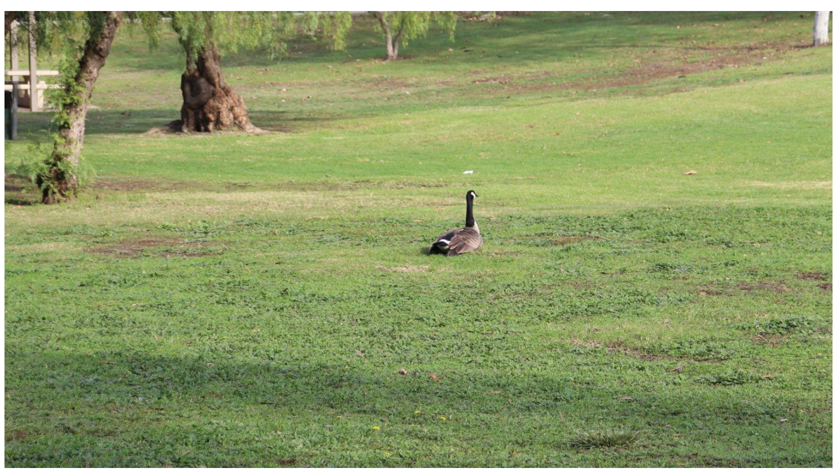


Figure 27. Canada goose (Branta canadensis) sits in the grass area.

Recommendations

1. General Recommendations
    a. Goals and Objectives
    b. Contaminants of Concern
2. Sustainable Recommendations
    a. Introduction
    b. Comprehensive Site Assessment
    c. Soil Remediation
        i. Bioremediation
            1. Phytoremediation
            2. Mycoremediation
            3. Fungal Remediation
        ii. Soil Amendments: Biosolids
        iii. Capping
    d. Urban Biodiversity
        i. Environmental Education
        ii. Urban Agriculture
        iii. Habitat Corridors
        iv. Road Diets
        v. Land Management and Habitat Restoration
    e. Energy Suitability
        i. Geothermal
        ii. Solar

General Recommendations

Goals and Objectives

The site visit to Culver City played an instrumental role in understanding the context and history of the Inglewood Oil Field and the impact it has had on the surrounding communities. The main objective for the site visit was to gain key perspectives into what recommendations would be most effective on the newly remediated site. The recommendations are also guided by the principles outlined by our client, which focus on transitioning the site into a net-zero, mixed use community. The redeveloped site will focus on harnessing long-term sustainability, and our recommendations are a reflection of that idea. The most effective way to measure long term sustainability is by creating a circular system on the site. Circular systems follow the ideology that waste is regenerated and nature and biodiversity are prioritized. The main goal of a circular system is to have communities work in harmony with nature and to reduce the overall strain on finite resources ("What Is a Circular Economy?"). We hope that these recommendations that revolve around circularity become a major theme in the remediation and redevelopment of the Inglewood Oil Field in years to come.

At the oil field, we were able to gain insight on the current condition of the site, which is still extracting oil on a daily basis. It is also apparent that the land is rundown and barren from the decades of extraction and contamination that took place on the site. Although the current condition of the site is dire, there was still a wide range of biodiversity that was observed in and around the oil field itself. This insight influenced the recommendation to conserve and protect the flora and fauna that are present in this region in order to restore biodiversity in this urban setting. To protect urban species going forward, the recommendation to incorporate habitat corridors and to regenerate the soil through bioremediation are highlighted. Additionally, a large aspect of the site visit was engaging with the local community to gain a better understanding of the knowledge of the oil field and the impacts it has on public health and the environment. A majority of the community responses emphasized a need for naturalization and greater accessibility to green space. After hearing these insights, the recommendations to preserve patches of habitat and incorporating urban agriculture on the site were created. Habitat restoration and urban agriculture support the idea of creating a circular system on the site as nature is preserved and food is cultivated and shared locally rather than importing produce from rural communities. Lastly, our recommendation to implement solar and geothermal energy is intertwined with circularity as the community will be energy resilient and source from renewable sources rather than fossil fuel extraction. These recommendations can serve as foundational steps towards effectively transitioning an urban oil field into a mixed-use community, potentially setting a precedent for future projects throughout the region.

Contaminants of Concern

As Inglewood Oil Field is redeveloped into a sustainable community there will be many legacy effects of its industrial past. One of these effects is potential contamination of media such as air, soil and water from hydrocarbon extraction. Oil pollutants can persist for long periods of time in terrestrial and aquatic environments as they adsorb to soil particles and degradation rates vary due to environmental conditions. Potential sources of these pollutants are wastewater, spills and leaks from pipelines and storage tanks, and drilling mud. The main pollutants in sediments resulting from oil and gas production are heavy metals, salts, naturally occurring radioactive materials (NORMs), oil and grease (O&G), benzene, toluene, ethylbenzene and xylene (BTEX), total petroleum hydrocarbon (TPH), and polycyclic aromatic hydrocarbon (PAHs) (Atoufi and Lambert, 43). If these pollutants are not removed from the environment there can be long term effects on human and environmental health. Contaminated soil is a major concern as humans can be exposed through direct ingestion, crops, dermal contact, indoor and outdoor inhalation of soil particulates, and/or migration to groundwater, with field workers and nearby communities at highest risk for exposure (Johnston et al., 195). Long term exposure to pollutants like benzene, are associated with detrimental health effects such as leukemia and anemia (CDC). Further, long term exposure to PAHs and heavy metals can cause kidney and liver damage (IDPH, *Polycyclic Aromatic Hydrocarbon (PAHs)*); (Balali-Mood et al.).

Pollutants associated with the oil field can also impact the hydrological resources such as surface water. Although there are no permanent streams or intermittent streams within the oil field, pollutants from the field can impact the larger watershed (Marine Research Specialists, 4.6-1). Surface runoff from the field is funneled into six retention basins; these basins discharge into storm drain basins and eventually into either Centinela Creek or Ballona Creek (Figure 25) (Figure 26) (Marine Research Specialists, 4.6-1). Ballona Creek is considered impaired under the Clean Water Act due to elevated concentrations of bacteria, cadmium, chlordane, copper, lead, silver, DDT, PAHs, polychlorinated biphenyls (PCBs), and zinc; these pollutants come from a variety of point and nonpoint sources (Marine Research Specialists, 4.6-6). Further, oil extraction has been shown to impact surface water by increasing chloride concentrations, salinity, and concentrations of pollutants such as TPHs, PAHs, and metals (Johnston et al., 195). These are concerns as changes in salinity can impact aquatic life and increased concentrations of pollutants like heavy metals can biomagnify through the food chain and bioaccumulate over time. Exposure to polluted water and contaminated riverine sediment also poses similar human health concerns as contaminated soil in terrestrial environments.

Contamination of media like soil, air, and water are important to consider as it could potentially limit future land use. For example, if the goal of restoration is to revegetate an area, that could be hindered by pollutants; the presence of oil pollutants in soil has been found to decrease disease resistance and stunt the growth of plants (Vu and Mulligan, 1917). Remediation of pollutants is essential to ensure that Inglewood is successfully redeveloped.

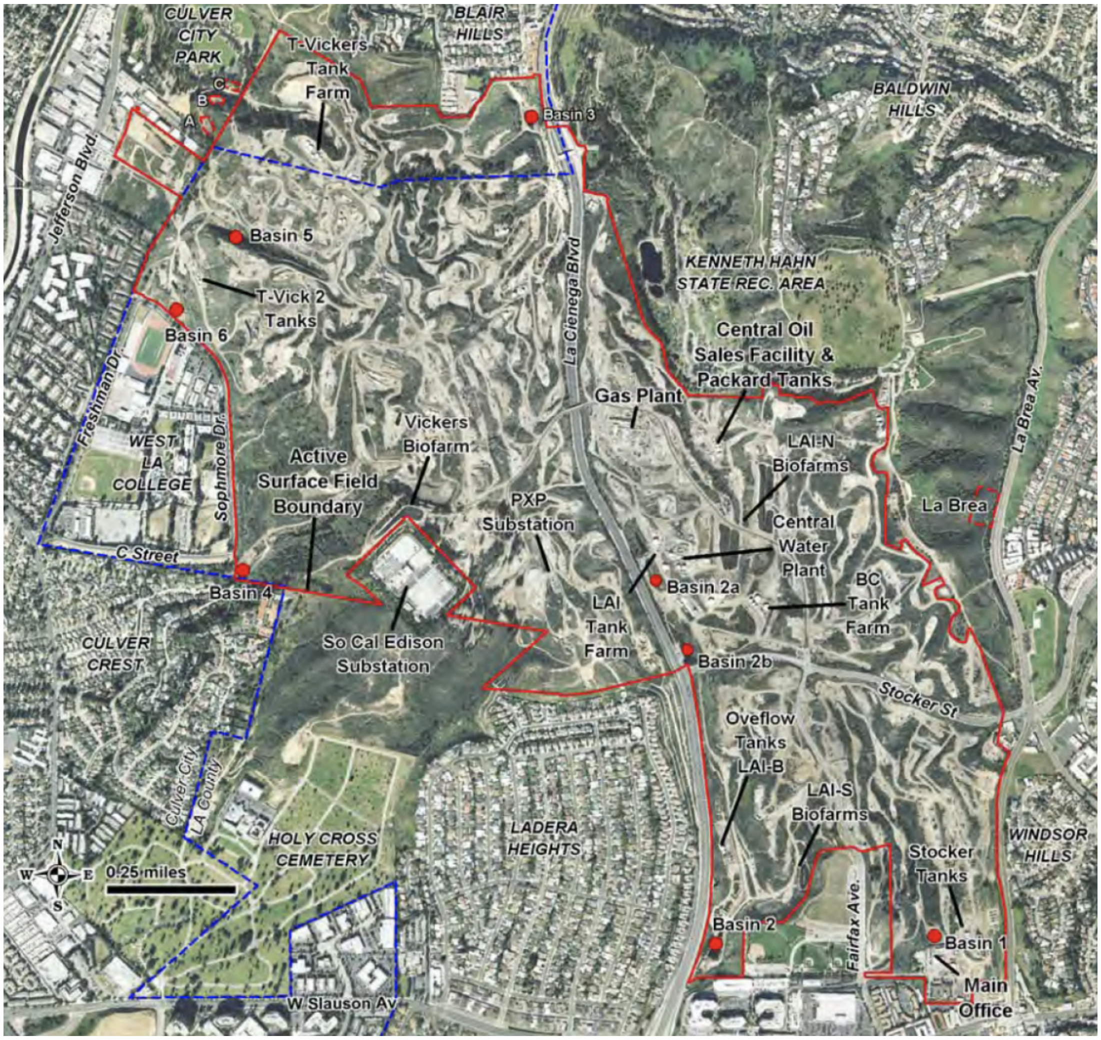


Figure 28. Location of Facilities within the Inglewood Oil Field. Source: MRS

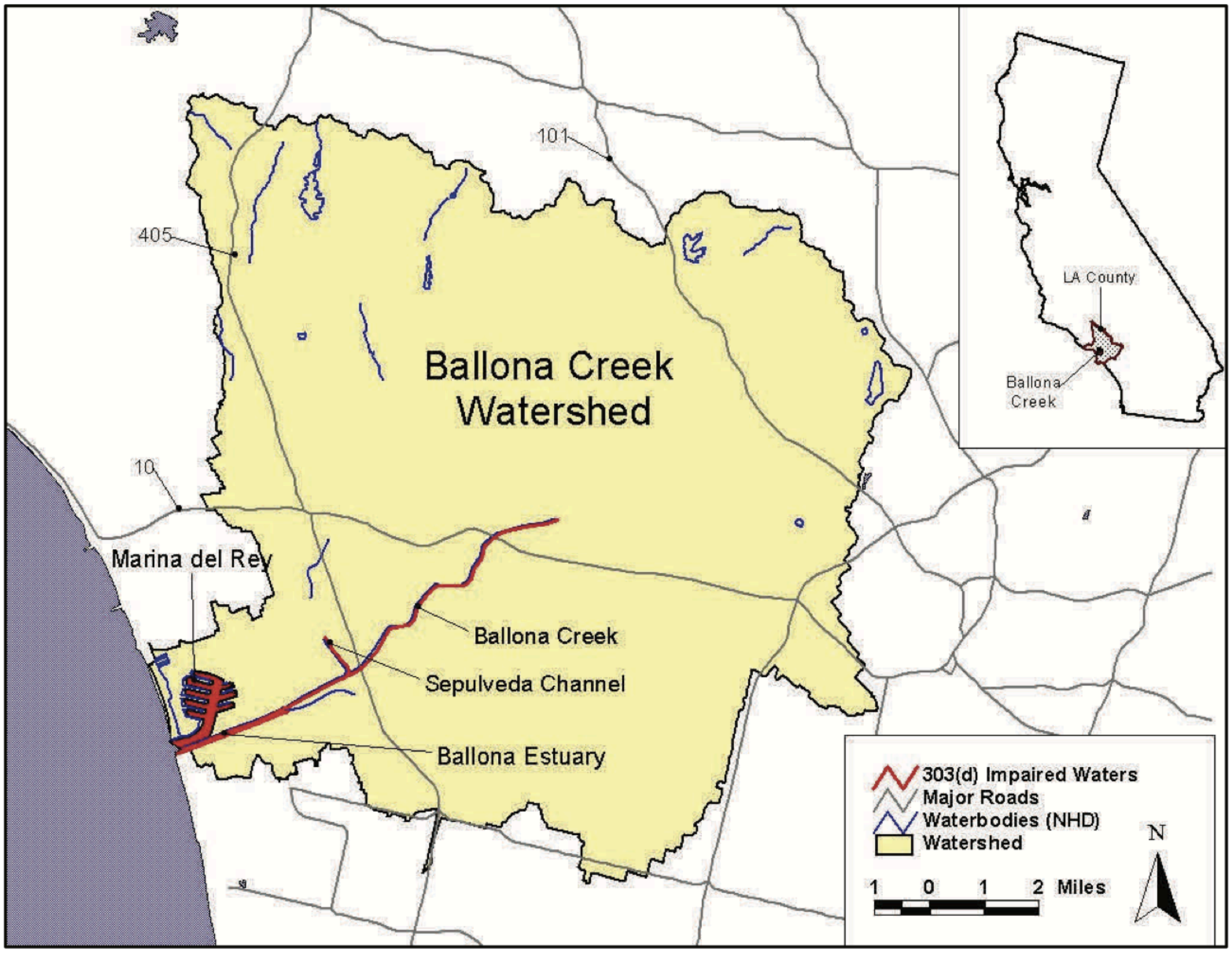


Figure 29. Ballona Creek Watershed Source. Source: California Water Boards

Sustainable recommendations

Introduction

As urban oil fields are decommissioned in the coming years, it becomes imperative to propose sustainable strategies beyond ceasing operations. Our recommendations emphasize forward-thinking approaches capable of remediating the contaminated soil due to the oil field. The focus is pioneering an eco-friendly and sustainable framework for restoring the Inglewood Oil Field.

In doing so, we recognize the critical importance of inclusivity. Our proposal integrates a comprehensive approach that actively includes and respects the perspectives of the indigenous communities and the diverse population in Inglewood. This involves fostering open dialogue, establishing partnerships, and incorporating cultural considerations into restoration. By intertwining sustainability with a commitment to inclusivity, we aspire to create a model for environmental restoration that addresses ecological concerns and uplifts and honors the unique heritage and diversity of the Inglewood community. Aligns with a vision that prioritizes environmental integrity and community well-being toward a cleaner and more equitable future.

Comprehensive Site Assessment

To begin, we recommend conducting a comprehensive site assessment to transform Inglewood Oil Field, forming a foundation for holistic development. This assessment serves various purposes, including evaluating environmental impacts to address contamination risks and ensure compliance with regulations. It also ensures adherence to regulatory requirements at different levels while prioritizing public health and safety. As part of this assessment, it is crucial to analyze the oil field site thoroughly, identifying the extent of contamination and types of pollutants present. The involvement of the Environmental Protection Agency (EPA) in establishing soil screening levels (SSLs) aids in the assessment and cleanup process, especially for properties intended for future residential land use or Superfund sites (Supplemental Guidance 2002). Furthermore, it is imperative to conduct an ecological assessment to evaluate potential risks to biodiversity (Supplemental Guidance 2002), wildlife Eco-SSLs (specifically the toxicity reference values). The general approach includes four steps: (1) conduct literature searches, (2) screen identified literature with exclusion and acceptability criteria, (3) extract, evaluate, and score test results for applicability in deriving an Eco-SSL, and (4) derive the value (Supplemental Guidance 2002). This comprehensive evaluation should consider factors such as soil composition, groundwater quality, and the challenges associated with oil field activities, ensuring a well-informed and responsible strategy.

Soil Remediation

The below outline shows possible recommendations that could be integral to the remediation process, offering viable strategies for addressing contamination at the Inglewood Oil Field. Moving on to the first remediation technique, let's delve into bioremediation, which utilizes plants and microorganisms to remove contaminants from the environment.

Bioremediation

Bioremediation, which includes the use of plants and microorganisms to remove contaminants from the environment, has received considerable attention as the most promising method for oil spill cleanup. Common forms of bioremediation include phytoremediation, which uses plants, and mycoremediation, which uses fungi. Phytoremediation requires selecting appropriate plant species like hyperaccumulator plants that can absorb and accumulate contaminants from the soil.

Certain mushrooms, such as oyster mushrooms, can be used for mycoremediation by breaking down hydrocarbons present in oil. Additionally, combining phytoremediation and mycoremediation can be beneficial; introducing mycorrhizal fungi to the soil enhances the symbiotic relationship between fungi and plant roots, improving the plant's ability to absorb nutrients and contaminants. This integrated approach considers plants' phytoremediation potential and incorporates the beneficial role of mycorrhizal fungi. By combining these strategies, this remediation technique aims to optimize contaminant removal, promote biodiversity, stabilize the soil, and contribute to the long-term sustainability of the Inglewood Oil Field.

Implementing bioremediation as a remediation technique requires creating a sustainable framework that evaluates effectiveness, ecological health, and long-term sustainability; planting and monitoring are crucial elements of this process. The process begins with assessing factors such as sunlight, soil type, and water availability and strategically selecting appropriate hyperaccumulator plants. Subsequently, there should be a focus on regular monitoring that acts as a proactive way to evaluate the health, growth, and efficiency of the planted vegetation in absorbing contaminants. This holistic approach guarantees ongoing assessment and understanding of the success of the remediation efforts and contributes to the overall environmental resilience of the Inglewood Oil Field.

Now, let's move on to explore phytoremediation, a technique employing plants to extract contaminants from the soil.

Phytoremediation

Phytoremediation, a remediation technique that employs plants, involves the uptake of contaminants by plant roots for stabilization, volatilization, or degradation (Pilon-Smits, 2005; Prasad and Singh, 2011; Ali et al., 2013). Each plant species typically targets specific types of contaminants, making it a versatile method for addressing soil pollution. However, phytoremediation may have a more extended timeframe for effectiveness, often taking several years to achieve desired results. Additionally, it is essential to note that most plant roots are sensitive to high oil concentrations and may struggle to penetrate deep soils, which could pose limitations in oil field remediation efforts (Alkorta et al., 2004; Yoon et al., 2006; Doty, 2008; Wu et al., 2010; Singh and Singh, 2017) (Michael-Igolima et al. 2022).

Transitioning from phytoremediation, let's focus on a specific plant species that demonstrates remarkable efficacy in cleansing contaminated environments: sunflowers.

Sunflowers

Sunflowers emerge as promising candidates for their efficacy in phytoremediation, an innovative and environmentally friendly technology designed to cleanse contaminated environments (Kaonda and Chileshe 482). Particularly adept at remediating soil tainted with heavy metals, sunflowers can absorb contaminants through their roots and store them in their tissues. Studies show that sunflowers demonstrated substantial removal efficiency, with iron removal reaching 53.7% in mine tailings after weeks of exposure (Kaonda and Chileshe 489). The remediation process involves harvesting sunflowers once they have absorbed a significant amount of contaminants and emphasizing the subsequent need for proper disposal or further treatment of the harvested biomass to ensure the effectiveness and sustainability of the overall phytoremediation strategy.

As we consider different plant species for phytoremediation, the efficacy of sunflowers and poplar trees becomes evident in their ability to absorb and metabolize various pollutant(s).

Poplar Trees

Another plant that could be used for phytoremediation are poplar trees. Laboratory studies of poplar trees have shown that they are effective at metabolizing volatile hydrocarbons and other pollutants. Volatile hydrocarbons are a known pollutant in oil spills, pipeline leaks, and improper disposal of oil field waste; they are also associated with human health effects like cancer and neurological issues (Doty et al., 16816). Doty et al. found that transgenic poplars, (*Populus tremula X Populus alba*), were able to remove and metabolize significant amounts of trichloroethylene (TCE), vinyl chloride, carbon tetrachloride, benzene, and chloroform from the air and hydroponic solutions (16816). The transgenic poplars have an overexpression of an enzyme, cytochrome P450 2E1, used in the metabolism of halogenated compounds like hydrocarbons (Doty et al., 16816). The removal of benzene is of particular interest as benzene is commonly associated with petroleum pollution. Field studies of the same transgenic poplars found that they removed more TCE from soil compared to wild type poplars (Legault et al., 6090). Ideally, poplars could be used in conjunction with other plants, like sunflowers for phytoremediation, and other remediation methods like mycoremediation and adding soil amendments.

Shifting our focus to mycoremediation, we explore how mushrooms can serve as critical agents in rehabilitating contaminated ecosystems.

Mycoremediation

Mycoremediation utilizes mushrooms as critical agents to harness the power of fungi in rehabilitating contaminated ecosystems (Medina-Bellver et al., 2005). This method involves introducing mushroom mycelium into the soil and breaking down hydrocarbons and organic pollutants through diverse metabolic capabilities. Success in mycoremediation is contingent on large-scale mushroom availability and environmental conditions conducive to mycelial growth (Medina-Bellver et al., 2005). Furthermore, monitoring mushroom growth and its effectiveness in degrading contaminants are integral to the process.

Furthermore, fungal remediation offers an emerging approach that leverages specific species of fungi to degrade contaminants.

Fungal remediation

Fungal remediation, an emerging approach, involves leveraging specific species of fungi to degrade contaminants (Houlihan Turner 9). Unlike phytoremediation and mycoremediation, fungal remediation primarily relies on fungi rather than plants or mushrooms. This technique is still in the developmental phase and is not yet commercially available. However, it holds promise in environmental remediation efforts, particularly in degrading contaminants. Fungi are a group of spore-producing organisms feeding on organic matter, including molds, yeast, mushrooms, and toadstools.

Concluding our discussion, compost remediation emerges as a cost-effective method, although it may not fully eliminate contaminants from the environment.

Compost remediation

Another method, compost remediation, involves adding compost to the soil (Houlihan Turner 9). While this process is cost-effective and can be swiftly implemented, it is essential to note that compost remediation may not eliminate contaminants. Instead, it focuses on containing them within the soil. Therefore, it may not qualify as an accurate remediation technique in the same sense as other methods. Both fungal and compost remediation show potential in environmental cleanup efforts. However, ongoing research and carefully considering their limitations are necessary for effective and responsible deployment in practical applications..

Transitioning from compost remediation to soil amendments, another method to address soil degradation is through the application of biosolids, which can significantly improve soil fertility and physical properties while also addressing contamination issues.

Soil Amendments: Biosolids

In addition to phytoremediation and mycoremediation, another method to address the degradation of surficial soils on the site is to introduce soil amendments. A soil amendment is any material added to a soil to improve its physical properties, such as water retention, permeability, water infiltration, drainage, aeration, and structure (Davis and Whiting). Soils on site are of the Ramona-Placentia association and consist of a mix of loam, and sandy loam, and artificial fill (MRS, 4.5-17). Artificial fill is from on site deposits and is used to grade the site for roads, building pads, and oil drilling pads (MRS, 4.5-17). There are currently several treatment and bioremediation sites within the field to address soil contamination with hydrocarbons, heavy metals, and other contaminants (MRS, 2-30).

One common soil amendment used is biosolids. Biosolids are the products of the municipal wastewater treatment process. During wastewater treatment, solids are separated from liquids; these solids are chemically and physically treated to produce a nutrient-rich semisolid material (EPA, “Basic Information about Biosolids”). Biosolids are often used in agriculture and land reclamation, particularly former mining sites, to increase the soil's ability to support vegetation. Adding biosolids can increase soil fertility, correct soil pH, better physical soil properties, and bind to trace metals (Brown and Henry, 7). Biosolids increase soil fertility by adding nutrients like nitrogen and phosphorus. Addressing nutrient deficiencies is an important step in restoring sites, as degraded and contaminated sites often have poor soil quality; for example, sites with mine tailings or metal contaminated soils often have phosphorus deficiencies and nutrient imbalances (Brown and Henry, 7). Petroleum contamination of soil is associated with a decrease in soil pH. Soil acidification occurs when hydrocarbons in crude oil react with salts and minerals in the soil; alkaline minerals become acidic (Devatha et al., 89). Incorporating biosolids into the soil can correct soil pH and decrease acidity as lime is sometimes added during the biosolid treatment process (Brown and Henry, 7). Further, biosolids can better physical soil properties. This is important for restoration practices, such as revegetation, as soils with properties like poor water holding capacity or poor water infiltration can lead to drought conditions. Biosolids address this by increasing the amount of organic matter in the soil; organic matter helps to form stable soil aggregates, which increase water infiltration and percolation (Brown and Henry, 7). Finally, adding biosolids can bind to trace metals in the soil. Heavy metals are a known component of crude oil and previous site assessments of Inglewood have found low levels of heavy metals in the soil (MRS, 4.1-39). In addition to being a human health concern, heavy metals can also inhibit plant growth. Adding biosolids addresses this as adding biosolids or biosolid compost can reduce plant uptake and bioavailability of zinc, lead, and cadmium (Brown and Henry, 8). Overall, using biosolids, or other soil amendments can greatly improve physical soil properties while addressing degradation issues.

Transitioning to the discussion of capping, this remediation technique involves covering contaminated materials to isolate them from the environment, thus reducing risks associated with exposure to contaminants.

Capping

Capping is a common practice used in landfills and the remediation of Superfund sites. Capping involves placing a cover over contaminated material such as landfill waste or contaminated soil (EPA, "Capping"). Capping does not remove contaminants from the environment but isolates them so they can't move through the environment; this reduces risk for humans and wildlife by reducing the chance of coming into contact with contaminants. Placing a cap over contaminated soil can contain pollutants and prevent them from contaminating water resources such as groundwater, and surface water like lakes and streams. Capping stops rain and snowmelt from seeping through the material and carrying contaminants into groundwater and keeps storm water runoff from carrying contaminated material offsite into lakes and streams (EPA, "Capping"). Capping also contains the contaminated material onsite by preventing wind erosion and reduces the risk of humans and wildlife tracking material offsite (EPA, "Capping").

Further, capping also protects air quality by controlling the release of volatile chemicals from waste (EPA, "Capping").

Depending on site conditions like size, climatic conditions like rainfall, contaminants present, and intended future use there are many different types of caps that could be used. Single-layer caps or multilayer systems can be used, with many choices of the capping materials including clay, concrete, asphalt, and high-density polyethylene (L. Liu et al., 209). Asphalt or concrete is used for parking lots or building slabs. Geomembranes are a sheet of plastic-like material, often high-density polyethylene, used to prevent downward drainage of water and upward escape of gases (EPA, "Capping"). Additional layers like a drainage layer, clay layer and vegetation may also be added. Drainage layers are composed of sand and gravel with slotted pipes that drain water that permeates the top layers away from the contaminated soil (EPA, "Capping"). Clay is applied in a compacted layer to prevent downward drainage of water (EPA, "Capping"). A vegetation layer requires clean topsoil to be brought in but can be used for erosion control and improved aesthetics.

Capping can be a simple, rapid, and effective way to eliminate risks associated with soil contamination. However, despite capping being quick and relatively inexpensive, there are also drawbacks. For example, capping may limit future land use and capped soil loses its natural environmental functions like supporting plant growth (Liu et al., 208). Further, in highly contaminated soils, this method is only applicable to correcting small areas, or those less than 2000 m^2 (L. Liu et al., 209). Site conditions also play a significant role in a cap's long term success. Cap stability is influenced by the depth and seasonal fluctuation of the groundwater table at the site and the nearby hydrogeological features (e.g., ponds, runoff) and sliding risk must be considered if the cap is placed on sloping ground (L. Liu at al., 209). Further, in areas with high rates of subsidence and in regions prone to earthquakes, there should be extra attention paid to appropriately designing the foundation (FRTR). This is of special concern for the Inglewood Oil Field because of its location along the Newport-Inglewood Fault Zone; this fault zone is seismically active and part of the San Andreas Fault System (MRS, 4.4-6). The Inglewood Oil Field has also long been associated with subsidence in the Baldwin Hills; between 1934 to 1961 more than two feet of subsidence-related, horizontal earth movement had occurred near the southeast boundary of the field (MRS, ES-14). Subsidence is a concern because the large-scale earth cracking and movement associated with subsidence could disrupt the cap and release hazardous contaminants into the environment. However, the risk of subsidence has been mitigated in some areas due to fluid injection for secondary recovery and portions of the Baldwin Hills are actually uplifting at a rate of 5 to 9 millimeters per year (MRS, ES-14). Overall, capping may be an effective way to contain contaminants but site conditions should be thoroughly considered to ensure long term stability and success of the cap.

Moving beyond ecological considerations, environmental education becomes imperative for effectively communicating with the public about the decommissioning process of the Inglewood

Oil Field. This educational approach addresses misconceptions, encourages responsible behavior, and promotes environmental stewardship

Environmental Education

In pursuit of a sustainable transformation for the Inglewood Oil Field, additional recommendations extend beyond ecological considerations to encompass the holistic well-being of the community. Embracing urban biodiversity and introducing inclusive signage featuring multiple languages and QR codes as part of the design symbolizes a commitment to effective communication and cultural inclusivity. This tangible expression honors the area's diverse heritage and is an educational tool for community members to engage with and appreciate the region's rich biodiversity.

Figure 30. Images demonstrate an example of multilingual signage about the diverse species in the urban environment that could be included as part of the design in the future.

Environmental education is crucial for effectively communicating with the public about the decommissioning of the Inglewood Oil Field. It addresses misconceptions and concerns by providing accurate information, encouraging individuals to take responsibility for protecting natural resources, and raising awareness about environmental conservation and sustainable practices. By empowering individuals with knowledge and understanding, environmental education promotes transparency, builds consensus, and ensures the success of decommissioning efforts. Additionally, environmental education raises awareness about environmental conservation and sustainable practices. Through hands-on activities, field trips, and interactive learning experiences, community members can better appreciate the region's ecological diversity and the significance of preserving it for future generations. By showcasing the benefits of biodiversity conservation and ecosystem restoration, educational initiatives inspire individuals to become advocates for environmental protection and advocate for positive change within their communities.

Shifting focus to urban agriculture, this recommendation aims to integrate areas for naturalization within the remediated site, fostering community engagement and promoting sustainable food production.

Urban Agriculture

As Inglewood Oil Field is remediated and restored to ecological health, we recommend incorporating areas specifically designed for naturalization with easy access to green space, which was a predominant response from our community survey. One recommendation is to incorporate an area reserved for urban agriculture in the form of a community garden or a small scale urban agricultural plot. In addition to fostering a sense of community, urban agriculture has many benefits related to food security and cooling effects on the environment.

As Inglewood Oil Field has been primarily used as an extraction site for the past hundred years, there will most likely be contamination of the soil and groundwater beneath the site. In order to build an urban agricultural plot or community garden on the remediated site, we recommend using raised garden beds to harvest fresh produce. The EPA states that, “these gardening techniques are preferred because the clean soil and organic matter used to build the raised beds creates a physical barrier between the gardeners/plants and possible contamination in the ground soils” (*Reusing Potentially Contaminated Landscapes: Growing Gardens in Urban Soils*). It is also recommended to cover exposed walkways with mulch to reduce the chances of dust and other contaminants from splashing back onto the crops. Additionally, “plants that produce fruiting bodies (for example, tomatoes, squash, apple and pear trees, and berries) are most appropriate for growing in potentially contaminated soil,” whereas root vegetables are more prone to be exposed to contaminants in the soil (*Reusing Potentially Contaminated Landscapes: Growing Gardens in Urban Soils*). However, if raised garden beds are used, it will be possible to choose produce such as root and lettuce crops as the plants will be protected from the contaminated soil. Lastly, it is recommended to use organic matter in the garden as it can “ bind to contaminants so that they are no longer mobile or bioavailable” (*Reusing Potentially Contaminated Landscapes: Growing Gardens in Urban Soils*). Compost can improve soil health by adding nutrients back into the soil and increase fertility. It would be beneficial to establish a composting program on site to create a closed loop system that regenerates food waste and increases the soil quality to cultivate fresh produce for the community.

Furthermore, Los Angeles is one of the largest cities in the United States with access to fresh foods, grocery stores and restaurants. However, not everyone who lives in the city has access to these opportunities as LA is home to some of the largest food deserts in the country. "Food deserts are geographical areas in which residents lack access to affordable, healthy foods. For urban areas, a food desert means that the majority of the population lives over 1 mile away from an affordable grocery store" ("Homelessness & Food Deserts in Los Angeles"). Because there is a lack of accessibility to fresh produce, many people in these marginalized communities rely on fast food and convenience stores to feed themselves and their families. Creating a large-scale urban garden on the remediated Inglewood site has the potential to bridge the gap between food insecurity and the surrounding communities in Los Angeles. As the garden is established and the produce begins to be harvested, a portion of the goods can be donated to local food banks or disadvantaged communities who do not have access to fresh produce. Additionally, creating a hub of sustainable agriculture will decrease food miles in the area, which is the distance from production to consumption (McClintock, 1). For example, rather than fresh produce being transported over great distances to reach the city, the produce will be sourced locally on site, which will sequentially decrease the amount of fossil fuels released into the atmosphere from transportation emissions.

Urban agriculture also has the potential to build community and foster a sense of connection between the land and the people who are involved with the garden. Oftentimes, living in urban spaces not only limits access to green space and natural areas but also restricts connections with the people in your community. Many people today are not aware of where their food is sourced from and what resources go into producing the food they are consuming. As people choose to work or volunteer in the garden, the act of planting and harvesting produce can reengage people with the natural environment and with each other through community. In the publication, *Why Farm the City? Theorizing Urban Agriculture through a Lens of Metabolic Rift,* Nathan McClintock states, "various case studies in North America have illustrated how gardens are a site of interaction between various ages and ethnic groups, where knowledge about food production and preparation is shared and community ties strengthened. UA produces new commons, by returning—at least partially—the means of production to urban populations" (McClintock, 10). Restoring control of the means of production to the community not only contributes to the decommodification of food but also serves as an educational tool accessible to people of all ages, providing an opportunity to learn about sustainable agriculture in ways that may not have been possible before.

Additionally, there are studies that support the idea that urban agriculture can have a cooling effect in heavily urbanized areas. Most urban centers have a large amount of concrete and impermeable surface that absorbs and retains heat which can cause the occurrence of the urban heat island effect. As urbanization continues to rise, this phenomenon is only expected to increase in the future. "Green spaces and vegetation play a vital role in reducing surface temperatures through evapotranspiration, where plants release water to the surrounding air, dissipating ambient heat" ("How Concrete, Asphalt and Urban Heat Increase Misery of Heat

Waves"). There is potential with the remediated Inglewood site to incorporate vegetation that can alleviate temperatures and lessen the impacts that may occur with a warming environment. Incorporating an urban agricultural garden is just one method that can reintroduce a natural environment into the city landscape of LA. Urban agriculture can continue to strengthen the city habitat and cultivate a resilient environment for future generations.

Habitat Corridors and Land Management Strategies

Inglewood Oil Field is located within the Baldwin Hills; a series of hills along the Newport-Inglewood fault. The site's topography- which includes scarps, canyons, and gullies- and the soil have great influence on the habitats and plant communities present. The site contains a mix of native and non-native shrublands, woodlands, herbaceous plant communities, and small areas of wetlands. Shrublands include California sagebrush scrub and coyote brush scrub communities while a majority of the woodlands are naturalized eucalyptus stands with one interior live oak woodland in the south west near West Los Angeles College (Figure 27-a). Herbaceous plant communities are mainly weed-dominated by castor beans, mustards and other non-native species; however there is about an acre of native grassland with wild oat and purple needlegrass in the southern part of the field (Figure 27-b). This area may be a remnant of grasslands that were likely historically found on the southern faces of the Baldwin Hills. These native perennial grasslands likely supported species such as bunchgrasses and annual wildflowers such as poppies and lupines (*Native Shrublands*). Most of the wetlands and riparian areas on the site are associated with man-made or altered, streams, drainage channels, and retention basins but support species such as Arroyo willow (*Salix lasiolepis*), narrow-leaf willow (*Salix exigua*), mulefat (*Baccharis salicifolia*), cottonwoods, and sycamores (MRS, 4.5-11). The willow dominated areas are of special concern as they are classified as southern willow scrub; this is considered a high priority community by the California Natural Diversity DataBase (MRS, 4.5-11).

The Baldwin Hills are ecologically rich and support a wide variety of species. However, many species found in the Baldwin Hills are generalists and have adapted to fragmentation and other effects associated with urbanization. For example, common species in the area are reptiles like western fence lizard (*Sceloporus occidentalis*) and side-blotched lizard (*Uta stansburiana*) and mammals like the pocket gopher (*Thomomys bottae*), gray fox (*Urocyon cinereoargenteus*), and raccoon (*Procyon lotor*) (CCI, 28). There is also a large number of bird species present in the Baldwin Hills. These species range from smaller species like the spotted towhee (*Pipilo maculatus*) and California quail (*Callipepla californica*) to larger raptors like the peregrine falcon (*Falco peregrinus*) and American kestrel (*Falco sparverius*) (CCI, 27).

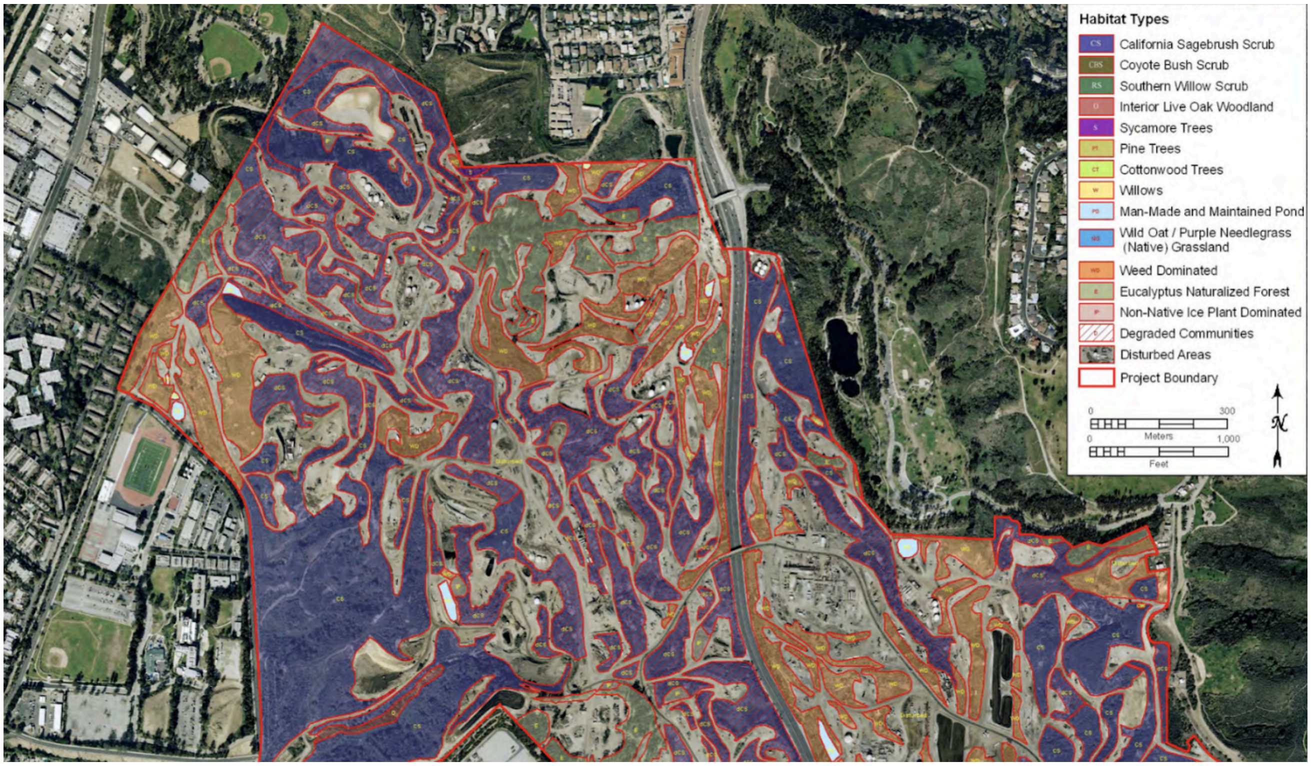


Figure 31-a. Plant Communities of the Inglewood Oil Field Area. Source: MRS

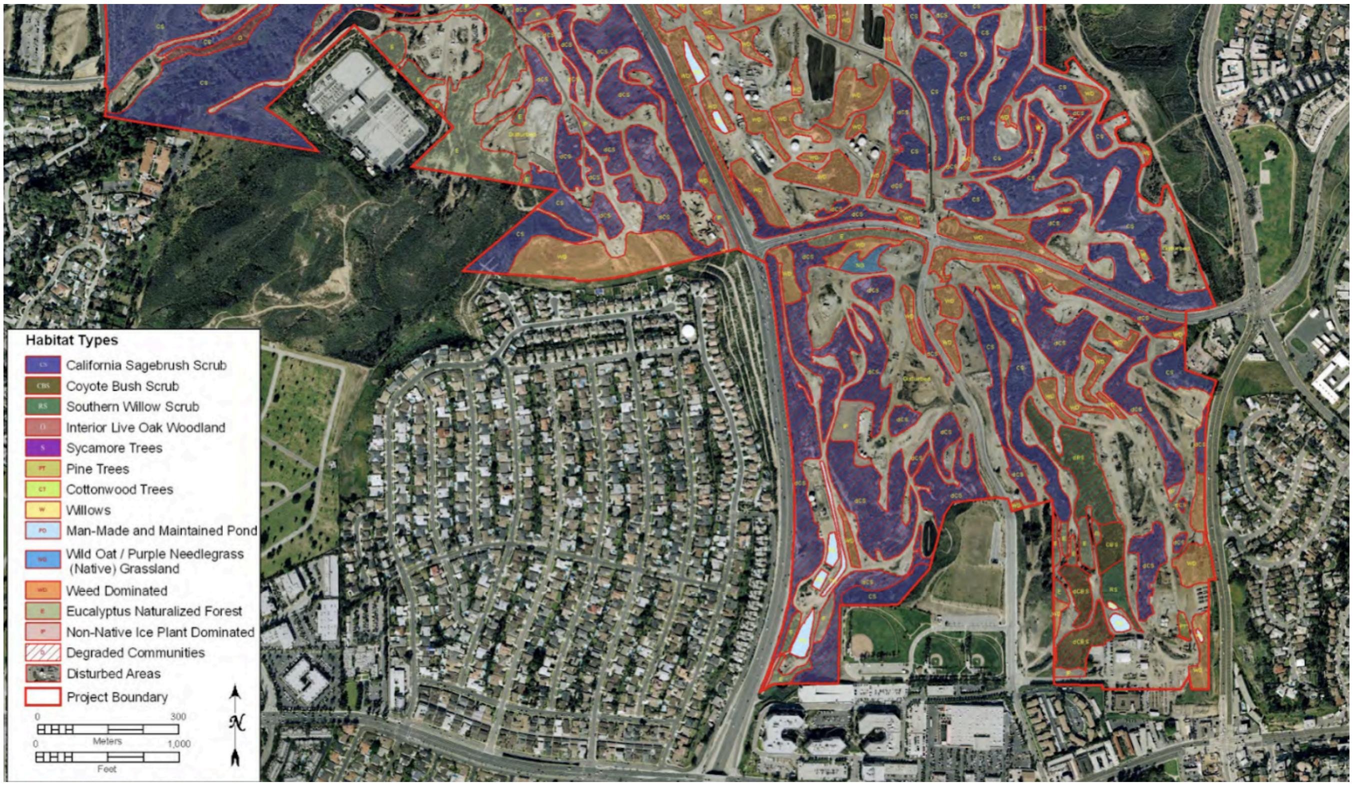


Figure 31-b. Plant Communities of the Inglewood Oil Field Area. Source: MRS

The oil field is connected to habitats such as the Ballona Wetlands through the Ballona Creek Channel and is adjacent to natural areas such as Baldwin Hills Scenic Overlook and Kenneth Hahn State Recreation Area (MRS, 4.5-15). However, despite its proximity and connection to natural areas, a majority of the habitat within the oil field is disturbed and fragmented due to industrial activity. Two ways to address fragmentation and increase habitat quality within the site are to protect any current intact habitat and to create habitat corridors within the field and to the surrounding natural areas. When preserving intact habitat, special attention should be given to maintaining areas that support native plant diversity. For example, the interior live oak stand in the west, the remnant patch of native grassland in the south, and the willow-dominated areas classified as southern willow scrub should remain intact and be assessed for management practices such as invasive species control.

Habitat Corridors

Habitat corridors, or wildlife corridors, are connections across the landscape that link habitat patches together. It is important to maintain or create habitat corridors in redevelopment because they increase connectivity. Habitat connectivity refers to how and to what degree distinct patches of habitat are connected (NOAA). Habitat corridors increase connectivity by facilitating dispersal and migration. This allows for increased genetic diversity and gene flow which can allow species to recolonize areas and aid in ecosystem recovery (Hilty et al., 21). Further, habitat corridors can help maintain ecosystem services that benefit human populations such as nutrient cycling, pollination, and seed dispersal (Hilty et al., 21.) There are several areas of intact habitat within the field that could be connected through habitat corridors; in the southwest adjacent to West LA College, in the north adjacent to Culver City Park, and in the east near Kenneth Hahn State Recreation Area (Figure 28). These areas could be connected to each other within the field and to the adjacent natural areas; Baldwin Hills Scenic Overlook and Kenneth Hahn State Recreation Area.

Creating habitat corridors is a complex process that requires balancing ecological concerns with the needs of multiple stakeholders at the landscape scale. The International Union for Conservation of Nature (IUNC) provides a series of guidelines for creating habitat corridors and conserving connectivity. These guidelines emphasize the importance of having clear objectives, strong delineation of boundaries, and understanding social and economic values. Establishing clear objectives are essential in creating habitat corridors; the objectives of a corridor influence how connectivity is achieved and its governance and management. There are many objectives for a habitat corridor that can increase connectivity: movement of individuals, genetic exchange, migration, multi-generational movement, maintenance/restoration processes, climate change adaptation, enhancement of recovery, and prevention of undesired flows like erosion or fire (Hilty et al., 25). Whatever objective is chosen, it should be clear and achievable to ensure effective management in the future. Strong delineation of boundaries is required in creating habitat corridors as strong boundaries differentiate the corridor from the surrounding land and indicate what is allowed or prohibited within them (Hilty et al., 24). Delineation of boundaries also requires effective governance and cooperation across stakeholders. If a corridor spans multiple jurisdictions, management actions should be coordinated and agreed boundaries should be demarcated by all entities governing and managing it (Hilty et al., 27). Finally, social and economic values should be understood and considered when creating habitat corridors. Habitat corridors not only provide ecological benefits; they can be used for outdoor recreation like walking trails, act as a source of pollinators in agricultural areas, and help define a community's sense of place (Hilty et al., 27). Incorporating social and economic values can gather or maintain support for corridors within the community.

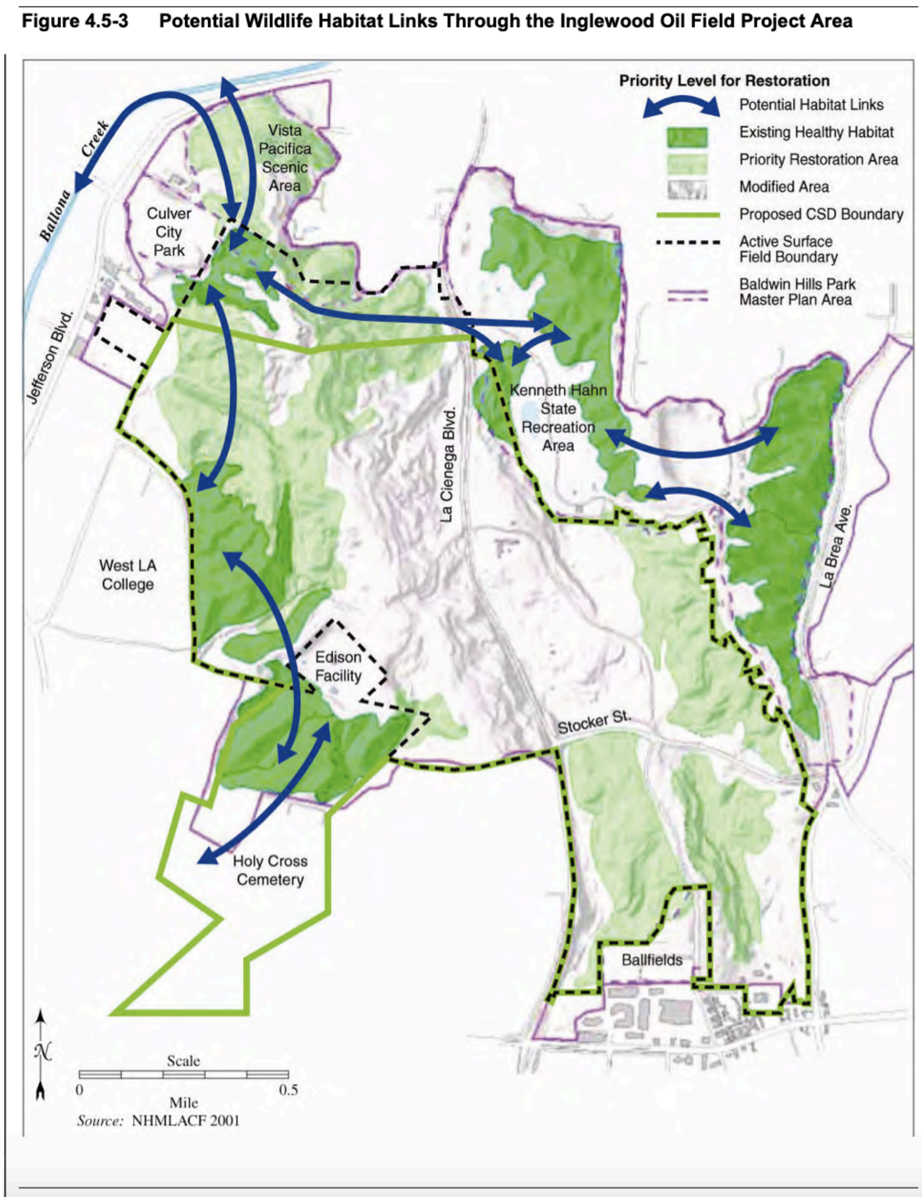


Figure 32. Potential Habitat Corridors in the Inglewood Oil Field. Source: MRS

Land Management and Habitat Restoration

There are also several areas within Inglewood Oil Field that could benefit from implementing habitat restoration and land management strategies; in the southeast on both sides of Stocker Street near the ballfields and in the northwest in between the areas of intact habitat near the college and park (Figure 28). These areas are important to maintain not only as potential habitat corridors but also for potential use by the community as natural areas for outdoor recreation. One major restoration and management strategy in these areas could be to manage invasive species. A significant portion of the plant communities in the field have invasive species and some areas are dominated by them. Managing invasive species is important as invasives increase competition for resources and can push out native species. There should be emphasis on managing species such as giant reed (*Arundo donax*), iceplant (*Carpobrotus edulis*), and pampas grass (*Cortaderia selloana*) that have a High rating by the California Invasive Plant Council. Species under this rating have severe ecological impacts on physical processes, plant and animal communities, and vegetation structure (Cal-IPC). These plants have attributes, such as their reproductive biology, that allow for high rates of dispersal and establishment (Cal-IPC). In addition to managing invasive species, areas within the field could also benefit from habitat restoration to restore ecological processes and increase biodiversity. Habitat restoration often includes planting with the hope of reestablishing native plant communities. One area that should be a focus of this type of restoration practice is the remnant native grassland in the south; this area could become part of a larger restored native perennial grassland. Native plants and communities are important in habitat restoration because they provide valuable resources and structure to the ecosystem. For example, there are specific associations of mycorrhizae with plants, invertebrates with woody debris, pollinators with flowers, and birds with structural habitat that can only be rebuilt by planting native plants (Dorner, 5). Further, compared to non-native varieties, native species require less maintenance as they are better adapted to resist damage from freezing, drought, common diseases, and herbivores (Dorner, 5). Restoring native plant communities can help reverse the biodiversity crisis while reducing the need for maintenance.

The Plant Conservation Alliance provides a framework for using native plants in restoration projects. The guide emphasizes choosing appropriate species for the site, identifying a reference community and the importance of genetics. The first step in native plant restoration is to establish clear goals and objectives with measurable criteria. This ensures good decision making in the planning process and helps define a monitoring plan to quantitatively evaluate the long-term success of the project (Dorner, 8). For example, if the goal is to increase available wildlife habitat, the objective should be to plant native plants that can provide food for local wildlife; a measurable criteria for this is to establish greater than 50% cover of native plant species that provide food for wildlife (Dorner, 8). Choosing appropriate species depends on site conditions like water, light, and nutrient availability, and understanding plant communities. Environmental conditions at the site influence what plants will be successful; understanding this ensures long term survival and establishment of plant species. Choosing appropriate species also requires understanding plant communities and relationships between plant species. Plants found together in communities may have symbiotic relationships and some species may also be dependent on the presence of certain other species (Dorner, 8). Further, choosing appropriate species is also important if the site is to go through several successional stages. Depending on the final community desired on site, it may not be the one that is initially planted; certain species may only be introduced after other species or environmental conditions have become established (Dorner, 18). Identifying a reference community is another way to identify appropriate species. Reference communities are located in environmental conditions similar to the restoration site and provide an idea about what plant species could be used for restoration. Finally, genetics are important to consider to ensure the long term success of a restoration project. Genetic variation within a species influences survival and growth. Ecotypes are a certain population of plants within a species that, due to different genetics, have a different form (height, leaf size, etc.), flowering time, resistance to diseases/pests or hardiness that is adapted to certain local environmental conditions (Dorner, 19). Individuals within an ecotype have a greater chance of survival in certain places or habitats because they have adapted to specific environmental conditions. Therefore it is important to source plants locally or stay within the ecotype, or more generally the ecoregion, to ensure plants are adapted to similar environmental conditions (Dorner, 20).

Road Diets

In regards to a design aspect recommendation for the remediated site, we believe the idea of implementing “road diets” will be beneficial for the community in addition to facilitating traffic. The idea of a road diet stems from John Gallagher’s book, *Reimagining Detroit*. Gallagher argues that many of the main roads and expressways that were constructed post World War II slash through major cities, rather than connecting them. He goes on to state that many roads are simply too wide and cuts off access for pedestrians and bikers to maneuver safely through the city (Gallagher). As the Inglewood Oil Field is redesigned, we want to keep the community and accessibility at the forefront of our recommendations. As roads are built on the site, we propose limiting the lane size to two lanes of traffic, incorporating bike lanes on both sides, and ensuring sidewalks for pedestrian convenience. Smaller lanes of traffic with increased accessibility will make the site more walkable and therefore more livable.

In addition to smaller lanes of traffic, we propose incorporating roundabouts rather than traffic lights to control the flow of traffic. Gallagher states, “It's simply a concrete island, often landscaped, that sits within the middle of an intersection around which traffic flows” (Gallagher). Incorporating roundabouts instead of traffic lights offers numerous benefits. Firstly, vehicles will not be idling at red lights, reducing both fuel consumption and emissions into the atmosphere as cars are not rapidly accelerating when the light changes. Additionally, “roundabouts are safer than traffic circles and even signalized intersections because, as with narrower streets and wider sidewalks, drivers aren't expecting to race through them as fast as possible” (Gallagher). Furthermore, roundabouts do not require any electricity to power them which keeps maintenance costs low and energy consumption down. Roundabouts with landscaping not only enhance the site aesthetically but also present opportunities for carbon sequestration through the vegetation they incorporate.

Energy Suitability

Geothermal Energy Potential

As the Inglewood Oil Field is decommissioned in the next decade, there is potential to transition the site to become carbon neutral by implementing renewable energy sources, specifically geothermal energy. There is recent research to support the recovery of water and heat from abandoned oil wells to produce electricity. In the journal of Petroleum Science and Engineering, the paper “A comprehensive review of geothermal energy extraction and utilization in oilfields,” analyzes the multidisciplinary technologies needed to develop geothermal energy from existing oilfields. The paper argues that there are economic benefits to retrofitting abandoned wells as the infrastructure is already in place and minimal drilling will need to occur. One byproduct of oil drilling is heated water. More often than not, this water is disposed of without utilizing the heat to potentially produce electricity. Once an oil well is abandoned, it becomes a liability and loses economic value as it is plugged. However, the paper states that, “existing wellbore is an access to subsurface geothermal resource, therefore an abandoned well could provide an opportunity for geothermal heat extraction. The concept of this method is to select and repurpose the depleted petroleum reservoir to geothermal reservoir and harvest the heat by working fluid injected from the surface” (Wang). Essentially, a double pipe heat exchanger would be constructed in the abandoned well and would inject a fluid into the well to re-extract the flowing water. This water would be pumped to other facilities to generate electricity, which can be used for heating and other industrial or commercial purposes.

As Inglewood Oil Field is remediated and developed into a mixed use community with various green spaces, housing developments and businesses, there is potential for geothermal energy to power these places. The paper, “Power Generation potential from Coproduced Fluids in the Los Angeles Basin,” from Stanford University studied various oilfields in the Los Angeles Basin, including Inglewood Oil Field. According to the study, “the oil and gas fields in the Los Angeles basin have a promising geothermal gradient of 2.0°F/100 ft while data collected by the DOGGR for 2010 reveals a 97% water cut for production in Los Angeles County oil fields" (Bennett). Important factors to consider when choosing a candidate well is the temperature of the reservoir and the fluid production rate. The study found that having a strong flow rate is necessary in order to produce a sufficient amount of energy rather than having extremely hot temperatures. The results concluded that the Inglewood Oil Field can produce 580 kW of power over the course of 30 years and generate $3.2 million at the net present value (Bennett). With this data collection, it would be beneficial to conduct another analysis of the field and determine the potential to generate geothermal energy in order to power the mixed use community that will be developed.

Methods

To harness the promising potential of geothermal energy on the Inglewood Oil Field, it is crucial to conduct a thorough analysis of the existing infrastructure on site. For the scope of this project, a preliminary analysis was executed in ArcGIS Pro with data on oil and gas wells from Enverus, a well known US energy platform. Well data was downloaded in the form of a point shapefile for the Los Angeles region and then filtered down to the Inglewood Oil Field. In ArcGIS Pro, wells were selected and turned into a new layer if the production status was 'Active', 'Inactive' or 'Active Injection.' We chose to filter the well status to solely encompass active oil extraction. Plugged wells, having already been filled with cement, would entail higher retrofitting costs. From here, the points were reprojected to NAD 1983 (US Foot) StatePlane California Zone 5. As mentioned earlier, the most important qualities to assess a candidate well for geothermal potential are fluid production rate, temperature and depth. The data extracted from the Enverus platform included information on the latest water production and total depth. Using this point data, an interpolation raster was created for latest water production and depth using the Kriging method. The Kriging method was chosen because it "assumes that the distance or direction between sample points reflects a spatial correlation that can be used to explain variation in the surface" (Childs). It is often used for soil science and geology. Once the two output rasters were generated from the point layer, they were each reclassified using the natural breaks method with five classes. A weighted overlay was then performed with the latest water production and depth reclassified rasters to assess which well points and areas are most suitable for geothermal implementation. In the weighted overlay tool, the latest water production was given a weight of 65% while depth was given a weight of 35%. After the tool was run, the raster calculator was used to only select values in the first category as this represents the most desired area. The point data was then layered on top of the weighted overlay output to visualize the location of the most suitable wells on the Inglewood Oil Field.

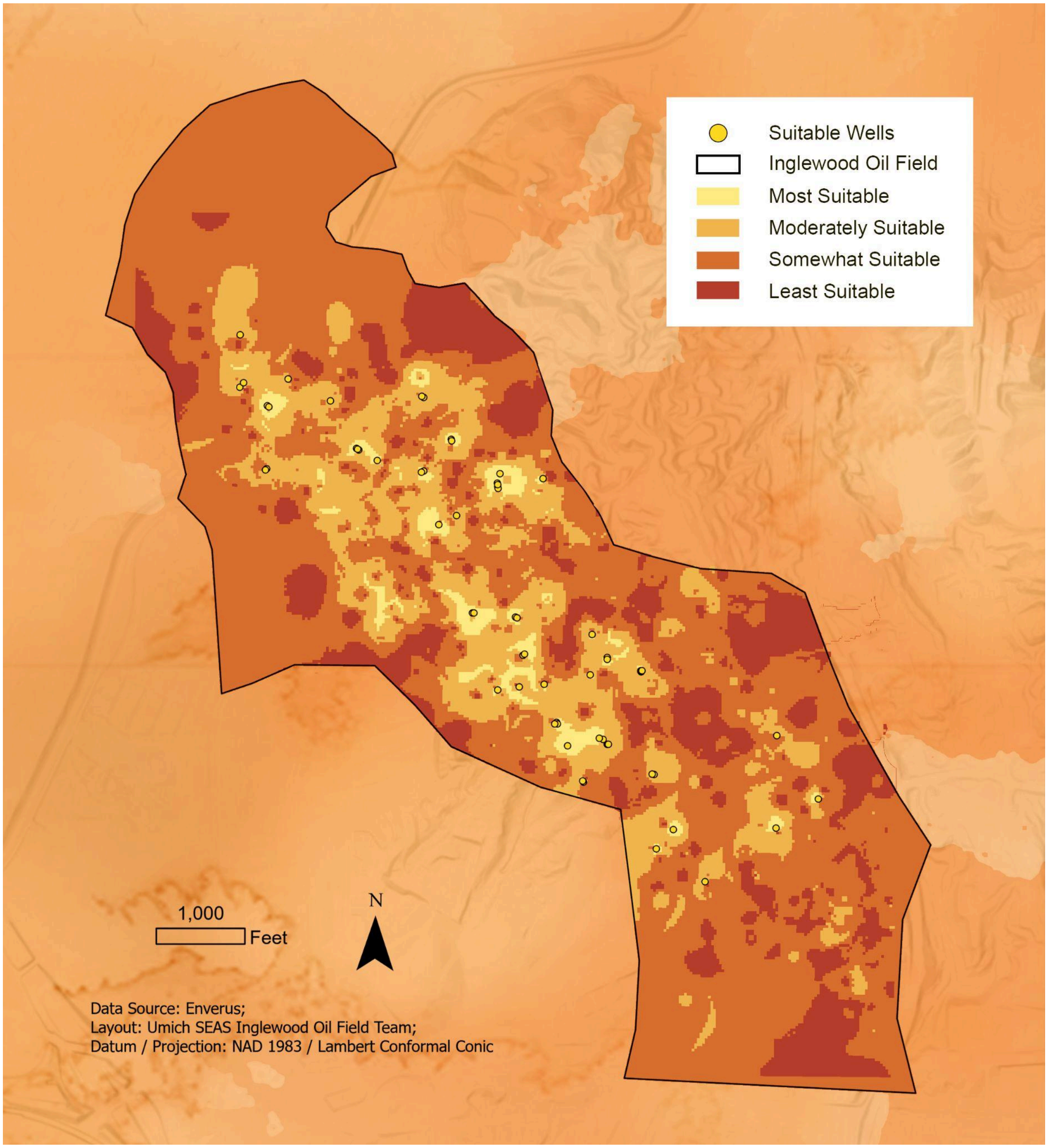


Figure 33. Most suitable wells for geothermal potential based on the well status, depth and latest water production. A weighted overlay was performed with interpolation rasters to determine the most suitable areas.

Well Number	**Latest Wtr Yield**	**Total Depth**	**Prod Status**	**Latitude**	**Longitude**
655	60672	9165	ACTIVE	34.002296	-118.368729
412	21999	3018	ACTIVE	34.000145	-118.37014
400	2030	2904	ACTIVE	34.002728	-118.373169
399	66292	2950	ACTIVE	34.002762	-118.373108

Table 12. This table shows the first four rows of the most suitable wells for geothermal implementation. Please see the Appendix for the full table.

Based on the weighted overlay index, the most suitable areas for geothermal potential are highlighted in Table 12. The dark red color indicates that the wells located in these areas are relatively deep and have a high water yield, which are both important factors when looking for a candidate well. The dark red zones are dispersed throughout the oil field, indicating that there is potential to implement geothermal energy on the remediated site. Table 12 gives a description of the specific wells that are located within the dark red zones. These wells are currently extracting oil and are not plugged or abandoned. As the site is decommissioned in phases, it would be important to keep these wells in mind when considering the implementation of geothermal energy. As this is a preliminary analysis, we recommend that further exploration is conducted to assess the geology beneath these wells to determine if geothermal energy construction is feasible.

Solar Energy Potential

Solar power has the potential to transition the remediated oil field into a net-zero community by effectively harnessing the power of the sun. California is well known as being one of the sunniest places to live in the United States, with more than 260 days of sunshine per year ("Weather in Los Angeles"). With the large amount of sun that Los Angeles is exposed to each year, implementing solar energy can play a critical role in reducing fossil fuel consumption and mitigating other effects of climate change. Even though the initial costs of investment may be higher for solar energy, the benefits in the long run out weigh initial construction costs. Some long term benefits of solar energy include an improvement in air quality due to a decrease in carbon emissions, energy independent cities, and lower energy costs. "By generating their own electricity, cities are less reliant on external energy sources and vulnerable to price volatility in the energy market. This independence enhances the resilience of urban communities, especially during times of crisis or grid outages" (*Solar Energy Meets Urban Spaces: The Evolution of Integrated Construction*). As the effects of climate change will continue to worsen throughout the century, the US is becoming more vulnerable to extreme weather events, which may cause an increase in power outages. The Inglewood Oil Field has the opportunity to become energy independent and remain resilient in the face of power outages by sourcing from renewable energy.

Los Angeles is an optimal location for solar panel implementation because the city receives a high amount of solar irradiance. “Solar irradiance measures how much solar power is reaching a particular area, and a higher figure implies greater solar panel efficiency” (Spivey). Los Angeles receives an average of 5.6 kilowatt-hours per square meter per day compared to a national average of 4.5. The architectural design featuring flat roofs that LA is known for provides an ideal setting for solar panels as well. Additionally, solar power requires significantly less water compared to nuclear power plants and can be instrumental in conserving water for the Los Angeles area. “According to California’s State Water Plan update, over 19% of the state’s electricity use goes to water-related purposes. Hence, increasing solar energy adoption in LA aids in larger water conservation efforts, especially crucial in a region frequently plagued with droughts” (Spivey). California has ambitious goals to achieve 100% clean energy by 2045 as outlined in the enactment of Senate Bill 100. With solar power being supported by legislation and other government sectors, it would be most beneficial to incorporate solar energy on the remediated Inglewood Oil Field site.

Methods

In order to assess the solar energy potential of the Inglewood Oil Field, we ran a solar suitability index of the site using ArcGIS Pro and utilized Digital Elevation Models from the California government database. In order to create a DEM of the entire Inglewood site, we had to download multiple files which included locations in Beverly Hills, Hollywood and Inglewood. These files were merged together in ArcGIS Pro which created an output raster of the elevation of the Inglewood Oil Field. The resolution of the DEM files were 30m x 30m and remained consistent throughout the analysis. Additionally, we obtained data from the National Land Cover Database to identify areas with barren land as this land cover is most suitable for installing solar panels. All data was projected in NAD27 / UTM zone 11N.

The first steps included running the Slope and Aspect tools in the Spatial Analyst toolbox in ArcGIS Pro to calculate the slope and aspect of the land from the digital elevation model. These tools produced one output raster each. The slope layer was then reclassified into two categories; a value of 1 was given to slopes less than or equal to 8 degrees, and a value of 0 was given to slopes greater than 8 degrees. This reclassification allowed us to easily identify low-angle areas that would be most effective at harnessing energy from the sun. Next, the aspect layer was reclassified into two categories; a value of 1 was given to areas with a southern facing slope, and a value of 0 was given to all other areas. Southern facing slopes are the most suitable for this solar index based on the location of the Inglewood Oil Field as southern slopes will absorb the greatest amount of sunlight. The NLCD layer was also reclassified into two categories; a value of 1 was given to the field ‘barren land’ and a value of 0 was given to all other fields. This step determined that there were no ‘barren land’ cells in the Inglewood Oil Field boundary, so this dataset was dropped from our analysis at this time.

The suitability index was then calculated by running the Raster Calculator tool in ArcGIS Pro. The reclassified slope and aspect rasters were overlaid with the equation Con(("Slope Raster" == 1) & ("Aspect Raster" == 1) ,1). This calculation allowed us to identify areas with low-angles and southern facing slopes which would be most suitable for solar panel installation. Lastly, we used the Extract by Mask tool to clip the output raster to the Inglewood Oil Field boundary.

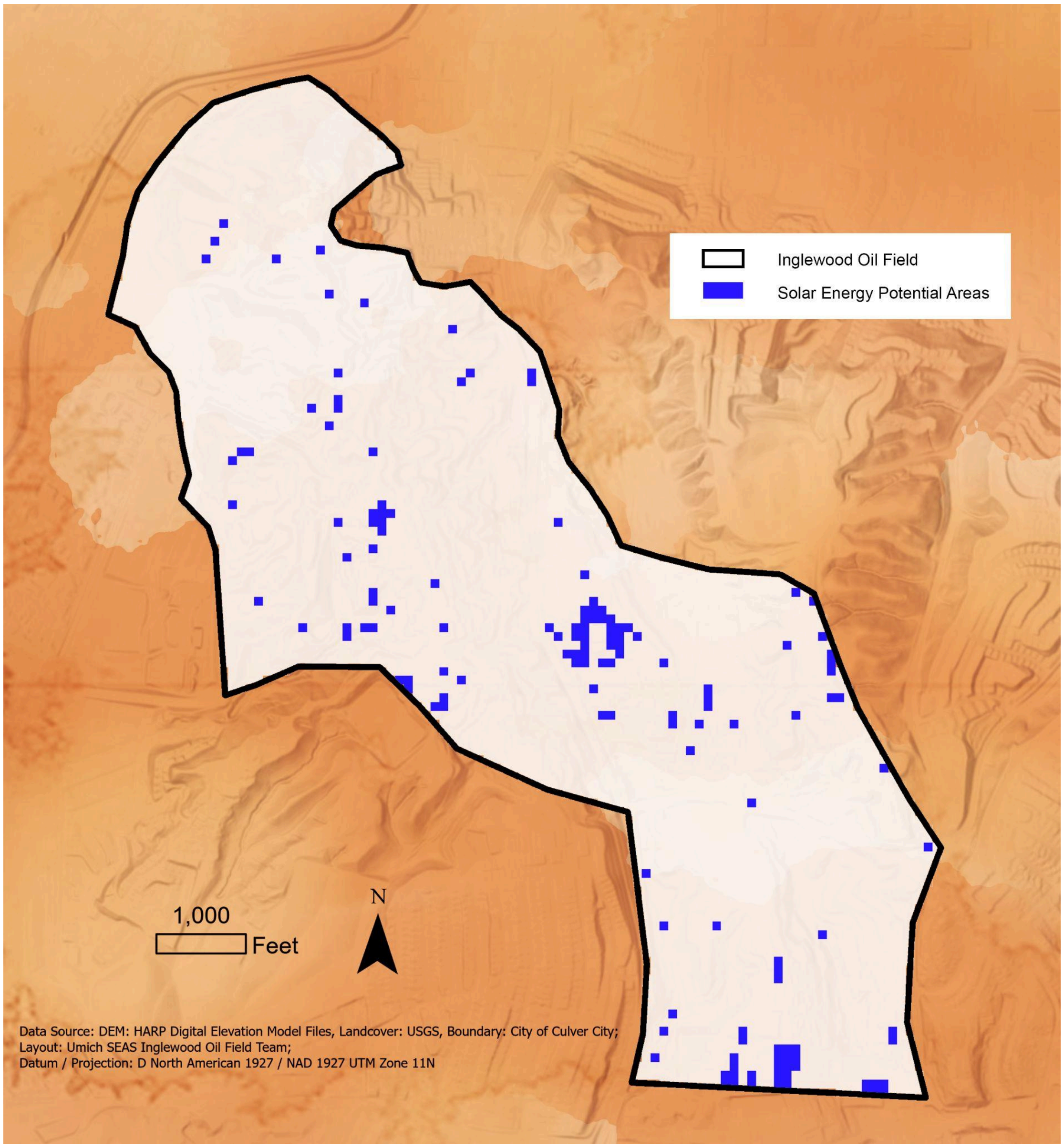


Figure 34. Suitable areas for solar energy potential based on slope and aspect.

Limitations and Recommendations

While the recommended strategies provide valuable insights for restoring the urban oil field, it is crucial to acknowledge certain limitations.These solutions are not one-size-fits-all or will be applicable everywhere; this is due to various factors such as adherence to local, state, and federal guidelines and environmental standards. Notably, the literature used for reference encompasses cases from Alaska, Saudi Arabia and Nigeria, introducing a potential lack of universal applicability. Recognizing the limitation of applicability, the effectiveness of the proposed solutions is dependent on site-specific conditions and the temporal dynamics of the restoration process, which introduces variability into outcomes. It is crucial to exercise caution when implementing living organisms, such as plants or fungi, for remediation, necessitating a meticulous plan to prevent unintended consequences and ensure proper disposal to avoid further harm. Additionally, the lack of literature on urban oil field restoration poses a challenge, emphasizing the need for further research to refine and optimize the proposed restoration strategies. This underscores the importance of conducting additional research before applying the recommended remediation measures to ensure their effectiveness in the unique context of the Inglewood Oil Field.

Conclusion: Measuring Success

It is crucial to invest in extensive site-specific research, monitoring, and adaptive management strategies to determine if the recommended strategies are successful. Collaborative efforts between scientists, environmentalists, design firms, and local communities are essential to fill the knowledge gaps and develop effective, context-specific restoration plans for urban oil fields.

Measuring the Success of Soil Remediation

Plant and soil surveys can be used for comprehensive monitoring to ensure the success of remediation and restoration practices implemented at the Inglewood Oil Field. Monitoring is "the collection and analysis of repeated observations or measurements to evaluate changes in condition and progress toward meeting a management objective" (Elzinga et al.). For plant and soil monitoring, a suggestion is a survey assessment, as "surveying can help collect baseline data on the existing environmental conditions of the project site and its surroundings to measure the changes and impacts caused by the project. Surveying can also help monitor the environmental conditions during and after the project execution and evaluate the effectiveness," (Oğuz & Pappas). In this case the survey process takes into account vegetation health, growth, and contaminant absorption efficiency, tracks remediation progress, and identifies areas for adjustments. Similarly, soil surveys involve assessing contaminant levels and changes over time through data collection. This continuous monitoring process provides valuable insights into the effectiveness of remediation efforts and allows for timely adjustments to achieve the desired outcomes. Integrating plant and soil surveys into the process allows for monitoring and enhances understanding of the effectiveness of the remediation strategies on the site. Monitoring post-implementation provides for ongoing efficacy assessments, enabling adaptation of approaches based on real-time observations. This iterative process ensures sustained success in remediating the oil field.

The following steps could be beneficial to ensure the success of plants and soil.

- **Defining the area of interest**: Begin by clearly delineating the geographic boundary of the area to be monitored. This ensures spatial accuracy and consistency in measuring progress over time (The Restoration Monitoring Tools Guide 2024).
- **Establishing a clear and consistent set of indicators:** Identify a set of variables or metrics that will be used to measure progress and determine if objectives are being met. These indicators provide valuable insights into the success of restoration efforts.
- **Establishing a baseline:** Before implementing restoration interventions, collect baseline data for the chosen indicators. This baseline serves as a reference point for evaluating changes over time and assessing the impact of interventions (The Restoration Monitoring Tools Guide 2024).
- **Collecting sustainable and reproducible input data:** Gather data on the chosen indicators at regular intervals using cost-effective, comparable, and consistent methods

across time and space. Validating data using transparent methods ensures its accuracy and reliability (The Restoration Monitoring Tools Guide 2024).

- **Report results**: Communicate progress and findings to decision-makers and stakeholders. This enables them to assess the extent to which objectives are being met and make informed decisions about future actions (The Restoration Monitoring Tools Guide 2024).

The fundamental steps listed above could be beneficial to ensure the success of plants and soils within the context of the Inglewood Oil Field.

Measuring the Success of Urban Agriculture

There are several protocols that project managers and leaders of the urban agriculture initiative can adopt on the remediated site to gauge the success of the project. The first measure of success that can be determined is if the site and surrounding communities are showing signs of environmental resilience. Environmental resilience can be measured in numerous ways, the first being to monitor the air quality near the urban garden. “Beyond providing fresh produce, urban farming actively contributes to improved air quality. Plants, acting as natural air purifiers, strategically placed in urban environments help filter pollutants, enhancing overall air quality” (“How Can Urban Farming Be Used as a Nature-Based Solution for Creating Urban Green Spaces”). It would be advantageous to regularly monitor air quality on a scheduled basis, either weekly or monthly, over an extended period. Furthermore, it is recognized that urban agriculture can mitigate the urban heat island effect by reducing surface temperatures through increased vegetative land cover. To assess the effectiveness of this approach, gathering data on surface temperatures via satellite imagery, using either private drones or government databases, can help determine the extent to which urban agriculture contributes to lowering surface temperatures in the city. One other indicator to determine environmental resilience is to monitor the presence of pollinators in the urban garden. Many plant and fruit crops depend on bees and other pollinators to produce their fruit, and it is predicted that an urban garden will increase the amount of pollinators in the area. “Some studies suggest that bee abundance and diversity increase with urban green space coverage and that bee diversity declines with increased impervious surface coverage in surrounding landscapes” (Zhao). Evaluating the abundance of pollinator species in the urban garden will determine whether the crops are attracting pollinators, thereby enhancing the overall biodiversity of pollinator species in the area.

Beyond tracking the environmental resilience of the urban garden, it's crucial to evaluate the degree of community engagement and the strength of partnerships associated with the initiative. Urban agriculture plays a vital role in establishing communal spaces where local residents can gather and cultivate food for their neighborhoods. This approach has the potential to reduce food miles and transportation emissions in Los Angeles by providing fresh produce to underserved areas near the remediated site. An overarching challenge for this initiative lies in securing an adequate workforce and volunteers for harvesting and distributing produce to the community. In order to overcome these obstacles, it would be beneficial to partner with local community groups that support the ideology around urban agriculture. One local organization called Los Angeles Food Policy Council, works to ensure food is healthy, affordable and sustainable for all. Their mission revolves around catalyzing, coordinating and connecting people across the LA region, including government, business and community groups working on food. In the 2017 agenda, the LA Food Policy Council outlines specific strategies for partnering with local food groups to strengthen environmental resiliency and to promote a good food economy (*Good Food for All Agenda*). Another local organization called LA Compost partners with local gardens to collect food scraps and discarded produce to avoid food waste entering the landfill. All the food waste is then turned into compost which can be redistributed to promote healthy soils and further the generation of healthy, sustainable food.

Measuring the Success of Renewable Energy

There are multiple methods to measure the success of a renewable energy system. The first method focuses on the technical indicators to assess the quality and efficiency of the energy system. “These include the capacity factor, which measures the ratio of actual output to potential output; the availability factor, which measures the percentage of time that your systems are operational; the energy yield, which measures the amount of energy produced per unit of installed capacity; and the performance ratio, which measures the ratio of actual output to expected output based on standard conditions” (“How Do You Assess the Success of Your Renewable Energy Projects?″). If solar and geothermal energy is implemented on the site, it would be beneficial to measure these technical indicators to determine if the systems are working to the highest and most efficient capacity.

Additionally, it is important to measure the financial investment of solar and geothermal energy. Some indicators to measure financial investment include “the net present value (NPV), which measures the difference between the present value of your cash inflows and outflows; the internal rate of return (IRR), which measures the annualized return on your investment; and the payback period, which measures the time it takes to recover your initial investment” (Gumintag). Conducting a long-term study of the financial payback of solar and geothermal energy on a remediated site can serve as a model for future renewable energy projects. Such a study can provide valuable insights into the economic viability and sustainability of integrating renewable energy sources into similar sites. By analyzing the financial returns over an extended period, stakeholders can make informed decisions about which renewable energy sources to prioritize and how to optimize their implementation for maximum benefit. This approach fosters a data-driven approach to renewable energy integration and helps pave the way for more widespread adoption of sustainable energy solutions.

The last indicator to measure is an environmental indicator which quantifies the impacts of the renewable energy system on natural resources and the climate. After implementing solar or geothermal energy on the site, it would be beneficial to quantify the amount of carbon emissions that were diverted from being released into the atmosphere. Additionally, assessing the amount of water saved compared to conventional energy sources can provide valuable insights into the environmental benefits of renewable energy integration. These studies can inform future efforts aiming to transition to renewable energy and promote long-term sustainability.

Conclusion

In conclusion, our Inglewood Oil Field remediation recommendations provide an inclusive approach, prioritizing sustainability. Through a concerted effort to restore ecological balance and embrace the diverse perspectives of the Inglewood community, our strategy integrates an array of innovative remediation techniques. From comprehensive planting initiatives to pioneering soil amendments, our approach hopes to foster a healthy transformation for the area as it moves forward. While we acknowledge the ongoing need for research, monitoring, and adaptive management to address potential challenges, our recommendations serve as a robust framework for advancing toward a more sustainable future. By uplifting and honoring the heritage of the communities and the broader Inglewood population, we aspire to create a cleaner, more equitable, and just transition for the environment and all residents.

Land Acknowledgment
"We respectfully acknowledge that the land we stand on is the ancestral territory of Chumas and Tongva (Gabrieleno) peoples The three Fires People: the Odawa, Ojibwe, and Bodewadami as well as Meskwahkiasahina (Fox), Peoria, and Wyandot, who have been its traditional stewards since time immemorial. As we address the urban oil field through sustainable approaches, we recognize the importance of honoring their cultural heritage and deep connection to this land.

This acknowledgment signifies our commitment to sustainable practices that integrate Indigenous knowledge and respect for the environment. We understand the historical impacts of industrial activities and are dedicated to working collaboratively with Indigenous communities, valuing their perspectives in our pursuit of responsible and ethical restoration.

We acknowledge the significance of reconciliation, environmental justice, and community collaboration in embracing this land acknowledgment. We aim to contribute to a future where sustainability is not just a concept but a lived reality that uplifts the land and its people for current and future generations.

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Appendix A: Pilot Survey

Inglewood Oil Field Community Survey

Hello! We are five graduate students of Landscape Architecture, Geospatial Data Sciences Ecosystem Science and Management, and Behavior, Education, and Communication from the University of Michigan. Our team objective is to gain an insight into ***community feedback regarding the Inglewood Oil Field***. The primary focus of this survey is to understand the relationship between the Inglewood Oil Field and the surrounding communities. This survey is completely ***anonymous*** and it will approximately take you ***3 minutes*** to complete.

We appreciate your time and effort in completing this survey. Your participation will help us gather valuable information on the local community's perspective.

Sense of the Inglewood Oil Field:

- Are you aware of the presence of urban oil fields in/around your neighborhood?
    - Yes
    - No
    - Not sure
- Are you aware that the city of Los Angeles is going to decommission (or remove from service) the Inglewood Oil Field operation in the next 10 years?
    - Yes
    - No
    - Not sure
- On a scale from 1- 5 where 1 is least concerned, and 5 is very concerned, how concerned are you in relation to living near an urban oil field site?
    - 1 Least concerned
    - 2 A little concerned
    - 3 Neutral
    - 4 Concerned
    - 5 Very Concerned
- Do you think there are benefits to living near an urban oil field?
    - Yes
    - No
    - Not sure
        - If answered **YES**: What benefit(s) are there living near an urban oil field? *[Please select all that apply]*
            - Job Creation
            - Revenue for the city/state
            - Increased property values
            - Energy infrastructure

            - Other, please specify
- Do you think there are risks to living near an urban oil field?
    - Yes
    - No
    - Not sure
        - If answered **YES**: What risk(s) are there living near an urban oil field? *[Please select all that apply]*
            - Potential oil spills
            - Air pollution
            - Water pollution
            - Noise
            - Light pollution
            - Traffic congestion
            - Other, please specify
- What neighborhood do you live in?
    - Inglewood
    - Ladera Heights
    - View Park-Windsor Hills
    - Baldwin Hills/Crenshaw
    - Westchester
    - Leimaert Park
    - Playa Vista
    - Culver City
    - West Adams
    - Lennox
    - Other (if not listed, please specify):
- How long have you lived in this neighborhood?
    - Less than 1 year
    - 1-5 years
    - 6-10 years
    - Over 10 years
- The Inglewood Oil Field operation will be decommissioned - or removed from service - within the next 10 years. What type of activities and/or design elements would you like to see implemented on this remediated site?
  A remediated site is a location that has undergone environmental cleanup to address contamination or pollution. *[Please select all that apply]*
    - Naturalization (plant garden, nature trails, wildlife habitat)
    - Community Gathering Space (Farmer's Market, community gardens)
    - Passive recreation (bird watching, space for picnics, hiking/walking trails)
    - Active recreation (space for sports, bike riding, running)

- Amenities (pools, basketball courts, tennis courts, park district facilities)
- Retail spaces (grocery store, pharmacies, small businesses)
- Other, please specify

Nature observation:

- Have you visited any of the following adjacent parks near the Inglewood Oilfield?
    - ***Kenneth Hahn State Recreation Area***
    - ***Baldwin Hills Scenic Overlook***
    - ***Norman O. Houston Park***
    - ***Reuben Ingold Park***
    - ***El Marino Park***
    - ***Blanco Park***
    - ***Culver City Park***
    - Yes
    - No
    - Not sure
- What motivates you to get outside?
    - Parks
    - Hiking trails
    - Exercise
    - Space for kids and family to come together
    - Nature and wildlife
    - Events and community activities
    - Desire for leisure and relaxation
    - Other, please specify
- How often do you spend time outdoors per week?
    - 0 - 2 days
    - 3 - 5 days
    - 6 - 7 days
- Do you feel that there is enough recreational space in your neighborhood?
    - Yes
    - No
    - Not sure
- What type of urban wildlife have you noticed in your neighborhood?
  [Please select all that apply]
    - Birds
    - Coyotes
    - Mountain Lion
    - Bobcat
    - Deer
    - Racoons

- Opossum
- Skunk
- Reptiles (snakes, lizards ect.)
- Insects (ants, bees, butterflies/moths ect.)
- Other, please specify

- Do you wish you knew more about the local wildlife in the neighborhood?
  - Yes
  - No
  - Not sure

Demographics:

- *What is your gender?
  - Female
  - Male
  - Other (please specify)
  - Prefer not to answer
- *Which category below includes your age?
  - Under 18
  - 18-24
  - 25-34
  - 35-44
  - 45-54
  - Above 54
- *Which race or ethnicity best describes you?
  - American Indian or Alaskan Native
  - Asian/Pacific Islander
  - Black or African American
  - Hispanic or Latino
  - White/Caucasian
  - Other (please specify)
  - Prefer not to say
- What is the highest level of education you have completed?
  - Less than high school degree
  - High school degree or equivalent
  - Some college but no degree
  - Bachelor's degree
  - Master's degree
  - Doctorate
  - Prefer not to say

- Optional question: Is there anything else you would like to add or any other comments you would like to share?

Appendix B: Final Survey

Inglewood Oil Field Community Survey

Hello! We are five graduate students of Landscape Architecture, Geospatial Data Sciences Ecosystem Science and Management, and Behavior, Education, and Communication from the University of Michigan.

Our team objective is to gain an insight into ***community feedback regarding the Inglewood Oil Field***. The primary focus of this survey is to understand the relationship between the Inglewood Oil Field and the surrounding communities. This survey is completely ***anonymous*** and it will approximately take you ***3 minutes*** to complete.

We appreciate your time and effort in completing this survey. Your participation will help us gather valuable information on the local community's perspective.

Sense of the Inglewood Oil Field:

- Are you aware of the presence of urban oil fields in/around your neighborhood?
    - Yes
    - No
    - Not sure
- Are you aware that the city of Los Angeles is going to decommission (or remove from service) the Inglewood Oil Field operation in the next 10 years?
    - Yes
    - No
    - Not sure
- On a scale from 1- 5 where 1 is least concerned, and 5 is very concerned, how concerned are you in relation to living near an urban oil field site?
    - 1 Least concerned
    - 2 A little concerned
    - 3 Neutral
    - 4 Concerned
    - 5 Very Concerned
- What benefit(s) are there living near an urban oil field? *[Please select all that apply]*
    - Job Creation
    - Revenue for the city/state
    - Increased property values
    - Energy infrastructure
    - Other, please specify
- What risk(s) are there living near an urban oil field? *[Please select all that apply]*
    - Potential oil spills
    - Air pollution

- Water pollution
- Noise
- Light pollution
- Traffic congestion
- Other, please specify

- What neighborhood do you live in?
  - Inglewood
  - Ladera Heights
  - Fox Hills
  - Westchester
  - Leimert Park
  - Playa Vista
  - Blanco - Culver Crest
  - Park West
  - Carlson Park
  - Jefferson
  - Blair Hills
  - Baldwin Hills
  - Baldwin Village
  - View Park
  - Windsor Hills
  - Other (if not listed, please specify):
- How long have you lived in this neighborhood?
  - Less than 1 year
  - 1-5 years
  - 6-10 years
  - Over 10 years
  - Not sure
- The Inglewood Oil Field operation will be decommissioned - or removed from service - within the next 10 years. What type of activities and/or design elements would you like to see implemented on this remediated site?
  A remediated site is a location that has undergone environmental cleanup to address contamination or pollution. *[Please select all that apply]*
  - Naturalization (plant garden, nature trails, wildlife habitat)
  - Community Gathering Space (Farmer's Market, community gardens)
  - Passive recreation (bird watching, space for picnics, hiking/walking trails)
  - Active recreation (space for sports, bike riding, running)
  - Amenities (pools, basketball courts, tennis courts, park district facilities)
  - Retail spaces (grocery store, pharmacies, small businesses)
  - Other, please specify

Nature observation:

- Have you visited any of the following adjacent parks near the Inglewood Oilfield?
    - ***Kenneth Hahn State Recreation Area***
    - ***Baldwin Hills Scenic Overlook***
    - ***Norman O. Houston Park***
    - ***Reuben Ingold Park***
    - ***El Marino Park***
    - ***Blanco Park***
    - ***Culver City Park***
    - ○ Yes
    - ○ No
    - ○ Not sure
- What motivates you to get outside? *[Please select all that apply]*
    - ○ Parks
    - ○ Hiking trails
    - ○ Exercise
    - ○ Space for kids and family to come together
    - ○ Nature and wildlife
    - ○ Events and community activities
    - ○ Desire for leisure and relaxation
    - ○ Other, please specify
- Optional question: Is there anything else you would like to add or any other comments you would like to share?

    Feel free to contact us if you have questions or recommendations!

    - Email: inglewoodresearch@umich.edu

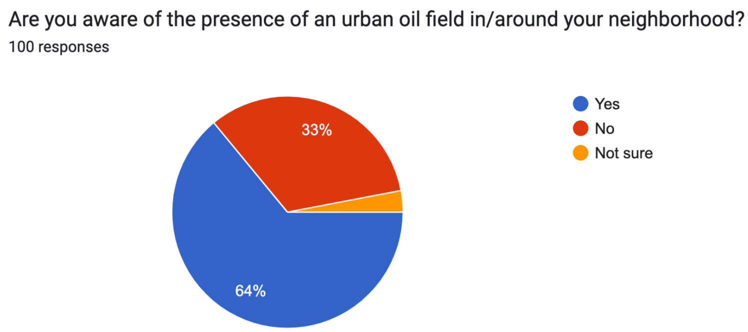
    - Instagram: @inglewood_umich

Appendix C: Survey Responses

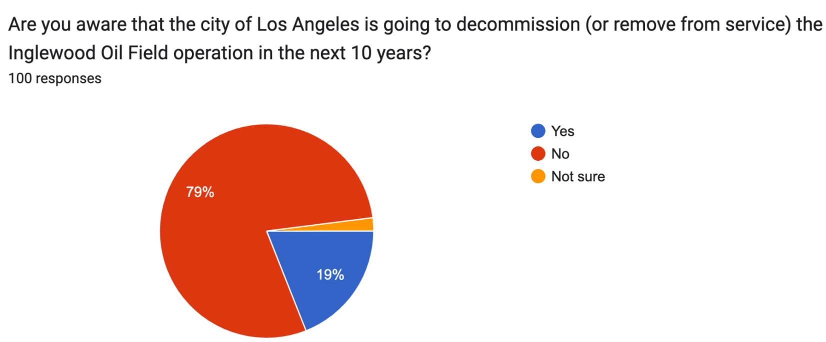
Responses to survey questions are included in summary form (e.g. pie/bar/etc. charts, averages.).

Sense of the Inglewood Oil Field:

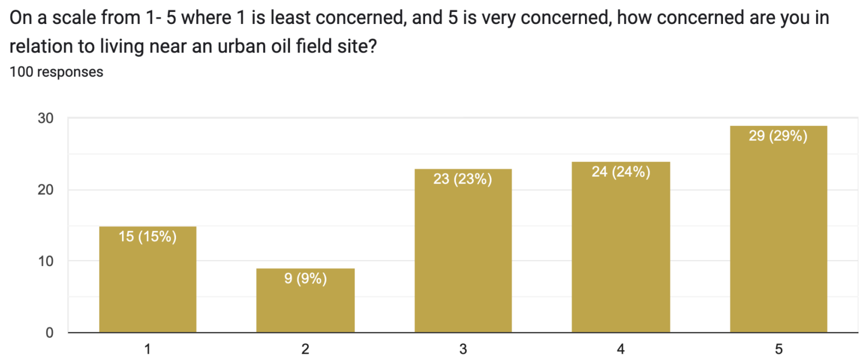
- Are you aware of the presence of urban oil fields in/around your neighborhood?



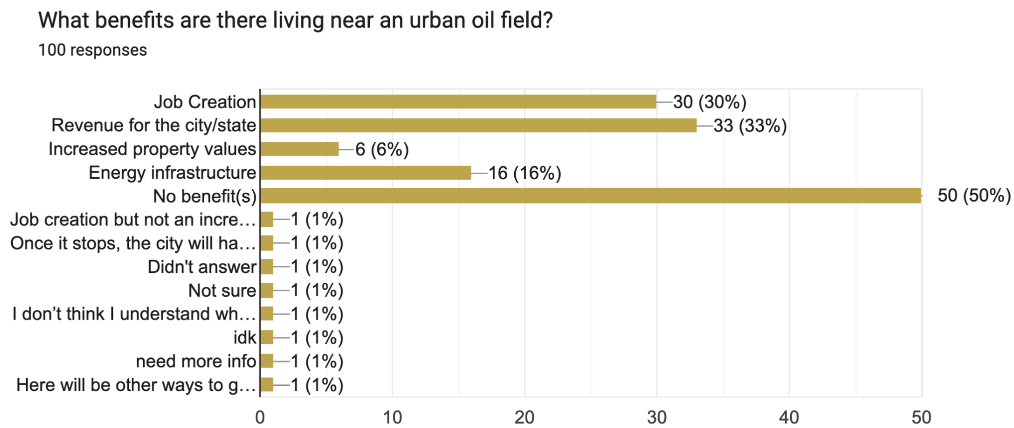
- Are you aware that the city of Los Angeles is going to decommission (or remove from service) the Inglewood Oil Field operation in the next 10 years?



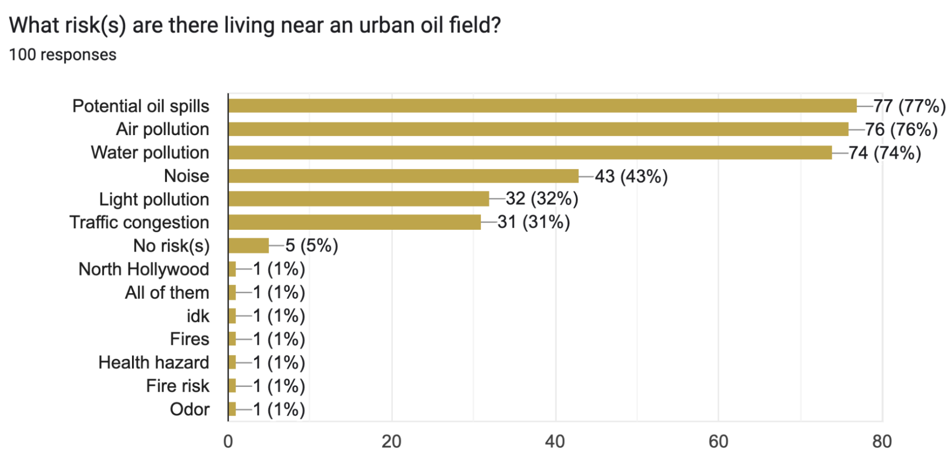
- On a scale from 1- 5 where 1 is least concerned, and 5 is very concerned, how concerned are you in relation to living near an urban oil field site?



- What benefit(s) are there living near an urban oil field? *[Please select all that apply]*

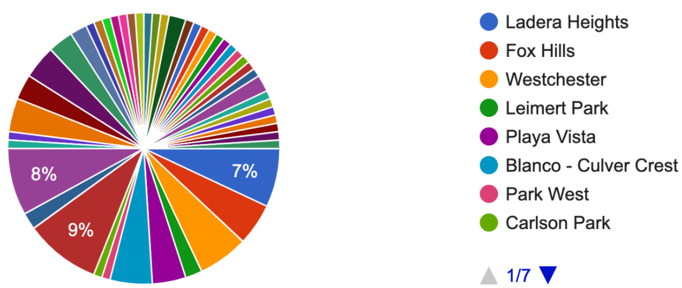


- What risk(s) are there living near an urban oil field? *[Please select all that apply]*



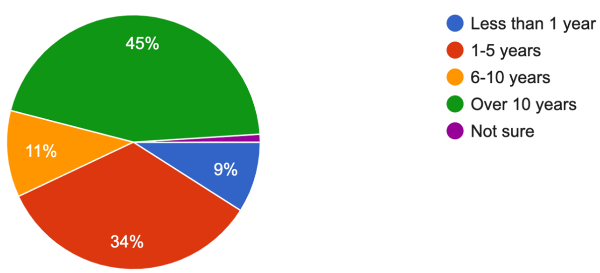
- What neighborhood do you live in?

What neighborhood do you live in?
100 responses

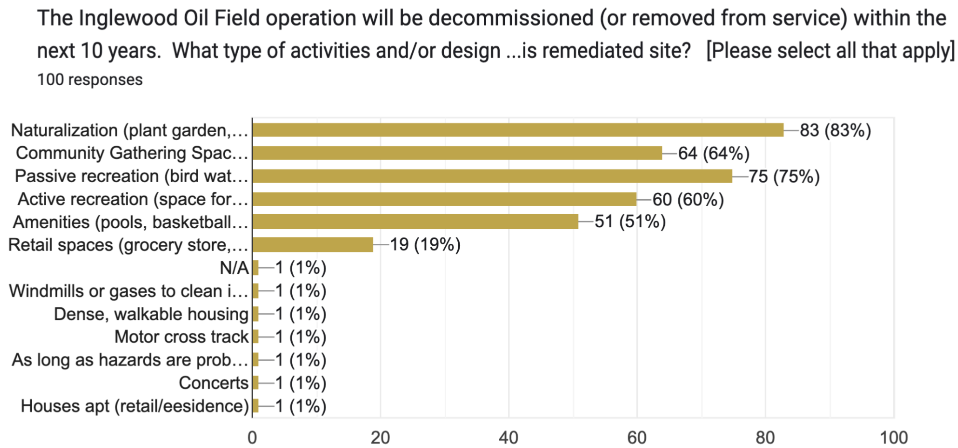


- How long have you lived in this neighborhood?

How long have you lived in this neighborhood?
100 responses

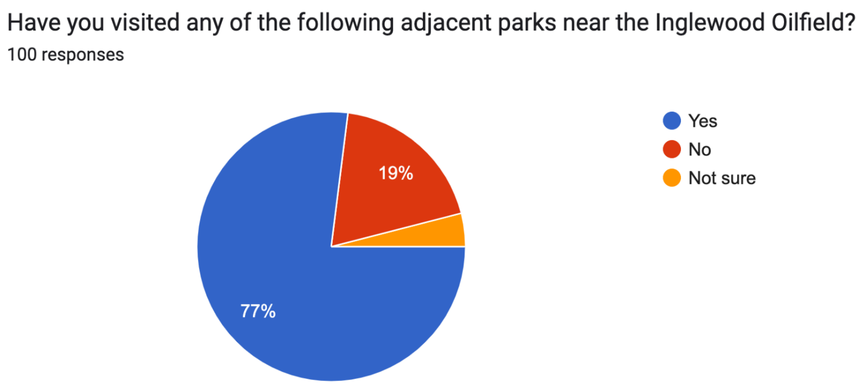


- The Inglewood Oil Field operation will be decommissioned - or removed from service - within the next 10 years. What type of activities and/or design elements would you like to see implemented on this remediated site?

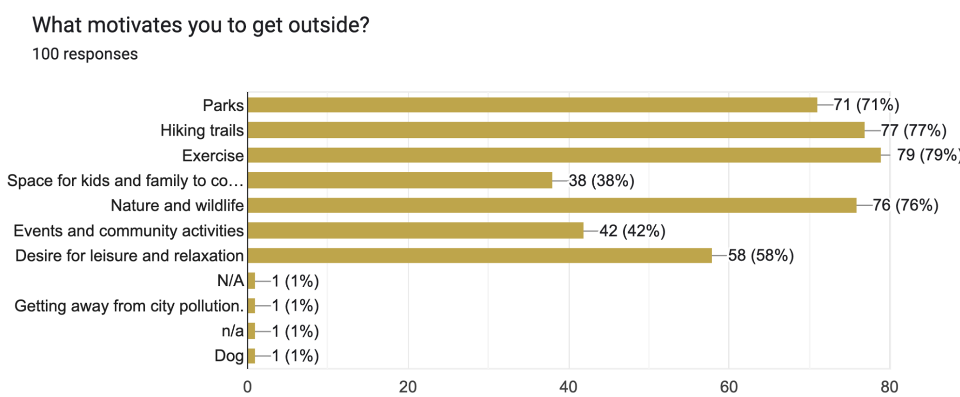


Nature observation:

- Have you visited any of the following adjacent parks near the Inglewood Oilfield?



- What motivates you to get outside? *[Please select all that apply]*



- Optional question: Is there anything else you would like to add or any other comments you would like to share?

    Feel free to contact us if you have questions or recommendations!
    - Email: inglewoodresearch@umich.edu
    - Instagram: @inglewood_umich

I wished to be more informed about the oil field

I think urban oil fields is a great concern for us to maintain the process for our life and belonging.

I'm a landscape architecture grad student who lives in the area and is very interested in this research/project! (Have been recommending it for a project for my own school) Would love to learn more/keep in touch: zdetweil@usc.edu

No concerns No music No fireworks

Appendix D: Montebello Oil Field Case Study

The Los Angeles Basin, an area of about 450 square miles bound by the Santa Monica Mountains on the northwest, the San Joaquin Hills on the southwest, the Puente Hills on the east, and the Palos Verdes Peninsula on the west, has one of the highest concentrations of crude oil in the world (Gautier et al.). The basin is home to sixty-eight named oil fields, including 10 fields that each contain more than 1 billion barrels of oil (Gautier et al.). One of these fields, the Montebello Oil Field, can be used as a case study for the remediation and redevelopment of the Inglewood Oil Field by comparing the sites' history, demographics, ecology, environmental issues, community involvement, and remediation and redevelopment strategies. The Montebello Oil Field has been recently redeveloped into a residential development with open space. The housing development consists of single family-homes and townhomes. Townhomes consist of two-, three- and four-story buildings with units ranging in size from 1,400 to 2,900 square feet and single-family homes are two- and three-stories and up to 4,500 square feet (Sprague, Montebello hills housing project; Toll Brothers). Homes currently available are listed between $3,300,000 and $3,400,000 (Toll Brothers) . In addition to housing the development will feature several public and private parks with an 11-foot wide, 1.7-mile multi use trail, and a 3.5 acre recreation center (Sprague, Montebello hills housing project; Toll Brothers).

Site History

Montebello and Inglewood Oil Field share similar site history. Both sites began producing in the early 20th century and were some of the most productive fields in the Los Angeles Basin. The Montebello Oil Field was discovered in 1917 and quickly became one of the primary oil-producing fields in California (USGS, 6). Montebello has produced over 200 million barrels of oil since its discovery, and in 2006 the oil field produced an average of about 1,800 barrels per day (Cook Hill Properties LLC et al., 3-1). As of 2018, the Montebello Oil Field had 832 (208 active, 20 idle, and 604 abandoned) wells (USGS, 6). The Montebello Hills Specific Plan, which details the redevelopment of the site into housing and open space while continuing to produce oil underground, was first approved by the Montebello City Council in 2015. The Montebello Oil Field was purchased by Sentinel Peak Resources in 2016. Sentinel Peak Resources, which also owns the Inglewood Oil Field, purchased the property from Freeport-McMoRan Oil and Gas for $742 million (Sprague, Court gives OK). In 2016, after the site was purchased by Sentinel Peak Resources, there was a change in developers from Newport Beach-based Cook Hill to Toll Brothers of Fort Washington, Pennsylvania (Sprague, Montebello hills housing project). The first phase of 349 homes was approved in January 2020 and homes are now available on the site (Sprague, Long-delayed Montebello hills project).

Like the Montebello Oil Field, Inglewood Oil Field has been operating for around a century. Drilling in the Baldwin Hills region of the Inglewood Oil Field began in September 1924 and the field was first commercially produced by Standard Oil Company of California Los Angeles;

approximately 145 barrels of oil were produced a day (Inglewood Oil Field). As of 2017, more than 400 million barrels of oil had been produced from the field (Inglewood Oil Field). When the oil field first began operating, the Baldwin Hills were undeveloped; as Los Angeles grew the area around the oil field urbanized. In 2008, the Los Angeles County Baldwin Hills Community Standards District (CSD) was adopted. The CSD came after residents raised concerns about oil and gas operations in the midst of a densely populated urban area. The Inglewood Oil Field was purchased by Sentinel Peak Resources in 2016; the field will continue to operate until it is decommissioned in stages during development (Inglewood Oil Field).

Demographics

The demographics of the areas surrounding the Montebello Oil Field and the Inglewood Oil Field are both similar and different.The Montebello Oil Field is contained within the city of Montebello just east of downtown Los Angeles. In 2023, Montebello had a population of 61,363 with an average household income of $93,957 (City of Montebello). Montebello is majority Hispanic or Latino, in 2023, 78.1% of the population was Hispanic or Latino; the remainder of the population was 14.2 % two or more races, 13.6% Asian, 6.7% White, 2.6% American Indian and Alaska Native, 0.9% Black or African American, and 0.1% Native Hawaiian and other Pacific Islander (Census Bureau, Montebello). Further, from 2018 to 2022, 36.4% of the population was foreign born (Census Bureau, Montebello).

In comparison to the Montebello Oil Field, the Inglewood Oil Field is located in multiple jurisdictions. The Inglewood Oil Field is located in the County of Los Angeles between Culver City, Los Angeles City and the City of Inglewood (MRS, 4.16-2). Culver City had an estimated population of 39,515 in 2022 and the average household income between 2018 and 2022 was $114,429 (Census Bureau, Culver City). In 2023, Culver City was 46.9% White, 20.3% Hispanic or Latino, 17.6% Asian, 14.7% two or more races, 8.0% Black or African American, 0.4% American Indian and Alaska Native, and 0.2% Native Hawaiian and other Pacific Islander (Census Bureau, Culver City). From 2018 to 2022, 24.1% of the population was foreign born 2018-2022 (Census Bureau, Culver City). The City of Inglewood is located south of the oil field. In 2022, Inglewood had an estimated population of 103,621 and average household income from 2018 to 2022 was $67,563 (Census Bureau, Inglewood). Inglewood is diverse; in 2023 the population was 49.3% Hispanic or Latino, 39.5% Black or African American, 13.7% two or more races, 5.3% White, 2.7% Asian, 1.0% American Indian and Alaska Native, and 0.3% Native Hawaiin and other Pacific Islander. 29.3% of Inglewood's population was foreign born persons 2018 to 2022.

Understanding the demographics of the areas around the oil fields is important as those populations are likely to be disproportionately affected by the oil field. Understanding these communities also has important environmental justice considerations as low-income and communities of color, like those bordering the Montebello and Inglewood Oil Fields, are disproportionately affected by pollution. Redevelopment and management decisions should consider these communities to ensure there is not an uneven burden of effects from the oil fields.

Ecology

The Montebello Oil Field supports similar plant communities and wildlife to the Inglewood Oil Field. Like Inglewood, a majority of Montebello Oil Field is disturbed due to a history of industrial activity. The biological conditions on the site include generally disturbed native and non-native plant communities in the central portion of the project site and existing restored and enhanced coastal sage scrub vegetation around the periphery (AECOM, 4.4-5). Around half of the site is Coastal Sage Scrub and with some areas Mulefat Scrub and very limited areas of Oak Woodland and Southern Willow Scrub (AECOM, 4.4-6). Inglewood is similarly a majority intact and disturbed sagebrush scrub with one stand of oak woodlands. However, Montebello supports coast live oak (Quercus agrifolia), while at Inglewood the oak woodland habitat supports interior live oak (Quercus wislizenii).

Field surveys from 2002 to 2008 documented 115 vertebrates and 68 invertebrates at the Montebello Oil Field; birds were the most numerous type of wildlife found (AECOM, 4.4-12). Three bird species observed on the site are considered California species of special concern (SSC) by the CDFW: coastal cactus wren (Campylorhynchus brunneicapillus couesi) nests in scattered patches of prickly pear cactus (Opuntia sp.); northern harrier (Circus cyaneus) and summer tanager (Piranga rubra) have occurred on-site as transients (AECOM, 4.4-12).
The diversity of reptile and mammal species on site at Montebello is lower than would be expected in larger native scrub patches with greater continuity with other natural areas (AECOM, 4.4-13). This is likely due to the degradation and fragmentation of habitat on site associated with oil and gas extraction. The most common reptiles were side-blotched lizard (Uta stansburiana) and western fence lizard (Sceloporus occidentalis). (AECOM, 4.4-13) Both of these lizard species are also common at Inglewood. The most common mammals found were Audubon's cottontail (Sylvilagus audubonii), California ground squirrel (Spermophilus beecheyi), Botta's pocket gopher (Thomomys bottae) and coyote (Canis latrans) (AECOM, 4.4-13). The pocket gopher has also been observed at Inglewood.

One major difference between the Montebello and Inglewood Oil Fields is that the Montebello Oil Field supports the California gnatcatcher (Polioptila californica californica), a federally threatened species. The sage scrub at Montebello supports coastal California gnatcatchers; they are a resident breeder on the site (AECOM, 4.4-12). The gnatcatcher's status requires that the redevelopment of Montebello includes project mitigation measures designed to minimize and avoid direct and indirect impacts to the coastal California gnatcatcher (AECOM, 4.4-1). These mitigation measures were implemented early, before the redevelopment began, and were achieved through creating and enhancing coastal sage scrub on natural slopes with native plant seeds collected from the Montebello Oil Field and the nearby Puente-Chino Hills areas and conducting annual trapping of brown-headed cowbirds (Molothrus ater) (Levine, 2). The brown-headed cowbird is a nest parasite, it lays eggs in the nest of other birds so the other birds may raise its young; this is associated with decreased nest success for the gnatcatcher. The presence of the gnatcatcher at Montebello requires that special attention be paid to restoring its habitat and ensuring long term success of the population despite the site being an active and reveloped oil field.

Environmental Issues

Due to the industrial nature of both sites the Montebello and Inglewood Oil Fields have many environmental issues. There are similar concerns for each site regarding contamination of media such as soil and water. However, one major difference is that contamination concerns from the Montebello Oil Field are associated with groundwater while at Inglewood there are contamination concerns for surface water. This is because groundwater (with the exception of localized, perched groundwater) is relatively deep beneath the site (i.e., approximately 180 feet); this minimizes the potential for adverse impacts to groundwater as a result of relatively shallow soil contamination (MRS, 4.6-16).

Potential sources and transport pathways that could affect groundwater quality in the Montebello Oil Field include large volumes of recycled produced water that have been reinjected since the 1960s to enhance oil production, old oil and gas wells that may be more likely to develop well-integrity issues than newer wells, and oil and gas wells with an uncemented annulus interval that intersects groundwater zones (Stanton et al., 42). Water is injected into wells to displace the oil and increase production from the well. If recycled water migrates to groundwater it can introduce contaminants such as Total Petroleum Hydrocarbons; TPH poses concerns for human health and ecological risk (Entrix Inc., ES-2). This is of a particular concern if groundwater is used for drinking water. Soil contamination is also a concern at Montebello. As of 2010, the estimated volume of petroleum hydrocarbon impacted soil requiring remediation during abandonment and/or redevelopment of Montebello is approximately 41,950 cubic yards (Entrix Inc., ES-10). Sites requiring soil remediation include well sites, the water treatment facility, the gas plant area, and pipelines. The former owner, Chevron, partially completed remediation of historic contamination on site between 1996 and 1997 (Entrix Inc., ES-2). There are several contaminants of concern for soil including TPH, BTEX, and heavy metals like arsenic, cadmium, cobalt, lead, mercury (Entrix, ES-2). All of these contaminants are also likely present in the soil at Inglewood Oil Field; therefore remediation methods that prove successful at Montebello could be applied to Inglewood as well.

Community Involvement

Montebello Oil Field and Inglewood Oil Field are unique in that they are both in the midst of densely populated areas. This had led to both sites having a history of community involvement in the management and redevelopment of the fields. The Inglewood Oil Field is under an additional set of regulations that protect the surrounding communities. The additional regulations come from the Los Angeles County Baldwin Hills Community Standards District (CSD). When adopted in 2008, the CSD was the most comprehensive site-specific set of regulations for any oil field in the state of California (Inglewood Oil Field). The CSD includes provisions such as a Community Advisory Panel designed to enhance communication between community representatives, the county, and the oil company; plans to reduce noise and odors associated with the field, a Community Alert Notification System or an automatic notification system in the event of an emergency related to operations, and an Annual Drilling Plan that identifies future oil field drilling activity and enhances the public's awareness of future planned activities (Inglewood Oil Field, Baldwin Hills CSD). The City Council of Culver City also plays a role in managing the field. The portion of the field that is within Culver City limits is in the process of terminating operations. This is due to an Oil Termination Ordinance adopted by the City Council of Culver City on October 25, 2021. Sentinel Peak Resources challenged the ordinance and a Settlement Agreement between the city and Sentinel was executed on December 7, 2023, to resolve Sentinel's potential legal claims (City of Culver City).

The redevelopment of the Montebello Oil Field has also included community involvement through litigation intended to prevent the redevelopment of the site. The environmental impact report for the Montebello Hills Specific Plan was challenged by Citizens for Public and Open Participation, stating that it was adequate. In 2016, the Superior Court of Los Angeles County rejected the lawsuit challenging the environmental impact report and allowed the housing development to go forward. (Sprague, Judge rejects environmental lawsuit). In 2018, this decision was upheld by the California Second District Court of Appeals (Sprague, Court gives OK).

Remediation Practices and Redevelopment Plans

The remediation and redevelopment of Montebello Oil Field is centered around creating housing and green space. The entire oil field is 488 acres and 174 acres will be used for the housing development (Sprague, Judge rejects environmental lawsuit). However, although part of the field is now zoned for housing, no changes to oil operations are planned or included as part of the redevelopment plan (Cook Hill Properties LLC et al., 3-3). All operational pipelines within the residential development area will be located underground and outside of residential lots (Cook Hill Properties LLC et al., 3-3). Further, no structures will be built over an abandoned well head and all habitable areas are required to be located a minimum distance of 100 feet from the well head of an operating oil well (Cook Hill Properties LLC et al., 3-3). The area designated for open space, approximately 314 gross acres or 64% of the site, will also be used for oil and gas production as well as for public facilities like trails and a habitat reserve for the California gnatcatcher (Cook Hill Properties LLC et al., 4-4).

Due to the industrial past of the Montebello Oil Field there were several planned remediation methods to address the contamination of the site. Many of these methods were aimed at addressing soil contamination. Site Specific Cleanup Levels for contaminants such as

TPH in groundwater and soil, and VOCs and metals in surficial and deep soil were established based on the results of the fate and transport analysis, human health risk assessment, and ecological risk assessment (Entrix Inc., ES-2). All soil containing compounds above the Site Specific Cleanup Levels are to be excavated, and the excavated soil will then be treated for disposal or reused during grading (Entrix Inc., ES-4). Management of contaminated soil also included treatment on-site in a biocell with bacteria or through thermal desorption, or trucking offsite for disposal at an appropriate landfill or treatment at an offsite facility for reuse (Entrix Inc., ES-4). The oil field and the adjacent area also underwent habitat restoration. As part of the requirements for the housing project, there were several restoration projects completed before development began to increase quantity and quality of coastal sage scrub on site. For example, as of 2014, 67.7 acres of coastal sage scrub had been created on natural slopes and 78 acres of coastal sage scrub had been enhanced on natural slopes (Levine, 2). Further, in 2011, as part of routine maintenance of retention basins, the oil field operator was required to restore the conservation values of approximately 1.35 acres of riparian habitat in connection with a Streambed Alteration Agreement between the California Department of Fish and Wildlife and the oil company (AECOM, 4.4-4) The restoration actions were considered to be beneficial to the existing California gnatcatcher population by increasing the quantity and quality of coastal sage scrub on site (AECOM, 4.4-3).

The Inglewood Oil Field will be redeveloped into a new mixed use community with residential, commercial, and public uses. However, unlike at Montebello, oil and gas operations will cease entirely as the site is redeveloped in phases. Part of the redevelopment is driven by the Oil Termination Ordinance established by the City Council of Culver City. The ordinance gives several guidelines and deadlines regarding the termination of oil extraction in the portion of the field located in Culver City. For example, as of November 24, 2021 onwards, drilling of new wells and redrilling of existing wells is prohibited in the Culver City portion of the field (City of Culver City). Further, by December 31, 2027, 15 wells must be capped in the Culver City portion of the field and by December 31, 2029 all remaining wells must be plugged and abandoned and the Culver City portion of the field must be closed (City of Culver City).

Lessons from Montebello

Due to the similarities between the Montebello and Inglewood Oil Fields, there are several redevelopment strategies and lessons learned from Montebello that can be applied to Inglewood. The first redevelopment strategy that can be applied to Inglewood is that habitat restoration prior to redevelopment is beneficial to maintaining healthy and productive ecosystems. Creating and enhancing coastal sage scrub habitat have resulted in a total of 147.2 acres of coastal sage scrub on site and an approximately twofold increase in the overall percent cover of native shrubs. (AECOM, 4.4-4). Increasing native plants is beneficial as native plants support a greater diversity of species than non-native plants. This is because native plants and native wildlife often form symbiotic relationships that non-native plants species cannot support.

Another redevelopment strategy from Montebello that can be used at Inglewood are the soil remediation and management methods. Many of the contaminants of concern found at Montebello are also a concern at Inglewood. The efficacy of the remediation methods used at Montebello should be examined and the most effective ones should be used at Inglewood. Finally, the conflict between the citizens and the city of Montebello shows the importance of effective communication regarding redevelopment. Litigation, like those instigated by Citizens for Public and Open Participation, could have been avoided if community concerns were properly addressed and there was effective communication between citizens, the city, and developers. The Baldwin Hills CSD already has several provisions that address this issue; these should continue as Inglewood is redevelopment to avoid conflict.

Appendix E: Low Impact Development

In February 2024, a prolonged atmospheric river triggered widespread flooding in Southern California, prompting evacuations and causing hundreds of mudslides. Even after the main system moved away, a secondary one intensified rainfall, setting new records. Some areas received over 14 inches in five days, with downtown L.A. experiencing its second-wettest three-day period on record. Since October, downtown L.A. has received 118% of its average annual rainfall, with higher elevations seeing the highest totals, while coastal cities received less rain (Toohey and Fry). Given this context and the amount of impervious surfaces in close vicinity to the site, it is strongly recommended that a stormwater system is implemented as an integral part of a sustainable design approach. Such a system would play a crucial role in alleviating the impacts of urban flooding exacerbated by various factors, including ineffective runoff management, deteriorating drainage infrastructure, and heightened runoff from local developments. Addressing issues such as sewage and stormwater backups, construction obstructions, and insufficient drainage maintenance is imperative to mitigate flood risks effectively.

In proposing an eco-friendly and sustainable framework for restoring the Inglewood Oil Field, it's evident that implementing such a strategy would contribute significantly to environmental restoration and serve as a proactive measure against urban flooding. By embracing sustainable practices, including stormwater management systems, resilient ecosystems can be created during the restoration process to withstand extreme weather events while promoting biodiversity and enhancing community well-being (The Growing Threat of Urban Flooding 8).

Furthermore, the Low Impact Development (LID) approach emerges as a promising ecologically-based stormwater management strategy (Low Impact Development: A Design Manual for Urban Areas). It emphasizes soft engineering techniques to manage rainfall on-site through a vegetated treatment network. Unlike conventional methods that rely on "pipe-and-pond" conveyance infrastructure, LID aims to sustain a site's pre-development hydrologic regime. It achieves this by employing techniques such as infiltration, filtration, storage, and evaporation of stormwater runoff close to its source. Utilizing distributed treatment landscapes, LID helps remediate polluted runoff and promotes sustainable stormwater management practices (The Growing Threat of Urban Flooding).

In conclusion, the proposed eco-friendly framework for restoring the Inglewood Oil Field addresses environmental restoration and urban flooding concerns. Given the prevalence of impervious surfaces nearby, integrating a stormwater system is crucial to mitigate flooding, address sewage backups, and prevent polluted runoff from damaging soil. The Low Impact Development (LID) approach offers a promising solution, emphasizing soft engineering techniques such as on-site rainfall management, infiltration, and filtration. By implementing these sustainable practices, the framework not only remediates polluted runoff and enhances bi odiversity but also safeguards against extreme weather events. Overall, the eco-friendly framework serves as a model for environmental stewardship in urban areas, supporting the restoration and long-term health of the soil ecosystem.

Appendix F: Geothermal Candidate Wells

Well Number	Latest Wtr Yield	Total Depth	Prod Status	Latitude	Longitude
655	60672	9165	ACTIVE	34.002296	-118.368729
412	21999	3018	ACTIVE	34.000145	-118.37014
400	2030	2904	ACTIVE	34.002728	-118.373169
399	66292	2950	ACTIVE	34.002762	-118.373108
394	0	3025	ACTIVE INJ	34.002686	-118.370033
131	0	3477	ACTIVE INJ	34.009033	-118.379387
100	26609	3690	ACTIVE	34.01255	-118.383865
1	25917	3696	ACTIVE	34.010921	-118.38385
381	25227	2560	ACTIVE	34.002254	-118.368759
129	36578	2835	INACTIVE	34.008713	-118.3787
274	41235	2660	ACTIVE	34.008213	-118.372505
36	3101	0	INACTIVE	34.008408	-118.382813
4214	0	6391	INACTIVE	34.010536	-118.380463
437	0	0	INACTIVE	34.004013	-118.375015
605	0	3610	INACTIVE	34.008003	-118.374199
5642	12250	0	ACTIVE	33.999996	-118.369987
4581	28310	3206	ACTIVE	34.00391	-118.373466
4214	29869	6391	INACTIVE	34.010536	-118.380463
4564	46686	3031	ACTIVE	34.001637	-118.374092
3254	36798	3408	ACTIVE	34.010357	-118.382813
6632	28318	2580	ACTIVE	34.000336	-118.363678
472	126299	3100	INACTIVE	34.004021	-118.375076
331	49430	3117	ACTIVE	33.997467	-118.363655
3363	33390	3191	ACTIVE	34.008373	-118.382851
5544	38383	3343	INACTIVE	34.00214	-118.370659
5611	30142	3028	INACTIVE	34.000656	-118.37188
5631	24656	3090	ACTIVE	34.000614	-118.371849
4343	84460	3367	ACTIVE	34.0084	-118.376961
367	42213	3259	INACTIVE	34.008354	-118.374115
467	37852	3124	ACTIVE	34.001835	-118.37236
437	0	3400	ACTIVE INJ	34.004013	-118.375015
427	2087	3040	ACTIVE	33.998814	-118.370857
436	51193	3062	ACTIVE	33.998852	-118.37088
438	69865	3200	ACTIVE	34.003883	-118.373413
742	25545	10197	ACTIVE	34.010681	-118.376991
430	54430	2803	ACTIVE	33.996777	-118.368103
450	143343	3136	ACTIVE	34.001739	-118.373299
362	76781	3550	INACTIVE	34.009399	-118.375946
330	67305	2950	ACTIVE	33.998383	-118.362106
221	44878	3412	ACTIVE	34.01033	-118.382751
360	27508	3530	ACTIVE	34.00935	-118.375931
445	54834	3733	ACTIVE	34.002296	-118.368774
447	30247	3000	ACTIVE	33.999077	-118.368233
903	28347	3640	ACTIVE	34.00703	-118.375717
701	1073	3620	ACTIVE	34.008369	-118.377037
901	86599	3640	ACTIVE	34.006737	-118.376366
304	21797	3695	ACTIVE	34.010712	-118.37706
605	0	3610	INACTIVE	34.008003	-118.374199
704	45585	3401	INACTIVE	34.00795	-118.374191
706	94719	3577	INACTIVE	34.008057	-118.374207
805	21805	3435	ACTIVE	34.007896	-118.374184
241	35577	3655	ACTIVE	34.009075	-118.379478
242	55315	3690	INACTIVE	34.009056	-118.379425
421	33807	3067	ACTIVE	34.000175	-118.370293
423	37762	3158	ACTIVE	33.999939	-118.371468
419	36239	2960	ACTIVE	33.997372	-118.367485
424	33838	3150	ACTIVE	34.000603	-118.371956
732	55426	9550	INACTIVE	34.011204	-118.38205
418	27554	3180	ACTIVE	33.999992	-118.369949
401	51314	2755	ACTIVE	34.002636	-118.370026
397	49425	2870	ACTIVE	34.003403	-118.370605
407	23739	3203	ACTIVE	33.999088	-118.368294
99	23598	3422	ACTIVE	34.01107	-118.383713
389	32333	4585	ACTIVE	33.995777	-118.366272
655	40	0	ACTIVE	34.002296	-118.368729
605	0	3610	INACTIVE	34.008003	-118.374199