



## IRRIGATION TECH SEMINAR SERIES

### **AGENDA:** Water Sources: Wells and Surface Water April 14, 2010

- 8:00 - 8:30 am                      Registration and Coffee
- 8:30 - 8:45 am                      Welcome
- 8:45 - 9:30 am                      Well Construction - Ken Schmidt                      Page 2
- 9:30 - 10:00 am                      Water Quality Treatment - Deborah Miller, Deerpoint Group                      Page 7
- 10:00 - 10:15 am                      Break
- 10:15 - 10:45 am                      Water Source Pump Demo - Bill Green, CIT                      Page 10
- 10:45 - 12:30 pm                      Field Trip to Fresno State Farm

Brought to you by:



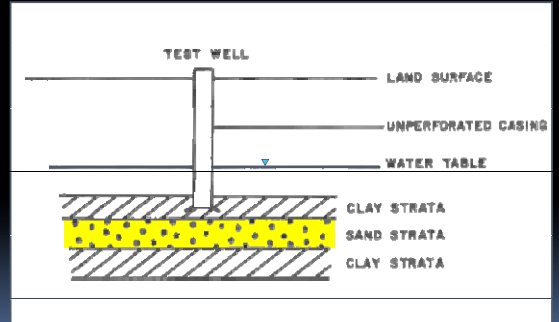
# WELL CONSTRUCTION

## Production Well Design, Construction, and Development

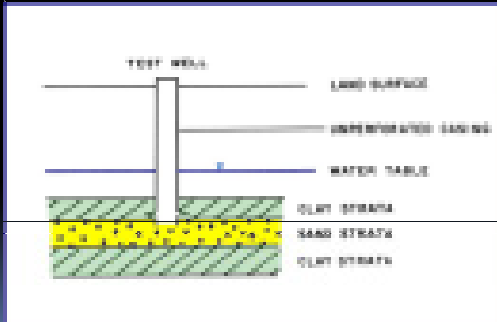
Ken Schmidt, PhD., CHG, PG

Center for Irrigation Technology - April 14, 2010

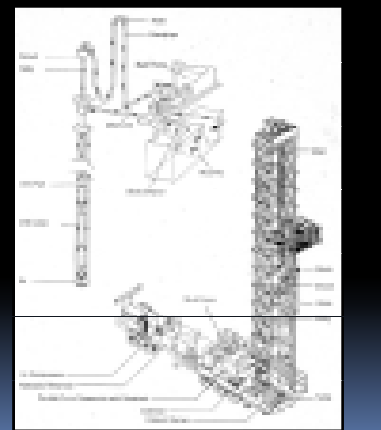
CASING HAMMER TEST WELL  
FIRST STAGE



CASING HAMMER TEST WELL  
SECOND STAGE



Rotary Drilling Rig



Rotary Test Hole  
Drilling Rig



Reverse Rotary Rig and Mud Pit



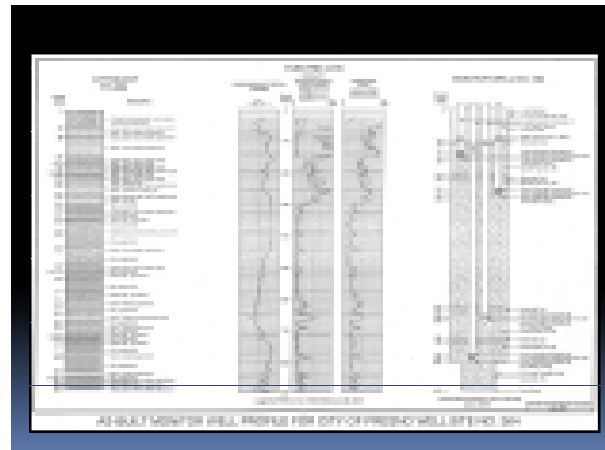
Drill Pipes



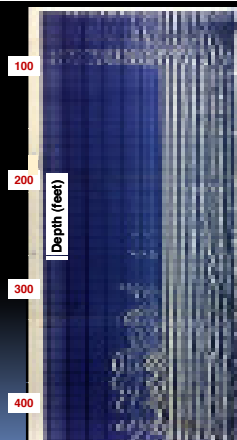
Drill Bit



Drill Cuttings



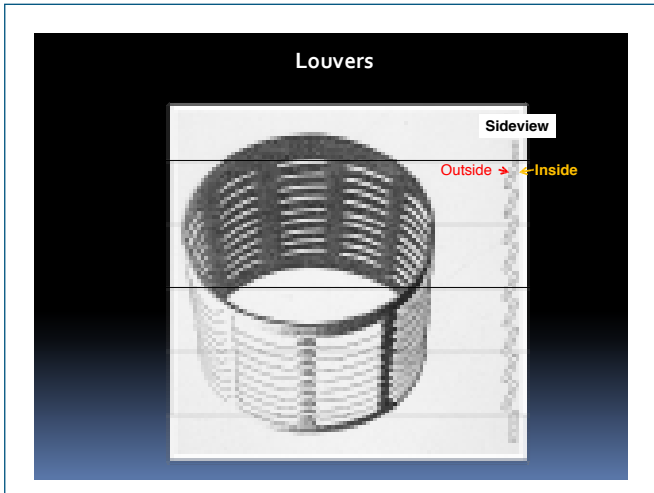
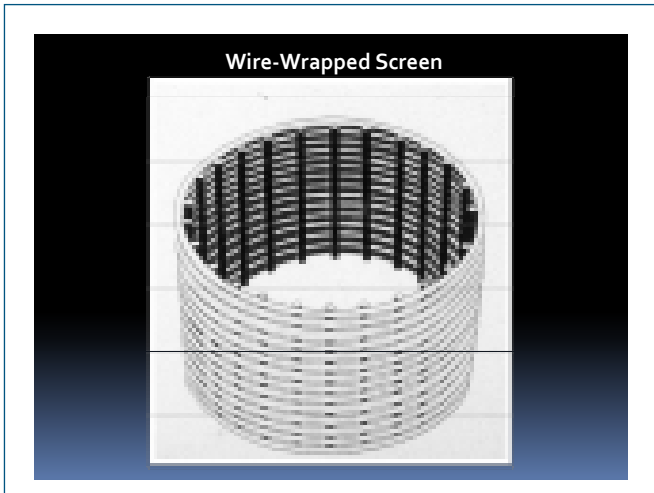
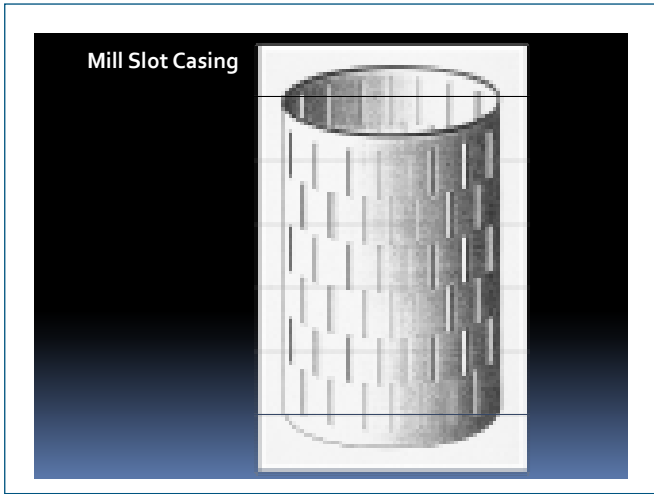
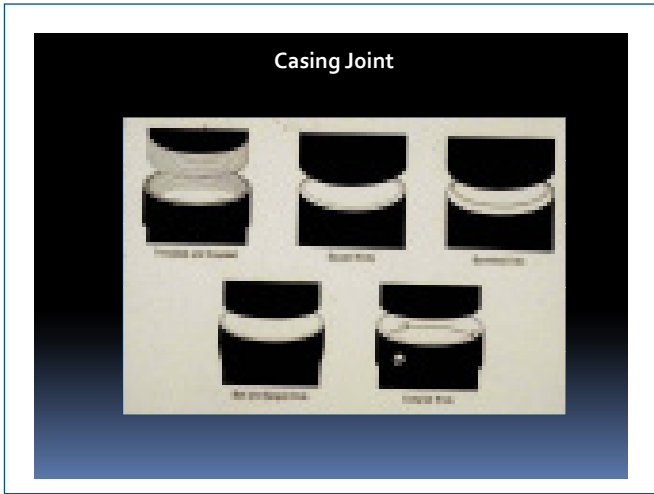
Sonic or Velocity Log



### Types of Casing

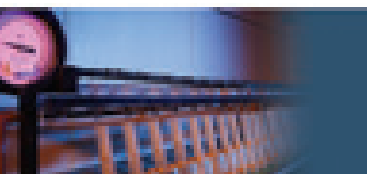
- ❖ Mild Steel
- ❖ Copper-Bearing Steel
- ❖ Cor-ten Steel
- ❖ Stainless Steel
- ❖ Plastic
- ❖ Fiberglass





**Common Casing Diameters for Supply Wells**

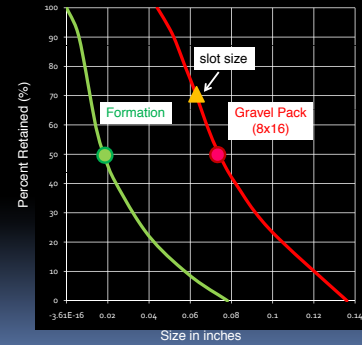
Type of Well	Diameter (inches)
Private Domestic Well	6-8
Irrigation and City Wells	12
	14
	16
	18
	20



### Gravel Pack Design

- Gravel should be uniform (uniformity coefficient = diam.  $d_{60}$  / diam.  $d_{10}$  should be 2-3)
  - less separation during installation, lower head loss, improved specific capacity
- Gravel should be clean and well rounded
  - less development time, less head loss, higher yield, more effective development
- Gravel should contain more than 90% silica
  - no loss of gravel pack volume due to dissolution
- Practical thickness: 3 – 6 inches

### Formation and Gravel Pack Sieve Analysis



Well Gravel (Tacna)



### Water Well Development

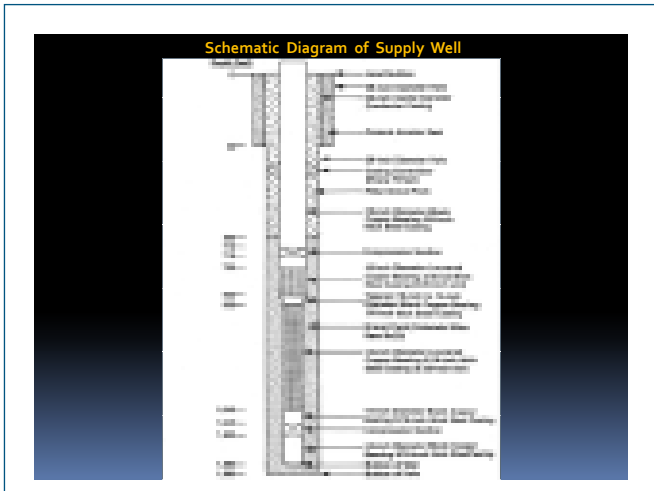
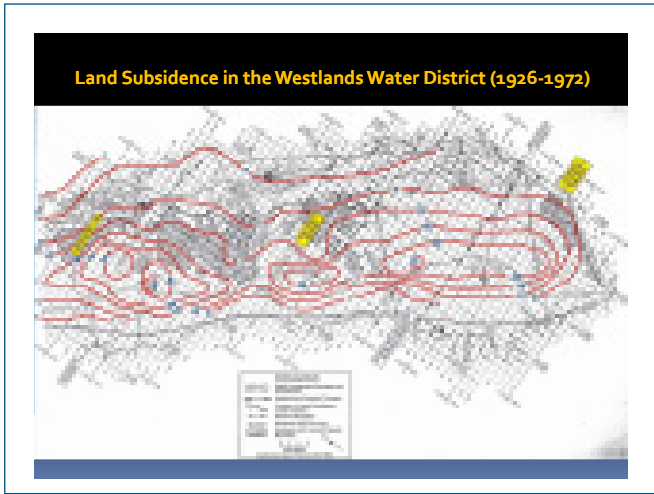
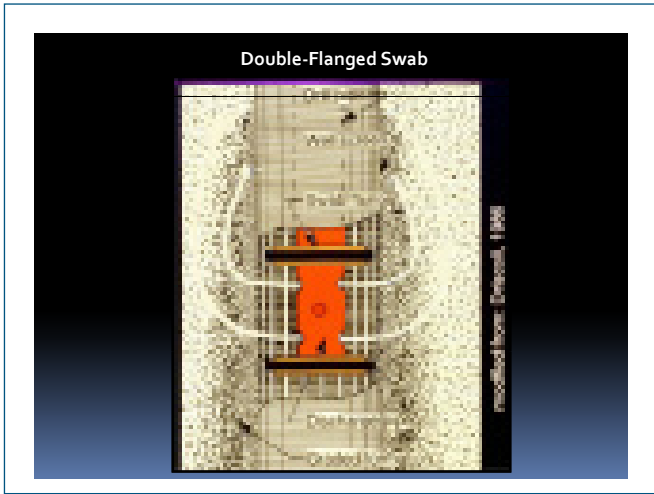
- ❖ Repair damage formation around borehole caused by drilling and construction
- ❖ Remove fines from gravel pack and nearby deposits
- ❖ Avoid turbulent flow in limited areas near perforations
- ❖ Increase specific capacity and well efficiency
- ❖ Prevent sanding
- ❖ Obtain longer well life

### Water Well Development Techniques

- ❖ Bailing and Swabbing
- ❖ Airlifting
- ❖ Airlift Swabbing
- ❖ Pumping and Surging

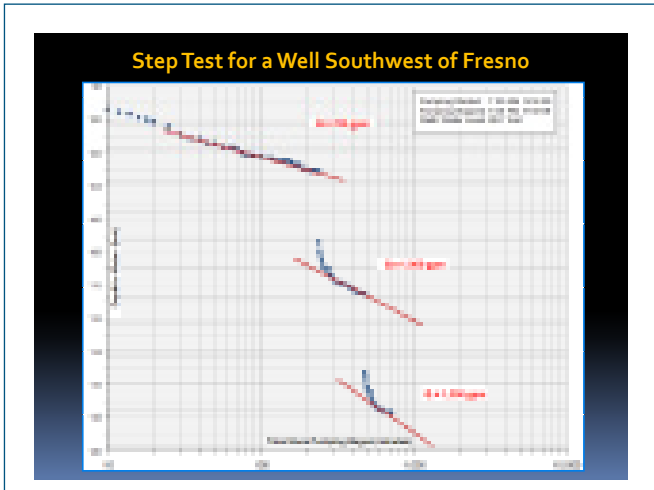
### Schematic Well Development





Schedule of Work Items for Supply Well

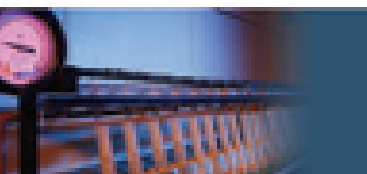
NO.	DATE	DESCRIPTION	STATUS	REMARKS
01	1/15/72	Start to install the well casing	Completed	
02	2/15/72	Install 2" x 20' screen for 10' depth	Completed	
03	3/15/72	Install 2" x 20' screen for 10' depth	Completed	
04	4/15/72	Install 2" x 20' screen for 10' depth	Completed	
05	5/15/72	Install 2" x 20' screen for 10' depth	Completed	
06	6/15/72	Install 2" x 20' screen for 10' depth	Completed	
07	7/15/72	Install 2" x 20' screen for 10' depth	Completed	
08	8/15/72	Install 2" x 20' screen for 10' depth	Completed	
09	9/15/72	Install 2" x 20' screen for 10' depth	Completed	
10	10/15/72	Install 2" x 20' screen for 10' depth	Completed	
11	11/15/72	Install 2" x 20' screen for 10' depth	Completed	
12	12/15/72	Install 2" x 20' screen for 10' depth	Completed	
13	1/15/73	Install 2" x 20' screen for 10' depth	Completed	
14	2/15/73	Install 2" x 20' screen for 10' depth	Completed	
15	3/15/73	Install 2" x 20' screen for 10' depth	Completed	
16	4/15/73	Install 2" x 20' screen for 10' depth	Completed	
17	5/15/73	Install 2" x 20' screen for 10' depth	Completed	
18	6/15/73	Install 2" x 20' screen for 10' depth	Completed	
19	7/15/73	Install 2" x 20' screen for 10' depth	Completed	
20	8/15/73	Install 2" x 20' screen for 10' depth	Completed	
21	9/15/73	Install 2" x 20' screen for 10' depth	Completed	
22	10/15/73	Install 2" x 20' screen for 10' depth	Completed	
23	11/15/73	Install 2" x 20' screen for 10' depth	Completed	
24	12/15/73	Install 2" x 20' screen for 10' depth	Completed	
25	1/15/74	Install 2" x 20' screen for 10' depth	Completed	
26	2/15/74	Install 2" x 20' screen for 10' depth	Completed	
27	3/15/74	Install 2" x 20' screen for 10' depth	Completed	
28	4/15/74	Install 2" x 20' screen for 10' depth	Completed	
29	5/15/74	Install 2" x 20' screen for 10' depth	Completed	
30	6/15/74	Install 2" x 20' screen for 10' depth	Completed	
31	7/15/74	Install 2" x 20' screen for 10' depth	Completed	
32	8/15/74	Install 2" x 20' screen for 10' depth	Completed	
33	9/15/74	Install 2" x 20' screen for 10' depth	Completed	
34	10/15/74	Install 2" x 20' screen for 10' depth	Completed	
35	11/15/74	Install 2" x 20' screen for 10' depth	Completed	
36	12/15/74	Install 2" x 20' screen for 10' depth	Completed	
37	1/15/75	Install 2" x 20' screen for 10' depth	Completed	
38	2/15/75	Install 2" x 20' screen for 10' depth	Completed	
39	3/15/75	Install 2" x 20' screen for 10' depth	Completed	
40	4/15/75	Install 2" x 20' screen for 10' depth	Completed	
41	5/15/75	Install 2" x 20' screen for 10' depth	Completed	
42	6/15/75	Install 2" x 20' screen for 10' depth	Completed	
43	7/15/75	Install 2" x 20' screen for 10' depth	Completed	
44	8/15/75	Install 2" x 20' screen for 10' depth	Completed	
45	9/15/75	Install 2" x 20' screen for 10' depth	Completed	
46	10/15/75	Install 2" x 20' screen for 10' depth	Completed	
47	11/15/75	Install 2" x 20' screen for 10' depth	Completed	
48	12/15/75	Install 2" x 20' screen for 10' depth	Completed	
49	1/15/76	Install 2" x 20' screen for 10' depth	Completed	
50	2/15/76	Install 2" x 20' screen for 10' depth	Completed	
51	3/15/76	Install 2" x 20' screen for 10' depth	Completed	
52	4/15/76	Install 2" x 20' screen for 10' depth	Completed	
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55	7/15/76	Install 2" x 20' screen for 10' depth	Completed	
56	8/15/76	Install 2" x 20' screen for 10' depth	Completed	
57	9/15/76	Install 2" x 20' screen for 10' depth	Completed	
58	10/15/76	Install 2" x 20' screen for 10' depth	Completed	
59	11/15/76	Install 2" x 20' screen for 10' depth	Completed	
60	12/15/76	Install 2" x 20' screen for 10' depth	Completed	
61	1/15/77	Install 2" x 20' screen for 10' depth	Completed	
62	2/15/77	Install 2" x 20' screen for 10' depth	Completed	
63	3/15/77	Install 2" x 20' screen for 10' depth	Completed	
64	4/15/77	Install 2" x 20' screen for 10' depth	Completed	
65	5/15/77	Install 2" x 20' screen for 10' depth	Completed	
66	6/15/77	Install 2" x 20' screen for 10' depth	Completed	
67	7/15/77	Install 2" x 20' screen for 10' depth	Completed	
68	8/15/77	Install 2" x 20' screen for 10' depth	Completed	
69	9/15/77	Install 2" x 20' screen for 10' depth	Completed	
70	10/15/77	Install 2" x 20' screen for 10' depth	Completed	
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72	12/15/77	Install 2" x 20' screen for 10' depth	Completed	
73	1/15/78	Install 2" x 20' screen for 10' depth	Completed	
74	2/15/78	Install 2" x 20' screen for 10' depth	Completed	
75	3/15/78	Install 2" x 20' screen for 10' depth	Completed	
76	4/15/78	Install 2" x 20' screen for 10' depth	Completed	
77	5/15/78	Install 2" x 20' screen for 10' depth	Completed	
78	6/15/78	Install 2" x 20' screen for 10' depth	Completed	
79	7/15/78	Install 2" x 20' screen for 10' depth	Completed	
80	8/15/78	Install 2" x 20' screen for 10' depth	Completed	
81	9/15/78	Install 2" x 20' screen for 10' depth	Completed	
82	10/15/78	Install 2" x 20' screen for 10' depth	Completed	
83	11/15/78	Install 2" x 20' screen for 10' depth	Completed	
84	12/15/78	Install 2" x 20' screen for 10' depth	Completed	
85	1/15/79	Install 2" x 20' screen for 10' depth	Completed	
86	2/15/79	Install 2" x 20' screen for 10' depth	Completed	
87	3/15/79	Install 2" x 20' screen for 10' depth	Completed	
88	4/15/79	Install 2" x 20' screen for 10' depth	Completed	
89	5/15/79	Install 2" x 20' screen for 10' depth	Completed	
90	6/15/79	Install 2" x 20' screen for 10' depth	Completed	
91	7/15/79	Install 2" x 20' screen for 10' depth	Completed	
92	8/15/79	Install 2" x 20' screen for 10' depth	Completed	
93	9/15/79	Install 2" x 20' screen for 10' depth	Completed	
94	10/15/79	Install 2" x 20' screen for 10' depth	Completed	
95	11/15/79	Install 2" x 20' screen for 10' depth	Completed	
96	12/15/79	Install 2" x 20' screen for 10' depth	Completed	
97	1/15/80	Install 2" x 20' screen for 10' depth	Completed	
98	2/15/80	Install 2" x 20' screen for 10' depth	Completed	
99	3/15/80	Install 2" x 20' screen for 10' depth	Completed	
100	4/15/80	Install 2" x 20' screen for 10' depth	Completed	



Well Efficiency

Flow Rate (gpm)	Measured Drawdown (ft)	Calculated Drawdown (ft)	Formation Loss (ft)	Well Drawdown (ft)	Well Efficiency (%)
1,700	2.89	36.0	33.1	11.4	74.0
2,000	3.21	34.0	30.8	10.6	68.0
2,700	4.18	30.0	25.8	10.1	58.0
3,000	4.58	28.0	23.4	9.4	57.0

where  $k = 0.01$   
 $F = 0.00$



# WATER QUALITY TREATMENT

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## Managing Water Quality for Irrigation



Deborah Miller  
Deerpoint Group, Inc.




Slide 1  
DLM1 Deborah Miller, 11/7/2009

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
## Water's Natural Impurities

Water impurities are combinations of these ions.

OH<sup>-</sup> Ca<sup>+2</sup> Mn<sup>+2</sup> HCO<sub>3</sub><sup>-</sup> Si<sup>+4</sup> Mg<sup>+2</sup>  
 Fe<sup>+3</sup> Na<sup>+</sup> SO<sub>4</sub><sup>-2</sup> Cl<sup>-</sup> Fe<sup>+2</sup> O<sup>-2</sup>

**Most Common Combinations**

Calcium	Bicarbonate Sulfate	Ca(HCO <sub>3</sub> ) <sub>2</sub> CaSO <sub>4</sub>
Magnesium	Bicarbonate Sulfate	Mg(HCO <sub>3</sub> ) <sub>2</sub> MgSO <sub>4</sub>
Sodium	Bicarbonate Sulfate Chloride	NaHCO <sub>3</sub> Na <sub>2</sub> SO <sub>4</sub> NaCl
Iron	Bicarbonate Hydroxide Sulfate	Fe(HCO <sub>3</sub> ) <sub>2</sub> Fe(OH) <sub>3</sub> FeSO <sub>4</sub>






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## Simplified Solubility Chart

	Cl <sup>-</sup>	HCO <sub>3</sub> <sup>-</sup>	OH <sup>-</sup>	NO <sub>3</sub> <sup>-</sup>	CO <sub>3</sub> <sup>=</sup>	SO <sub>4</sub> <sup>=</sup>	S <sup>=</sup>	PO <sub>4</sub> <sup>-3</sup>
Na <sup>+</sup>	S	S	S	S	S	S	S	S
K <sup>+</sup>	S	S	S	S	S	S	S	S
NH <sub>4</sub> <sup>+</sup>	S	S	S	S	S	S	S	S
Ca <sup>+2</sup>	S	SS	VSS	S	I	VSS	X	I
Mg <sup>+2</sup>	S	S	I	S	VSS	S	X	I
Fe <sup>+2</sup>	S	SS	VSS	S	VSS	S	I	I
Fe <sup>+3</sup>	S	I	I	S	I	S	X	I
Cu <sup>+2</sup>	S	I	I	S	I	S	I	I
Mn <sup>+2</sup>	S	X	VSS	S	I	S	I	I
Zn <sup>+2</sup>	S	X	VSS	S	I	S	I	I

S Soluble, over 5000 mg/l  
 SS Slightly Soluble, 2000-5000 mg/l  
 VSS Very Slightly Soluble, 20-2000 mg/l  
 I Insoluble, less than 20 mg/l  
 X Not a Compound

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## Common Irrigation Water Quality Issues

- Hardness
- Alkalinity
- pH
- Iron and Manganese
- Bacteria
- Algae
- Fertigation






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## Managing Water Quality Challenge # 1

- **Hard water**  
Defined as the presence of four common divalent cations: Ca, Mg, Fe, Mn.
- **Alkaline water**  
Defined as the presence of carbonates.
- **pH**

*Calcium & Magnesium Carbonate Scale & Deposits*







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### Calcium Carbonate Scale

	Low	Moderate	High
Total Hardness (ppm as CaCO <sub>3</sub> )	<100	100 – 300	>300
Bicarbonate Alkalinity (ppm as CaCO <sub>3</sub> )	<100	100 – 300	>300
pH	< 7.0	0 – 8.0	>8.0

- Even small amounts of hardness & alkalinity greatly increase precipitation of iron and manganese.
- Even small amounts of hardness & alkalinity can react with fertilizers & cause precipitation.

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### Removal of Scale After It Forms

Never the preferred option.

Difficult to achieve complete scale removal.

Usually more expensive than preventative maintenance.




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### Managing Water Quality Challenge #2



High levels of iron & manganese

Sometimes with hydrogen sulfide

Often with bacteria

**"Rusty" Water & Deposits**



**Bacterial Slimes**

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### Iron & Manganese Precipitation

	Low	Moderate	High
Fe (ppm)	< 0.2	0.2 – 1.5	> 1.5
Mn (ppm)	< 0.1	0.1 – 1.0	> 1.0
H <sub>2</sub> S (ppm)	< 0.2	0.2 – 2.0	> 2.0

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### Managing Water Quality Challenge #3

- Bacteria
- Nuisance Organisms
- Pathogenic Bacteria – excluded from today's discussion

**"Rusty" Water & Deposits**

**Bacterial Slimes**




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### Managing Water Quality Challenge #4

### Algae

Poor Filter Performance

Plugged Emitters




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### Managing Water Quality Challenge #5

- How to add soil amendments and fertilizers to the irrigation water without creating additional precipitation ?

*Amendments & Fertilizers*

*Reacting with Water*



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### Solutions for Water & Amendment/Fertilizer Incompatibilities

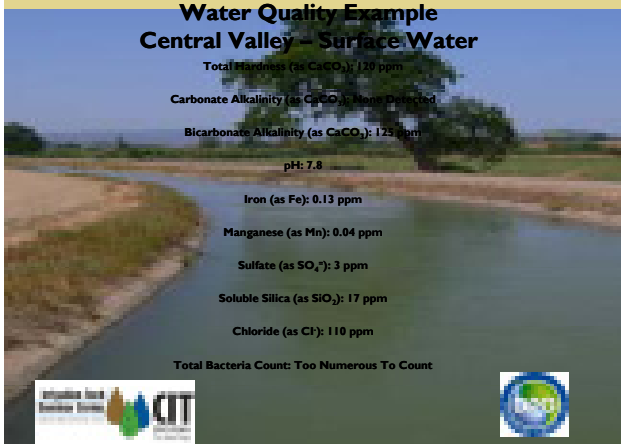
- Always run a jar test for compatibility.
- Pay special attention to compounds which are classified as "I" or "VSS" on the Simplified Solubility Chart.



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### Water Quality Example Central Valley – Surface Water

Total Hardness (as CaCO<sub>3</sub>): 120 ppm  
 Carbonate Alkalinity (as CaCO<sub>3</sub>): None Detected  
 Bicarbonate Alkalinity (as CaCO<sub>3</sub>): 120 ppm  
 pH: 7.8  
 Iron (as Fe): 0.13 ppm  
 Manganese (as Mn): 0.04 ppm  
 Sulfate (as SO<sub>4</sub><sup>-2</sup>): 3 ppm  
 Soluble Silica (as SiO<sub>2</sub>): 17 ppm  
 Chloride (as Cl<sup>-</sup>): 110 ppm  
 Total Bacteria Count: Too Numerous To Count



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### Water Quality Example Central Valley – Well Water

Total Hardness (as CaCO<sub>3</sub>): 1360 ppm  
 Carbonate Alkalinity (as CaCO<sub>3</sub>): None Detected  
 Bicarbonate Alkalinity (as CaCO<sub>3</sub>): 150 ppm  
 pH: 7.7  
 Iron (as Fe): 0.22 ppm  
 Manganese (as Mn): 0.13 ppm  
 Sulfate (as SO<sub>4</sub><sup>-2</sup>): 1379 ppm  
 Soluble Silica (as SiO<sub>2</sub>): 21 ppm  
 Chloride (as Cl<sup>-</sup>): 200 ppm  
 Total Bacteria Count: 160 colonies/ml




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Thank you.



# WATER SOURCE PUMP DEMO




**Pacific Gas and Electric Company**

Presents...

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The Agricultural Pumping Efficiency Program (APEP)

Helping California...




Center for Irrigation Technology

## APEP Funding and Organization...

- Funding through PG&E using the Public Purpose Program Charge under auspices of California Public Utilities Commission
- PG&E is Program Manager and has ultimate responsibility
- Center for Irrigation Technology- CIT (a part of CSUFresno) for design and field implementation
- CSU, Fresno Foundation is the sub-contracting entity on behalf of CIT

2




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## APEP Goals and Objectives...

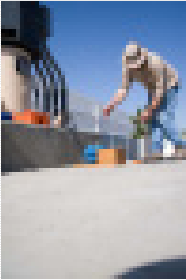
- Overall Goal is ENERGY conservation- **20% of the energy consumed in California is used to move water.**
- Objectives are:
  1. Get efficient pumping systems (hardware) in the field
  2. Make sure that all systems are managed correctly (maintain pumping efficiency and minimize WATER use)

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## APEP offers...



1. Subsidized pump efficiency tests- always start with getting a pump test
  - 25 to 75 HP- \$150
  - 75+ HP- \$200
2. Incentives for pump retrofit/ repair- any HP
3. Technical Assistance
4. Education

4




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## APEP eligibility...

1. Eligible pumps...
  - Agricultural pumps
  - Municipal pumps
  - Large Turf, Golf Courses, Parks, Recreational
  - Tertiary treated waste water
2. Ineligible pumps- Primary and Secondary treated waste water, industrial, change in condition


5




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## 1. Know how to specify an efficient pump...

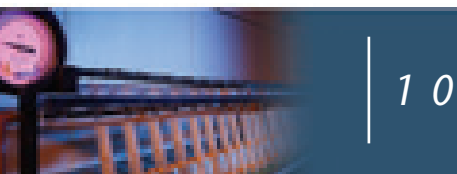
- Not trying to make you into an engineer...



6



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### OPE is a Combination of Efficiencies...



- ❑ 1. Bowl Efficiency (the pump itself) is only one aspect of Overall Pumping Plant Efficiency- OPE
- ❑ Must also consider:
  - 2. Transmission efficiency and losses (shafts, bearings, pulleys, etc.)
  - 3. Driver efficiency or the efficiency of the power source (motor, engine, etc.)

7

### The "Operating Condition" of a pump...

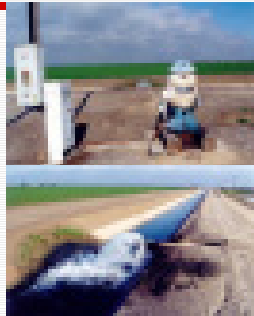
- ❑ The combination of flow and pressure is termed the "Operating Condition".
- ❑ Every pump has a combination of flow and pressure (lift or TDH) as it operates...



8

### What is Flow?

- ❑ Flow is the volume of water pumped measured in Gallons per Minute or GPM
- ❑ Flow can also be measured in cubic feet/second or CFS



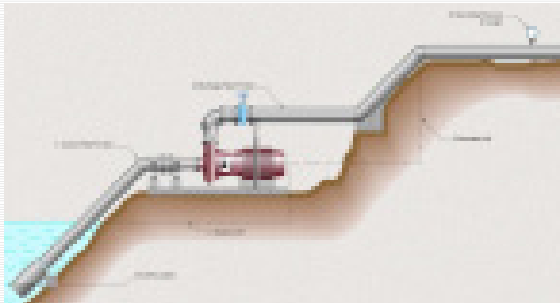
9

### Main components of TDH

- ❑ The main components for calculating Total Dynamic Head are;
  - The lift in feet from the water source
  - The pressure required to properly operate the irrigation system
  - Accounting for friction losses (pressure losses) because of pipes, turns, valves, etc.

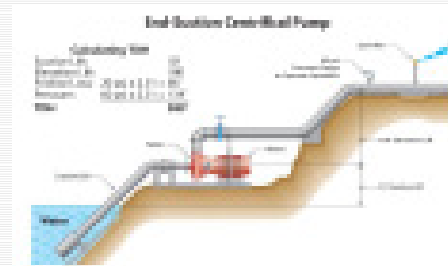
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### Diagram showing TDH components



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TDH example- Total Lift from the water source level (PWL) to the field level + the pressure to operate the irrigation system

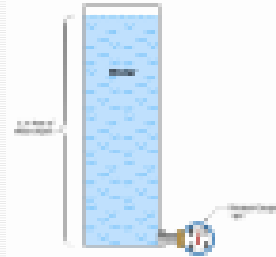


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## The constant to convert psi to feet of head

- Every 2.31 feet of water depth equals 1 psi. If you dive into a swimming pool you notice the pressure on your ears increases the deeper you go. Every 2.31 feet deeper you dive increases the pressure by 1 psi



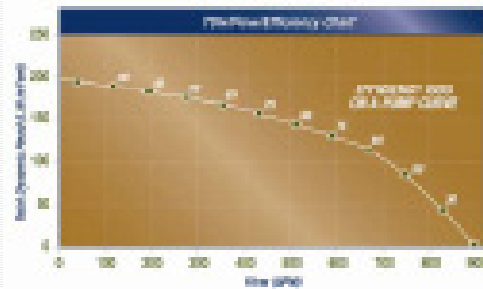
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## The "Pump Performance Curve"...

- A pump can operate over a range of operating conditions.
- Pump manufacturers know this and produce "Pump Performance Curves" for each pump.
- Performance curves show the different combinations of flow and pressure (TDH) that a particular pump will develop.

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## Efficiency Isos Superimposed on the curve...



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Example Results from a Well Rehabilitation Project in Selma, 20 hp pump

	12/5/2003	4/17/2004
Date of Test	12/5/2003	4/17/2004
Standing Level	55	59
Pumping Level	102	90
Flow Rate	303	630
Specific Yield	6.5	20.3
kWhrs per ac-ft	300	152
OPE	35%	61%
Cost per ac-ft	\$45.07	\$22.86
Cost of Project	\$2702	

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## Energy Cost Bottom Line Equation...

The "bottom line equation":

$$\text{\$ per year} = \text{\$ per kWh} \times \text{kWh/AF} \times \text{AF/yr}$$

**\\$ per kWh :** Utility rate and operation

**kWh/AF:** TDH and OPE

**AF/yr:** Management factor,  
combined with irrigation  
system uniformity

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## What is the role of the water well?

- Regarding pump efficiency:
  - Fluctuating pumping water levels affect the OPE and change the kWh per acre-ft
- Regarding energy conservation:
  - The closer to the surface the pumping water level, the lower the potential cost per acre-foot of water

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### How does well rehabilitation figure in?

$$\text{kWh/AF} = 1.024 \times \text{TDH} / \text{OPE}$$

- ❑ Reduce “TDH” (system pressure lowered; or, pumping lift decreased)
- ❑ Improve OPE (hardware, as discussed in earlier sessions)



### Conclusion:

- ❑ Decreasing a well’s drawdown can save energy, increase flow rate, increase system pressure.
- ❑ APEP can therefore provide an incentive grant (purchase energy) from a project that improves well capacity and pump efficiency.



### Guidelines for evaluating the well:

Check out these tips!

- 1) Comparison to other wells in the area
- 2) Historical data of the well/pump (testing)
- 3) Video camera inspection of well screen or perforations



### WET Lab Pump Display Demo

- ❑ 50 HP Vertical Turbine demo
- ❑ Same info on projected on screen that a pump test gives you
  - Flow
  - TDH
  - Energy in measured off meter
  - Resulting OPE

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### APEP 2009- 2011

- ❑ The Agricultural Pumping Efficiency Program has been extended through 2011 as a PG&E Customer Energy Efficiency offering, funded through the Public Purpose Programs Charge under the auspices of the California Public Utilities Commission. Information pertaining to APEP contained in the pamphlets and brochures may be outdated. Please call APEP at **1.800.845.6038** or log on to [www.pumpefficiency.org](http://www.pumpefficiency.org) for current information regarding eligibility, educational seminars, pump tests and incentives for pump retrofits. Eligibility now extends to agricultural, large turf, and municipal (including tertiary-treated water) water pumping customers with PG&E electric or natural gas accounts. Residential, commercial, industrial process, primary sewage and secondary sewage pumps are ineligible.



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### Disclaimers as per CPUC...

- ❑ California consumers are not obligated to purchase any full fee service or other service not funded by this program. This program is funded by California utility ratepayers under the auspices of the California Public Utilities Commission.
- ❑ Los consumidores en California no estan obligados a comprar servicios completos o adicionales que no esten cubiertos bajo este programa. Este programa esta financiado por los usuarios de servicios públicos en California bajo la jurisdiccion de la Comisión de Servicios Públicos de California.

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