

**ADVANCED CORE ANALYSIS**  
***FLUID COMPATIBILITY STUDY***

**Leonard Rice Engineers, Inc.**  
**Bellvue Treatment Plant Water**  
**& Terry Ranch Groundwater**

**FINAL REPORT**

**Submitted to:**

**Leonard Rice Engineers, Inc.**

**November 30, 2020**

**Performed by:**

**Core Laboratories, Inc.**  
**Advanced Technology Center**  
**6316 Windfern**  
**Houston, Texas 77040**

**HOU-202005420**

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November 30, 2020

Leonard Rice Engineers, Inc.  
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Denver, Colorado 80204  
USA

Attention: Joel Barber & Allan Foster

Subject: Fluid Compatibility Study  
Fluids: Bellvue Treatment Plant Water  
& Terry Ranch Groundwater  
File: HOU-202005420

Presented in this report are the results of a Fluid Compatibility study performed on Bellvue Treatment Plant Water & Terry Ranch Groundwater and comprised of the following tests:

- Fluid:Fluid Compatibility Analysis
- Routine Water Analysis

We sincerely appreciate the opportunity to be of service to you and Leonard Rice Engineers, Inc. with this analysis and look forward to working with you on future projects. If you should have, any questions concerning this report or if you require additional information, please do not hesitate to contact us.

Sincerely,

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## SUMMARY

The Houston Advanced Technology Center of Core Laboratories received two (2) water samples on October 2, 2020 from Leonard Rice Engineers, Inc. The water samples were identified as Bellvue/Dugens Treatment Plant water and Terry Ranch groundwater and arrived in 5 gallon plastic sealed pales, as noted in the photographs in the Appendix of this report.

The samples were provided for fluid:fluid compatibility testing. Each pale was opened and the waters were tested "as received" without any filtering of the fluids. The waters were then mixed into client specified ratios to create 1000ml mixtures, which were each stored in clear sealed graduated glass cylinders to allow for periodic visual observations. The requested fluid ratios are presented below:

Bellvue Treatment Water (90%) & Terry Ranch Groundwater (10%)  
Bellvue Treatment Water (70%) & Terry Ranch Groundwater (30%)  
Bellvue Treatment Water (60%) & Terry Ranch Groundwater (40%)  
Bellvue Treatment Water (42%) & Terry Ranch Groundwater (58%)  
Bellvue Treatment Water (30%) & Terry Ranch Groundwater (70%)

All testing was performed and maintained at a temperature of 68°F. The pH, clarity and color of both waters was recorded before mixing; with both noted as colorless and clear. The pH of the Bellvue treatment water was 8.35 and the pH of the Terry Ranch groundwater was 8.33.

Each test mixture/ratio was documented for initial observations (color, clarity, precipitation, reactivity, emulsions) immediately upon mixing and were then stored in a dark environment to minimize exposure to light, in order to help prevent any biological growth. The initial observations for each mixture was the same indicating no reaction upon mixing, with no precipitation or emulsion and each noted as clear and colorless.

After **24-hours**, the pH of each mixture/ratio was measured which ranged from approximately 8.3 to 8.4. Observations were again noted, and described as the same as the initial observations (no reaction, no precipitation, no emulsion, clear & colorless).

After **7-days**, the pH of each mixture/ratio was again determined, which ranged from approximately 8.2 to 8.3 and with similar observations (no reaction, no precipitation, no emulsion, clear & colorless).

The mixtures were left for a further day (**8-days**) where each fluid was then agitated for a period of 60 minutes, observations were again recorded which were the same as the previous observations (no reaction, no precipitation, no emulsion, clear & colorless).

Further pH measurements and observations were recorded again at **15-days** and **21-days**, after first agitating the mixtures for a period of 60 minutes. No change in observations was noted, with the mixtures still indicating no reaction, no precipitation, no emulsion, clear & colorless. The pH measurements indicated approximately 8.1-8.2.

The fluid:fluid compatibility testing was then concluded; with no apparent change noted for the observations from the time of initial mixing through to the conclusion of the 21-days test period. The pH results also indicated minimal to no change.

A routine water analysis with addition of single ion determination of potassium (K) was scheduled for the 70% Bellvue Treatment Water & 30% Terry Ranch Groundwater mixture. This mixture together with a sample of the 100% Bellvue Treatment Water and a sample of the 100%

Terry Ranch Groundwater were sent to Core laboratories' Reservoirs Fluid Services (RFS) laboratory in Broussard, Louisiana for analysis.

The 70% Bellvue Treatment Water & 30% Terry Ranch Groundwater mixture indicated total dissolved solids (TDS) of 150 mg/L, individual cations and anions together with plotted mineral analysis pattern are presented in this report.

Routine water analysis was performed on both the 100% Bellvue Treatment Water and 100% Terry Ranch Groundwater as a quality assurance check and indicated TDS of ~75 mg/L and 323 mg/L, respectively. The analyses for these 100% waters inclusive of the mineral analysis pattern plots are presented in the Appendix section of this report.

## FLUID:FLUID COMPATIBILITY LABORATORY PROCEDURES

1. Client provided two water samples (Bellvue Treatment Plant water, and Terry Ranch groundwater) to be tested for fluid:fluid compatibility at 68°F.

Water 1: Bellvue Treatment Plant  
Water 2: Terry Ranch Groundwater

2. The waters were tested “as-received” with no filtering prior to testing.
3. The waters 1 and 2 were maintained at room temperature 68°F and then mixed at 90:10, 70:30, 60:40, 42:58, and 30:70 ratios to create 1000ml mixtures. These mixtures were stored in clear, sealed graduated glass cylinders.

### Step 3

Water 1 (90%) & Water 2 (10%)  
Water 1 (70%) & Water 2 (30%)  
Water 1 (60%) & Water 2 (40%)  
Water 1 (42%) & Water 2 (58%)  
Water 1 (30%) & Water 2 (70%)

4. Each test mixture / ratio was documented for initial observations and then stored in a darkened environment to minimize the exposure to light, and aid in the prevention of biological growth.
5. Observations (color, clarity, precipitation, reactivity, emulsions) were documented on all the test mixtures immediately upon mixing.
6. After 24 hours further observations for each mixture were documented together with measurement of the pH of each mixture / ratio.
7. Subsequent, observations and pH measurements were also documented after periods of 7 days, 8 days, 15 days and 21 days.
8. For the observations and pH measurements documented at 8, 15 and 21 days, these were recorded after agitation of each mixture for a period of 60 minutes.
9. At the conclusion of testing after 21 days, a routine water analysis was then performed on the 70% Bellvue Treatment Plant & 30% Terry Ranch groundwater mixture.

## FLUID:FLUID COMPATIBILITY REPORT

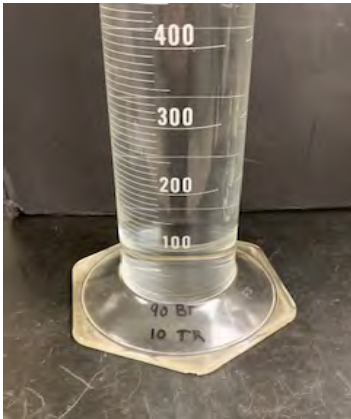
Temperature: 68°F

Fluids: Bellvue Treatment Plant Water & Terry Ranch Groundwater

Company: Leonard Rice Engineers, Inc.  
File: HOU-202005420

### Observations just after mixing at 68°F

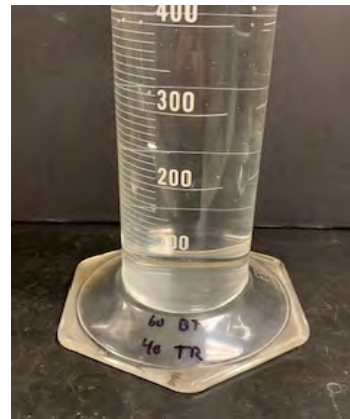
Fluid 1	Fluid 2	Fluid Ratio	pH	Color	Clarity	Precipitates	Reactivity	Emulsion	Comments
Bellvue Treatment Plant	-	100%	8.35	colorless	clear	-	-	-	-
-	Terry Ranch Groundwater	100%	8.33	colorless	clear	-	-	-	-
Bellvue Treatment Plant	Terry Ranch Groundwater	90% : 10%	-	colorless	clear	no	no	no	no reaction upon mixing
Bellvue Treatment Plant	Terry Ranch Groundwater	70% : 30%	-	colorless	clear	no	no	no	no reaction upon mixing
Bellvue Treatment Plant	Terry Ranch Groundwater	60% : 40%	-	colorless	clear	no	no	no	no reaction upon mixing
Bellvue Treatment Plant	Terry Ranch Groundwater	42% : 58%	-	colorless	clear	no	no	no	no reaction upon mixing
Bellvue Treatment Plant	Terry Ranch Groundwater	30% : 70%	-	colorless	clear	no	no	no	no reaction upon mixing



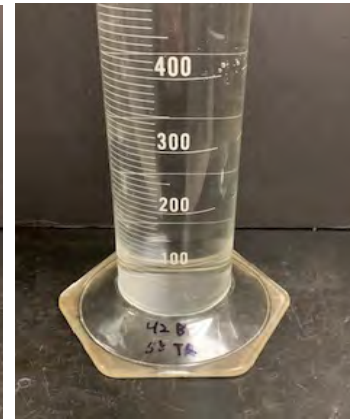
90% Bellvue  
10% Terry Ranch



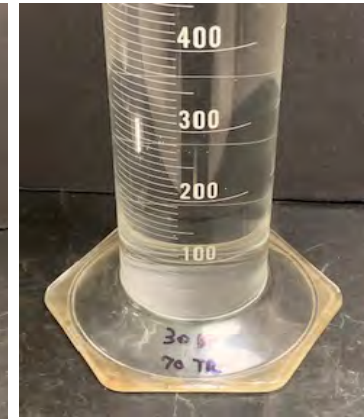
70% Bellvue  
30% Terry Ranch



60% Bellvue  
40% Terry Ranch



42% Bellvue  
58% Terry Ranch



30% Bellvue  
70% Terry Ranch

## FLUID:FLUID COMPATIBILITY REPORT

Temperature: 68°F

Fluids: Bellvue Treatment Plant Water & Terry Ranch Groundwater

Company: Leonard Rice Engineers, Inc.  
File: HOU-202005420

### Observations after 24 hour at 68°F

Fluid 1	Fluid 2	Fluid Ratio	pH	Color	Clarity	Precipitates	Reactivity	Emulsion	Comments
Bellvue Treatment Plant	Terry Ranch Groundwater	90% : 10%	8.33	colorless	clear	no	no	no	no reaction between fluids
Bellvue Treatment Plant	Terry Ranch Groundwater	70% : 30%	8.33	colorless	clear	no	no	no	no reaction between fluids
Bellvue Treatment Plant	Terry Ranch Groundwater	60% : 40%	8.32	colorless	clear	no	no	no	no reaction between fluids
Bellvue Treatment Plant	Terry Ranch Groundwater	42% : 58%	8.35	colorless	clear	no	no	no	no reaction between fluids
Bellvue Treatment Plant	Terry Ranch Groundwater	30% : 70%	8.36	colorless	clear	no	no	no	no reaction between fluids



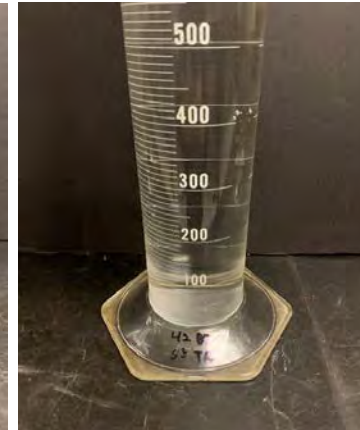
90% Bellvue  
10% Terry Ranch



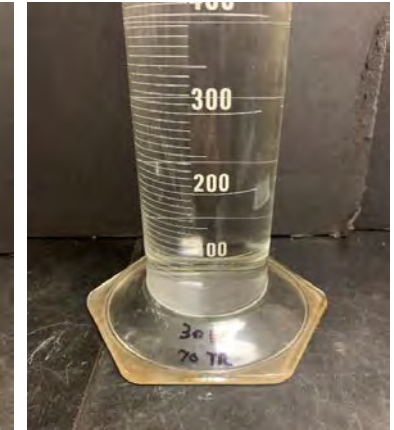
70% Bellvue  
30% Terry Ranch



60% Bellvue  
40% Terry Ranch



42% Bellvue  
58% Terry Ranch



30% Bellvue  
70% Terry Ranch

## FLUID:FLUID COMPATIBILITY REPORT

Temperature: 68°F

Fluids: Bellvue Treatment Plant Water & Terry Ranch Groundwater

Company: Leonard Rice Engineers, Inc.  
File: HOU-202005420

### Observations after 7 days at 68°F

Fluid 1	Fluid 2	Fluid Ratio	pH	Color	Clarity	Precipitates	Reactivity	Emulsion	Comments
Bellvue Treatment Plant	Terry Ranch Groundwater	90% : 10%	8.29	colorless	clear	no	no	no	no reaction between fluids
Bellvue Treatment Plant	Terry Ranch Groundwater	70% : 30%	8.30	colorless	clear	no	no	no	no reaction between fluids
Bellvue Treatment Plant	Terry Ranch Groundwater	60% : 40%	8.29	colorless	clear	no	no	no	no reaction between fluids
Bellvue Treatment Plant	Terry Ranch Groundwater	42% : 58%	8.33	colorless	clear	no	no	no	no reaction between fluids
Bellvue Treatment Plant	Terry Ranch Groundwater	30% : 70%	8.32	colorless	clear	no	no	no	no reaction between fluids



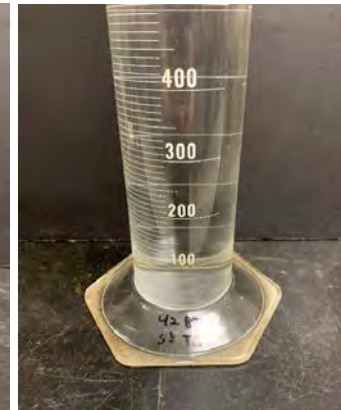
90% Bellvue  
10% Terry Ranch



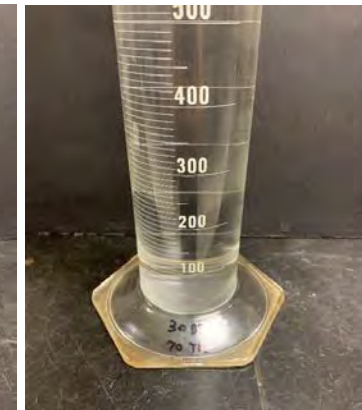
70% Bellvue  
30% Terry Ranch



60% Bellvue  
40% Terry Ranch



42% Bellvue  
58% Terry Ranch



30% Bellvue  
70% Terry Ranch



## FLUID:FLUID COMPATIBILITY REPORT

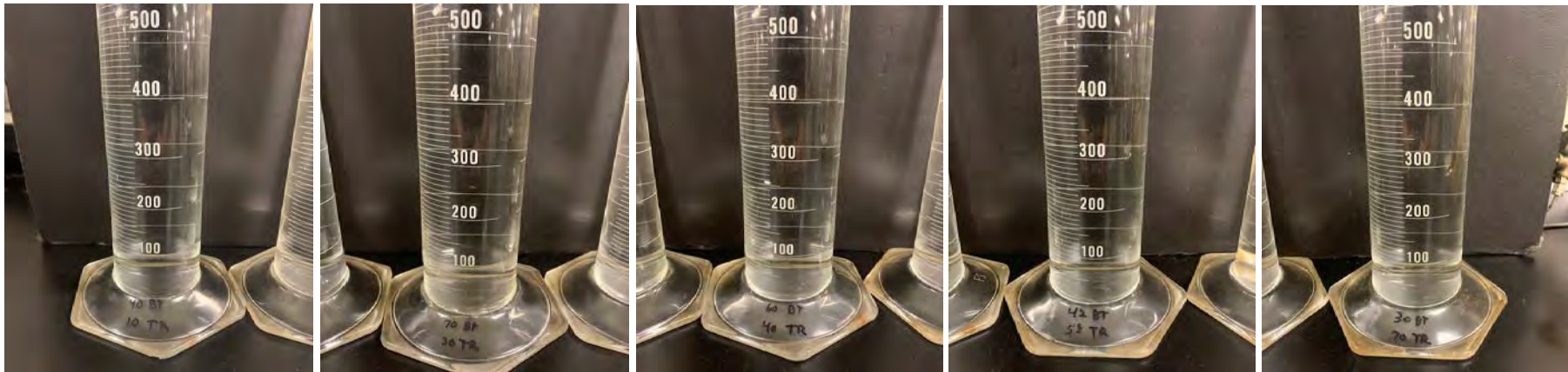
Temperature: 68°F

Fluids: Bellvue Treatment Plant Water & Terry Ranch Groundwater

Company: Leonard Rice Engineers, Inc.  
File: HOU-202005420

### Observations after 8 days at 68°F after 60 minutes of agitation

Fluid 1	Fluid 2	Fluid Ratio	pH	Color	Clarity	Precipitates	Reactivity	Emulsion	Comments
Bellvue Treatment Plant	Terry Ranch Groundwater	90% : 10%	-	colorless	clear	no	no	no	no reaction between fluids
Bellvue Treatment Plant	Terry Ranch Groundwater	70% : 30%	-	colorless	clear	no	no	no	no reaction between fluids
Bellvue Treatment Plant	Terry Ranch Groundwater	60% : 40%	-	colorless	clear	no	no	no	no reaction between fluids
Bellvue Treatment Plant	Terry Ranch Groundwater	42% : 58%	-	colorless	clear	no	no	no	no reaction between fluids
Bellvue Treatment Plant	Terry Ranch Groundwater	30% : 70%	-	colorless	clear	no	no	no	no reaction between fluids



90% Bellvue  
10% Terry Ranch

70% Bellvue  
30% Terry Ranch

60% Bellvue  
40% Terry Ranch

42% Bellvue  
58% Terry Ranch

30% Bellvue  
70% Terry Ranch

## FLUID:FLUID COMPATIBILITY REPORT

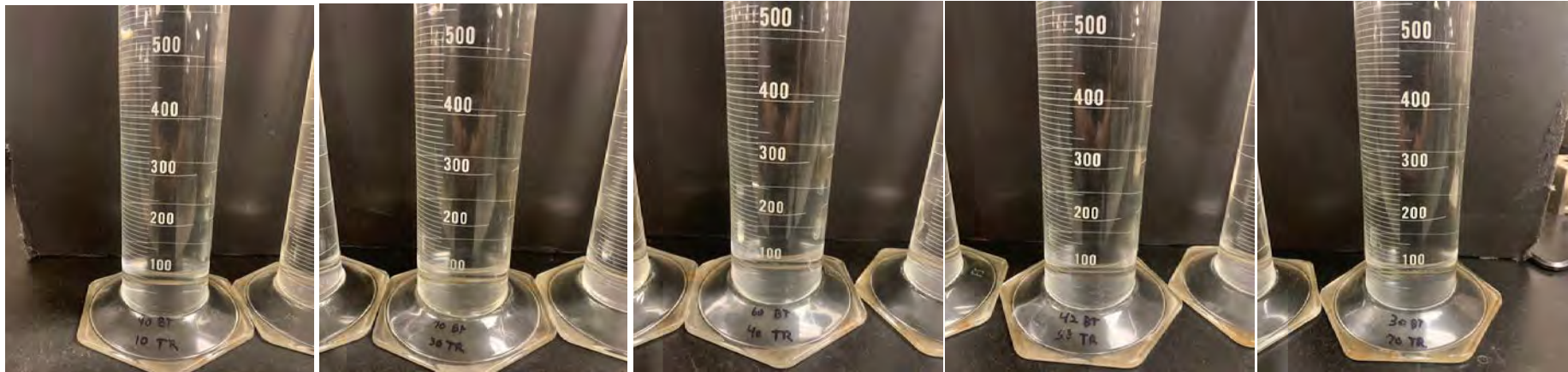
Temperature: 68°F

Fluids: Bellvue Treatment Plant Water & Terry Ranch Groundwater

Company: Leonard Rice Engineers, Inc.  
File: HOU-202005420

### Observations after 15 days at 68°F after 60 minutes of agitation

Fluid 1	Fluid 2	Fluid Ratio	pH	Color	Clarity	Precipitates	Reactivity	Emulsion	Comments
Bellvue Treatment Plant	Terry Ranch Groundwater	90% : 10%	8.07	colorless	clear	no	no	no	no reaction between fluids
Bellvue Treatment Plant	Terry Ranch Groundwater	70% : 30%	8.09	colorless	clear	no	no	no	no reaction between fluids
Bellvue Treatment Plant	Terry Ranch Groundwater	60% : 40%	8.09	colorless	clear	no	no	no	no reaction between fluids
Bellvue Treatment Plant	Terry Ranch Groundwater	42% : 58%	8.11	colorless	clear	no	no	no	no reaction between fluids
Bellvue Treatment Plant	Terry Ranch Groundwater	30% : 70%	8.15	colorless	clear	no	no	no	no reaction between fluids



90% Bellvue  
10% Terry Ranch

70% Bellvue  
30% Terry Ranch

60% Bellvue  
40% Terry Ranch

42% Bellvue  
58% Terry Ranch

30% Bellvue  
70% Terry Ranch

## FLUID:FLUID COMPATIBILITY REPORT

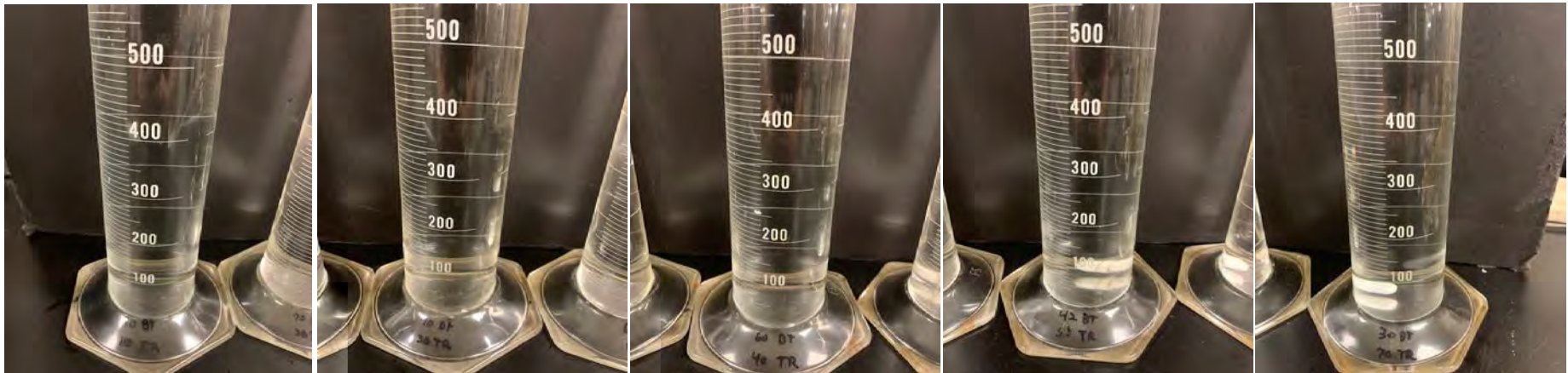
Temperature: 68°F

Fluids: Bellvue Treatment Plant Water & Terry Ranch Groundwater

Company: Leonard Rice Engineers, Inc.  
File: HOU-202005420

### Observations after 21 days at 68°F after 60 minutes of agitation

Fluid 1	Fluid 2	Fluid Ratio	pH	Color	Clarity	Precipitates	Reactivity	Emulsion	Comments
Bellvue Treatment Plant	Terry Ranch Groundwater	90% : 10%	8.21	colorless	clear	no	no	no	no reaction between fluids
Bellvue Treatment Plant	Terry Ranch Groundwater	70% : 30%	8.20	colorless	clear	no	no	no	no reaction between fluids
Bellvue Treatment Plant	Terry Ranch Groundwater	60% : 40%	8.20	colorless	clear	no	no	no	no reaction between fluids
Bellvue Treatment Plant	Terry Ranch Groundwater	42% : 58%	8.19	colorless	clear	no	no	no	no reaction between fluids
Bellvue Treatment Plant	Terry Ranch Groundwater	30% : 70%	8.23	colorless	clear	no	no	no	no reaction between fluids



90% Bellvue  
10% Terry Ranch

70% Bellvue  
30% Terry Ranch

60% Bellvue  
40% Terry Ranch

42% Bellvue  
58% Terry Ranch

30% Bellvue  
70% Terry Ranch

**Routine Water Analysis**

RFS ID No. 202006045-01

Sample Date: November 4, 2020

**70 % Bellvue Treatment Plant / 30 % Terry Ranch Groundwater**

Cations		Test Method	(mg/l)	MW	Valence	Meq/l
Calcium	Ca <sup>+2</sup>	ICP	21	40.08	2.0	1.06
Iron (dissolved)	Fe <sup>+2</sup>	ICP	<0.01	55.85	2.0	0.00
Magnesium	Mg <sup>+2</sup>	ICP	2.6	24.31	2.0	0.21
Potassium	K <sup>+</sup>	ICP	3.1	39.10	1.0	0.08
Sodium	Na <sup>+</sup>	ICP	12	22.99	1.0	0.52

Anions		Test Method	(mg/l)	MW	Valence	Meq/l
Alkalinity (as Bicarbonate)	HCO <sub>3</sub> <sup>-</sup>	Titration	92	61.02	1.0	1.51
Carbonate	CO <sub>3</sub> <sup>-2</sup>	Titration	0.0	60.01	2.0	0.00
Chloride	Cl <sup>-</sup>	Titration / IC	4.6	35.45	1.0	0.13
Sulfate	SO <sub>4</sub> <sup>-2</sup>	IC	15	96.06	2.0	0.32

Total Cation Meq's	2
Total Anion Meq's	2
TDS (mg/l)	150
TDS (ppm)	151
Ion Balance	0.028

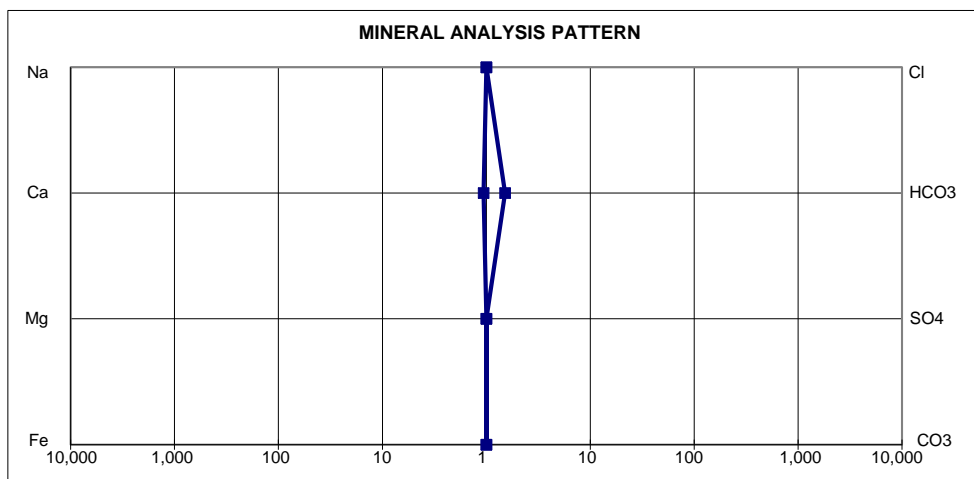
Stability Index at 100 °F	-1.49
Stability Index at 200 °F	-0.02

% Deviation in Meq. Bal.	2.32
% Deviation in TDS	24.74

pH	7.60
Resistivity (Ohm-Meter) at 77 °F	23.81
Conductivity, microSiemens/cm	420
Specific Gravity 60 / 60 °F	0.9996

**QA/QC Run ID's**

ICP	11202020
IC - Anions	11192020
IC - Organic Acids	N/A
Titration - Bicarbonates and Chloride	11192020





## **Appendix**

### **Photos – Fluids Received**

**Routine Water Analysis – Terry Ranch Groundwater**

**Routine Water Analysis – Bellvue Treatment Plant Water**



# FLUIDS RECEIVED

Bellvue/Dugens Treatment Plant Water  
(5 gallons)



### Routine Water Analysis

RFS ID No. 202006045-02

Sample Date: November 18, 2020

100 % Terry Ranch Ground Water

Cations		Test Method	(mg/l)	MW	Valence	Meq/l
Calcium	Ca <sup>+2</sup>	ICP	43	40.08	2.0	2.15
Iron (dissolved)	Fe <sup>+2</sup>	ICP	<0.01	55.85	2.0	0.00
Magnesium	Mg <sup>+2</sup>	ICP	5.4	24.31	2.0	0.44
Potassium	K <sup>+</sup>	ICP	9.5	39.10	1.0	0.24
Sodium	Na <sup>+</sup>	ICP	31	22.99	1.0	1.33

Anions		Test Method	(mg/l)	MW	Valence	Meq/l
Alkalinity (as Bicarbonate)	HCO <sub>3</sub> <sup>-</sup>	Titration	210	61.02	1.0	3.46
Carbonate	CO <sub>3</sub> <sup>-2</sup>	Titration	0.0	60.01	2.0	0.00
Chloride	Cl <sup>-</sup>	Titration / IC	4.0	35.45	1.0	0.11
Sulfate	SO <sub>4</sub> <sup>-2</sup>	IC	20	96.06	2.0	0.41

Total Cation Meq's	4
Total Anion Meq's	4
TDS (mg/l)	323
TDS (ppm)	323
Ion Balance	0.017

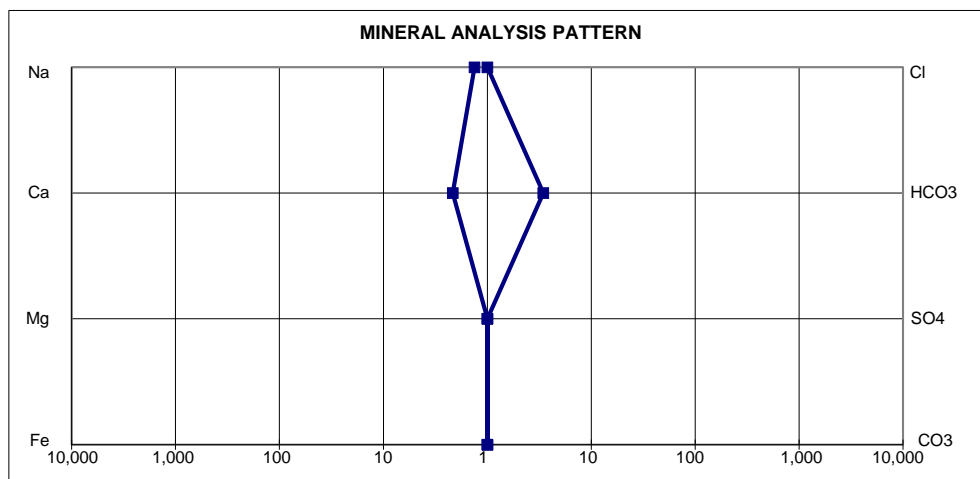
Stability Index at 100 °F	-0.86
Stability Index at 200 °F	0.69

% Deviation in Meq. Bal.	2.28
% Deviation in TDS	31.48

pH	8.14
Resistivity (Ohm-Meter) at 77 °F	10.20
Conductivity, microSiemens/cm	980
Specific Gravity 60 / 60 °F	0.9997

**QA/QC Run ID's**

ICP	11202020
IC - Anions	11192020
IC - Organic Acids	N/A
Titration - Bicarbonates and Chloride	11192020





### Routine Water Analysis

RFS ID No. 202006045-03

Sample Date: November 18, 2020

100 % Bellvue Treatment Plant

Cations		Test Method	(mg/l)	MW	Valence	Meq/l
Calcium	Ca <sup>+2</sup>	ICP	12	40.08	2.0	0.60
Iron (dissolved)	Fe <sup>+2</sup>	ICP	<0.01	55.85	2.0	0.00
Magnesium	Mg <sup>+2</sup>	ICP	1.4	24.31	2.0	0.12
Potassium	K <sup>+</sup>	ICP	0.53	39.10	1.0	0.01
Sodium	Na <sup>+</sup>	ICP	<5.96	22.99	1.0	0.05

Anions		Test Method	(mg/l)	MW	Valence	Meq/l
Alkalinity (as Bicarbonate)	HCO <sub>3</sub> <sup>-</sup>	Titration	42	61.02	1.0	0.69
Carbonate	CO <sub>3</sub> <sup>-2</sup>	Titration	0.0	60.01	2.0	0.00
Chloride	Cl <sup>-</sup>	Titration / IC	5.0	35.45	1.0	0.14
Sulfate	SO <sub>4</sub> <sup>-2</sup>	IC	13	96.06	2.0	0.27

Total Cation Meq's	1
Total Anion Meq's	1
TDS (mg/l)	75
TDS (ppm)	75
Ion Balance	0.176

Stability Index at 100 °F	-2.22
Stability Index at 200 °F	-0.79

% Deviation in Meq. Bal.	17.34
% Deviation in TDS	28.84

pH	7.02
Resistivity (Ohm-Meter) at 77 °F	45.45
Conductivity, microSiemens/cm	220
Specific Gravity 60 / 60 °F	0.9995

**QA/QC Run ID's**

ICP	11202020
IC - Anions	11192020
IC - Organic Acids	N/A
Titration - Bicarbonates and Chloride	11192020

