IRRIGATION WATER MANAGEMENT PLAN

Landowner's Objective

The landowner raises several varieties of potatoes for processing. Small grain is also raised on this farm, but its value as a cash crop is minimal. The purpose of the grain as a rotation crop is to help control erosion, maintain soil organic matter, and for disease and pest control. Irrigation takes place only on the fields in potato production.

This landowner's goals are to increase the net profit of his production and to reduce the risk of crop loss due to disease or drought. This grower contracts with a food processor before the growing season. The contract includes certain quality standards for the crop that influence the final price paid. The grower uses nutrient and pesticide management, in addition to soil and water management to achieve the crop quality standards and to increase marketable yields. Research by the University of Maine, McCains, and the grower's own experience has shown that supplemental irrigation can not only increase total yields, but also increase the quality, consistency, and value of the potato crop. Results of research by the Maine Agricultural Experiment Station on the benefits of supplemental irrigation are shown in the Crop Yield Response section of the Appendix

Healthy plants that are not stressed by drought are better able to resist disease. Inconsistent applications of water can cause misshapen tubers. The grower understands that excessive soil water can cause tuber rot. To reduce the potential for tuber rot, this grower will allow some moisture stress to the crop by applying less irrigation water than required to keep moisture near field capacity. This will allow capacity for natural rainfall between irrigation applications and reduce the chance of excess moisture. It will also reduce the volume of water that needs to be pumped and stored for irrigation.

This plan addresses the grower's objective of minimizing the risk of crop loss caused by drought. This area has experienced dry summers and extended periods of limited rainfall that have had significant effect on crop quality and yield. In some growing seasons, no supplemental irrigation is required, and in others, only two or three applications are necessary. The grower understands that water from the Meduxnekeag River is not always available for irrigation when flow rates are low since other designated uses, as determined by water quality standards or other regulations, could be impaired by irrigation water withdrawal. From his experience, rainfall records, and consultation with irrigation specialists, this grower has decided that 4 inches[1] of irrigation water available to the crop will be adequate for all but the driest years. He also understands and accepts the risk that in some very dry years, both the river and the proposed storage pond will not provide adequate water volume to insure the desired crop quantity and quality. This risk minimizes the area of wetlands that could be impacted by more or larger irrigation ponds.

Current and Future Irrigation Water Needs

Currently the landowner is irrigating approximately 100 acres on the Home Farm and 40 acres on the West Farm with a maximum annual net application of 4.0 inches. The pumping volume is based on a irrigation system efficiency of 75%. Irrigation system efficiency is the ratio of the amount of irrigation water available for crop production to the amount of irrigation water

[1] The amount of irrigation water available to the crop will vary according the growers needs. The quality of the crop and/or the dependability of the yield will determine the irrigation needs.

withdrawn from a water source. System efficiency includes conveyance losses to the field and uniformity of application. A travelling gun sprinkler irrigation system is the most practical and economically feasible system to use on both farms. Well managed, travelling gun sprinklers typically have a system efficiency of 75%. This results in a current maximum annual pumping volume of 44 acre feet on the Home Farm and 18 acre feet on the West Farm. The landowner's objective is to increase irrigation to a maximum of 190 acres on the Home Farm and a maximum of 84 acres on the West Farm which would result in maximum annual pumping volumes of 84 acre feet and 37 acre feet for the Home Farm and West Farm respectively.

Irrigation Water Management Plan Worksheets

The irrigation water management plan worksheets summarizes the management techniques that the landowner will be using to insure the most efficient use of irrigation water. Theoretically an application depth of up to 50% of the available water capacity could be applied per irrigation. However, it has been found by experience that applying lesser amounts more frequently and keeping the soil moisture level below field capacity is more effective for potato production. The time to irrigate is decided from soil moisture levels determined by methods shown in the worksheet. Applying lesser amounts more frequently minimizes losses from deep percolation and surface runoff, allows for storage in the root zone for rainfall, and can reduce tuber rot. A separate worksheet is shown for the landowner's two farms.

IRRIGATION WATER MANAGEMENT PLAN WORKSHEET
(Home Farm)

OWNER	*Hypothetical*	PLANNER	*K. Roble*
TOWN	*New Limerick*	DATE	*25 April, 2000*
FARM NAME	*Home Farm*	TOTAL CROP ACRES	*332*

FIELD NUMBER	*1*	*2*	*3*
IRRIGATED ACRES	*142*	*92*	*98*
CROP TO IRRIGATE	*Potatoes*	*Potatoes*	*Potatoes*
EFFECTIVE ROOT DEPTH (in.)	*15*	*15*	*15*
AVAILABLE WATER CAPACITY (in.)	*2.91*	*2.91*	*2.91*
PEAK CONSUMPTIVE USE (in/day)	*.17*	*.17*	*.17*
CROP ROTATION	*Potatoes/grain*	*Potatoes/grain*	*Potatoes/grain*
PREDOMINATE SOIL TYPE	*Linneus*	*Linneus*	*Linneus*
GROSS WATER APPLIED PER IRRIGATION (in.)	*0.75*	*0.75*	*0.75*
NET WATER APPLIED PER IRRIGATION (in.)	*0.56*	*0.56*	*0.56*
WATER USE / APPLICATION (ac-ft)	*8.9*	*5.8*	*6.1*
PLANNED PUMPING RATE (gpm)	*450*	*450*	*450*
LANDOWNER'S SEASONAL NET WATER NEEDS (in)	*4*	*4*	*4*
SEASONAL WATER PUMPED (NET/GROSS, ac-ft)	*47/63*	*31/41*	*33/43*
SCHEDULING METHOD	*Checkbook and feel methods*	*Checkbook and feel methods*	*Checkbook and feel methods*
TYPE OF SPRINKLER	*Travelling gun*	*Traveling gun*	*Traveling gun*
SYSTEM EFFICIENCY (%)	*75*	*75*	*75*
POTENTIAL WATER SOURCES	*A,B,D,E*	*A,B,D,E*	*A,B,D,E,G*

NOTES:

Of the total crop acres on this farm, crops will be rotated so that no more than 190 acres will require irrigation in any one year. The maximum gross seasonal irrigation water needs for this farm will be 84 ac-ft.

IRRIGATION WATER MANAGEMENT PLAN WORKSHEET
(West Farm)

OWNER	*Hypothetical*	PLANNER	*K. Roble*
TOWN	*New Limerick*	DATE	*25 April, 2000*
FARM NAME	*West Farm*	TOTAL CROP ACRES	*146*

FIELD NUMBER	*4*	*5*	
IRRIGATED ACRES	*84*	*50*	
CROP TO IRRIGATE	*Potatoes*	*Potatoes*	
EFFECTIVE ROOT DEPTH (in.)	*15*	*15*	
AVAILABLE WATER CAPACITY (in.)	*2.91*	*2.91*	
PEAK CONSUMPTIVE USE (in/day)	*.17*	*.17*	
CROP ROTATION	*Potatoes/grain*	*Potatoes/grain*	
PREDOMINATE SOIL TYPE	*Linneus*	*Linneus*	
MAX. GROSS WATER APPLIED PER IRRIGATION (in.)	*.75*	*.75*	
WATER USE / APPLICATION (ac-ft)	*5.3*	*3.1*	
PLANNED PUMPING RATE (gpm)	*450*	*450*	
LANDOWNER'S SEASONAL NET WATER NEEDS (in.)	*4*	*4*	
SEASONAL WATER PUMPED (NET/GROSS, ac-ft)	*28/37*	*17/23*	
SCHEDULING METHOD	*Checkbook and feel methods*	*Checkbook and feel methods*	
TYPE OF SPRINKLER	*Travelling gun*	*Travelling gun*	
SYSTEM EFFICIENCY (%)	*75*	*75*	
POTENTIAL WATER SOURCES	*C,F*	*C,F*	

NOTES:

Of the total crop acres on this farm, crops will be rotated so that no more than 84 acres will require irrigation in any one year. The maximum gross seasonal irrigation water needs for this farm will be 37 ac-ft.

Alternative Analysis

The Proposed and Potential Water Sources Worksheet summarizes all of the possible water sources that are available to meet the landowner's irrigation water needs. A separate worksheet is provided for each farm or farm unit. The notes following each worksheet states the potential of each source and discuss the impacts of using the sources for irrigation withdrawals. The alternative chosen will best meet the irrigation water requirements as stated in the objectives while minimizing the impacts on wetland, ponds, or streams.

PROPOSED AND POTENTIAL WATER SOURCES WORKSHEET
Home Farm

LANDOWNER	*Hypothetical*		
FARM NAME	*Home Farm*		
TOWN	*New Limerick*		
PLANNER	*K. Roble*	DATE	*April 25, 2000*

SITE NUMBER	A	*B*	*D*
TYPE OF SOURCE	*Meduxnekeag River*	*Proposed embankment pond*	*Potential embankment/ excavation pond*
DRAINAGE AREA	*31 sq. mi.*	*286 acres*	*100 acres*
PUMPING RATE (cfsm) (river or stream)	*.032*	-	-
STORAGE CAPACITY (ac-ft)	-	*40-48*	*35*
MAXIMUM DEPTH (ft)	-	*13*	*10*
POOL AREA (ac)	-	*9*	*9*
MAXIMUM FILL HEIGHT (ft)	-	*18*	*12*
EMBANKMENT LENGTH (ft)	-	*600*	*400*
VOLUME OF FILL (cy)	-	*14,000*	*5,000*
SOIL TYPE	-	*Monarda*	*Monarda*
WETLAND ACRES	-	*6.5*	*9*

PROPOSED AND POTENTIAL WATER SOURCES WORKSHEET
Home Farm (continued)

LANDOWNER	*Hypothetical*		
FARM NAME	*Home Farm*		
TOWN	*New Limerick*		
PLANNER	*K. Roble*	DATE	*April 25, 2000*

WATER SOURCE	E	*G*	
TYPE OF SOURCE	*Existing excavated pond*	*Potential excavated pond*	
DRAINAGE AREA	*4 acres*	*30 acres*	
PUMPING RATE (cfsm) (river or stream)		-	
STORAGE CAPACITY (ac-ft)	*5*	*8*	
MAXIMUM DEPTH (ft)	*6*	*10*	
POOL AREA (ac)	*1*	*1*	
MAXIMUM FILL HEIGHT (ft)	*0*	-	
EMBANKMENT LENGTH (ft)	*NA*	-	
VOLUME OF FILL (cy)	*NA*	*16,000 excavation*	
SOIL TYPE	*Monarda*	*Monarda*	
WETLAND ACRES	*0*	*1*	

NOTES:

Total supplemental irrigation water needs for the Home farm is 84 ac-ft. Approximately 50 ac-ft of storage will be available between the existing pond at Site E and the proposed pond at Site B. The remaining 34 ac-ft of irrigation water for the proposed system will come from the Meduxnekeag River at Site A . The grower has been pumping as much as 44 ac-ft from the river. Therefore, the proposed pond at Site B should result in less water needed from the Meduxnekeag River. The grower plans to minimize the effects on both the Meduxnekeag River and the wetlands at Site B by irrigating from the river when flows are not low and using pond storage when river flows are low. This reduces the size of the pond and the area of wetland impact. If future regulations restrict direct pumping from the river, additional storage will be required. For information, when the river is flowing at 0.3 cfsm, irrigation withdrawal will be 10% of the flow. Any irrigation water withdrawals will not result in a violation of designated uses of any water body. All potential water sources are described below.

Site A: Existing source of water, pumping at 450 gpm has provided a maximum yearly volume of 44 ac-ft., however, in two of the last 6 years, pumping had to be suspended at times due to low stream flows.

Site B: An embankment pond with a storage capacity of 40 acre feet is being proposed at this time. If suitable soil is available from the pool area, the embankment could be expanded to add approximately an additional 8 acre feet of storage capacity. An intermittent stream feeds this site.

Site D: Not proposed as a water source at this time, since more wetland would be affected for less storage. An excavated pond in the wetland is possible, but it would be costly to obtain significant storage capacity. One acre-foot of volume is about 1600 c.y. of excavation, in addition to the overburden that would need to be removed.

Site E: Potentially could be expanded, but the site is relatively small. The existing pond may be used as a water supply for one application on about 70 acres. Recharge would likely be slow, since the site is high on the watershed.

Site G: A potential excavated pond in a wooded wetland. Monarda soils generally have a perched water table near the surface October-May. Unless test pits confirm a consistent high water table or a recharging spring, this site is not suitable. The watershed is not large enough to support a water supply from surface runoff.

The Significant Sand & Gravel Aquifer Map identifies an aquifer just east of the farm. The aquifer is mapped as greater than 50 gpm, but it is unknown if it could support 450 gpm. Also, the aquifer is located adjacent to the river, so likely, water withdrawal would essentially be removed from the surface flow.

PROPOSED AND POTENTIAL WATER SOURCES WORKSHEET
West Farm

LANDOWNER	*Hypothetical*		
FARM NAME	*West Farm*		
TOWN	*New Limerick*		
PLANNER	*K. Roble*	DATE	*April 25, 2000*

WATER SOURCE	C	*F*	
TYPE OF SOURCE	*Existing pond*	*Meduxnekeag River*	
DRAINAGE AREA	*20 acres*	*30 sq. miles*	
PUMPING RATE (cfsm) (river or stream)		*0.033*	
STORAGE CAPACITY (ac-ft)	*16*	-	
MAXIMUM DEPTH (ft)	*12*	-	
POOL AREA (ac)	*2*	-	
MAXIMUM FILL HEIGHT (ft)	*NA*	-	
EMBANKMENT LENGTH (ft)	*NA*	-	
VOLUME OF FILL (cy)	*NA*	-	
SOIL TYPE	*Linneus, Monarda*	-	
WETLAND ACRES	*NA*	-	

NOTES:

Total supplemental irrigation water needs for this farm is 37 ac-ft.

Site C: An existing embankment/excavated pond. This pond was constructed below a spring in glacial till soils, but has a slow recharge. The pond currently provides most of the irrigation water supply.

Site F: The grower uses the river when flows are not low. The proposed expanded irrigation water needs will come from the Meduxnekeag River at this site. Any irrigation water withdrawals will not result in a violation of designated uses of the stream. For information, when the river flow is 0.33 cfsm at this location, 10% is removed at the pumping rate of 450 gpm.

There are no mapped significant aquifers on this farm. Water yields from bedrock wells are much too low for irrigation.

Summary

All proposed irrigated acres for the landowner are included in this irrigation water management plan. The plan consists of two farms that have separate water sources. The supplemental irrigation water needs shown for both farms are the maximum amounts that would be needed depending on the crop rotation. Annually the combined acres in potato production from both farms will be approximately 50% of the total combined acreage.

From experience, the landowner's potato quantity and quality of production goals are met by being able to apply a seasonal net of 4 inches of supplemental irrigation. Therefore, the planned irrigation water supplies for each farm is the volume needed to provide a net application of 4 inches on all acres in potato production. The proposed water supplies are considerably less than the theoretical net of 6.5 inches of supplemental irrigation that would be needed to guarantee that the consumptive use requirements are met 8 years out of 10. Providing water supplies that insure a supplemental net irrigation of only 4 inches will help minimize the effect on surface streams, wetlands, and ground water supplies.

At this time the only proposed additional water supply development is the embankment pond at Site B for the Home Farm. The pond will have an effect on 6.5 acres of wetland. A total of 50 acre feet of storage will be provided by ponds at sites B and E. The remaining 34 acre feet of water needed for the Home Farm will come from the Meduxnekeag River at Site A. In the future if these three sources are not adequate to supply the supplemental irrigation water needs, then the ponds at Sites D, E, and G would be developed. The river will be used during higher flow rates when irrigation withdrawals will not cause an adverse impact on the stream habitat. The ponds will be used during low flow periods. The pond at Site B will be filled when a high flow rate occurs in the intermittent stream supplying the pond.

At this time the existing water sources will be used for all of the supplemental irrigation water needs for the West Farm. Management techniques will be similar to the Home Farm by using the river source during high flows and using the pond source during low flows. Other sources not mentioned in this plan would have to be found if the existing sources do not meet the landowner's crop production objectives.

Appendix

Crop Yield Response

Several studies of supplemental irrigation of potatoes in Maine between 1956 and 1989 showed increases in total yield of 25 to 130 cwt./acre with the conclusion that irrigation will optimize yields and insure quality in about three out of every four years. Research by the Maine Agricultural Experiment Station for the Aroostook Soil and Water Management Board reported U.S. No. 1 potato yield increases of 25% and 40% respectively for the years 1994 and 1995 when 9.1 and 6.3 inches of rain fell in June through August. The four-year study, averaging the four potato varieties tested, predicted the 10-year average yield increase to be 48-cwt./acre total and 38 cwt./acre U.S. #1.

Crop Water Needs

Evapotranspiration is the sum of the evaporation of water from the soil and plant surfaces plus the water that transpires through the plant tissues. Therefore, evapotranspiration equates to the total water needs or consumptive use for plant growth. The University of Maine conducted supplemental irrigation studies on four potato varieties at the Aroostook Farm in Presque Isle from 1992 through 1997. Estimated total annual crop evapotranspiration (Et_c), assuming adequate soil moisture, ranged from 12.0 to 15.1 inches for the first four years of the study. Calculations of average evapotranspiration for potatoes in Central Aroostook by the radiation method using mean monthly climate values fall within the range of the study. The results of these calculations are included in Table 1. The actual evapotranspiration may vary depending on potato variety, actual climate conditions, and any allowance for water stress by the crop. Supplemental irrigation is provided when rainfall does not meet the crop water needs.

Seasonal water needs determination

Table 1 summarizes the method used to determine the seasonal water needs for potatoes in central Aroostook county. The effective precipitation is the amount of mean rain that is stored in the root zone and is useable by the crop. The computations indicate that at least 6.7 inches of seasonal effective precipitation will occur 8 years out of 10. Statistically, 2 years in 10 will have less than 6.7 inches of effective precipitation. The net irrigation requirement is the difference between the average evapotranspiration and the effective precipitation. Traveling gun irrigation has an application efficiency of approximately 75%.

In theory, up to 8.7 inches of supplemental irrigation water would have to be available in order to meet the total potential water needs for potatoes in central Aroostook in 8 years out of 10. The calculated maximum net irrigation application (6.5 inches) coincides with the maximum amount of irrigation water applied by some irrigators (6 to 7 inches) in central Aroostook in 1995, a very dry year when less than 7 inches of rain fell in June, July, and August.

The maximum rain in 2 years in 10 and the minimum-recorded monthly rain shown in Table 1 are for information. The maximum rain in 2 years in 10 means that statistically, less monthly rain than the amount indicated will fall in 2 out of 10 years. The season total is not statistically correct.

The supplemental irrigation water needs depend on the objectives of the landowner. For example, 8.7 inches of water would have to be available for irrigation if it is necessary to insure

full potential consumptive use requirements of the crop 8 years out of 10. Only 6.8 inches of irrigation water would be needed if the objective was to insure the mean or average consumptive use requirements.

Table 1 (All data shown is in inches)

Month	½ May	June	July	August	½ Sept.	Season
ET_c	.92	2.52	4.69	3.96	1.09	13.2
Mean rain	1.56	2.91	4.01	4.07	1.72	14.3
Mean Effective Precipitation	.84	1.61	2.41	2.35	.93	8.1
Max. rain 2 years in 10	.96	1.83	2.98	2.64	1.09	9.5
Min. recorded rain[2]	.24	.88	1.75	.93	.43	9.0[3]

Mean net irrigation requirement	5.1
Mean gross irrigation requirement @ 75% efficiency	6.8
Minimum effective precipitation 8 years out of 10	6.7
Net irrigation requirement to insure seasonal Et_c 8 yrs. out of 10	6.5
Gross irrigation @ 75% efficiency to insure seasonal Et_c 8 yrs. out of 10	8.7

[2] Years of record: 1959-1988
[3] Season precipitation for single year.