DISPOSAL OF PRODUCTION DIVISION WASTES

By

W. L. Martin

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of

Division of Production

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BY

* W. L. MARTIN

Any discussion of the problems of disposal of oil field wastes is likely to be looked to for a solution for a specific case and in this particular instance might be construed as a recommendation from the A. P. I. Committee on Waste Disposal. For this reason I want to state that this paper will not attempt to solve these problems, but will attempt to set out the circumstances which make the problem so annoying and discuss in a general way the merits and faults of present practices. It will attempt to give a clearer understanding of the field man's responsibility as well as that of the executives. It is generally agreed that the serious consequences always attendant on this problem can be materially decreased through a better understanding of the cause and effect of production wastes---why they are objectionable and what rights the public have for objecting to them.

Production wastes may be classified in four groups, namely---(1) Waste Oil, (2) Saline Waters, (3) Drilling Mud, (4) Gases & Vapors. Of these four groups, the most aggravating are the first two and inasmuch as very little has been done, by the Committee, on the last two groups a discussion of them will not be included in this paper. I appreciate, however, that you may well be interested in one condition coming under the last group. I refer to the wastes incident to the manufacture of carbon black and the only encouragement I can offer is that the problem will necessarily be solved eventually, but it will have to be solved by those most affected by such waste.

Waste disposal is not peculiar to the oil industry--practically every in-

*The Prairie Oil & Gas Company, Independence, Kansas.

dustry has had such a problem and I believe it can be truthfully stated that in every case in which the problem has been solved, the former waste was converted to a revenue producing product. These problems were solved due to agitation against the disposal of such wastes in a manner that was objectionable to individuals or the public in general. And as in the case with our industry, such complaints were followed by legal actions which compelled the elimination or limited the methods of disposal which could be used. Regardless of whether or not we consider our wastes objectionable or liable to cause damage to our neighbors or the public, the statutes of the several states make it obligatory on the producer to prevent the escape of waste from our properties (See App.). In many instances the courts have allowed damages because of the escape of such wastes. Apparently, it is only a question of time until the opposition to the escape of our waste will become strong enough to force us, as an economical measure, to dispose of them in such a manner as will not be objectionable to anyone, and, without doubt, such disposal will also be effected at a profit. It is also apparent that we cannot escape the moral responsibility for the effect of such wastes as may interfere with the orderly conduct of business, private or public, for after all we are the public which is affected.

The responsibility for preventing wastes and for their disposal rests upon the field man. The realization of the seriousness of this responsibility and the effectiveness of control methods can only be brought about by a well-planned educational program. The field man is primarily concerned with the production of the maximum amount of oil at a minimum cost. Consequently, his tendency is to dispose of these wastes at the least possible expense to his property, in order to keep down his production cost. If, however, the cost of litigation, settlement of claims, and present methods of disposal were included in the cost of production, such practices would, in most cases, reflect a marked increase in production costs.

Although there is very little information available as to the extent to

which these wastes may pollute surface or underground waters or their detrimental effects on soil and vegetation, we are well aware of the success with which claims for damage resulting therefrom are prosecuted. Without such data, we are confronted with regulations which, in effect, consider the mere presence of such wastes as detrimental regardless of the quantity or concentration.

WASTE OIL

The principal source of waste oil is emulsions, either direct or as a result of their treatment. I believe it is definitely conceded that emulsions are the result entirely, of some mechanical operations incident to oil recovery. Also, that, under given operating conditions, the type and volume of emulsion is relative to the chemical content and volume of water which is produced. Consequently, it is reasonable to suppose that study to improve recovery methods should eliminate or greatly reduce emulsions. Even where no attempt is made to reduce this volume, the amount of waste resulting from practical treating methods, should be so small as to offer no serious problem of disposal if impounded and burned.

Oil lost in pulling tubing may be considerable and a source of annoyance if proper precautions are not taken to prevent its escape at the well. Several companies are making a practice of installing concrete derrick floors with a pick-up pit and have found that such practice is economical aside from preventing the escape of oil.

The escape of oil from tank batteries, pipe line pumps, and traps is easily and inexpensively prevented by the construction of earthen dikes, and the recovery of much merchantable oil is possible by the use of properly designed oil-water separators. While the loss of any amount of oil is an economic waste, even the escape of small amounts may be very costly, for the public has come to associate the presence of oil with the escape of salt water. For this reason, many salt water claims could be avoided if care is taken to remove all oil from water before disposing of the water. Table I. [illegible] the visibility of oil films of various thick-

Approximate Thickness of Film	Appearance of Film	Approximate Amount of Oil Required for Film. One Square Mile in Area.
.0000015"	Barely visible under most favorable light conditions	25 gallons
.000003 "	Visible as silvery sheen on surface of water	50 gallons
.000006 "	First trace of color may be observed	100 gallons
.000012 "	Bright bands of color are visible	200 gallons
.00004 "	Colors begin to turn dull	666 gallons
.00008 "	Colors are much darker	1,332 gallons

FROM A.P.I. MANUAL ON DISPOSAL OF REFINERY WASTES

TABLE I

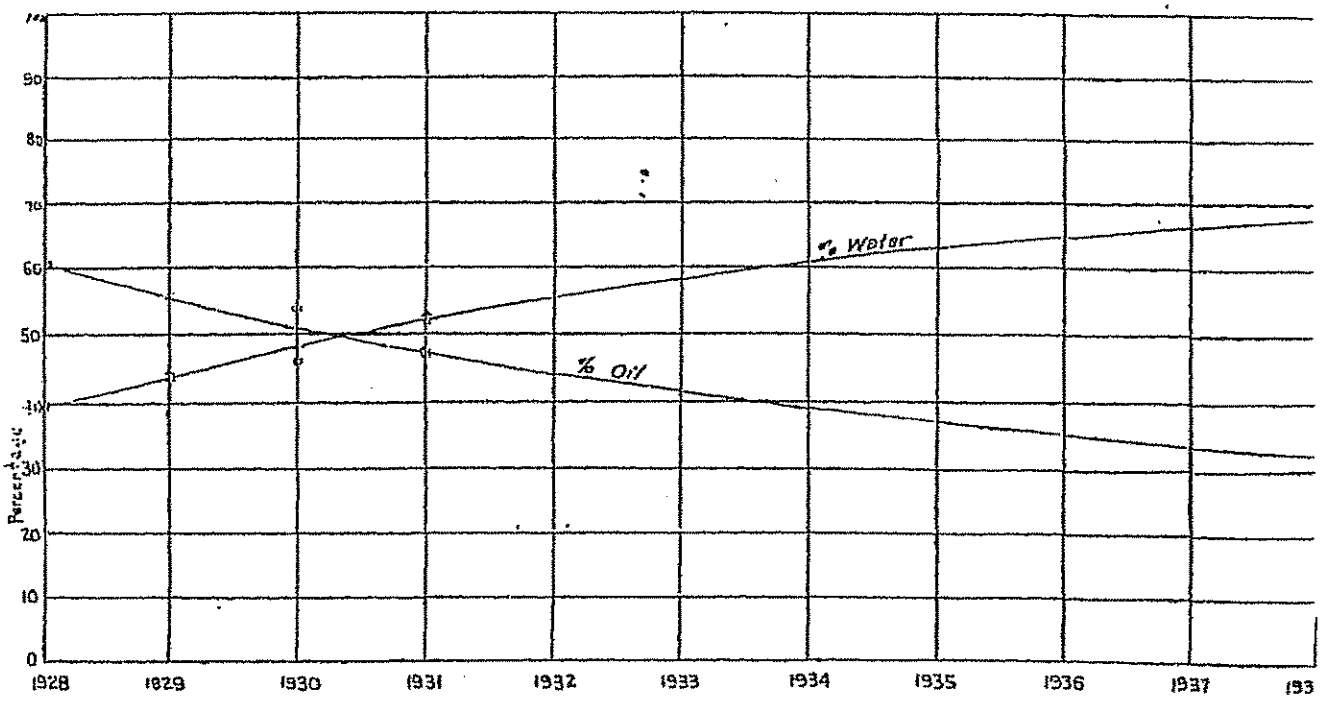

FIG. I. Showing Percentages of Oil and Water--Panhandle Area

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nesses and the volume of oil per square mile under such film conditions. From this table it will be noted that very small quantities of escaped oil will be noticeable on small streams.

The extent of pollution of surface waters by oil and its effect on soil and vegetation cannot be determined by any published data at this time, although many cases could be cited where the presence of oil has been beneficial. Experience teaches us that allowing oil to escape from our properties is a costly practice. Oil soaked ground around wells and tanks and in natural drainage is just as much evidence of poor housekeeping as a greasy floor in front of the kitchen stove. The escape of waste oil can be prevented.

SALINE WATER

Without question, the greatest disposal problem that the industry faces is that of water produced with the oil. Such waters vary in chemical content in which the chlorides of sodium, calcium, and magnesium usually predominate. The concentraction of the dissolved contents vary, usually ranging in specific gravity from 1.001 to 1.175. Table II shows analyses of waters typical of the various mid-continent producing areas, in which it is seen that sodium, calcium and magnesium salts predominate, and that many carry relatively high percentages of bromine and iodine which are sufficiently in demand to make their recovery interesting.

Until such times as methods are developed which will provide for the profitable recovery of these various salts, the logical method which will lessen the damage resulting from the disposal of this water is to reduce the volume produced. It is possible to accurately determine the source of water in wells. In new wells, this is done by making chemical analyses of all waters encountered in drilling and recording the corresponding depth. By comparing the analysis of water produced with those of waters encountered in drilling it is possible to determine fairly accurately the volume from any possible source in the well. Where such analyses were not made during drilling, it is possible to locate the source of water. The

	EAST TEXAS	SCHURR POOL Rice Co. Kan.	RITZ-CANTON Viola	RITZ-CANTON Wilcox	SEMINOLE [1] Simpson	SEMINOLE [1] Upper Wilcox
Alum. & Iron Oxides (Al_2O_3 & Fe_2O_3)						
Silicon Dioxide (SiO_2)						
Calcium (Ca)	1347.69	636.31	1408.40	1048.20	8414	7633
Magnesium (Mg)	327.22	289.48	430.79	308.05	1743	1557
Sodium (Na)	24189.95	7079.31	14966.89	5312.18	49867	48352
Chloride (Cl)	39643.47	12420.50	26796.62	10718.65	96150	92196
Sulphate (So_4)	286.76	124.27	20.36	182.08	542	390
Carbonate (Co_3)					None	None
Bicarbonate (HCo_3)	426.80	650.32	40.68	162.68	55	None
Iodine (I)	274.71		Trace			
Bromine (Br)	716.96		Trace			
Strontium (Si)						
	67207.56	21200.19	45663.74	17731.84	157071	150328

	LEA COUNTY NEW MEXICO	PANHANDLE [2] (Bottom)	AUGUSTA AND ELDORADO FIELDS, KANSAS [3] Bottom	AUGUSTA AND ELDORADO FIELDS, KANSAS [3] Top
Alum. & Iron Oxides (Al_2O_3 & Fe_2O_3)	62.5	536	84	22
Silicon Dioxide (SiO_2)	82.5	50		
Calcium (Ca)	2635.6	6190	1333	7464
Magnesium (Mg)	809.5	2006	278	2436
Sodium (Na)	14432.64	48100	9093	57363
Chloride (Cl)	28897.45	90650	16058	110912
Sulphate (So_4)	2501.3	169	1962	7
Carbonate (Co_3)				
Bicarbonate (HCo_3)	129.32	87.3	18	67
Iodine (I)				
Bromine (Br)				
Strontium (Si)			None	2683
	50546.81	147800.	28824	180954

Note--- 1 (Engineering Report Seminole Pool. U. S. Bureau of Mines, July, 1928
2 (Private Source)
3 (Bureau of Mines Technical Paper #404)

TABLE II. TYPICAL ANALYSES OF OIL FIELD BRINES

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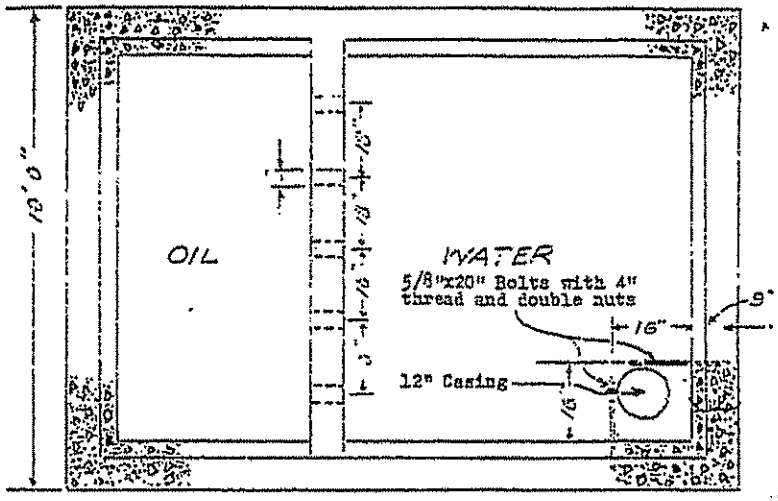
use of dyes has been successful in identifying the source in respect to a given casing string. A method has been developed and patented which, it is contended, will definitely locate the source by taking advantage of the relative electrical conductivity of salt solutions. This method has been successfully employed on the Pacific Coast.

It is axiomatic that the volume of water increases as oil production decreases due, both, to water encroachment in the producing strata and from leaking casings. Consequently, the lifting cost is increased by the increased percentage of water in the fluid handled, greater corrosion of equipment and increase of emulsions. Figure I shows a comparison of oil and water percentage in the Panhandle Area. A similar record on individual wells would be of much value in control of water in the wells.

As in the case of oil, no reliable data is available as to the pollutive effects of oil field brines. And, likewise, under present statutes, it is not material, for apparently the escape of a few barrels of brine may be annoying and costly under certain conditions, while under other conditions the escape of thousands of barrels may cause no inconvenience. As a result, the lease making only a few barrels of brine may often be forced to pay for offences which, seemingly, it could not have been responsible. Therefore, it is imperative that each lease take every precaution in the disposal of its water.

As noted before, whatever disposal method used, it is necessary to thoroughly separate and recover any oil accompanying the water before its disposal. This is easily accomplished on the average lease by the use of a simple separator between lease tanks and point of disposal (See Fig. II). However, where conditions require the separation of all suspended matter and a very low oil content and the handling of large volumes of water, a carefully designed separator must be used. (Theory and design data is available through this committee). Such traps or separators properly located also prevent the escape of free oil from the lease.

The methods of disposal in general practice in the Mid-Continent area are as



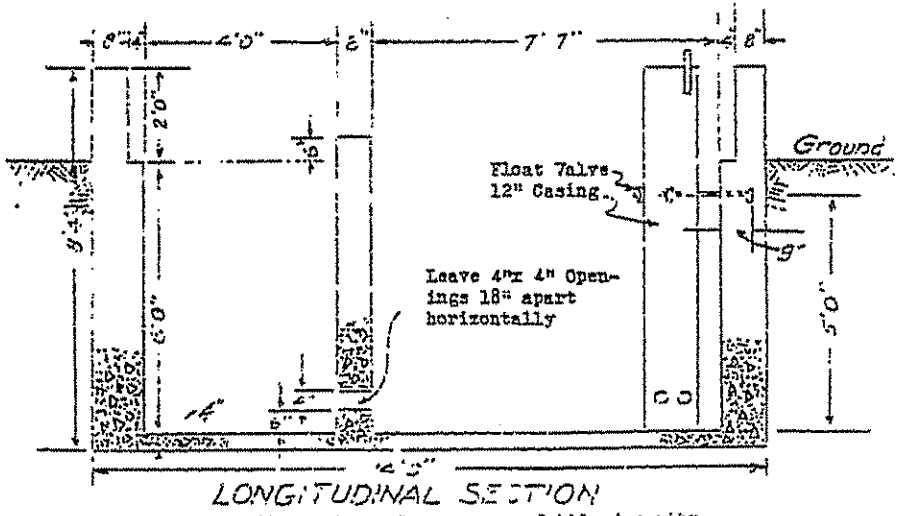


FIG. II. [illegible] (Courtesy of the [illegible] of California)

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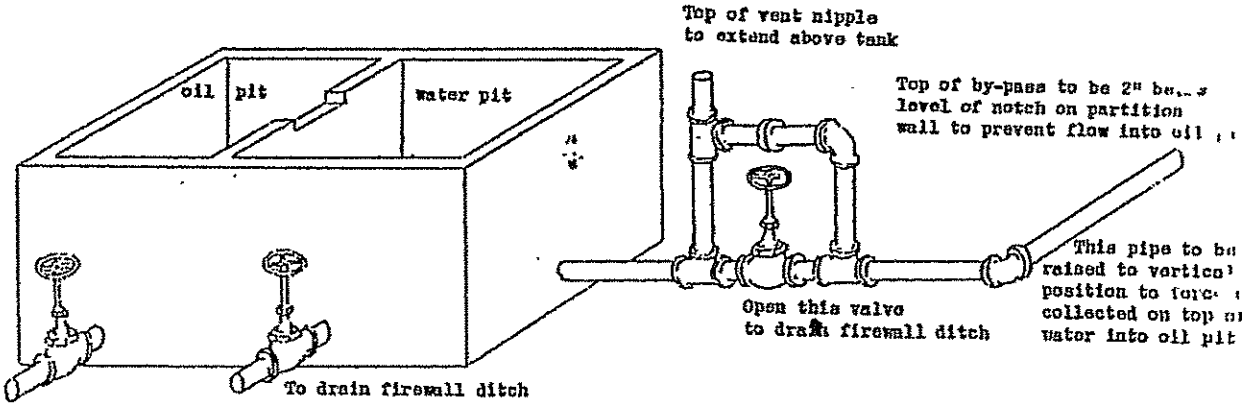

Note: Dimentions for this trap to be governed by amount of water to be handled.

FIG. 3. Waste Water Separator

(Courtesy of the Ohio Oil & Refining Compa...

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follows:

1. Unrestricted flow to natural drainage.

2. Impounding in earthen storage for

A. Dumping in flood stage.

B. Evaporation and Seepage.

3. Conducting to polluted waters by

A. Individual systems.

B. Community Systems.

4. Return to subsurface formations.

There are some who contend that the first is the cheapest method and take a chance on being able to settle all claims for damages on reasonable terms. This may have been true in some instances, but invariably when such was the case, it was due to the fact that the operators who were making a bona-fide effort to handle their wastes were penalized along with and because of those who made no effort to do so. Very often small amounts of water may be disposed of in this manner, provided, of course, there is enough surface water to sufficiently dilute it. However, we must bear in mind that the claimant or the courts are usually the judges of the extent of an alleged injury.

Probably the safest of these methods, where the volume is not too great and rainfall sufficiently frequent, is that of impounding and dumping at the proper time, however, great care must be exercised. The writer can cite one case where this dumping method has been applied and not always with the aid of rainfall, but in this case, an understanding was had that the State Authorities would not object so long as the chloride content of the receiving stream did not exceed a maximum set by them. This stream is the supply for several municipal water systems and to date no objection has been raised, which evidently fixes the limit set as a safe one.

We are only "kidding" ourselves when we think we can dispose of salt water by solar evaporation from earthen ponds. The highest rate of solar evaporation is

reported from Nevada and amounts to .0043 bbls. per square foot of water surface per day. The best information available gives an average for the Mid-Continent area of .001 bbls. per day. In other words, a pond 100 ft. square would evaporate only 10 bbls. per day, if there were no rainfall. However, the rainfall throughout this same section equals the evaporation, so nothing is gained through solar evaporation alone. What we have attributed to evaporation was due to seepage, and this method of disposal is often employed, but with very few exceptions it is impractical. Eventually, such seepage may either follow an impervious stratum to the surface where it may affect vegetation or may find its way to fresh water sources, either surface or subsurface, and in such quantities as to be objectionable.

The theory that seepage tends to filter out the objectionable salts has been thoroughly disproven. Schmidt and Devine in Bureau of Mines Bulletin R. I. 2945, state that "any ions present in the water such as sodium and potassium, which tend to deflocculate the clay will render the clay relatively impervious to the infiltration of water. On the other hand, such ions as calcium and magnesium, which flocculate the soil will conversely cause the clay to become relatively permeable * * * * * * *. Results (of their experiments) indicate that the presence of Calcium and Magnesium* * * * * * increases the rate of seepage through clay independently of the presence or absence of sodium". If such flocculation does occur we may find a decrease of some salts in the seepage, but necessarily an increase in other salts which may be more objectionable than the original brine. Therefore, we cannot expect to successfully impound salt water without seepage, and that disposal by seepage is not as practical as methods which will confine the water to definite and known channels.

Many attempts at artificial evaporation have been made but usually with very little success. Usually, where large volumes of water are produced, there is a shortage of fuel. When the volumes are small it is often practical to supplement solar evaporation with sprays. The disadvantage of this method lies in the fact that in such cases the volume is reduced, but the concentration is increased so that

its escape will be more serious. Probably, the most useless attempt at evaporation is the burning of gas over the surface of a pond. If we cannot expect more than a 10% reduction in volume by heating in a boiler, it can readily be seen how little can be obtained in burning an open flame over a large surface without motion. And, again, what little reduction in volume is obtained is more than offset by the increased concentration of the seepage. The use of vacuum pans for evaporation is out of the question, due to excessive initial cost, if they are to be operated only as a means of disposal. Their only practical use would be in the recovery of marketable salts.

The only successful disposal systems are those which conduct oil free waste water to coastal waters, polluted streams, or streams of sufficient volume that resulting mixture will have a harmless concentration. These systems are operated either independently or as community undertakings. The latter is preferable for the reason that unit control precludes the possibility of the lax methods of one operator working a hardship on the more prudent operators. And, it has been proven, that even the community plan cannot be successfully operated if it does not have the support of all operators, and, more important, the approval of enforcement agencies. The State of Texas, through its Fish, Game and Oyster Commission has sanctioned such plans by passing emergency legislation to permit the organization of such disposal companies. (S.B.No. 46, Chap. 49). (See App.).

Under the community plan all waste waters are conducted to a central plant. Even if such waters have been run through separators on the leases they are again separated so as to exclude all oil and solids. From this separator the water is conducted to the final disposal by pipe line. In a few cases the final disposal must be held up for certain periods to prevent pollution of irrigation waters or during extremely low water periods.

There have been numerous attempts to return waste water to subsurface formations, but, almost without exception, these have been proven impractical except for a short period of time. It can probably be stated as a general rule that,

unless such water can be returned by gravity, it will not be successful. Pumping under pressures which continually increase, not only means costly operation, but the ultimate contamination of fresh water strata is practically assured. In addition, there is the probability of migration to producing sands and a rehandling of the water. Therefore, this method cannot be considered practical except under the condition noted above.

Very little study has been undertaken by the oil industry looking to the development of processes for the economical disposal of oil field brines. The writer has knowledge of but one company which is attempting a complete recovery and this under conditions that do not generally obtain in producing fields. In another case, however, a company is successfully treating 60,000 barrels of brine per day in order to recover 500 lbs. of iodine and that brine is not as rich in iodine as some of the brines in this section. The oil companies, apparently, are not interested in becoming manufacturing chemists, still one cannot but wonder why more research has not been done, to not only eliminate a costly waste product but to also recover the salable products of that waste--especially when we find that the value of such products in each barrel of waste water amounts to as much as $2.50 per bbl. If the expenditures on dry holes in search of oil valued at $1.00 per barrel is justified, how much would we be justified in spending to recover products valued at $2.50 per bbl?

From the foregoing discussion, we can draw the following conclusions:

A. The escape of waste oil is avoidable, is due to carelessness only, and should be treated as such. A clean lease indicates a prudent operator. The prevention and recovery of waste oil is profitable.

B. No successful method, of general application, has been devised for disposal of salt water.

C. Certain methods of salt water disposal in common use are not only inefficient but impractical and hazardous.

D. No disposal method will operate satisfactorily except it be carefully planned and conscientiously applied by all parties concerned.

E. There is need for such research as will convert [illegible] waste into profitable products.

STREAM POLUTION LAW
H.B. No. 12.

An Act providing that it shall be unlawful to throw, cast, discharge or deposit crude petroleum, oil, acids sulphur, salt water, oil refinery wastes, or oil well wastes in any of the waters of this State; providing that salt water and treated sulphur water may be deposited in the tidal waters of this State and providing that salt water, under certain circumstances, may be deposited in the fresh waters of this State; providing for the enforcement of this Act, disposition of fines and fees of the arresting officers; providing that this Act shall be cumulative of all laws relating to the subject matter of this Act, and declaring an emergency.

BE IT ENACTED BY THE LEGISLATURE OF THE STATE OF TEXAS:

Section 1. It shall be unlawful to throw, cast, discharge or deposit crude petroleum, oil, acids, sulphur, salt water, oil refinery wastes or oil well wastes in or on any stream, water course or natural body of water of this State or in such proximity thereto that such crude petroleum, oil, acids, sulphur, salt water, oil refinery wastes or oil well wastes will reach such stream, water course or natural body of water; providing, however, that salt water or sulphur water, when such sulphur water is so treated that it will not be harmful to aquatic life or marine organisms, may be deposited in the tidal waters of this State; and providing further that when it is charged that there is a violation of this Act by throwing, casting, discharging or depositing crude petroleum, oil, refinery wastes or oil well wastes into any of the waters of this State adequate proof must be submitted that crude petroleum, oil refinery wastes or oil well wastes or accumulations of such deposits, covered an area of such water in excess of ten thousand (10,000) square feet or was on the surface of a river, stream, bayou or channel of this State for a distance in excess of three hundred (300) feet.

Section 2. Provided that salt water may be discharged into a fresh water stream or other natural body of fresh water of this State at such times and in such quantities that it will not be harmful to nor contribute to the injury nor prevent the propogation of aquatic life, nor render such water unfit for livestock, domestic or irrigation purposes. All discharges of salt water contributing to conditions inhibited by this Act or cumulative of conditions inhibited by this Act shall be violations of this Act; providing that any and all discharges of salt water into a fresh water stream or other natural body of fresh water of this State, that produces or contributes to a salinity in excess to two thousand parts of salt in one million parts of water shall be violations of this Act.

Section 3. Any person violating any provision of this Act or any director or officer of a corporation or member of a firm or partnership or receiver whose corporation, firm, partnership or receivership is responsible for the operations causing a violation of any provision of this Act shall be deemed guilty of a misdemeanor and upon conviction shall be fined in a sum not less than two hundred dollars ($200) nor more than one thousand dollars ($1,000), and each day that such violation is committed shall constitute a separate offense. The Game, Fish and Oyster Commission and its representatives is charged with the duty of enforcing the provisions of this Act and all fines and fees of the arresting officer, imposed for violations of this Act, shall be remitted to the Game, Fish and Oyster Commission and deposited in the State Treasury to the credit of the Special Game Fund.

Section 4. This Act shall be cumulative of all laws relating to the subject matter of this Act. If any part of this Act shall be held unconstitutional or inoperative all remaining parts of this Act shall remain in full force and effect.

Section 5. The fact that the present polution laws of this State are inadequate and difficult of enforcement and there is urgent need of a more adequate law to preserve important natural resources of this State, creates an emergency and an imperative public necessity that the constitutional rule requiring bills to be read on three several days in each House be suspended, said Rule is hereby suspended and this Act shall take effect from and after its passage, and it is so enacted.

Approved August, 1931.
Effective 90 days after adjournment.

(Note: H. B. No. 12 passed the House by a vote of 77 yeas, 22 nays; passed the Senate by a vote of 31 yeas, 0 nays.)

(S.B. No. 46) Chapter 49.

An Act to provide for the creation of corporations to prevent the pollution of streams and to that end empowering such corporations to gather, impound and store water containing salt or other substances produced in the drilling or operation of oil wells or other wells; and authorizing such corporations to charge reasonable rates for service; and prohibiting discrimination between patrons; and conferring upon such corporations the power of condemnation of necessary land and rights; authorizing corporations interested in the proper disposition of such waters to subscribe for, own and vote stock in corporations created hereunder; and declaring an emergency

Be it enacted by the Legislature of the State of Texas:

Section 1. That in the mode provided in Chapter 2 of Title 25 of the Revised Statutes of Texas of 1911 corporations may be created for the purpose of gathering, storing, and impounding water containing salt or other substances produced in the drilling and operation of oil and other wells, and to prevent the flow thereof into streams at times when the latter may be used for irrigation.

Section 2. Such corporations, in addition to the general powers conferred by such title upon private corporations, may acquire, own, and operate ditches, canals, pipe lines, levees, reservoirs, and their appliances appropriate for the gathering, impounding or storage of such water, and for the protection of such reservoirs from inflow or damage by surface waters; with further power to condemn lands and rights necessary therefor under like procedure as is provided in condemnation by railroads; and also to cross with their ditches, canals, and pipe lines under any highways, canals, pipe lines, railroads, and tram or logging roads; conditioned that the use thereof be not impaired longer than essential to the making of such crossings; provided that, no right is conferred to pass through any cemetery or under any residence, school house or other public building nor to cross any street or alley of any incorporated city or town without the consent of the authorities thereof.

Section 3. In the localities in which they operate and to the extent of the facilities provided, such corporations shall serve all producers of such water in the gathering, impounding, and storage of such waters in proportion to the needs of such producers, at fair and reasonable charges, and without discrimination between such producers under like conditions. Corporations interested in the proper dis-

position of such maters may subscribe for, own, and vote stock in the corporations which may be created hereunder.

Section 4. The importance of this Act, and the absence of any law upon the subject, and the necessity for the immediate relief afforded thereby creates an emergency and an imperative public necessity that the constitutional provision requiring bills to be read on three several days, be suspended, and it is so suspended, and that this Act be in force and effect from and after its passage, and it is so enacted.

(Note. — S. B. No. 46, passed the Senate by a two-thirds vote, yeas 22, nays 0; and passed the House of Representatives by a two-thirds vote, yeas 107, nays 1.)

Approved April 2, 1918.
Became a law April 2, 1918.