GUIDE OF THE KEYLINE HYDROLOGIC DESIGN AND THE USE OF THE YEOMANS PLOW FOR MEDITERRANEAN AGROSILVOPASTORAL SYSTEMS

LIFE REGENERATE (LIFE16 ENV/ES/000276)

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What the Keyline Hydrologic Design is?

Keyline Design is a soil management system developed in Australia in the fifties of the last century by the farmer and engineer P. A. Yeomans. Keyline Design combines rainwater harvesting and conservation of soil moisture with land regeneration techniques.

On what elements is the Keyline Design based?

Understanding the keyline design requires to take a look at the landscape and find out the natural runoff lines and the contour lines of the terrain. It is necessary to identify the pattern of **ridges** and **valleys** in the terrain. A valley is defined as the low area at the side of ridges, while a ridge is identified as the line of maximum elevation that joins two or more slopes in an undulating relief. From a hydrological point of view, ridges and slopes drive by gravity water towards the valleys. Topographically, there is a point of special interest in the landscape, called the **key point** (Figure 2). It is an inflexion point of the slope of a terrain, where the steeper higher slope meets the flatter lower slope and, therefore, the distance between contour lines becomes enlarged.

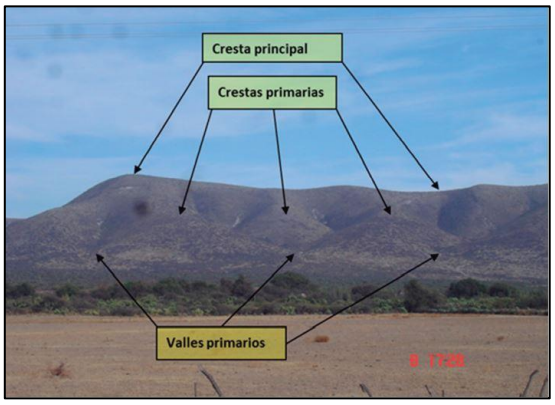


Figure 1: Ridges and valleys in the landscape. Source: Instituto Mexicano de Tecnología del Agua

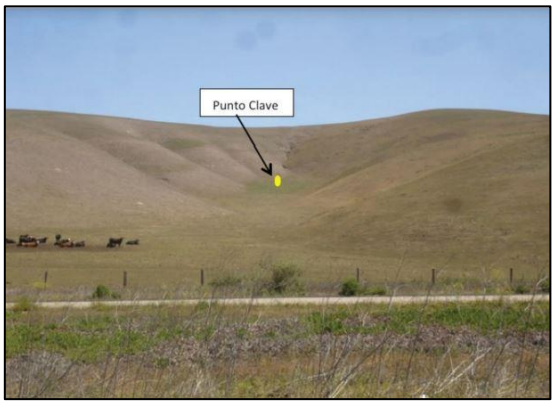
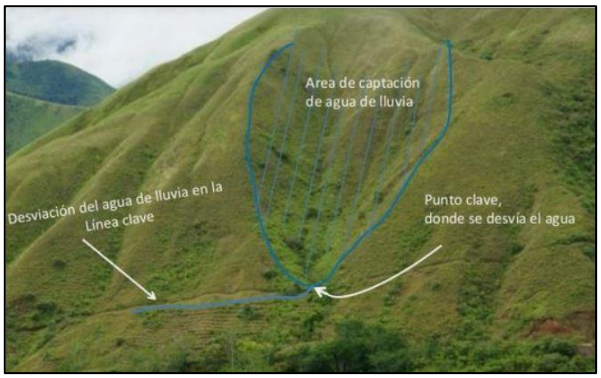
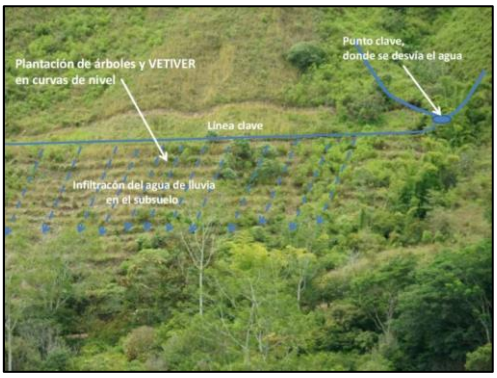


Figure 2: Identification of the Keypoint. Source: Instituto Mexicano de Tecnología del Agua.

The key point is important because it indicates an area of water accumulation in the terrain. The contour line passing through the key point is called the **Keyline** (Figure 3). The Keyline runs horizontally from both sides of the key point, so that every point on the keyline has the same height or elevation as the key point. Then, trenches are plowed parallel to the keyline, both above and below it, in order to drive the water flow from the valley to the crest. This management allows the water to reach usually dry areas and retain soil moisture longer. For a better understanding of this concept it is recommended to watch the following explanatory video, whose reference can be found at the end of the present document.

The distance between trenches will vary according to the soil type and slope steepness. So that, the lesser water retention capacity and the steeper the slope, the closer the trenches.





Figures 3 and 4: Identification of the Keypoint and the Keyline on the landscape.

What elements are needed to execute a Keyline work?

The execution of a keyline work engages important previous tasks of analysing the terrain and designing on the map. The most important phase is defining the keyline, or keylines if the terrain is large and many changes of slope exist.

Once the design is completed on the map, the coordinates of the contour lines are entered into a GPS device in order to transfer the information on the ground, as described and illustrated on the next page.

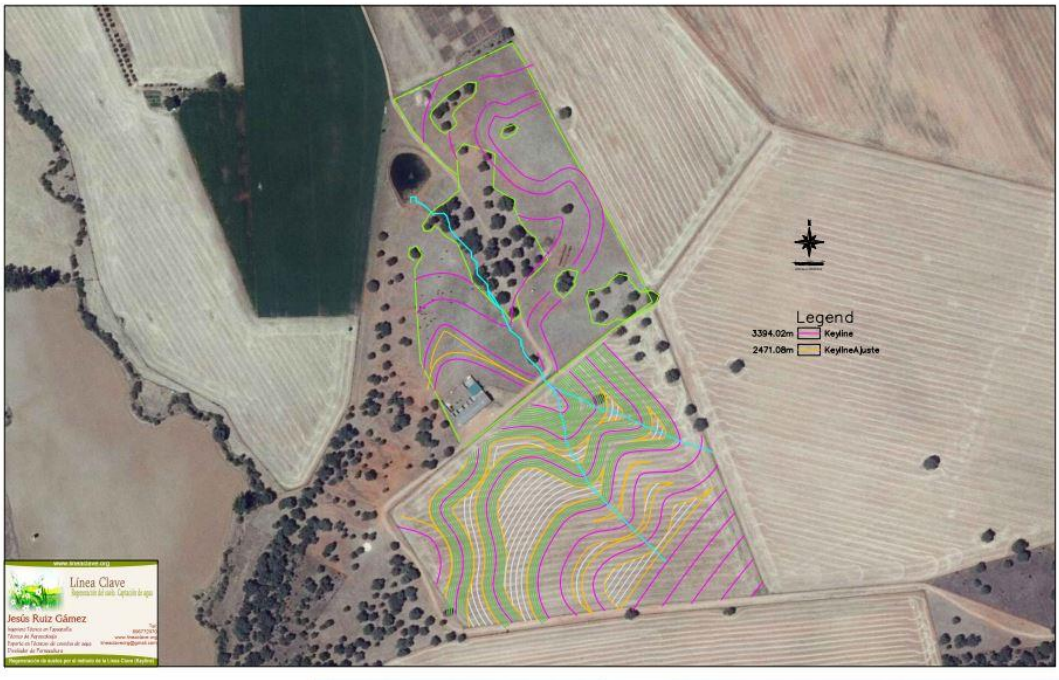
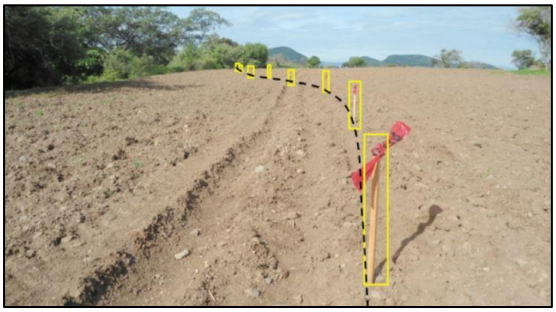


Figure 5: Keyline design executed at the Muñovela Experimental Farm (IRNASA-CSIC). Barbadillo, Salamanca. The Keyline is shown in purple.

Two methods are commonly used to mark keylines in the soil:

- Wooden sticks are driven into the ground to mark the keyline or lines, so that they can be seen even if there is long grass. It is advisable to paint the top of the sticks in a bright color.

- Direct marking: the operator who handles the GPS device moves walking along the designed keyline. The operator is followed by a tractor equipped with a specific subsoiler for this technique, or other tillage implement able to mark the keyline in the ground. Then, further trenches parallels to the keyline are made with the specific equipment described in the following page.



Figures 6 and 7: Line marked with wooden sticks; Direct marking with a GPS station and adapted tillage implement.

Figure 8: Aerial image after the execution of the Keyline design in Freixo do Meio (Portugal).

The keyline concept is associated with the use of a subsoiler plow specific for this technique: **the Yeomans plow®.**

What is the Yeomans® plow?

The Yeomans plow is a type of plow designed by **P.A. Yeomans in Australia**. His idea was to develop a **farming implement** that would meet two objectives:

- Its use must produce in soil and subsoil conditions favorable for thriving and proliferating soil organisms (plants, microorganisms, invertebrates, insects, etc.).
- It has to be resistant and durable, as well as effective, efficient and reliable.

Figures 9 and 10: Original Yeomans® subsoiler; He-Va Grasstiller subsoiler (Yeomans type).

How is the Yeomans plow used?

The Keyline system has a holistic approach by which, aside of water harvesting, fertile soils are generated as well. The system involves a 3 to 5 years plan in which the tillage depth is increasing yearly. An increase of 10 cm over the usual tillage depth is applied the first year, 10 cm deeper the second year, and so on until a depth of 45 cm is reached. In this way, the soil microorganisms activity allows plant roots go progressively deeper. Once the soil is deep enough, the plan is no longer applied.

Figure 11: Conversion process using Yeomans plow and ground effect.

This management is recommended for open pastures or scarcely scrubby or wooded areas. It is also recommended for croplands with degraded and compacted soils showing water erosion, with undulating topography and slopes of less than 8%. It is also advisable to apply the Keyline system in new tree plantations, construction of water points and other infrastructures such as ponds, roads...

If a replication plan includes a Keyline design, a Yeomans plow similar to the one acquired for the LIFE Regenerate project could be used. With this type of plow, the deep reached by the plow tips can be very precisely controlled. The tillage depth to be applied should be adjusted according to the characteristics of the soil and the area (bare soil, low vegetation, presence of roots, etc.)

What are the benefits?

- Reduce the erosion of runoff, avoiding the loss of the nutrient rich top layer of soil.
- Reduce waterlogging, the excess of water easily flow through underground channels without disturbing the soil (without overturning the soil horizon).
- Increase water retention and distribution in soil, since water is homogeneously distributed over the area, improving the soil structure as well.
- Increases carbon retention. As the soil becomes wetter the soil microbial activity becomes higher. This speeds up the decomposition of plant residues that remain in soil after harvest, increasing in such a way the organic carbon content of soils.
- Increases soil fertility. As soil microbial activities increase due to improved conditions of moisture, temperature and aeration, every year the soil becomes deeper and more fertile without using chemical fertilizers.
- Soils where the Keyline system is applied retain more moisture and, therefore, plants and other soil organisms cope better with summer droughts.

Other possible applications: Prevention of *Phytophthora* spreading

Plant diseases caused by the fungus Phytophthora can be prevented by improving soil drainage. The use of the Yeomans plow to prevent this type of disease will follow the same instructions as above:

- In field plots suspicious of presence of *Phytophthora*, trees will be surveyed for disease symptoms.
- Contour lines and the Keylines will be indentified on the map, and its coordenates entered into a GPS device. Then, keylines and trenches are made with a tractor equipped with the Yeomans plow.
- Once keylines are made, water will easily flow through them avoiding waterlogging and, therefore, the occurrence and dispersal of *Phytophthora*.

Figure 12: Making keylines with the Yeomans plow at the Muñovela Experimental Farm (IRNASA-CSIC, Barbadillo, Salamanca)

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