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Four Points by Sheraton Denver Southeast



HOMEBREWING *with* **ALTITUDE**

NHC – Denver 2007

Beer Color and Residual Alkalinity: A Practical Example



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Thank You!

- All malts provided by Briess Malting and Ingredients Co.
- Yeast provided by White Labs Inc.
- Hops provided by Morebeer.com

- All the work provided by Rick Bobbitt and Scott Jackson of KROC!



Why Water Matters

- The water and the malts drive the mash chemistry and the enzyme activity.
- Adding Brewing Salts Always Affects Flavor and pH.
- Calcium, Magnesium, and Carbonate affect pH.
- Sulfates accentuate hop bitterness, making it more crisp.
- Sodium and Chloride accentuate the malt flavors.



Review of pH

- The target mash pH range for **EVERY** beer, *regardless of style*, is: 5.4-5.8 @ room temperature.
- pH papers are made to be used on room temperature samples.
- pH meters with ATC adjust the measured pH of the sample *to the calibration temperature*.
- Calibration solutions are most accurate *at room temperature*.

What does water pH mean?

- pH can be interpreted as the ratio of negative ions to positive ions.

NOT MUCH

QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

- The water may seem Hard, but it's usually Alkaline.



What is Hard Water?

- Hard water contains high amounts of Calcium and Magnesium. (et. al.)
- Hard water pH can range from 5-10.
 - Acidic (<7) or Alkaline (>7)
 - pH depends on the balance of hardness to alkalinity.
- Hard water is **GOOD** for brewing because calcium is an *important co-factor* for many brewing bio-chemical reactions.



What is Soft Water?

- Soft water does not contain high levels of calcium, magnesium, or other cations.
- Soft water pH can range from 7-10.
- Soft water can be alkaline, but alkaline water is not necessarily soft.



What does Water Softening Do?

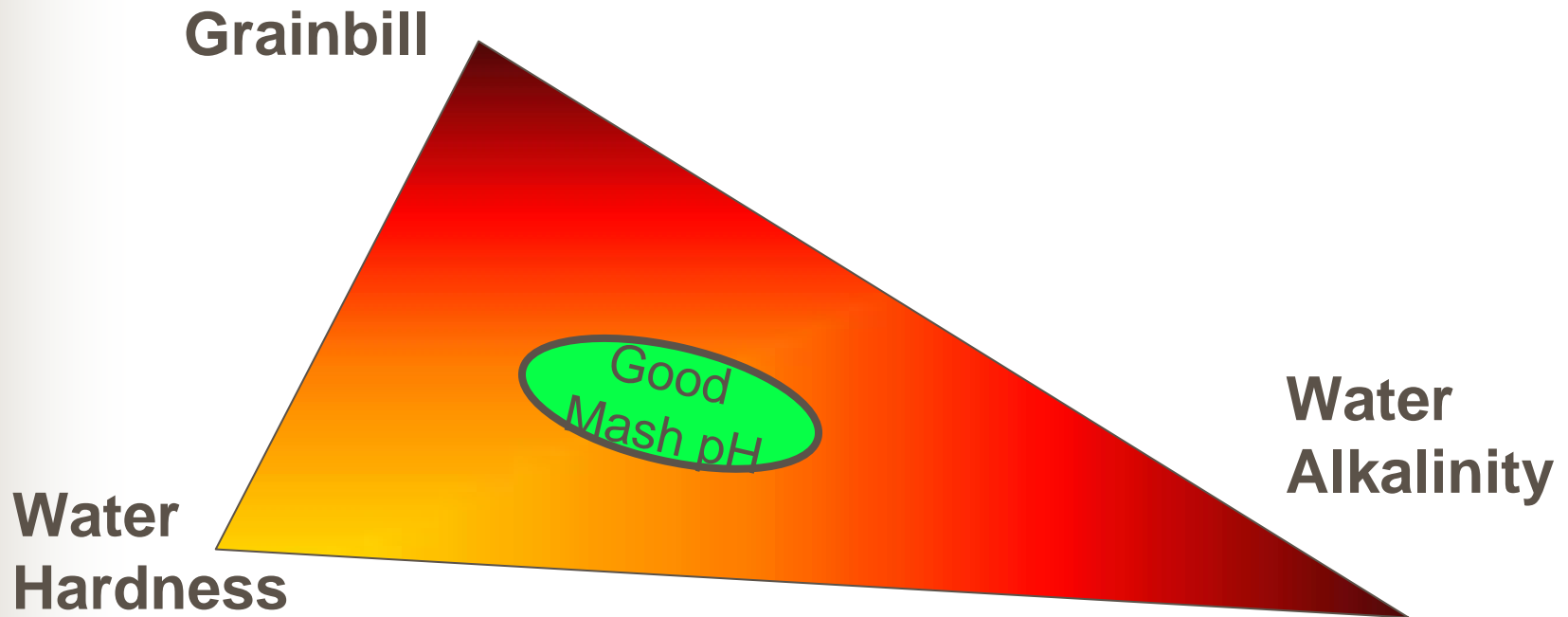
- Salt-based Water Softeners exchange sodium ions for calcium, magnesium, iron, etc.
 - *Throwing the baby out with the bath water.*
- Water Softeners do not affect the alkalinity.
 - **The result is *extra-alkaline* water.**

Residual Alkalinity



- Mash (and beer) pH is the net effect of the Hardness, Alkalinity, and the Grainbill.
 - **RA = alkalinity - (Ca/3.5 + Mg/7)**
 - Units are mEq/L
 - **High RA** means you should brew dark beers
 - **Low RA** means you should brew **light beers**

Balancing a Triangle



- Hardness, Alkalinity, and Grainbill acidity balance to determine your mash pH.



RA and Classic Brewing Waters

- Most water reports contain the individual annual averages for a particular mineral.
- As listed, all the minerals do not add up to a “real” water. A real water should have all the ion charges sum to zero.
- Check the RA for the Classic Waters, does it make sense?

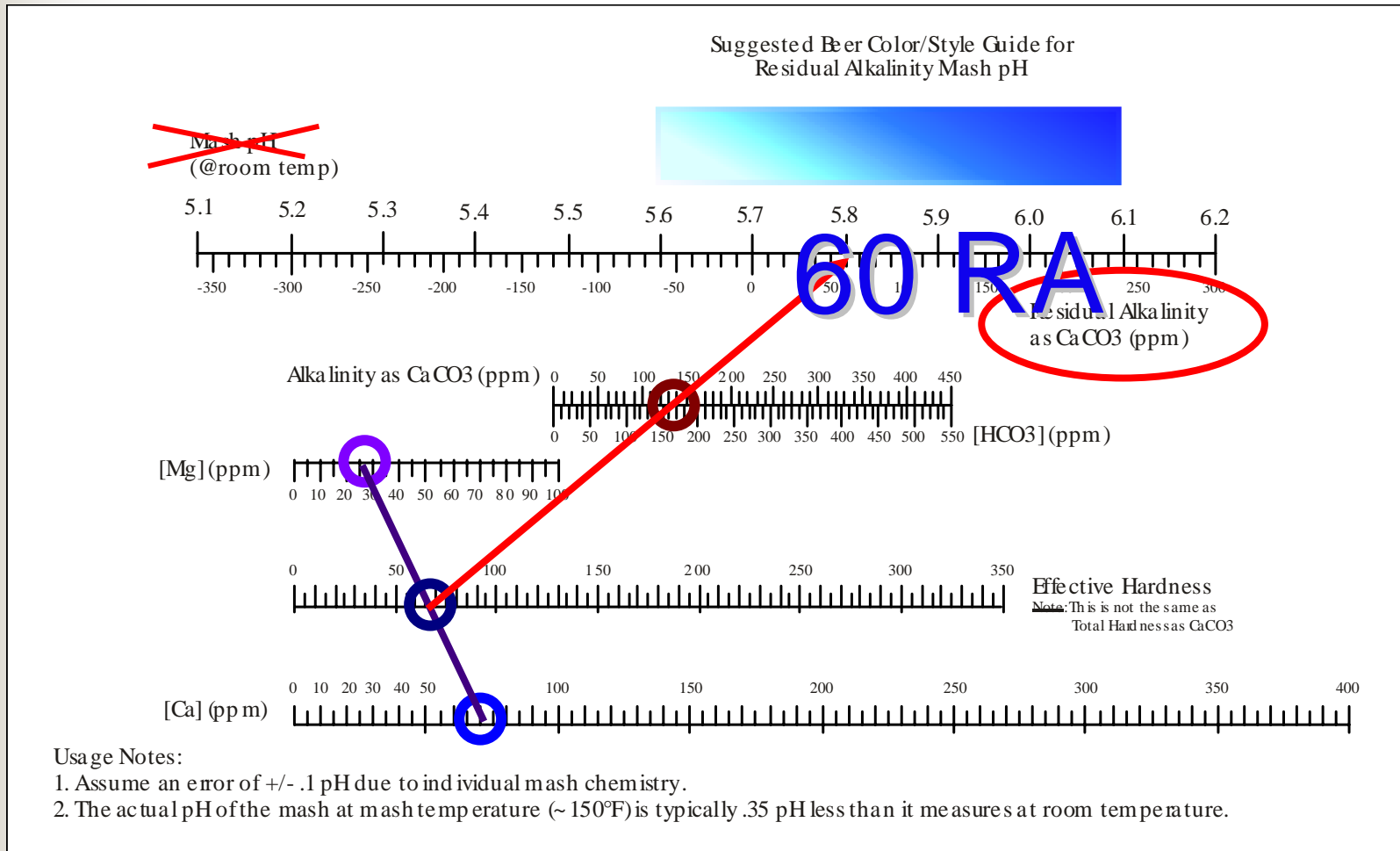
Famous Brewing Waters

Water Profiles From Notable Brewing Cities

| City | Calcium (Ca ⁺²) | Magnesium (Mg ⁺²) | Bicarbonate (HCO ₃ ⁻) | Beer Style | RA (ppm as CaCO ₃) | Color Range (°SR) |
|-----------|--------------------------------|----------------------------------|---|------------------|-----------------------------------|----------------------|
| Pilsen | 10 | 3 | 3 | Pilsener | -6 | 5-10 |
| Dortmund | 225 | 40 | 220 | Export Lager | -3 | 5-10 |
| Vienna | 163 | 68 | 243 | Vienna Lager | 50 | 8-14 |
| Munich | 109 | 21 | 171 | Oktoberfest | 50 | 9-14 |
| London | 52 | 32 | 104 | British Pale Ale | 30 | 8-12 |
| Edinburgh | 100 | 18 | 100 | Scottish Ale | 50 | 9-14 |
| Burton | 352 | 24 | 320 | India Pale Ale | -3 | 5-10 |
| Dublin | 118 | 4 | 319 | Dry Stout | 175 | 20-24 |

Numbers are given in parts per million (ppm).
These numbers are ANNUAL AVERAGES

Residual Alkalinity Nomograph



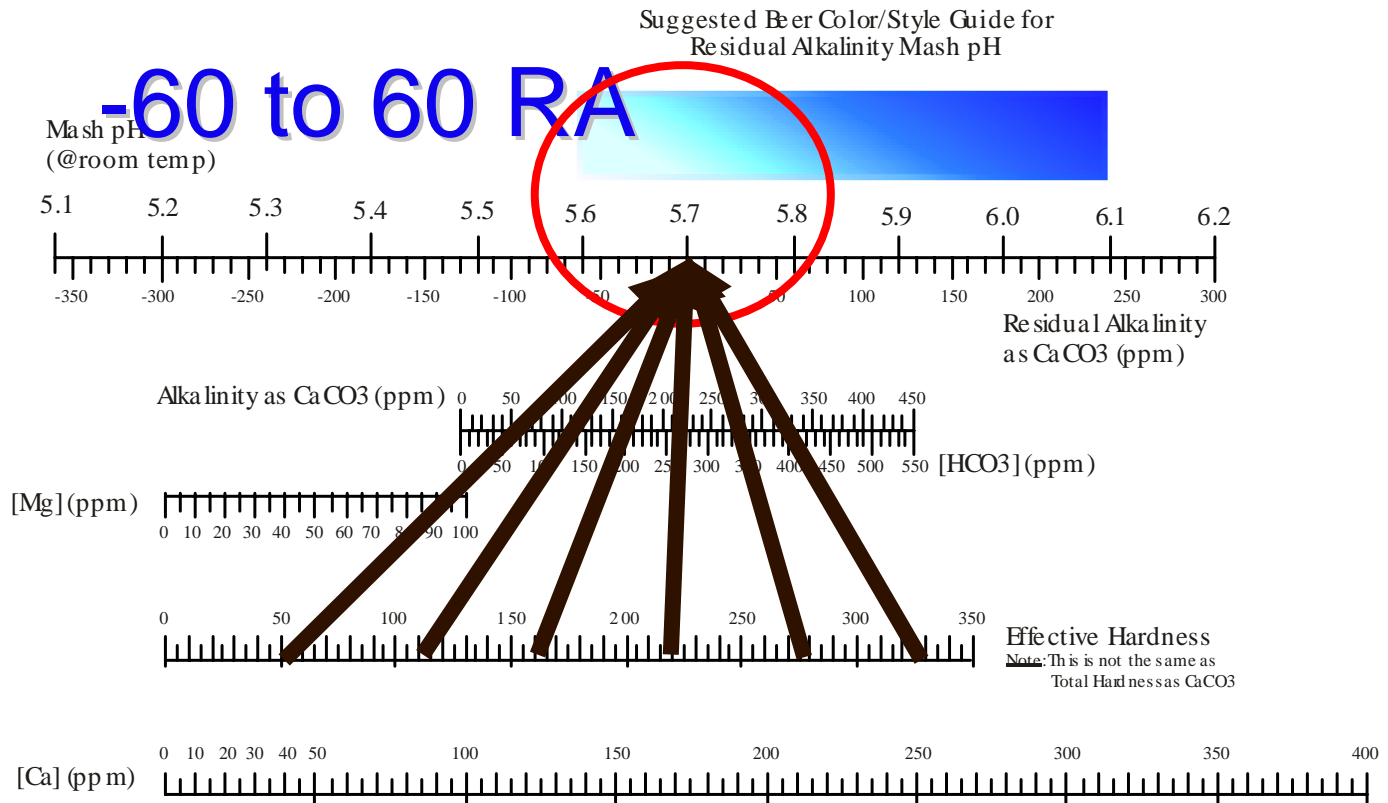
Effective Hardness is the (Ca/3.5 + Mg/7) quantity.



What does the Nomograph Do?

- Calculates the **Residual Alkalinity** of your water based on your water report.
- It *estimates* the pH of a BASE-MALT-ONLY! mash (i.e., 100% 2 Row).
- It *suggests* a Color Range for Beers that you can brew with *your water* and *your residual alkalinity* to achieve the proper mash pH range i.e., 5.4-5.8 pH.

Brewing a Pale Beer...

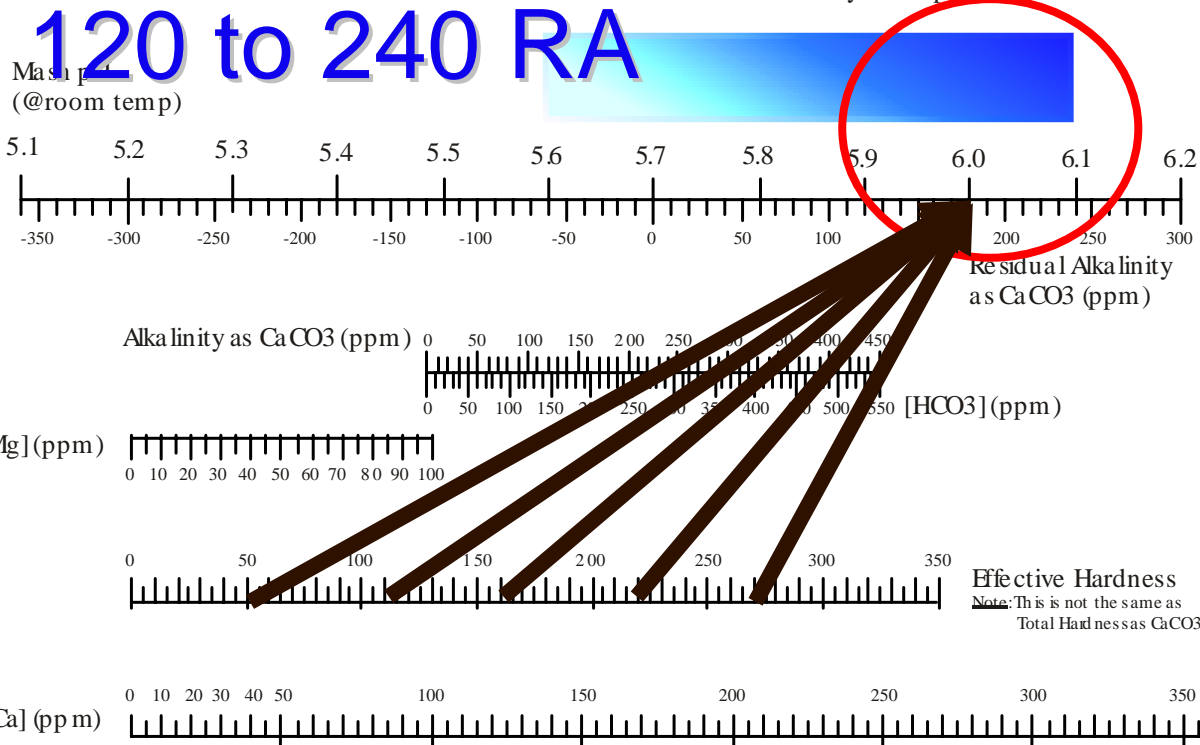


Usage Notes:

1. Assume an error of +/- .1 pH due to individual mash chemistry.
2. The actual pH of the mash at mash temperature (~150°F) is typically .35 pH less than it measures at room temperature.

Brewing a Dark Beer...

Suggested Beer Color/Style Guide for
Residual Alkalinity Mash pH



Usage Notes:

1. Assume an error of +/- .1 pH due to individual mash chemistry.
2. The actual pH of the mash at mash temperature (~150°F) is typically .35 pH less than it measures at room temperature.

Pale Mash RA worksheet

| Source Water | Calcium (ppm) | Magnesium (ppm) | Bicarbonate (ppm) | Sodium (ppm) | Chloride (ppm) | Sulfate (ppm) | Water pH |
|---------------------|---------------|-----------------|-------------------|--------------|----------------|---------------|----------|
| (ppm) | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| Target Water | | | | | | | |

| Effective Hardness | Residual Alkalinity as CaCO3 | Est. SRM (Low) | Est. SRM (Hi) |
|--------------------|------------------------------|----------------|---------------|
| 0.0 | 0.0 | 5 | 10 |
| 0.0 | 0.0 | 5 | 10 |

| Target Residual Alkalinity | Mash Water Volume (gal) | Additional Eff. Hardness Needed | Additional Alkalinity Needed | Target RA Est. SRM (Low) | Target RA Est. SRM (Hi) |
|----------------------------|-------------------------|---------------------------------|------------------------------|--------------------------|-------------------------|
| -128.0 | 5 | 128.0 | 0.0 | 0 | 0 |

| Target Color (SRM) | Est. RA (low) | Est. RA (Hi) |
|--------------------|---------------|--------------|
| 6 | -49 | 10 |

| Acid Adjustment | Bottle Conc. | Est. Acid-Only Mash Addition (ml) | Mash Water Addition (ml) |
|-----------------|--------------|-----------------------------------|--------------------------|
| Hydrochloric | 37% | 4.0 | |
| Phosphoric | 10% | | |
| Lactic | 88% | 4.1 | |

5 grams Gypsum
 5 grams Calcium Chloride
 5 grams Epsom Salts
 2 grams Baking Soda

| Salt Additions | Chalk CaCO3 | Gypsum CaSO4 *2H2O | Calcium Chloride CaCl2*2H2O | Epsom Salt MgSO4 *7H2O | Baking Soda NaHCO3 |
|-------------------|-------------|--------------------|-----------------------------|------------------------|--------------------|
| Amt Added (grams) | | 5 | 5 | 5 | 2 |

| Contributed Hardness | Contributed Alkalinity |
|----------------------|------------------------|
| 108.8 | 62.9 |

| Salt Contributions (ppm) | Calcium (ppm) | Magnesium (ppm) | HCO3 (ppm) | Sodium (ppm) | Chloride (ppm) | Sulfate (ppm) |
|--------------------------|---------------|-----------------|------------|--------------|----------------|---------------|
| | 132.0 | 24.6 | 76.8 | 28.9 | 127.5 | 250.4 |

| Effective Hardness | Residual Alkalinity as CaCO3 | Est. SRM (Low) | Est. SRM (Hi) |
|--------------------|------------------------------|----------------|---------------|
| 108.8 | -45.8 | 1 | 6 |

| Adjusted Mash (ppm) | Calcium (ppm) | Magnesium (ppm) | Alkalinity as CaCO3 | Sodium (ppm) | Chloride (ppm) | Sulfate (ppm) |
|---------------------|---------------|-----------------|---------------------|--------------|----------------|---------------|
| | 132.0 | 24.6 | 62.9 | 28.9 | 127.5 | 250.4 |

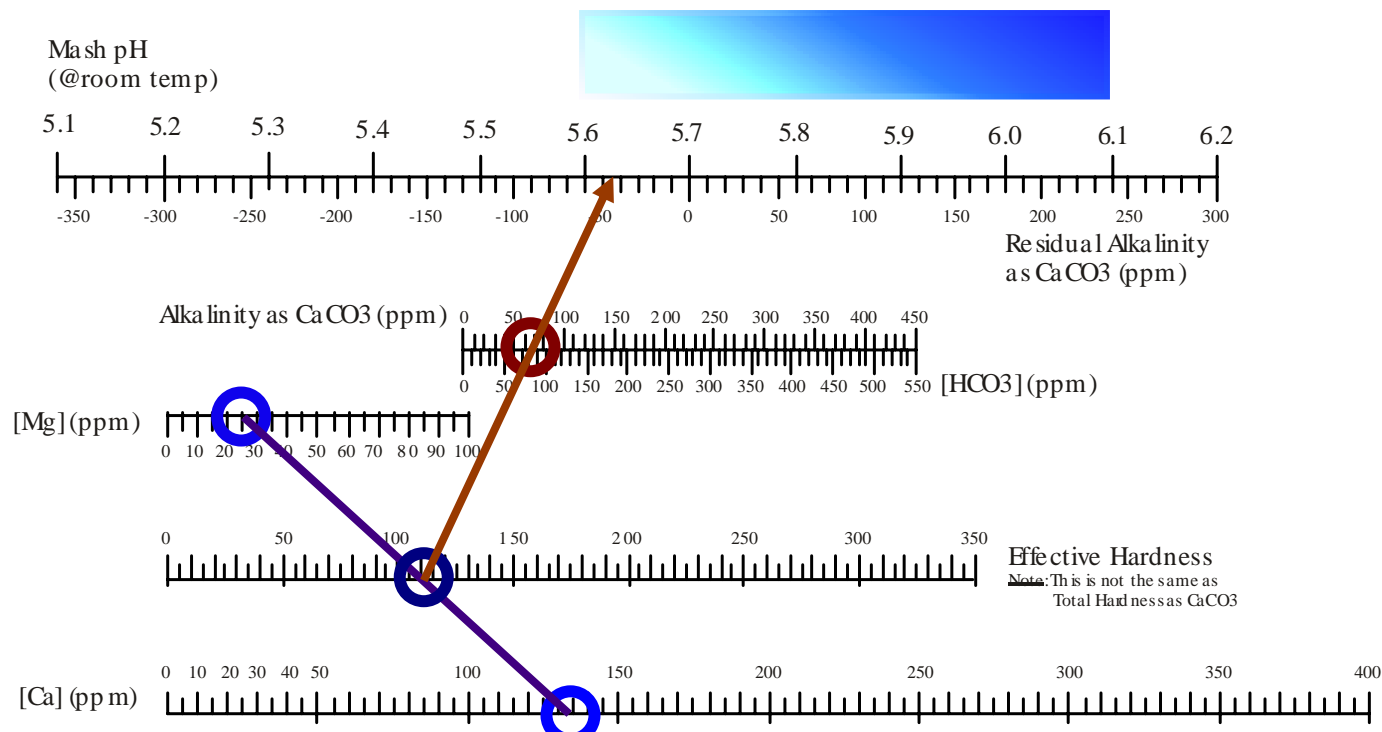


Palmer Precipitous Pale Recipe

- 7 lbs. 2 Row Malt
- 2.5 lbs. Vienna
- 1 lbs. Briess Carapils
- 0.5 lbs. Caramel 40
- .75 oz. Horizon @ 60
- 0.5 oz Amarillo @ 30
- 0.5 oz Willamette @ 15
- OG 1.050
- 41 IBUs
- Color 6 SRM (*Morey*)
- White Labs WLP 001
 - California Ale

Pale Ale Water Example

Suggested Beer Color/Style Guide for Residual Alkalinity Mash pH



Usage Notes:

1. Assume an error of +/- .1 pH due to individual mash chemistry.
2. The actual pH of the mash at mash temperature (~150°F) is typically .35 pH less than it measures at room temperature.

Palmer's Sweet 4N Stout Recipe

- 7 lbs Briess 2 Row
- 1 lbs. Roast Barley
- 1 lbs. Briess Carapils
- 0.5 lbs. Caramel 40
- 0.5 lbs. Caramel 80
- 0.5 lbs. Special Roast
- 0.5 lbs. Dark Choc. malt
- 0.5 lbs. Black Malt
- 1.5 oz Challenger @ 60
- 0.5 oz Willamette @ 15
- OG 1.050
- 36 IBUs
- Color 45 SRM (*Morey*)
- White Labs WLP 001
 - California Ale

Stout Mash RA worksheet

| Source Water (ppm) | Calcium (ppm) | Magnesium (ppm) | Bicarbonate (ppm) | Sodium (ppm) | Chloride (ppm) | Sulfate (ppm) | Water pH |
|-----------------------|------------------|--------------------|----------------------|--------------|-------------------|---------------|----------|
| | | | | | | | |
| Target Water | | | | | | | |

| Effective Hardness | Residual Alkalinity as CaCO ₃ | Est. SRM (Low) | Est. SRM (Hi) |
|--------------------|--|----------------|---------------|
| 0.0 | 0.0 | 5 | 10 |
| 0.0 | 0.0 | 5 | 10 |

| Target Residual Alkalinity | Mash Water Volume (gal) | Additional Eff. Hardness Needed | Additional Alkalinity Needed | Target RA Est. SRM (Low) | Target RA Est. SRM (Hi) |
|----------------------------|-------------------------|---------------------------------|------------------------------|--------------------------|-------------------------|
| 200.0 | 5 | 0.0 | 200.0 | 22 | 26 |

| Target Color (SRM) | Est. RA (low) | Est. RA (Hi) |
|--------------------|---------------|--------------|
| 45 | 427 | 486 |

| Acid Adjustment | Bottle Conc. | Est. Acid-Only Mash Addition (ml) | Mash Water Addition (ml) |
|-----------------|--------------|-----------------------------------|--------------------------|
| Hydrochloric | 37% | 0.0 | |
| Phosphoric | 10% | | |
| Lactic | 88% | 0.0 | 0 |

5 grams Calcium Carbonate
 5 grams Epsom Salt
 5 grams Baking Soda

| Salt Additions | Chalk CaCO ₃ | Gypsum CaSO ₄ *2H ₂ O | Calcium Chloride CaCl ₂ *2H ₂ O | Epsom Salt MgSO ₄ *7H ₂ O | Baking Soda NaHCO ₃ |
|-------------------|-------------------------|---|---|---|--------------------------------|
| Amt Added (grams) | 5 | | | 5 | 5 |

| Salt Contributions (ppm) | Calcium (ppm) | Magnesium (ppm) | HCO ₃ (ppm) | Sodium (ppm) | Chloride (ppm) | Sulfate (ppm) |
|--------------------------|---------------|-----------------|------------------------|--------------|----------------|---------------|
| | 105.9 | 24.6 | 349.9 | 72.3 | 0.0 | 103.0 |

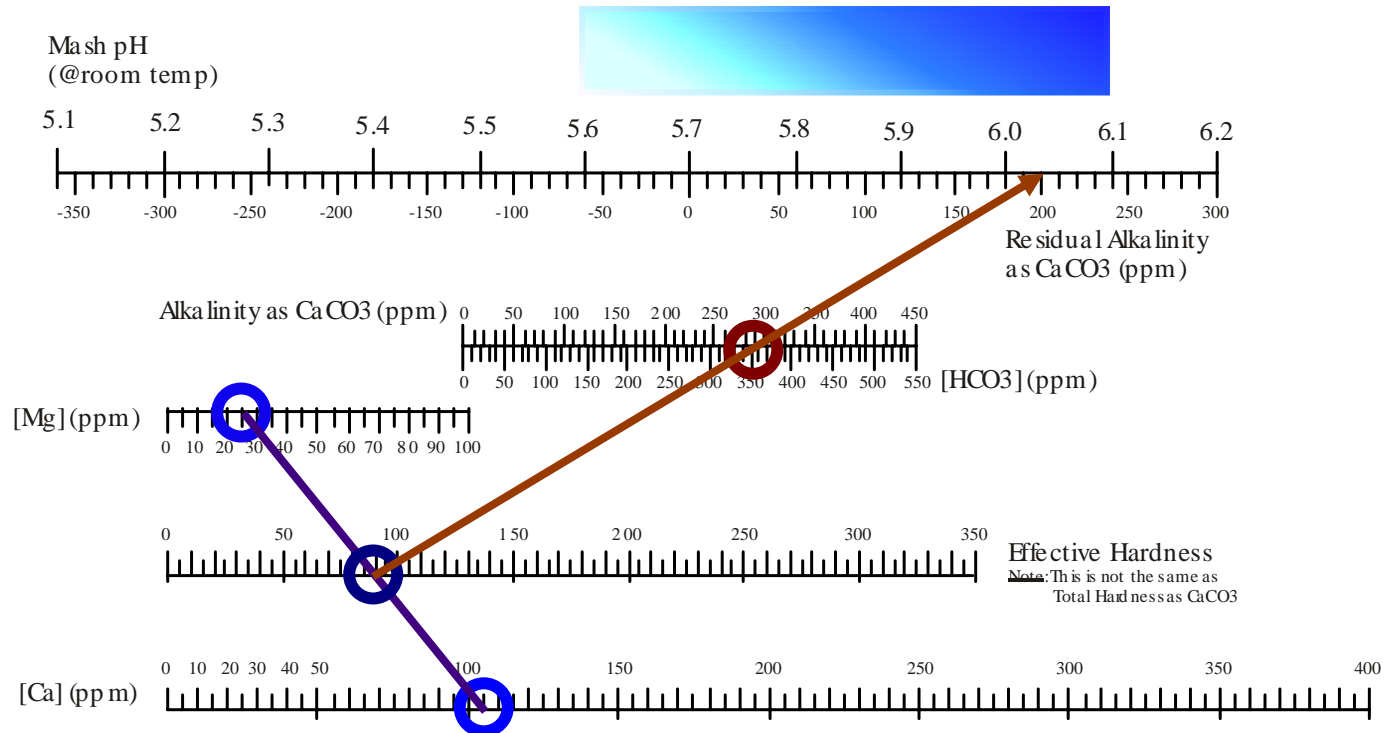
| Contributed Hardness | Contributed Alkalinity |
|----------------------|------------------------|
| 90.1 | 286.8 |

| Adjusted Mash (ppm) | Calcium (ppm) | Magnesium (ppm) | Alkalinity as CaCO ₃ | Sodium (ppm) | Chloride (ppm) | Sulfate (ppm) |
|---------------------|---------------|-----------------|---------------------------------|--------------|----------------|---------------|
| | 105.9 | 24.6 | 286.8 | 72.3 | 0.0 | 103.0 |

| Effective Hardness | Residual Alkalinity as CaCO ₃ | Est. SRM (Low) | Est. SRM (Hi) |
|--------------------|--|----------------|---------------|
| 90.1 | 196.7 | 21 | 26 |

Stout Water Example

Suggested Beer Color/Style Guide for Residual Alkalinity Mash pH



Usage Notes:

1. Assume an error of +/- .1 pH due to individual mash chemistry.
2. The actual pH of the mash at mash temperature (~150°F) is typically .35 pH less than it measures at room temperature.



The Experiment....

- Brew both beers with both waters:
 - Pale Ale with Pale Ale Water
 - Pale Ale with Stout Water
 - Stout with Stout Water
 - Stout with Pale Ale water



The Brewers....

QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

Scott (not Steve) and Rick.



Experimental Procedure - Water

- Brewing water was built from *distilled* using packets of salts for 5 gallons, dissolved into the mash. (*They wouldn't dissolve into the distilled water.*)
- The sparge water was distilled, and as such, would not change the mash pH appreciably.
- The remaining salt was added to the boil after sparging to make up the difference to achieve the intended water profile.

Action Shot 1



- The Jackson Backyard Brewery



Basic Brewing Procedure for both styles:

- Mashed in with 4 gallons of water for 11–12 pounds of grain. (1.3-1.4 qts/lb.)
- Single Infusion Mash at 154°F (67.7°C) for 60 minutes.
- Mashed Out with 2 gallons of hot water (~165°F).
- Batch Sparged to collect about 7.5 gallons in the boil kettle.

Pale Fermentation



Pale w/ Pale

Pale w/ Stout



The Brewing of the Pale....

- Pale Ale w/
Pale Water
 - Yield 71%
 - OG 1.046
 - FG 1.009
 - AA = 80%
 - **5.5 Mash pH**
 - **4.5 Beer pH**

- Pale Ale w/
Stout Water
 - Yield 71%
 - OG 1.046
 - FG 1.010
 - AA = 78%
 - **6.1 Mash pH**
 - **4.7 Beer pH**



Pale Ale Tasting Notes:

- Pale with Pale water (4.5 pH)
 - Big head and very good retention
 - Malty, fruity, and hoppy aroma.
 - Clean, assertive, but non-astringent bitterness.
 - Smooth mouthfeel



Pale Ale Tasting Notes con't:

- Pale with Stout Water (4.7 pH)
 - Large head that fades quickly.
 - Poor hop aroma, some diacetyl.
 - Harsh bitterness, astringent, minerally.
 - Malt flavor is shallow, mostly bitter.
 - Smooth mouthfeel up front, yet astringent finish.
 - Malt and bitterness are not balanced.

The Brewing of the Stout....

- Stout w/
Stout Water
 - Yield 69%
 - 4 gallons
 - OG 1.054
 - FG 1.016
 - AA = 70%
 - **5.4 Mash pH**
 - **4.6 Beer pH**

- Stout w/
Pale Water
 - Yield 66%
 - 4.5 gallons
 - OG 1.055
 - FG 1.018
 - AA = 67%
 - **4.9 Mash pH**
 - **4.2 Beer pH**

Fermentation of the Stout



■ Pale Water (left)

Stout Water (right)



Sweet Stout Tasting Notes:

- Stout with Pale water (4.2 pH)
 - Chocolate aroma, vegetal, solvent aromas
 - Creamy dark head that fades
 - Flavor is thin, sharp, vegetal, one dimensional roast
 - Mouthfeel is creamy, yet dry and thin.
 - Taste is one dimensional, too much roast.



Sweet Stout Tasting Notes con't:

- Stout with Stout Water (4.6 pH)
 - Complex chocolate, coffee, dark caramel aroma.
 - Dark creamy head with great retention
 - Complex flavor, hint of smoke, fruity, roasty, low sweetness for a sweet stout (oh well)
 - Smooth and creamy mouthfeel
 - Lovely complex beer.



Thank You!