TEMA Oil and Gas

Anolyte

an environmentally friendly alternative biocide for the Oil and Gas Industry

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DBI
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Green Battery Kill Study

Riecks 1H Frac Study

Anolyte

an environmentally friendly alternative biocide for the Oil and Gas Industry

Background

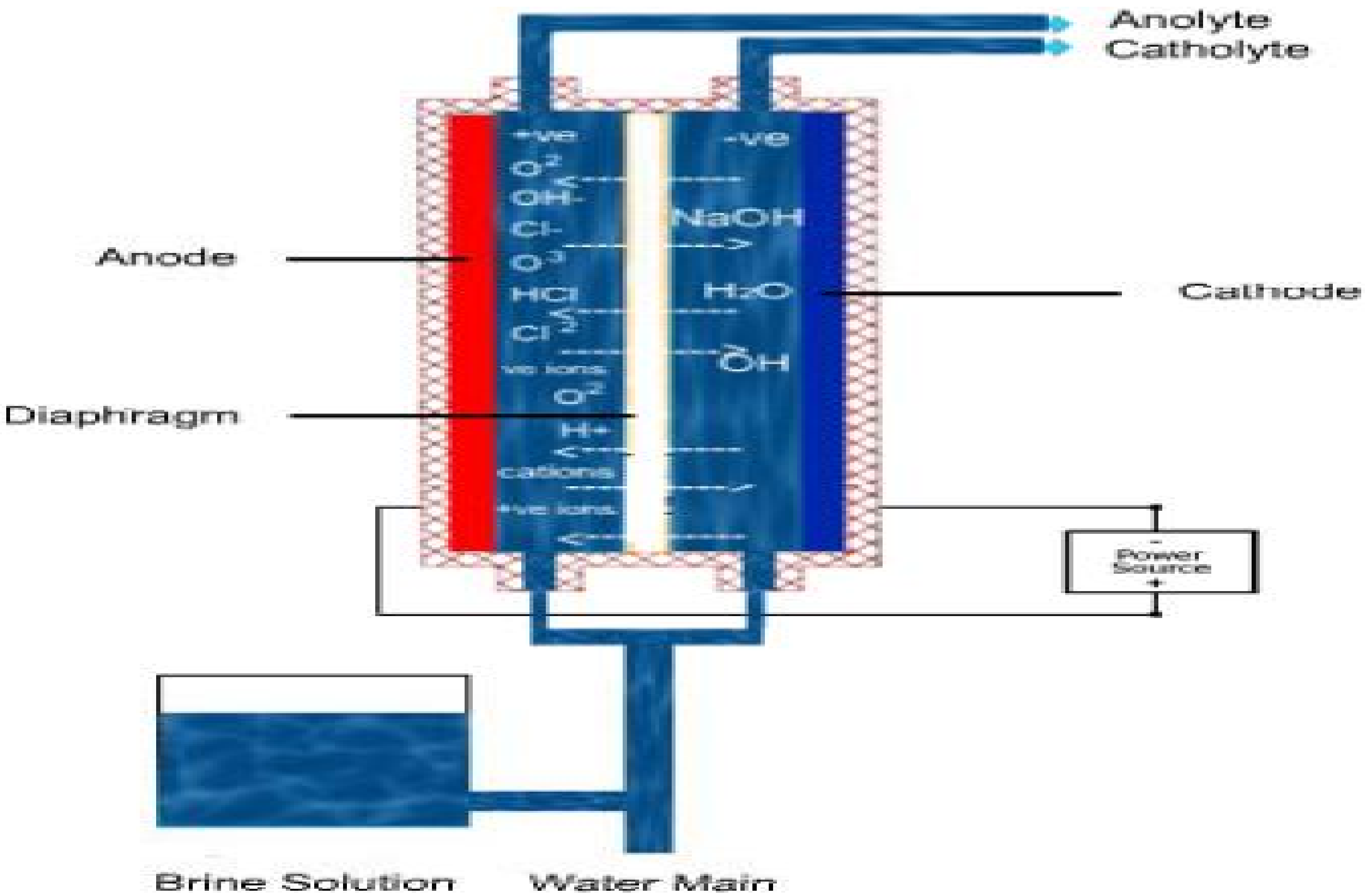
- The Oil and Gas Industry is one of the largest consumers of biocides.
- The biocides are used to control MIC, biofilms, and H_2S development.
- The recent boom in use of large hydraulic fracturing has rapidly increased the use of biocides.


Acid Producing
Bacteria

Background of Anolyte

- **EPA Approval**
- Although the field of electro‐chemical activation (ECA) technology has existed for more than 40 years, companies producing anolyte solutions have only recently approached the U.S. Environmental Protection Agency (EPA) seeking registration. This due to the lack of advances in equipment that can reliably deliver the solutions in the consistent, repeatable manner needed to meet and pass the battery of various EPA product registration tests.
- **Envirocleanse obtains registration as Biocide #** 84680‐1

Basic Production of Anolyte



of

- The electrolytic generator produces consistently high quality, pure hypochlorous acid ($HOCl$) from unassuming food grade precursors – salt ($NaCl$). Production of Anolyte is similar to the process of fabricating standard sodium hypochlorite ($NaOCl$) with one significant difference. Sodium hypochlorite combines the chlorine (Cl_2)produced in the electrolytic reaction with caustic soda (lye/sodium hydroxide) to stabilize the chlorine. Elimination of sodium and caustic soda by the use of high rejection membrane technology produces pure $HOCl$. With the sodium removed, the benefits of $HOCl$ in the Anolyte become immediately evident when used as a biocide. Elimination of the caustic soda makes disinfection possible without the high pH elements associated with sodium hypochlorite. The Anolyte is delivered at a neutral pH (7–8) or lower thereby delivering high efficacy with short contact times and without the caustics.

- The full equation may be represented like this:

  $Cl_2 + H_2O \longrightarrow HOCl + HCl$
  $HOCl \longrightarrow OCl^{-} + H^{+}$

  HOCl is the "active ingredient." The OCl^{-} is a bank or reservoir of less active chlorine.

- HOCL concentration is pH dependent and can be produced at 1500 ppm at a pH of 4.5 which also enhances scale inhibitor performance.

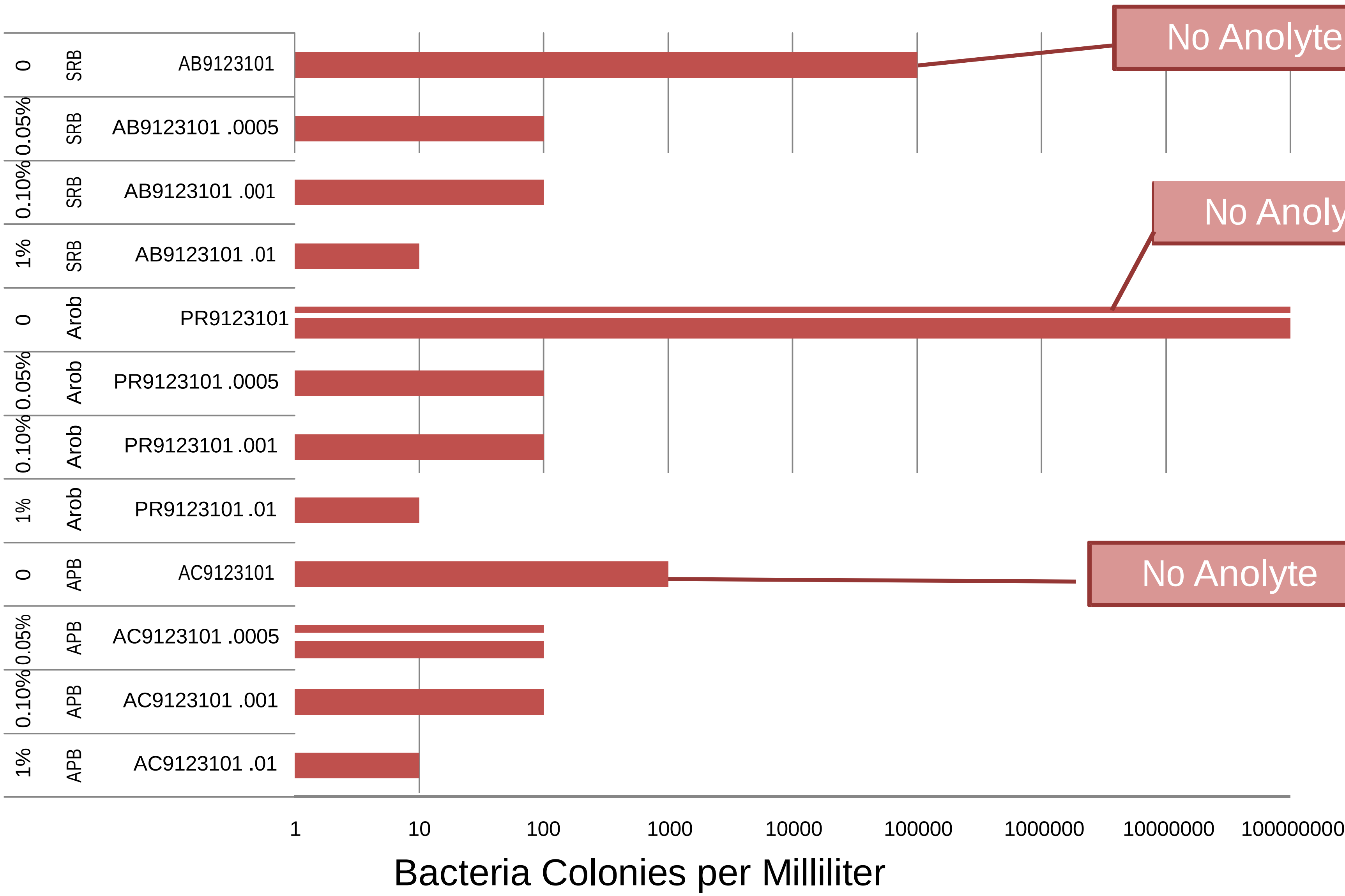
DBI Kill Study Results on Chesapeake Little Hoss Field

Chronology

- DBI was presented with problem to design study for Universal Coatings and Envirocleanse in early December 2009
- Samples were collected from Chesapeake Little Hoss field on December 31, 2009 and TEMA Green field on January 15, 2010
- Water samples were immediately subjected to API RP 38 method for bacterial content. (Serial Dilution) and complete anion and cation analysis.

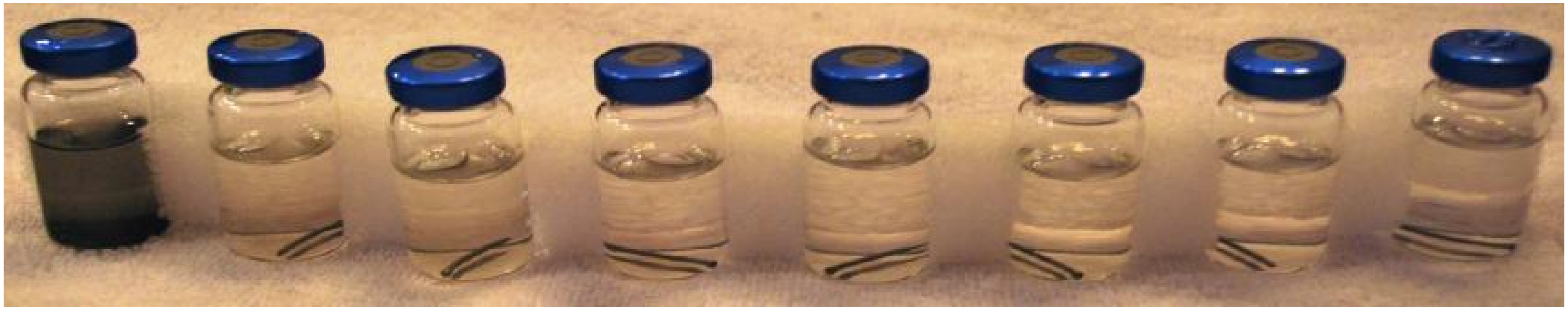
Locations Sampled	Lab Identification #
Little Hoss X2, X3, X4	09123101
Little Hoss B8, B10	09123102
Little Hoss Z1, Z2	09123103
Little Hoss X2 ***sep***	09123104
Little Hoss T1/T3	09123105
Little Hoss B6	09123106
Little Hoss Y6	09123107
Green 3H	10011503
Green 2H	10011504

Little Hoss X2, X3, X4



Little Hoss X2, X3, X4
SRB Photos

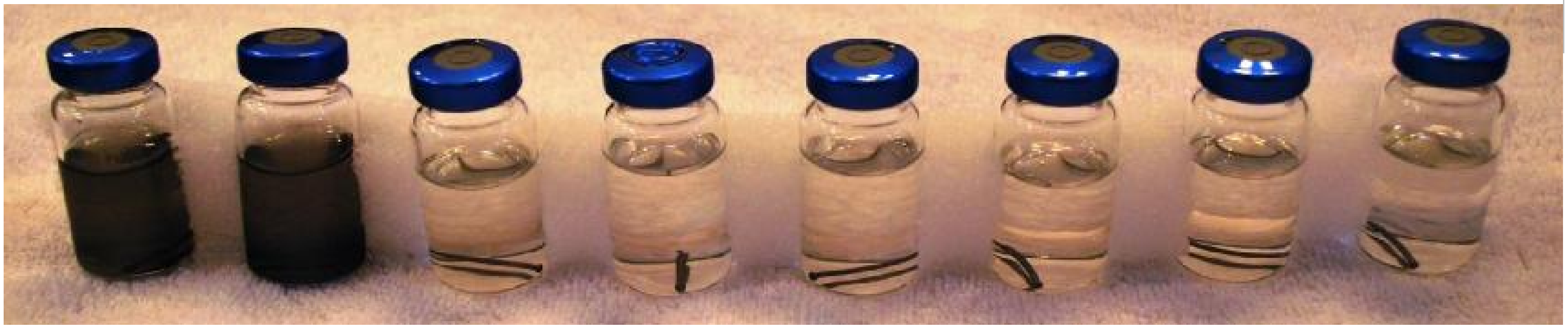
Produced water with no Anolyte added



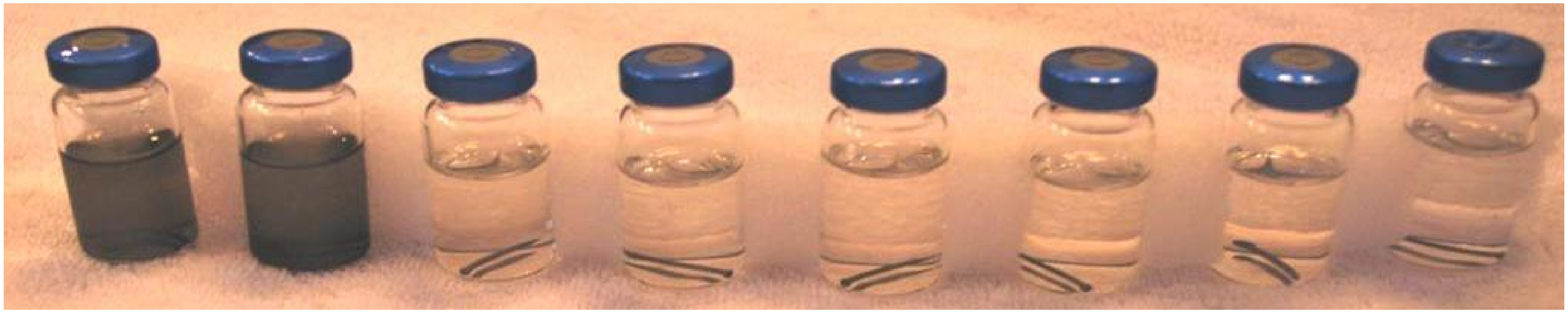
Produced water with 10000 ppm Anolyte added

Anolyte used was 500ppm active

Little Hoss X2, X3, X4
SRB Photos



Produced water with 1000 ppm Anolyte added



Produced water with 500 ppm Anolyte added

Anolyte used was 500ppm active

Little Hoss X2, X3, X4
Phenol Red (Aerobic) Photos

Produced water with no ppm Anolyte added

Produced water with 10,000 ppm Anolyte added

Anolyte used was 500ppm active

Little Hoss X2, X3, X4
Phenol Red (Aerobic) Photos

Produced water with 1000 ppm Anolyte added

Produced water with 500 ppm Anolyte added

Anolyte used was 500ppm active

Little Hoss X2, X3, X4
APB (Acid Producing Bacteria) Photos

Produced water with no ppm Anolyte added

Produced water with 10,000 ppm Anolyte added

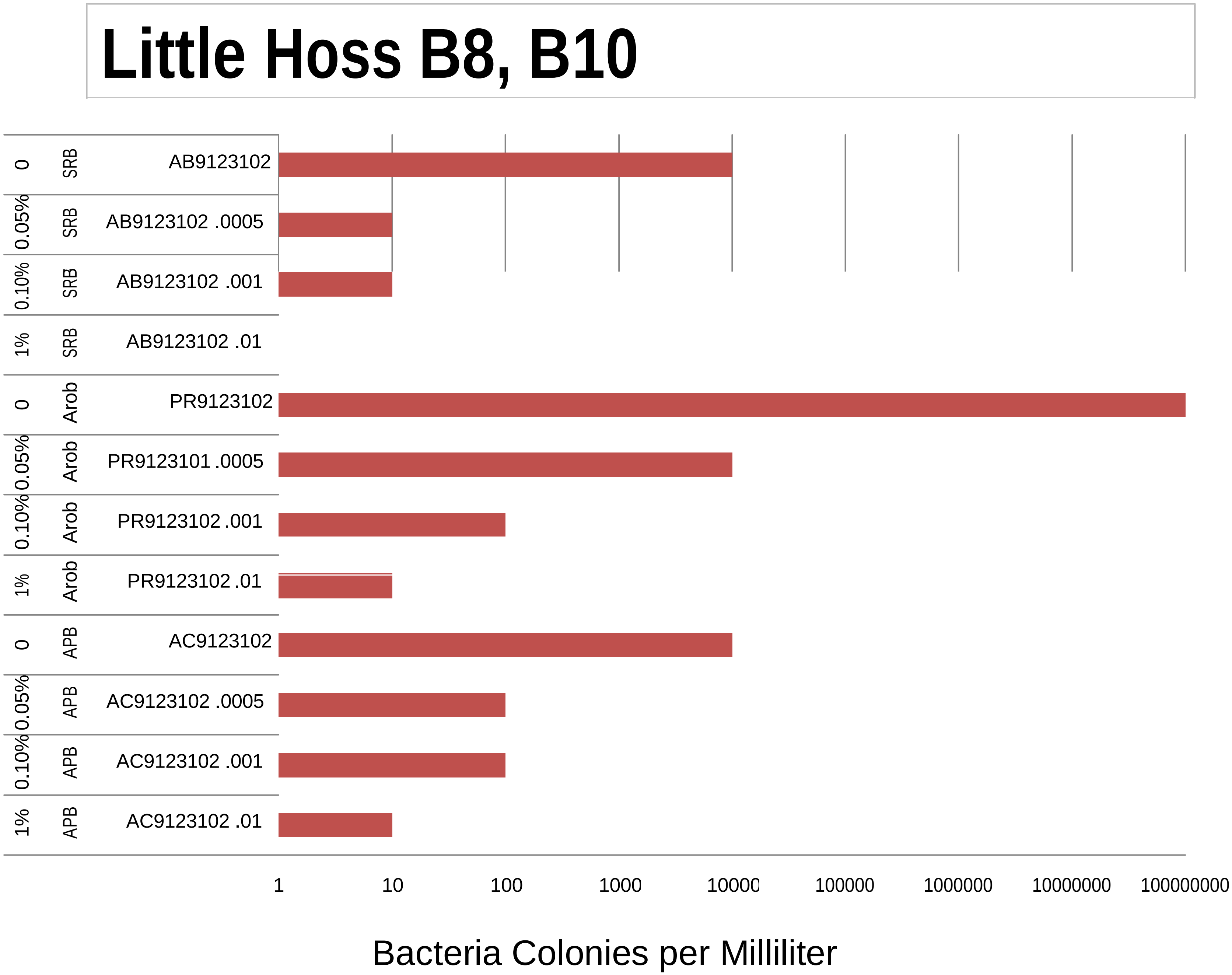
Anolyte used was 500ppm active

Little Hoss X2, X3, X4
APB (Acid Producing Bacteria) Photos

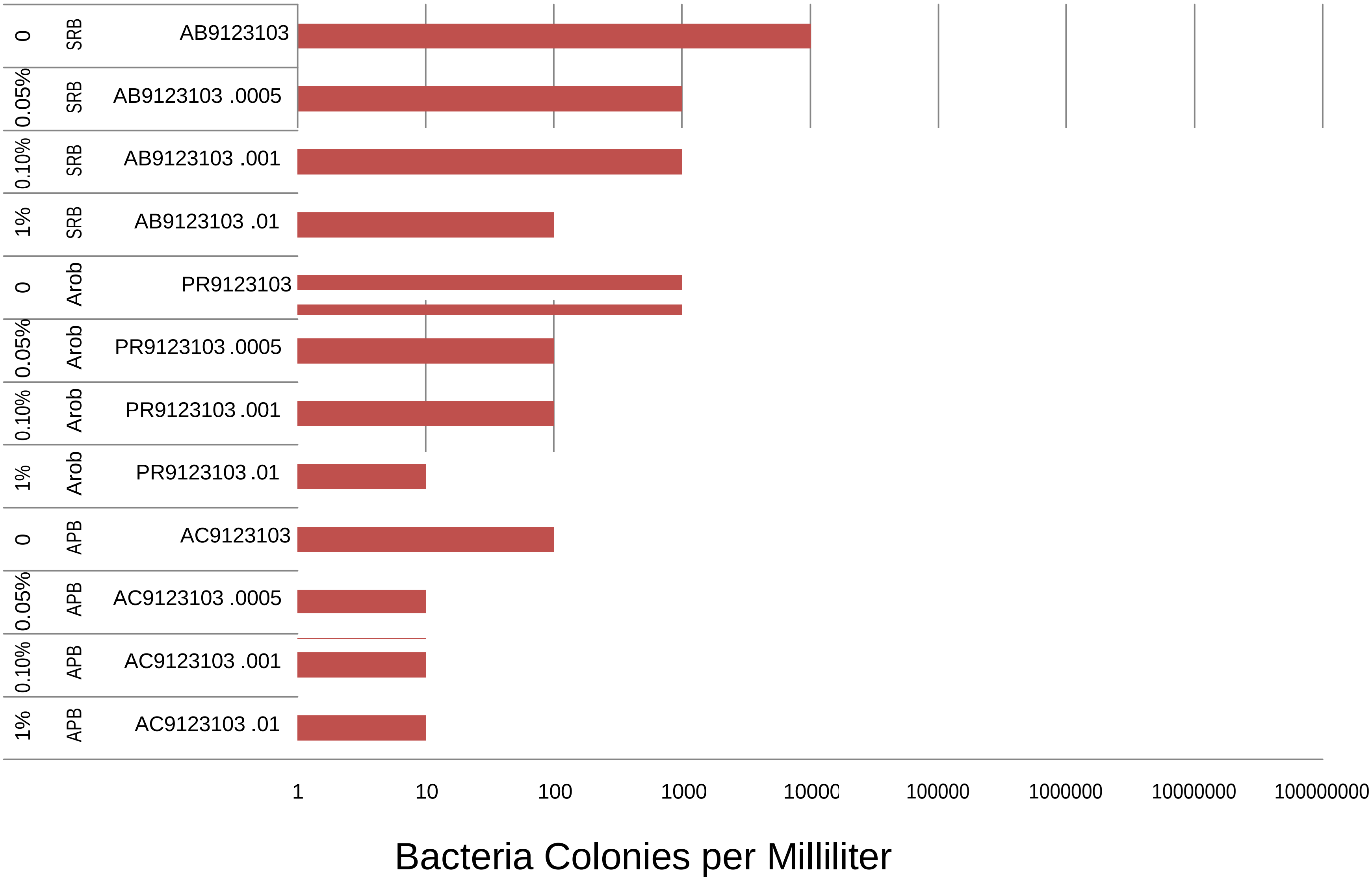
Produced water with 1000 ppm Anolyte added

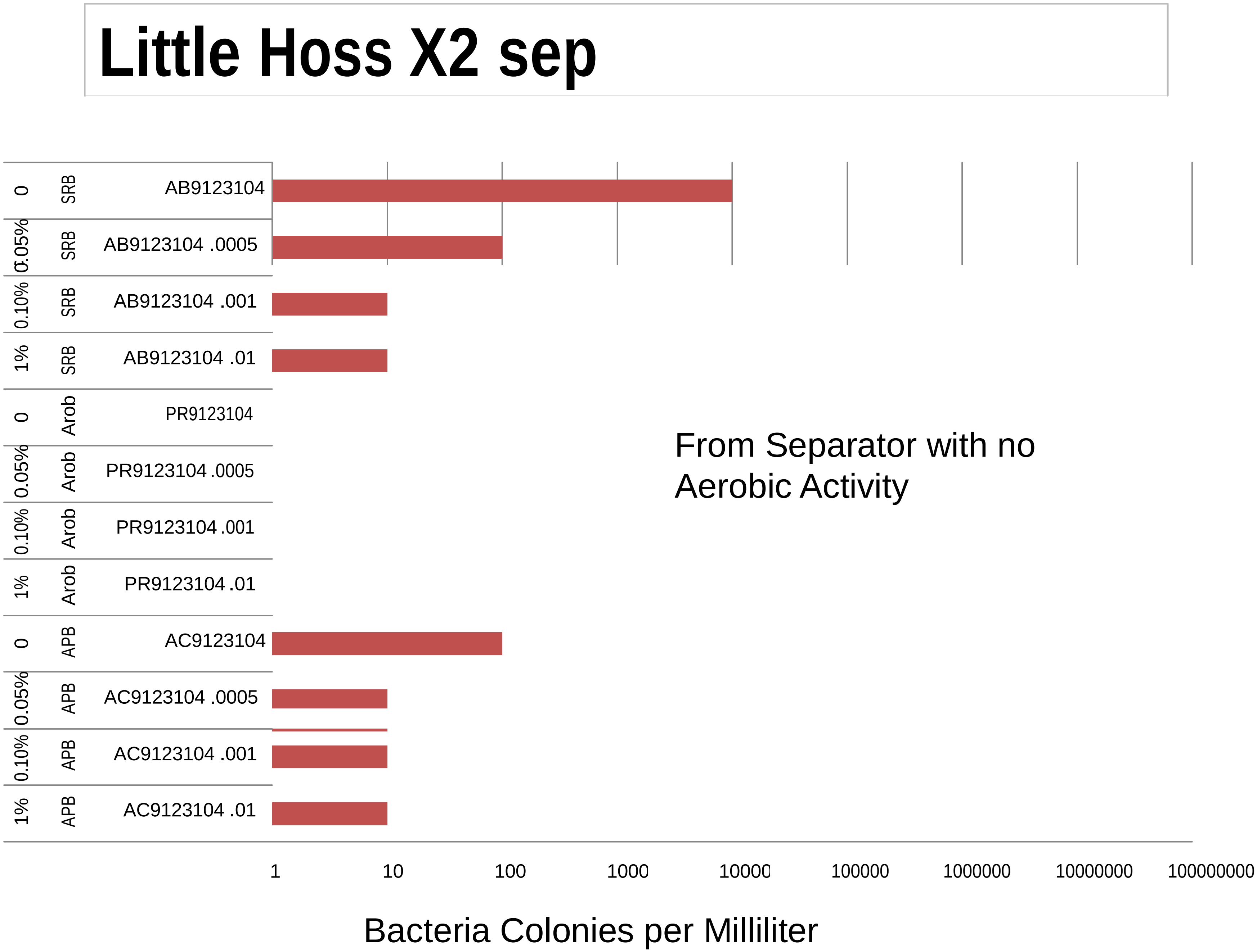
Produced water with 500 ppm Anolyte added

Anolyte used was 500ppm active


Little Hoss B8, B10
0 SRB AB9123102
0.05% SRB AB9123102 .0005
0.10% SRB AB9123102 .001
1% SRB AB9123102 .01
0 Arob PR9123102
0.05% Arob PR9123101 .0005
0.10% Arob PR9123102 .001
1% Arob PR9123102 .01
0 APB AC9123102
0.05% APB AC9123102 .0005
0.10% APB AC9123102 .001
1% APB AC9123102 .01
1
10
100
1000
10000
100000
1000000
10000000
100000000
Bacteria Colonies per Milliliter

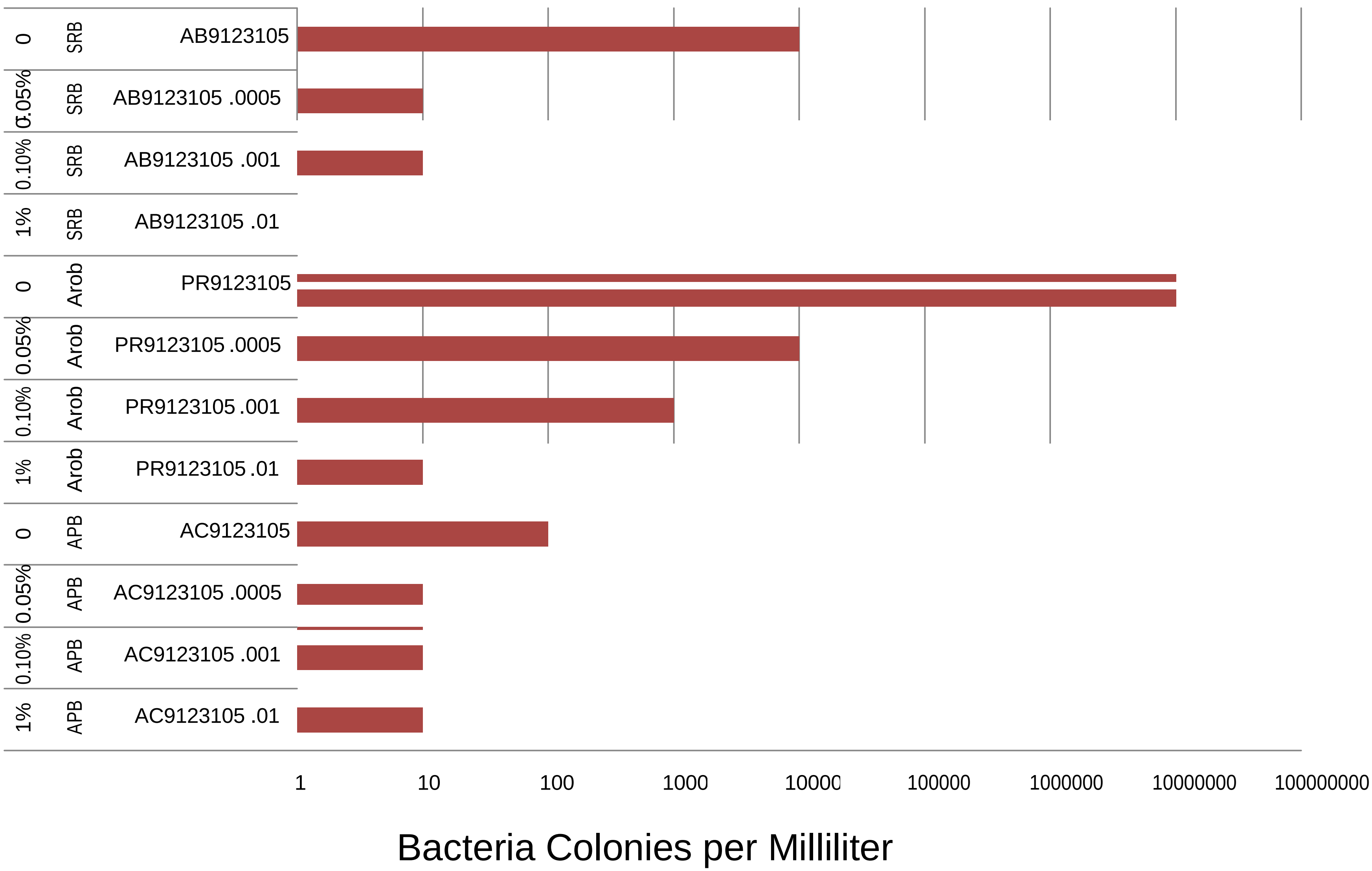
Little Hoss Z1, Z2



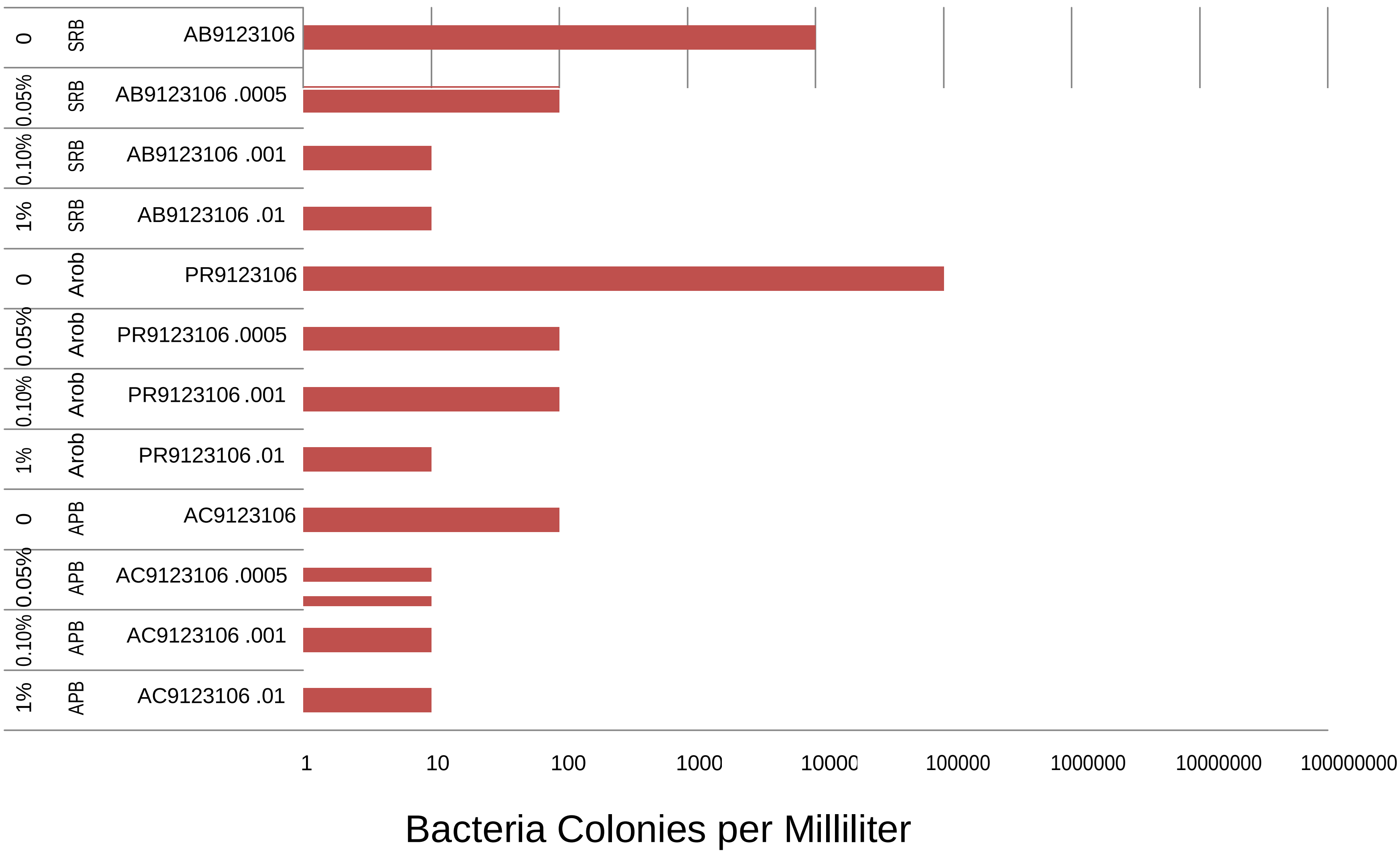


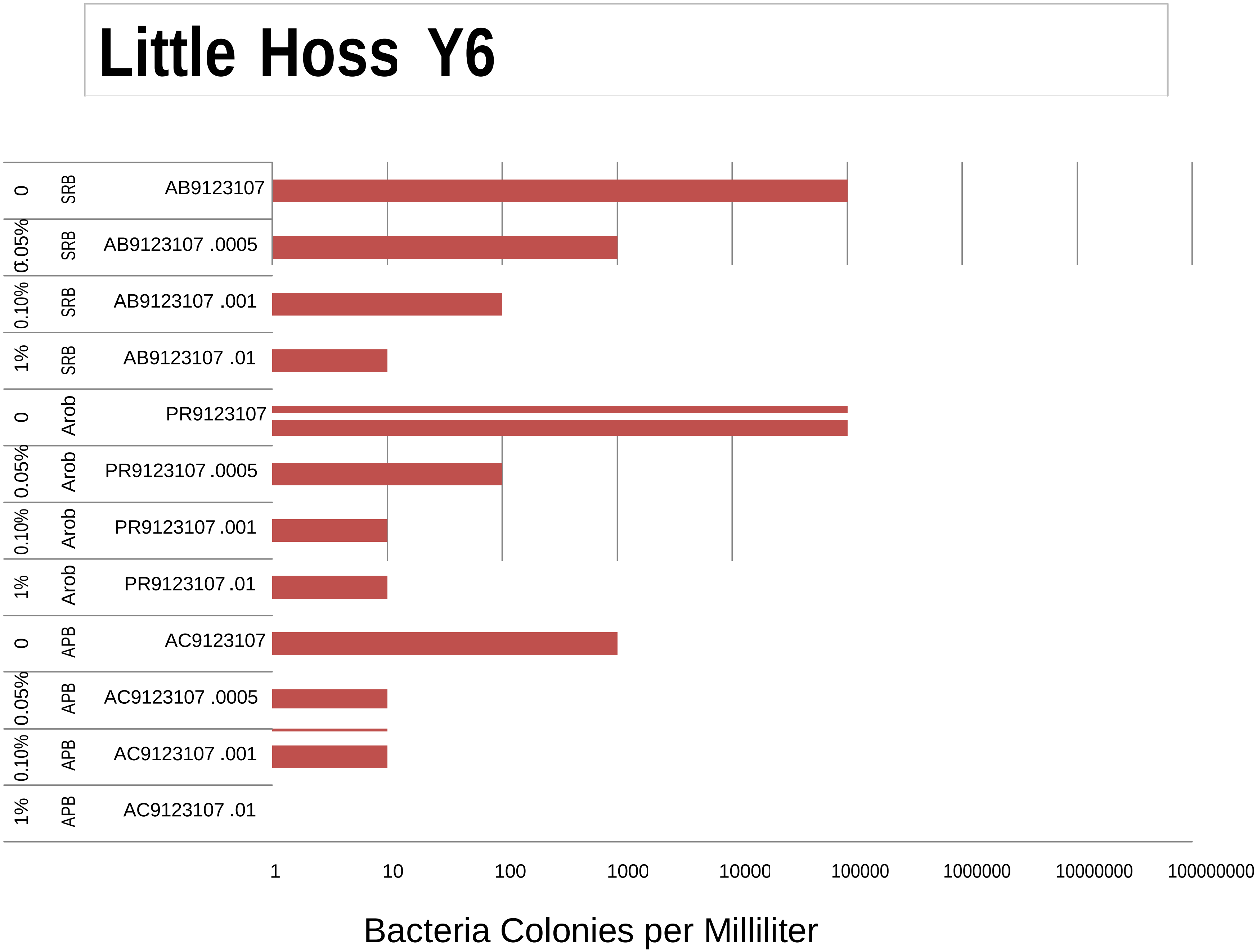
Little Hoss X2 sep
0 SRB AB9123104
0.05% SRB AB9123104 .0005
0.10% SRB AB9123104 .001
1% SRB AB9123104 .01
0 Arob PR9123104
0.05% Arob PR9123104 .0005
0.10% Arob PR9123104 .001
1% Arob PR9123104 .01
0 APB AC9123104
0.05% APB AC9123104 .0005
0.10% APB AC9123104 .001
1% APB AC9123104 .01
From Separator with no Aerobic Activity
1
10
100
1000
10000
100000
1000000
10000000
100000000
Bacteria Colonies per Milliliter

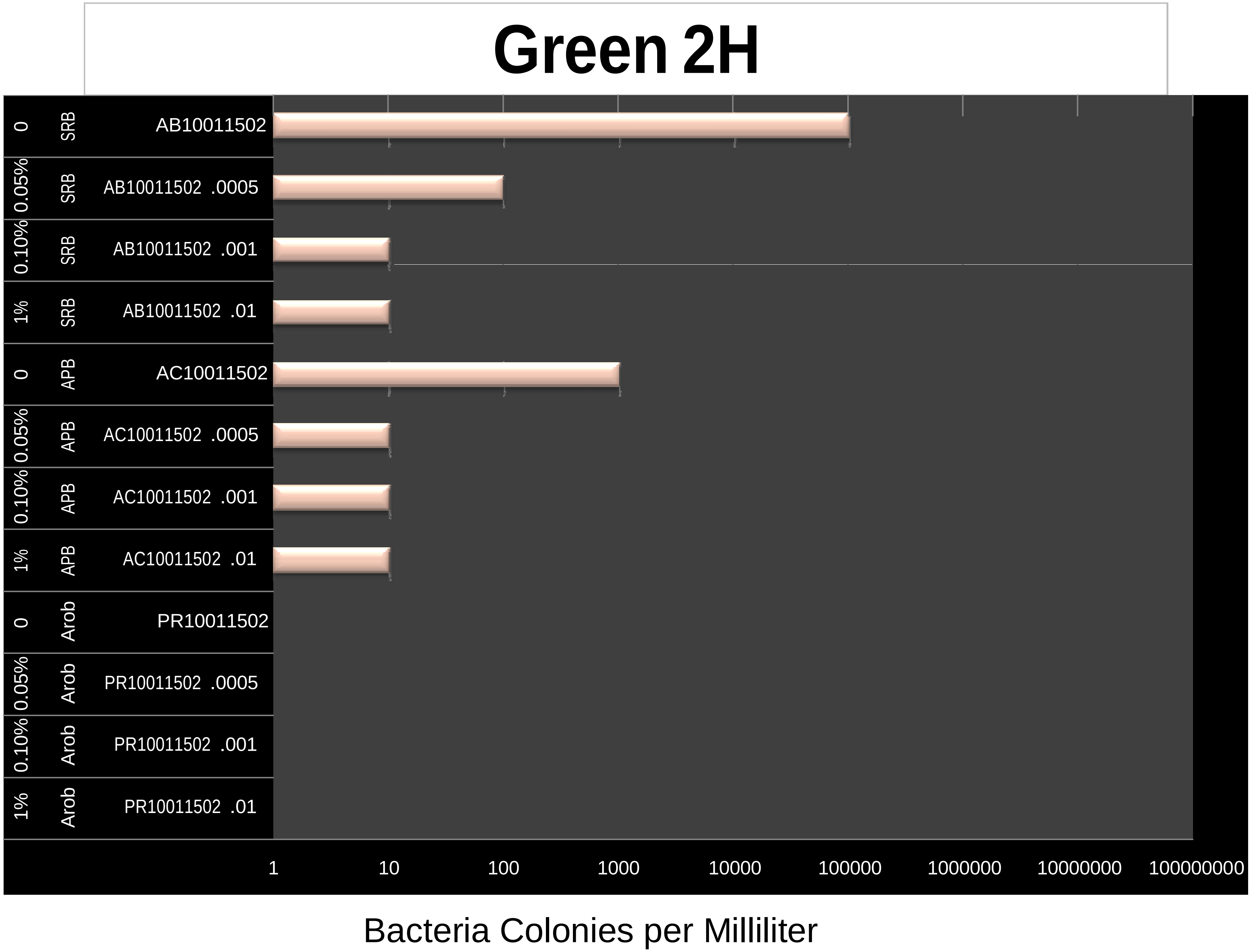
Little Hoss T1/T3



Little Hoss B6




Little Hoss Y6
0
SRB
AB9123107
0.05%
SRB
AB9123107 .0005
0.10%
SRB
AB9123107 .001
1%
SRB
AB9123107 .01
0
Arob
PR9123107
0.05%
Arob
PR9123107 .0005
0.10%
Arob
PR9123107 .001
1%
Arob
PR9123107 .01
0
APB
AC9123107
0.05%
APB
AC9123107 .0005
0.10%
APB
AC9123107 .001
1%
APB
AC9123107 .01
1
10
100
1000
10000
100000
1000000
10000000
100000000
Bacteria Colonies per Milliliter


Green 2H
0
SRB
AB10011502
0.05%
SRB
AB10011502 .0005
0.10%
SRB
AB10011502 .001
1%
SRB
AB10011502 .01
0
APB
AC10011502
0.05%
APB
AC10011502 .0005
0.10%
APB
AC10011502 .001
1%
APB
AC10011502 .01
0
Arob
PR10011502
0.05%
Arob
PR10011502 .0005
0.10%
Arob
PR10011502 .001
1%
Arob
PR10011502 .01
1
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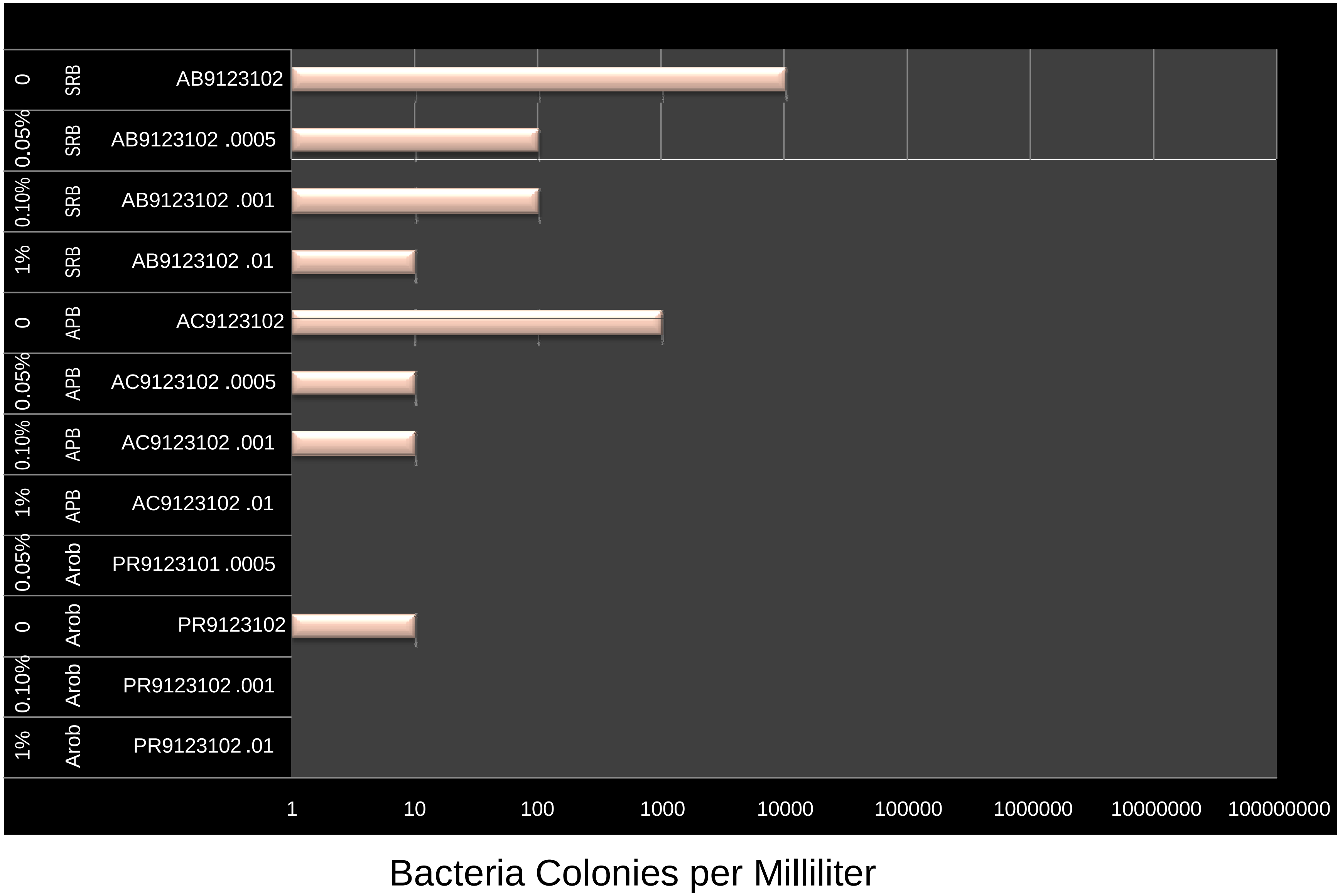
100
1000
10000
100000
1000000
10000000
100000000
Bacteria Colonies per Milliliter

Green 3H



0 SRB AB9123102
0.05% SRB AB9123102 .0005
0.10% SRB AB9123102 .001
1% SRB AB9123102 .01
0 APB AC9123102
0.05% APB AC9123102 .0005
0.10% APB AC9123102 .001
1% APB AC9123102 .01
0.05% Arob PR9123101 .0005
0 Arob PR9123102
0.10% Arob PR9123102 .001
1% Arob PR9123102 .01
1
10
100
1000
10000
100000
1000000
10000000
100000000
Bacteria Colonies per Milliliter

of

- The TEMA Green samples were collected from the location separator. Samples collected from the tanks would have been more similar to Chesapeake findings. Generally very little aerobic activity is found in samples that have not been exposed to the air.

of

- Anolyte performed adequate kill at all concentrations of the above waters tested.
- Anolyte used in this test was 500 ppm “active” HOCl.
- A stronger 1500-1700 ppm “active” HOCl is available.
- The 500 ppm inoculation rate was marginal.
- The 1000 and 10,000 ppm performed excellently.

Anolyte vs competition

Anolyte will be compared with other biocides commonly used in the oil and gas industry.

- Most common – Glutaraldehyde, THPS, Glut/Quat blends, Bleach
- Anolyte – more economical than all except bleach. **(Bleach is very corrosive and has many by products)**
- Anolyte much more environmentally friendly.
- No by products or residuals
- No interferences with other frac chemicals and will increase effectiveness of the scale inhibitor by lowering the overall pH slightly.

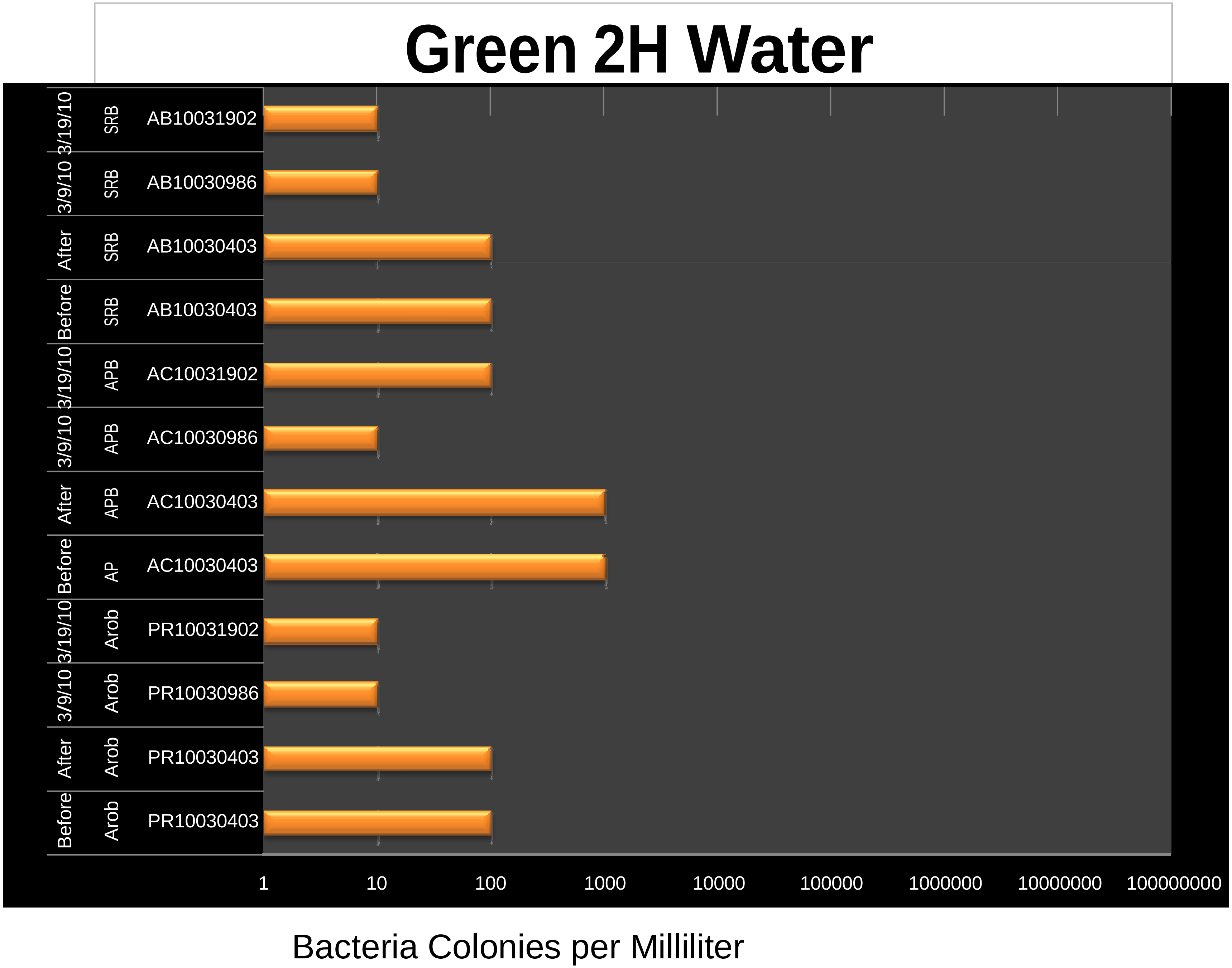
Anolyte vs competition

Anolyte will be compared with other biocides commonly used in the oil and gas industry.

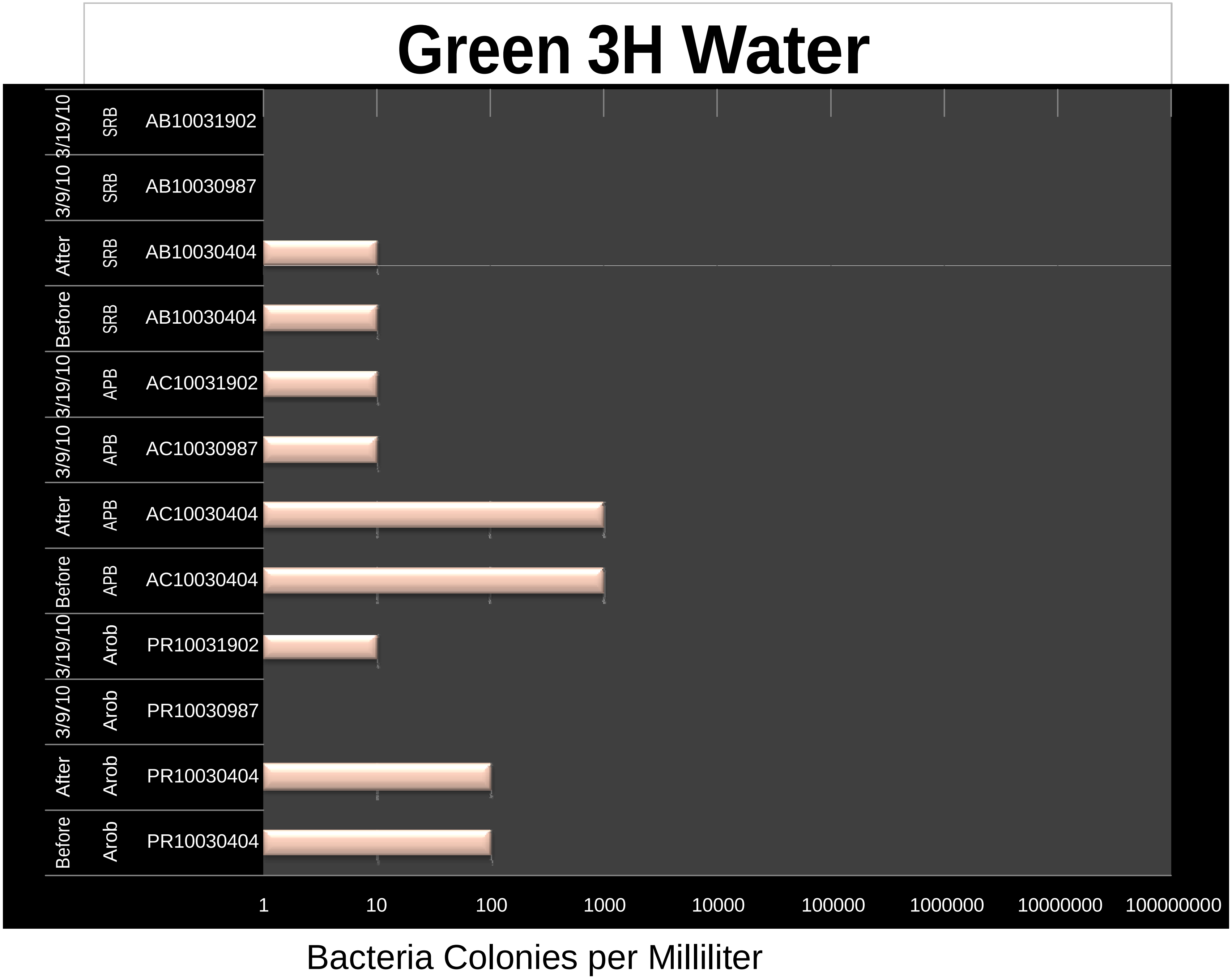
- Biodegradable
- Non flammable
- Inhibits biofilm formation
- Complete biocidal activity, incl. bacteria, viruses, spores, cysts, fungus
- No demonstrable evidence of resistance to Anolyte

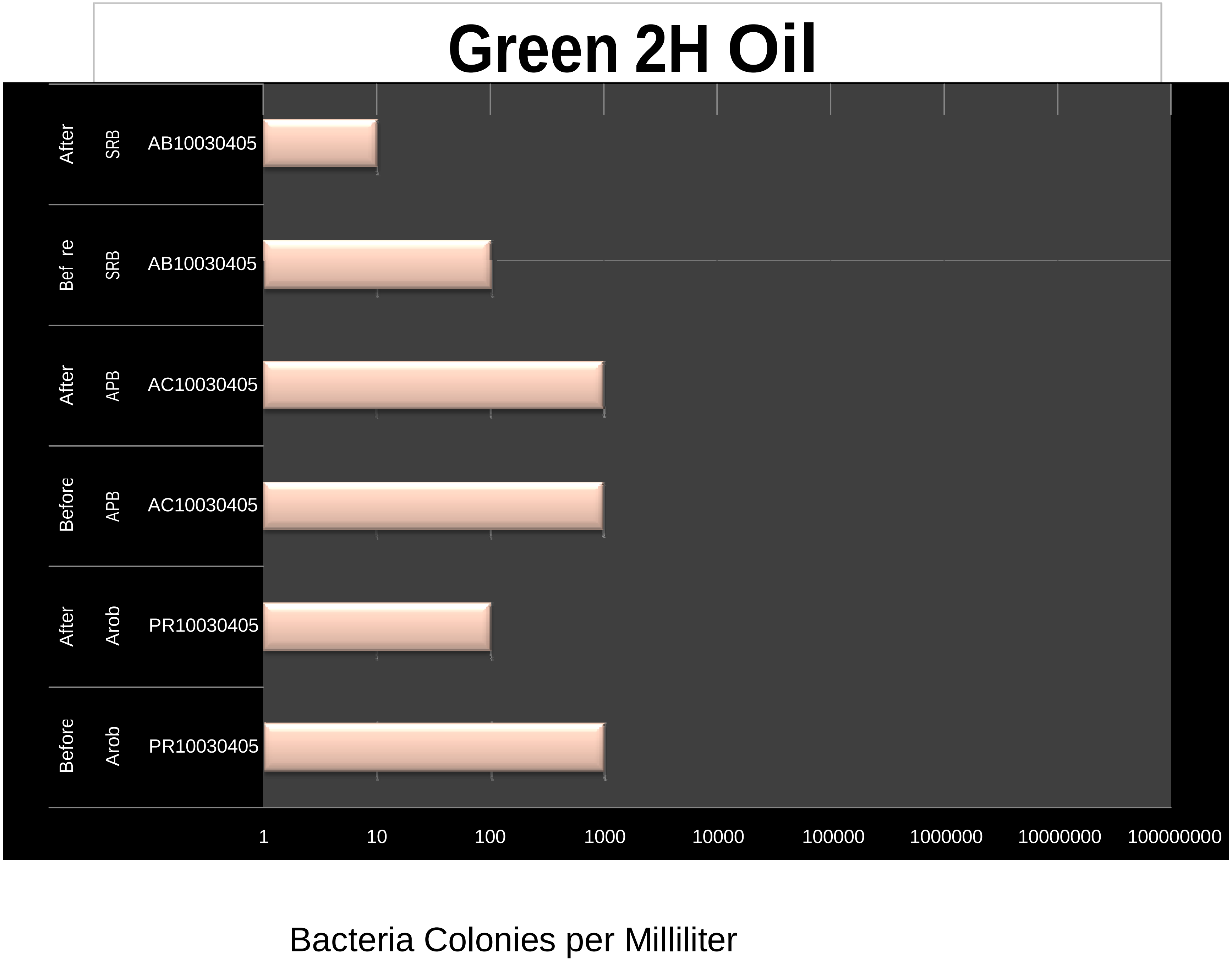
2H 3H Results

- On 03/04/2010 the Green 2H and 3H battery was treated with 10 gallons of Anolyte in each tank. The battery contains a water and oil tank for each well (4 tanks)
- Anolyte was introduced via side stream of a centrifugal circulation pump.
- Tanks were sampled immediately before and after treatment.
- Tank 3H Oil did not have enough water to circulate and was treated through thief hatch.



Green 2H Water
3/19/10
SRB
AB10031902
3/9/10
SRB
AB10030986
After
SRB
AB10030403
Before
SRB
AB10030403
3/19/10
APB
AC10031902
3/9/10
APB
AC10030986
After
APB
AC10030403
Before
AP
AC10030403
3/19/10
Arob
PR10031902
3/9/10
Arob
PR10030986
After
Arob
PR10030403
Before
Arob
PR10030403
1
10
100
1000
10000
100000
1000000
10000000
100000000
Bacteria Colonies per Milliliter


Green 3H Water
3/19/10 SRB AB10031902
3/9/10 SRB AB10030987
After SRB AB10030404
Before SRB AB10030404
3/19/10 APB AC10031902
3/9/10 APB AC10030987
After APB AC10030404
Before APB AC10030404
3/19/10 Arob PR10031902
3/9/10 Arob PR10030987
After Arob PR10030404
Before Arob PR10030404
1
10
100
1000
10000
100000
1000000
10000000
100000000
Bacteria Colonies per Milliliter


Green 2H Oil
After
SRB
AB10030405
Bef re
SRB
AB10030405
After
APB
AC10030405
Before
APB
AC10030405
After
Arob
PR10030405
Before
Arob
PR10030405
1
10
100
1000
10000
100000
1000000
10000000
100000000
Bacteria Colonies per Milliliter

Green Battery

- No suitable samples were obtained from Green 3H Oil tank.
- Results of water tank kill indicate that a kill was obtained but more circulation would have increased effectiveness.
- No results were obtained from Green 3H Oil tank but with circulation results and greater kill 5 days later it is believed this was not successful.

Green Battery

- **Kill remained for 15 days.**
- Recommendation is to repeat on water tanks on a monthly basis and determine if tank production of H_2S gases is reduced on this and other facilities by the reduction of all bacteria but in particular SRB

Riecks 1H

Frac Study

Riecks 1H Frac Study Matrix

- Frac on Riecks 1H ended up being a 2 stage frac with a total of 1.2 MM gallons pumped.
- Anolyte was used as the biocide and was pumped at a rate of 0.5 gallons per 1000 (500 ppm)
- The frac was pumped on 03/15 and 03/16 2010

Riecks 1H Frac Study Matrix

- Source water was from an open pond located nearby and the source water was sampled on 02/18/2010 and a complete water analysis performed by DBI with bacterial content also tested.

Comprehensive Oilfield Water Analysis

Chem<ol O..S.Omer.		Analysis NurrCer:	10021301
Production Customer.	IEMA 01& Gas	Date Sampled:	F<bua<y 18, 2010
Loase/ME!d:	Re<b Frac w.tt<	O...Recewd:	F<bua<y 18, 2010
Sample Point:	**NR**	**Date Completed:**	F<buary 18, 2010

PHYSICAL PROPERTIES

pH:	6,50 *(Lab)*	T....'''''''''''	100 *mg/1*
u.ns«y:	- •J4 *IWg.>l*	TOIBIotsscf.lecl SOikls:	*'l'>1 mgll*
Spocific G''"''v:	M99g/ccm	DiSsol'lt!d:	Omg't
System Temperc C Xe:	*15"F*	''''''''''CD,:	O.OOmg't
Pressu<e:	14.7 *psi*	TOIBIIOrftSln!J'IgRl'I:	0.015
001>0:	8WPOo		***ohm meter @ 75F***

BRINE COMPOSITION

CATIONS	C911«ntrri9n mg/L	''r'''j L	ANIONS	CwKcntrotktn mg/t	'77eQ L
Barium	5	0	**Chloride**	900	ZS
Calcium	34	Z	**Carbonate**	0	0
Iron	0	0	**Bicarbonate *(Lab)***	0	0
Malpesium	4	0	**Sulfate**	12	0
Manganese	0.0	0			
Potassium	0	0			
Sodium	0	0			
Strontium	2	0			
Total Cations	*45*	*2*	*Total Anions*	*912*	*26*

Ionic/J;J/.;ma *8.1996*

Oil & Grease *Content* mg:1

SCALE IN DEX

Temperature (°F)	**$CaCO_3$**	**$CaSO_4$**	**$BaSO_4$**	**$SrSO_4$**
75	0.46	0.05	126.10	0.01

A scaling index greater than 1.000 indicates scaling. Calculations are based on a constant pressure of 1000psi.

Greg Swindle — **Analyst**

February 18, 2010 — Date

West l40 Suire 1

Mngton,Te 76017

DownHol e SAT(tm)

FORIIIATIIOH WATER CHEMISTRY INPUT

R:eek.s Frac Water

R:eport Oclte:	02-1 2010	Sam:pl:ed:	02-18-ln10
Sample-#:	0		at 1513

CATIONS		ANIONS Cak:ium (as	
Ca)	33.610	Cl>lo<ide (as Cl)	900.00
Magnesium (as M!g)	3.90	Sutfate (as S04)	12..00
Barium (as Ba)	5.00	Bromine (as Br)	0.00
Siron:tium (as Sr.)	1.90	O.S:sol\ted C02 (a.s C02)	12-25
Sodum (as Na)	552.:z,Q	Bicarbonate (as HC03	30.00
Potassium (as K)	0.00	Camonate- (as G03)	0.00
Lithium (as Mg)	0.00	S;ica (as SiQ:2)	0.00
Ammonia as NIH3)	0.00	H2S (as H2S	0.00
Aluminum (as Al)	0.00	P.hospnate (.as P0 41)	0.00
Iron (as Fe)	0.11(1	N'itrate (as N03)	0.00
Boron (as 8)	0.00	Fluo<icle (as F)	0.00
Manganes-e (as Mn)	0.0200		
Zinc (as Zn)	0.00		
lead (as Pb)	0.00		

PARAMETERS

piH	50
T ature (0F)	75.00
Densit)'(gfmL)	0.999
Pressure	14.70
Cakuloted T. D.S.	1539
M'olar Cond-uctivity	2976

CORROSION RATE II'REOICTIOH

CO_2 - H_2S Rate (mpy)	(J.l0306

FR EJICM CREE k SOFTW"IU.- INC..
KIMB-ERTON a flARES HIU ROADSKIMBERTON.. PA 1.9442

DownHolle SAT(tm)

FORMATION WATER OEPOSmON
POTENTIAL INDICATORS

f.eek.s Frac Water

f.eport Date: 02-1 2010 Sampled: 02-18-2010
Sample#: 0 at 1513

SATURATION LEVEL		FREE ION MOMENTARY EXCESS (ppm)	
Calcile {CaCOa	0.00384	Calcite {CaC03)	-169
Aragonite (CaCOa)	0.00331	Aragonite {CaC03)	-196
W<1herile {BaC03)	< 0.001	*Wrtherite* (BaCOa)	-1558
Strontiante (SrC03)	< 0.001	Stronbanhe (Srt)Qa)	-494
Magnesite (MgC03)	< 0.001	Magnesite (MgC03)	-9.71
Anhydrite {CaS04)	< 0.001	Anhydrite {Ca504)	-1588
Gypsum {CaS042H20	0.00109	Gypsum {CaS04"2H20	-1374
Barite {BaS04)	7 69	Barite (BaS04)	700
Celestite {SrS04)	0.00165	Celestite (SrS0$_4$)	-214.22
Fluorite (CaF2)	0 00	Ruorie (CaF2)	8.43
CalCium pnospnate	0.00	calcrum pnospnate	>-0.001
Hydroxyapatite	0 00	Hydroxyapatite	-480 85
Silica (Si02)	0 00	Silca (Si02)	-116.78
Brucite {Mg{OH)2)	< 0.001	Brucile {Mg{OH]2)	-6 86
Magnesium silicate	0 00	Magnesium slicate	-211.15
Iron hydroxKie {Fe{CHJa)	0.469	Iron hydroxKie {Fe{OH)a)	<0.001
Strengite {FeP04" 2H20)	0 00	Strengite (FeP04"2H20)	>-0.001
Siderite (FeC03)	00211	*SK!erite* {FeC03)	.190
Halite (NaCI)	< 0.001	Halite (NaCl)	419525
Thena.nfte (Na2S04)	< 0.001	*Thenar<ite* {Na2S04)	-106446
Iron suffide (FeS)	0 00	Iron sulfide (FeS)	.744

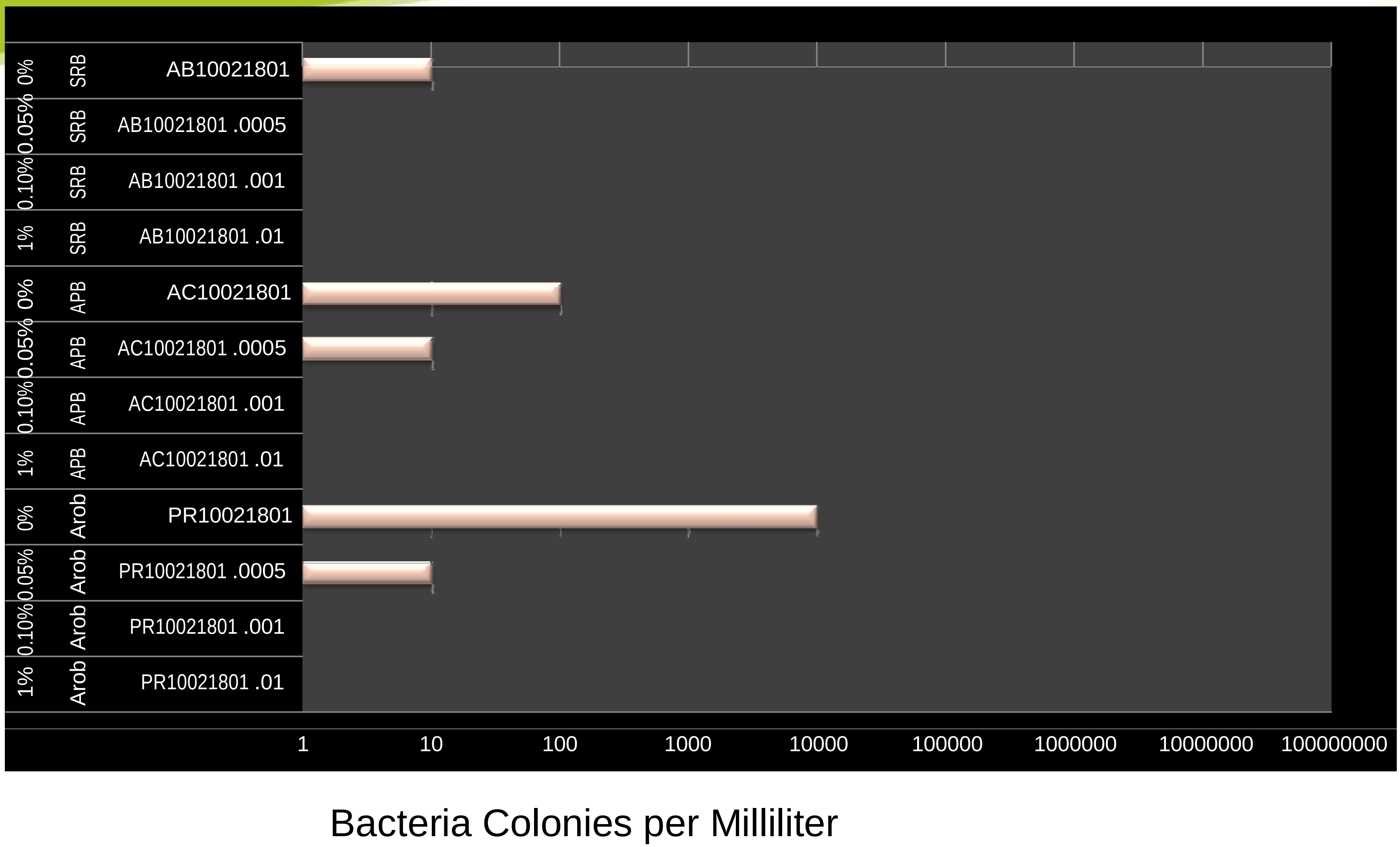
SIMPLE INDICES		BOUND IONS	TOTAL	FREE
Langelier	-2.23	Calcium	33.60	*3327*
Ryzna<	10.96	Barium	5.00	500
Puci:orius	I UII	Garbonste	0 006117	0.003QQ
Larson-Skold Index	86.40	Phosohate	0.00	000
Stiff Davis ndex	-2 38	Sulfate	12.00	111 2
Oddo-Tomson	-2.26			

OPERATING CONDITIONS

Temperatute (OF)	75.00
Time(mins)	300

FRENCH CREEK SORWARE. INC.
KIMGERTON a. HARES HIU ROADSKIMBERTON.. PA 19442

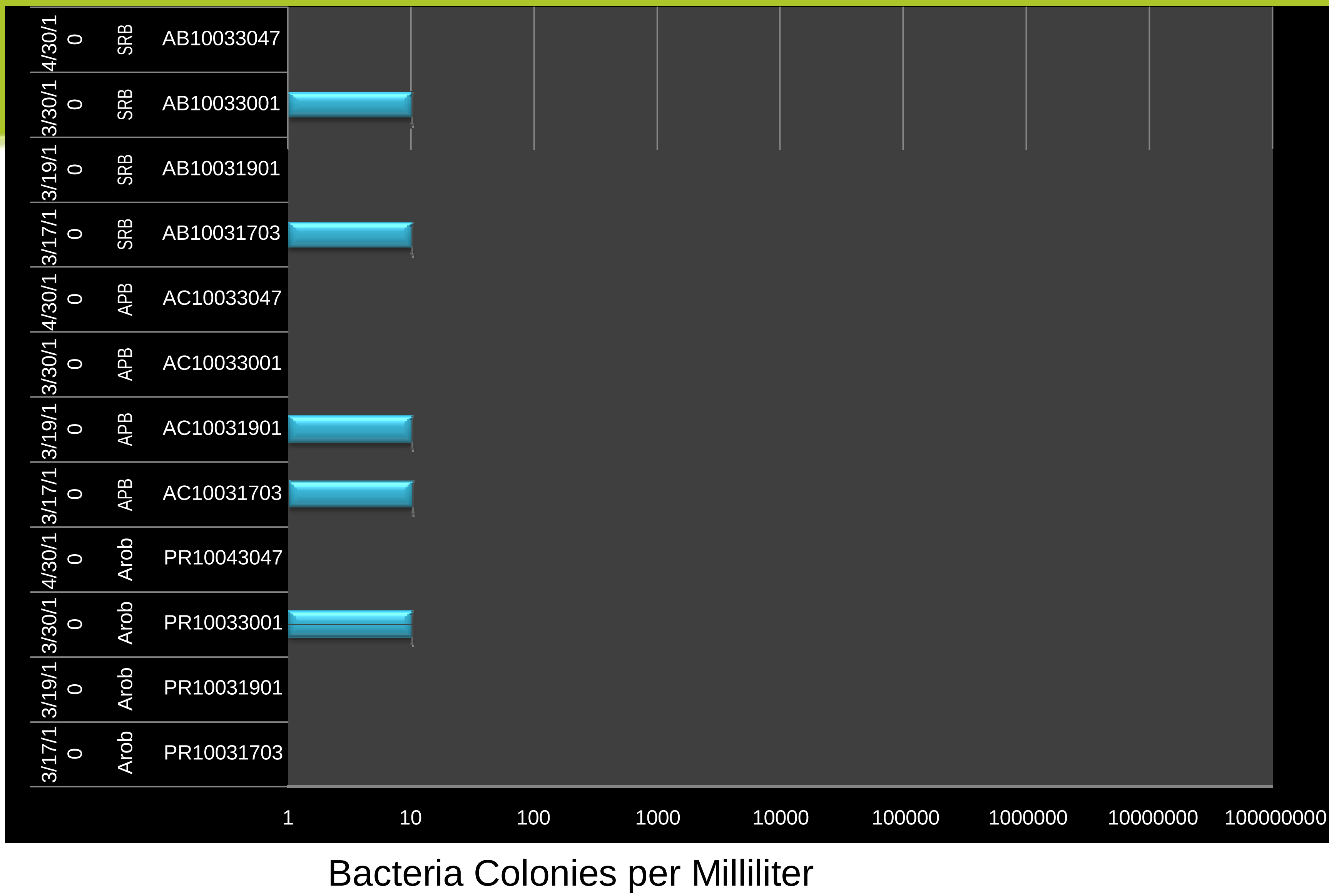
Riecks 1H Frac Study



Results

- Well was sample 1 hour into flowback on 03/17/2010
- Well was sampled on 03/19/2010
- Well was sampled on 03/30/2010 the well was in production at this time.
- Well was sampled on 04/30/2010

Riecks 1H Frac Study



Conclusions

- The well will continued to be monitored but at this time the results show that almost complete sterilization of the formation occurred during the frac using Anolyte as the biocide.
- The results also are comparable with other biocides commonly used in hydraulic fracturing but with a much less harmful biocide.

- More case studies are planned but only to reconfirm the results and improve the delivery of Anolyte.
- Anolyte shows potential to be used in tank sterilization to impede both aerobic and anaerobic bacteria strains.
- The TEMA Riecks 1H study using Anolyte as a biocide shows potential to revolutionize water sterilization in hydraulic fracturing.