Interpreted Drillers' Log Tables in the KGS WWC5 Database

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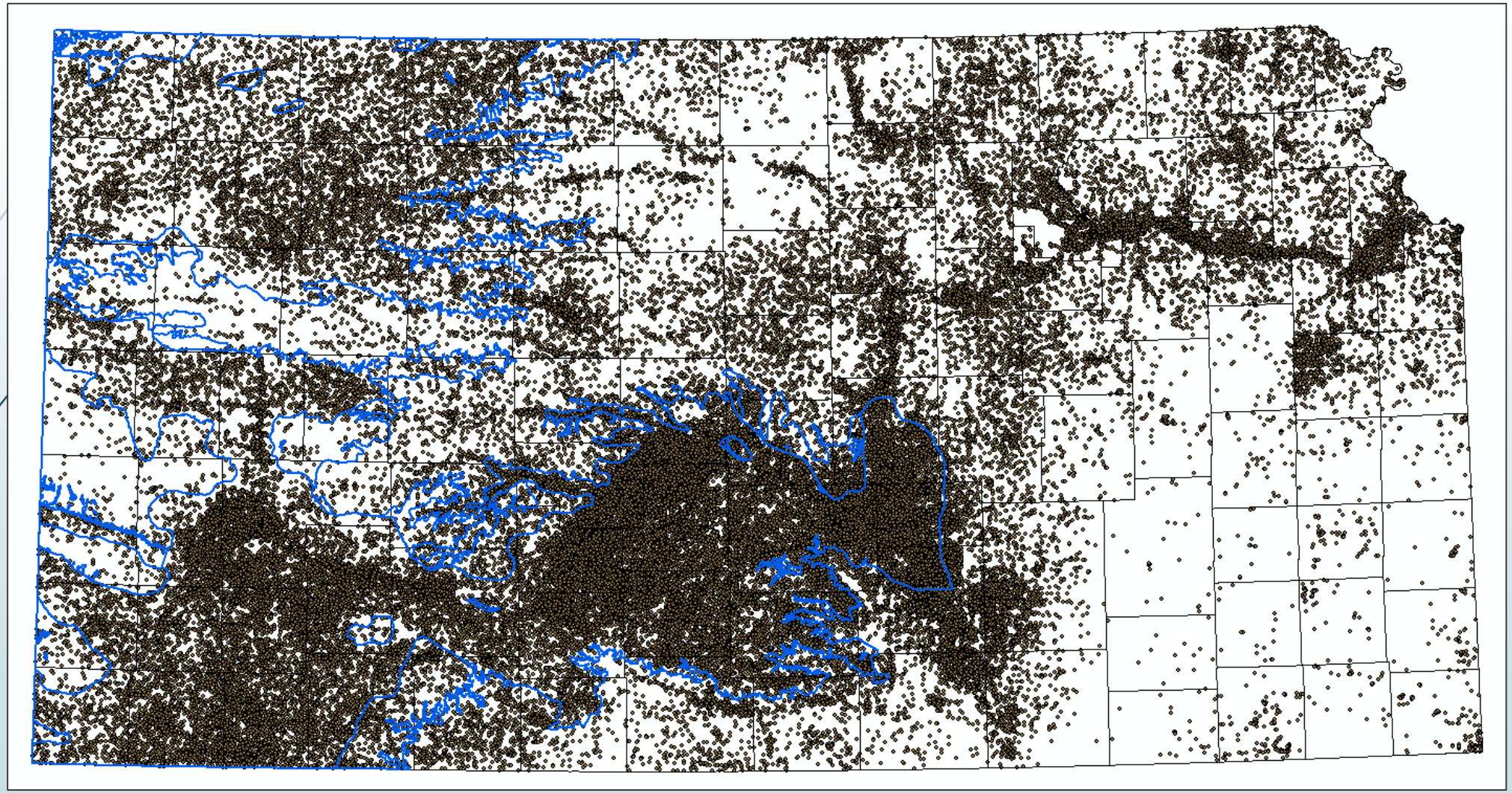
WWC5 (Water Well Completion) Database

- Water well drillers submit forms for completed wells to KDHE (since 1975)
- KGS is charged by statute to archive and serve that data
  - Does so in WWC5 database
  - Well info (location, depth, owner, etc.) entered into WELLS table
  - Lithologic (really mostly *sediment*) logs transcribed into LOGS table
    - An ongoing and labor-intensive process
    - Much of it done by Dana Adkins-Heljeson
    - Near-verbatim transcription, with some corrections and modifications for consistency
- Scanned forms also stored so all original information is available
- Web interface: http://www.kgs.ku.edu/Magellan/WaterWell/index.html

Logs Transcribed as of Oct. 29, 2019



~152,000 logs (wells); ~1,080,000 depth intervals total

Typical Log

Original (completion form)

FROM	TO	LITHOLOGIC LOG
0	42	top soil
42	76	sand clay & sand strips
76	121	sand & sand rock strips
121	142	sand clay
142	156	sand & sand rock strips
156	196	Sand Good
196	200	oker & Shale

Transcribed (LOGS table)

Lithologic Log (Log data entered by KGS.)		
	From: 0 ft. **to** 42 ft.	topsoil
	From: 42 ft. **to** 76 ft.	sand clay & sand strips
	From: 76 ft. **to** 121 ft.	sand & sand rock strips
	From: 121 ft. **to** 142 ft.	sand clay
	From: 142 ft. **to** 156 ft.	sand & sand rock strips
	From: 156 ft. **to** 196 ft.	sand good
	From: 196 ft. **to** 200 ft.	Ochre and shale

Does "sand clay" mean "sand, clay" or "sandy clay"? What does "sand rock" mean?

HyDRA (Hydrostratigraphic Drilling Record Assessment) project

- Procedures to develop quantitative aquifer models from lithologic logs
  - Spatial distributions of properties like hydraulic conductivity and specific yield for use in groundwater flow models
- Building on earlier PST(+) project run by Allen Macfarlane
  - Practical Saturated Thickness
- KGS has used HyDRA procedures in model development for several years
- Have just added a table representing first two steps to WWC5
  - Plus two supporting tables
- Scripts for custom processing and subsequent steps available soon

Simple way to quantify logs

- Assign each description a percentage coarse value, for example . . .
  - Clay: 0% coarse
  - Sandy silt: 15% coarse
  - Sand and clay: 60% coarse
  - Fine silty sand: 85% coarse
  - Gravel: 100% coarse
- Compute aquifer property values from % coarse values
- USGS folks in California started doing this a long time ago
  - Burow et al., 2004, USGS Scientific Investigations Report 2004-5232
- Efficient, but a little limited (single purpose)

How we're quantifying logs

- Standardization
  - Represent each description in terms of percentages of one or more standardized lithology codes, for example . . .
    - "clay" is 100% c
    - "fine sand and clay" is 60% fsnd, 40% c
    - "fine sand with clay and caliche streaks" is 60% fsnd, 20% c, 20% ca
  - We're using 71 standardized lithology codes
- Categorization
  - Lithologies are grouped into a smaller number of aquifer property categories
  - Category percentages are computed from lithology percentages
  - Aquifer properties are computed from category percentages
- More flexible than simple percentage coarse approach
  - Standardized logs are richer representation of original logs
  - Categorization can be project- and property-specific
  - WWC5 interpreted logs table based on a single five-part categorization, *but* . . .
  - Scripts for custom processing will be available soon

The Translation Table

- Logs are standardized by passing them through the translation table
  - WWC5.TRANSLATION_TABLE
- The translation table contains a list of *unique* descriptions with corresponding standardized representations (lith codes & percentages)
- Only ~146,000 unique descriptions appear in the LOGS table (over 1 million depth intervals) because many descriptions are used frequently
  - "clay" represents ~75,000 depth intervals, "fine sand" ~33,500
- At the other end of the spectrum are thousands of long, detailed descriptions each representing only one or two depth intervals
- The current translation table contains ~26,000 entries but standardizes about 80% of the depth intervals because the most common descriptions have been translated
- Translation of remaining descriptions (~120,000) is ongoing

Example Translation Table Entries

Row	Description	Lithology Percentages	Lithology Codes	Number of Depth Intervals
1	clay	100	c	74798
2	top soil	100	ts	51605
3	fine sand	100	fsnd	33457
45	clay and caliche	60, 40	c, ca	2528
53	fine sand and clay	60, 40	fsnd, c	1847
89	clay and caliche with sand streaks	50, 40, 10	c, ca, snd	1012
256	fine to medium sand and gravel 10% clay (loose)	90, 10	fmsdg, c	300
5058	medium sand with fine clay layers	70, 30	msnd, c	6
4773	silt, soft, pale yellowish brown, damp	100	s	7
16804	med. to lar. sand and gravel (lost circulation)	100	mcrssdg	1
23150	gravel with caliche and sand and clay streaks, reddish brown, poorly sorted	50, 30, 10, 10	g, ca, snd, c	1

Example Log + Standardized Version

Top Depth (feet)	Bottom Depth (feet)	Description	Lithology Percentages	Lithology Codes
0	42	topsoil	100	ts
42	76	sand clay and sand strips	50, 40, 10	snd, c, cesd/cg
76	121	sand and sand rock strips	80, 20	snd, cesd/cg
121	142	sand clay	60, 40	snd, c
142	156	sand and sand rock strips	80, 20	snd, cesd/cg
156	196	sand good	100	snd
196	200	ochre and shale	60, 40	m, sh

"sand clay" interpreted as "sand, clay"

"sand strips" and "sand rock strips" interpreted as cesd/cg which means "cemented sand and/or gravel"

Shortcomings of Standardization Approach

- Labor-intensive
- Descriptions are interpreted in isolation (while going through list of unique descriptions that still need to be translated), not in spatial context
- Same standardized representation is applied to all occurrences of a description, regardless of spatial context
- Interpretations can be
  - Subjective
  - Inconsistent
  - And just plain wrong every so often
- But impact of these problems is reduced when results are aggregated
- Looking into ways to automate process for greater efficiency & consistency

The Lithology Codes Table

- Logs are categorized using the lithology codes table
  - WWC5.LITHOLOGY_CODES
- This table lists:
  - The 71 standardized lithology codes
  - Descriptions (definitions) of those codes
  - The property category for each code
- Lithology percentages for each depth interval are converted to category percentages using this table

Code	Description	Category
sh	shale	1
fmsc	fine to medium silty clay	2
fss	fine silty sand	3
msnd	medium sand	4
mcrsg	medium to coarse gravel	5

Example table entries (one from each category)

The Interpreted Logs Table

- Logs with standardized representations and category percentages added
  - WWC5.INTEPRETED_LOGS
- Implemented as a *view*
  - Query that acts like a table
  - Generated from underlying tables every time it's accessed, so always up to date
- Also includes
  - Dominant category (category with maximum percentage)
  - Proportion-weighted average category number
    - Kind of a surrogate aquifer property

Example Log in Interpreted Logs Table

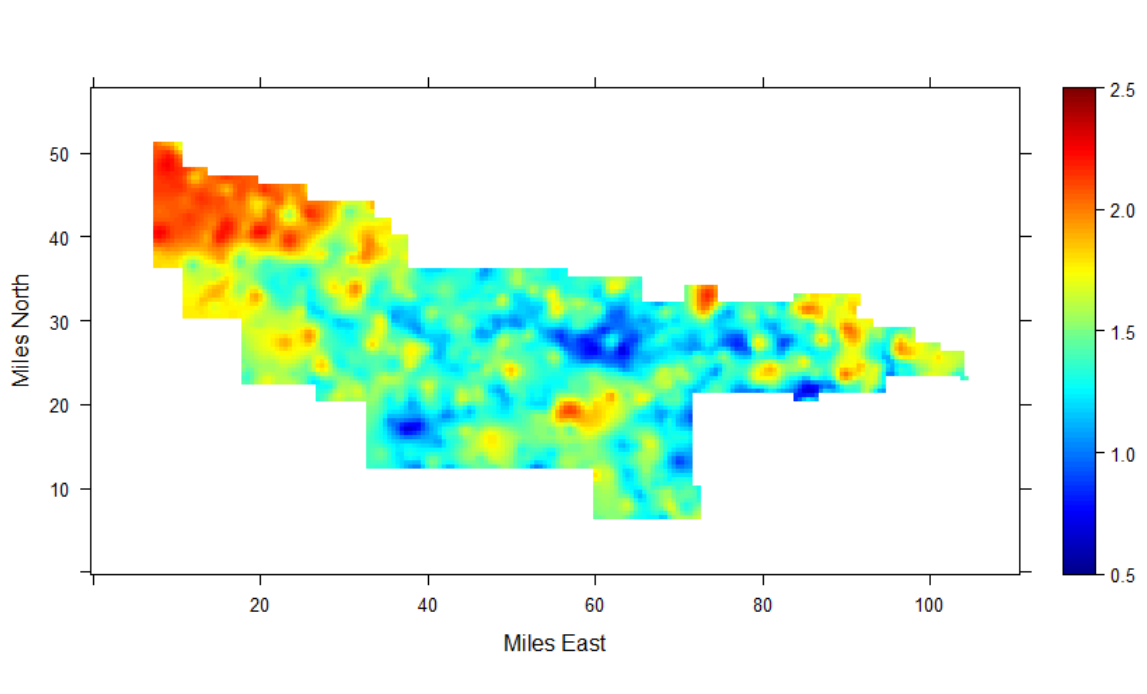
Top	Bottom	Description	LithPercs	LithCodes	% Cat1	% Cat2	% Cat3	% Cat4	% Cat5	DomCat	AveCat
0	42	topsoil	100	ts	0	100	0	0	0	2	2
42	76	sand clay and sand strips	50, 40, 10	snd, c, cesd/cg	40	0	10	50	0	4	2.7
76	121	sand and sand rock strips	80, 20	snd, cesd/cg	0	0	20	80	0	4	3.8
121	142	sand clay	60, 40	snd, c	40	0	0	60	0	4	2.8
142	156	sand and sand rock strips	80, 20	snd, cesd/cg	0	0	20	80	0	4	3.8
156	196	sand good	100	snd	0	0	0	100	0	4	4
196	200	ochre and shale	60, 40	m, sh	40	60	0	0	0	2	1.6

(column names abbreviated here)

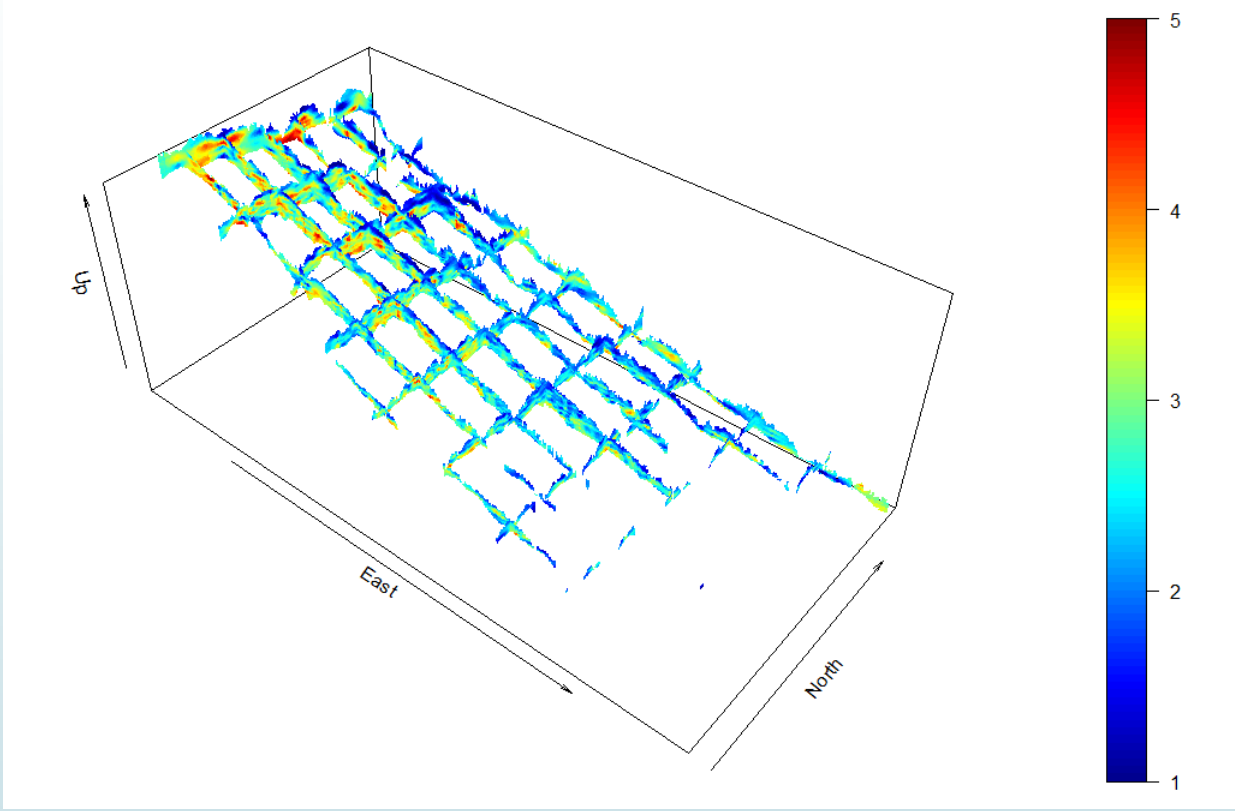
The table also contains the well and depth interval IDs (not shown) for tying into WELLS and LOGS tables

Category Proportions → Aquifer Models

log10(K [ft/d]), GMD1



Proportion-Weighted Average Category, GMD4



Subsequent processing used to generate property grids from category proportions
Code + documentation will be included in upcoming report

Accessing Tables

- INTERPRETED_LOGS table will be publicly accessible soon
  - Details to be determined
  - Contact Geoff Bohling (geoff@kgs.ku.edu) for information
- TRANSLATION_TABLE and LITHOLOGY_CODES will also be available
  - Document production of INTERPRETED_LOGS table
  - Serve as starting point for customized analyses
    - Using those soon-to-be-available scripts & programs
    - Or using tools of your own choosing