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HTO EMISSION FROM CONTAMINATED SURFACES AND DISTRIBUTION IN THE ENVIRONMENTAL MEDIA: SUMMARY OF DATA COLLECTED DURING FIELD STUDY IN CANADA IN JULY 1992 (1)

March 1994

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日本原子力研究所
Japan Atomic Energy Research Institute

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HTO Emission from Contaminated Surfaces and Distribution in the Environmental Media: Summary of Data Collected during Field Study in Canada in July 1992 (1)

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HTO emission from contaminated land surfaces and distribution in the environmental media were studied to provide databases for testing and validating short-range tritium transfer models. Field experiments were conducted over a wetland area in the Chalk River Laboratories of AECL and a grassed field near the Pickering Nuclear Generating Station, under an OECD/IEA Cooperative Research Program on the Environmental, Safety and Economic Aspects of Fusion Power. The experiments were designed to study short-term variations of HTO concentrations in the environmental media such as air, soil, plant leaves and pool water and correlations between them, to measure vertical profiles of the air HTO concentrations and to evaluate exchange velocities of HTO vapor between land surfaces and the atmosphere. Meteorological measurement was also made to back up data analysis. This report documents the HTO concentration data collected during an intensive study on HTO behavior with a brief discussion and analysis and the meteorological data.

Keywords: Field experiment, Tritiated water, Behavior, Wetland, Grassland, Concentration, Emission rate, Exchange velocity, HTO flux, Loss rate

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土壌HTOの大気への放散と環境媒体中分布に関する野外実験（1992年7月カナダ）野外実験データ集（1）

日本原子力研究所東海研究所保健物理部
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（1994年3月4日受理）

草地土壌や湿地などに存在するトリチウム水（HTO）が人の被ばくに至るプロセスおよび移行のパラメータ等を明らかにすることを目的として，IEA／OECD核融合環境・安全性・経済性に関する研究協力協定のもとで，HTOの野外挙動実験をカナダとの協力のもとに実施した。実験は，カナダAECL（チョークリバー研究所，ホワイトシェル研究所），オンタリオハイドロ研究所および原研の研究者が協力して平成4年7月に実施した。実験場所として，HTOで定常的かつ比較的均一に汚染している場所，すなわち，ひとつは湿地的特徴を有するチョークリバー研究所廃棄物処理場周辺，および典型的な草地であるピッカリング発電所敷地周辺が選ばれた。

原研が実施した項目は，(1)準平衡状態にある環境媒体中（空気，土壌，植物，プール水）におけるHTO濃度レベルの短期変動とその相関関係，(2)HTOの大気への放散過程に関して，空気中HTO濃度の地表高分布，地表と大気間の水蒸気交換速度，HTOフラックスおよび土壌中HTOの大気への放散率，(3)植物に関連して，有機結合トリチウムの生成，植物葉からの空気中HTOの取入れ速度等である。

本報告は，主として上記(1)，(2)に関して得られたデータをまとめたものである。実験方法および予備的な解析結果が加えられている。また，解析に必要な実験場の微気象要素のモニタリング結果が付録に掲載されている。それらは，日射強度，放射収支量，5高点の空気中温度と湿度（絶対，相対），土壌とプール水の温度，地中熱流束および風速などである。今後，本成果とカナダ側の成果とを結合することによって，HTOの環境挙動を十分に解明するとともに，核融合施設から放出されるトリチウムの環境被ばく線量評価モデルの検証に必要なデータベースとして整備する。なお，環境安全研究部からの成果は，野外実験データ集(2)として別に報告される予定である。

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1. INTRODUCTION

Releases of tritium may occur in the form of tritiated hydrogen gas (e.g. T_2 and HT) from facilities that handle tritium in large quantities such as fusion test reactors and tritium recovery plants. Atmospheric HT is easily incorporated into soil water as tritiated water (HTO) by microbial activities[1, 2, 3]. Atmospheric HTO on the other hand deposits onto soils directly. HTO in soil can be readily emitted to the atmosphere through evaporation and transpiration. In realistic assessment of an impact of a tritium release, a rate at which the emission occurs is necessary to be well understood, since HTO is approximately 20,000-fold more radio-hazardous than HT[4].

This study was carried out with cooperation of scientists from the Chalk River and Whiteshell Laboratories of Atomic Energy of Canada Limited (AECL), the Ontario Hydro Research Division (OHRD) and the Japan Atomic Energy Research Institute (JAERI), who carried out independent but complementary experiment.

The authors have conducted an intensive study on behavior of HTO in July 1992 over a wetland at the Chalk River Laboratories and a grassland near the Pickering Nuclear Generating Station (PNGS). Our specific objectives are (1) to study short-term variations of HTO concentrations in the environmental media such as air, soil, plant leaves and pool water and correlations between them, (2) to measure vertical profiles of air HTO concentration, (3) to evaluate HTO fluxes and exchange velocities of HTO vapor between land surfaces and the atmosphere, (4) to measure organically bound tritium concentrations relating to HTO concentrations in plant leaves, and (5) to measure a rate at which air HTO is incorporated into uncontaminated leaves of potted plants.

This paper presents an experimental method, theory on which the experiment is based, and the data collected during the study on (1), (2) and (3) with a brief discussion and analysis. The data not directly pertaining to tritium such as meteorological data are listed in Appendices A and B for future analysis. They are air, soil and pool water temperatures, absolute and relative humidities, solar radiation and net-radiation intensities, soil heat flux and wind speed. The results of (4) and (5) will be reported separately.

2. Theory

2.1 Analysis of HTO flux from land surfaces to the atmosphere and loss rate of soil HTO

Water vapor flux

An analytical method on which the experimental design was based is a heat balance method. A bulk water (H_2O + HTO) vapor flux E ($g/m^2 \cdot s$) between the atmosphere and land surfaces is given by Equations (1) and (2)[5] on the assumption that a heat consumption of a vegetation cover is negligible.

$$R-G(0) = lE + H \quad \cdots\cdots(1)$$

$$E = \frac{(R - G(0))}{l}\left[1 - \frac{\gamma}{k+\gamma}\frac{(T_1 - T_2)}{(T_{w1} - T_{w2})}\right] \quad \cdots\cdots(2)$$

R (w/m^2) is the net-radiation flux, H (w/m^2) is the sensible heat flux and T_1, T_2 (℃), T_{w1}, T_{w2} (℃) are dry and wet temperatures in air at two different heights away from the ground, respectively. These were measured at locations in the fields. l ($w \cdot s/g$) is the latent heat of water, k(mmHg/℃) is the gradient of saturation water vapor pressure at the wet temperatures and γ (mmHg/℃) is a constant 0.505. The heat flux at the ground surface G(0) (w/m^2) is calculated by

$$G(0) = G(3) + \rho_s \cdot C_s (\Delta T / \Delta t) \cdot z \quad \cdots\cdots(3)$$

where G(3) (w/m^2) is the soil heat flux at 3 cm underground and was measured, ρ_s (g/m^3) is the density of soil, C_s($w \cdot s/g \cdot$℃) is the heat capacity of soil at constant pressure, ΔT (℃) is the change in a mean temperature within 0-3 cm soil layer in time Δt and z(m) is a depth of 0.03 m at which the heat flux G(3) was measured. Because there was no measurement about the soil density in the fields, it was evaluated on the assumptions that the soil consisted of 50 vol.% solid material and 25 vol.% water and that they had densities of $2.7 \times 10^6 g/m^3$ [6] and $1.0 \times 10^6 g/m^3$, respectively.

The solid material consists of quartz and clay and the heat capacities of quartz and clay are 0.8 $w \cdot s/g \cdot$℃ and 0.92 $w \cdot s/g \cdot$℃ [6], respectively, with an average value of 0.86. In calculation, the heat capacities for soil constituents were assumed to be 0.86 $w \cdot s/g \cdot$ ℃ for solid and 4.2 $w \cdot s/g \cdot$℃ for water. Then $\rho_s \cdot C_s$ was given by

$$\rho_s \cdot C_s = 0.5 \times 0.86 \times 2.7 \times 10^6 + 0.25 \times 4.2 \times 1.0 \times 10^6 = 2.2 \times 10^6 \ (w \cdot s/m^3 \cdot ℃)$$

Exchange velocity of water vapor

A water vapor flux is proportional to an exchange velocity of water vapor between land surfaces and the atmosphere and to a gradient of water vapor density in the

atmosphere. Then the bulk water vapor flux E is also expressed by

$$V_{ex} = E / (h_1 - h_2) \quad \cdots\cdots(4)$$

where V_{ex} (m/s) is the exchange velocity and h_1, h_2 (g/m^3) are water vapor densities at two different heights.

HTO vertical flux

A molecular diffusibility of water vapor is always negligible compared with a turbulent diffusibility of the atmosphere. Hence the exchange velocity of the bulk water vapor can apply to the HTO vapor. The flux-gradient relationship for HTO is given by

$$F_{HTO} = V_{ex} \cdot (C_1 - C_2) \quad \cdots\cdots(5)$$

where F_{HTO} ($Bq/m^2 \cdot s$) is a vertical HTO flux and C_1, C_2 (Bq/m^3) are the air HTO concentrations at two heights.

Loss rate of soil HTO

A loss rate of HTO deposited in the soil was evaluated on the assumption that transfer of HTO to the atmosphere occurred from the top soil layer (0-5 cm) and a water content of the soil was 25 vol.%. The loss rate L(%/h) is given by

$$L = (F_{HTO}/S) \times 100 \quad \cdots\cdots(6)$$

where S (Bq/m^2) is the activity density in the top soil layer.

2.2 A model to predict a correlation between tritiated water concentrations in air, soil and plant leaves under steady-state conditions

A tissue-free-water-tritium (TFWT) concentration of plant leaves is given by an activity balance equation (7)[7, 8]

$$\frac{dC^{pw}}{dt} = V_{ex} (C^a - \gamma \cdot h^s \cdot C^{pw}) \cdot LAI / M + T_e \cdot C^{srz} / M \quad \cdots\cdots(7)$$

where C^{pw} (Bq/ml) is the TFWT concentration of plant leaves, C^a (Bq/m^3) is the air HTO concentration, C^{srz} (Bq/ml) is the soil water HTO concentration around a root zone, T_e ($ml/m^2 \cdot s$) is a transpiration rate, M (ml/m^2) is a volume of vegetation water per unit area of soil, γ (1/1.1) is the vapor pressure ratio between H_2O and HTO, h^s (ml/m^3) is the saturation water vapor density at leaf temperature and LAI is a leaf area index. The equation considers exchange of water vapor at leaf surface via stomata and uptake of soil water through roots and also that the transpiration rate of leaf water was equal with the uptake rate of soil water via roots.

At steady-state conditions, $dC^{pw}/dt = 0$,

$$T_e \cdot C^{srz} / M = - V_{ex} (C^a - \gamma \cdot h^s \cdot C^{pw}) \cdot LAI / M . \quad \cdots\cdots(8)$$

The transpiration rate is also combined with the gradient of water vapor density

$$T_e = V_{ex} (h^s - h^a) \cdot LAI \quad \cdots\cdots(9)$$

where h^a (ml/m^3) is the water vapor density at ambient temperature.

Then,

$$V_{ex} (h^s - h^a) \cdot C^{srz} = - V_{ex} (C^a - \gamma \cdot h^s \cdot C^{pw})$$

$$(h^s - h^a) \cdot C^{srz} = - (C^a - \gamma \cdot h^s \cdot C^{pw}) \quad \cdots\cdots(10)$$

When a specific activity of air moisture C^{aw} is used instead of C^a , Eq.(10) is written by

$$(h^s - h^a) \cdot C^{srz} = - (C^{aw} \cdot h^a - \gamma \cdot h^s \cdot C^{pw}) . \quad \cdots\cdots(11)$$

When the leaf temperature equals the ambient temperature, h^a / h^s means the relative humidity (RH), and Eq.(11) becomes

$$(1 - RH) \cdot C^{srz} = - (C^{aw} \cdot RH - \gamma \cdot C^{pw}) . \quad \cdots\cdots(12)$$

Eqs.(11) and (12) explain the correlation between tritiated water concentrations in air, soil and plant leaves under steady-state conditions. This correlation will be verified through measurement of the concentrations at the Pickering experimental field.

3. FIELD EXPERIMENT AT CHALK RIVER LABORATORY (CRL) SITE

3.1 Site description

The experimental field, as shown in Fig.3-1, is located in a complex area consisted of a wetland and a lake (Perch Lake). The field layout is shown in Fig.3-2. The wetland consists of shallow open pools and channels of water interspersed with hummocks of spongy soil and low vegetation. The pool water is contaminated by tritium migrating from a liquid disposal area which locates 0.8 km up from Perch Lake. Perch Lake water is also slightly contaminated as the tritium has been carried with surface water and groundwater to the lake. The measurements were carried out when a wind blew from the wetland side. As shown in Fig.3-2, a JAERI meteorological tower, which was 2 m away from AECL's tower, was set up on a narrow roadway at the southern edge of the wetland. A detailed description of the CRL experimental field quoted from AECL's report[9] is given in Appendix C.

3.2 Experimental method

3.2.1 Measuring items and time

Air, plant leaves and pool water samples were collected in the CRL field at respective predetermined time intervals and HTO concentrations of these samples were measured. A soil core was sampled only once. Table 3-1 summarizes the sampling items and time. Meteorological measurement was made continuously during the experiment.

3.2.2 HTO concentrations in air

HTO in air was sampled at a flow rate of 3 L/min for one or two hours using an air sampler. Fig.3-3 is a schematic of the air sampler. It consists of a column filled with Molecular Sieves 4A, an air buffer, a digital gas meter and a pump. To measure vertical profiles of HTO concentration in air, air was pumped at the sampling heights of 12.5, 25, 58, 97.5 and 247 cm above the ground surface using chlorovinyl tubes connected to the inlet of columns. The Molecular Sieves 4A of 30 g in each column after sampling of the air HTO were soaked in low-tritium water (70 ml) in a bottle, and the bottle was shaken and allowed to stand more than 12 hours. The supernatant water was purified with a membrane filter (type AA pore size 0.8 μm), and a filtrate of 40 ml was counted for tritium with 60 ml of Aquasol-2 by liquid scintillation.

3.2.3 HTO concentrations in pool water

Pool water samples were taken from the surface layer of pool water (0 - 10 cm). The sample water was purified with the membrane filter, and a filtrate of 8 ml was counted for tritium with 12 ml of Aquasol-2 by liquid scintillation.

3.2.4 HTO concentrations in plant leaves

Plant (Alder) leaves growing at the southern edge of the wetland were sampled. The leaves were usually collected at 150 cm height as planned, and only once, were collected at a time from different heights of 10, 50, 100 and 180 cm. Each plant sample was soaked in low-tritium water (70 ml) in a bottle, and the bottle was shaken and allowed to stand more than 12 hours. Then the supernatant water was decolorized by activated charcoal powder and subsequently was purified with the membrane filter. A filtrate of 8 ml was counted for tritium with 12 ml of Aquasol-2 by liquid scintillation.

3.2.5 HTO concentrations in soil water

A soil core was taken down to a depth of 20 cm using a soil core sampler with a diameter of 5 cm. The soil core was segmented into 4 sections of each 5 cm. Each segmented sample was soaked in low-tritium water (70 ml) in a bottle, and the bottle was shaken and allowed to stand more than 12 hours. The supernatant water was purified with the membrane filter. A filtrate of 8ml was counted for tritium with 12 ml of Aquasol-2 by liquid scintillation.

3.2.6 Meteorological measurement

Air temperature, air humidity (absolute and relative), wind speed, solar radiation and net-radiation intensities, and soil heat flux were continuously measured. An averaging time of these meteorological elements was set to one hour. Soil and pool water temperatures were measured at respective predetermined time intervals. The JAERI meteorological tower, as shown in Fig.3-4, consists of five aspirated radiation shielded wet and dry thermometers placed at the same heights as the inlet tubes for air sampling, a pyranometer at 3 m height above the ground, an anemometer at 2.8 m, a net-pyrradiometer at 1.8 m, three soil heat flux sensors and three soil thermometers.

3.3 Experimental results (CRL study)

3.3.1 Air HTO concentrations

Time trends of the HTO concentrations in air moisture, i.e. specific activity,

(Bq/ml) measured at the different heights are shown in Table 3-2 (15:00 - 18:00 July 14 and 10:00 July 15 - 10:00 July 16) and Fig.3-5 (10:00 July 15 - 10:00 July 16). Absolute humidity data calculated from the water collected in the column are also shown in Table 3-2. The air HTO concentrations measured at all the heights varied between 2 and 24 Bq/ml during one day and night. The concentrations rapidly increased after 18:00 July 15 and reached a peak at 22:00, and then slightly decreased until 7:30 July 16. Subsequently, the concentrations markedly decreased, and then at 9:00 July 16 became almost the same concentrations as those during the daytime on July 15. It seems that these characteristic variations of HTO concentrations in the night are related to the atmospheric conditions; during the time when the atmosphere was stable in the night, the HTO concentrations were high. This was considered to occur by the reason that the vapor from the pool water having a high specific activity hung over the pool surface to raise the concentration because of weak atmospheric mixing.
From 22:00 July 15 to 7:30 July 16, the HTO concentrations had kept gradually decreasing. This was explained by that the HTO vapor supply from the pool water to the atmosphere reduced because of the decreases of the surface water temperature (Appendix Table A-2, Fig.A-5) and the pool water concentration. The relationship between the HTO concentrations in air, pool water and alder leaves will be described in Section 3.3.6.

Time trends of the air HTO concentrations expressed by " Bq/m^3 " at the different heights are shown in Table 3-2 and Fig.3-6. The concentrations measured at all the heights varied between about 20 and 240 Bq/m^3 during one day and night. The air concentrations (Bq/m^3) decreased more rapidly than the concentrations (Bq/ml, specific activity) did from 22:00 July 15 to 6:00 July 16. This suggests that the decrease of concentration (Bq/m^3) was affected by the decreases of both specific activity and absolute humidity (Appendix Fig.A-2).

3.3.2 Vertical profiles of HTO concentration in air

Vertical profiles of the air HTO concentration (Bq/m^3) over the ground in log-linear plot are shown in Fig.3-7(a) to Fig.3-7(d). It was a general tendency that the concentrations at 12.5 cm height were the highest and those at 247 cm height were the lowest, as the source of HTO was in the pool water. It is also seen that the concentration decreases almost exponentially with increasing height away from the ground. No obvious slope is seen from midnight to early morning (2:00 to 6:30 July 16 : Figs.3-7(c) and 7(d)), but during the other time, the slope changed with time.

As shown in Fig.3-7(a), the slope became steeper from 10:30 to 14:30.
Vertical profiles of the HTO specific activity (Bq/ml) are shown in Fig.3-8(a) to Fig.3-8(d). The profiles were shown to have generally the similar tendency in a shape and slope to those of the HTO concentrations (Bq/m^3).

3.3.3 Pool water HTO concentrations

Table 3-3 and Fig.3-9 show time trends of the pool water HTO concentration. The concentration was 70 Bq/ml until 13:00 July 15, and then gradually increased and reached a peak concentration of 90 Bq/ml at 20:00. Then it rapidly decreased until 23:00 July 15 and reached 40 Bq/ml. The large variation in concentration was an unexpected result and the reason to explain this variation was not clear.

3.3.4 HTO concentrations in tissue-free-water of alder leaves

Tissue-free-water-tritium (TFWT) concentrations and water contents of the alder leaves sampled at 150 cm height are listed in Table 3-4. Fig.3-10 shows the time variation of the TFWT concentration. The concentration increased from about 20 Bq/ml at 10:00 July 15 to 45 Bq/ml at 18:00 and slowly decreased. Then it remained unchanged at about 25 Bq/ml during the night and began to increase again from 8:00 July 16. The TFWT concentration varied collectively between 1/2 and 1/3 of the pool water concentration.

TFWT concentrations and water contents of the alder leaves sampled from the different heights at 13:20 July 15 are given in Table 3-5. Fig.3-11 shows the vertical profile of the TFWT concentration above the ground. The result shows that no clear correlation existed between the concentration and height. In the range of 10 - 180 cm height, the concentration varied in a factor of 1.2.

3.3.5 Soil water HTO concentrations

Tritiated water concentrations and water contents in the soil sampled at 16:30 July 14 are given in Table 3-6. Fig.3-12 shows a depth profile of the concentration. The concentration increased with depth and was about 0.5 Bq/ml in the top layer (0 - 5 cm) and about 15 Bq/ml in the layer of 15 - 20 cm. This shows that the soil HTO was being carried from the lower soil layer to the upper.

3.3.6 Relationship between tritiated water concentrations in air, alder leaves and pool water

Fig.3-13 shows the relationship between the tritiated water concentrations in air (58 and 247 cm), alder leaves (150 cm) and pool water. The TFWT concentration of

alder leaves seems to vary together with the pool water concentration, but, in detail, does not varied simultaneously. This was because that the TFWT concentration was affected by both concentrations of the pool water moving up through the roots, a part of which contacted with the surface pool water, and the air moisture which was taken up by vapor exchange between the leaf water in stomata during daytime. After the HTO evaporation from the leaves had stopped by closing of the stomata at night, the TFWT concentration was kept unchanged at the level of about 25 Bq/ml in the night.

The air HTO concentration increased in parallel roughly with the pool water and TFWT concentrations during the daytime, but continued to increase while the pool water and TFWT concentrations started to decrease. One possible explanation is that the vapor exchange velocity between the atmosphere and pool surface was getting smaller in the night (from 19:00 July 15) since the atmosphere was getting stable, and hence the vapor from the pool water having a higher specific activity than that of the air moisture hung over the pool surface to raise the air HTO concentration. Subsequently, the air concentration gradually changed as explained in section 3.3.1.

3.3.7 Meteorological measurement data

The absolute and relative humidities are listed in Appendix Table A-1. The solar radiation and net-radiation intensities, soil heat flux at 3 cm underground, soil and pool water temperatures, and wind speed are listed in Appendix Table A-2. The dry and wet temperatures are listed in Appendix Table A-3. The soil heat flux at the soil surface, bulk water vapor flux (evapo-transpiration rate), Boen ratio and energy balance are listed in Appendix Table A-4. The time variations of the absolute humidity, relative humidity, air, soil and pool water temperatures, solar radiation and net-radiation intensities, soil heat flux, wind speed, and the vertical profiles of the absolute humidity and air temperature are shown in Appendix Fig. A-1 to Fig. A-9.

4. FIELD EXPERIMENT AT PICKERING SITE

4.1 Site description

The experimental field, as shown in Fig.4-1, is located about 1 km northwest of the Pickering Nuclear Generating Station (PNGS) near Lake Ontario. Soil and plants on this place are contaminated by HTO deposited from the air as a results of routine emissions from the reactors. The field, which measures 75 m wide and 180 m long, is flat and covered with grasses of about～50 cm height all around. And the field is bounded on the south by a public road and the north by a narrow band of trees. The layout of the field is shown in Fig.4-2. The soil can be characterized as a neutral loam or clay loam. Measurements were made with winds from the northwest through southeast to avoid the HTO plume from the reactors. A detailed explanation about the Pickering experimental field quoted from the AECL's report[9] is given in Appendix C.

4.2 Experimental method

4.2.1 Measuring items and time

Sampling items and time are shown in Table 4-1. Air, plant leaves and soil samples were collected as planned and HTO concentrations of these samples were measured. Meteorological measurement was made continuously during the experiment.

4.2.2 HTO concentrations in air

HTO in air was sampled and analyzed by the same method as mentioned previously in Section 3.2.2. The inlet tubes for air sampling were placed at five different heights of 12, 27, 57, 101 and 244 cm to measure HTO vertical profiles. Those heights were sightly different from the CRL experiment. The air was sampled at the location of the JAERI meteorological tower, as shown in Fig.4-2.

4.2.3 HTO concentrations in plant leaves

Plant leaves of hawthorn were collected to measure TFWT concentrations at two heights of 60 and 180 cm above the ground. The tree with a height of 2.8 m locates in the field as shown in Fig.4-2. The concentration was analyzed by the identical method with that used in the CRL experiment.

4.2.4 HTO concentrations in soil water

Soil cores were taken down to a depth of 20 cm using a soil core sampler with a diameter of 3 cm at points A and B at given time intervals. Each core was divided into four sections of each 5 cm. The soil sampling points are shown in Fig.4-2. The soil water concentration was measured by the same method as that used in the CRL experiment.

4.2.5 Meteorological measurement

Meteorological measurement was made as mentioned in the previous section (3.2.6).

4.3 Experimental results (Pickering study)

4.3.1 Air HTO concentrations

Time trends of the HTO concentrations in air moisture, i.e. specific activity (Bq/ml) measured at different heights are shown in Table 4-2 (9:00 July 21 - 12:00 July 22 and 14:20 July 23 - 18:50 July 23) and Fig.4-3 (9:00 July 21- 12:00 July 22). Absolute humidity data are also listed in Table 4-2. The air HTO concentrations measured at all the heights varied between 0.03 and 0.4 Bq/ml during one day and night. The concentrations at the Pickering field were considerably lower than those at the CRL field. Wind direction data confirmed that there was no effect of the reactor plume on the experimental results.

The time trends showed small peaks at 22:00 July 21 and 4:00 July 22. This characteristic trend was related to the atmospheric conditions. As was discussed in Section 3.3.1, it is considered that during the time when the concentration peaks appeared, the exchange velocities were small coincidentally (see Fig.5-2) and then the water vapor from soil to the atmosphere hung over the surface to raise the HTO concentration (Bq/ml). The relationship between the HTO concentrations in air, plant leaves and soil will be described in Section 4.3.5.

Time trends of the air HTO concentrations expressed by "Bq/m^3" at different heights are shown in Table 4-2 and Fig.4-4. The concentrations measured at all the heights varied between 0.4 and 3.0 Bq/m^3 during one day and night. The trends showed that the air HTO concentrations (Bq/m^3) were mutually related to the specific activity in air (Bq/ml) and absolute humidity.

4.3.2 Vertical profiles of HTO concentration in air

Vertical profiles of the air HTO concentration (Bq/m^3) are shown in Fig.4-5(a) to Fig.4-5(c). The profiles show a tendency that the concentration decreases exponentially in general with increasing height. But the concentrations at 57 cm height were usually typically higher than those at other heights to deviate from exponential fit. It is supposed that the high HTO concentration vapor evaporated from the grasses, which was about the average height of 50 cm, was supplied to the lower layer (～57 cm height) of the atmosphere. This typical concentration rise was not found at the CRL field, where the plants were of unequal height. Vertical profiles of the specific activities (Bq/ml) (Fig.4-6(a) to Fig.4-6(c)) had the same tendency as those of the concentrations (Bq/m^3).

4.3.3 HTO concentrations in tissue-free-water of hawthorn leaves

TFWT concentrations and water contents of the hawthorn leaves collected at 60 and 180 cm heights are given in Table 4-3. Time variations of the TFWT concentrations are shown in Fig.4-7. The concentrations at 60 cm varied between 0.8 and 1.2 Bq/ml and those at 180 cm varied between 0.7 and 1.1 Bq/ml. The latter was slightly lower than the former except at 15:00 July 21 and 5:00 July 22.

4.3.4 Soil water HTO concentrations

Tritiated water concentrations and water contents in the soil collected at points A and B are given in Table 4-4(a) and 4(b). Time histories of the soil HTO depth profile are shown in Fig.4-8(a) and 8(b) for points A and B, respectively. The concentrations in the top layer (0 - 5 cm) at point A changed from 0.5 to 0.9 Bq/ml (average 0.67±0.12 Bq/ml) and at point B changed from 0.5 to 0.8 Bq/ml (average 0.66±0.1 Bq/ml) during one day and night. The concentrations in the 15-20 cm layers were usually higher than those in the other layers.

4.3.5 Relationship between tritiated water concentrations in air, hawthorn leaves and soil water

Time trends of the HTO concentrations (Bq/ml) in air moisture (57, 101 and 244 cm heights), plant leaves (60 and 180 cm heights) and soil (0-5 and 15-20 cm layers at point A) during one day and night are shown in Fig.4-9. There was no obvious relationship between the concentrations. The air HTO concentration at 57 cm was about 1/3 and that at 244 cm was 1/6 of the top soil water concentration. The TFWT concentrations of hawthorn leaves seems to be strongly affected by both water concentrations in the top (0-5 cm) and deeper soil (15-20 cm) layers. No remarkable

variation for the HTO concentrations (Bq/ml) was seen in the environmental media under quasi-steady state conditions; the ratio of the maximum to minimum concentrations was 2.7 for the air and less than 1.6 for the soil and hawthorn leaves.

4.3.6 Meteorological and evaporation measurement data

The absolute and relative humidities are listed in Appendix Table B-1. The solar radiation and net-radiation intensities, soil heat flux at 3 cm underground, soil temperature and wind speed are listed in Appendix Table B-2. The dry and wet temperatures are listed in Appendix Table B-3. The soil heat flux at the soil surface, bulk water vapor flux (evapo-transpiration rate), Boen ratio and energy balance are listed in Appendix Table B-4. The time variations of the absolute humidity, relative humidity, air and soil temperatures, solar radiation and net-radiation intensities, soil heat flux, wind speed, and the vertical profiles of the absolute humidity and air temperature are shown in Appendix Fig.B-1 to Fig.B-9.

5. ANALYSIS

5.1 HTO flux from land surfaces to the atmosphere and loss rate of soil HTO derived from measurements conducted at Pickering experimental field

Water vapor flux

The flux was calculated from various parameters used in Eq.(2) measured at two heights: 57 and 244 cm. The lower measurement was conducted just above the mean height of the grass, 50 cm. Fig.5-1 shows a variation of the evaluated bulk water vapor flux with time at the Pickering field (9:00 July 21 - 12:00 July 22). In the fluxes those toward the atmosphere varied with time from 0 to 0.12 $g/m^2 \cdot s$ with a maximum around 15:00 July 21. The fluxes gradually decreased to around 0 $g/m^2 \cdot s$ at 24:00 July 21 while the net-radiation intensity became negative from 20:00 July 21. There were still the fluxes at very low level even in the night. In the fluxes those toward the land surfaces appeared several hours before the dawn. This was in consistent with the observation that the water vapor densities at 244 cm height were higher than those at 57 cm height during the corresponding period of time as seen in Appendix Fig.B-2 (also Fig.5-3).

Exchange velocity of water vapor

The exchange velocity was evaluated by Eq.(4). Fig.5-2 shows a short-term variation of the evaluated exchange velocity with time (9:00 July 21 - 12:00 July 22). The

variation for the HTO concentrations (Bq/ml) was seen in the environmental media under quasi-steady state conditions; the ratio of the maximum to minimum concentrations was 2.7 for the air and less than 1.6 for the soil and hawthorn leaves.

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Exchange velocity of water vapor

The exchange velocity was evaluated by Eq.(4). Fig.5-2 shows a short-term variation of the evaluated exchange velocity with time (9:00 July 21 - 12:00 July 22). The

velocity varied from 0 to 0.23 m/s through the period with an average value of 0.15 m/s and was high in the daytime while the solar radiation intensity and wind speed were high. The pattern of variation was similar to that of the solar radiation intensity and wind speed (Appendix Figs.B-8 and B-9). In the night, the velocity decreased to less than 0.05 m/s, except around the midnight (1:00 - 2:00 July 22) when a sudden increase of wind speed occurred (Appendix Fig.B-9). A mean exchange velocity averaged over 9:00 July 21 to 9:00 July 22 was 0.1 m/s.

HTO vertical flux

The HTO flux was evaluated by Eq.(5). The time trends of C_1 and C_2 in Eq.(5) are shown in Fig.5-3. The HTO concentration at 57 cm height (C_1) was usually higher than that at 244 cm (C_2). This confirmed that transfer of the HTO vapor from soil to the atmosphere existed even in the night. The concentration levels reversed momentarily from 1:00 to 3:00 July 22 reflecting the sudden increase of the wind speed, in consequence, of the exchange velocity (Fig.5-2). Fig.5-4 shows a variation of the evaluated HTO vertical flux with time. The flux ranged from -100 to 1100 Bq/m^2•h and there existed the fluxes at very low level during the night. The negative fluxes (deposition) occurred coincidentally with the reversal of the HTO concentration levels between the two heights. A mean flux averaged over 24 hours was 230 Bq/m^2•h.

Loss rate of soil HTO

The loss rate (i.e. reemission rate) of the soil HTO is shown in Fig.5-5. It varied with time within -0.3 to 3 %/h and an average rate over 24 hours (10:00 July 21 to 10:00 July 22) was 0.66 %/h. This average value is 2 to 8 times smaller than those found in the HT field release studies carried out in France[10] and Canada[11,12] . The discrepancy may be attributable to the differences in the depth profiles of the deposited HTO in soil and to the differences in the atmospheric and land conditions during the studies. It was known that the depth profiles of soil HTO were almost exponential for the HT release cases[3,13] , but in the present case, the soil HTO distribution was rather uniform within the soil.

5.2 Test of a plant model to predict TFWT concentration

In calculation of the TFWT concentration by Eq.(12), the values of the variables such as RH, C^{srz}(in 15-20 cm layer) and C^{aw} (at 150 cm height) in the equation and the pool water concentration at an arbitrary time were read by interpolation from the plots of the respective data on the graphic papers.

A correlation curve between the measured and predicted TFWT concentrations is shown in Fig.5-6. The TFWT concentrations of the alder leaves collected at the height of 150 cm at the CRL field were predicted by Eq.(12) using the pool water HTO concentration for C^{srz} because there was no measurement of C^{srz} and the results are shown by the marks □. The predicted TFWT concentrations are larger by a factor 1 to 2 than the measured ones. The marks ○ with the goodness of fit for the alder leaves were predicted on the assumption that C^{srz} is 0.7 times the pool water concentration. The marks△ show the predicted concentrations for the hawthorn leaves collected at the height of 150 cm at the Pickering field. The soil HTO concentration in the 15-20 cm layer was used for C^{srz} . The predicted values are about 1.5 times smaller than the measured ones. This discrepancy may be caused by that the hawthorn leaves partly took up the water with higher concentration from the deeper soil layer than 20 cm depth. These results demonstrate that a TFWT concentration in the daytime can be predicted within a factor 2 by Eq.(12), which considers uptake of soil water via roots and exchange of water vapor at leaf surfaces (stomata) under quasi-steady state conditions.

6. Conclusions

The field experiments on HTO emission from contaminated land surfaces and distribution in the environmental media were conducted at two sites in Canada in July 1992. The major analytical findings are summarized below.

6.1 CRL site study

Behavior of HTO over a wetland in the Chalk River Laboratories was studied where atmospheric HTO was supplied mainly from water pools and plants growing on hummocks. In the air-plant-pool water system under quasi-steady state conditions, short-term variations of HTO concentrations in the environmental media and correlations between them were studied. The intensive study was conducted from 9:00 July 15 to 11:00 July 16.

(1) The HTO concentrations in air moisture, i.e. specific activity (Bq/ml), measured at the heights of 12.5 cm to 247 cm, increased in parallel roughly with the surface pool water (0-10 cm) concentration and the tissue-free-water-tritium (TFWT) concentration of alder leaves (at 150 cm height) growing at the edge of the wetland during the daytime.

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(2) The concentrations in air moisture, however, continued to increase sharply after sunset while the pool water and TFWT concentrations started to decrease. One possible explanation was that the vapor exchange velocity between the atmosphere and surfaces was getting smaller in the night since the atmosphere was getting stable, and hence the vapor arising from the pool water, which had a higher specific activity than that of the air moisture, hung over the surface to raise the air HTO concentration near the ground surface.

(3) The TFWT concentration of alder leaves fluctuated within the levels of 1/2 to 1/3 of the pool water concentration during one day and night. In the night, the TFWT concentration remained unchanged at about the similar concentration level as that in the daytime near sunset. This is in consistent with the idea that no vapor exchange occurs at night after closing of stomata.

(4) It was seen that the air HTO concentration (in Bq/ml and Bq/m^3) decreased almost exponentially with increasing height away from the surface in the daytime. No obvious slope was seen from midnight to early morning, but during the other time the slope changed with time. These trends were very similar to those of the air temperature.

(5) The surface pool water HTO concentration was shown to vary from 40 to 90 Bq/ml during one day and night with a peak concentration after sunset at 20:00. Then it rapidly decreased and reached 40 Bq/ml at 2:00 in the next morning. The large variation in concentration was an unexpected result and the reason to explain this variation was not clear.

(6) An activity balance model to express the relationship between the HTO concentrations in air moisture, soil and plant water, which considers exchange of water vapor at leaf surface and uptake of pool water by plant through roots, was tested. And it was demonstrated that there was the clear correlation between the concentrations in the daytime and that the TFWT concentration of alder leaves could be predicted by the model in a factor 2 from both HTO concentrations in the pool water and air moisture. It is noted that a part of the roots of alder was in contact with the surface pool water in this case.

6.2 Pickering study

Behavior of HTO over a grassland in the Pickering field was studied where

atmospheric HTO was supplied from fairly uniform contaminated soil, plant, and grasses covering over the ground with a height of～50 cm. In the air-plant-soil system under quasi-steady state conditions, short-term variations of HTO concentrations in the environmental media and correlations between them were studied. The intensive study was conducted from 9:00 July 21 to 12:00 July 22.

(1) The HTO concentration in the top soil layer (0-5 cm) water slightly fluctuated during one day and night. The average concentrations were 0.67 ±0.12 Bq/ml at measuring point A and 0.66±0.1 Bq/ml at measuring point B. The concentrations in the 15-20 cm layers were usually higher than those in the other layers.

(2) The HTO concentrations in air (Bq/ml) at 57 and 244 cm heights varied at the levels of about 1/3 and 1/6 of the top soil water HTO concentrations, respectively.

(3) No significant air HTO concentration (in Bq/ml and Bq/m^3) peak was observed through the days. A maximum to minimum concentration ratio was 2.7 for the air and 1.6 for the soil and hawthorn leaves.

(4) From after sunset to several hours before the dawn, there were small air concentration peaks. As was discussed in Section 4.3.1, it was supposed that during the time when the concentration peaks appeared, the atmospheric mixing was small and then the water vapor from the soil to the atmosphere hung over the surface to raise coincidentally the HTO concentration (specific activity) near the ground level.

(5) It was seen that the air HTO concentration decreased almost exponentially with increasing height away from the ground surface in the daytime. Compared with the CRL results, the noticeable concentration rise for the measurement at 57 cm height to deviate from exponential fit was observed both in the daytime and nighttime. The height of 57 cm is about 10 cm higher than the height of the average grass cover.

(6) It was demonstrated that the TFWT concentration of hawthorn leaves in the daytime under quasi-steady state conditions could be predicted by the activity balance model in a factor 2.

(7) The exchange velocity of water vapor between the atmosphere and land surfaces varied from 0 to 0.23 m/s during one day and night with an average value of 0.10 m/s. The exchange velocities were large in the daytime (an average value 0.15 m/s) when

the solar radiation intensity and wind velocity were high. In the night, the velocity decreased to less than 0.05 m/s.

(8) The HTO flux between the atmosphere and land surfaces varied from -100 to 1100 Bq/m² •s during one day and night. There existed the fluxes toward upward at very low level even in night and sometimes those toward downward (deposition). The downward fluxes occurred coincidentally with occurrence of the reverse gradient of the air HTO concentrations between at 57 and 244 cm heights. An average flux over 24 hours was 230 Bq/m²•s.

(9) The loss rate (i.e. remission rate) of the soil HTO to the atmosphere ranged -0.3 to 3 %/h during one day and night. An average value over 24 hours was 0.66 %/h.

(10) The average loss rates were smaller in a factor 2 to 8 than corresponding values found in the French and Canadian HT release experiments. The descrepancy was considered to be attributable to the differences in the depth profiles of the HTO deposited in the soils and to the differences in the atmospheric and land conditions during the experiments.

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Table 3−1 Sampling and measuring protocol at CRL site.

CRL Site

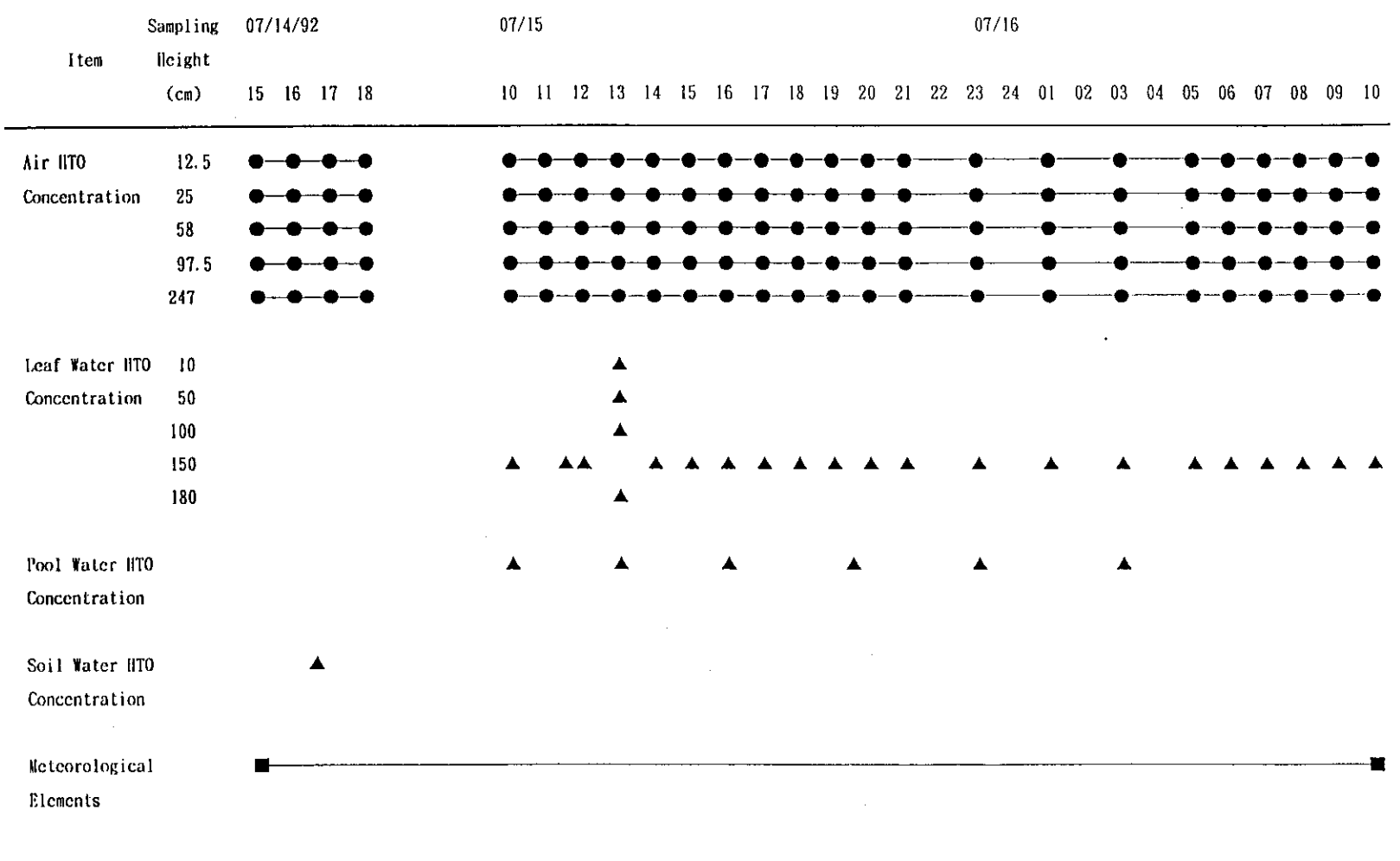


Table 3－2 HTO concentration in air and absolute humidity at different heights.

CHALK RIVER EXPERIMENTAL SITE (AIR)

NO.	DATE	SAMPLER START	SAMPLER STOP	SAMPLING TIME (h)	HEIGHT (cm)	SAMPLING VOLUME (m^3)	HTO CONCENTRATION (Bq/ml)	HTO CONCENTRATION (Bq/m^3)	HUMIDITY (g/m^3)
1	14-July	15:00	16:00	1:00	12.5	0.18	1.17	15.11	12.94
2		15:00	16:00	1:00	25.0	0.18	1.43	18.26	12.76
3		15:00	16:00	1:00	58.0	0.18	1.71	20.23	11.85
4		15:00	16:00	1:00	97.5	0.18	-	-	-
5		15:00	16:00	1:00	247.0	0.18	1.55	16.87	10.88
6		16:00	17:00	1:00	12.5	0.18	2.45	31.71	12.92
7		16:00	17:00	1:00	25.0	0.18	2.27	26.98	11.86
8		16:00	17:00	1:00	58.0	0.18	2.17	24.68	11.36
9		16:00	17:00	1:00	97.5	0.18	2.09	22.91	10.96
10		16:00	17:00	1:00	247.0	0.18	1.67	17.75	10.66
11		17:00	18:00	1:00	12.5	0.18	3.47	39.82	11.48
12		17:00	18:00	1:00	25.0	0.18	3.15	34.49	10.96
13		17:00	18:00	1:00	58.0	0.18	2.83	29.97	10.58
14		17:00	18:00	1:00	97.5	0.18	2.53	26.46	10.44
15		17:00	18:00	1:00	247.0	0.18	1.85	17.91	9.67
16	15-July	10:00	11:00	1:00	12.5	0.18	2.58	31.83	12.35
17		10:00	11:00	1:00	25.0	0.18	2.19	27.13	12.37
18		10:00	11:00	1:00	58.0	0.18	1.90	22.81	11.99
19		10:00	11:00	1:00	97.5	0.18	1.80	21.69	12.03
20		10:00	11:00	1:00	247.0	0.18	1.91	18.95	9.94
21		11:00	12:00	1:00	12.5	0.18	3.23	40.01	12.39
22		11:00	12:00	1:00	25.0	0.18	3.09	36.44	11.79
23		11:00	12:00	1:00	58.0	0.18	2.86	31.78	11.11
24		11:00	12:00	1:00	97.5	0.18	2.97	32.53	10.97
25		11:00	12:00	1:00	247.0	0.18	2.30	23.48	10.23
26		12:00	13:00	1:00	12.5	0.18	4.42	52.28	11.83
27		12:00	13:00	1:00	25.0	0.18	3.80	43.26	11.38
28		12:00	13:00	1:00	58.0	0.18	3.62	37.30	10.29
29		12:00	13:00	1:00	97.5	0.18	3.56	37.60	10.55
30		12:00	13:00	1:00	247.0	0.18	2.59	24.74	9.56
31		13:00	14:00	1:00	12.5	0.18	6.29	69.58	11.06
32		13:00	14:00	1:00	25.0	0.18	5.20	58.23	11.20
33		13:00	14:00	1:00	58.0	0.18	4.77	49.44	10.36
34		13:00	14:00	1:00	97.5	0.18	4.43	44.87	10.12
35		13:00	14:00	1:00	247.0	0.18	3.23	29.32	9.07
36		14:00	15:00	1:00	12.5	0.18	6.30	72.03	11.43
37		14:00	15:00	1:00	25.0	0.18	5.38	58.42	10.86
38		14:00	15:00	1:00	58.0	0.18	4.66	46.15	9.89
39		14:00	15:00	1:00	97.5	0.18	4.24	39.35	9.28
40		14:00	15:00	1:00	247.0	0.18	3.04	27.67	9.10
41		15:00	16:00	1:00	12.5	0.18	8.53	85.23	9.99
42		15:00	16:00	1:00	25.0	0.18	7.49	73.22	9.77
43		15:00	16:00	1:00	58.0	0.18	6.99	56.58	8.09
44		15:00	16:00	1:00	97.5	0.18	6.36	55.62	8.75
45		15:00	16:00	1:00	247.0	0.18	5.15	43.00	8.34
46		16:00	17:00	1:00	12.5	0.18	9.61	91.20	9.49
47		16:00	17:00	1:00	25.0	0.18	8.13	73.98	9.10
48		16:00	17:00	1:00	58.0	0.18	7.31	56.25	7.69
49		16:00	17:00	1:00	97.5	0.18	4.34	36.54	8.41
50		16:00	17:00	1:00	247.0	0.18	6.62	51.94	7.84

Table 3－2 Cont'd

CHALK RIVER EXPERIMENTAL SITE (AIR)

NO.	DATE	SAMPLER START	SAMPLER STOP	SAMPLING TIME (h)	HEIGHT (cm)	SAMPLING VOLUME (m^3)	HTO CONCENTRATION (Bq/ml)	HTO CONCENTRATION (Bq/m^3)	HUMIDITY (g/m^3)
51	15-July	17:00	18:00	1:00	12.5	0.18	10.26	91.09	8.88
52		17:00	18:00	1:00	25.0	0.18	8.56	74.53	8.71
53		17:00	18:00	1:00	58.0	0.18	7.78	60.20	7.74
54		17:00	18:00	1:00	97.5	0.18	7.01	54.01	7.71
55		17:00	18:00	1:00	247.0	0.18	5.40	40.68	7.53
56		18:00	19:00	1:00	12.5	0.18	10.66	91.37	8.57
57		18:00	19:00	1:00	25.0	0.18	9.50	80.06	8.43
58		18:00	19:00	1:00	58.0	0.18	8.73	70.71	8.10
59		18:00	19:00	1:00	97.5	0.18	7.52	58.10	7.73
60		18:00	19:00	1:00	247.0	0.18	5.88	42.33	7.20
61		19:00	20:00	1:00	12.5	0.18	15.74	156.66	9.96
62		19:00	20:00	1:00	25.0	0.18	14.67	153.59	10.47
63		19:00	20:00	1:00	58.0	0.18	13.68	138.73	10.14
64		19:00	20:00	1:00	97.5	0.18	12.91	122.90	9.52
65		19:00	20:00	1:00	247.0	0.18	10.92	100.16	9.17
66		20:00	21:00	1:00	12.5	0.18	17.19	181.32	10.55
67		20:00	21:00	1:00	25.0	0.18	14.84	162.31	10.94
68		20:00	21:00	1:00	58.0	0.18	14.34	160.66	11.20
69		20:00	21:00	1:00	97.5	0.18	13.77	139.09	10.10
70		20:00	21:00	1:00	247.0	0.18	10.43	109.77	10.52
71		21:00	23:00	2:00	12.5	0.36	23.82	243.15	10.21
72		21:00	23:00	2:00	25.0	0.36	21.47	225.69	10.51
73		21:00	23:00	2:00	58.0	0.36	22.65	207.72	9.17
74		21:00	23:00	2:00	97.5	0.36	20.96	202.24	9.65
75		21:00	23:00	2:00	247.0	0.36	18.30	160.20	8.75
76		23:00	1:00	2:00	12.5	0.36	22.69	205.32	9.05
77		23:00	1:00	2:00	25.0	0.36	21.64	171.07	7.91
78		23:00	1:00	2:00	58.0	0.36	20.20	175.11	8.67
79		23:00	1:00	2:00	97.5	0.36	19.09	147.01	7.70
80		23:00	1:00	2:00	247.0	0.36	13.16	92.31	7.02
81	16-July	1:00	3:00	2:00	12.5	0.36	19.11	150.19	7.86
82		1:00	3:00	2:00	25.0	0.36	17.62	137.73	7.82
83		1:00	3:00	2:00	58.0	0.36	18.29	141.83	7.75
84		1:00	3:00	2:00	97.5	0.36	17.64	135.61	7.69
85		1:00	3:00	2:00	247.0	0.36	15.53	113.48	7.31
86		3:00	5:00	2:00	12.5	0.36	19.54	143.03	7.32
87		3:00	5:00	2:00	25.0	0.36	18.50	130.14	7.04
88		3:00	5:00	2:00	58.0	0.36	19.25	139.53	7.25
89		3:00	5:00	2:00	97.5	0.36	18.31	133.33	7.28
90		3:00	5:00	2:00	247.0	0.36	17.33	123.11	7.10
91		5:00	6:00	1:00	12.5	0.18	19.21	139.95	7.28
92		5:00	6:00	1:00	25.0	0.18	18.55	131.51	7.09
93		5:00	6:00	1:00	58.0	0.18	18.45	133.57	7.24
94		5:00	6:00	1:00	97.5	0.18	18.41	131.25	7.13
95		5:00	6:00	1:00	247.0	0.18	16.43	114.19	6.95
96		6:00	7:00	1:00	12.5	0.18	19.92	153.94	7.73
97		6:00	7:00	1:00	25.0	0.18	18.77	127.87	6.81
98		6:00	7:00	1:00	58.0	0.18	18.89	150.61	7.97
99		6:00	7:00	1:00	97.5	0.18	18.26	144.87	7.93
100		6:00	7:00	1:00	247.0	0.18	17.69	134.72	7.62

Table 3－2 Cont'd

CHALK RIVER EXPERIMENTAL SITE (AIR)

NO.	DATE	SAMPLER START	SAMPLER STOP	SAMPLING TIME (h)	HEIGHT (cm)	SAMPLING VOLUME (m^3)	HTO CONCENTRATION (Bq/ml)	HTO CONCENTRATION (Bq/m^3)	HUMIDITY (g/m^3)
101	16-July	7:00	8:00	1:00	12.5	0.18	17.82	166.82	9.36
102		7:00	8:00	1:00	25.0	0.18	18.03	170.39	9.45
103		7:00	8:00	1:00	58.0	0.18	16.70	154.12	9.23
104		7:00	8:00	1:00	97.5	0.18	16.31	158.12	9.69
105		7:00	8:00	1:00	247.0	0.18	13.90	128.57	9.25
106		8:00	9:00	1:00	12.5	0.18	6.60	58.84	8.91
107		8:00	9:00	1:00	25.0	0.18	6.61	67.90	10.27
108		8:00	9:00	1:00	58.0	0.18	5.00	48.00	9.61
109		8:00	9:00	1:00	97.5	0.18	4.28	41.44	9.68
110		8:00	9:00	1:00	247.0	0.18	2.81	24.41	8.68
111		9:00	10:00	1:00	12.5	0.18	5.27	51.27	9.73
112		9:00	10:00	1:00	25.0	0.18	5.04	51.31	10.18
113		9:00	10:00	1:00	58.0	0.18	4.34	39.06	9.01
114		9:00	10:00	1:00	97.5	0.18	3.84	34.74	9.06
115		9:00	10:00	1:00	247.0	0.18	2.49	21.17	8.49

Table 3－3 HTO concentration in pool water at various times.

CRL SITE (POOL WATER)

DATE		HTO CONCENTRATION (Bq/ml)
15-July	10:00	70.6
	13:00	70.4
	16:00	82.6
	19:25	89.6
	23:00	39.2
16-July	3:00	37.7

Table 3－4 HTO concentration and water content of alder leaves. The sampling height of the leaves was 150 cm.

CRL SITE (PLANT)

DATE		HTO CONCENTRATION (Bq/ml)	WATER CONTENT (% of wet wt)
15-July	10:05	18.2	62.9
	11:25	23.3	63.4
	12:05	27.7	63.3
	14:00	34.2	63.5
	15:00	38.8	59.7
	16:00	42.4	57.7
	17:15	45.2	60.6
	18:00	44.4	58.4
	19:00	37.3	61.3
	20:00	34.4	62.5
	21:00	28.4	63.4
	23:00	29.8	68.5
16-July	1:00	27.9	66.9
	3:00	22.4	71.7
	5:00	24.0	72.9
	6:00	21.6	77.4
	7:00	27.1	69.8
	8:00	23.6	67.0
	9:00	27.3	63.7
	10:00	34.3	62.6

Table 3－5 HTO concentration and water content of alder leaves at different heights at 13:20 July 15, 1992.

CRL SITE (PLANT)

DATE		HEIGHT (cm)	HTO CONCENTRATION (Bq/ml)	WATER CONTENT (% of wet wt)
15-July	13:18	10	33.3	69.6
	13:22	50	27.3	69.5
	13:25	100	31.8	62.8
	13:13	180	29.7	62.3

Table 3－6 HTO concentration and water content of soil near JAERI meteorological tower at 16:30 July 14, 1992.

CRL SITE (SOIL)

DATE		DEPTH	HTO CONCENTRATION (Bq/ml)	WATER CONTENT (% of dry wt)
14-July	16:30	0- 5cm	0.41	18.7
		5-10cm	1.30	19.1
		10-15cm	11.25	19.6
		15-20cm	15.15	19.3

Table 4－1 Sampling and measuring protocol at Pickering site.

Pickering Site

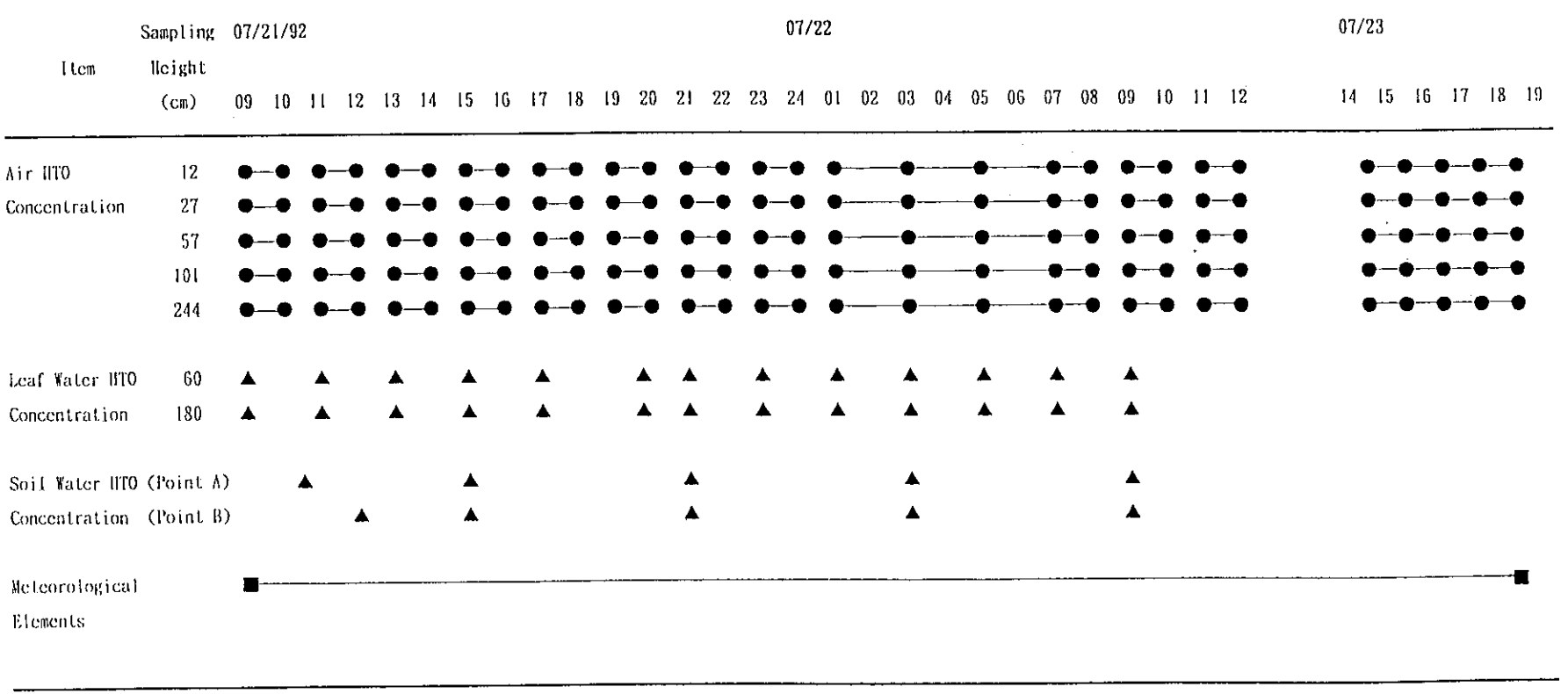


Table 4－2 HTO concentration in air and absolute humidity at different heights.

PICKERING EXPERIMENTAL SITE (AIR)

NO.	DATE	SAMPLER START	SAMPLER STOP	SAMPLING TIME (h)	HEIGHT (cm)	SAMPLING VOLUME (m^3)	HTO CONCENTRATION (Bq/ml)	HTO CONCENTRATION (Bq/m^3)	HUMIDITY (g/m^3)
1	21-July	9:00	10:00	1:00	12.0	0.18	0.25	2.10	8.41
2		9:00	10:00	1:00	27.0	0.18	0.16	1.26	8.07
3		9:00	10:00	1:00	57.0	0.18	0.18	1.44	8.13
4		9:00	10:00	1:00	101.0	0.18	0.12	0.96	7.95
5		9:00	10:00	1:00	244.0	0.18	0.14	1.06	7.72
6		11:00	12:00	1:00	12.0	0.18	0.21	1.81	8.46
7		11:00	12:00	1:00	27.0	0.18	0.14	1.13	7.91
8		11:00	12:00	1:00	57.0	0.18	0.16	1.28	8.23
9		11:00	12:00	1:00	101.0	0.18	0.13	0.97	7.72
10		11:00	12:00	1:00	244.0	0.18	0.08	0.62	7.80
11		13:00	14:00	1:00	12.0	0.18	0.18	1.56	8.77
12		13:00	14:00	1:00	27.0	0.18	0.17	1.45	8.47
13		13:00	14:00	1:00	57.0	0.18	0.33	2.89	8.63
14		13:00	14:00	1:00	101.0	0.18	0.13	1.08	8.27
15		13:00	14:00	1:00	244.0	0.18	0.10	0.80	8.28
16		15:00	16:00	1:00	12.0	0.18	0.18	1.54	8.59
17		15:00	16:00	1:00	27.0	0.18	0.20	1.62	8.08
18		15:00	16:00	1:00	57.0	0.18	0.26	2.17	8.39
19		15:00	16:00	1:00	101.0	0.18	0.13	1.02	7.82
20		15:00	16:00	1:00	244.0	0.18	0.06	0.50	7.80
21		17:00	18:00	1:00	12.0	0.18	0.20	1.61	7.89
22		17:00	18:00	1:00	27.0	0.18	0.15	1.21	8.12
23		17:00	18:00	1:00	57.0	0.18	0.16	1.32	8.22
24		17:00	18:00	1:00	101.0	0.18	0.13	1.06	8.19
25		17:00	18:00	1:00	244.0	0.18	0.10	0.78	7.86
26		19:00	20:00	1:00	12.0	0.18	0.16	1.12	7.08
27		19:00	20:00	1:00	27.0	0.18	0.13	0.90	7.12
28		19:00	20:00	1:00	57.0	0.18	0.17	1.23	7.09
29		19:00	20:00	1:00	101.0	0.18	0.10	0.73	7.01
30		19:00	20:00	1:00	244.0	0.18	0.07	0.49	7.20
31		21:00	22:00	1:00	12.0	0.18	0.32	2.40	7.54
32		21:00	22:00	1:00	27.0	0.18	0.26	1.99	7.52
33		21:00	22:00	1:00	57.0	0.18	0.32	2.52	7.88
34		21:00	22:00	1:00	101.0	0.18	0.18	1.28	7.26
35		21:00	22:00	1:00	244.0	0.18	0.11	0.80	7.39
36		23:00	0:00	1:00	12.0	0.18	0.27	1.94	7.21
37		23:00	0:00	1:00	27.0	0.18	0.18	1.33	7.19
38		23:00	0:00	1:00	57.0	0.18	0.24	1.83	7.63
39		23:00	0:00	1:00	101.0	0.18	0.13	0.97	7.19
40		23:00	0:00	1:00	244.0	0.18	0.05	0.37	7.34
41	22-July	1:00	3:00	2:00	12.0	0.36	0.22	1.37	6.27
42		1:00	3:00	2:00	27.0	0.36	0.18	1.16	6.47
43		1:00	3:00	2:00	57.0	0.36	0.15	0.97	6.57
44		1:00	3:00	2:00	101.0	0.36	0.17	1.08	6.29
45		1:00	3:00	2:00	244.0	0.36	0.17	1.14	6.52
46		3:00	5:00	2:00	12.0	0.36	0.41	2.30	5.58
47		3:00	5:00	2:00	27.0	0.36	0.37	2.03	5.48
48		3:00	5:00	2:00	57.0	0.36	0.38	2.28	6.07
49		3:00	5:00	2:00	101.0	0.36	0.31	1.71	5.54
50		3:00	5:00	2:00	244.0	0.36	0.18	1.06	5.81

Table 4－2 Cont'd

PICKERING EXPERIMENTAL SITE (AIR)

NO.	DATE	SAMPLER START	SAMPLER STOP	SAMPLING TIME (h)	HEIGHT (cm)	SAMPLING VOLUME (m^3)	HTO CONCENTRATION (Bq/ml)	HTO CONCENTRATION (Bq/m^3)	HUMIDITY (g/m^3)
51	22-July	5:00	7:00	2:00	12.0	0.36	0.29	1.81	6.20
52		5:00	7:00	2:00	27.0	0.36	0.18	1.19	6.69
53		5:00	7:00	2:00	57.0	0.36	0.22	1.52	6.79
54		5:00	7:00	2:00	101.0	0.36	0.18	1.19	6.72
55		5:00	7:00	2:00	244.0	0.36	0.10	0.69	6.71
56		7:00	8:00	1:00	12.0	0.18	0.17	1.46	8.87
57		7:00	8:00	1:00	27.0	0.18	0.14	1.22	8.84
58		7:00	8:00	1:00	57.0	0.18	0.12	1.11	9.54
59		7:00	8:00	1:00	101.0	0.18	0.09	0.81	9.09
60		7:00	8:00	1:00	244.0	0.18	0.13	1.18	9.19
61		9:00	10:00	1:00	12.0	0.18	0.20	1.75	8.62
62		9:00	10:00	1:00	27.0	0.18	0.18	1.27	7.04
63		9:00	10:00	1:00	57.0	0.18	0.16	1.51	9.36
64		9:00	10:00	1:00	101.0	0.18	0.12	1.09	9.12
65		9:00	10:00	1:00	244.0	0.18	0.14	1.17	8.27
66		11:00	12:00	1:00	12.0	0.18	0.14	1.23	8.66
67		11:00	12:00	1:00	27.0	0.18	0.08	0.70	8.61
68		11:00	12:00	1:00	57.0	0.18	0.12	1.00	8.48
69		11:00	12:00	1:00	101.0	0.18	0.09	0.74	7.86
70		11:00	12:00	1:00	244.0	0.18	0.06	0.49	7.94
71	23-July	14:20	15:20	1:00	12.0	0.18	0.06	0.68	11.83
72		14:20	15:20	1:00	27.0	0.18	0.03	0.37	11.72
73		14:20	15:20	1:00	57.0	0.18	N.D.	N.D.	11.67
74		14:20	15:20	1:00	101.0	0.18	0.10	1.17	11.17
75		14:20	15:20	1:00	244.0	0.18	0.05	0.55	11.28
76		15:30	16:30	1:00	12.0	0.18	0.07	0.87	12.00
77		15:30	16:30	1:00	27.0	0.18	0.06	0.74	11.33
78		15:30	16:30	1:00	57.0	0.18	0.06	0.56	10.00
79		15:30	16:30	1:00	101.0	0.18	N.D.	N.D.	9.94
80		15:30	16:30	1:00	244.0	0.18	N.D.	N.D.	10.83
81		16:40	17:40	1:00	12.0	0.18	0.13	1.45	11.00
82		16:40	17:40	1:00	27.0	0.18	0.09	1.19	12.89
83		16:40	17:40	1:00	57.0	0.18	0.07	0.88	12.56
84		16:40	17:40	1:00	101.0	0.18	0.07	0.80	11.83
85		16:40	17:40	1:00	244.0	0.18	0.05	0.64	11.83
86		17:50	18:50	1:00	12.0	0.18	0.23	2.89	12.61
87		17:50	18:50	1:00	27.0	0.18	0.19	2.35	12.39
88		17:50	18:50	1:00	57.0	0.18	0.27	2.56	9.61
89		17:50	18:50	1:00	101.0	0.18	0.19	2.18	11.44
90		17:50	18:50	1:00	244.0	0.18	0.17	1.93	11.33

* N.D: Not detected.

Table 4－3 HTO concentration and water content of hawthorn leaves. The sampling heights of the leaves were 60 and 180 cm.

PICKERING SITE (PLANT)

DATE		HTO CONCENTRATION at 60cm (Bq/ml)	WATER CONTENT (% of wet wt)	HTO CONCENTRATION at 180cm (Bq/ml)	WATER CONTENT (% of wet wt)
21-July	9:00	1.09	53.7	0.98	55.8
	11:00	1.15	54.4	0.97	54.0
	13:00	1.15	52.5	0.99	54.2
	15:00	0.90	58.6	1.04	54.8
	17:00	1.02	55.4	0.90	55.1
	19:44	1.18	56.7	0.89	54.2
	21:00	0.98	55.5	0.91	54.3
	23:00	0.89	57.9	0.84	55.3
22-July	1:00	0.85	58.9	0.71	55.8
	3:00	0.95	56.7	0.84	56.1
	5:00	0.88	55.5	0.91	53.0
	7:00	0.78	55.3	0.76	54.8
	9:00	1.13	53.3	0.83	54.7

Table 4－4(a) HTO concentration and water content in soil at point A.

PICKERING SITE (SOIL, POINT A)

DATE		HTO CONCENTRATION (Bq/ml)				WATER CONTENT (% of dry wt)			
		0- 5cm	5-10cm	10-15cm	15-20cm	0- 5cm	5-10cm	10-15cm	15-20cm
21-July	10:30	0.64	0.62	0.72	-	57.8	53.4	45.7	-
	15:00	0.87	0.83	0.83	1.10	75.9	58.6	50.5	41.2
	21:00	0.52	0.59	0.74	1.20	72.5	48.4	42.7	38.0
22-July	3:00	0.60	0.61	0.75	1.09	70.4	57.2	43.5	40.7
	9:00	0.72	0.61	0.66	1.02	64.3	53.9	44.1	39.7

Table 4－4(b) HTO concentration and water content in soil at point B.

PICKERING SITE (SOIL, POINT B)

DATE		HTO CONCENTRATION (Bq/ml)				WATER CONTENT (% of dry wt)			
		0- 5cm	5-10cm	10-15cm	15-20cm	0- 5cm	5-10cm	10-15cm	15-20cm
21-July	11:50	0.50	0.73	0.69	-	73.3	47.3	42.6	-
	15:00	0.64	0.75	1.03	1.36	66.4	52.2	42.5	38.4
	21:00	0.80	0.68	0.88	1.10	55.1	52.8	40.2	31.4
22-July	3:00	0.70	0.67	0.88	1.15	58.0	55.5	45.3	34.8
	9:00	0.68	0.71	0.90	1.04	58.9	48.9	38.0	33.0

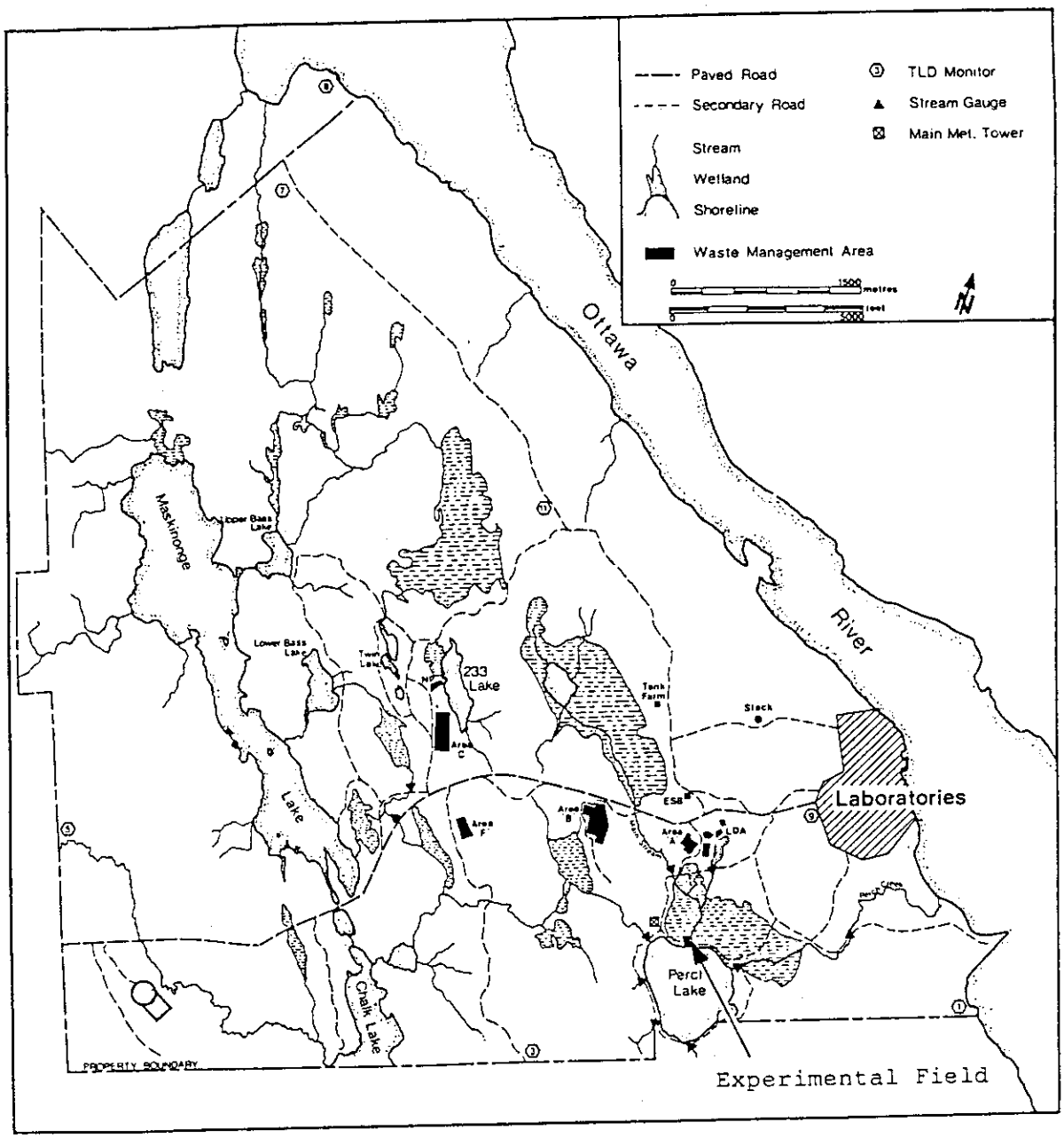


Fig. 3－1 Aerial view of CRL experismental site.

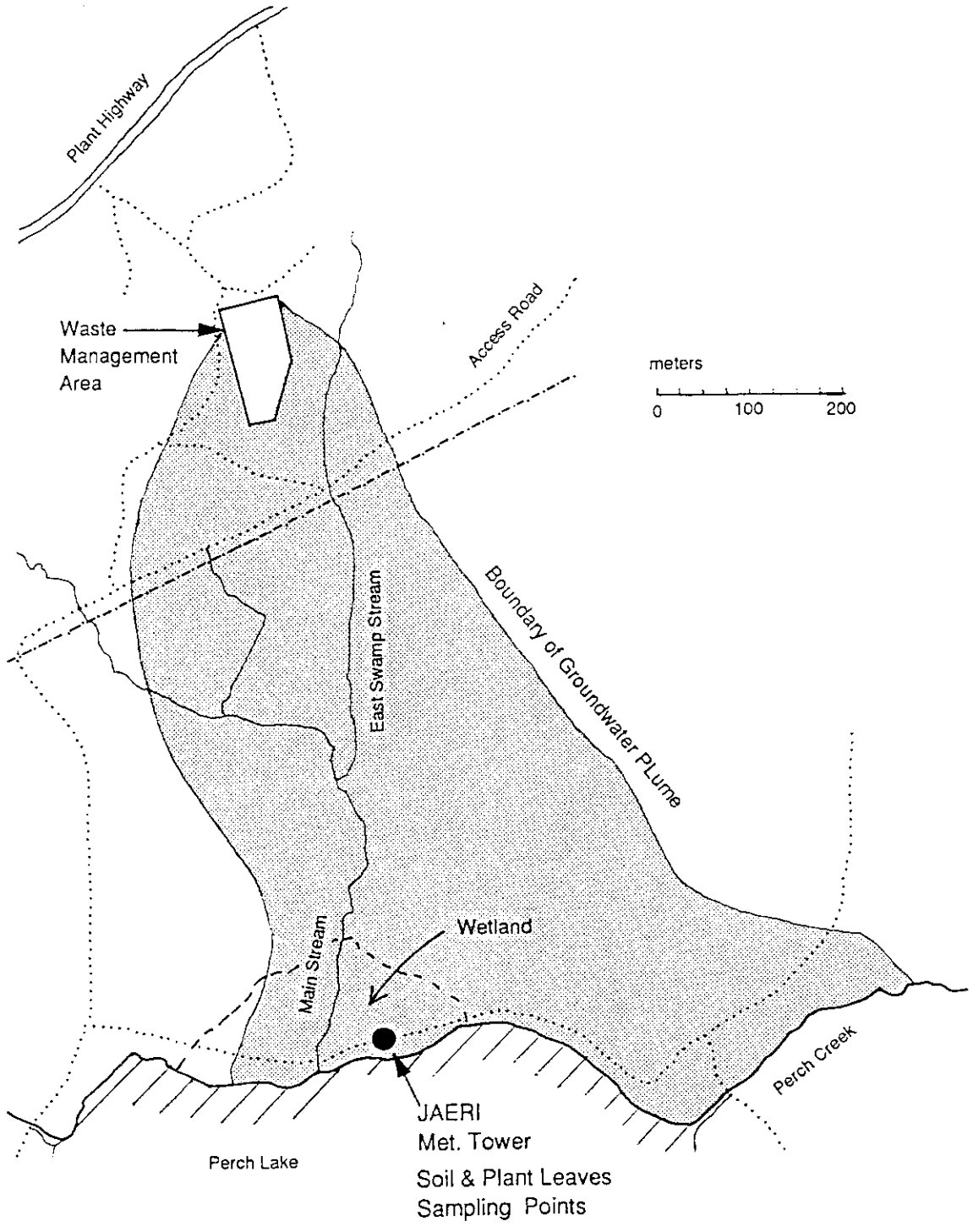
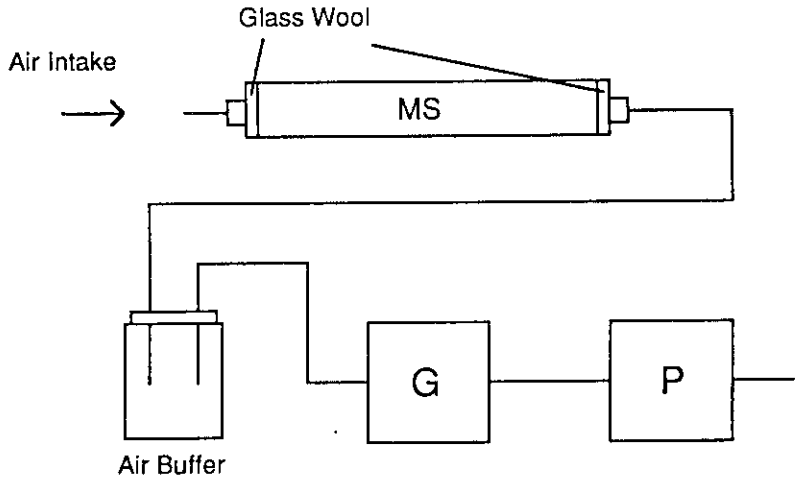


Fig. 3－2 Layout of CRL experimental field. Location of JAERI meteorological tower and sampling points.



MS : Molecular Sieves 4A
Air Buffer : 100 mL Plastic Bottle
G : Digital Gas Meter
P : Mini Pump with Flow Meter

Fig. 3－3 Scheme of HTO air sampler with M.S. 4A column.

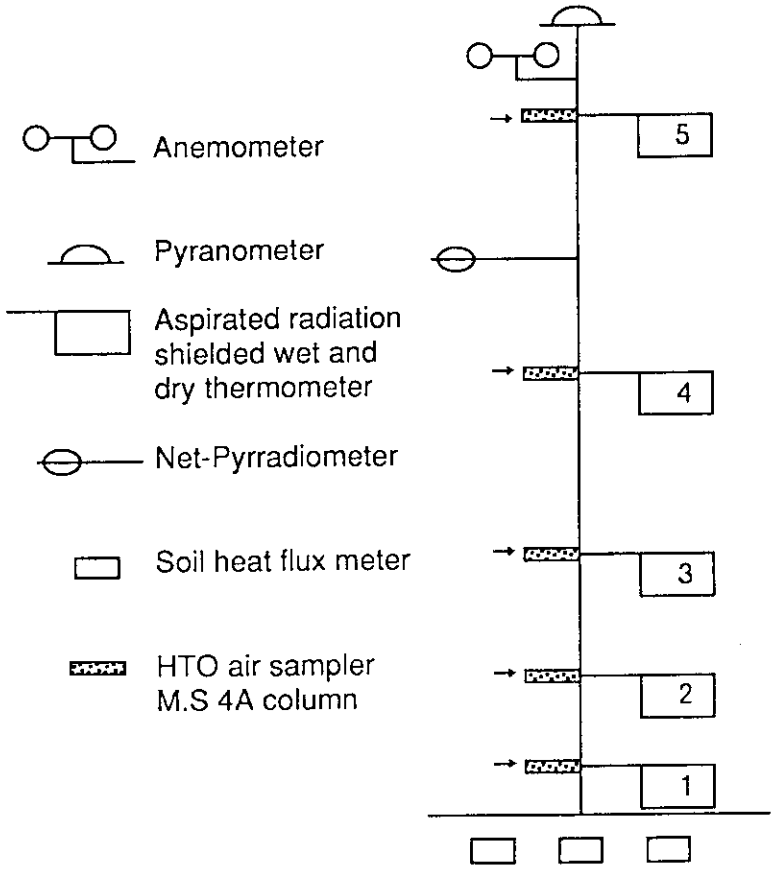


Fig. 3－4 Set-up of JAERI meteorological tower.

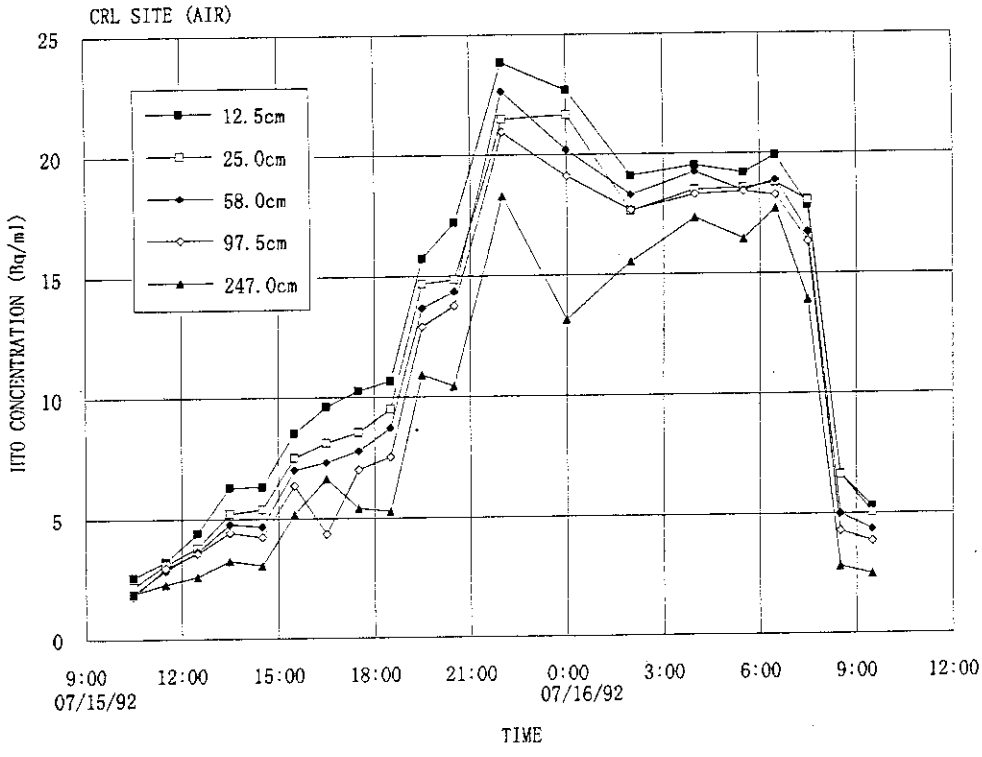


Fig. 3－5 Time histories of HTO air concentration at different heights (in Bq／ml) .

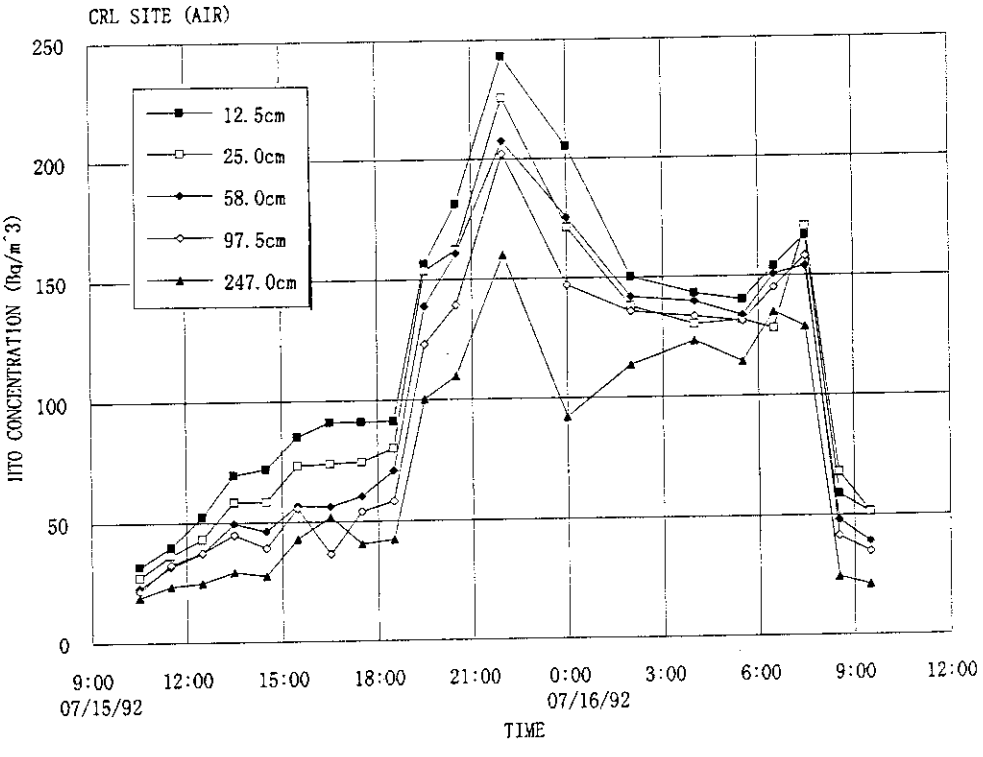


Fig. 3－6 Time histories of HTO air concentration at different heights (in Bq／m^3) .

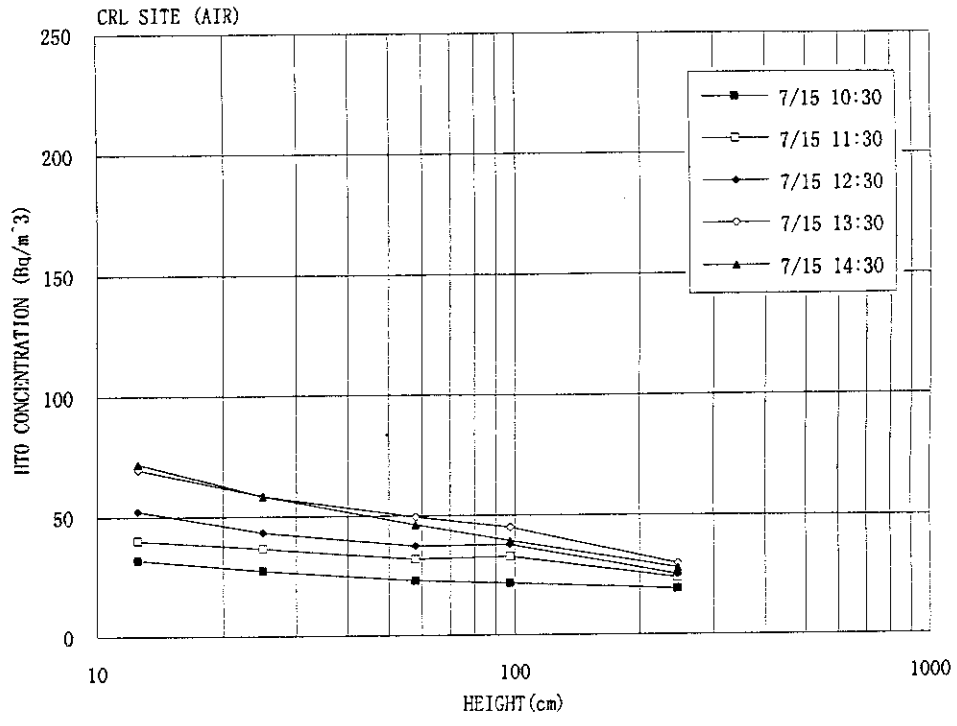


Fig. 3－7(a) Vertical profiles of HTO air concentration at various times (in Bq／m³) (from 10:30 July 15 to 14:30 July 15) .

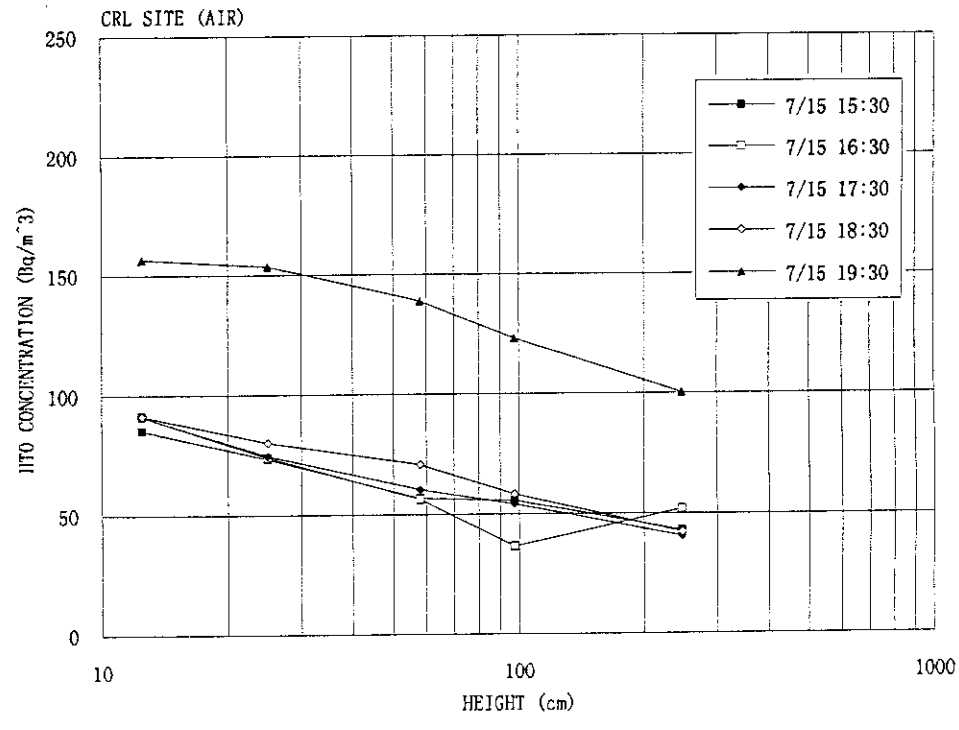


Fig. 3－7(b) Vertical profiles of HTO air concentration at various times (in Bq／m³) (from 15:30 July 15 to 19:30 July 15) .

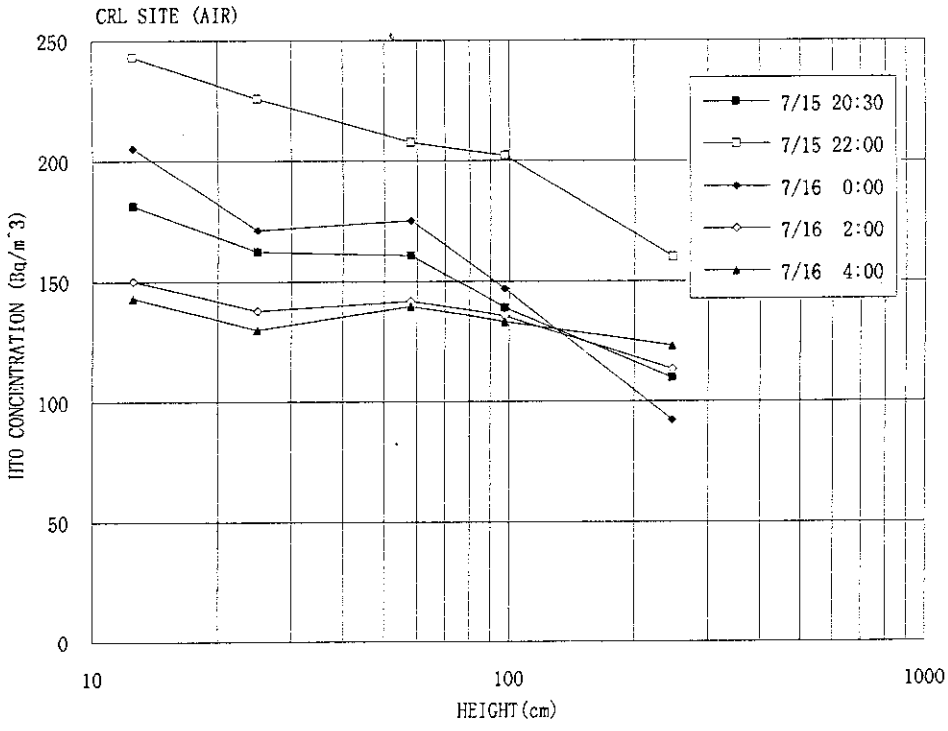


Fig. 3－7(c) Vertical profiles of HTO air concentration at various times (in Bq／m³) (from 20:30 July 15 to 4:00 July 16).

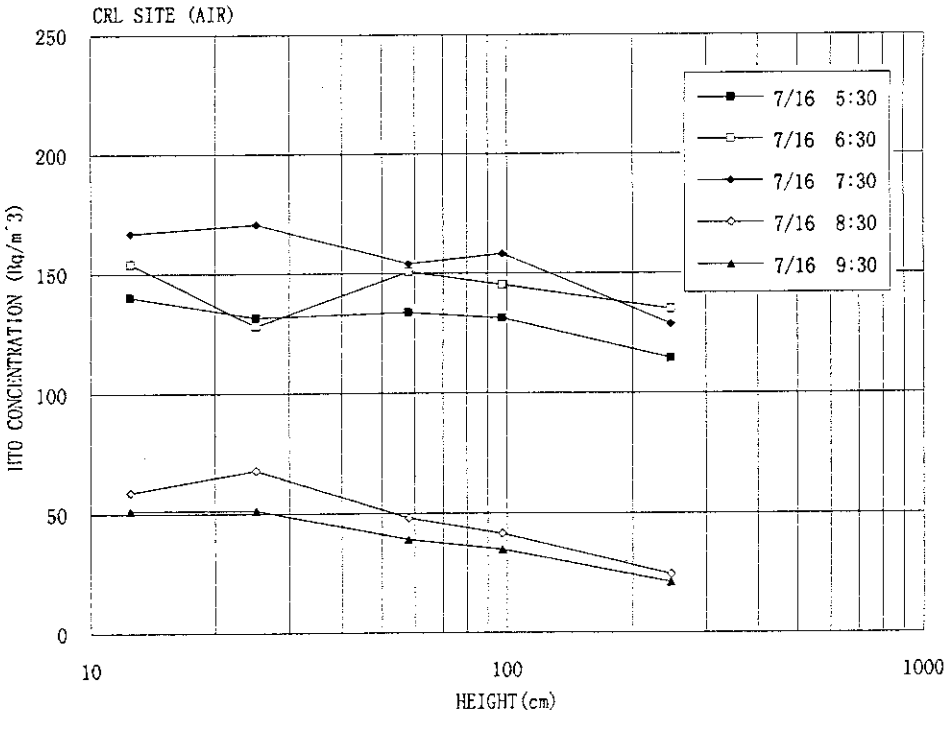


Fig. 3－7(d) Vertical profiles of HTO air concentration at various times (in Bq／m³) (from 5:30 July 16 to 9:30 July 16).

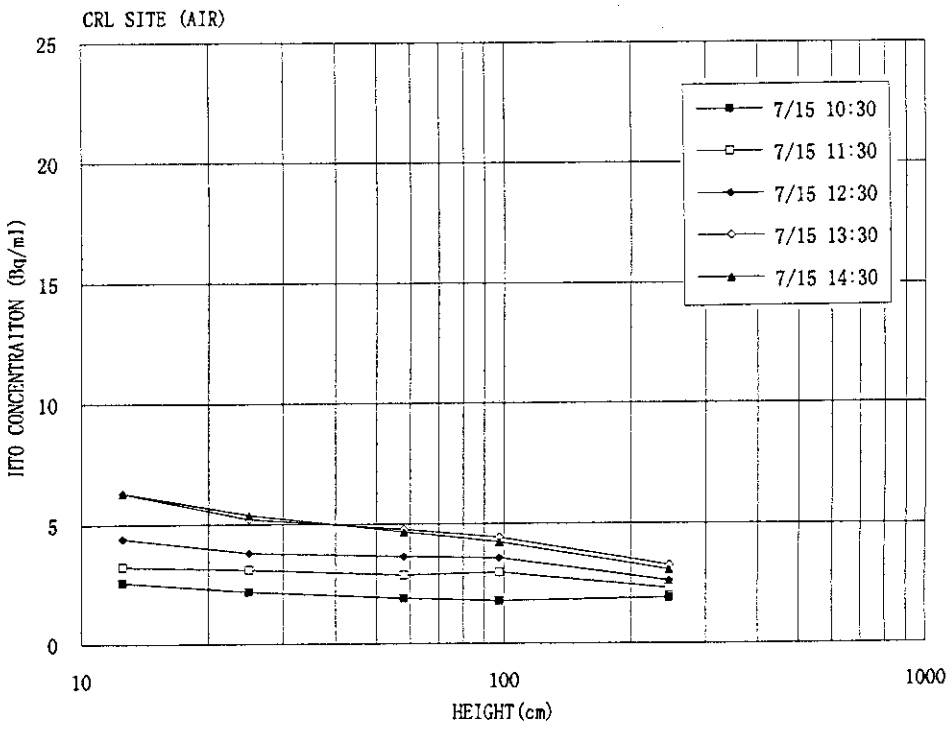


Fig. 3－8(a) Vertical profiles of HTO air concentration at various times (in Bq／ml) (from 10:30 July 15 to 14:30 July 15) .

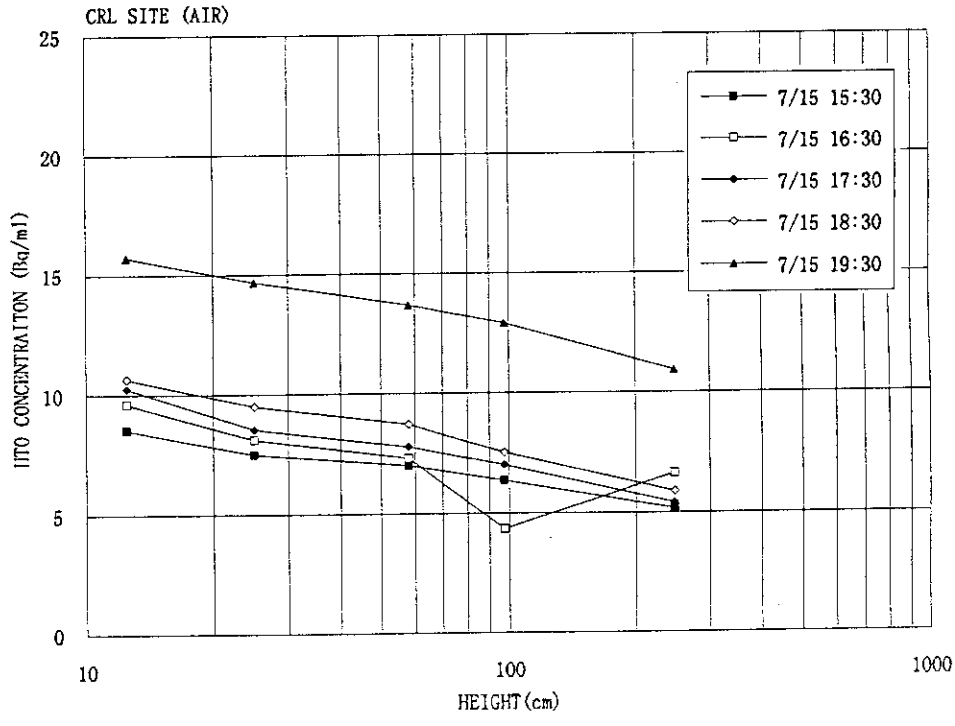


Fig. 3－8(b) Vertical profiles of HTO air concentration at various times (in Bq／ml) (from 15:30 July 15 to 19:30 July 15) .

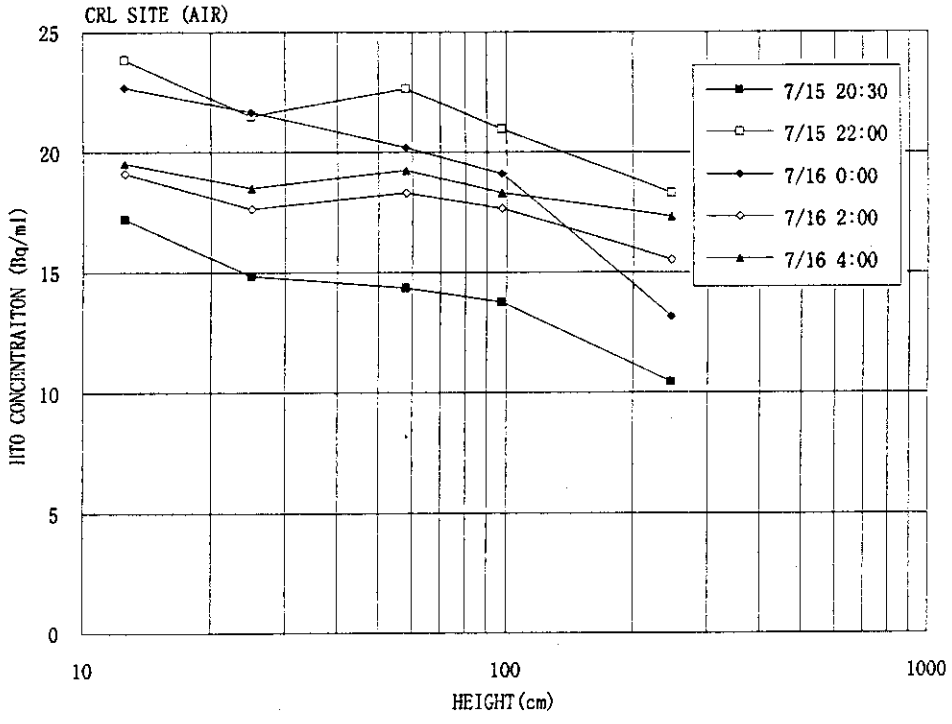


Fig. 3－8(c) Vertical profiles of HTO air concentration at various times (in Bq／ml) (from 20:30 July 15 to 4:00 July 16) .

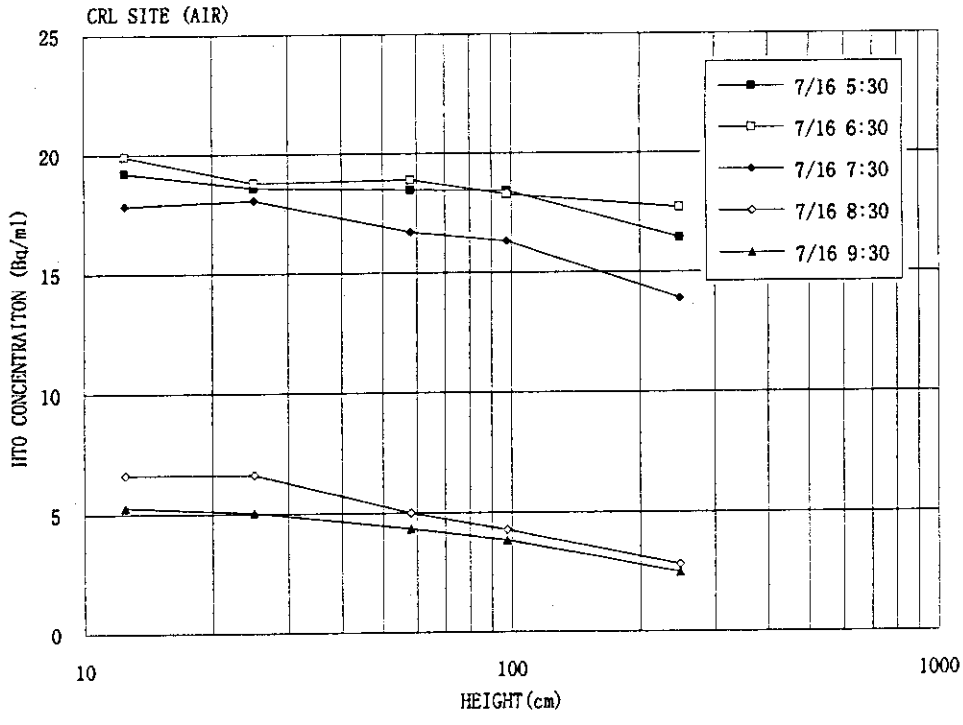


Fig. 3－8(d) Vertical profiles of HTO air concentration at various times (in Bq／ml) (from 5:30 July 16 to 9:30 July 16) .

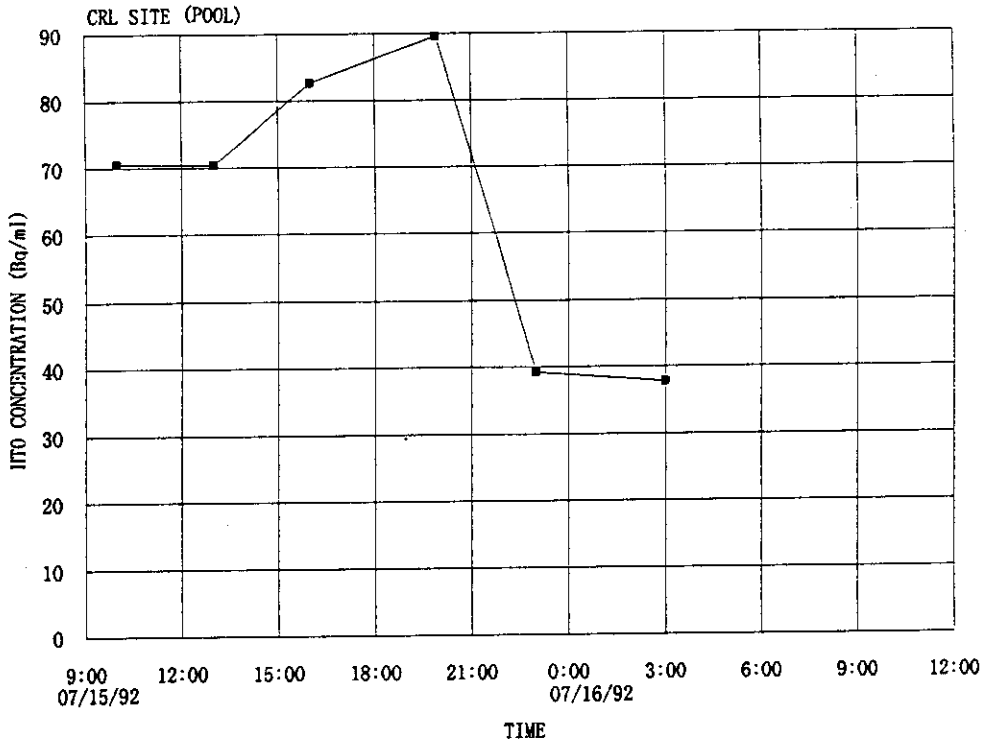


Fig. 3－9 Short-term variation of pool water HTO concentration.

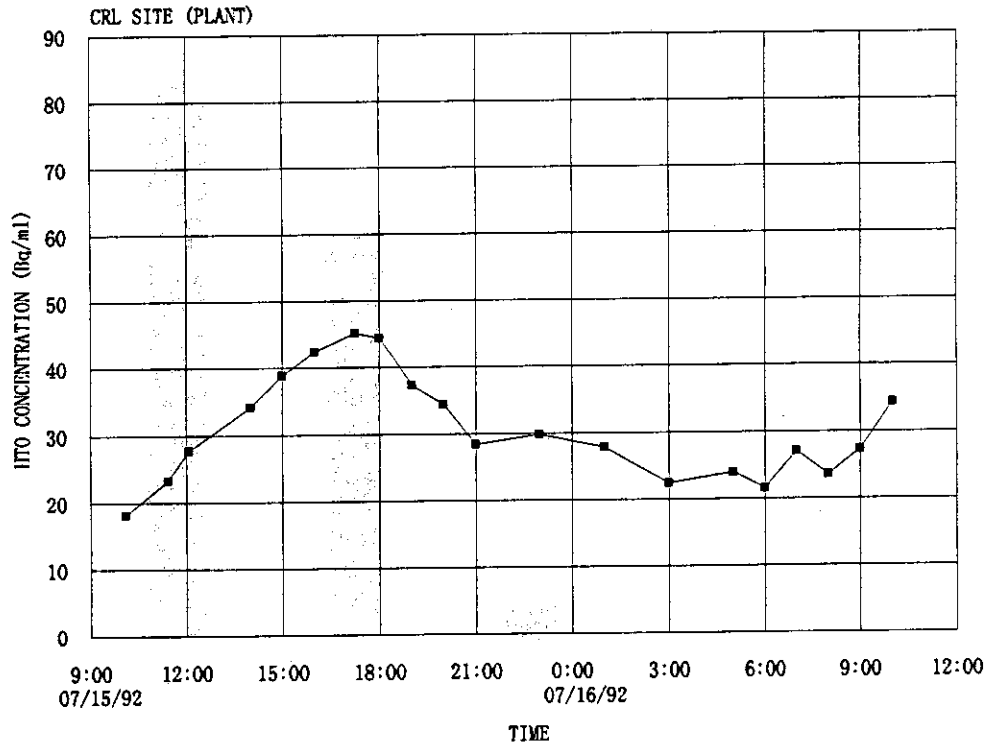


Fig. 3－10 Short-term variation of alder leaf HTO concentration. The leaves growing at the edge of the wetland were collected at 150 cm height.

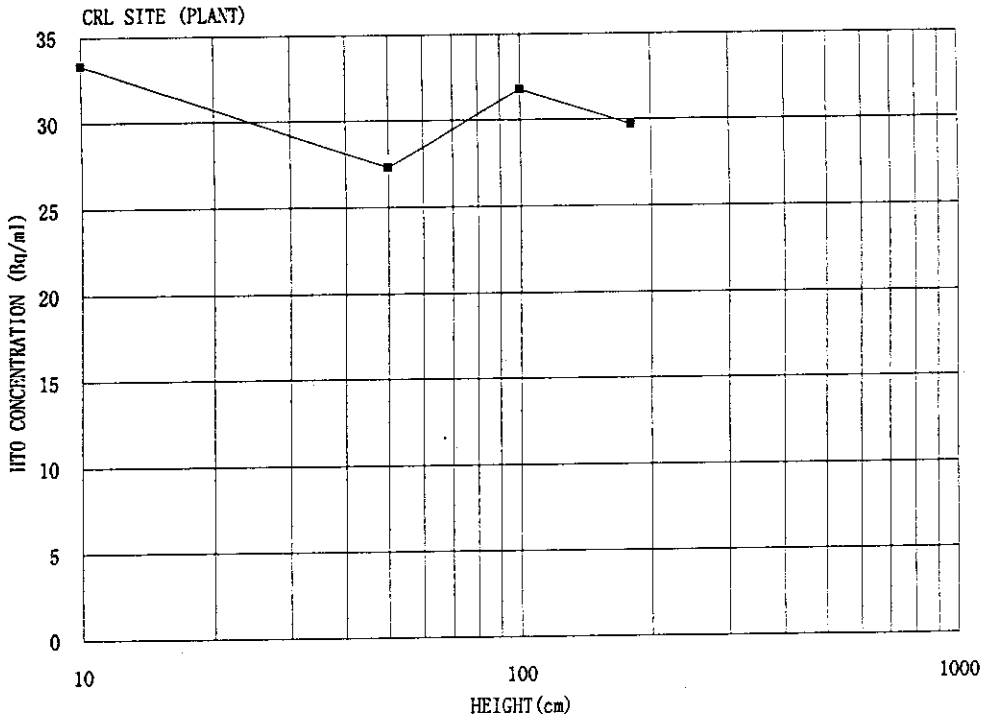


Fig. 3－11 Height profile of alder leaf HTO concentration at 13:20 July 15, 1992.

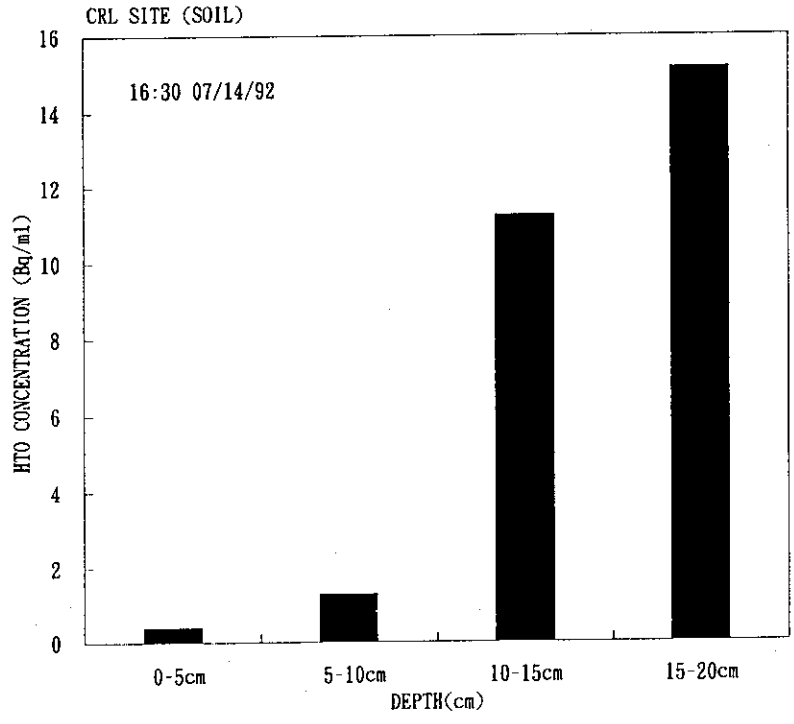


Fig. 3－12 HTO soil depth profile at 16:30 July 14, 1992.

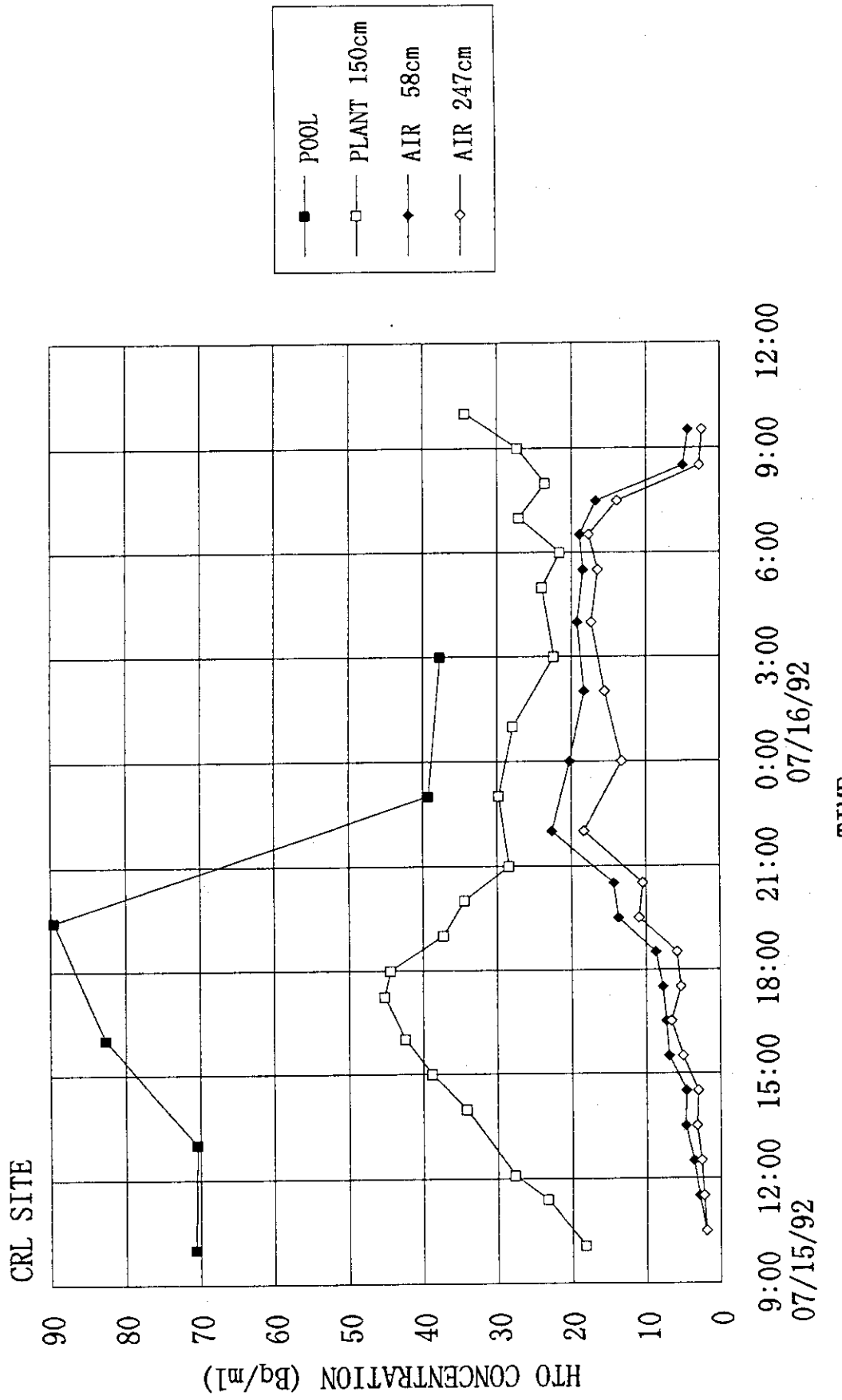


Fig. 3－13 Comparison of HTO concentrations in air (at 58 and 247 cm heights), plant leaves (alder, at 150 cm height) and pool water.

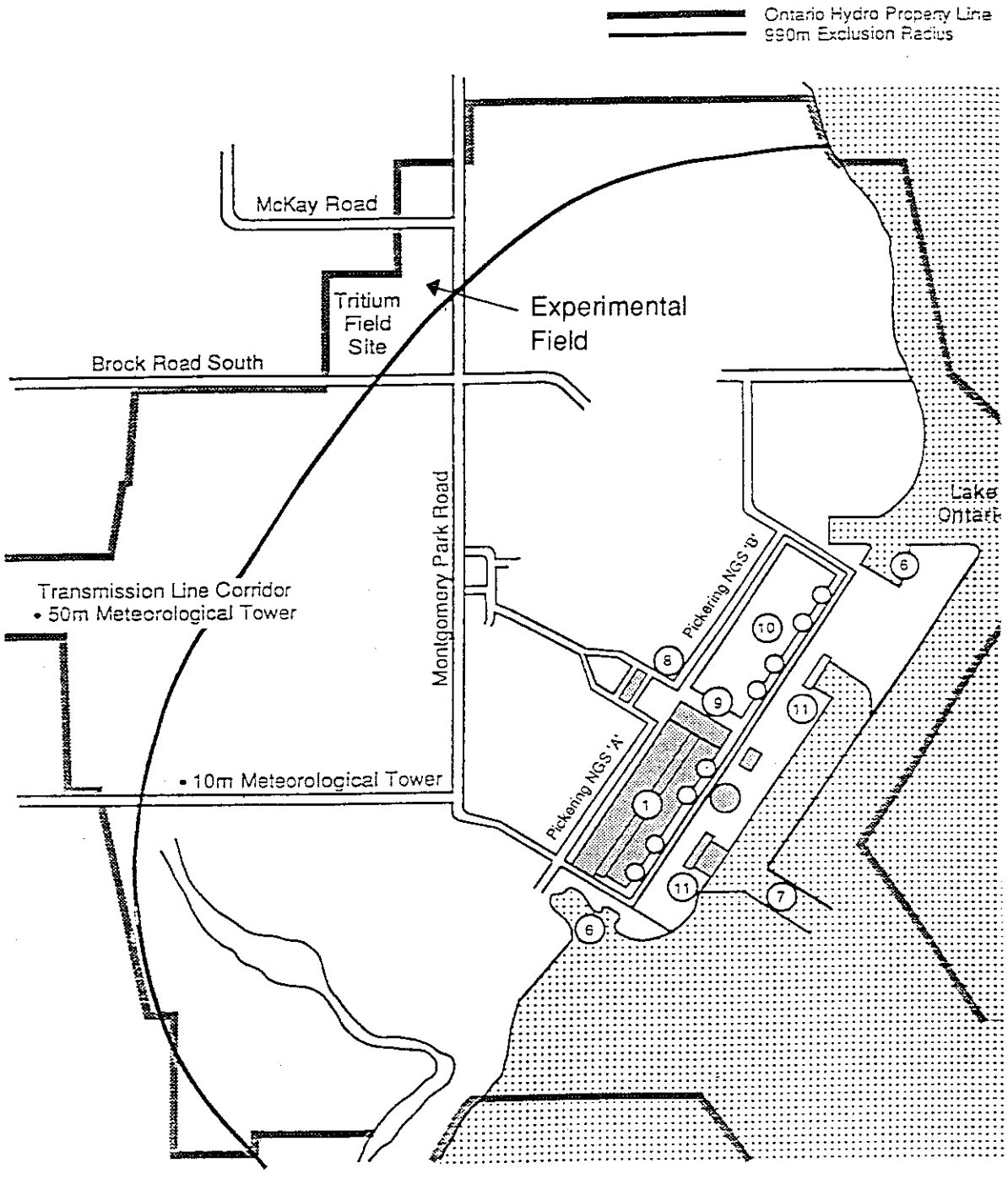


Fig. 4－1 Aerial view of Pickering experimental site.

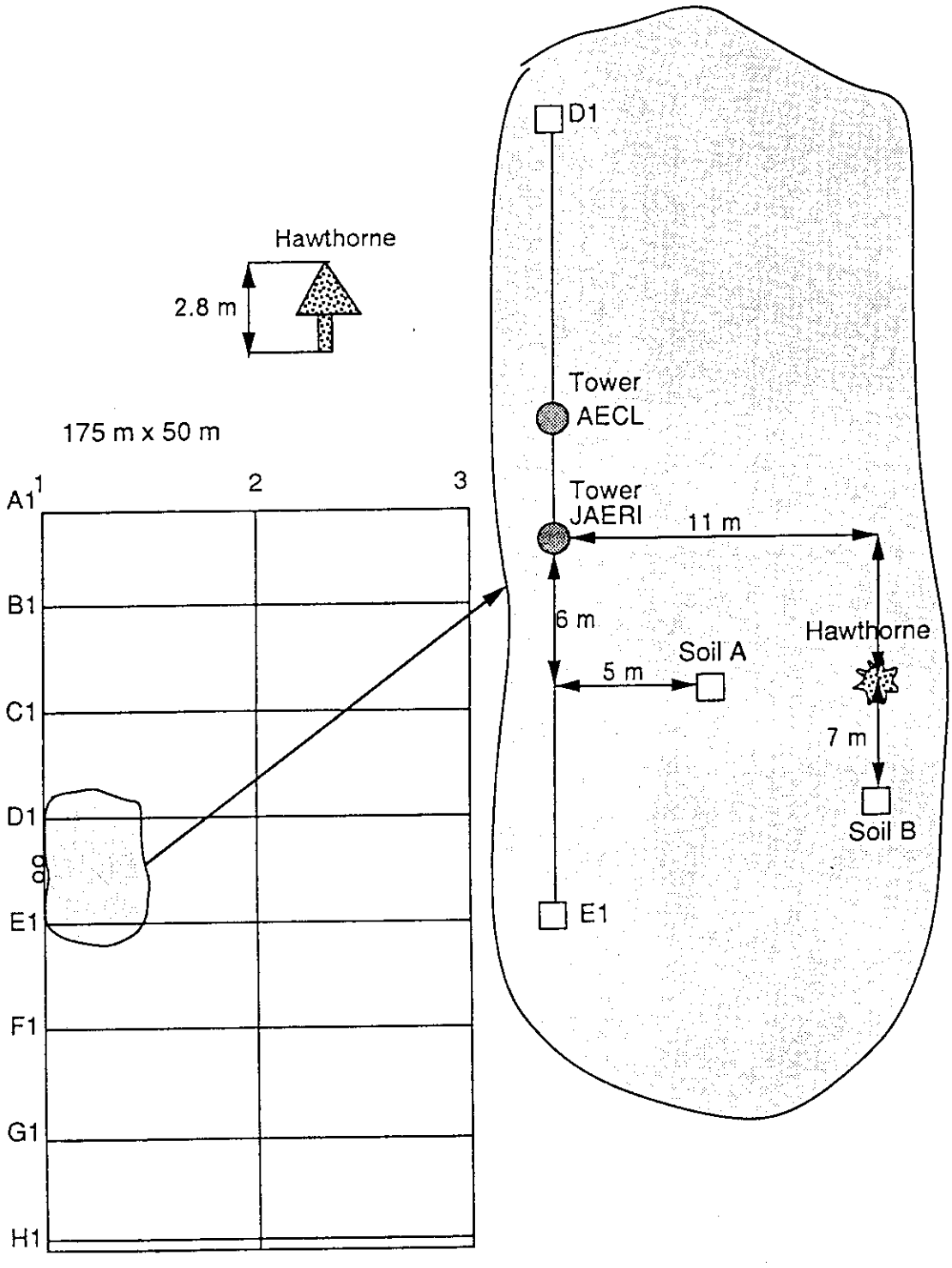


Fig. 4－2 Layout of Pickering experimental field. Location of JAERI meteorological tower and sampling points.

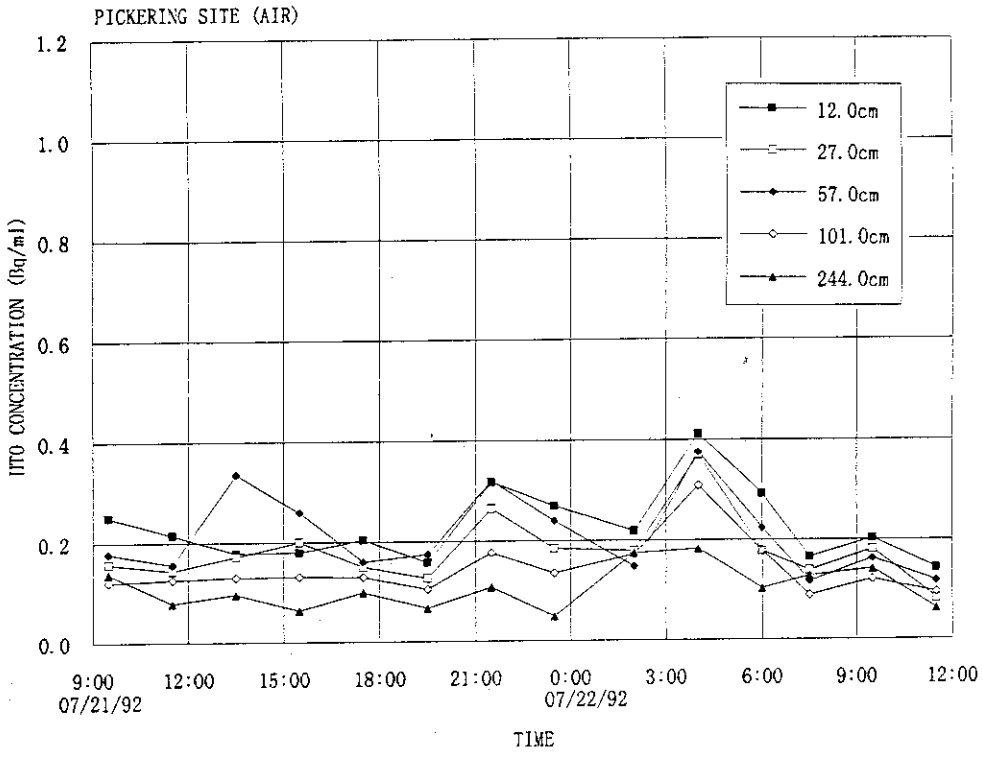


Fig. 4－3 Time histories of HTO air concentration at different heights (in Bq／ml).

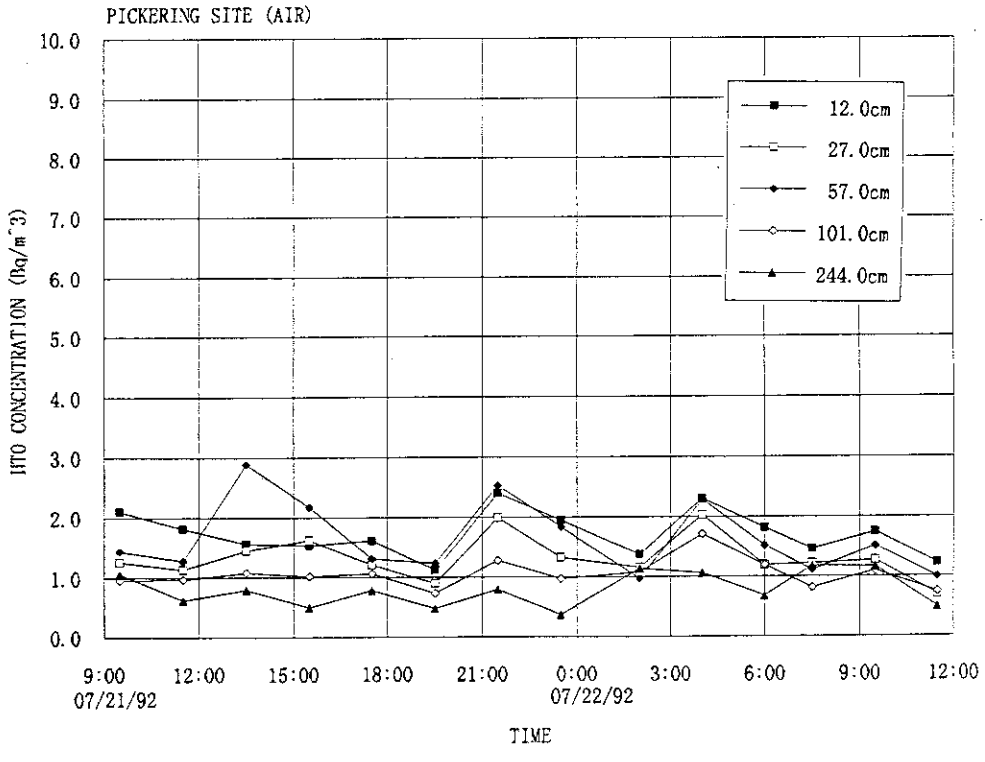


Fig. 4－4 Time histories of HTO air concentration at different heights (in Bq／m^3).

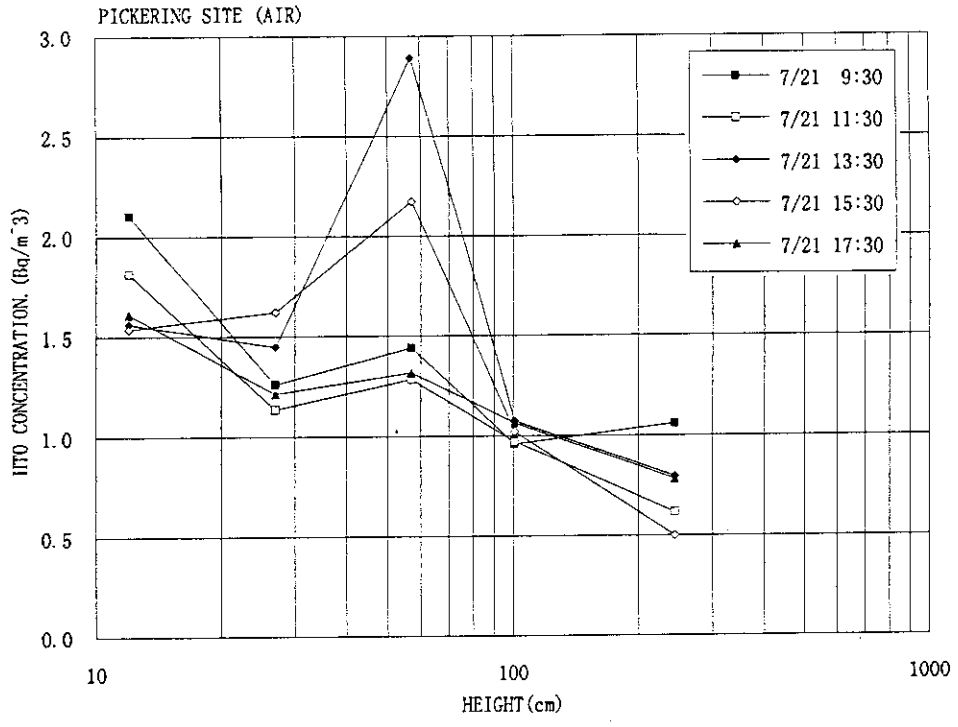


Fig. 4－5(a) Vertical profiles of HTO air concentration at various times (in Bq／m³) (from 9:30 July 21 to 17:30 July 21) .

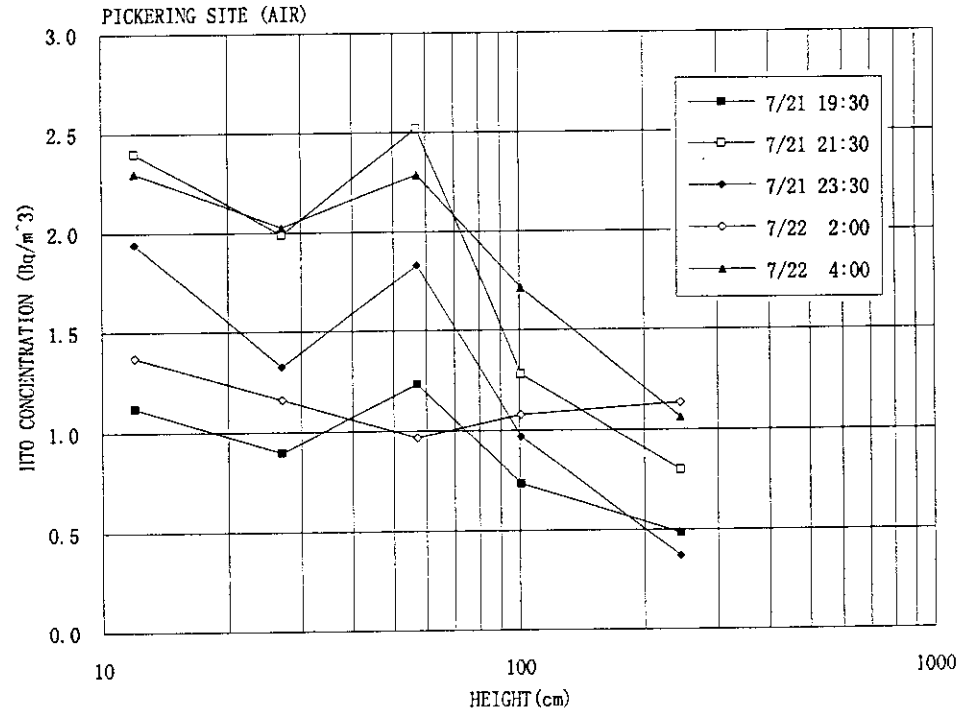


Fig. 4－5(b) Vertical profiles of HTO air concentration at various times (in Bq／m³) (from 19:30 July 21 to 4:00 July 22) .

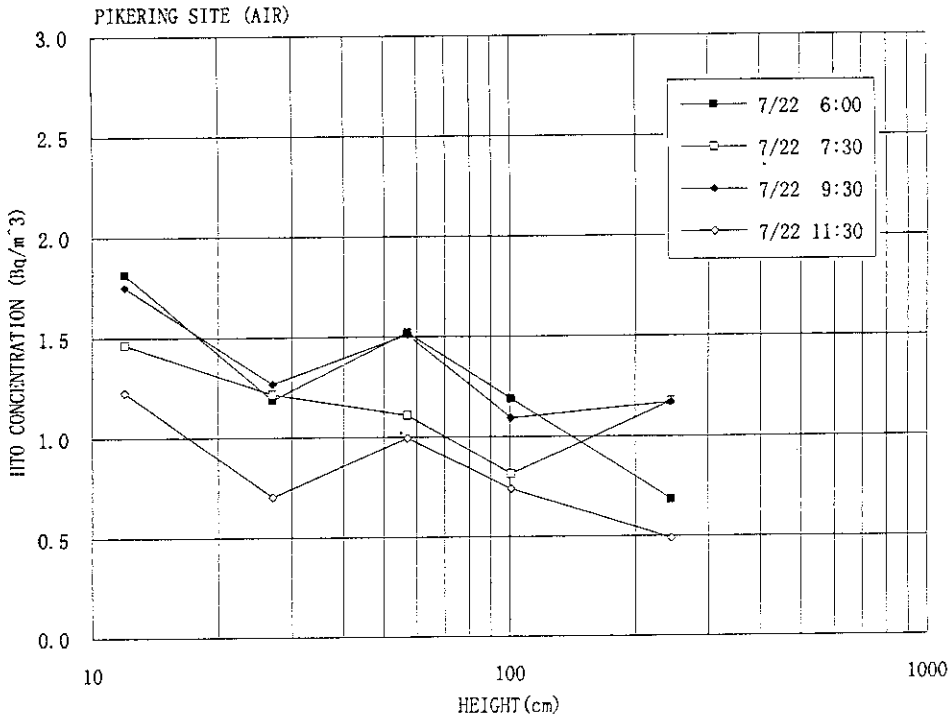


Fig. 4－5(c) Vertical profiles of HTO air concentration at various times (in Bq／m^3) (from 6:00 July 22 to 11:30 July 22) .

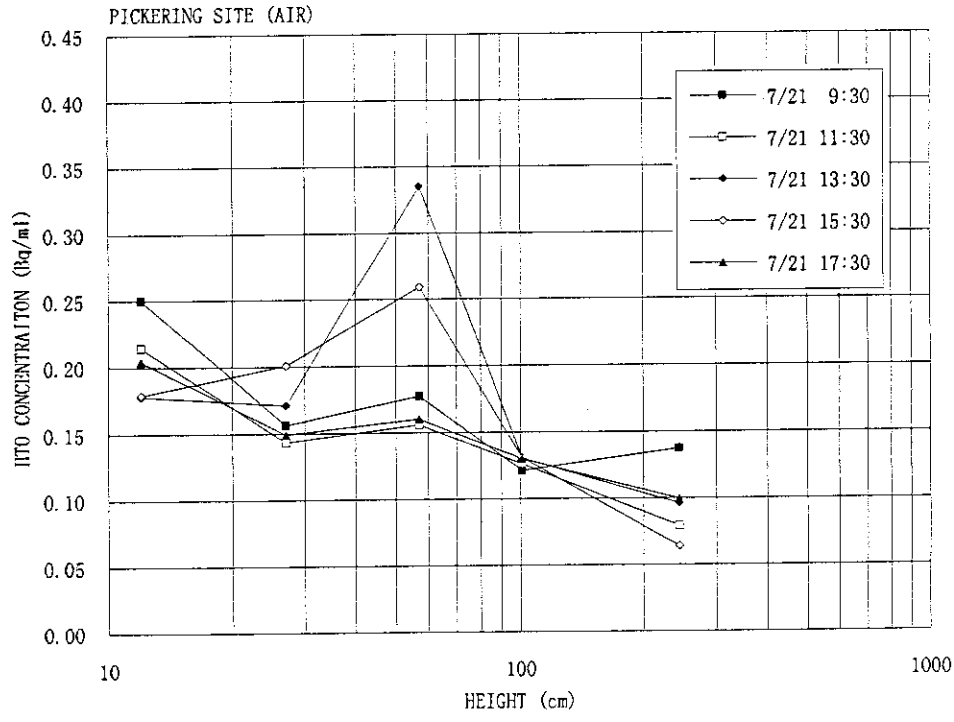


Fig. 4－6(a) Vertical profiles of HTO air concentration at various times (in Bq／ml) (from 9:30 July 21 to 17:30 July 21) .

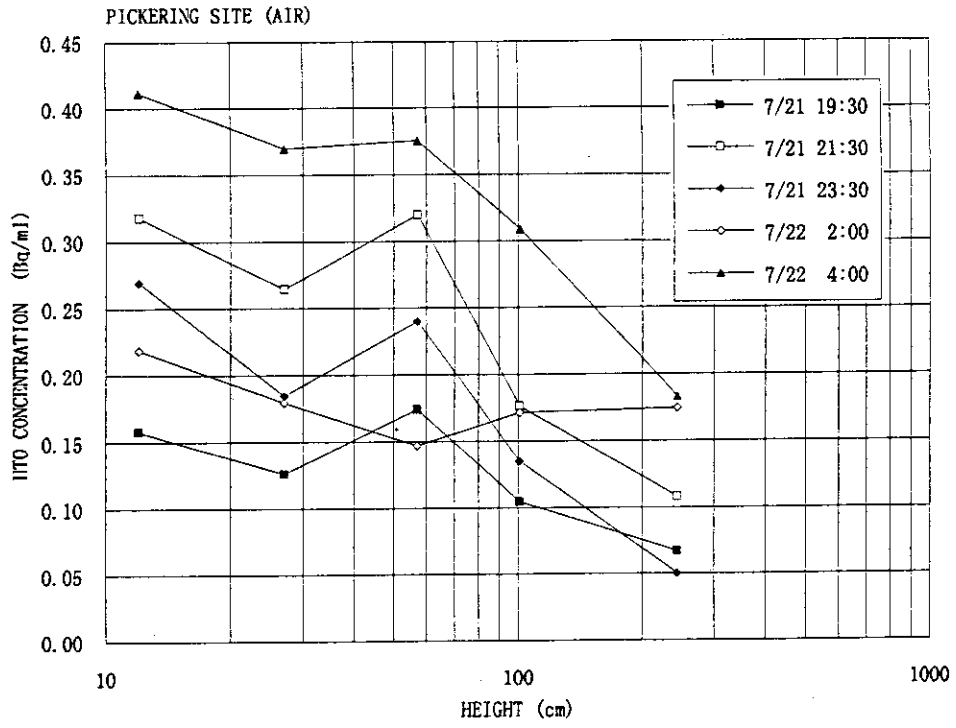


Fig. 4－6(b) Vertical profiles of HTO air concentration at various times (in Bq／ml) (from 19:30 July 21 to 4:00 July 22) .

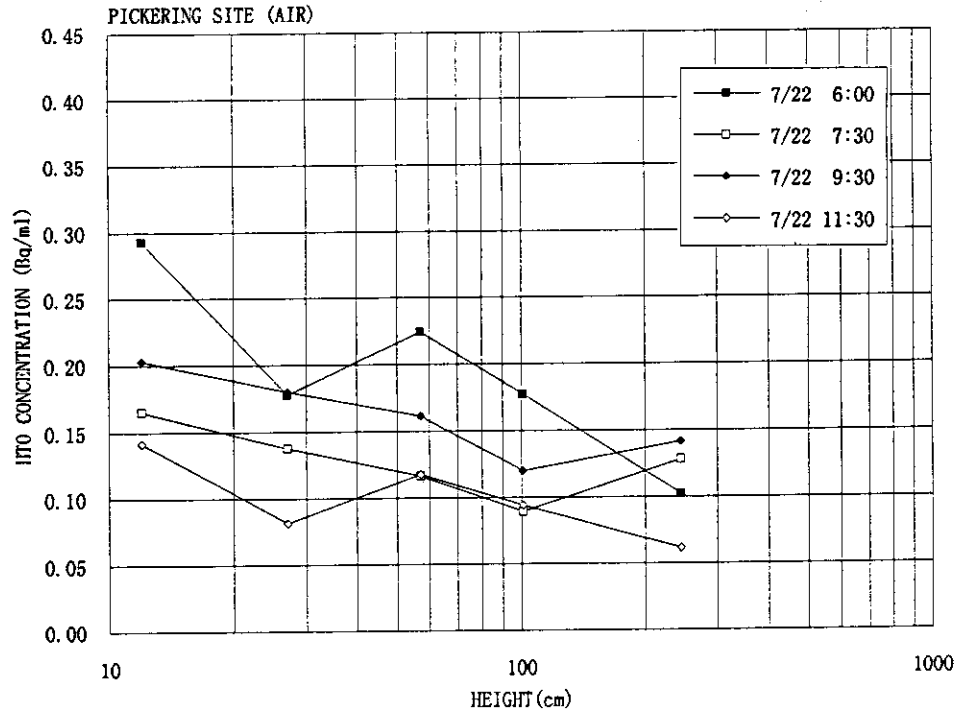


Fig. 4－6(c) Vertical profiles of HTO air concentration at various times (in Bq／ml) (from 6:00 July 22 to 11:30 July 22) .

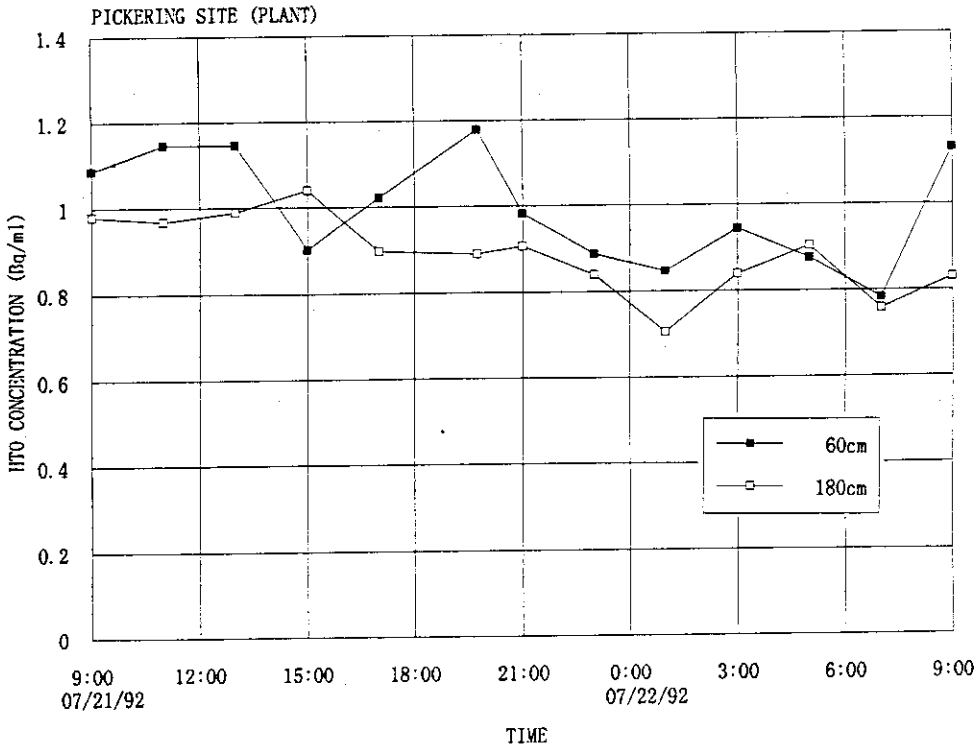


Fig. 4－7 Short-term variation of hawthorn leaf HTO concentration. The leaves were collected at 60 and 180 cm heights.

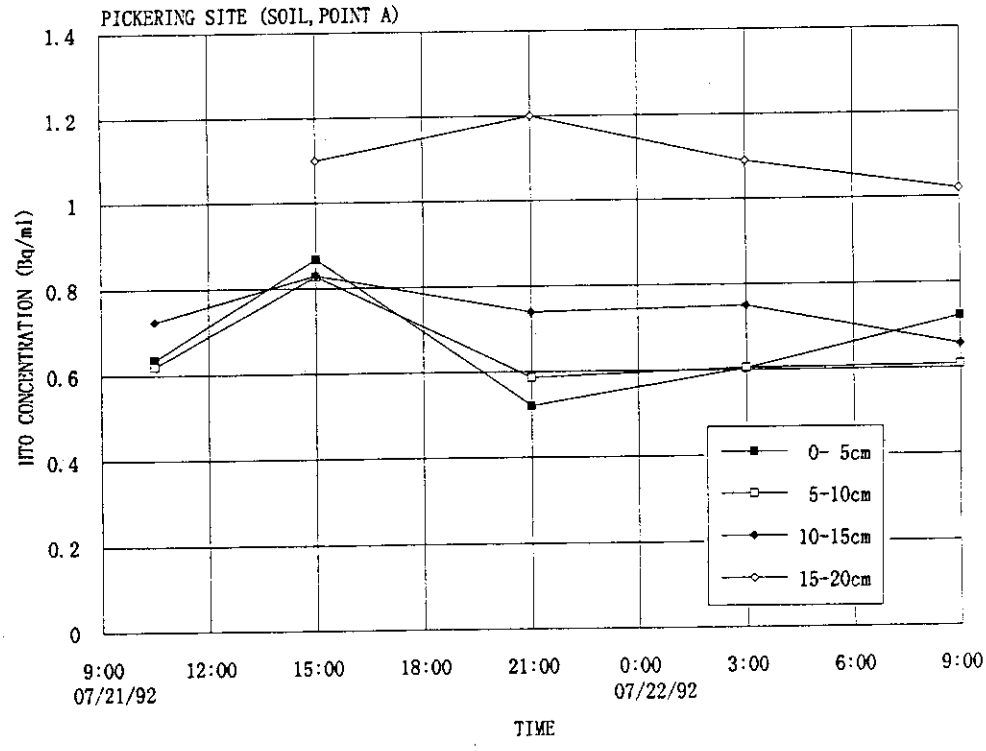


Fig. 4－8(a) Time history of soil HTO depth profile at point A.

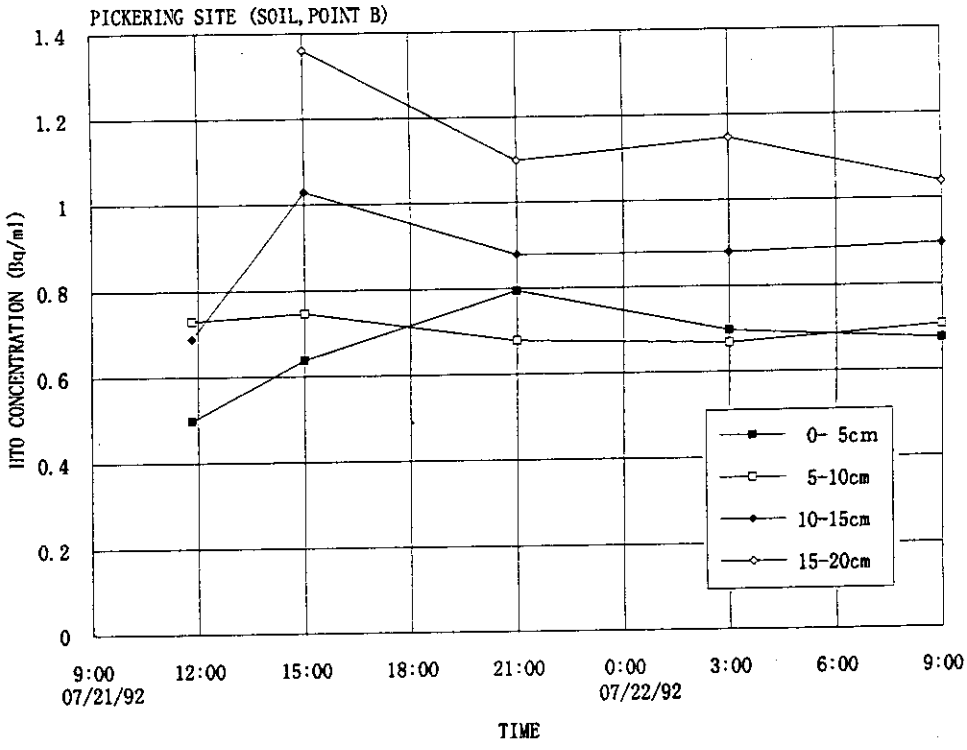


Fig. 4－8(b) Time history of soil HTO depth profile at point B.

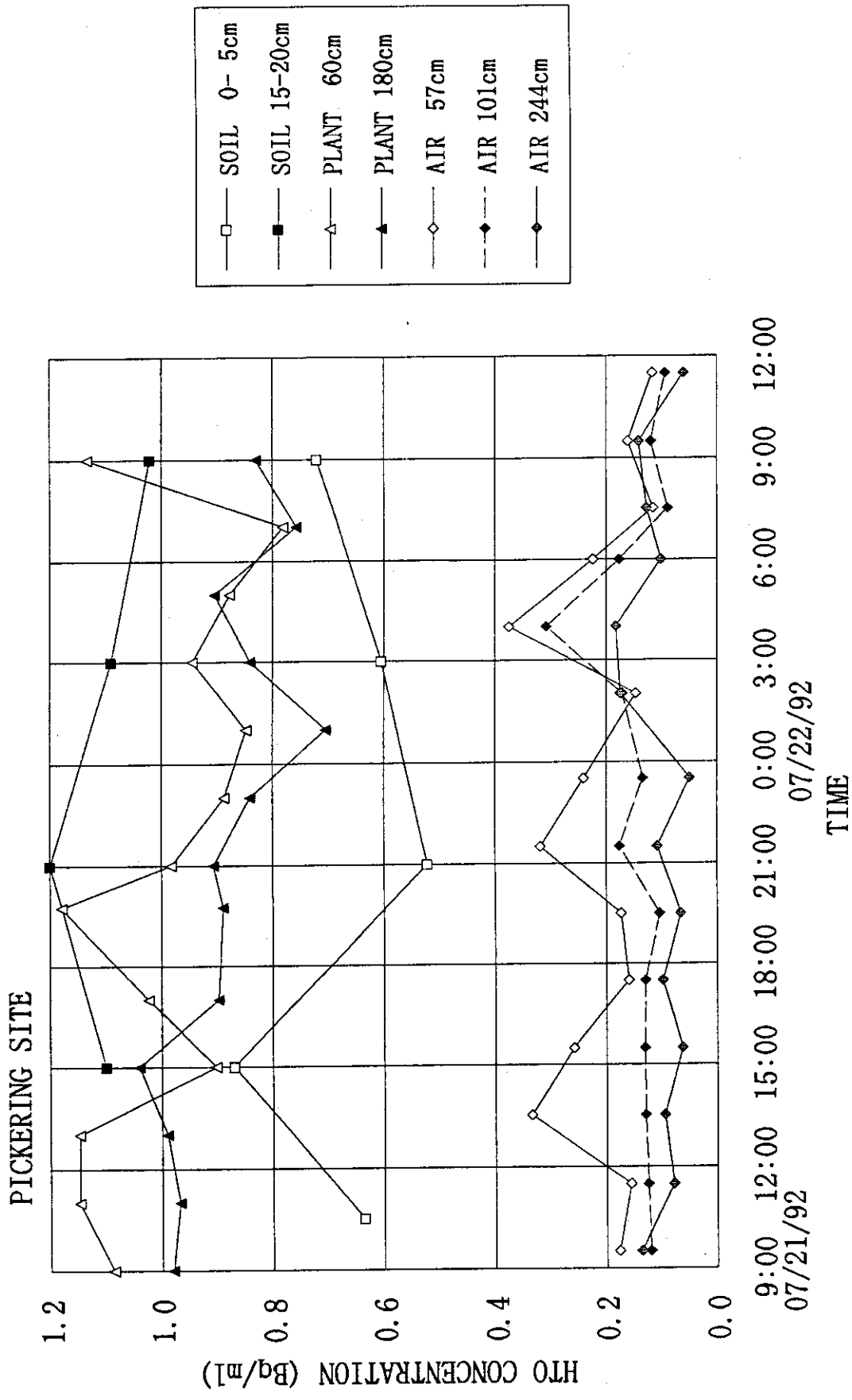


Fig. 4－9 Comparison of HTO concentrations in air (at 57, 101 and 244 cm heights), plant leaves (hawthorn, at 60 and 80 cm heights) and soil water (0－5 and 15－20 cm layers at point A).

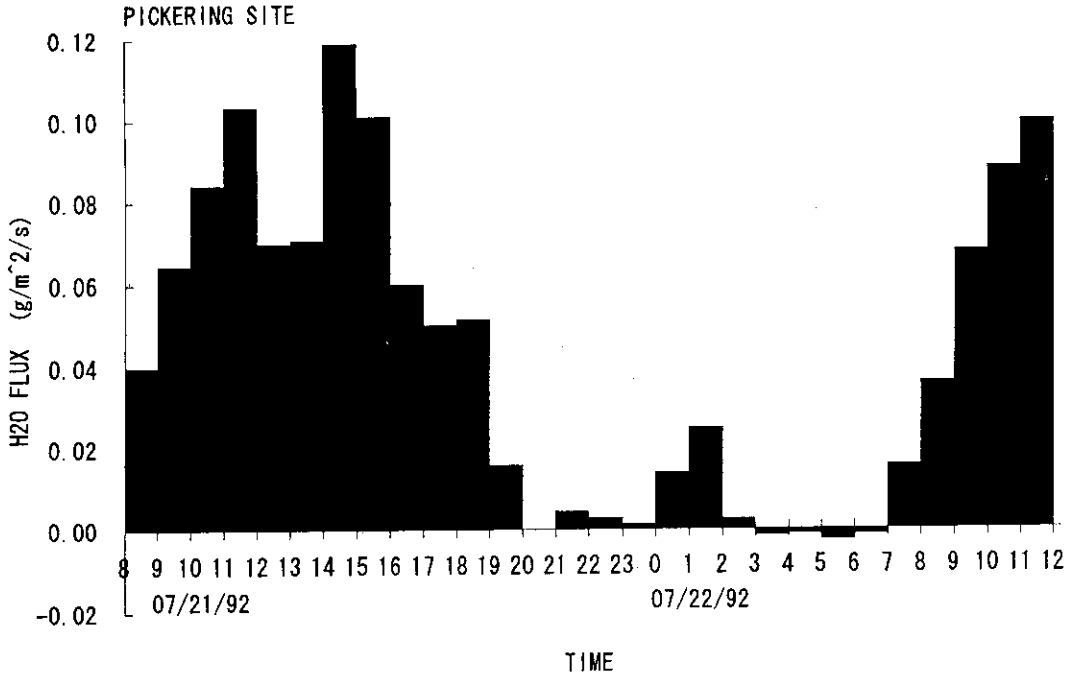


Fig. 5－1 Variation of evaluated bulk water vapor flux with time around JAERI tower.

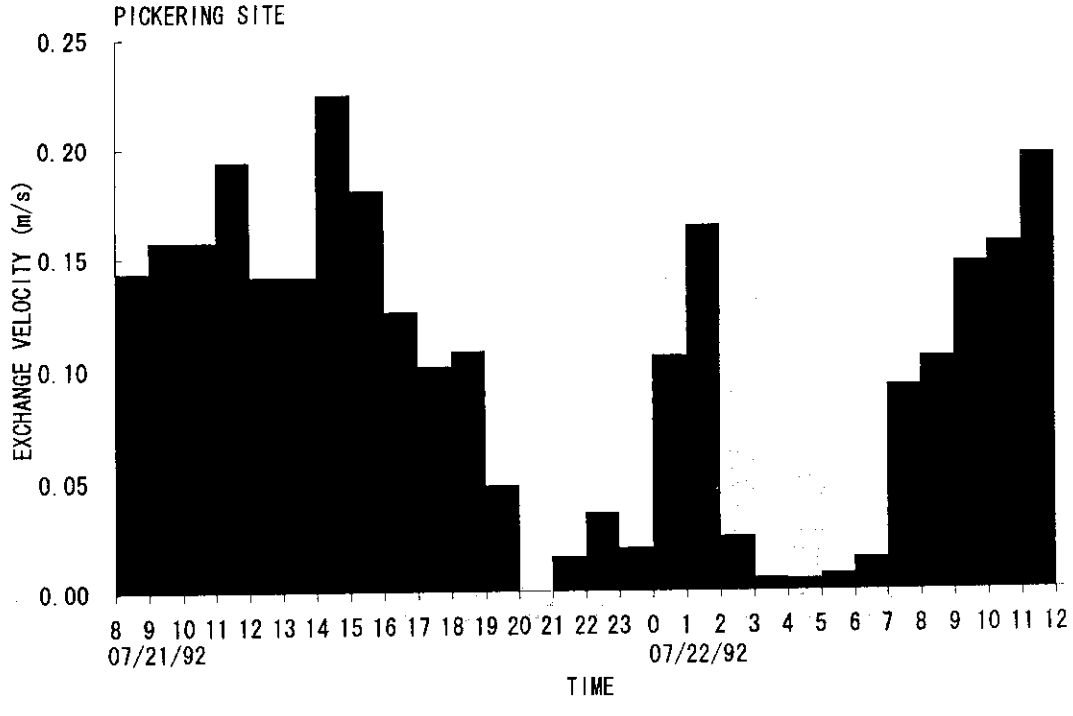


Fig. 5－2 Evaluated exchange velocity of water vapor between surfaces (at 57 cm: soil+vegetation height) and the atmosphere (at 244 cm).

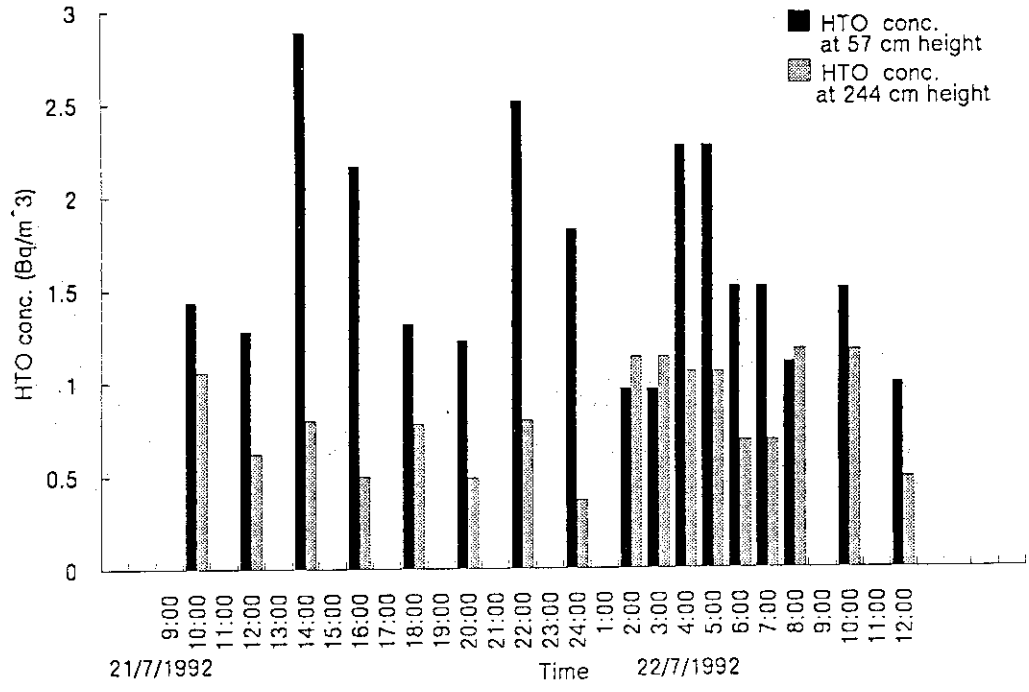


Fig. 5-3 Air HTO concentration difference between 57 and 244 cm heights.

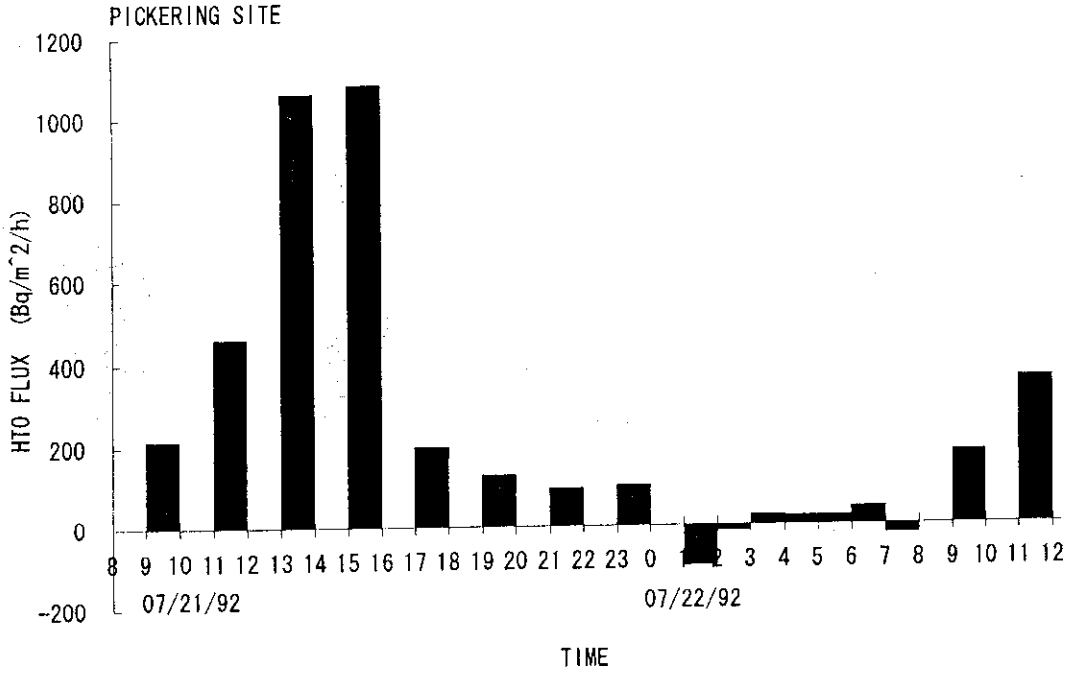


Fig. 5-4 Variation of evaluated HTO flux between surfaces (at 57 cm: soil+vegetation height) and the atmosphere (at 244 cm).

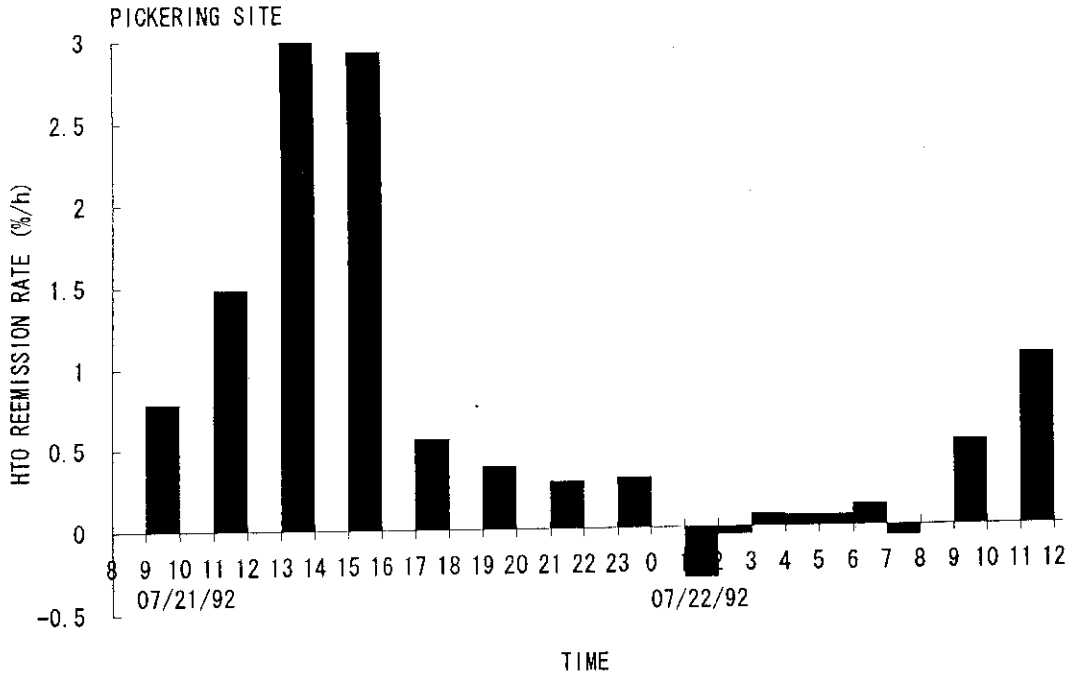


Fig. 5－5 Evaluated loss rate (reemission rate) of HTO in soil (0－15 cm) at Pickering filed.

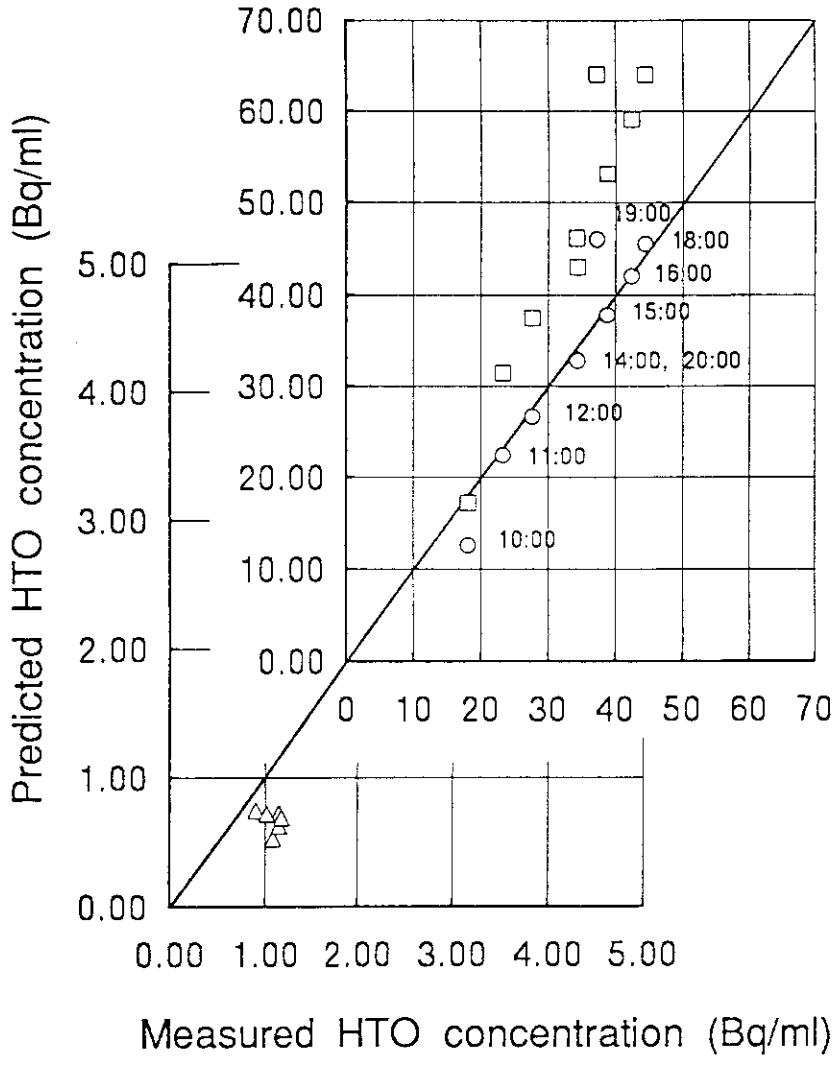


Fig. 5－6 Comparison of leaf HTO concentrations between measured and predicted ones.
□=Alder leaves at 150 cm height (CRL field) ; the soil water HTO concentrations are assumed to be the same as those of the pool water. ○=Alder leaves at 150 cm height; the soil water HTO concentrations are assumed to be 0.7 times those of the pool water.
△=Hawthorn leaves at 60 cm height (Pickering field) .

APPENDIX A Meteorological Data at the CRL Site (Tables and Figures)

In Appendix A, tables and figures on the meteorological measurements at the CRL field are summarized. They are solar radiation and net-radiation intensities*, wind speed*, absolute and relative humidities*, dry and wet air temperatures* at five different heights, temperatures of pool water* and soil, soil heat fluxes at the ground surface and 3 cm underground* , evapo-transpiration rate*, Boen ratio and energy balance. The superscript* attached indicates that the corresponding values are averaged over 60 minutes.

List of Tables and Figures in Appendix A (CRL site data)

Table A－1 Absolute and relative humidities measured with aspirated radiation shielded dry and wet thermometers.

CHALK RIVER EXPERIMENTAL SITE

NO	DATE	START	STOP	ABSOLUTE HUMIDITY (g/m^3)					RELATIVE HUMIDITY (%)				
				at 12.5cm	at 25cm	at 58cm	at 97.5cm	at 247cm	at 12.5cm	at 25cm	at 58cm	at 97.5cm	at 247cm
1	15-July	10:00	11:00	14.21	13.64	12.80	12.63	12.25	74.1	75.1	73.2	72.9	71.6
2		11:00	12:00	13.35	12.84	11.79	11.46	10.87	62.5	62.4	59.4	58.1	56.4
3		12:00	13:00	13.19	12.55	11.66	11.28	10.51	56.5	56.2	54.0	52.8	50.7
4		13:00	14:00	12.89	12.21	11.38	10.94	10.21	52.9	52.1	50.1	48.9	47.1
5		14:00	15:00	12.72	11.92	10.91	10.37	9.68	46.9	46.4	44.7	43.6	42.3
6		15:00	16:00	12.07	11.19	10.22	9.68	9.02	44.2	43.3	41.2	39.9	38.4
7		16:00	17:00	11.20	10.45	9.62	9.07	8.38	42.6	41.1	39.1	37.5	35.6
8		17:00	18:00	10.76	9.96	9.21	8.76	8.14	41.8	39.9	37.7	36.2	34.5
9		18:00	19:00	10.16	9.54	8.85	8.28	7.75	43.7	40.7	38.0	35.6	34.0
10		19:00	20:00	11.86	10.97	10.85	10.39	9.52	60.7	55.3	54.3	52.0	47.9
11		20:00	21:00	12.68	12.40	12.13	11.96	11.05	90.3	88.2	87.4	86.7	79.6
12		21:00	22:00	11.44	11.10	10.91	10.81	10.33	96.6	93.9	93.9	93.9	88.4
13		22:00	23:00	10.67	10.31	10.12	10.00	9.31	97.9	94.6	95.0	95.0	86.0
14		23:00	0:00	9.95	9.50	9.21	8.93	7.84	95.8	91.3	89.7	86.9	70.6
15	16-July	0:00	1:00	9.62	9.22	9.03	8.84	7.95	96.1	92.2	91.3	89.6	76.5
16		1:00	2:00	9.06	8.74	8.62	8.57	8.39	98.4	95.0	95.4	96.1	95.7
17		2:00	3:00	8.55	8.21	8.09	8.04	7.88	99.0	95.5	96.1	96.9	97.1
18		3:00	4:00	8.17	7.84	7.73	7.69	7.57	99.6	95.9	96.7	97.6	98.2
19		4:00	5:00	7.85	7.51	7.43	7.40	7.29	99.7	96.1	96.9	97.9	98.6
20		5:00	6:00	7.73	7.40	7.31	7.29	7.20	100.0	96.1	97.0	98.2	98.9
21		6:00	7:00	8.00	7.68	7.62	7.63	7.57	99.4	95.7	96.8	98.2	99.5
22		7:00	8:00	9.49	9.18	9.61	9.15	8.99	94.7	91.0	95.7	92.0	91.7
23		8:00	9:00	10.40	10.00	9.55	9.31	8.88	79.5	76.9	73.6	72.0	69.3
24		9:00	10:00	11.05	10.47	9.89	9.51	8.79	68.6	67.5	65.7	64.1	59.7

Table A－2 Solar radiation, net radiation, soil heat flux at 3 cm underground, soil and pool water temperatures, and wind speed.

CHALK RIVER EXPERIMENTAL SITE

NO.	DATE	START	STOP	SOLAR RADIATION (kW/m^2)	NET RADIATION R (kW/m^2)	SOIL HEAT FLUX at 3cm underground (W/m^2)			AVE	TEMPERATURE (℃) POOL	SOIL	SOIL	AVE (SOIL)	WIND SPEED (m/s)
1	13-July	19:51	20:51	0.006	-0.080	-35.87	-40.58	-52.62	-43.02					0.30
2		20:51	21:51	0.000	-0.075	-38.24	-42.35	-53.83	-44.81					0.30
3		21:51	22:51	0.001	-0.062	-37.97	-40.98	-50.52	-43.16					0.30
4		22:51	23:51	0.000	-0.047	-31.28	-33.80	-41.21	-35.43					0.20
5		23:51	0:51	0.001	-0.042	-29.45	-31.37	-37.94	-32.92					0.30
6	14-July	0:51	1:51	0.000	-0.035	-25.95	-27.52	-33.06	-28.84					0.30
7		1:51	2:51	0.000	-0.028	-23.50	-24.66	-29.39	-25.85					0.30
8		2:51	3:51	0.000	-0.025	-21.36	-22.19	-26.37	-23.31					0.30
9		3:51	4:51	0.000	-0.025	-21.36	-21.60	-25.64	-22.87					0.30
10		4:51	5:51	0.000	-0.025	-20.97	-20.82	-24.83	-22.21					0.30
11		5:51	6:51	0.008	-0.017	-18.65	-18.15	-21.37	-19.39					0.30
12		6:51	7:51	0.024	-0.002	-13.22	-13.21	-15.36	-13.93					0.40
13		7:51	8:51	0.064	0.033	-5.40	-5.60	-5.16	-5.39					0.40
14		8:51	9:51	0.094	0.058	5.83	5.29	7.33	6.15					0.30
15		9:51	10:51	0.164	0.113	16.14	16.07	18.42	16.88					0.30
16		10:51	11:51	0.312	0.245	44.28	45.92	50.80	47.00					0.40
17		11:51	12:51	0.443	0.359	72.17	78.62	78.50	76.43					0.80
18		12:51	13:35	0.163	0.111	9.76	7.88	4.71	7.45	17.50	20.30	20.20	20.25	1.43
19		13:35	13:52	0.184	0.130	10.66	9.41	7.90	9.32					0.26
20		13:52	14:00	0.163	0.110	14.31	13.21	11.29	12.94		25.00	25.60	25.30	1.41
21		14:00	15:00	0.330	0.253	30.50	31.80	35.48	32.59	18.40	23.50	24.00	23.75	0.97
22		15:00	16:00	0.538	0.415	74.16	86.58	95.04	85.26		25.00	25.60	25.30	0.70
23		16:00	17:00	0.510	0.378	48.13	60.35	76.69	61.72	19.50	25.00	26.20	25.60	0.65
24		17:00	18:00	0.404	0.282	31.82	19.52	23.79	25.04	19.70	23.10	23.30	23.20	0.70
25		18:00	19:00	0.205	0.106	10.70	4.23	1.97	5.63					0.64
26		19:00	20:00	0.124	0.031	-5.36	-5.52	-10.12	-7.00					0.36
27		20:00	21:00	0.024	-0.005	-22.99	-24.58	-36.89	-28.15					0.27
28		21:00	22:00	0.000	-0.066	-32.25	-33.33	-46.85	-37.48					0.31
29		22:00	23:00	0.000	-0.069	-35.95	-35.92	-49.79	-40.55					0.36
30		23:00	0:00	0.000	-0.071	-37.97	-36.66	-50.76	-41.80					0.36

Table A－2 Cont'd.

CHALK RIVER EXPERIMENTAL SITE

NO.	DATE	START	STOP	SOLAR RADIATION (kW/m^2)	NET RADIATION R (kW/m^2)	SOIL HEAT FLUX at 3cm underground (W/m^2)			AVE	TEMPERATURE (℃) POOL	SOIL	SOIL	AVE (SOIL)	WIND SPEED (m/s)
31	15-July	0:00	1:00	0.000	-0.070	-39.14	-36.90	-50.44	-42.16					0.32
32		1:00	2:00	0.000	-0.069	-39.49	-36.86	-49.91	-42.09					0.34
33		2:00	3:00	0.000	-0.066	-38.98	-36.39	-49.03	-41.47					0.32
34		3:00	4:00	0.000	-0.068	-39.84	-36.62	-49.19	-41.88					0.34
35		4:00	5:00	0.000	-0.055	-38.59	-35.29	-46.04	-39.97					0.36
36		5:00	6:00	0.006	-0.033	-26.80	-24.47	-30.72	-27.33					0.56
37		6:00	7:00	0.060	0.017	-16.65	-15.80	-18.87	-17.11					0.65
38		7:00	8:00	0.120	0.080	-0.42	-0.94	0.52	-0.28					0.72
39		8:00	9:00	0.294	0.219	20.03	15.72	17.37	17.71					1.14
40		9:00	10:00	0.543	0.439	49.61	76.90	88.91	71.81	16.8	21.2	21.5	21.4	0.92
41		10:00	11:00	0.629	0.484	116.60	108.80	141.00	122.13	17.8	24.7	25.7	25.2	0.60
42		11:00	12:00	0.689	0.511	117.10	102.20	131.20	116.83	20.0	26.9	28.5	27.7	0.66
43		12:00	13:00	0.673	0.420	103.00	81.50	110.40	98.30	21.5	28.2	29.8	29.0	0.78
44		13:00	14:00	0.659	-	82.30	64.80	86.70	77.93	21.2	28.1	29.8	29.0	1.03
45		14:00	15:00	0.833	0.711	102.10	82.50	112.30	98.97	23.0	29.8	30.8	30.3	1.41
46		15:00	16:00	0.710	0.556	81.90	61.20	78.60	73.90	24.2	29.8	30.5	30.2	1.49
47		16:00	17:00	0.601	0.451	42.30	37.80	53.40	44.50	23.2	28.0	29.2	28.6	1.63
48		17:00	18:00	0.486	0.347	25.10	5.76	2.25	11.04	23.0	26.9	27.8	27.4	1.40
49		18:00	19:00	0.326	0.193	8.91	-0.27	3.18	3.94	22.5	25.0	25.8	25.4	1.29
50		19:00	20:00	0.166	0.038	4.59	-16.19	-25.60	-12.40	21.2	23.1	23.0	23.1	0.59
51		20:00	21:00	0.030	-0.069	1.32	-39.20	-58.99	-32.29	19.5	20.9	20.3	20.6	0.38
52		21:00	22:00	0.000	-0.084	0.73	-50.80	-71.70	-40.59					0.40
53		22:00	23:00	0.000	-0.089	0.81	-51.30	-70.40	-40.30	17.8	17.9	17.0	17.5	0.61
54		23:00	0:00	0.000	-0.086	0.89	-50.70	-68.20	-39.34					0.78

Table A－2 Cont'd.

CHALK RIVER EXPERIMENTAL SITE

NO.	DATE	START	STOP	SOLAR RADIATION (kW/m^2)	NET RADIATION R (kW/m^2)	SOIL HEAT FLUX at 3cm underground (W/m^2)			AVE	TEMPERATURE POOL	SOIL (℃)	SOIL	AVE (SOIL)	WIND SPEED (m/s)
55	16-July	0:00	1:00	0.000	-0.087	0.85	-49.90	-66.80	-38.62	16.2	15.8	15.0	15.4	0.47
56		1:00	2:00	0.000	-0.088	0.70	-50.50	-67.20	-39.00					0.39
57		2:00	3:00	0.000	-0.086	0.27	-52.10	-69.00	-40.28	15.0	14.2	13.1	13.7	0.42
58		3:00	4:00	0.000	-0.085	0.27	-52.30	-68.40	-40.14					0.42
59		4:00	5:00	0.000	-0.083	0.31	-52.50	-68.10	-40.10	14.0	12.8	11.9	12.4	0.42
60		5:00	6:00	0.006	-0.076	0.00	-50.40	-64.40	-38.27	13.8	12.2	11.2	11.7	0.40
61		6:00	7:00	0.087	-0.010	0.54	-42.00	-53.00	-31.49	13.8	12.7	11.8	12.3	0.38
62		7:00	8:00	0.242	0.140	2.10	-25.30	-28.40	-17.20	14.4	13.5	12.8	13.2	0.40
63		8:00	9:00	0.406	0.299	4.20	39.96	52.50	32.22	15.3	18.3	18.1	18.2	0.74
64		9:00	10:00	0.545	0.430	12.40	86.30	109.50	69.40	17.2	22.0	22.2	22.1	2.08
65		10:00	11:00	0.674	0.530	23.60	95.00	120.90	79.83					2.74
66		11:00	12:00	0.781	0.589	27.50	89.50	120.40	79.13					2.54
67		12:00	13:00	0.845	0.478	48.70	108.00	120.60	92.43					2.31
68		13:00	14:00	0.857	0.677	65.20	102.00	140.30	102.50					1.73
69		14:00	15:00	0.809	0.639	69.30	81.90	110.90	87.37					2.54
70		15:00	16:00	0.614	0.465	52.70	49.50	65.60	55.93					2.01
71		16:00	17:00	0.322	0.226	19.30	10.20	6.40	11.97					1.54

Table A－3 Dry and wet temperatures at different heights.

CHALK RIVER EXPERIMENTAL SITE

NO.	DATE	START	STOP	TEMPERATURE (at12.5cm) DRY (℃)	TEMPERATURE (at12.5cm) WET (℃)	TEMPERATURE (at25cm) DRY (℃)	TEMPERATURE (at25cm) WET (℃)	TEMPERATURE (at58cm) DRY (℃)	TEMPERATURE (at58cm) WET (℃)	TEMPERATURE (at97.5cm) DRY (℃)	TEMPERATURE (at97.5cm) WET (℃)	TEMPERATURE (at247cm) DRY (℃)	TEMPERATURE (at247cm) WET (℃)
1	13-July	19:51	20:51	14.89	14.56	14.93	14.48	14.65	14.27	14.44	14.15	14.46	14.22
2		20:51	21:51	14.27	14.07	14.19	13.85	13.96	13.64	13.82	13.58	13.63	13.44
3		21:51	22:51	13.40	13.26	13.31	12.98	13.04	12.76	12.86	12.68	12.63	12.49
4		22:51	23:51	13.63	13.48	13.54	13.20	13.27	13.00	13.09	12.92	12.87	12.73
5		23:51	0:51	13.50	13.35	13.42	13.09	13.17	12.90	12.99	12.82	12.73	12.61
6	14-July	0:51	1:51	13.65	13.50	13.54	13.21	13.32	13.05	13.14	12.97	12.88	12.76
7		1:51	2:51	13.71	13.57	13.62	13.28	13.39	13.11	13.21	13.04	12.96	12.85
8		2:51	3:51	13.87	13.74	13.79	13.48	13.58	13.32	13.40	13.25	13.17	13.06
9		3:51	4:51	13.92	13.85	13.88	13.62	13.69	13.46	13.51	13.39	13.35	13.24
10		4:51	5:51	13.99	13.94	13.93	13.71	13.78	13.56	13.64	13.51	13.50	13.38
11		5:51	6:51	13.99	13.94	13.94	13.72	13.78	13.56	13.62	13.51	13.42	13.33
12		6:51	7:51	14.43	14.34	14.36	14.10	14.24	13.97	14.08	13.92	13.90	13.75
13		7:51	8:51	14.73	14.60	14.62	14.33	14.46	14.14	14.30	14.08	14.10	13.89
14		8:51	9:51	15.42	15.15	15.30	14.90	15.10	14.62	14.95	14.58	14.79	14.37
15		9:51	10:51	16.07	15.65	15.89	15.25	15.72	14.98	15.53	14.89	15.28	14.57
16		10:51	11:51	17.04	16.39	16.61	15.75	16.37	15.33	16.17	15.24	15.96	14.97
17		11:51	12:51	18.67	17.19	18.16	16.40	17.78	15.83	17.51	15.62	17.13	15.19
18		13:52	13:35	17.64	16.35	17.41	15.79	17.23	15.49	16.93	15.24	16.72	14.91
19		13:35	13:52	16.99	15.18	17.15	15.35	17.32	15.43	17.43	15.74	17.69	16.16
20		13:52	14:00	18.00	16.58	17.81	16.25	17.63	15.87	17.44	15.74	17.07	15.33
21		14:00	15:00	18.83	17.05	18.41	16.45	18.15	16.06	17.91	15.86	17.50	15.44
22		15:00	16:00	21.30	18.23	20.28	17.55	19.82	16.84	19.59	16.67	18.94	15.99
23		16:00	17:00	22.10	18.07	21.41	17.50	20.82	16.69	20.68	16.52	20.10	15.92
24		17:00	18:00	22.37	17.82	21.61	17.23	21.22	16.48	21.08	16.29	20.53	15.58
25		18:00	19:00	21.06	17.27	20.85	16.77	20.72	16.28	20.55	16.00	20.21	15.50
26		19:00	20:00	19.54	17.56	19.58	17.29	19.48	16.99	19.40	16.87	19.13	16.49
27		20:00	21:00	16.46	16.06	16.49	15.87	16.28	15.69	16.19	15.65	16.18	15.58
28		21:00	22:00	14.60	14.43	14.57	14.23	14.37	14.09	14.23	14.02	14.19	14.02
29		22:00	23:00	13.40	13.27	13.32	13.02	13.10	12.85	12.94	12.76	12.82	12.70
30		23:00	0:00	12.44	12.34	12.36	12.06	12.14	11.90	11.98	11.81	11.83	11.72

Table A－3 Cont'd.

CHALK RIVER EXPERIMENTAL SITE

NO.	DATE	START	STOP	TEMPERATURE (at12.5cm)		TEMPERATURE (at25cm)		TEMPERATURE (at58cm)		TEMPERATURE (at97.5cm)		TEMPERATURE (at247cm)	
				DRY (℃)	WET (℃)	DRY (℃)	WET (℃)	DRY (℃)	WET (℃)	DRY (℃)	WET (℃)	DRY (℃)	WET (℃)
31	15-July	0:00	1:00	11.70	11.61	11.64	11.35	11.41	11.18	11.27	11.10	11.04	10.98
32		1:00	2:00	11.10	11.03	11.03	10.75	10.81	10.59	10.67	10.52	10.37	10.28
33		2:00	3:00	10.63	10.56	10.52	10.27	10.31	10.11	10.15	10.02	9.87	9.81
34		3:00	4:00	10.13	10.07	10.04	9.76	9.81	9.60	9.64	9.50	9.34	9.26
35		4:00	5:00	9.97	9.93	9.87	9.62	9.66	9.46	9.49	9.37	9.27	9.20
36		5:00	6:00	11.41	11.44	11.31	11.18	11.15	11.05	11.02	10.99	10.98	10.96
37		6:00	7:00	12.38	12.40	12.22	12.12	12.10	12.01	11.96	11.95	11.76	11.76
38		7:00	8:00	13.30	13.30	13.01	12.92	12.85	12.76	12.64	12.66	12.37	12.41
39		8:00	9:00	14.70	14.47	14.29	13.98	14.00	13.71	13.77	13.57	13.41	13.31
40		9:00	10:00	18.68	16.89	17.81	16.10	17.32	15.66	17.02	15.45	16.85	15.21
41		10:00	11:00	21.94	18.77	21.01	18.03	20.37	17.19	20.20	17.00	19.99	16.64
42		11:00	12:00	23.79	18.86	23.14	18.27	22.51	17.28	22.43	17.01	22.03	16.42
43		12:00	13:00	25.29	19.29	24.53	18.58	23.98	17.75	23.79	17.40	23.27	16.63
44		13:00	14:00	26.02	19.35	25.35	18.64	24.82	17.86	24.55	17.44	24.02	16.70
45		14:00	15:00	27.86	19.88	26.93	19.01	26.07	17.99	25.61	17.43	24.96	16.67
46		15:00	16:00	27.96	19.48	27.05	18.55	26.31	17.58	25.93	17.04	25.39	16.34
47		16:00	17:00	27.33	18.66	26.75	17.91	26.17	17.09	25.87	16.56	25.45	15.87
48		17:00	18:00	26.98	18.22	26.45	17.45	26.08	16.75	25.88	16.33	25.46	15.69
49		18:00	19:00	25.22	17.13	25.36	16.72	25.27	16.16	25.20	15.69	24.87	15.14
50		19:00	20:00	22.26	17.24	22.53	16.69	22.64	16.64	22.63	16.29	22.56	15.60
51		20:00	21:00	16.61	15.60	16.63	15.39	16.41	15.09	16.31	14.92	16.41	14.24
52		21:00	22:00	13.71	13.38	13.68	13.09	13.38	12.79	13.22	12.64	13.48	12.35
53		22:00	23:00	12.27	12.08	12.27	11.77	11.90	11.44	11.69	11.23	12.18	10.86
54		23:00	0:00	11.46	11.08	11.49	10.69	11.26	10.32	11.28	10.08	12.59	9.72

Table A－3 Cont'd.

CHALK RIVER EXPERIMENTAL SITE

NO.	DATE	START	STOP	TEMPERATURE (at12.5cm) DRY (℃)	TEMPERATURE (at12.5cm) WET (℃)	TEMPERATURE (at25cm) DRY (℃)	TEMPERATURE (at25cm) WET (℃)	TEMPERATURE (at58cm) DRY (℃)	TEMPERATURE (at58cm) WET (℃)	TEMPERATURE (at97.5cm) DRY (℃)	TEMPERATURE (at97.5cm) WET (℃)	TEMPERATURE (at247cm) DRY (℃)	TEMPERATURE (at247cm) WET (℃)
55	16-July	0:00	1:00	10.83	10.48	10.82	10.12	10.62	9.84	10.58	9.65	11.47	9.27
56		1:00	2:00	9.40	9.26	9.39	8.96	9.08	8.69	8.86	8.53	8.57	8.21
57		2:00	3:00	8.29	8.21	8.22	7.85	7.86	7.54	7.61	7.36	7.24	7.01
58		3:00	4:00	7.42	7.39	7.36	7.03	6.98	6.72	6.73	6.54	6.35	6.21
59		4:00	5:00	6.70	6.68	6.60	6.29	6.26	6.02	6.02	5.86	5.66	5.55
60		5:00	6:00	6.41	6.41	6.34	6.04	5.97	5.74	5.72	5.58	5.36	5.28
61		6:00	7:00	7.10	7.05	7.05	6.71	6.70	6.45	6.50	6.36	6.14	6.10
62		7:00	8:00	10.84	10.37	10.96	10.15	10.88	10.50	10.73	10.01	10.47	9.73
63		8:00	9:00	15.40	13.27	15.29	12.89	15.26	12.50	15.22	12.28	15.05	11.83
64		9:00	10:00	18.95	15.31	18.33	14.60	17.79	13.90	17.56	13.49	17.42	12.83
65		10:00	11:00	20.92	16.44	19.87	15.54	19.13	14.72	18.86	14.25	18.57	13.48
66		11:00	12:00	22.54	17.59	21.24	16.55	20.42	15.60	20.23	15.08	19.95	14.36
67		12:00	13:00	24.16	18.74	23.14	17.91	22.21	16.85	21.89	16.31	21.45	15.50
68		13:00	14:00	25.96	20.05	25.29	19.56	24.18	18.35	23.74	17.82	23.04	16.80
69		14:00	15:00	26.88	21.08	25.91	20.32	24.89	19.15	24.47	18.50	24.06	17.53
70		15:00	16:00	27.17	20.85	26.42	20.27	25.53	19.11	25.20	18.53	24.53	17.48
71		16:00	17:00	25.05	20.00	24.81	19.67	24.36	18.80	24.29	18.38	24.21	17.46

Table A－4 Soil heat flux at ground surface, evapo-transpiration rate, Boen ratio and energy balance.

CHALK RIVER EXPERIMENTAL SITE

NO	DATE	START	STOP	SOIL HEAT FLUX at SURFACE, G(0) (W/m^2)	EVAPO-TRANSPIRATION RATE, E (g/m^2/s)	BOEN RATIO H/LE (-)	(H+LE+G(0))/R (-)
40	15-July	9:00	10:00	142.97	0.074	0.67	1.01
41		10:00	11:00	192.38	0.091	0.33	1.01
42		11:00	12:00	162.45	0.115	0.25	1.01
43		12:00	13:00	122.02	0.096	0.29	1.01
44		13:00	14:00	77.02	-	0.33	-
45		14:00	15:00	123.60	0.172	0.43	1.01
46		15:00	16:00	71.16	0.148	0.37	1.01
47		16:00	17:00	16.22	0.141	0.28	1.01
48		17:00	18:00	-11.77	0.116	0.28	1.01
49		18:00	19:00	-31.64	0.079	0.18	1.01
50		19:00	20:00	-55.28	0.037	0.03	1.00
51		20:00	21:00	-76.99	0.003	0.00	1.00
52		21:00	22:00	-69.33	-0.007	-0.09	1.00
53		22:00	23:00	-69.03	-0.010	-0.18	1.00
54		23:00	0:00	-58.04	-0.023	-0.51	0.99
55	16-July	0:00	1:00	-57.32	-0.020	-0.42	0.99
56		1:00	2:00	-54.97	-0.007	1.08	1.02
57		2:00	3:00	-56.24	-0.005	1.46	1.03
58		3:00	4:00	-162.96	0.013	1.79	0.91
59		4:00	5:00	-162.91	0.012	2.09	0.88
60		5:00	6:00	-37.51	-0.005	2.43	1.07
61		6:00	7:00	-30.73	0.002	5.05	0.43
62		7:00	8:00	-16.44	0.049	0.33	1.02
63		8:00	9:00	32.98	0.095	0.16	1.01
64		9:00	10:00	70.16	0.128	0.17	1.01

H: SENSIBLE HEAT FLUX　　L: LATENT HEAT FOR VAPORIZATION OF WATER 580(cal/g)
R: NET RADIATION FLUX

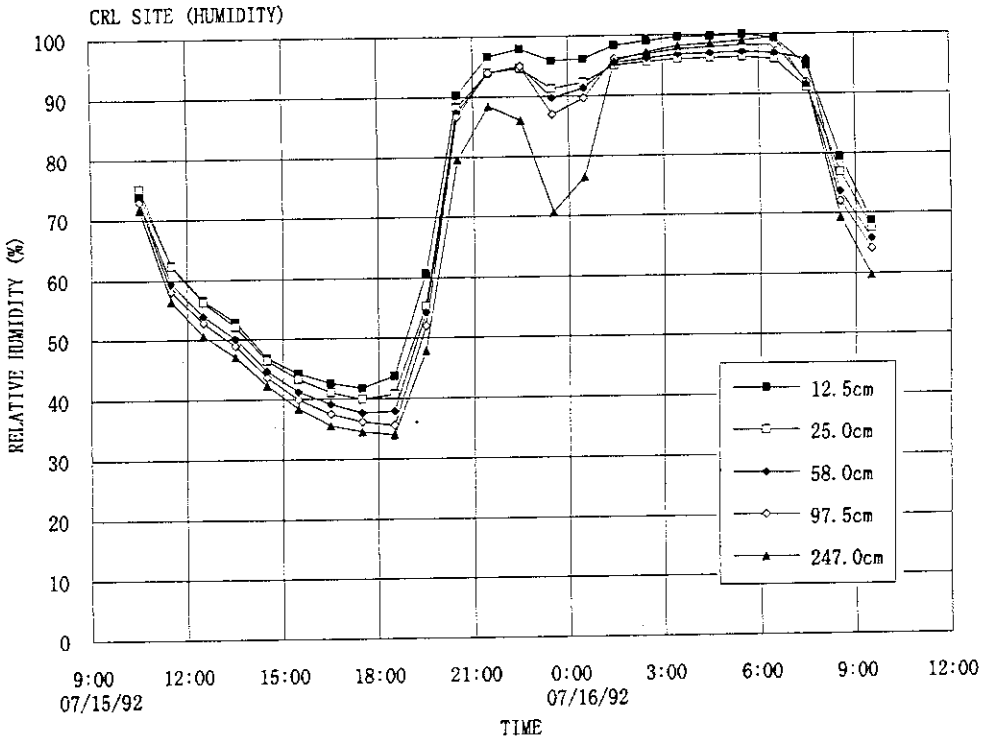


Fig. A－1 Relative humidities measured with aspirated radiation shielded dry and wet thermometers.

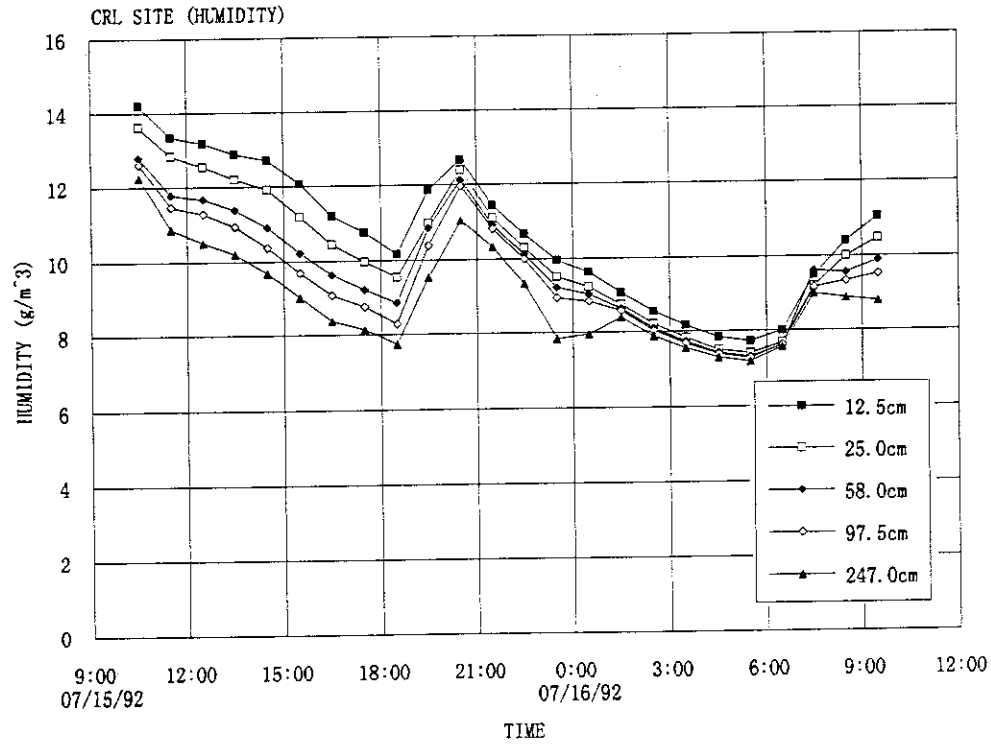


Fig. A－2 Absolute humidities measured with aspirated radiation shielded dry and wet thermometers.

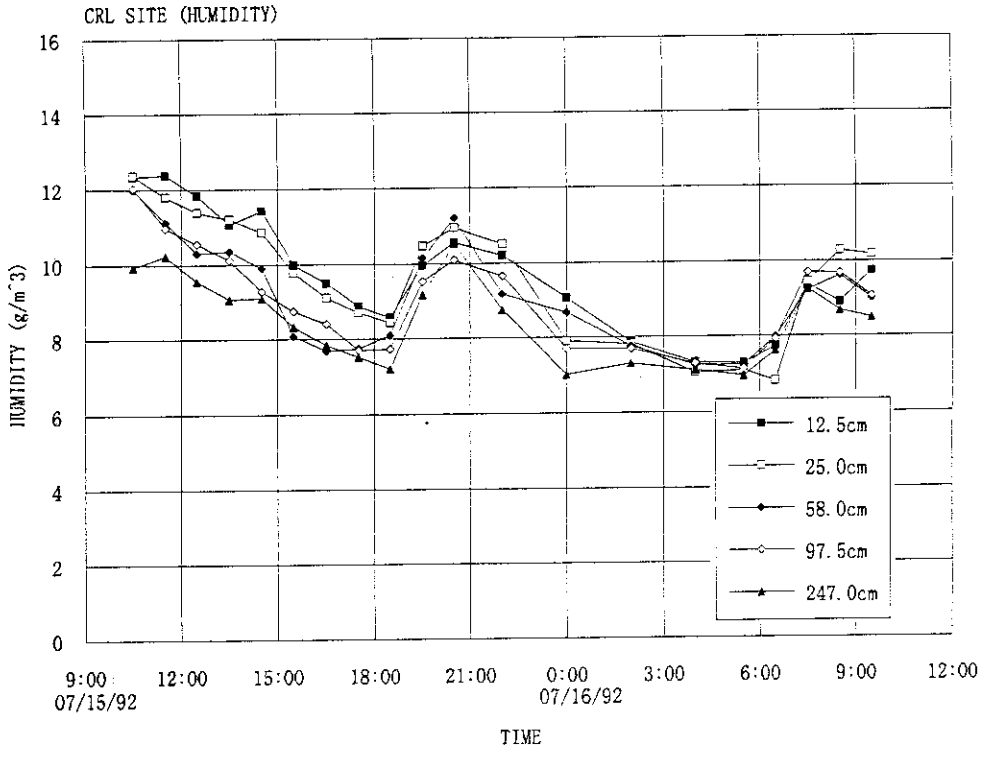


Fig. A－3 Absolute humidities calculated from weights of water collected in M.S. 4A columns.

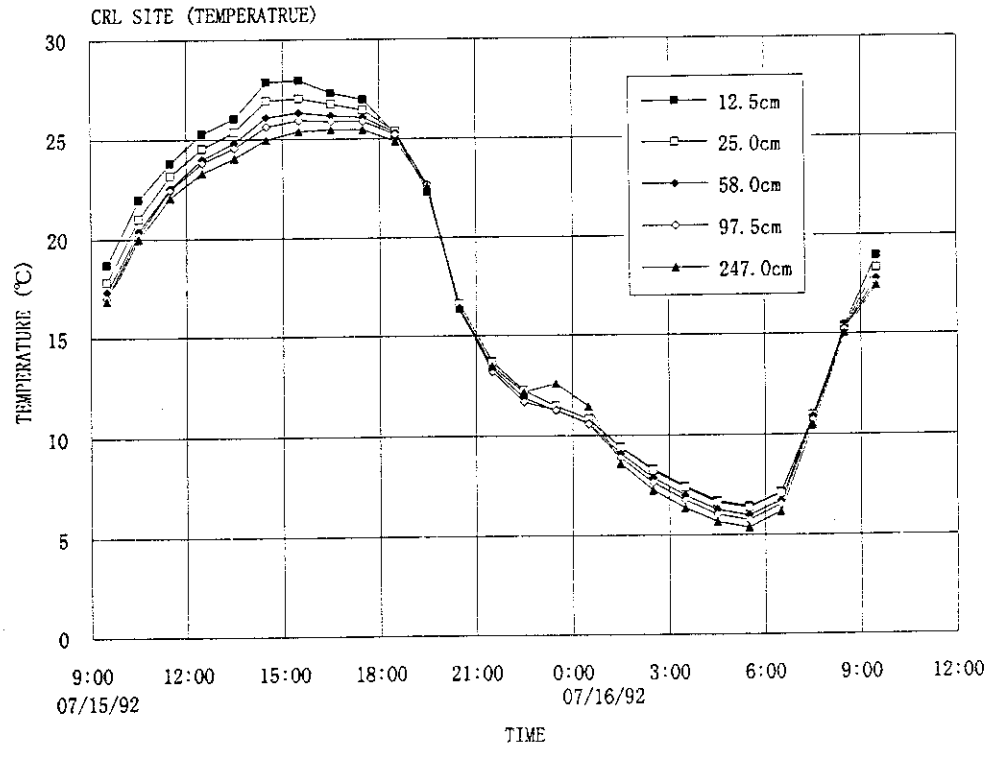


Fig. A－4 Variations of air temperatures at different heights with time.

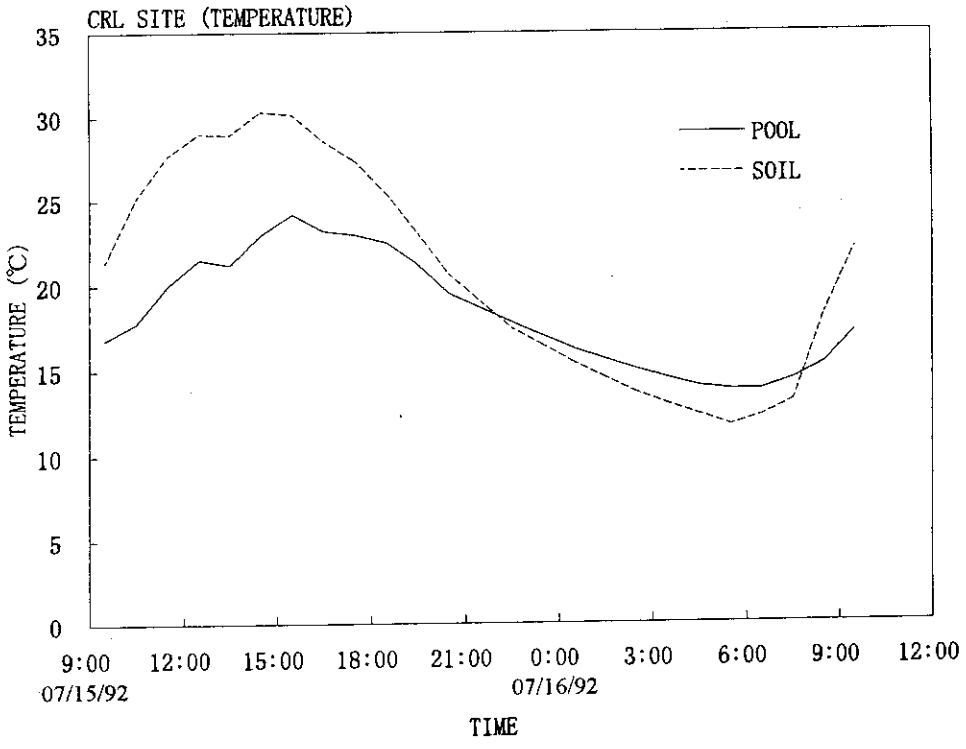


Fig. A－5 Variations of soil and pool water temperatures with time.

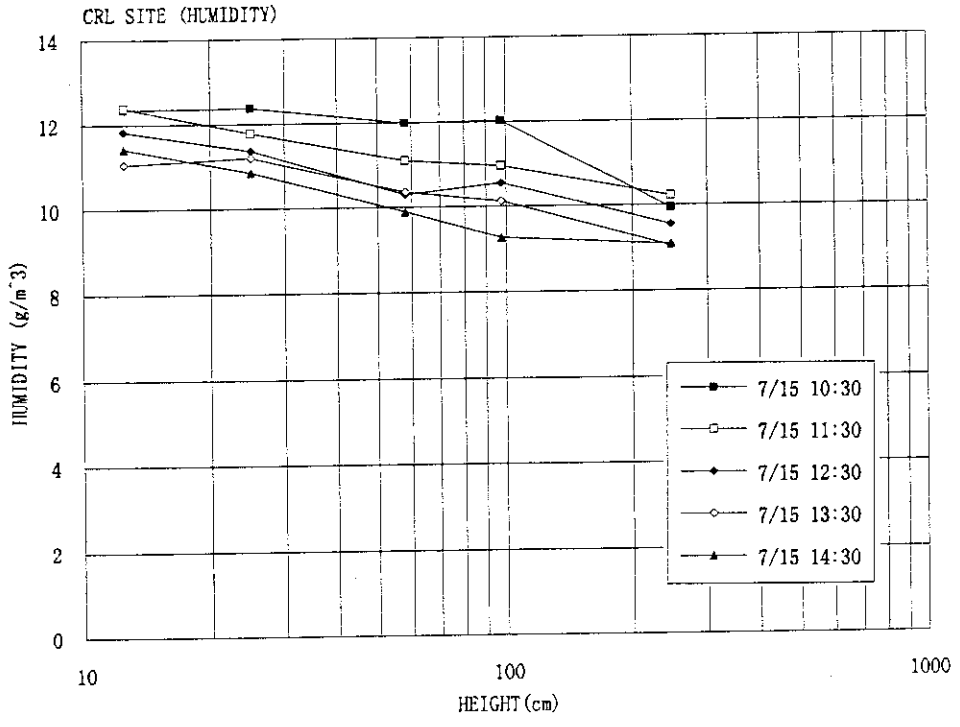


Fig. A－6(a) Height profiles of absolute humidity measured with dry and wet thermometers (10:30 July 15 to 14:30 July 15)

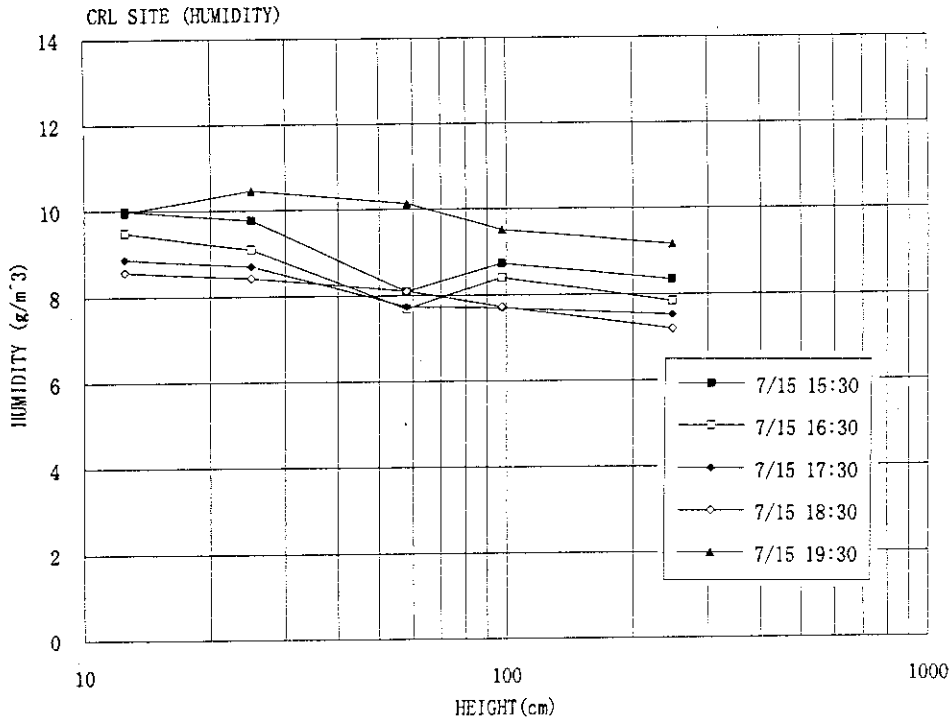


Fig. A－6(b) Height profiles of absolute humidity measured with dry and wet thermometers (15:30 July 15 to 19:30 July 15)

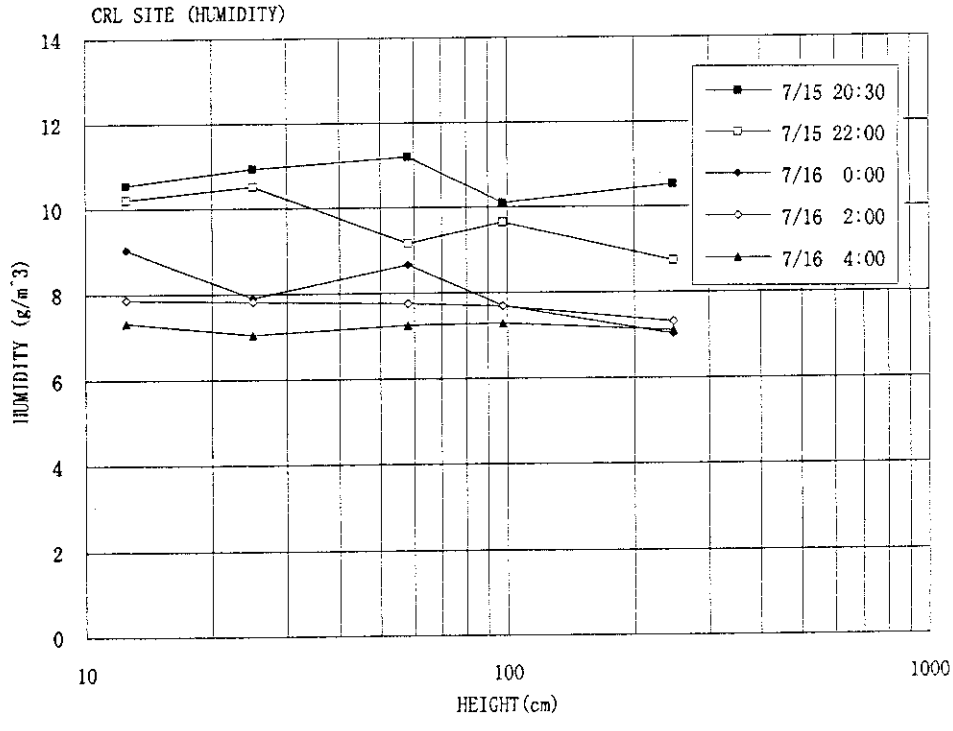


Fig. A－6(c) Height profiles of absolute humidity measured with dry and wet thermometers (20:30 July 15 to 4:00 July 16)

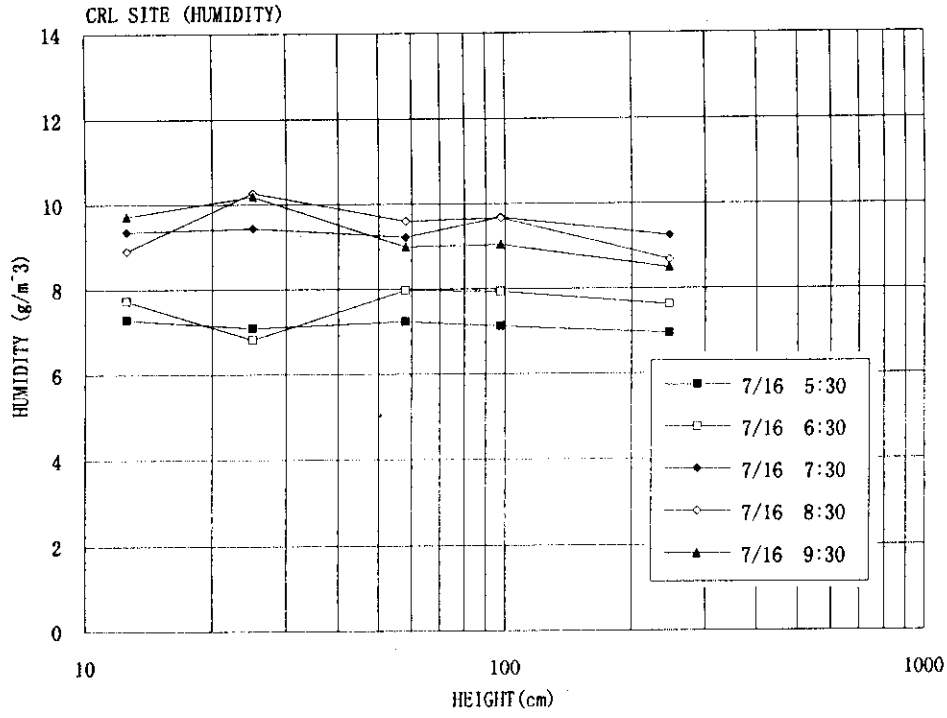


Fig. A－6(d) Height profiles of absolute humidity measured with dry and wet thermometers (5:30 July 16 to 9:30 July 16)

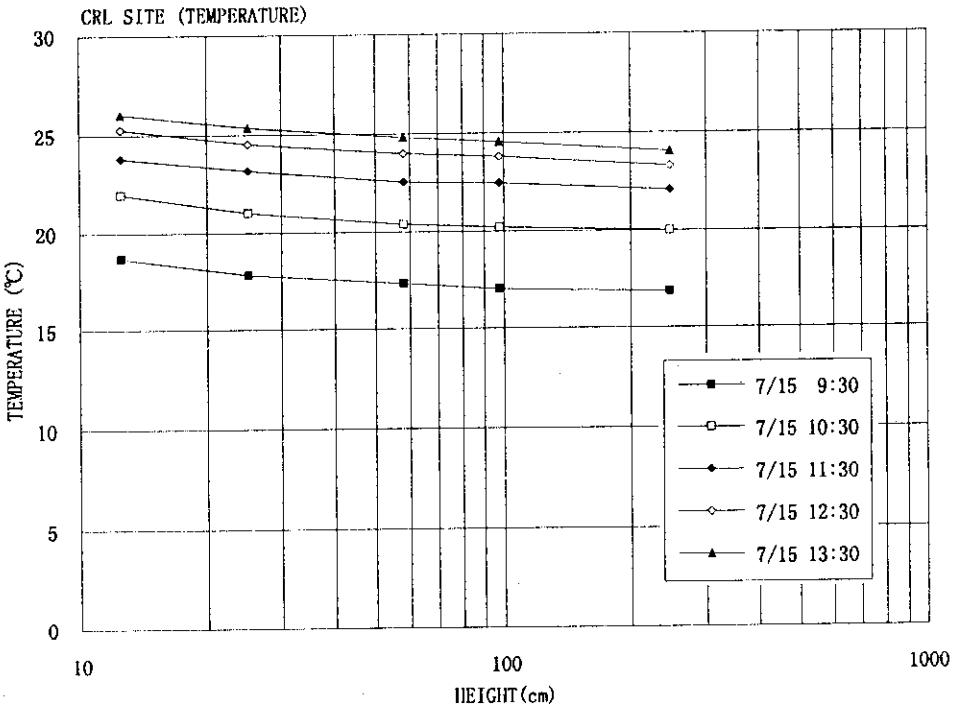


Fig. A－7(a) Air temperature height profiles (9:30 July 15 to 13:30 July 15)

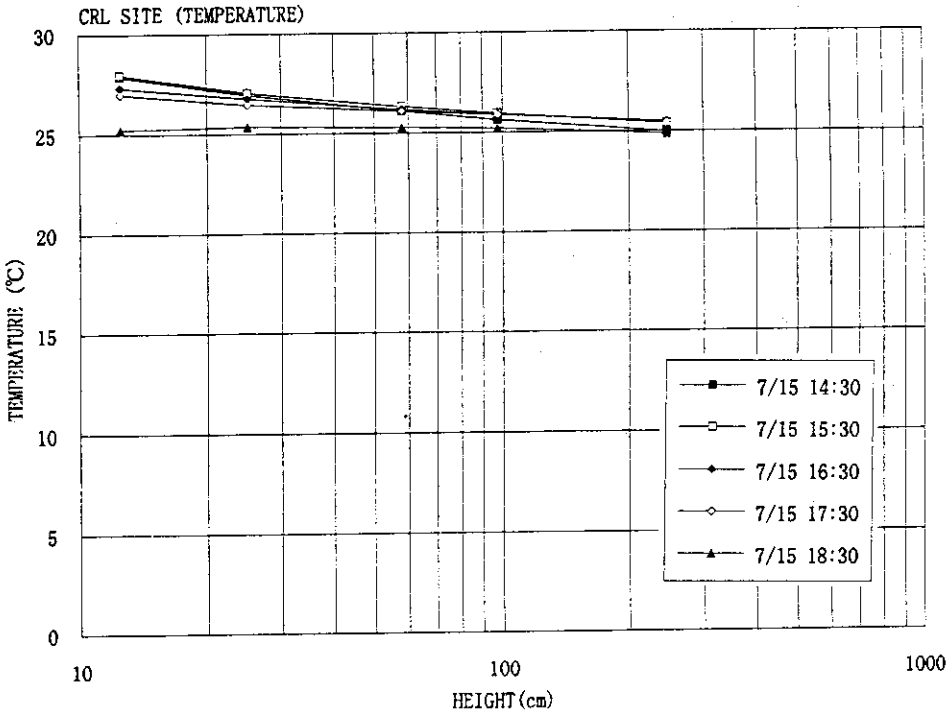


Fig. A－7(b) Air temperature height profiles (14:30 July 15 to 18:30 July 15)

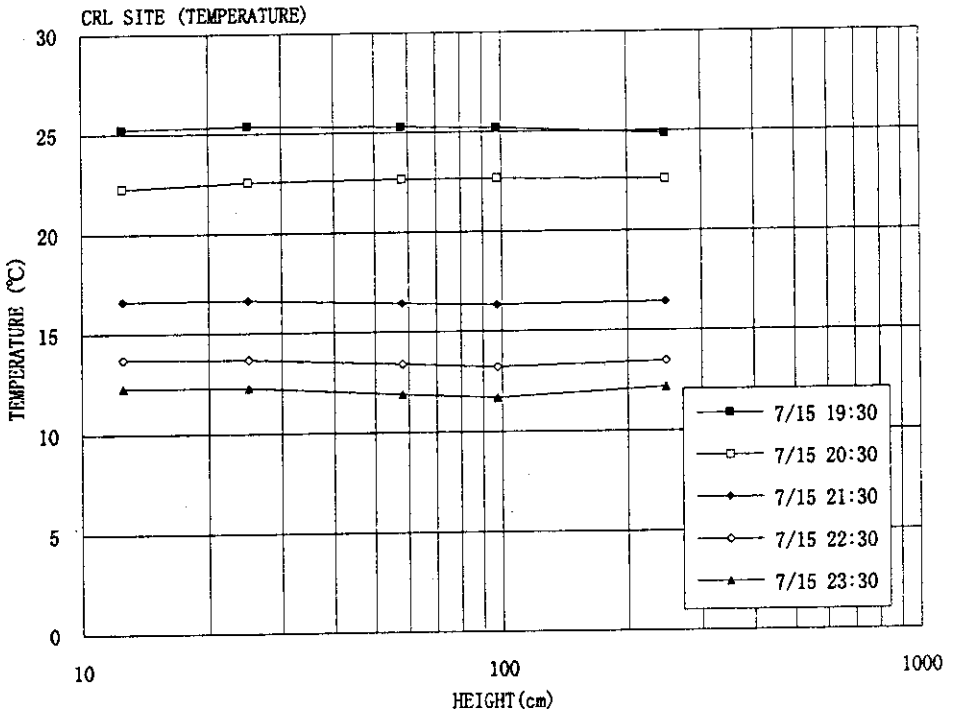


Fig. A－7(c) Air temperature height profiles (19:30 July 15 to 23:30 July 15)

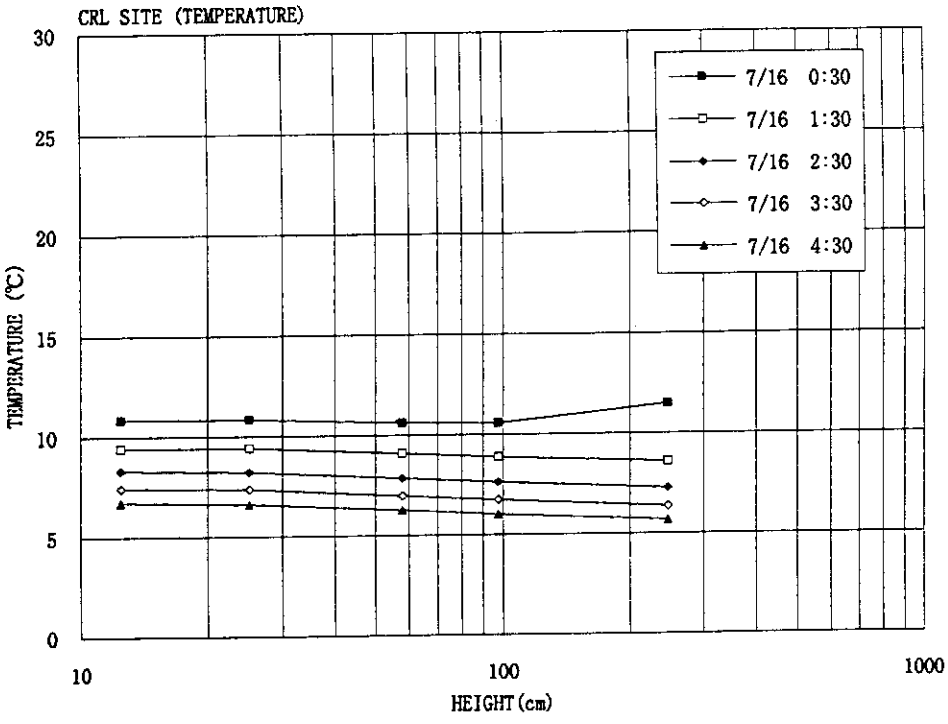


Fig. A－7(d) Air temperature height profiles (0:30 July 16 to 4:30 July 16)

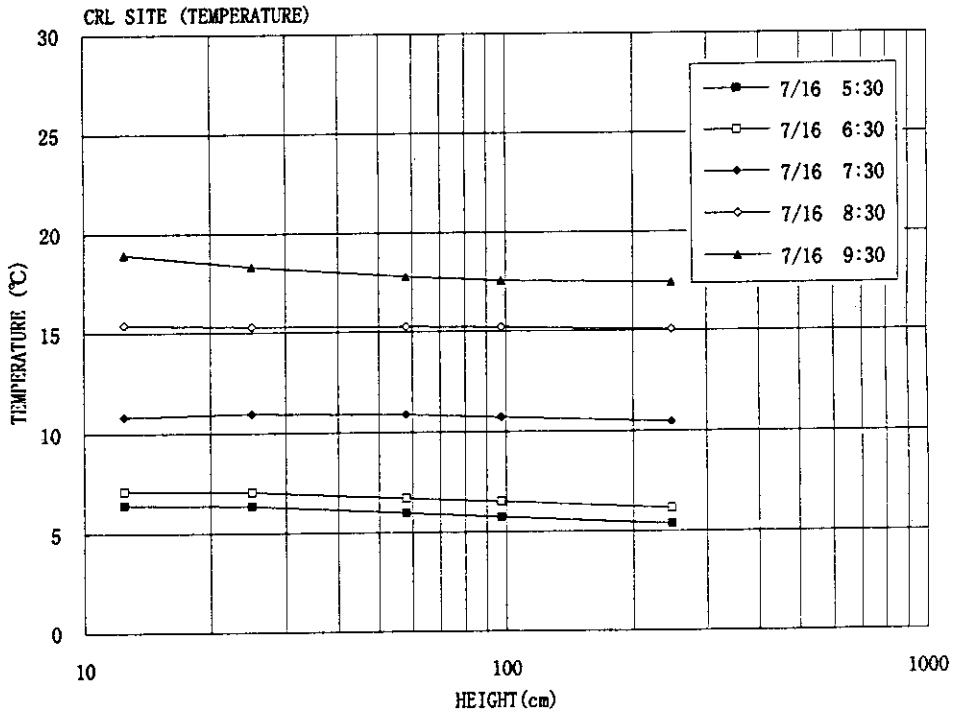


Fig. A－7(e) Air temperature height profiles (5:30 July 16 to 9:30 July 16)

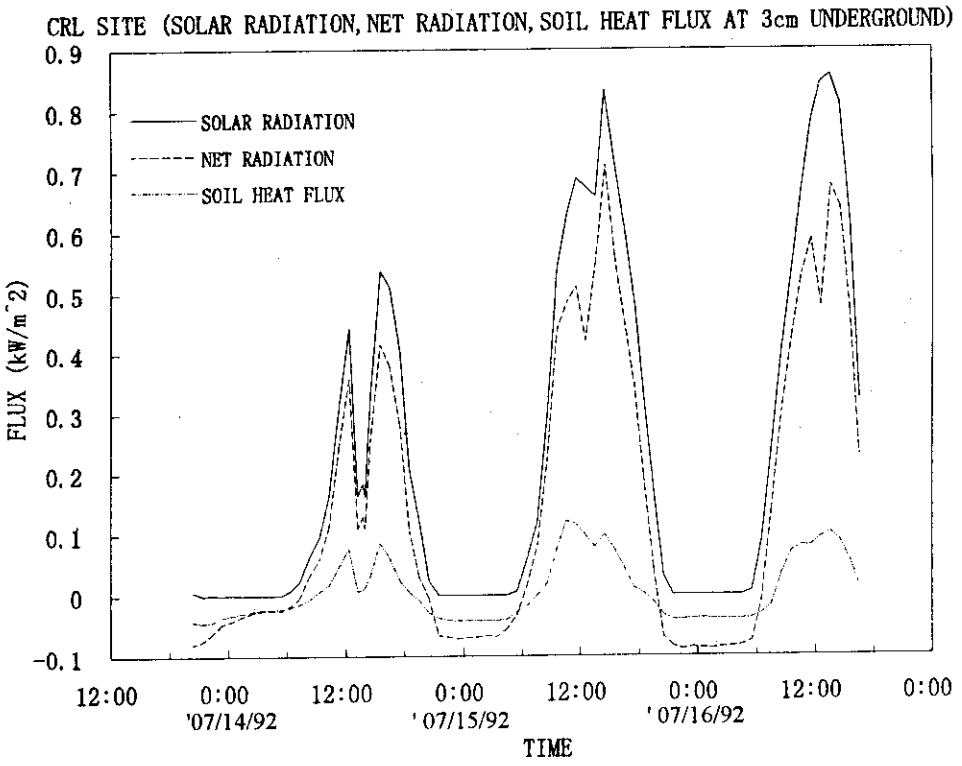


Fig. A－8 Variations of solar radiation, net radiation and soil heat flux with time.

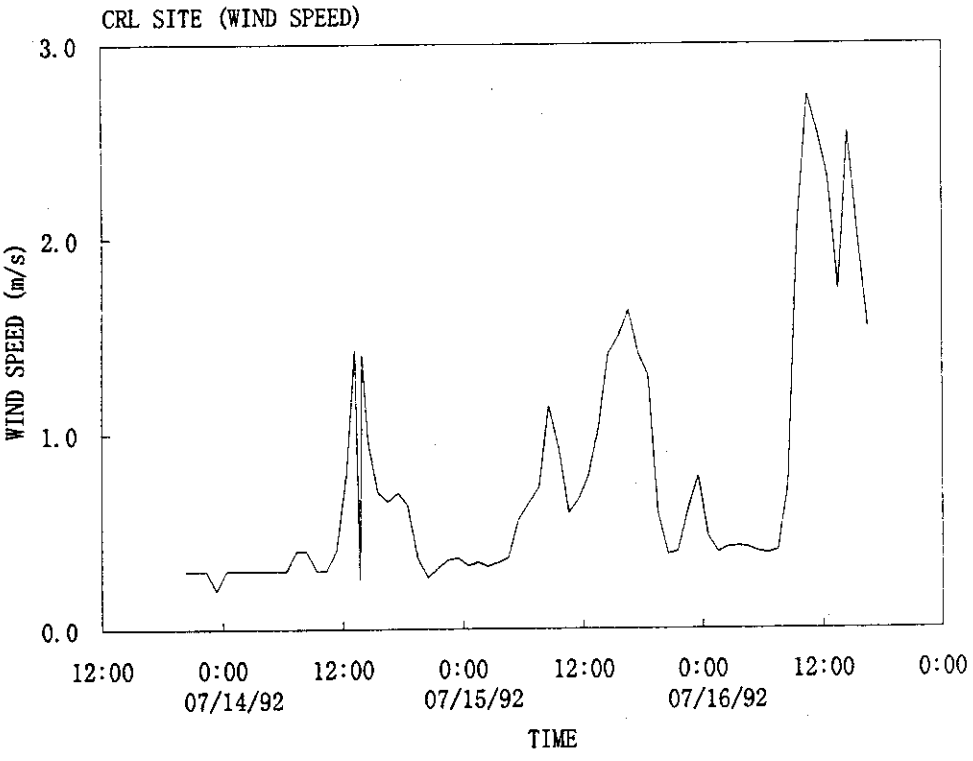


Fig. A－9 Variation of wind speed with time at 2.8 m height.

APPENDIX B Meteorological Data at the Pickering Site (Tables and Figures)

In Appendix B, tables and figures on the meteorological measurements at the Pickering field are summarized. They are solar radiation and net-radiation intensities*, wind speed*, absolute and relative humidities*, dry and wet air temperatures* at five different heights, temperature of soil, soil heat fluxes at the ground surface and 3 cm underground* , evapo-transpiration rate*, Boen ratio and energy balance. The superscript* attached indicates that the corresponding values are averaged over 60 minutes.

List of Tables and Figures in Appendix B (Pickering site data)

Table B－1 Absolute and relative humidities measured with aspirated radiation shielded dry and wet thermometers.

PICKERING EXPERIMENTAL SITE

NO	DATE	START	STOP	ABSORUTE HUMIDITY (g/m^3)					RELATIVE HUMIDITY (%)				
				at 12cm	at 27cm	at 57cm	at 101cm	at 244cm	at 12cm	at 27cm	at 57cm	at 101cm	at 244cm
9	21-July	8:00	9:00	9.31	7.61	8.81	8.73	8.53	73.4	72.7	73.0	73.4	72.7
10		9:00	10:00	9.69	9.15	8.95	8.80	8.54	66.5	67.2	68.1	68.6	68.5
11		10:00	11:00	9.81	9.16	8.93	8.71	8.39	61.7	62.9	64.3	64.9	64.7
12		11:00	12:00	9.80	9.07	8.91	8.67	8.38	58.3	59.0	60.5	60.6	60.3
13		12:00	13:00	9.71	9.13	8.99	8.79	8.49	60.3	60.0	61.0	61.0	60.4
14		13:00	14:00	9.89	9.32	9.18	8.98	8.68	59.9	60.0	60.6	60.5	59.8
15		14:00	15:00	10.15	9.55	9.40	9.19	8.87	57.9	58.2	59.3	59.4	59.0
16		15:00	16:00	9.74	9.20	9.08	8.86	8.52	55.0	55.1	56.1	56.0	55.2
17		16:00	17:00	9.22	8.69	8.60	8.41	8.12	54.8	53.8	54.2	53.8	52.8
18		17:00	18:00	9.15	8.65	8.57	8.34	8.07	54.1	53.2	53.6	53.0	52.0
19		18:00	19:00	9.22	8.79	8.71	8.53	8.24	55.0	54.3	54.5	54.1	52.9
20		19:00	20:00	8.48	8.17	8.12	8.01	7.80	56.3	54.4	54.4	54.0	52.7
21		20:00	21:00	7.68	7.37	7.34	7.25	7.12	62.4	58.2	56.9	55.5	53.9
22		21:00	22:00	7.95	7.72	7.72	7.64	7.43	82.3	75.9	71.6	67.5	61.8
23		22:00	23:00	8.03	7.82	7.87	7.85	7.79	80.4	74.7	72.5	70.8	68.7
24		23:00	0:00	7.80	7.60	7.67	7.67	7.61	84.8	78.7	75.6	73.7	71.0
25	22-July	0:00	1:00	7.33	7.01	7.01	6.96	6.88	74.8	69.1	67.4	66.1	64.3
26		1:00	2:00	6.96	6.63	6.65	6.59	6.50	71.3	65.6	64.3	63.0	61.2
27		2:00	3:00	7.01	6.82	6.90	6.88	6.79	81.8	75.9	73.5	71.4	68.1
28		3:00	4:00	6.46	6.55	6.82	7.07	7.11	95.8	93.3	91.2	88.6	81.2
29		4:00	5:00	6.70	6.74	7.04	7.22	7.26	95.3	90.7	88.6	85.5	80.0
30		5:00	6:00	7.03	7.09	7.44	7.67	7.81	95.3	91.6	89.8	88.3	85.0
31		6:00	7:00	7.95	7.82	7.94	8.04	8.03	91.3	88.1	87.0	86.9	85.5
32		7:00	8:00	8.83	8.42	8.33	8.31	8.16	79.5	77.6	77.1	77.5	76.5
33		8:00	9:00	9.06	8.57	8.46	8.34	8.11	68.6	66.8	67.6	67.7	66.7
34		9:00	10:00	8.81	8.25	8.11	7.95	7.64	58.5	56.8	57.9	57.8	56.7
35		10:00	11:00	9.23	8.64	8.42	8.20	7.85	53.5	53.5	54.6	54.5	53.6

Table B－2 Solar radiation, net radiation soil heat flux at 3 cm underground and soil temperatures, and wind speed.

PICKERING EXPERIMENTAL SITE

NO.	DATE	START	STOP	SOLAR RADIATION (kW/m^2)	NET RADIATION R (kW/m^2)	SOIL HEAT FLUX at 3cm underground (W/m^2)			AVE	SOIL TEMPERATURE (℃)			AVE	WIND SPEED (m/s)
1	21-July	0:00	1:00	0.000	-0.071	-22.10	-25.60	-16.20	-21.30					1.25
2		1:00	2:00	0.000	-0.074	-22.60	-26.20	-16.90	-21.90					1.24
3		2:00	3:00	0.000	-0.071	-23.30	-26.90	-17.60	-22.60					1.17
4		3:00	4:00	0.000	-0.065	-22.50	-25.80	-17.10	-21.80					1.24
5		4:00	5:00	0.000	-0.043	-19.10	-22.60	-14.60	-18.77					0.54
6		5:00	6:00	0.001	-0.066	-24.00	-30.90	-18.60	-24.50					0.41
7		6:00	7:00	0.066	-0.046	-24.00	-31.20	-19.60	-24.93					0.68
8		7:00	8:00	0.220	0.057	-12.20	-21.60	-10.60	-14.80					0.11
9		8:00	9:00	0.377	0.216	11.70	9.72	2.74	8.05	16.7	16.0	15.8	16.2	1.45
10		9:00	10:00	0.511	0.371	45.00	2.47	24.00	23.82	18.2	18.0	17.0	17.7	1.32
11		10:00	11:00	0.680	0.484	69.00	23.90	39.00	43.97	19.2	19.5	18.8	19.2	1.30
12		11:00	12:00	0.678	0.553	72.50	61.10	42.90	58.83	19.8	20.3	20.0	20.0	1.41
13		12:00	13:00	0.405	0.343	42.10	50.70	28.60	40.47	19.9	20.0	20.2	20.0	1.20
14		13:00	14:00	0.437	0.335	30.20	39.60	23.40	31.07	20.4	20.2	21.0	20.5	1.64
15		14:00	15:00	0.570	0.576	37.40	48.70	28.20	38.10	20.6	20.9	21.6	21.0	1.41
16		15:00	16:00	0.562	0.457	39.60	55.80	30.40	41.93	20.8	20.9	21.2	21.0	1.61
17		16:00	17:00	0.364	0.238	20.10	31.30	20.40	23.93	20.3	20.1	20.7	20.4	1.48
18		17:00	18:00	0.350	0.188	10.80	17.10	13.60	13.83	20.1	19.7	20.0	19.9	1.56
19		18:00	19:00	0.315	0.17	0.38	4.39	7.45	4.07	19.4	18.6	19.0	19.0	1.46
20		19:00	20:00	0.161	0.027	-11.60	-9.13	-2.25	-7.66	19.0	18.0	18.0	18.3	1.21
21		20:00	21:00	0.023	-0.069	-20.50	-22.20	-12.90	-18.53	18.0	17.0	17.1	17.4	0.75
22		21:00	22:00	0.000	-0.074	-26.00	-31.90	-20.20	-26.03	17.0	16.2	16.2	16.5	0.53
23		22:00	23:00	-0.001	-0.076	-26.80	-32.60	-21.80	-27.07	16.1	15.6	15.8	15.8	0.69
24		23:00	0:00	0.000	-0.071	-27.70	-33.80	-22.70	-28.07	15.8	15.1	15.0	15.3	0.50

Table B－2 Cont'd

PICKERING EXPERIMENTAL SITE

NO.	DATE	START	STOP	SOLAR RADIATION (kW/m^2)	NET RADIATION R (kW/m^2)	SOIL HEAT FLUX at 3cm underground (W/m^2)			AVE	SOIL TEMPERATURE (℃)			AVE	WIND SPEED (m/s)
25	22-July	0:00	1:00	0.000	-0.067	-27.40	-33.30	-22.70	-27.80	15.2	15.0	15.0	15.1	0.75
26		1:00	2:00	0.000	-0.075	-27.50	-32.40	-22.30	-27.40					0.87
27		2:00	3:00	0.001	-0.072	-28.50	-33.80	-22.90	-28.40	14.5	14.0	14.0	14.2	0.57
28		3:00	4:00	0.001	-0.059	-31.40	-39.50	-26.00	-32.30					0.35
29		4:00	5:00	0.000	-0.054	-31.20	-40.00	-26.10	-32.43	13.8	13.2	13.1	13.4	0.44
30		5:00	6:00	0.001	-0.056	-29.80	-38.00	-24.80	-30.87	13.5	13.0	13.0	13.2	0.34
31		6:00	7:00	0.065	-0.038	-26.80	-33.90	-22.50	-27.73	13.7	13.0	13.0	13.2	0.50
32		7:00	8:00	0.194	0.060	-12.80	-20.90	-11.10	-14.93	14.2	13.6	13.8	13.9	0.68
33		8:00	9:00	0.306	0.172	10.80	-1.80	3.50	4.17	15.2	14.8	14.8	14.9	0.92
34		9:00	10:00	0.497	0.323	30.40	16.00	15.10	20.50	16.7	16.2	15.9	16.3	1.64
35		10:00	11:00	0.650	0.444	61.70	31.30	34.50	42.50	18.0	18.0	17.5	17.8	1.72
36		11:00	12:00	0.781	0.560	63.60	73.70	42.00	59.77	18.7	19.6	20.2	19.5	2.00
37		12:00	13:00	0.685	0.509	51.80	82.20	41.20	58.40					2.00
38		13:00	14:00	0.631	0.478	31.20	63.30	35.10	43.20					2.00
39		14:00	15:00	0.577	0.453	25.30	51.50	27.80	34.87					1.83
40		15:00	16:00	0.667	0.469	21.80	51.60	26.70	33.37					2.13
41		16:00	17:00	0.660	0.452	16.90	39.80	24.90	27.20					2.04
42		17:00	18:00	0.381	0.217	4.55	15.50	13.80	11.28					1.66
43		18:00	19:00	0.141	0.061	-0.58	6.00	4.39	3.27					1.18
44		19:00	20:00	0.045	-0.002	-5.33	-2.86	-1.65	-3.28					0.77
45		20:00	21:00	0.005	-0.027	-9.53	-10.40	-6.00	-8.64					0.36
46		21:00	22:00	0.000	-0.026	-11.60	-14.90	-9.19	-11.90					0.31
47		22:00	23:00	0.000	-0.026	-12.30	-15.60	-10.10	-12.67					0.38
48		23:00	0:00	0.000	-0.025	-12.30	-15.10	-10.20	-12.53					0.31

Table B－2 Cont'd

PICKERING EXPERIMENTAL SITE

NO.	DATE	START	STOP	SOLAR RADIATION (kW/m^2)	NET RADIATION R (kW/m^2)	SOIL HEAT FLUX at 3cm underground (W/m^2)			AVE	SOIL TEMPERATURE (℃)			AVE	WIND SPEED (m/s)
49	23-July	0:00	1:00	0.000	-0.022	-12.10	-15.30	-10.40	-12.60					0.48
50		1:00	2:00	0.000	-0.022	-12.40	-13.90	-10.80	-12.37					1.02
51		2:00	3:00	0.000	-0.016	-11.30	-13.10	-9.95	-11.45					0.57
52		3:00	4:00	0.000	-0.014	-10.10	-11.30	-8.95	-10.12					1.05
53		4:00	5:00	0.000	-0.015	-9.37	-10.40	-8.46	-9.41					0.55
54		5:00	6:00	0.001	-0.014	-8.94	-10.40	-7.70	-9.01					0.55
55		6:00	7:00	0.009	-0.005	-8.91	-9.72	-7.62	-8.75					0.74
56		7:00	8:00	0.029	0.013	-7.58	-7.21	-6.65	-7.15					1.09
57		8:00	9:00	0.051	0.025	-6.38	-6.39	-6.20	-6.32	15.8	15.0	15.5	15.4	0.74
58		9:00	10:00	0.071	0.040	-2.52	-1.13	-2.58	-2.08	16.0	15.2	15.9	15.7	1.57
59		10:00	11:00	0.082	0.051	-0.89	1.64	-1.08	-0.11	16.0	15.4	16.0	15.8	1.77
60		11:00	12:00	0.202	0.147	9.57	15.90	6.73	10.73	16.8	16.0	16.8	16.5	1.77
61		12:00	13:00	0.270	0.200	16.30	21.10	12.40	16.60					2.02
62		13:00	14:00	0.204	0.148	14.60	21.00	10.90	15.50	17.1	16.8	17.1	17.0	1.79
63		14:00	15:00	0.302	0.224	18.20	30.20	13.30	20.57	17.9	17.2	18.0	17.7	1.71
64		15:00	16:00	0.619	0.494	32.30	87.10	23.70	47.70	18.5	18.2	19.0	18.6	2.27
65		16:00	17:00	0.595	0.434	30.50	56.30	26.00	37.60	19.0	18.7	19.0	18.9	2.94
66		17:00	18:00	0.492	0.298	20.90	24.50	22.00	22.47	19.0	18.2	18.8	18.7	2.29
67		18:00	19:00	0.312	0.142	11.40	5.52	14.40	10.44	19.0	18.0	18.1	18.4	1.58
68		19:00	20:00	0.154	0.034	4.35	1.13	7.90	4.46					1.48
69		20:00	21:00	0.023	-0.050	-3.81	-9.13	-1.20	-4.71					0.79
70		21:00	22:00	-0.001	-0.055	-12.90	-16.00	-10.50	-13.13					0.45
71		22:00	23:00	-0.001	-0.048	-18.30	-19.30	-15.60	-17.73					0.24
72		23:00	0:00	-0.001	-0.047	-21.50	-20.50	-18.50	-20.17					0.25

Table B－2 Cont'd

PICKERING EXPERIMENTAL SITE

NO.	DATE	START	STOP	SOLAR RADIATION (kW/m^2)	NET RADIATION R (kW/m^2)	SOIL HEAT FLUX at 3cm underground (W/m^2)			AVE	SOIL TEMPERATURE (℃)			AVE	WIND SPEED (m/s)
73	24-July	0:00	1:00	-0.001	-0.051	-22.3	-19.9	-19.6	-20.60					0.31
74		1:00	2:00	-0.001	-0.048	-22.8	-20.2	-20.2	-21.07					0.30
75		2:00	3:00	-0.001	-0.046	-23.8	-20.4	-20.8	-21.67					0.29
76		3:00	4:00	-0.001	-0.047	-24.5	-20.7	-21.3	-22.17					0.31
77		4:00	5:00	-0.001	-0.055	-24.5	-19.6	-21.6	-21.90					0.42
78		5:00	6:00	0.001	-0.057	-21.9	-18.5	-19.7	-20.03					0.45

Table B－3 Dry and wet temperatures at different heights.

PICKERING EXPERIMENTAL SITE

NO.	DATE	START	STOP	TEMPERATURE (at12cm)		TEMPERATURE (at27cm)		TEMPERATURE (at57cm)		TEMPERATURE (at101cm)		TEMPERATURE (at244cm)	
				DRY (℃)	WET (℃)	DRY (℃)	WET (℃)	DRY (℃)	WET (℃)	DRY (℃)	WET (℃)	DRY (℃)	WET (℃)
1	21-Jul	0:00	1:00	13.18	11.58	13.53	11.56	13.81	11.72	13.95	11.77	14.11	11.8
2		1:00	2:00	12.31	11.25	12.61	11.27	12.94	11.46	13.13	11.57	13.38	11.65
3		2:00	3:00	11.88	11.02	12.19	11.06	12.48	11.25	12.67	11.36	12.88	11.44
4		3:00	4:00	12.08	11.22	12.33	11.2	12.54	11.33	12.61	11.38	12.73	11.41
5		4:00	5:00	11.86	11.12	12.09	11.13	12.39	11.36	12.52	11.47	12.68	11.53
6		5:00	6:00	8.35	7.97	9.2	8.6	10.3	9.72	11.04	10.42	11.82	10.97
7		6:00	7:00	11.09	10.19	11.25	10.08	11.48	10.2	11.54	10.25	11.67	10.27
8		7:00	8:00	12.79	11.2	12.5	10.75	12.41	10.64	12.29	10.56	12.18	10.4
9		8:00	9:00	14.88	12.12	14.4	11.6	14.03	11.29	13.79	11.11	13.54	10.81
10		9:00	10:00	17.23	13.49	16.1	12.54	15.48	12.09	15.06	11.76	14.59	11.32
11		10:00	11:00	18.73	14.24	17.23	13.05	16.41	12.49	15.84	12.04	15.26	11.5
12		11:00	12:00	19.69	14.64	18.17	13.39	17.44	12.94	16.94	12.51	16.43	12.03
13		12:00	13:00	18.95	14.25	17.99	13.36	17.44	13	17.05	12.66	16.64	12.22
14		13:00	14:00	19.39	14.58	18.35	13.68	17.91	13.37	17.55	13.04	17.17	12.62
15		14:00	15:00	20.4	15.21	19.29	14.27	18.69	13.89	18.26	13.53	17.77	13.05
16		15:00	16:00	20.56	14.95	19.58	14.11	19.05	13.78	18.66	13.43	18.24	12.96
17		16:00	17:00	19.69	14.17	19.01	13.44	18.71	13.24	18.45	12.96	18.18	12.6
18		17:00	18:00	19.78	14.15	19.11	13.45	18.83	13.26	18.57	12.96	18.33	12.62
19		18:00	19:00	19.64	14.15	19.06	13.55	18.82	13.38	18.6	13.13	18.37	12.78
20		19:00	20:00	17.8	12.73	17.76	12.45	17.65	12.36	17.56	12.22	17.5	12.01
21		20:00	21:00	14.38	10.45	14.85	10.39	15.19	10.53	15.37	10.53	15.57	10.51
22		21:00	22:00	10.21	8.63	11.11	8.87	12.09	9.36	12.91	9.69	13.97	10.02
23		22:00	23:00	10.79	9	11.6	9.21	12.21	9.56	12.58	9.73	12.96	9.86
24		23:00	0:00	9.37	8.05	10.23	8.31	11.06	8.8	11.5	9.02	12.01	9.22

Table B－3 Cont'd

PICKERING EXPERIMENTAL SITE

NO.	DATE	START	STOP	TEMPERATURE (at12cm) DRY (℃)	TEMPERATURE (at12cm) WET (℃)	TEMPERATURE (at27cm) DRY (℃)	TEMPERATURE (at27cm) WET (℃)	TEMPERATURE (at57cm) DRY (℃)	TEMPERATURE (at57cm) WET (℃)	TEMPERATURE (at101cm) DRY (℃)	TEMPERATURE (at101cm) WET (℃)	TEMPERATURE (at244cm) DRY (℃)	TEMPERATURE (at244cm) WET (℃)
25	22-July	0:00	1:00	10.47	8.17	11.06	8.17	11.49	8.39	11.70	8.45	11.97	8.51
26		1:00	2:00	10.38	7.76	10.99	7.76	11.39	7.99	11.59	8.03	11.85	8.08
27		2:00	3:00	8.17	6.64	9.00	6.90	9.73	7.36	10.19	7.59	10.78	7.81
28		3:00	4:00	4.06	3.76	4.76	4.26	5.85	5.17	6.94	6.03	8.53	6.93
29		4:00	5:00	4.79	4.44	5.71	5.00	6.87	5.96	7.90	6.70	9.15	7.41
30		5:00	6:00	5.61	5.25	6.42	5.76	7.58	6.75	8.40	7.42	9.35	8.05
31		6:00	7:00	8.44	7.71	8.77	7.76	9.24	8.12	9.48	8.34	9.74	8.47
32		7:00	8:00	12.59	10.62	12.21	10.07	12.15	9.96	12.01	9.87	11.92	9.69
33		8:00	9:00	15.57	12.22	15.09	11.58	14.65	11.27	14.38	11.04	14.16	10.73
34		9:00	10:00	17.81	13.02	17.20	12.27	16.58	11.86	16.25	11.57	15.93	11.15
35		10:00	11:00	20.14	14.37	19.00	13.40	18.22	12.87	17.80	12.49	17.35	11.99
36		11:00	12:00	20.95	15.50	18.99	14.12	18.29	13.63	17.76	13.21	17.28	12.76
37		12:00	13:00	20.91	15.59	19.37	14.51	18.57	13.95	18.06	13.54	17.57	13.08
38		13:00	14:00	20.81	15.38	19.61	14.50	18.84	13.94	18.35	13.52	17.85	13.02
39		14:00	15:00	20.69	15.32	19.68	14.56	18.98	14.05	18.54	13.68	18.10	13.22
40		15:00	16:00	21.39	15.67	20.41	14.95	19.64	14.39	19.14	13.99	18.67	13.48
41		16:00	17:00	21.68	15.65	20.57	14.80	19.86	14.29	19.41	13.90	19.00	13.45
42		17:00	18:00	20.07	14.62	19.55	14.11	19.05	13.73	18.72	13.44	18.43	13.03
43		18:00	19:00	18.12	13.53	17.96	13.18	17.73	12.98	17.60	12.80	17.53	12.53
44		19:00	20:00	17.04	12.96	16.97	12.70	17.06	12.57	17.07	12.44	17.15	12.26
45		20:00	21:00	14.77	12.70	14.90	12.51	15.14	12.44	15.35	13.37	16.00	12.19
46		21:00	22:00	13.39	12.25	13.58	12.08	13.95	12.07	14.37	12.06	15.43	12.02
47		22:00	23:00	13.77	12.19	14.07	12.01	14.54	12.07	14.88	12.08	15.45	12.10
48		23:00	0:00	13.34	12.08	13.53	11.93	13.79	11.95	14.03	11.96	14.62	11.92

Table B－3 Cont'd

PICKERING EXPERIMENTAL SITE

NO.	DATE	START	STOP	TEMPERATURE (at12cm) DRY (℃)	TEMPERATURE (at12cm) WET (℃)	TEMPERATURE (at27cm) DRY (℃)	TEMPERATURE (at27cm) WET (℃)	TEMPERATURE (at57cm) DRY (℃)	TEMPERATURE (at57cm) WET (℃)	TEMPERATURE (at101cm) DRY (℃)	TEMPERATURE (at101cm) WET (℃)	TEMPERATURE (at244cm) DRY (℃)	TEMPERATURE (at244cm) WET (℃)
49	23-July	0:00	1:00	13.21	11.97	13.45	11.79	13.84	11.82	14.23	11.83	14.95	11.85
50		1:00	2:00	14.36	11.90	14.64	11.72	14.83	11.75	14.99	11.73	15.22	11.69
51		2:00	3:00	13.72	12.11	13.93	11.90	14.15	11.89	14.40	11.85	14.96	11.78
52		3:00	4:00	14.88	12.28	15.14	12.07	15.26	12.07	15.38	12.03	15.65	11.96
53		4:00	5:00	14.00	12.97	14.23	12.77	14.35	12.73	14.43	12.69	14.70	12.59
54		5:00	6:00	13.55	12.79	13.77	12.59	13.85	12.55	13.89	12.51	14.12	12.41
55		6:00	7:00	13.75	12.72	13.91	12.48	13.96	12.43	13.98	12.39	14.04	12.31
56		7:00	8:00	14.31	12.91	14.50	12.67	14.50	12.60	14.50	12.53	14.53	12.43
57		8:00	9:00	13.88	13.44	13.92	13.17	13.87	13.07	13.81	13.01	13.74	12.89
58		9:00	10:00	14.85	14.43	14.90	14.18	14.81	14.06	14.75	14.00	14.70	13.84
59		10:00	11:00	15.42	15.12	15.44	14.89	15.34	14.78	15.26	14.72	15.18	14.57
60		11:00	12:00	17.07	16.74	16.97	16.39	16.71	16.16	16.54	16.00	16.35	15.75
61		12:00	13:00	17.73	16.40	17.64	15.98	17.35	15.71	17.16	15.49	16.97	15.20
62		13:00	14:00	18.11	16.24	18.04	15.89	17.82	15.71	17.67	15.57	17.53	15.37
63		14:00	15:00	19.63	16.87	19.36	16.39	19.00	16.13	18.78	15.91	18.59	15.66
64		15:00	16:00	21.92	17.73	21.40	17.14	20.81	16.71	20.44	16.38	20.08	15.98
65		16:00	17:00	21.64	18.22	21.10	17.76	20.45	17.28	20.02	17.01	19.46	16.50
66		17:00	18:00	21.05	18.26	20.61	17.90	20.06	17.48	19.64	17.25	19.14	16.79
67		18:00	19:00	20.62	17.82	19.95	17.38	19.57	17.09	19.32	16.90	19.03	16.62
68		19:00	20:00	19.58	17.06	19.05	16.69	18.89	16.56	18.77	16.41	18.65	16.22
69		20:00	21:00	16.62	15.81	16.92	15.27	17.28	15.49	17.45	15.60	17.76	15.69
70		21:00	22:00	12.27	11.82	12.92	12.32	13.80	13.12	14.53	13.80	15.75	14.63
71		22:00	23:00	9.68	9.35	10.34	9.90	11.52	11.04	12.71	12.20	14.36	13.67
72		23:00	0:00	8.59	8.33	9.15	8.76	10.30	9.89	11.68	11.26	13.54	13.07

Table B－3 Cont'd

PICKERING EXPERIMENTAL SITE

NO.	DATE	START	STOP	TEMPERATURE (at12cm) DRY (℃)	TEMPERATURE (at12cm) WET (℃)	TEMPERATURE (at27cm) DRY (℃)	TEMPERATURE (at27cm) WET (℃)	TEMPERATURE (at57cm) DRY (℃)	TEMPERATURE (at57cm) WET (℃)	TEMPERATURE (at101cm) DRY (℃)	TEMPERATURE (at101cm) WET (℃)	TEMPERATURE (at244cm) DRY (℃)	TEMPERATURE (at244cm) WET (℃)
73	24-July	0:00	1:00	8.83	8.62	9.59	9.24	10.87	10.51	12.09	11.71	13.45	12.87
74		1:00	2:00	7.94	7.74	8.50	8.20	9.68	9.38	11.09	10.85	12.79	12.35
75		2:00	3:00	7.16	6.98	7.77	7.49	9.06	8.80	10.45	10.29	12.21	11.87
76		3:00	4:00	6.70	6.52	7.32	7.02	8.64	8.38	10.12	9.94	11.64	11.36
77		4:00	5:00	8.02	7.80	8.68	8.26	9.61	9.27	10.36	10.08	11.32	10.87
78		5:00	6:00	8.38	8.12	9.15	8.73	10.90	9.64	10.78	10.24	11.43	10.84

Table B－4 Soil heat flux at ground surface, evapo-transpiration rate, Boen ratio and energy balance.

PICKERING EXPERIMENTAL SITE

NO	DATE	START	STOP	SOIL HEAT FLUX at SURFACE, G(0) (W/m^2)	EVAPO-TRANSPIRATION RATE, E (g/m^2/s)	BOEN RATIO H/LE (-)	(H+LE+G(0))/R (-)
9	21-July	8:00	9:00	36.17	0.040	0.85	1.00
10		9:00	10:00	51.94	0.064	1.03	1.00
11		10:00	11:00	70.12	0.084	1.02	1.00
12		11:00	12:00	74.64	0.103	0.90	1.00
13		12:00	13:00	40.46	0.070	0.77	1.00
14		13:00	14:00	40.19	0.071	0.71	1.00
15		14:00	15:00	47.22	0.119	0.82	1.00
16		15:00	16:00	40.72	0.101	0.69	1.00
17		16:00	17:00	12.98	0.060	0.54	1.00
18		17:00	18:00	5.93	0.050	0.49	1.00
19		18:00	19:00	-12.96	0.052	0.46	1.00
20		19:00	20:00	-19.82	0.016	0.23	1.00
21		20:00	21:00	-36.17	-0.131	-0.91	0.96
22		21:00	22:00	-42.45	0.004	-4.04	1.01
23		22:00	23:00	-38.62	0.003	-6.98	1.02
24		23:00	0:00	-37.80	0.001	-13.30	1.04
25	22-July	0:00	1:00	-32.06	0.014	-2.08	1.02
26		1:00	2:00	-35.61	0.025	-1.67	1.02
27		2:00	3:00	-36.61	0.003	-7.03	1.02
28		3:00	4:00	-39.60	-0.002	3.99	1.00
29		4:00	5:00	-39.73	-0.001	4.27	1.00
30		5:00	6:00	-34.52	-0.003	2.20	1.00
31		6:00	7:00	-26.52	-0.001	2.35	1.00
32		7:00	8:00	-3.38	0.016	0.66	1.00
33		8:00	9:00	23.63	0.036	0.69	1.00
34		9:00	10:00	44.83	0.068	0.68	1.00
35		10:00	11:00	71.09	0.088	0.73	1.00
36		11:00	12:00	90.18	0.100	0.94	1.00

H: SENSIBLE HEAT FLUX
L: LATENT HEAT FOR VAPORIZATION OF WATER 580(cal/g)
R: NET RADIATION FLUX

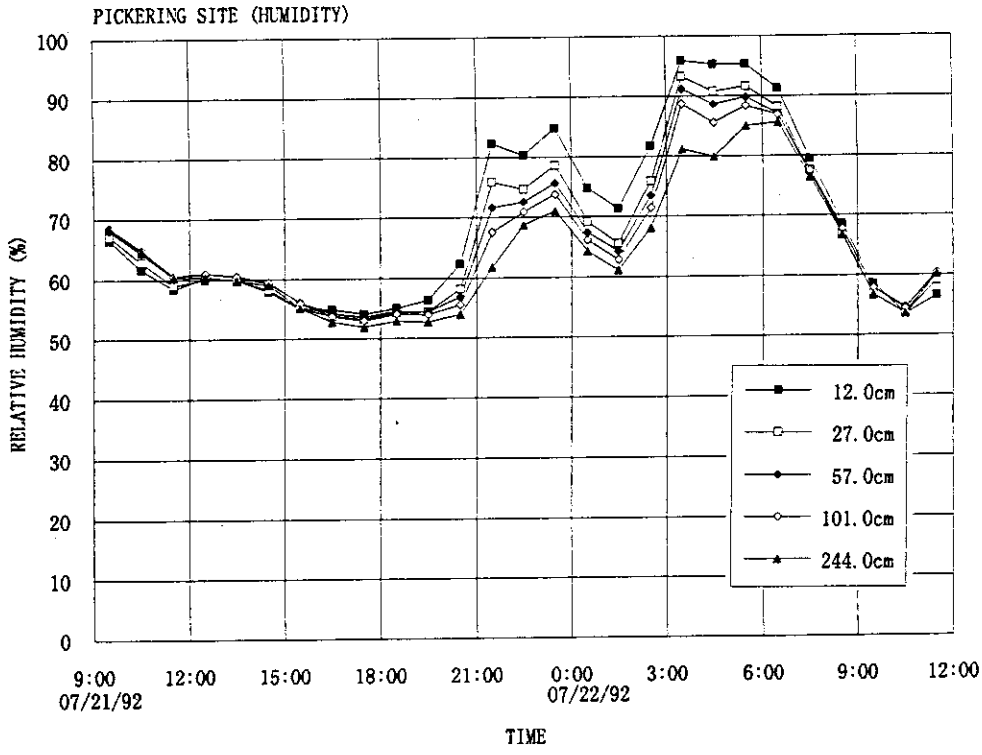


Fig. B－1 Relative humidities measured with aspirated radiation shielded dry and wet thermometers.

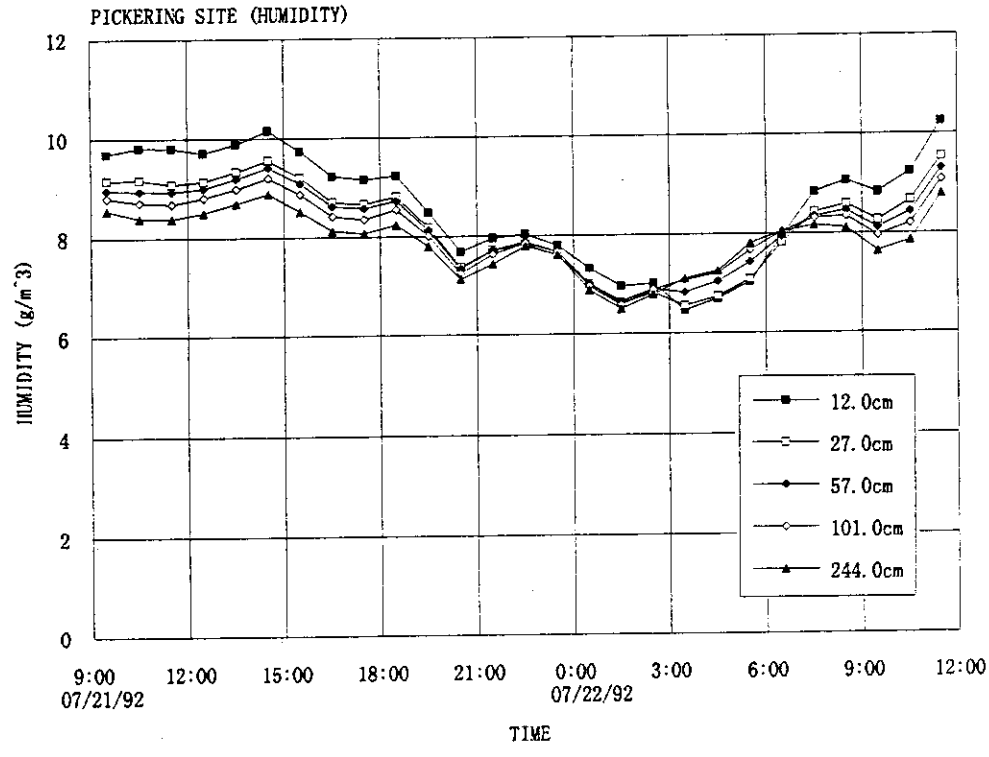


Fig. B－2 Absolute humidities measured with aspirated radiation shielded dry and wet thermometers.

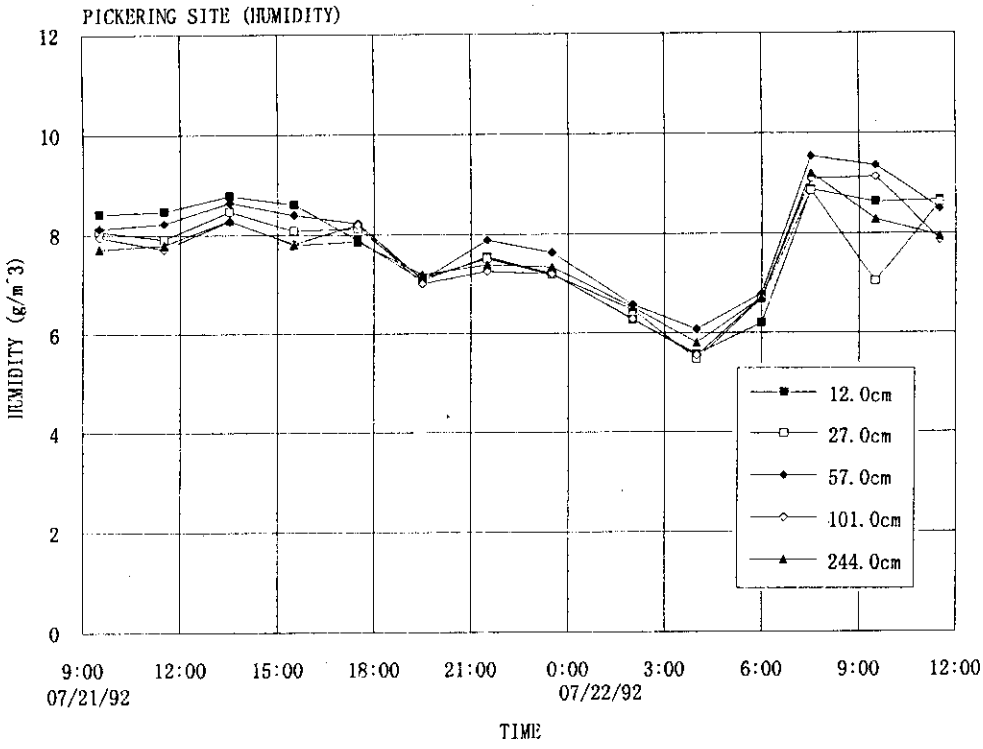


Fig. B－3 Absolute humidities calculated from weights of water collected in M.S. 4A columns.

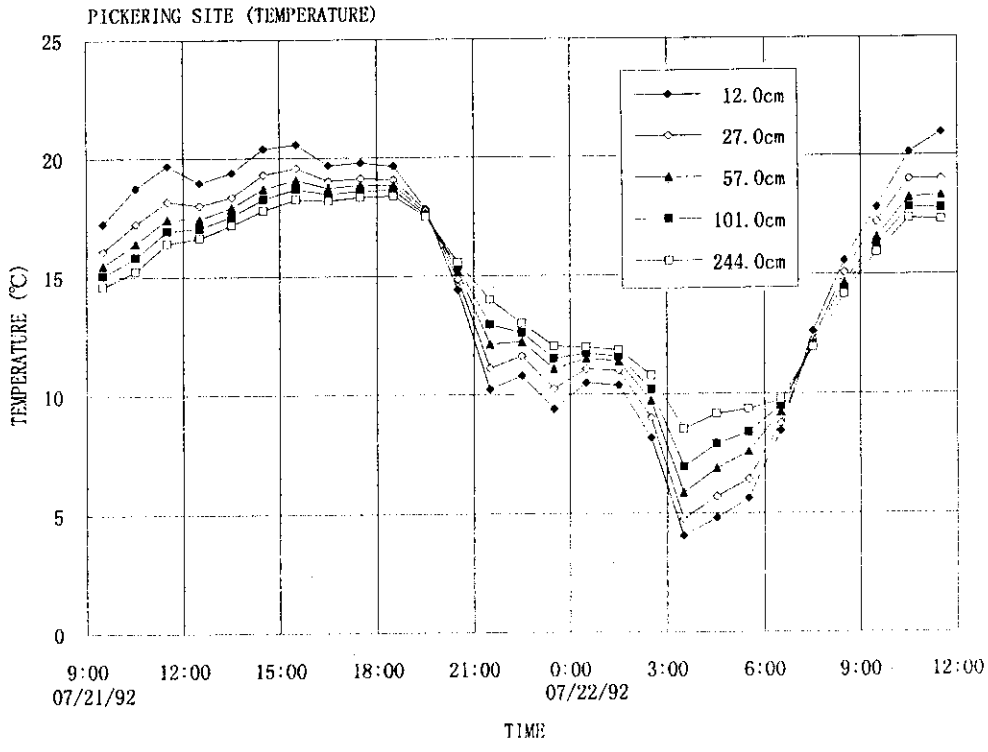


Fig. B－4 Variations of air temperatures at different heights with time.

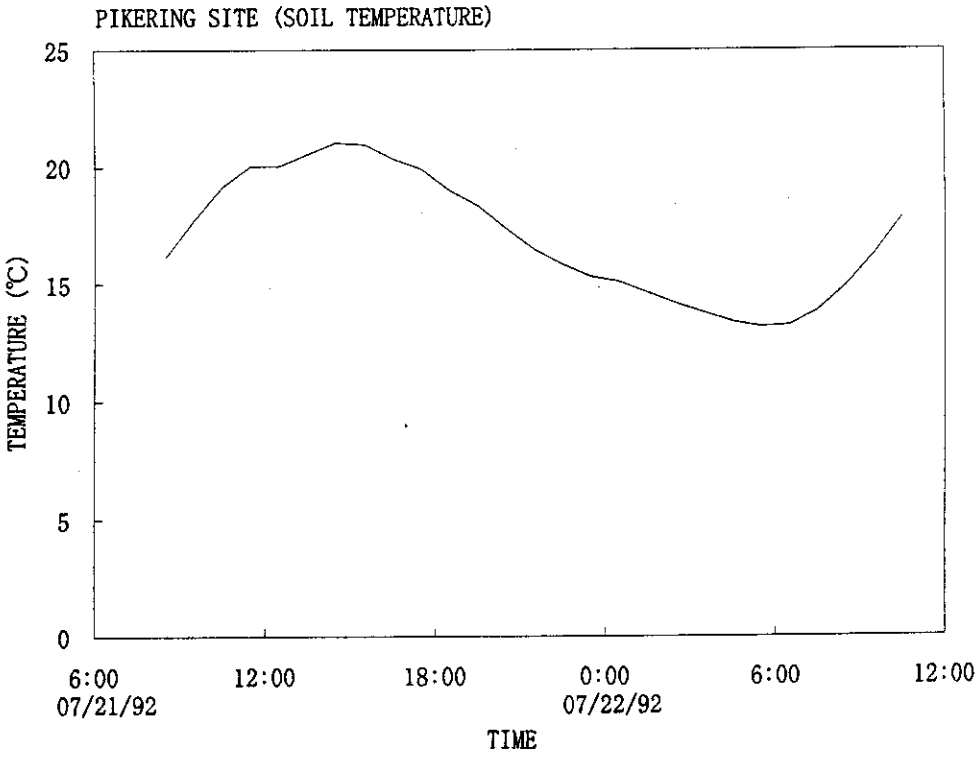


Fig. B－5 Variations of soil temperature with time.

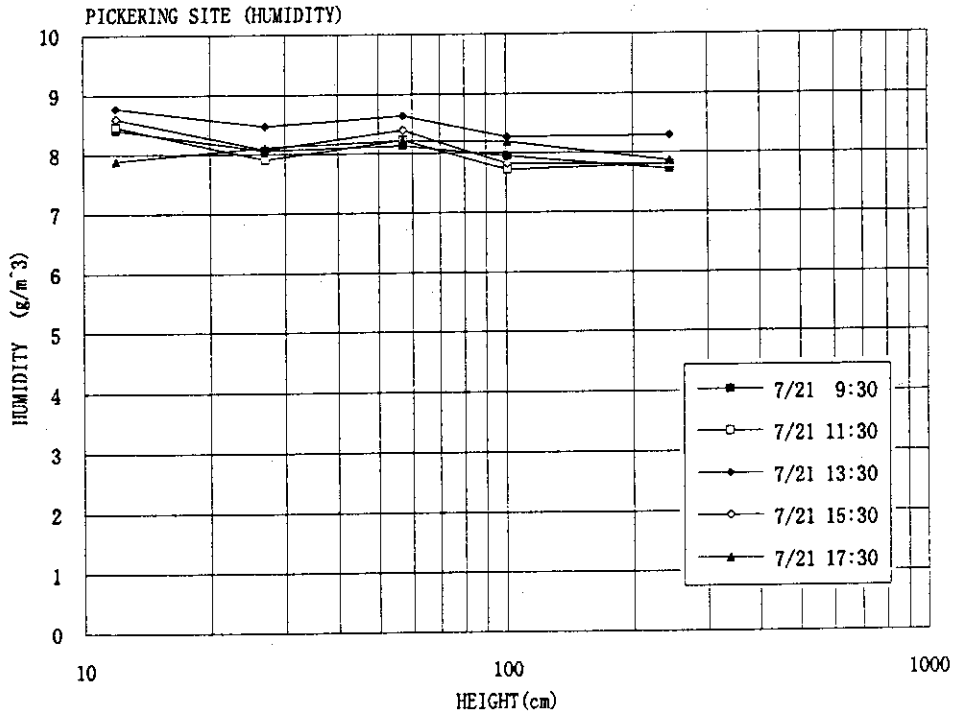


Fig. B－6(a) Height profiles of absolute humidity measured with dry and wet thermometers (9:30 July 21 to 17:30 July 21)

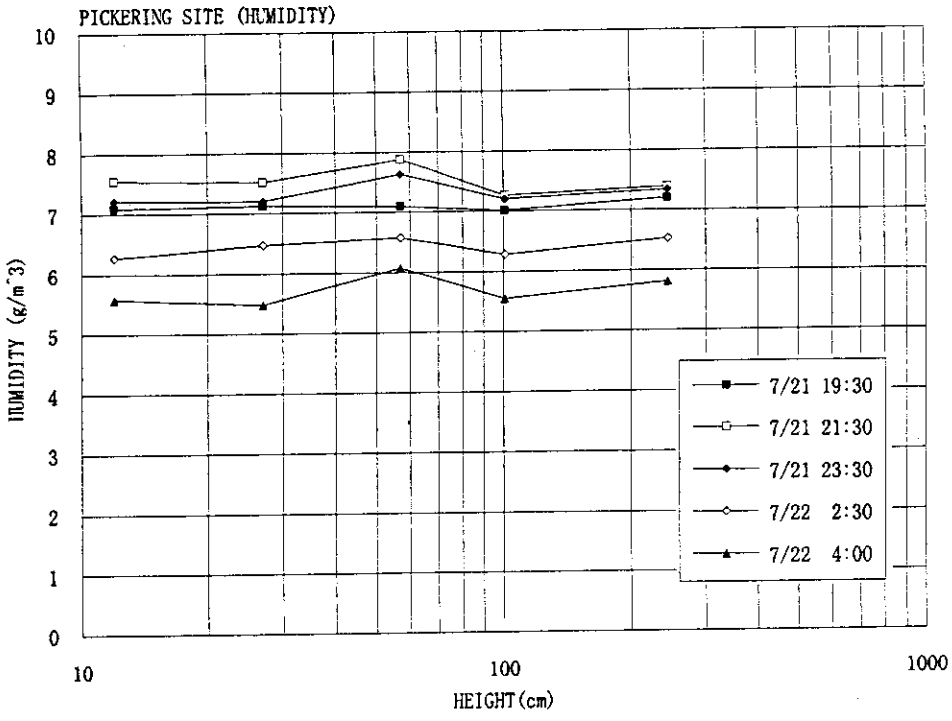


Fig. B－6(b) Height profiles of absolute humidity measured with dry and wet thermometers (19:30 July 21 to 4:00 July 22)

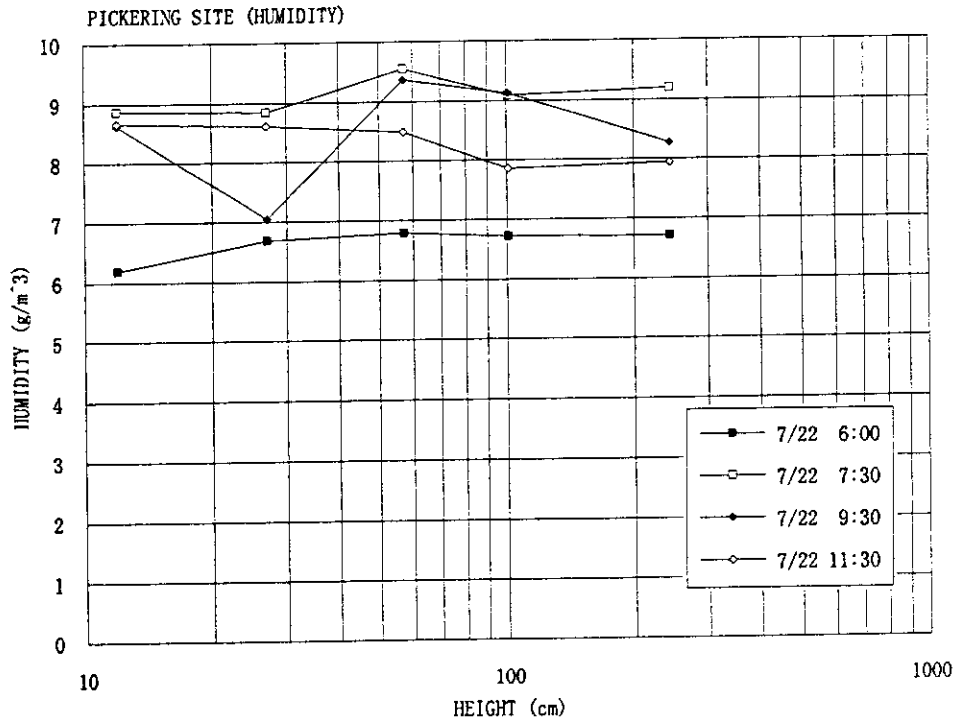


Fig. B－6(c) Height profiles of absolute humidity measured with dry and wet thermometers (6:00 July 22 to 11:30 July 22)

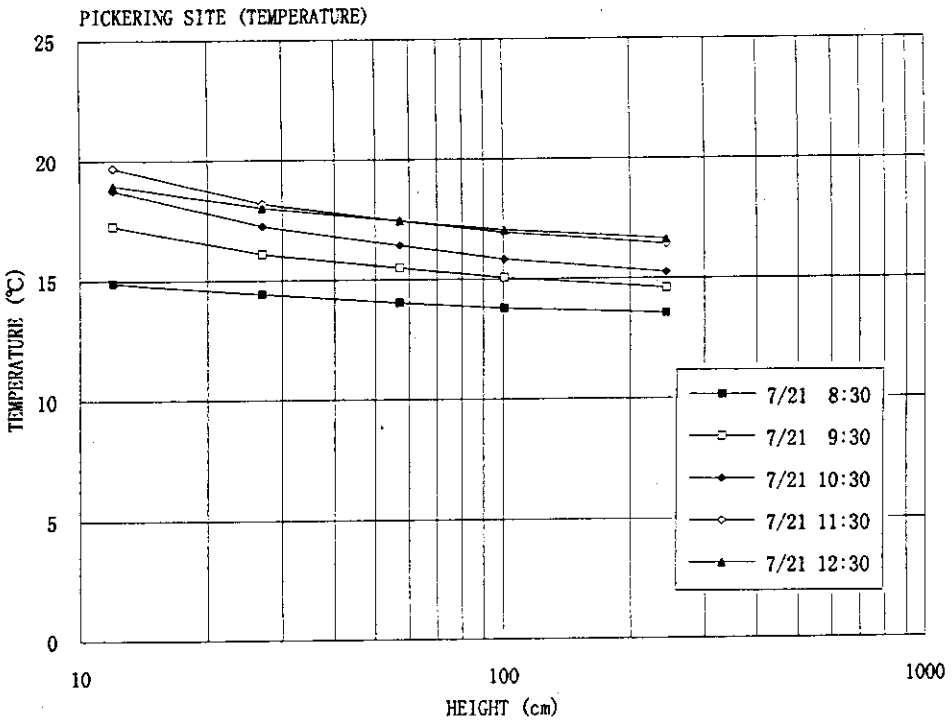


Fig. B－7(a) Air temperature height profiles (8:30 July 21 to 12:30 July 21)

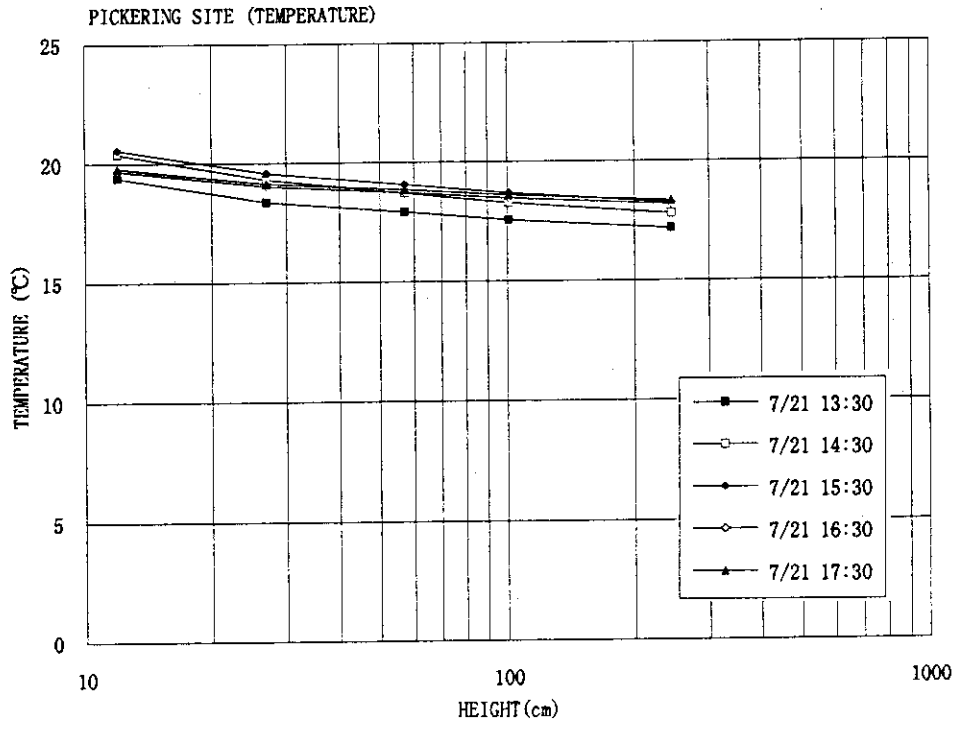


Fig. B－7(b) Air temperature height profiles (13:30 July 21 to 17:30 July 21)

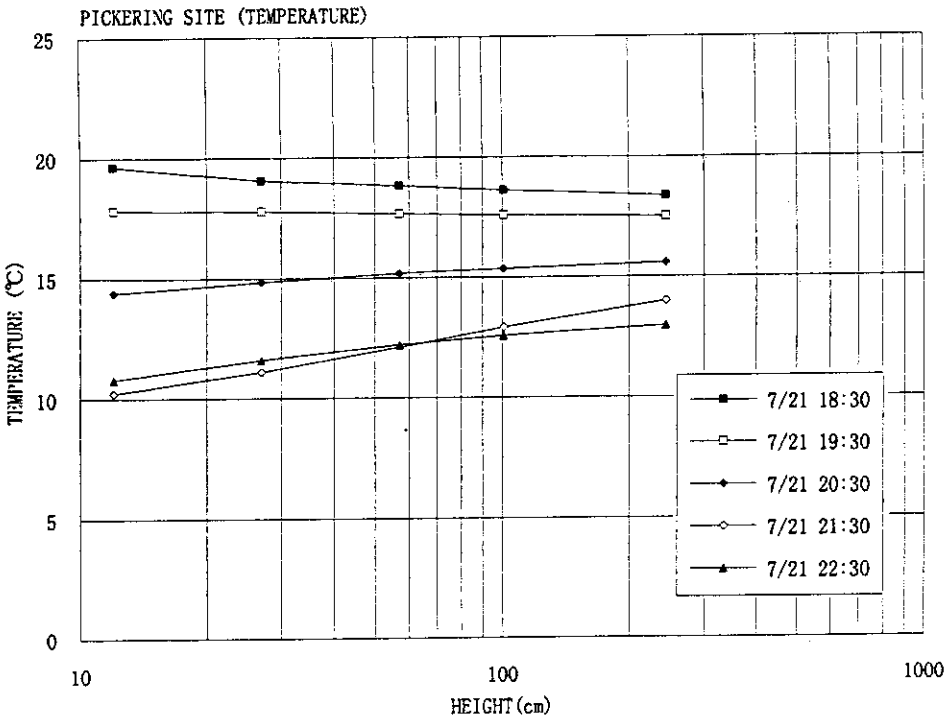


Fig. B－7(c) Air temperature height profiles (18:30 July 21 to 22:30 July 21)

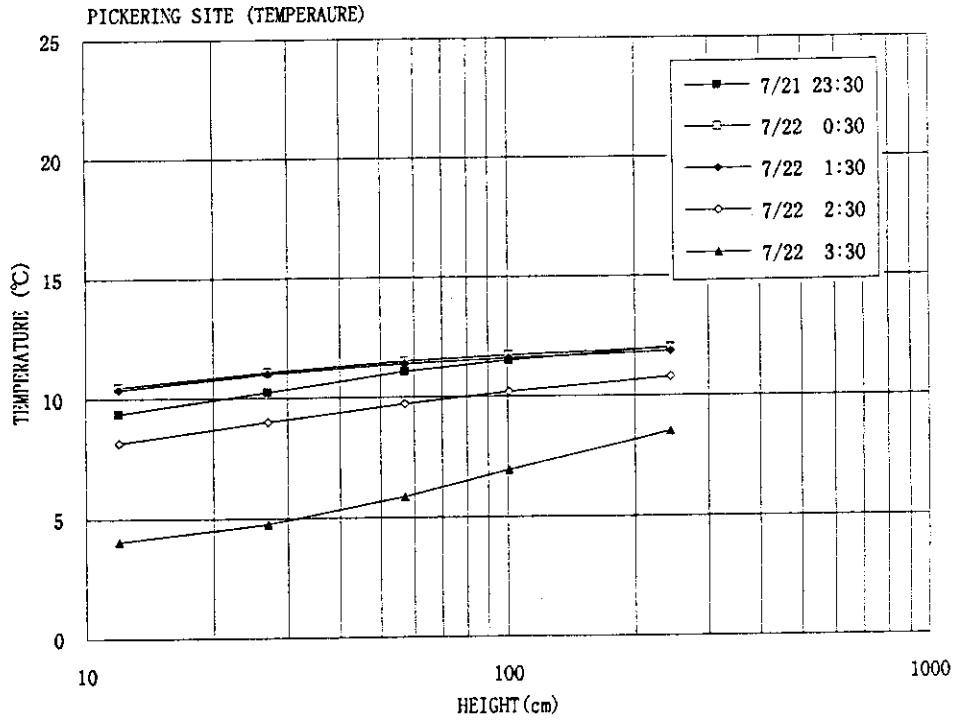


Fig. B－7(d) Air temperature height profiles (23:30 July 21 to 3:30 July 22)

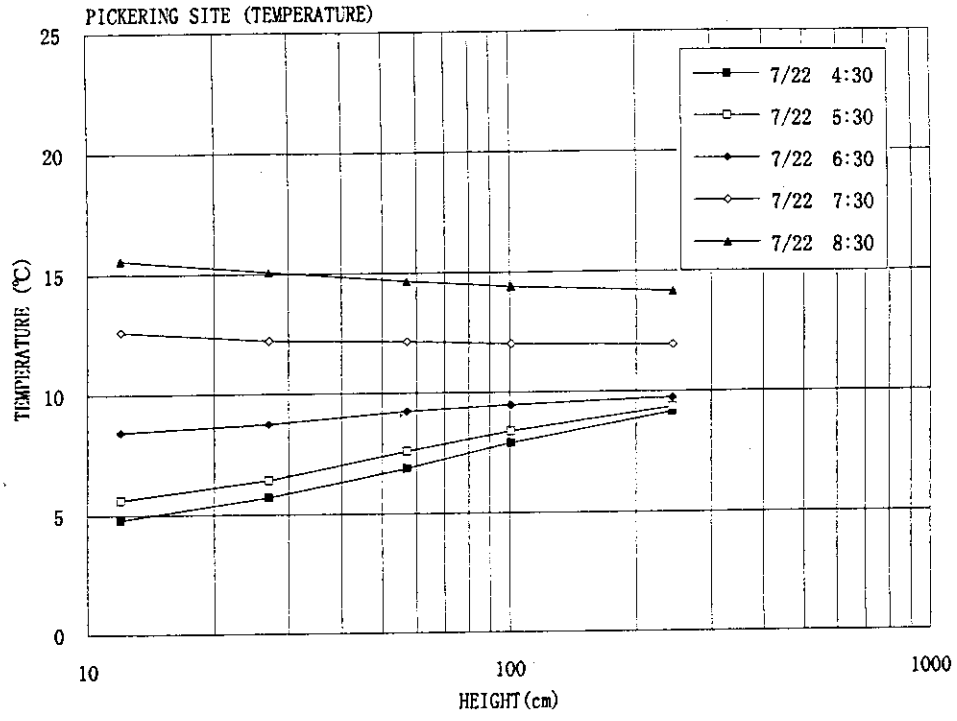


Fig. B－7(e) Air temperature height profiles (4:30 July 22 to 8:30 July 22)

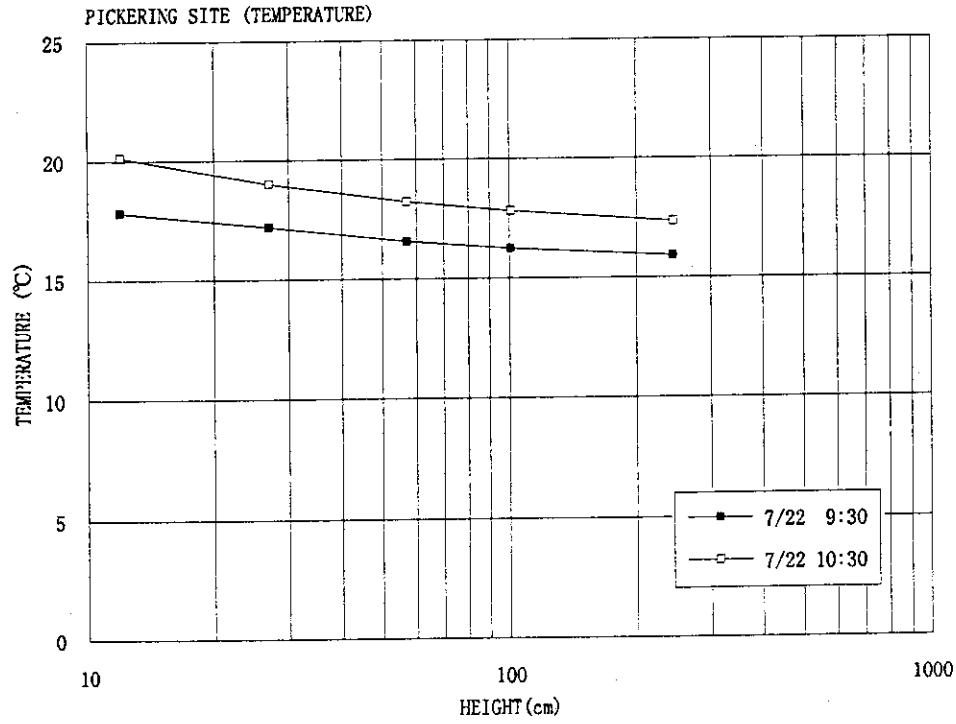


Fig. B－7(f) Air temperature height profiles (9:30 July 22 to 10:30 July 22)

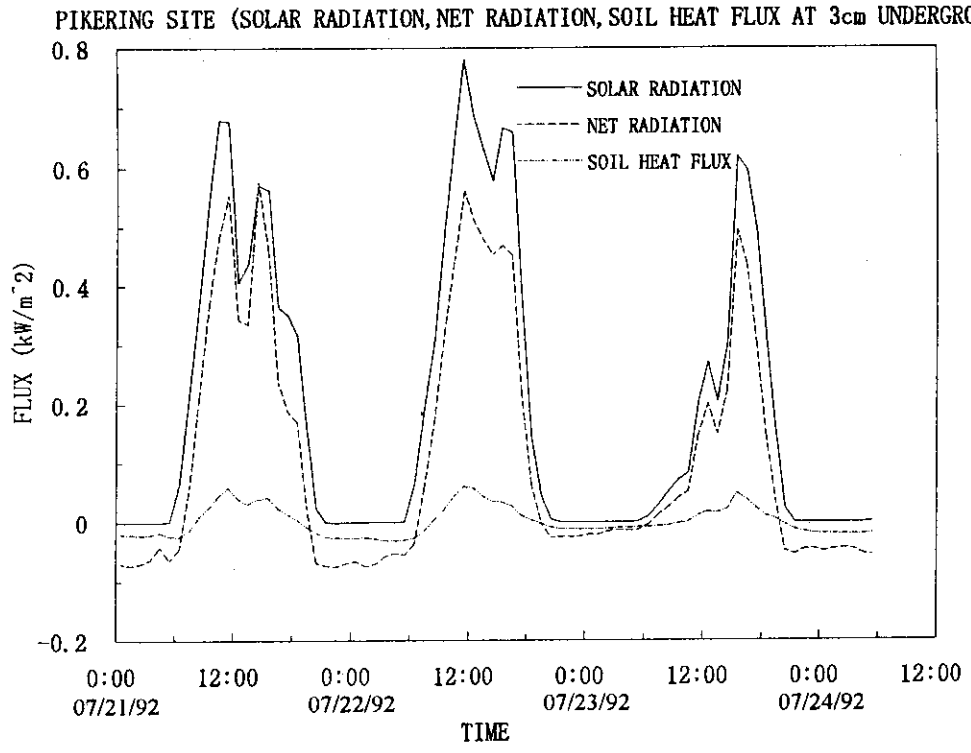


Fig. B－8 Variations of solar radiation, net radiation and soil heat flux with time.

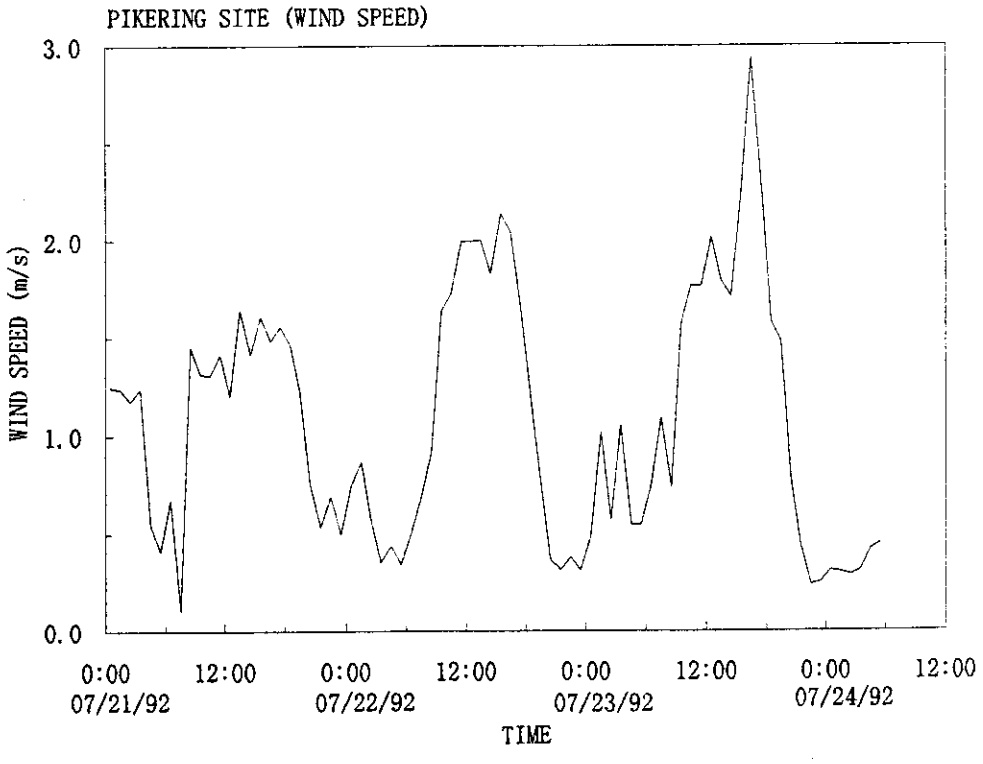


Fig. B－9 Variation of wind speed with time at 2.8 m height.

APPENDIX C Details of the Experimental Sites

Characteristics of the experimental sites were investigated by the Canadian teams. This detailed description of the experimental sites was quoted from the Canadian report on the present field study (Davis, Amiro, Workman and Corbett, 1993[1])

1. CRL experimental site

The CRL site is contaminated from below by tritium migrated through an extensive sand aquifer from a liquid dispersal area (LDA). The LDA has been in operation for 35 years, and the tritium has been carried with surface water and groundwater to Perch Lake, a small, shallow lake about 750 m away (Fig.3-2). The tritium forms a well defined underground plume that is narrow near the source, but broadens to a width of about 1000 m at Perch Lake. The plume has been intensively studied over a period of 30 years (Parsons, 1963[2]; Merritt, 1969[3] ; Barry and Entwistle, 1975[4] ; Killey, 1983[5]). The total inventory of subsurface tritium has been estimated at 370 TBq. In 1991, concentrations on the plume centerline 1 m below the surface ranged from a few hundred Bq/ml near the source to less than 100 Bq/ml near Pearch Lake.

The land is high, well-drained and treed near the LDA, but became lower, flatter and wetter toward Perch Lake. The forest gives way to a wetland within about 100 m of the lake, with shallow open pools and channels of water interspersed with hummocks of spongy soil and low vegetation. Principal species in the wetland include speckled alder (Alnus rugosa), common cattail (Typha latifolia) and meadowfern (Myrica gale), each of which covers about 20 % of the vegetated area. Sweet fern (Myrica asplenifolia) and black alder (Ilex verticillata) each cover a further 10 %, and grasses of various species account for 5 %. The remaining area is covered by a number of herbaceous species, including leatherleaf (Chamaedaphne), honeysuckle (Lonicera sp.), bugleweed (lycopus sp.), arrowhead (Sagittaria sp.), goldenrod (Solidago sp.) and labrador tea (Ledum groenlandicum). The general canopy height is about 1 m, with the alder shrubs reaching over 2 m. Based on wind profile measurements, the roughness length and displacement height at the site are 0.11 m and 0.1 m, respectively (Amiro and Corbett, 1993[6]).

A narrow roadway runs between the wetland and Perch Lake. The experimental instrumentations of AECL and JAERI were set on the roadway at the southern edge of the wetland (Fig.3-2) and measurements were made for any wind with a northerly

component. The fetch over the wetland is heterogeneous. The area of water and vegetation are randomly placed, and the fraction of the area covered by water decreases from about 0.5 at the southern margin to zero at the edge of the forested area 100 m to the north. The gradient in the triritum groundwater concentration is fairly week below the wetland, with changes of less than a factor of two over 100 m or more. Monthly averaged HTO-in-air concentrations north of the wetland are typically a few hundred Bq/m^3 in summer (Workman, Davis, Wood and Barry, 1993[7]). Concentrations decrease markedly away from the ground, indicating that HTO is being lost from the surface to the atmosphere.

2. Pickering experimental site

The Pickering experimental site locates 1 Km to the northeast of the Pickering Nuclear Generating Station (Fig.4-1). Vegetation and soil in the field are contaminated by HTO deposited from the air as a results of routine emissions from the reactors. HTO concentrations in air are about 65 Bq/m^3 when the wind blows the reactor plume across the field, and 1-10 Bq/m^3 when the plume is not present (Neil, 1992[8]).

A low ridge lies between the reactor and the experimental site, and the field slopes very gradually away from the reactor. The field is bounded to the south by a public road, beyond which rises a substantial hill. To the south of the hill lies an industrial area and then, at a distance of about 800 m, Lake Ontario. The experimental instrumentations of AECL and JAERI were set on the south side of the field (Fig.4-2) and measurements were made with windows from the northwest through northeast. Winds from these directions carry the reactor plume away from the field, and reach the field undisturbed by the hill or by Lake Ontario. The field upwind of the measurement location was roughly uniform for about 60 m, at which point the grassland was interrupted by a narrow band of trees oriented east-west. HTO concentrations in soil and vegetation on the field showed little systematic spatial variation.

Soil properties show some variation across the field, but the soil can be generally characterized as a neutral loam or clay loam. The sand fraction varies between about 20 and 50 %, the silt between 30 and 40 %, and the clay between 20 and 40 %. The organic content is about 5-6 %, and the soil is reasonable well-drained except in the southeast corner. The vegetation is dominated by grasses and legumes about 40 cm high, with some herbaceous species and a few trees and shrubs. The roughness length

for the site is 0.025 m, and the displacement height 0.05 m (Amiro and Corbett, 1993[6]). Each area had an extensive thatch of dead grasses, which was not included in the biomass sampling.

References in Appendix C

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2) Parsons P.J.:The movement of tritium from the Chalk River Liquid Disposal Area, Unpublished report, AECL-1739 (1963).

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6) Amiro B.D. and Corbett B.J.:Atmospheric K values to estimate tritium fluxes at Chalk River Laboratories and Pickering Nuclear Generating Station, 1992 July, unpublished report, TR-590 (1993).

7) Workman W.J.G., Davis P.A., Wood M.J. and Barry P.J.:Measurements of the spatial distribution of tritium-in-air above a chronically contaminated surface, Proc. of the 26th Mid-Year Topical Meeting of the Health Physics Society, Lake Coeur d'Alene, Idaho (1993).

8) Neil B.C.J.:Transfer factors for the environmental pathway model CEDM-HT for chronic emissions of tritiated hydrogen gas, Ontario Hydro report, HSD-ST-91-45 (1992).