AQUATIC BIO MONITORING
IN
LITTLE FIVE MILE,
WEST BROOK
AND
BIG FIVE MILE CREEKS
Fayette and Gonzales Counties, Texas

A Case Study Proving the Biological Integrity
Of Ephemeral Creeks Receiving Fresh, Produced Water
Discharges From the Reklaw Formation East
Of the 98th Meridian; Onshore, Texas

January 16, 2014

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ABSTRACT:

Fresh water produced from shallow oil wells located in southwest Fayette County, Texas has been discharged to the land surface since 1945. The Texas Railroad Commission (TRRC) regulated these discharges under 16 Texas Administrative Code (TAC) Section 3.8 (Statewide Rule 8) for many years. Beginning in 1995 discharges of this produced water, from the Carrizo-Wilcox, Reklaw and Bartosh formations, were allowed and regulated under the National Pollution Discharge Elimination System (NPDES) and both the TRRC and the Environmental Protection Agency (EPA) now administer permits and regulatory compliance standards for these discharges. The water is of exceptional quality. It typically contains total dissolved solids (TDS) contents of less than 500 mg/l and chloride contents of less than 20 mg/l. Ephemeral creeks in the area of these discharges contain 100 percent concentrations of produced water eight to nine months of each year when air temperatures often exceed 100 degrees Fahrenheit and rainfall is very low or non-existent. This produced water is an important source of usable water to livestock owners in the area and receiving creeks support an abundance of wildlife, aquatic life and bird life.

Proposed new regulatory standards for the implementation of whole effluent toxicity (WET) testing proposed by the TRRC in 2012 and the EPA in late 2013 required WET testing and experiments be performed by affected operators to insure compliance, including MCA Petroleum Corporation (MCA). Most of these WET experiments find Promelas (minnows) pass standards at the outfall source point, but occasionally D. pulex (water fleas) fail minimum survival rates (EPA-821-R-02-012, 40 CFR 136.3 (2021.0).

In-stream WET experiments taken downstream of discharge outfalls, however, typically pass both fresh water test species based on EPA and Texas Surface Water Quality Standards (TSWQS). Toxicity Identification Evaluations (TIE) at end of pipe source points show the produced water contains both natural non-carbonate and bicarbonate ion imbalances. These imbalances come into equilibrium downstream in short periods of time. No “classic” forms of toxins were found in the produced water in TIEs. Occasional D. pulex mortality in WET tests at source points is a result of the natural characteristics of the formation water in the Reklaw formation.

The intent of the Federal Clean Water Act (CWA) is to prohibit pollution of our nation’s surface waters. TSWQS, 30 TAC 307.6 (e)(2)(B)(4) states: “Water in the state must be maintained to preclude adverse toxic effects on aquatic life, terrestrial life, livestock, or domestic animals, resulting from contact, consumption of aquatic organisms, consumption of water, or any combination of the three.”

Many living organisms rely on this discharged water. It poses no threat to aquatic life and contributes greatly to the biological integrity of the receiving area.

INTRODUCTION:

Oil was first discovered in Fayette County, Texas near the township of Cistern in 1945. Subsequent oil exploration in the southwest portion of Fayette County resulted in nine other oil fields being discovered by 1953. All these fields produce from thin sandstones (less than 15 feet thick) of the Reklaw formation (Eocene) overlying the massive Carrizo Wilcox Aquifer. Depth of these Reklaw reservoirs is typically 1850-2350 feet below the surface depending on regional dip and structural traps related to faulting in the subsurface. Total cumulative oil production from these ten oil fields from 1945 through 2013 has been approximately 12,789,000 barrels. Today, this shallow oil trend in Fayette County produces approximately 200 barrels per day from 68 oil wells. Please see Figure 1.

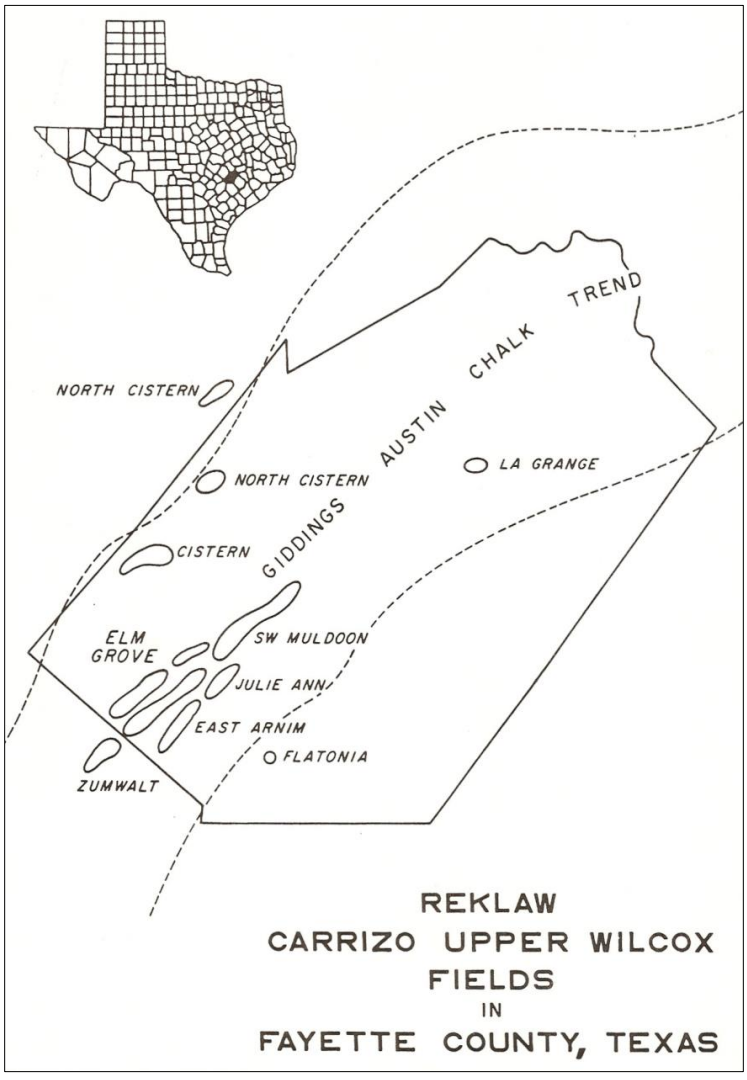


Figure 1

Crude oil produced from the Reklaw formation is of exceptional quality. It is very sweet and contains sulfur content of less than 0.5 ppm. Until 1964 much of this shallow oil produced in Fayette County was taken to a refinery in San Antonio and made into newspaper ink or was barged to the East Coast of the United States for high-end lubricant refining.

Associated water from crude oil production in the Reklaw formation is unique in that it is very fresh and meets numerical compound criteria for drinking water in Texas as set forth by Texas Water Quality Standards, 31 TAC 290. Its total dissolved solids (TDS) content is generally less than 500 mg/l and its chloride content is generally less than 20 mg/l. This is very usable water and has contributed greatly to livestock and wildlife watering in the receiving area. In very hot and very dry months between April and October, fresh produced water that sits in ditches, gullies, ephemeral creeks and stock ponds on private land in the area is often the only surface water there is. In the severe drought of the 1950s, many local ranchers in and around the community of Flatonia that benefit from this produced water on their land remember this water as having saved them from economic ruin. Besides cattle, produced water was occasionally used for irrigation purposes throughout the 1950s.


Fathead Minnows (Promelas) in Fresh Produced Water Discharges

The existence of fresh water in thin transgressive sands of the Reklaw formation (sometimes also called Newby sands) likely occurred at sediment deposition during Eocene geological time. These sands are further exposed to hydraulic recharge where the Reklaw outcrops on the surface up-dip towards the northwest. There is an impermeable shale barrier of approximately 10-12 feet thick that separates the lower-most Reklaw sand from the massive Carrizo Wilcox Aquifer below. No hydrologic conductivity is believed to exist between the Carrizo and the Reklaw. One hundred feet or more of impervious marine Reklaw shale forms a barrier between the Carrizo Wilcox and overlying Queen City sands.

Sediment subsidence (slumping) within the basin south eastward toward the shoreline during Eocene time resulted in faulting. Crude oil likely migrated up fault planes from deeper source beds found in marine shale in the lower Wilcox formation and found structural traps in shallow Reklaw sands to accumulate in. Discoveries were made in Fayette County by mapping surface faults and projecting fault displacement to deeper depths. See Type Log, Figure 2.

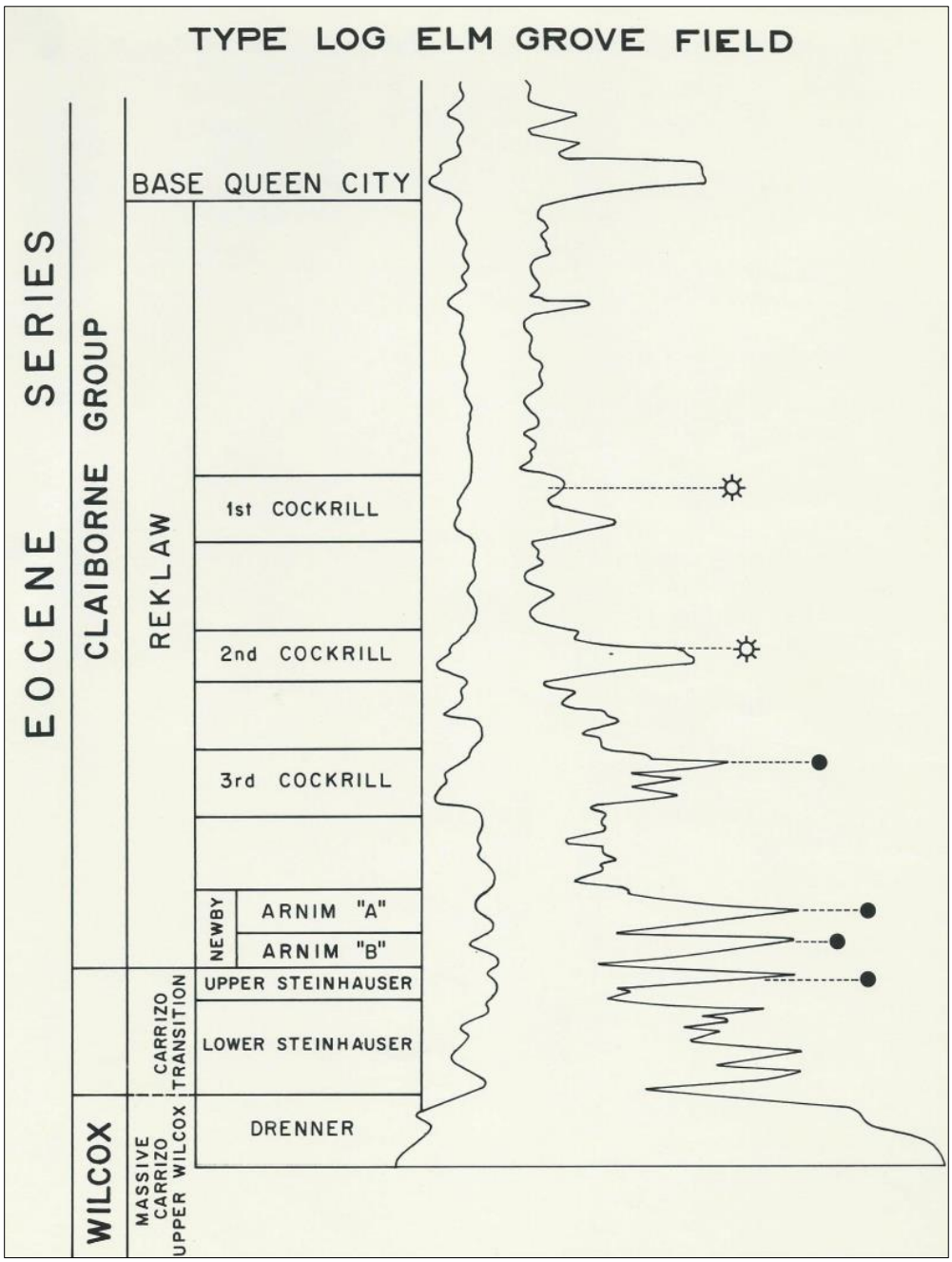


Figure 2

Thin sands of the Reklaw formation are not considered groundwater sources for humans by the United States Geological Society. Fresh water in Reklaw sands in southwest Fayette County, because of their association with hydrocarbons in subsurface structural traps, would never be considered source water for human consumption. When this water is separated, treated and retained at oil facilities, it is then discharged to the land surface containing only residual amounts of hydrocarbons with concentrations of generally less than seven ppm.

The Code of Federal Regulations 40 CFR 453 (E) allows produced water to be discharged to the land surface west of the 98th meridian without EPA permits as long as the produced water "is of good enough quality to be used for wildlife and livestock watering…" Fresh, produced water east of the 98th meridian is better water and contains lower TDS than produced water west of the 98th meridian. It is also used extensively for wildlife and livestock watering. The 98th meridian as a means of dividing arid regions in the United States from wet regions is arbitrary and has no relevance in determining the actual existence or need for surface water in Texas.

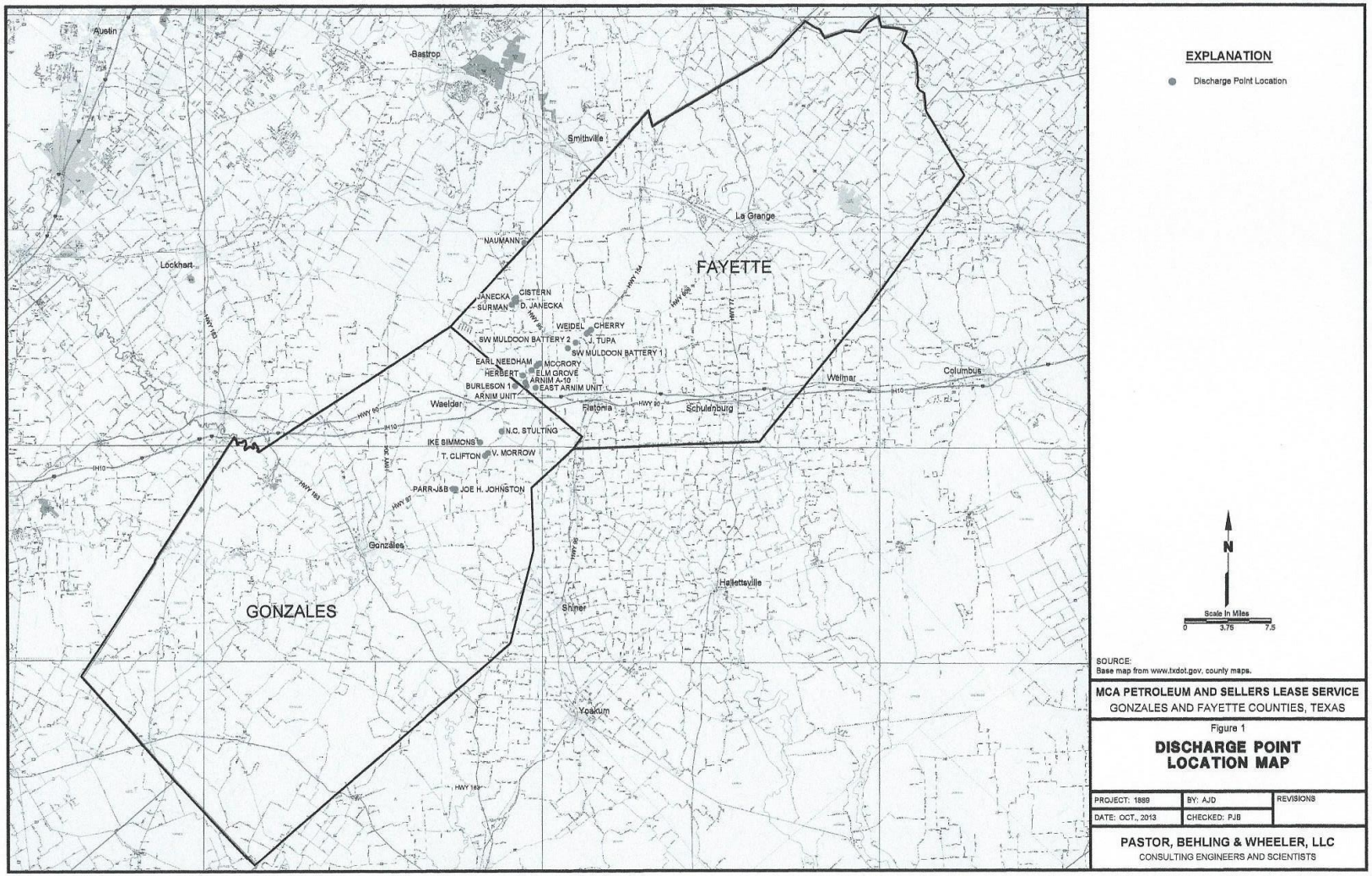
Much of Central Texas east of the 98th meridian has suffered from severe drought the past four years. Fayette County and Gonzales Counties are currently classified as below normal rainfall to moderate drought conditions by the United States Agriculture Department. Fayette and Gonzales County east of the 98th meridian are currently drier than Wilson and Atascosa Counties, where other fresh, produced water discharges occur west of the 98th meridian with no permit requirements.

Fresh, produced water from the Reklaw formation east of the 98th meridian provides a valuable source of surface water that would otherwise not exist if it were not for shallow oil production in the area. This produced water is not a "waste," it is a valuable natural resource. Please see Appendix 1, FAYETTE AND GONZALES COUNTY DROUGHT CONDITIONS.

Little Five Mile and West Brook Creeks in southwest Fayette County are considered ephemeral creeks that occasionally receive storm water runoff during normal rainfall months of November through March and subsequently become "intermittent" creeks containing stagnant pools. The other seven to eight months out of each year these creeks contain 100 percent concentrations of fresh, produced water from shallow stripper wells producing from the Reklaw formation in the area. These two creeks traverse south where they converge with Big Five Mile Creek in northern Gonzales County slightly south of the Fayette, Gonzales County line. From these creek convergences in northern Gonzales County it is less than 2.2 miles before Big Five Mile Creek converges with Peach Creek and another 22.8 miles before Peach Creek converges with the Guadalupe River.

Because of very high evaporation rates in extreme Texas heat, minor ground absorption and livestock and wildlife use, fresh, produced water from Fayette County seldom reaches Peach Creek unless in periods of unusually high rainfall. Please see Figure 3.

Figure 3


Austin
Bastrop
Smithville
La Grange
NAUMANN
Lockhart
FAYETTE
JANECKA
CISTERN
SURMAN
D. JANECKA
WEIDEL
CHERRY
SW MULDOON BATTERY 2
J. TUPA
SW MULDOON BATTERY 1
EARL NEEDHAM
MCCRORY
HERBERT
ELM GROVE
ARNIM A-10
BURLESON 1
EAST ARNIM UNIT
ARNIM UNIT
Waelder
Flatonia
Schulenburg
Weimar
Columbus
N.C. STULTING
IKE SIMMONS
T. CLIFTON
V. MORROW
PARR-J&B
JOE H. JOHNSTON
Gonzales
GONZALES
Hallettsville
Shiner
Yoakum
EXPLANATION
Discharge Point Location
N
Scale in Miles
0
3.75
7.5
SOURCE:
Base map from www.txdot.gov. county maps.
MCA PETROLEUM AND SELLERS LEASE SERVICE
GONZALES AND FAYETTE COUNTIES, TEXAS
Figure 1
DISCHARGE POINT
LOCATION MAP
PROJECT: 1889
BY: AJD
REVISIONS
DATE: OCT., 2013
CHECKED: PJB
PASTOR, BEHLING & WHEELER, LLC
CONSULTING ENGINEERS AND SCIENTISTS

Ephemeral creeks in Fayette and Gonzales Counties that receive fresh, produced water have no recreation use capability. The habitat for aquatic species has never been assessed but is believed to be incidental, at best, 30 TAC 307.3 (29). Minnows, small fin fish, snakes, frogs, turtles, beavers, otters, tadpoles, bugs and insects can often be seen in these creeks full of produced water.

A complete understanding of the ecosystem of Little Five Mile and West Brook Creeks to the Big Five Mile Creek convergence in southwest Fayette and northern Gonzales Counties and how fresh, produced water from shallow oil wells contributes to that environment and biota is critical in determining the role that implementation of new WET standards should be applied to proposed regulatory standards. Please see enclosed USGS TOPO MAP.

Typical Fresh, Produced Water Ditch

REGULATORY HISTORY:

Since 1945 fresh, produced water from shallow Reklaw oil wells has been discharged to the land surface and regulated under Texas Statewide Rule 8 by the TRRC, 16 TAC 3.8. In 1977, the National Pollution Discharge Elimination System (NPDES) was created. Under provisions of the CWA and the NPDES, the EPA proposed to eliminate all produced water discharges from oil and natural gas facilities in the United States. In 1995, MCA submitted sufficient scientific data to EPA, Region 6 to prove the usable quality of water from the Carrizo Wilcox, Reklaw and Bartosh Formations east of the 98th meridian and inland of the Chapman Line. Fresh, produced water from these formations was exempted from the proposed zero-discharge rule and special regulatory standards were established under the NPDES to allow these discharges to continue. Those standards included a maximum TDS limit of 3000 mg/l and the stipulation that oil in water (OIW) concentrations not exceed 35 ppm in any single grab of the discharge effluent. Exemptions for fresh produced water discharges were set forth in EPA General Permit TXG290000 in 1995. Volumes of produced water, TDS and OIW concentration data must be filed annually with EPA, Region 6 by all operators. Subsequent revisions of TXG290000 have all contained exemptions for fresh, produced water from the Carrizo Wilcox, Reklaw and Bartosh formations east of the 98th meridian and regulatory standards for these discharges remained the same as those implemented in 1995.

Livestock Pond Containing Fresh, Produced Water

In 1985 the TRRC began to require permits for these fresh water discharges. TRRC permits must be renewed every five years. Permitting requirements include compound analyses for metals and volatile organics, TDS and chlorides, OIW concentrations, volumes of water to be discharged, approval from surface owners receiving the discharge and notification of affected landowners for one-quarter mile downstream. Additionally, OIW must be reported to the TRRC every quarter, for the previous three months.

For nearly 70 years, fresh, produced water from shallow Reklaw oil wells in Central Texas clearly met surface water quality standards defined by the CWA, and the TSWQS and neither the EPA nor the TRRC felt compelled to significantly change or add additional regulatory standards to these discharges.

"Fred"

Fred, a large snapping turtle, has lived in a fresh, produced water discharge ditch in Southwest Muldoon Field in Fayette County for over 11 years.

Rules applicable to these discharges changed in 2012, however, when the TRRC suddenly began to require WET testing of the effluent in the permitting renewal process and in subsequent quarterly reporting. Affected operators were given no prior notice of the rule change, no chance to comment, and no opportunity to comply with new WET standards, TWC 26.024. Re-permitting applicants were given one chance to pass 48 hour acute toxicity testing. These provisions do not comply with applicable Texas Surface Water Quality Standards and its implementation guidance, TWC 26.131 (B) for WET testing in Texas.

In December 2013, EPA, Region 6 published a proposed draft for modification to the current applicable General Permit for these discharges, TXG330000. That modification draft also now also includes 48 hour WET testing on a pass or fail and cease discharging basis. Dischargers are given 60 days to comply. The EPA is required to adhere to applicable Texas law (TSWQS) in administering NPDES

permits, CWA 301 (b)(1)(C). Sixty days to pass WET tests, or fail and cease discharging does not comply with Texas law. Additional WET testing to determine "persistent toxicity" in the discharge cannot be achieved if the discharges are shut in after one test has failed as required by both the EPA and the TRRC.

The comment period for Draft NPDES Permit TXG330000 ended January 16, 2014. A significant number of affected parties commented to EPA, Region 6 regarding the potential economic ramifications to small business and local economies should operators not be able to comply with WET standards in the new permit. A number of affected land owners receiving fresh, produced water commented to EPA, Region 6 about the usable quality of the produced water and its importance to livestock and wildlife watering. EPA, Region 6 and the TRRC have agreed to meet with fresh, produced water dischargers that wish to present scientific data that may, or may not, have bearing on the manner in which WET standards are applied. A final General Permit will be published in subsequent months.

EPA, Region 6 has acknowledged the usable quality of this fresh, produced water and its potential importance to Texas surface waters. It should be the express desire of all parties that these discharges are regulated in exact accordance with implementation guidance for WET standards set forth in TSWQS and that comply with the CWA. This fresh, produced water is a valuable natural resource that should not be wasted.

WHOLE EFFLUENT TOXICITY TESTING, TIE AND TRE:

In 2012, to comply with new WET standards imposed by the TRRC during the re-permitting process, some affected operators began performing 48 hour acute toxicity tests and experimentation under EPA 821-R-02-012, 40 CFR 136.3(2021.0). All discharge facilities in Fayette and Gonzales Counties were ultimately tested. In 98 percent of those facilities tested, Promelas (minnows) species survived WET tests in 100 percent effluent concentrations. Over 50 percent of the time, however, Daphnia pulex (D. pulex) species failed WET standards. D. pulex tests were found to fail one 48 hour acute WET test but several weeks later, at the same facility, D. pulex survival rates would pass WET standards entirely. No persistent toxicity of the effluent can be established in these discharges, 30 TAC 307.3 (39).

Given the onerous pass or fail parameters being imposed by the TRRC, however, WET experiments persisted and significant work was done by operators to establish patterns in failed D. pulex species to identify toxicity and possible toxicity reduction evaluation methods (TRE). Over $200,000 have been spent thus far by two affected operators on various tests to ensure compliance with 60 day, pass or fail WET standards. This has posed a significant financial hardship on marginal stripper well operators affected by the proposed new rule. In one case, the TRRC ordered a facility that failed one WET test to cease discharging. That facility was shut down completely and oil production was lost for many months at great financial loss.

Fresh, Produced Water Outfall

To comply with 60 day pass or fail WET tests proposed by the EPA and the TRRC, two operators in Fayette and Gonzales Counties performed the following:

- Toxicology assessments were initiated by Baker Hughes Petrolite on D. pulex organisms and concentrations of water clarifiers used as a flocculent producer to "polish" water at discharge facilities. An internal maximum concentration of this production chemical was set based on these toxicology assessments.

- Oil in water concentrations were monitored closely by operators at effluent outfalls using non-solvent, UV fluorescence technology. Separation schemes were changed, retention and residence time was added to facilities, coalescing plates were changed and/or added in separators, flow rheology was altered at piping in separation facilities, internal separator flow was changed by use of baffles, spreaders and down comers and injection locations for production chemicals were changed. Though current regulatory standards require maximum OIW concentrations of 35 ppm in a single grab, in many cases OIW was reduced to less than seven ppm concentrations or less on a weighted average of multiple single grab and composite samples. A series of D. pulex experiments were initiated on ranges of OIW concentrations from five ppm up to 35 ppm. Observable morality in D. pulex increased in OIW concentrations exceeding 28 ppm; no significant improvement in D. pulex survival rates occurred, however, in OIW below 18

ppm. Concentrations as low as five ppm have no effect on D. pulex survival in produced water from the Reklaw formation.

- Bacteria studies of individual wells and commingled produced water streams were initiated by an independent laboratory in Houston (Dixie). No bacteria issues were found. Bacteria and algae mats grow in warm temperatures in pits and retention ponds but that is considered a normal, healthy characteristic of fresh water. Algae are a valuable food source for aquatic life.

- A pilot test was initiated by Carbonair on a production facility in Gonzales County exhibiting fairly consistent D. pulex mortality at end of pipe using a series of liquid phase particulate filter canisters, organic clay vessels and a large carbon filtration vessel. Two successive WET experiments immediately downstream from the filtration system failed minimum D. pulex survival rates, however. High pump pressure rates through vessels and significant filter media loss indicates that filtration cannot be economically achieved for these marginal stripper well facilities.

- Non-pathogenic microbial bacteria treatments by Micro-Bac Technologies were introduced into retention ponds and vessels in separation and treatment systems to improve the biodegradation of hydrocarbons and other organics through enzyme production. The clarity of produced water improved dramatically and oil in water concentrations reduced significantly.

- Additional compound analyses of produced water were undertaken by Accutest at various facilities in both Fayette and Gonzales Counties failing D. pulex tests. Emphasis was placed on metal content and total dissolved solids using EPA 200.7 methodology. No conclusive data was obtained from this phase of analytical research as all compounds tested were less than maximum limits set forth in EPA 200.7 and 30 TAC 307.6.

- The first of three toxicity identification evaluations (TIE) was initiated at produced water discharge production facilities in Fayette and Gonzales Counties. The discharge facilities chosen for TIEs were representative of other Reklaw producing wells, containing similar water characteristics, in a northeast to southwest trending strike orientation. Produced water in these facilities is basically from the same producing interval (Arnim 'A' oil sand) of other wells in the Reklaw trend in Central Texas east of the 98th meridian.

  The first TIE was performed on a discharge facility in Gonzales County (Sellers Lease Service (SLS), Thomas Clifton) that had consistently failed minimum D. pulex survival rates in WET tests. D. pulex mortality was found to be due to ion imbalances in the produced water that caused high alkalinity values. The produced water exhibited high sodium bicarbonate and low calcium concentrations. These characteristics are typical of natural

groundwater conditions in the Reklaw formation in this area. Pretreating the produced water samples with aeration, filtration, and C18 solid phase extraction to eliminate alkalinity and to add hardness values to the water had little to no effect on reducing WET testing toxicity to D. pulex.

- Baker Hughes Petrolite undertook X-Ray Fluorescence interpretations of minerals in produced water held in retention and residence ponds from several discharge facilities. A composite of mineral solids was obtained through pore filter analysis. The results of these analyses were used in post TIE discussions by Atkins North America.

- WET experiments were initiated on produced water discharges using both D. Pulex and Promelas based on EPA 821-R-02-012 methodology at discharge source point outfalls and various distances downstream, both on-lease and off-lease, for data comparisons. The results of these experiments confirmed the further downstream fresh, produced water was sampled the more likely it was that D. pulex species would survive and meet WET standards. This was attributed to ion imbalances coming into equilibrium as bicarbonate alkalinity vented or dissolved in the receiving discharge runway or ephemeral ditch, gully or creek.

- To comply with the July 31, 2012 publication of EPA General Permit TXG330000 for stripper wells producing from the Carrizo Wilcox, Reklaw and Bartosh formations east of the 98th meridian, Section C (a)(b)(c)(d), a series of WET tests were initiated by Atkins North American on produced water in Gonzales and Fayette Counties using marine organisms on a 24 hour acute basis. These tests all passed survival rates with 100 percent No Observable Effect Concentrations (NOEC). Altering water characteristics from fresh to saline to comply with marine WET tests brought ion composition imbalances into immediate equilibrium. Marine organisms are equally sensitive to toxicity in produced water as fresh water organisms. Successful marine WET tests supported the theory of natural ion imbalances in the water and gave further proof to there being no toxins in the produced water. Please see Appendix 2, MARINE WET TESTS.

- A series of 48 hour acute toxicity experiments were initiated substituting Daphnia magna for Daphnia pulex by Atkins North America. Substituting D. magna had no effect on WET results and further proved the existence of natural ion imbalances in the water.

- A series of ion patterning and ion-driven toxicity modeling was initiated on several discharge facilities in Fayette and Gonzales Counties by ALS Environmental.

- The last of three TIEs was undertaken by Atkins North America on two additional discharge facilities in Fayette County, Texas. These facilities were chosen on the basis of failed D. pulex experiments and successful Promelas tests and because of suspected high alkalinity values. Those facilities produce water from the Reklaw formation and correlated to the TIE done in Gonzales County by SLS. Please see Appendix 3, SUMMARY OF TIEs.

CONCLUSIONS TO WET TESTING AND TIE/TRE STUDIES:

Based on data obtained through TIEs at end of pipe and successful WET experiments downstream, there appears to be no classic chemical toxins in the fresh, produced water from the Reklaw formation in Fayette and Gonzales Counties. D. pulex mortality appears to be the result of ion imbalances in the produced water from bicarbonate and non-carbonate alkalinity and possibly from minor, non-carbonate silicate content from produced formation clays. All of these causes for D. pulex mortality are due to the natural characteristics of the formation water being produced.

Daphnia species are clearly not the proper fresh water species to be using in WET standards for the Reklaw formation as occasional mortality for D. pulex is not an indication of aquatic health in the receiving area. Downstream WET tests prove that.

Based on extensive research and changes in separation and treatment protocol there does not appear to be any economically feasible way to alter natural ion imbalances in the water that cause D. pulex mortality at end of pipe.

INSTREAM AQUATIC BIO MONITORING:

WEST BROOK CREEK:

Southwest Muldoon Field Battery 1 (TXG330038-0026) produces 2,873 barrels per day of fresh water from 12 wells that produced from the Reklaw formation. Oil is separated from water through multiple horizontal and vertical separators; the water is treated with minor concentrations of flocculent producing water clarifiers and is retained for approximately 24 hours in on-site tankage and permanent holding pits. It then flows into a large stock pond built for livestock consumption approved by the surface owner before being discharged to the land surface. All species pass WET tests at the discharge source point. Please see Appendix 4, MCA SOUTHWEST MULDOON FIELD BATTERY 1 DISCHARGE FACILITY.

The produced water travels downstream in discharge runways built by the operator and is captured by landowners in stock ponds for livestock purposes before it leaves the oil and gas lease boundaries approximately 4,408 feet from of the source point. Both species in WET tests also pass at various stages downstream on lease premises, in the discharge runway and in stock ponds.

Rare Texas River Otters live in one of the on-lease stock ponds in Southwest Muldoon Field. This stock pond contains 100 percent fresh, produced water. Please see Appendix 6, RARE TEXAS RIVER OTTERS.

Produced water from Southwest Muldoon Field Battery 1 eventually enters West Brook Creek. WET tests were performed on January 21 and 22, 2014 at West Brook Creek and FM 2762, approximately 1.82 miles downstream of the discharge source point. Both species passed with NOEC of 100 percent. Produced water remains stagnant or in very low-flow status in normal rainfall periods in West Brook Creek for 6.15 miles downstream of the source discharge point in Southwest Muldoon Field before converging with Big Five Mile Creek in Gonzales County. Please see enclosed USGS TOPO MAP. Please see Appendix 5, WEST BROOK CREEK BIO MONITORING REPORT.

LITTLE FIVE MILE CREEK:

A total of six fresh, produced water discharge facilities release water indirectly into Little Five Mile Creek. These facilities discharge a total of 1,850 barrels of water per day, all from one primary producing interval (Arnim 'A' oil sand) of the Reklaw formation.

Fresh, Produced Water in Fayette County, Texas

WET experiments of these six discharge facilities consistently pass Promelas in 48 hour acute tests and fail D. pulex at various rates of mortality in various rates of effluent concentrations at end of pipe source points. No persistent toxicity of the produced water can be established. Please see Figure 4.

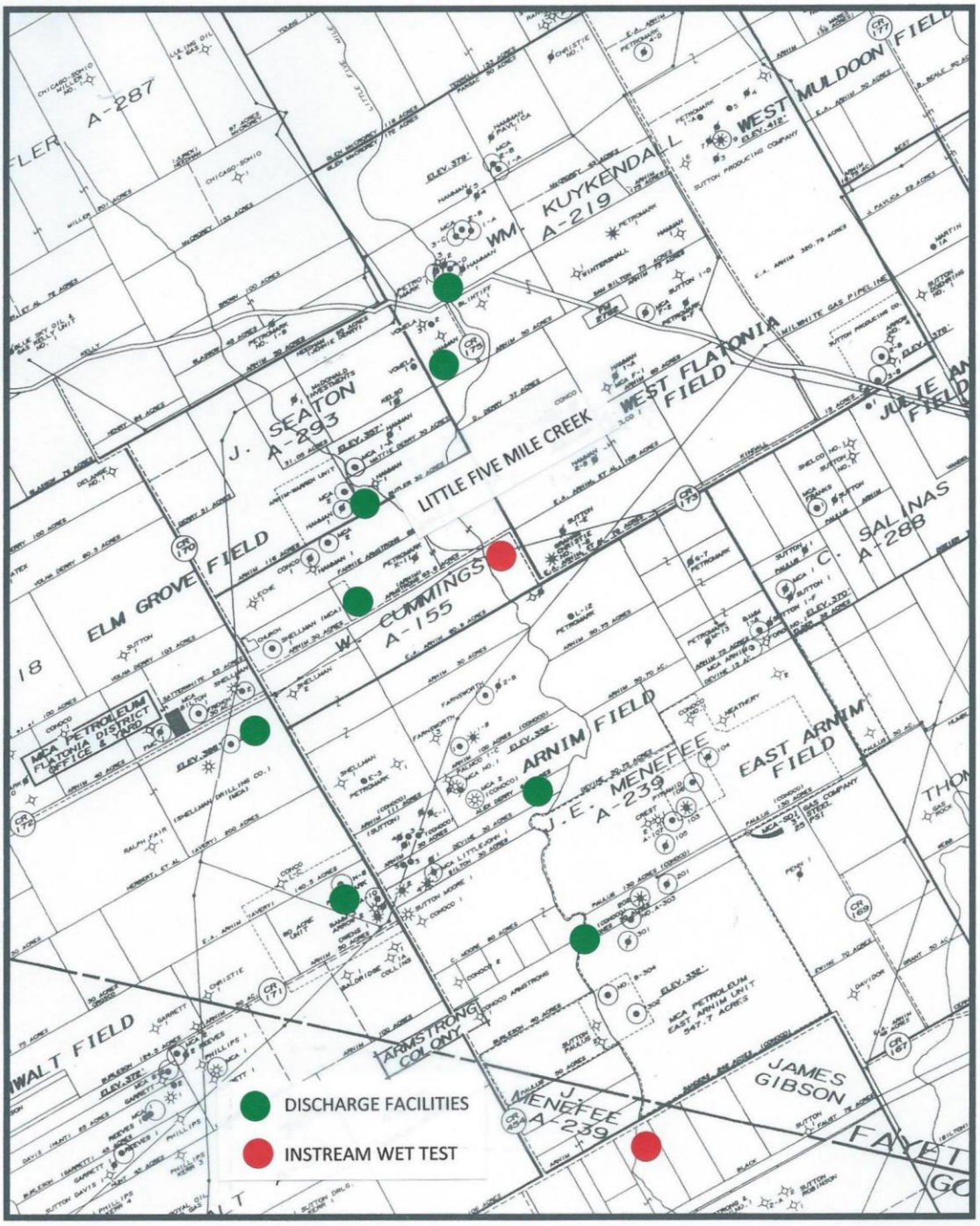


Figure 4

The MCA Arnim Unit No. 1 produced water discharge facility (TXG330000-0028) failed D. pulex survival standards on December 10, 2013 at end of pipe with NOEC of less than 32 percent. Six days later, a subsequent WET experiment of the source discharge point 340 feet downstream, in a stock pond used to capture produced water for livestock purposes, revealed that D. pulex passed WET standards with NOEC of 100 percent. A TIE was performed of this facility at the source point outfall by Atkins North America on December 5, 2013. No chemical toxicity was found and the results of the TIE showed the cause of D. pulex mortality was believed to be a combination of non-carbonate ion species that contribute to high alkalinity and minor aluminum silicate matter of submicron size, believed to be produced formation clays. Within 340 feet of the discharge point source, and after approximately 12 hours of residence time in the above referenced stock pond, ion imbalances in the water had come into equilibrium and D. pulex passed WET standards. Please see Appendix 7, MCA ARNIM UNIT DISCHARGE FACILITY.

In a Fluid Sensitivity Evaluation performed in 1984 by David K. Davies and Associates, the primary producing sand in the Reklaw formation that discharges fresh, produced water into Little Five Mile Creek was found to contain an abundance of very fine clay minerals. By thin section analysis and scanning electron microscopy, these clays were determined to be primarily kaolinite, illite and chlorite. These clays are typically referred to as migrating clays and once they become detached from the quartz matrix in the reservoir, usually from fluid shear and differential pressure drop between bottom-hole reservoir pressure and the well bore, these particles get produced up-hole with oil and water. This formation clay is so small (less than 0.5 micron) it is essentially non-filterable. The principle chemical composition of kaolinite is aluminum silicate. Clay fines are a natural characteristic of all formation water produced from Reklaw sands in Central Texas. Other similar reservoir mineralogy studies in the Reklaw formation confirm that. Please see Appendix 8, FLUID SENSITIVITY EVALUATION.

Though D. pulex mortality rates vary in WET experiments from source point outfalls of discharge facilities along Little Five Mile Creek, the actual water in the creek passes all WET test organisms. In-stream WET tests prove the biological integrity of the receiving ditch, gully or ephemeral creek. This fresh, produced water poses no threat to aquatic life or to the environment.

Upstream of the MCA McCrory Discharge Facility (TXG330038-0030) no water can be found in Little Five Mile Creek due to extreme and prolonged drought. From that discharge source point and downstream of four additional production facilities approximately 1.3 miles, WET tests performed at Little Five Mile Creek and Dozier Road always pass both D. pulex and Promelas species. A WET test was performed January 21 and 22, 2014 at the same location and both Promleas and D. pulex passed with 100 percent NOEC.

Downstream of two additional discharge facilities along Little Five Mile Creek, an additional 1.1 miles downstream, WET tests performed at Little Five Mile Creek and Gonzales County Road (GCR) 455 historically pass both species of fresh water organisms in WET tests. The last WET tests taken at Little Five Mile Creek and GCR 455 were performed on January 21 and 22, 2014. Both Promelas and D. pulex passed 100 percent NOEC.

Rainfall in southwest Fayette County is currently below normal for the months of October, November and December 2013 and January 2014. The only rainfall received in the area of Little Five Mile Creek prior to January 21, 2014 was 1.29 inches received the first week of January. That rain occurred over a 28 hour period. No storm runoff has occurred into Little Five Mile Creek since October 2013. At the time of WET sampling on January 21, 2014, the creek contained 100 percent concentrations of fresh, produced water from upstream facilities. No flow was observed anywhere along Five Mile Creek on January 21, 2014.

Fresh, produced water in Little Five Mile Creek supports approximately 89 cattle scattered along the creek located on small ranches and farms. Many of these farms have cow/calf operations and rely heavily on water to sustain their cattle. Many of the ranchers in this area have lived in the Armstrong Colony area for four generations or more. Those families rely on cattle for a living. Wildlife and aquatic life along the creek is significant. Please see Appendix 9, LITTLE FIVE MILE CREEK BIO MONITORING REPORTS.

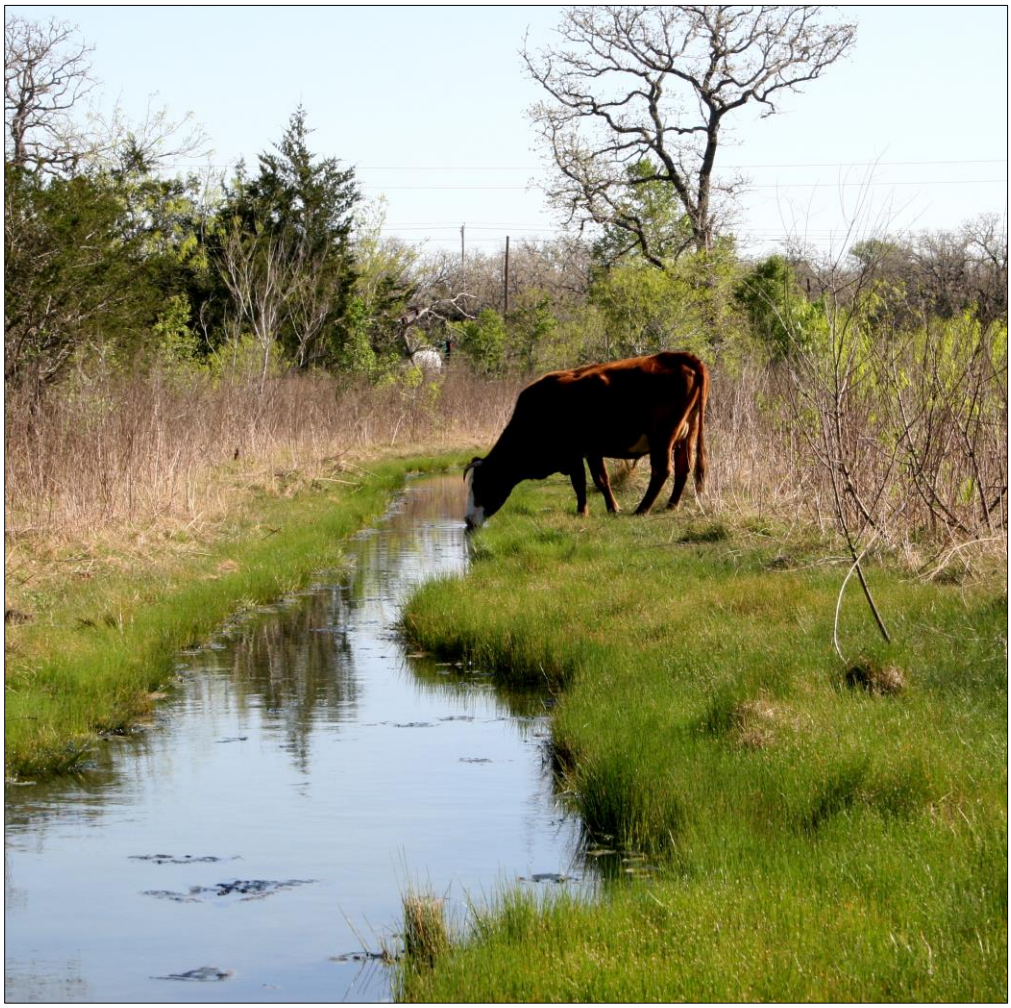
UNNAMED DRAINAGE:

West of Little Five Mile Creek, two facilities operated by MCA discharge fresh, produced water onto private land. The MCA Herbert (TXG330038-0021) discharges 225 barrels of water per day to the land surface. That water is captured by the cattle rancher owning the surface estate in one large lake, Avery Lake, on USGS topographical maps (see enclosed USGS TOPO MAP). On December 16, 2013, D. pulex experiments failed at EOP at this facility with less than 32 percent NOEC. On January 2, 2014, approximately 2551 feet downstream of the source point outfall in a ditch located on-lease, at the mouth of Avery Lake, D. pulex passed WET standards with 100 percent NOEC. In periods of abnormal rainfall when runoff is high, water in Avery Lake spills out of the pond and crosses Hunt Lane. From there it enters an unnamed ditch west of the lake then turns south towards Little Five Mile Creek. The same cattle rancher owns that land also. Please see Appendix 10, MCA HERBERT DISCHARGE FACILITY.

In this pasture west of Avery Lake, the MCA Arnim A-10 (TXG330038-0020) discharges 129 barrels per day of fresh, produced water to the land surface. On December 16, 2013, D. pulex failed a 48 hour WET experiment with less than 32 percent NOEC. On January 2, 2014, approximately 368 feet downstream from the outfall, in a stock pond built to capture fresh, produced water from the Arnim A-10

and Herbert discharge facilities, D. pulex passed WET standards with 100 percent NOEC. Please see Appendix 11, MCA ARNIM A-10 DISCHARGE FACILITY.

Fresh, produced water from the MCA Herbert and MCA Arnim A-10 facilities theoretically converge into an unnamed gully that traverses south and southwest approximately 1.25 miles and enters Little Five Mile Creek slightly south of Gonzales County Road 455. The term theoretical is used to honor the dip of the drainage basin southward. In reality, produced water rarely spills from Avery Lake due to high evaporation rates. Seldom does fresh, produced water from these two facilities reach Little Five Mile Creek. When produced water does reach that creek from this unnamed drainage it is significantly diluted with storm water runoff . Fresh, produced water running into Avery Lake and downstream of the MCA Arnim A-10 facility supports an additional 61 head of cattle.



Livestock Watering in Produced Water Discharge Runways

BIG FIVE MILE CREEK:

Little Five Mile Creek and West Brook Creek converge with Big Five Mile Creek in Northern Gonzales County. At the point of convergence there would theoretically be 5,119 barrels of fresh, produced water per day flowing from a total of seven discharge facilities. However, water is rarely seen flowing at the Big Five Mile Creek convergence unless it is in periods of unusually high rain runoff. From the Big Five Mile Creek convergence it is 2.2 miles to Peach Creek and 23 miles to the Guadalupe River.

WET tests were performed January 21 and 22, 2014 at Big Five Mile Creek and Texas State Highway 90 in Gonzales County. At the time of WET sampling, no observable flow could be seen in Big Five Mile Creek. Both Promelas and D. pulex passed WET standards with 100 percent NOEC. Please see Appendix 12, BIG FIVE MILE CREEK BIO MONITORING REPORT.

SUMMARY:

Bicarbonate and non-carbonate alkalinity, including minor aluminum silicates in the produce water from formation clay, often cause inconsistent D. pulex survival rates in WET tests taken at end of pipe. Based on the success of WET tests taken downstream of source points, WET standards as those proposed by the TRRC and EPA, Draft NPDES Permit TXG330000 may not be the most accurate means of measuring the sustainability of aquatic life and overall health in ephemeral creeks receiving these discharges. These receiving creeks are clearly very robust and full of many different kinds of life, including aquatic life.

TIE's of produced water consistently point to the natural characteristics of formation water in the Reklaw as being the cause of occasional D. pulex mortality. There is no classic, contaminate-related toxicity in this produced water. **"Depending on the discharge situation, TDS toxicity may not be viewed with the same level of concern as other, more traditional, toxicants. These discharge situations often do not require the conservative safety factors required by other toxicants."(Major Ion Toxicity in Effluents; Goodfellow ,etal., 1999)**

Filtration of sub-micron size clay fines in the produced water effluent is economically not practical for these marginal, stripper wells. Previous filtration tests performed during TRE efforts had no effect on reducing D. pulex mortality. Clay fines are related to kaolinites, a natural occurring component of the earth's minerals. Pretreating produced water samples with aeration, filtration and C18 solid phase extraction to eliminate alkalinity, and to add hardness values to the water, had little to no effect on reducing WET testing mortality to D. pulex. **"Cost-effective waste treatment control options for a facility, whose effluent is toxic because**

of total dissolved solids (TDS) or because of specific ion(s), are scarce, at best." (Goodfellow, et al., 1999).

Disposal of fresh, produced water to off-premise commercial injection facilities is not economically feasible for these marginal, stripper wells. Over 6,000,000 barrels of usable water is discharged to the land surface in Fayette and Gonzales Counties each year. Disposal fees per incremental barrel of water can now be as high as seven dollars per barrel with transportation costs.

On site re-injection of this produced water cannot be achieved economically. The volumes of water requiring injection are too great and individual discharge facilities are often miles apart. 16 TAC (1)3.46)(a) states that produced water cannot be re-injected that would "cause the pollution of freshwater strata unproductive of oil and gas." The depth of unusable, brackish water in Fayette and Gonzales Counties determined by the TRRC Groundwater Advisory Unit is 3,300 feet below the surface. The second largest groundwater aquifer in Texas (Carrizo Wilcox) is immediately below the Reklaw formation, above 3,300 feet, and is used extensively throughout Central Texas for human consumption.

It would be senseless to inject usable, good quality fresh water back into saline reservoirs. That would be a horrific waste of Texas' natural resources.

New TRRC rules promoting "recycling" of produced oilfield wastes cannot be applied to thin sands of the Reklaw formation with limited permeability. Clay contents and fluid sensitivity to those clays (See Appendix 8) would result in very high injection pressures and would not be cost effective given the large volumes of water requiring injection. The possibility of creating hydrologic conductivity between the Carrizo Wilcox and Reklaw formations under high surface injection pressures would pose a threat to the second largest groundwater aquifer used for human consumption in Texas.

If WET standards are implemented as proposed under the EPA's Draft NPDES Permit TXG330000, affected operators will not be able to comply.

In-stream WET experiments sampling 100 percent concentrations of produced effluent in receiving ephemeral creeks consistently prove the absence of toxicity to aquatic life. Clearly, natural ion composition imbalances at the end of pipe degrade and diminish downstream, 30 TAC 307.3 (39). Daphnia may not be the best test organism to use in proposed WET standards or perhaps a single species of fresh water organism test is sufficient. Texas Surface Water Quality Standards §307.6(e)(2)(b) provides the regulatory venue for specific exemptions for WET mortality that is the result of an "excess, deficiency, or imbalance of dissolved inorganic salts (such as sodium, calcium, potassium, chloride or bicarbonate) that are in the effluent, or that are in source waters."

The produced water that keeps ephemeral creeks full in this part of Texas provide habitat for wildlife, birds and reptiles. Shrubs and large hardwood trees with extensive root systems that grow along these creeks produce important nutrients for aquatic life. This constant source of surface water enables thick ground cover and vegetation to grow along creek banks and prevents erosion from occurring. Non source point pollution from sedimentation, pesticides, toxic metals and agricultural related fecal matter is the single greatest threat to Texas surface waters. Siltation from erosion is especially harmful to fish and aquatic life. Ephemeral creeks in Fayette and Gonzales Counties full of fresh, produced water actually helps prevent pollution. If this water was removed from the ecosystem there would be no aquatic life to protect.

This Five Mile Creek, West Brook and Big Five Mile Creek case study can be applied to other ephemeral creeks receiving fresh, produced water east of the 98th meridian and inland of Texas coastal waters. Successful WET tests and experiments taken downstream of discharge source points known to have ion composition imbalances in produced water have been achieved in Peach Creek in Fayette and Gonzales Counties and Live Oak , Pin Oak and Buckner Creeks in Fayette County.

Fresh, produced water discharges have been made in this part of Central Texas for nearly 70 years with no environmental harm whatsoever. They are a valuable, irreplaceable contribution to Texas surface waters.

Fresh, Produced Water in Fayette County, Texas

Ducks in Little Five Mile Creek, Fayette County, Texas

Appendix 6

RARE TEXAS RIVER OTTERS

Game-Camera Photographs of Rare Texas River Otters in Fresh, Produced Water Discharges; Fayette County, Texas.

River Otters Returning to Texas Waterways

Sightings of the elusive Texas river otter have increased, some in unexpected places, according to Texas Parks and Wildlife Department Biologist Gary Calkins. Otters have been spotted much farther west than expected, and even as far north as Wichita Falls.

"There were sightings in Gonzales, that was kind of a surprise," said Calkins, who leads TPWD's tri-annual effort to survey rivers and monitor otter population trends. "But the real westerly sightings, those stick out in my mind."

Calkins started receiving reports of otter sightings after two Passport to Texas radio broadcasts about his otter research aired last year. The biologist owes the sightings to more eyes looking and increased public interest rather than any significant change in the state otter population. Passport to Texas is TPWD's radio series of 90-second weekday feature stories airing on about 100 stations across the state.

These sightings are somewhat of a surprise, since usually otters like to keep out of sight of humans.

"Otters live in the water, and are not something people normally look for," said Calkins. "They are really kind of a shy, retiring animal and do most of their hunting right at dawn or right at dusk so they are not something you are normally going to stumble across."

Historical range maps have shown in the past otters occurring from East to Central Texas, but too much trapping in the past limited them to the eastern quarter of the state. Department reports now show that the animals are returning to their historic range.

Calkins says river otters are an indicator of how healthy the surrounding environment is. Otters feed on things like fish and crawfish, which are very sensitive to pollutants.

"If you have crawfish and a lot of prey items in the waterway, otters are going to be more noticed in the system and show that it's generally doing well ecologically," said Calkins. "It shows there is enough food to sustain them, and the prey items are really sensitive so that's kind of a key."

These new developments with the state's otter population will be important in future research.

"What this is going to do is work as background information on what we do next on otter management," said Calkins.

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