

LOCATION DIAGRAM

Chisago County Cross Section Supplement

This supplement assists users with the visualization of aquifer units present in Chisago County, Minnesota. It was compiled using data developed for the Part A and Part B Geologic Atlases of Chisago County, Minnesota (C-22). Stratigraphic interpretation of unconsolidated Quaternary sediments by Gary Meyer of the Minnesota Geological Survey of the University of Minnesota (MGS). Interpretation of bedrock surfaces and extent by Tony Runkel and Terrence Boerboom of the MGS. Hydrogeologic interpretation John Barry of the Minnesota Department of Natural Resources (DNR). GIS, cartography, and graphic design by Holly Johnson of the DNR.

This document includes a map of the county depicting hydrogeologic cross section line locations and aquifer test locations. Cross section lines are located at 0.6 mile (1 km) intervals. Wells within 500 meters north and south of each line were used to determine the contacts between geologic units along the line. Cross sections are shown with a vertical exaggeration of 50x. Bold brightly colored lines depict mapped buried sand and gravel aquifers. Bold black lines depict the top of bedrock and geologic contacts of underlying bedrock units (ignore the thin brown stratigraphic boundary lines that are below the top of bedrock). The cross sections also show the well locations used to develop the cross sections and road locations to be used as land surface reference marks. Click on a cross section number to jump to the corresponding cross section.

Five of the cross sections were developed for the Chisago County Part B atlas. These select cross sections depict a more detailed final product and include a legend to allow the user to interpret additional information such as groundwater residence time and groundwater flow direction. Published cross sections are denoted in plan view with an asterisk next to the cross section line number. It is not feasible to offer all cross sections in this supplement with the same level of detail.

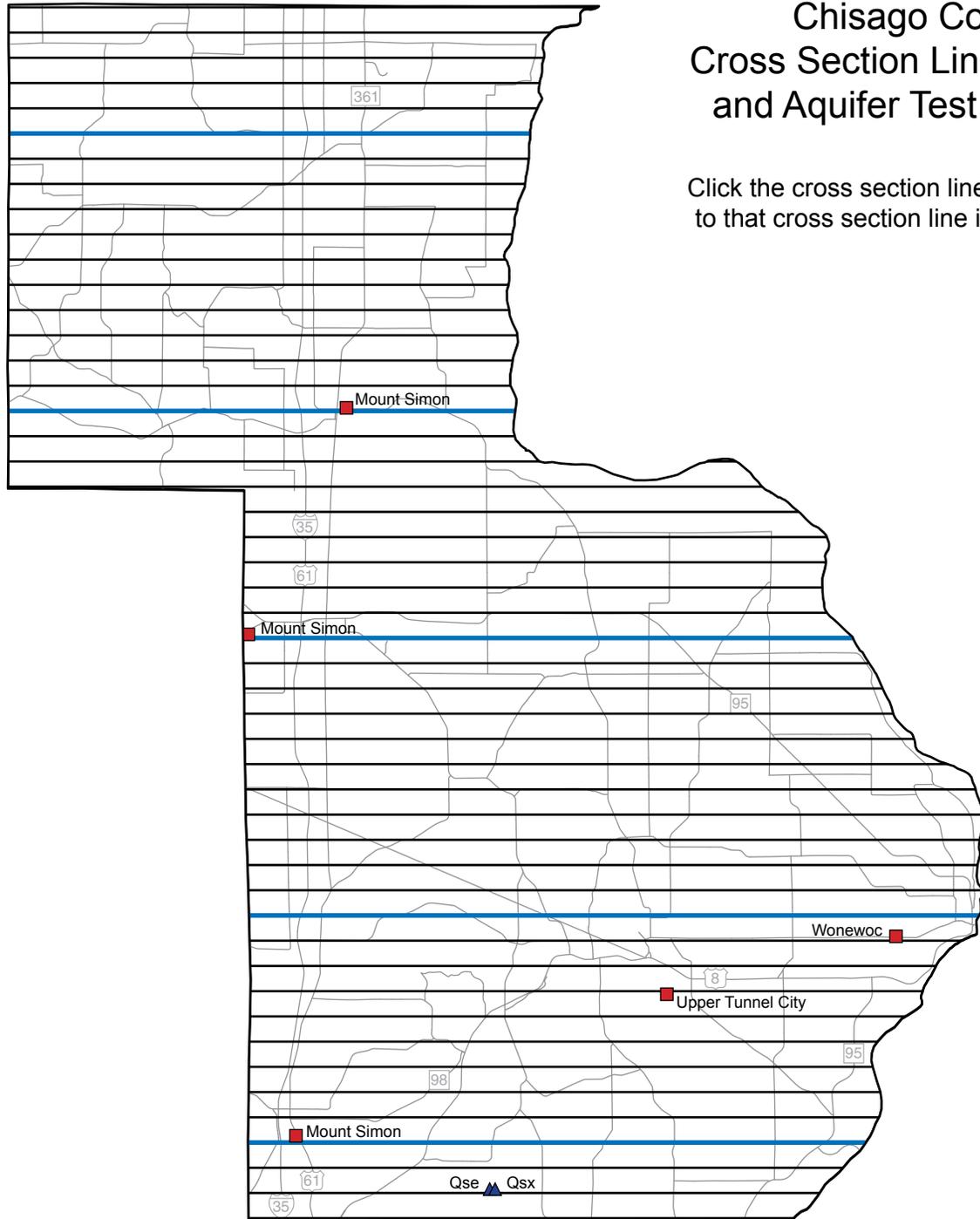
Figure 1 differentiates buried sand and gravel aquifer units from non-aquifer till units and Figure 2 shows the sequence of bedrock geologic units, hydrogeologic units, and hydrogeologic unit properties present in the county. Table 1 lists specific capacity and transmissivity values for aquifers in the county. Specific capacity data were determined from short-term pumping or well development tests performed when the well was drilled. Values listed in the table are from information listed in the County Well Index and include data for all wells with a casing diameter greater than or equal to 12 inches. Pumping data for smaller diameter wells are included in Table 1 because no large diameter wells are constructed in the surficial aquifer or Mesoproterozoic volcanic rock. Wells included in Table 1 were pumped for at least four hours and had a pumping water level a minimum distance of at least two feet above the well screen and inside the casing. Transmissivity data were calculated from longer-term aquifer tests conducted for the Minnesota Department of Health.

This document can be found at http://www.dnr.state.mn.us/waters/programs/gw_section/mapping/platesum/chiscga.html.



Chisago County: Cross Section Line Locations and Aquifer Test Locations

Click the cross section line number to jump to that cross section line in the document.



- Aquifer test**
- Bedrock aquifer
 - ▲ Buried sand and gravel aquifer

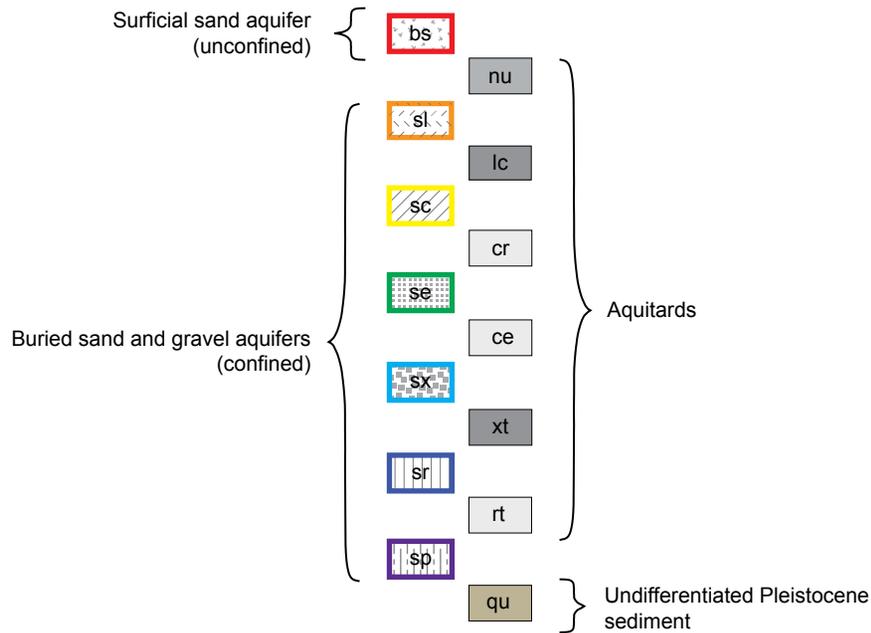


Figure 1. Quaternary buried sand and gravel aquifers are shown as patterns, aquitard units are shown as shades of gray, and undifferentiated Pleistocene sediment is shown in brown. Aquitards are low-permeability till and other fine-grained units that restrict groundwater movement. Buried sand and gravel aquifers are outlined in the color shown on the cross sections.

Geologic Unit		Hydrogeologic Unit	Hydrogeologic Unit Properties
Jordan Sandstone		Jordan aquifer	Relatively high intergranular permeability
			Relatively low permeability
St. Lawrence Formation			Relatively low permeability
Tunnel City Group	Mazomanie Formation	Upper Tunnel City aquifer	Relatively low intergranular permeability with high permeability bedding fractures
	Lone Rock Formation		Confining unit, not shown on cross sections; included with Ctc aquifer unit
	Mazomanie Formation	Upper Tunnel City aquifer	Relatively low intergranular permeability with high permeability bedding fractures
	Lone Rock Formation		Confining unit, not shown on cross sections; included with Ctc aquifer unit
Wonewoc Sandstone		Wonewoc aquifer	Moderate intergranular permeability
Eau Claire Formation			Relatively low permeability
Mt. Simon Sandstone		Mt. Simon aquifer	Moderate intergranular permeability
Mesoproterozoic Sedimentary Rock		Undifferentiated aquifer	Moderate intergranular permeability
Mesoproterozoic Volcanic Rock		Volcanic nonaquifer unit	Very low to low fracture permeability, very low yield aquifer

- Aquifer, relatively high permeability
- Aquitard, relatively low permeability
- Volcanic nonaquifer, very low yield
- High permeability bedding fracture

Figure 2. Sequence of bedrock geologic units, hydrogeologic units, and hydrogeologic unit properties in Chisago County.

Table 1. Specific capacity from well development tests and transmissivity from aquifer tests for selected large-capacity wells.

[gpm/ft, gallons per minute per foot; gpd/ft, gallons per day per foot; dash marks (--) indicate no data available]

Aquifer	Specific Capacity (gpm/ft) ¹					Transmissivity from Aquifer Test (gpd/ft) ²				
	Well Diameter (inches)	Mean	Minimum	Maximum	No. of Tests	Well Diameter (inches)	Mean	Minimum	Maximum	No. of Tests
Surficial sand ³	8	20	11	30	2	--	--	--	--	--
Buried sand and gravel										
sl	--	--	--	--	--	--	--	--	--	--
sc	--	--	--	--	--	--	--	--	--	--
se	12	20	--	--	1	12	137,000	--	--	1
sx	12–18	7	4	11	2	12	142,000	--	--	1
qu	18	102	--	--	1	--	--	--	--	--
Bedrock										
St. Peter–Prairie du Chien–Mt. Simon ⁴	12	20	--	--	1	--	--	--	--	--
Upper Tunnel City–Eau Claire ⁴	16	35	--	--	1	--	--	--	--	--
Upper Tunnel City–Wonewoc ⁴	14	9	--	--	1	16	40,000	35,000	45,000	2
Wonewoc	18	47	--	--	1	18	104,000	--	--	1
Wonewoc–Mt. Simon ⁴	18	9	--	--	1	--	--	--	--	--
Mt. Simon	12–18	17	8	26	12	12–24	20,100	8,100	32,000	2
Mt. Simon–Hinckley ⁴	24	28	--	--	1	24	40,000	--	--	1
Volcanic rock ³	6	0.008	0.004	0.013	7	--	--	--	--	--

Wells selected for inclusion in the table were pumped for at least four hours and had a pumping water level a minimum distance of at least two feet above the well screen and inside the casing.

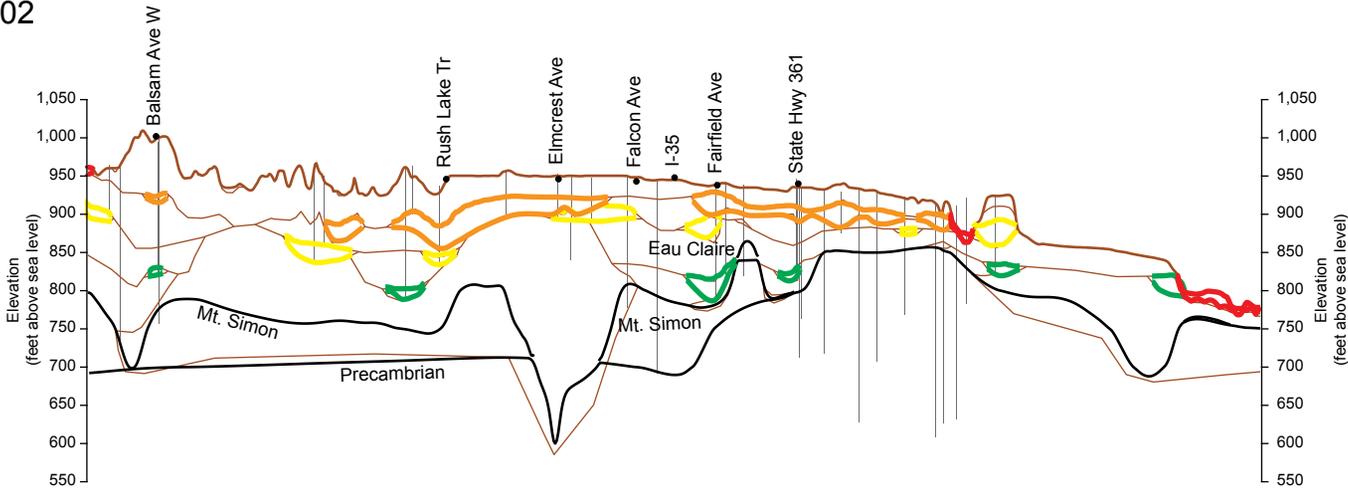
¹Data adapted from the County Well Index.

²Data adapted from aquifer tests conducted for the Minnesota Department of Health.

³Less than 12-inch diameter wells constructed in surficial sand aquifer or Mesoproterozoic volcanic rock.

⁴Well constructed across more than one aquifer.

02



EXPLANATION FOR CROSS SECTION

Aquifers grouped by stratigraphy

Surficial aquifer
— surficial sand

Buried sand and gravel aquifers

- sl — sx
- sc — sr
- se — sp

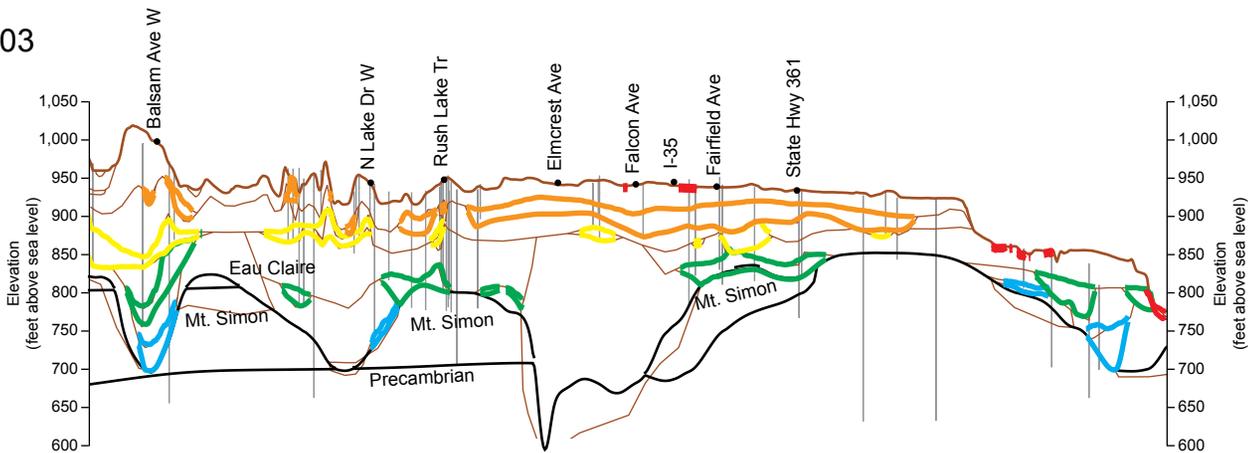
Symbols and labels

- | Well location
- Land surface
- Stratigraphic boundary
- Bedrock contact
- 21.1 If shown, chloride concentration equals or exceeds 5 parts per million.
- 7.2 If shown, nitrate-nitrogen concentration equals or exceeds 1 part per million.
- 3000 If shown, groundwater residence time in years, estimated by carbon-14 (¹⁴C) isotope analysis

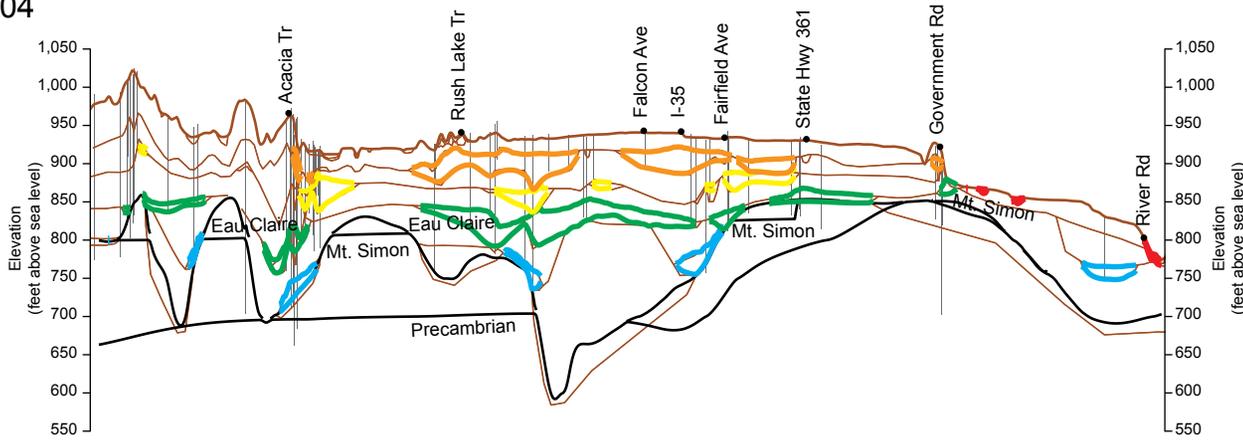
Tritium age

- █ Cold War era: water entered the ground during the peak period of atmospheric tritium concentration during nuclear bomb testing, 1958–1959 and 1961–1972 (greater than 15 tritium units [TU]).
- █ Recent: water entered the ground since about 1953 (8–15 TU).
- █ Mixed: water is a mixture of recent and vintage waters (greater than 1 TU to less than 8 TU).
- █ Vintage: water entered the ground before 1953 (less than or equal to 1 TU).
- █ Well not sampled for tritium.

03



04



EXPLANATION FOR CROSS SECTION

Aquifers grouped by stratigraphy

- Surficial aquifer
- surficial sand
- Buried sand and gravel aquifers
- sl — sx
- sc — sr
- se — sp

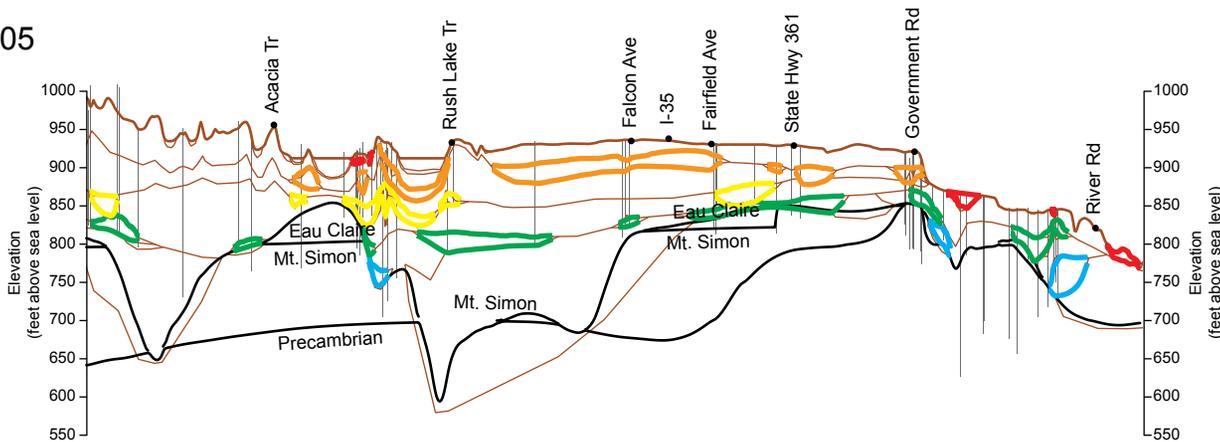
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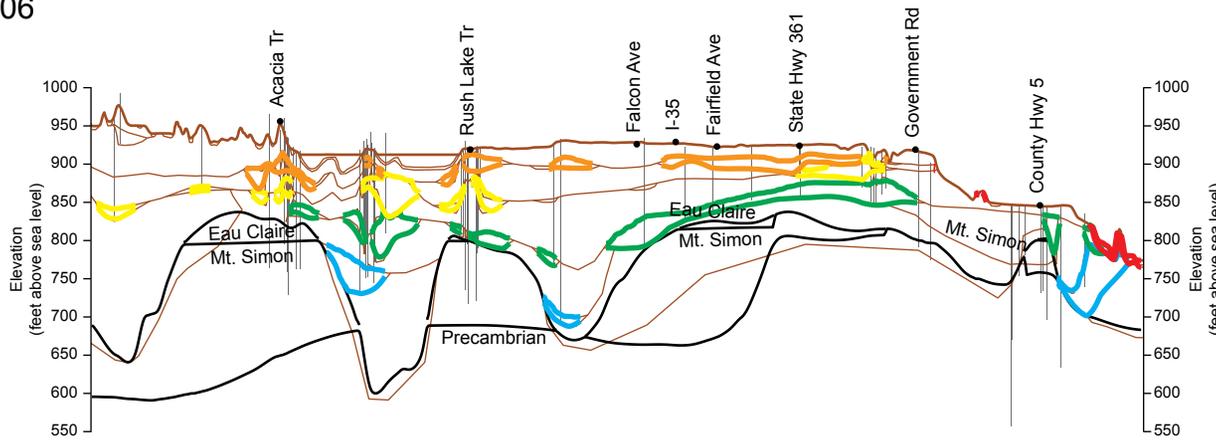
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05



06



EXPLANATION FOR CROSS SECTION

Aquifers grouped by stratigraphy

- Surficial aquifer
- surficial sand
- Buried sand and gravel aquifers
- sl — sx
- sc — sr
- se — sp

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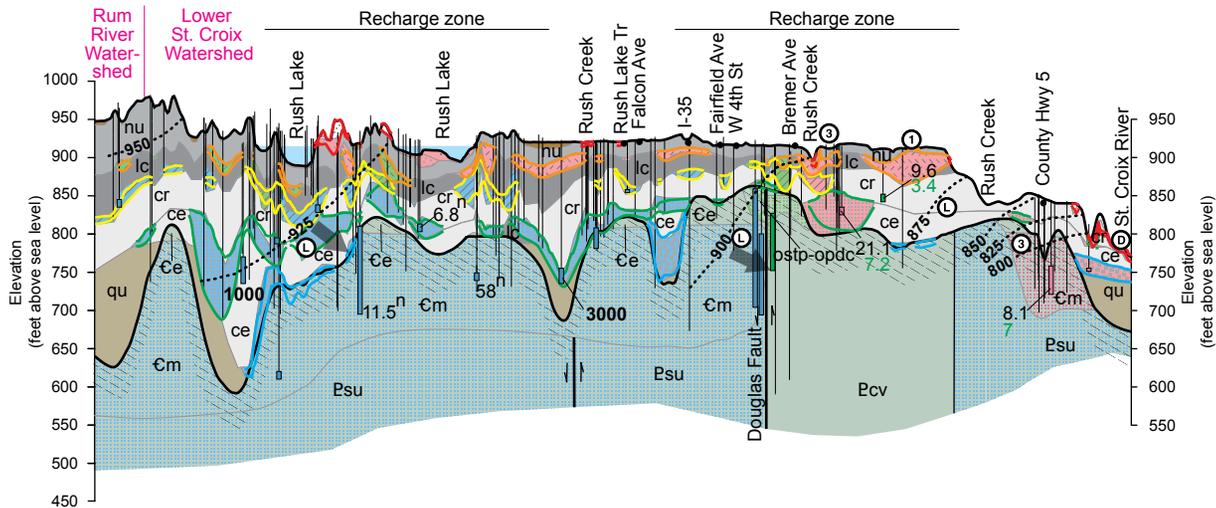
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07

See next page for complete explanation

Line A



Aquifers grouped by stratigraphy

Interpreted tritium age is indicated by background color

Surficial aquifer

Surficial sand

Buried sand and gravel aquifers

sl

sc

se

sx

sr

sp

Interpreted tritium age is indicated by pattern color

Sedimentary bedrock aquifers

** St. Peter/Prairie du Chien

* Jordan

** Upper Tunnel City

* Wonewoc

* Mt. Simon

* Undifferentiated Mesoproterozoic

Enhanced-permeability zone

* Primarily intergranular flow

** Intergranular and fracture flow

Symbols and labels

21.1 If shown, chloride concentration equals or exceeds 5 parts per million. Naturally occurring high chloride concentrations are shown with a superscript n.

7.2 If shown, nitrate-nitrogen concentration equals or exceeds 1 part per million.

3000 If shown, groundwater residence time in years, estimated by carbon-14 (¹⁴C) isotope analysis

General direction of groundwater flow

Approximate equipotential contour

Geologic contact

Land or bedrock surface

Lake

Direction of fault movement, arrows indicate relative movement

Tritium age

Darker color in small vertical rectangle (well screen symbol) indicates tritium age of water sampled in well. Lighter color indicates interpreted age of water in aquifer.

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Well was not sampled for tritium.

EXPLANATION FOR CROSS SECTIONS 7 (A), 18 (B), 27 (C), 38 (D), AND 47 (E)

Bedrock aquitards

€sl St. Lawrence Formation

€e Eau Claire Formation

Bedrock nonaquifer units

€cf Mesoproterozoic Volcanic Rock–Clam Falls Volcanics

€cv Mesoproterozoic Volcanic Rock–Chengwatana Group

€nb Mesoproterozoic Volcanic Rock–North Branch Volcanics

Quaternary aquitards grouped by texture

Aquitard Percent sand*

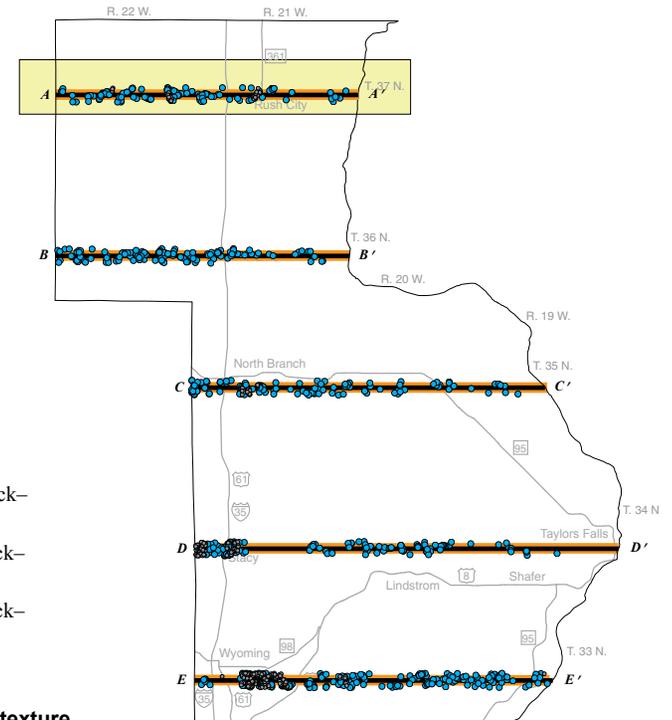
cr, ce, rt > 60

nu > 40 and ≤ 50

lc, xt > 30 and ≤ 40

qu Undifferentiated Pleistocene sediment, texture and relative hydraulic conductivity unknown

*Relative hydraulic conductivity

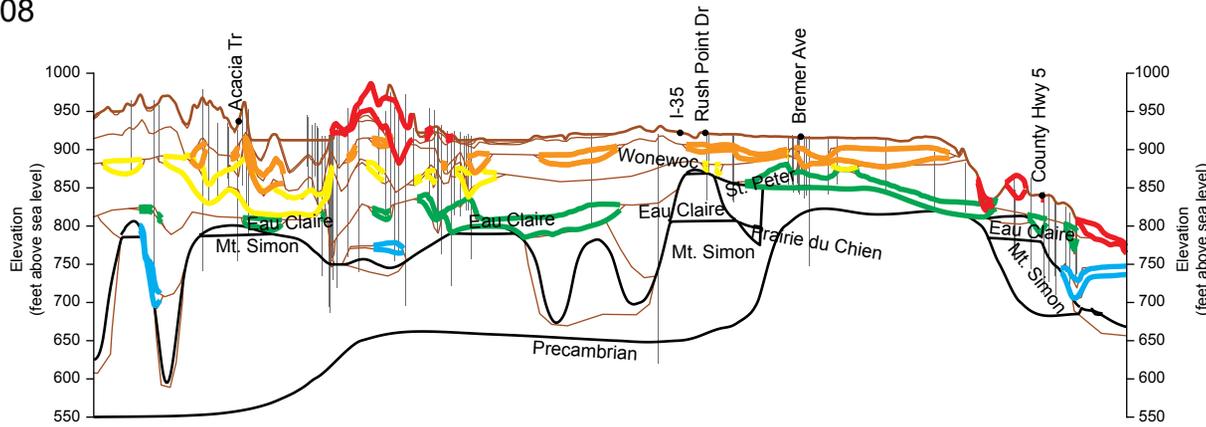


Orange lines show the location of cross sections shown in the Chisago County Geologic Atlas Part B, which are coincident with the geologic cross section lines from Part A (shown in black). Circles indicate the locations of wells used to generate the hydrogeologic cross sections. Blue circles indicate wells displayed in the cross sections. Gray circles indicate wells that are not shown in areas of high well density. These wells were removed to show underlying detail.

Groundwater conditions

- ① Infiltration through a thin layer of overlying, fine-grained material to an underlying aquifer
- ② Groundwater recharge from an overlying surficial aquifer to a buried aquifer
- ③ Groundwater leakage from an overlying buried aquifer to an underlying buried aquifer
- ④ Groundwater leakage through multiple aquifers and fine-grained layers
- Ⓓ Groundwater discharge to surface-water body
- Ⓕ Lateral groundwater flow
- ⊙ Groundwater movement out of cross section

08



EXPLANATION FOR CROSS SECTION

Aquifers grouped by stratigraphy

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- surficial sand
- Buried sand and gravel aquifers
- sl
- sc
- se
- sx
- sr
- sp

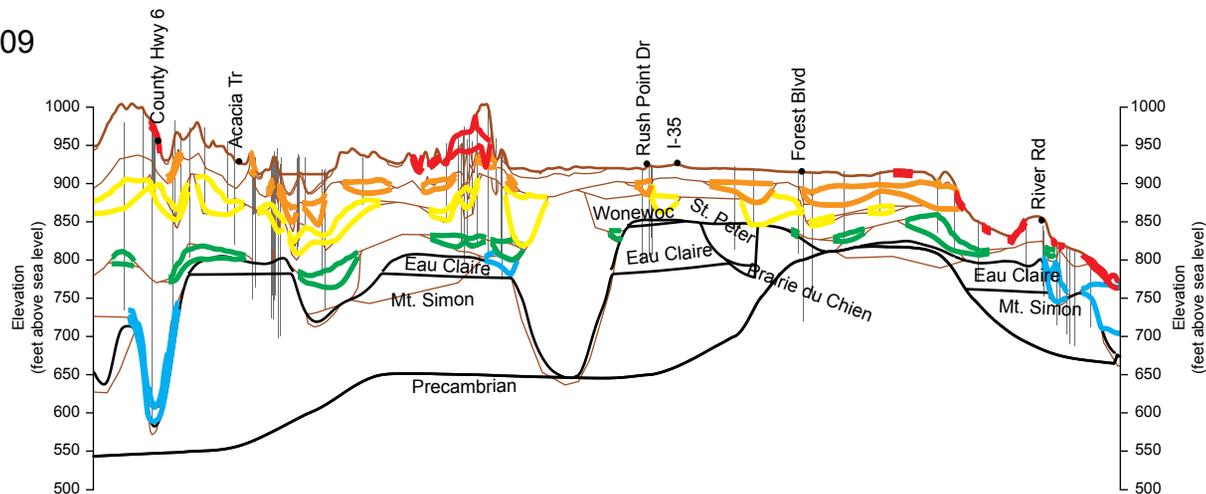
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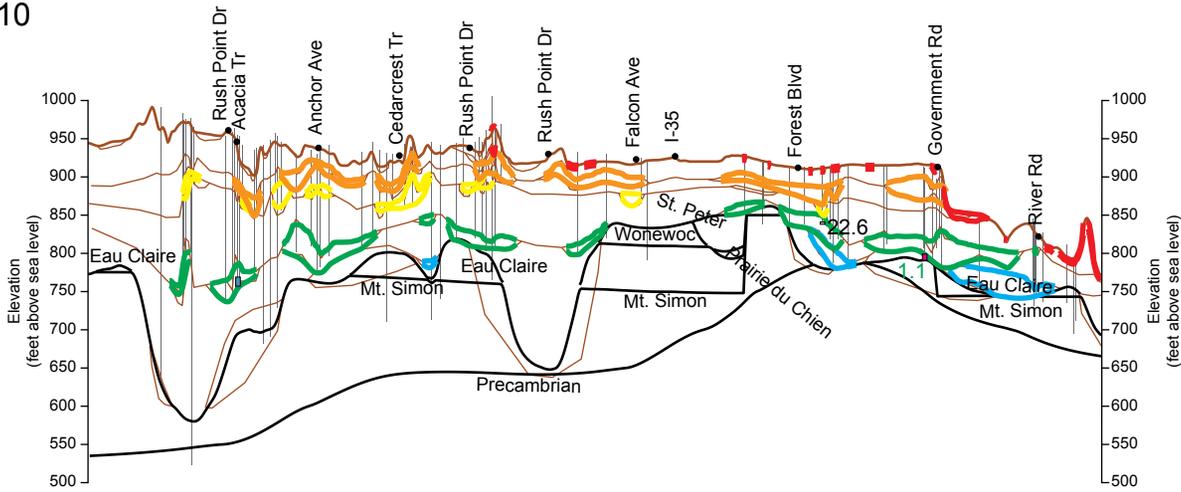
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- Well not sampled for tritium.

09





EXPLANATION FOR CROSS SECTION

Aquifers grouped by stratigraphy

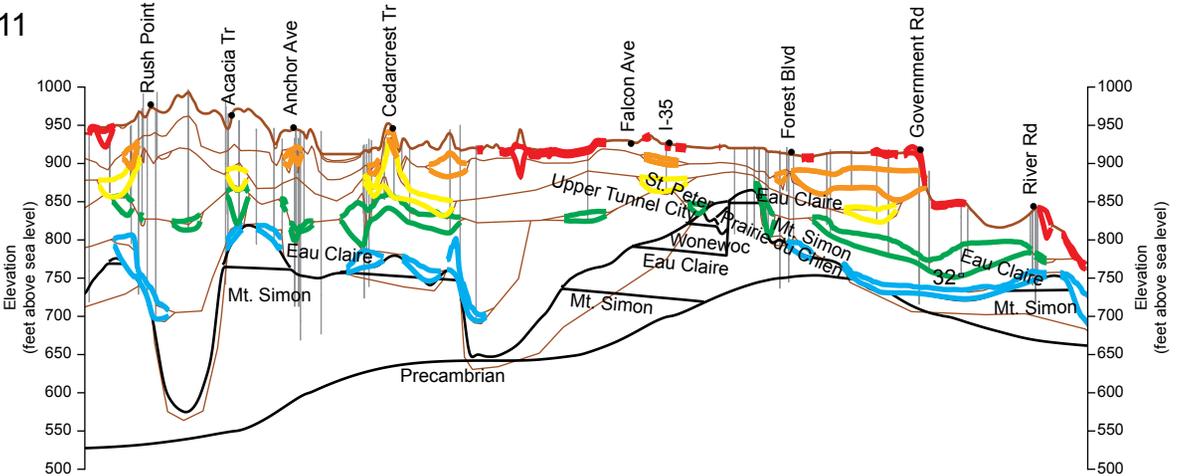
- Surficial aquifer
 - surficial sand
- Buried sand and gravel aquifers
 - sl
 - sc
 - se
 - sx
 - sr
 - sp

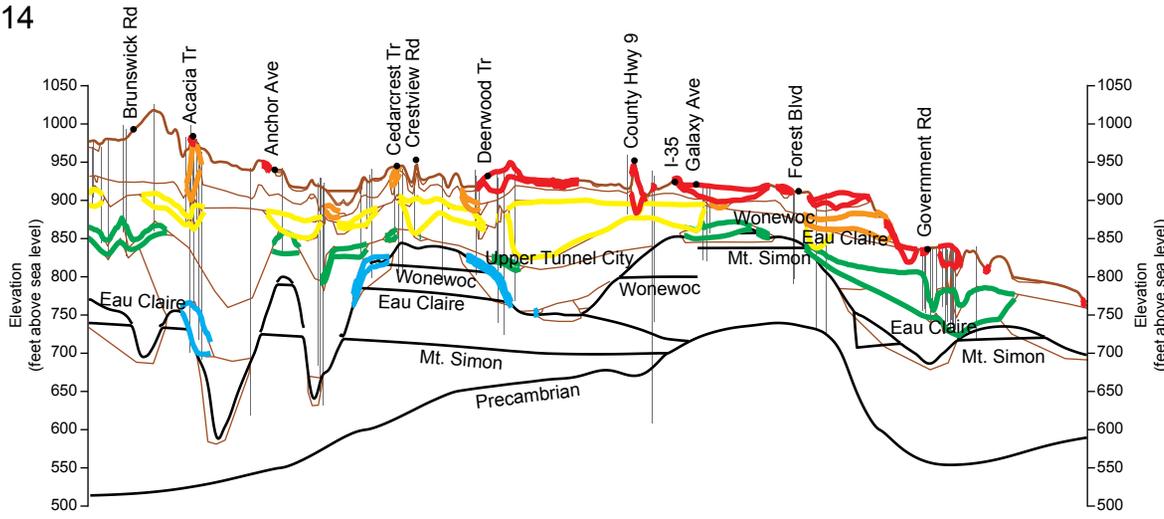
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EXPLANATION FOR CROSS SECTION

Aquifers grouped by stratigraphy

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 - surficial sand
- Buried sand and gravel aquifers

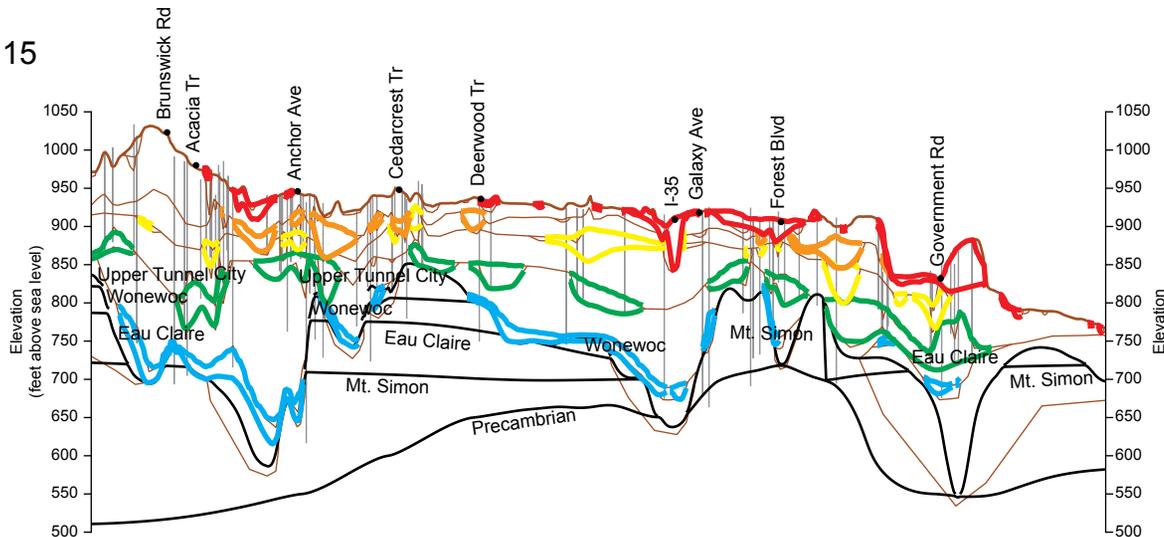
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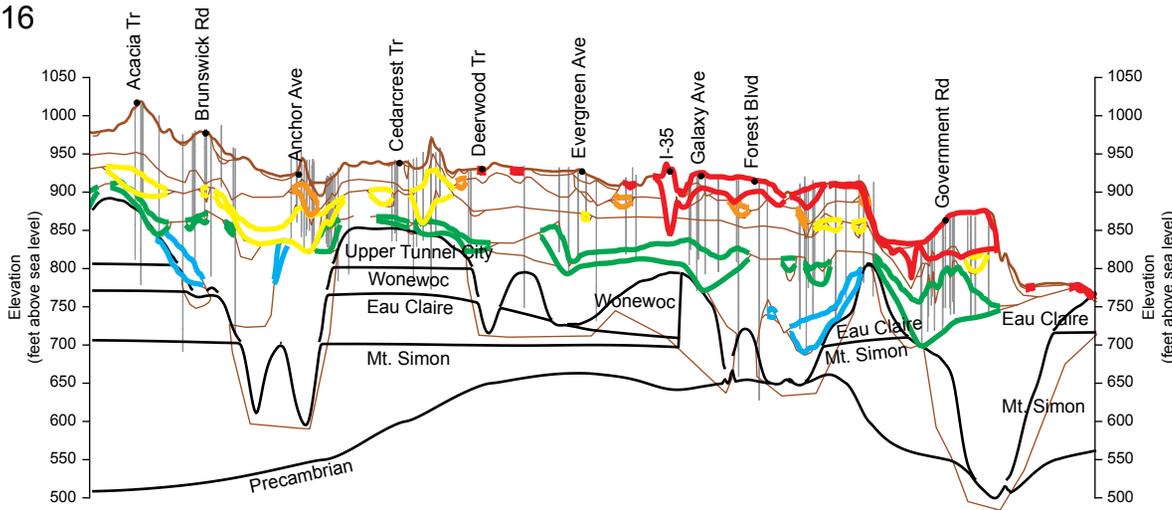
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EXPLANATION FOR CROSS SECTION

Aquifers grouped by stratigraphy

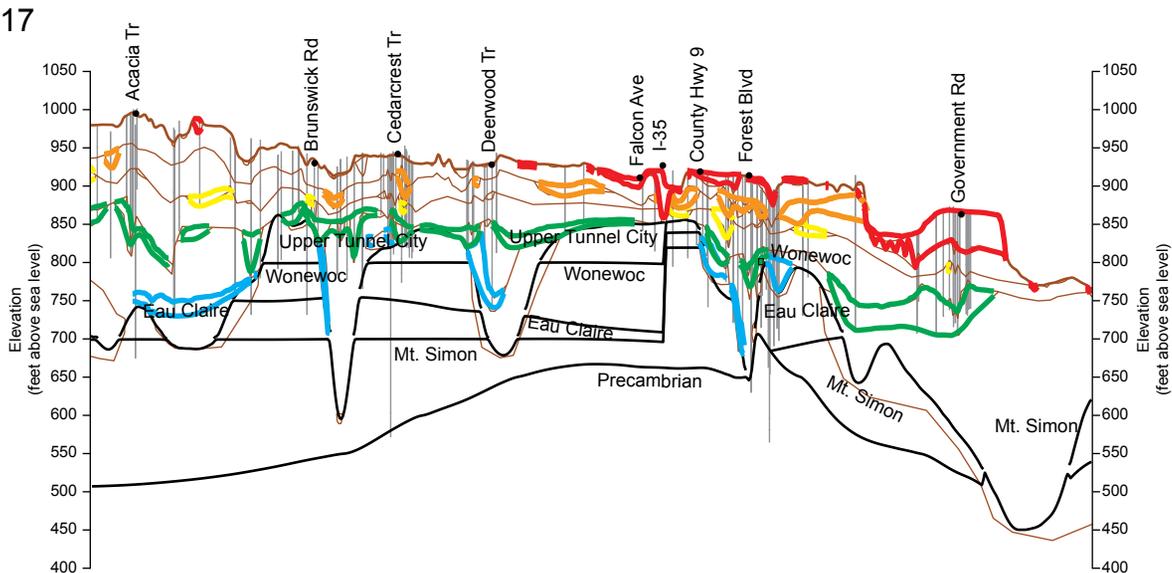
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7 (A), 18 (B), 27 (C), 38 (D), AND 47 (E)**

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sl

sc

se

sx

sr

sp

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* Cw Wonewoc

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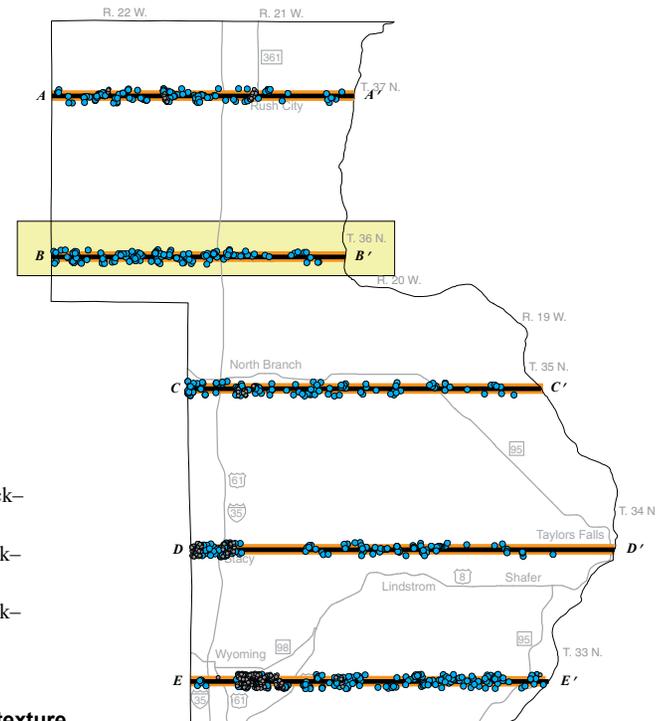
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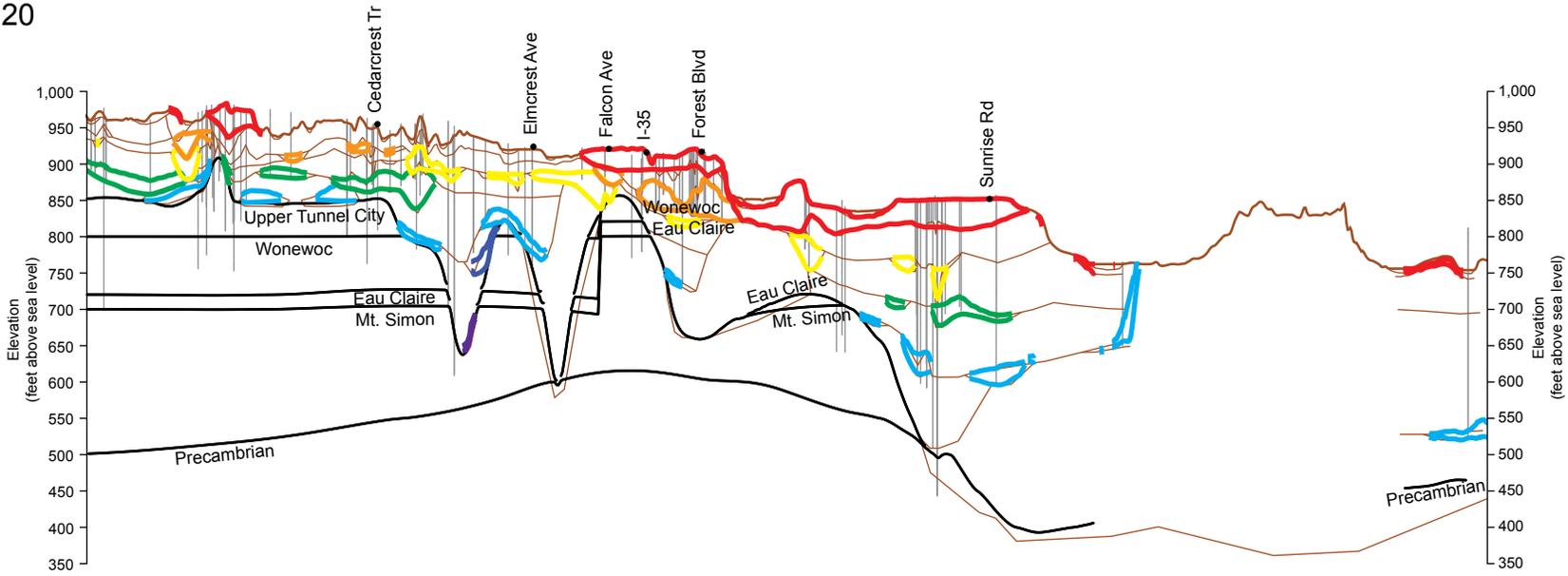
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EXPLANATION FOR CROSS SECTION

Aquifers grouped by stratigraphy

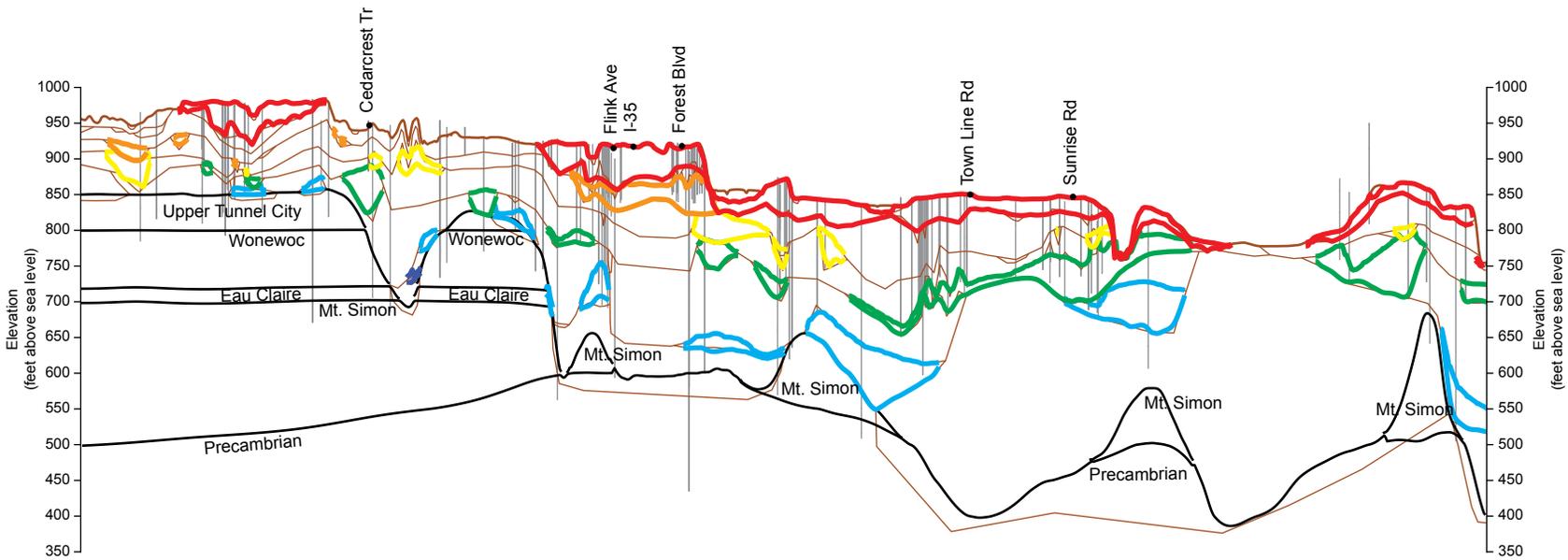
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Symbols and labels

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EXPLANATION FOR CROSS SECTION

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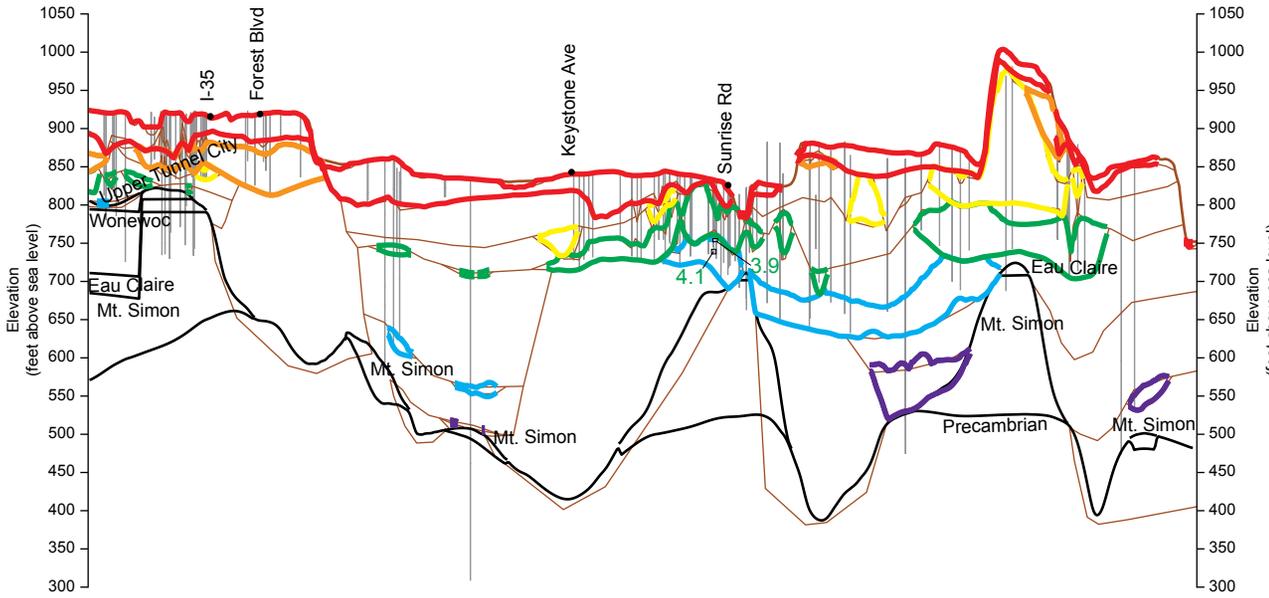
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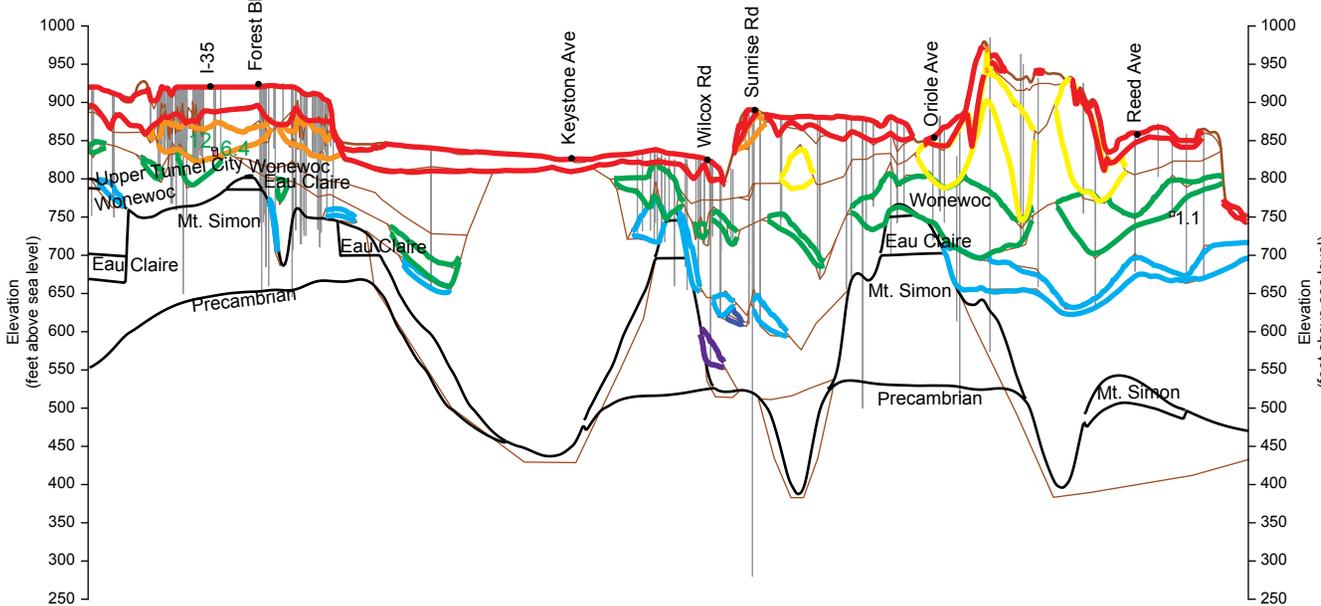
- Surficial aquifer
- surficial sand
- Buried sand and gravel aquifers
- sl — sx
- sc — sr
- se — sp

Symbols and labels

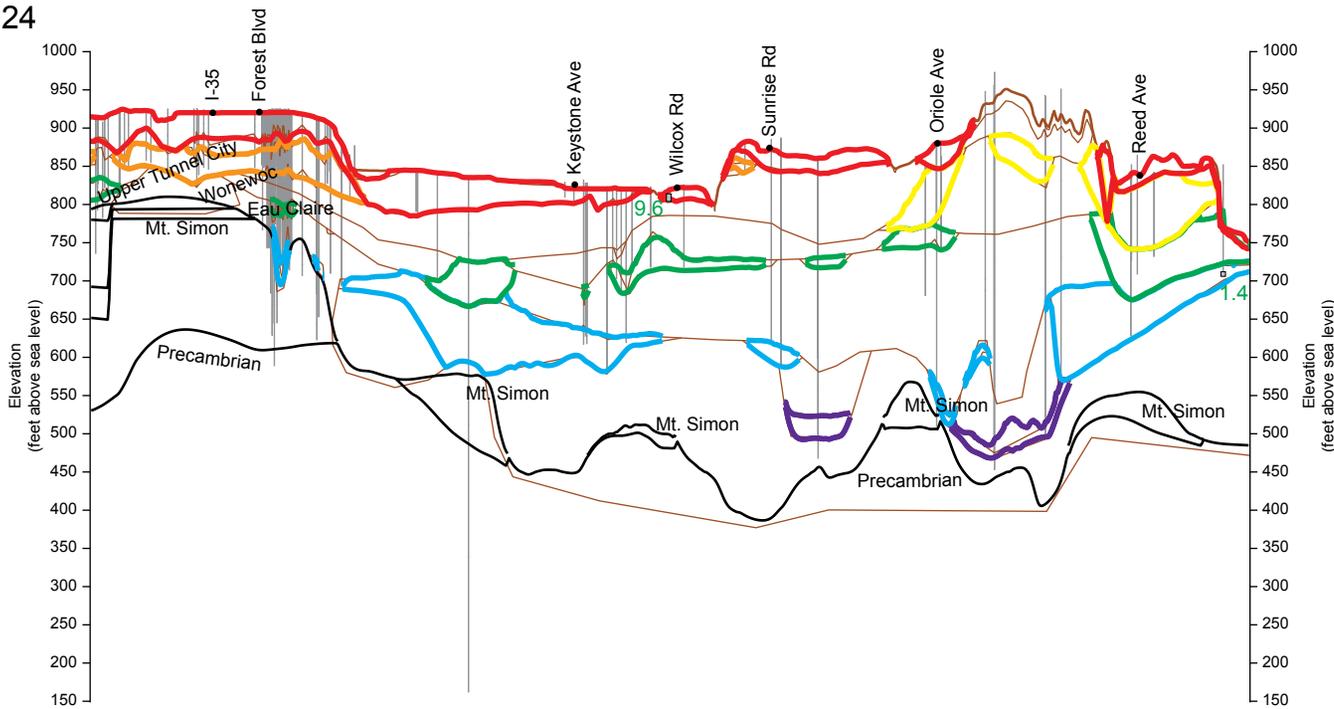
- Well location
- Land surface
- Stratigraphic boundary
- Bedrock contact
- 21.1 If shown, chloride concentration equals or exceeds 5 parts per million.
- 7.2 If shown, nitrate-nitrogen concentration equals or exceeds 1 part per million.
- 3000 If shown, groundwater residence time in years, estimated by carbon-14 (¹⁴C) isotope analysis

Tritium age

- █ Cold War era: water entered the ground during the peak period of atmospheric tritium concentration during nuclear bomb testing, 1958–1959 and 1961–1972 (greater than 15 tritium units [TU]).
- █ Recent: water entered the ground since about 1953 (8–15 TU).
- █ Mixed: water is a mixture of recent and vintage waters (greater than 1 TU to less than 8 TU).
- █ Vintage: water entered the ground before 1953 (less than or equal to 1 TU).
- Well not sampled for tritium.



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EXPLANATION FOR CROSS SECTION

Aquifers grouped by stratigraphy

- Surficial aquifer
- surficial sand
- Buried sand and gravel aquifers
- sl
- sc
- se
- sx
- sr
- sp

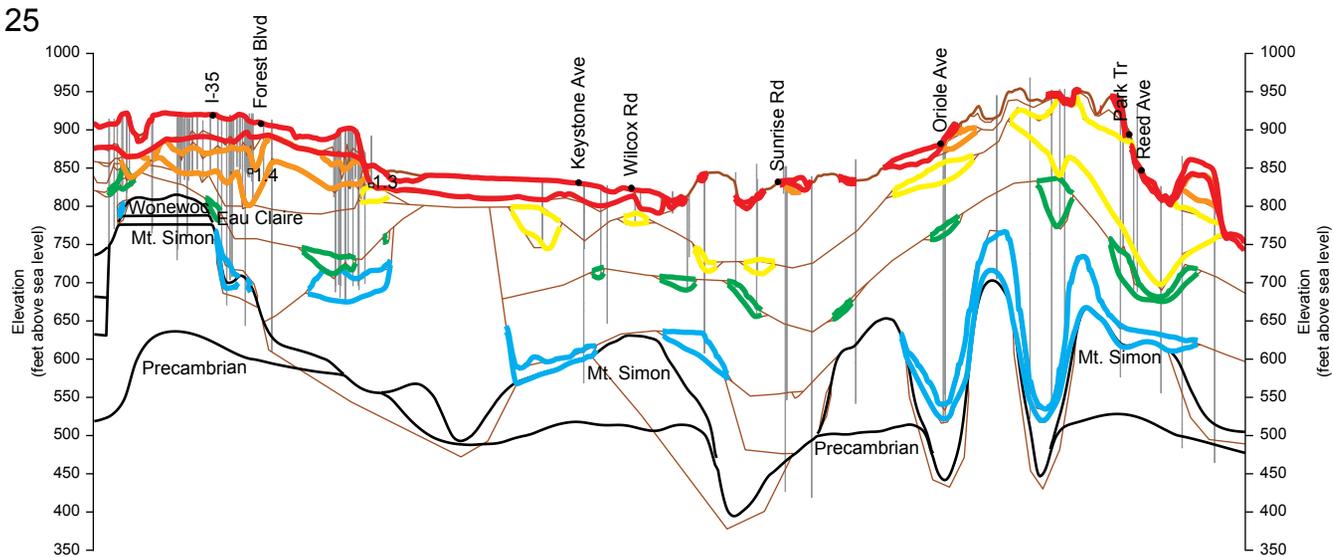
Symbols and labels

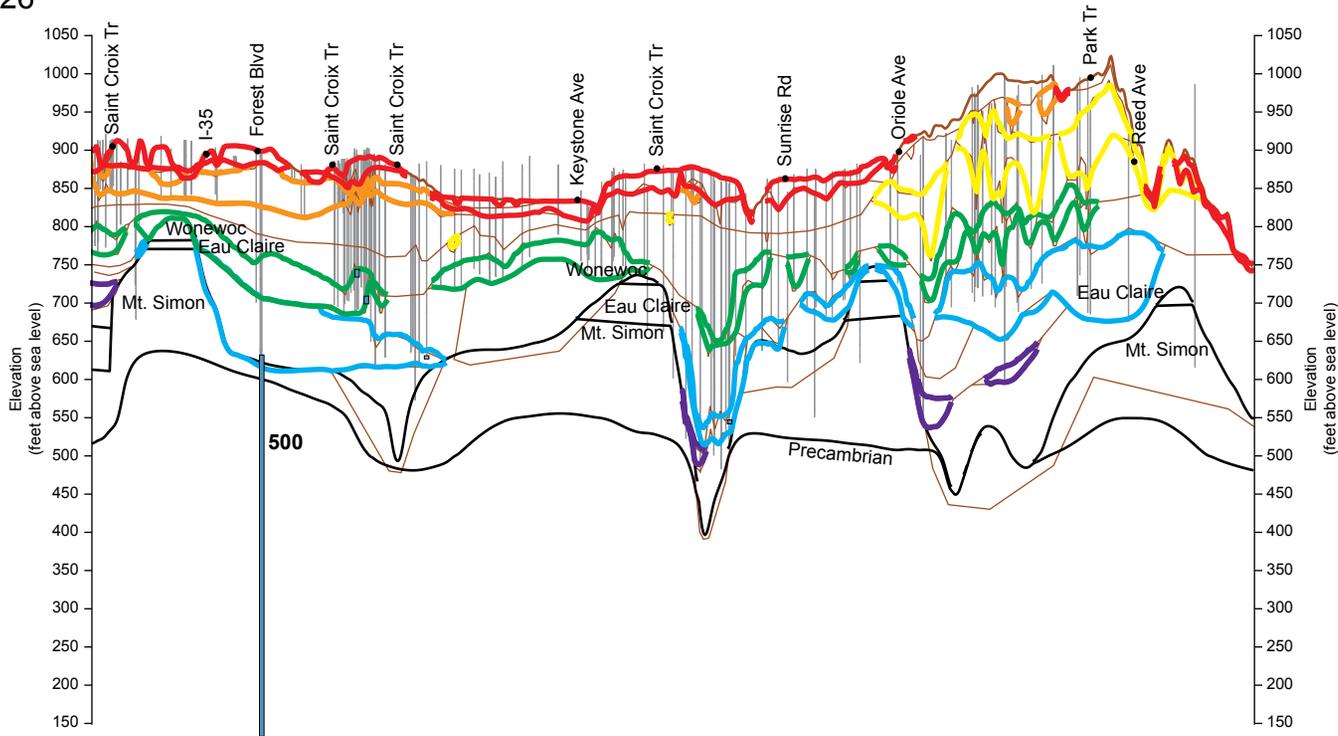
- Well location
- Land surface
- Stratigraphic boundary
- Bedrock contact
- 21.1 If shown, chloride concentration equals or exceeds 5 parts per million.
- 7.2 If shown, nitrate-nitrogen concentration equals or exceeds 1 part per million.
- 3000 If shown, groundwater residence time in years, estimated by carbon-14 (¹⁴C) isotope analysis

Tritium age

- █ Cold War era: water entered the ground during the peak period of atmospheric tritium concentration during nuclear bomb testing, 1958–1959 and 1961–1972 (greater than 15 tritium units [TU]).
- █ Recent: water entered the ground since about 1953 (8–15 TU).
- █ Mixed: water is a mixture of recent and vintage waters (greater than 1 TU to less than 8 TU).
- █ Vintage: water entered the ground before 1953 (less than or equal to 1 TU).
- Well not sampled for tritium.

25

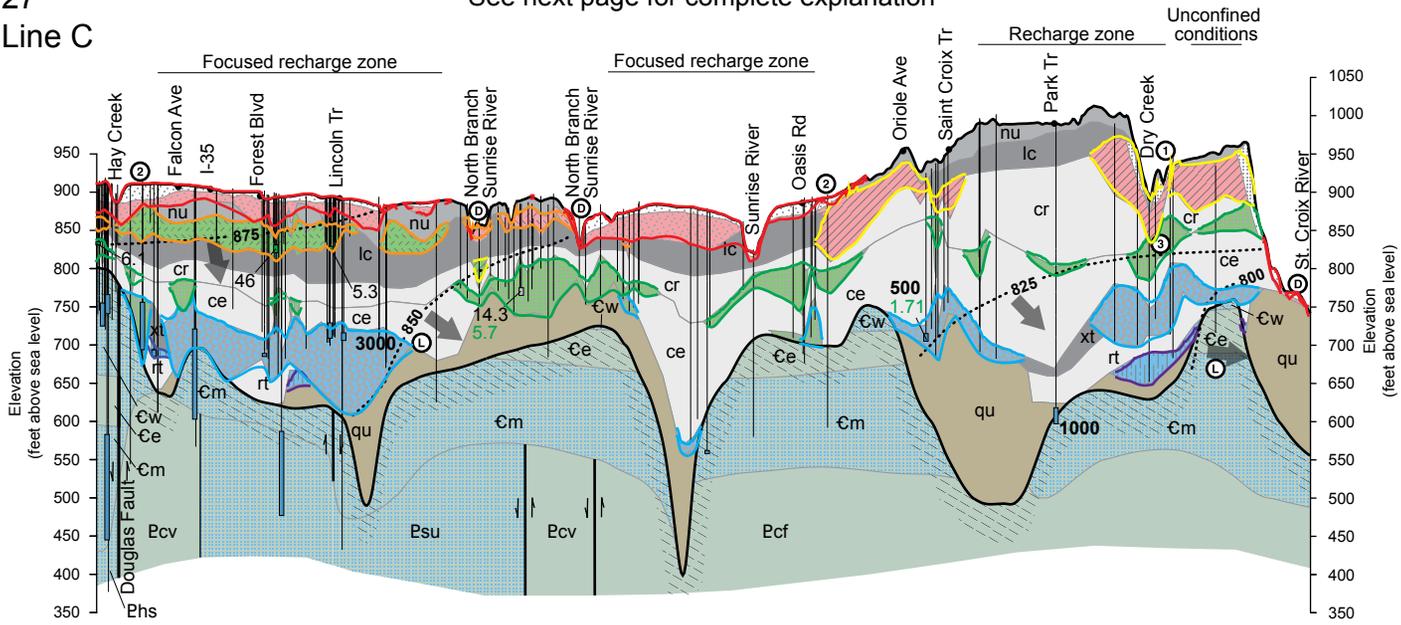




Aquifers grouped by stratigraphy		EXPLANATION FOR CROSS SECTION		Tritium age	
Surficial aquifer			Well location	█	Cold War era: water entered the ground during the peak period of atmospheric tritium concentration during nuclear bomb testing, 1958–1959 and 1961–1972 (greater than 15 tritium units [TU]).
— surficial sand		—	Land surface	█	Recent: water entered the ground since about 1953 (8–15 TU).
Buried sand and gravel aquifers		—	Stratigraphic boundary	█	Mixed: water is a mixture of recent and vintage waters (greater than 1 TU to less than 8 TU).
— sl	— sx	—	Bedrock contact	█	Vintage: water entered the ground before 1953 (less than or equal to 1 TU).
— sc	— sr	21.1	If shown, chloride concentration equals or exceeds 5 parts per million.	█	Well was not sampled for tritium.
— se	— sp	7.2	If shown, nitrate-nitrogen concentration equals or exceeds 1 part per million.		
		3000	If shown, groundwater residence time in years, estimated by carbon-14 (¹⁴ C) isotope analysis		

See next page for complete explanation

Line C



**EXPLANATION FOR CROSS SECTIONS
7 (A), 18 (B), 27 (C), 38 (D), AND 47 (E)**

Aquifers grouped by stratigraphy

Interpreted tritium age is indicated by background color

Surficial aquifer

Surficial sand

Buried sand and gravel aquifers

sl

sc

se

sx

sr

sp

Interpreted tritium age is indicated by pattern color

Sedimentary bedrock aquifers

** St. Peter/Prairie du Chien

* Jordan

** Upper Tunnel City

* Wonewoc

* Mt. Simon

* Undifferentiated Mesoproterozoic

Enhanced-permeability zone

* Primarily intergranular flow

** Intergranular and fracture flow

Symbols and labels

21.1 If shown, chloride concentration equals or exceeds 5 parts per million. Naturally occurring high chloride concentrations are shown with a superscript n.

7.2 If shown, nitrate-nitrogen concentration equals or exceeds 1 part per million.

3000 If shown, groundwater residence time in years, estimated by carbon-14 (¹⁴C) isotope analysis

General direction of groundwater flow

Approximate equipotential contour

Geologic contact

Land or bedrock surface

Lake

Direction of fault movement, arrows indicate relative movement

Tritium age

Darker color in small vertical rectangle (well screen symbol) indicates tritium age of water sampled in well. Lighter color indicates interpreted age of water in aquifer.

Cold War era: water entered the ground during the peak period of atmospheric tritium concentration during nuclear bomb testing, 1958–1959 and 1961–1972 (greater than 15 tritium units [TU]).

Recent: water entered the ground since about 1953 (8–15 TU).

Mixed: water is a mixture of recent and vintage waters (greater than 1 TU to less than 8 TU).

Vintage: water entered the ground before 1953 (less than or equal to 1 TU).

Well was not sampled for tritium.

Bedrock aquitards

St. Lawrence Formation

Eau Claire Formation

Bedrock nonaquifer units

Mesoproterozoic Volcanic Rock–Clam Falls Volcanics

Mesoproterozoic Volcanic Rock–Chengwatana Group

Mesoproterozoic Volcanic Rock–North Branch Volcanics

Quaternary aquitards grouped by texture

Aquitard Percent sand*

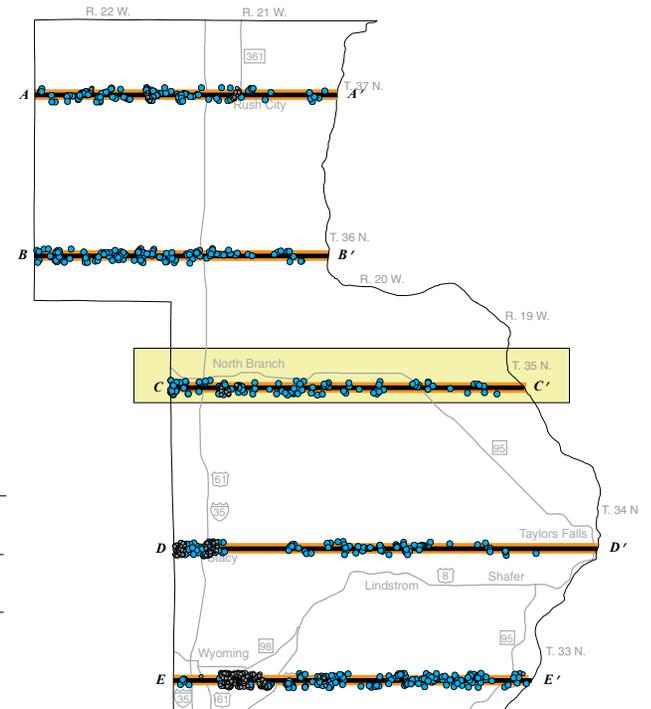
cr, ce, rt > 60

nu > 40 and ≤ 50

lc, xt > 30 and ≤ 40

qu Undifferentiated Pleistocene sediment, texture and relative hydraulic conductivity unknown

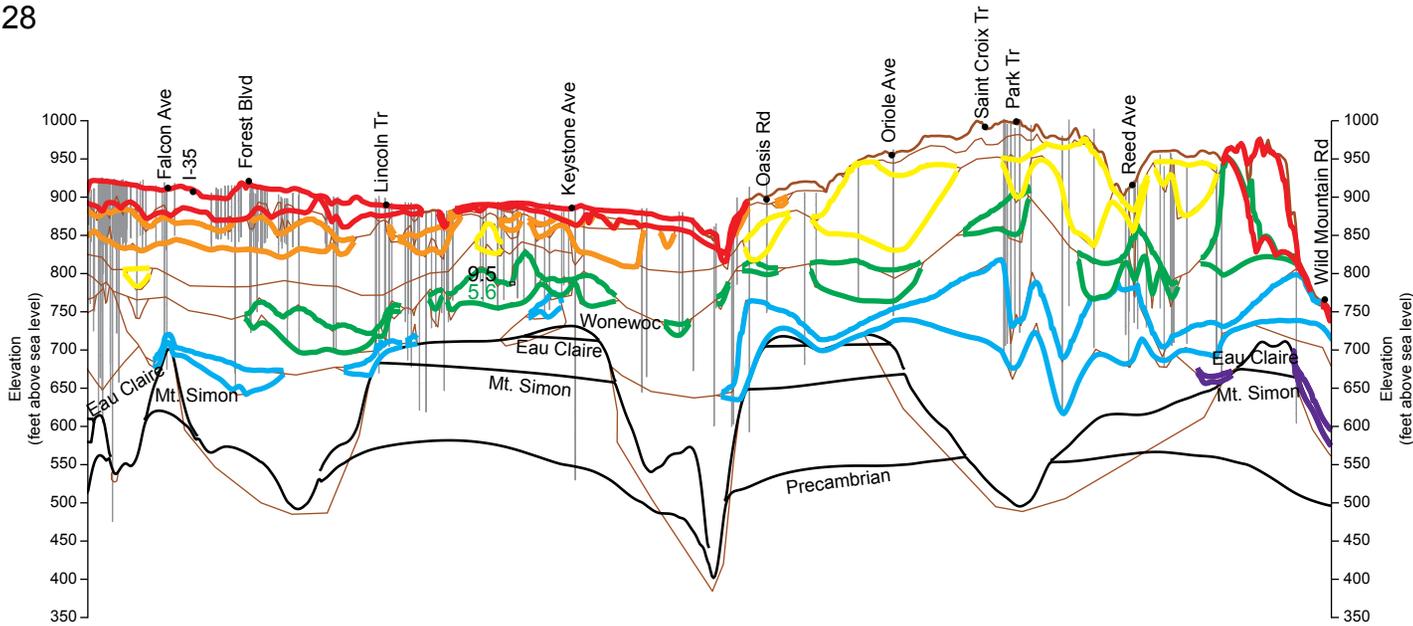
*Relative hydraulic conductivity



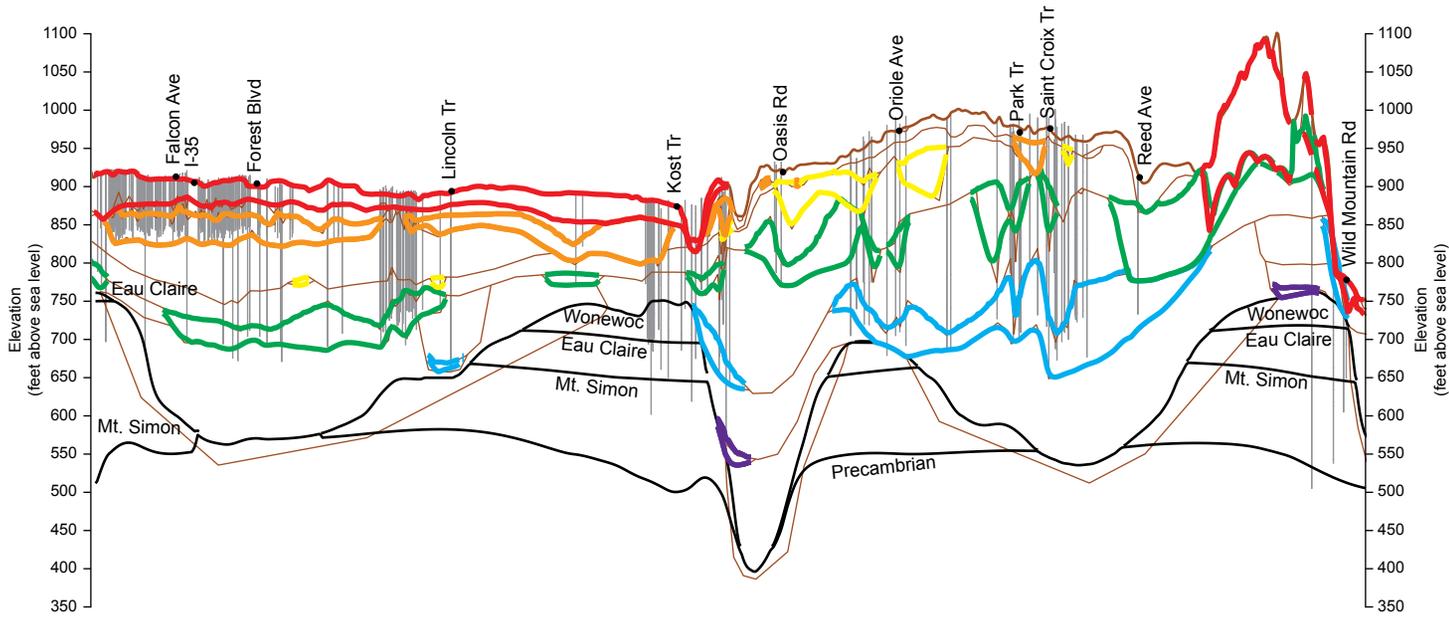
Orange lines show the location of cross sections shown in the Chisago County Geologic Atlas Part B, which are coincident with the geologic cross section lines from Part A (shown in black). Circles indicate the locations of wells used to generate the hydrogeologic cross sections. Blue circles indicate wells displayed in the cross sections. Gray circles indicate wells that are not shown in areas of high well density. These wells were removed to show underlying detail.

Groundwater conditions

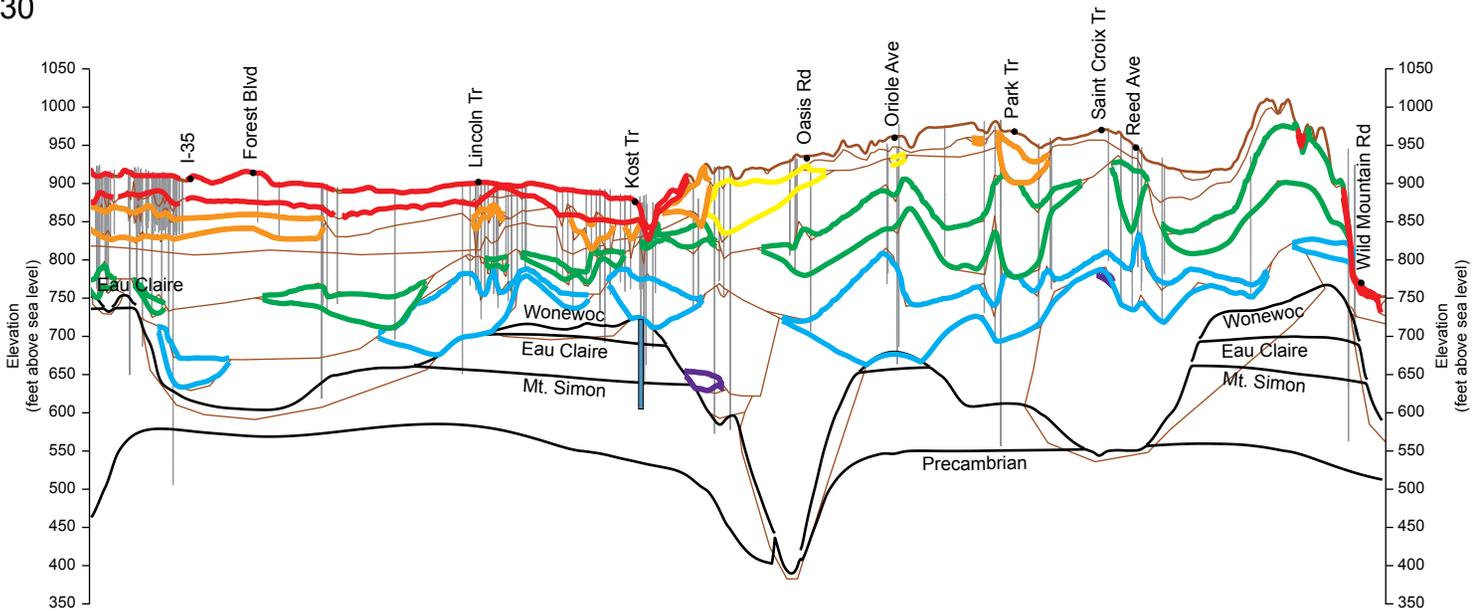
- ① Infiltration through a thin layer of overlying, fine-grained material to an underlying aquifer
- ② Groundwater recharge from an overlying surficial aquifer to a buried aquifer
- ③ Groundwater leakage from an overlying buried aquifer to an underlying buried aquifer
- ④ Groundwater leakage through multiple aquifers and fine-grained layers
- Ⓓ Groundwater discharge to surface-water body
- Ⓕ Lateral groundwater flow
- ⊙ Groundwater movement out of cross section



EXPLANATION FOR CROSS SECTION		
Aquifers grouped by stratigraphy	Symbols and labels	Tritium age
Surficial aquifer	Well location	█ Cold War era: water entered the ground during the peak period of atmospheric tritium concentration during nuclear bomb testing, 1958–1959 and 1961–1972 (greater than 15 tritium units [TU]).
— surficial sand	— Land surface	█ Recent: water entered the ground since about 1953 (8–15 TU).
Buried sand and gravel aquifers	— Stratigraphic boundary	█ Mixed: water is a mixture of recent and vintage waters (greater than 1 TU to less than 8 TU).
— sl — sx	— Bedrock contact	█ Vintage: water entered the ground before 1953 (less than or equal to 1 TU).
— sc — sr	21.1 If shown, chloride concentration equals or exceeds 5 parts per million.	□ Well was not sampled for tritium.
— se — sp	7.2 If shown, nitrate-nitrogen concentration equals or exceeds 1 part per million.	
	3000 If shown, groundwater residence time in years, estimated by carbon-14 (¹⁴ C) isotope analysis	



EXPLANATION FOR CROSS SECTION		
Aquifers grouped by stratigraphy	Symbols and labels	Tritium age
Surficial aquifer	Well location	█ Cold War era: water entered the ground during the peak period of atmospheric tritium concentration during nuclear bomb testing, 1958–1959 and 1961–1972 (greater than 15 tritium units [TU]).
— surficial sand	— Land surface	█ Recent: water entered the ground since about 1953 (8–15 TU).
Buried sand and gravel aquifers	— Stratigraphic boundary	█ Mixed: water is a mixture of recent and vintage waters (greater than 1 TU to less than 8 TU).
— sl — sx	— Bedrock contact	█ Vintage: water entered the ground before 1953 (less than or equal to 1 TU).
— sc — sr	21.1 If shown, chloride concentration equals or exceeds 5 parts per million.	□ Well was not sampled for tritium.
— se — sp	7.2 If shown, nitrate-nitrogen concentration equals or exceeds 1 part per million.	
	3000 If shown, groundwater residence time in years, estimated by carbon-14 (¹⁴ C) isotope analysis	



EXPLANATION FOR CROSS SECTION

Aquifers grouped by stratigraphy

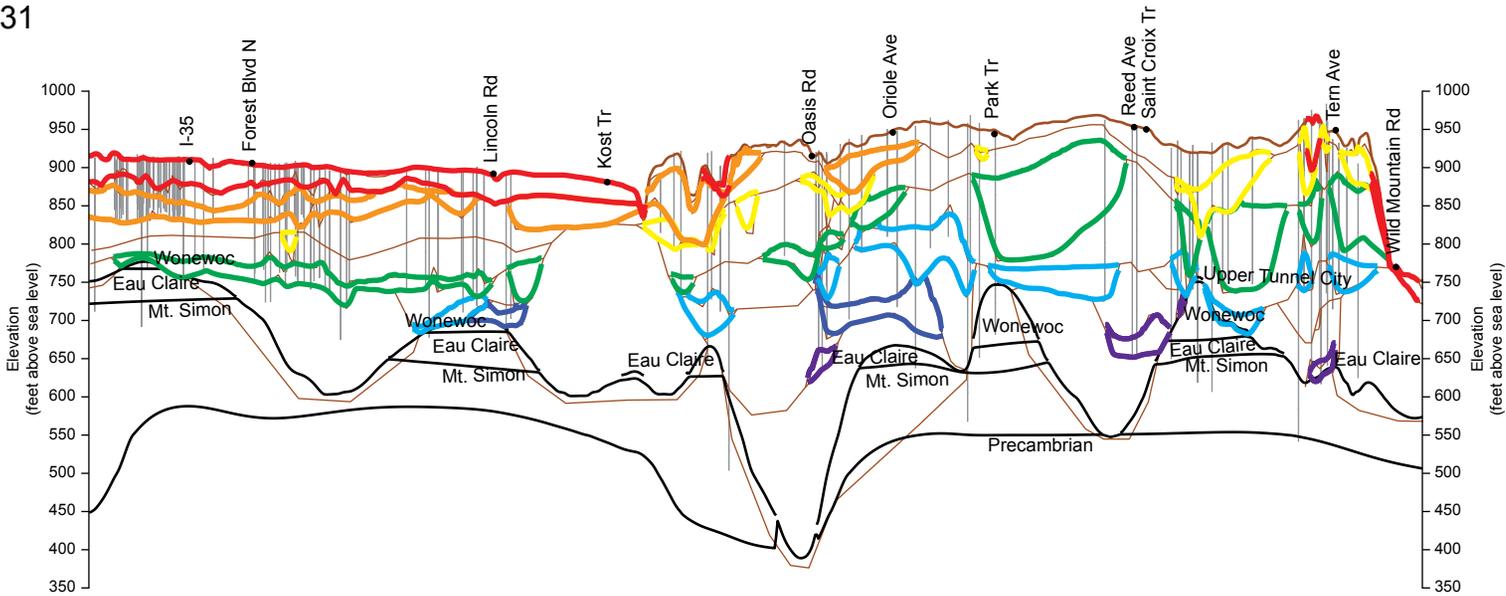
- Surficial aquifer
- surficial sand
- Buried sand and gravel aquifers
- sl — sx
- sc — sr
- se — sp

Symbols and labels

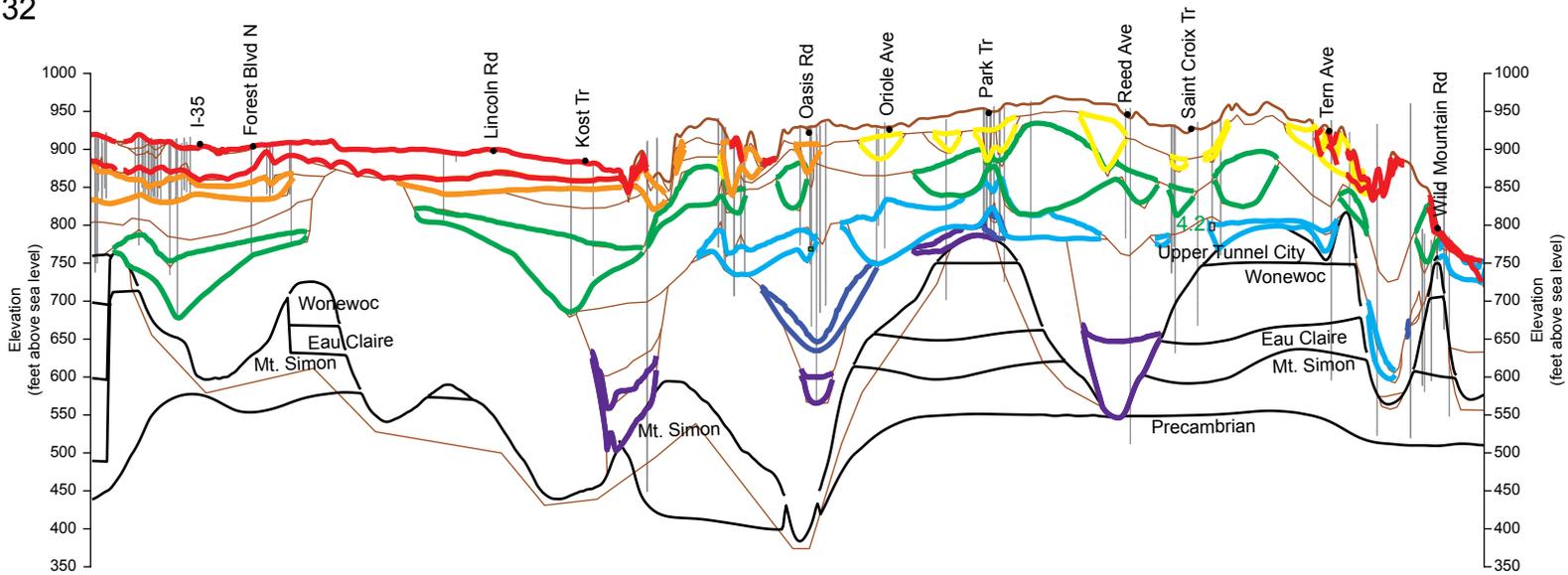
- | Well location
- Land surface
- Stratigraphic boundary
- Bedrock contact
- 21.1 If shown, chloride concentration equals or exceeds 5 parts per million.
- 7.2 If shown, nitrate-nitrogen concentration equals or exceeds 1 part per million.
- 3000 If shown, groundwater residence time in years, estimated by carbon-14 (¹⁴C) isotope analysis

Tritium age

- █ Cold War era: water entered the ground during the peak period of atmospheric tritium concentration during nuclear bomb testing, 1958–1959 and 1961–1972 (greater than 15 tritium units [TU]).
- █ Recent: water entered the ground since about 1953 (8–15 TU).
- █ Mixed: water is a mixture of recent and vintage waters (greater than 1 TU to less than 8 TU).
- █ Vintage: water entered the ground before 1953 (less than or equal to 1 TU).
- Well was not sampled for tritium.



EXPLANATION FOR CROSS SECTION		
<p>Aquifers grouped by stratigraphy</p> <p>Surficial aquifer</p> <ul style="list-style-type: none"> — surficial sand <p>Buried sand and gravel aquifers</p> <ul style="list-style-type: none"> — sl — sx — sc — sr — se — sp 	<p style="text-align: center;">Symbols and labels</p> <ul style="list-style-type: none"> Well location — Land surface — Stratigraphic boundary — Bedrock contact 21.1 If shown, chloride concentration equals or exceeds 5 parts per million. 7.2 If shown, nitrate-nitrogen concentration equals or exceeds 1 part per million. 3000 If shown, groundwater residence time in years, estimated by carbon-14 (¹⁴C) isotope analysis 	<p style="text-align: center;">Tritium age</p> <ul style="list-style-type: none"> █ Cold War era: water entered the ground during the peak period of atmospheric tritium concentration during nuclear bomb testing, 1958–1959 and 1961–1972 (greater than 15 tritium units [TU]). █ Recent: water entered the ground since about 1953 (8–15 TU). █ Mixed: water is a mixture of recent and vintage waters (greater than 1 TU to less than 8 TU). █ Vintage: water entered the ground before 1953 (less than or equal to 1 TU). □ Well was not sampled for tritium.



EXPLANATION FOR CROSS SECTION

Aquifers grouped by stratigraphy

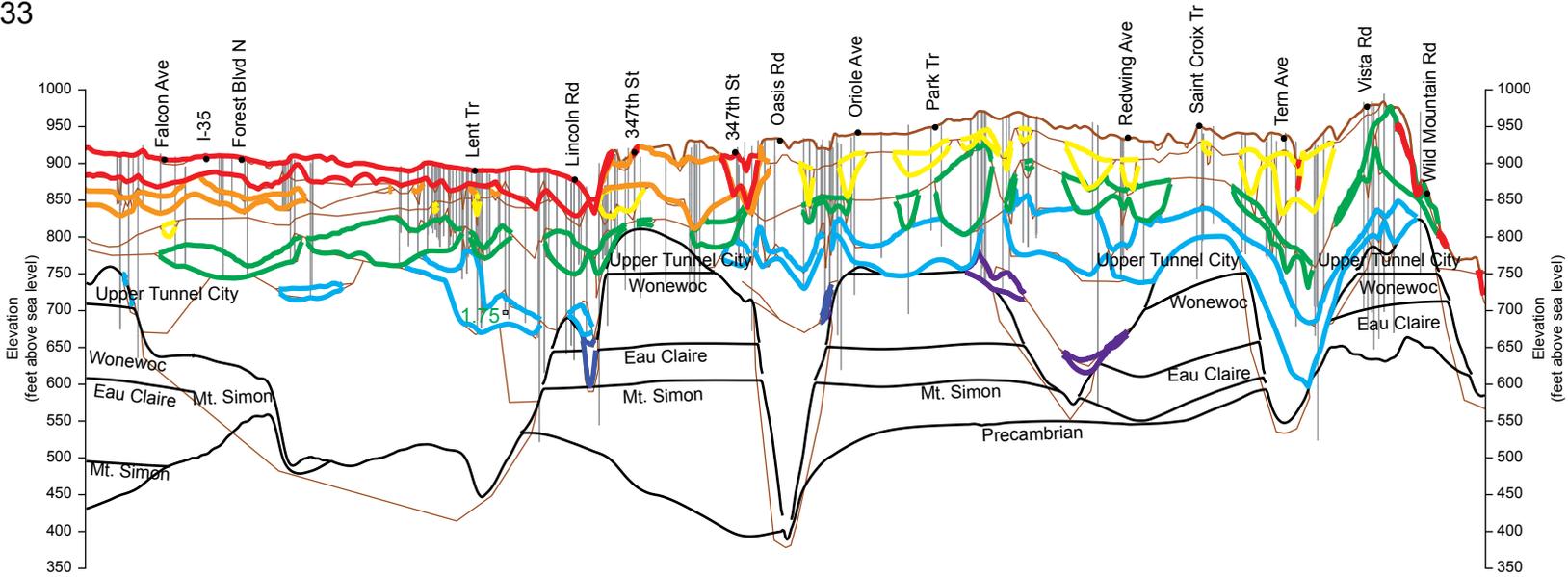
- Surficial aquifer
- surficial sand
- Buried sand and gravel aquifers
- sl — sx
- sc — sr
- se — sp

Symbols and labels

- Well location
- Land surface
- Stratigraphic boundary
- Bedrock contact
- 21.1 If shown, chloride concentration equals or exceeds 5 parts per million.
- 7.2 If shown, nitrate-nitrogen concentration equals or exceeds 1 part per million.
- 3000 If shown, groundwater residence time in years, estimated by carbon-14 (¹⁴C) isotope analysis

Tritium age

- Cold War era: water entered the ground during the peak period of atmospheric tritium concentration during nuclear bomb testing, 1958–1959 and 1961–1972 (greater than 15 tritium units [TU]).
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- Mixed: water is a mixture of recent and vintage waters (greater than 1 TU to less than 8 TU).
- Vintage: water entered the ground before 1953 (less than or equal to 1 TU).
- Well was not sampled for tritium.



EXPLANATION FOR CROSS SECTION

Aquifers grouped by stratigraphy

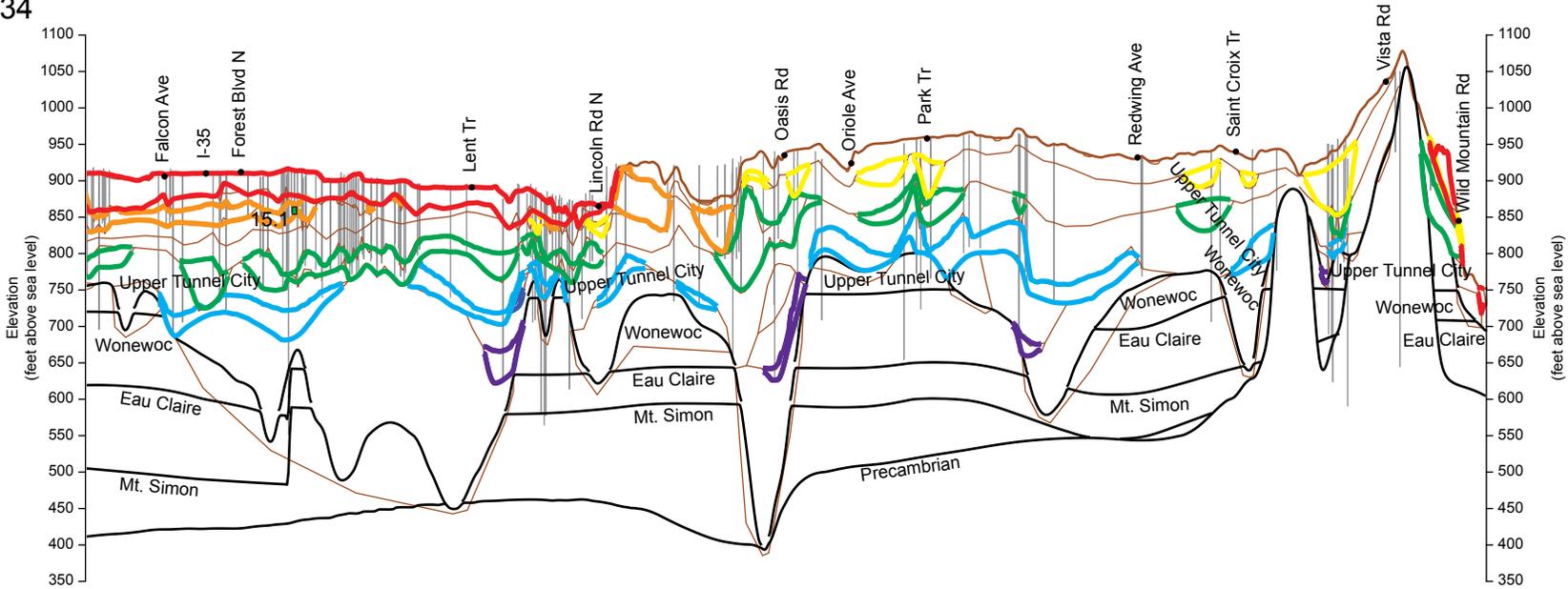
- Surficial aquifer
- surficial sand
- Buried sand and gravel aquifers
- sl — sx
- sc — sr
- se — sp

Symbols and labels

- | Well location
- Land surface
- Stratigraphic boundary
- Bedrock contact
- 21.1 If shown, chloride concentration equals or exceeds 5 parts per million.
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- 3000 If shown, groundwater residence time in years, estimated by carbon-14 (¹⁴C) isotope analysis

Tritium age

- █ Cold War era: water entered the ground during the peak period of atmospheric tritium concentration during nuclear bomb testing, 1958–1959 and 1961–1972 (greater than 15 tritium units [TU]).
- █ Recent: water entered the ground since about 1953 (8–15 TU).
- █ Mixed: water is a mixture of recent and vintage waters (greater than 1 TU to less than 8 TU).
- █ Vintage: water entered the ground before 1953 (less than or equal to 1 TU).
- Well was not sampled for tritium.



EXPLANATION FOR CROSS SECTION

Aquifers grouped by stratigraphy

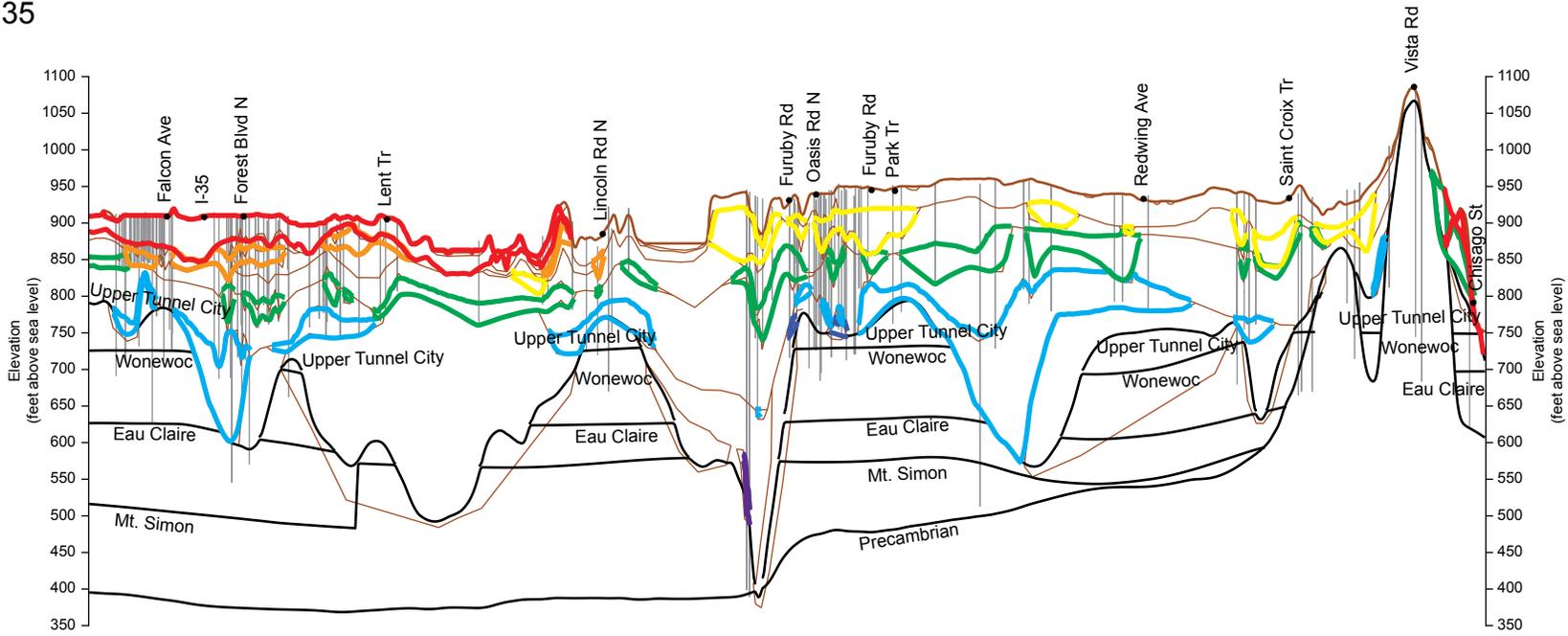
- Surficial aquifer
- surficial sand
- Buried sand and gravel aquifers
- sl — sx
- sc — sr
- se — sp

Symbols and labels

- | Well location
- Land surface
- Stratigraphic boundary
- Bedrock contact
- 21.1 If shown, chloride concentration equals or exceeds 5 parts per million.
- 7.2 If shown, nitrate-nitrogen concentration equals or exceeds 1 part per million.
- 3000 If shown, groundwater residence time in years, estimated by carbon-14 (¹⁴C) isotope analysis

Tritium age

- █ Cold War era: water entered the ground during the peak period of atmospheric tritium concentration during nuclear bomb testing, 1958–1959 and 1961–1972 (greater than 15 tritium units [TU]).
- █ Recent: water entered the ground since about 1953 (8–15 TU).
- █ Mixed: water is a mixture of recent and vintage waters (greater than 1 TU to less than 8 TU).
- █ Vintage: water entered the ground before 1953 (less than or equal to 1 TU).
- Well was not sampled for tritium.



EXPLANATION FOR CROSS SECTION

Aquifers grouped by stratigraphy

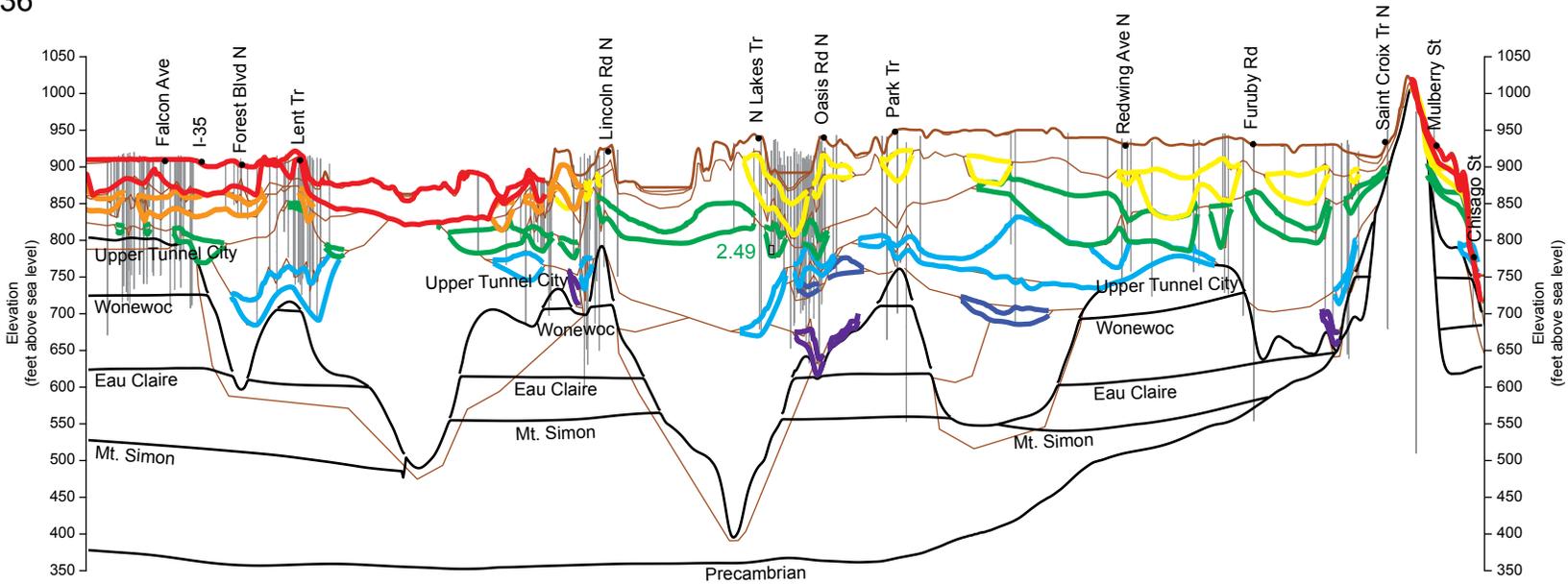
- Surficial aquifer
- surficial sand
- Buried sand and gravel aquifers
- sl — sx
- sc — sr
- se — sp

Symbols and labels

- Well location
- Land surface
- Stratigraphic boundary
- Bedrock contact
- 21.1 If shown, chloride concentration equals or exceeds 5 parts per million.
- 7.2 If shown, nitrate-nitrogen concentration equals or exceeds 1 part per million.
- 3000 If shown, groundwater residence time in years, estimated by carbon-14 (¹⁴C) isotope analysis

Tritium age

- Cold War era: water entered the ground during the peak period of atmospheric tritium concentration during nuclear bomb testing, 1958–1959 and 1961–1972 (greater than 15 tritium units [TU]).
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- Mixed: water is a mixture of recent and vintage waters (greater than 1 TU to less than 8 TU).
- Vintage: water entered the ground before 1953 (less than or equal to 1 TU).
- Well was not sampled for tritium.



EXPLANATION FOR CROSS SECTION

Aquifers grouped by stratigraphy

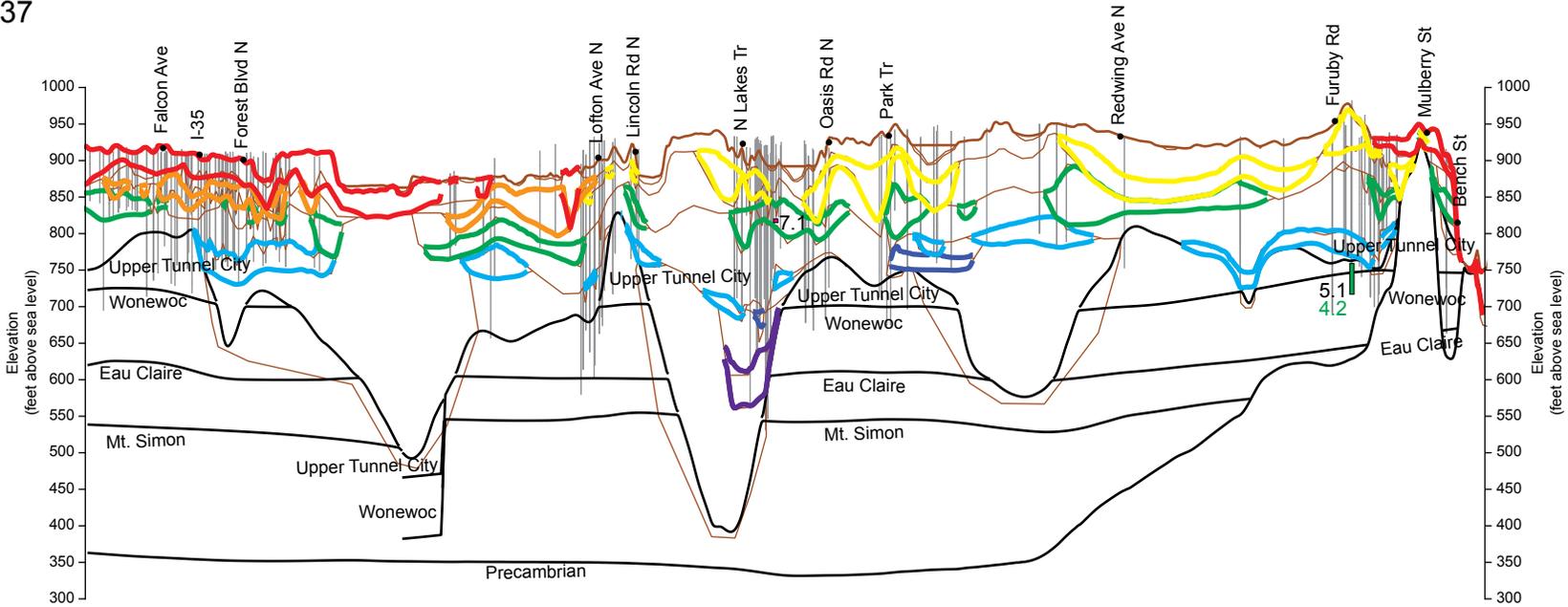
- Surficial aquifer
- surficial sand
- Buried sand and gravel aquifers
- sl — sx
- sc — sr
- se — sp

Symbols and labels

- Well location
- Land surface
- Stratigraphic boundary
- Bedrock contact
- 21.1 If shown, chloride concentration equals or exceeds 5 parts per million.
- 7.2 If shown, nitrate-nitrogen concentration equals or exceeds 1 part per million.
- 3000 If shown, groundwater residence time in years, estimated by carbon-14 (¹⁴C) isotope analysis

Tritium age

- Cold War era: water entered the ground during the peak period of atmospheric tritium concentration during nuclear bomb testing, 1958–1959 and 1961–1972 (greater than 15 tritium units [TU]).
- Recent: water entered the ground since about 1953 (8–15 TU).
- Mixed: water is a mixture of recent and vintage waters (greater than 1 TU to less than 8 TU).
- Vintage: water entered the ground before 1953 (less than or equal to 1 TU).
- Well was not sampled for tritium.



EXPLANATION FOR CROSS SECTION

Aquifers grouped by stratigraphy

- Surficial aquifer
- surficial sand
- Buried sand and gravel aquifers
- sl — sx
- sc — sr
- se — sp

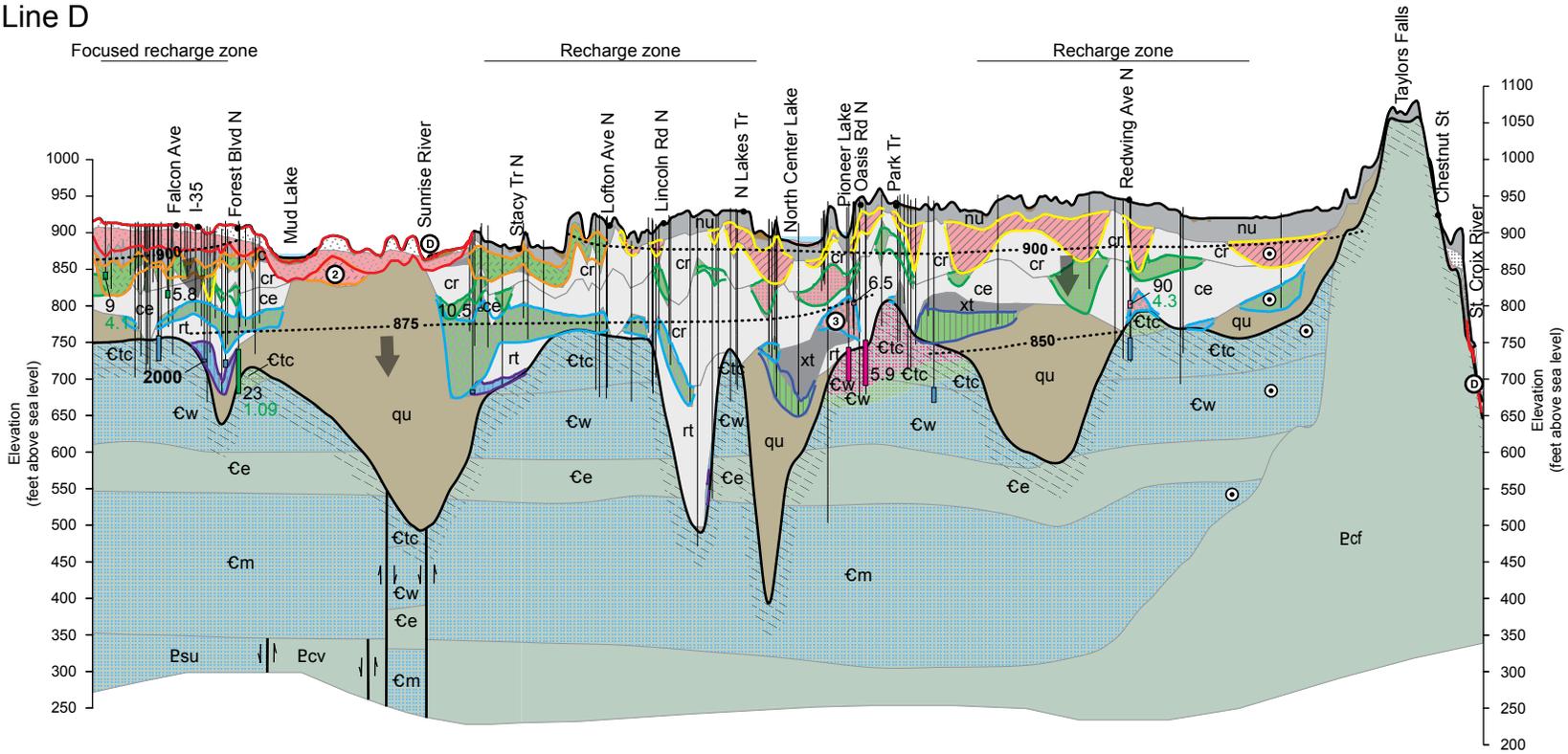
Symbols and labels

- Well location
- Land surface
- Stratigraphic boundary
- Bedrock contact
- 21.1 If shown, chloride concentration equals or exceeds 5 parts per million.
- 7.2 If shown, nitrate-nitrogen concentration equals or exceeds 1 part per million.
- 3000 If shown, groundwater residence time in years, estimated by carbon-14 (¹⁴C) isotope analysis

Tritium age

- Cold War era: water entered the ground during the peak period of atmospheric tritium concentration during nuclear bomb testing, 1958–1959 and 1961–1972 (greater than 15 tritium units [TU]).
- Recent: water entered the ground since about 1953 (8–15 TU).
- Mixed: water is a mixture of recent and vintage waters (greater than 1 TU to less than 8 TU).
- Vintage: water entered the ground before 1953 (less than or equal to 1 TU).
- Well was not sampled for tritium.

Line D



**EXPLANATION FOR CROSS SECTIONS
7 (A), 18 (B), 27 (C), 38 (D), AND 47 (E)**

Aquifers grouped by stratigraphy

Interpreted tritium age is indicated by background color

Surficial aquifer

Surficial sand

Buried sand and gravel aquifers

sl

sc

se

sx

sr

sp

Interpreted tritium age is indicated by pattern color

Sedimentary bedrock aquifers

** St. Peter/Prairie du Chien

* Jordan

** Upper Tunnel City

* Wonewoc

* Mt. Simon

* Undifferentiated Mesoproterozoic

Enhanced-permeability zone

* Primarily intergranular flow

** Intergranular and fracture flow

Symbols and labels

21.1 If shown, chloride concentration equals or exceeds 5 parts per million. Naturally occurring high chloride concentrations are shown with a superscript n.

7.2 If shown, nitrate-nitrogen concentration equals or exceeds 1 part per million.

3000 If shown, groundwater residence time in years, estimated by carbon-14 (¹⁴C) isotope analysis

General direction of groundwater flow

Approximate equipotential contour

Geologic contact

Land or bedrock surface

Lake

Direction of fault movement, arrows indicate relative movement

Tritium age

Darker color in small vertical rectangle (well screen symbol) indicates tritium age of water sampled in well. Lighter color indicates interpreted age of water in aquifer.

Cold War era: water entered the ground during the peak period of atmospheric tritium concentration during nuclear bomb testing, 1958–1959 and 1961–1972 (greater than 15 tritium units [TU]).

Recent: water entered the ground since about 1953 (8–15 TU).

Mixed: water is a mixture of recent and vintage waters (greater than 1 TU to less than 8 TU).

Vintage: water entered the ground before 1953 (less than or equal to 1 TU).

Well was not sampled for tritium.

Bedrock aquitards

St. Lawrence Formation

Eau Claire Formation

Mesoproterozoic Volcanic Rock–Clam Falls Volcanics

Mesoproterozoic Volcanic Rock–Chengwatana Group

Mesoproterozoic Volcanic Rock–North Branch Volcanics

Quaternary aquitards grouped by texture

Aquitard Percent sand*

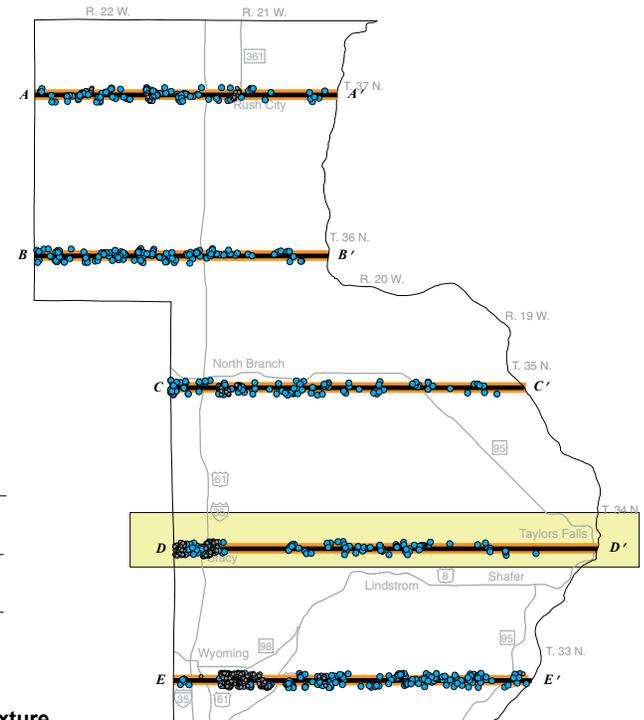
cr, ce, rt > 60

nu > 40 and ≤ 50

lc, xt > 30 and ≤ 40

qu Undifferentiated Pleistocene sediment, texture and relative hydraulic conductivity unknown

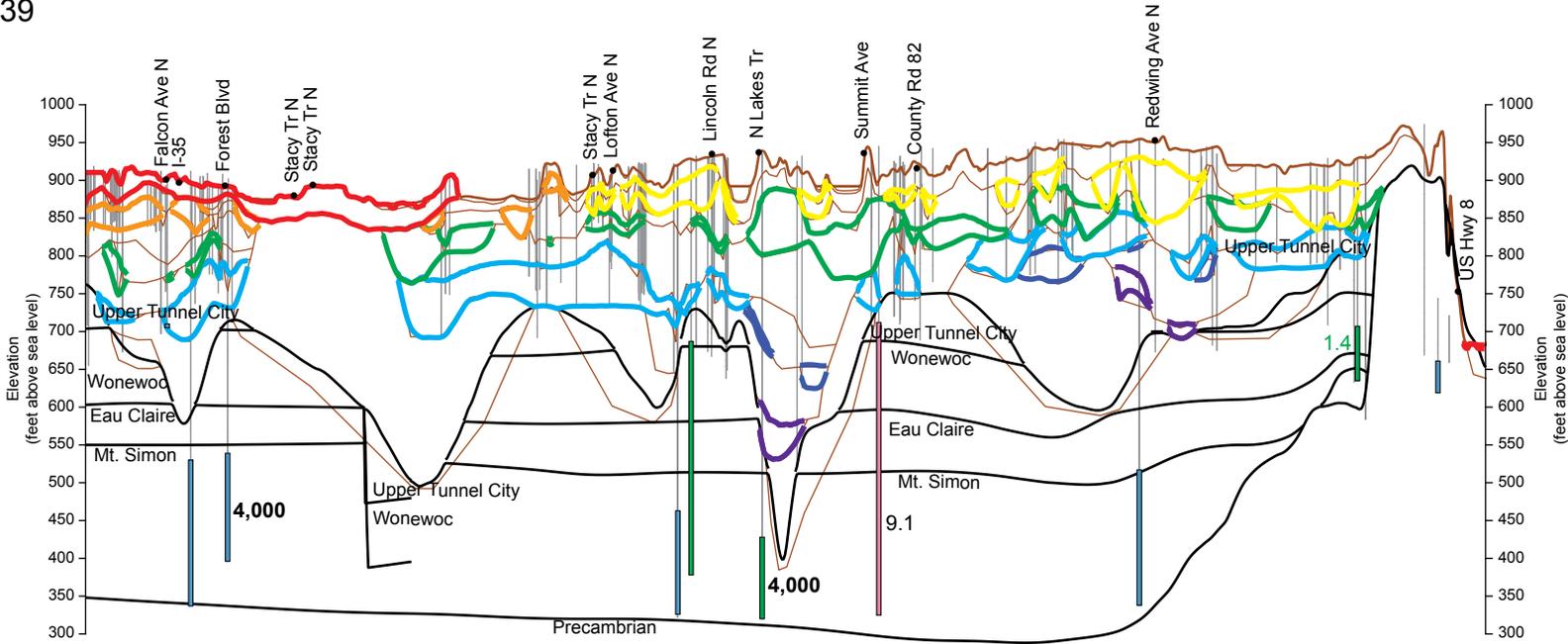
*Relative hydraulic conductivity



Orange lines show the location of cross sections shown in the Chisago County Geologic Atlas Part B, which are coincident with the geologic cross section lines from Part A (shown in black). Circles indicate the locations of wells used to generate the hydrogeologic cross sections. Blue circles indicate wells displayed in the cross sections. Gray circles indicate wells that are not shown in areas of high well density. These wells were removed to show underlying detail.

Groundwater conditions

- ① Infiltration through a thin layer of overlying, fine-grained material to an underlying aquifer
- ② Groundwater recharge from an overlying surficial aquifer to a buried aquifer
- ③ Groundwater leakage from an overlying buried aquifer to an underlying buried aquifer
- ④ Groundwater leakage through multiple aquifers and fine-grained layers
- Ⓓ Groundwater discharge to surface-water body
- Ⓕ Lateral groundwater flow
- ⊙ Groundwater movement out of cross section



EXPLANATION FOR CROSS SECTION

Aquifers grouped by stratigraphy

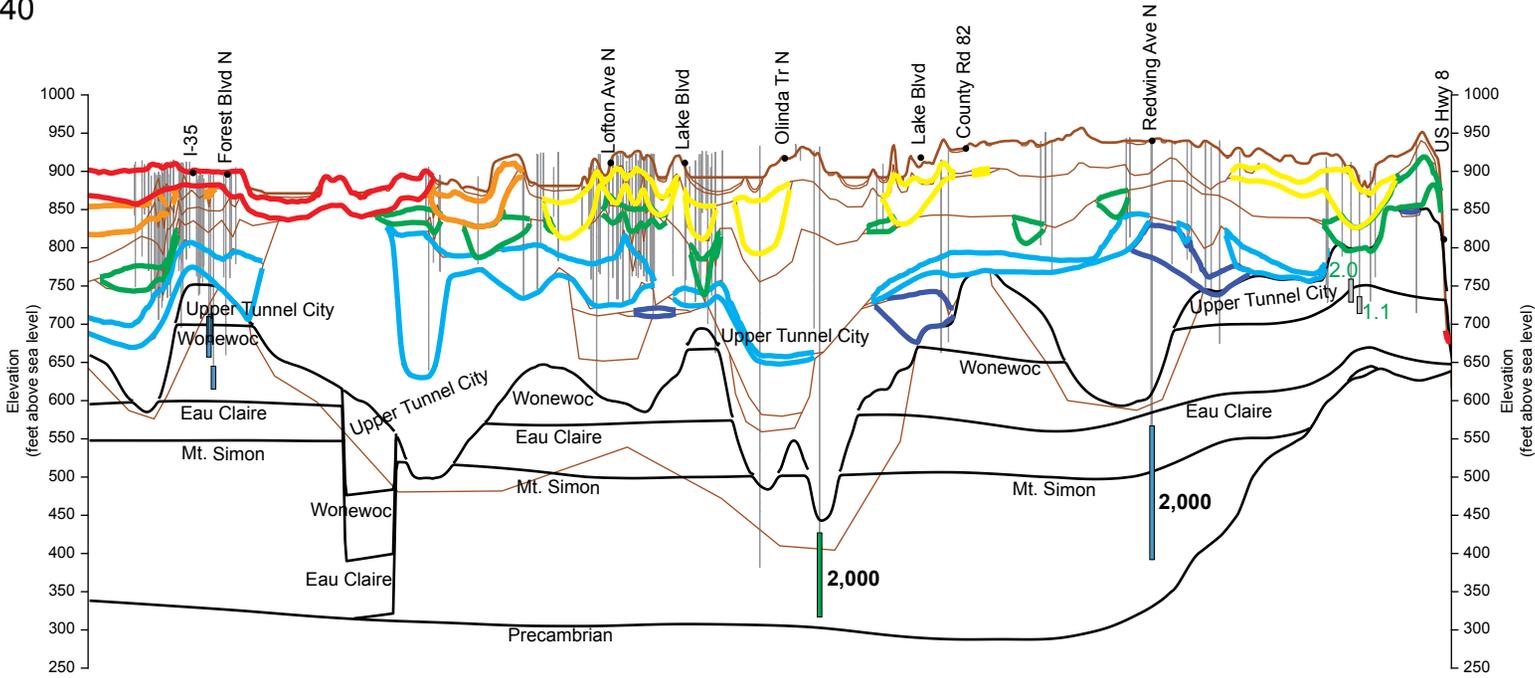
- Surficial aquifer
- surficial sand
- Buried sand and gravel aquifers
- sl — sx
- sc — sr
- se — sp

Symbols and labels

- Well location
- Land surface
- Stratigraphic boundary
- Bedrock contact
- 21.1 If shown, chloride concentration equals or exceeds 5 parts per million.
- 7.2 If shown, nitrate-nitrogen concentration equals or exceeds 1 part per million.
- 3000 If shown, groundwater residence time in years, estimated by carbon-14 (¹⁴C) isotope analysis

Tritium age

- Cold War era: water entered the ground during the peak period of atmospheric tritium concentration during nuclear bomb testing, 1958–1959 and 1961–1972 (greater than 15 tritium units [TU]).
- Recent: water entered the ground since about 1953 (8–15 TU).
- Mixed: water is a mixture of recent and vintage waters (greater than 1 TU to less than 8 TU).
- Vintage: water entered the ground before 1953 (less than or equal to 1 TU).
- Well was not sampled for tritium.



EXPLANATION FOR CROSS SECTION

Aquifers grouped by stratigraphy

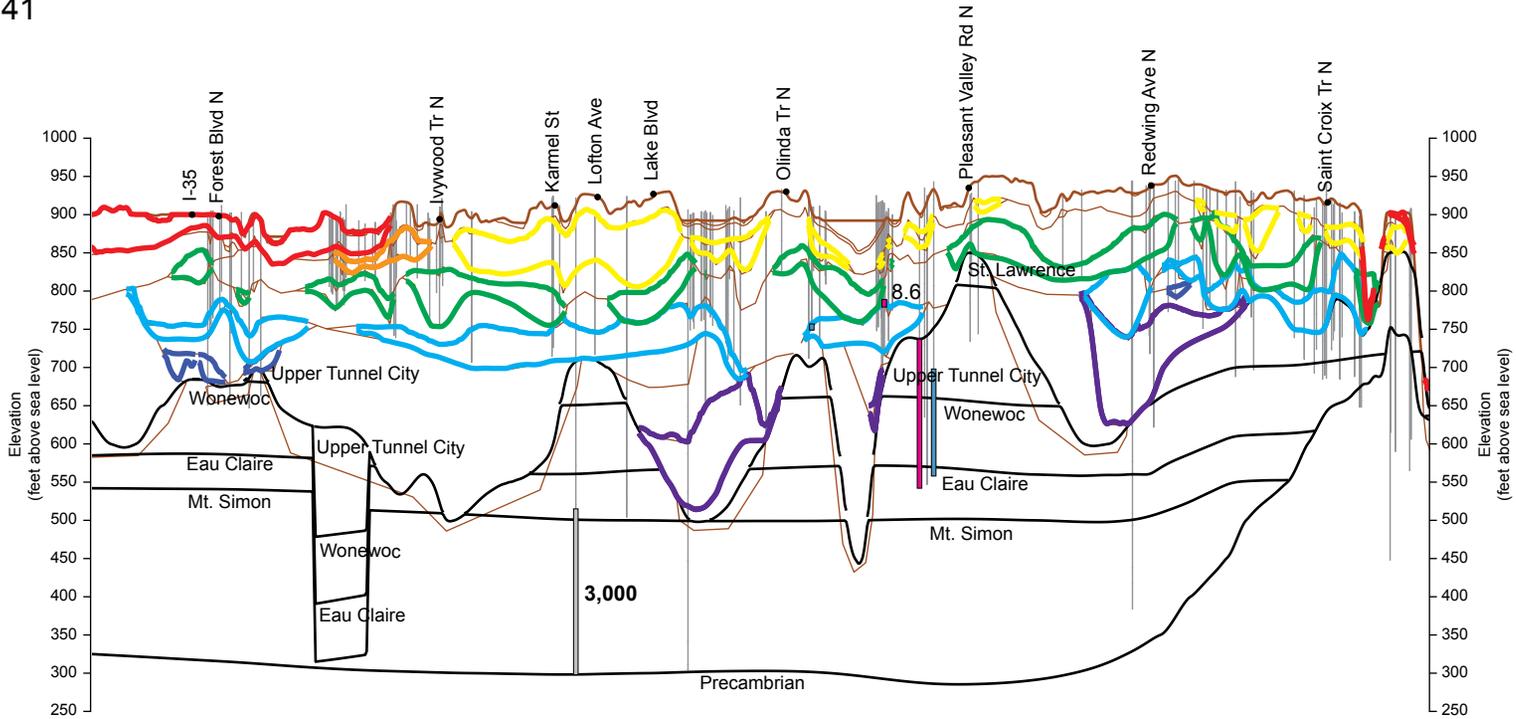
- Surficial aquifer
- surficial sand
- Buried sand and gravel aquifers
- sl — sx
- sc — sr
- se — sp

Symbols and labels

- Well location
- Land surface
- Stratigraphic boundary
- Bedrock contact
- 21.1 If shown, chloride concentration equals or exceeds 5 parts per million.
- 7.2 If shown, nitrate-nitrogen concentration equals or exceeds 1 part per million.
- 3000 If shown, groundwater residence time in years, estimated by carbon-14 (¹⁴C) isotope analysis

Tritium age

- Cold War era: water entered the ground during the peak period of atmospheric tritium concentration during nuclear bomb testing, 1958–1959 and 1961–1972 (greater than 15 tritium units [TU]).
- Recent: water entered the ground since about 1953 (8–15 TU).
- Mixed: water is a mixture of recent and vintage waters (greater than 1 TU to less than 8 TU).
- Vintage: water entered the ground before 1953 (less than or equal to 1 TU).
- Well was not sampled for tritium.



EXPLANATION FOR CROSS SECTION

Aquifers grouped by stratigraphy

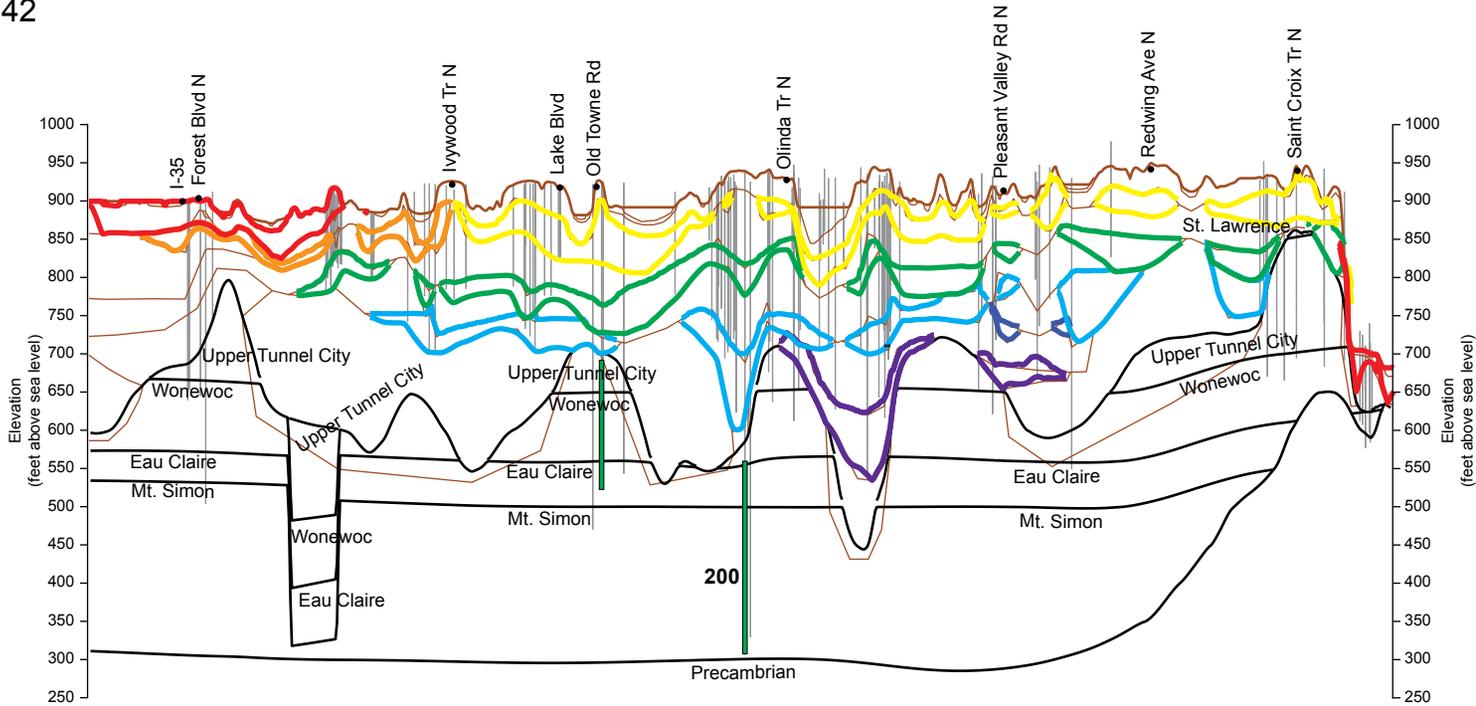
- Surficial aquifer
- surficial sand
- Buried sand and gravel aquifers
- sl — sx
- sc — sr
- se — sp

Symbols and labels

- | Well location
- Land surface
- Stratigraphic boundary
- Bedrock contact
- 21.1 If shown, chloride concentration equals or exceeds 5 parts per million.
- 7.2 If shown, nitrate-nitrogen concentration equals or exceeds 1 part per million.
- 3000 If shown, groundwater residence time in years, estimated by carbon-14 (¹⁴C) isotope analysis

Tritium age

- █ Cold War era: water entered the ground during the peak period of atmospheric tritium concentration during nuclear bomb testing, 1958–1959 and 1961–1972 (greater than 15 tritium units [TU]).
- █ Recent: water entered the ground since about 1953 (8–15 TU).
- █ Mixed: water is a mixture of recent and vintage waters (greater than 1 TU to less than 8 TU).
- █ Vintage: water entered the ground before 1953 (less than or equal to 1 TU).
- Well was not sampled for tritium.



EXPLANATION FOR CROSS SECTION

Aquifers grouped by stratigraphy

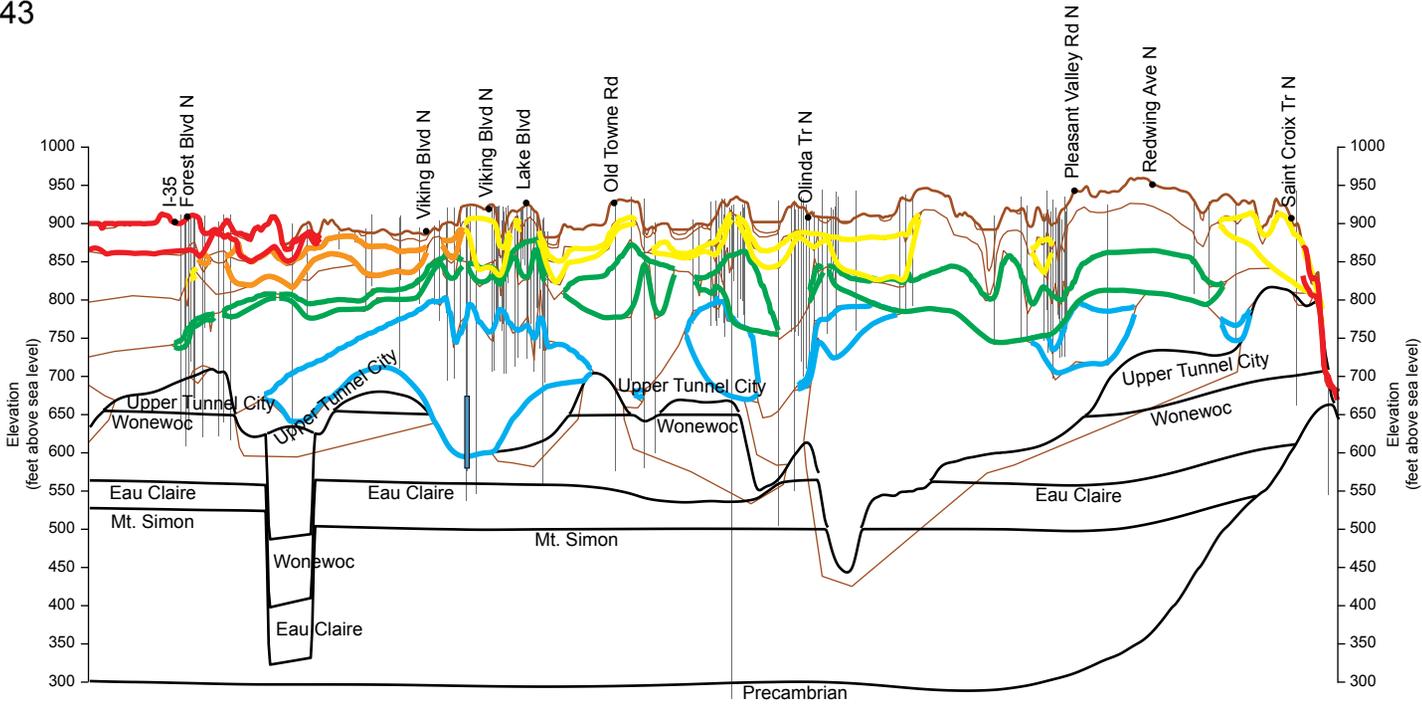
- Surficial aquifer
- surficial sand
- Buried sand and gravel aquifers
- sl — sx
- sc — sr
- se — sp

Symbols and labels

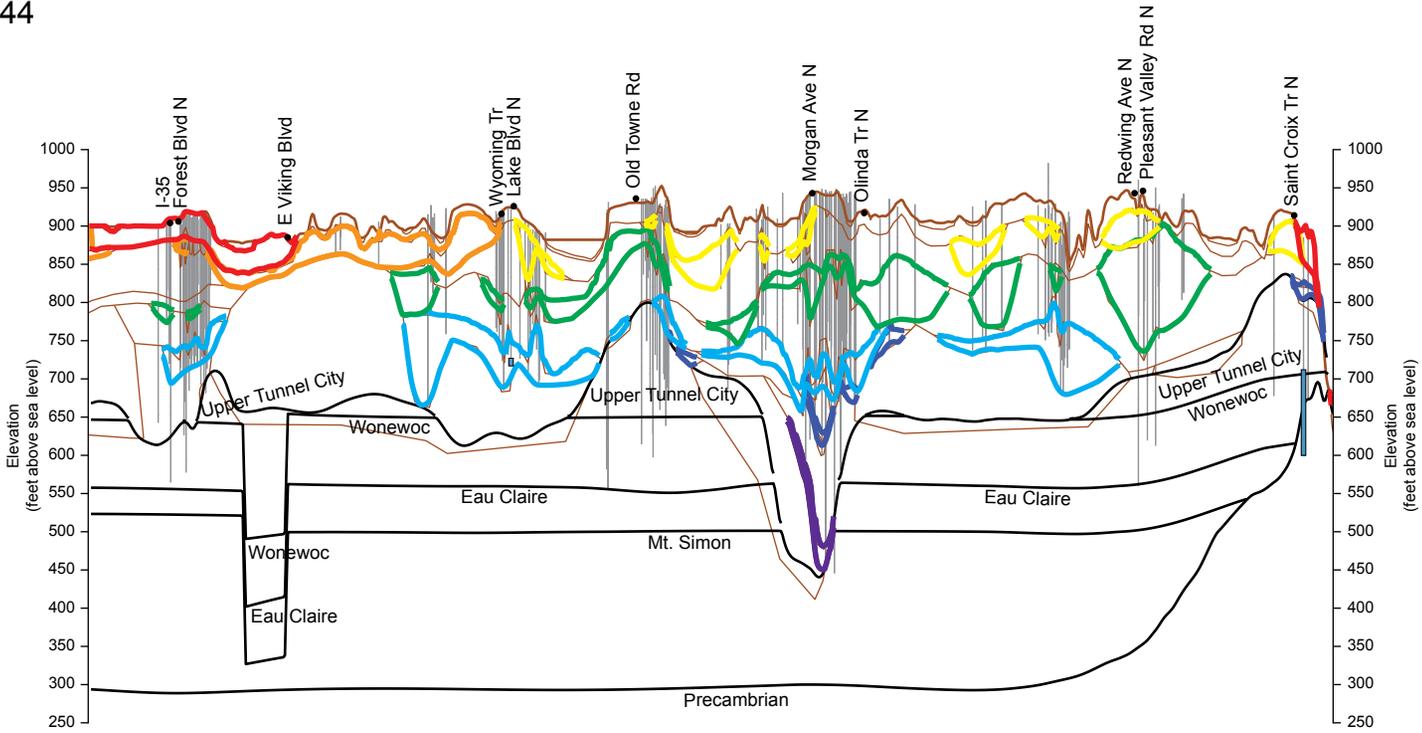
- | Well location
- Land surface
- Stratigraphic boundary
- Bedrock contact
- 21.1 If shown, chloride concentration equals or exceeds 5 parts per million.
- 7.2 If shown, nitrate-nitrogen concentration equals or exceeds 1 part per million.
- 3000 If shown, groundwater residence time in years, estimated by carbon-14 (¹⁴C) isotope analysis

Tritium age

- █ Cold War era: water entered the ground during the peak period of atmospheric tritium concentration during nuclear bomb testing, 1958–1959 and 1961–1972 (greater than 15 tritium units [TU]).
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EXPLANATION FOR CROSS SECTION		
Aquifers grouped by stratigraphy	Symbols and labels	Tritium age
Surficial aquifer	Well location	█ Cold War era: water entered the ground during the peak period of atmospheric tritium concentration during nuclear bomb testing, 1958–1959 and 1961–1972 (greater than 15 tritium units [TU]).
— surficial sand	— Land surface	█ Recent: water entered the ground since about 1953 (8–15 TU).
Buried sand and gravel aquifers	— Stratigraphic boundary	█ Mixed: water is a mixture of recent and vintage waters (greater than 1 TU to less than 8 TU).
— sl — sx	— Bedrock contact	█ Vintage: water entered the ground before 1953 (less than or equal to 1 TU).
— sc — sr	21.1 If shown, chloride concentration equals or exceeds 5 parts per million.	□ Well was not sampled for tritium.
— se — sp	7.2 If shown, nitrate-nitrogen concentration equals or exceeds 1 part per million.	
	3000 If shown, groundwater residence time in years, estimated by carbon-14 (¹⁴ C) isotope analysis	



EXPLANATION FOR CROSS SECTION

Aquifers grouped by stratigraphy

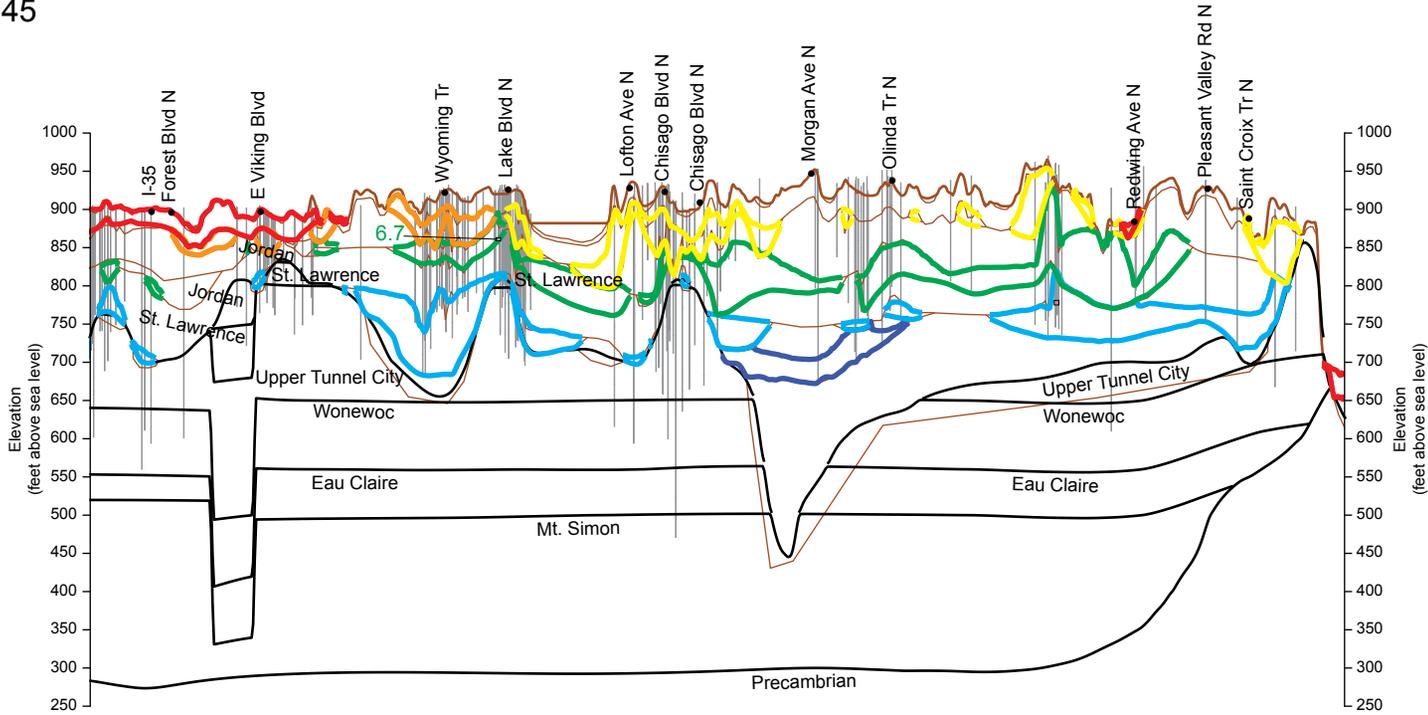
- Surficial aquifer
- surficial sand
- Buried sand and gravel aquifers
- sl — sx
- sc — sr
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Symbols and labels

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- Land surface
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EXPLANATION FOR CROSS SECTION

Aquifers grouped by stratigraphy

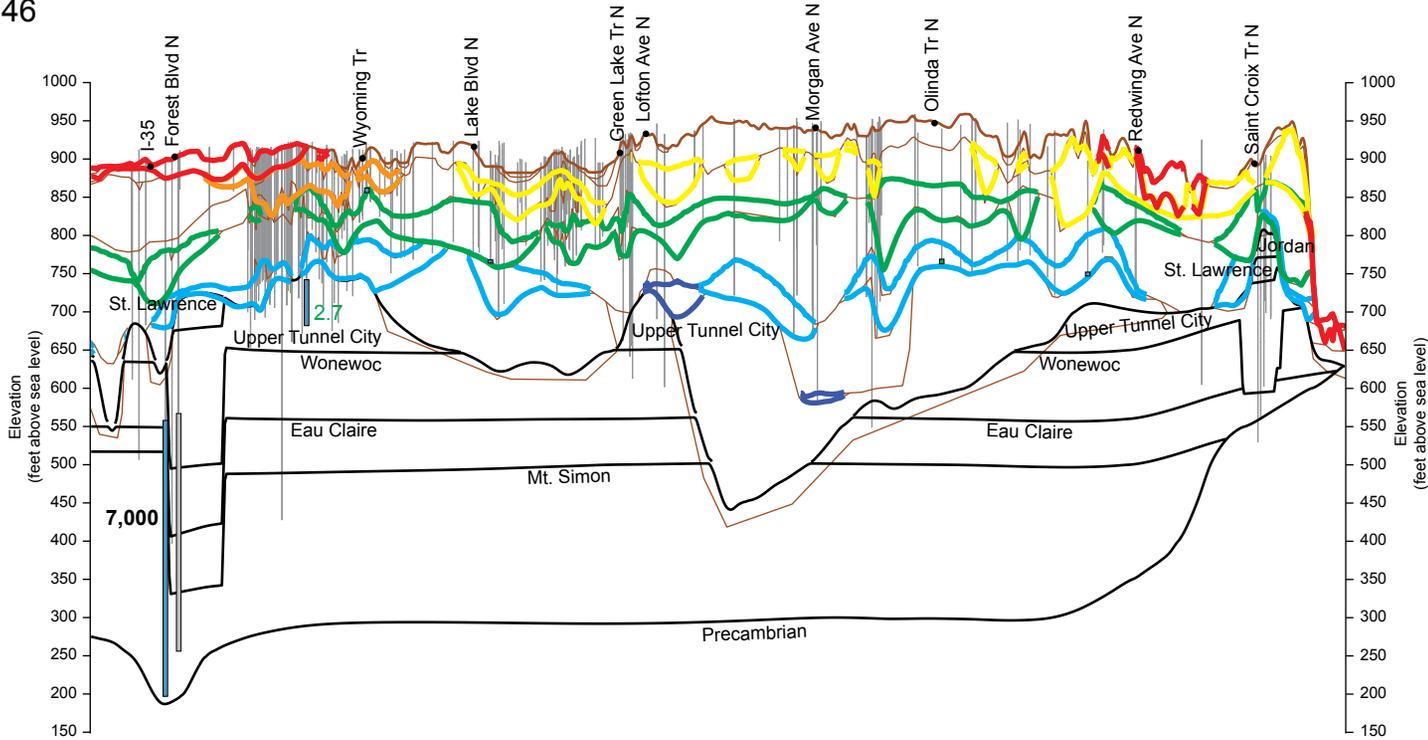
- Surficial aquifer
- surficial sand
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- sc — sr
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Symbols and labels

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Aquifers grouped by stratigraphy

- Surfacial aquifer
- surficial sand
- Buried sand and gravel aquifers
- sl — sx
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Symbols and labels

- | Well location
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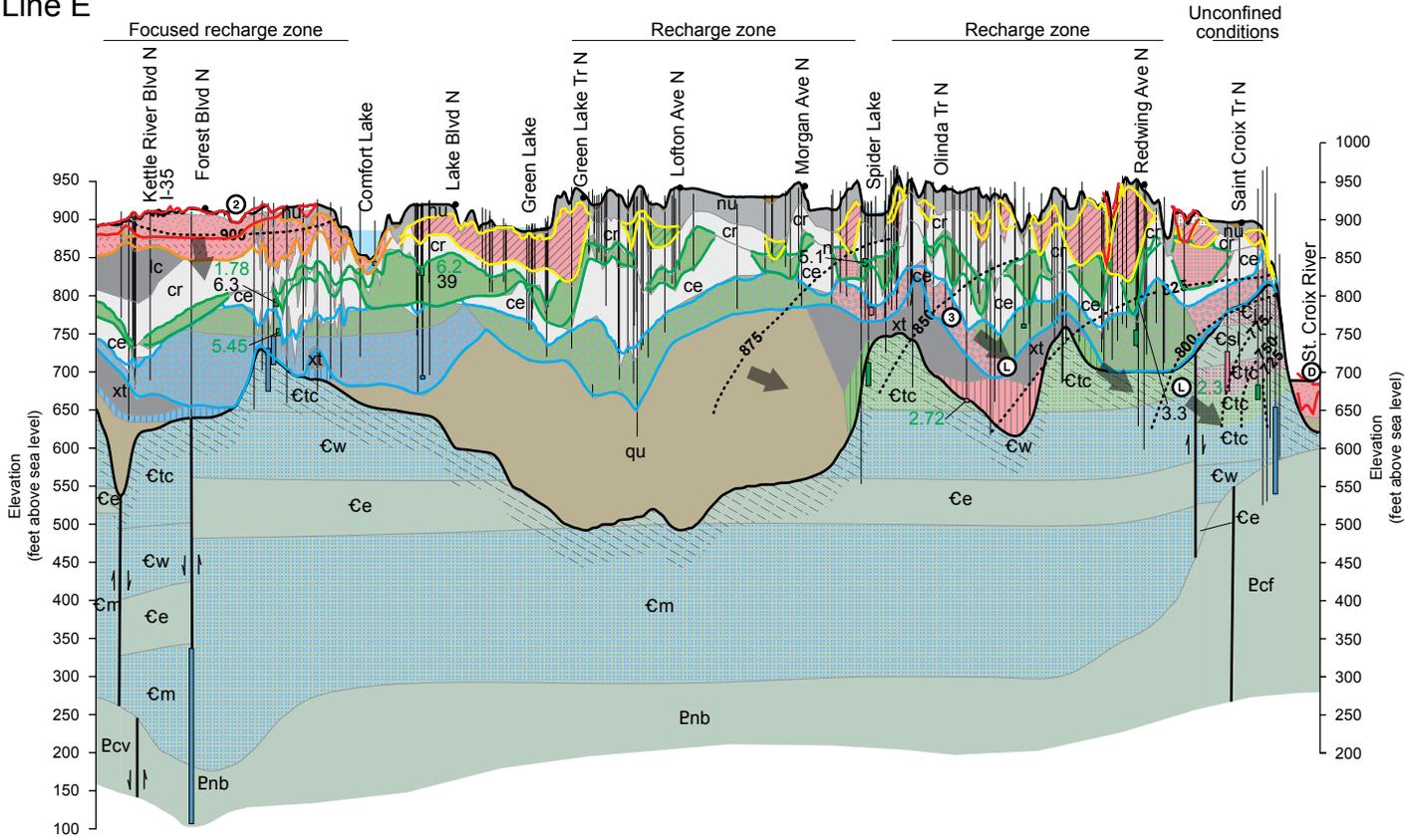
Tritium age

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See next page for complete explanation

Line E



**EXPLANATION FOR CROSS SECTIONS
7 (A), 18 (B), 27 (C), 38 (D), AND 47 (E)**

Aquifers grouped by stratigraphy

Interpreted tritium age is indicated by background color

Surficial aquifer

Surficial sand

Buried sand and gravel aquifers

sl

sc

se

sx

sr

sp

Interpreted tritium age is indicated by pattern color

Sedimentary bedrock aquifers

** St. Peter/Prairie du Chien

* Jordan

** Ctc Upper Tunnel City

* Cw Wonewoc

* Cm Mt. Simon

* Psu Undifferentiated Mesoproterozoic

Enhanced-permeability zone

* Primarily intergranular flow

** Intergranular and fracture flow

Symbols and labels

21.1 If shown, chloride concentration equals or exceeds 5 parts per million. Naturally occurring high chloride concentrations are shown with a superscript n.

7.2 If shown, nitrate-nitrogen concentration equals or exceeds 1 part per million.

3000 If shown, groundwater residence time in years, estimated by carbon-14 (¹⁴C) isotope analysis

General direction of groundwater flow

Approximate equipotential contour

Geologic contact

Land or bedrock surface

Lake

Direction of fault movement, arrows indicate relative movement

Tritium age

Darker color in small vertical rectangle (well screen symbol) indicates tritium age of water sampled in well. Lighter color indicates interpreted age of water in aquifer.

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Vintage: water entered the ground before 1953 (less than or equal to 1 TU).

Well was not sampled for tritium.

Bedrock aquitards

Csl St. Lawrence Formation

Ce Eau Claire Formation

Bedrock nonaquifer units

Pcf Mesoproterozoic Volcanic Rock–Clam Falls Volcanics

Pcv Mesoproterozoic Volcanic Rock–Chengwatana Group

Pnb Mesoproterozoic Volcanic Rock–North Branch Volcanics

Quaternary aquitards grouped by texture

Aquitard Percent sand*

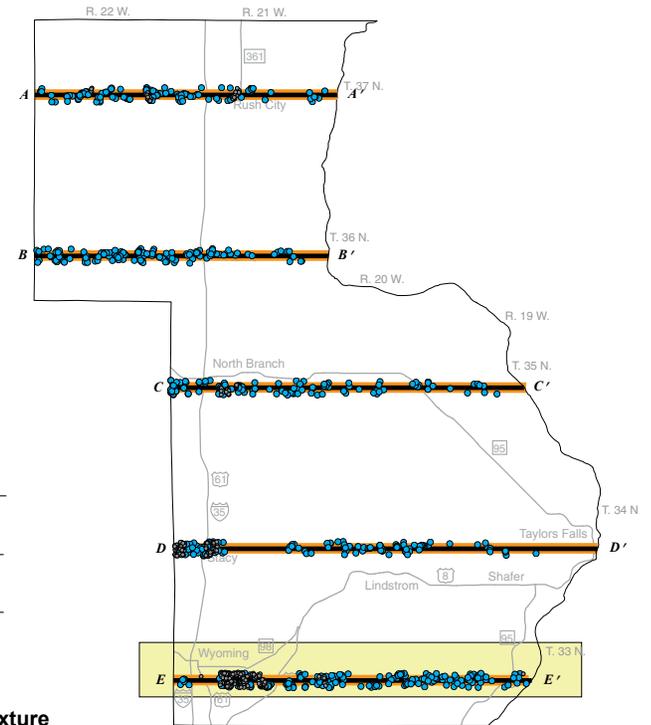
cr, ce, rt > 60

nu > 40 and ≤ 50

lc, xt > 30 and ≤ 40

qu Undifferentiated Pleistocene sediment, texture and relative hydraulic conductivity unknown

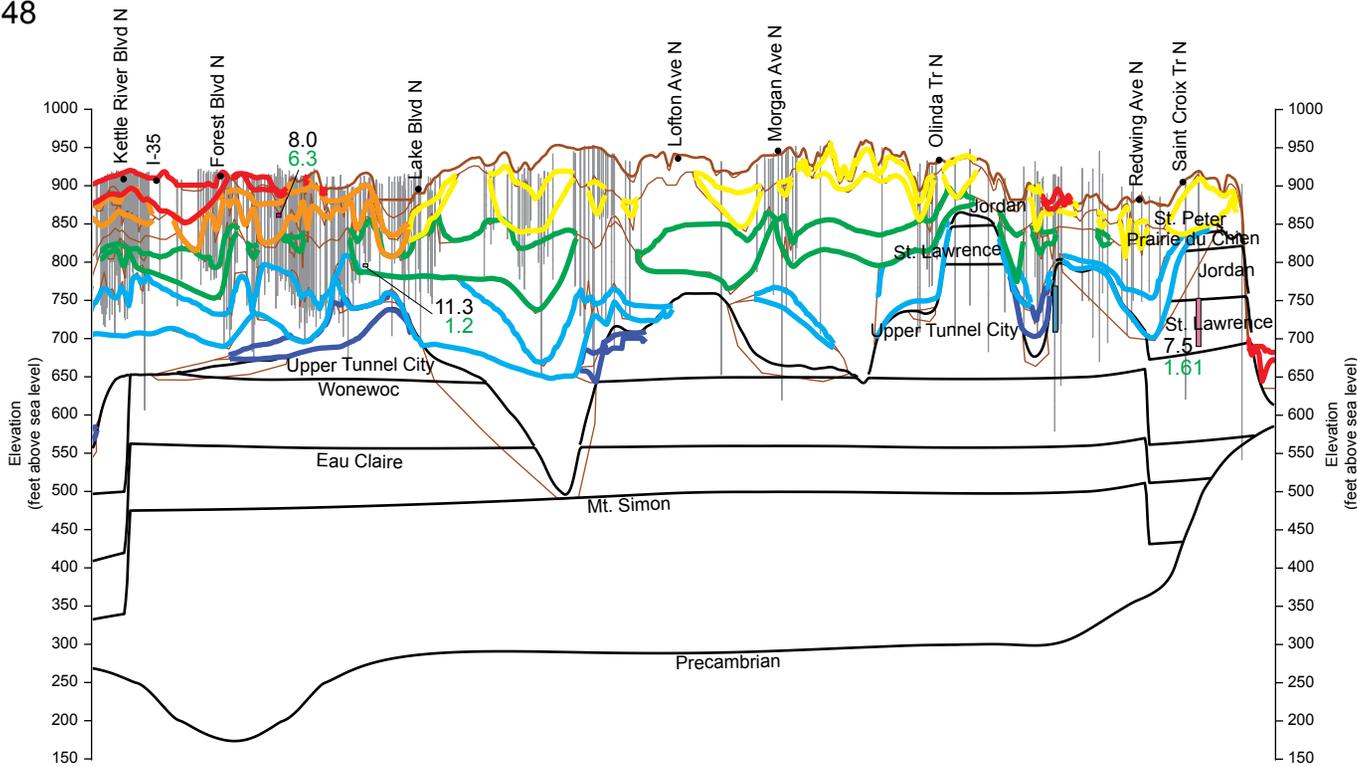
*Relative hydraulic conductivity



Orange lines show the location of cross sections shown in the Chisago County Geologic Atlas Part B, which are coincident with the geologic cross section lines from Part A (shown in black). Circles indicate the locations of wells used to generate the hydrogeologic cross sections. Blue circles indicate wells displayed in the cross sections. Gray circles indicate wells that are not shown in areas of high well density. These wells were removed to show underlying detail.

Groundwater conditions

- ① Infiltration through a thin layer of overlying, fine-grained material to an underlying aquifer
- ② Groundwater recharge from an overlying surficial aquifer to a buried aquifer
- ③ Groundwater leakage from an overlying buried aquifer to an underlying buried aquifer
- ④ Groundwater leakage through multiple aquifers and fine-grained layers
- Ⓓ Groundwater discharge to surface-water body
- Ⓕ Lateral groundwater flow
- ⊙ Groundwater movement out of cross section



EXPLANATION FOR CROSS SECTION

Aquifers grouped by stratigraphy

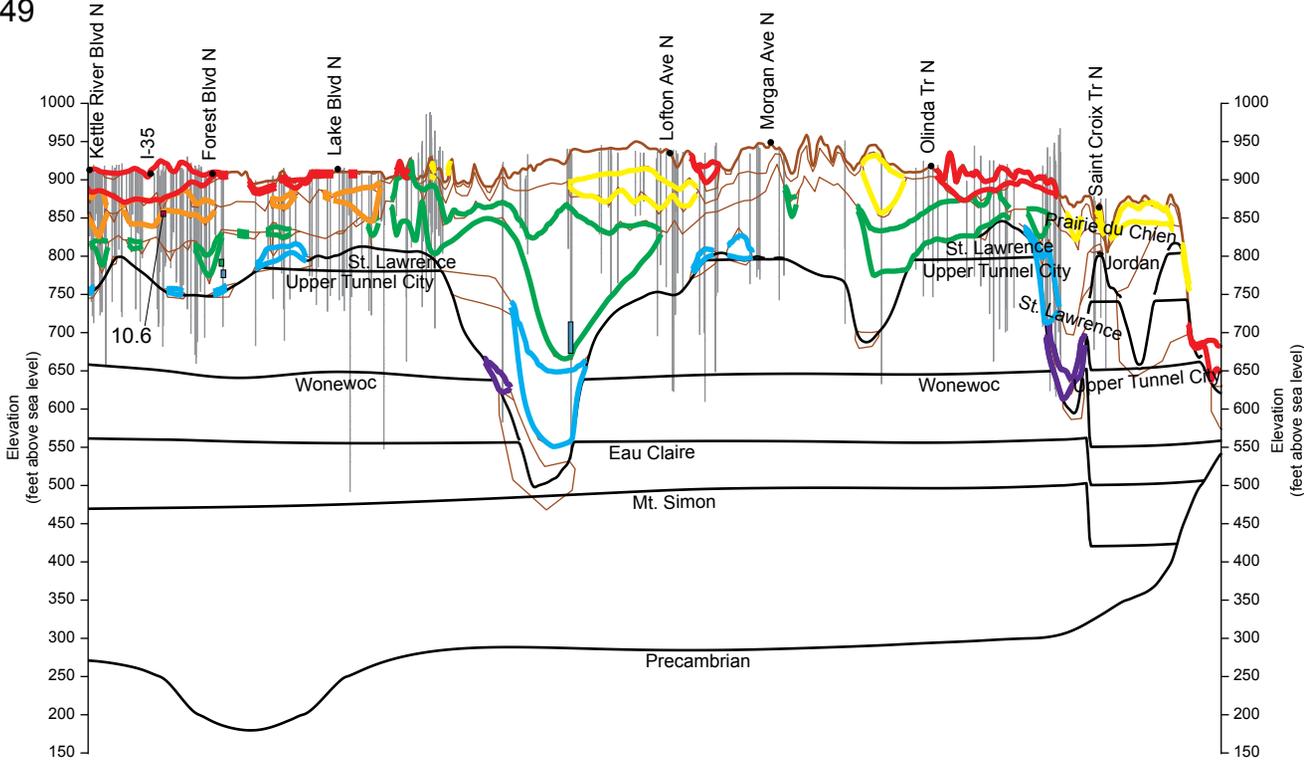
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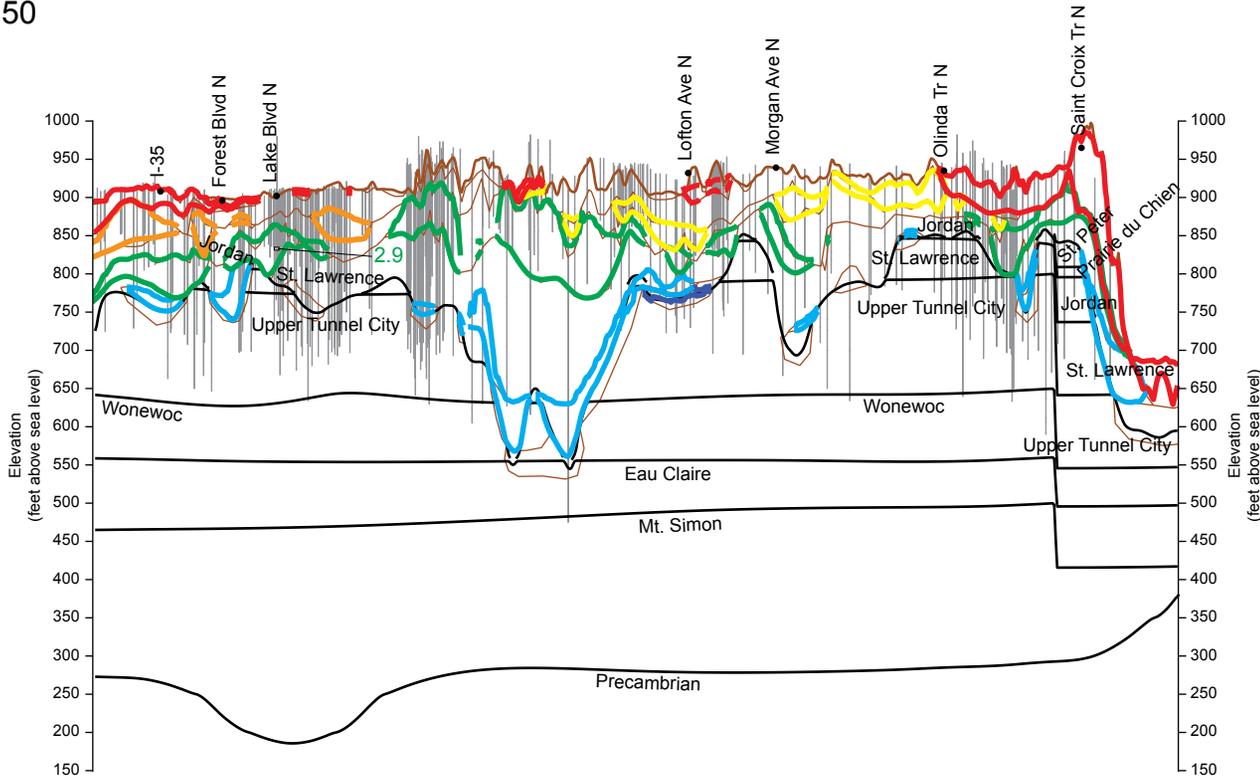
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The DNR Information Center

Minnesota Department of Natural Resources
Ecological and Water Resources Division
500 Lafayette Road

St. Paul, MN 55155-4025

For more information call 651-296-6157 or 888-646-6367

<http://www.mndnr.gov/waters>

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