

# LAND FORMATION

## Field Development

Field development is the configuration of the field shape and surface slope as well as the installation of water control structures to optimize water management and crop production, conserving resources and improving operational efficiency. Most important to rice is accurate and easy management of water application, depth, and drainage so that crop growth is improved, and weeds are controlled. Also important is water conservation—through increases in water use efficiency and by minimizing the likelihood of accidental drainage. Another goal is more efficient use of land, tillage, and harvest equipment. This can be achieved by reducing the number of levees, straightening the levees, or making them smaller.

## History

Much of the Central Valley is naturally fairly level, ranging from two to five feet of fall per mile (Willson 1979), so not much leveling was done in the early days of the rice industry. Consequently, most early efforts towards field improvement were in clearing native vegetation and building irrigation water structures such as canals, drains, weir boxes, and levees. The prevailing belief at the time was to leave the soil surface between the levees alone because rice grew poorly in cut areas and rank in fill areas. By the mid-1920s, growers began to see the economic benefits of leveling, although the first heavy earth movers and landplanes capable of major land formation were not available until 1935 (anonymous, 1948). Leveling became widespread after WWII, with a sharp increase in the 1960s. A key concern was whether to maintain the natural contours, which was cheaper, or to make the slope uniform so straight levees could be used, but at a higher cost (Figure 1). Wick (1970), estimated an equipment efficiency gain of 12-15%, 10% higher yield, faster initial



Figure 1. Typical contour levees required in unleveled land, above. Land leveled to uniform slope with parallel levees, below.

flooding, more precise depth management, gain in productive land, and increased land value by leveling for parallel levees. The leveling system most commonly used depended on installing a matrix of grade stakes, based on a detailed survey map, which guided the equipment drivers.

Accuracy was dependent on the skill of the operator to match cuts and fills with specifications. In the early 1970s, laser-guided equipment (Figure 2) revolutionized land accuracy, automating some equipment operations and eliminating the need to set a complex matrix of grade stakes. With the adoption of the laser and its exceptional accuracy, growers changed their view of how flat fields could be.

Slopes decreased to zero with laser leveling, allowing for wider levee spacing and bigger basins. In addition, in those areas where rice is



Figure 2. Typical scraper for leveling equipped with laser receiver that guides position of cutting blade. Signal is received from laser beam on stand in foreground. Scrapers may be equipped with single, dual or satellite guided receivers

the only crop, fields were specifically developed for rice using permanent levees and little or no slope. Today, a high percentage of rice fields are laser leveled and have parallel levees. Those which do not are usually in areas where rice is rotated with other crops.

More recently, Global Positioning Systems (GPS) have been used for precision leveling, because GPS systems can be used to map field elevation in three dimensions, with an accuracy of up to 0.1 inches. This is more accurate than laser leveling, and it is easier to set up, as GPS leveling does not require the laser towers that are required for laser leveling. GPS leveling is less troublesome than laser leveling, as it is not hampered by dust and wind, whereas laser leveling can be negatively affected by both.

The necessary equipment is a tractor equipped with surveying software, a GPS receiver, and a base reference point. The scraper (which levels the soil) can be adjusted based on the field elevation map and can be controlled from inside the cab with the software.

## Site Selection

Rice fields require the ability to pond water, so soils with low infiltration rates are necessary to prevent excessive water use. Desirable rice soils are those with high clay content (35 to 60%) in the topsoil or subsoil, or which have a

cemented layer or hardpan in the subsoil. The most productive rice soils have deeper topsoils although good rice yields may come from shallower soils if crop nutrition needs are adequately met. Fields developed along the edges of the Sacramento Valley and near streams often have more variable soil types across short distances, which should be factored into the development plan. Fields formed from naturally flat topography benefit from less disturbance of topsoils compared to fields developed on steeper land where less fertile subsoils are exposed during leveling. It is especially difficult to farm rice when a calcareous or sodic subsoil is brought to the surface. Such soils often have soil chemistry problems that are difficult to correct.

## Leveling

Land leveling allows maintenance of a uniform water depth within the basin (the area between the levees, also called a paddy) and greatly facilitates subsequent management practices for stand establishment, weed control, and field drainage for harvest. When a new field is developed or an old one is improved, an engineering plan is usually developed that includes all the features of the new field such as the placement of levees and whether they are straight or contour. It also includes the position of roads, landings, irrigation intakes, canals, drains, and other necessary structures. Often, several leveling options may be prepared and the producer decides which best fits his situation.

How a field is leveled depends on the crops grown, irrigation method, field configuration, soil type, and cost. About two-thirds of rice fields in the Sacramento Valley are set up to grow rice only, while the others grow row and field crops in a rice rotation. Fields growing rice only often have little or no slope while those in a crop rotation usually have slopes of 0.05 to 0.1%.

Fields may have a uniform slope across the whole field or the slope will vary because the natural contour of the land varies. Soil type will affect how a field is leveled, primarily as it relates to whether or not a soil can economically support crops other than rice. Although good for rotational crops, inclusions of well-drained soil in a rice field should be avoided if possible to minimize the volume of water needed to maintain a flood.

Cost is frequently the primary determinant of how a field is leveled. Very steep ground is most economically leveled into a series of ‘benches,’ each separated by a levee. This avoids the need to cut down large hills and fill in deep valleys and it leaves more topsoil in place. The area between the levees in benched fields is essentially a small field with its own uniform slope.

There are consequences to leveling, which is that moving the soil can cause changes in fertility (discussed in the next section), as well as possibly bringing up weed seeds that were buried deeper in the soil profile. The year after a new leveling event, growers may see weed species that were previously thought to be eradicated, as well as weeds in different locations throughout the field.

## Soil Fertility

Leveled fields frequently have infertile and fertile spots related to the cuts and fills. Since most nutrients in the soil are concentrated in the plow layer, and subsoils are usually alkaline and may have infertile cemented hardpans, the effects of leveling on crop nutrition should be a primary consideration during the planning stage. The leveling plan should consider the depth to infertile subsoil and try to avoid it. The National Resources Conservation Service has irrigation land leveling specifications: “In cut areas, when highly permeable or otherwise unsuitable subsoil conditions are encountered, the cuts shall

be over excavated and the topsoil replaced. In the fill areas, if specified, the topsoil will be stripped, the fills partly made and the topsoil replaced.” (NRCS 2000). While more expensive, this method will help reduce the damage from deep cuts and help maintain uniformity of soil fertility.

## Levees

Levees can be either permanently installed or taken down annually and reinstalled each spring. Permanent levees predominate in rice-only areas while annually installed temporary levees are common in mixed cropping areas or where a rotation crop may be grown occasionally. Construction of permanent levees should be integrated with the leveling plan because they are larger and require more soil. Temporary levees are built by pulling a large disk ridger or levee squeeze across the prepared field, gathering soil from a width of 11 to 13’. To prevent seepage, temporary levees often require the construction of two parallel levees with a borrow pit (indentation) between them. When the levees are knocked down and the field worked, the soil returns to its original position. In some rice-only fields, the individual basins are large (>25 ac) and the levees around them are wide enough for roads, which gives complete access for management. The benefits of permanent levees include freedom from annual installation, road access, no borrow-pits, and roll-overs. Roll-overs are flattened areas at the ends of levees for equipment to cross over from basin to basin. The disadvantages of permanent levees are that perennial weeds grow which may contaminate the crop and rodents establish and cause leaks. Some annual repair work is necessary to keep weeds and rodents under control, using herbicides, rodent baits, traps, and discs to repair holes.

Temporary levees take extra work to build and may require a fresh map or survey of the levee locations each year. Fields in a rotation usually need a fresh levee survey when coming back into rice. Temporary levees are usually free of perennial weeds and rodents. The big advantage to temporary levees is that they can be constructed after soil preparation, making it easier to quickly prepare a large field. Irrigation boxes for temporary levees are usually reinstalled each year, although some growers leave the boxes in from year-to-year and just remove the levee. Temporary levees are built on the prepared field, first marking their location, then pulling the levee. A large rice ridger can work in unplowed soil, but takes several passes to gather sufficient soil for the levee. A squeeze or crowder requires that the ground be loosened first by plowing and drying, then a single pass will create the levee. Both types leave a borrow pit, which means there is unproductive land.

All three levee types, temporary, permanent, and roads, use approximately the same amount of land. A typical leveled field usually has 3-5% of the land in levees. An unleveled field with contour levees may have as much as 10% of the land in levees.

The orientation of levees relative to wind direction can be an important consideration during the planning stages, particularly if the basins are long. Strong winds blowing across the surface of long basins will ‘pile’ the water on the downwind side, which may cause erosion damage to field sides and levees, and sometimes breaches in levees. In addition, the deeper water may impact rice growth and possibly uproot plants. Levees that are crosswise to the wind help reduce the damaging effects. Larger basins are more susceptible to the effects of wind but are more efficient in many respects, so some compromises are necessary.

## Grade

Grade refers to the slope of the land surface. This means small elevation changes across the field, called either the ‘slope’ or ‘fall’. Because rice needs fairly shallow and uniform water depth large variations in elevation cannot be tolerated. Slope is usually expressed in tenths of a foot per hundred feet of distance or as a percentage. For example, a slope of 0.1’/100’ is the same as 0.1%. A 0.1% fall is equivalent to one foot every thousand feet. One foot is too great a fall for high-yield rice production so levees are necessary to break up the field and make sure that water depth will vary no more than 3-4”, and preferably no more than 2.5”. Many fields are leveled to much less than 0.1%, often 0.02 to 0.05%, allowing for wide levee spacing and greater efficiency. Many fields that are used only for rice have no slope at all and are completely flat. Others have compound grades so that levees are set at an angle to the edges of the field. Many fields have more than one grade, so that levee spacing is not uniform across the field. This is usually related to the cost of leveling which may make it impractical to establish a uniform grade.

Two goals of leveling and setting levees are to space them far enough apart to minimize their number, but close enough together so that the fall between, which affects water depth, does not exceed what the crop can tolerate. Two examples in the shaded box deal with these primary goals.

The point of the first example is that you choose your levee spacing consistent with the slope of the land and the needs of the crop. Usually, when the leveling plan is developed based on the criteria discussed above, you can determine levee spacing on the map. If the field falls in two directions, the calculation is the same although the levees will not be perpendicular to the side of the field. In practice, levee positions can be



done with a laser transit simply by finding those spots in the field that represent the desired fall.

The second example is really the corollary of the first. This may be useful if you know the slope and levee spacing, but the water on the low side is too deep and you want to move the levees.

## Irrigation Systems

Water delivery and distribution must be considered in the development of the field. While the levees are the primary means of controlling and containing water, other structures are necessary to regulate and distribute it. The method of water management is also integrated into the field development plan. Several irrigation system design options are discussed in the section on Water Management.

### Irrigation boxes

Weir boxes in each levee are the primary means of regulating water flow and depth. Several materials have been used to build weir boxes, including wood, steel, cement, plastic, and fiberglass. Figure 3 is a typical wooden rice box. Redwood is cheap and easily repaired and is useful in fields where levees and boxes are removed annually. Fields with permanent levees often use more durable materials such as corrugated plastic pipes connected to steel drop

boxes. All have common properties including a flume or pipe to move water from one side of a levee to the other, and removable ‘flash boards’ which hold water back to a given depth and let the excess flow over the top. Water level in the basin above the box is regulated by adding or removing boards. Weir boxes are usually placed near the ends of levees, often on both ends, and sometimes opposite ends in adjacent levees to promote water circulation. The size and number of rice boxes are dependent on the required capacity to move water from one basin to another. Rice boxes, as in Figure 3, are typically 18” high, 48” long, and 24-48” wide. The pipe diameter in permanent rice weirs is usually 12-18”.

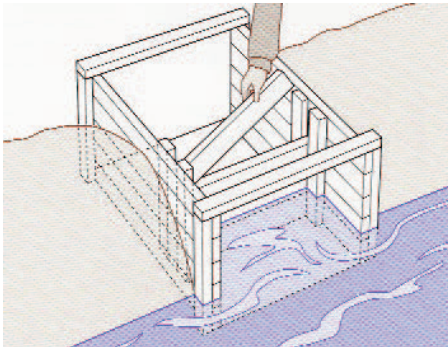


Figure 3. Typical wooden rice box. From: Hill et.al. 1991.