Geological Aspects of Unitization in the Petroleum Fields of Louisiana: A Brief Overview

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Louisiana ranks among the top four states of the U.S.A. in oil and gas production.

The petroleum industry conducts exploration and production operations in the state of Louisiana under the regulatory guidelines of the Louisiana Office of Conservation. Unitization of petroleum reservoirs is a critical activity of the industry, which involves the equities of the mineral right owners. This article focuses on the geological considerations underlying the unitization process and related activities of the petroleum industry. The illustrative examples presented herein represent simplified situations for discussion purposes; they have no real names of the petroleum fields, producing horizons and units outlined.

An operator is issued a permit to drill a well for exploration for and/or production of oil and gas on a lease basis or a voluntary unit or a conservation (compulsory) unit. The boundaries of a conservation unit may be delineated in some of the various ways briefly reviewed by the author in *TPG* (Pages 1-4), May, 2002. At the request of an applicant (operator or any interested party), an oil unit or a gas unit is established for a sand, a zone or a formation. For the unitization purposes, a sand implies a stratigraphic interval containing a reservoir stratum capable of producing hydrocarbons (oil or gas and condensate). A zone is a relatively large stratigraphic interval comprising a number of sands. A formation is a standard recognized stratigraphic unit , such as the Cotton Valley Formation, Hosston Formation, Sligo Formation, Tuscaloosa Formation, Wilcox Formation, Sparta Formation, Miocene Formation, etc. For a conservation unit to be established, a sand , a zone or a formation is defined in a specific well (referred to as the " Definition Well") with the depths (electric log measurements) of the top and the base of the defined interval identified as encountered in the well. In the same field, units of a sand and a zone including the sand may exist geographically separated or share a common boundary, as illustrated in Figures 1 and 2.

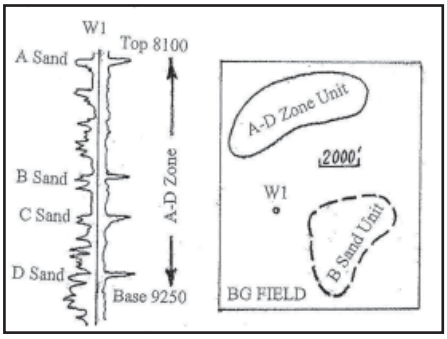


Figure 1.

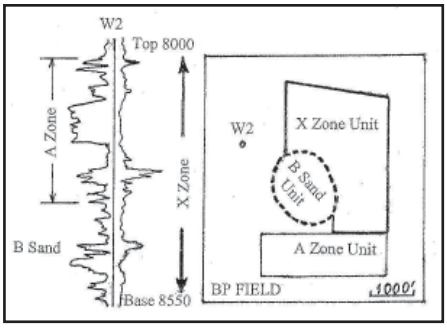


Figure 2.

In order for a conservation unit to be established for a sand in a field, it is required that the applicant demonstrate the productivity of the sand based on an actual production test in the field. A test that has been completed either in the well drilled in the unit or elsewhere in the field is acceptable for the unitization purposes. However, it is not uncommon that an operator wants to establish a conservation (pre-drill or undrilled) unit for a sand in a field where a commercial production from the sand has not been established. In such a case, the Office of Conservation considers the applicant's request for the waiver of test in the field and may approve it based on a review of the stratigraphic correlation of the sand from the productive well in a different field to a well in the general area or another field where a new unit for the sand is proposed as indicated in Figure 3. A similar geological consideration applies to a zone or a formation as reflected in Figure 4. The waiver of test in the field policy paves the way to the establishment of pre-drill units. Such units for deep drilling which costs tens of millions of dollars, set equities in advance of drilling, for risk reward purposes. This, thus, facilitates the protection of the monetary risk investment made by the operator and working interest owners. As such, the waiver of test in the field policy fosters the exploration for oil and gas from deeper pools. This has

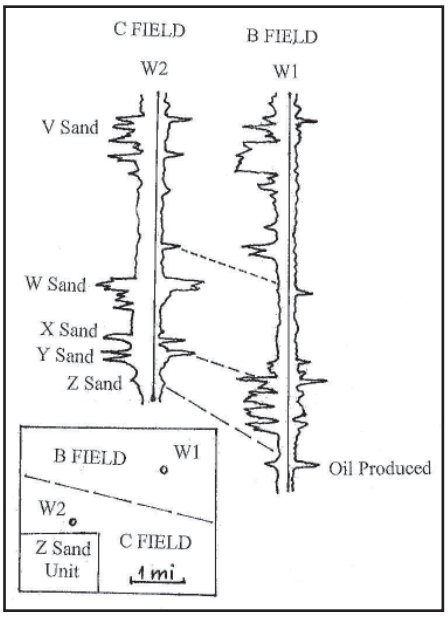


Figure 3.

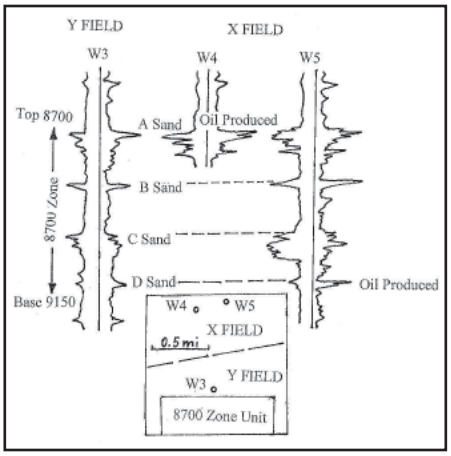


Figure 4.

resulted in discoveries of new pools in existing fields as well as new field discoveries in Louisiana.

Essentially for economic reasons, an applicant may want a conservation unit for a zone rather than a single sand. In such case, each of the sands included in the zone is geologically mapped utilizing the available geological and engineering information from all the wells drilled in the area, and the productive areas of all sands combined to form a (composite) unit for the zone, as illustrated in Figure 5.

Sometimes a situation, as reflected in Figure 6 occurs when the unit well (No.1) of a sand unit ceases production, and an operator drills a successful well (No.2) in an updip position in the same unit. In light of the new geological information (the elevation of the sand and the current water level in the reservoir, etc.) from the new well , the geology of the reservoir is remapped and the boundaries of the production unit are redelineated.

A unit or units of a reservoir which has ceased production for an extended period of time (one year and ninety days or more) may be terminated under certain statutory guidelines.

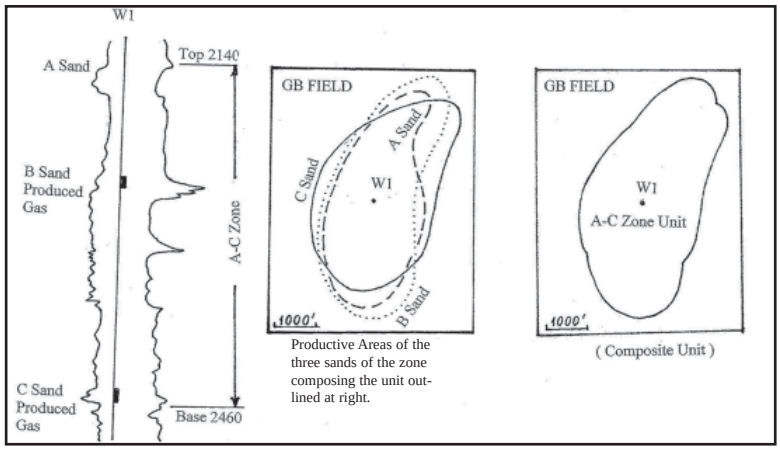


Figure 5.

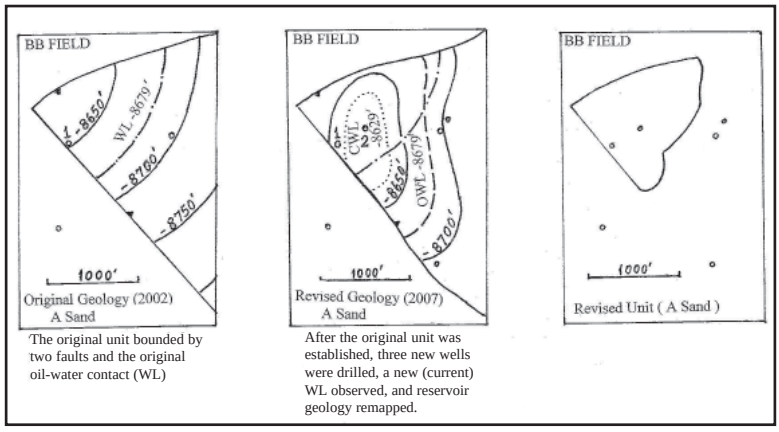


Figure 6.

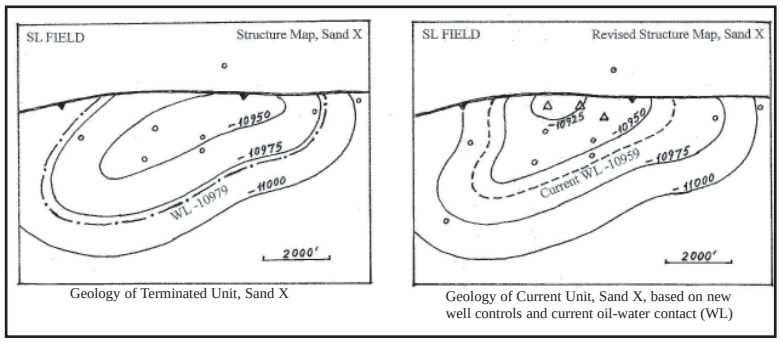
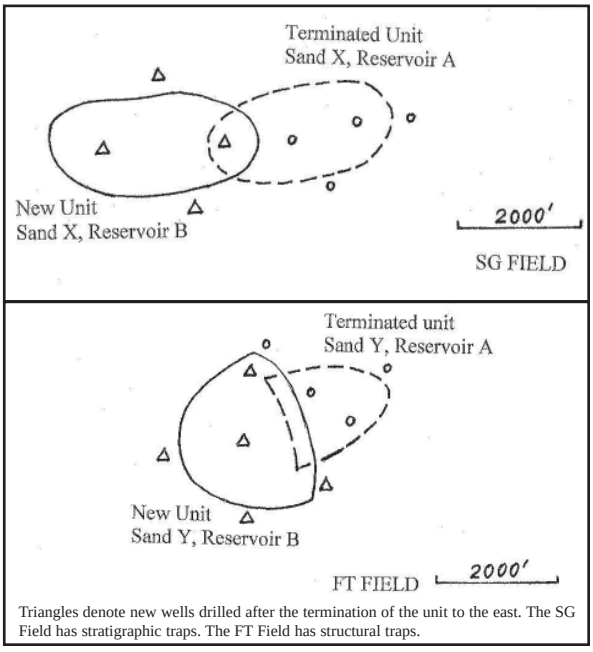


Figure 7.

When an operator drills new wells (triangles in Figure 7) in a terminated sand unit and successfully completes a well in the sand, the geology of the reservoir is remapped with new information from the additional well(s) including a new (current /shallower) water level in the reservoir, and a new configuration of the unit is established, as illustrated in Figure 7, that indicates a smaller size of the current unit relative to the terminated unit.

According to a policy of the Office of Conservation, an applicant may form an undrilled unit for a reservoir different from "that for which a terminated unit was created, and which undrilled unit includes lands within a previously terminated unit, the unit well for the undrilled unit may fall within or outside of the confines of the previously terminated unit". This concept is exemplified by the cases of structural and stratigraphic traps existing in producing fields as illustrated in Figure 8.



Triangles denote new wells drilled after the termination of the unit to the east. The SG Field has stratigraphic traps. The FT Field has structural traps.

Figure 8.

In some cases, an applicant wants to form a unit for a zone which stratigraphically includes several sands

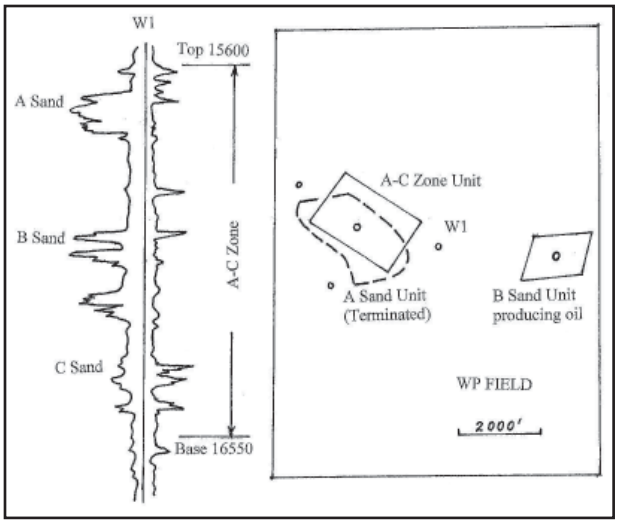


Figure 9.

one of which was unitized in the past, but the unit for that sand has been terminated and is included in the unit for the zone proposed by the applicant. The Office of Conservation will allow that "provided sufficient evidence exists to establish that one or more reservoirs within the proposed zone definition (other than the pool for which the units were terminated) can reasonably be expected to encounter oil/gas in commercial quantities". For example, the unit for A-C Zone as depicted in Figure 9 may be acceptable.

Some common cases of unitization as well as the cases reviewed above are summarized in Table 1. This is reflective of a current trend in the industry, although it does not represent the whole spectrum of possible cases. Any applicant or operator intending to accomplish unitization activities in Louisiana is required to adhere to the regulatory procedures and guidelines of the Louisiana Office of Conservation operating under the state law. In this regard, it may be beneficial to contact appropriate staff members of this Office located at 617 North Third Street, 9th Floor, Baton Rouge, Louisiana 70802 (Phone No. (225) 342-5540).

Table 1

Applicant's Unit Proposals	Louisiana Office of Conservation Activity
A. Units in undrilled areas	Names New Fields, Grants Waiver of Test in the Field (WTIF), Conducts Unitization Hearings (UH), and Issues Orders (IO).
B. Units in existing fields:	
1. First unit(s) for an ununitized sand not tested in the field (Figure 3)	WTIF, UH, IO
2. First unit(s) for an ununitized *zone* with sand members not tested in the field (Figure 4)	WTIF, UH, IO
3. First unit(s) for an ununitized *zone* with a sand member(s) tested in the field (Figure 5)	UH, IO
4. Revision of an existing unit (Figure 6)	UH, IO
5. A new unit in a terminated unit (Figure 7)	UH, IO
6. A new unit overlapping a terminated unit (Figure 8)	UH, IO
7. A new *zone* unit overlapping a terminated unit of a sand member (Figure 9)	Meeting required of potential Applicant's representatives, UH, IO
8. Additional unit(s) for a unitized sand or zone	UH, IO
9. Unit(s) for an ununitized sand tested in the field	UH, IO

Acknowledgement: The author thanks Commissioner James H. Welsh, Assistant Commissioner Gary P. Ross and Senior Attorney W. Stephen Walker of the Louisiana Office of Conservation, for their important suggestions germane to this article. The illustrations used herein are adapted from the public records of oil and gas hearings of the Office of Conservation.

Reviewed by AIPG Associate Editors: John L. Berry, CPG-04032 and John F. White, CPG-04632.

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SCIENCE IN THE NEWS

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Mars Volcanoes May Re-Erupt, Hawaii Comparison Shows

A trio of volcanoes on Mars may have been created by a similar geologic process to the one that formed the Hawaiian Islands, a new study says. The observations also suggest that the three Martian volcanoes might not be extinct.

If sufficiently large eruptions do eventually occur, they could spew enough heat-trapping carbon dioxide and water into the atmosphere to warm the red planet up from its current cold, dry state - at least for a little while.

Those are the findings of a research team led by Jacob Bleacher of Arizona State University and NASA's Goddard Space Flight Center in Greenbelt, Maryland.

To read more: **http://news.nationalgeographic.com/news/2007/10/071018-mars-volcanoes.html**

Or: **http://tinyurl.com/3bpgdd**

Delineation of Petroleum Reservoir Boundaries for Unitization in Louisiana: An Overview of Practices and Trends

Madhurendu B. Kumar, Ph.D., R.P.G., CPG-03106

A drilling and production unit for a petroleum reservoir is the maximum area representing a portion or entirety of the reservoir that can be drained efficiently and economically by one well. Unitization is the process of integrating separately-owned tracts of land, mineral leases, and other property interests overlying the reservoir for joint development or production of the reservoir. Unitization allows a maximal recovery of hydrocarbons (oil and gas or gas and condensate) from a reservoir, prevention of the drilling of unnecessary wells and protection of the correlative rights of the mineral owners. Additionally, unitization provides the basis for the distribution of the proceeds of producing wells and well costs, and avoidance of lease rentals and expirations. A drilling and production unit formed for the exploration for and production of hydrocarbons can be any one of the following types: Declared Unit (based on the pooling provision of the lease concerned), Voluntary Unit (predicated on a voluntary agreement of all parties with an interest in the unit), Single Well Conservation Unit (resulting from public hearing held by the Louisiana Office of Conservation), Reservoir wide (multi-well) Unit (established by the Louisiana Office of Conservation, encompassing the entirety of the reservoir based on at least 75% of the working interest ownership and 75% of the mineral ownership), and Deep Well Unit (multi-well unit covering the reservoir below 15,000 ft, established by the Louisiana Office of Conservation). Any well drilled and completed as a gas or oil producer may be operated on a lease basis or has to have a unit (of any of these types) that the well will drain. The details of the procedure for establishing the various types of units are outside the scope of this article, but are addressed by Harrison (1976), Sabate (1991), and Pritchard (1991). This report focuses on the delineation of unit boundaries.

A drilling and production unit may be geographic or geologic, depending upon the nature of its boundaries. A geographic unit is characterized by arbitrary boundaries that may reflect property lines, lease boundaries, government section lines, roads, or some major geological features, such as surface shore lines, river banks, subsurface fault lines, permeability barriers, etc. Geographic units represent a norm for the petroleum fields of North Louisiana. The unit size varies widely depending on the portions of government section, precedent for the field or producing horizon, depth of well and/or cost of drilling and completion. Gas units are normally larger than oil units, normally ranging from 40 to 640 acres.

Geologic units are most common in South Louisiana, although geographic units do exist. Generally, geographic units are formed when available well controls are not adequate to define the productive limit of the reservoir or the geology (specially in salt dome fields) is too complex for geologic mapping, making it impossible to ascertain geologic boundaries of units. In some fields, initially geographic units were established, and subsequently as more well controls become available, they have been revised to form geologic units. Important factors that control the size of a geologic unit are geology, productive area, lease position, precedent in a field, producing horizon or trend, and economics.

Adopted unit geology is important for the purpose of unitization. It is the geology which constitutes the basis for the unit adopted by the Louisiana Office of Conservation. "Adopted geology" includes definition of producing horizon (sand or zone/reservoir), subsurface elevations of the horizon penetrated in the wells, depths and throws of faults, dip and strike of the horizon and faults, and down-dip productive limit. For unitization purposes, the data previously used in unit determinations are not allowed to be re-interpreted in order to honor the adopted geology. However, in the event new well controls clearly warrant a revision of the adopted geology, the latter is revised with a minimal change in the unit boundaries. Obviously, unitization geology is distinctly different from exploration geology. Unitization geology must honor all available data, while exploration geology may reflect the personally novel creative approach or geologic philosophy of the exploration geologist, who may completely ignore the previously interpreted geology.

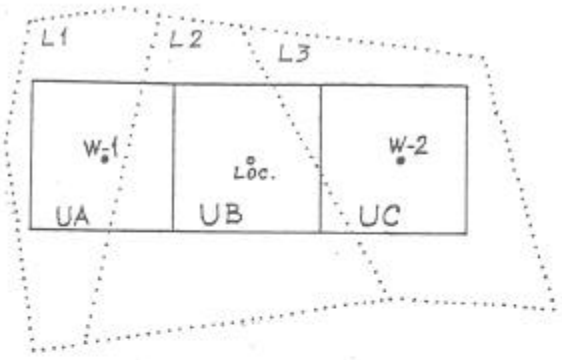

FIGURE 1. GEOGRAPHIC UNITS
(FIRST YEAR)

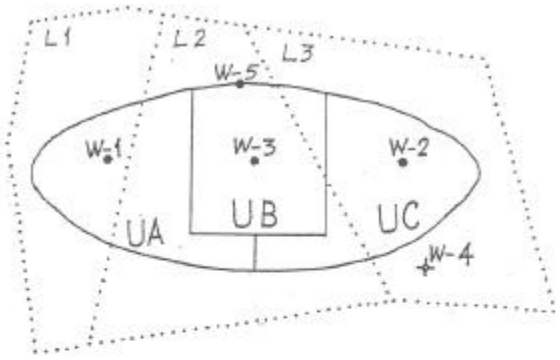

FIGURE 2. GEOLOGIC UNITS
(SECOND YEAR)

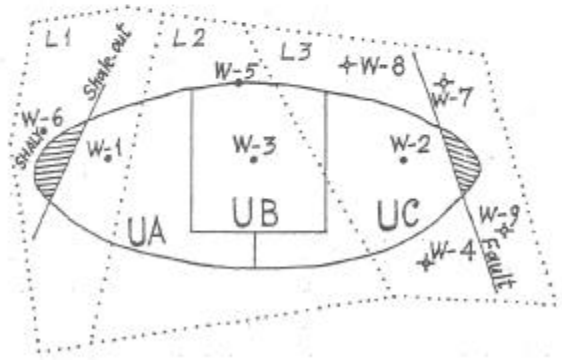

FIGURE 3. REVISED GEOLOGIC UNITS
(THIRD YEAR)

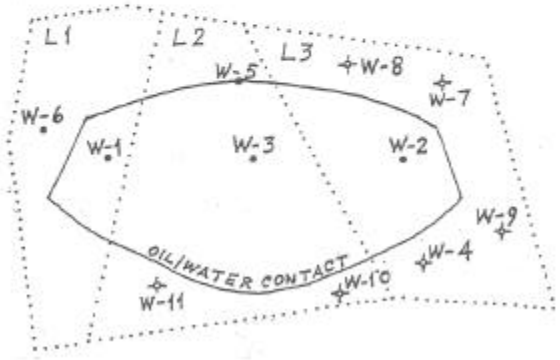

FIGURE 4. RESERVOIRWIDE UNIT
(FOURTH YEAR)

The boundaries of a geological unit may be predicated on one or more geological features, such as subsurface fault traces, oil/water (O/W) or gas/water (G/W) contacts, spill points, sand pinch-out or shale-out, or permeability barrier, which is recognized essentially based on the anomalous production characteristics of wells. In case no fluid (O/W or G/W) contact is observed in any of the wells drilled into the reservoir, an "Assumed Productive Limit" (APL) is utilized as one of the unit boundaries. An APL may be predicated on the highest known water level (HKW) or the lowest known hydrocarbons level (LKH) encountered in an adjacent well or an arbitrary level mid-way between the HKW and the LKH, or an assumed down-dip extension of the proven hydrocarbon column or productive sand thickness, depending upon the structural configuration of the reservoir. One sand thickness below the LKH may be used in an area of low structural dip ; more sand thicknesses below the LKH may be used in a steeply dipping area, such as salt dome fields. APL placement also can be influenced by structural position of the unit well, thickness of productive horizon (sand/zone), lease position and well spacing or resulting unit size.

Whenever a new well is drilled, its potential impact on the boundaries of the unit concerned is evaluated by the unit operator or party concerned. If a change in the previously adopted unit geology is warranted, unit boundaries are revised through a due process. As additional wells are drilled, the pattern or configuration of units may change. A trend of such changes is illustrated in Figures 1 through 4, which depict the progressive development of a hypothetical petroleum field composed of one reservoir in South Louisiana. In this field there are three leases, namely, L1, L2 and L3, denoted by dotted lines. The field has been developed and produced over a period of four years. The first year status of the field is shown in Figure 1 with two successful wells (W-1 and W-2) drilled 2 mi apart and three Conservation geographic units (UA, UB and UC) of identical size and shape established; the unit UB was not yet drilled. In the second year, as shown in Figure 2, W-3 was successfully drilled and completed to drain the unit UB, while W-1 and W-2 continued producing from units UA and UC. Additionally, W-4 and W-5 were drilled, which helped to establish the O/W contact of the reservoir. On the basis of the structure contour mapping of the reservoir, its productive limit was delineated as shown. The geographic units UA, UB and UC created previously were dissolved and new revised geologic (Conservation) units were simultaneously created, which differ significantly in shape and size from the previous geographic units. Figure 3 shows that in the third year, four new wells (W-6 through W-9) were drilled. These two wells established a shale-out boundary of the reservoir to the west, and a fault boundary to the east , resulting in the deletion of some non-productive acreage from units UA and UC. Finally, during the fourth year, as indicated in Figure 4, additional wells

(W-10 and W-11) were drilled to the south. Based on the revised structure map of the reservoir, its southern boundary extended southward to include some additional productive acreage. Subsequently, an enhanced recovery project was initiated for the field. To this end, the previous three units UA through UC were dissolved and simultaneously a reservoir wide (Conservation) unit was established to facilitate hydrocarbon production from multiple wells. As a result of the changes that occurred in the unit configuration during the course of the progressive development of the field, the equity or participation percentage of each interest owner in the production has significantly changed. In reality, the Irene and Port Hudson Fields in South Louisiana have similar histories of unitization.

More often than not, it is a significant professional challenge to determine the unit boundaries. It is more so, when multiple separately-owned tracts of land are to be included within a unit, since the unit boundaries determine the relative equities of each individual or party concerned. Historically, unitization has precipitated highly contested hearings, lasting over extended periods of time. Records of all of these activities are maintained in the Office of Conservation in Baton Rouge. Information pertaining to past and future unitization hearings also may be obtained from this office.

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Dr. Kumar has been serving as Geologist Supervisor with the Louisiana Office of Conservation for over 19 years. He has attended numerous Conservation Public Hearings, conducted and supervised geologic evaluations and delineation of petroleum reservoir boundaries, and prepared thousands of Conservation Orders and made recommendations to the Commissioner of Conservation on hundreds of contested cases of unitization, often with State Exhibits. He has published over forty technical reports pertaining to petroleum geology, salt domes, and computer applications.

The author gratefully acknowledges the comments of Frank W. Harrison, Jr., CPG-02500, who reviewed the original manuscript.

Peer Reviewed by AIPG Associate Editors: John L. Berry, CPG-04032, Gretchen M. Gillis, CPG-09693, and John F. White, CPG-04632.