Rainfall Capture and Storage for Marin Agriculture

Background

Farming and ranching in Marin has always been limited by water availability. Row crop farms are few and generally small (under 20 acres with few exceptions), but increasingly such operations are being developed on livestock ranches to add diversity to ranch income. One of the main factors limiting row cropping is the scarcity of irrigation water throughout most of rural Marin County.

Poor water-bearing properties of most of the bedrock underlying Marin means that the county's water is primarily supplied by surface sources. Marin Municipal Water District (MMWD), North Marin Water District (NMWD), or one of the six small community water districts serve residents of most urban and smaller communities. Rural landowners outside of water district service areas rely on springs and wells for domestic water. Water for livestock and dairy operations comes from on-farm reservoirs, wells, springs, and, in very limited areas, from water districts. Irrigation for Marin's row crop farms is supplied by wells, riparian water, and on-farm reservoirs.

The Marin Countywide Plan contains policies and programs that demonstrate County government's support for exploration and development of small-scale alternative water sources for agriculture.

Definitions

Acre-foot. A volumetric measurement equal to 325,851.43 gallons.

Appropriative water right. Approval needed from State Water Resources Control Board (SWRCB) for capture and storage of runoff from a natural channel.

Jurisdictional. Water that is captured and stored that is subject to the SWRCB Division of Water Rights' permitting jurisdiction. Typically this is water that flows within a natural channel that has a bed and banks.

Natural channel. A naturally occurring channel that has a bed and banks.

Non-jurisdictional. Water that is captured and stored that is not subject to the SWRCB Division of Water Rights' permitting jurisdiction. Typically this is rainwater that falls directly into a pond, runs off of building roofs, or comes from upland hillslopes. Water that formerly flowed within a natural channel, but where grading or other changes have eliminated the bed and banks, is still considered jurisdictional and requires an appropriative water right. The SWRCB does not regulate groundwater if it's not in a classified subterranean channel.

Rainfall capture. Collection of rainwater that falls directly into a pond or other storage structure.

Sheet flow. Rainwater that flows above ground and not within a natural channel.

Upland. A part of the landscape that does not include a natural channel.

Methods for Capturing and Storing Water

Collection and storage of direct rainfall or upland sheet flow may in some cases be a viable alternative to the historic tradition of capturing and storing water that flows within a natural channel. Impounding stream flow is now highly regulated, requiring an appropriative water right from the State Water Resources Control Board (SWRCB). Appropriative rights are difficult, if not impossible to obtain, and require a lengthy and costly application process.

More promising options for developing additional agricultural water sources include capture and storage of non-jurisdictional water. Rainwater that falls directly into storage ponds or is collected from roofs of agricultural buildings can be stored and used without an appropriative water right. Roof runoff can be collected via gutter systems and directed to storage tanks, water bladders, or storage ponds. Upland sheet flow that runs off of hillsides can, in many cases,[1] also be stored and used for irrigation or livestock water without an appropriative right.

[1] *In some cases, storage of what appears to be upland sheet flow may require an appropriative water right, a determination that must be made by personnel from the SWRCB Division of Water Rights.*

Rainwater can be stored above or below ground, with below-ground storage limited to tanks and structural water storage systems made of modular components. Above-ground storage can be in tanks, ponds, or portable water storage bladders.

The amount of water required for a given operation, a property's size, topographic setting, and other factors, as well as cost considerations for collection, storage, and distribution, will determine the best options for each farm or ranch.

On-Farm Water Requirements

On-farm water needs are highly variable, depending on crops, soils, and location in Marin. Determining the actual water demand should be done on a case-by-case basis, depending on crops and site characteristics. One successful vegetable grower produces a wide variety of vegetables including lettuce and other leafy greens utilizing only 1 to 1.5 acre-feet per acre per season.

Local farmers grow potatoes and tomatoes without any irrigation on sites with deep soils. Some tree fruits, especially those grown on standard rootstocks, can be successfully dry farmed after they are established, but yield increases substantially with irrigation. According to a local apple producer, apples on some semi-dwarfing rootstocks, planted at 400 trees/acre, can be successfully grown with only about .3 to .5 acre-foot per acre per season.

A vast majority of Marin County's agricultural land is used for animal agriculture, primarily beef cattle production, dairying, and sheep ranching. On most ranches, livestock water comes from developed springs and/or stock ponds. Mature cattle need, on average, about 15 gallons per day. A 100-head beef herd would require close to 2 acre-feet per year, allowing for evapotranspiration from the pond surface.

Marin Rainfall and Potential Water Yield

Rainfall varies within Marin County's agricultural areas, and is generally highest in Tomales. Table 1 provides rainfall amounts during various storm events for selected locations in Marin County, illustrating the potential for capture and storage of significant volumes of water for on-farm use. Table 2 provides average annual rainfall amounts for similar locations. By definition, a 2-year storm would occur, on average, every 2 years; a 100-year storm would occur, on average, every 100 years. A 2-year 24-hour storm would therefore be the rainfall event one could expect during a 24-hour period on the average of every 2 years (Schwankl et al. 2007). Not all of this rainfall would result in upland sheet flow, since some will soak into the soil, but a large portion of it could, especially during less frequent (25-year and 100-year) storms (Schwankl et al. 2007).

Table 1. Rainfall amounts for storm return intervals in selected areas of Marin County (Source: Isopluvial maps from U.S. Department of Commerce National Oceanic and Atmospheric Administration Special Studies Branch, Office of Hydrology, National Weather Service for U.S. Department of Agriculture Engineering Division, Soil Conservation Service December 1972)

Location	2-year 24-hour storm			25-year 24-hour storm			100-year 24-hour storm		
	(in)	(gal/acre)	(ft^3/acre)	(in)	(gal/acre)	(ft^3/acre)	(in)	(gal/acre)	(ft^3/acre)
Bolinas	3.5	95,033	12,705	6.5	176,490	23,595	7.5	203,643	27,225
Chileno and Hicks Valleys	3.5	95,033	12,705	5.5	149,338	19,965	7.0	190,067	25,410
Novato	3.0	81,457	10,890	4.7	127,617	17,061	6.2	168,345	22,506
Point Reyes	3.0	81,457	10,890	5.5	149,338	19,965	6.5	176,490	23,595
Tomales	3.7	100,464	13,431	6.5	176,490	23,595	7.5	203,643	27,225

Table 2. Average annual rainfall amounts in selected areas of Marin County (Source: PRISM MAP Isohyets 800 meter annual rainfall based on 1971-2010 data: *http://prism.oregonstate.edu*)

Location	Approximate average annual rainfall in inches
Bolinas	36
Chileno and Hicks Valleys	41
Novato	30
Point Reyes Station	32
Tomales	37

Potential water yield from barn roofs can be estimated by multiplying roof area by storm event rainfall data or annual rainfall for a given location. For example, a dairy with 40,000 square feet of roofing in an area with average annual precipitation of 41 inches could generate about 1.08 acre-feet of runoff per year:

41 inches = 1.14 feet
40,000 ft^2 x 1.14 feet = 45,600 $feet^3$
45,600 $feet^3$ x 1 gallon/.13 $feet^3$ = 350,769 gallons
350,769 gallons x 1 acre-foot/325,851.43 gallons = 1.08 acre-feet

If the dairy were located in Tomales, a 25-year 24-hour storm producing 176,490 gallons per acre would yield .5 acre-foot:

40,000 ft^2 x 1 acre/43,560 ft^2 = .92 acre
.92 acre x 176,490 gallons per acre = 162,370 gallons
162,370 gallons x 1 acre-foot/325,851.43 gallons = .5 acre-foot

Water yield from upland watersheds can be calculated similarly, but must account for water infiltration, especially early in the rainy season before soils are saturated.

Permits and Water Rights

Non-jurisdictional ponds. Upland rainfall catchment ponds to store non-jurisdictional water from direct rainfall, roof runoff, or upland sheet flow may not require any permits in Marin County if they are properly designed and sited. An agricultural grading permit exemption may be granted under Marin County Code section 23.08.030 (2) (c) for: "Grading necessary for agricultural operations unless such grading will create a cut or a fill presenting an undue potential for failure which would endanger any structure intended for human or animal occupancy or any public road, or could obstruct any watercourse or drainage conduit." Such exemptions must be applied for through Marin County Department of Public Works (DPW) by submitting a letter to DPW requesting the exemption, describing the proposed work, and explaining how it falls under the code scion cited above. Landowners and/or their design engineers should contact the SWRCB to arrange for a site inspection to determine if a planned pond will truly capture and store non-jurisdictional water. The SWRCB Water Rights Division can be contacted by telephone at (916) 341-5300.

Jurisdictional ponds. Ponds that capture and store jurisdictional water require the landowner to obtain an appropriative water right from the SWRCB. This is a process that can take up to ten years and may cost many tens of thousands of dollars, including costs for environmental studies. Agricultural grading permit exemptions may also apply to jurisdictional storage ponds. Storage of jurisdictional water will likely require registration through the SWRCB Division of Water Rights, Statement of Water Diversion and Use Program (*http://www.waterboards.ca.gov/waterrights/water_issues/programs/diversion_use/*).

Marin County, the National Park Service, and the Marin Resource Conservation District are working together to design and permit irrigation storage ponds in the Pine Gulch Creek watershed in Bolinas. Farmers who depend on riparian irrigation water from Pine Gulch Creek will be able to store creek water in the proposed ponds, avoid-

ing pumping directly out of the creek during summer months when flow levels are critical for endangered Coho salmon. Pond design and permitting for the water storage ponds, ranging in size from three to 26 acre-feet, has taken over 10 years to date. The ponds require appropriative water rights, and although they are exempt from grading permits, the Marin County Planning Department has required environmental review due to the presence of the California red-legged frog and other sensitive resources in the project area. Approvals and environmental work have cost over $250,000.

Stock ponds and small domestic use ponds. The SWRCB also issues licenses for stock water and small domestic use ponds that are limited to 10 acre-feet. Water impounded in these structures cannot be used for irrigation. An instruction booklet on filing an application to appropriate water is available on the SWRCB Division of Water Rights website (*http://www.waterboards.ca.gov/waterrights/*) under Permitting and Petitions, then Forms. Agricultural grading permit exemptions may also apply to small stock ponds and domestic use ponds.

Storage tanks. Above-ground water tanks and bladders require building permits unless they hold less than 5,000 gallons and do not exceed a 2:1 height to width ratio. Underground tanks and modular storage systems generally require building permits and grading permits if significant excavation occurs. In some cases, agricultural building permit grading permit exemptions may apply, although both exemptions must be granted through an application process.

Costs for Design, Permitting, and Construction

Costs for design, permitting and construction or purchase of water storage systems varies widely depending on many factors.

Design costs. Design costs would be highest for engineered ponds, and lowest for simple, above-ground tank or bladder storage systems.

Permitting costs. Permitting costs would be highest for ponds that store jurisdictional water, due to the time and study required to obtain an appropriative right, while permitting costs would be lower for bermed ponds that store non-jurisdictional water, or for tanks, bladders or below-ground storage systems.

Construction/purchase costs. Pond construction can run from about $20,000 to $40,000 for a small stock pond to well over $1 million for a lined 30-acre-foot pond. Construction costs are highest for bermed ponds that require extensive earth moving. Storage tanks and bladders require lower investment, although underground modular storage systems are costly. Underground modular storage systems are structural and have the advantage of being able to bear substantial weight above the ground surface.

Army surplus or similar portable water storage bladders come in many sizes, from 100 up to 50,000 gallons. Five-thousand-gallon bladders can be purchased for several thousand dollars.

Costs for water delivery piping, pumps, and electricity should also be factored in when evaluating water capture and storage methods, as long-term energy costs can be substantial.

Getting Started

Agricultural producers considering rainfall capture and storage can start exploring the potential for different methods by determining their water requirements and deciding if above ground or below-ground storage is most appropriate for the volume of water needed and for site conditions. Table 3 compares different methods and shows their advantages, disadvantages, and probable permit requirements.

If capture and storage from roof runoff into above ground tanks less than 5,000 gallons is proposed, no permits should be required unless the roof or barn is modified, in which case a building permit could be needed. Tanks larger than 5,000 gallons may also require building permits. Ponds that collect only rainwater that falls directly into them without running off of the ground surface may also be very simple to permit, with only a grading permit or grading permit exemption.

An engineer may be consulted to help design gutters, size water pumps, and provide project guidance for roof runoff projects and to design berm constructed ponds. Underground tanks, depending on the amount of excavation involved, may also be subject to grading permits or grading permit exemptions.

If hillslope runoff into a pond appears to be the best option, an engineer should be consulted to help locate the preferred pond site and provide a conceptual pond design. The SWRCB Division of Water Rights should then be contacted to determine whether or not the proposed pond would be jurisdictional. If the design and location are determined to be non-jurisdictional, a fully engineered design should be prepared and a grading permit or grading permit exemption would be required.

If the SWRCB Division of Water Rights determines that a proposed pond would be jurisdictional, the time and cost involved and the probability of obtaining a water right should be seriously considered before moving ahead with this type of project.

Table 3. Advantages, disadvantages, and permit requirements for water capture and storage methods

Water Capture Method	Advantages	Disadvantages	Permits Needed
Roof runoff	No permits needed, non-jurisdictional	Only available where sufficient roof area exists	None for collection from existing roofs
Upland sheet flow	Large volumes can be obtained, often non-jurisdictional	Requires ponds for storage, which are costly to construct	None for sheet flow capture, grading permit or grading permit exemption needed for storage pond construction
Direct capture of rainwater	Non-jurisdictional	Water volume limited by area of pond; pond must be bermed so that runoff is excluded; construction costs for bermed ponds are high due to volume of earth movement required	Grading permit or grading permit exemption needed for bermed ponds
Stream flow	Large volumes can be captured	Requires appropriative water rights which are difficult and very costly to obtain	Water rights, grading permit or grading permit exemption
Water Storage Method	**Advantages**	**Disadvantages**	**Permits Needed**
Pond	Can store large volumes of water	High design and construction costs	Grading permit or grading permit exemption, appropriative water rights in some cases
Above ground tank	Relatively low cost	Limited storage capacity	Building permit needed for over 5,000 gallons or for smaller tanks with less than a 2:1 height/width ratio; Marin County agricultural building permit exemption may apply
Portable bladder	Relatively low cost, can be moved when empty	Less storage capacity than ponds but greater than many tanks	Building permit needed for over 5,000 gallons or for smaller tanks with less than a 2:1 height/width ratio; Marin County agricultural building permit exemption may apply
Underground modular storage systems	These systems are structural, so land area above can be used for vehicle parking or other weight-bearing use	High cost	Building permits are needed for storage over 5,000 gallons; grading permit or grading permit exemption is needed for excavation

Resources

Additional information and assistance can be obtained from the United State Department of Agriculture, Natural Resources Conservation Service (NRCS):

NRCS Petaluma Field Office (707) 794-1242; 1301 Redwood Highway, Suite 170, Petaluma CA 94954

NRCS, Agriculture Handbook Number 590. Ponds – Planning, Design Construction: *http://www.in.nrcs.usda.gov/pdf%20files/PONDS.PDF*

Citations

Lawrence J. Schwankl, Terry L. Prichard, and Blaine R. Hanson. 2007. Storing Runoff from Winter Rains; Reducing Runoff From Irrigated Lands PUBLICATION 8211. 3 pp.

Prepared by Lisa Bush and David J. Lewis, June 2010. More information about diversifying your operation is available at the Grown in Marin website under Resources for Farmers at http:growninmarin.org, or by calling the UCCE Farm Advisor's office at 415/499-4204.