# *KEYLINE DESIGN Mark IV*
# *'Soil, Water & Carbon for Every Farm'*
# *Building Soils, Harvesting Rainwater, Storing Carbon*


## *Abe Collins*[i] *& Darren J. Doherty*[ii]


**Introduction**

Keyline Design was first developed by the great Australian, P.A. Yeomans (1904-1984), in the late 1940's & 50's initially as a practical response to the unpredictable rainfall regime he found on his new property, 'Nevallan', to the west of Sydney, New South Wales, Australia. Soil Conservation, as developed by the US Army Corp of Engineers was the predominant practice of the time and for a time Yeomans was influenced by this, though soon found somewhat deficiencies with the pattern of water flow its application expressed. Yeomans went on to devote the rest of his life to the promotion, research and development of Keyline Design and in doing so was labelled by Permaculture co-originator Bill Mollison as '…one of Australia's greatest patriots…[iii]'.

Influenced[iv] by the likes of prominent organic agriculture figures in Andre Voison, Friend Sykes, Newman Turner & Louis Bromfield (among many others!) Yeomans has been attributed with being the 1st person to accelerate soil formation through the stacking of methods, overturning the myth that it took 1000 years to create an inch of topsoil. Yeomans proclaimed that '…the landman's job is not so much to conserve soil as it is to develop soil, to improve his soil his soil and to make it more fertile than it ever was…'.[v]

The development of the Permaculture concept owes much to P.A. Yeomans[vi], not only for its enduring and effective landscape patterning, but also for the integrated business framework that he developed over the 40 odd years that he worked in developing a myriad of enterprises around Keyline®. From the 1950 - 1970's there was a nationally (in Australia) published 'Keyline' magazine, authorship of articles & books, at least three operational broadacre R&D farms under his control, CSIRO support (up until 1958), a 'Keyline Foundation', an established international property design & development consultancy, Chisel Plow, 'Delver', 'Tritter', 'Keyline Plow', Lockpipe, 'Bunyip Level', and 'Ag-Yo' or 'Yobanite' manufacture & sales. How Yeomans managed such a diverse business model over many years is a tribute to the man's capability and is unparalleled in the Permaculture (or Agriculture!) industry despite the devices of modern communications.

Stunned by the loss of his brother-in-law Jim Barnes, in a grass fire in 1944 on 'Nevallan', Yeomans brought to bear his vast experience as a mine overseer and earthmover to capture and store rainwater in large ponds (referred to in Australia as 'farm dams') across broadacre landscapes which 'so lush and green all year round, they would be virtually fireproof'[vii] and droughtproof. Similar climate regions across the world suffer similarly and the clearly the adoption of Keyline methods would be a primary form of solid-state risk management for both rural and urban landscapes alike. I commonly get requests from clients and correspondents to design both fireproof & droughtproof landscapes and fortunately Keyline provides the effective template.

According to Yeomans the 'inseparable trinity of landscape design' were climate, landshape and water supply, with roads, trees, buildings, fencing & soils being the 'more negotiable remainder of the hierarchy'. Yeomans labeled this prioritization the 'Keyline Scale of Permanence' as a foundation to the process involved with planning permanent landscapes. Interestingly it is now evident that the loss of carbon in agricultural soils. I commonly say that Permaculture itself 'lacks a clear decision making process'[viii]: the Keyline Scale of Permanence' and latterly Allan Savory's landmark 'Holistic Management® Model' ably provide the models for the Permaculture 'toolkit'. These methodologies lack the integrated design principles such as those espoused and continually expanded by Permaculturalists, so combining these approaches makes obvious sense and follows the intellectual pathway led by Yeomans, Savory, David Holmgren, Bill Mollison along with Dr. John Todd[ix], Dr. George Chan & Gunter Pauli[x] among others.

The following article serves to outline many of these processes as part of the ongoing evolution of Keyline or Keyline Design Mark IV as I am calling it, and was developed by Abe Collins & myself for our various seminars.

**The Keyline Plan**

*"A comprehensive design strategy for agricultural and urban development based on fundamental, repeating land shapes that have been created by water" Abe Collins*

Key components:

- Rapid development of biologically active, fertile soil within a systematically designed landscape. During an average three-year conversion phase, four to six inches of new topsoil are typically formed each year. This new topsoil stores large quantities of water in the landscape.
- Design for the harvest, storage and distribution of water on the landscape forms the foundation of the Keyline Plan.
- Run-off water is stored in dams. This water is later released for rapid, gravity-powered flood-irrigation.
- Roads, forests buildings and fencing follow primary water layout and fit together within the lay of the land.
- The Keyline landscape is a permanent landscape in which every infrastructure component helps ensure the maintenance and renewal of the topsoil within it.

*"The hallmarks on the properties of successful Keyline farmers are lakes with water birds, contour and ridge line roads and contoured strip forests, dark fertile soil, luxuriant healthy green crops and feed." Ken Yeomans*[xi]

**<u>New Topsoil Can Be Created Quickly</u>**

**Factors that determine soil fertility:**

- ✓ The mineralogical and structural framework
- ✓ The prevailing climate
- ✓ The soil's biotic associations

Soil has a life and environment of its own. The biotic association can be modified through modification of the soil microclimate.

Soil life responds dramatically to ideal air, moisture, food and temperature conditions. These conditions are simple to create with grazing, subsoiling and dependable rainfall or irrigation. Life begets Life. Plants, their roots and attendant exudates are the solar harvesters and the raw food of soil life. Grazing animals are '*biological accelerators*' they are the most effective tool we can use to speed mineral cycling, and graziers affect enough land to make a large impact.

**Graziers can build topsoil more quickly than anyone else on earth!**

The work of the Yeomans Family, their forebears and contemporaries, Savory and more recently Collins, Dr. Llewellen Manske[xii], & others have clearly demonstrated a variety of means available to increase air, water and organic materials: only the scientists who policy-makers choose to listen to need convincing.

**Keyline Planning is based on permanence,** beginning with the two most permanent features of the landscape:

**1. Climate**, which has moulded and created the topography
Of the dominant climatic factors, temperature, wind, annual distribution of humidity, rainfall. Water is the easiest to work with ("control") and gain benefit from.
**2. Existing Land Shape and Form** (Topography) including underlying geology

**Combining Holistic Management® Land Planning with Keyline Planning:**
Steps:

1. Form a Holistic Goal, including detailed land/ecosystem process description in the Future Resource Base.
2. Get Topographical Maps. Analyze landscape using Keyline insights. Identify Keypoints, Keylines, ideal water storage areas, water diversion lines, possible irrigable areas, road layouts, tree lines, etc.
3. Gather all pertinent information, study and prepare maps and overlays. Take a year or two.
4. Brainstorm many possible layouts for the planned developments.
5. Create the ideal plan based on the best ideas.
6. Develop the plan gradually through Holistic Management® Financial Planning so that each investment makes rather than costs money.

Holistic Management® Planned Grazing and Keyline Soilbuilding go hand in hand. The growing season grazing plan gives you a structured, holistic framework to plan the use of tools (grazing animal impact, subsoiler plow) in the soilbuilding project.

**Water Control is Paramount!**
Water and rainfall determine land development. We have to get water right to get everything else right - design follows water.

New, "artificial" water lines…diversions, dam walls, channels - become permanent land features. Other infrastructure components follow.

Direct rainfall and irrigation water are spread evenly on the land by a unique cultivation pattern, which is an artificial water line…Keyline Cultivation.

**Natural water lines:**
Water flowing over land has a pattern of flow and predictable path lines of movement.

- ✓ The contour line…the edge of a lake is a true contour line. Flow is perpendicular to the contour, forming shallow S-curves from the ridge to the valley.
- ✓ Water drainage lines- streams
- ✓ Water divide lines – "watersheds," main ridge crests

**Artificial water lines:**
Human earthworks that influence flow of water and store water.
Diversions, irrigation channels, dams, Keyline Cultivation pattern, swales. (Also, drainage ditches, which are not central to Keyline.)

Artificial water lines in Keyline are designed for the most efficient water resource development.

Proper design of farms and cities must fit with the existing design in the natural landscape.

**<u>The Geography of Landscape</u>**
*Three water lines, three land shapes & one special pattern.*

**#1 LANDSCAPE DESIGN LINE**
**The Contour Water Line**
The shore of a lake. A level line running across the landscape, a set vertical distance from the next contour line. Water will always run perpendicular to the contour.

**#2 LANDSCAPE DESIGN LINE**
**The Water Drainage Line**
The centre of watercourses: streams, rivers drainage lines of the land. Dendritic (branching) patterns.

**#3 THE WATER DIVIDE LINE**
**The Crests of Main & Primary Ridges**

Vegetation slows the movement of water over and through the land. Vegetation, its variety and/or its absence, and soil organisms stabilize soil and land shapes.

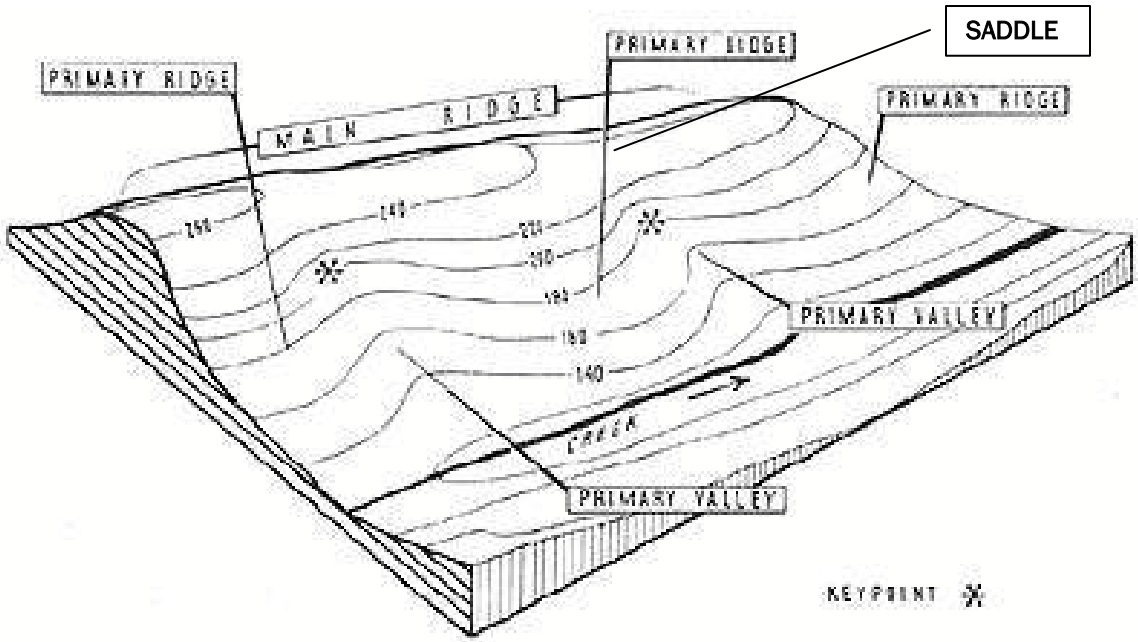
In a stabilized landscape, there are three land shapes we consider in relation to Keyline development:

1. **The main ridge**
2. **The primary valley**
3. **The primary ridge**

The **main ridge** is the first land shape. It begins at the convergence of two water drainage lines. Look around…it is the horizon. The crest of a ridge is synonymous with a water divide line. The crest of a ridge is usually less steep than the sides of the ridge.
Main ridges are a reverse image of the dendritic branching of water **drainage lines (streams/rivers).** You could follow main ridges around the world, except where they go in circles around lakes. The interplay of main ridges and water drainage lines are the anatomy of the landscape.

**Primary Valleys** form in (erode into) the sides of **Main Ridges**. Primary Valleys are divided by **Primary Ridges**.
A primary valley has a primary ridge on either side, so there is always one more primary ridge than primary valleys in a main ridge system.
Primary Valleys are the first place water flows in a rainstorm.

Primary valleys are the smallest of the three land shapes. They are the only true "valley" shapes in the landscape. (Big valleys are actually watersheds.)
The centreline of a primary valley is usually less steep than the sides of the valley.
Where a primary valley intrudes far into a main ridge, you have:
A **SADDLE.** Roads usually cross over main ridge crests across saddles.
Next to a SADDLE is a **HILL.**



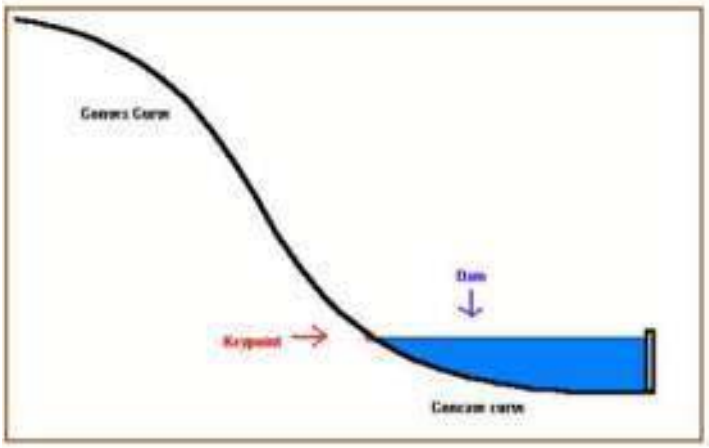

**LAKES and PONDS** are located in depressions in the landscape.

Walk up from the end of a main ridge, (above the confluence of two streams) and it eventually runs into another ridge…you can go left or right on a main ridge. This pattern repeats endlessly. It almost seems designed to shed water. It is primarily the result of the underlying geological skeleton, the urge of water to get back to the sea (water flows downhill) and the moderating influence of vegetation and soil life.

Fragments Between:

- ✓ Tidal Areas
- ✓ Flood Plains

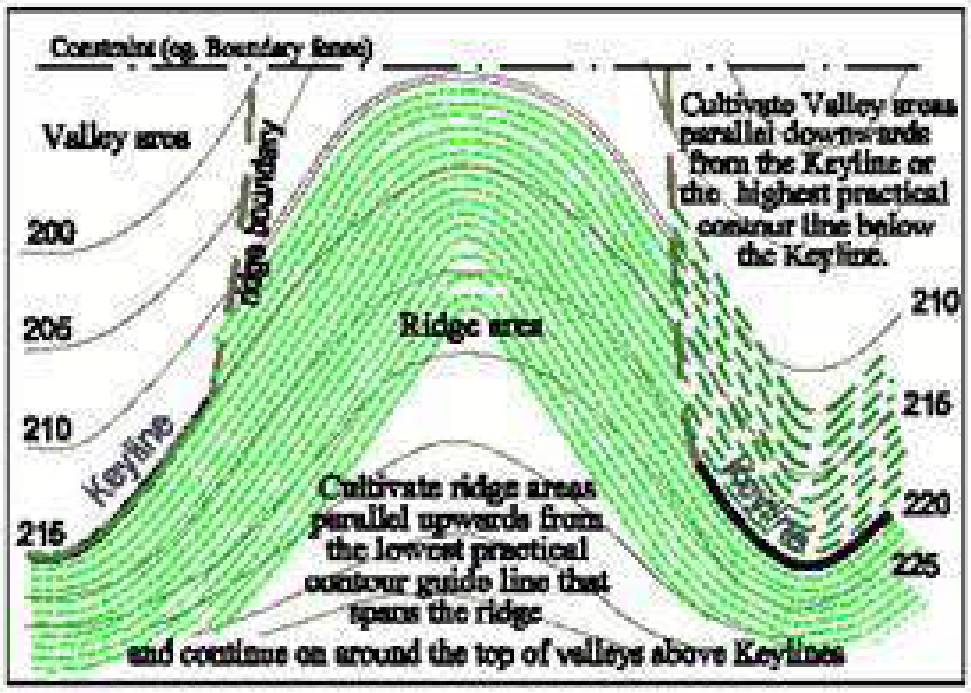
**The Keypoint.**
Every primary valley has a **KEYPOINT**. It is the point at which the primary valley gets suddenly steeper. The steepest slopes in the landscape usually occur in the centre of the valley above the Keypoint….between the Keypoint and the top of the main ridge.




Identifying the Keypoint, and attendant Keyline, is the starting point for Keyline design.

The **Keyline** is a contour line carried in both directions from the Keypoint**, in the valley shape, but not extending out onto the ridges.** Below the Keyline, the accompanying (next-door) primary ridge centre is steeper than the primary valley centre.
Above the Keyline, the primary valley centre is steeper than the primary ridge centre.

***Cultivate parallel to the Keyline both above and below the keypoint in the valleys. Cultivate parallel and upward from any selected contour line on the ridges. When there is no Keyline to work from (lower in the valleys, or on ridges) use contour guidelines to cultivate parallel to (upward from on ridges, downward from in valleys.) This is Keyline pattern cultivation. Water will drift from the valley shapes toward the ridges.***




**The Main Ridge**
Main ridges occupy the most land in the landscape.
They are not level, but slope. This creates a rising relationship in the Keypoints of adjacent primary valleys.

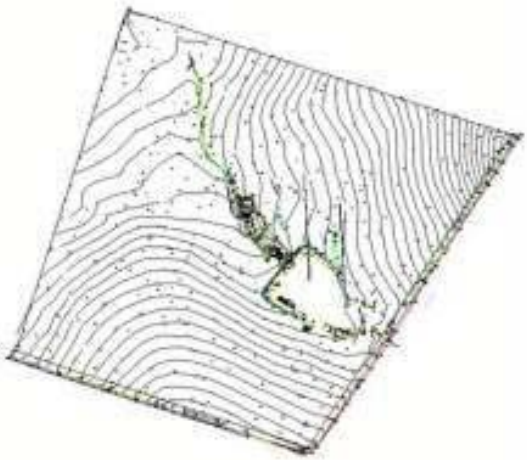
**CONTOUR MAPS ARE BASIC TO UNDERSTANDING KEYLINE.**
Contour maps show the above land features clearly.
Contours are level lines, a set vertical distance from each other.
Close lines indicate steep land, more widely spaced lines indicate less steep land.

With a good contour map and the farmer to provide details, we can design a landscape which will include:

- ✓ Water diversion, storage, irrigation channels, irrigable land and water control structures
- ✓ Catchment size
- ✓ Slope Indices
- ✓ Size of dam walls.
- ✓ Areas to leave, plant, cut trees.
- ✓ Sites for farm buildings
- ✓ Location of subdivision fences, stock watering points, paddock layout.

Contour maps from Government sources, especially of rural landscapes, only provide contour intervals of 10-20+m. Surveyor-produced contour maps are more expensive but are very accurate and provide contour intervals of between 100mm (very flat landscapes) and 1-2m for more undulating or steep landscapes.

Overlaying contours onto an Aerial Photo provides an advanced base to design a landscape with. Using Geographic Information System (GIS) and Computer Aided Design (CAD) software can really enhance the design and development potential of a landscape and form a base from which to easily create a 'Bill of Quantities' for all aspects of the landscape and its development.



**CATEGORIES OF WATER AVAILABLE TO A FARM**

- ✓ **Absorbed Rainfall** – high quality, low price. Good soil holds great quantities of water. Developing topsoil is probably the most cost-effective way to enhance the water cycle and store water on the farm.
- ✓ **Run off from** rain falling on the farm. Rainfall has exceeded the field capacity of the soil, and runs off. Poor design will accelerate this.
- ✓ **External Sources of Surface Wate**r. Water flowing onto the farm.
- ✓ **Ground Water-** Pumped or spring fed.

Table 1. Change in the capacity of soil to store water (litres/ha) with changes in levels of soil organic carbon (OC) to 30 cm soil depth. Bulk density 1.2 g/cm$^3$

| Change in OC level | Change in OC (kg/m$^2$) | Extra water (litres/m$^3$) | Extra water (litres/ha) | $CO_2$ sequestered (t/ha) |
|---|---|---|---|---|
| 1% | 3.6 kg | 14.4 | 144,000 | 132 |
| 2% | 7.2 kg | 28.8 | 288,000 | 264 |
| 3% | 10.8 kg | 43.2 | 432,000 | 396 |
| 4% | 14.4 kg | 57.6 | 576,000 | 528 |

Source: www.amazingcarbon.com

**Designing for the environment:**
Understand the basic land shapes and design in accordance with enhancement of the water cycle by primarily slowing the movement of water over the land. (That is what life does, too.) Start as high as possible, by increasing the fertility and water holding capacity of the primary valleys and ridges. Maintain or develop productive or revegetation forests along the ridges and creek lines for landscape protection and to optimise nutrient or energy cycling, flows and utilisation.
Introduce artificial water lines: the diversion channel, the dam wall, the irrigation channel. Again incorporate productive or revegetation forest strips and plantings with these features.

**Contours / Keylines**
The Keyline is the contour line drawn through the keypoint.
**Remember!** *Keylines do not usually wrap continuously from one primary valley to the next. They have a rising relationship as one moves from one primary ridge to another*.

On a contour map, the Keypoint is apparent, because the contour lines are closer together above it, and further apart below it. On a primary ridge, the centre of the ridge is typically flatter than the sides of the ridge, closer to the valley. (Contour lines are further apart in the centre, closer on the sides.) As the contour lines change direction and head into the valley, the lines will diverge if they are below the Keyline and converge if they are above the Keyline.
Water always flows perpendicular to the contour. This can be understood when we observe the heavier flow in the valleys, and the drier ridges.

**KEYLINE PATTERN CULTIVATION:**
**Causes water to drift away from valley centres and toward ridge crests, where it is held until it soaks in. Rainfall and irrigation water are spread evenly over undulating land.**
The simplest way to accomplish this, given an internal laser guidance system, or just a good feel for slope, is to plough slightly downhill from a given point in a valley centre out onto the accompanying ridge.

**In primary valleys**, we cultivate parallel to the Keyline above it and below it. Above it, it is often too steep for ploughing, but not always. The point at which we shift from valley pattern to ridge pattern cultivation, below the Keyline, is located where the valley floor becomes the ridge wall, or where the contour line shifts direction, in going from primary valley to primary ridge shape. This ploughing pattern will quickly become quite steep/angular, at which point a new contour line should be marked and ploughed parallel to and downward.
*Anywhere lower in the primary valley, we cultivate parallel and below a contour guideline.*


On **primary ridges**, *we cultivate parallel and upwards from any contour guideline*. It's good to stake a number of guidelines, i.e., not plough mindlessly too far from a guideline.

In practice, one would lay out the Keyline across the primary valley, then carry that contour line out onto and around both ridges, then cultivate upward from that in long plough passes. You would then plough downward from that line, *restricting yourself to the valley shape. (The ridges would be* ploughed *parallel and upward from a lower contour guideline. In tighter valleys, there are tricks for simplifying difficult ploughing. However, the basic principles must be stuck by, or water will flow the wrong way, concentrating in the wrong places.*

**The Keyline Scale of Permanence:**

1. Climate
2. Land Shape
3. Water
4. Roads
5. Trees
6. Buildings
7. Subdivision
8. Soil

## 3. WATER

**The two costs of water**

- ✓ Cost in money: cost of improving soils, building dams and irrigation layout, irrigation operation.
- ✓ Cost in Water itself: i.e., it is expensive to always have water available. More cost effective to have water to bring you through dry times….100% drought-proofing would cost a fortune.

**Stored Water, a 2nd Savings Account**: Water in a dam can be traded for, say, a crop of pasture. A full dam, and dry fields in a drought is a sign of failure. Use water in dams for irrigation whenever necessary. Dams can and should be designed to be interlinked so as to be able to move water where it is needed during prolonged dry periods.

**Farm Dams**

Keyline dams always have a large pipe with baffle plates and a valve, through the bottom, for irrigation and control purposes.

**Good sites** for valley dams generally have:

- ✓ A flatter valley floor slope, backing water up further with less wall.
- ✓ A short wall site.
- ✓ Width of valley behind the dam wall
- ✓ Suitable location for spillway
- ✓ Suitable soils (will hold water)
- ✓ Suitable foundation material

Highest site for a storage dam wall in a primary valley is below the Keypoint. This is called a Keypoint Dam. The Keyline is the top water level of the dam. Other types of dams include: Saddle Dams, Turkey Nests & Contour or Ridge Dams

Water levels of dams can be connected by a diversion, falling at 1:400+. Or, water from the lockpipe of one dam can be carried by a diversion to the Keyline of another Keypoint Dam. Sometimes, a dam lower than at the Keypoint is desirable for a whole range of factors.

**Other types of dams include:**

Saddle Dams

Valley Dams

Contour Dams

Ring Dams

**Water Channels**

When developing the water resources of a farm, there are two primary water channels:

1. First, for diverting run off, stream flow or pumped water into a dam. Called a diversion or catchment drain and generally slopes at 1:400+
2. Second, for carrying water for irrigation purposes
    a. on hilly land, dug into ground, slopes at 1:400+
    b. on flat land, generally flat, built above land with two banks, called the Flood-flow irrigation channel
    c. The Irrigation Channel is an important artificial water line. Above it is rain pasture, below it is irrigated pasture.
    d. related water control lines are steering banks, perpendicular to contour
3. Drainage ditches are also water channels, but they are not central to Keyline

The Keypoints of successive primary valleys will often have a rising/falling relationship.
Keypoint dams can be connected by diversion channels. If the fall of the diversion is less than the fall of the water drainage line (stream) an increasingly large area of land will be irrigable between the dams and the water drainage line. We design accordingly.

**IRRIGATION**

**Hillside Irrigation: Keyline Pattern Irrigation.** Flood irrigation of hilly land made possible by *Keyline Cultivation Pattern*. Water is stored in large dams, released through large pipes in the base of the dams, and is moved in irrigation channels dug into the ground. These channels have to have a fall of at least 1:300. Flags are positioned in the ditches, and spill water onto the land below the irrigation channel.

- ✓ Ploughing must be continued indefinitely to spread water evenly.
- ✓ Irrigation can be at rates of up eight acres per hour, with one person control.

**Flat Land – Keyline Flood-flow irrigation.** Water is stored in even larger dams, which tend to be shallower. Water is released through large (2') pipes in the base of the dam. Water is moved in channels which are located above the surface of the land. The channel is generally level. Gates in the channels are opened, and water spreads in a wide sheet across the land in irrigation bays. Irrigation bays are bounded by "steering banks," which run perpendicular to contour.

- ✓ Water can be applied at 20-50 acres/hour.
- ✓ Cultivation need only happen during the soil-building conversion period of three years.

**Traditional Irrigation:**

- ✓ Border Check Irrigation…similar to flood flow, but slow.
- ✓ Contour Bay Irrigation…Rice Paddies.
- ✓ Furrow Irrigation…common for vegetables and orchards.
- ✓ Spray Irrigation…common, expensive, lots of machinery.
- ✓ Drip tape…vegetables. Not a broad-acre strategy. Lots of plastic.

Slow irrigation drowns soil aerobes. Slow irrigation is not generally sustainable.
**No conventionally irrigated civilization has ever survived.**

**4. ROADS**

Roads on contour require less energy to travel. They do not erode easily or concentrate run-off.
Roads are built in relation to water control lines.

**Possible locations of roads.**

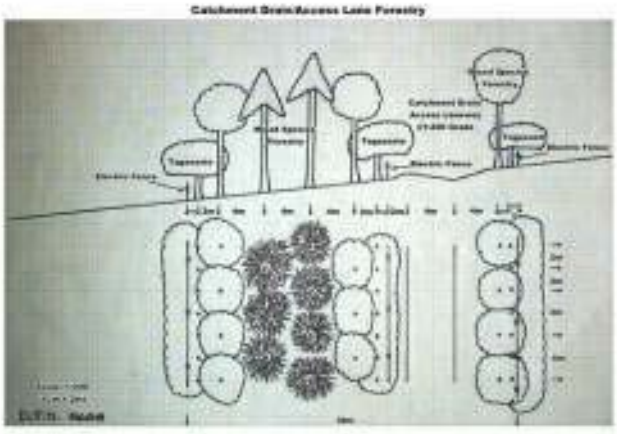
1. Along boundary lines. Generally not on contour, often difficult to maintain, tend to self-destruct. Useful for fence maintenance. I wouldn't invest much in these roads, if at all. Use a flail mower to maintain.
2. On ridge crests (watershed lines, main ridge centres). High, dry, easy to maintain. Good site for a main road.
3. Located by water channels: diversion channels, irrigation channels, irrigation areas.
    a. Below diversions…dry, cross dams that cross valleys.
    b. Above irrigation channels in hilly country…bridges are often necessary.
    c. Below Flood-flow irrigation channels.
    d. At low end of irrigation area.
    e. Along streams.

**5. TREES**

Tree locations fall into place when the first four factors have been considered. Clearing of trees and planting of trees should be considered in light of the four first landscape design considerations.

**Contour Strip Forests**….generally follow the patterns of water harvesting/distribution channels, as well as the roads. Trees usually border roads, and are located above irrigation channels. It is good to plant trees along riparian corridors and around lakes and ponds. Pasture and crop land are separated by contoured tree lines. In the long run, trees do not interfere with productive crop land, they enhance it.

- ✓ Trees act as mineral pumps
- ✓ Trees reduce the effects of wind
- ✓ Trees give edge effect
- ✓ Trees can be designed to provide browse
- ✓ Trees provide wildlife habitat
- ✓ Shelter



Contoured timber belts in hill country are generally spaced so that the top of the mature trees will be level with the base of the next higher belt of trees.

**Keyline soil development on pastureland prior to tree establishment will accelerate tree growth.** ***Build soil fertility first.***

**6. BUILDINGS**

Building should be placed to optimise the potential energy flows eg.

a. Not too exposed. The best view is a often a costly one from an energy consumption perspective
b. Good solar access to enable energy efficient house and building design
c. Topographic protection from prevailing wind direction
d. Build your shed higher than the house so as to use the shed water tank for gravity-fed water to the house
e. On a slope to allow good air & water drainage, gain gravity potential & out of danger from floods

**7. FENCES**

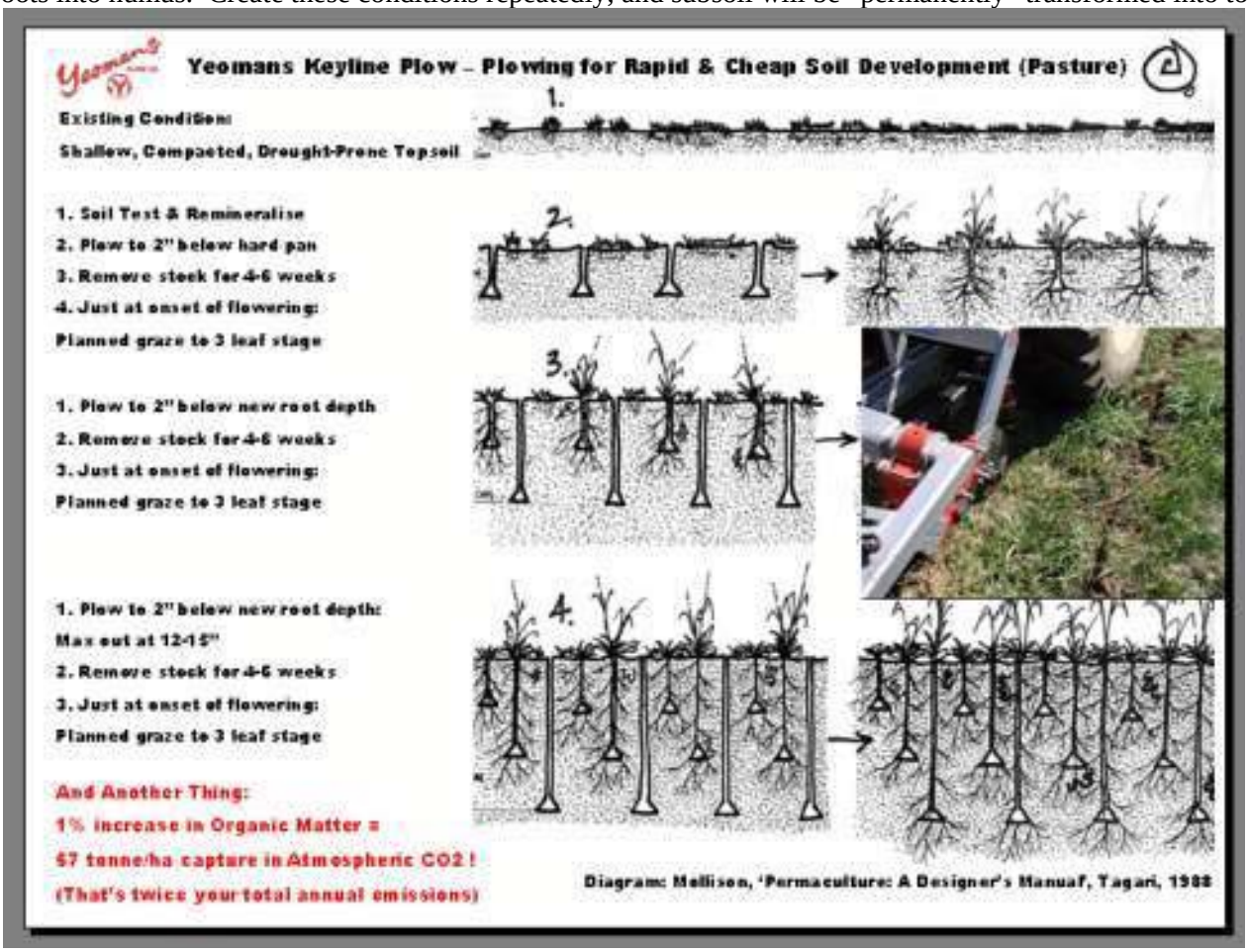
Follows all of the other infrastructure layout. Many paddocks are good. Temporary fence offers flexibility. Fences are built according to natural and artificial water lines. My rule of thumb is to build fences:

a. Along creeks, drainage lines and main ridge crests so as to create drainage line protection and to connect allow flows of wildlife from the bottom to the top of landscapes
b. Lightweight electric internal fencing according to stock type for planned or management intensive grazing
c. All dams and open water bodies to remove stock access
d. Along shelterbelts, strip forests, forest plantations & revegetation forests or areas of natural significance that need protection

**8. SOIL**

**Subsoil can be quickly turned into topsoil. Development & Maintenance of Soil fertility is a product of management.**

Good grazing gives the greatest return for the least energy input in increasing soil fertility. The subsoiler greatly accelerates normal topsoil formation under pasture. Conversion of subsoil to topsoil involves creating repeated biological climaxes. Soil life requires air, moisture, warmth, space & plenty of high energy, high protein food. Create these conditions, & soil life will respond, transforming some portion (often about 10%) of plant exudates & sloughed grass roots into humus. Create these conditions repeatedly, and subsoil will be "permanently" transformed into topsoil.



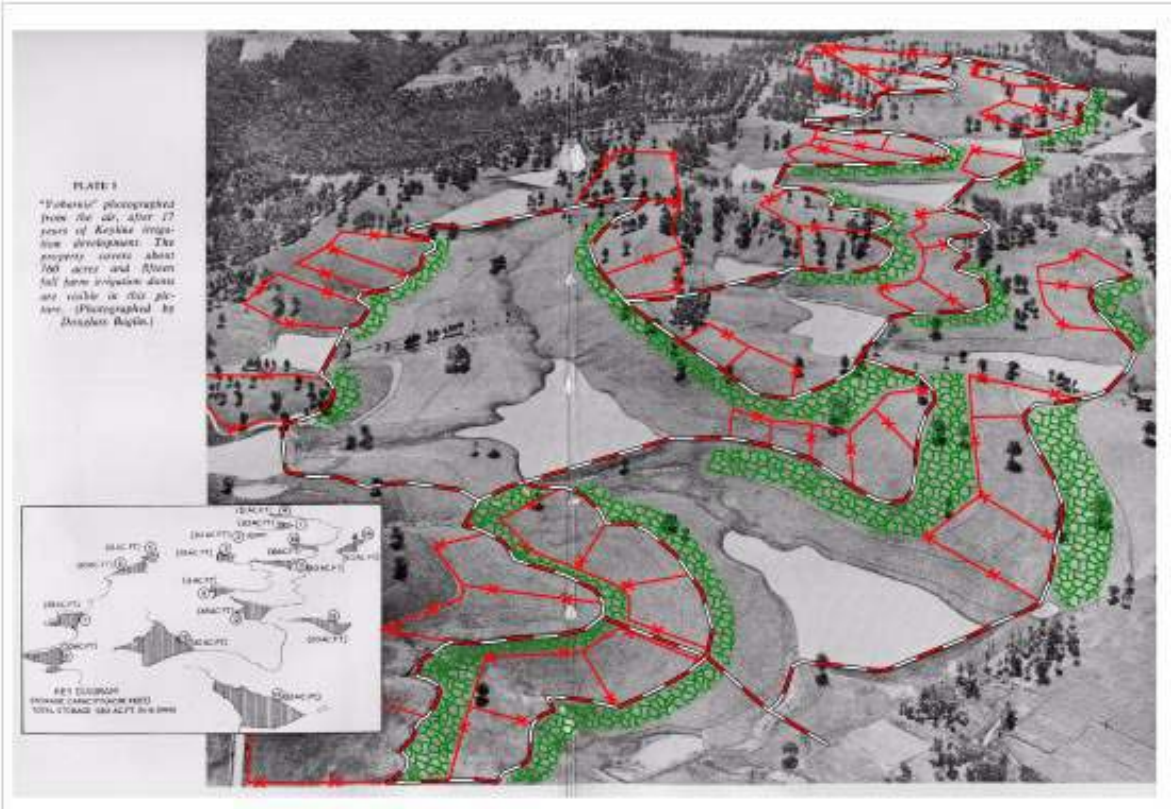
**Urban design.**

The ‘KeylineScale of Permanence’ can be applied to urban design in a way that insures that water supply is clean and perpetual, transport uses minimal energy, as roads are located on or close to contours, wastewater is used to “irrigate” city forests.

- ✓ Most useful in the design of new cities.
- ✓ Dams are located with water lines at Keyline®.
- ✓ Roads are laid out in relation to water control lines.
- ✓ Cities are designed from the crest of main ridges downward.
- ✓ Trees are planted/ left in relation to water control lines
- ✓ City Forests provide cleansing and valuable construction materials.

**Urban SubDivision Design.**

*Yobarnie Urban Retrofit* – In early 2007 we were advised that ‘Yobarnie’ was sold by the family who bought the property off of the Yeomans family in the late 1960’s for rumoured sale price of over AUD$40 million. At this price ‘Yobarnie’ is unlikely to remain in agriculture. I have redesigned property as a peri-urban/rural residential low density subdivision, this landscape according to the design principles outlined in P.A. Yeomans 1971 tome, ‘The City Forest.’



**Key Resources:**

**Information on Keyline**

- Keyline Designs – Ken B. Yeomans – www.Keyline.com.au
- Yeomans Keyline Plows – Allan J. Yeomans – www.yeomansplows.com.au
- Broadacre Permaculture Design & Development – Darren J. Doherty – www.permaculture.biz
- On line Books – Soil & Health Library – www.soilandhealth.org

**Carbon Farming**

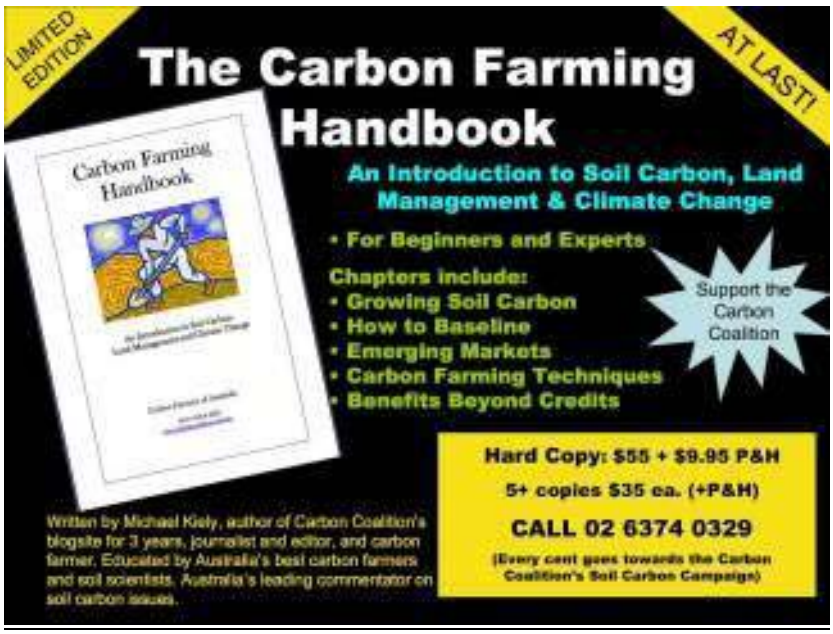
- Carbon Farmers of America – Abe Collins – www.carbonfarmersofamerica.com
- Amazing Carbon – Dr. Christine Jones – www.amazingcarbon.com.au
- Carbon Coalition – Michael Kiely – www.carboncoalition.com.au
- Soil Food Web Institute - www

**Holistic Management®**

- Publisher of 'In Practice' newsletter, Holistic Management® Resources & Certified Educator Program – Holistic Management® International – www.holisticmanagement.org
- Holistic Management® Australia – www.holisticmanagement.org.au

**Interesting!**

- Publisher of 'Stipa' newsletter - Native Grass Association Inc – www.stipa.com.au
- Peter Andrews work - Natural Sequence Farming - www.nsfarming.com
- International Permaculture Courses & Forum - Permaculture Research Institute – www.permaculture.org.au
- Integrated value-added family farm operation - Polyface Farm – Joel Salatin & Family – www.polyface.com
- Great grass farming newspaper - The Stockman Grass Farmer – www.stockmangrassfarmer.com




---

i Carbon Farmers of America co-founder, www.carbonfarmersofamerica.com, Swanton, VT

ii Australia Felix Permaculture, www.permaculture.biz, Bendigo, VIC

iii Mollison, B., Permaculture Design Certificate Course, Tyalgum, NSW, 1995

iv Yeomans, A.J., Homage to P.A. Yeomans, Gold Coast, QLD, 1993

v Yeomans, P.A., The Challenge of Landscape, Keyline Press, Sydney, NSW, 1958, pp 166.

vi Hill, S.B., Yeomans Keyline Design for Sustainable Soil, Water, Agroecosystem & Biodiversity Conservation: A Personal Social Ecology Analysis, University of Western Sydney, NSW, 2001

vii www.lacewing.org, Keyline & Fertile Futures, Sydney, NSW, 2007

viii Doherty, D.J., Permaculture Design: Emerging Paradigms & Processes for Broadacre Permaculture, Keyline® Design Course, Two Rock, CA, 2007

ix http://www.toddecological.com/ecomachines/principles.html, Principles for Designing Eco-Machines, Burlington, VT, 2008

x http://www.zeri.org/about_science_behind_zeri.htm, About ZERI: The Science Behind It, 2008

xi http://www.keyline.com.au/, Yeomans, K.B., Keyline Designs, Gold Coast, QLD, 2005

xii http://www.ag.ndsu.nodak.edu/dickinso/grassland/rangrpt.htm, UND, 2008