Northern NY Agricultural Development Program
2013-14 Project Report

Evaluating Agronomic and Environmental Benefits of Tile Drainage in Northern New York

Project Leader:
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Cooperating Producers/Agencies:
. Miner Institute Dairy Farm
. New York State Department of Environmental Conservation
. Lake Alice Wildlife Management Area
. SUNY Plattsburgh Department of Earth and Environmental Science

Background:
Tile drainage has been an important practice for Northern NY dairy, beef, field crop, vegetable, and apple producers for over 100 years. Agronomic benefits of tile drainage are well known, but soil conservation and water quality benefits are not as well documented. Given the importance of tile drainage to the continued profitability and sustainability of NNY farms, long-term research on both the agronomic and environmental benefits associated with tile drainage is needed.

The dominant phosphorus (P) loss pathway in many agricultural fields in the Northeast is due to surface water runoff and soil erosion. In general, the literature shows that tile drainage tends to reduce total P loss due to a reduction in erosion. While tile drainage may facilitate some loss of nitrogen (N) compared to undrained conditions, increased crop yield from tile drains also contributes to greater crop N uptake. Given the multiple potential agronomic and environmental benefits of tile drainage, there is a need to better quantify the environmental aspects of tile drainage to support practical, cost-effective tile drainage BMPs in the future.

Methods:

Miner Institute and NNYADP Funding for Initial Plot Establishment

With previous funding provided by Miner Institute and the Northern New York Agricultural Development Program, four replicated field-scale runoff plots were established at the Lake Alice Wildlife Area in Chazy, NY (2012-2013). The objective was to construct and instrument field-scale runoff plots (150 ft. x 75 ft.) with subsurface tile drainage and surface water monitoring equipment.

Runoff instrumentation was designed and tested in the laboratory to capture real-time changes in runoff from surface and subsurface pathways during storm events.

The subsurface tile drainage was installed at an average depth of approximately 3.5 ft. below the soil surface in each plot. Plots were randomly assigned to the drained or undrained treatment, with undrained plots managed by plugging the end of the tile main.

Three tiles are centered in each plot and drain to a main line that outlets to individual concrete traffic manholes where flows are gauged (see Figure 1 in the Appendix). Surface runoff collection trenches were installed along the lower edge of each plot. Tile mains and surface runoff trenches outlet to individual concrete manholes (4 ft. inside diameter) where flows are measured using v-notch weirs made from 5-gallon buckets equipped with pressure transducers-data loggers that continuously record water level.

Individual standard curves were generated in both the laboratory and field by relating water levels in buckets (e.g., water level is inferred by pressure data collected by a pressure transducer in the bottom of each bucket) to measured flow values. Good predictive relationships were obtained between water levels and measured flows (R^2 ~ 0.96 to 0.99) and were used to calculate flows from each water flow pathway-plot combination.

The objective of this study was to compare P losses between drained and undrained plots over the 2014 drainage season.

Two large storm events in June 2014 were measured, as well as events in August and December. For these events, autosamplers were utilized to take multiple water samples over the event duration to enable more accurate P loading estimates, as P concentrations can vary over a storm event. All runoff pathways were continuously measured during the season anytime flow occurred.

Plots were managed as a cool season grass (*Philaris arundinacea*) during establishment, and in spring 2014, the field and plots were plowed, disc-harrowed, and corn for silage (*Zea mays* L.) was planted across the slope at approximately 34,000 kernel/acre on June 17 (planted late due to very wet May 2014). Approximately 26 lb of N, 40 lb of P_2O_5, and 60 lb of K_2O/acre were applied through the planter as a starter fertilizer. Soil P and K levels (Cornell system) are in the low to very low range. No manure was applied before planting. In mid-November 2014, approximately 4,000 gallons/acre of liquid dairy manure was broadcast without incorporation.

Event-based loads and total load over the season were calculated for each plot. Due to the fact that there are only two replicates/treatment, and that field hydrology is known to be highly variable, data were non-normally distributed. Therefore, a nonparametric statistical test was used to test for possible differences between drained and undrained median loads.

Results and Discussion:

The 2014 growing season was marked by a wet May (Figure 2, Appendix). Two events in June were intensively monitored (e.g., autosamplers were used), as well as one in August and one large precipitation and snowmelt event in December 2014 following liquid dairy manure application.

The vast majority of runoff that occurred in tile-drained plots was from tile drain flow, with just 3% of the total runoff volume occurring as surface water runoff (Figure 4, Appendix).

There were no statistical differences (e.g., $P \geq 0.05$) between drained and undrained plots for total P soluble-reactive P, total suspended solids (TSS; an index of the magnitude of surface or subsoil erosion), or total runoff volume for events during April 21 to August 28 (Table 1, Appendix).

For the runoff event that occurred December 24 to December 26, following manure application in November, suspended solids, total P, and soluble reactive P losses in undrained plots were approximately two-fold greater than tile-drained plots (Figures 5-7, Appendix).

Erosion that occurred from tile-drained plots (as measured by total suspended solid loads) was about half of the amount from undrained plots (Figure 5, Appendix).

The fact that undrained plots had approximately twice the SRP and TP loads exported compared to tile-drained plots for the December 2014 runoff event indicates that the greater surface runoff and erosion associated with undrained plots was associated with greater total and soluble P losses compared to tile-drained plots for this event (Figure 6.)'

Phosphorus applied to the soil surface in the form of manure may have acted as P source to surface water runoff and may help explain results.

While these results are compelling and are representative of field conditions, results were not statistically significant based on the nonparametric test used (e.g., $P \geq 0.12$). This is probably due to the fact that only two replications per treatment are possible at this site due to space limitations. Phosphorus losses by runoff pathway, i.e., surface runoff versus tile drainage flow, also support the assertion that undrained plots increased the amount of surface runoff leaving the field, presumably resulting in the greater observed total and soluble reactive P losses (Figure 7, Appendix).

Conclusions/Outcomes/Impacts:

Results from this project support the literature and field studies in that tile drainage can reduce soil erosion and associated P transport in surface runoff. In addition, our results showed that tile-drained plots resulted in lower soluble-reactive P transport from the field following manure application. The plots in our study are designed to mimic larger-scale agronomic, hydrological, and nutrient management (e.g., both N and P transport dynamics) in similar soil types found in the NNY region. While having two replications per plot limits the ability to show statistical significance, large differences were found in total and soluble-reactive P following fall manure application. Tile-drained plots reduced surface water runoff volume by approximately one half compared to undrained plots, while resulting in about one half of the total and soluble reactive P loads exported after a fall manure application. Results support previous studies showing undrained conditions result in greater P losses compared to tile-drained conditions.

Outreach:

In October 2013, Miner Institute cosponsored a tile drainage and water quality extension meeting at the Institute with the Lake Champlain Basin Program. Peter Wright (USDA-NRCS State Conservation Engineer) Dr. Matthew Helmers (Iowa State), Larry Geohring (Cornell University), Dr. Bianca Mobius-Clune (formerly with Cornell, now with USDA) spoke at the meeting. The tile drainage study supported by NNYADP was covered at this meeting and some attendees toured the site.

Additionally, Laura Klaiber (M.S. candidate in soil science at UVM) presented two peer-reviewed abstracts in 2014 related from this project: (i) A poster abstract at the 2014 national SERA-17 meeting in Des Moines, IA (a group of US scientists from land grant universities and other institutions studying phosphorus), (ii) A peer-reviewed poster/abstract at the 2014 annual American Society of Agronomy-Crop Science Society-Soil Science Society of America Meeting in Long Beach, CA; (iii) One article related to Laura's work and this project was published in the Miner Instituted Farm Report; (iv)

Some results from this project were presented at a tile drainage meeting held in St. Albans, VT in January 2015 by UVM extension.

Next Steps:

Runoff will continue to be monitored during spring 2015 and fall 2015. Additionally, shallow groundwater wells will be installed in spring 2015 to better describe shallow subsurface flows that could impact runoff dynamics. Results will be summarized in Laura Klaiber's M.S. thesis throught he University of Vermont, Plant and Soil Science Department. A peer-reviewed abstract will be presented at the 2015 ASA-CSSA-SSSA meeting in Minneapolis, MN.

Acknowledgments:

Original funding to support the creation of the runoff plots at Lake Alice was provided by internal grant funding by the William H. Miner Agricultural Research Institute. Year-one monitoring of plots was supported NNYADP funding.

Reports and/or articles where results of this project have been presented:
Laura Klaiber presented two peer-reviewed abstracts in 2014 (see Outreach section). One article related to this project was written by Laura Klaiber and published in the Miner Instituted Farm Report. Select results from this project were presented at a tile drainage meeting held in St. Albans, VT in January 2015 by UVM extension. Laura Klaiber also presented her work from this study at the University of Vermont Plant and Soil Science Seminar in December 2014.

For More Information:
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Photos: Photos available on request via Dropbox link.

Appendix

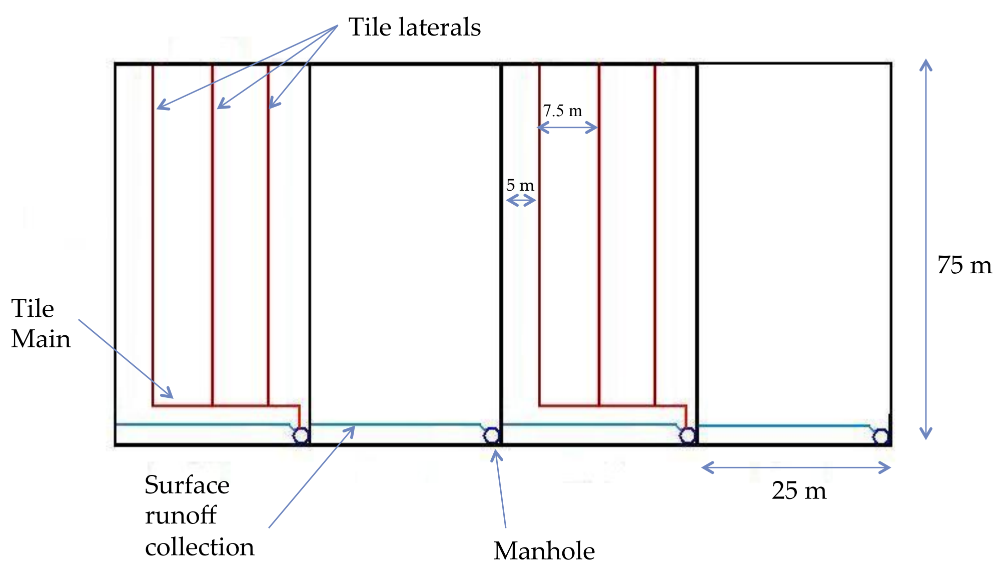

Figure 1. Runoff plot layout at Lake Alice Wildlife Management Area, Chazy, NY.

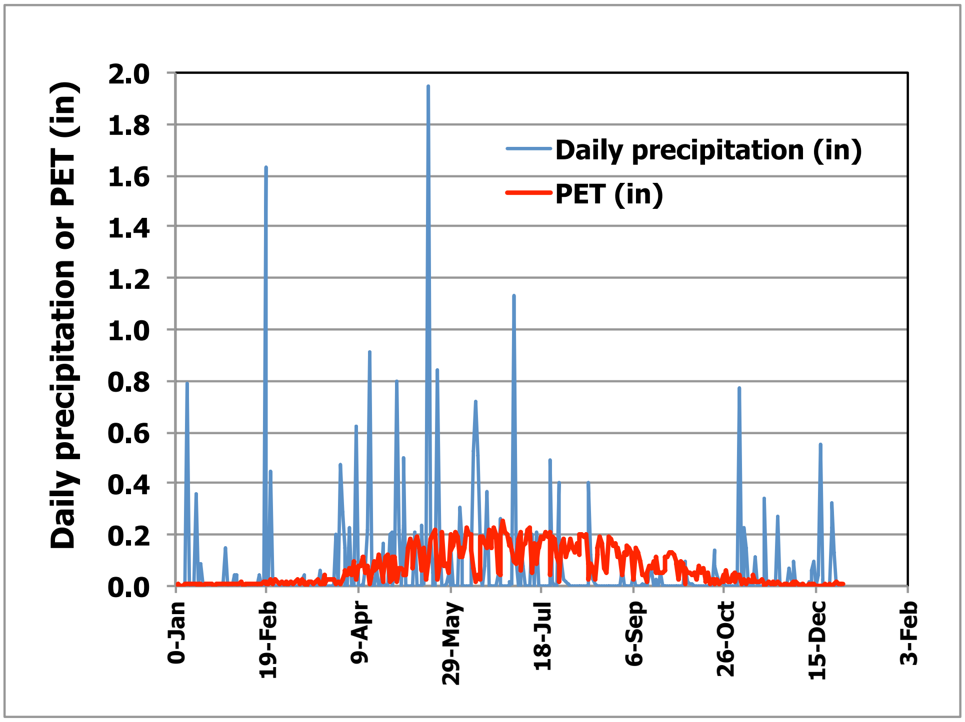

Figure 2. Daily rainfall and potential evapotranspiration estimates (PET data courtesy of Northeast Regional Climate Center at Cornell University).

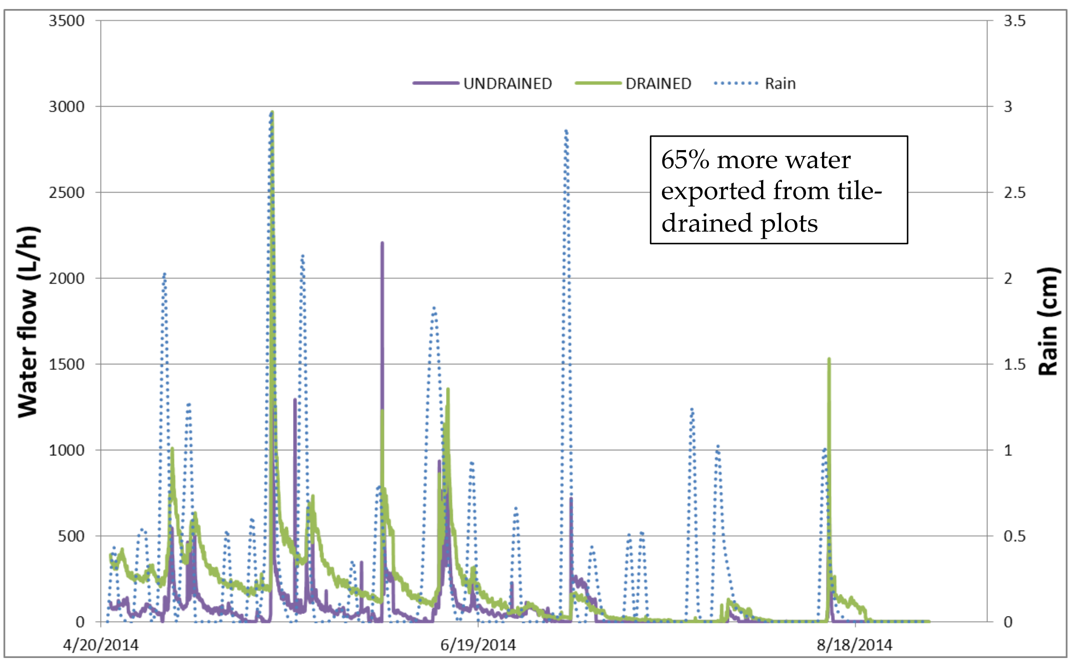

Figure 3. Total runoff (subsurface tile drainage + surface runoff) from drained and undrained plots during April 2014 to late-August 2014.

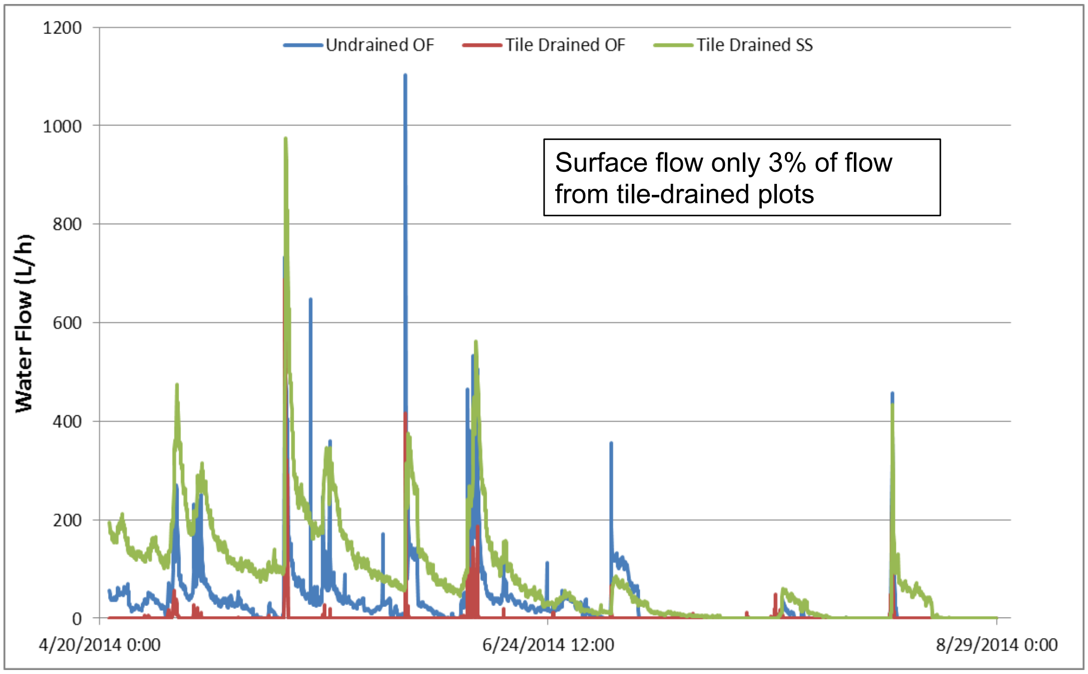

Figure 4. Total runoff by pathway (OF = overland flow; SS = subsurface tile drainage runoff) from drained and undrained plots April 2014 to late-August 2014.

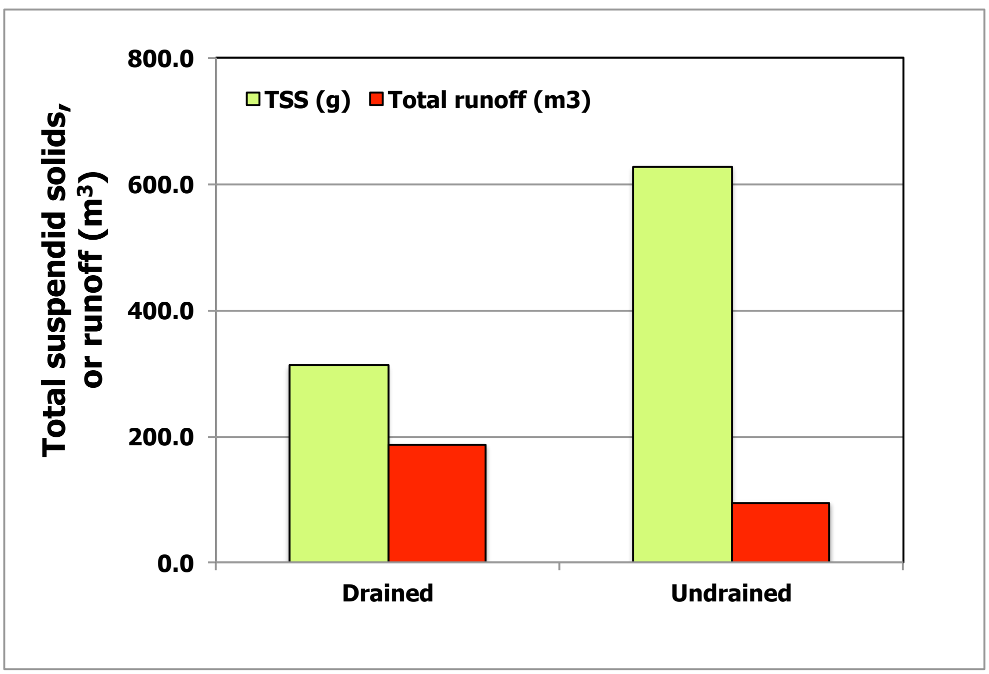

Figure 5. Total suspended solid and runoff loads for drained and undrained plots for the December 24 to December 26, 2014 event.

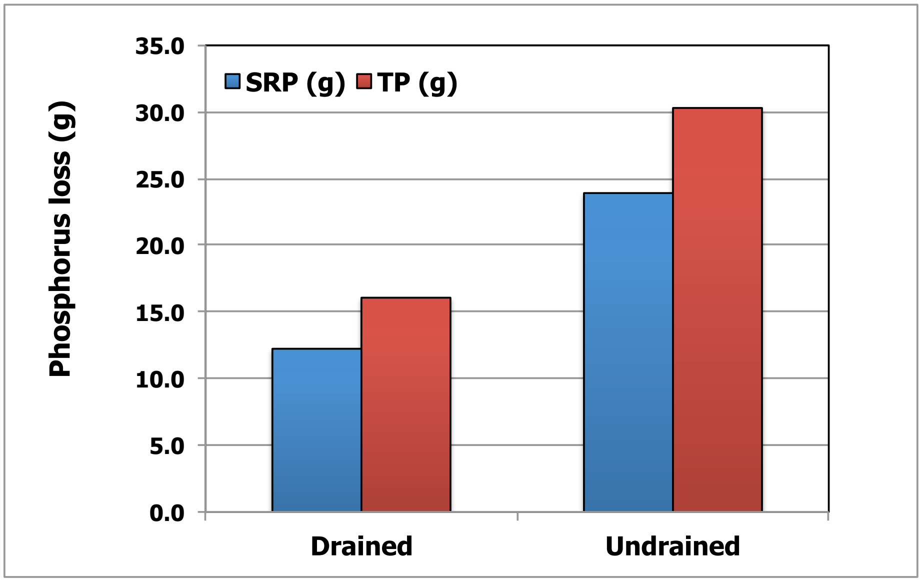

Figure 6. Soluble-reactive P (SRP) and total P (TP) loads for drained and undrained plots for the December 24 to 26th runoff event.

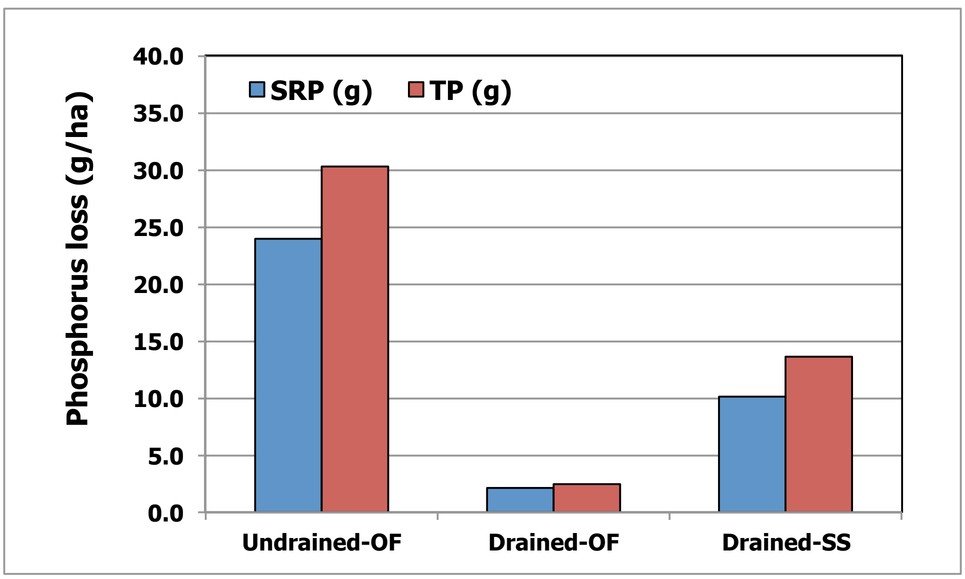

Figure 7. Estimated P loads by runoff pathway from drained and undrained plots for the December 2014 runoff event. OF is overland flow or surface runoff and SS is subsurface tile drain flow.

Table 1. Runoff volume (Runoff), soluble-reactive P (SRP), total P (TP), and total suspendid solids (TSS) loads for 2014 events and total losses over the season.

6/11 Event	Runoff (L/ha)	SRP (g/ha)	TP (g/ha)	TSS (kg/ha)
UNDRAINED	117, 258	2.3	10.1	3.42
TILED	187, 027	0.56	4.6	0.68
6/24 Event				
UNDRAINED	13, 995	0.03	0.1	0.07
TILED	21, 573	0.04	0.2	0.01
8/13 Event				
UNDRAINED	41, 395	2.5	6.3	1.27
TILED	58, 191	1.6	4.5	0.42
Season (Apr21-Aug28)				
UNDRAINED	1, 387, 251	15.0	79.8	78.43
TILED	4, 027, 165	18.7	122.3	36.40