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# Forensic Environmental Assessment and Hydrology in Louisiana's First Oil Field: A 100-Year Recreation of Historical Land Use

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## Abstract

*Approximately 110 years after the discovery of oil in Louisiana, fourth- and fifth-generation landowners filed a legacy lawsuit to recover damages resulting from alleged environmental contamination of family property from oil exploration, extraction, and storage. As part of the complaint, the descendants claimed that, due to the new technology of the oil industry, their uneducated ancestor could not have had reasonable knowledge and business relationships to fully understand the contracts he signed with oil companies to lease his land for oil exploration. Forensic environmental assessment and hydrology enabled the recreation of the site's historical land use and its potential for environmental impacts. Forensic analyses utilizing records and sources from disciplines typically not consulted in engineering studies provided essential insight into the origins of drainage alterations and contaminant transport across the site, including family records that demonstrated the plaintiffs' ancestors had knowledge of (and contributed to) the site's purported deteriorated conditions.*



## Keywords

Environmental assessment, hydrology, drainage, land use, Louisiana, oil, forensic engineering


## Overview

A lawsuit filed by fourth- and fifth-generation landowners claimed environmental damage of family property resulting from oil exploration, extraction, and storage activities dating back to 1901 in Louisiana's first oil field. As part of the claim, family members alleged that the predecessor oil company took advantage of an uneducated, non-English-speaking farmer to avoid responsibility for environmental damages incurred on his land. Attorneys for the defendant, British Petroleum (BP), approached the author (forensic engineer) regarding the feasibility of reconstructing conditions on the plaintiffs' land before, during, and immediately after oil exploration in context of the larger Jennings Oil Field (site of Louisiana's first successful oil well) from approximately 1900 to the 1930s. Additionally, the defendant's attorneys had specific interest in determining the level of knowledge the original owner and his descendants had regarding early oil industry operations, specific operational activities on their land, and business managerial involvement pertaining to those activities. To address allegations of environmental contamination and lack of landowner knowledge dating back more than 110 years, four key areas of forensic environmental engineering and forensic hydrologic investigations were necessary:

1. Development of the Jennings Oil Field with a focus on Section 47 of Acadia Parish with respect to standard practices impacting the landscape.

2. Construction, use, and operation of earthen storage tanks for oil and produced water.

3. Discharge practices of earthen storage tanks and their effects on drainage and contaminant transport.

4. Knowledge and involvement of plaintiffs' ancestors regarding oil operations on their land.

The forensic engineering (FE) approach utilized ASTM E1527, *Standard Practice for Environmental Site Assessment: Phase I Environmental Site Assessment Process*, to recreate site conditions and personal knowledge dating to the beginning of the 20th century[1]. Since early industrial operations pre-dated governmental reporting requirements typically reviewed as part of the Phase I investigation[2], the list of suggested resources detailed in Section 8.3.4 Standard Historical Sources of ASTM E1527 was instrumental to this FE investigation. That list of sources of

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information regarding the history of property uses, included, but was not limited to, aerial photographs, recorded deeds and leases, court proceedings, United States Geological Survey (USGS) topographic maps, miscellaneous maps, newspaper archives, and local libraries.

Scientific investigations of present-day pollutant concentrations from legacy oil field wastes focus on collection and analysis of water, sediment, flora, and fauna — and on analysis of contaminant transport pathways[3,4,5,6]. While generating considerable data and insight into lingering effects of early oil field operations, such studies do not provide environmental assessments of legacy oil fields when they were in operation.

Site-specific land uses and impacts from oil field operations on natural water bodies that existed more than a century ago require a forensic engineering investigation. A forensic environmental assessment that includes surface water contaminant transport must recreate a landscape and local environment that no longer exist, cannot be sampled, and are beyond the memory of any living person. An equivalent forensic engineering question would be: What was the structural integrity of the steel used in a building constructed 110 years ago that no longer exists? Engineering principles in historic context support the forensic engineer in answering those questions.

Answering historic questions of land use and hydrologic changes — and of specific knowledge by people no longer living — requires a time-series analysis of multiple and varied documents in conjunction with engineering expertise. For land use changes, this is a straight-forward process of comparing maps and aerial photographs to interpret how and why features changed in the time periods between the documents. Interpreting those changes from two-dimensional images to three-dimensional ground conditions requires remote sensing and aerial photography training. Coupling the images with the engineering hydraulics and physics of water, biology of vegetative changes, and construction of oil field infrastructure reveals the history of the land and its drivers for change.

This process is similar when reconstructing a person's knowledge when that person is not available for a deposition. Conducting a reasonably exhaustive search[7] on an individual will produce a multitude of documents, most of which do not specifically answer the question of what a person knew or should have known. Connecting those disparate pieces of information in a time series of documents, however, can reveal when a person gained knowledge of a specific action. For example, the United States federal census includes a question regarding each person's occupation. A time-series analysis of federal census records demonstrates that the original landowner, the uneducated, French-speaking patriarch, self-identified as an "oil king" and the owner of an oil field in 1910[8], whereas his occupation was farming in 1900[9]. Clearly, his situation changed over that decade, supported and confirmed when analyzing contracts and business filings dates pertaining to the oil company he formed after oil was discovered on his property.

To fulfill the scope of charge, this FE investigation consisted of:

1. Literature review of the standard practices of oil extraction/storage and produced salt water disposal from the early 1900s to approximately 1932 and how they were applied to the subject property;

2. Review of lease histories and lawsuits pertaining to the subject property with respect to potentially environmentally damaging practices;

3. Engineering analyses and interpretation of historic maps, aerial photographs, technical reports, and survey data for contemporary land and water alterations resulting from oil extraction and storage on the subject property; and

4. Landowner family history regarding knowledge of oil and gas operations in general and of specific operations on their properties.

## Jennings Oil Field and Section 47

September 21, 1901 was the beginning of the oil industry in Louisiana when Scott Heywood brought in a gusher near present-day Evangeline, Louisiana (**Figure 1**) that "spewed sand and oil for seven hours, until a nearby rice field resembled a black lake[10]." Early oilmen understood crop damage from oil extraction was a possibility. Heywood acknowledged that the flowing oil of that first well ruined several acres of the farmer's (Mr. Clement's) rice field, but he had paid Mr. Clement $10 in advance for any damage that might occur as a result of drilling activities[11]. Thus, the owners understood that oil infrastructure would be constructed on their land if drilling were successful. Original landowners of the subject property in Section 47 were Eugene Houssiere and Arthur Latreille, who signed their first oil exploration lease in April 1901 (five months before Heywood brought in the first successful well). The lease allowed for "mining and operating for oil, gas, and laying pipelines, and of building tanks, stations

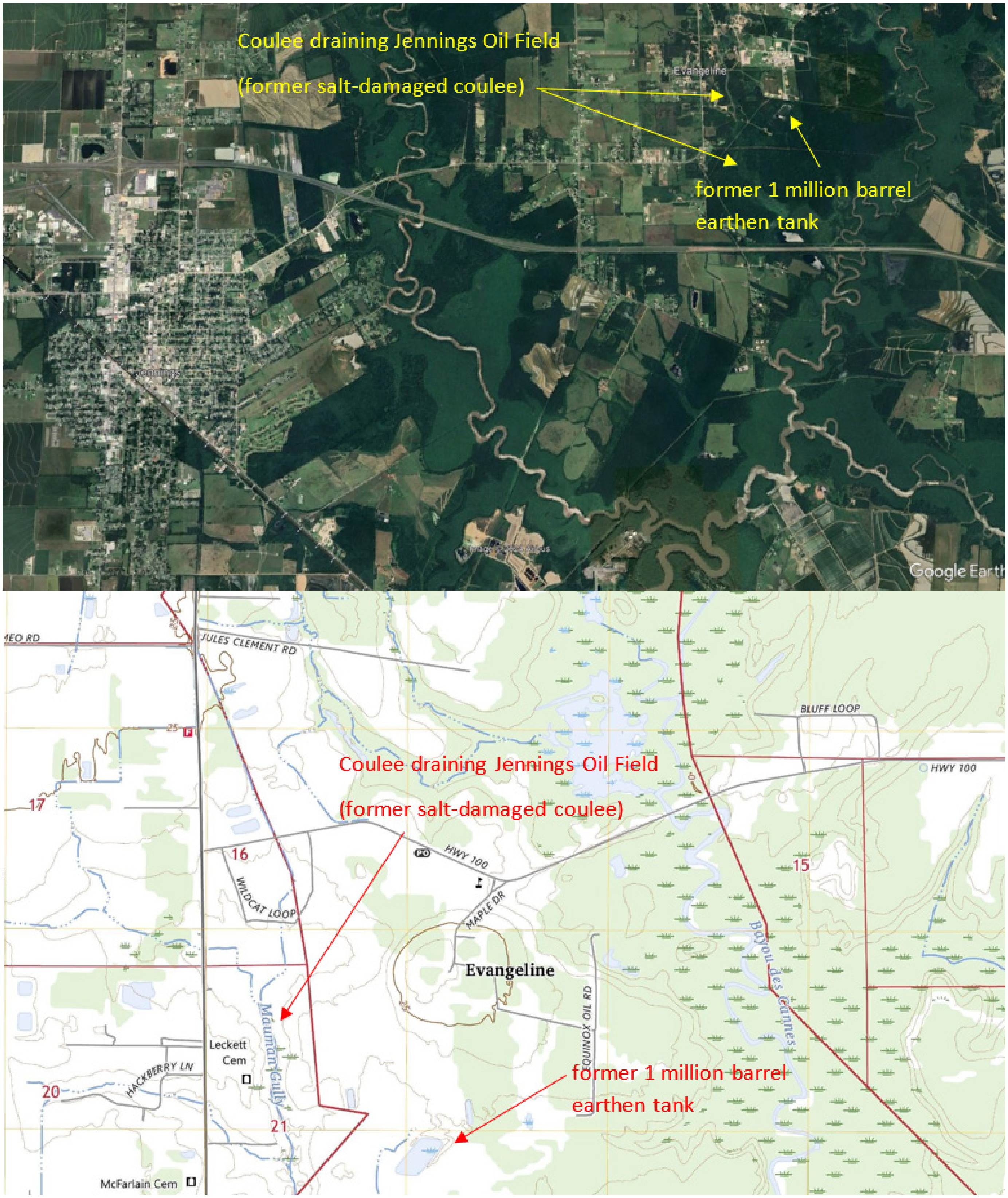



**Figure 1**

Vicinity images of the Jennings Oil Field and Section 47. Evangeline, Louisiana in Acadia Parish is located 40 miles east of Lake Charles, Louisiana. Prior to oil discovery in the Jennings Field, rice farming was the predominant occupation of its residents. French-speaking, uneducated Cajuns were among its early settlers, adding to the complexity of historical investigations in this region. The 1 million barrel earthen storage tank just south of the subject property is still visible in present-day photographs and maps[16,17].

and structures thereon to take care of said products[12].” On August 4, 1904, Producers Oil Company, part of the Texas Company, brought in the first great Jennings gusher on the Houssiere-Latreille tract. Following that success, Producers Oil put down several wells “in rapid succession[13].” By 1906, the Jennings Oil Field had 92 wells, five of which were in Section 47 on the plaintiffs’ land[13]. By 1910, the field had expanded to 445 wells with 73 on the plaintiffs’ land, 57 of which were producing oil[14]. Over the next 90 years, Houssiere family members executed 30 leases for oil and gas exploration on their property in Section 47[15].

Applying environmental engineering expertise and analyzing suggested informational sources detailed in ASTM E1527 for engineering applicability determined the development of the Jennings Oil Field and Section 47 resulted in the following key points in the forensic environmental assessment:

1. The Jennings Oil Field had an environmentally “messy” history of spilling gushers — something not unique to the Jennings Field. These actions were part of the culture of the boom era and universally practiced by operators in early oil fields before the onset of environmental regulations.

2. Rapid development of the Jennings Oil Field contributed to environmental degradation of the field and its surrounding areas. Constructing oil field infrastructure to store and manage crude oil lagged behind successful drilling operations.

## Use of Earthen Storage Tanks

Production in the Jennings Oil Field reached 80,000 barrels daily within a few months of the first successful well. It was a “mad rush to get the oil out first” with the result that earthen tanks built “by the hundreds of thousand barrels each”[11] and above-ground pipelines crisscrossed the field to transport oil from wells to storage tanks to the rail station for shipment to buyers. Building earthen tanks to store oil prior to shipment was an oil field practice that became the norm[11] throughout the field. Even when storage capacity exceeded three million barrels (with oil transported from the field through pipelines and rail cars), storage remained a significant problem[10].

The USGS determined that tankage in the Jennings field at the close of 1904 was about 30,000,000 barrels — the larger portion of which was in earthen reservoirs. Their opinion was that earthen tanks had been “found fairly satisfactory” and much cheaper than steel tanks. The USGS additionally commented that some of the earthen tanks had “nothing done to them beyond excavating to the required depth” while others were lined with timber or were covered with a “light board roof.” Their estimate of an earthen tank’s capacity was 25,000 to 350,000 barrels[13].

The U.S. Bureau of Mines provided guidance in reservoir construction, suggesting that “the outside slope of the embankment... when finished should be thoroughly sprinkled with oil” to prevent bank erosion during heavy rains. They further commented that “it is good practice when the reservoir is in use to oil the slope two or three times a year” to prevent vegetation growth and subsequent death, which (when dry) was a fire hazard[18].

Contemporary newspapers from 1902 to around 1920 reported oilmen “believed” the “immense earthen oil tanks” were the “proper” method for handling the millions of barrels of oil. When tanks were “properly constructed,” the “siepage [sic] is not thought to exceed one-fourth of an inch,” and it was “claimed” that the sediment associated with the crude oil, asphaltum, and paraffin prevented oil from seeping farther into the earth[18]. Scott Heywood’s brother, Alba, testified that Jennings-Heywood Syndicate earthen tanks experienced “only 10 percent” oil losses to seepage, leakage, and evaporation[19].

Seepage losses varied due to construction methods, soil types, and oil characteristics. Wooden-lined tanks built on clay soils tamped by mules or machines had lower loss rates than tanks constructed solely from plowing dirt to the depth of the underlying clay and pushing it to the outside to create impounding levees[20]. Oil seeps were commonly observed through levee walls and on the ground adjacent to the tanks[21,22]. As oil was a valuable commodity, tank owners attempted to recapture as much of the seeped oil as possible by building ditches or moats around the perimeters of their tanks and using pick-up pumps to return oil to the reservoirs (**Figure 2**).

Between the smaller, immediate-need well storage pits and the larger, longer-term collection earthen tanks, the Jennings Oil Field became dotted with open pits resembling oil lakes, visible in aerial photographs as late as the 1950s (**Figure 3**). In **Figure 3** and subsequent figures, the outlined areas mark the boundaries of the plaintiffs’ properties at issue in this case.

Oil was not the only liquid stored in the massive earthen tanks. Produced water was an unwelcomed by-product of oil drilling operations. Heywood called it the “fatal salt

**Figure 2**
Photograph looking northeast on the Houssiere-Latreille property of earthen and steel oil tanks with pipelines, collection ditches, and pick-up pumps. For scale, a man stands in front of an earthen oil storage tank. Its containment levee is taller than the man. Wooden oil derricks on Houssiere-Latreille property are visible in the background[23]. See **Figure 5** for a plan view of this location on the Hervey map.

water intrusion[11]." As will be discussed in the following section, initially, the salt water drained across the oil field to naturally low areas, collected in the central coulee, and eventually discharged into Bayou Des Cannes, contaminating streams and ruining rice fields.

Oil producers argued "the Record clearly establishes that there is no way to care for the salt water that comes up from the ground with the oil, than to allow it to flow to the Gulf in the natural drain[25]." Further, they stated that "the discharge of salt water is practically a condition upon which the ordinary use and enjoyment of oil lands depends. The discharge of salt water is part and parcel of the process of mining oil... ." This opinion was also shared by the Heywood Oil Company, Bass & Benckenstein, and the Texas Company in their brief to the Louisiana Supreme Court, "[salt] is not a merchantable commodity. It must be gotten rid of. And the natural outlet is toward the sea from whence it came[26]." Thus, early oilmen understood produced water could impact soils and water as it flowed

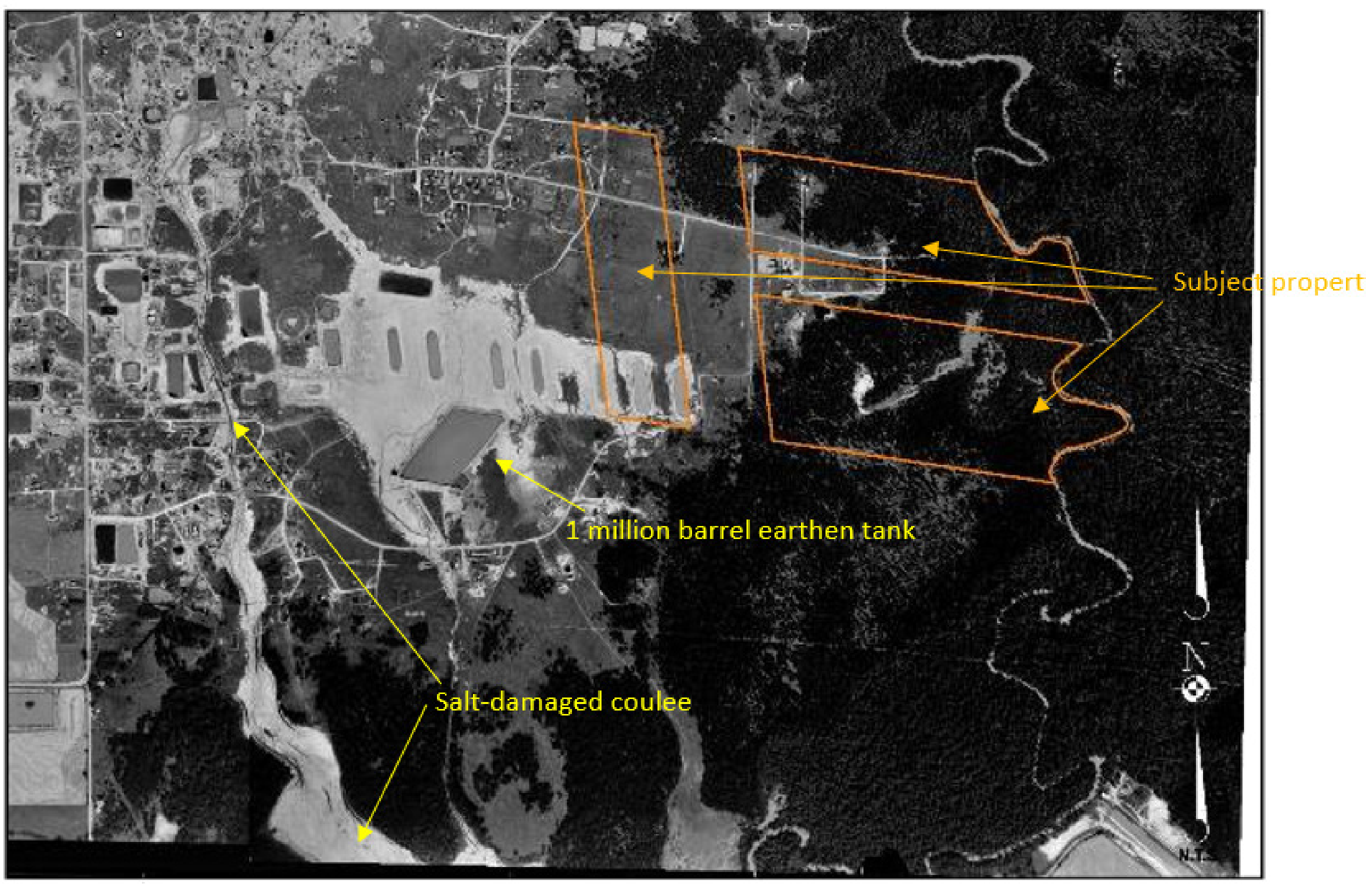



**Figure 3**
Photograph of the three properties of interest outlined in orange in Section 47 and of Jennings Oil Field in 1953. Massive earthen storage tanks are obvious on the Houssiere-Latreille and surrounding properties. Bayou Des Cannes is on the eastern edge of the subject property. The salt-damaged coulee from the center of Jennings Field is in the southwestern portion of the photograph[24]. The outlines of the three properties of interest will also appear on subsequent images.

downstream, but the best way to remove it from the oil field was to allow it to drain naturally. As will be discussed in the following section, oil field infrastructure altered those natural drainage patterns in the Jennings Oil Field.

Several thousand barrels of produced water accompanied several hundred barrels of oil — a ratio that led to the next big storage problem in the Jennings Oil Field. The problem was so pervasive that state legislators enacted a law requiring oil field operators to store the produced water from March 1 to September 1 (the rice growing season) and release it into natural waterways during fall and winter months. According to Heywood, "when this law went into effect, the old empty earthen tanks became as valuable to store salt water as they had been to store crude petroleum[11]."

By the 1920s, the petroleum industry recognized that large quantities of salt water that accompanied field production were becoming storage and disposal problems. The technical means of minimizing or eliminating the effects of produced water upon the environment were much less obvious, and, for a lengthy period, field operators contended with a shortage of scientific data on which to base disposal efforts. In practice, technical advances for brine disposal and their applications to new and existing fields lagged behind the accelerating pace and geographic range of field exploration and development[27].

Among early professional reports, the U.S. Bureau of Mines published *The Disposal of Oilfield Brines* nearly three decades after the discovery of oil in the Jennings Field. Their work provided a review to date of knowledge on the subject and noted that the "disposal of brines produced with crude oil and natural gas has long been a constant source of trouble to oil and gas operators, as well as to farmers and stock-raisers in the vicinity of producing fields[28]."

In Louisiana, the number of fields increased dramatically, quadrupling total production of oil and gas during the decade. Each field had unique characteristics that affected which methods were appropriate for its production, storage, and disposal. During the 1930s, brine discharge continued to surface impoundments or to water bodies[27]. The initial slow pace of engineering advancement for oil field brine disposal did not indicate the quest for improved methods of disposal had ceased, and, during this period, associated problems became better understood.

A patent filed in 1937 stated, "Another important factor in the operation of such an oil well is the disposal of the salt water recovered with the oil. Several solutions have been tried but in every instance are open to conspicuous objections. … When this refuse salt water can be impounded in storage pits, this practice is frequently followed. However, the maintenance of storage pits is subject to limitations both as to capacity and feasibility of locating them near the head of the well… . In many instances, the salt water is allowed to drain into existing running streams, but, in this case, there is a limit to what can be done without acting contrary to the public interest or infringing upon the rights of neighboring land owners[29]." Until engineers developed a viable solution to produced water disposal, natural drainage outlets would continue, albeit as the least preferred method.

Among the leading entities in advancing oilfield disposal practices, the American Petroleum Institute (API) was the first national trade association for the oil industry[30]. In 1920, API began collecting and publishing oil industry statistics. That effort continues today as a leading and credible source of industry data utilized worldwide. The organization also developed and published industry standards, recommended practices, and policies beginning in 1924[31].

At the annual meeting of the Production Division of the API in 1930, V.L. Martin, Chairman of the Standing Committee on Disposal of Production Wastes, reported "suggested remedies" to production waste disposal. His suggestion as "the most practical [method] of salt water disposal at present seems to be accomplished by dilution." That is, disposal into natural water bodies. He further stated, "While such practice is contrary to law, it is the only method available which will reduce the potential damage to water supplies[32]." In other words, dilution is the solution to pollution, according to the API in 1930.

During the 1931 meeting, V.L. Martin reported an update on the Standing Committee on Disposal of Production Wastes, stating that his committee's accomplishments were "not up to [their] own expectations,[33]" due in large part "to the lack of pertinent data to such work." He stated that, "The committee feels that it cannot recommend any radical changes in methods of disposing of wastes without setting out definitely the objectionable effects resulting from present methods of disposal… . To date, we have been unable to secure any authoritative information as to the effects of production division wastes on live stock, land, vegetation, surface water, etc."

Twelve years into its work supporting the petroleum industry and recommending best practices, standards, and policies, the API continued to lack the necessary data to produce a standard of practice for the disposal of produced water, leaving operators to follow best practices and legal restrictions applicable in their areas of operation. While no longer on the "bleeding edge" of oil field management, operators in the Jennings Oil Field were nonetheless on the "leading edge," operating without industry standards regarding brine disposal but within well-known, acknowledged industry practices.

Applying environmental engineering expertise and analyzing suggested informational sources detailed in ASTM E1527 for engineering applicability determined earthen storage tanks resulted in the following key points in the forensic environmental assessment:

1. Earthen storage tanks were widely used, obvious features in the Jennings Oil Field.

2. It was common knowledge that earthen storage tanks seeped oil. Oil field infrastructure included ditches and pumps specifically to recapture seeped oil.

3. Produced water became an environmental contaminant on land and in water bodies located downstream from the Jennings Oil Field, necessitating its storage during the agricultural growing season.

4. For more than 30 years, surface storage and direct discharge into surface water bodies were well-known, acknowledged, and accepted practices for produced water storage and discharge.

5. Earthen tanks were present at least into the 1950s on the subject land and throughout the Jennings Oil Field — even after improved storage and transportation made them obsolete.

6. The time line of direct disposal of produced water into natural water bodies continued at least into the 1930s — 30 years after the discovery of oil in the Jennings field.

## Salt Water Discharge, Hydrology, and Drainage

As a waste by-product, produced water from oil operations freely flowed across the oil field surface, collected in ditches and coulees, and ultimately discharged into Bayou Des Cannes. Within four years of the first successful oil well, environmental damage from salt water discharges was evident in downstream rice fields. On August 21, 1905, William McFarlain filed suit against many of the operators in the Jennings Oil Field for oil and salt water damage to his downstream property[34]. Civil Engineer J. H. Hervey surveyed the Jennings Oil Field in response to the lawsuit filed by McFarlain, stating his map "was intended for a drainage map and tankage map" (**Figure 5**). When questioned about how waste oil drained from the wells, Hervey testified that "it goes thru [sic] the ditches that were made by natural drainage to the natural drainage of the main country[35]."

Researchers have utilized extensive soil, water, flora, and fauna sampling/testing to track past oil field produced water drainage into surface waters and groundwater[3,4,5,6]. Employing forensic environmental assessment and forensic hydrologic engineering through the methodology detailed in ASTM E1527, while not providing constituent concentrations, provides analyses of conditions contemporary to times of oil field operations.

The USGS EarthExplorer website[36] has multiple data sets of historic aerial photographs for use in a time-series analysis. For example, a historic aerial photograph and map time-series analysis shows the evolution of the natural drainage coulee in the center of the Jennings Oil Field to a salt-damaged drain through downstream fields and into Bayou Des Cannes from 1905 to 1953 by interpreting important land characteristics as they change. **Figure 4**, a 1933 aerial photograph, provides additional context to **Figure 5**, the 1905 field map, and to Hervey's salt water drainage description.

In **Figure 4**, two water bodies border Section 47 of the Jenning Oil Field: Bayou Des Cannes to the east and the central drainage coulee to the west. Even though the photograph does not contain topographic data, the "water flows downhill," or down elevation gradient, understanding of hydrology informs the forensic hydrologist that higher elevations are present between those two water bodies. The central coulee is a low elevation linear feature in this landscape — surface water flows into it. The central coulee drains downstream (downhill) to Bayou Des Cannes, an even lower elevation linear feature. Also, natural ditches and bayous typically increase in width as they flow downstream due to additional runoff they receive and transport along their paths to their discharge points in larger water bodies. In between low elevations natural drainage channels higher points of elevation must exist[37].

Vegetation differences evidenced in **Figure 4** also indicate elevation differences, thus, hydrology and drainage directions. Vegetation on land closer to natural water bodies is dense with tree canopies; vegetation farther away (uphill) is dense with prairie grasses (or rice). Upland

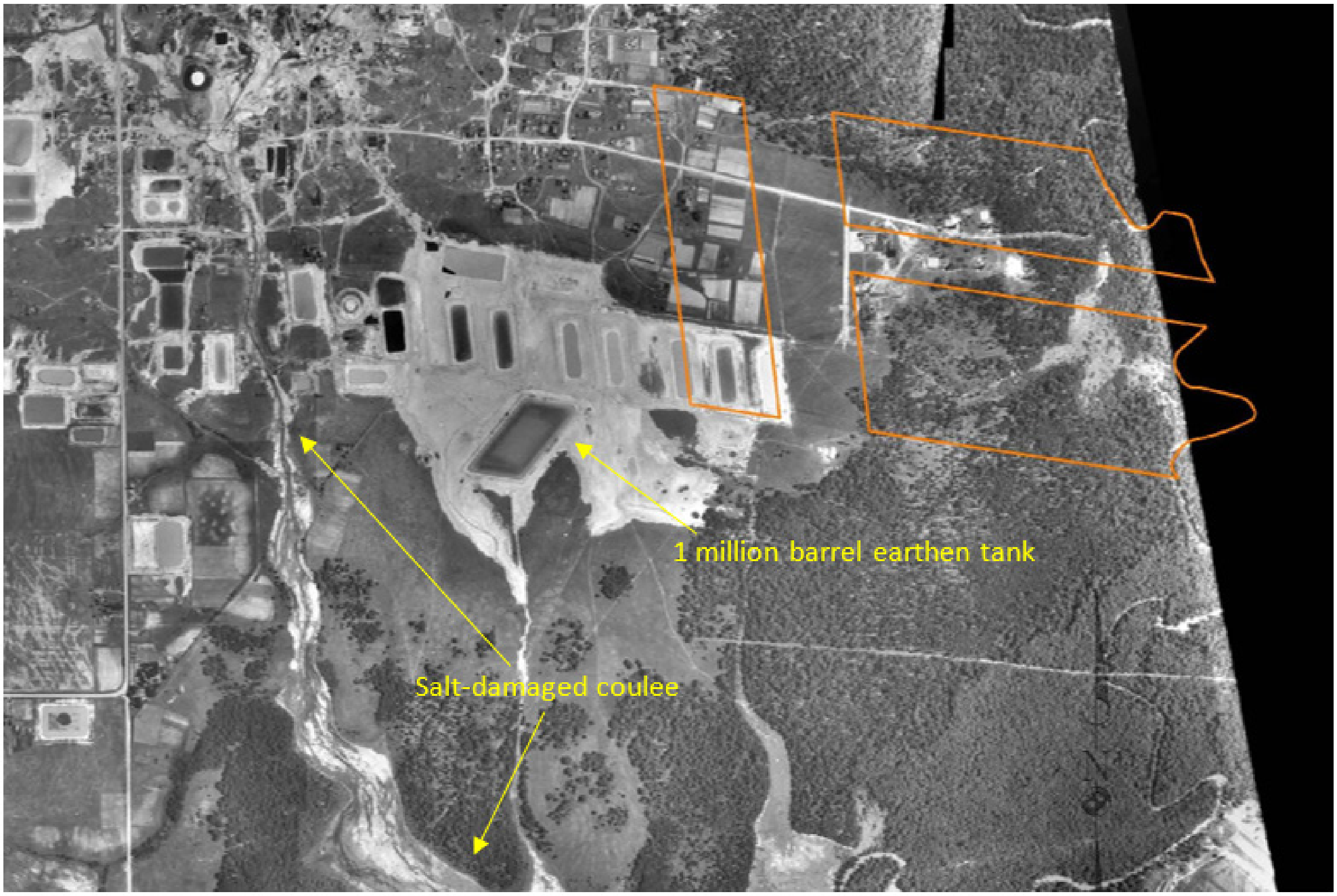
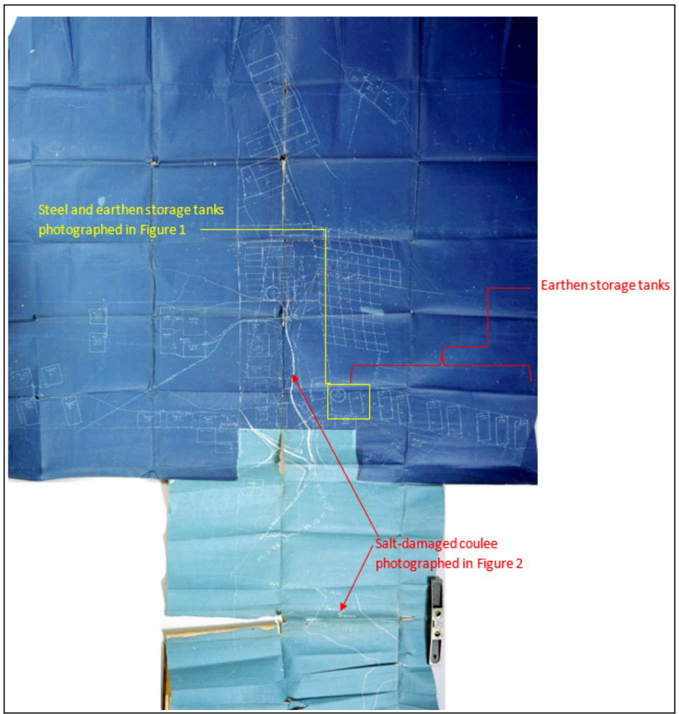



**Figure 4**

The earliest photograph of the three properties of interest dates to 1933[39]. The light-colored area in the center of the photograph illustrates vegetation removal as part of safe operational practices around open crude oil storage tanks. Light-colored meandering shapes along natural drainage pathways illustrate salt deposits or salt scarring of the land by produced water.




vegetation cannot grow and survive in wetter soils. Wetland vegetation present in low-lying elevations close to water bodies possess evolutionary adaptations that allow it to grow in saturated conditions[38]. The first successful well in Jennings Oil Field was in Mr. Clement's rice field, located in the northwestern corner of **Figure 4**. Although oil operations have disturbed the natural and cultivated vegetation in the vicinity of his former rice field, vegetated land extant is farther from natural water bodies and presents as grass (not tree canopy). Therefore, vegetative patterns also support north-to-south natural drainage through the oil field with west-to-east drainage closer to Bayou Des Cannes. It is

**Figure 5**

Hervey map detailing the Jennings Oil Field, specifically the drainage and earthen storage tanks on and near plaintiffs' properties. Oil field infrastructure had begun altering the natural drainage pattern by 1907 when Hervey produced this map. Produced water flowed down the center coulee and discharged into the rice field south of the Jennings Oil Field, ruining crops. Ultimately, the salt water entered Bayou Des Cannes, contaminating irrigation water of downstream farmers[23].

important to note that vegetation changes from winter leaf-off or drought killing grasses, for example, could reflect the dates of the photographs versus environmental responses to possible contaminant transport.

Color variations in **Figure 4** also provide information on vegetation and drainage impacts from oil operations. The lightest colors are predominantly locations devoid of vegetation, that contain infrastructure, or are salt scarred. Locations devoid of vegetation are generally by design in **Figure 4** (e.g., the tops of banks of earthen tanks and land between and around earthen tanks). Dying vegetation was a fire hazard in an open field; appropriate maintenance would have been to minimize vegetation near crude oil facilities. The presence of infrastructure generally creates straight lines or geometric patterns (straight lines and right angles are rare in nature). Longer linear features are roads, while smaller square or rectangular-shaped features are typically buildings. However, larger square or rectangular shaped features can be bare fields.

Knowing land uses of the surrounding areas is essential to differentiate geometric shapes of similar sizes when viewing two-dimensional images. Salt scarring is easily confused with a lack of vegetation near oil field infrastructure exposed to produced water. For example, the central area of **Figure 4** is likely a combination of vegetation removal for safety and salt deposits from produced water. The easiest method to distinguish salt scarring from produced water runoff and contaminant transport is to analyze the shapes of the light areas farthest from the earthen tanks. A non-geometric, naturally meandering pattern strongly suggests salt scarring from overland flow of produced water versus vegetation loss by design. The salt water follows the natural (or altered) drainage patterns determined by topography. Produced water has a higher density than fresh water, so it moves as a stratified layer along the bottom of the drainage ditch and under the fresh water precipitation. Also, salt in produced water does not evaporate with the water. Thus, the lightest colors in **Figure 4** present in meandering patterns along drainage paths are more likely to be salt deposits (scarring) than vegetation removal.

The time-series analysis approach requires applying the techniques used to analyze **Figure 4** to subsequent chronological photographs. Comparing the 1933 aerial photograph (**Figure 4**) to the 1940 aerial photograph (**Figure 6**), the 1940 image shows vegetation returning to the western fringes and in the northwestern portion of the wooded area[40]. Land to the south of the salt-scarred coulee is less vegetated than in 1933. The area around the large

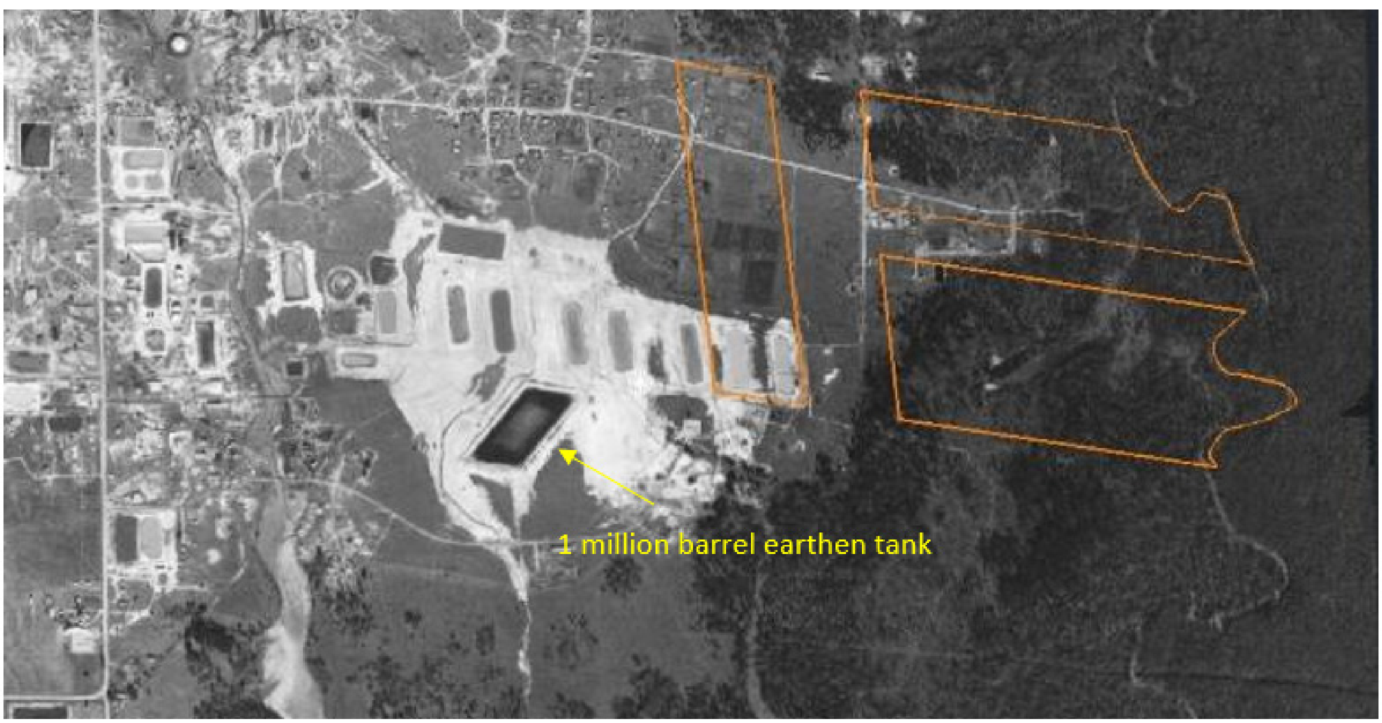
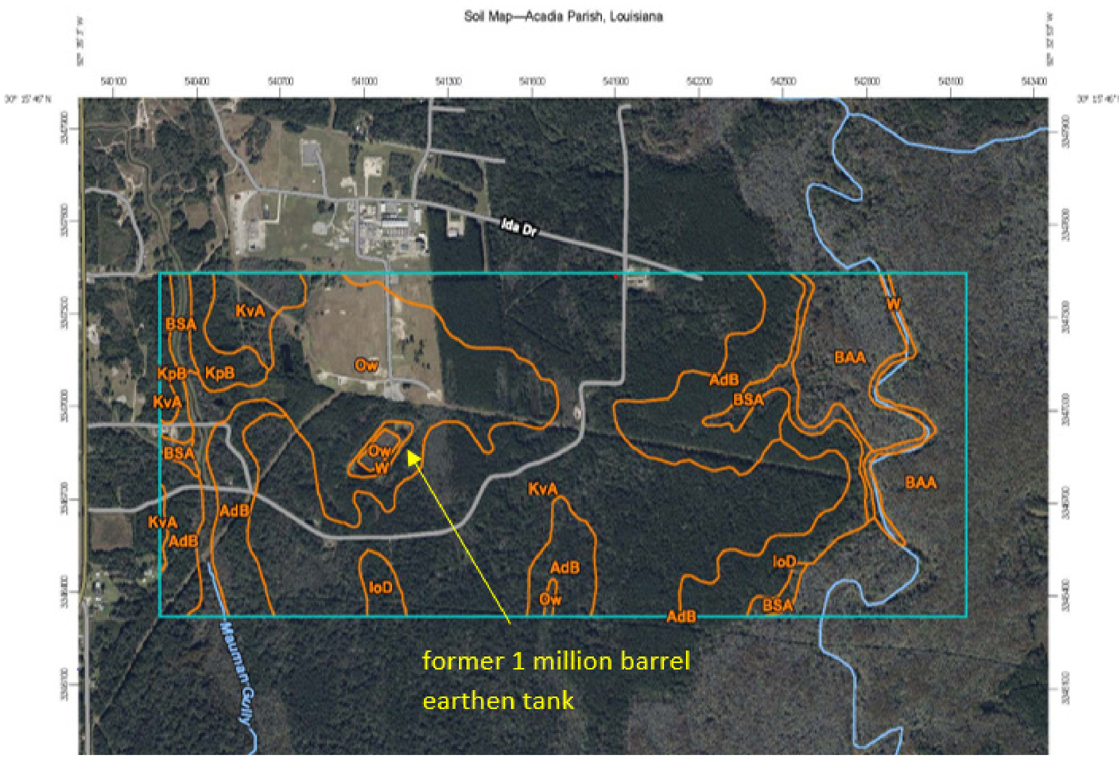



**Figure 6**

A 1940 aerial photograph of the subject property and surrounding area[40]. Comparing this photograph to the 1933 photograph as part of a time-series analysis illustrates changes on the land surface. When performing the FE analysis, it is important to determine the date of the photographs to account for seasonal changes with respect to water levels and vegetation growth.

earthen tanks appears to be slightly re-vegetated. The tank on the northern edge of the southern portion of the subject property appears to drain to the edge of the sparse vegetation through a small ditch. This tank was likely used to store salt water until it could be discharged during the regulated months between September and March, and the ditch likely directed the discharge to minimize the impact of the overland flow of the salt water. Support for this conclusion comes from undisturbed soil types in the subject area. Silty loam soils on the subject property facilitated drainage toward Bayou Des Cannes while the frequently flooded Basile and Brule soils adjacent to Bayou Des Cannes (**Figure 7**)




| Map Unit Symbol | Map Unit Name | Acres in AOI | Percent of AOI |
|---|---|---|---|
| AdB | Acadiana silt loam, 1 to 3 percent slopes | 104.1 | 13.1% |
| BAA | Barbary mucky clay, 0 to 1 percent slopes, frequently flooded | 132.1 | 16.6% |
| BSA | Basile and Brule, 0 to 3 percent slopes, frequently flooded | 22.3 | 2.8% |
| IoD | Iota silt loam, 3 to 8 percent slopes | 37.4 | 4.7% |
| KpB | Kaplan silt loam, 1 to 3 percent slopes | 18.3 | 2.3% |
| KvA | Kinder-Vidrine complex, 0 to 1 percent slopes | 343.2 | 43.1% |
| Ow | Oil-waste land | 128.0 | 16.1% |
| W | Water | 10.9 | 1.4% |
| **Totals for Area of Interest** | | **796.5** | **100.0%** |

**Figure 7**
Present-day soil survey on the subject properties and surrounding land[41]. For areas unaltered by oil field operations, present-day data informs past hydrology and drainage patterns on the subject land. Interestingly, the 1 million barrel earthen tank just south of the plaintiffs' properties presently map as oil-waste land and water — the remaining tank infrastructure continues to hold water.

encouraged produced water ponding, leading to salt scarring shown in the 1940 photograph (**Figure 6**)[41].

Extending the aerial photograph time-series analysis to more recent decades, available in GoogleEarth, reveals that in the half century since the 1940 photograph, the subject area was no longer an active oil field, and the two large, earthen storage tanks on the subject property were severely degraded (**Figure 8 top**). The eastern tank appears filled in with sediment and its perimeter levees removed, while the western tank retained its shape and ability to hold liquids, although greatly reduced in capacity. More than 100 years after the discovery of oil on the subject property, the area appears environmentally recovered with healthy vegetation covering locations of former earthen tanks (**Figure 8 bottom**). In fact, the entirety of the Jennings Oil Field experienced immense recovery from 1995 to 2009 with the dozens of earthen storage tanks infilled and closed and the main coulee revegetated over its former salt scars.

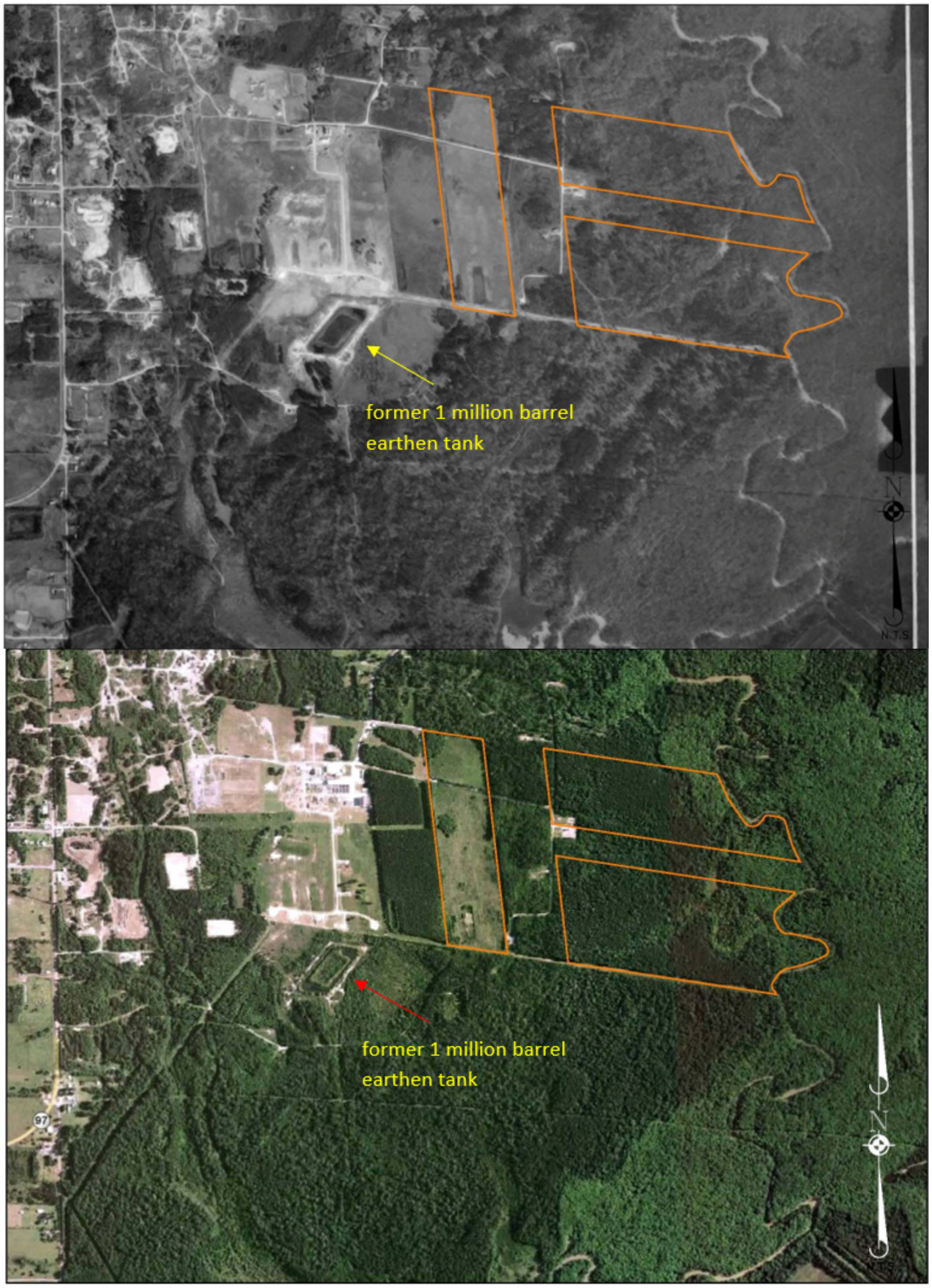
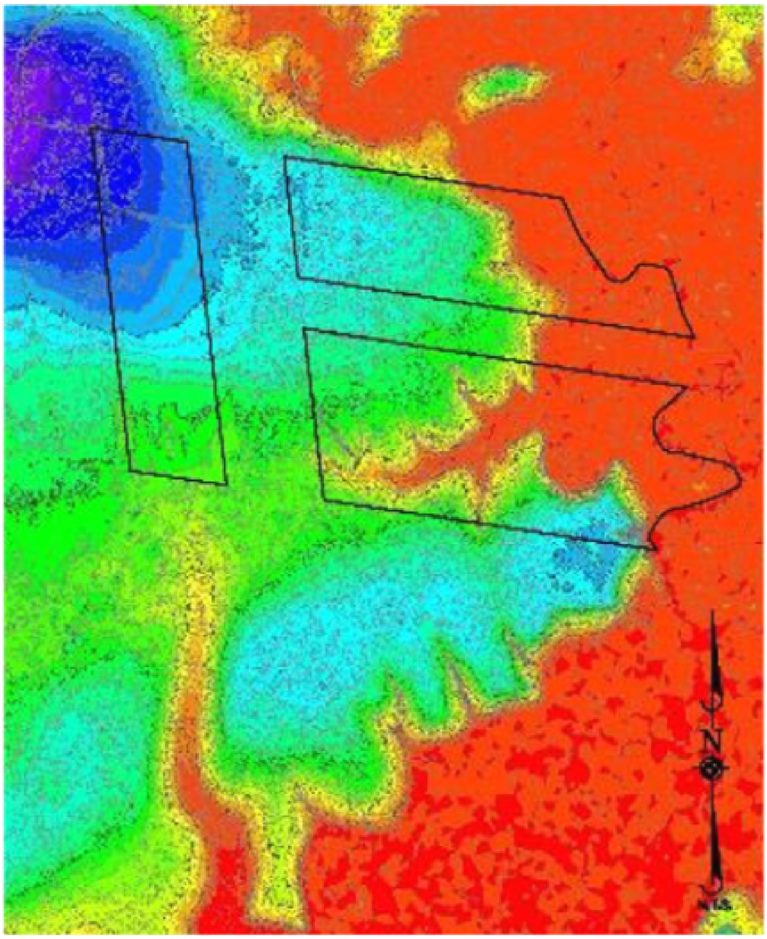



**Figure 8**
1995 (top)[42] and 2009[43] (bottom) aerial photographs of the subject property and surrounding area. The Jennings Oil Field experienced immense recovery from 1995 to 2009 with the closure of earthen storage tanks and revegetation in previously denuded areas.

Coupled with the historic drainage map and aerial photographs, a present-day topographic map utilizing LiDAR (Light Detection and Ranging) data provides further insight into historic drainage patterns. Small topographic features difficult to discern on hand-drawn maps and large-scale aerial photographs are more evident in the millions of data points collected with LiDAR (**Figure 9**).

Higher elevations are represented by purple and blue, medium elevations are represented by green and yellow, and lower elevations are represented by orange and red. The coulee on the southeastern portion of the subject property is clearly illustrated as a west-to-east "finger" draining between two areas of higher elevation (as discussed previously for the central drainage coulee) into Bayou Des Cannes. This is the area designated as the "salt water discharge impact area" in the plaintiff's expert report[45]. A similar coulee, shown as a yellow-orange-red finger, drains south (down elevation gradient) from the western portion of the subject property.

Based on the down elevation gradient, the coulee on the southeastern outlined




| Minimum Elevation (ft) | Maximum Elevation (ft) |
|---|---|
| -0.03 | 0.00 |
| 0.00 | 2.00 |
| 2.00 | 4.00 |
| 4.00 | 6.00 |
| 6.00 | 8.00 |
| 8.00 | 10.00 |
| 10.00 | 12.00 |
| 12.00 | 13.00 |
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| 16.00 | 17.00 |
| 17.00 | 18.00 |
| 18.00 | 20.00 |
| 20.00 | 22.00 |
| 22.00 | 24.00 |
| 24.00 | 26.00 |
| 26.00 | 28.00 |
| 28.00 | 30.00 |
| 30.00 | 38.12 |

**Figure 9**
LiDAR map of the subject property shows that it is at lower elevations than surrounding property. The three properties of interest are outlined in black. The salt dome on which most of the 1930s drilling took place is located in the northwestern corner of the map (purple and blue round shape). Surface water flowed to and across the subject property from higher, adjacent elevations, transporting oil field wastes to Bayou Des Cannes and other lower lying areas[44].

property is the surface water runoff collection point for only a small portion of the subject property. As illustrated in **Figure 9**, based on elevation gradient, the western part of the subject property drains predominantly to the south, consistent with Hervey's description in the McFarlain case. The northern part of the property drains predominantly to the east into Bayou Des Cannes, again based on elevation gradient. Therefore, the southeastern part of the subject property is, for the most part, the only contributing drainage area to that coulee.

Land south of the subject property (on the northeastern corner of Section 40) is the dominant surface water runoff source for the coulee on the subject property due to its higher elevations. The LiDAR map in **Figure 9** shows a higher elevation in blue in that northeastern corner of Section 40. Based on topographic analysis with the highest elevations delineating the drainage watersheds, approximately half of that area in blue drains north into the coulee on the subject property, and approximately half drains south into Bayou Des Cannes. Thus, the area designated as the "salt water discharge impact area" by plaintiffs' experts predominantly receives surface water runoff, historically including salt water and oil from the oil fields — from the property south of the subject property.

**Figure 10** also illustrates altered natural drainage patterns resulting from oil field infrastructure. The gold-outlined drainage subcatchment in the south-central area of the photograph outlines the diverted overland flow path water must take between and around large earthen storage tanks. The green-outlined drainage subcatchment

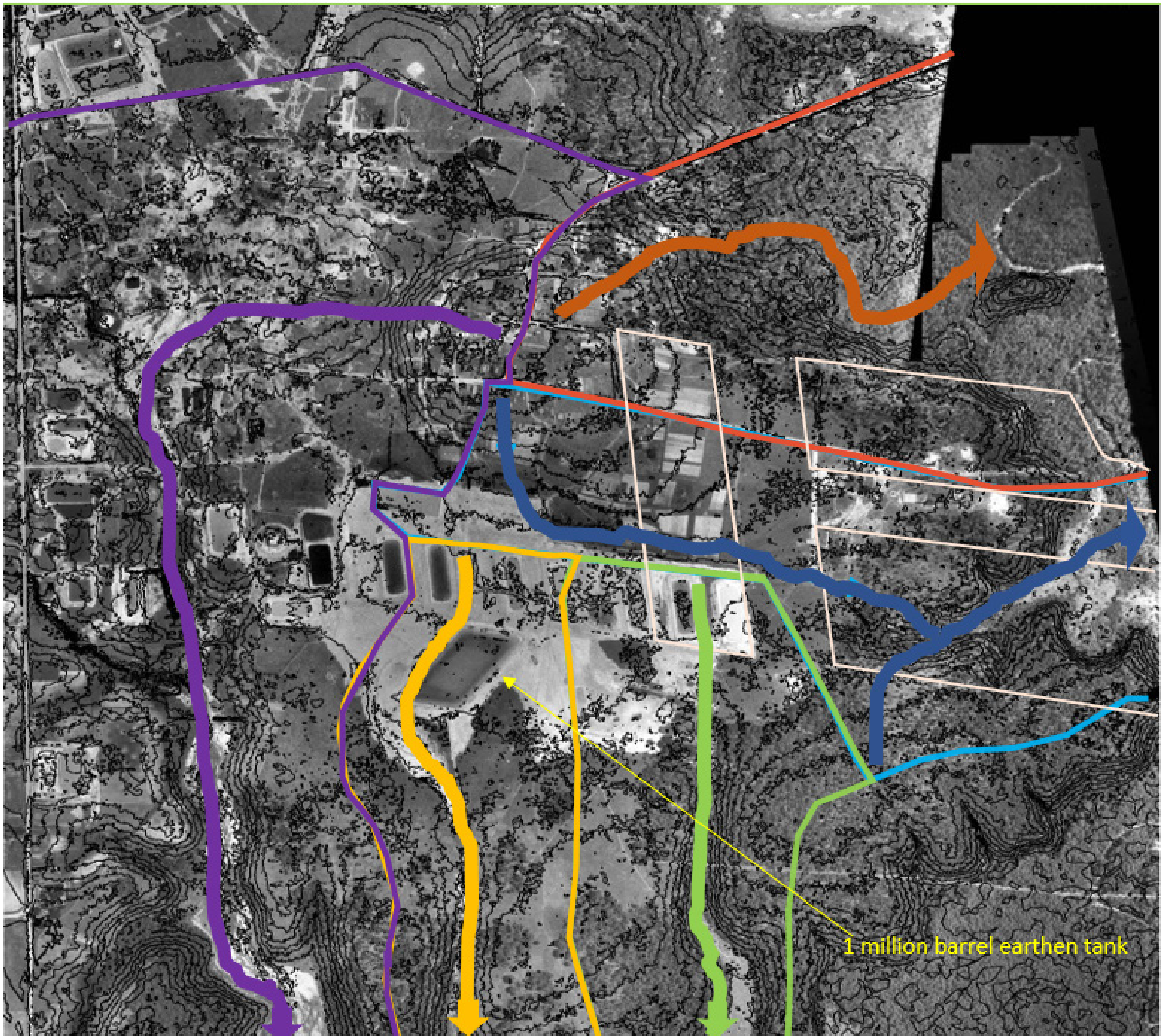


**Figure 10**
LiDAR elevations[44] overlaid on the 1953 aerial photograph[24] with thick lines and arrows to illustrate overland flow directions. Each color is a separate drainage subcatchment based on higher elevations around its perimeter. Forensic hydrologic analysis refuted plaintiffs' claim of salt water scarring on their property by the defendant's action when combining elevation and property boundary data with a historical aerial photograph.

east of the gold subcatchment also depicts a diverted overland flow path between earthen storage tanks. Prior to tank construction, overland water flow would have followed the natural land contour and flowed from higher elevations to lower elevations. For this area, that dominant flow path is toward the south, eventually discharging into Bayou Des Cannes.

Analysis of historic USGS topographic maps support this interpretation. The 1960 topographic map, closer in time to oil field operations than LiDAR data, illustrates an elongated white area at the same location as the "salt water discharge impact area" (**Figure 11**)[46]. Based on the contour lines, the area that drains through this arm of Bayou Des Cannes is limited to that including and immediately surrounding the southeastern portion of the subject property. The northeastern portion of the property flows to the northeast and east, and the western portion of the subject property shows a predominantly southern flow direction.

Historic aerial photograph and topographic map analyses, two-dimensional representations of actual land

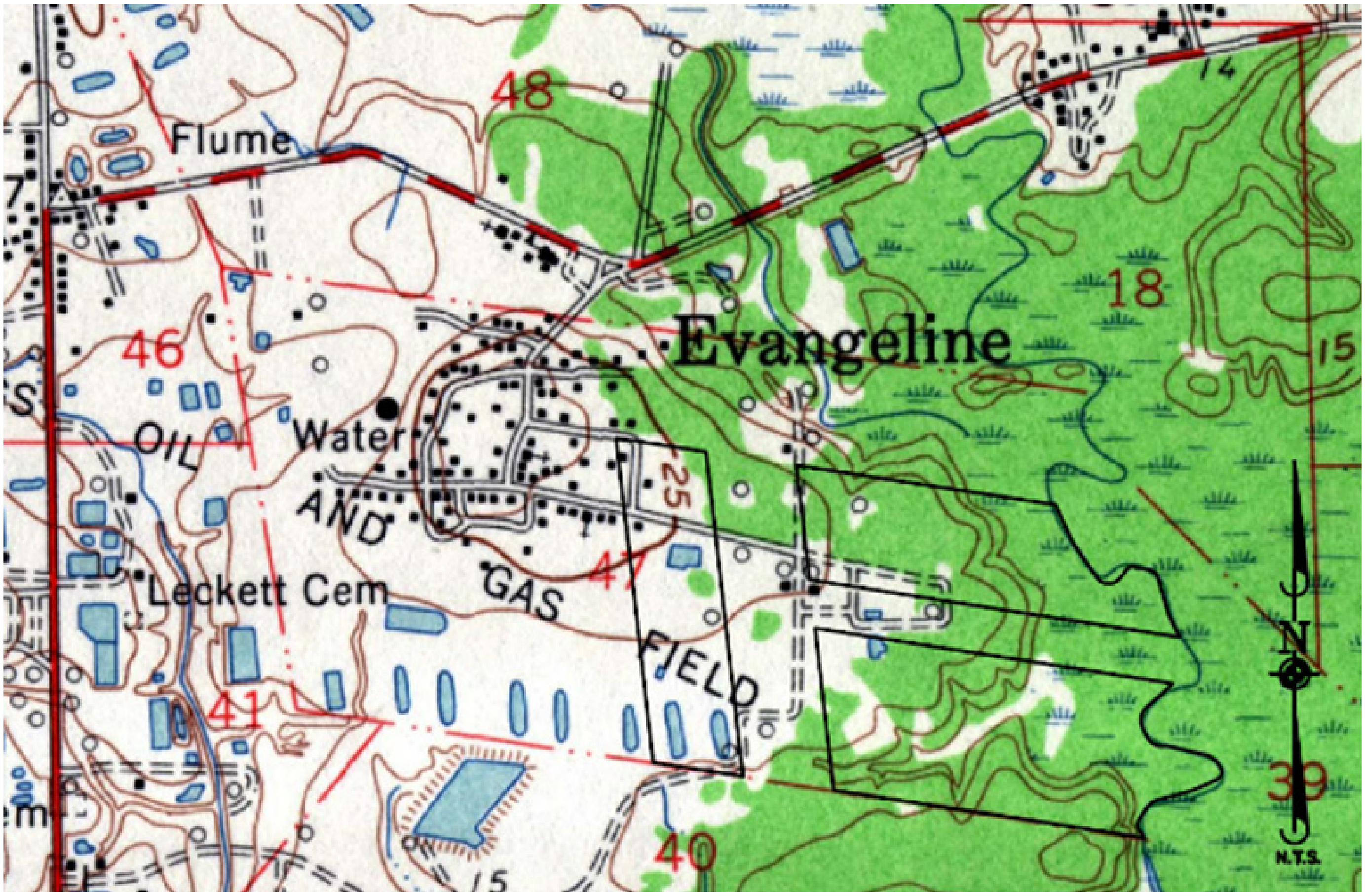


**Figure 11**

A 1960 U.S. Geological Survey topographic map of the subject property and surrounding area[46]. LiDAR data collected 50 years later exhibit flow patterns and altered drainage paths consistent with oil field operations mapped in 1907.

conditions close in time to oil field operations, are essential tools for forensic hydrology and drainage engineering. Coupled with contextual knowledge of field operations and historic land uses, the forensic engineer can prepare a detailed analysis of how an altered landscape evolved over more than a century.

Applying hydrology and drainage engineering expertise and analyzing suggested informational sources detailed in ASTM E1527 for engineering applicability determined the following key points in the forensic hydrology investigation:

1. Present-day survey data can corroborate testimony provided 110 years earlier regarding drainage patterns and contaminant transport from the oil field to surrounding areas.

2. Time-series analyses of aerial photographs and maps illustrate natural and built environmental changes resulting from upstream oil field stressors. Readily available GoogleEarth can be a good starting point for photographs. For a longer period of record, USGS EarthExplorer has photographs dating back to the 1940s. For historic topographic maps, USGS topoViewer has maps dating from 1880 to 2024.

3. Compiling data from multiple sources (including maps, photographs, testimony, and government reports) provides insight into historic land use and potential pollutant transport that predates environmental reporting requirements.

## Family Knowledge of Oilfield Operations

As part of the claim, family members alleged that the predecessor oil company took advantage of an uneducated, non-English-speaking farmer to avoid responsibility for environmental damages incurred on his land. The plaintiffs alleged that for more than 30 years, out-of-state companies constructed and utilized earthen storage tanks for crude oil and produced water with the knowledge that such technology was environmentally detrimental to their ancestors' property. Further, the plaintiffs alleged those predecessor companies contractually obligated their ancestors to their disadvantage due to their lack of business and industry knowledge.

Determining what someone knew (or should have known) 110 years in the past is a difficult task. ASTM E1527 recommends landowner interviews to ascertain their knowledge of environmental liens and spills on their property. Such interviews are not possible with deceased owners, and taking the word of current owners as to what their ancestors knew or did not know can be risky. The forensic environmental assessment approach to this part of ASTM E1527 requires investigating the family through their records, including land transactions, censuses, business archives, newspaper articles, lawsuits, and professional publications.

The first generation owner was Eugene Houssiere. U.S. federal census data in 1900 for Eugene listed him as an unnaturalized farmer who could not speak English[9]. By 1910, Eugene was an "oil king" and the owner of an oil field who spoke only French[8]. By 1920, he reported that he could speak English and that his profession was a "capitalist[47]." Eugene Houssiere testified in the McFarlain case, during which he answered in the affirmative when asked if he were an oil man[48]. Additionally, the plaintiff's attorneys in the McFarlain case described him as "an oil man himself, interested in the oil field and the oil industry[49]."

A second generation owner was Charles Houssiere who was "quite involved in the management of the rapidly growing Houssiere and Latreille concerns" (e.g., Houssiere-Latreille Oil Company and others)[50]. A colleague remarked of Charles that he "had the best brain for figures of any businessman I ever knew. He could add mazes of figures in his head, knew the assessed valuation of every ward and town and their millages. He had his fingers on every deal in the parish, and knew what land, crops, cattle, oil leases and timber were worth." He further stated that "although oil was [his] stock and trade… he could hold his own in any sort of deal." Hildebrand continued, "You never got the best of Charles R. Houssiere in a deal. ... His mind worked like a machine gun in action. He could always out think you." Hildebrand even went so far as to suggest that if Charles had been older — and come into the family oil business earlier — that "he would have seen to it that things were done differently" with respect to the litigation involving the Jennings-Heywood Oil Syndicate[51].

A third generation owner was Charles Houssiere, Jr., who earned a master's degree in chemical engineering from the Massachusetts Institute of Technology and a doctorate degree in petroleum engineering from the University of Texas, Austin, researching oil and gas topics for his master's thesis and dissertation. Charles Houssiere, Jr. worked extensively in the oil business as an academic and as an engineer. He was a member of the Society of Professional Well Logging Analysts and American Institute of Mining Engineers — Society of Petroleum Engineers[52].

Louise Ismerie Houssiere, sister to Charles Houssiere, Jr., was another third-generation owner who worked seven summers (1934-1940) in the office of an independent oil operator (likely Houssiere-Latreille Oil Company). She attended the Massachusetts Institute of Technology and received a master of science degree in geology in June 1941 with a thesis entitled "Studies in Salt Resistant Drilling Muds." She worked as a research chemist and drilling mud engineer in the Baroid Division of the National Lead Company, as the chief micropaleontologist for the Southern Texas Division of Texaco, Inc., and as a subsurface geologist and reservoir engineer with Sohio Petroleum Company[50].

Members of the Houssiere family owned multiple petroleum-related businesses beginning in 1903 with the Houssiere-Latreille Oil Company and continuing through the mid-1950s. The business objects and purposes included leasing land for developing, drilling, buying, and selling natural gas, oil, and petroleum — and for constructing and managing infrastructure conducive to petroleum operations. They signed oil leases on behalf of themselves and the family businesses, set contract terms for royalty payments in crude oil rather than in cash, and included clauses to ensure aggressive drilling on their land, which included potential environmental impacts they could observe on a daily basis[15]. Multiple generations of the Houssiere family had specific knowledge of oil field technology, personally engaged in the business of oil on their property, and aggressively directed drilling on their lands.

Utilizing the techniques and suggested informational sources detailed in ASTM E1527 for a time-series analysis of visibly evolving site conditions and of personal knowledge of oil operations, analyzing family and business histories resulted in the following key points in the forensic environmental assessment:

1. Contemporary testimony regarding site conditions and operations a century ago is obtainable without owner interviews. For this case, litigation photographs, maps, and testimony from the property owner in 1907 depicted or described site conditions just six years after the discovery of oil on the plaintiffs' properties.

2. Source evaluation is essential when presented with conflicting information. Legal documents (including contracts, business filings, and land transactions) are the most credible sources of information. Multiple legal documents created over a 50-year period refuted many plaintiffs' claims.

3. It is possible to interpret what a person in the past knew or should have known. One's education, publications, and occupations evidence a person's technical knowledge. A person's documented living and working environments reveal what one should have known. Walking a property, smelling petroleum, and signing oil exploration leases are examples that a person should have known oil operations were occurring on one's property — even if that condition were not explicitly stated in a written document.

4. Information that a person could be reasonably expected to know is demonstrated through a preponderance of evidence, taken in totality, through deductive or inductive reasoning. For example, directing lease holders to aggressively drill on one's land, receiving crude oil rather than money for royalty payments, and placing newspaper advertisements offering oil field services illustrate one has knowledge, interest, and expertise in crude oil exploration and management.

## Conclusion

This FE investigation validated that the modern Phase I Environmental Site Assessment methodology detailed in ASTM E1527 is appropriate for the discovery and interpretation of facts regarding human and physical conditions relative to allegations of environmental contamination, altered drainage, and uninformed landowners that occurred more than 100 years ago. Through documentary research detailed in ASTM E1527, this FE investigation demonstrated that claims the predecessor oil company took advantage of an uneducated, non-English-speaking farmer to avoid environmental responsibility on their leased lands were false.

The original landowner, as well as several of his descendants in multiple generations (including the plaintiffs' generation), possessed technical and business knowledge of oil exploration and storage operations on their land. Impacts of oil exploration, storage, and transportation were open and obvious — from earthen storage tanks of tens of thousands of barrels capacity to pipe-strewn former rice fields to law suits from downstream neighbors. The potential for environmental damage from oil operations was known in the industry and accepted as an inevitable consequence of extracting oil. The plaintiffs' ancestors understood that produced water discharge and crude oil seepage were simply costs of doing business — costs they considered acceptable in pursuit of their own oil business objects and purposes.

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