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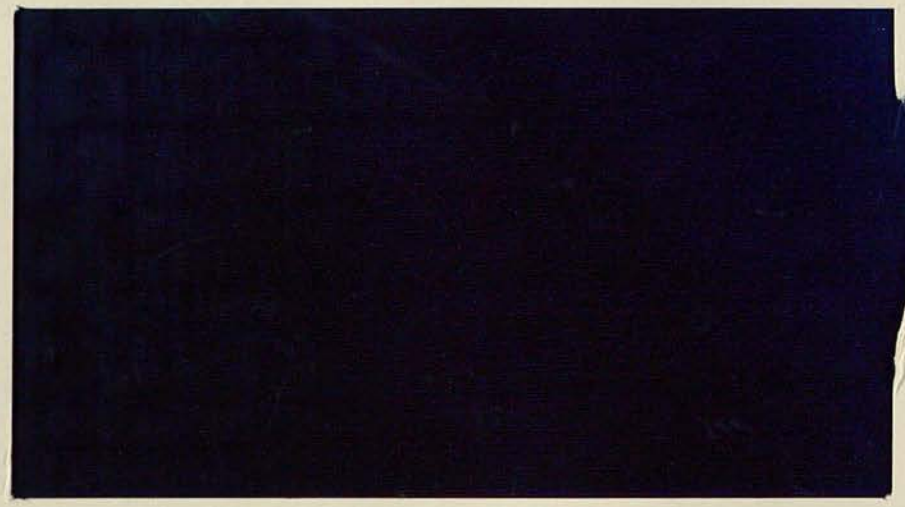

WORKING PAPER SERIES

University of California, Davis
Department of Agricultural Economics

PROBLEMS ASSOCIATED WITH ESTABLISHING A WATER MARKET IN CALIFORNIA AND STRATEGIES FOR THEIR SOLUTION

by

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1. Introduction

From microeconomic theory, we know that to use water resources efficiently, (1) if it is directly consumed, each consumer's marginal utility of water must be equal, or (2) if it is used as a productive input, each user's marginal value product of water must be equal, or (3) if it is allocated between direct consumptive use and productive input use, the marginal utility of water in consumption must be equal to the marginal value product of water in production. To achieve these ideal situations, a water market which connects each water user has to exist and work well.

Howitt[10] has already shown that the introduction of a water market would bring millions of dollars economic benefits to California. Even so, the real situation in water resources' use in California seems not going toward the introduction of a water market so smoothly. Why is the movement towards a water market so slow ? The reasons are the existence of barriers against the introduction of a water market which originate in (1) water law, (2) the water pricing policy by the U.S.Bureau of Reclamation(U.S.B.R.) in Federal Water Projects, (3) the water pricing policy by the Department of Water Resources(D.W.R.) in the State Water Projects, (4) water pricing policies by water districts, and (5) the lack of insurance policies

for dry years.

Until these problems are solved, water rights holders who are intrested in selling or buying water will not have any incentive to trade water through a water market. Therefore, I discuss about (a) why these problems are the barriers against the introduction of a water market, and (b) how we can solve these problems.

2. Water Rights Law

(2.1) Riparian Rights

The main features of riparian rights are as follows;

1. Riparian rights are attached to riparian lands which are adjacent to the river. Therefore, riparian land owners automatically hold riparian rights. Riparian rights holders can't sell their riparian rights without selling their riparian lands. But, when a riparian rights holder lease some pieces of his riparian lands to someone(for example, person A), he can lease his riparian rights attaehed to the lands to person A. But person A must use the water just on those riparian lands. Therefore, riparian rights are not transferable.
2. Riparian rights are superior to appropriative

rights. But there is an exception: The appropriator possessed the superior right if he began using water before a riparian land owner had aquired his property. If the appropriator began using water later, then his right was junior.

3. Riparian rights are not quantified. But a riparian rights holder must use water correlatively with other riparian rights holders. However, as they can use abundant water, they have little incentive to use water efficiently though the water use must be reasonable and beneficial. Generally speaking, as they can use water as much as they want, they have the incentive to use water until the marginal value product of water reaches zero, even though the opportunity cost of water is positive.
4. The water captured by riparian rights must be used on riparian lands. Selling the water is prohibited. Therefore, the market to trade water captured by riparian rights is illegal.

In order to encourage riparian rights holders to use water more efficiently, in 1980 the State Legislature took a major step forward by making it possible to transfer riparian rights and the water captured by the riparian rights which have been statutorily adjudicated and quantified.

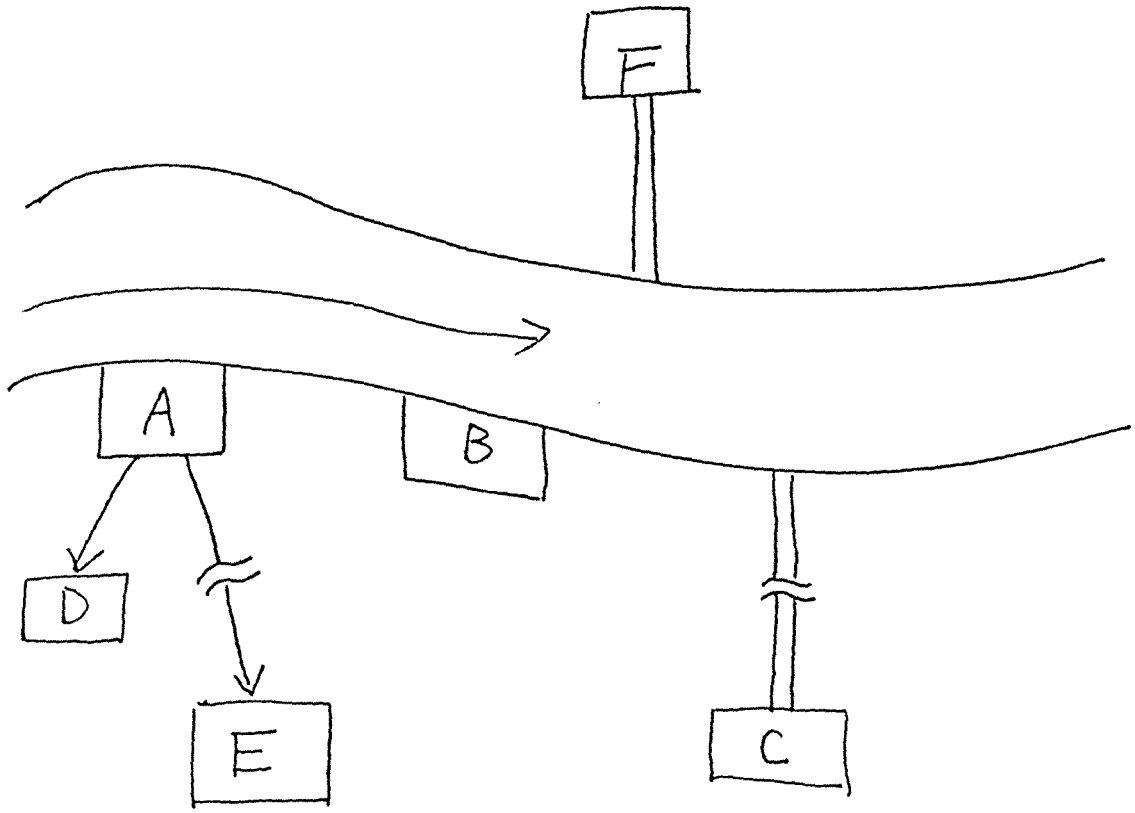


Fig 1

Nevertheless, the legislation does not ensure incentives for riparian rights holders to adjudicate and quantify their riparian rights. Even though riparian rights holders are able to transfer their water rights and the water through adjudication and quantification, the possibility for them to benefit may be small. The reasons are as follows;

a. To adjudicate and quantify their riparian rights in court may require considerable expense and time.

b. The possibility to transfer water from person A to person D may be small. This is because, as person D's land is close to the river, person D may be able to use groundwater easily.

c. The possibility to transfer water from person A to person E may be small. Because, to transfer water, a cannal which connects person A and person E must be available. If it is not, the construction costs of the cannal may exceed the benefits of the water transfer.

d. The State Water Resources Control Board has no jurisdiction over riparian rights. Therefore, when person A is going to transfer water, some downstreamers whom might be injured by the transfer may enter a lawsuit against the transfer. In

order for person A to proceed with the transfer, the transferred water price must be higher than the water transportation costs plus expected court costs. If the price is so high, the transferees may not want to buy the water.

e. Even though person A transfers some amount of water to person C, person C may not be able to capture the amount of water. Because, if riparian rights holder B's water right is not quantified, person B may capture the amount of water like a free rider.

f. After person A had made a contract to transfer water to person C, a dry year may occur and bring some damages to person A.

g. The adjudicated riparian rights which have not been used for five years must be forfeited.

Until these kinds of problems have been solved, riparian rights holders may not have any incentive to adjudicate and quantify their riparian rights and then to transfer them.

(2.2) Pre-1914 Appropriative Rights

The main features of pre-1914 appropriative rights are as follows;

1. Earlier water users have higher priority to water

use than those following, i.e., first in time, first in right.

2. The S.W.R.C.B. has no jurisdiction over pre-1914 appropriative rights. Therefore, when problems occur over water use with pre-1914 appropriative rights, they must go to court.
3. Pre-1914 appropriative rights are not quantified. Therefore, as the rights holders can use abundant water, they have little incentive to use water efficiently though the water use must be reasonable and beneficial.
4. My understanding is that pre-1914 appropriative rights holders can transfer their rights without selling their land and the water captured by the rights, "if others are not injured by such transfers". But to transfer the rights, the rights holders must adjudicate their rights in court.

I went to the S.W.R.C.B. and the D.W.R, and asked some water rights specialists about the transferability of pre-1914 appropriative rights. One said that pre-1914 appropriative rights holders can transfer their rights without selling their land, but the others said that water rights are attached to land and therefore pre-1914 appropriative rights holders can't

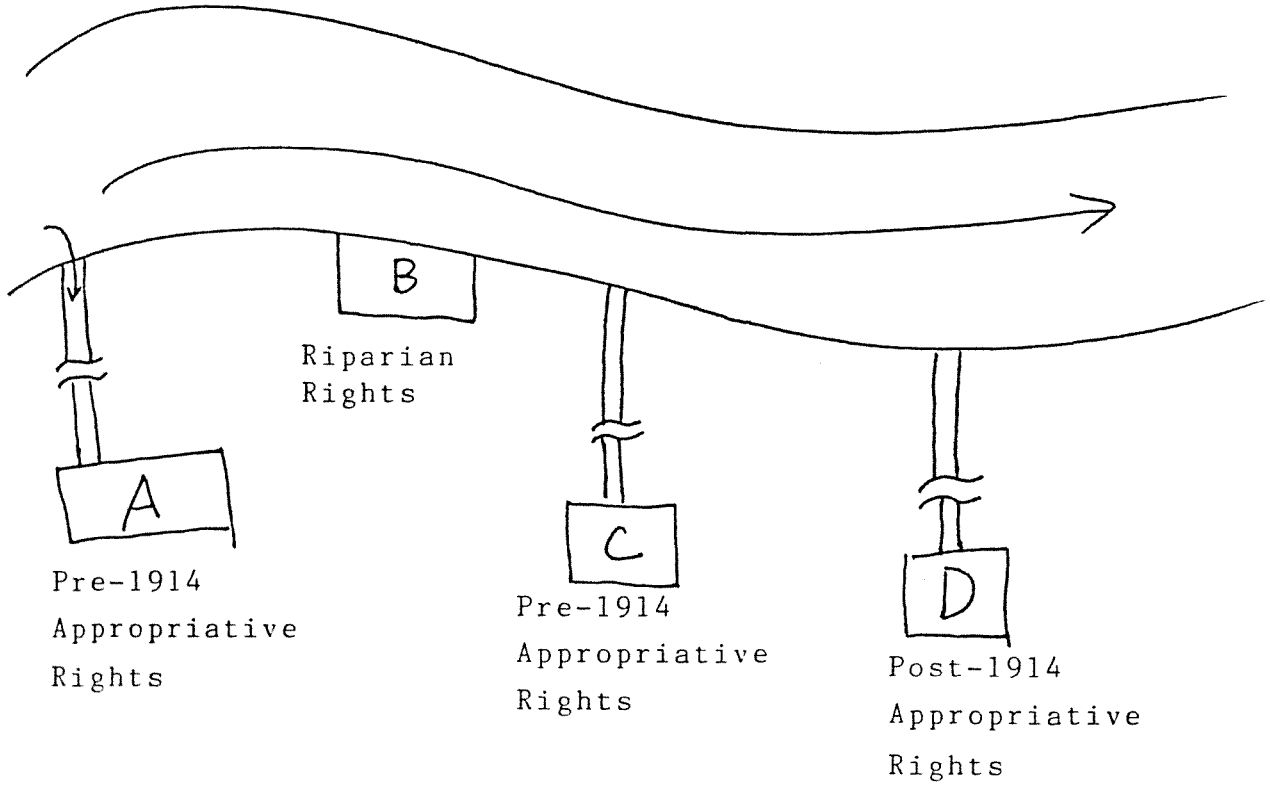

B
Riparian
Rights
A
Pre-1914
Appropriative
Rights
C
Pre-1914
Appropriative
Rights
D
Post-1914
Appropriative
Rights

Fig 2

transfer their rights without selling their land. So, I think that the understanding about the transferability of the rights is confused and flexible. But according to transferability of the water captured by the rights, their opinions were coincident, i.e., the water is transferable.

Even if pre-1914 appropriative rights holders could transfer their rights or the water, those transfers may not occur so easily. The reasons are as follows;

a. To adjudicate the rights in court, the rights holders must incur high adjudication costs and the process may require considerable time.
b. After the rights holders had made a contract to transfer water, a dry year may occur and hurt them.
c. When the rights holders are going to transfer water, someone whom may be injured by the transfer may enture a lawsuit against the transfers. In order for person A to proceed with the transfer, the transferred water price must be higher than the water transportation costs plus expected court costs. If the price is so high, the transferees may not want to buy the water.

d. Even though person A transfer some amount of water to person D, person D may not be able to capture the amount. Because, as person B's and C's water rights are not quantified, they may capture the amount of water like free riders.

(2.3) Post-1914 Appropriative Rights

The main features of post-1914 appropriative rights are as follows;

1. The S.W.R.C.B. has jurisdiction over the rights.
2. Post-1914 appropriative rights are quantified. Even so, the rights were, until 1969, recorded only as to flow rate and seasonal restrictions but not total quantities. Moreover, return flows are not quantified.
3. According to transferability of post-1914 appropriative rights and the water captured by the rights, my understanding is that the rights holders can transfer their rights or the water if they could obtain approval of the transfer from the S.W.R.C.B.

Even so, because of imperfect quantification of the rights, non-quantification of return flows and the high priority of the S.W.R.C.B. to avoid any trouble by the transfer, it appears that the

mere possibility of a third party who may be injured by the transfer may be sufficient to disallow the transfer.

I also asked some S.W.R.C.B. and D.W.R. water specialist about the transferability of post-1914 appropriative rights. One said that post-1914 appropriative rights holders can transfer their rights without selling their land, but the others said that water rights are attached to land, therefore post-1914 appropriative rights holders can't transfer their rights without selling their land. So, I think that the understanding of the transferability of the rights is confused and flexible. But, about transferability of the water captured by the rights, their opinions were coincident, i.e., the water is transferable.

4. A right which has not been used for five years must be forfeited. But, when an appropriator transfer the unused right or the water captured by the right, it is interpreted that the right is no more an unused right.

Even though the rights and the water are transferable and the policy of forfeit of the rights unused for five years push appropriators to transfer

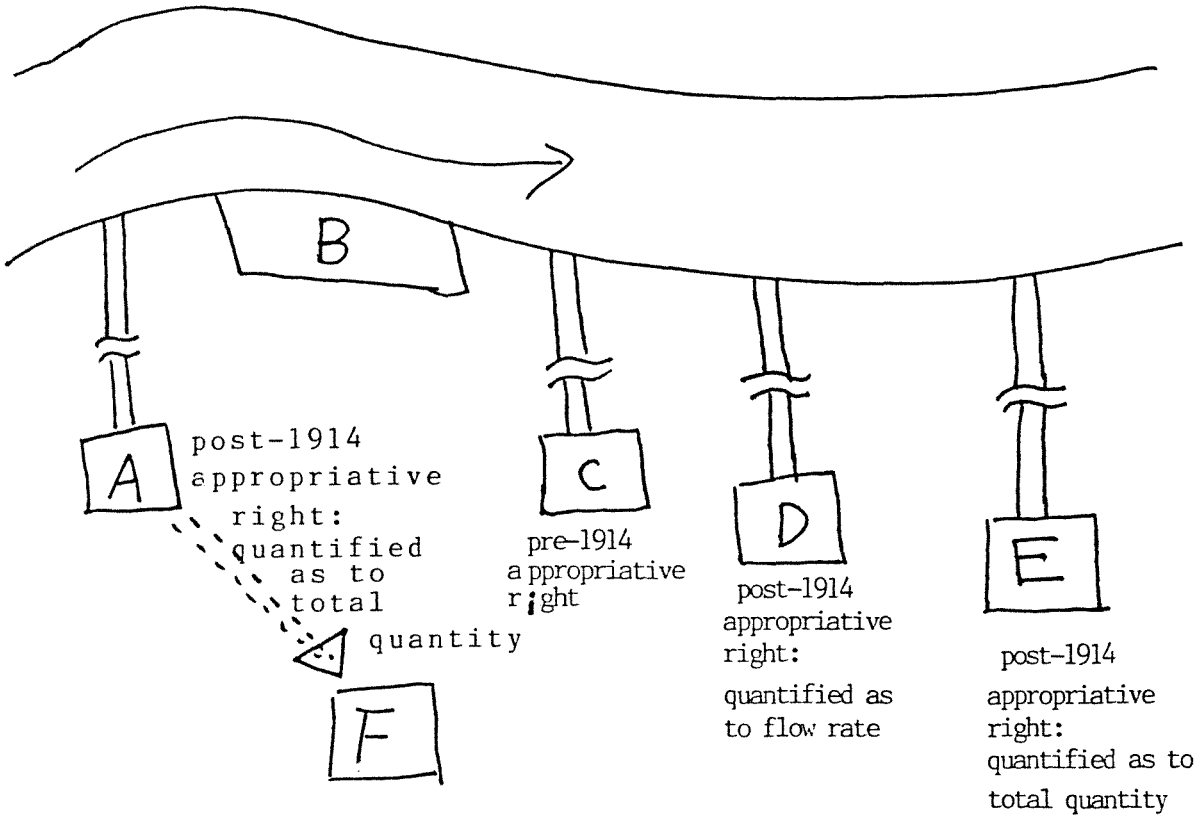

B
A
post-1914 appropriative right: quantified as to total quantity
F
C
pre-1914 appropriative right
D
post-1914 appropriative right: quantified as to flow rate
E
post-1914 appropriative right: quantified as to total quantity

Fig 3

their rights and the water, those transfers may not occur easily. The reasons are as follows;

a. Generally speaking, the S.W.R.C.B. does not allow the transfer of the rights or the water from person A to person F if the transfer may injure downstream water users.

The transfer from person A to person E is the most likely for the S.W.R.C.B. to allow. But in this case, even though person A transfer some amount of water to person E, person E may not be able to capture the amount. Because, as person B's and C's water rights are not quantified and person D's right is quantified as to flow rate, they capture the amount of water like free riders.

b. After person A had made a contract to transfer water, a dry year may occur and hurt him.

(2.4) Groundwater Rights

The main features of groundwater rights are as follows;

1. Groundwater rights are associated with ownership of the land overlying a groundwater basin and constrained only by the doctrine of correlative rights which establishes an obligation to share

water from a common groundwater basin.

Therefore, the rights are not quantified and not transferable without selling the overlying land. groundwater rights holders are not allowed to transfer groundwater to non-overlying land owners.

2. Unexercised groundwater rights are not lost by prior and inconsistent use of water by neighboring landowners. But, the State Supreme Court has held that those rights can be lost through prescription to a prior user who consistently utilizes the water in an overdrafted basin.
3. Groundwater may be "appropriated" for off-site uses only if the needs of overlying users have been met first.

Due to the features mentioned above, overdraft problems known as the "tragedy of the commons" are caused.

a. From feature No.2, to avoid loss of rights by prescription, overlying landowners seek to maximize their uses.
b. From features No.1 and No.3, groundwater is subject to both correlative and appropriative rights. Anyone who takes more than his correlative share

or who pumps non-surplus water for his appropriative right may succeed in establishing a prescriptive right to the additional water. This possibility may encourage widespred pumping of groundwater until the overdraft on some supplies force competitors into court to clarify their conflicting claims. But court costs are very expensive. Then, groundwater users may not want to go to court and may still continue overdrafting until the groundwater basin is severely damaged.

3. Federal Water Projects

(3.1) Water Tolls

Water tolls are as follows;

1. Water tolls have been determined by "ability to pay rule". But generally speaking, the U.S.B.R. has set water tolls equal to 75 percent of the estimated ability to pay. Once the tolls are determined by contracts, those will be constant with no inflation and with no interest for 40 years. Therefore, the tolls are so cheap and do not reflect the opportunity cost of the water. This causes over-utilization of water.

2. Water tolls consist of three kinds of payments, i.e., a fixed payment covering construction costs which is determined on a basis of contractual water quantity, a fixed payment covering facilities maintenance costs which is determined on a basis of contractual water quantity, and a variable payment covering water transporting costs which is determined on a basis of the water quantity actually used.

(3.2) Water Transfer

1. Federal water projects must be done under the permission of water rights use by the S.W.R.C.B. Therefore, to transfer water, the permission by the S.W.R.C.B. is necessary. But, transfers among a federal water project's contractors can occur without filing with the board as long as:
   a. The points of diversion and places of use under the permit do not change.
   b. There is no third party injury
   c. The water is put to beneficial use.
2. Transfers among contractors are usually easily accomplished once the U.S.B.R. approval is granted. But, the federal policy requires that the transfers approved incur both transportation costs and administration costs.

3. If an agency external to the F.W.P. is interested in federal water, the U.S.B.R. would prefere to deal with it directly rather than through a contractor. But to transfer water to the outside, surplus water must exist in the project and it must be surplus to other federal contractor needs. This is a permanent transfer which the Bureau encourage and approve.

Transfers are possible, as I mentioned above, but they may not occur. The reasons are;

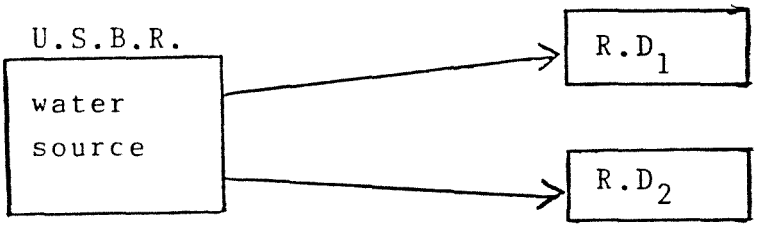
a. The S.W.R.C.B. may not allow a transfer because of the possibility of injury to third parties.
b. The risk of a dry year occurring after the transfers.
c. There is no possibility for contractors who transfer water to be able to make any profit.

I will show an example of the difficulty of a transfer among contractors. For the simplicity, I will make some assumptions.

ASSUMPTIONS

1. There are only two contractors. One is $R.D_1$ and the other is $R.D_2$. $R.D_i$ is i th reclamation district.
2. $R.D_1$'s and $R.D_2$'s distance from the water source is the same. Therefore, payment as water trans-

portation costs per unit quantity is the same for both of them.



3. P_t : payment covering water transportation costs per unit quantity

   Q_i : i th contractor's contractual water quantity

4. $R.D_1$ has the possibility to be a transferor.

   $R.D_2$ has the possibility to be a transferee.

These situations are shown in Fig. 4.

Under the water pricing policy by the U.S.B.R, $R.D_1$'s water use quantity will be Q^*, leaving unused water of the amount $(Q_1 - Q^*)$. On the other hand, $R.D_2$ will use all of his contractual water quantity(Q_2), and will want to use more water. This is because, when $R.D_2$ buys additional water, $R.D_2$ can buy it at the price(P_t) which is just water transportation costs. However, $R.D_1$ has no incentive to transfer his unused water, for these reasons;

1. $R.D_1$ can't make any profit by transferring his unused water.
2. $R.D_1$ may consider risks which a dry year occur after he has transferred the unused water and hurt him.

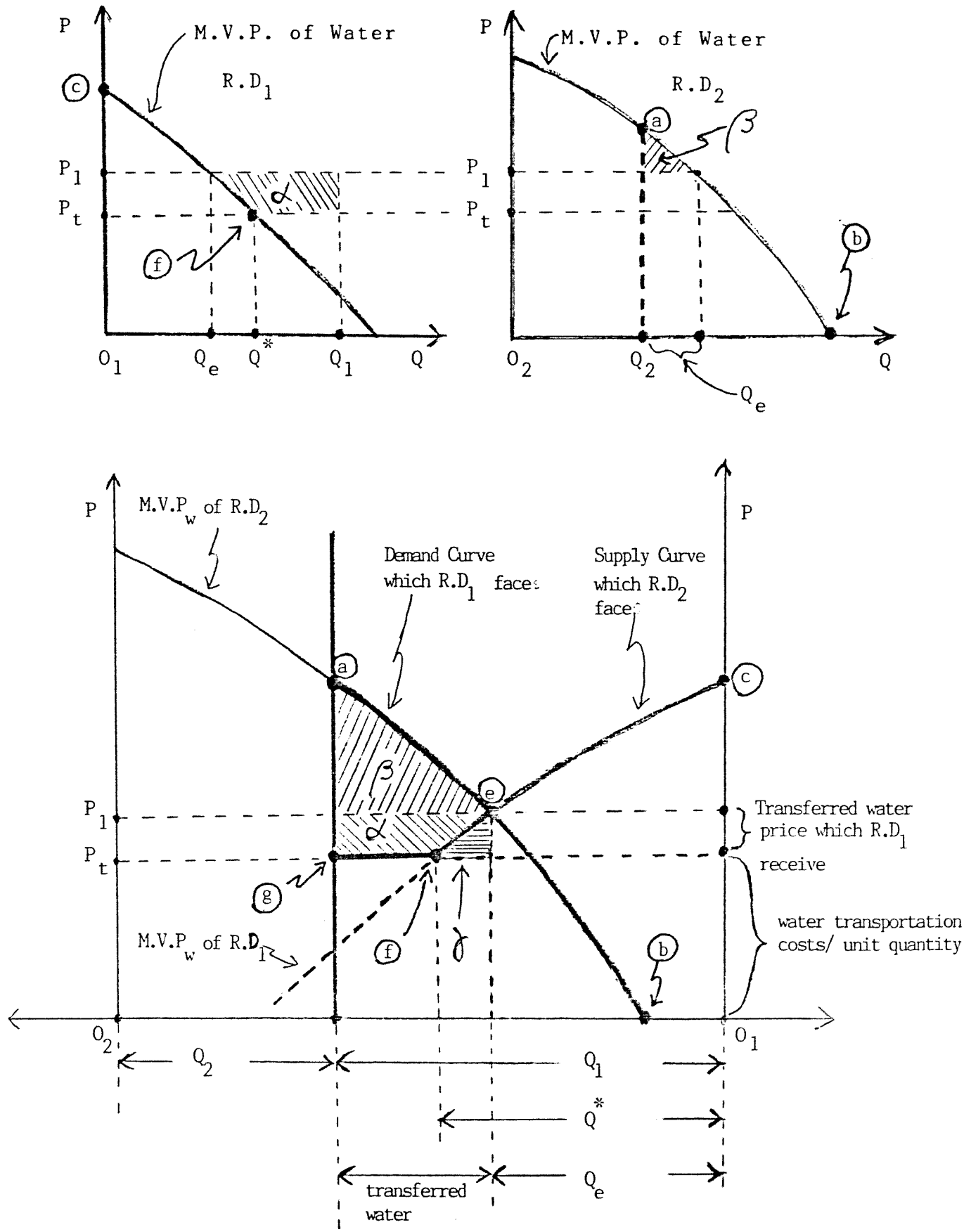

P
M.V.P. of Water
R.D1
c
P1
Pt
f
α
O1
Qe
Q*
Q1
Q
P
M.V.P. of Water
R.D2
a
β
P1
Pt
b
O2
Q2
Qe
Q
P
M.V.Pw of R.D2
Demand Curve
which R.D1 faces
Supply Curve
which R.D2
faces
a
c
e
β
α
P1
Pt
g
f
γ
b
M.V.Pw of R.D1
Transferred water
price which R.D1
receive
water transportation
costs/ unit quantity
O2
O1
Q2
Q1
Q*
Qe
transferred
water

Fig.4

(3.3) Strategies To Encourage Water Transfers

1) Permission To Make Profits Through Water Transfers

I discuss what will happen if we allow that $R.D_1$ and $R.D_2$ can negotiate the price of transferred water without any intervention by the U.S.B.R. In this case, I assume that $R.D_1$ and $R.D_2$ have no monopolistic and monopsonistic power, i.e., $R.D_1$ behaves like an atomistic competitive supplier and $R.D_2$ behaves like an atomistic competitive demander.

When $R.D_2$ buys water from $R.D_1$, the demand curve for the transferred water is the line(ⓐⓑ) shown in Fig.4. When $R.D_1$ transfers water, his supply curve is the line(Q_1Q^* ⓕⓒ) shown in Fig. 4. But the supply curve which $R.D_2$ faces is the line(ⓖⓕⓔⓒ) shown in Fig. 4. The equilibrium price and quantity of water transferred are determined as follows;

1. The price per unit quantity which $R.D_2$ pays to $R.D_1$ is $(P_1 - P_t)$
2. The water quantity which $R.D_1$ transfers to $R.D_2$ is $(Q_1 - Q_e)$

Therefore, net increment of social economic surplus is equal to [the increment of $R.D_1$'s economic surplus (α) + the increment of $R.D_2$'s economic surplus(β)].

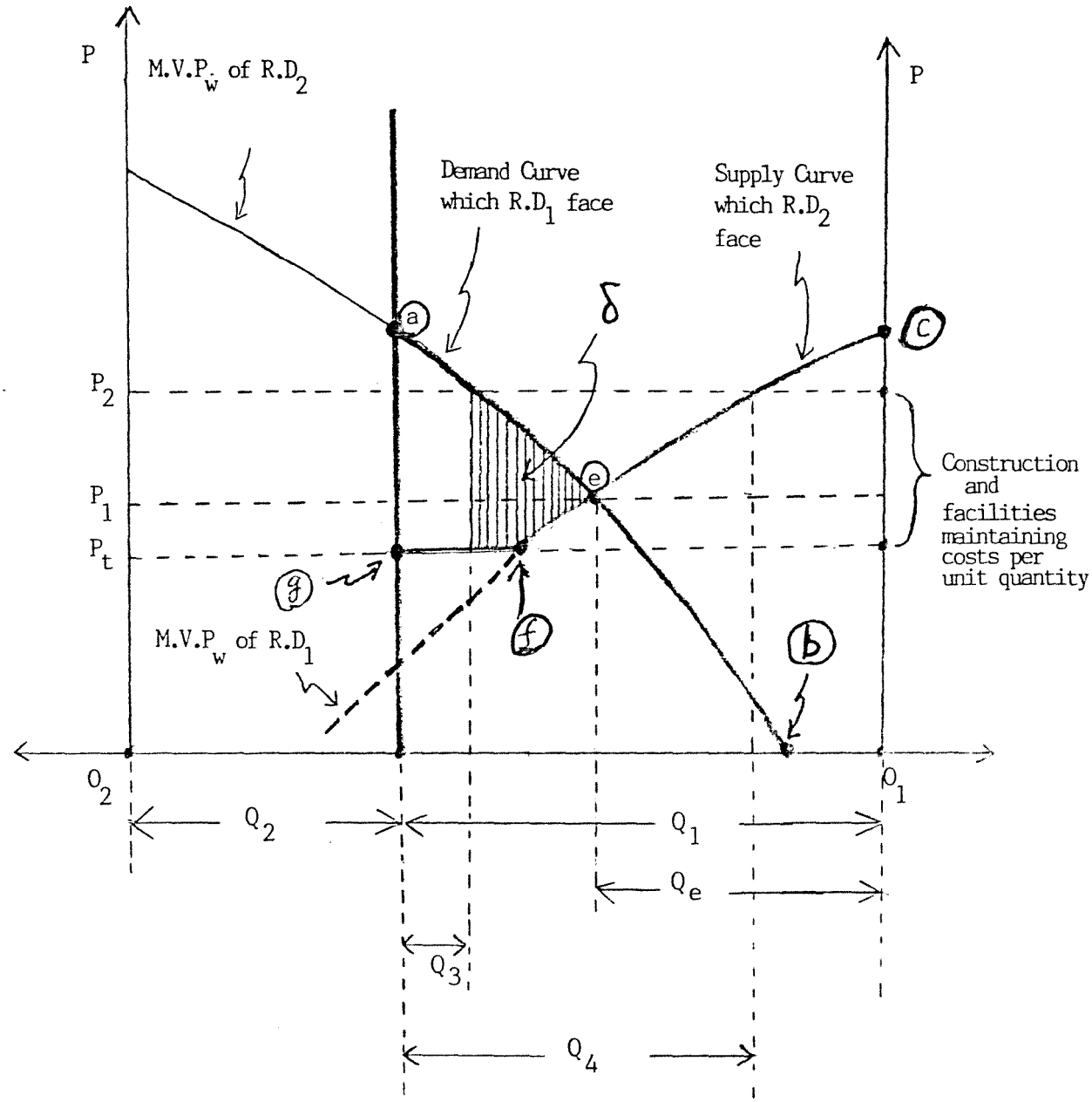

P
M.V.P$_w$ of R.D$_2$
Demand Curve which R.D$_1$ face
Supply Curve which R.D$_2$ face
P
δ
a
c
P$_2$
P$_1$
P$_t$
e
Construction and facilities maintaining costs per unit quantity
g
f
M.V.P$_w$ of R.D$_1$
b
O$_2$
O$_1$
Q$_2$
Q$_1$
Q$_e$
Q$_3$
Q$_4$

Fig. 5

But, when we compare this social economic surplus to that in the situation which in the first stage we could allocate Q_e to $R.D_1$ and $Q_2 + (Q_1 - Q_e)$ to $R.D_2$, we know the former case's social economic surplus is smaller than that of the latter's and the difference between them is δ shown in Fig.4.

Under the current water pricing policy by the U.S.B.R., as I explained before, each contractor's construction and facilities maintenance costs are determined on a basis of each contractor's contractual water quantity. Therefore, even if $R.D_1$ transfers some amount of water to $R.D_2$, $R.D_1$ still must pay the same amount of construction and facilities maintenance costs as that of before the transfer. Then we may think that it is a good policy to determine $R.D_1$'s or $R.D_2$'s construction and facilities maintenance costs on a basis of each one's actually used water quantity when $R.D_1$ transfer water to $R.D_2$. That is to say, when $R.D_1$ transfers some amount of water to $R.D_2$, as the substitution for $R.D_1$, $R.D_2$ must pay some amount of $R.D_1$'s construction and facilities maintenance costs on a basis of the water quantity which $R.D_2$ obtains by the transfer. But this policy is not socially

efficient compared to the free water trade policy just explained. In Fig. 5, the notations which are the same as those in Fig.4 have the same economic meanings. $(P_2 - P_t)$ means construction and facilities maintenance costs per unit quantity which $R.D_2$ must pay associated with the transferred water as the substitution for $R.D_1$. When we introduce this policy, $R.D_1$ will try to sell Q_4 but $R.D_2$ will try to buy Q_3. Then $R.D_1$ can sell only Q_3. As the result, when we compare the social economic surplus gained by this policy to that of free water trade just before explained, the former is smaller than the latter, and the difference between them is δ .

2) Introduction of Insurance Policies For Dry Years

In the former case 1), I analyzed the economic effects of a water transfer among contractors supposing that weather conditions are stable and normal. But in the real world, there are some risks of dry years. Therefore, if there is no dry year's insurance policy and water transfer contracts' legal grounds are uncertain, transferors may overestimate the damages from dry years. In other words, under the situations which transferors can't anticipate the dry years' impacts on their economic situations with certainty, they may have risk adverse than that with certainty. As the result,

Table 1

Types of water transfer contracts	Types of Insurance Policies	Types of Risk Sharing
Non-cancelable Contract	A transferor and a transferee collaborately share the transferor's Expected Dry Year Income Damage(E.D.I.D.)	Share risks through sharing dry year income damages
	A transferor and a transferee collaborately share the transferor's crop insurance costs which can cover the E.D.I.D. .	Share risks through dry year insurance costs
	Once a dry year occurs , a transferor can set the special water price which is higher than the contract's water price determined on a normal year basis	Share risks through setting the dry year special price
Partially-cancelable contract	Once a dry year occurs , a transferor and a transferee collaborately share the ex-ante contracted transferring water quantity	Share risks through sharing water
Perfectly-cancelable contract	A transferee can negotiate with a transferor for a water price which can be cheaper than a normal year basis water price to cover some percentage of the transferee's dry year risks	Share risks through negotiating for a water price

water transfers among contractors may not occur or may occur at a lower level than that the most socially desirable.

I will now discuss how to solve these uncertainties. The first thing to do is to classify types of water transfer contracts. The second thing to do is to prepare dry years' insurance policies. These things are shown in Table 1.

We can classify water transfer contracts to three types, i.e., (1) Non-cancelable contracts (2) Partially- cancelable contracts (3) Perfectly-cancelable contracts.

A non-cancelable contract means that even if a dry year occurs, a transferor must transfer the water quantity for which the transferor had made the contract.

A parcially-cancelable contract means that if a dry year occurs, a transferor can decrease some percentage of the transferred water quantity for which the transferor had made the contract. The percentage shall be determined when the contract is made.

A perfectly-cancelable contract means that if a dry year occurs, a transferor immediately can stop the transfer of water.

A non-cancelable contract is so risky for

a transferor in a dry year, that it is necessary to insure the transferor in case of a dry year. If not done, nobody may want to transfer water. In the non-cancelable contract's case, I introduce three kinds of insurance policies.

[Policy 1]

In the first stage, a transferor and a transferee collaborately estimate the transferor's expected dry year's income damage(E.D.I.D.) on the basis of that the transferor may not be damaged if he does not transfer the water.

In the second stage, the transferor and the transferee negotiate how much of the E.D.I.D. they will each assume. After that, they deposit that amount for a dry year.

[Policy 2]

In the first stage, a transferor and a transferee estimate the transferor's E.D.I.D.

In the second stage, the transferor buys crop insurance which can cover dry years damages.

In the third stage, they negotiate how much of the insurance costs they will each assume.

[Policy 3]

Once a dry year occurs, a transferor can set the special water price which is higher than the

contract's water price determined on a normal year basis. When they make a normal year basis water transfer contract, in case of dry year damages, they negotiate for the dry year special water price level.

In the case of a partially-cancelable contract, a transferor and a transferee negotiate for how much percentage of the contracted transfer water the transferor can cut in the case of a dry year.

In the case of a perfectly-cancelable contract, this contract is risky for a transferee in case of a dry year. Therefore, in the first stage, a transferor and a transferee determine the quantity of transferred water and the price of the water on the basis of normal weather conditions. In the second stage, the transferee can negotiate with the transferor for a water price which can be cheaper than the normal year basis price to cover some percentage of the transferee's dry year risks.

When we use these policies, in the first stage, through negotiation, a transferor and a

transferee choose which insurance policy they want to use. The insurance policy with the lowest transaction costs will be chosen. When they make a contract, a bilateral contract will be desirable.

4. State Water Projects

(4.1) Water Tolls

Water tolls are as follows;

1. Water tolls have been determined by full costs basis.
2. Water tolls consist of three kinds of payments,
   (a) A fixed payment covering construction costs which is determined on a basis of contractual water quantity,
   (b) A fixed payment covering facilities maintenance costs which is determined on a basis of contractual water quantity,
   (c) A variable payment covering water transportation costs which is determined in some cases on a basis of contractual water quantity, and in other cases on a basis of the water quantity actually used.

(4.2) Water Transfer

1. If the D.W.R. allows, water transfers among

contractors are possible without the S.W.R.C.B's allowance.

2. Some contractors who want to buy water from other contractors must have used up their original contractual water quantity. If not so, they are not allowed to buy water from other contractors. When they buy the additional water, they can buy it by paying only its transportation costs.

As above mentioned, the water pricing policy of the S.W.P. is quite similar to that of the F.W.P. though the water tolls of the S.W.P. are higher than those of the F.W.P. Therefore, transfers among the S.W.P. contractors are possible, but they may not occur by the same reasons as those in the F.W.P. Hence, the strategies explained in section 3 are available to encourage water transfers among contractors.

5. Irrigation Districts

(5.1) Organizational Features

1. An irrigation district(for short, I.D.) is a co-operative non-profit organization. But an I.D. can impose charges or taxes on it's membership or on land within it's jurisdiction.

2. An I.D. is governed by a board of directors elected by voting who usually represent large water users. The directors are primarily concerned with expanding future water supplies from outside sources and avoiding interference from outsiders in their allocation decisions. Therefore, they don't have any incentive to transfer water to the outside.
3. A board of directors hires water managers. Most managers are engineers whose principal goal is to maximize the supply of water at the lowest possible average cost. They don't have any incentive to save water or to transfer the water to the outside. This is because even though the I.D. transfers water and earn some revenue, their salaries are not determined on water transfer revenues.

(5.2) Water Tolls

Water tolls consist of three kinds of payments;

1. A water toll or "user charge". This is determined on a per unit water quantity basis.
2. A general service charge. This is determined on a per acre basis. That is to say, this is a fixed cost not related to the amount of water delivered.
3. Land taxes. These are determined on a per acre basis, not related to the amount of water delivered.

These components of water prices vary tremendously among districts.

(5.3) Water Transfers

By the Irrigation District Law, irrigation districts can transfer their water legally but they are not allowed to transfer their water rights. Water transfers are limited to "surplus water".

(5.4) Water Pricing Policies And Water Transfers

Water transfers are legally possible but each I.D's members' incentives for water transfers will be effected by it's water pricing policies. I will analyze the effects of I.D's water pricing policies on it's water transfers.

[Water Pricing Policy 1]

For simplicity, I will make some assumptions.

ASSUMPTIONS

(1) The water price per unit quantity to members is determined on an average costs basis and the board of directors' goal is to deliver all of the entitlement water to the members at the lowest average cost.

(2) The board of directors determines the sizes of water delivery facilities as the average cost

becomes the lowest at the entitlement water quantity ($\bar{Q}$). In Fig. 6, $\bar{Q}$ means the I.D's entitlement water quantity.

(3) Each member's water payment is charged by the water quantity which is actually used.

(4) When the I.D. sells water to the outside, the board of directors deal with it directly rather than through a member.

(5) The water selling revenue is used for decreasing the water price to members.

(6) Each member behaves like a competitive demander when they buy water from the I.D. Therefore, they perceive that the water price to members is given and do not know the I.D's water delivery cost function. Here, the cost function consists of ⓐ water facilities construction costs(i.e., fixed costs), ⓑ water facilities maintenance costs(i.e., fixed costs), ⓒ water transportation costs(for example,pumping energy cost,etc., i.e., variable costs)

(7) Each member's entitlement water quantity is determined by the board of directors.

If the members' aggregate demand curve($=\sum_{i=1}^{n}$ i th member's marginal value product curve of water) is D_2, all of the entitlement water ($\bar{Q}$) is delivered

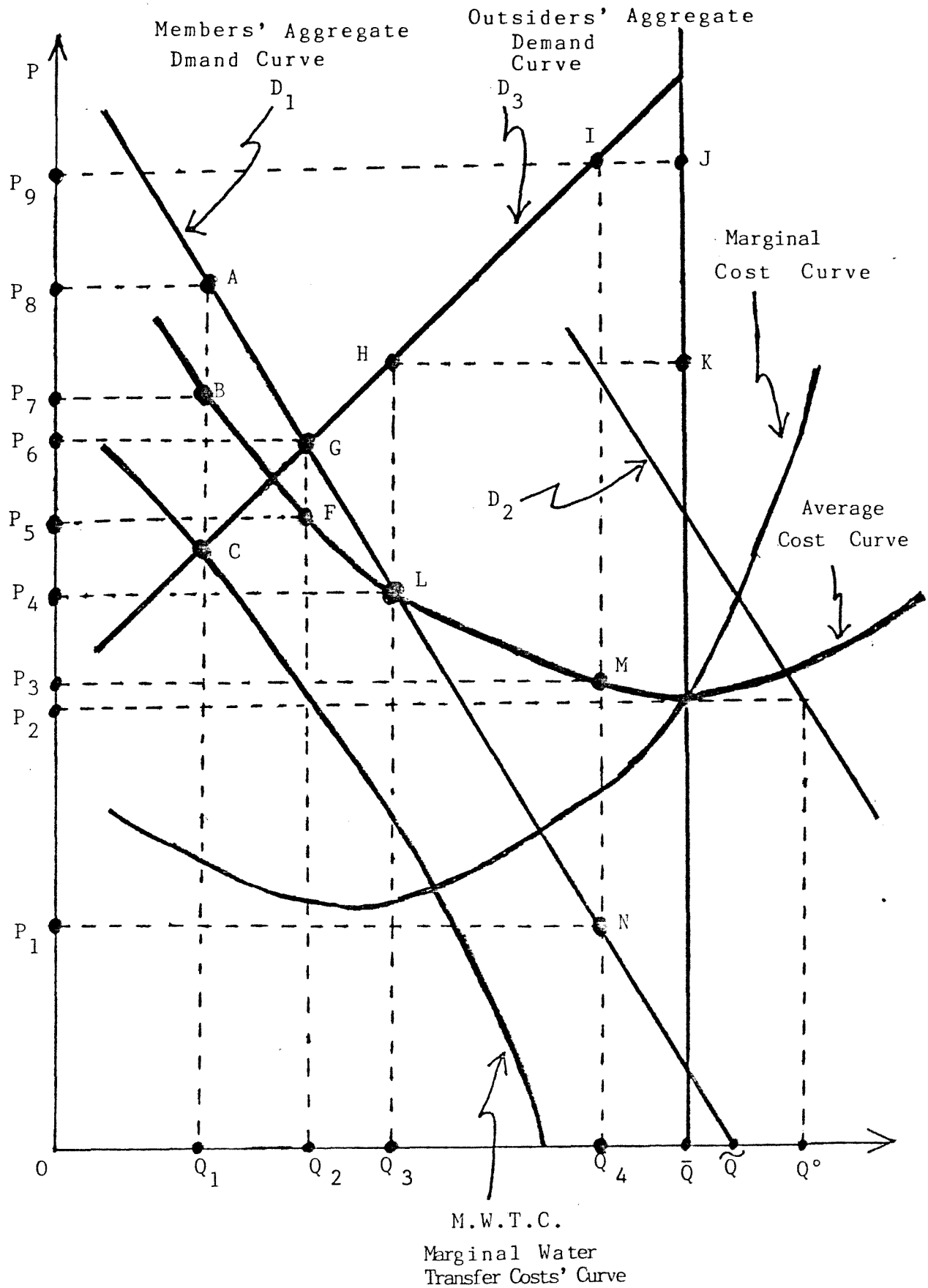

Members' Aggregate Dmand Curve
Outsiders' Aggregate Demand Curve
Marginal Cost Curve
Average Cost Curve
P
D1
D3
D2
P9
P8
P7
P6
P5
P4
P3
P2
P1
A
B
C
F
G
H
I
J
K
L
M
N
0
Q1
Q2
Q3
Q4
Q̄
Q̃
Q°
M.W.T.C.
Marginal Water Transfer Costs' Curve

Fig. 6

to members at the price P_2. Therefore, no unused surplus water exists but the excess demand ($Q^{\circ} - \bar{Q}$) exist.

If the members' aggregate demand curve is D_1, Q_3 of water is delivered to members at the price P_4. As the result, unused surplus water($\bar{Q} - Q_3$) exist. In this situation, when the I.D. sells the unused water to the outsiders and the water selling revenue is used for decreasing the water price to members because of the feature of an I.D's non-profit organization, what will happen ? As the unused water selling revenue , the I.D. can receive the revenue(Area $Q_3\bar{Q}KH$). After that, if this revenue is used for decreasing the water price to members, the water quantity which is used by members will increase over Q_3. Then, the unused water will decrease, so that the water selling revenue will decrease. As the result, the water price will increase again and so on. Through these adjustments, the final equibrium water use will be achieved so that the water selling revenue(Area $Q_4\bar{Q}JI$) becomes equal to the payment(Area P_3P_1NM) to subsidize water delivery costs. That is, the water price to members will be P_1 and the I.D's total water use will be Q_4 . As the result, unused water surplus decrease from ($\bar{Q} - Q_3$) to ($\bar{Q} - Q_4$), or namely the

I.D. comes to sell water of the amount($\bar{Q} - Q_4$).

This pricing policy has another demerit. All members can capture economic benefits of the water transfer through the decrease of water price even though some members might not contribute to the transfer. Therefore, the members who contributed to the transfer may lose their incentives to transfer water.

[Water Pricing Policy 2]

For simplicity, I will make some assumptions.

ASSUMPTIONS

(1) The same as (1) of [Water Pricing Policy 1].

(2) The same as (2) of [Water Pricing Policy 1].

(3) The same as (3) of [Water Pricing Policy 1].

(4) The same as (4) of [Water Pricing Policy 1].

(5) When the I.D. sells water to the outside, the board of directors allocates the water selling revenue to each member on a basis of each member's contribution to the water transfer. Each member behaves like a price taker when they receive their water selling revenue from the board of directors.

(6) The same as (6) of [Water Pricing Policy 1].

(7) The same as (7) of [Water Pricing Policy 1].

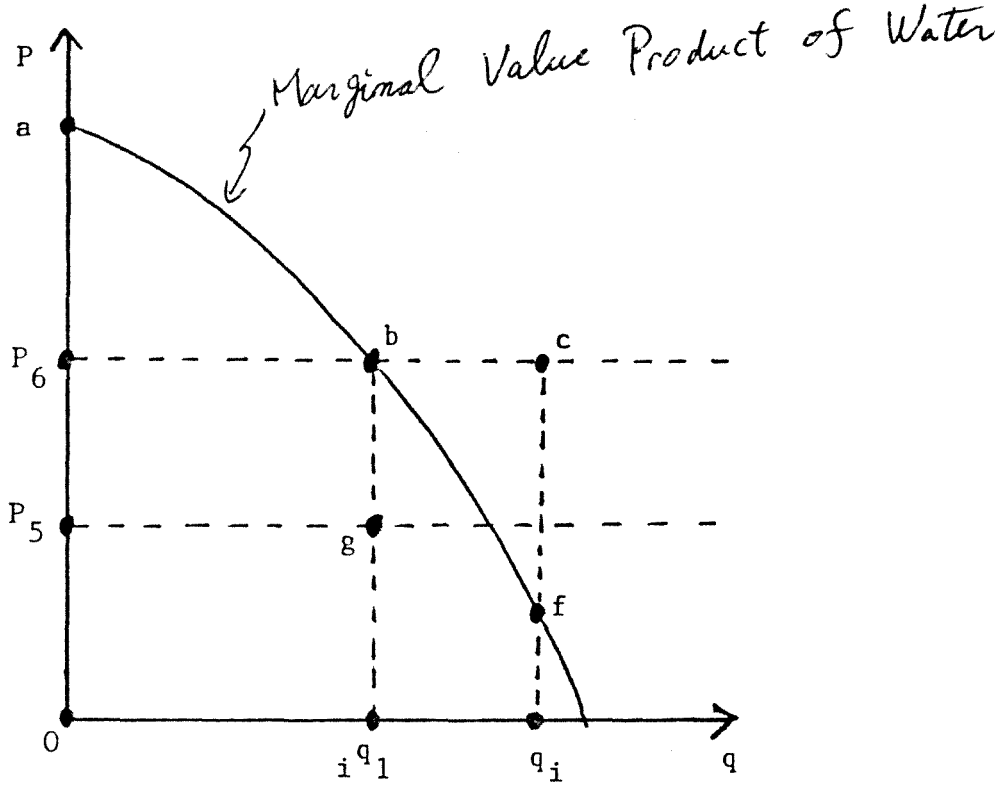


Fig. 7

I will analyze this case on the premise that the members' aggregate demand curve is D_1 in Fig.6. When the I.D. sells water to the outside, the amount of transferred water will be determined proceeding along the members' aggregate demand curve(D_1)[= the members' aggregate marginal value product curve of water]. Hence, the amount of transferred water will be $(\bar{Q} - Q_2)$ and the amount of water which is used by the members will be Q_2. As the result, the water delivery price will be P_5 , and the water price per unit quantity which each member receives depending on their contribution to the transfer will be P_6 .

i th member's subjective equilibrium situation associated with the water transfer is shown in Fig. 7. In the figure, the notations which are the same as those in Fig 6 have the same economic meanings, and q_i is the i th member's entitlement water quantity. i th member will sell the amount of water($q_i - {}_iq_1$) and will use the amount of water(${}_iq_1$). $\bar{Q}$ should be equal to $\sum_{i=1}^{n} q_i$ and Q_2 should be equal to $\sum_{i=1}^{n} {}_iq_1$. i th member's economic surplus on his subjective equilibrium is,

[Gross Products Selling Revenue(Area $ab_i q_1 O$) - The expense of Water Purchase from the I.D(Area $P_5 g\ _i q_1 O$] + [Gross Water Selling Revenue(Area $bcq_i\ _i q_1$) - Decrease of Products' Selling Revenue Caused by the Water Selling(Area $bfq_i\ _i q_1$)]
= (Area $abgP_5$) + (Area bcf)

[Water Pricing Policy 3]

For simplicity, I will make some assumptions.

ASSUMPTIONS

(1) The water charge to members is determined on a per acre basis unrelated to the amount of water.

(2) The same as (2) of [Water Pricing Policy 1].

(3) The same as (4) of [Water Pricing Policy 1]

(4) The same as (5) of [Water Pricing Policy 2]

(5) The same as (7) of [Water Pricing Policy 1]

I will analyse this case on the premise that the members' aggregate demand curve is D_1 in Fig. 6. When water transfers are prohibited, the I.D. uses all of the entitlement water($\bar{Q}$). But when water transfers are allowed and when water selling revenues are allocated to each member depending on their contribution to the transfer, the amount of transferred water will be determined

proceeding along the members' aggregate demand curve(D_1)[= the members' aggregate marginal value product curve of water]. Hence, the amount of transferred water will be ($\bar{Q} - Q_2$) and the amount of water which is used by the members will be Q_2 . The water price per unit quantity which each member receives depending on their contribution to the transfer will be P_6 .

[Water Pricing Policy 4]

Determine the water quantity of the transfer so that the marginal water transfer cost becomes equal to the outside demanders' marginal value product of water(= outsiders' aggregate demand curve).

I will define "Marginal Water Transfer Cost (M.W.T.C.)" as follows;

M.W.T.C. = Marginal Decrease of Products' Selling Revenues caused by Marginal Water Transfer(ΔQ) - Marginal Decrease of Water Delivery Cost caused by Marginal Water transfer(ΔQ)

I will analyse this case on the premise that the members' aggregate demand curve is D_1 in Fig. 6 . The amount of transferred water will be ($\bar{Q} - Q_1$), and this policy can achieve the most

socially efficient water transfer. However, in accomplishing this policy, there are some difficulties.

(a) To transfer the amount of water($\bar{Q} - Q_1$), the I.D. must set the water delivery price to members at P_8 . Then, the water quantity used by members will be Q_1 . In this case, through the water delivery to the members of the amount(Q_1), the profit(Area P_8 P_7 B A) will come to exist within the I.D. But , as the I.D. is a non-profit organization, the profit must be re-allocated to the members.

How to re-allocate the profit is a very difficult problem. If the profit was used to decrease the water price to members, the water quantity used by members will be over Q_1. Then the I.D. can't sell the amount of water ($\bar{Q} - Q_1$).

To which members and how much the profit should be re-allocated is a difficult problem. Should the profit be re-allocated to the members who contribute to the transfer ? And so on.

(b) How can the I.D. know the M.W.T.C. ?

By the reasons of above mentioned difficult problems,

to accomplish this policy is very difficult.

Through the analyses of above mentioned four cases, we know,

$T.W.Q_4 > T.W.Q_2 = T.W.Q_3 > T.W.Q_1$

Here, $T.W.Q_i$ is the Transferred Water Quantity by i th Water Pricing Policy. Therefore, I conclude that, the water pricing policy which is easily accomplished and efficient, although not the most efficient, is [Water Pricing Policy 2] or [Water Pricing Policy 3] . The both will bring the same economic benefit to the society through a water transfer.

6. Strategies Toward Establishing A Water Market

(6.1) Surface Water

To establish a water market, it's necessary to develop the following three strategies.

1. Quantification of Water Rights

If water rights are not quantified, we may have a problem originating in the legal uncertainty similar to that when an upper-stream water rights holder transfers water to a down-streamer, an intermediate down-streamer who owns non-quantified water rights may capture the transferred water. Because of this possibility, the upper-streamer may lose

the incentive to transfer water.

How can we encourage non-quantified water rights holders to quantify their water rights ? The policies to encourage the quantification are as follows;

(a) Reduction of The Quantification Costs

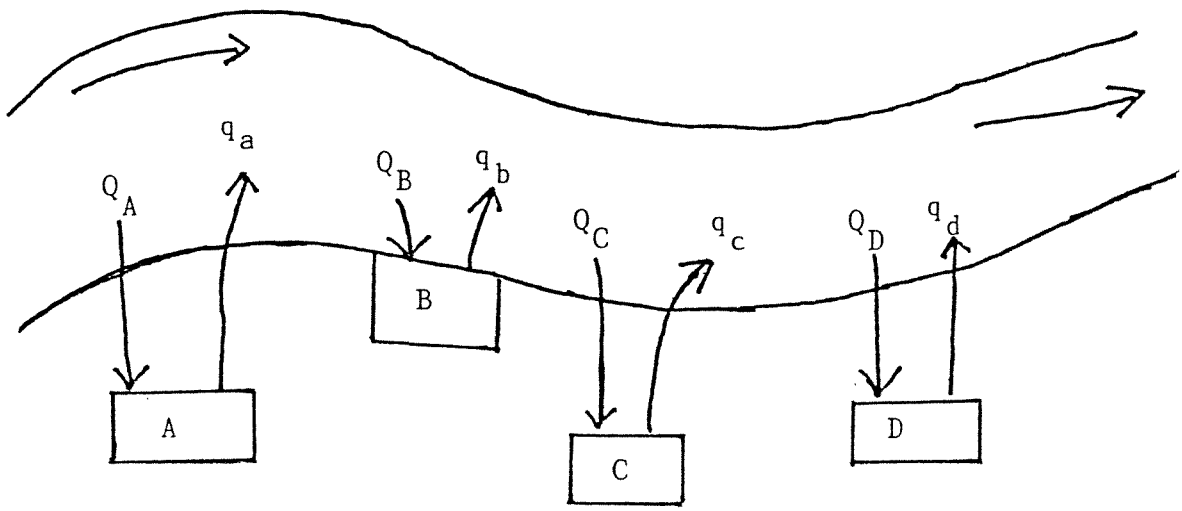
As the substitution for the non-quantified water rights holders who want to quantify their rights, the state agencies(for example, the S.W.R.C.B. or the D.W.R.) take formalities to quantify water rights. And when the holders apply to ask the agencies to quantify their water rights, the application formalities should be simplified. Through these, the quantification costs for the appricants will be decreased.

(b) The Legal Clarification of The Allowance of Making Profits Through Water Transfers

It should be legally clarified that after the non-quantified water rights' holders have quantified their rights, they are allowed to make profits through transfers of water or the rights.

2. Dry Year Insurance Policies

Even though water transfers are legally possible, if there is no dry year insurance policy,



E

Fig. 8

water rights holders may have no incentive to transfer water . Because, after they made contracts to transfer water, an extreme dry year may hurt them. Due to this risk, they prefer not to transfer water or even if they might transfer water, the amount of transferred water will be very small compared to the most socially desirable transfer of water. But, by introducing dry year insurance policies, the transfers will become possible.
I will show some dry year insurance policies.
In Fig. 8, Q_i is the i th person's water taking amount from the river, and q_i is i th person's returnflow.

[CASE 1]

(1) Transfer water from person(A) to Person(D).

(2) Q_A, Q_B, Q_C and Q_D are quantified.

(3) q_a, q_b, q_c and q_d are quantified.

In this case, the dry year insurance policies shown in Table 1 are available.

[CASE 2]

(1) Transfer water from person(A) to person(E).

(2) Q_A and Q_D are quantified.

(3) Q_B, Q_C, q_a, q_b, q_c and q_d are non-quantified.

Generally speaking, the S.W.R.C.B. doesn't allow this kind of water transfer because of the possibility of down-streamer injuries. Down-streamers (person(B) or person(C)) may oppose the transfer because of dry years' risks of the injuries by the transfer. When down-streamers oppose the transfer, from the stand point of the past worst dry year's damage, they will complain. Therefore, the possibility that the transfer is accepted without down-streamers' opposition is very low even though the probability of an extreme dry year occurring is very small. Or even if the transfer is accepted by down-streamers, the amount of transferred water will be much smaller than the most socially desirable amount in a normal year.

However, by introducing dry year insurance policies, the transfer will become possible.

Insurance Policy 1

In the first stage, person(A) and person(E) make a contract for the amount of water transfer and the price on a normal year basis. The amount should be determined as not to injure down-streamers on a normal year nasis.

Once a dry year occurs, person(A) must stop

the transfer in order not to injure down-streamers.

Insurance Policy 2

In the first stage, person(A) and person(E) make a contract for the amount of water transfer and the price on a normal year basis. The amount should be so determined as not to injure down-streamers on a normal year basis.

When a dry year occurs, down-streamers have the right to request person(A) and person(E) to cut some percentage of the amount of transferred water depending on the situation of the dry year.

[CASE 3]

(1) Transfer water from person(A) to person(E).

(2) Q_A, Q_B, Q_C and Q_D are quantified.

(3) q_a, q_b, q_c and q_d are quantified.

In this case, person(A) can transfer some percentage of the amount of water($Q_A - q_a$) to person(E). And person(A) and person(E) can use the insurance policies shown in Table 1.

When we quantify returnflows, it will be desirable for the society to define normal year basis returnflows and dry year returnflows separately. For example, it would be better to quantify person(A)'s returnflow in the case of a normal

year and in the case of a dry year separately. Here, $\hat{q}_a$ means the normal year's returnflow and q'_a means the dry year's returnflow ($\hat{q}_a > q'_a$). If we don't define person(A)'s returnflow separately, to averse dry year risks, person(A) will insist that his returnflow is q'_a in a normal year, too. If so, even in a normal year, for down-streamers, the available amount of the river flow will become smaller than that in not the case.

3. Interlink of Water Transfer Facilities

To establish a water market, there must exist enough physical water transportation facilities and those facilities must be available for any transferor and any transferee at any time. In the current situation, the Federal Water Projects', the State Water Projects' and individual water districts' water transportation facilities are not well interlinked. As this is the case, to establish a water market, i.e., to transfer any desired amount of water from any transferor to any transferee at any time, we may have to spend quite a lot of money for the construction of water transportation facilities. The investment costs may exceed the social benefits from water transfers.

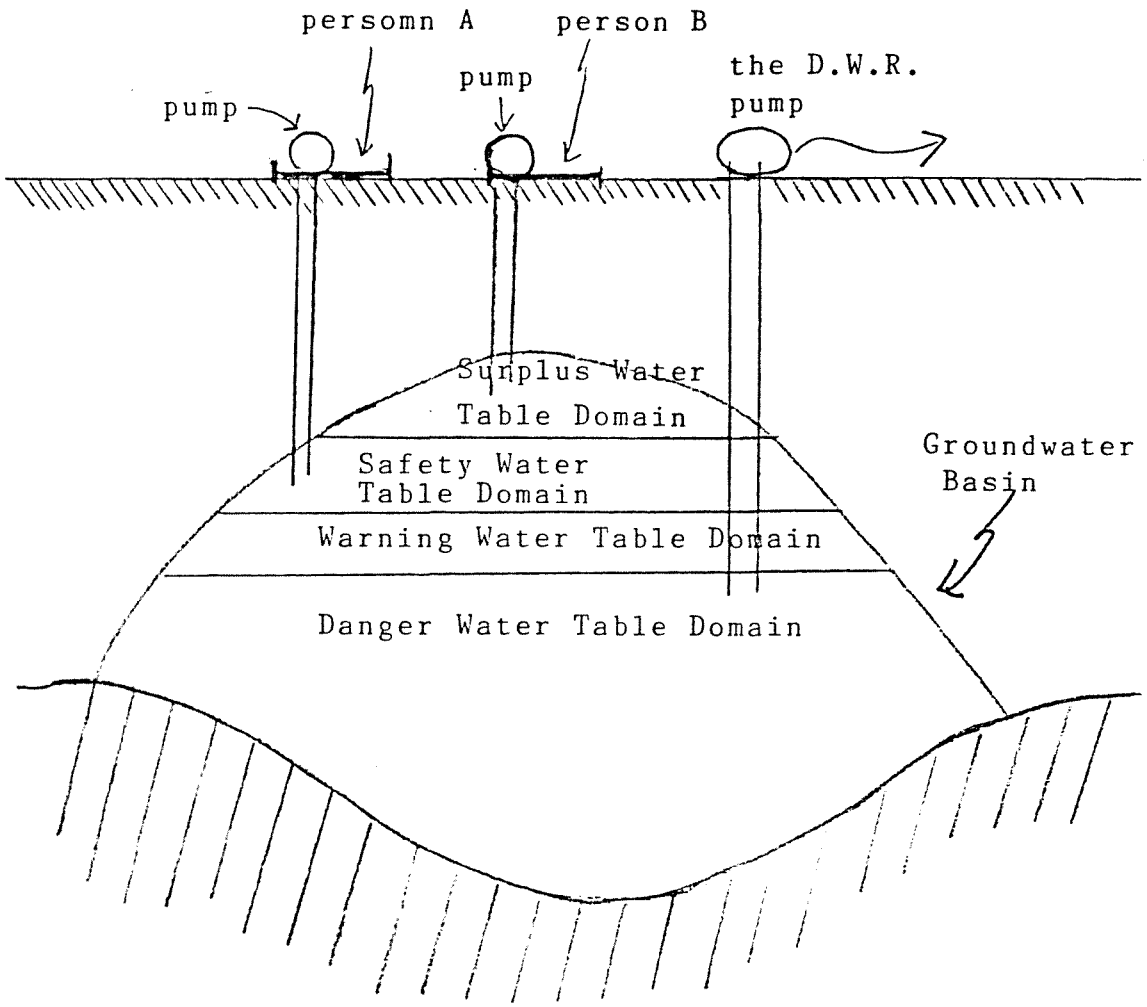

persomn A
person B
pump
pump
the D.W.R.
pump
Surplus Water
Table Domain
Safety Water
Table Domain
Warning Water Table Domain
Danger Water Table Domain
Groundwater
Basin

Fig.9

(6.2) Groundwater

In considering groundwater use, how to efficiently use groundwater without causing overdraft problems is the most important consideration. A Quantity Contrl Policy and a Price Control Policy are available for controlling groundwater.

1. Quantity Control

Groundwater rights are not quantified and to quantify the rights without the risk of overdrafting is very difficult. For example, in 1949 the State Supreme Court tried to quantify each groundwater user's rights based on each user's highest five years of pumping. But this device sent people scurrying to the pumphouse in an effort to establish their uses at as high an average as possible. As the result, overdrafting problems were accelerated.

Furthermore, the information costs of assuming how much of water quantity should be attached to each user's groundwater righ are quite high.

2. Price Control

We can control suitable groundwater use by charging a suitable price per unit quantity for groundwater, but the users are allowed to use

the water as much as they want. But every groundwater user must use watermeter to mesure the amount of water they use.

[CASE 1 of Price Control]

(1) Groundwater table is in the Surplus Groundwater Table Domain (see Fig. 9).

The landowners whose lands are overlying the groundwater basin are allowed to use water as much as they want without paying any price.

Nobody is allowed to transfer the groundwater to the users whose lands are not overlying the basin except for the D.W.R. The D.W.R. should construct pumping facilities and transfer the surplus water at the price per unit quantity which is equal to the pumping costs per unit quantity. But when a dry year occurs and the overlying landowners request to stop the transfer, the D.W.R. immediately should stop the transfer. For the buyers of the surplus water, this policy is risky in a dry year. But they can enjoy using the surplus water at a low price in a normal year.

[CASE 2 of Price Control]

(1) Groundwater table is in the Safety Groundwater Table Domain (see Fig. 9).

In a normal year, the landowners whose lands are overlying the basin are allowed to use water as much as they want without paying any price. The D.W.R. is allowed to transfer some percentage of the water within the Safety Domain to the users whose lands are not overlying the basin at the price per unit quantity which is equal to [the pumping costs + some profits(α)] per unit quantity. This profits(α) are used for buying the dry year recharging water. The transferees are allowed to negotiate with the D.W.R. according to α by considering the risk of the dry year's stop of water supply.

In a dry year, the transfer should be stopped immediately. As the overlying landowners' groundwater use increases, the groundwater table may reach to the Warning Domain. If the situation occurs, the D.W.R. charges the dry year apecial price per unit quantity for the groundwater use, but the users can use the water as much as they want. And the revenue from the charges is used for buying the recharging water. This method of special price charging has the following two results. One is to restrain the users' dry year water demand. Another is to secure revenue for buying the recharging water.

To secure the recharging water safely, it would be better that in advance of a dry year, the groundwater users whose lands are overlying the basin make a contract to buy water from other water rights holders in case of a dry year. When they make a contract, the dry year insurance policies shown in Table 1 are available.

[CASE 3 of Price Control]

(1) Groundwater table is in the Warning Groundwater Table Domain(see Fig. 9).

NO water transfer to the users whose lands are not overlying the basin is allowed.

In a normal year, the D.W.R. charges the normal year price per unit quantity for the groundwater use, but the landowners whose lands are overlying the basin can use as much as they want. This method of charging has two results. One is to reduce the demand for the groundwater in order to increase the groundwater table from the Warning Domain to the Safety Domain. Another is to secure revenue for buying the recharging water which contributes to increase the groundwater table.

In a dry year, the D.W.R. charges the dry year price per unit quantity which is higher than the normal year price for the groundwater use,

but the users can use the water as much as they want. This dry year price charging has two results. One is to restrain the users' dry year water demand increment. Because, in a dry year, the groundwater users may expect higher products' prices than those in a normal year. If so, the users' expected marginal value product curves of water will shift to the right. As the result, if the charging price was same as that in a normal year, the demand for the groundwater will increase. Another result is to secure revenue for buying the recharging water.

Same as the [CASE 2 of Price Control], to secure the recharging water safely, the dry year insurance policies shoen in Table 1 are available.

The merits of the Price Control Policy compared to the Quantity Control Policy are (1) Once we had quantified each overlying landowner's groundwater right, the quantity will be fixed to each of them forever even though in the future their technology levels may largely different from the current situations, (2) We can control groundwater more efficiently with less information costs.

7. Conclusion

Through microeconomic theoty and some analyses assuming the economic effects of the establishment of a water market, we know that the establishment will bring economic benefits to the society. But the fact which the society can get economic benefits through the establishment may not exactly guarantee that transferors or transferees will be able to receive some economic benefits. Previous to water transfers through a water market, if transferors or transferees could not expect their economic benefits and demerits, they will lose their incentives to transfer water. Especially, ex-ante estimation of their economic benefits and demerits in case of a dry year is very difficult.

For the economic benefits and demerits to be ex-ante expectable, we must solve the following problems;

(1) legal uncertainties originating in non-quantified water rights.

To encourage water rights holders to quantify their water rights, (a) the quantification costs should be decreased, (b) it should be legally defined that transferors can make profits through water transfers.

(2) water pricing policy problems originating in Federal Water Projects and the State Water Projects.

(a) the water pricing policies should be improved so that transferors can make profits through water transfers.

ⓑ transfer approval criteria should be clearly defined[5].

(3) problems originating in a water district's water pricing policy.

When a district transfers water to the outside, the allocation rule of the water transfer revenues should be clearly defined so that transferors can get rewards depending on their contributions to the water transfer. If the revenues are used to decrease the water price to members, the members who contributed to the transfer will lose their incentives to transfer water, or the amount of transferred water will be less than that the most socially desirable.

(4) problems originating inconsistency of Federal Water Project's or the State Water Projects' water pricing policies with water districts' water pricing policies.

Even though Federal Water Project's or the State Water Projects' water pricing policies work so well as to encourage water districts to transfer water, if water districts' water pricing policies don't work well to encourage their members to transfer water, no water will be transferred. On the other hand, even though water districts' water pricing policies work so well as to encourage their members to transfer water, if Federal Water Project's or the State Water Projects' water pricing policies don't work well to encourage

water districts to transfer water, no water will be transferred.

(5) lack of dry year insurance policies

Even though transferors and transferees could expect their economic merits and demerits in a normal year basis, if they could not expect their economic merits and demerits in case of a dry year, they may not have any incentive to transfer water. Or even if some amount of water was transferred, the amount will be less than that the most socially desirable.

If we failed to establish a water market system which includes dry year insurance policies, the water market will not work well.

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