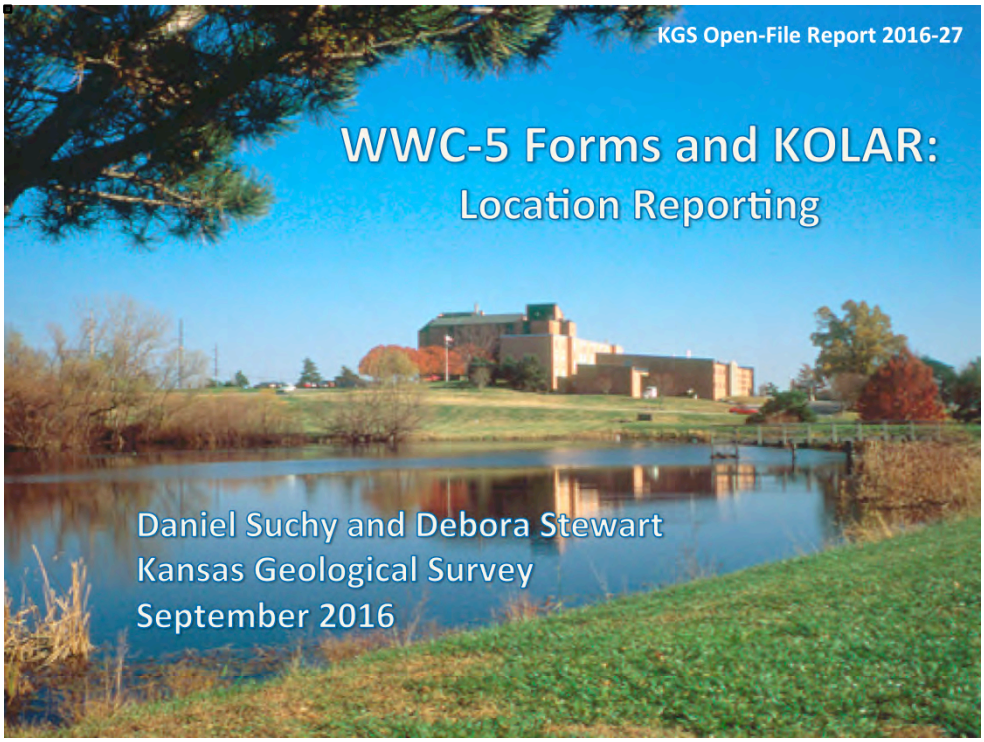


My name is Dan Suchy, and I am here today with my associate, Deb Stewart. We are from the Kansas Geological Survey, which is the repository for water well records in the state.

The Data Resources Library at the Kansas Geological Survey

Water Well Completion Records (WWC-5s) are submitted to KDHE (the regulatory agency) but eventually they come to us in the Data Resources Library (DRL) at the Kansas Geological Survey (KGS), where we archive the records and make them available to the public. We also enter data from the paper records, scan the paper documents, and post the data and the scanned documents to our public website so that anyone can access them remotely.

However, completion records submitted electronically online via KOLAR bypass our manual data entry process. After approval by the KDHE, the data the driller submitted are automatically uploaded to our public website along with a system-generated image of the form.

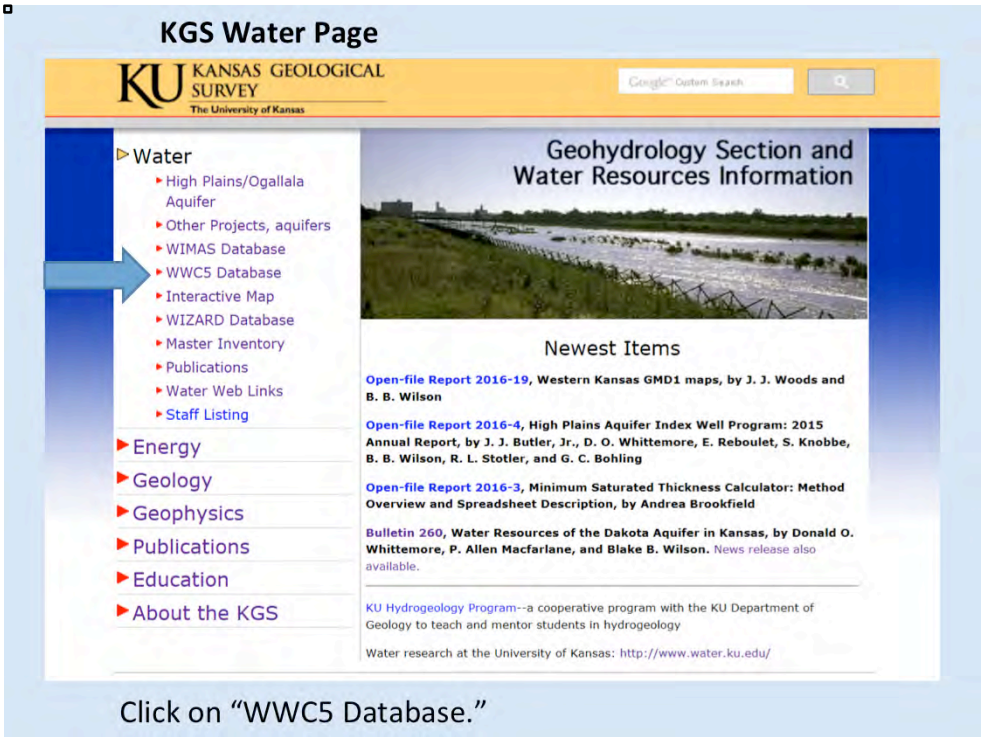
Topics

- KGS WWC-5 website
- Section, Township, Range
- Latitude/Longitude Coordinate Systems
- Datums
- GPS

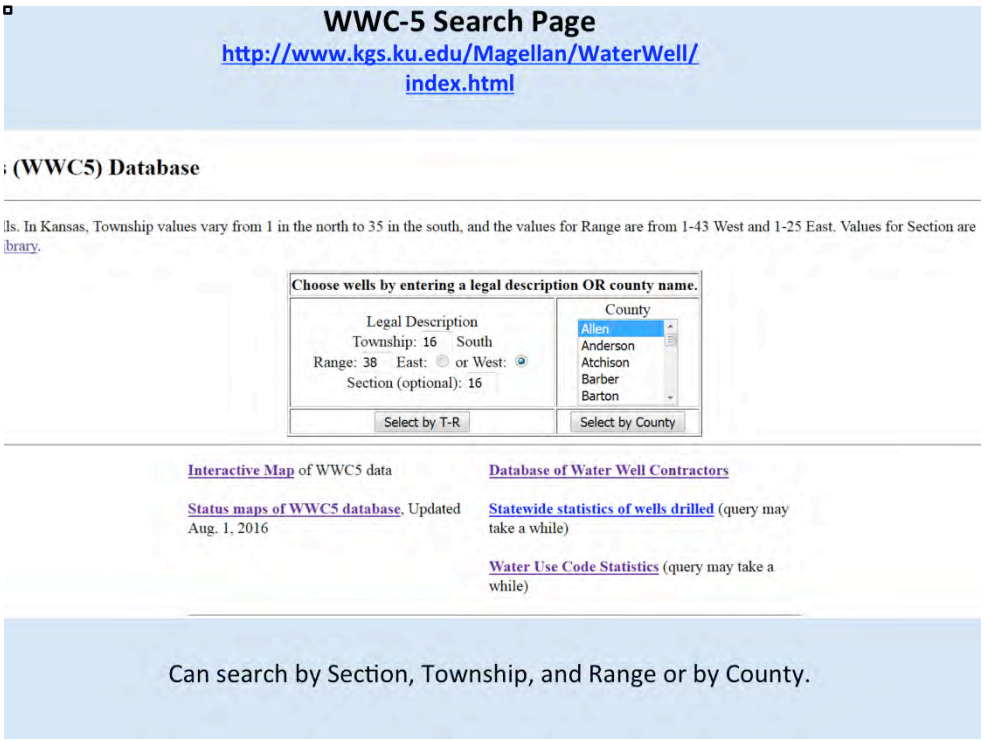
The Data Resources Library at the Kansas Geological Survey

Ideally, a point location, such as latitude and longitude, is the most accurate, and that is why we ask for that and start with that on the KOLAR WWC-5 forms. However, we still need section, township, range, and the quarter divisions within each section because we still file all the paper forms using that location information. Most of the searches online for water well records are done by section, township, and range, and many people still work within that system. After all, it is the legal land description. First, we have been asked to review our WWC-5 website. And then we will go through a short overview of the Public Land Survey System in Kansas—that is, section, township, and range—and how to use it so that we all are familiar with how it works. Then we will go into latitude, longitude, and datums, and eventually we'll talk a little bit about GPS devices.

First, we will briefly show you our website and how to find the relevant features for those of us in the water well industry. Here is our homepage. And for pretty much everybody in the water well industry, the most relevant link on this page is the "Water" link. If you click on that link, you get the following page.



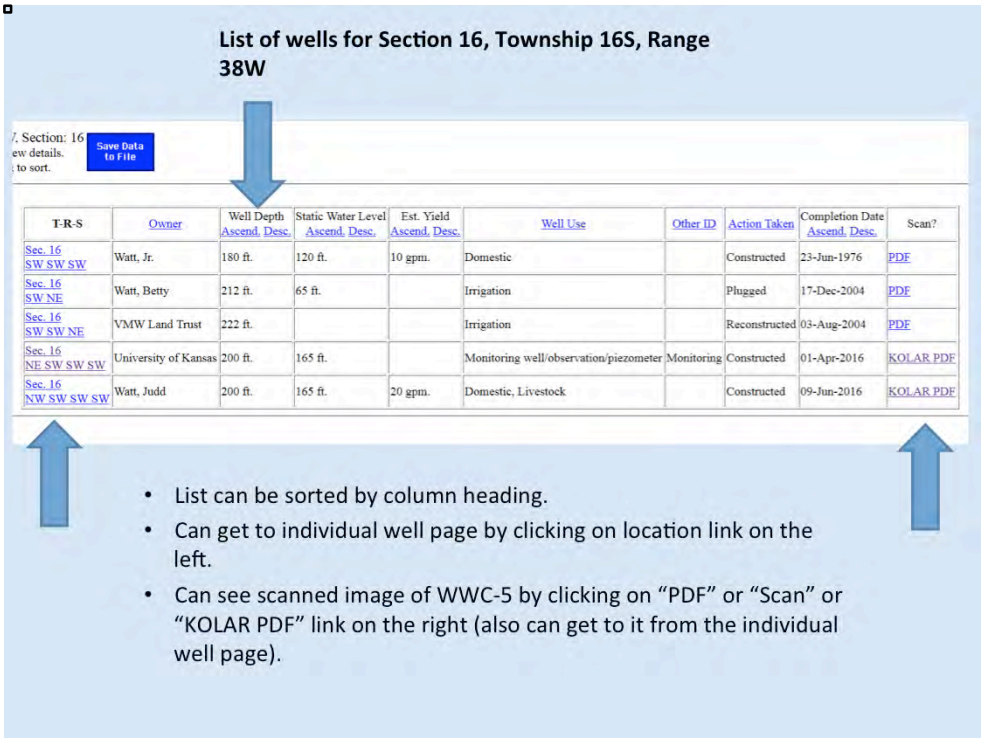
We have three water databases: WIMAS, WIZARD, and WWC5. WIMAS records water rights in the state. WIZARD records the water level measuring program that the KGS is involved with every year. The WWC5 database records all the water well completion records (WWC-5s) that the water well drillers have turned in; this is the one that will likely be of most use to you.



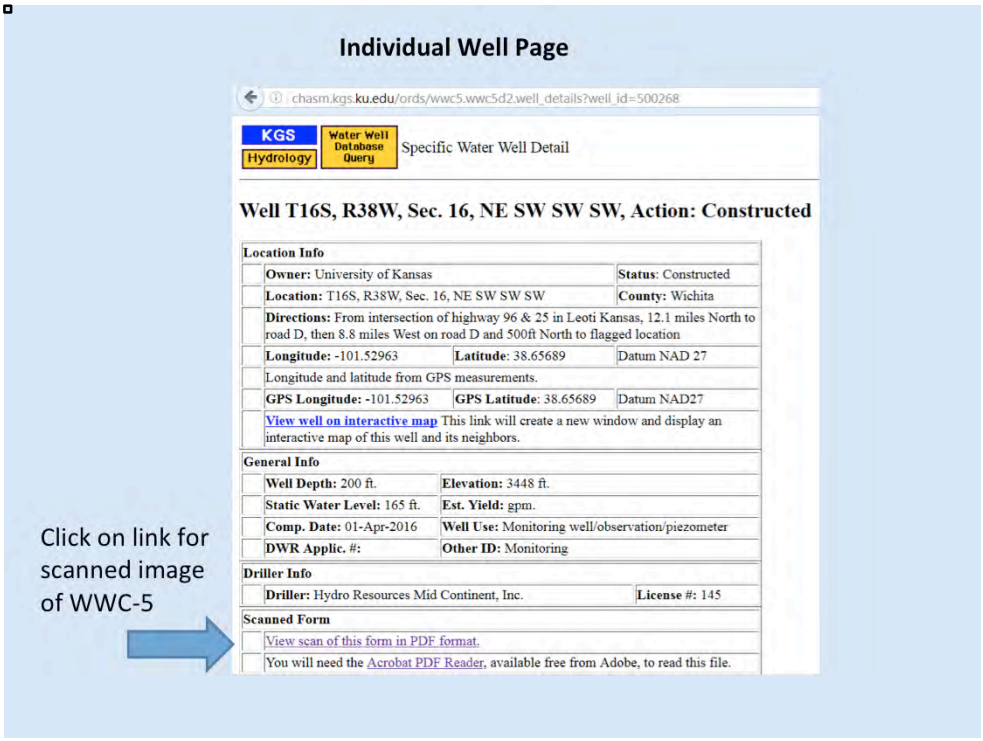
If you click on “WWC5 Database” on the “Water” page, you will get this WWC5 search page. You can search by section, township, and range, or you can search by county. Or if you want to see a list of wells for an entire township, just put in the township and range numbers, but no section number. Be sure to activate the little dot beside either East or West, depending on whether you want to search in the East or the West ranges.

Also, please note that you can get to the interactive WWC5 mapping tool directly by clicking on the “Interactive Map” link here, or you can get to it from the individual well page, which we will show you in a minute.

In this case, we have entered the location of a KGS Index Well in Wichita County. If you search on that location, you will get the following page.

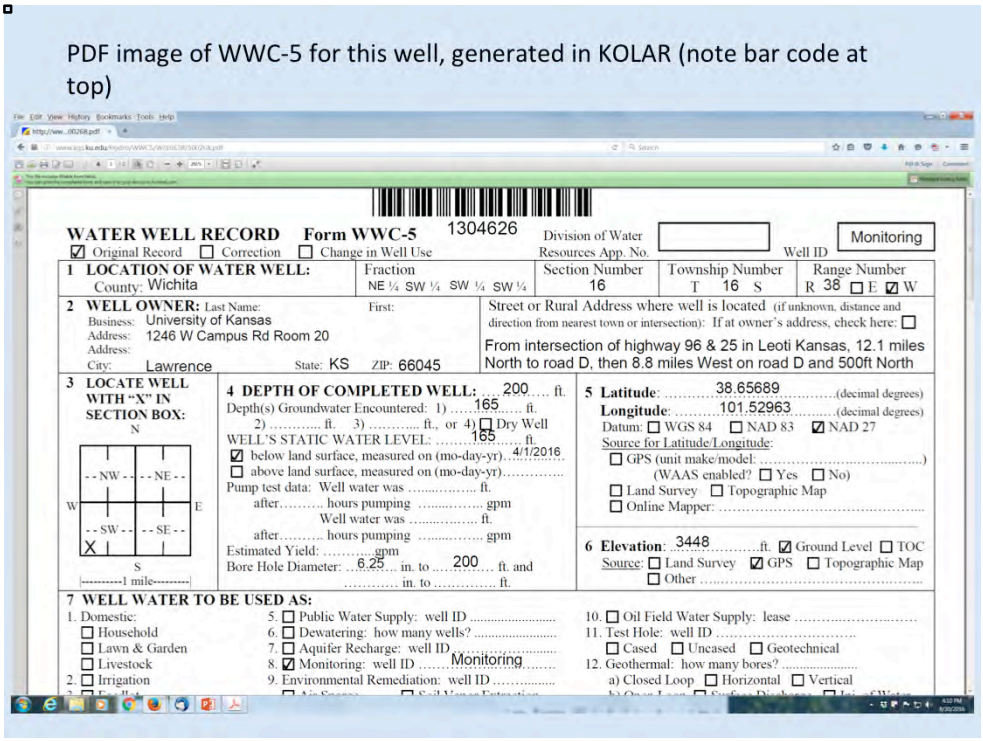


This is a chart showing all the records we have for water wells in this section. We show five wells in that section. You can perform different functions on this page (see notes on slide). For example, if you get a list of 50 or 100 wells and you only want to see the most recent ones, you can sort by completion date in descending order, which will bring the most recent wells to the top of the list. Or, you can sort the wells by depth in descending order, which will bring the deepest wells to the top of the list. If you click on one of the “PDF” or “KOLAR PDF” links on the right, you will see a scanned image of the WWC-5 form for that particular well. If you click on the fourth location link on the left, you will get the following page.



This is part of the individual well page that shows the basic information about that well. Here again you can access a scanned image of the WWC-5 itself by clicking on the indicated link.

PDF image of WWC-5 for this well, generated in KOLAR (note bar code at top)



WATER WELL RECORD Form WWC-5 1304626 Division of Water Resources App. No. Well ID Monitoring

☑ Original Record ☐ Correction ☐ Change in Well Use

1 LOCATION OF WATER WELL: County: Wichita | Fraction: NE ¼ SW ¼ SW ¼ SW ¼ | Section Number: 16 | Township Number: T 16 S | Range Number: R 38 ☐ E ☑ W

2 WELL OWNER: Last Name: First: Business: University of Kansas Address: 1246 W Campus Rd Room 20 Address: City: Lawrence State: KS ZIP: 66045

Street or Rural Address where well is located (if unknown, distance and direction from nearest town or intersection): If at owner's address, check here: ☐

From intersection of highway 96 & 25 in Leoti Kansas, 12.1 miles North to road D, then 8.8 miles West on road D and 500ft North

3 LOCATE WELL WITH "X" IN SECTION BOX: N / W / E / S; NW, NE, SW, SE; X; ----------1 mile----------

4 DEPTH OF COMPLETED WELL: 200 ft.
Depth(s) Groundwater Encountered: 1) 165 ft. 2) ..... ft. 3) ..... ft., or 4) ☐ Dry Well
WELL'S STATIC WATER LEVEL: 165 ft.
☑ below land surface, measured on (mo-day-yr) 4/1/2016
☐ above land surface, measured on (mo-day-yr)
Pump test data: Well water was ..... ft. after ..... hours pumping ..... gpm
Well water was ..... ft. after ..... hours pumping ..... gpm
Estimated Yield: ..... gpm
Bore Hole Diameter: 6.25 in. to 200 ft. and ..... in. to ..... ft.

5 Latitude: 38.65689 (decimal degrees)
Longitude: 101.52963 (decimal degrees)
Datum: ☐ WGS 84 ☐ NAD 83 ☑ NAD 27
Source for Latitude/Longitude:
☐ GPS (unit make/model:) (WAAS enabled? ☐ Yes ☐ No)
☐ Land Survey ☐ Topographic Map
☐ Online Mapper:

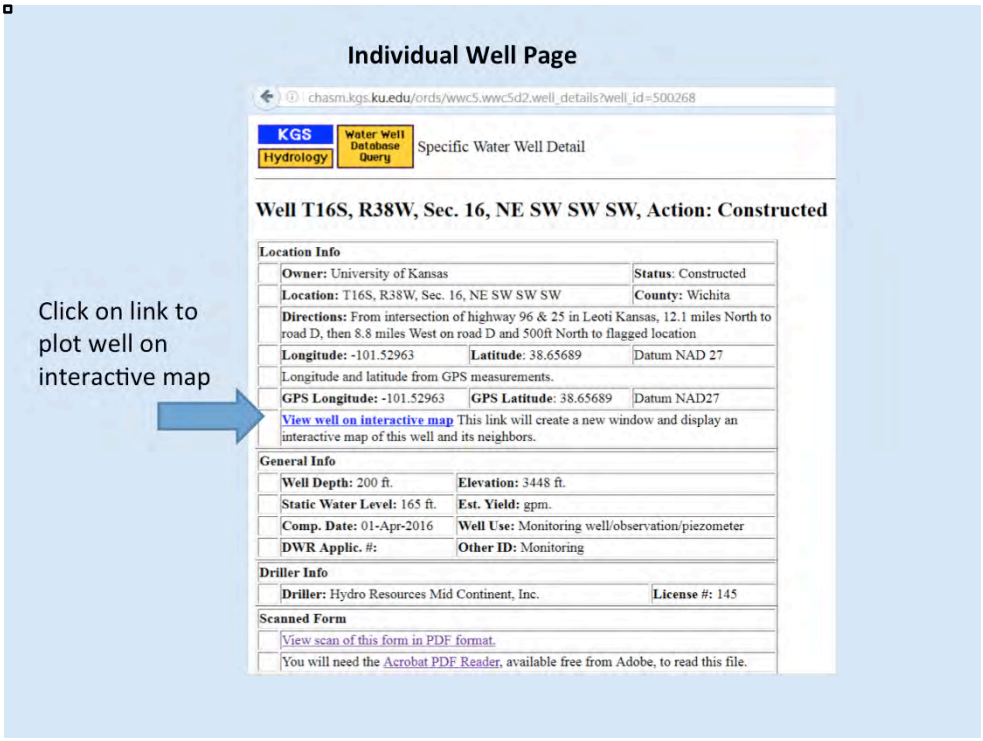
6 Elevation: 3448 ft. ☑ Ground Level ☐ TOC
Source: ☐ Land Survey ☑ GPS ☐ Topographic Map ☐ Other

7 WELL WATER TO BE USED AS:
1. Domestic: ☐ Household ☐ Lawn & Garden ☐ Livestock
2. ☐ Irrigation
5. ☐ Public Water Supply: well ID
6. ☐ Dewatering: how many wells?
7. ☐ Aquifer Recharge: well ID
8. ☑ Monitoring: well ID Monitoring
9. Environmental Remediation: well ID
10. ☐ Oil Field Water Supply: lease
11. Test Hole: well ID ☐ Cased ☐ Uncased ☐ Geotechnical
12. Geothermal: how many bores? a) Closed Loop ☐ Horizontal ☐ Vertical

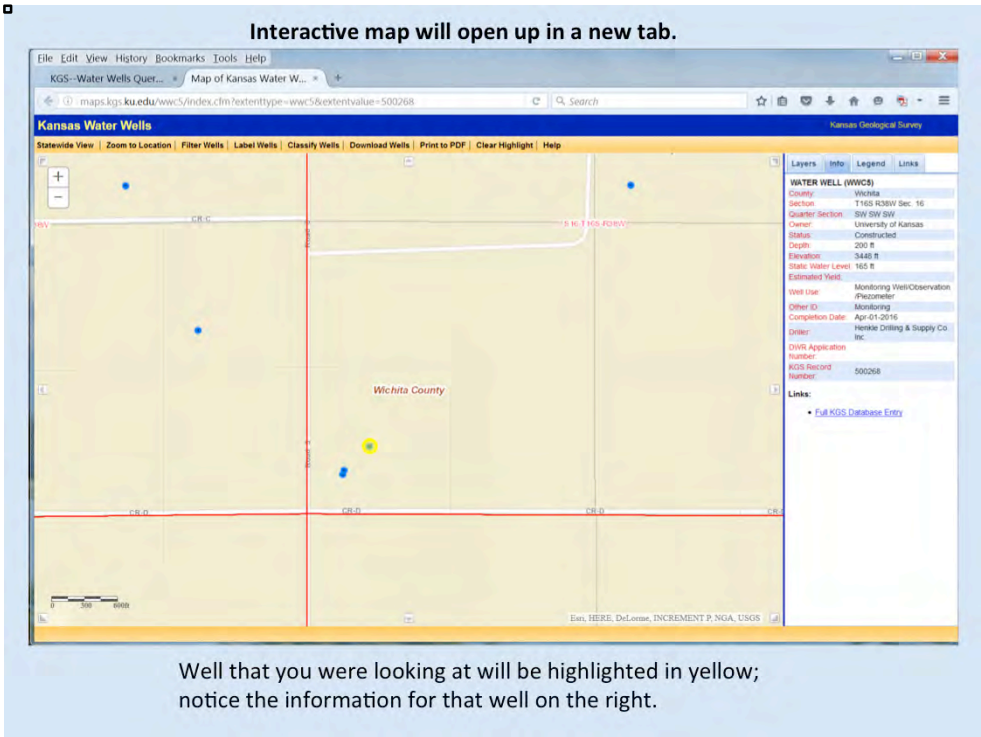
Here is a scanned image of the upper part of the WWC-5 for this well. The bar code at the top indicates that this image was created by KOLAR.

Also, note the latitude and longitude are given in decimal degrees and that NAD 27 is checked for the datum. Once this information is entered into KOLAR, then the county, fraction, and section, township, and range fields fill in automatically. Notice that the quarters are listed down to four divisions.

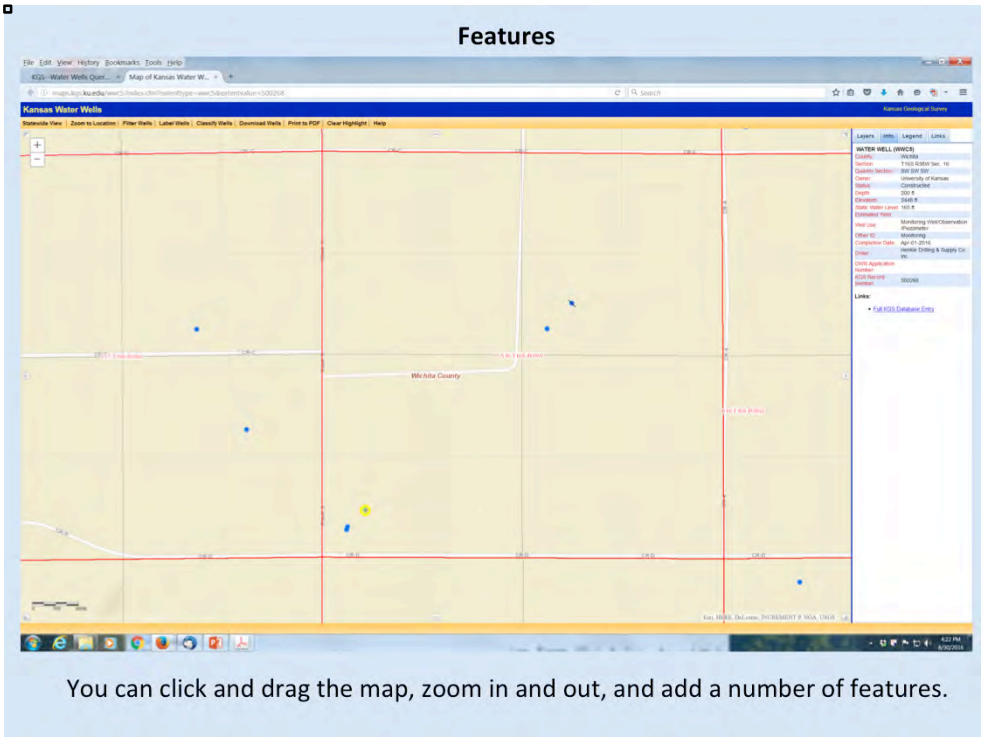
Also note the great written description of the location, which is very important in backing up the other location information.



If we go back to the individual well page, you can plot this well on an interactive map by clicking on the “View well on interactive map” link. It will open up a new tab or a new window that shows the mapping tool.

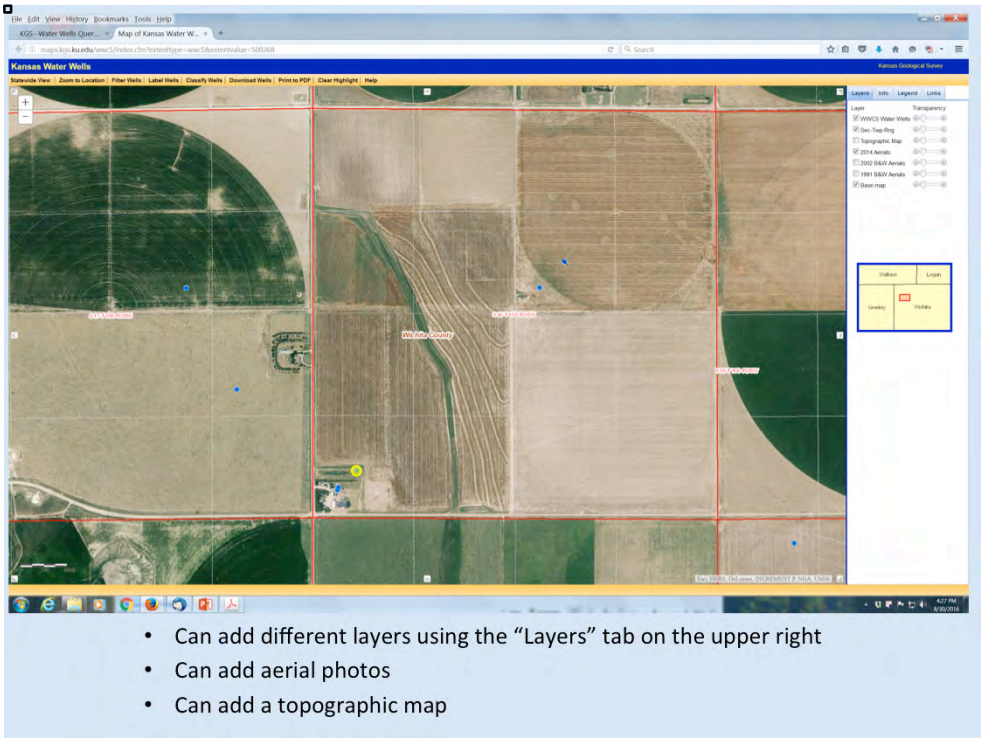


This is what that mapping tool looks like. The water wells are indicated by the blue dots on the map. The individual well that you were looking at will be highlighted in yellow on the map, and basic information for that well will be shown on the right. If you click on one of the other wells on the map, its basic information will show up on the right. The red lines outline the section boundaries; and the section, township, and range are shown in the center of each section. Also, the county name is given.



You can click and drag the map, zoom in and out, and add a number of features.

You can click and drag the map to move to other locations, zoom in and out by using the scroll wheel on your mouse or by using the “+” or “-” buttons in the upper left corner of the map, or add a number of other features such as layers by using the “Layers” tab near the upper right corner of the map.



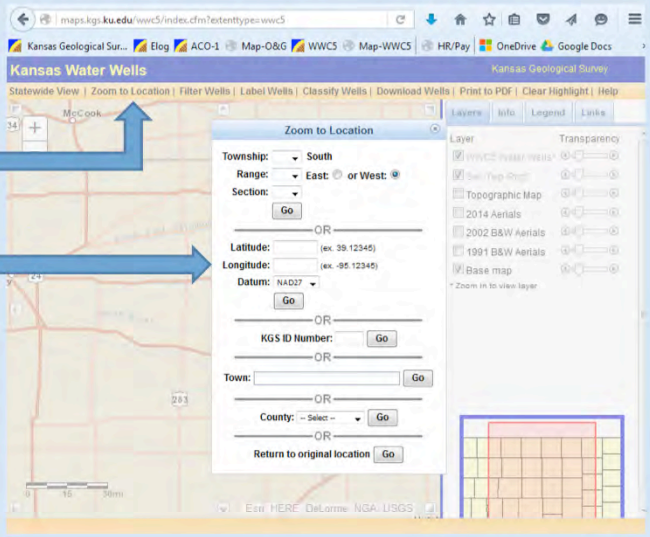
- Can add different layers using the “Layers” tab on the upper right
- Can add aerial photos
- Can add a topographic map

You can add a number of different layers to the map using the “Layers” tab (for example, aerial photos or a topographic map).

KGS Interactive Map of WWC-5 data

http://maps.kgs.ku.edu/wwc5/index.cfm?extenttype=wwc5

- Zoom to location
- Enter latitude, longitude, and datum, then click 'Go'

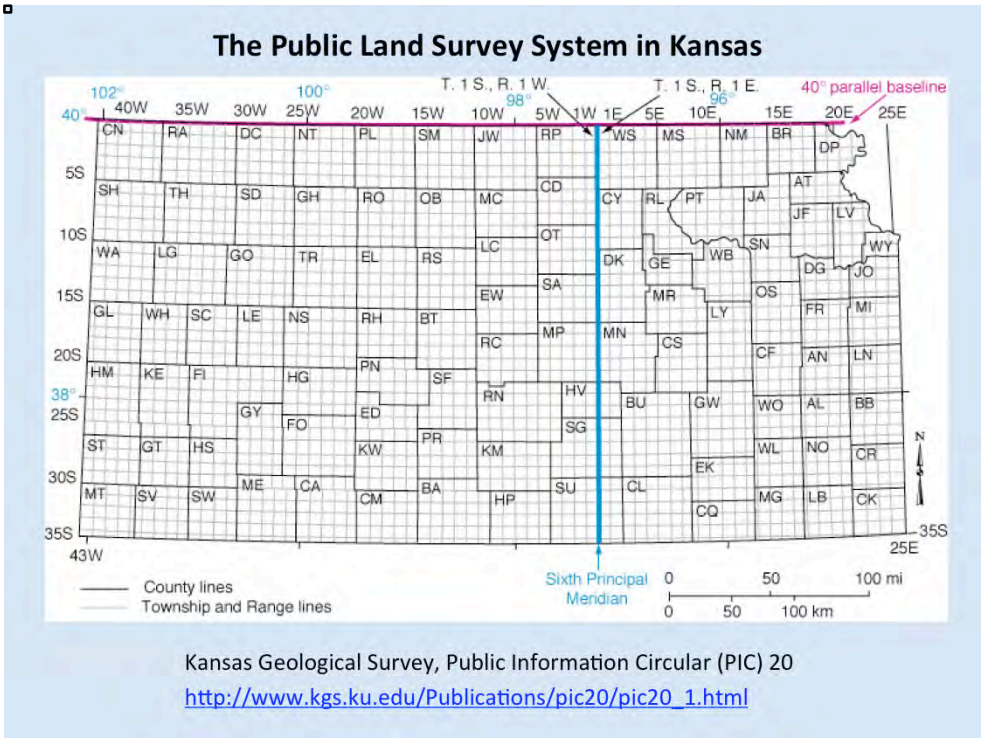


There are also a number of functions listed in the orange bar at the top of the map, such as showing well labels, zooming to a different location, or double checking your well location based on the lat/long values you have. If you ever need help using these tools or navigating our website, feel free to call us.

Now we will return to the original purpose of this presentation, which is reporting well location information. As it is in real estate, when it comes to water wells, everything is location, location, location. There are many places in Kansas where, if you drill at one location, you stand a pretty good chance of getting a successful well, but if you go a short distance away, you will not hit water. Location is so important! Also, if you are looking at a water well record and you don't know where that well is located, or if it is located in the wrong place, that record is useless to you.

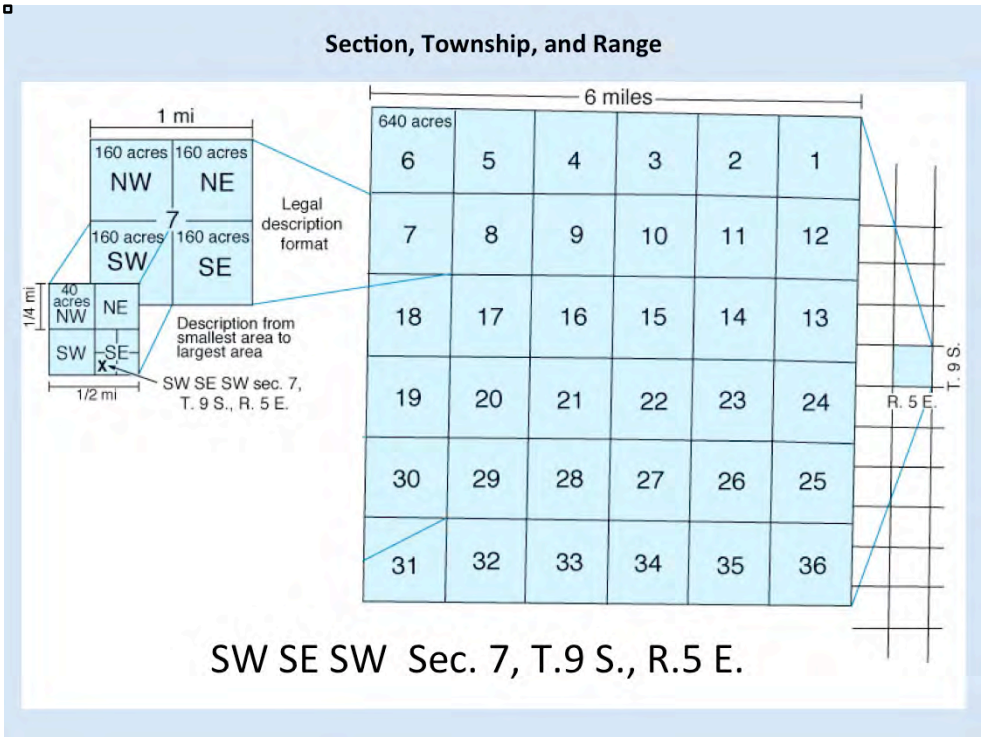
The collection of water well records that we have in the KGS Data Resources Library, most of which are recorded in our online database, are a tremendous information resource for anyone looking to drill a water well in the state. They tell you so much about the possibilities of drilling a successful well in a particular location and about what to expect when you drill that well. People use this information every day to make important decisions about whether and where to drill wells.

The problem we run into is that many well records that come to us have inaccurate locations. We spend a lot of time in the DRL trying to correct water well locations. And so we have put together this presentation to try to help you to submit the accurate well location information that we all need.



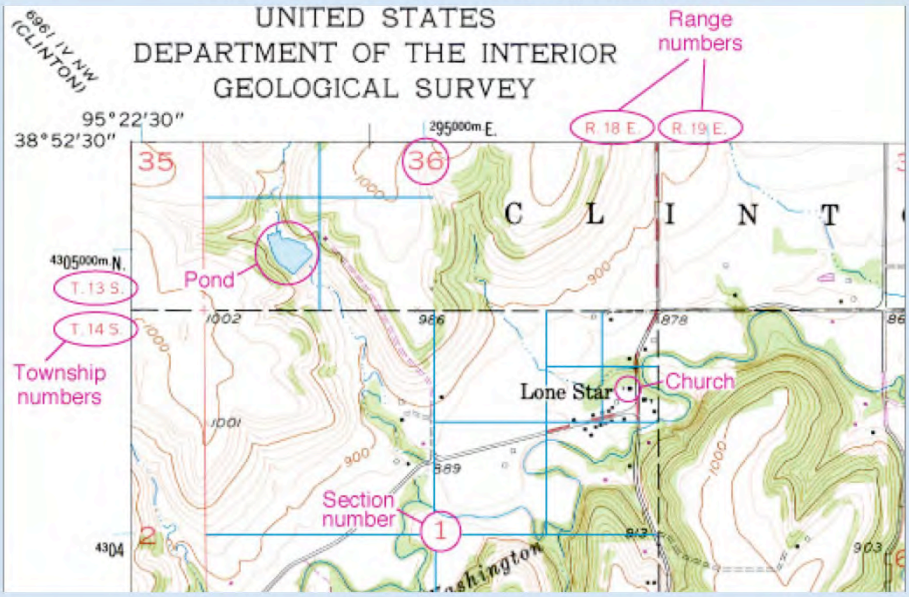
Kansas Geological Survey, Public Information Circular (PIC) 20
http://www.kgs.ku.edu/Publications/pic20/pic20_1.html

This is a map showing the basic structure of the Public Land Survey System (PLSS) in Kansas. Essentially this is a reference grid laid down on the Earth's surface that allows us to describe a location or a particular parcel of land. It is based on land surveys carried out on the surface of the Earth. The basic reference lines in our state are the 40th parallel at the Kansas/Nebraska border, and the Sixth Principal Meridian, which happens to run through the middle of Wichita. Townships are laid out across the state —a perfect one is 6 miles by 6 miles square—and they are given township and range numbers. Each of the small gray squares on this map outlines a township. The townships are numbered from 1 to 35 South, and they are given range numbers from 1 to 25 East and 1 to 43 West.



Within each township, which again is 6 miles by 6 miles square, there are 36 sections, which are 1 mile by 1 mile square. They are numbered 1 to 36 back and forth across the township as shown here. You will never see more than 36 sections in a township. Each 1-mile-square section is then divided into quarters, those quarters are divided into quarters, and so forth. In this example, we have chosen Township 9 South and Range 5 East, and then we have chosen section 7 within that township. The section is then divided into quarters, and we have placed an "X" at the location we wish to describe. The legal land description of that location is the Southwest quarter of the Southeast quarter of the Southwest quarter of Section 7, Township 9 South, Range 5 East, which is usually written as shown in the slide. Note that the legal description of quarters goes from smallest division on the left to largest division on the right.

USGS Topo. Map, small area in Douglas County, KS



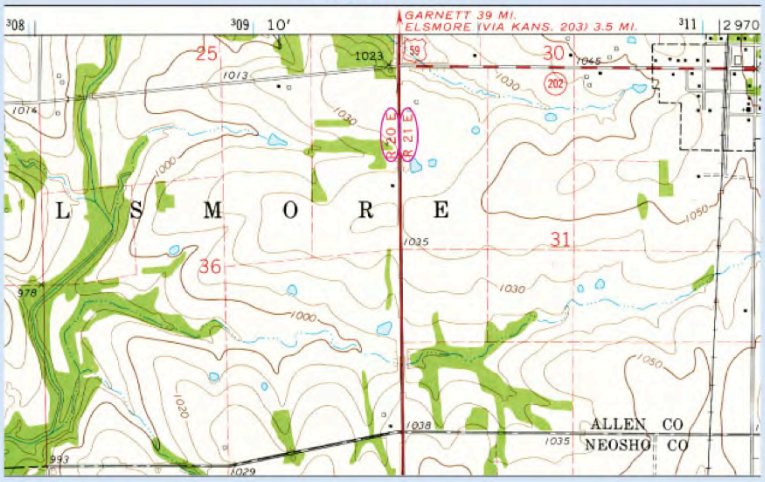
Church in Lone Star is in SE NE NE sec. 1, T.14S., R.18E.
Pond is in SW SW sec. 36, T.13S., R.18E.

Here you can see a small portion of a USGS topographic map showing the village of Lone Star southwest of Lawrence in Douglas County. The section numbers are shown, as are the township and range numbers. You can see that the locations of the church in Lone Star and the pond to the northwest of it are located as listed at the bottom of the slide.

Common Mistakes Made
when reporting section, township, & range:

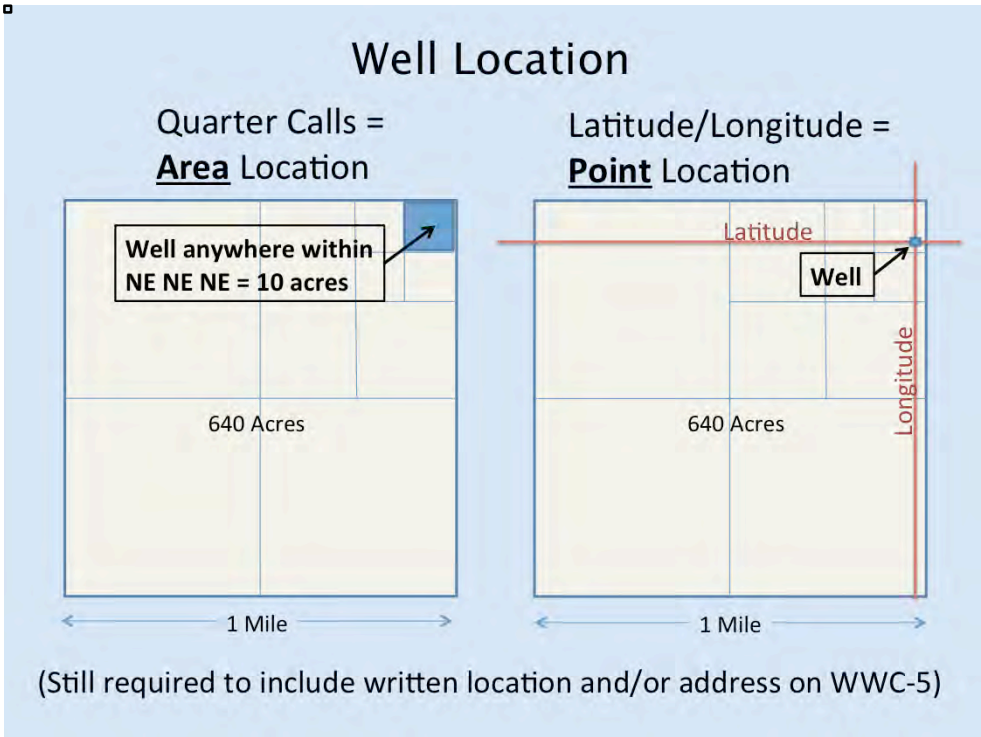
- Listing quarters in the wrong order (must be smallest to largest, left to right).
- Switching township and range numbers.
- Mislabeling ranges as to East and West.
- Designating two townships and two ranges (a section can be in only one township, which is designated by one township number and one range number).

Irregularities



- Edges of the state
- Military properties (e.g., Fort Riley)
- Major rivers
- Range 8 East
- Irregular sections (surveying adjustments)

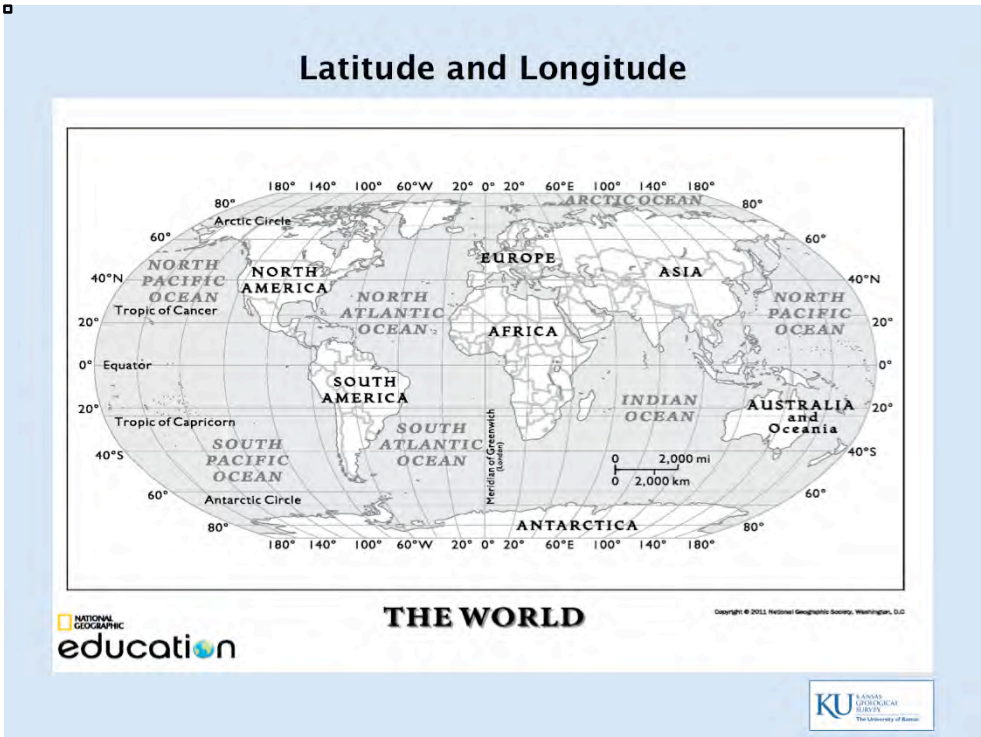
Not all townships or sections are perfect. Irregularities are pretty common around the state, particularly in the places listed on the slide. Here you can see where a surveyor coming from one direction had to change course to meet up with a survey coming from the other direction so that the section corners would meet.



For our purposes for locating wells, legal land descriptions such as the Public Land Survey System (PLSS)—that is, Section-Township-Range and quarter calls—provide an estimate of a well location by defining an area; the well may be located anywhere within that area. For example, a 1-mile section is 640 acres, a quarter section is 160 acres, ¼ of that is 40 acres, and ¼ of that is 10 acres. So, if we have information about a well location down to three quarter divisions of a section, then all we really know is that that well is somewhere within that 10-acre parcel. That is why, if people are working with this method, we ask them to divide the quarters down to four divisions, which brings us down to 2.5 acres and is more precise than 10 acres.

Latitude and longitude, on the other hand, if done correctly, give a much more precise well location. It is essentially a point location. It is a coordinate, or grid, system that enables us to describe a well location by the intersection of two lines, one running east/west (lines of latitude), and the other running north/south (lines of longitude).

In either case, it is still very important to include a written location or address on the WWC-5 form, too, as a double-check of the well location.

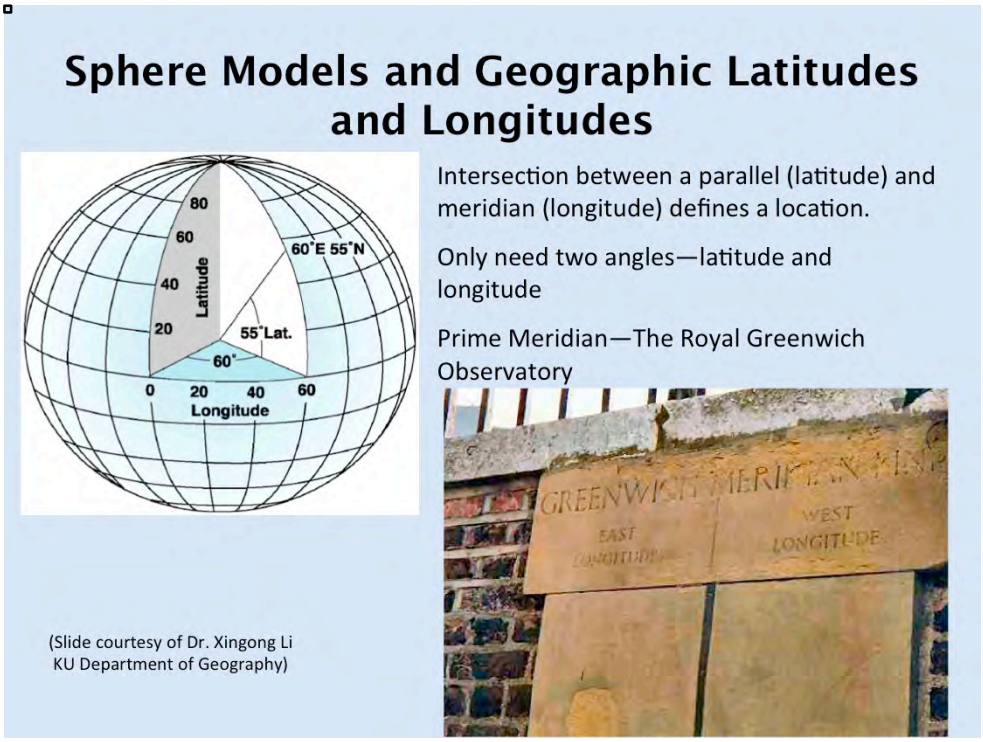


When filling out water well completion records (WWC-5s) in KOLAR, the latitude and longitude of the well location are required. Here is a global view of the lat/long coordinate grid.

Note the PRIME MERIDIAN (0 degrees, which runs through Greenwich, England) and the north/south lines of LONGITUDE, which are designated as west or east of the Prime Meridian.

Note the EQUATOR and the east/west lines of LATITUDE, which are designated as north or south latitude.

Together these form a GRID, or coordinate system, over the Earth that allows us to locate ourselves on the surface of the Earth.



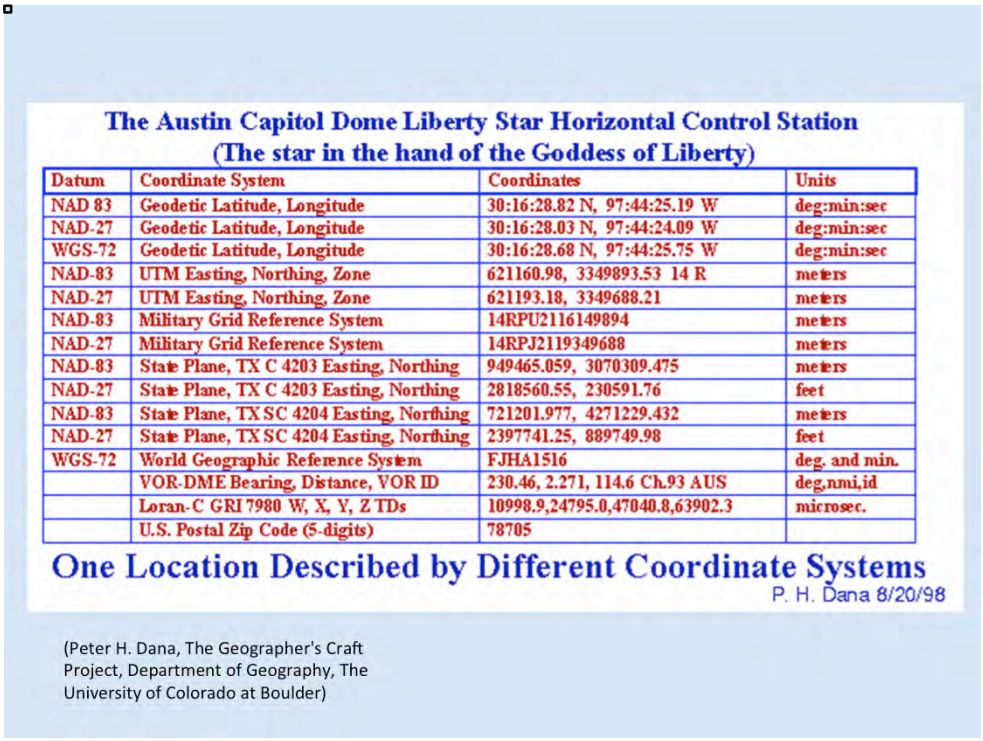
A coordinate system provides a way to specify a location on Earth. It is a reference grid system.

Lines of latitude run east and west (with the equator = zero) and for our purposes measure the distance north from the equator.

Lines of longitude run north and south (Greenwich meridian is zero) and for our purposes measure the distance west of the Prime Meridian in Greenwich, England.

In actual fact, they are measured as angles from the center of the Earth. For example, 55 degrees N latitude is defined as the intersection of a line drawn at a 55-degree angle northward from a line parallel to the equator. Likewise, 60 degrees E longitude is drawn at a 60-degree angle eastward from the Prime Meridian.

Kansas lies within the following coordinates:
37 degrees N to 40 degrees North
~ 94.5 degrees to ~102 degrees West, reported as negative (- 94.5 to -102).



The Austin Capitol Dome Liberty Star Horizontal Control Station
(The star in the hand of the Goddess of Liberty)

Datum	Coordinate System	Coordinates	Units
NAD 83	Geodetic Latitude, Longitude	30:16:28.82 N, 97:44:25.19 W	deg:min:sec
NAD-27	Geodetic Latitude, Longitude	30:16:28.03 N, 97:44:24.09 W	deg:min:sec
WGS-72	Geodetic Latitude, Longitude	30:16:28.68 N, 97:44:25.75 W	deg:min:sec
NAD-83	UTM Easting, Northing, Zone	621160.98, 3349893.53 14 R	meters
NAD-27	UTM Easting, Northing, Zone	621193.18, 3349688.21	meters
NAD-83	Military Grid Reference System	14RPU2116149894	meters
NAD-27	Military Grid Reference System	14RPJ2119349688	meters
NAD-83	State Plane, TX C 4203 Easting, Northing	949465.059, 3070309.475	meters
NAD-27	State Plane, TX C 4203 Easting, Northing	2818560.55, 230591.76	feet
NAD-83	State Plane, TX SC 4204 Easting, Northing	721201.977, 4271229.432	meters
NAD-27	State Plane, TX SC 4204 Easting, Northing	2397741.25, 889749.98	feet
WGS-72	World Geographic Reference System	FJHA1516	deg. and min.
	VOR-DME Bearing, Distance, VOR ID	230.46, 2.271, 114.6 Ch.93 AUS	deg,nmi,id
	Loran-C GRI 7980 W, X, Y, Z TDs	10998.9,24795.0,47040.8,63902.3	microsec.
	U.S. Postal Zip Code (5-digits)	78705	

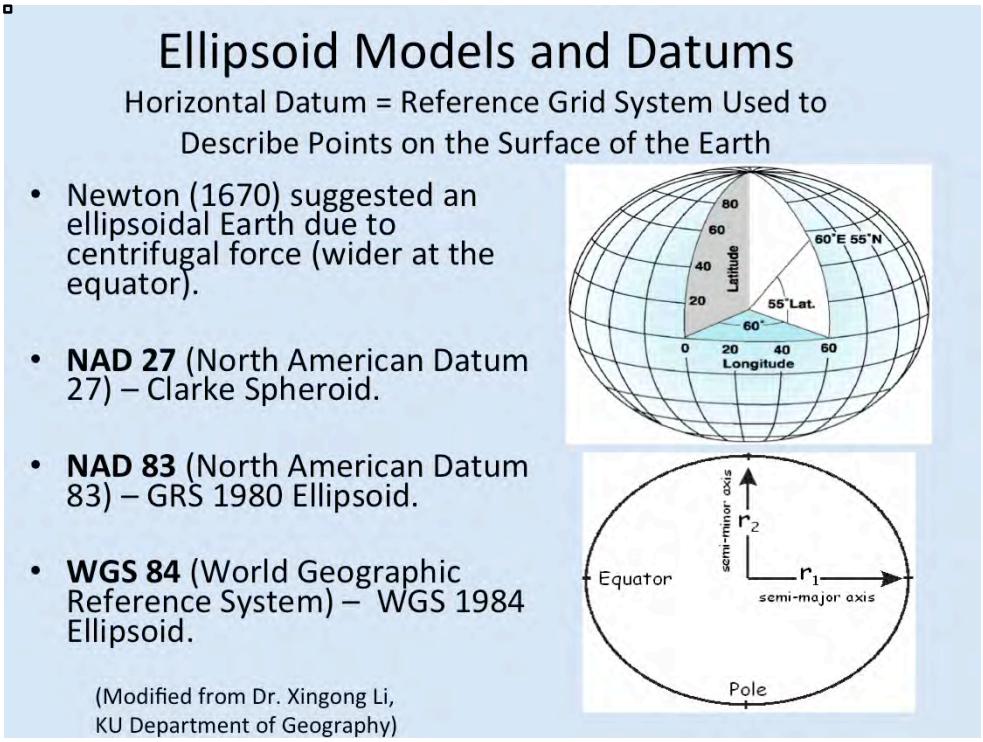
One Location Described by Different Coordinate Systems

P. H. Dana 8/20/98

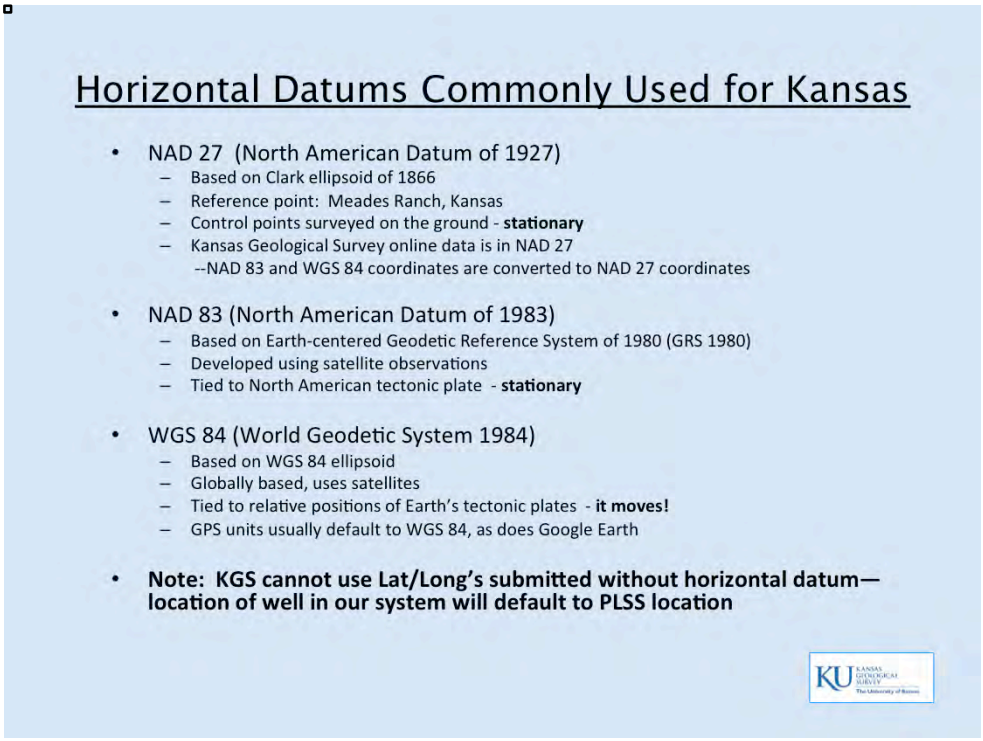
(Peter H. Dana, The Geographer's Craft Project, Department of Geography, The University of Colorado at Boulder)

The latitude/longitude system is only one of many coordinate systems.

This table shows the same location (the star in the hand of Goddess of Liberty statue at the Austin Capitol Dome) described differently using different coordinate systems. You see lat/long, but you also see UTM (Universal Transverse Mercator) system, a military grid system, and state plane coordinates, etc. We do sometimes get people submitting some of these other coordinates, especially state plane coordinates, but we don't have an easy way of dealing with these other systems, and so we ask you to please do not use them. Submit your coordinates as latitude and longitude. Just be sure to tell us which datum you used.



We can't talk about lat/long without talking about datums. And we can't really talk about datums without mentioning ellipsoids or spheroids. A sphere is essentially a round ball that is perfectly circular in cross section. A spheroid approaches the shape of a perfect sphere. An ellipse is somewhat flattened relative to a perfect circle. And so an ellipsoid is a 3D shape that is somewhat flattened relative to a perfect sphere. The Earth is not a perfect sphere. And Isaac Newton, as early as 1670, realized that the shape of the Earth is more accurately described as an ellipsoid that bulges at the equator due to centrifugal force caused by the Earth's rotation about its axis. In fact, it is even more complex than that due to differences in elevation and gravity, etc. So, to deal with this when trying to measure latitude and longitude, people over the years have set up different types of theoretical reference spheroids or ellipsoids that are tied to the earth in different ways. They use these shapes to define their coordinate grids on the surface of the Earth. And thus we come up with the concept of **datums**, which essentially are these reference grid systems set up over the Earth for defining your location on the Earth. The three datums that are most often used are called NAD 27, NAD 83, and WGS 84.



NAD 27, or the North American Datum that was set up in 1927, was based on the Clarke Spheroid and is tied to the North American continent.

NAD 83, or the North American Datum of 1983, was based on the GRS 1980 ellipsoid and is tied to the North American continent.

WGS 84, or the World Geographic Reference System that was set up in 1984, was based on the WGS 1984 ellipsoid and is tied generally to the Earth's geologic crustal plates.

So each one is tied to a different reference ellipsoid, which causes the latitude and longitude readings to be slightly different from one system to the next.

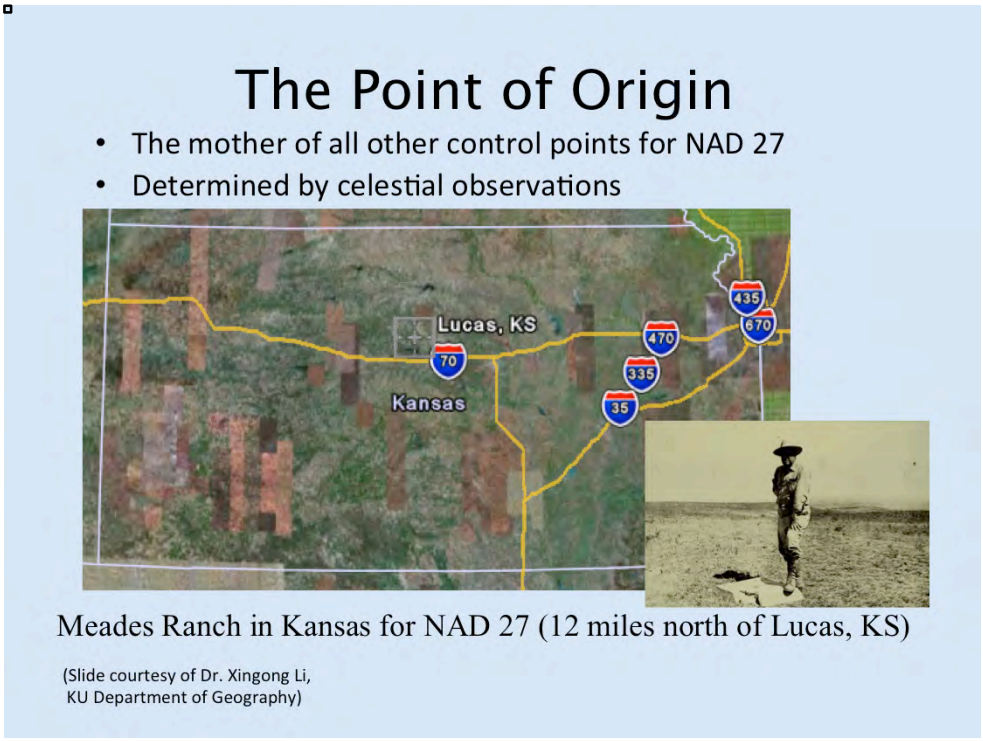
Also, while the NAD 27 datum was measured on the ground with the help of celestial observations (that is, using the stars, sun, etc., to locate oneself), the NAD 83 and WGS 84 datums were based on satellite measurements and thus are much more accurate.

When WGS 84 was initiated in the 1980s, it was nearly identical to NAD 83. However, since then the North American tectonic plate has moved relative to the other tectonic plates and, consequently, relative to the WGS 84 grid. As a result, NAD 83 coordinates in Kansas now differ from WGS coordinates by roughly 3.5 feet, and that difference will increase over time.

The difference between NAD 27 coordinates and those of NAD 83 and WGS 84 is much greater than that, as we will see in the next slide.

Note: The KGS online mapping programs cannot use lat/longs submitted without datum; the location of the well will default to PLSS location.

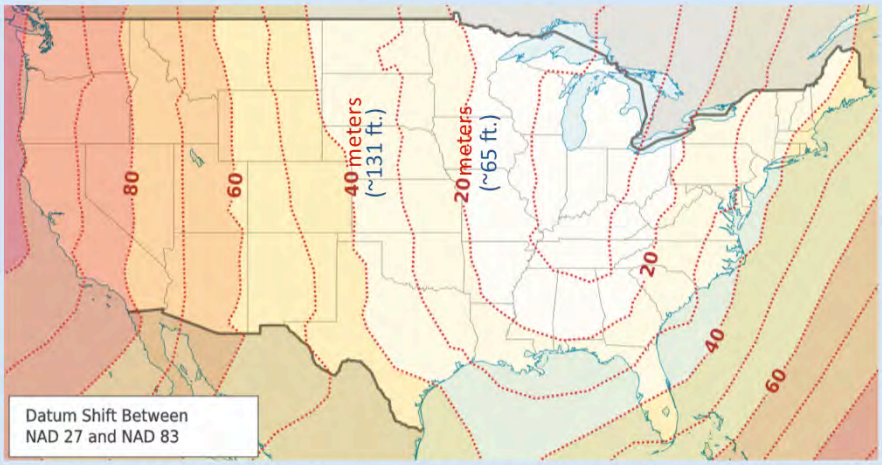
For general purposes in the midcontinent, many consider NAD 83 and WGS 84 nearly interchangeable.



For NAD 27, the primary control point from which all others are measured in North America is located 12 miles north of Lucas, Kansas. NAD 83 and WGS 84 do not have one specific control point.

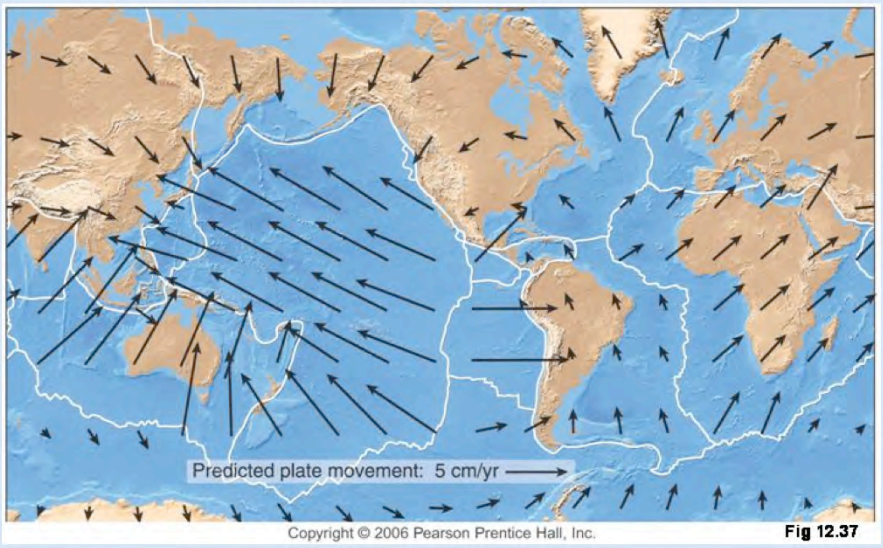
Datum shift between NAD 27 and NAD 83

- Horizontal Datum Shift: **same coordinates with different horizontal datums result in different locations**



Graphic modified from: http://en.wikipedia.org/wiki/North_American_Datum#mediaviewer/File:Datum_Shift_Between_NAD27_and_NAD83.png

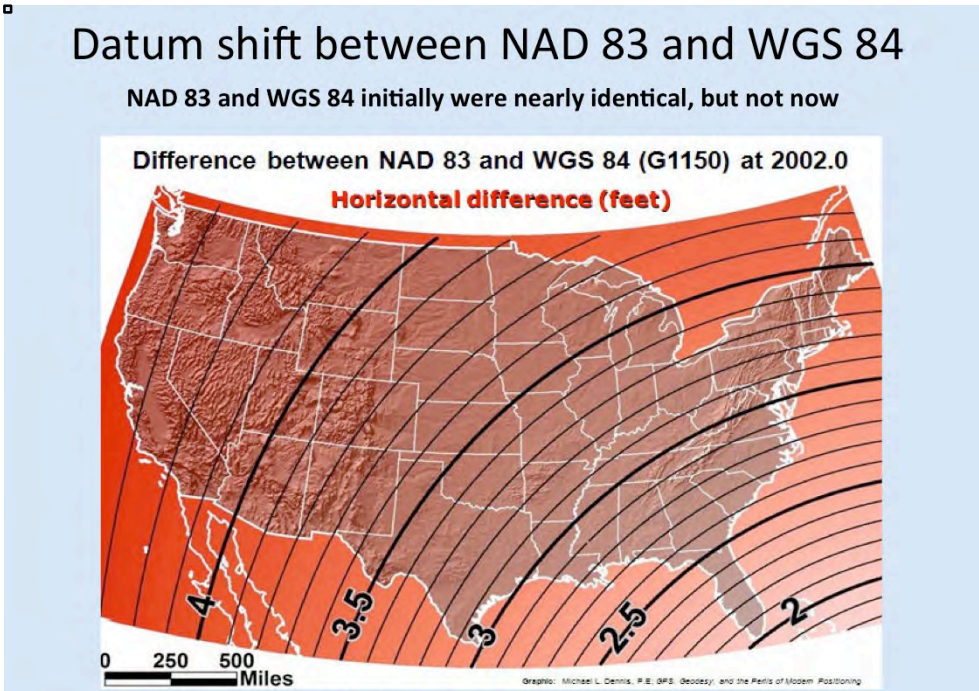
The difference between NAD 27 and NAD 83 in Kansas ranges from 20 to 40 meters (roughly 65 to 131 feet). So, changing the datum can potentially change the reported location of the well by up to 130 feet, which can place it in another section or on someone else's property.



- WGS 84 horizontal datum is tied to the relative rate of movement of the tectonic plates, but its reference pole, meridian, and equator are very close to the geographic north pole, the Greenwich Prime Meridian, and the geographic equator. Other places on Earth's surface move relative to that reference ellipsoid.

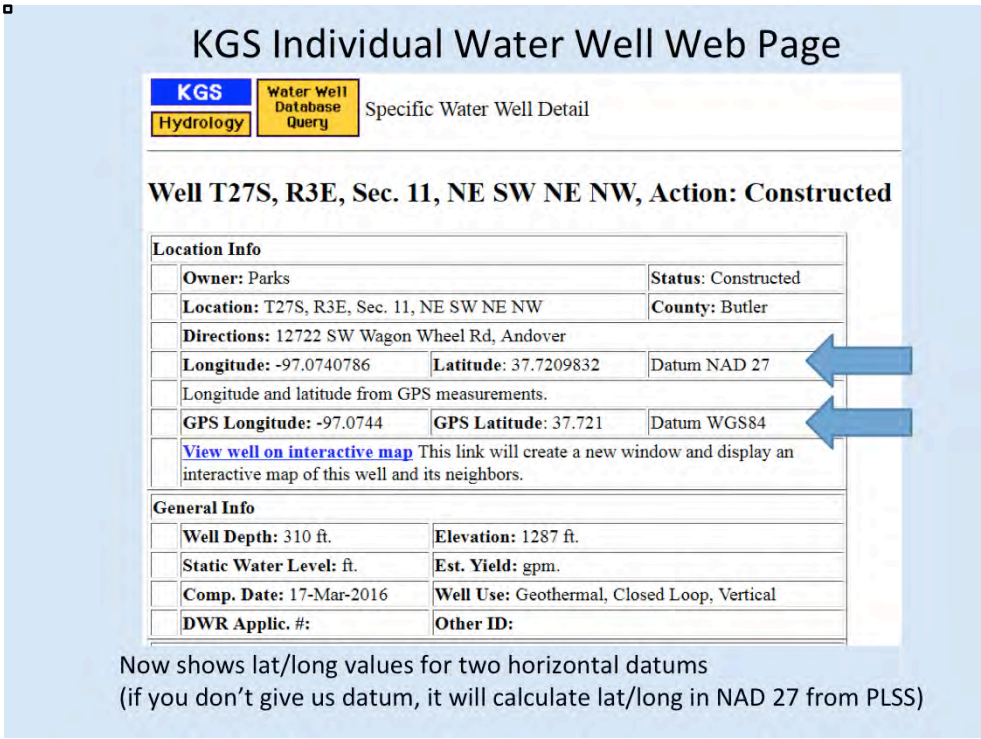
(Credit: Pearson Prentice Hall, Inc.)

As previously mentioned, WGS 84 is tied to the relative positions of tectonic plates on the Earth's surface, the boundaries of which are shown in white on this map. The direction and amount of such movement are shown by the direction and sizes of the arrows on this map. Much of the continental U.S. moves on average 1-2 cm/year or 10-20 cm/decade relative to London. Some places, such as Hawaii, move as much as 10 cm/year, or 1 meter per decade, relative to England. So you can see that over time the relative plate positions can change by significant amounts.

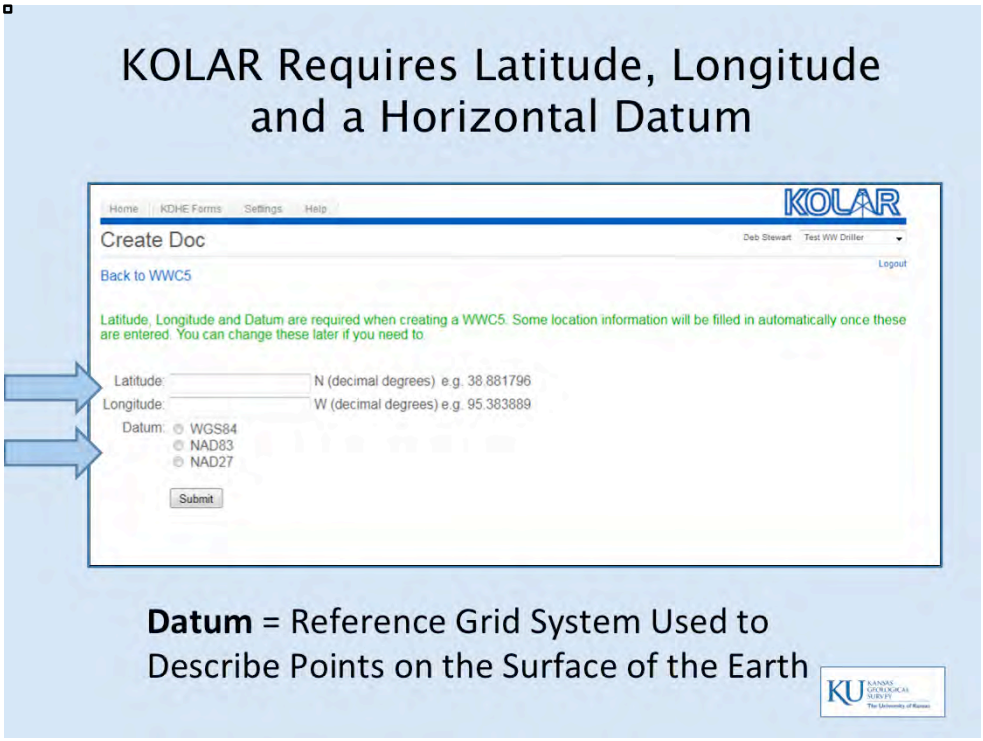


(Graphic from: http://www.spatial-ed.com/datums/datums-basics/532-convert-wgs84-nad83.html)

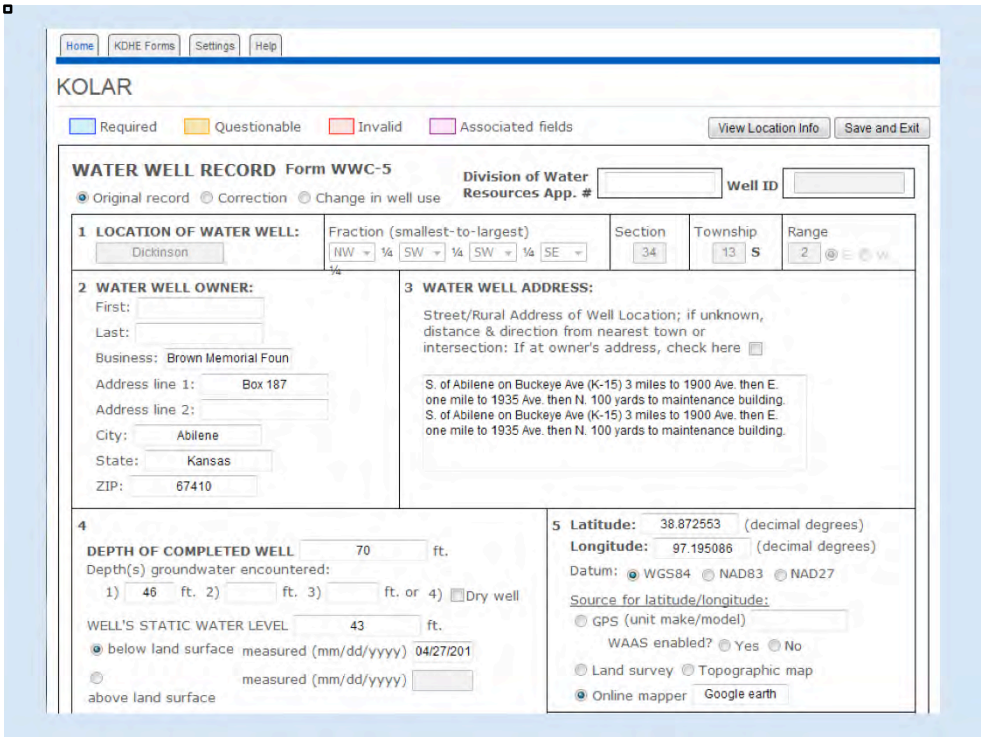
The difference between NAD 83 and WGS 84 in Kansas presently ranges from about 3.4 feet to 3.7 feet, which is not really that much if you're simply trying to find a well, and that is why the two are sometimes used interchangeably in much of North America. But that difference will increase over time as the Earth's tectonic plates move. But, as I said before, the difference between these two horizontal datums and NAD 27 can be up to 130 feet in Kansas, and so it is very important for you to give us the datum you are using when you give us latitude and longitude for a well location.



The KGS individual water well web page now shows lat/longs for two different horizontal datums, NAD 27 and the datum that was submitted by the driller. So now you won't be confused if you see that the lat/long coordinates you submitted are not exactly the ones shown on our website. If you don't give us the datum, we can't use the lat/long and the location information will revert to the PLSS, and the lat/long will be calculated in NAD 27 based on the center of the smallest quarter division you give us. That is, if you give us three quarter divisions, it will calculate the center of that 10-acre parcel. If you give us four quarter divisions, it will calculate the center of that 2.5-acre parcel.

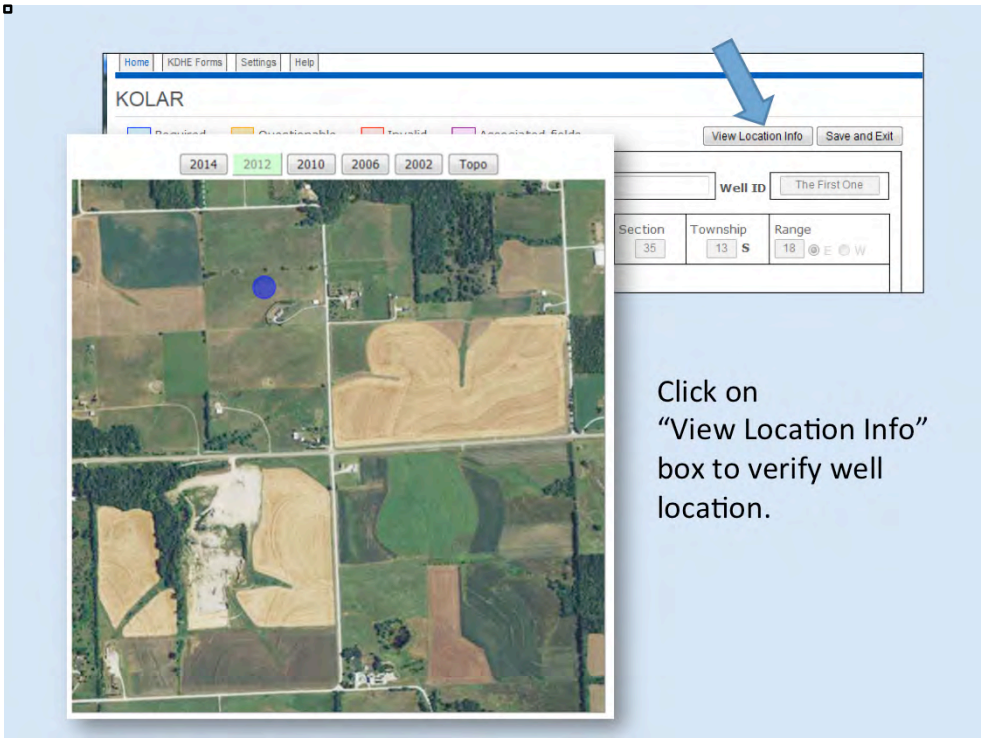


If you submit your WWC-5s through KOLAR, which we hope that eventually all water well drillers in Kansas will do, KOLAR requires latitude and longitude in decimal degrees and it requires that you tell us which horizontal datum you used.

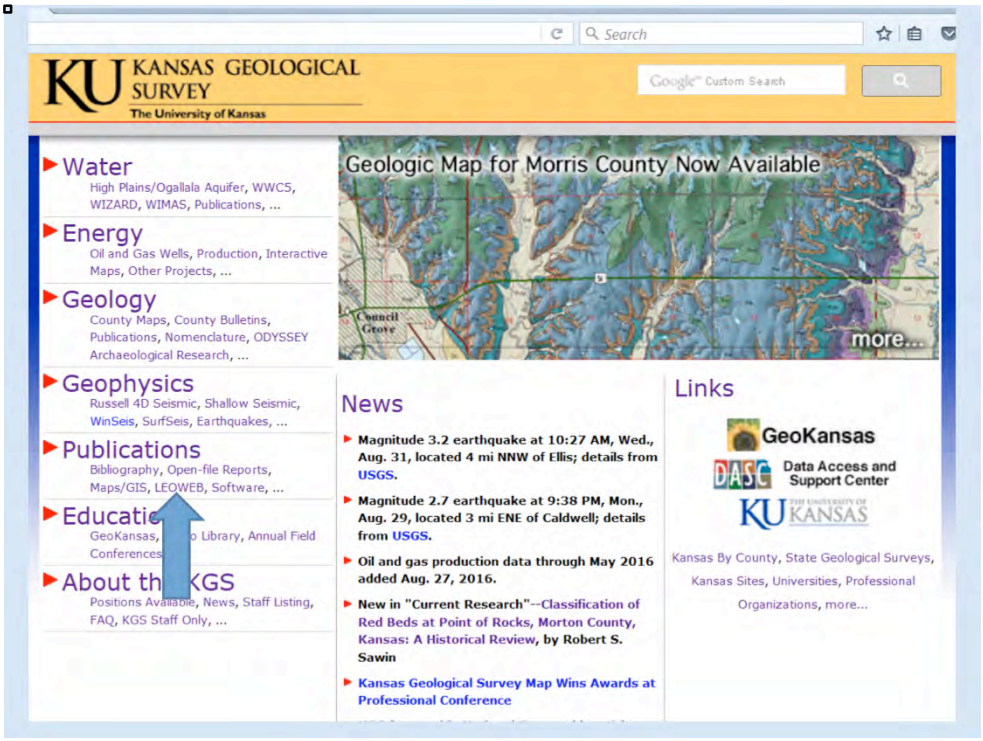


The nice thing is that, once you have entered the latitude and longitude, these fields fill in automatically: county, section-township-range, and quarters (down to four divisions).

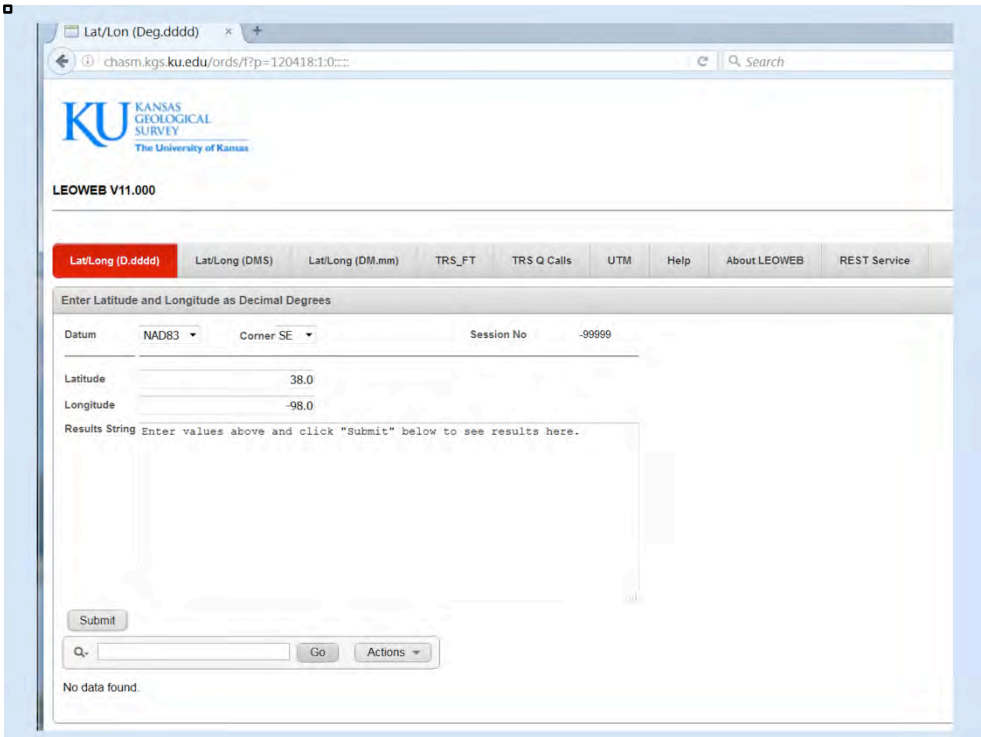
If you click on the “View Location Info” button in the upper right corner, it will give you an image of the section with a dot showing the location of the well according to the lat/longs that you entered.



This is what you will see if you click on the "View Location Info" button on the KOLAR form; it will show you a view of the section with an aerial photo and a blue dot showing the location of the well as you entered it. If it looks right, you're OK. If it doesn't look right, you may want to go back and adjust your lat/long values or your datum to put it where it needs to be.

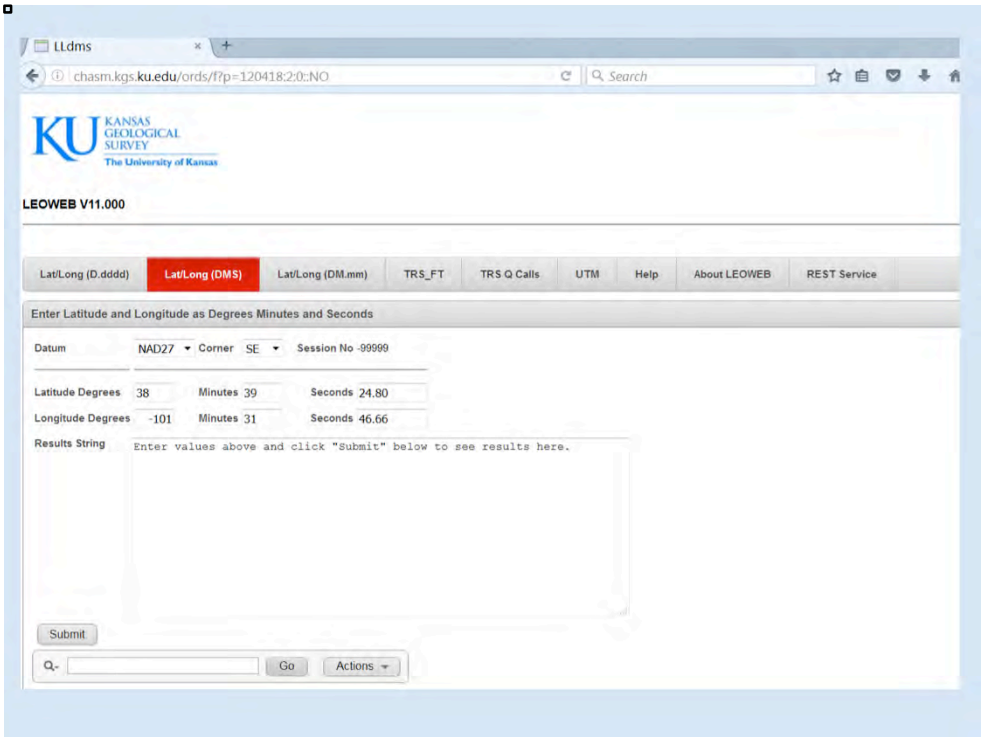


For those of you still submitting paper WWC-5s, or if you need it for other purposes, there is a program on our website called LEOWEB that will convert latitude and longitude to section, township, and range, and vice versa. Click on the link identified by the arrow.

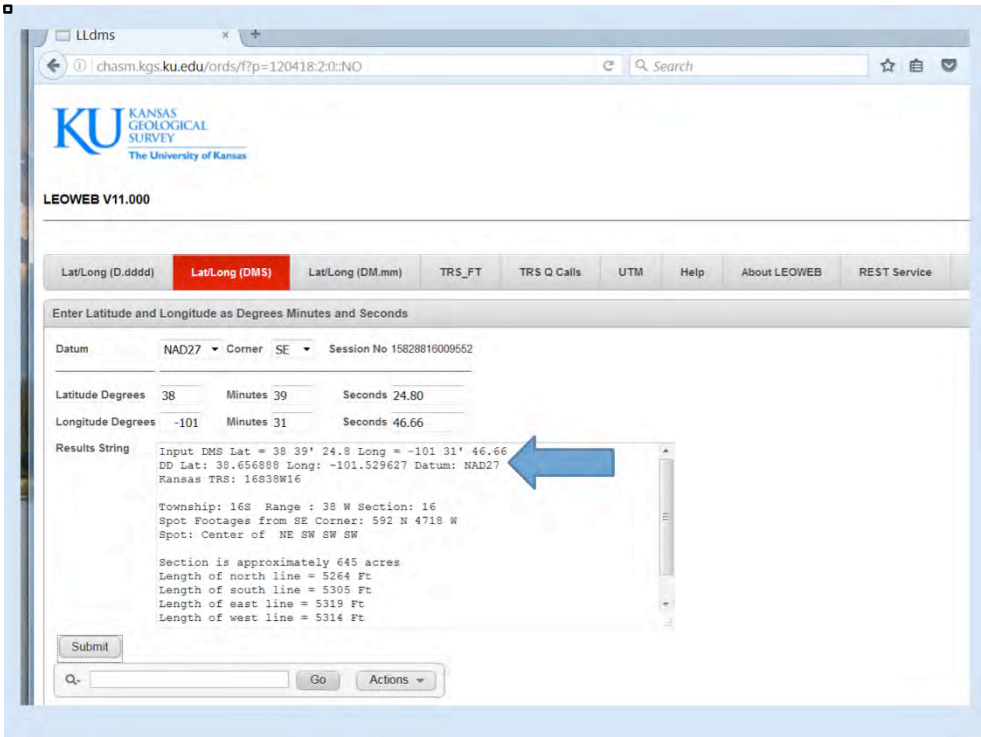


If you click on the LEOWEB link, you will get this page. It initially asks for decimal degrees, but you have the option of using degrees, minutes, and seconds, or degrees and decimal minutes by choosing the corresponding tab.

Or, as I said, you can also convert township-range-section and quarter calls to lat/longs.

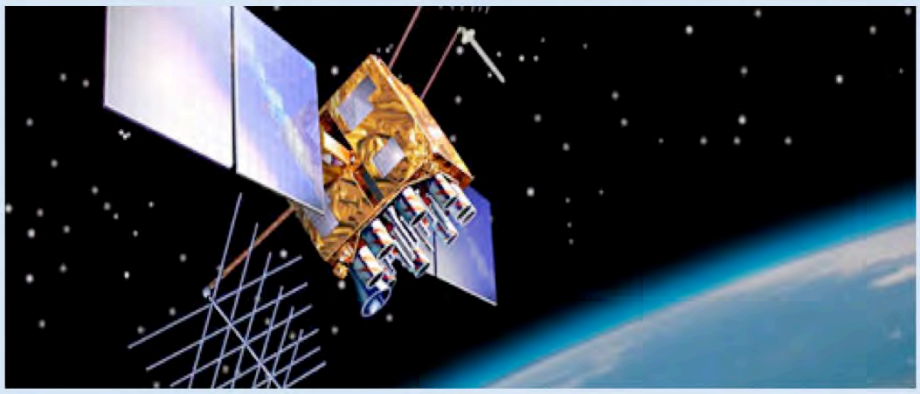


If you have a GPS device that only gives lat/longs in degrees, minutes, and seconds, you could use LEOWEB to give you those coordinates in decimal degrees, although there are other options out there that we will mention later. If you enter your degrees, minutes, and seconds values using the "Lat/Long (DMS)" option and click "Submit," you will get the following.



This is where you will see that it gives you the values in decimal degrees.

The Global Positioning System (GPS)



A user's GPS device receives signals from satellites operated by the U.S. government and uses that information to calculate the user's position and time.

(Image from http://www.gps.gov/systems/gps/)

Now we will discuss the Global Positioning System (GPS) and the devices you might use to get latitude and longitude coordinates for well locations that you can then enter into KOLAR.

WHAT IS GPS?

"The Global Positioning System (GPS) is a U.S.-owned utility that provides users with positioning, navigation, and timing (PNT) services.

This system consists of three segments:

- the space segment
- the control segment
- the user segment

The U.S. Air Force develops, maintains, and operates the space and control segments.

The user segment of GPS technology (receiver equipment) is now in everything from cell phones and watches to bulldozers, shipping containers, and ATM's. "

(http://www.gps.gov/systems/gps/)

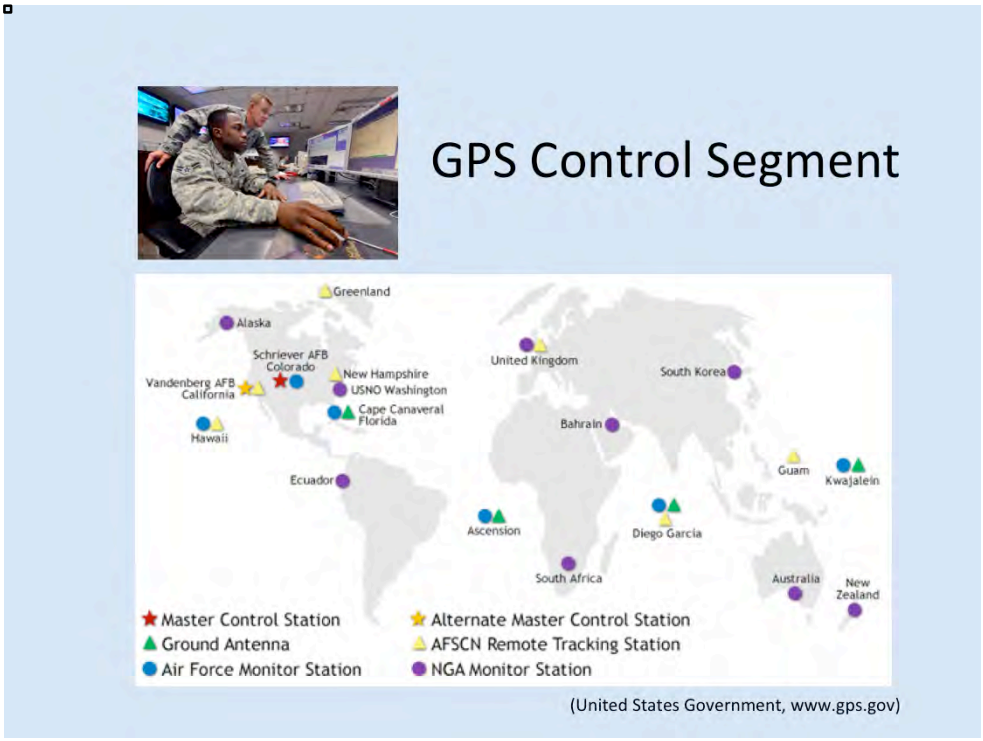
http://www.gps.gov/systems/gps/

GPS Space Segment

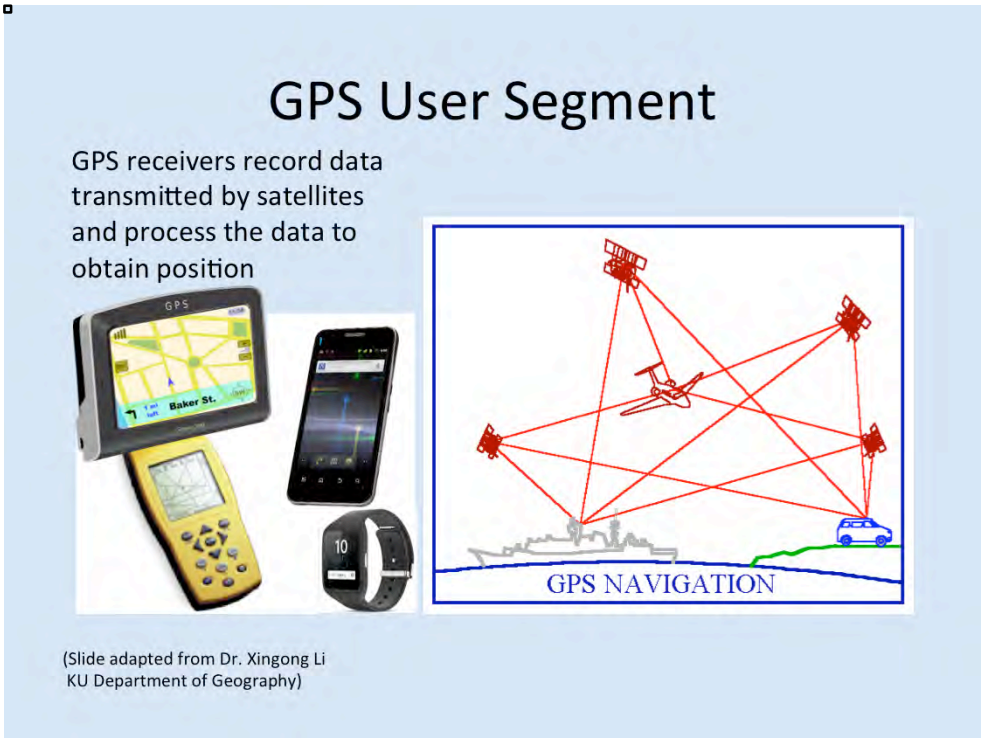
- A satellite-based global positioning system.
- It uses **distance measurements** to determine locations in 3-dimensional space.
- Typically it uses data from 4 different satellites that are part of a 24-satellite constellation.

(Slide courtesy of Dr. Xingong Li
KU Department of Geography)

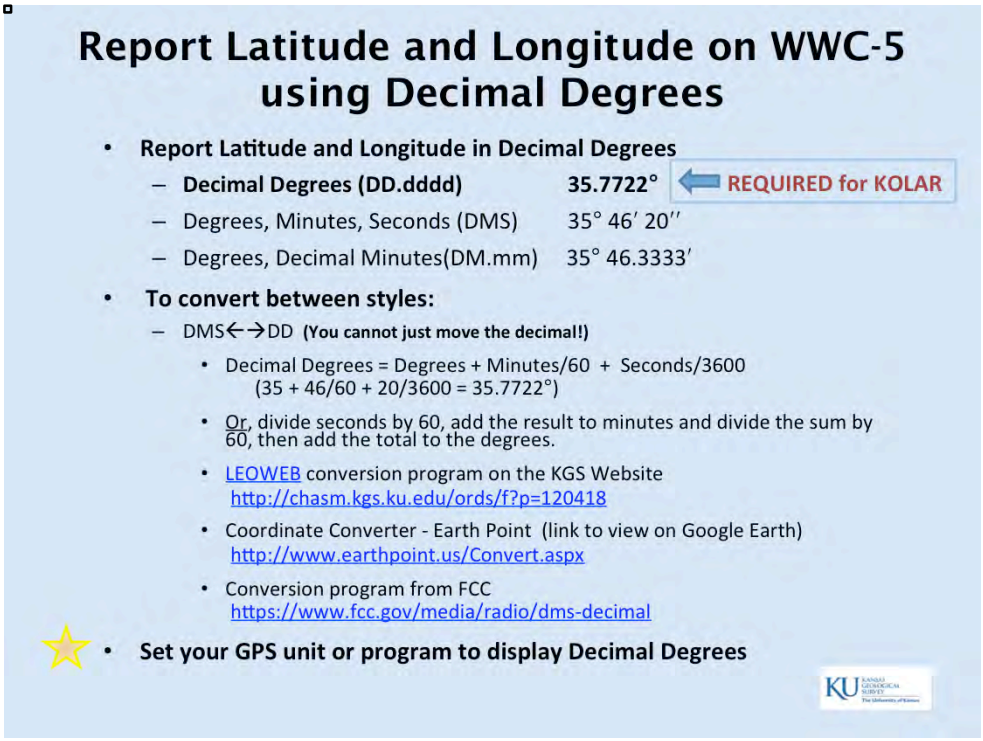
The GPS space segment is operated by the U.S. Air Force, and it consists of a constellation of 24 satellites that orbit the Earth.



The U.S. Air Force constantly controls, monitors, and operates the GPS satellites orbiting the Earth.



1. GPS satellites broadcast radio signals that provide their locations, status, and precise time from on-board atomic clocks.
2. The GPS radio signals travel through space at the speed of light, more than 299,792 km/second.
3. A GPS device on the ground receives the radio signals, usually from at least four satellites within view, noting the exact times of arrival of each of the signals. It then applies a mathematical formula that uses the amount of time it took for the signals to travel to the GPS device from each satellite to calculate its distance from each satellite.
4. Once a GPS device knows its distance from at least four satellites, it can use geometry to determine its location on Earth in three dimensions.



Your GPS device may record latitude and longitude as degrees, minutes, and seconds; in degrees and decimal minutes; or in decimal degrees. **Kolar requires that lat/longs be reported in decimal degrees.**

Don't get rid of values if they are not in decimal degrees – they can be converted. Just remember there are 60 minutes in one degree, and 60 seconds in one minute. If you want to convert, you can divide the seconds by 60 (which will give a decimal value), add that result to the minutes and divide that sum by 60 (which also will give a decimal value), then add that result to the degrees. Or you can simply use one of the following conversion tools:

- KGS's LEOWEB tool: http://chasm.kgs.ku.edu/ords/f?p=120418
- Earth Point Coordinate Converter: http://www.earthpoint.us/Convert.aspx
- FCC Program: https://www.fcc.gov/media/radio/dms-decimal

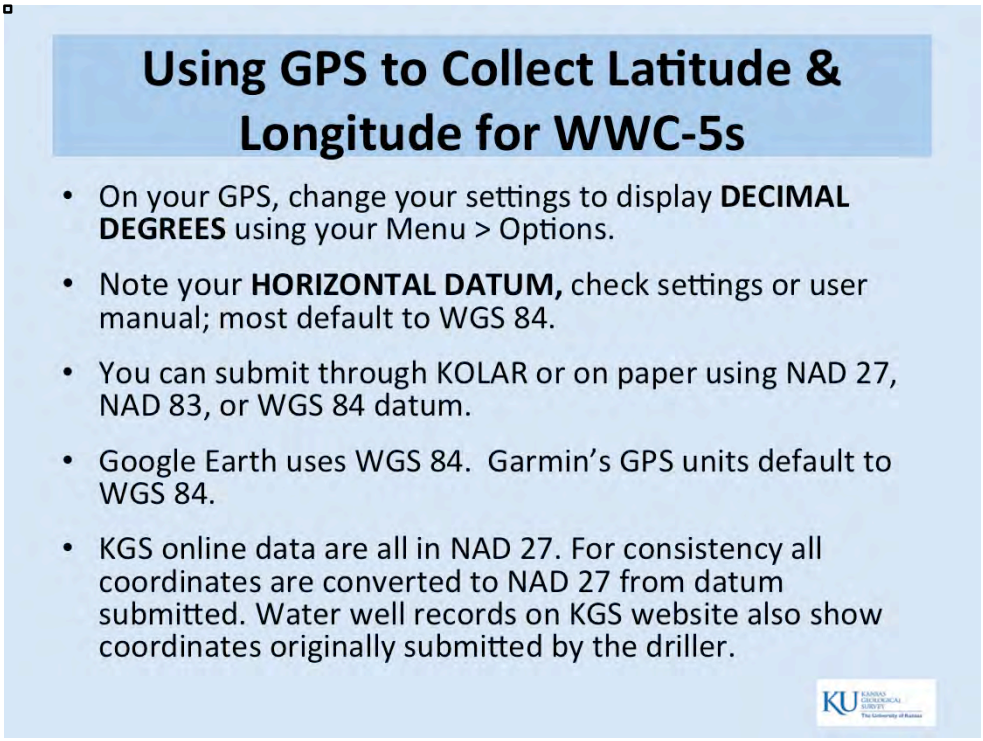
Disclaimer: Software programs and applications (apps) mentioned in this presentation are provided as examples only. The KGS does not recommend privately marketed programs or apps and does not provide support in their use.

Handheld GPS units

- Come in a variety of sizes and styles

(Images from Garmin.com website)

GPS units come in a wide variety of sizes and styles, and they are made by a number of manufacturers. These images come from the Garmin website. Some have buttons and screens; others are strictly touchscreen. Prices listed online on the Garmin website ranged from $109 to $599. And of course, the suite of applications and functions that you get depends on the price that you pay.



You have to know your datum and report it with the latitude and longitude coordinates in decimal degrees.

Tip - change your GPS or app settings to display in decimal degrees.

To find the datum: look in your settings, FAQ page, or user's manual to find what horizontal datum is used by your device or program. Some devices have an option to change it, if you prefer.

It doesn't matter which datum you use to report your coordinates, but you must report the correct datum or the location will not be correct.

Kansas Geological Survey converts all coordinates to datum NAD 27 to maintain consistency. In the WWC-5 website, the original coordinates and original datum (those reported by the driller on the completion report) display along with the KGS NAD 27 values.

Mobile Phone App

- Software applications for smartphones and tablet computers.
- Many apps available. Some free, others minimal fee.
- Good accuracy if satellite coverage available. Find one that displays accuracy, and then monitor and record it when taking a reading.
- Uses satellites, instead of cell phone tower relays.
- Email coordinates and/or store them.
- **Read Settings, Help and FAQ pages for best results.**
- **Adjust settings.**
- Some apps can drain your battery – carry a charger, or turn off the location function when not using.

- Verify location by entering latitude and longitude to Google Earth, Find Latitude Longitude, or on KOLAR.

A wide variety of software applications are available for smartphones and tablet computers that allow you to determine latitude and longitude for a particular location.

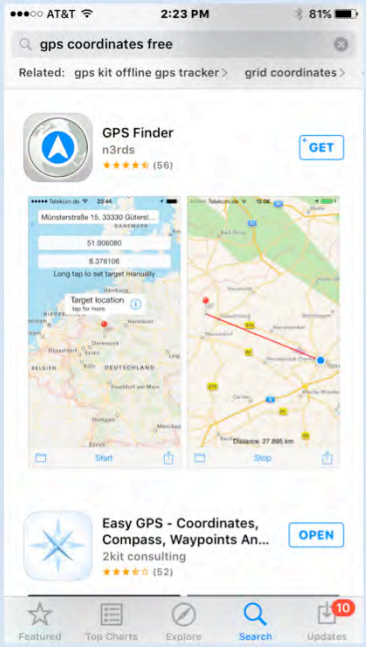
Some are free and some charge a minimal fee.

Mobile phone apps are fine for reporting most well locations (not for legal surveys, remediation sites).

It is very important to also report the address or written description of the well location. This provides a check.

Mobile Phone Apps - Finding a program

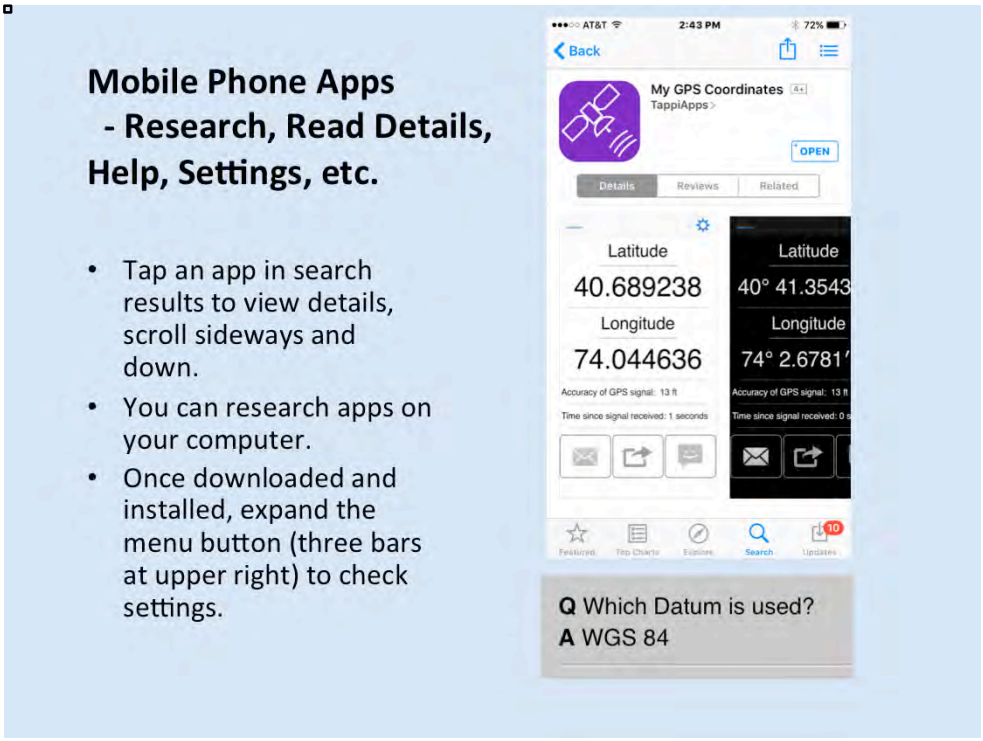
- Search App Store; for example, search for "GPS Coordinates Free."
- Tap an app in search results to view details, scroll sideways and down for information:
  - Purpose of app - provide location
  - Date of updates
  - Read reviews
- Download & Install



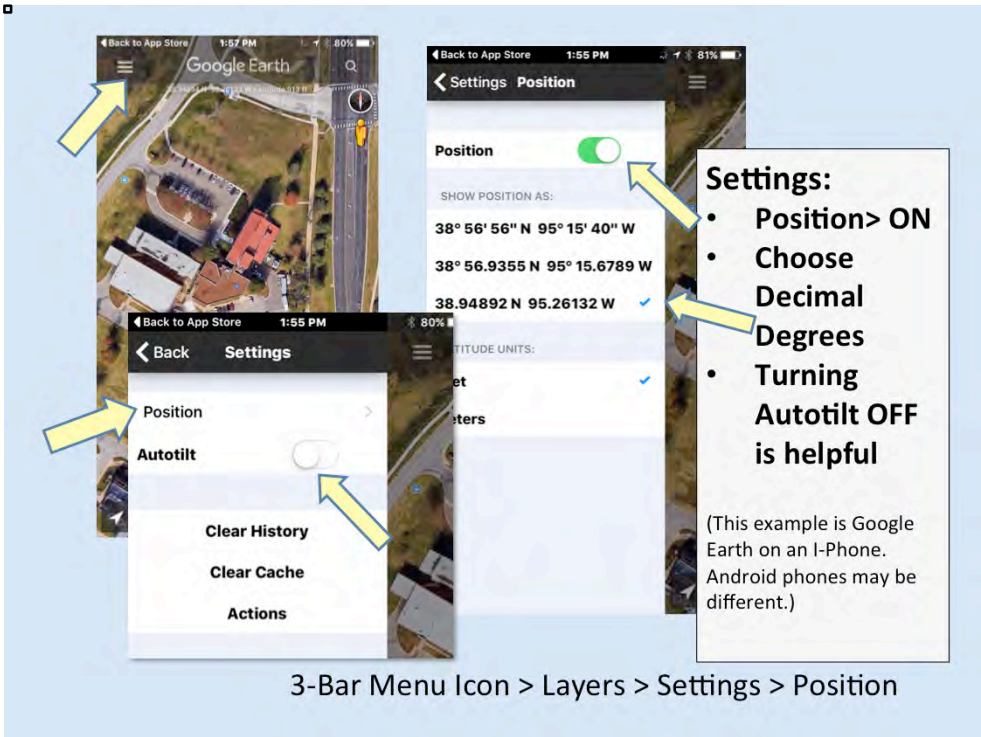
Mobile phone apps that give lat/longs have been developed for a wide variety of applications.

Search to find one that fits your needs. The notes on the slide offer some pointers.

Find an app that will provide the coordinates of your location, rather than a navigational app in which you enter a location and it directs you to that location.



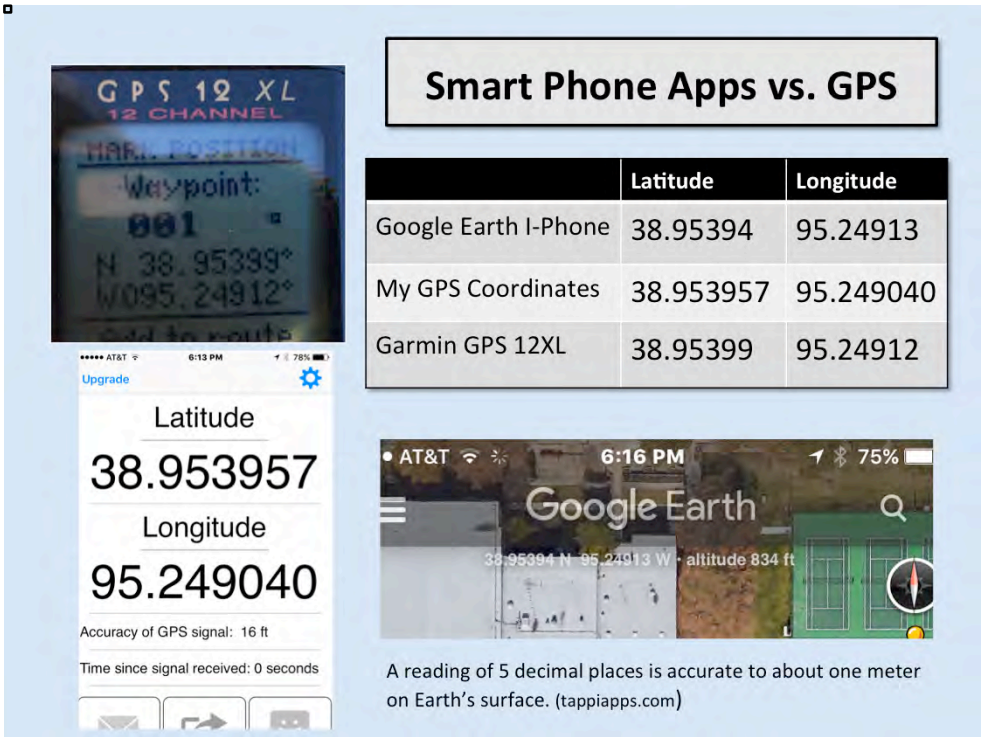
It is a good idea to find an app that allows you the option of reporting lat/longs in decimal degrees. Also be sure to find out which datum it uses.



Investigate choices on your app and look at the menu and settings options. Play around with different choices. You can always reset them if you prefer.

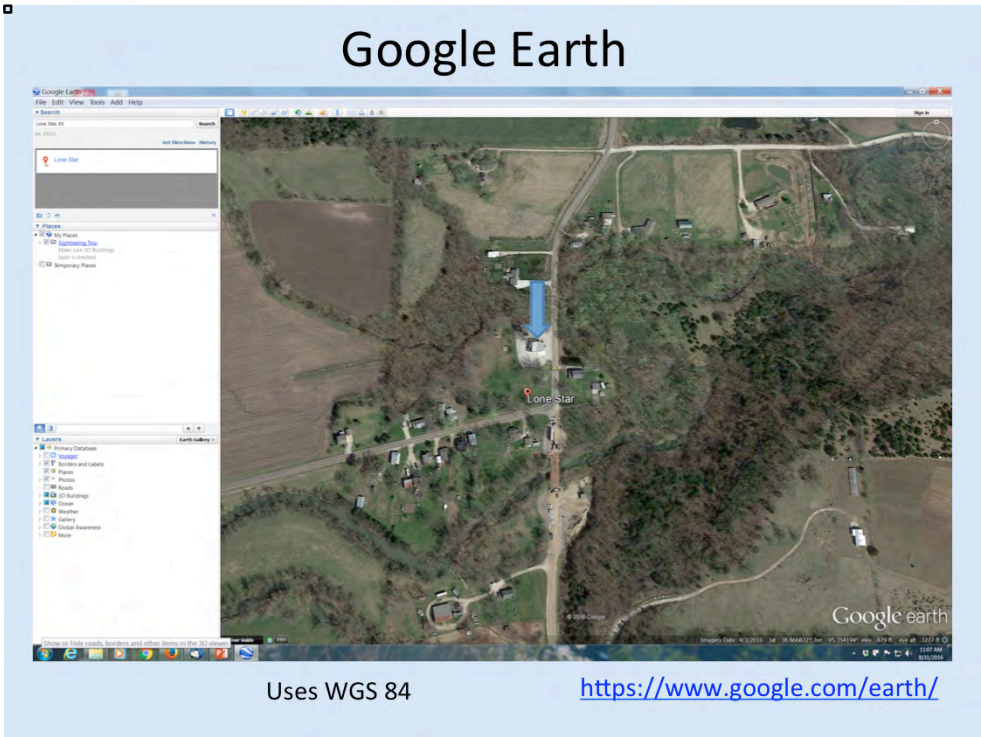
This smartphone app by Google Earth allows you to choose coordinates displayed in decimal degrees by following the above sequence of commands.

You may also prefer to turn off the autotilt feature on a mapping program to make certain you are looking straight down on the Earth's surface so as to get an accurate lat/long reading of your well location.



This table compares GPS readings from three different devices at the same location. Although not identical, they are very close.

Note the GPS device used in this exercise is not a professional survey grade device, but is used by KGS researchers in the field to locate wells.

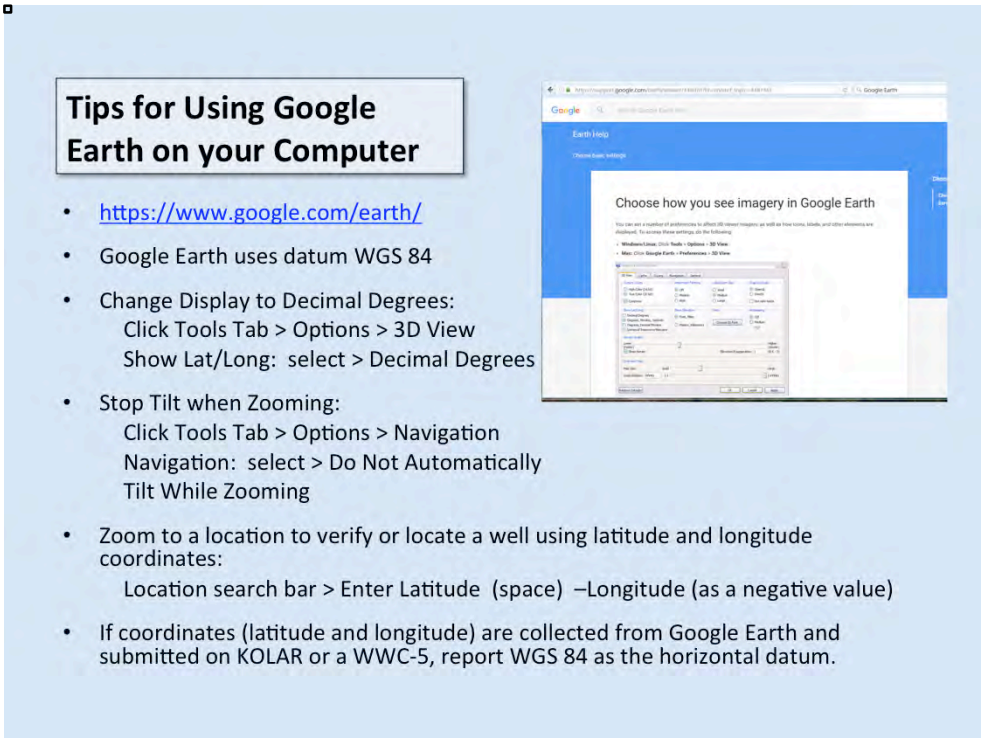


Some people like to use Google Earth on a computer. The program can be downloaded from the website shown at the bottom of the slide.

Here you see the little village of Lone Star, which is southwest of Lawrence in Douglas County. The location of the church in Lone Star (shown by blue arrow) was referenced in an earlier slide that showed a close-up of a USGS topo map when we were talking about section, township, and range. This is just a screen shot, but if you are working in Google Earth, you can place your cursor over the location you want (for example, the church in Lone Star), and in the lower right of the screen it will give you the latitude and longitude of that point location. In the next slide, we zoom in to the lower right part of the screen to show you those lat/longs.

You can use Google Earth to verify that your lat/long coordinates are correct (or to collect coordinates). Enter lat/long values into the search bar, and then check the spot that plots on the image. If you see that your location is not correct, place your cursor at the correct well location on the aerial photo and check the coordinates at the bottom of the screen. Google Earth uses a datum of WGS 84, so if you report lat/long's from Google Earth on a WWC-5, report datum as WGS 84. (Note: If you collected lat/longs using a datum other than WGS 84 on your GPS, and then enter those into Google Earth, the spot will be in a different position).

This is the lower right of the Google Earth screen from the previous slide, showing the latitude and longitude of the church in Lone Star. Notice they are given in decimal degrees, because the settings within Google Earth were changed by the user to show them that way.

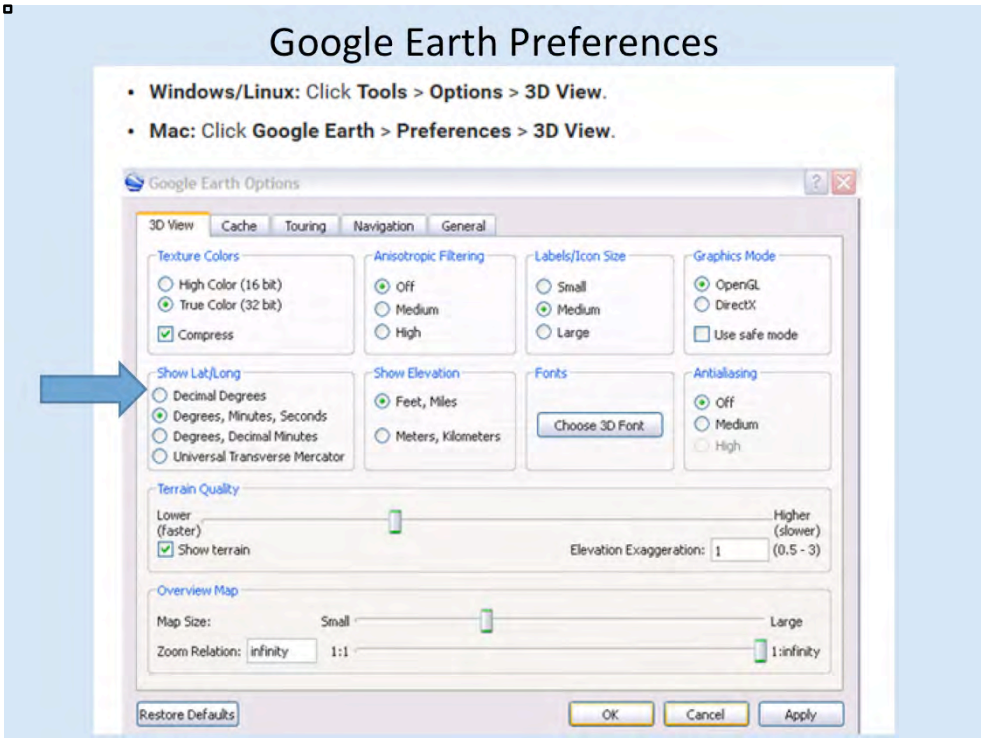


https://www.google.com/earth/

Note that Google Earth uses datum WGS 84.

You can change the settings to display lat/longs in decimal degrees (see slide).

Longitude in the Western Hemisphere is reported as a negative value. A position west of the Prime Meridian in England (to the left if looking at a globe) is in the Western Hemisphere and is reported as a negative value.



Here is a closer look at the Google Earth Preferences page. Here is where you can change it to read in decimal degrees.

Verify that the coordinates you report actually place the well at the correct location, by using:

- KOLAR "View Location Info" button
- KGS WWC-5 Interactive Mapper
- Google Earth

Important to still include the Written Description of the well:

- Address, and/or
- Directions to the well

Proof the coordinates when you enter them on a WWC-5. Copy and paste whenever possible. Writing coordinates down works, but it is better to save waypoints on a GPS and upload them to your computer or to email coordinates from an app while you are on the drilling site.

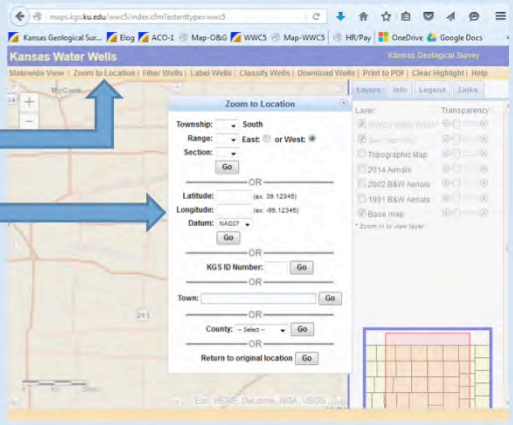
Check that the location typed in actually locates the well correctly.

Written description is still very important (users don't think in coordinates). It provides verification of well location in case latitude or longitude is mis-typed or measured inaccurately.

KGS Interactive Map of WWC-5 data

http://maps.kgs.ku.edu/wwc5/

- Zoom to location
- Enter latitude, longitude, and datum, then click 'Go'



Verify coordinates are accurate by entering them in the KGS mapping program and viewing the location on the returned map.

http://maps.kgs.ku.edu/wwc5/

WWC-5 Forms and KOLAR: Location Reporting - Addendum

Daniel Suchy and Debora Stewart
Kansas Geological Survey, Data Resources Library
Open 8-12 and 1-5 Monday through Friday
Phone: 785-864-2161
Email: datares@kgs.ku.edu
September 2016 for KDHE GWTS Fall 2016 Seminar

Selected References and Websites

- Kansas Geological Survey http://www.kgs.ku.edu/
  - WWC-5 Database http://www.kgs.ku.edu/Magellan/WaterWell/index.html
  - WWC-5 Interactive Mapper http://maps.kgs.ku.edu/wwc5/index.cfm?extenttype=wwc5
- Kansas Department of Health and Environment Geology & Well Technology Section http://www.kdheks.gov/geo/index.html
  - Water Well and Technical Support http://www.kdheks.gov/waterwell/index.html
  - KOLAR https://kolar.kgs.ku.edu/welcome.cfm
- Coordinate Converter - KGS LEOWEB (also provides PLSS) http://chasm.kgs.ku.edu/apex/f?p=120418
- Coordinate Converter - Earth Point (link to view on Google Earth) http://www.earthpoint.us/Convert.aspx (note Earth Point's Kansas PLSS layer available as an add-on for Google Earth does not have quarter calls.)

continued

- Coordinate Systems Overview - University of Colorado
  http://www.colorado.edu/geography/gcraft/notes/coordsys/coordsys.html
- Geodetic Datum Overview - University of Colorado
  http://www.colorado.edu/geography/gcraft/notes/datum/datum.html
- GPS.gov (Official U.S. government information about the Global Positioning System (GPS) and related topics) http://www.gps.gov/systems/gps/

Apps discussed during presentation/exercise:

- Google Earth for iPhone
- Google Earth for Android devices: Google My Maps - has additional features
- My GPS Coordinates
- Easy GPS
- Handy GPS
- Coordinate Converter

Disclaimer: Software programs and applications (apps) mentioned in this presentation are provided as examples only. The Kansas Geological Survey does not recommend privately marketed programs or apps and does not provide support in their use.