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Project: GIS Analysis of Historic Springs in Dijon France

My goal for this project was learn how to obtain, plot, and analyze geologic data with GIS. Using springs locations collected in 2011, I wanted to compare springs known to be flowing in 1850 with those still flowing in 2011. For springs that are no longer flowing, I wanted to determine likely reasons the springs had ceased to flow: changes in hydrogeological conditions, urbanization, or other causes.

This research grew out of my interest in Henry Darcy's "Public Fountains of the City of Dijon" (Darcy, 1856), which contains an inventory of historic Dijon springs (Attachment 1). The springs inventory was part of his research to find a spring that could supply water to the city of Dijon in the 1840s. In the end, Darcy selected the Rosoir Spring located 12 km NW of Dijon and built an aqueduct to transport its water to Dijon. The Rosoir water supplied the "public fountains" of Dijon, which were cast iron fountains located at 100-m intervals on city streets in all neighborhoods. The fountains provided free, cool, clean water for domestic purposes, street washing, and fire suppression; Darcy's system ended centuries of water borne illnesses and elevated Dijon to the number two position in European cities (after Rome) for the quality and quantity of its water.

The springs inventory lists water sources that the people of Dijon had used for centuries. Although Darcy describes them in the book, he rejected all of them for his water supply system because altogether they did not provide as much water as the Rosoir spring. These are minor springs; as Darcy stated, the care that people had taken to collect

the water from these small springs and convey it to fountains in the city shows the meager output of the springs and the desperate need for water.

In Dijon during the summer of 2011, I researched these historic springs. Darcy's inventory is referenced to cadaster locations; the Archives Municipales de Dijon has the original copy of this large Napoleonic-era canvas-reinforced map (Figs. 1 and 2). I transferred the cadastral locations to a Dijon city map using Darcy's description of nearby roads and other features. I then set off by automobile, bus, or bicycle, to find the locations. Some locations bore no evidence of a spring. Some spring locations are in city neighborhoods; nearby streets bear the names of the springs but residents, even long-time residents, have no knowledge of springs. Some locations are rural and given over to the "gens du voyage" (traveling people or people without fixed domiciles). This field project gave me abundant French speaking opportunities with a broad cross section of the French population.

I used a Garmin GPSMAP 62 series to record locations of springs. Of the 45 springs listed in Darcy's book, I conducted a field check in search of about 20 and located 15.

## **Work Plan**

My work plan consisted of the following components, which were not always done in the order listed here. Because of the difficulty obtaining data, I did several iterations using improved data.

- Collect spring locations in the field and photograph their 2011 conditions
- Obtain base map and geological map of Dijon
- Plot spring locations
- Use GIS capabilities to analyze springs

## Process

1. Transfer Garmin points to shape file was done through the Garmin website.
2. Find a base map and geologic map. This step involved several restarts. I tried to download a 1:50000 geologic map from the BRGM (Bureau de recherches géologiques et minières, the French geological survey) but was informed that I would have to purchase a license for about \$300. My request for a student discount did not meet BRGM qualifications.

Seeking a viable alternative, I found the BRGM InfoTerre website ([InfoTerre.brgm.fr](http://InfoTerre.brgm.fr)) where I was able to take a screen shot of two maps, one showing geology and cultural features and the other displaying only geology (Figs. 3 and 4). The InfoTerre site is for French people seeking digital information of all types. The geologic map has a detailed legend and in information button that identifies lithology.

I used Google as a base map to georeference the BRGM screen shot locations but the correlation of points between the two maps was estimated at 0.0001 x 110,000 (about 120 m), which was not satisfactory. Julio suggested I use an aerial photo basemap, which was easily downloaded by pressing a button on the ArcGIS screen. I georeferenced the BRGM InfoTerre screenshot geologic map to the Bing aerial photo base map, using GEO 326G/386G Software Tips (Fig. 5). I used the centers of four intersections located in the four corners of Dijon: N, E, S, and W. The Bing aerial photo began to have drawing errors (Fig. 6) so I stopped using it after receiving a vector format geologic map of Dijon from BRGM.

On December 3, well into the project, BRGM provided a 1/50,000 geologic map of Dijon in vector format harmonized for ArcGIS (projection is Lambert 93 EPSG-2154).

I unzipped the file and added it to the basemap. It did not require any additional georeferencing. Its layers show surface geology, geologic features such as springs and fossil locations, and geologic structure such as faults (Fig. 7).

3. I also downloaded DEMs from ASTER ([earthexplorer.usgs](http://earthexplorer.usgs)) and made a mosaic of the two DEMs covering the Dijon area. I contoured the DEMs at a contour interval of 10 m. After contouring the DEM, I smoothed the contours. ASTER GDEM is a product of METI and NASA.

4. At a late date in the project, I created a geodatabase. I had neglected to do so at the beginning of the project and I needed a geodatabase to add attachments to appear as popup photos. With Julio's help, I imported the GPS points into geodatabase as a feature class and changed symbology to show springs flowing in 1850. (Layer called Springs1850). I attached photo popups to this layer (Figs. 8 and 9).

5. I queried the spring locations to determine whether altitude correlated with spring flow (Figs. 10 and 11). It was not necessary to use a query on the few data points in my attribute table but it would be useful with a larger data set. The query showed a surprising result: high altitude springs were flowing but low altitude springs were not.

6. Figure 12 is a screenshot of the final map.

### **Geologic Analysis**

The geologic setting of Dijon is somewhat similar to that of Austin; limestone hills lie to the west, NE-SW trending faults cross the area, and the faulting has downdropped the layers on the east side of the fault. The limestone west of Dijon is

Jurassic in age and the downdropped area east of Dijon is a deep graben filled with Oligocene sediments.

Querying the data on springs in the Jurassic limestone on the west side of Dijon showed that springs at high elevations that were flowing in 1850 were still flowing in 2011 whereas springs at lower elevations had ceased to flow (Fig. 10). The Frêne and Billenois springs at elevations of 356 and 339 m respectively still flowed in 2011. Persil and Sainte-Anne springs, at lower elevations (319 and 308 m), had ceased to flow. Sainte Anne owes its water to an underlying marly layer (Rat, 1972). The higher elevation springs may have been flowing in July/August 2011 because of abundant rainfall that summer. These springs are in rural, plateau areas of jointed and fractured limestone. The large flat surface of the plateaux allows water to infiltrate and it flows easily to springs on the slopes of the combes (dry valleys in limestone).

None of the springs in the Oligocene on the eastern side of Dijon were flowing in July/August 2011. The elevations of these springs range from 240 to 260 m. It obviously also rains in these area but because they are urban, water does not infiltrate easily and is thus less available for spring flow.

### **Future Work**

This study was the initial stage of using GPS for geological purposes, conducting fieldwork in France, and using GIS to analyze geological data. Future steps include learning more about GIS and using its tools more skillfully, obtaining more data points and French hydrologic data to analyze groundwater levels, finding additional spring

locations, particularly in the Jurassic limestone to the northwest of Dijon, where the large Rosoir Spring is located.



Figure 1. Photograph of the cover of the Dijon cadaster, a Napoleonic-era index of property and landmarks in Dijon. The city is divided into sections labeled by the letters of the alphabet (Archives Municipales, Dijon)



Figure 2. Section F of the cadaster showing the area of two springs, the Boudronée and Ribottée (Darcy's number 14 in the Appendix). I did not find these springs. Local residents didn't know anything about them but streets in the area bear the names of Boudronée and Ribottée.



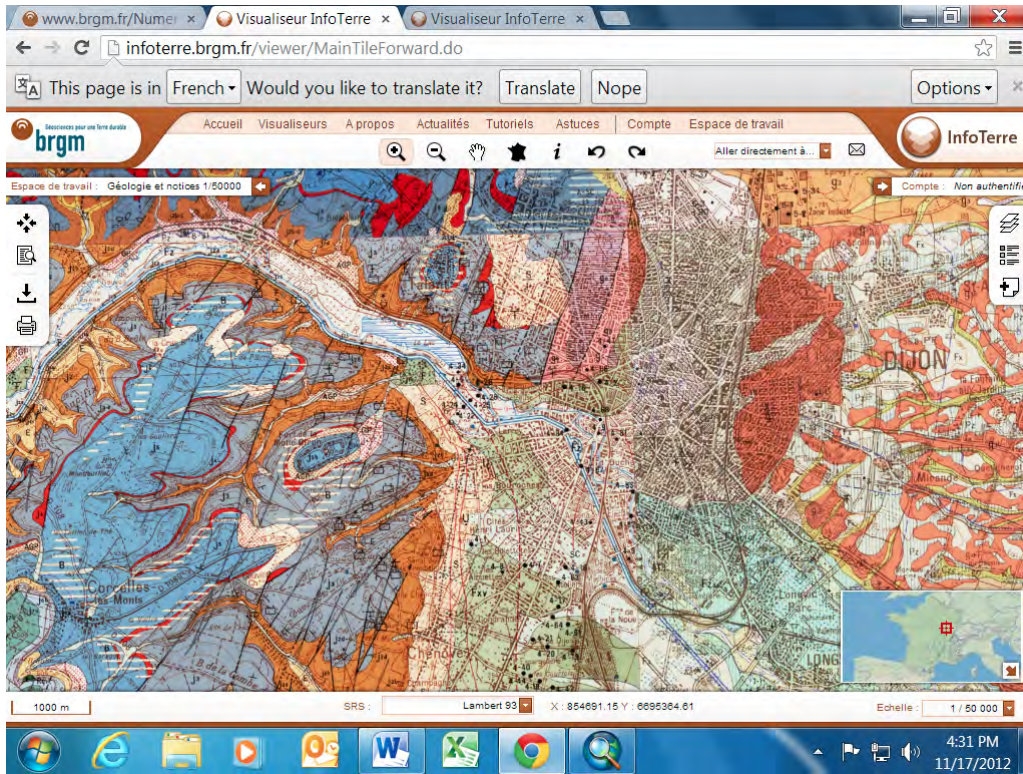


Figure 3. Screenshot of BRGM's Infoterre site.



Figure 4. Screen shot of geologic map (from Infoterre, showing roads and geology). Source: BRGM.



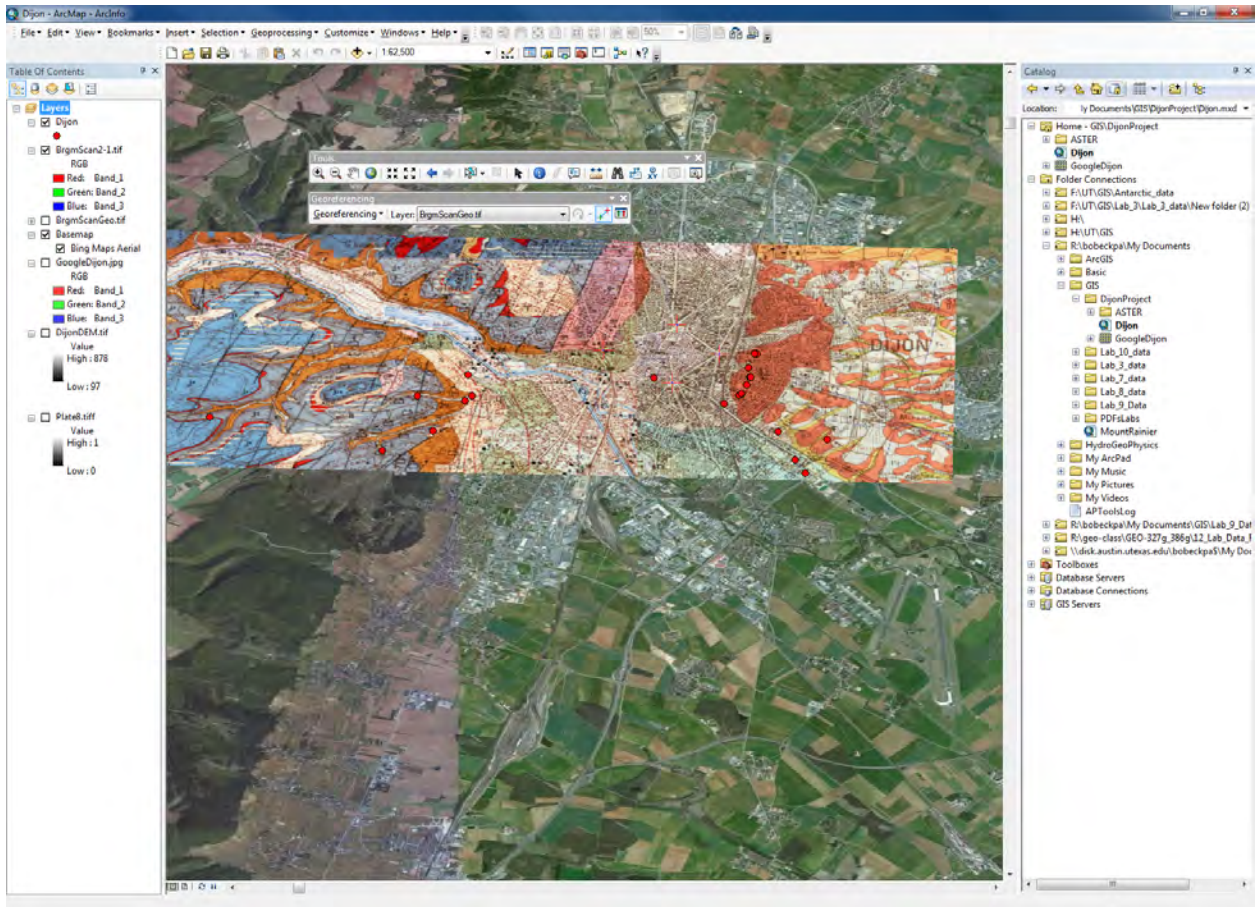


Figure 5. BRGM screenshot (Fig. 3 shown above) georeferenced to BING aerial photo basemap.11/29/12

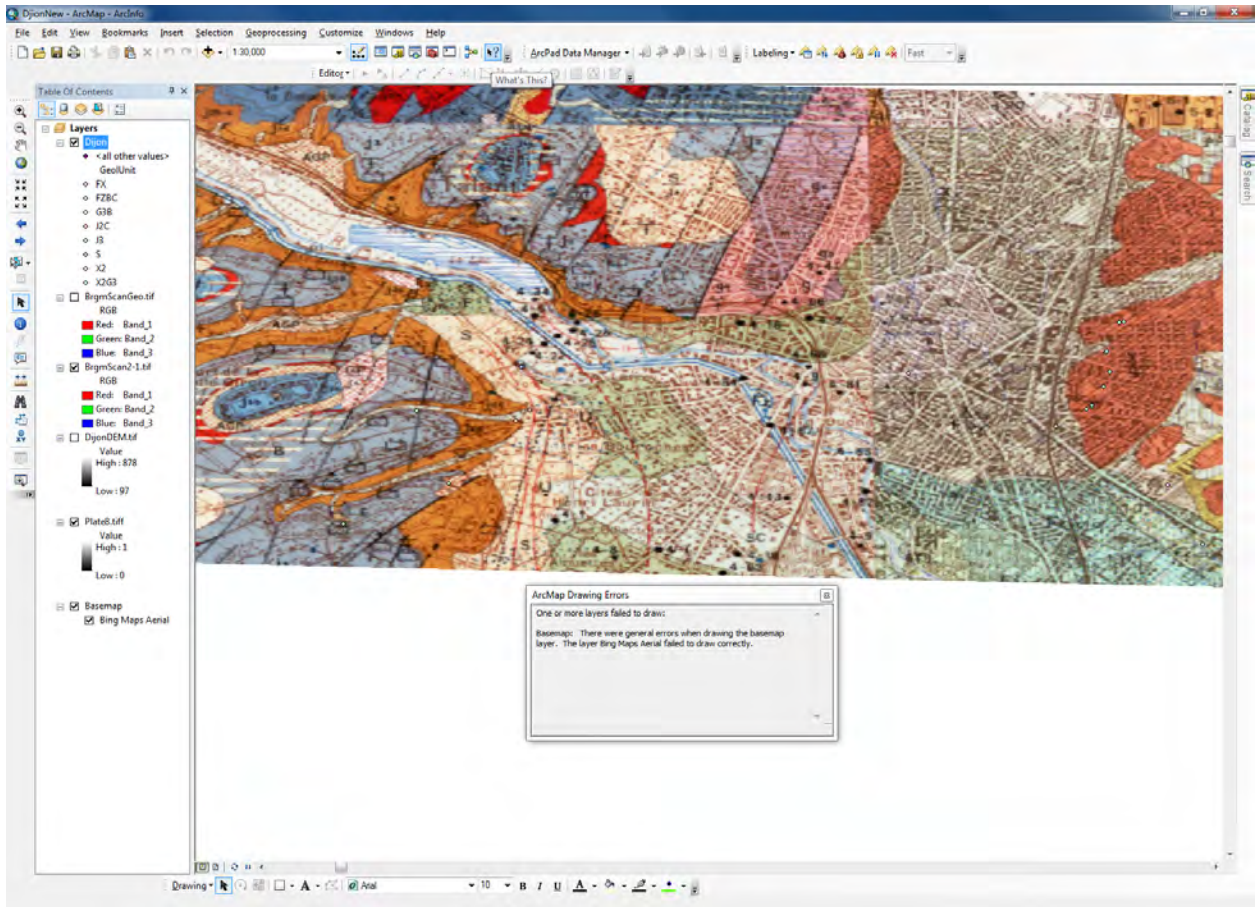


Figure 6. The Bing basemap began having drawing errors, so I stopped using it. Software malfunction. 12/2/12



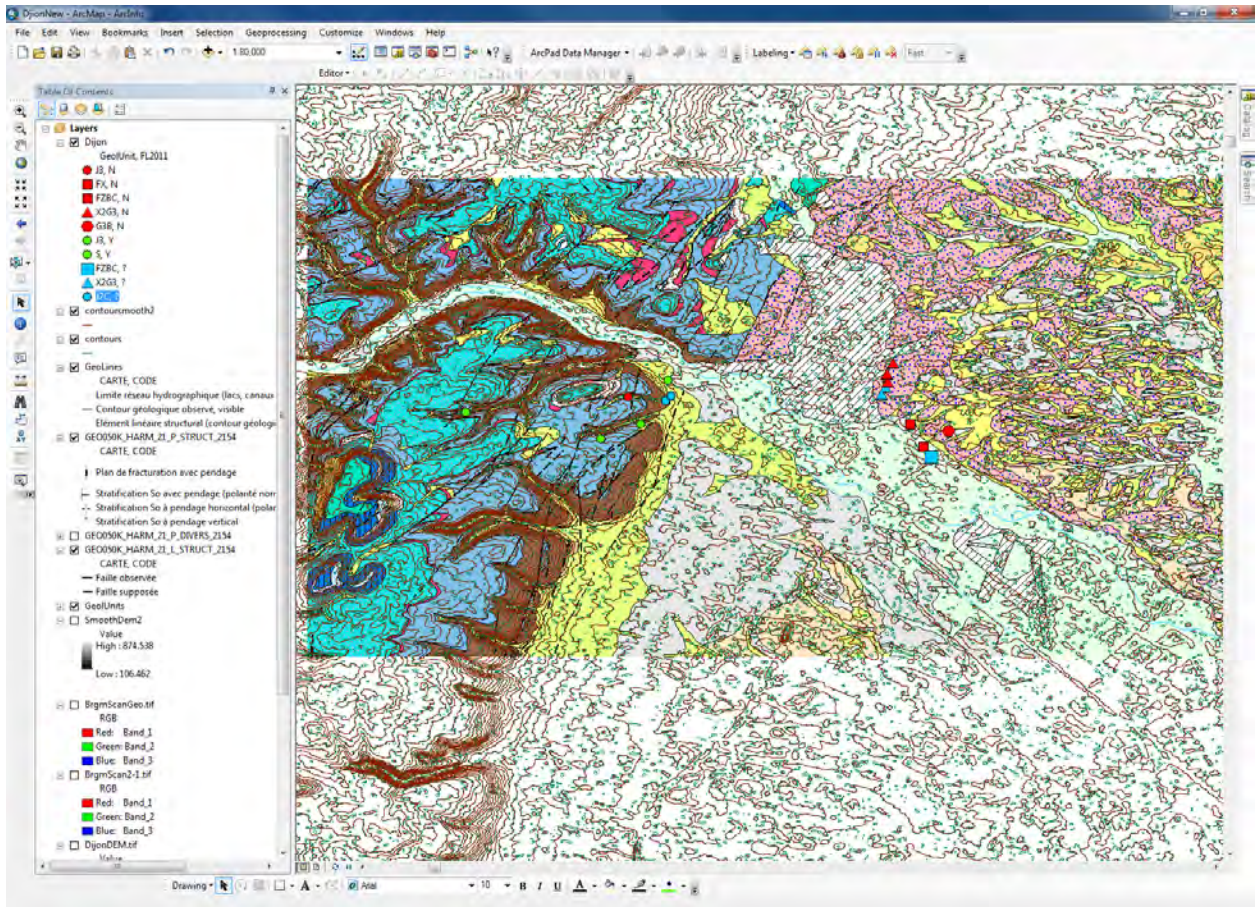


Figure 7. BRGM 1/50,000 geologic vector map, contoured at 10 m intervals, smoothed, with locations of historic springs and symbols to show their status as of 2011. Green indicates flowing springs (on left side of map), red non-flowing springs, and blue indicates lack of access to the spring. Screenshot dated 12/4/12.

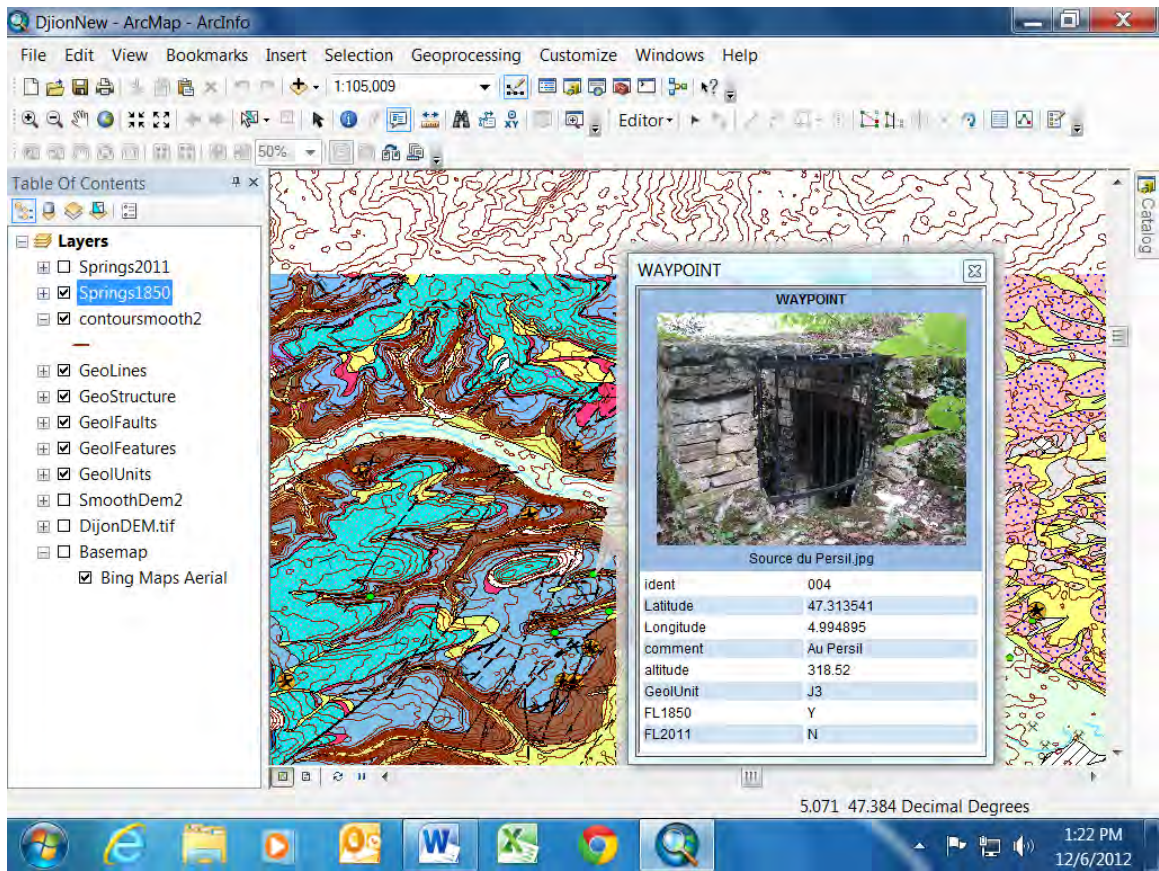


Figure 8. Photograph showing Source au Persil, a historic spring located in Upper Jurassic limestone, surrounded by a dry stone wall, and now closed with an iron gate. Stairs provide access to the water. The spring was not flowing in 2011.



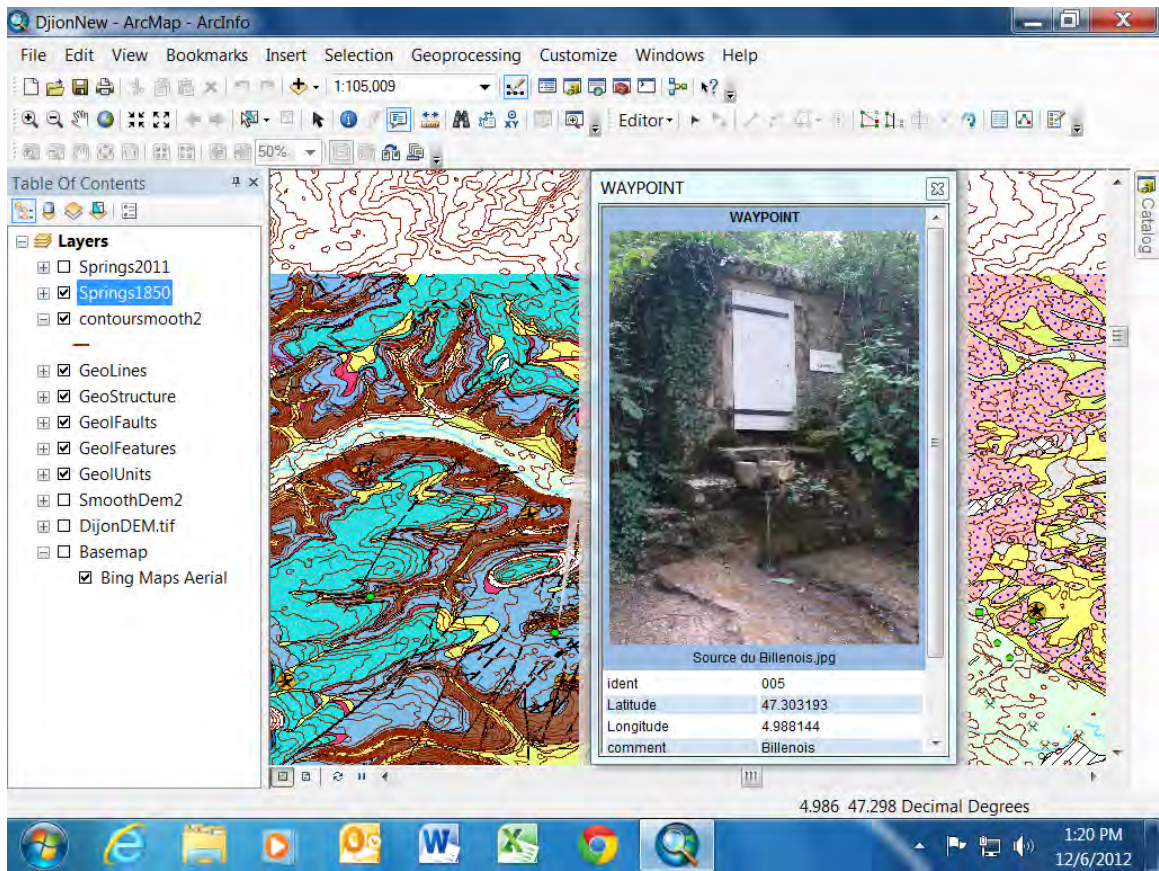


Figure 9. Photograph showing Source du Billenois, a historic spring located in Upper Jurassic limestone. The spring is housed in a stone building, and was still flowing in 2011.



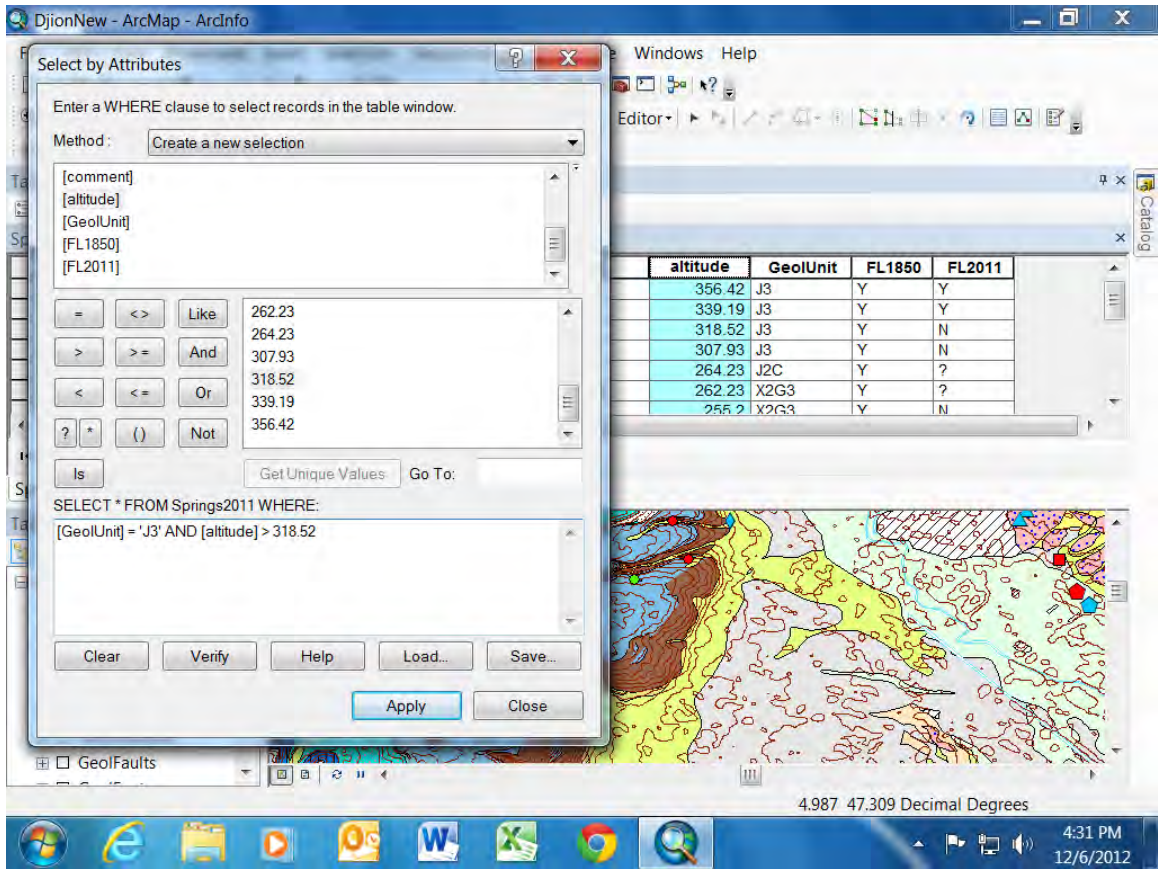


Figure 10. Screen shot showing Select by Attributes query to find springs in the Upper Jurassic above 318 m of altitude.

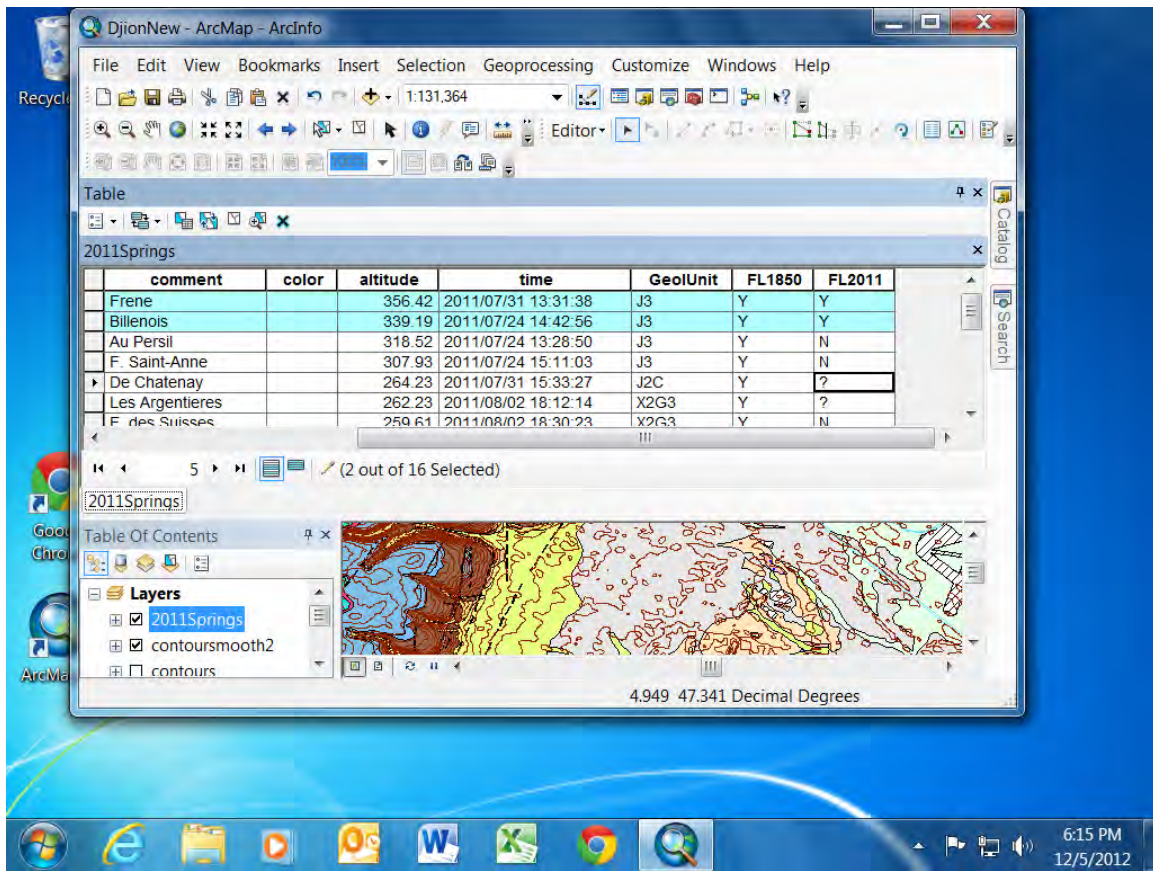


Figure 11. Screen shot showing results of Sort by Attributes (Fig. 14). Note that the higher elevation springs were flowing (Y in column FL2011) whereas lower elevation springs in same unit were not flowing (N in same column).



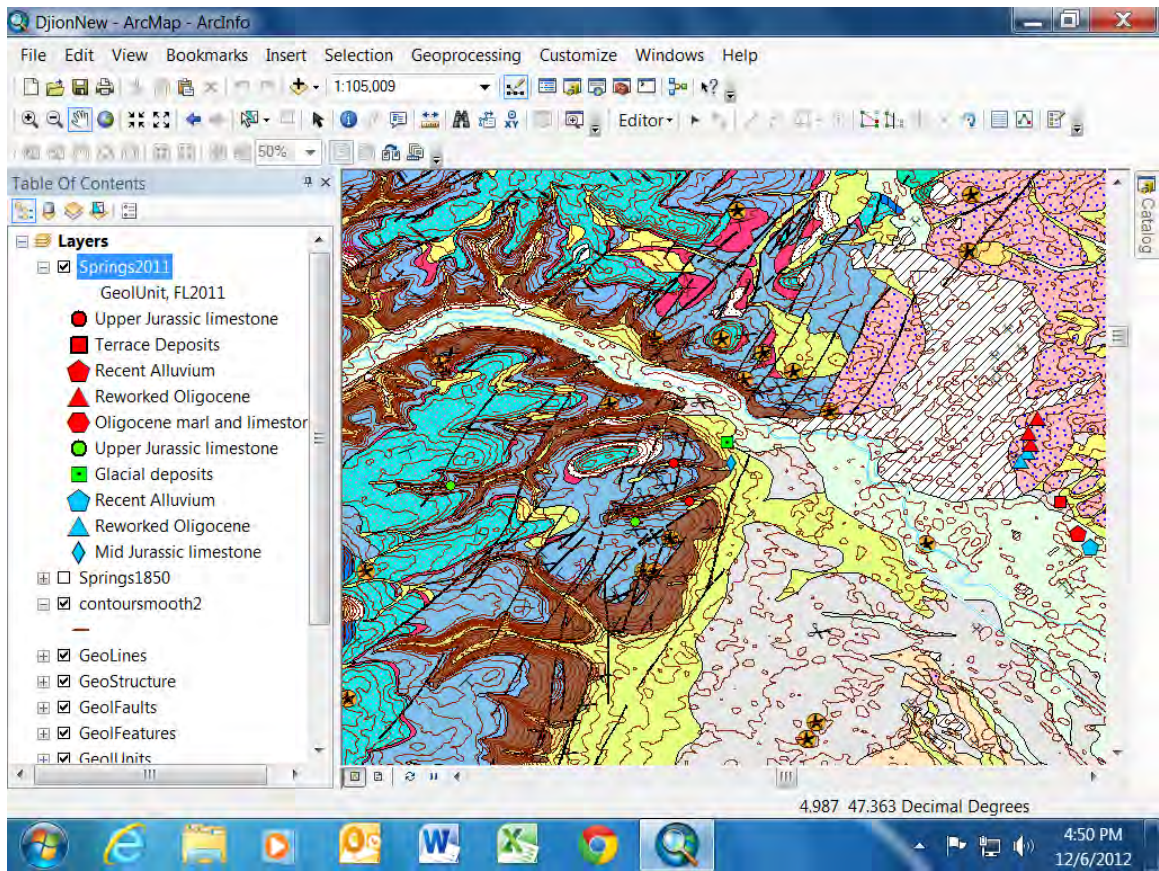
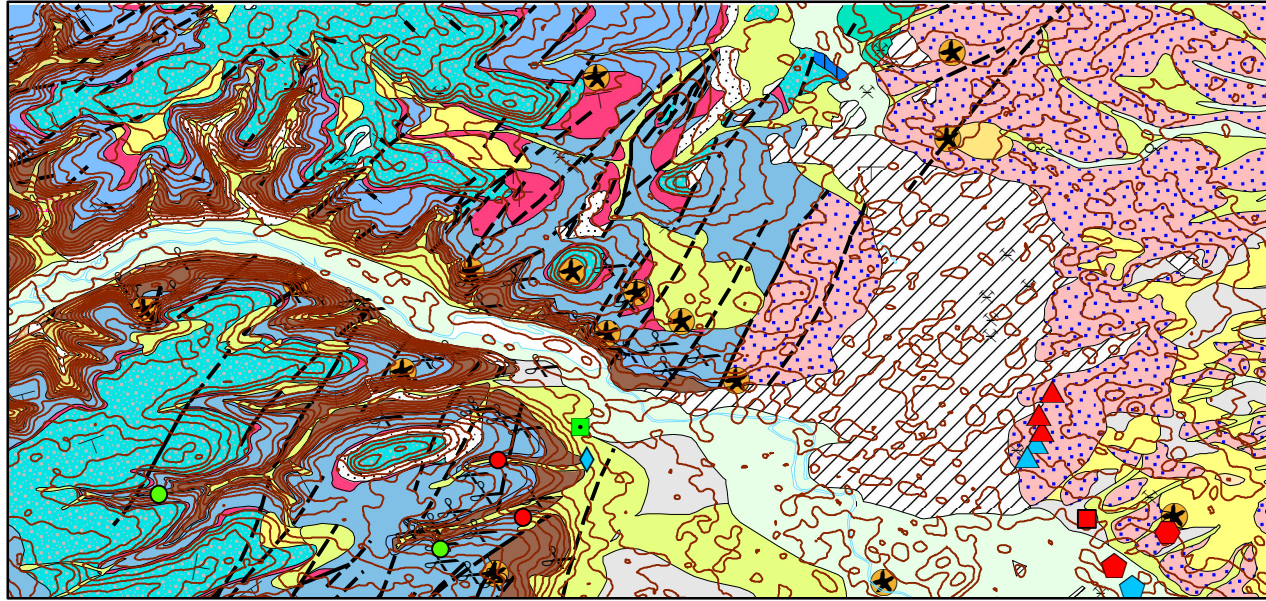


Figure 12. Map showing geology of Dijon and conditions of historical springs in 2011.

## GIS Analysis of Historical Springs, Dijon France



1:100,000

Historical Springs in 2011

Not Flowing

Flowing

Not Accessible

● Upper Jurassic limestone

● Upper Jurassic limestone

● Recent Alluvium

■ Terrace Deposits

■ Glacial deposits

▲ Reworked Oligocene

⬠ Recent Alluvium

◆ Mid Jurassic limestone

▲ Reworked Oligocene

⬠ Oligocene marl and limestone

Attachment: Appendix One of Darcy's Public Fountains of the City of Dijon.

The list of 45 springs located in the Dijon area was prepared by former Mayor Victor Dumay, colleague of Darcy and promoter of Dijon's water system.

#### A. List of Springs Located in the Dijon Area

The following is a historical note on the construction of the public fountains of Dijon written by Mr. Dumay, former mayor of this city, in the second edition of *Courtépée*, Volume Four, Page 668:

*Mr. Dumay's Note.* "The Dijon area, with a total surface area of 4,032 hectares, 86 ares contains numerous springs that contribute water to the three basins or valleys of the Norges, the Suzon and the Ouche. The Norges and the Suzon flow from north to south and the Ouche flows from west to east. In the Ouche and Suzon basins, groundwater occurs at different depths in wells. These basins extend beneath the city although the mountain chain that separates them subsides and disappears at the surface near the point where the spring reservoir was built.

"Here is a list of the springs based on this natural division. The list is organized as if one were descending each river in turn along each of its banks, except for the Norges basin. Although the Norges basin springs are called springs, their combined discharges would not approach the summer discharge of the Rosoir spring.

#### I. NORGES BASIN (North of Dijon)

"1. Maupas Spring, near the local road from Ruffey, in the ditch where it pours its meager water (No. 13, Section F of the cadastral survey of Dijon).

"2. Saule Spring, near the boundary between the districts of Dijon and Ruffey (185, F).

"3. Pré Buouillon Spring, near the Épirey property (190, F).

"4. Chemin de Ruffey Spring, along the most eastern road leading to this commune (133, F). It is a meager spring.

"5. Champs Renaud Spring, at the junction of the eastern road from Ruffey and the road from the Éprey property. When the city sold the pasture where it is located, it reserved a pond of 240 square meters on the west side of the latter road (201, F).

"6. Friandes Spring, 140 meters north of the Pouilly enclosure onto which it flows (no. 580 and 625, Section E)



“7. Pouilly Spring, within the fence of the farm belonging to Mr. Henri Weiss (642, E). After supplying a large area of water, its course crosses the road from Ruffey. It dries up in the summer.

“8. Ebazoirs, or Soyer Spring, on the south side of the road from Montmusard, on the Cromois property near the Saint-Apollinaire district (160, K). Under the 9 October 1801 law, this village is called Fontaine Soyer [Soyer Spring].

“9. Reposoir Spring, on the side of the small road from Quetigny (K, across from no. 121).

“10. Mirande Spring, within the fence surrounding the house of Mr. Cugnotet (218, K). There is no water for three months.

“11. Bois de Guyton [Guyton Woods] or Pâquier de la Bataille [Battle Pasture] or Arceau Spring, on the north side of the road from Chevigny to Mirande, near this hamlet (2, N). It is abundant and never dries up. The city kept an area of 500 square meters around it when they sold the pasture on 27 April 1844.

“12. Morveau Spring. It fills ditches and supplies an ornamental lake on the farm of this name, former fief of the famous chemist Guyton (32 and 33, N).

## II. SUZON BASIN, LEFT OR EAST BANK

“13. Pâquier de Dijon [Dijon Pasture] to the east of the road from Ruffey, on communal property. It is covered by a small monument in cut stone built by the city in 1838 (F 279a).

“14. Boudronnée Spring, formerly called Ribottée. There are three springs, one inside the farm and two outside on property that the city had reserved for itself on 27 April 1844 when it sold the remaining pastures south of this property (57, 58, 65, G). These springs are abundant. The water flows through an aqueduct into a branch of the Suzon, called the Terreaux.

“15. Porte Saint-Nicolas Spring. It is immediately downstream of the bridge at the opening of the old gate of this name, on the left bank of the arm of the Suzon that flows around the city (418, H). A roof covers it and there are two or three steps that go down to it.

“—Lower in the same streambed near the arch built in 1841 to cross the road from Gray, several small springs were observed to flow strongly even before the summer. These springs seemed to be formed only by water from the Boudronnée and Montmusard Springs, based on the underground trench that used to be used to convey the water to the Champ-Damas and to the Place de la Sainte-Chapelle.

“16. Montmusard Springs (Mons Musarum) or Saulon Springs, inside the enclosure built by the first president Fyot de Lamarche (100, 104, 113, 131, G). The upper lake (or small spring) is fed by other springs that occur there and by water coming from the vicinity of Lochères to the northeast and leaving from the communal property of Saint-Apollinaire.

“17. Foullet or Foulot Spring, today within the enclosure of the farm of Champ-Maillot (5, K), (Campus a Mallo). It was repaired by the city in 1585 and 1648.

“18. Swiss Spring, formerly Bergeris and Champ-Maillot (5, K). The city built a roof to cover it in 1584, and it was reconstructed in the year X [1802]. Its current name comes from the camp set up on the plateau and used by about thirty thousand Swiss under the orders of Jacques de Watteville to besiege Dijon from 8 to 13 September 1513.

“19. Creux d’Enfer [Depths of Hell] Spring. It was embellished with a rockwork grotto in 1823. It supplies the basin called Creux-d’Enfer whose tower was built at the same time the beautiful trees were planted (48, L).

“20. Petites Roches Spring. They are located on land that was sold by the city on 25 May 1810. There they form small reservoirs or ponds (16. L and 482. M.)

“21. Groches Springs. These are located near the alley of this name, going up the road from Argentières (108, L). There are three springs in a group but only one of them, about 50 meters from the road, is perennial. A resolution and a judgment by the office of the mayor of Dijon, on 9 July and 23 August 1755, required a person named Gaudelet to leave a path 4 1/2 feet wide (1.50 m) on either side, and ordered masonry repairs.

“22. Péjoces Springs, 100 meters north of the road from Auxonne, on the communal pathway that ends there, called Ruelle of the Péjoces (331, M). In 1838 it was converted into a monument of cut stone at the city’s expense. The spring is very abundant and kitchen gardens have been established along its course using the water it provides.

“23. Mande Spring, a short distance to the north of the road from Auxonne on a communal road called Chemin des Cailloux (51, 58, M). It is very abundant in the summer. In 1828, at the city’s expense, it was covered by a roof and provided with a basin, all in cut stone.

“24. Pâquier de Bray [Bray’s Pasture] Spring, in the pasture belonging to the city, to the south and very near the road from Auxonne, at the point where this road rises and turns to the north (38, O). It is very abundant and one of the strongest in the region.

“25. Pont Barreau Spring, on the northern side of the same road from Auxonne at the entrance of the Chemin aux Vaches (46, N). It is perennial but not abundant. The City sold the pasture adjoining the road on 27 April 1844 but kept the spring and some land around it.

## RIGHT BANK (WEST)

“26. Suzon Spring, across from Pouilly. It is located right in the stream bed, below the talus of the road from Ahuy about 100 meters downstream of the bridge located across from Pouilly (28, C).

“27. Suzon Spring, near Saint-Martin, also in the streambed below the road called Ruelle Saint-Martin leading to Fontaine (93, C).

“These two springs are abundant, seem to come out of the hillside to the west.”

## III. OUCHE BASIN – RIGHT (NORTH) BANK

“28. Vaisson Spring, in front of the mill of this name at the foot of talus south of the road from Paris (22, 23, V). It supplies a large wash house built of cut stone.

“29. Perrières Spring, at the western end of the common property registered under no. 237 of Section U in the cadastral survey. It is at the bottom of the quarry and dries up during great droughts. It is reached by going down a stairway built under a roof that covers it.

“30. Champmol Spring, located within the fence that surrounds the provincial asylum (former Chartreuse, 736, V). It is an abundant spring that supplies a reservoir and flows immediately into the Ouche at the southeast corner of the fence that surrounds the institution.

“31. Chartreux Spring, formerly Raines Spring, (*fons Ranaram*). It comes out through seven openings in cut stone at the foot of talus on the road from Paris near Auxerre, near the gate to the mental institution (767, V). Immediately in front of it there is a large public wash house and a watering trough (764, V) at a lower location. It then crosses the botanical garden and flows into the Ouche, almost across from the large watering place of the mill of this name, after supplying fishing reservoirs. It used to fill up the Etang-l'Abbé, west of the botanical garden, forbidden by an agreement entered into on 7-15 August 1782 between the city and the monks, endorsed by Intendant Amelot on 4 May 1786, and from there the spring went along a straight channel to the middle of the Harquebuse.

“It was previously connected to another small spring that is today preserved under the name of Raines (no. 33 below) that entered the city through the tower of that name, flowed through the enclosure of the Saint-Bénigne abbey, flowed behind the choir of the Saint-Philibert church, flowed along the Rue du Tillot, crossed Rue Cazotte and flowed into the Suzon at Pont Arnot (Pont des Arnots, or archways) at the point where its channel has very pronounced sinuosity. When the new wall around the city was built, there were legal proceedings between the mayor's office and the Saint-Bénigne abbey over the use of this water which is often used for the defense of the city. A compromise was reached on 10 November 1429 that settled the ownership, fishing and flooding

rights. This spring is very abundant, but it dries up in the summer. It seems that it was perennial before the road from Auxerre was built above it.

“32. Another Chartreux Spring. It is within the outer fence of the former charterhouse between the mental hospital and the botanical garden where its course connects to that of the preceding spring (75, 753, V). It also dries up in summer.

“At the bottom of the streambed of the entire part of the Ouche that runs southward along the fence that encloses the former chartreuse and particularly in the low spot called the Priest’s hollow and the Ouche hollow, there are springs coming from the hill located to the north. The presence of the springs is revealed by the very palpable temperature difference between the upper and lower layers of water.

“33. Raines Spring discharges at the corner of an enclosure located in the old trench owned by the city and transferred to the state on 25 April 1796 across from the Avenue de l’Arquebuse, on the side of the local ring road (804, 805, V). The spring follows the rampart wall, flows under the Porte d’Ouche and flows along the drainage ditch of the channel from Rue Porte d’Ouche. As previously mentioned, it was formerly connected to the Chartreux Spring (no. 31 above).

“\_\_ We will not mention some springs, especially the spring called Touillon which discharges into the bed of the false stream in the Ile neighborhood, because they seem to be only infiltrations from the mill-course of the Saint-Etienne mill, which is at a higher level.

#### RIGHT BANK (SOUTH BANK)

“34. Frêne Spring is on communal property almost at the top of the north slope of the Combe-au-Serpent (242 X). It always produces a bit of water even during the greatest droughts.

“35. Charpeignotte Spring, in a cherry orchard on the north slope of the combe of the same name (673 X). It is very feeble, but it does not dry up.

“36. Carrière-Rollin Spring, a good spring. It is in a pit at the back of a quarry. (255 X).

“37. Carrière-Pillet (255 X). It is under a roof. It is reached by going down several steps. Its water maintains at a very low temperature.

“38. Cayen Spring near the Boullemier property (255 X). It is under a roof two meters square down four steps. It was repaired in 1840.

“39. Chatenay Spring. Discharges from an enclosing wall to the north of the property of this name (453, X) and flows onto the road.

“40. Girond. This spring consists of a well located between this farm and that of Bel-Air (470, X). The overflow from this well flows through an underground conduit into a pond downstream to the south near the road. Its abundant water never dries up.

“41. Larrey, or Ouche Spring, formerly called Oise (610, V). There are three springs. The main spring flows under a roof constructed by the city in 1761. Its course is 786 meters to the free board of the channel into which it flows. At 628 meters from the roof it is crossed by the Larrey bridge. The spring is very abundant, but it dries up during great droughts. A clever fountain-maker from Montbéliard named Flammand was summoned by the city in July 1617 to provide fountains. He proposed to convey this spring on the Charlieu curtain to distribute it in the Porte Ouche neighborhood.

“42. Deux Heures Spring. It is on the north slope of the Persil combe (400 X), it flows from north to south. It crosses a piece of communal property where there is a type of pond.

“43. Persil Spring. It is halfway up the southern slope of the same combe (330, X). It consists of a well dug into the rock, 50 centimeters wide, 70 centimeters long and 1 meter deep. Four or five steps lead down to it. Its water is not abundant, but it never dries up.

“44. Billenois Spring issues forth from the bottom of the southern slope of the Saint-Joseph combe (127, Y). Its abundant water flows into a pond 5 meters in diameter. Ownership of it (and the land, an area of 70 square meters where it discharges) is guaranteed to the city by a treaty of 18 March 1843 concluded with Mr. de Sassenay.

“45. Sainte-Anne Spring discharges from the same hill as the preceding spring but at a higher point (139, Y). In accordance with the treaty mentioned above, the city is the owner of 1 hectare 10 ares and 40 centares [11,040 square meters] of land that surrounds it. Its water is the most pure of all those in the district, but it is not abundant. It is collected in a masonry basin that serves as a watering place. In 1824, the spring was enclosed in a cut stone monument decorated with columns of the Paestum order with a entablature topped by an arched façade.

“To complete this note on the surface waters in the district of Dijon, we will add:

“1. That the Ouche river (*Oscara, Osera, Oscia*) that runs though Dijon from west to east for a length of about 8,100 meters divides Dijon into two unequal parts. Its source is at Lusigny, near Bligny, a section of present-day Beaune. According to experiments conducted by Mr. Darcy from 8 to 11 July 1833 during a period of great drought, (pages 59 to 95 of his *Mémoire*) the river can produce a minimum discharge of 23 cubic meters per minute (1,725 inches). Its water is of good quality but often full of silt. It never freezes and has an swampy odor during the summer.

“2. That the Suzon (or according to the usage in Dijon, simply Suzon, without the article, *Susio, Sisunus*) is a torrent which begins 5 kilometers upstream of Val-Suzon,



canton of Saint-Seine, and ends in the Ouche below the city after traversing 4,700 meters in the Dijon area. Because it is intermittent and the volume of its water is variable, it is impossible to gauge it, even approximately. Note: One branch known as the Vieux-Terreux branches off the main streambed upstream of the city next to the former convent of the Capucins and flows from west to east into the Ouche near Neuilly. The springs mentioned under numbers 16 to 25 above belong to the basin of this branch, whose length is 6,300 meters.

“3. Finally, the Burgundy Canal was begun in 1784 (the first stone of the obelisk in the basin in Dijon was laid by the Prince of Condé on 24 July of that year) and the part between Dijon and the Saône was opened for navigation on 14 December 1808. The part between Dijon and the Yonne was opened on 2 January 1833. Over its course of 5,600 meters across the area, it trends west almost parallel to the Ouche streambed which supplies it”

*Courtépée* --“Several springs within the Dijon district have been repaired and decorated by buildings.”

“1. Swiss Springs, formerly Bergis or Champmaillot springs, was covered in 1584 by a roof bearing the Coat of Arms of the City. It was reconstructed in year X [1802]. Its discharge was reduced to 1 deciliter per minute, so repairs were done during the autumn of 1847. With a masonry basin to collect its water, this spring today produces 12 liters per minute. A chemical analysis done in 1843 by Mr. Barruel of Paris gave the following results for 1/2 liter: saline residue 0.19 gram or 38 per 100,000 composed of calcium carbonate with traces of magnesium, iron oxide and manganese and unweighable traces of lime.”

“2. The Larrey or Ouche Spring, formerly called Oise Spring, has three springs. One of the springs discharges under a roof constructed by the city in 1761. A second spring located under a neighboring vineyard was rediscovered in September 1847 and provides more water than the preceding one, to which it has been connected by a masonry aqueduct. In doing this work, several Roman medallions made of silver from the Early Roman Empire were found 2.50 meters below the ground. Workers also discovered more than 1 kilogram of bronze medallions so oxidized that they formed a mass.”

“Thirty-four observations done over three years in all seasons by Mr. Perrey, professor on the Faculté des Sciences in Dijon, indicate that the average temperature of this spring is 12.12 ° Centigrade, with a variation of only 2/10 of a degree less and 3/10 of a degree more.”

“A fountain-maker from Montbéliard named Flamand was called upon by the city in July 1617 to find springs. He proposed to convey this spring on the Charlieu curtain to distribute it throughout the Porte d’Ouche neighborhood. Today it flows into the Burgundy Canal after flowing for a length of 786 meters.

“3. The Sainte-Anne Spring occurs in a magnificent setting but has a meager flow. Its water is collected in a masonry basin that serves as a watering place. It is the purest of all the springs of Dijon since it has a residue of only 0.077 gram per 1/2 liter, or 15.4 per 100,000, according to the analysis of Mr. Barruel. The residue is composed of calcium carbonate with traces of magnesium, iron oxide and manganese, without sulfate or chlorides, at least in appreciable quantity. In 1824, the spring was enclosed in a cut-stone monument decorated with columns of the Paestum order, with a entablature topped by an arched façade.”

“ The land where the spring is located was transferred from the city to Mr. Jean Carnet by a deed issued 17 February 1661 with the only reservation being that of an easement for drawing water for the benefit of the inhabitants. Through an exchange dated 18 March 1843, the city bought back the property and 1 hectare 10 ares and 40 centares of land that surrounds it, on which plantings were done.”

“4. The Creux-d’Enfer [Depths of Hell] Spring was embellished with a rockwork grotto in 1823. It supplies the basin known as Creux-d’Enfer, and the periphery was planted at the same time with beautiful trees and converted into a promenade. Repairs were made to this spring in 1847, because its volume had been decreasing every year.”

“5. The Mande Spring located on a communal road a short distance north of the road from Auxonne was covered with a roof in 1828 and provided with a basin, all in cut stone, at the city’s expense.”

“6, 7. Similar work was done in 1838 on the Pâquier Spring of Dijon, to the east of the road from Ruffey, and on the Péjoces Spring, located 100 meters north of the route from Auxonne, on a communal footpath that ends there.

“8. In 1847, a circular masonry basin 5 meters in diameter was built around the abundant spring of Pâquier de Bray, [Bray’s Pasture] located south of the road from Auxonne, giving a regular course to its water. The 15-are [1500 square meter] park that surrounds it was planted with trees at the same time.

## **Acknowledgments**

DEMS were obtained from ([www.earthexplorer.usgs](http://www.earthexplorer.usgs))

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