Gas Well Deliquification Workshop

Sheraton Hotel, Denver, Colorado

February 27 – March 2, 2011

Plunger Lift Remote Surveillance Improves Shale Well Production

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Business Development

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- INTRODUCTION
- WELL SELECTION
- POWER OF SURVEILLANCE
- OPTIMIZING & TROUBLESHOOTING
- CONCLUSION
- ADDENDUM

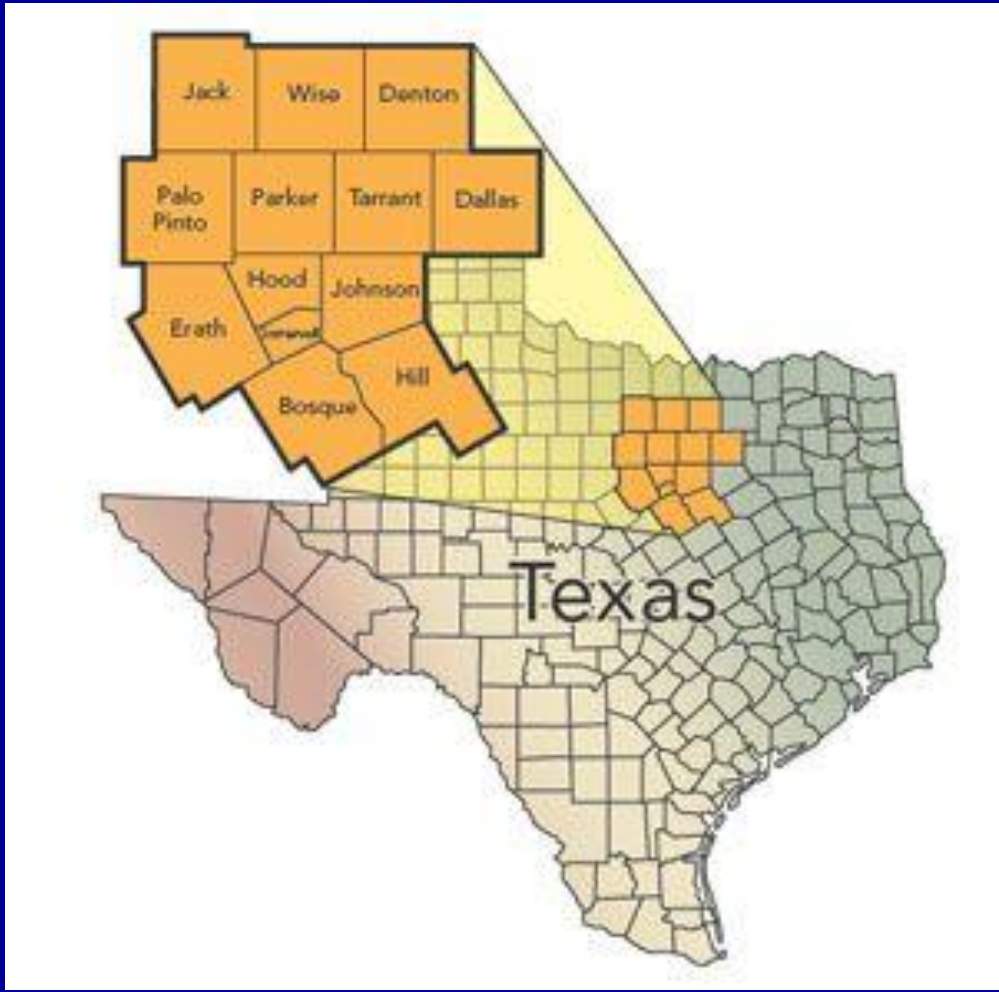
INTRODUCTION
XTO Fort Worth Operations

OPERATIONS

- North/South Areas
- 7 Foremen
- 50+ operators
- 1900 wells

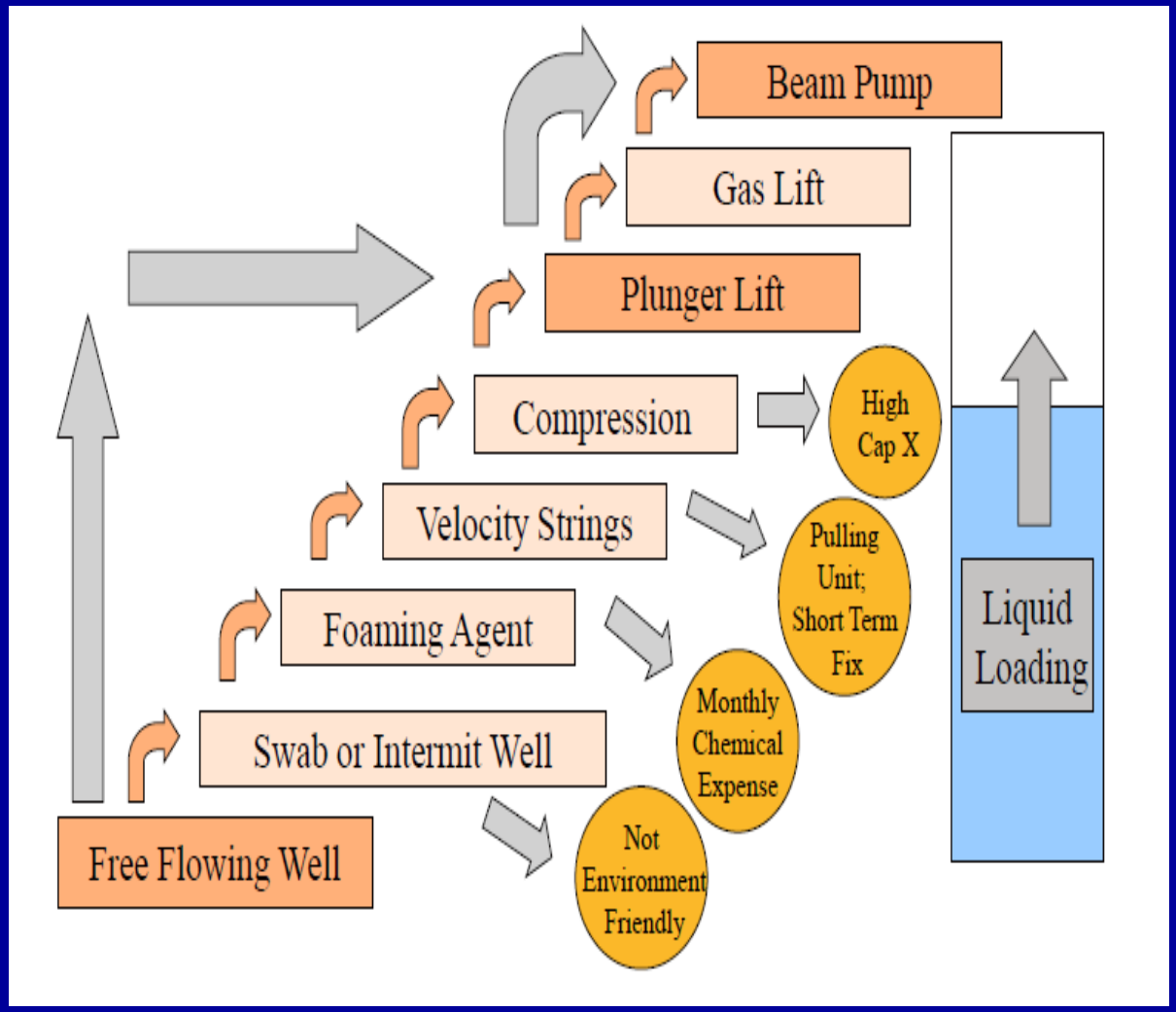
  Daily Averages

  - 900,000 Mcf
  - 110,000 Bbls Water



INTRODUCTION
2008 Dilemma

- Over 90% of wells in US are liquid loaded. (Marathon Analysis)
- Gas lift effective, yet costly. Overused.
- Venting and foaming agents inconsistent.
- 100 wells on stand alone PL. Limited results.
- Decided to explore plunger lift with remote monitoring and control.



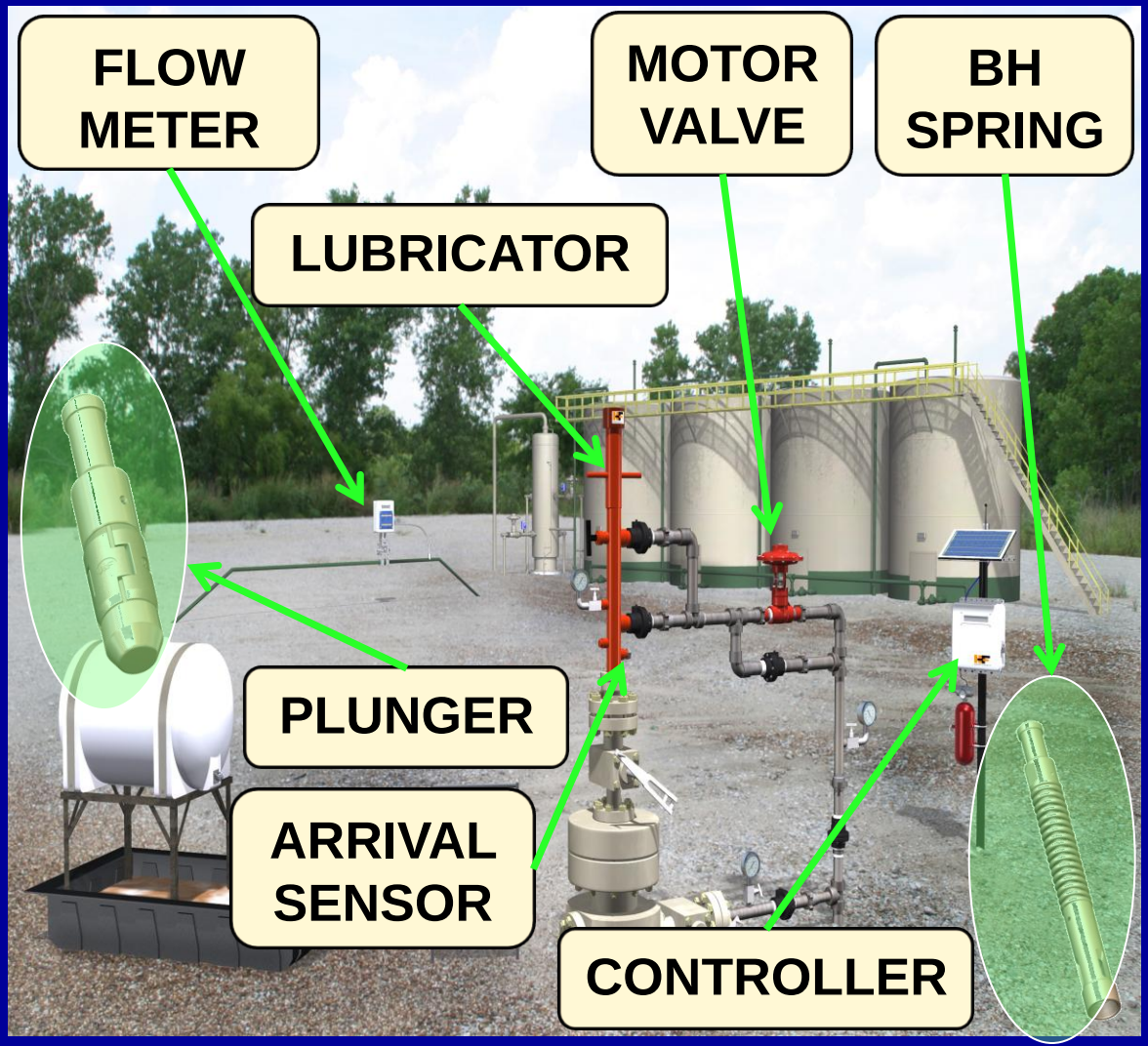
INTRODUCTION
Objectives

PROCESS

- Installed 50 systems with telemetry from various suppliers.
- Utilized real time data for root cause analysis.

GOALS

- Improve production.
- Reduce downtime.
- Reduce operational cost.
- Rapid payback.



INTRODUCTION
Examples

	PRODUCTION	DOWNTIME	VENTING	REPLACE PLUNGER
WELL # 1				
BEFORE	148 Mcf / d	22 %	3 X per Wk	Quarterly
AFTER	186 Mcf / d	8 %	None	None
	(25.7% Increase)	(63.6% Decrease)		
WELL # 2				
BEFORE	82 Mcf / d	60 %	Daily	Quarterly
AFTER	212 Mcf / d	10 %	None	None
	(158 % Increase)	(83.3% Decrease)		

INTRODUCTION
Inclusive Lifting Cost ($ / Mcf)

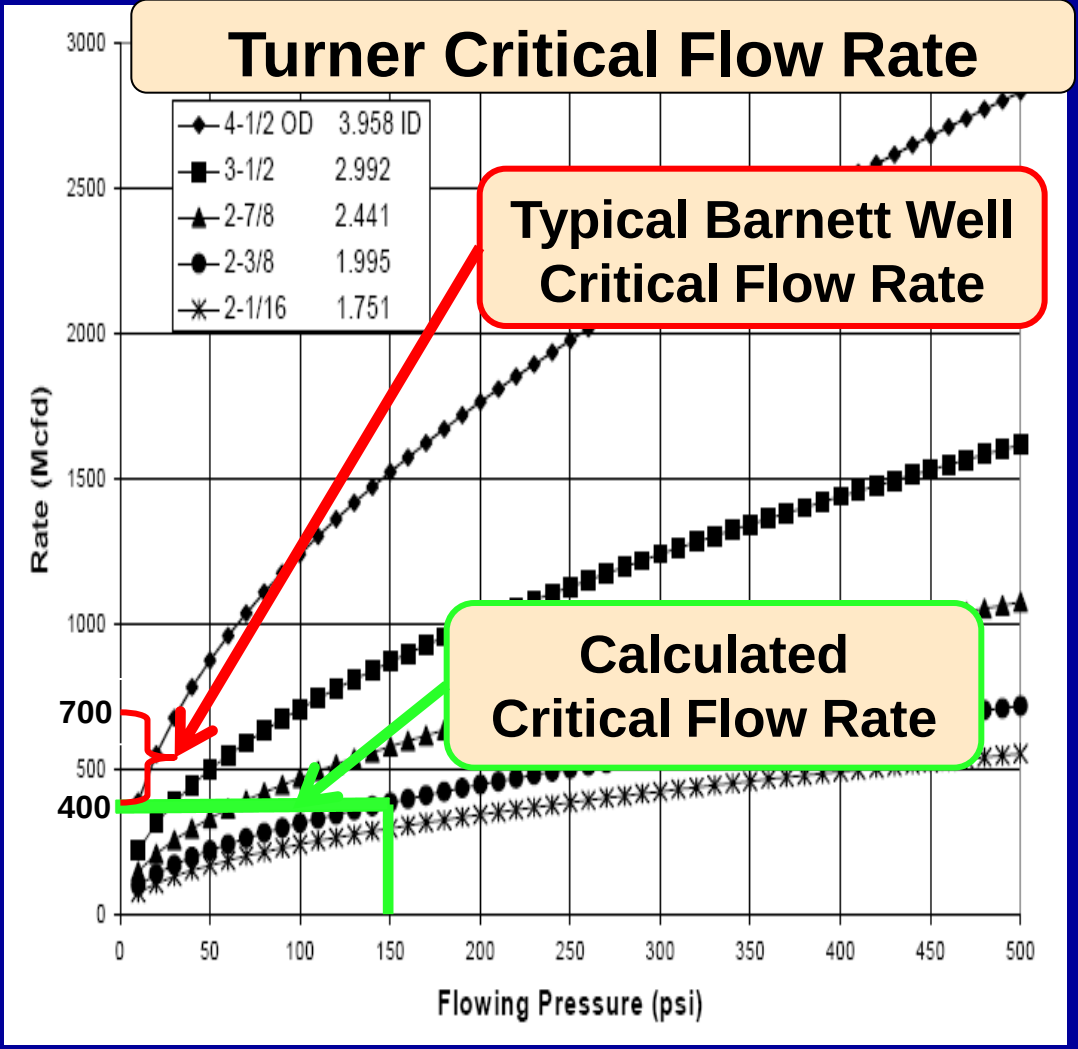
LIFT METHOD	LIFTING COST COMPARISON ($ / Mcf)		
	MIN	MAX	AVERAGE
Gas Lift	**$ 1.04**	**$ 1.30**	**$ 1.17**
Plunger Lift – No Telemetry	**$ 0.25**	**$ 5.80**	**$ 2.27**
Plunger Lift – With Telemetry	**$ 0.19**	**$ 0.90**	**$ 0.50**

- **Lifting costs reduced up to 75% with automation !**
- **Optimization provides additional value, discussed later**
- **Downtime occurs at lower frequency and duration**
- **Coordination between field and office proved crucial**

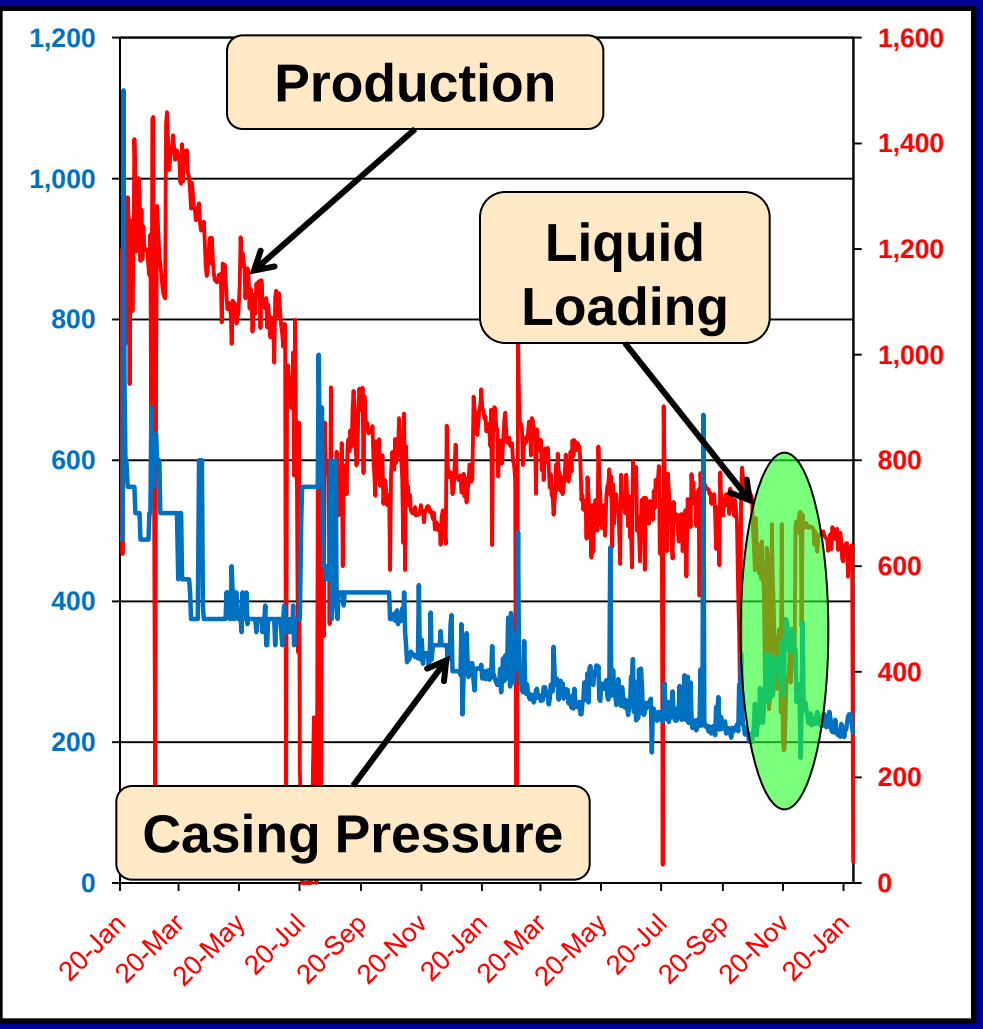
WELL CANDIDATE SELECTION
Signs of Loading

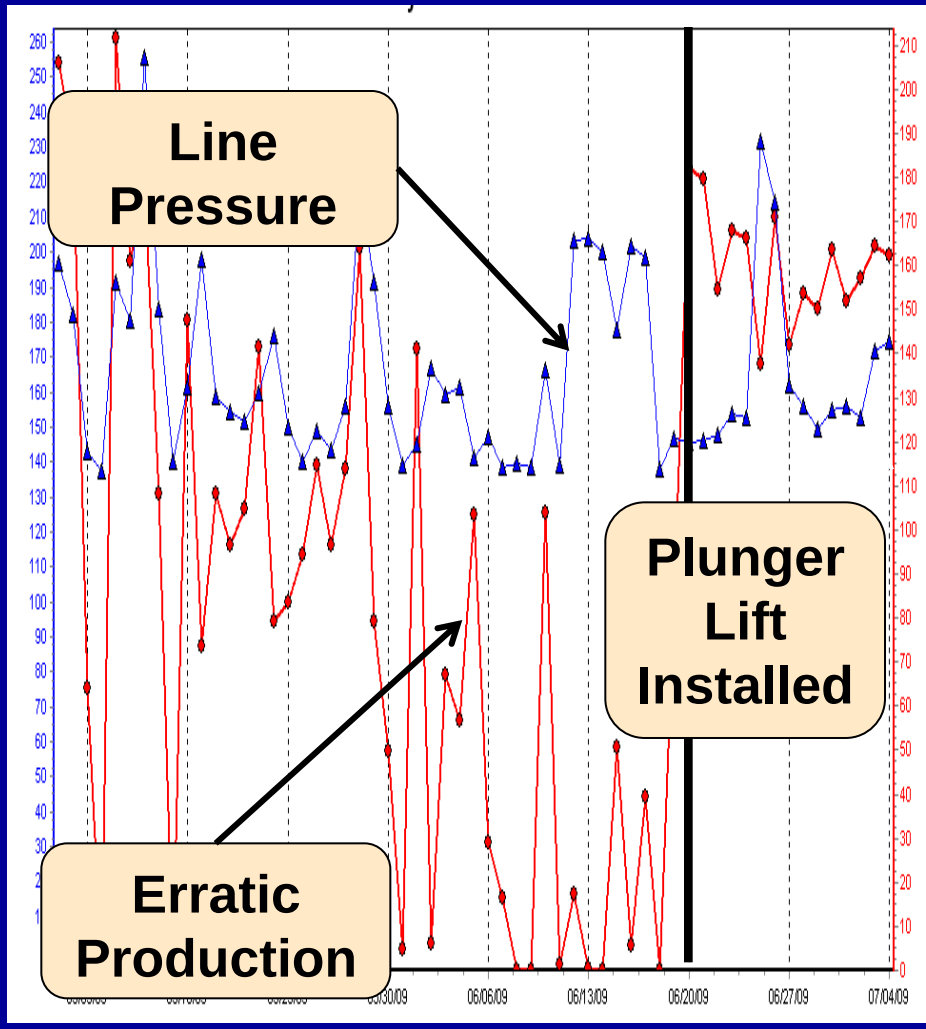
Critical Flow Rate

- Minimum flow rate at which liquid is carried to the surface.
- Experience indicates Turner under predicts onset of loading.
- Loading occurs down hole long before visible at surface.
- Guo et al. predicts critical rate based on down hole conditions
  - ~750 Mcf/d



WELL CANDIDATE SELECTION
Signs of Loading





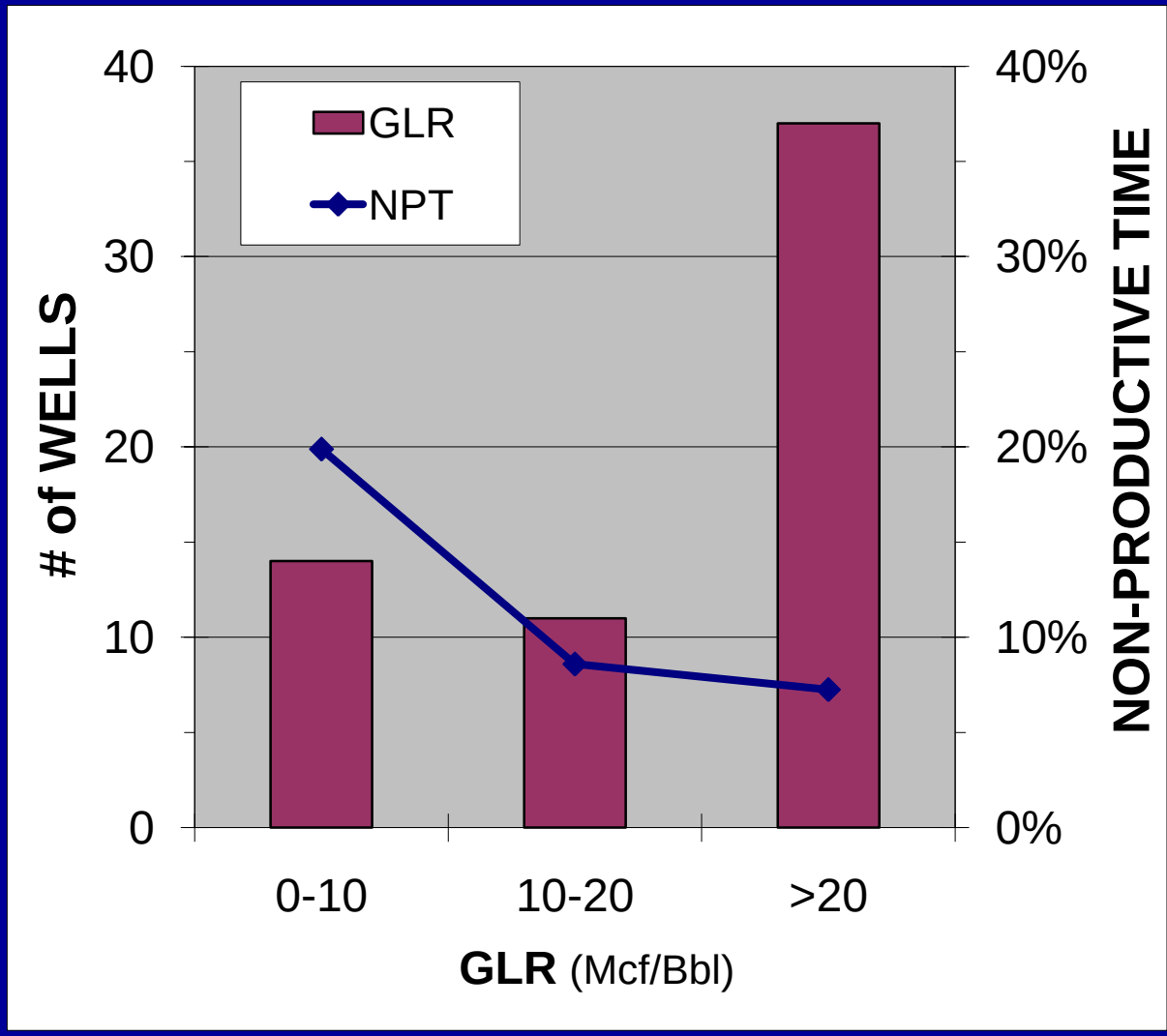
WELL CANDIDATE SELECTION
Flow Rate vs Liquid Produced

WELL	MCF/D	BBLS/D	GLR	LINE PRESSURE	LIFT PRESSURE (CP-LP)
Well # 1	550	204	**2.7**	135	500
Well # 2	550	94	**5.8**	180	500
Well # 3	300	61	**4.9**	140	720
Well # 4	550	56	**9.8**	60	540
Well # 5	480	54	**8.9**	70	400
Well # 6	600	50	**12.0**	180	500
Well # 7	200	35	**5.7**	320	540
Well # 8	477	30	**15.9**	140	300
Well # 9	460	27	**17.0**	130	300

WELL CANDIDATE SELECTION
Gas to Liquid Ratio vs Non Productive Time

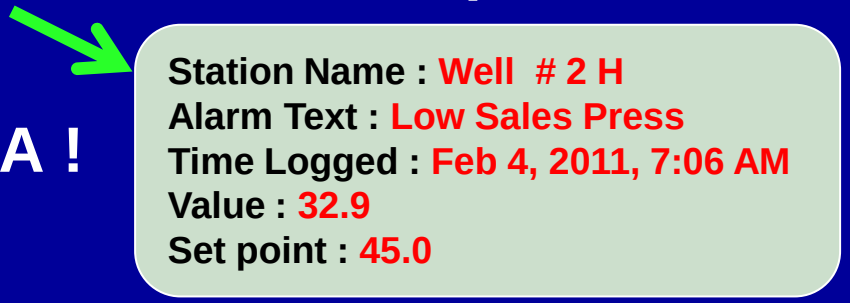
- **Low GLR wells can prove difficult !**
- **Low GLR wells with higher flow rates are easier**

Non-Productive Time (NPT) is Unplanned Downtime



POWER OF SURVEILLANCE
Benefits

- Leverage expert operator skills over many wells
- Daily pinpoint lease operator top priorities
- Remote manual close (weather, pipeline, tank levels)
- Real time alarm notification (tank levels, line pressure, fast arrivals, well shut-in, etc)
- Faster troubleshooting – DATA !
- Rapid leak detection
- Detect some EFM calibration issues
- Reduce equipment damage



KNOW NOW, ACT NOW, PROFIT MORE!

POWER OF SURVEILLANCE
Tools

Well Name	Last Polled Date	Last Polled Time	Batt. Volts	State	Time Remain.	Pressures (psi) Tube	Case	Sales	Flow Rate	Velocity (ft/min)	Today Gas	Today Arr.	Today Fails	Yesterday Gas	Yesterday Arr.	Yesterday Fails	Target Gas	Target %
Well Names	01/26/11	08:42:07	12.8	Plunger Falling	00:06:06	437	497	154	0	477	26	8	0	362	18	0	320	113.1
	01/26/11	08:41:26	11.9	Plunger Falling	00:10:23	354	369	151	0	194	40	4	0	291	13	0	450	64.6
	12/22/10	09:29:58	11.8	Manual Mode	00:00:00	1	478	0	0	0	0	0	0	0	0	0	0	0.0
	01/30/11	19:09:24	13.1	Manual Mode	00:00:00	-4	465	82	0	0	0	0	0	0	0	0	450	0.0
	01/31/11	08:52:38	12.9	Production Mode	01:48:00	63	174	75	575	529	63	4	0	509	10	0	700	72.7
	01/31/11	09:24:49	13.1	Manual Mode	00:00:00	542	542	56	0	0	3	9	3	350	13	0	0	0.0
	01/28/11	13:39:10	14.1	Plunger Falling	00:20:35	485	641	94	0	887	19	5	1	227	15	3	360	63.0
	01/26/11	08:42:50	13.6	Manual Mode	00:00:00	46												
	01/31/11	08:51:14	12.8	Plunger Rising	00:34:19	10												
	01/26/11	08:41:12	14.5	Production Mode	00:45:19	13												
	01/26/11	08:40:55	14.1	Plunger Rising	03:44:17	11												
	01/26/11	08:41:04	14.0	Plunger Falling	00:11:01	21												
	01/26/11	08:40:22	13.7	Production Mode	00:25:42	6												
	01/26/11	08:42:10	13.5	Plunger Rising	00:36:16	94												
	01/26/11	08:40:00	13.8	Plunger Rising	03:06:50	14												
	01/26/11	08:42:22	12.7	Plunger Rising	00:44:28	16												
	01/26/11	08:42:24	13.6	Plunger Rising	03:39:53	14												
	01/25/11	10:52:08	11.2	Manual Mode	00:00:00	15												
	01/25/11	10:52:55	11.5	Plunger Rising	00:23:59	13												
	01/21/11	16:28:54	11.5	Manual Mode	00:00:00	1												
	01/26/11	08:40:20	11.5	Manual Mode	00:00:00	3												
	01/26/11	08:41:00	11.6	Plunger Rising	00:55:27	14												
	01/26/11	08:41:17	13.8	Production Mode	01:33:42	13												
	01/31/11	08:52:47	12.9	Production Mode	00:17:24	14												
	01/26/11	14:05:23	13.3	Plunger Rising	00:40:33	14												
	01/26/11	08:40:34	12.8	Plunger Rising	00:59:47	19												
	01/26/11	08:41:38	12.4	Pressure Building	00:00:00	32												

WELL SUMMARY SCREEN

REAL TIME SNAPSHOT

10043 | 67° F Temp | 13.1 Volts | 10:33:28 | 01/26/2011

No Arrival | Lift Pressure Building | 02:17:37 Start Time | 01:44:53 Elapsed Time | 02:44:40 Time Remaining

0 | VALVE A : CLOSED | VALVE B : DISABLED

OPERATING MODE: Automatic | VALVE A: CLOSE

177.53 psig | 1.766 Bbls | LIQUID LOAD (CP - TP)

571.9 Act | 518.7 Req'd | 500.0 Adj'd | LIFT PRESSURE (CP - SLP)

PLUNGER VELOCITY | 651 ft/min

TUBING PRESSURE | CASING PRESSURE | SALES PRESSURE

626.6 psig | 706.7 psig | 134.7 psig

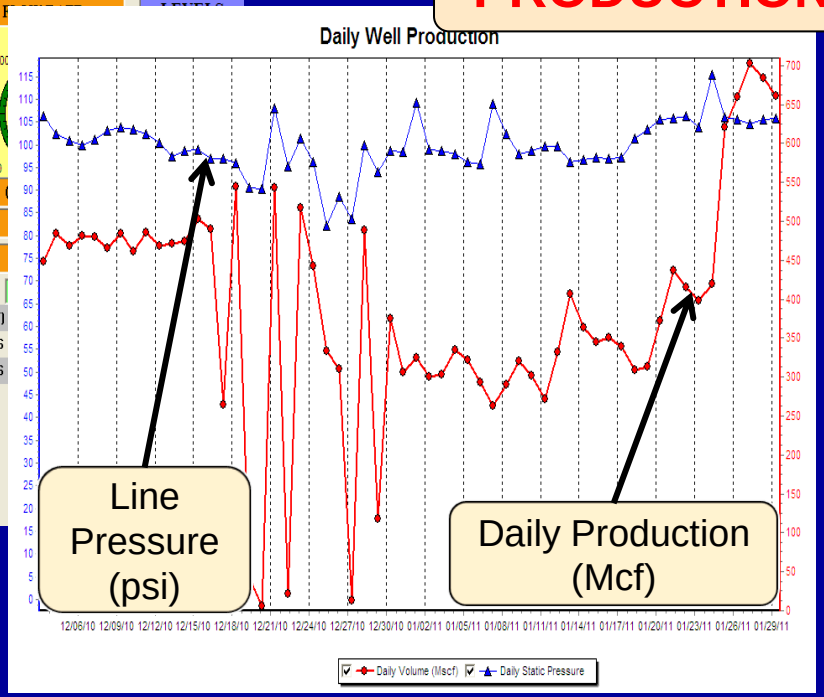
ALARM SETTINGS
High Line Pressure 300
Low Line Pressure 60

CONTROL SETTINGS
Fall Time 00:25 (HH:MM)
Build Mode Lift Pressure > 500 psi
No Arrival # 0 | Adjusted Build Value 500 psi
Flow Rate < 1000.0 (Mscf/D)

GAS (MSCF) | ARRIVALS | FAILURES

NO ARRIVAL ADJUSTMENT
Plunger Rise Time Allowed (HH:MM) 01:30
Valve B Max Open Time (HH:MM) Disabled
"No Arrivals" Allowed Before Shut-in 2
"No Arrival" Build Adjustment Factor 50 psi

PRODUCTION !



RIGHT INFORMATION
RIGHT FORMAT
ANYTIME
ANYWHERE

POWER OF SURVEILLANCE
Tools

Plunger Lift Cycle Report

Station Name:
Report Range: 02/01/11 08:00 To 02/02/11 14:43
Site ID: 10058

Last Poll Time: 02-FEB-11 02:40PM
Temperature: 30°F
System Voltage: 13.6 V

PRODUCTION !

Run #	AT CLOSE Time	Pressures (psi) CP	TP	SLP	CP-TP	Fluid in Tbg	AT OPEN Time	Pressures (psi) CP	TP	SLP	Act. Lift	Req'd Lift	RUN DATA Plunger Rise Time (min)	Plunger Rise Velocity (ft/min)	Arrivals Good	Arrivals Miss	Open Duration	Close Duration	PRODUCTION DATA Gas (Mscf)	Liquid (Bbls)
5341	02			2	151	45	0.41	02/01/11 07:54AM	510	427	150	360	183	7.28	1050				1:54	10.2	0.0
5342	02			8	146	53	0.47	02/01/11 09:50AM	508	417	147	360	197	7.65	1000				1:44	11.7	0.0
5343	02			1	145	55	0.49	02/01/11 11:46AM	505	416	145	360	201	7.68	995				1:45	10.6	0.0
5344	02/01/11 11:57AM	434	381		146	53	0.47	02/01/11 01:42PM	504	413	144	360	197	7.58	1009				1:44	10.5	0.0
5345	02/01/11 01:53PM	431	382		144	49	0.44	02/01/11 03:34PM	501	416	141	360	187	7.40	1034	1		00:10	01:41	11.0	0.0
5346	02/01/11 03:45PM	430	381		140	49	0.44	02/01/11 05:24PM	499	411	139	360	186	7.42	1031	1		00:10	01:39	10.7	0.0
5347	02/01/11 05:35PM	428	375		137	53	0.47	02/01/11 07:12PM	497	409	137	360	193	7.67	998	1		00:11	01:36	10.6	0.0
5348	02/01/11 07:24PM	425	375		136	50	0.45	02/01/11 08:59PM	494	409		360	185	7.38	1036	1		00:10	01:34	10.7	0.0
5349	02/01/11 09:09PM	423	372		134	51	0.45	02/01/11 10:54PM	495	408	135	360	188	7.53	1015	1		00:11	01:44	10.4	0.0
5350	02/01/11 11:05PM	424	375		135	49	0.44	02/02/11 12:58AM	498	414	138	360	185	7.58	1009	1		00:11	01:53	10.0	0.0
5351	0					53	0.47	02/02/11 02:48AM	496	405	136	360	193	7.95	962	1		00:11	01:38	11.7	0.0
5352	0					51	0.46					360	191	7.63	1002	1		00:11	01:55	10.9	0.0
5353	0					49	0.44					360	210	8.35	916				05:37	11.9	0.0
5354	02					60	0.54					360	225	8.18	935				01:08	11.6	0.0
5355	02/02/11 12:16PM	454	410		158	44	0.39					360	176	6.63	1153				00:43	11.0	0.0
5356	02/02/11 01:10PM	433	398		144	35	0.32	02/02/11 02:30PM	498	425	138	361	155	6.35	1204				01:20	10.5	0.0

Cycle #

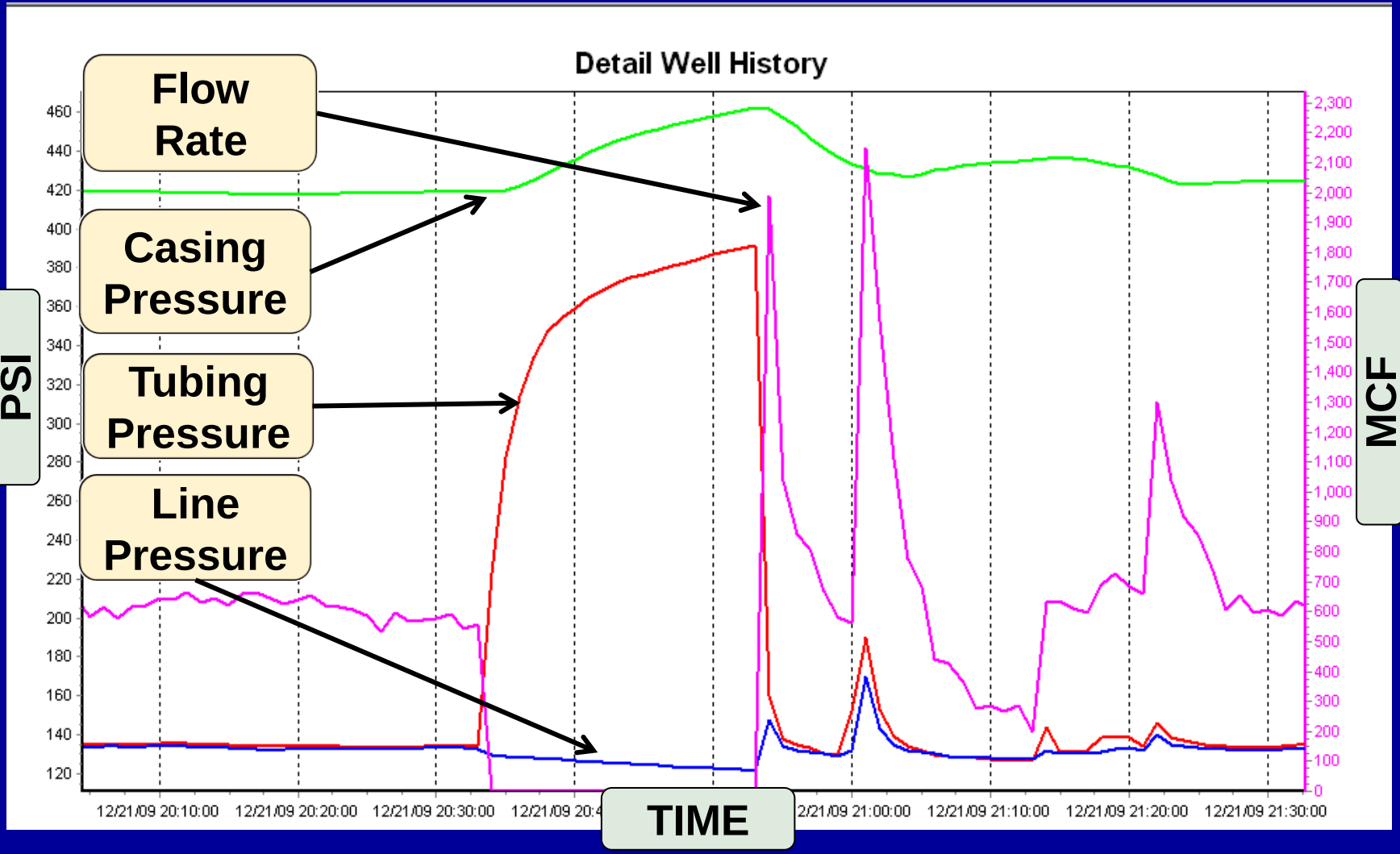
PLUNGER VELOCITY

Liquid Load (CP – TP)

Lift Pressure (CP – LP)

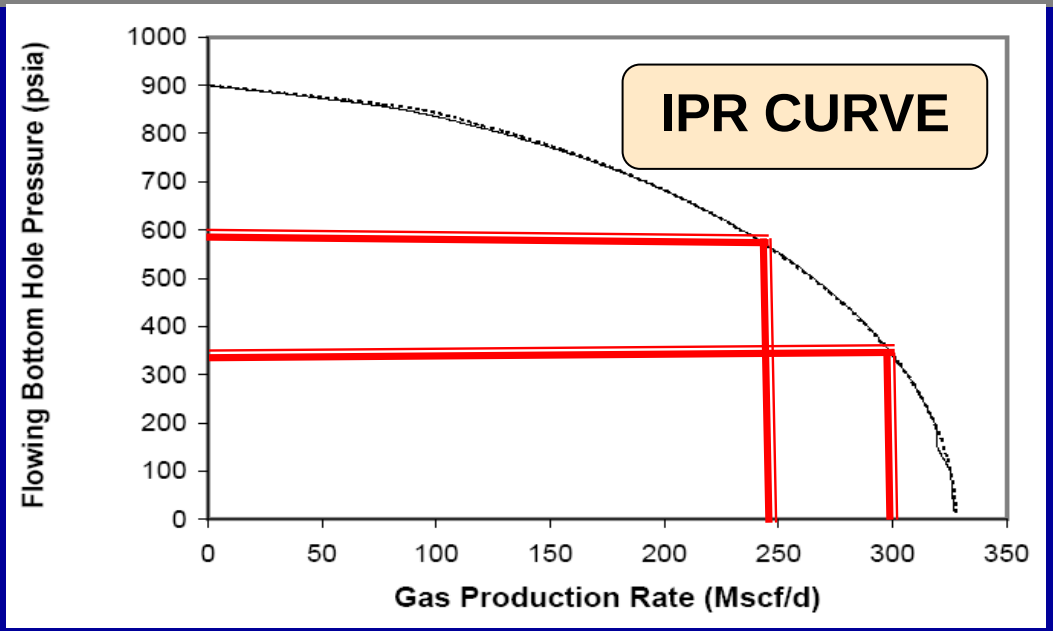
CLOSE TIME

POWER OF SURVEILLANCE
Tools



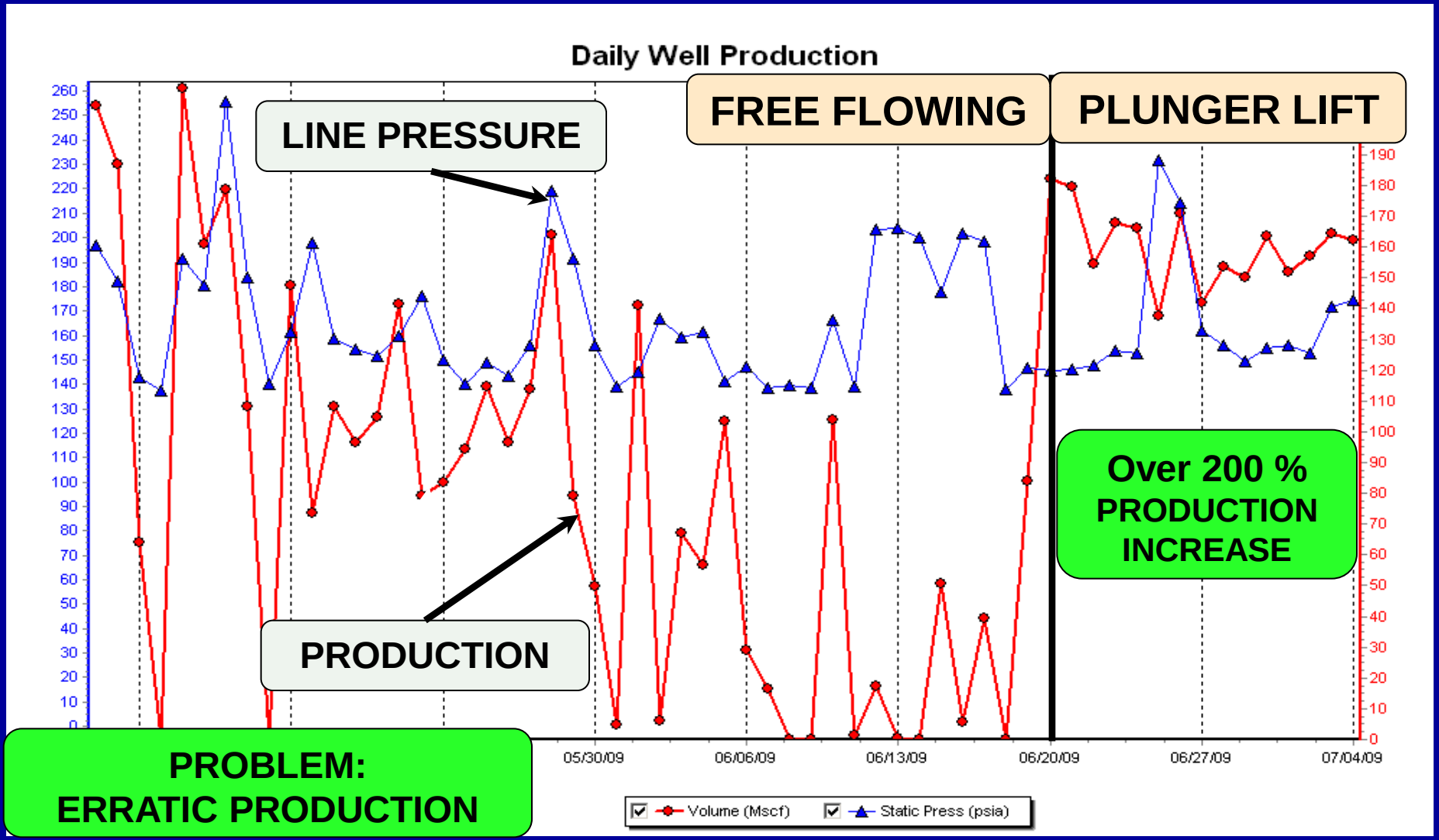
OPTIMIZING SHALE WELLS
Process

- **FOCUS ON PRODUCTION!**
- **Use reliable hardware**
- **Minimize restrictions**
  - **BH Spring to pipeline**
- **Review on each cycle**
  - **Fluid in Tubing**
  - **Lift Pressure**
  - **Plunger Velocity**
  - **Gas Produced**
- **Short afterflow on initial cycles**
- **Troubleshoot – DATA !**

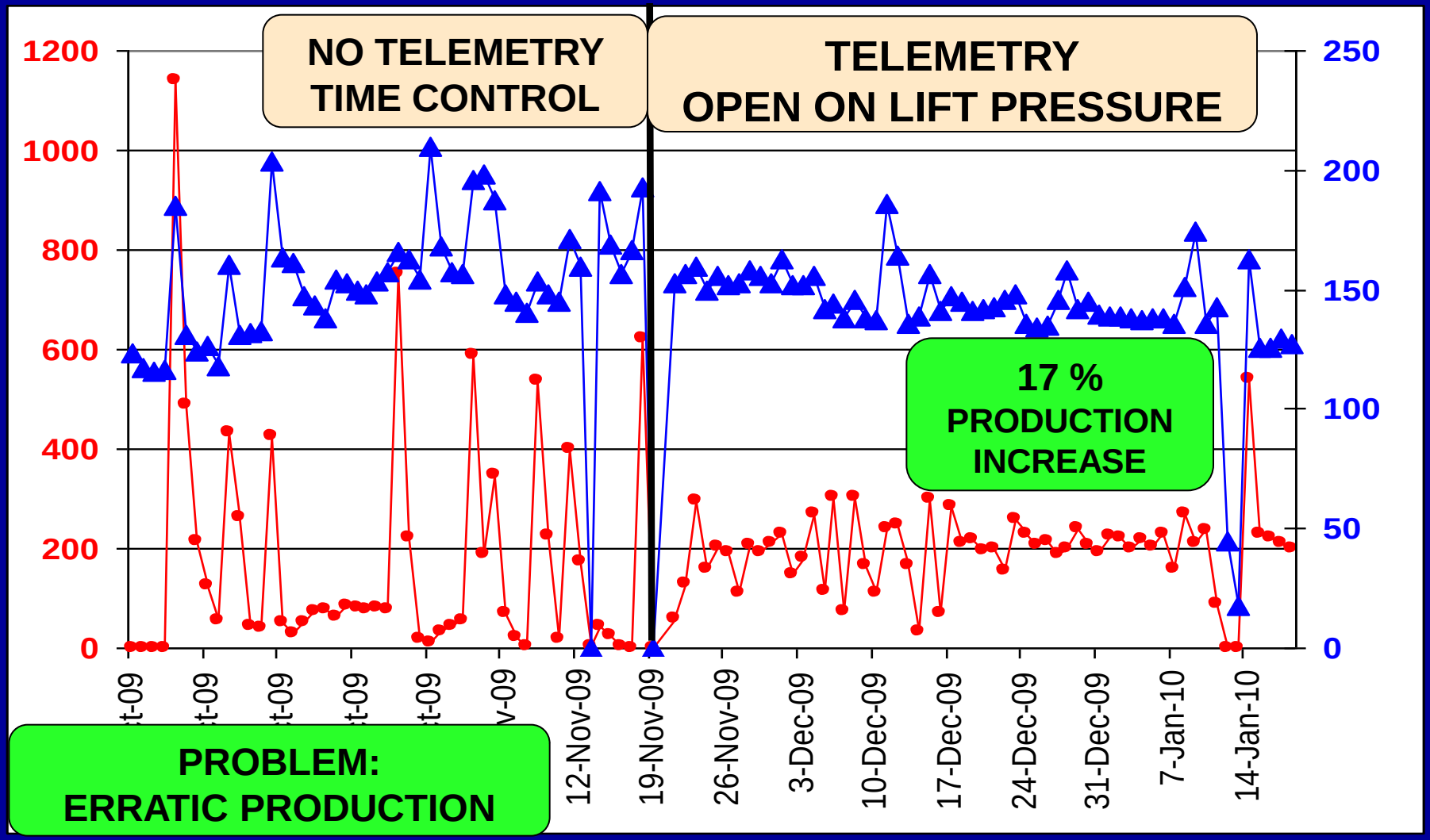


- **OPERATE AT LOWEST POSSIBLE CP**
  - **Many cycles each day**
  - **Open when fall time elapses**
  - **Fast falling plungers**
  - **Standing valves**

OPTIMIZING SHALE WELLS
Examples



OPTIMIZING SHALE WELLS
Examples



OPTIMIZING SHALE WELLS
Examples

Plunger Lift Cycle Report

Station Name:
Report Range: 02/01/11 08:00 To 02/13/11 20:49
Site ID: 10099

Last Poll Time: 13-FEB-11 08:48PM
Temperature: 58°F
System Voltage: 13.2 V

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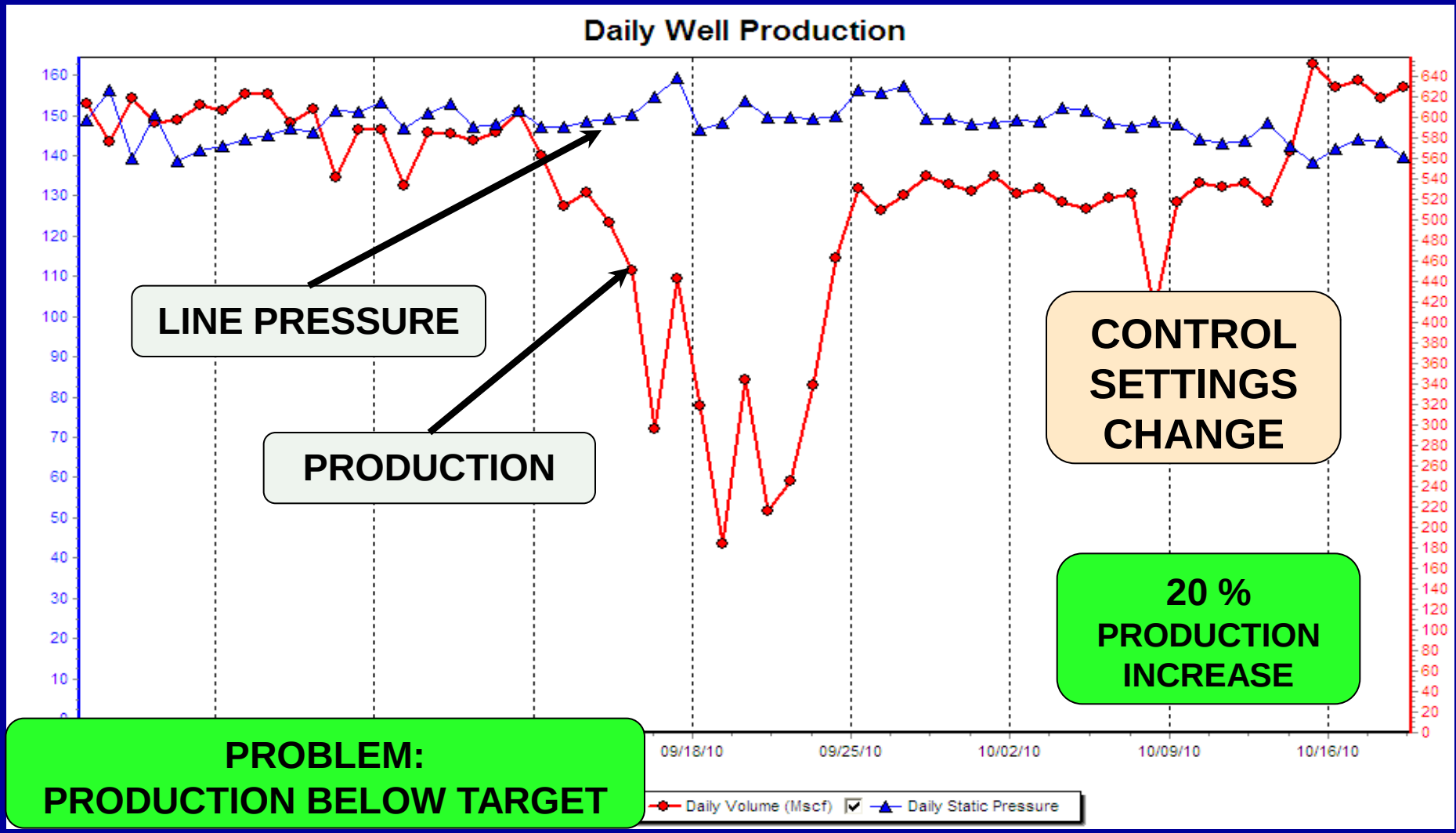
	AT CLOSE						AT OPEN						RUN DATA						PRODUCTION DATA	
		Pressures (psi)						Pressures (psi)					Plunger Rise		Arrivals					
Run #	Time	CP	TP	SLP	CP-TP	Fluid in Tbg	Time	CP	TP	SLP	Act. Lift	Req'd Lift	Time (min)	Velocity (ft/min)	Good	Miss	Open Duration	Close Duration	Gas (Mscf)	Liquid (Bbls)
3460	02/13/11 04:36AM	314	253	135	61	0.54	02/13/11 05:15AM	355	326	134	220	210	5.83	1339	1		00:06	00:38	6.0	0.0
3461	02/13/11 05:21AM	312	254	135	58	0.52	02/13/11 06:02AM	354	337	134	220	204	4.58	1704	1		00:05	00:40	5.5	0.0
3462	02/13/11 06:07AM	314	256	133	58	0.52	02/13/11 06:44AM	353	326	133	220	204	6.03	1294	1		00:07	00:36	5.8	0.0
3463	02/13/11 06:51AM	311	251	134	60	0.54	02/13/11 07:33AM	354	331	134	220	209	5.12	1526	1		00:06	00:41	5.3	0.0
3464	02/13/11 07:39AM	313	256	133	57	0.50	02/13/11 08:14AM	351	321	132	219	200	6.00	1302	1		00:07	00:35	6.4	0.0
3465	02/13/11 08:21AM	310	251	132	59	0.53	02/13/11 09:01AM	352	330	132	220	205	4.93	1583	1		00:05	00:39	5.3	0.0
3466	02/13/11 09:07AM	312	259	134	52	0.47	02/13/11 09:50AM	356	348	136	220	192	4.07	1920	1		00:05	00:43	5.9	0.0
3467	02/13/11 09:55AM	315	257	137	59	0.52	02/13/11 10:40AM	359	337	139	220	208	4.73	1650	1		00:05	00:44	5.4	0.0
3468	02/13/11 10:45AM	317	262	139	55	0.49	02/13/11 11:25AM	357	339	137	220									0.0
3469	02/13/11 11:31AM	317	251	138	66	0.59	02/13/11 12:07PM	354	323	134	220									0.0
3470	02/13/11 12:13PM	312	254	134	59	0.52	02/13/11 12:54PM	356	329	136	220									0.0
3471	02/13/11 01:01PM	314	254	136	60	0.54	02/13/11 01:42PM	357	332	137	220									0.0
3472	02/13/11 01:48PM	315	257	137	59	0.52	02/13/11 02:32PM	358	342	138	220									0.0
3473	02/13/11 02:37PM	318	262	138	56	0.50	02/13/11 03:16PM	358	337	137	220									0.0
								381	160											
								381	162											
								310	144											
								326	136											
								329	133											
								340	133											

FALL TIME (15 MIN)
CLOSE TIME (MUCH LONGER)
LIFT PRESSURE (220 PSI)

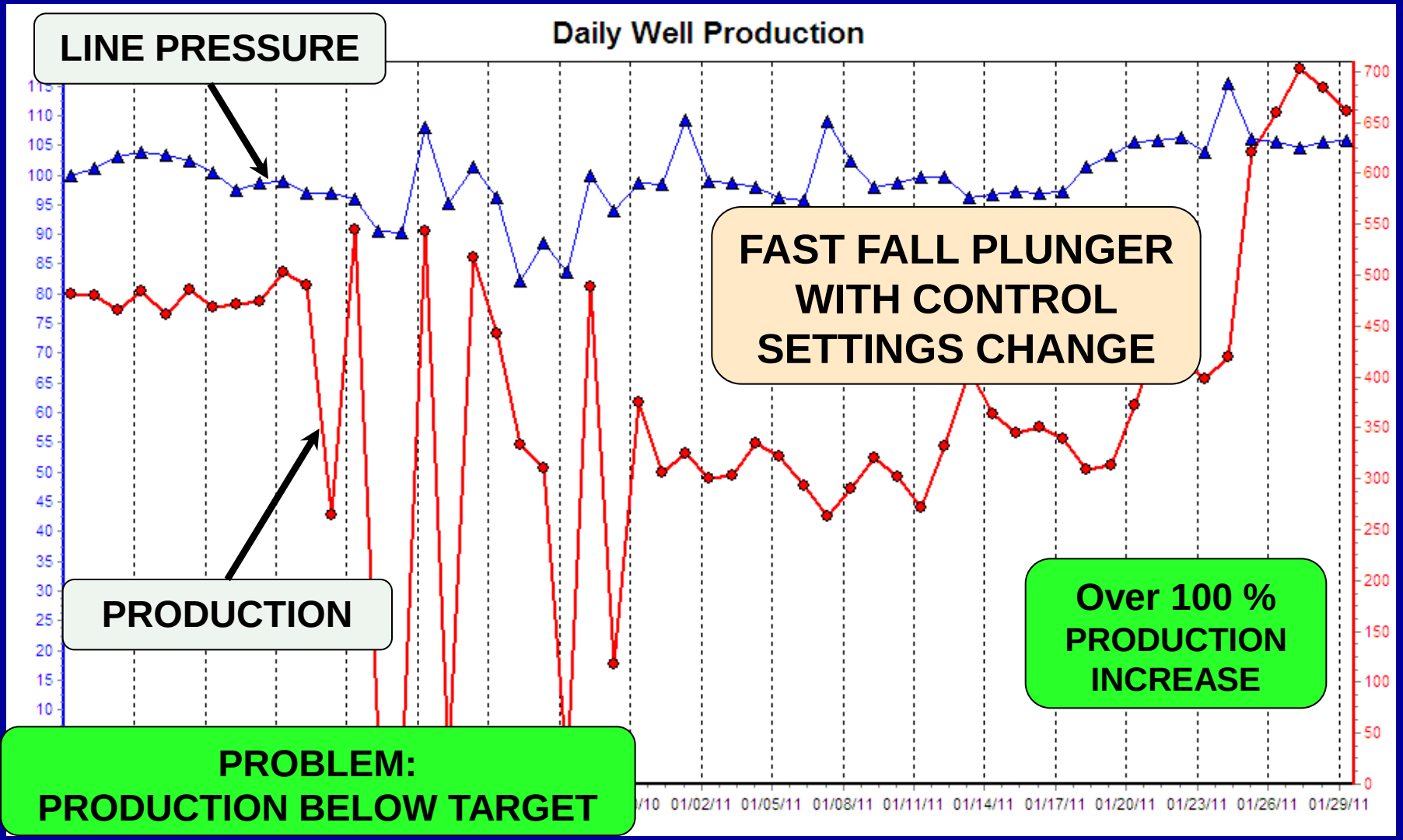
PROBLEM:
PLUNGER VELOCITY IS FAST
Increase Afterflow or Decrease Close Time ?

REDUCE LIFT PRESSURE WILL SHORTEN CLOSE TIME . PLUNGER WILL MAKE MORE CYCLES PER DAY.

OPTIMIZING SHALE WELLS
Examples



OPTIMIZING SHALE WELLS
Examples



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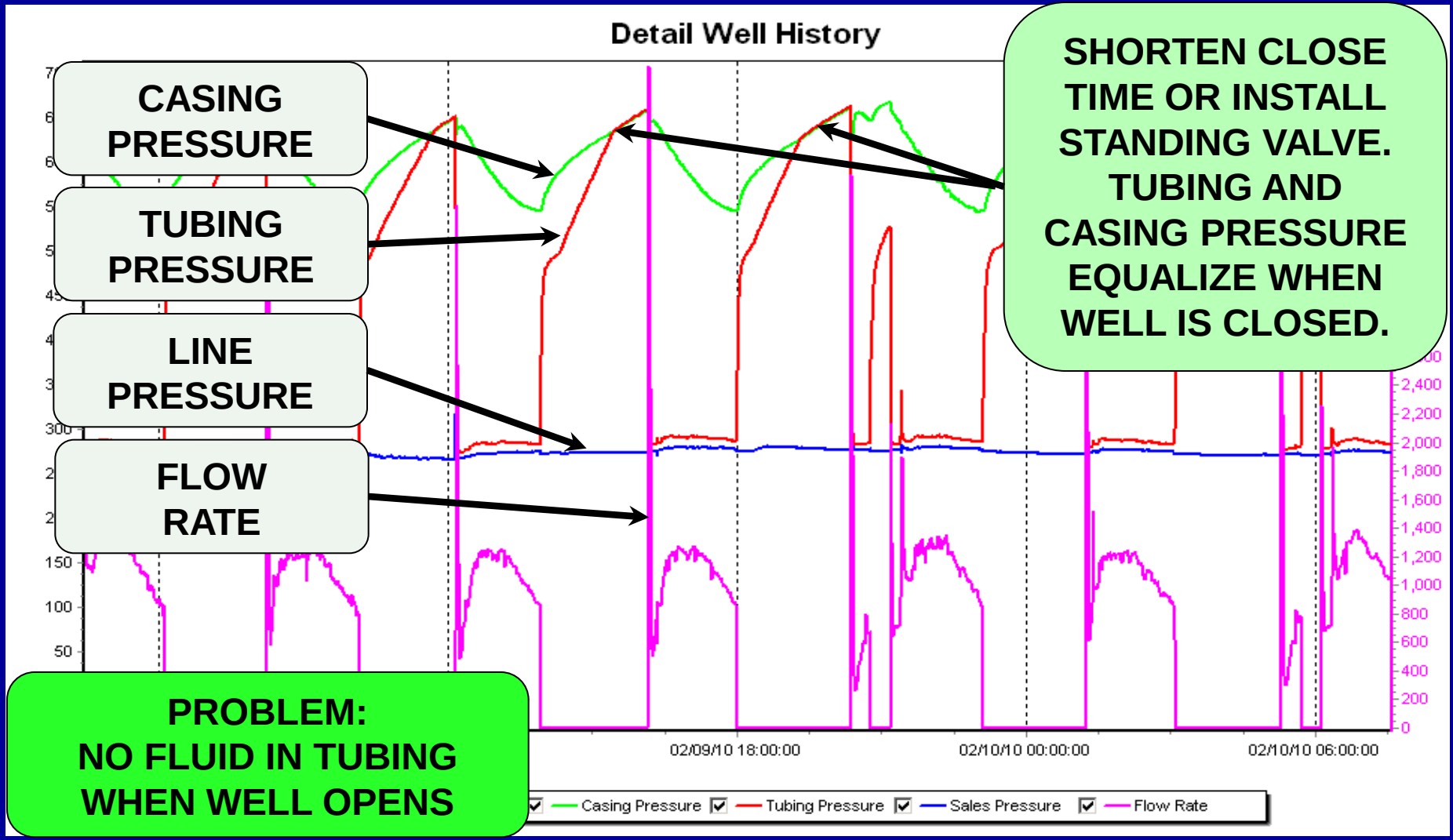

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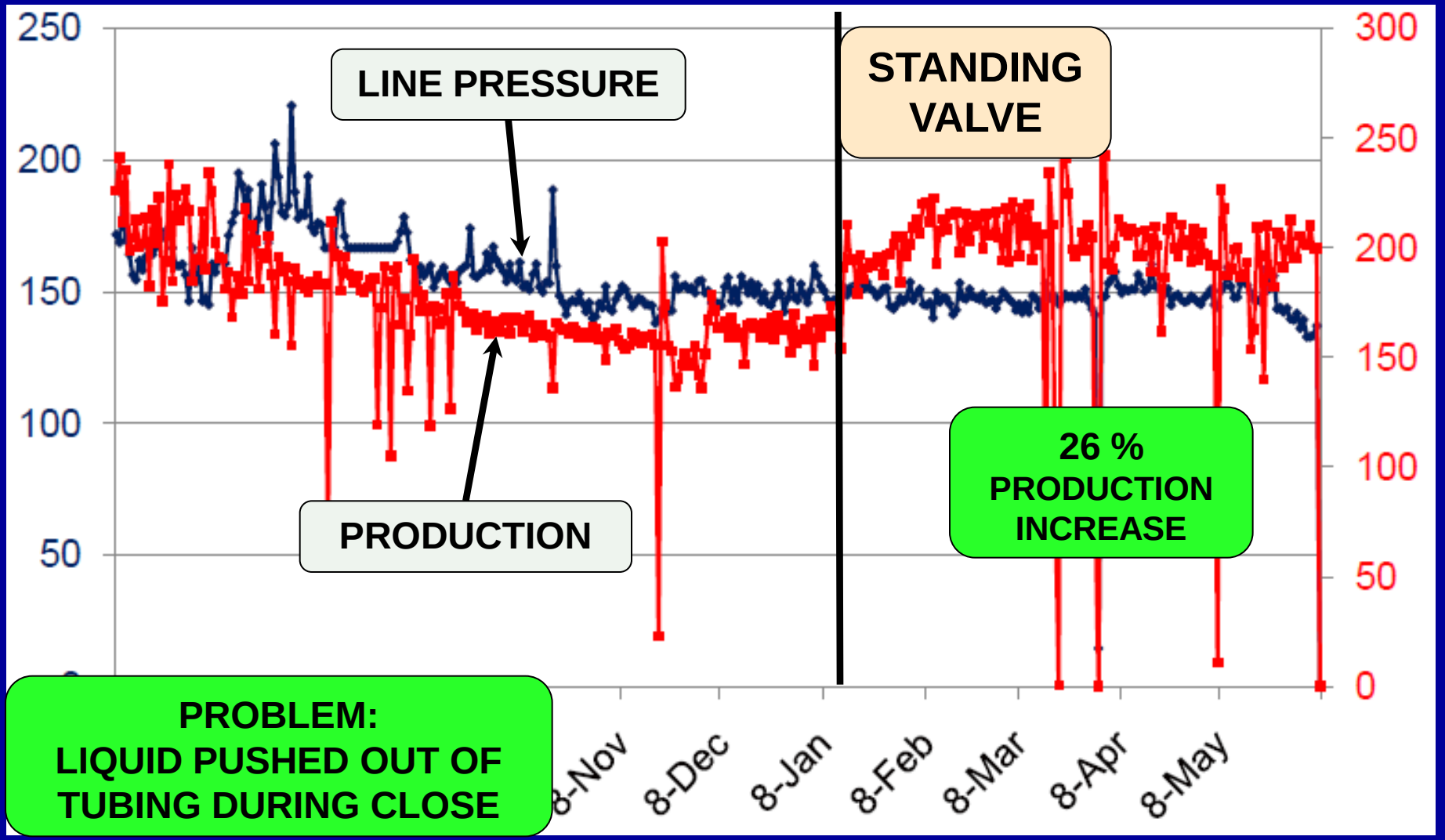
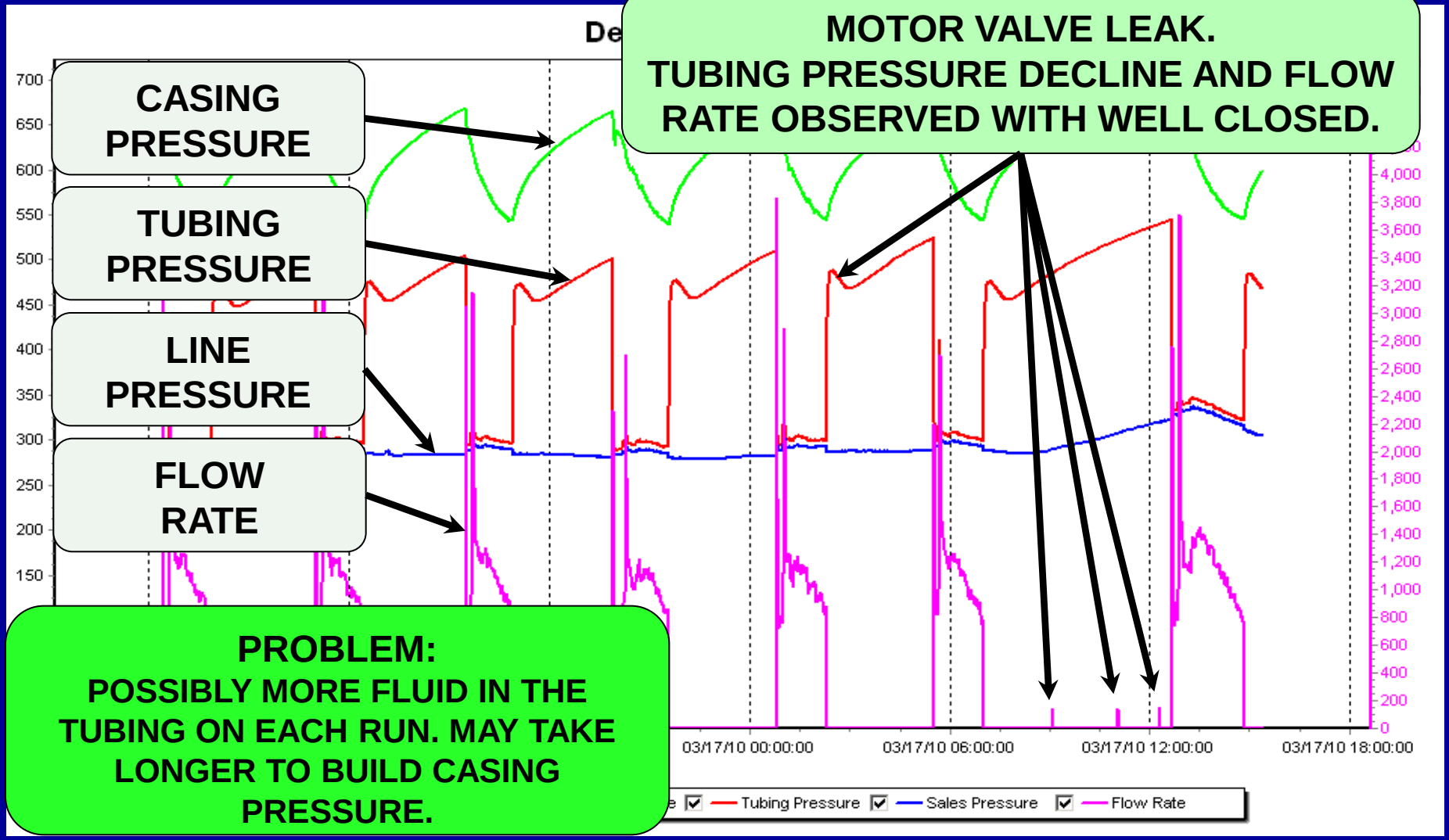
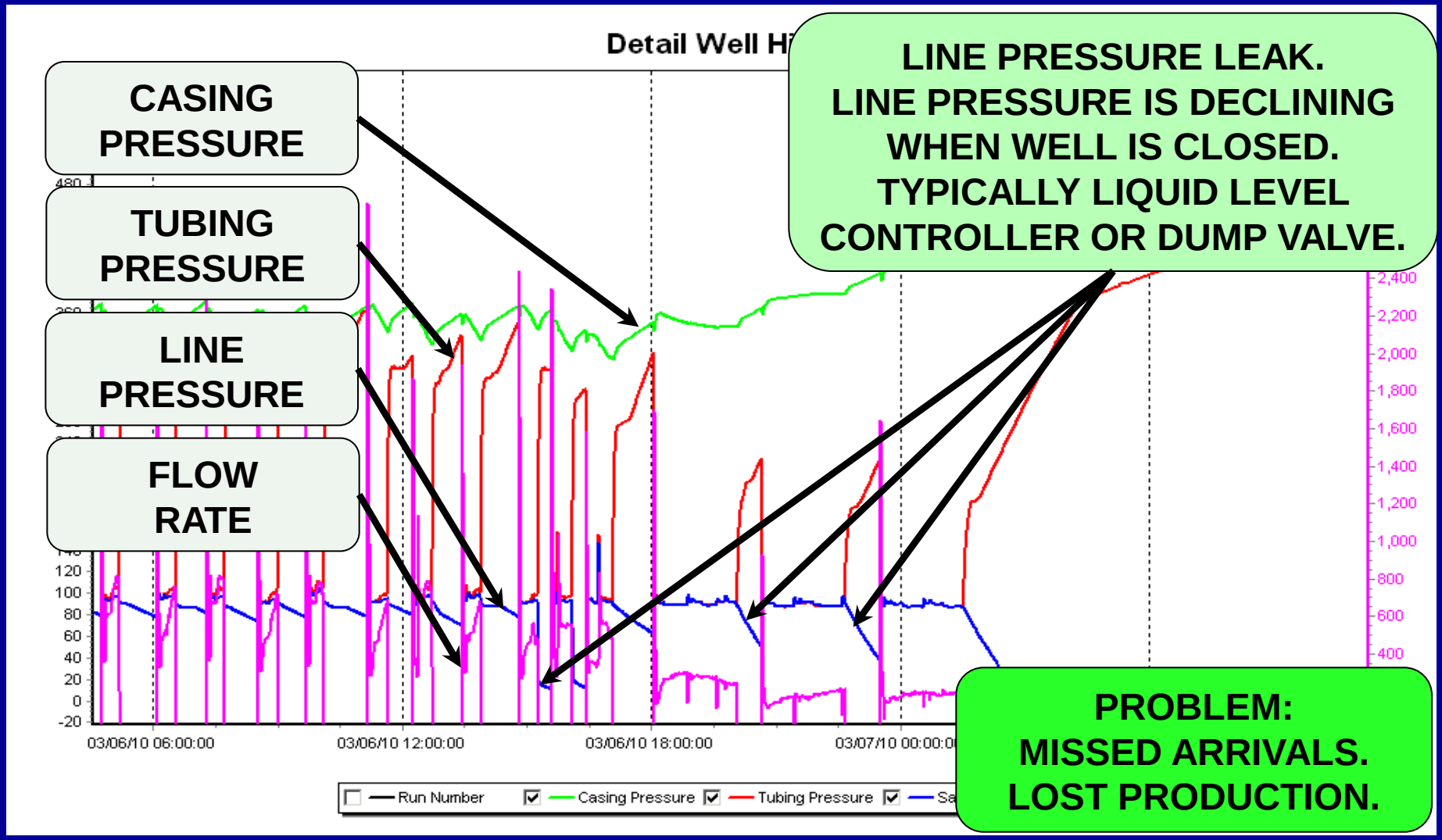


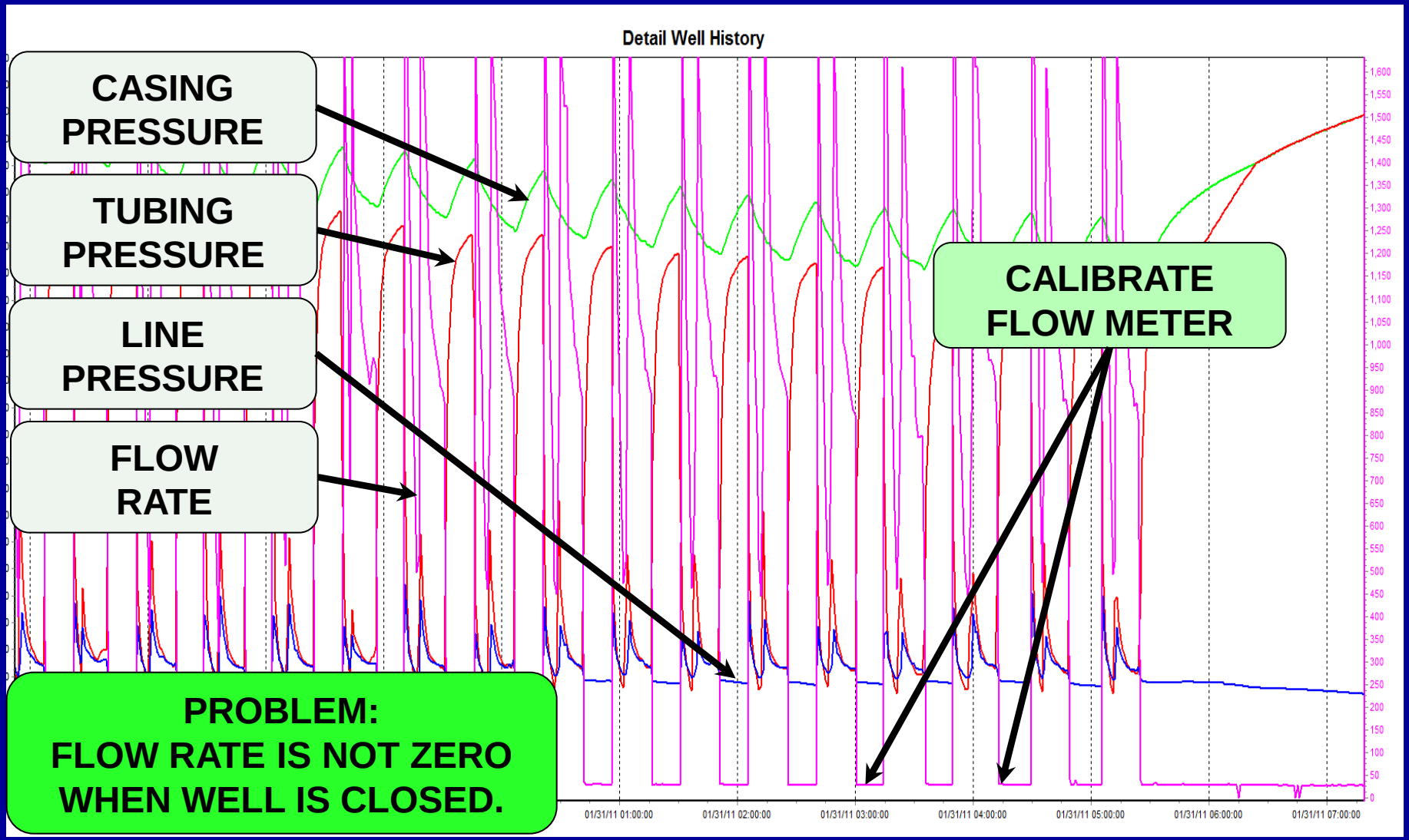
TROUBLESHOOTING SHALE WELLS
Examples



TROUBLESHOOTING SHALE WELLS
Examples



TROUBLESHOOTING SHALE WELLS
Examples



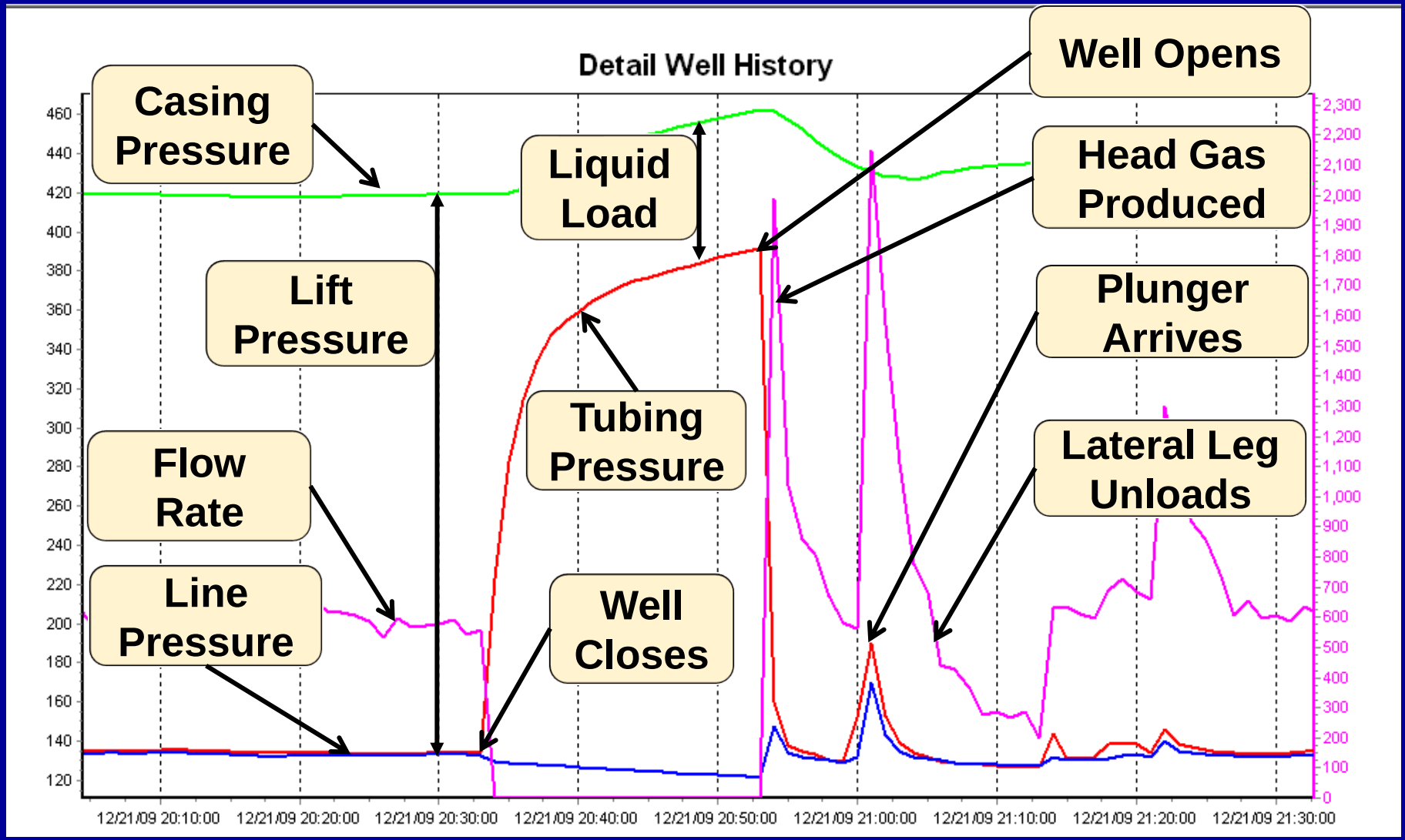
CONCLUSION
Plunger lift improves shale production

- **Shale well production dramatically improves when**
  - **Liquid is removed**
  - **Unplanned downtime is minimized**
  - **Plunger lift cycles are optimized**
- **Plunger Lift**
  - **Effectively removes liquid from shale wells**
  - **Is cost effective with a rapid payback**
  - **Is a long term solution**
- **Plunger Lift with Surveillance and Real Time alarms**
  - **Supplement field knowledge with in house “optimizers”**
  - **Provides real time data for root cause analysis**

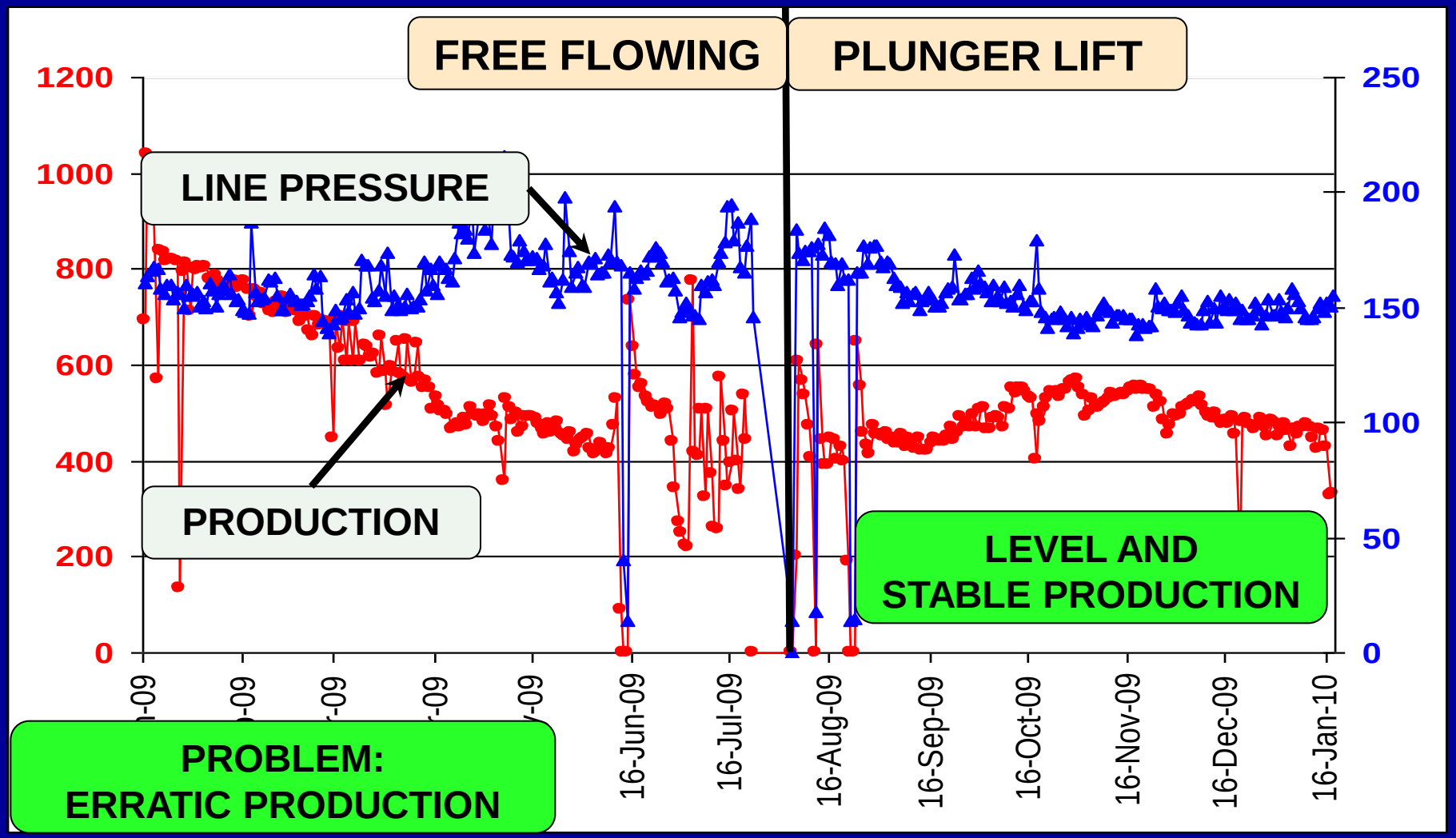
KNOW NOW
ACT NOW
PROFIT MORE!

ADDENDUM

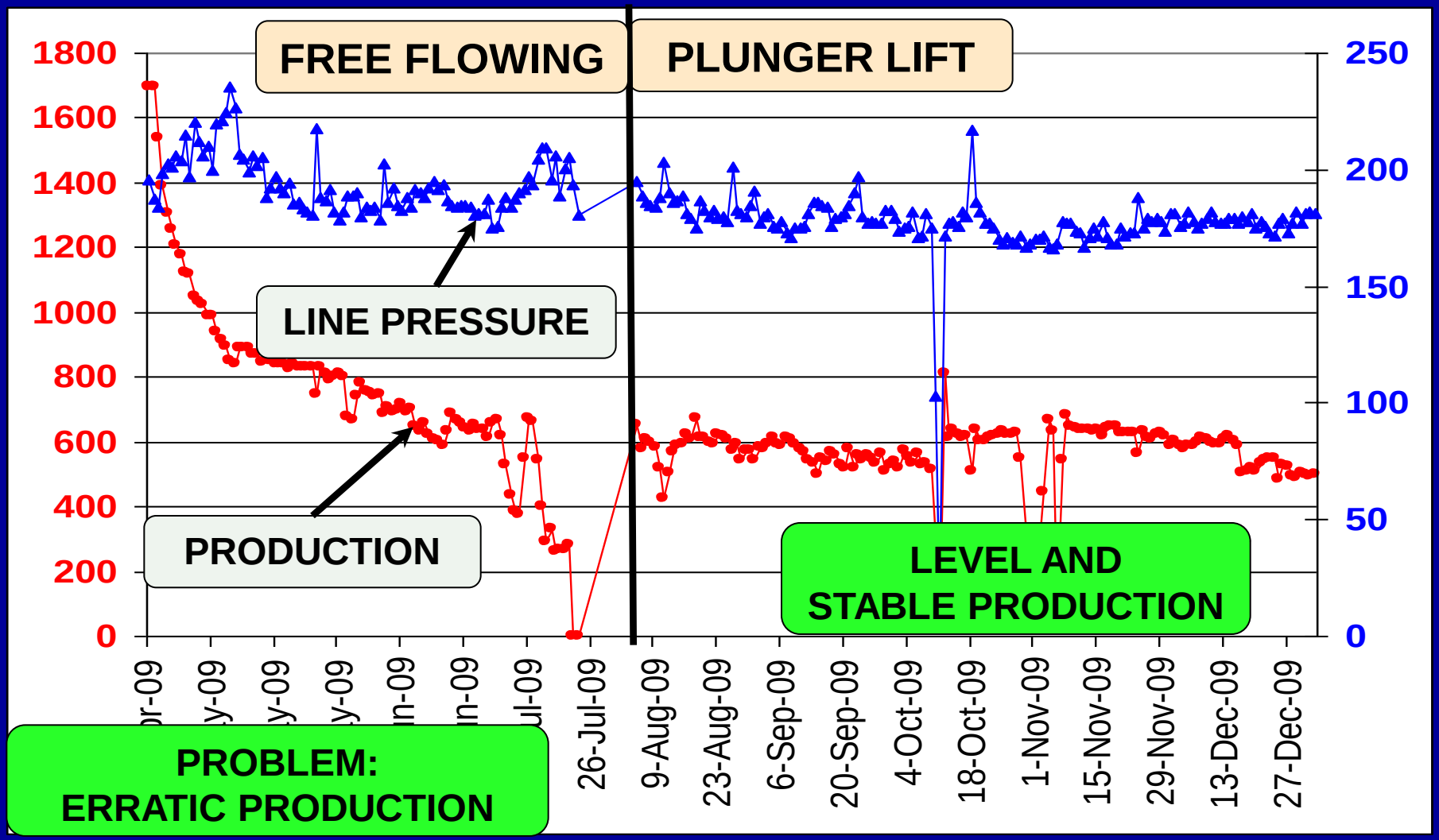
POWER OF SURVEILLANCE
Tools



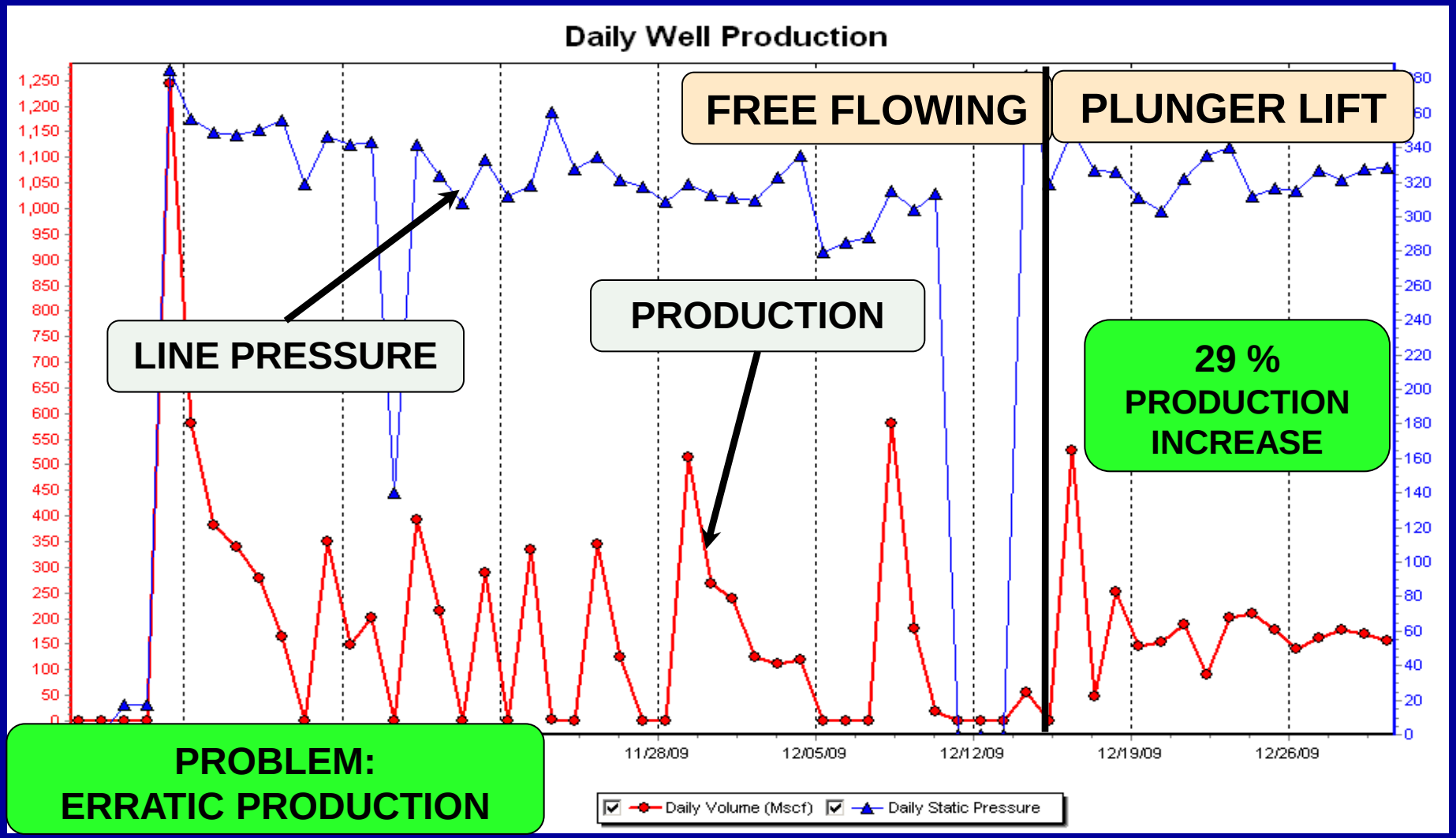
OPTIMIZING SHALE WELLS
Examples



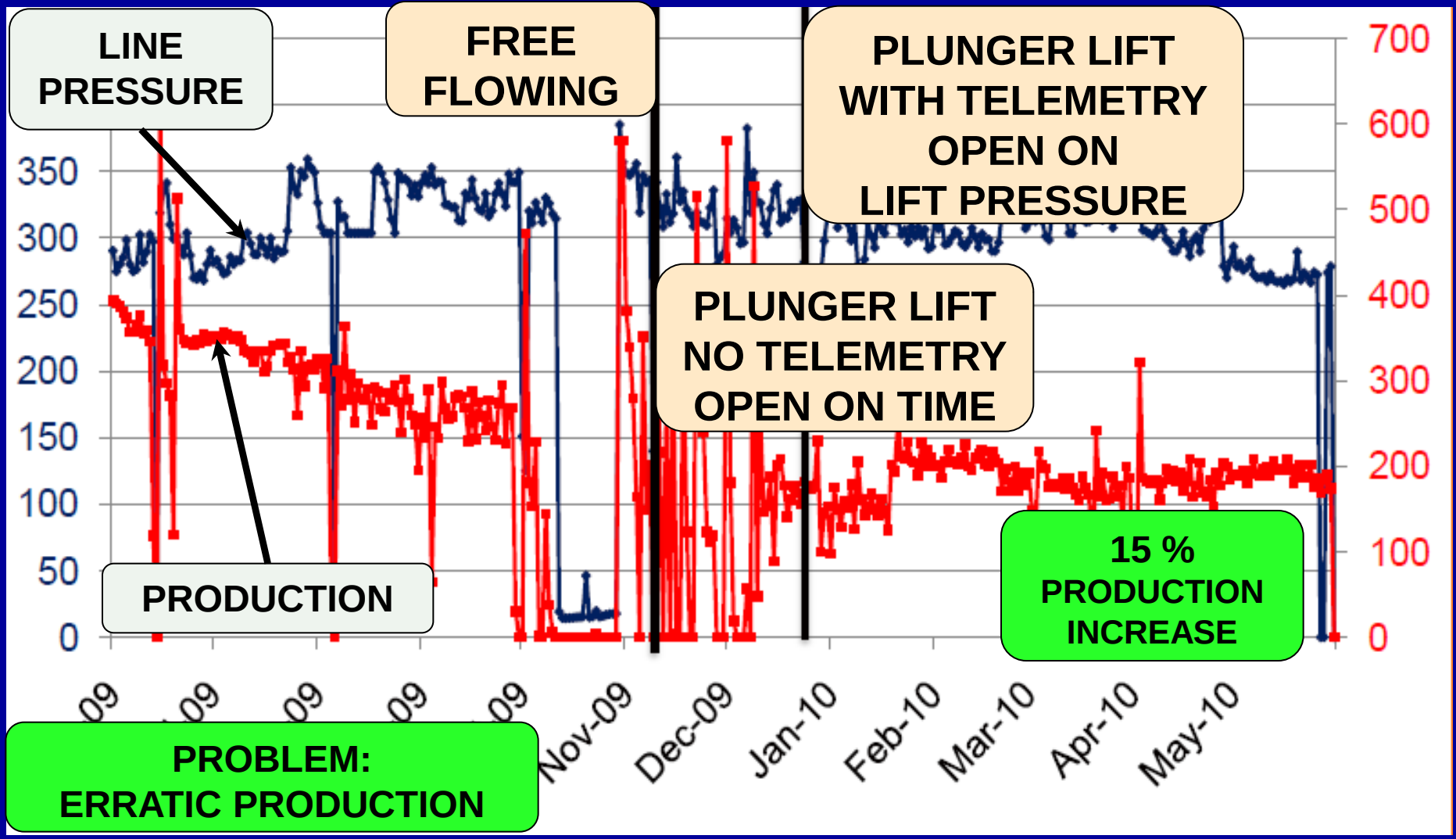
OPTIMIZING SHALE WELLS
Examples



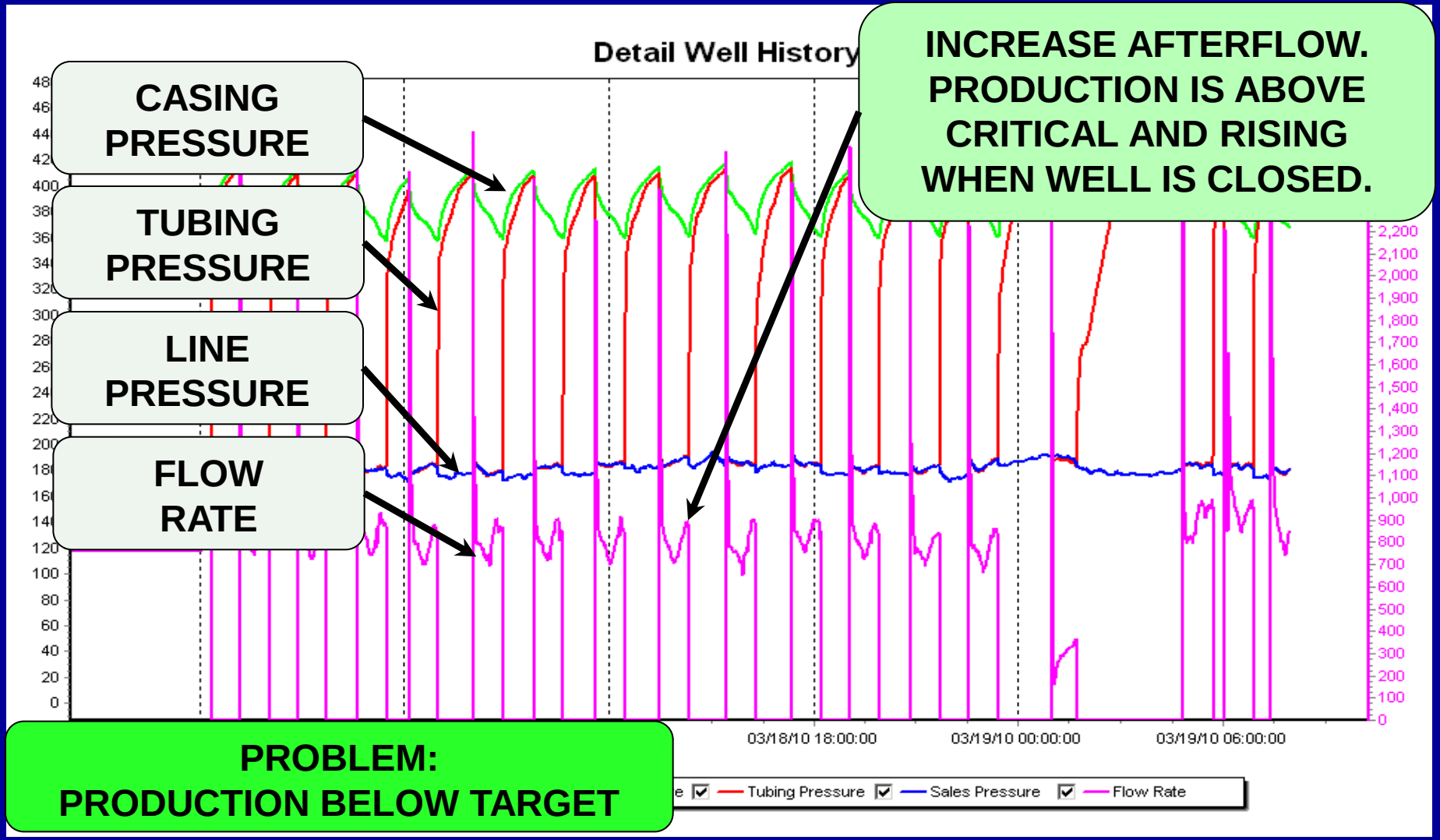
OPTIMIZING SHALE WELLS
Examples



OPTIMIZING SHALE WELLS
Examples



OPTIMIZING SHALE WELLS
Examples



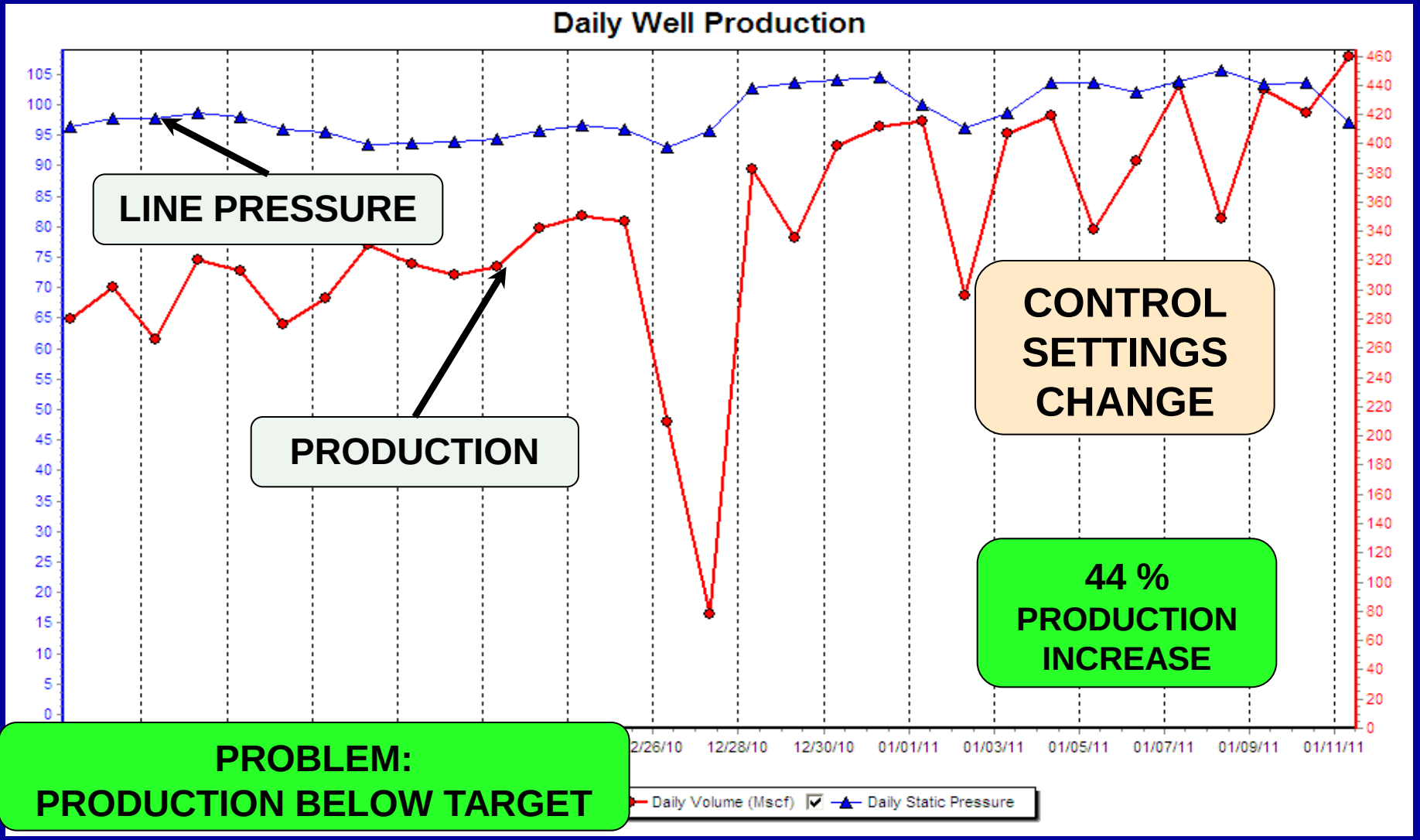
OPTIMIZING SHALE WELLS
Examples

	AT CLOSE						AT OPEN						RUN DATA						PRODUCTION DATA	
		Pressures (psi)						Pressures (psi)					Plunger Rise		Arrivals					
Run #	Time	CP	TP	SLP	CP-TP	Fluid in Tbg	Time	CP	TP	SLP	Act. Lift	Req'd Lift	Time (min)	Velocity (ft/min)	Good	Miss	Open Duration	Close Duration	Gas (Mscf)	Liquid (Bbls)
95	01/30/11 09:01PM	318	281	170	37	0.33	01/30/11 09:16PM	330	289	167	163	172	13.85	546	1		00:33	00:15	15.5	0.0
96	01/30/11 09:50PM	317	275	163	42	0.38	01/30/11 10:05PM	329	294	161	168	181	8.38	903	1		00:28	00:15	13.8	0.0
97	01/30/11 10:34PM	317	275	162	41	0.37	01/30/11 10:49PM	326	292	162	165	179	7.47	1014	1		00:27	00:15	13.6	0.0
98	01/30/11 11:16PM	313	281	161	32	0.29	01/30/11 11:31PM	324	301	162	162	159	7.57	1000	1		00:27	00:15	13.8	0.0
99	01/30/11 11:59PM	313	273	161	40	0.36	01/31/11 12:14AM	323	290	161	163	175	7.43	1018	1		00:27	00:15	13.2	0.0
100	01/31/11 12:42AM	312	276	160	36	0.32	01/31/11 12:57AM	322	294	160	162	166	6.85	1105	1		00:26	00:15	12.9	0.0
101	01/31/11 01:24AM	311	275	159	36	0.32	01/31/11 01:39AM	321	292	159	162	165	6.95	1089	1		00:26	00:15	13.1	0.0
102	01/31/11 02:06AM	311	272	160	38	0.34	01/31/11 02:21AM	320	289	161	159	172	7.63	991	1		00:27	00:15	13.3	0.0
103	01/31/11 02:49AM	309	274	160	34	0.31	01/31/11 03:04AM	319	294	160	158	163	7.42	1020	1		00:27	00:15	13.2	0.0
104	01/31/11 03:31AM	308	273	161	35	0.32	01/31/11 03:46AM	318	292	161	158	165	7.15	1058	1		00:27	00:15	12.8	0.0
105	01/31/11 04:13AM	308	272	164	36	0.32	01/31/11 04:29AM	318	293	162	156	167	7.65	989	1		00:27	00:15	13.2	0.0
106	01/31/11 04:56AM	308	272	162	36	0.32	01/31/11 05:11AM	318	294	162	157	166	7.18	1054	1		00:27	00:15	13.2	0.0
107	01/31/11 05:39AM	307	271	161	36	0.32	01/31/11 05:54AM	318	292	161	157	167	7.08	1068	1		00:27	00:15	12.9	0.0
108	01/31/11 06:21AM	306	269	162	38	0.34	01/31/11 06:36AM	316	287	162	155									0.0
109	01/31/11 07:05AM	307	267	161	40	0.36	01/31/11 07:20AM	317	288	161	15									0.0
110	01/31/11 07:50AM	310	257	161	54	0.48	01/31/11 08:05AM	320	273	161	16									0.0
111	01/31/11 08:35AM	310	264	163	45	0.40	01/31/11 08:50AM	319	280	161	15									0.0
										169	15									0.0
										169	14									0.0
										169	148									0.0

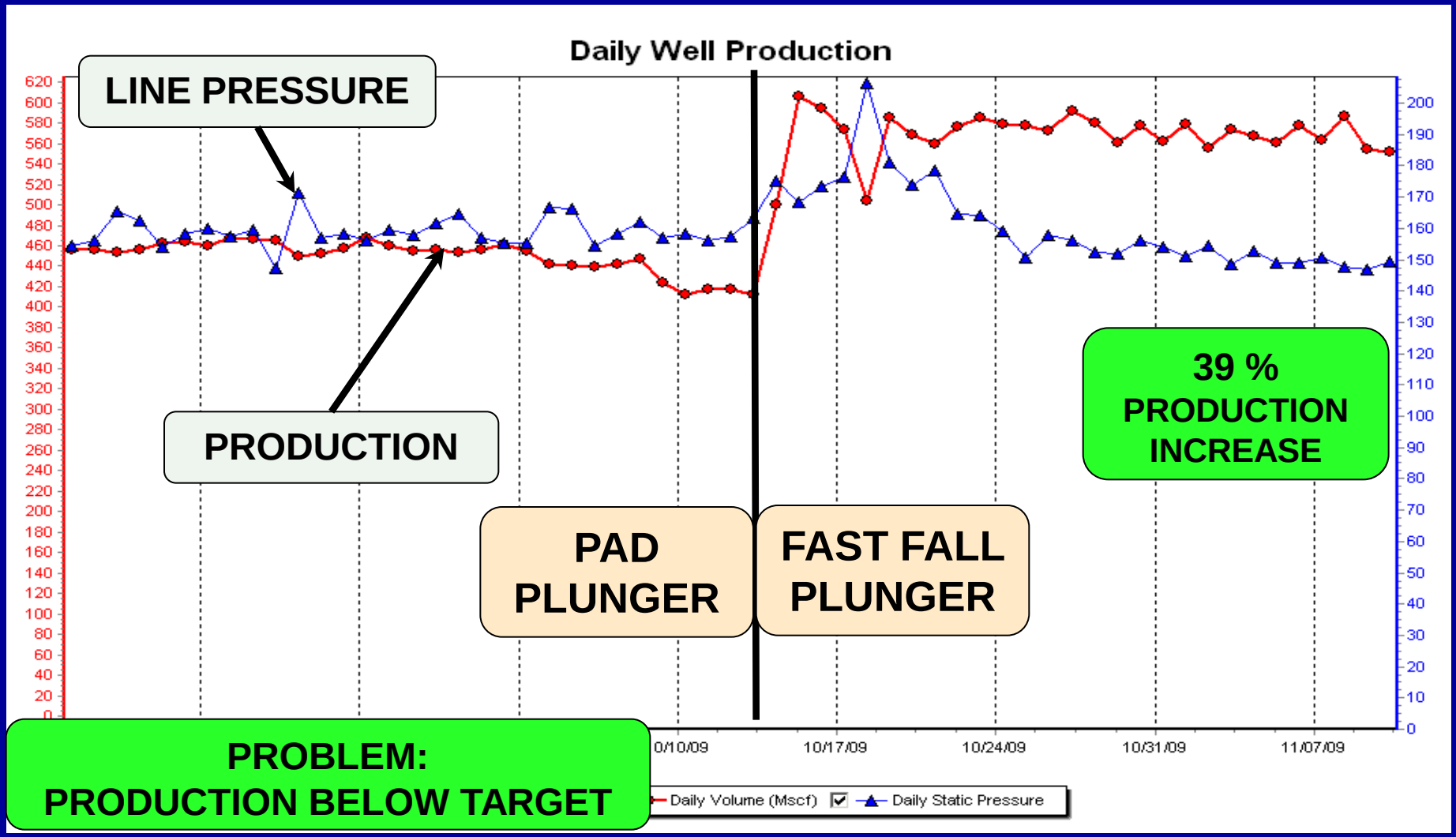
PROBLEM:
PRODUCTION BELOW TARGET

PLUNGER FALL TIME IS 15 MIN.
CLOSE TIME SAME AS FALL TIME.
PLUNGER VELOCITY IS FAST.
INCREASE AFTERFLOW.
MONITOR PRODUCTION.

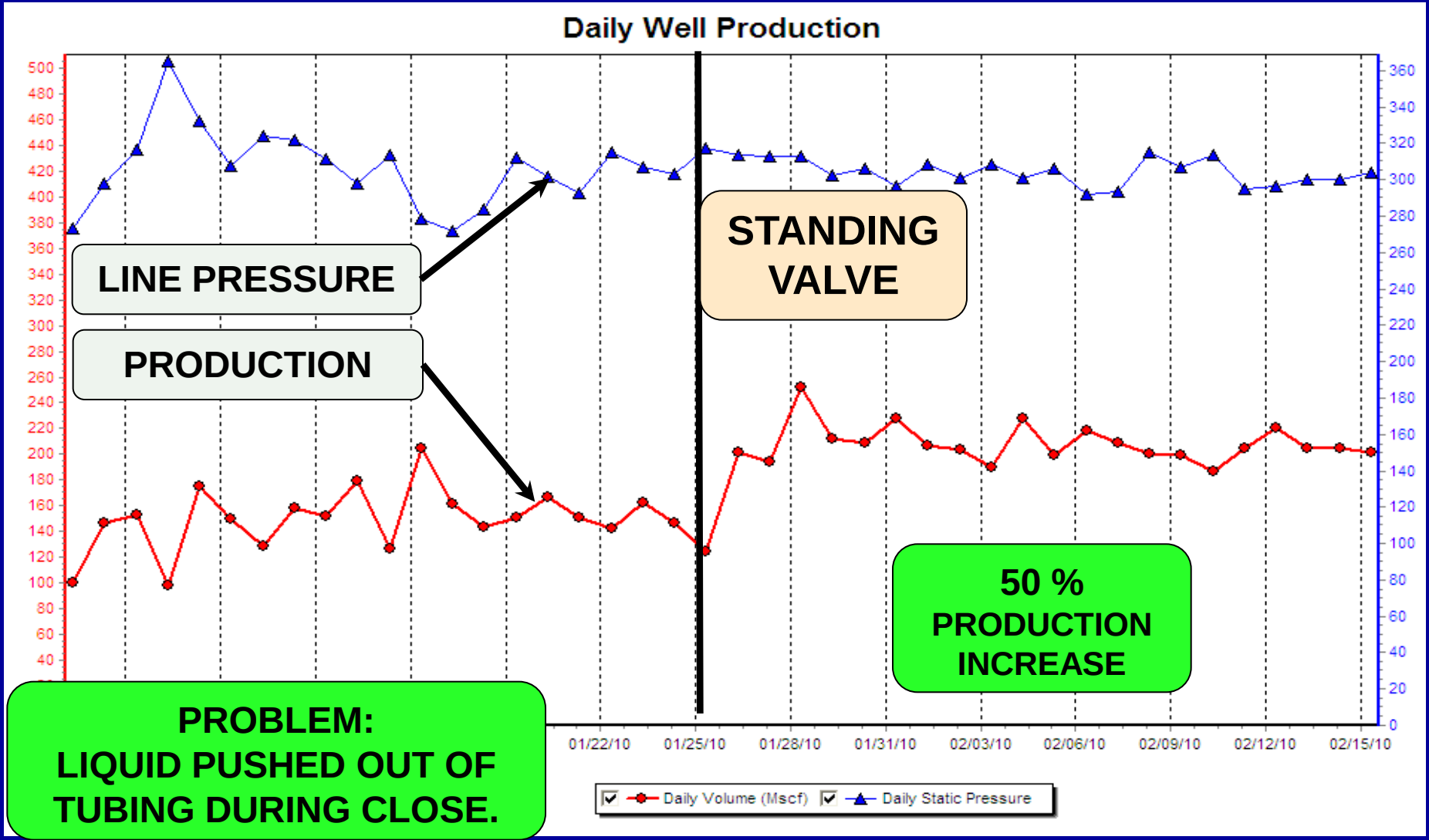
OPTIMIZING SHALE WELLS
Examples



OPTIMIZING SHALE WELLS
Examples



OPTIMIZING SHALE WELLS
Examples



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