



Historic Water

2013 AHA National Convention

Philadelphia, PA

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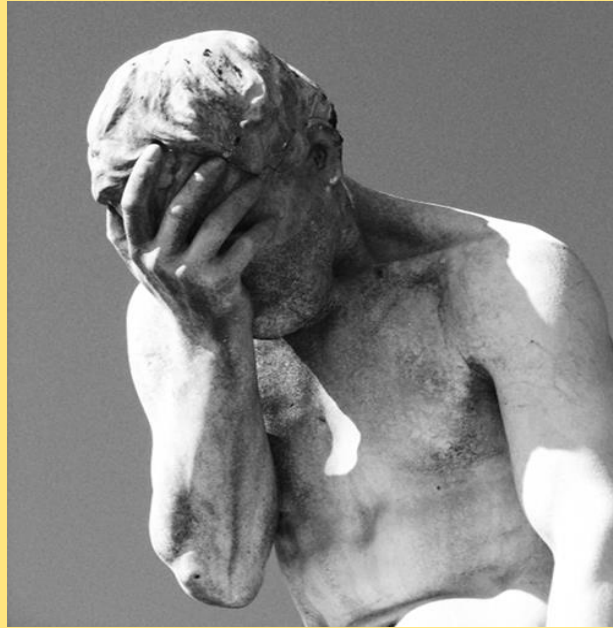
We know that water from some locations makes great beer.

We also know that a brewer can get into trouble trying to recreate those waters.



Avoiding water problems is this presentation's goal

**Those that fail to learn from history
are doomed to repeat it.**



Certificate of Authenticity

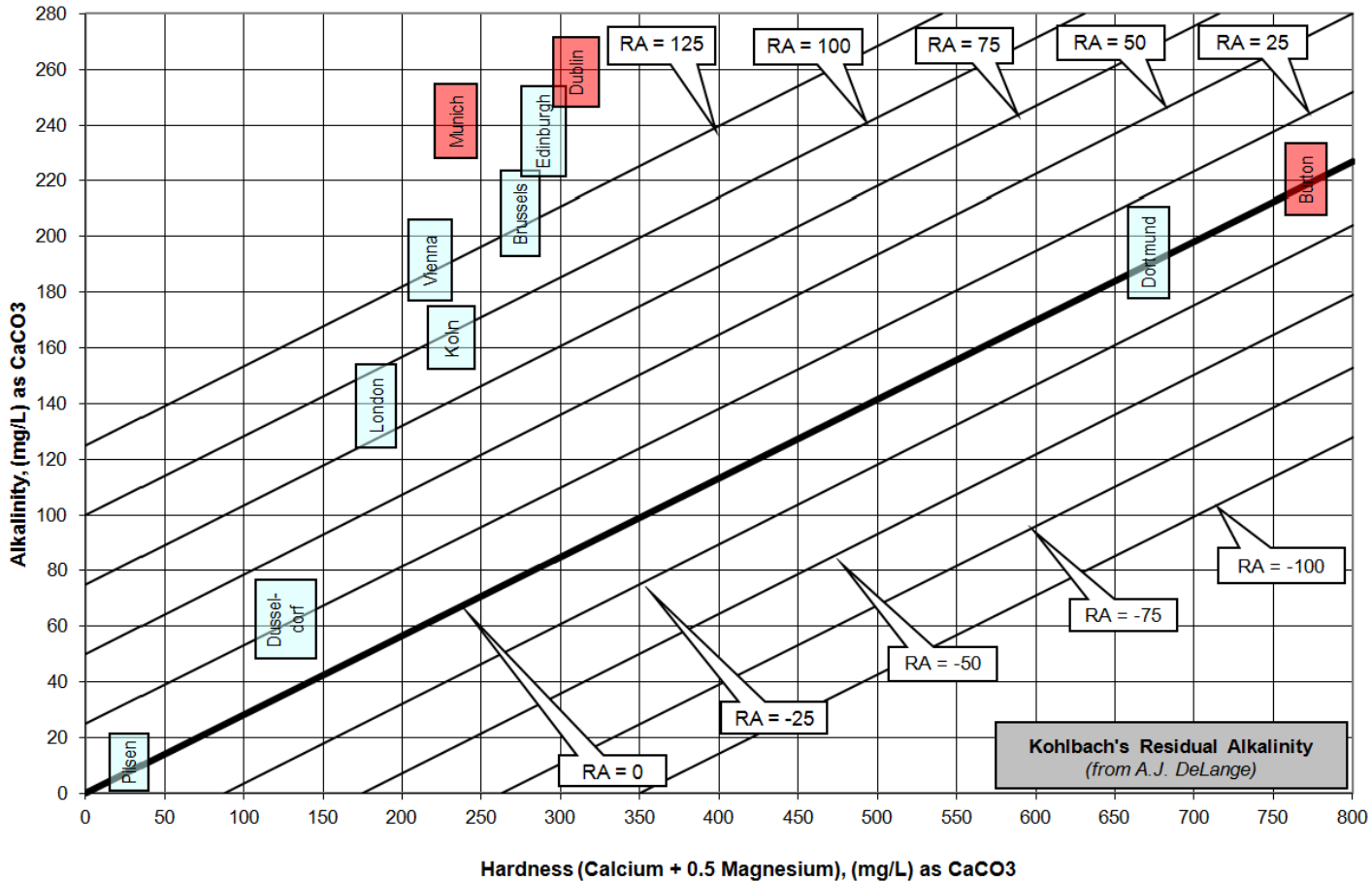


This certifies that your water has passed through the golden urethra of Ninkasi and is destined to create heavenly beer.

Have a Nice Day!



Historic Waters



Off to Burton



Burton on Trent

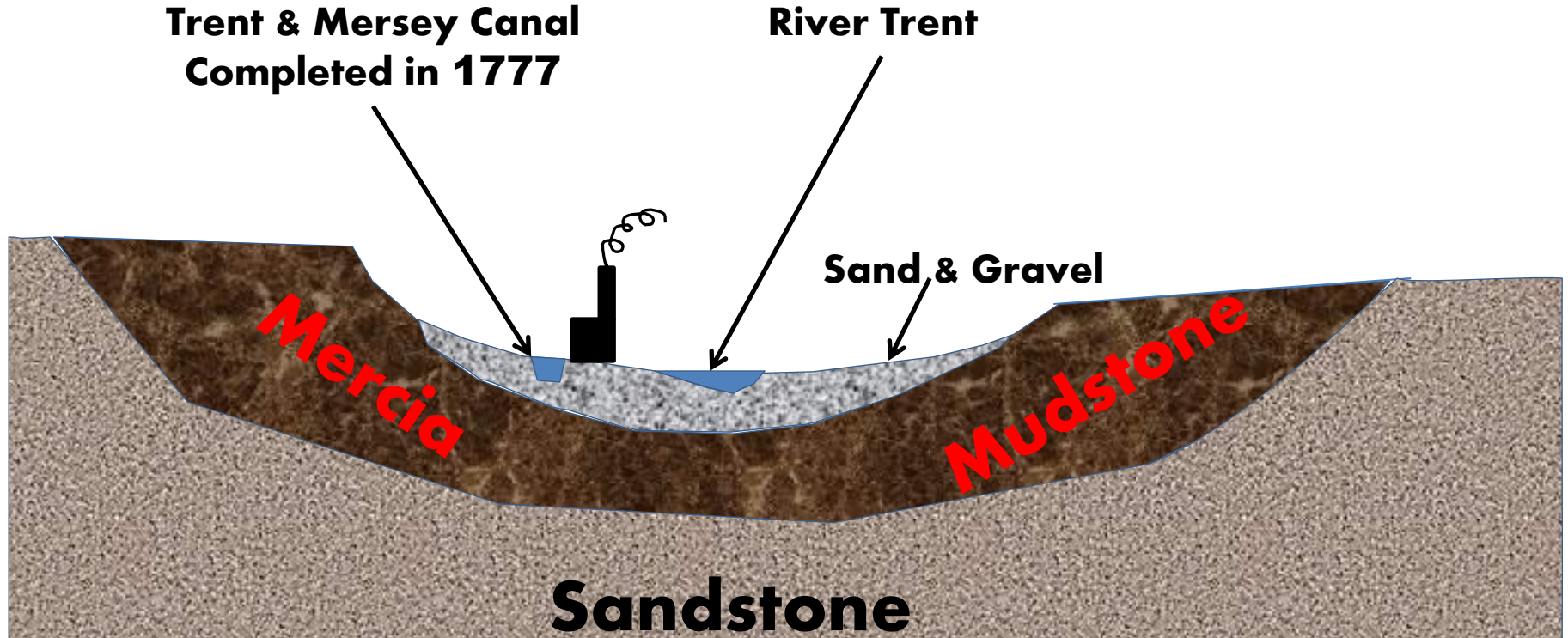
- **Small town in the English Midlands, between Birmingham and Nottingham.**
 - **A brewing center since the 11th century.**
 - **Rose to brewing prominence in the 1800's.**
 - **First Pale Ales in the 1820's**
 - **Broad valley, about 150-feet deep.**
 - **Noted, minerally water character.**

Current Burton Water Profiles

Ion	Coors Shallow Well (mg/L)	Marston Shallow Well (mg/L)
Calcium	151	344
Magnesium	35	80
Sodium	53	39
Chloride	68	64
Sulfate	208	822
Bicarbonate	379	362
Residual Alkalinity	182	4

Source: UK Environmental Agency-Midlands Region

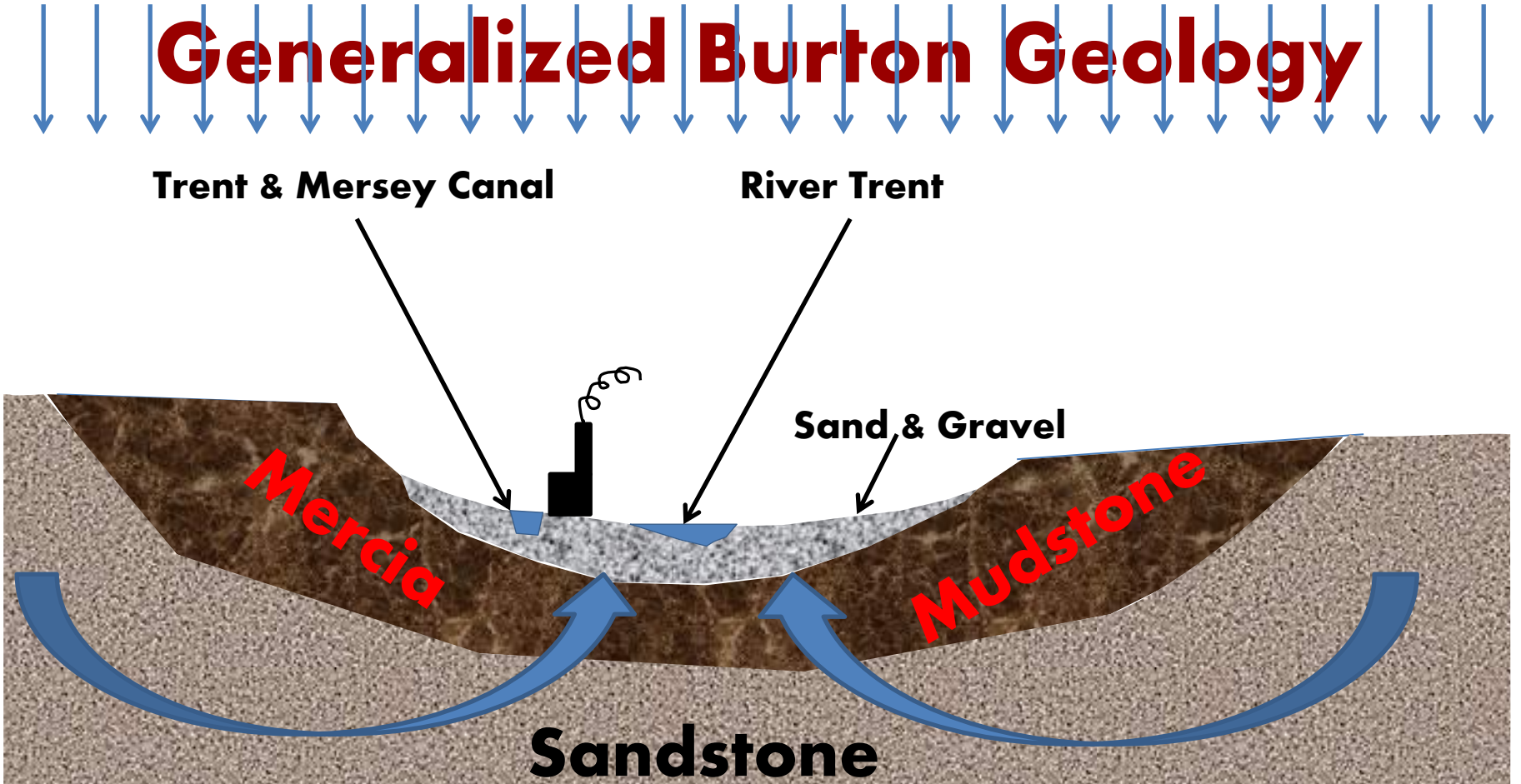
Very Generalized Burton Geology



Mercia Mudstone

- **Also known as Keuper Marl.**
- **Relatively clayey formation with low permeability.**
- **Contains gypsum, chalk, and dolomite which contribute calcium, magnesium, sulfate, and bicarbonate to water that flows through it.**

Generalized Burton Geology



Estimated Burton Water Profile

Ion	Concentration (mg/L)
Calcium	275
Magnesium	40
Sodium	25
Chloride	35
Sulfate	610
Bicarbonate	270
Residual Alkalinity	3

Estimated Burton Water Profile

Ion	Concentration (mg/L)
Calcium	275
Magnesium	40
Sodium	25
Chloride	35
Sulfate	610
Bicarbonate	270
Residual Alkalinity	3

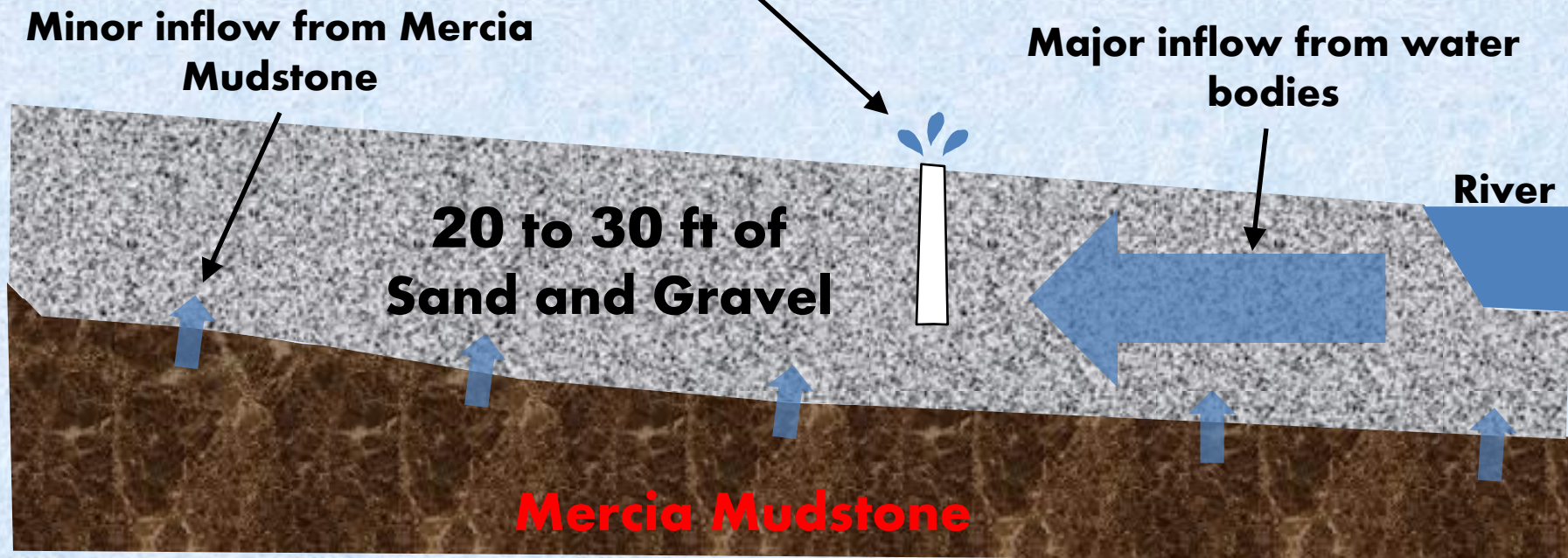
Don't

What is wrong with using a Burton profile?

- **Highly mineralized water that is **not** representative of the dilution from rainfall and river water that would occur in wells in the Sand and Gravel aquifer.**
- **Permeability of Sand and Gravel is 10,000 to 100,000 times greater than Mercia Mudstone.**
- **Water from river, canal, and shallow aquifer would dilute the mineralized water from the deeper Mercia Mudstone.**

Dilution in the Sand and Gravel Aquifer

Shallow Well Withdrawal



What might a Burton profile have been with dilution?

- **Good Question???**
- **It would have probably varied with rainfall and pumping.**

Pale Ale Water Profile

Ion	Concentration (mg/L)
Calcium	140
Magnesium	18
Sodium	25
Chloride	55
Sulfate	300
Bicarbonate	110
Residual Alkalinity	-20

Source: Bru'n Water

Burton/Pale Ale Comparison

Ion	Burton Profile (mg/L)	Pale Ale Profile (mg/L)
Calcium	275	140
Magnesium	40	18
Sodium	25	25
Chloride	35	55
Sulfate	610	300
Bicarbonate	270	110
Residual Alkalinity	3	-20

Advice for Pale Ale Brewing Water

- **Avoid excessive ion concentrations.**
- **Keep **Magnesium** below 40 ppm or the flavor is likely to be harsh or astringent.**
- **Use at least 100 ppm **Sulfate** to help dry the beer finish. But for better hop expression 'pop', use 300 to 350 ppm sulfate.**
- ****Sulfate** at over 350 ppm may create 'sulfury' or other 'off flavor' perceptions.**

Advice for Pale Ale Brewing Water (continued)

- Keep **Chloride** concentration low to avoid clashing with the desirable high sulfate content, becomes 'minerally'.
- Due to high water hardness from the calcium and magnesium, some **Alkalinity** is likely needed in the mashing water in order to avoid an overly low mash pH.
- A mash pH of **5.3** to **5.4** is desirable for pale ales.

Éirinn go Brách





Ireland



- **Famous for stout and porter breweries.**
- **Dry stout is a signature of Ireland.**
- **Notable Irish stout breweries include:**

– **Beamish**



– **Murphy's**



– **Guinness**



Irish Geology

- **Much of Central Ireland is composed of Limestone.**
- **Southern Ireland is composed of Limestone and Sandstone.**
 - **Hard & alkaline water is likely found in limestone areas.**
- **Granite is found in a few locales around Ireland.**
 - **Softer and less alkaline water is likely found in granite and sandstone areas.**

Irish Geology

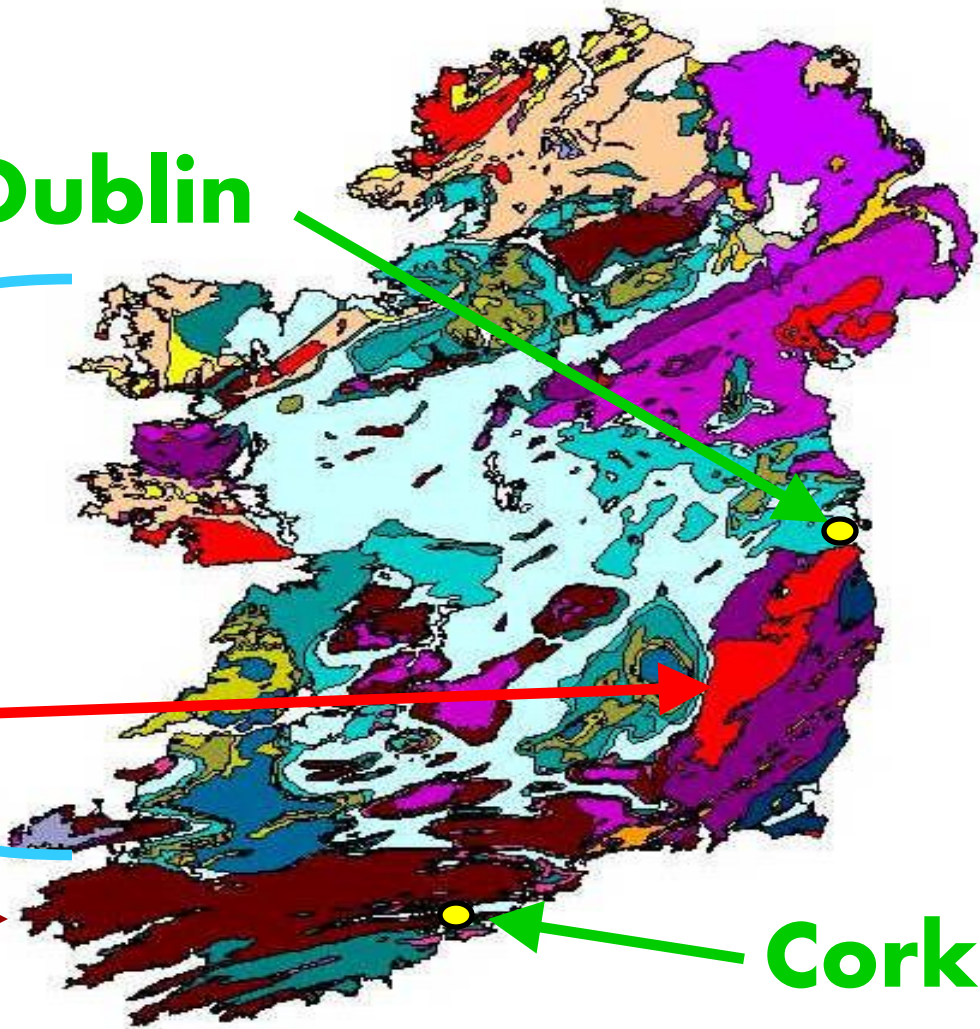
Dublin

Limestone

Granite

Sandstone

Cork



Irish Hydrogeology

- **Groundwater and Surface Water in Central Ireland is likely to be hard and alkaline.**
- **Surface Water in sandstone areas of Southern Ireland may be soft and non-alkaline.**
- **Surface Water runoff from the Granitic areas is typically soft and non-alkaline.**

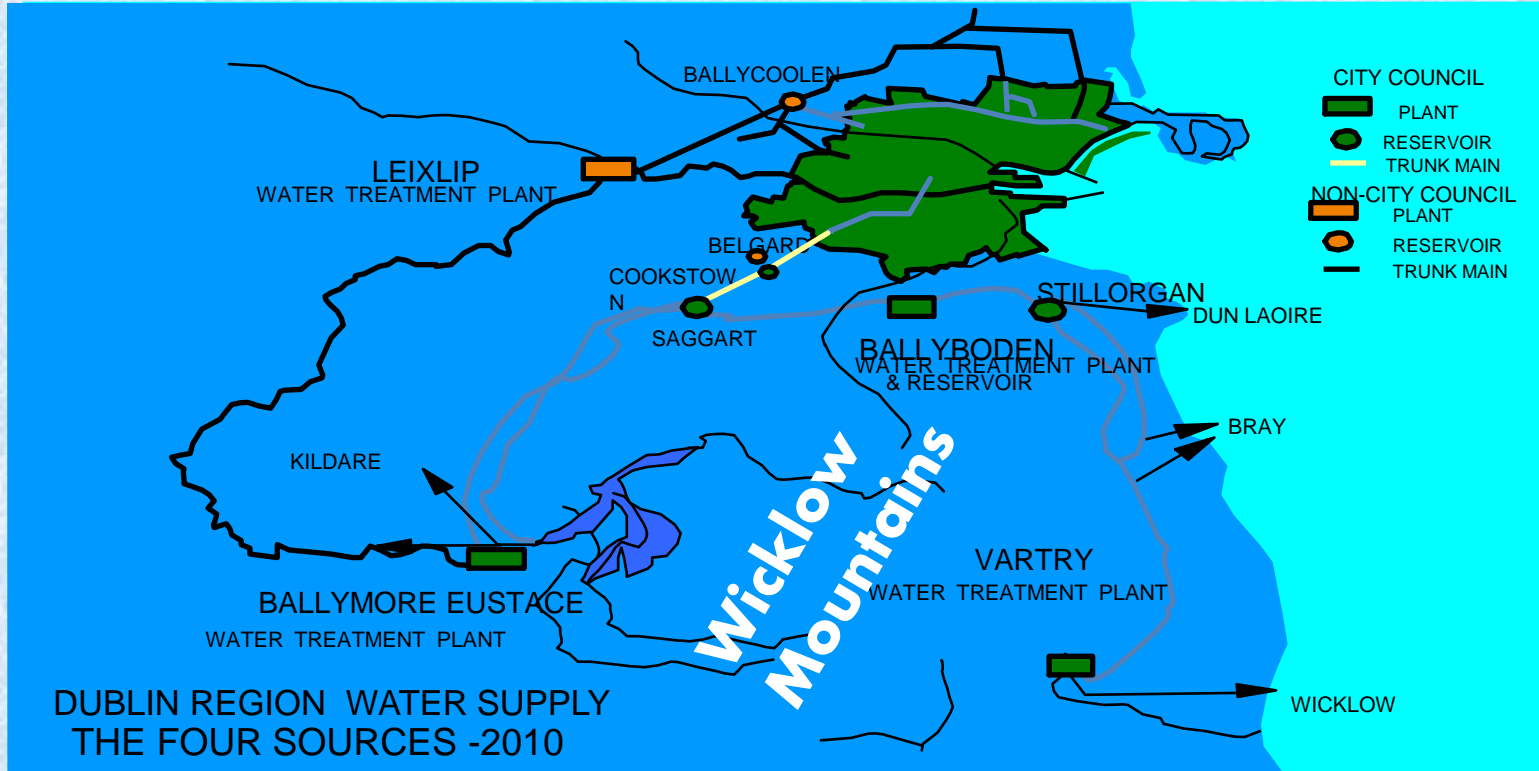
Historic Dublin Water Supply

- **Poddle River and local wells were probably the original water sources.**
- **The Grand Canal was in operation by 1780 and was used to supplement the water supply.**

Modern Dublin Water Supply

- **A system of reservoirs was started in the 1860's**
- **Runoff from the Wicklow Mountains is the primary source**
- **Granitic geology leaves the water soft and non-alkaline**

Modern Dublin Water Supply



Source: Dublin City Council

Modern Dublin Water Supply

- **Water quality varies around the city due to varying sources.**
- **Leixlip water quality tends to vary since the Liffey River picks up alkaline groundwater in the lowlands.**
- **Ballymore and Stillorgan water quality is more consistent and typically has lower hardness and alkalinity than Leixlip.**

Historic Dublin Brewing

- **Guinness started brewing at St. James Gate in 1759.**
- **Shallow wells on the property supplied water to the brewery.**
- **The Grand Canal was in place by 1780 and is only $\frac{3}{4}$ -mile from the Guinness property.**
- **Grand Canal leakage would likely recharge the local groundwater supply.**

Historic Guinness Water

- **Guinness water source was probably **NOT** very alkaline for much of its history.**
- **When Wicklow Mountain reservoirs were created, Guinness water supply almost certainly had low alkalinity.**
- **Now Guinness uses RO technology to maintain consistent low alkalinity & mineralization in their water supply.**

Historic Cork Water

- **Local groundwater is hard and alkaline.**
- **River Lee water is somewhat soft and has little alkalinity.**
- **River Lee water is the primary source for Cork and its breweries.**
- **It is reasonable to assume that Cork water quality is similar to Wicklow.**

Purported Dublin Water Profile

Ion	Concentration (mg/L)
Calcium	120
Magnesium	4
Sodium	12
Chloride	19
Sulfate	55
Bicarbonate	315
Residual Alkalinity	173

Purported Dublin Water Profile

Ion	Concentration (mg/L)
Calcium	120
Magnesium	4
Sodium	12
Chloride	19
Sulfate	55
Bicarbonate	315
Residual Alkalinity	173

Don't

Estimated Wicklow Water Profile

Ion	Concentration (mg/L)
Calcium	18
Magnesium	2
Sodium	13
Chloride	20
Sulfate	22
Bicarbonate	35
Residual Alkalinity	14

Source: Ballymore Eustace Water report

How did they brew?

- **A common brewing practice in some regions was pre-boiling the water.**
- **Pre-boiling has the effect of reducing hardness and alkalinity.**
- **Boiling is effective when the water has high Temporary Hardness (alkalinity).**
- **Carbon Dioxide is driven out of the water by the boiling causing chalk to settle out of solution.**

Estimating the Decarbonation Effect of Boiling

- Boiling effects only **Calcium** and **Bicarbonate** concentrations.

$$Ca_{end} (ppm) = Ca_{start} (ppm) - \left[\frac{(HCO_{3\ start} (ppm) - HCO_{3\ end} (ppm))}{3.05} \right]$$

- Ending **Bicarbonate** concentration will typically fall between **40** and **80 ppm**.
- Use the following formula to estimate the ending **Calcium** concentration after boiling and decanting.
- The **Calcium** concentration after boiling cannot be less than **12 ppm** (**12 to 20 ppm** is typical).

“Boiled” Dublin Water Profile

Ion	Concentration (mg/L)
Calcium	37
Magnesium	4
Sodium	12
Chloride	19
Sulfate	55
Bicarbonate	60
Residual Alkalinity	21

Boiled/Wicklows Comparison

Ion	Boiled Dublin Profile (mg/L)	Wicklows Profile (mg/L)
Calcium	37	18
Magnesium	4	2
Sodium	12	13
Chloride	19	20
Sulfate	55	22
Bicarbonate	60	35
Residual Alkalinity	21	14

Advice for Stout and Porter Brewing Water

- Although hard and alkaline waters exist in Ireland, **Dry Stout** brewing requires **low alkalinity** water.
- Use separate pale malt mashing and roast malt steeping for **Dry Stout**. Combine after mashing.
- A low wort pH (say 5.0 to 5.2) in the kettle can be expected due to the use of low alkalinity water for **Dry Stouts**.

Advice for Stout and Porter Brewing Water (continued)

- Use **higher alkalinity** water for brewing stouts and porters when using typical brewing methods where all grains are mashed together.
- Even with high roast malt percentage, the **bicarbonate** content of the mashing water is not likely to exceed **180 ppm. (RA~90)**

Advice for Stout and Porter Brewing Water (continued)

- A slightly higher mash pH of 5.5 to 5.6 can help extract more roast malt flavor and character for most stouts and porters. The higher pH tends to smooth those flavors.
- The concentrations of **magnesium**, **sodium**, **chloride**, and **sulfate** may all be relatively low and should not be notable in the beer flavor.

On to Bavaria



Munich

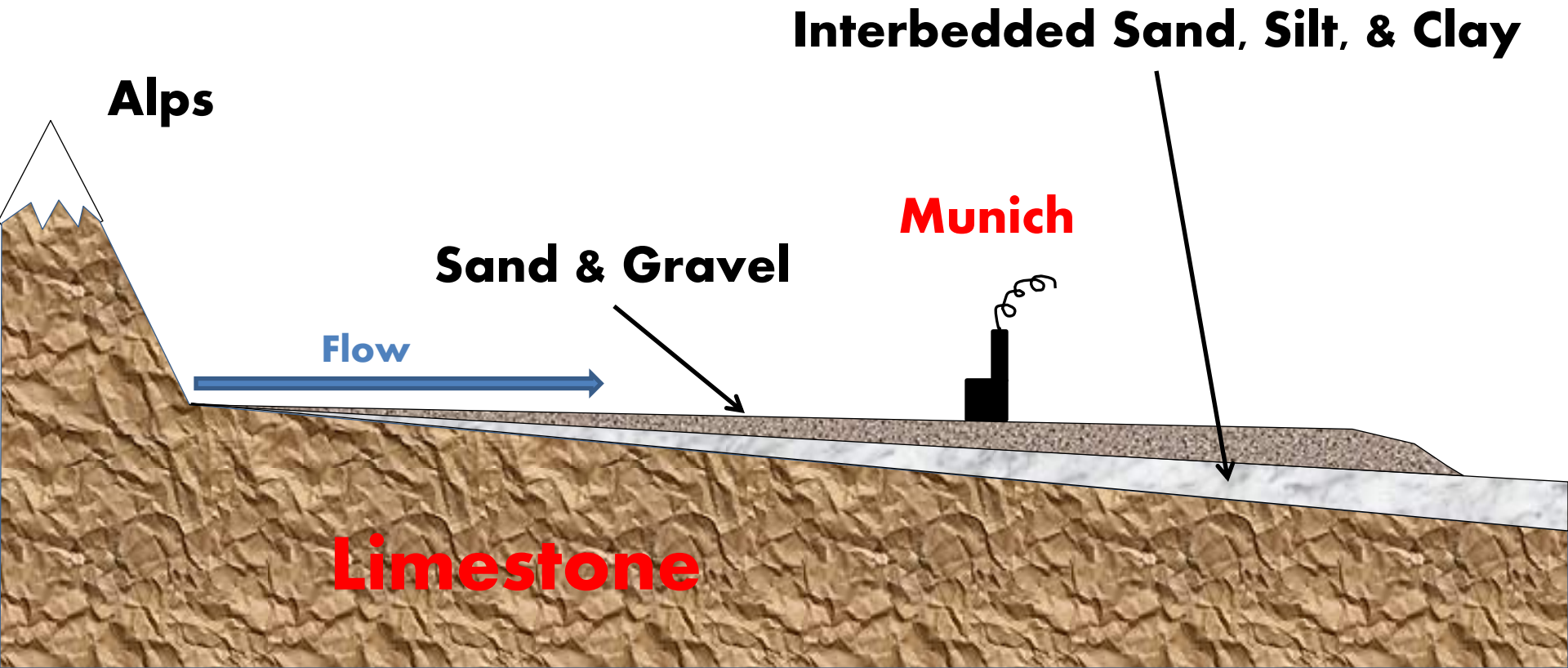


- **Famous for both pale and dark beers.**
- **Major breweries include:**
 - **Paulener, Augustinerbrau, Hacker Pschorr, Spaten, Hofbrauhaus, Lowenbrau.**
- **Although the Isar River flows from the Alps through Munich, the water supply is largely from groundwater.**

Bavarian Geology

- **Down slope of the Alps.**
- **Several carbonate rock layers in the Alps.**
- **Carbonate rock is at or near ground surface in the mountains, but is deep around Munich.**
- **Sand and Gravel outwash plain at ground surface around Munich.**

Very Generalized Bavarian Geology



Estimated Munich Water Profile

Ion	Concentration (mg/L)
Calcium	77
Magnesium	17
Sodium	4
Chloride	8
Sulfate	18
Bicarbonate	295
Residual Alkalinity	179

Source: Stadtwerke München GmbH

'Boiled' Munich Water Profile

Ion	Concentration (mg/L)
Calcium	12
Magnesium	17
Sodium	4
Chloride	8
Sulfate	18
Bicarbonate	100
Residual Alkalinity	64

?

Influence of Reinheitsgebot

- **Originated in Bavaria.**
- **German Purity Law restricts treatments and ingredients in beer.**
- **No liquid acid additions allowed, but promoting the production of natural acids (lactic) is OK!**
- **Acid rest or acid malt are allowable and useful measures to neutralize excess alkalinity.**

Effects of Lactic Acid

- **Lactic acid is a natural, organic acid.**
- **Lactic acid formula is: $C_3H_6O_3$**
- **Leaves Lactate in the beer: $C_3H_5O_3$**
- **Lactate can be tasted by most people at 300 ppm.**
- **1 ppm of lactate added to beer for every ppm of bicarbonate neutralized.**
- **Neutralizing ~100 ppm bicarbonate is not likely to have a significant taste impact.**

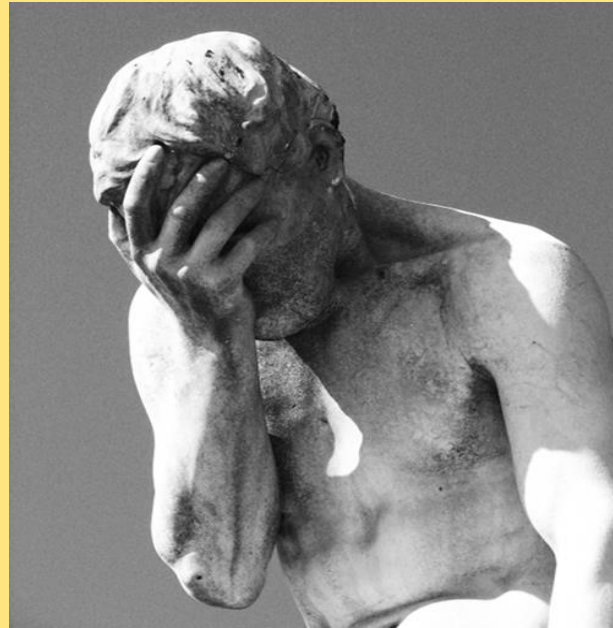
Advice for Brewing Bavarian Styles

- **Low Calcium** is typical.
- **Minor Magnesium** content is typical.
- **Sodium, Chloride, and Sulfate** are very low.
- **Moderate Alkalinity** is OK for dark beers.
- **Low Alkalinity** or **Acidification w/ Lactic** is needed for pale beers.

Guide for Brewing with Historic Water Profiles

- Don't use historic profiles as-is.
- Review the flavor ion levels (**Mg**, **Na**, **SO₄**, and **Cl**). May mimic those levels.
- Ignore **Ca** and **HCO₃** levels and adjust them to fit your mash requirements.
- Review what the effect of boiling would have on **Ca** and **HCO₃** levels to gauge what water historic breweries used.

Don't be this guy!



Historic Water Questions?

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brewing water information**