Characteristics and Use of Separated Manure Solids (following anaerobic digestion) For Dairy Freestall Bedding, and Effects on Animal Health and Performance in Three Iowa Dairy Herds

A.S. Leaflet R2321

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Summary and Implications

This summary provides data regarding characteristics (dry matter content and environmental mastitis pathogen counts) of separated manure solids following anaerobic digestion and usage in freestalls on 3 Iowa dairy farms (separated and used on 1 dairy, transported and used at 2 other dairies). Dry matter content of fresh separated solids was 28-40%. Dry matter content of separated solids once in stalls increased to 60-80% (50-60% during winter). Anaerobic digestion (once properly achieved) resulted in coliform bacteria levels < 10^2 (detection levels) but levels of all bacteria were elevated to baseline stall values following < 12 hr. time in stalls. Cow comfort, cleanliness, and feet and leg health were excellent on the bedded manure solids in all 3 herds. SCC remained constant or decreased following use of separated with no associated increases in clinical mastitis. This data shows that composted manure solids can provide a comfortable, effective bedding source if a consistent product is generated and managed properly, and stall, alley, and milking management areas are optimized. However, presence of other organisms (Johne's and salmonella) in separated materials should be evaluated and taken into consideration if separated solids from one dairy are used by other dairies.

Introduction

Bedding materials are used in most types of housing for dairy and other animals and are generally required to improve animal comfort and cleanliness, and assist in removal of moisture from the stall / housing environment. The choice of bedding materials by farms is related to the manure system used, availability and cost of materials, and personal preference with a desire to optimize or maximize the above requirements. Technology to separate solid material from the liquid portion of cow manure and the use of this material as animal bedding has been known for > 30 years. There is a resurgence of interest in using manure solids that is growing from an increase in the installation of methane digesters, and regulations involving manure storage and application. Also scarcity and high price of certain organic beddings (sawdust) has also increased interests.

Study objectives were to evaluate the characteristics of separated manure solids, following the material through anaerobic digestion (Herd 1) , fresh use or stockpiling, and usage in stalls as well as its impact on herd performance in 3 herds, and provide insight into conditions and techniques necessary to make this technology successful.

Materials and Methods

Study participants:

Dairy # 1 is a 700 cow dairy in NE IA. They have 2 lactating cow free stall barns and manure goes to and through an anaerobic digester. In early March 2006, the dairy put in a screw press solid separator (Fan) post digester and started using the separated solids (mainly fresh) for bedding freestalls. Excess separated solids were piled up and used as needed or remained piled until another part of the project where those solids were transported (starting August 2006) and used for bedding on 2 other 120+ cow dairies (Dairies # 2 and 3). All herds had mattresses in freestalls. New bedding material was added every 7- 10 days in herd 1, and 3-4 days in herds 2-3. Stalls were groomed and maintained during every milking. Data was collected on all 3 dairies through March 2007.

Sample collection:

Samples were collected on a biweekly basis from Dairy 1. Samples included 1) raw manure from alleys in both barns; 2) manure effluent flowing from the digester outlet (post anaerobic digestion but prior to separation); 3) fresh separated manure solids (right off separator; 4) excess separated solids stored in a pile; and 5) separated solids bedding samples from the freestalls. Samples from freestalls were obtained from compiling grab samples from 5% of stalls within a pen or barn. Samples were also taken biweekly on dairies 2 and 3. These samples included: 1) separated solids stored in pile; and 2) separated solids bedding samples from the freestalls. Samples were frozen and transported monthly to ISU for subsequent analysis.

Bulk tank milk samples were taken for bacterial analysis and both creamery and DHI data was available. Manure and separated solids were evaluated for Salmonella and Johne's through proper culture techniques (ISUCVM Clin Micro).

Dry matter content:

25 grams of each sample was placed in 5 individual aluminum trays. Trays were placed in a drying oven for 24 hours, reweighed, and dry matter content was calculated.

Environmental mastitis organism counts

10 grams of sample material were added to 90 ml of phosphate buffered saline and mixed thoroughly. Samples were then serially diluted with 6 dilutions ($10^{-2} – 10^{-6}$) plated on MacConkey agar (total gram negatives and

coliforms) and Trypticase soy blood agar (total bacteria and alpha streptococci). Plates were read at 24 and 48 hours.

Results and Discussion

Preliminary characteristics of manure/ manure solids for herd 1 were presented in the 2007 Animal Industry report (R2203). Dry matter content of fresh separated solids was 28-41% (avg. 34%) with piled solids running ~2-5% higher DM. DM% of solids prior to stall application were ~34% (herd 1 and herds 2-3 after 11/06 when all herds were using fresh solids) and ~37% (herds 2-3 up to 10/06 when stockpiled solids from herd 1 were being used).

Dry matter content of solids bedding in stall for all 3 herds are shown in Fig. 1. Variability is partly due to sample time in relation to when fresh solids were applied. DM% of solids in stalls averaged 65-75% during summer-fall, and 50-60% during winter (less drying – curtains closed).

Log CFU bacteria counts / gram of separated solids material prior to stall application are shown in Figure 2. Data was similar across all 3 herds. Total gram negatives, coliform, and alpha strep. (after May - digester temperature optimized) ranged from $10^{4-5,}$ $10^{2-3}$and 10^{4-5}, respectively. Coliform numbers were low/non detectable after digestion.

Log CFU bacteria counts in solids bedding from freestalls in herd 1 (S and N barn) and herds 2-3 are shown in Fig. 3-6. Gram negative and alpha streps averaged $10^{6-7.5}$ and were reasonably constant across times and herds. Coliform counts averaged 10^{5-7}, 10^5, and 10^4 for herds 1-3, respectfully, showing differences in coliforms across herds. Coliform numbers tended to decrease ~ 1-2 log fold during late fall-winter months.

DHI- somatic cell counts (SCC) for all 3 herds over a 4 year period (pre and post solids use) are shown in Fig. 7 Herd 1 averages 250-350,000 with seasonal trends for higher summer SCC. SCC has declined slightly in herd 1 since solids use (DHI and creamery SCC). Herd 2 averages 200-300,000 (since 4/2005 – higher before that) and has maintained that average (exception of 2 monthly spikes of 400-500). Herd 3 averages 100-200,000 SCC, and had maintained that average throughout the 1st year of solids use (slightly more monthly variability). Summer 2007 saw elevated SCC but recent numbers are 150-200,000.

Pooled weekly bulk tank milk cultures (taken biweekly) are shown in Table 1. All herds had no Strep. ag. and some evidence (low to moderate amounts) of Staph. aureus (contagious). Herds 1and 2 had very high levels of environmental streps., coagulase negative staphs. (skin organisms), and some high Coli counts (> 200) indicating issues with milking preparation and teat cleanliness prior to unit attachment. This combined with some Staph. aureus may be the reason for higher SCC in these dairy (although SCC has decreased since solids use). Herd 3 showed very good bulk tank results for environmental and skin bacteria (some elevation on 11/28 and 4/3) indicating excellent premilking sanitation and a major reason for lower SCC.

All herds continue to use separated manure solids for bedding and report decreased clinical mastitis, better feet and legs, improved stall usage and comfort, and decreased culling due to feet and leg issues.

Only 1 sample from 1herd (> 100 samples of raw manure, digester effluent and manure solids on all 3 herds) was positive for Salmonella. All 3 herds had some positive tests for Johne's in their raw manure. Once digester temperature was optimized (June 2006), 90+% of digester effluent samples (only 1 positive sample) and all separated solids samples were Johne's negative on fecal culture.

This data shows that composted manure solids can provide a comfortable, effective, economical bedding source if a consistent product is generated and managed properly, and stall, alley, and milking management areas are optimized. Differences in herd performance in this study were not due to bedding source. Rather, it was due to bedding maintenance, and particularly to differences in milking management and performance.

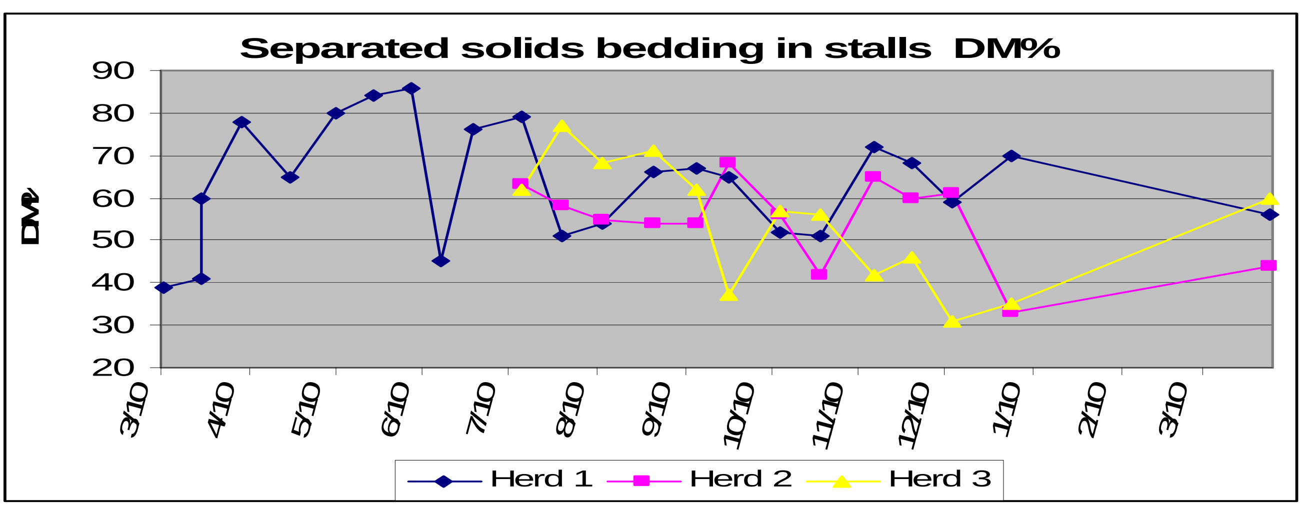

Figure 1. Dry matter % of separated manure solids bedding on mattresses in freestalls in 3 dairy herds over a 1 year period.

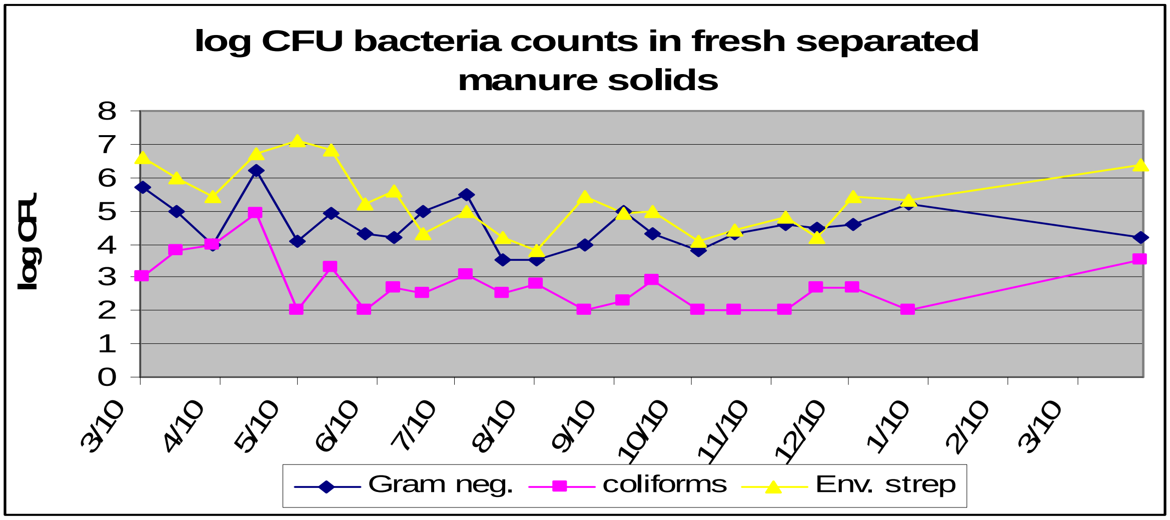

Figure 2. Log CFU/g bedding bacteria counts in fresh separated manure solids (solids to be applied to stalls at all 3 farms).

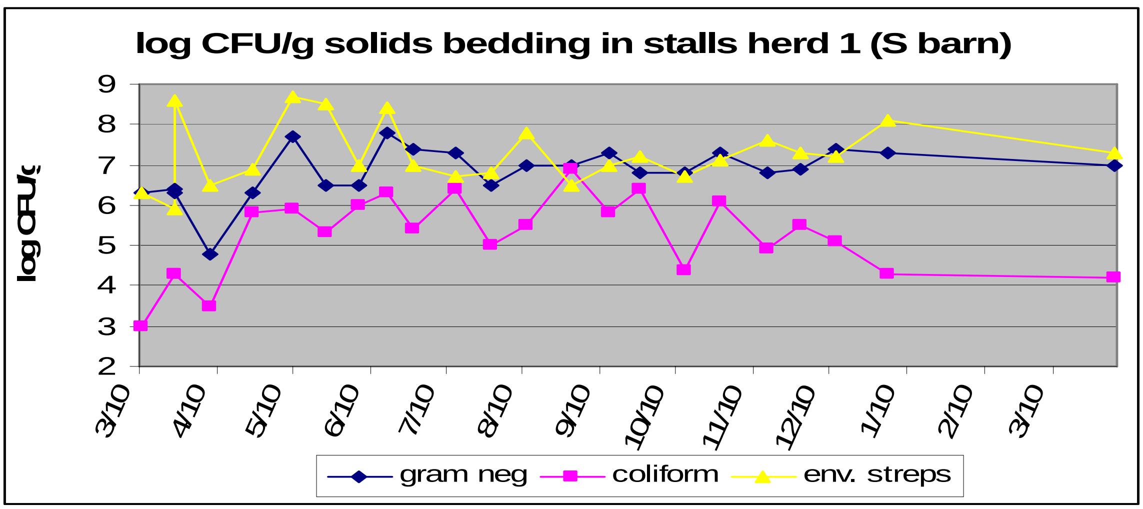

Figure 3. Log CFU/g bedding bacteria counts in freestalls in South barn of herd 1 over a 1 year period.

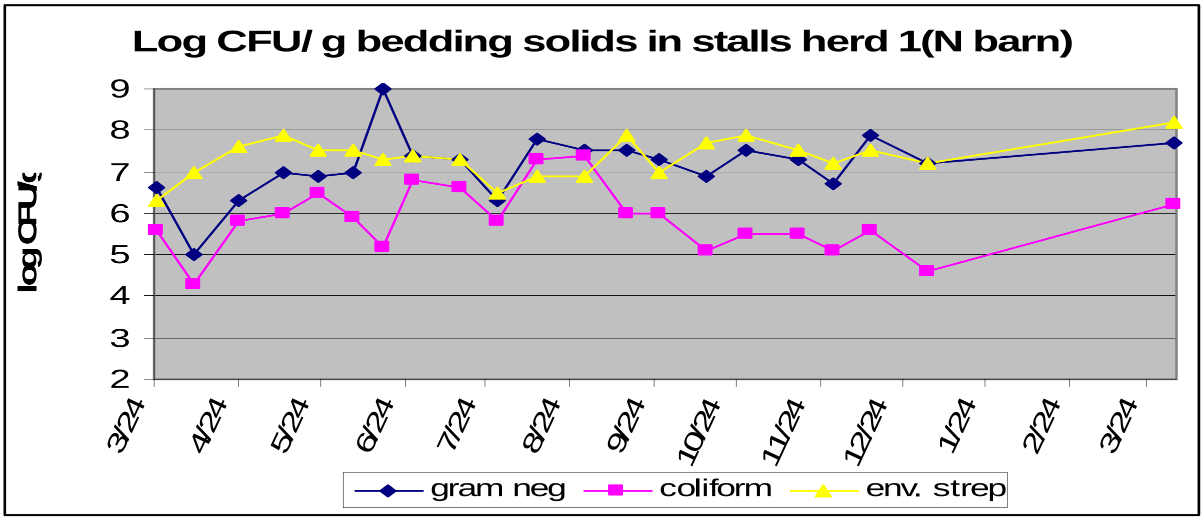

Figure 4. Log CFU/g bedding bacteria counts in freestalls in North barn of herd 1 over a 1 year period.

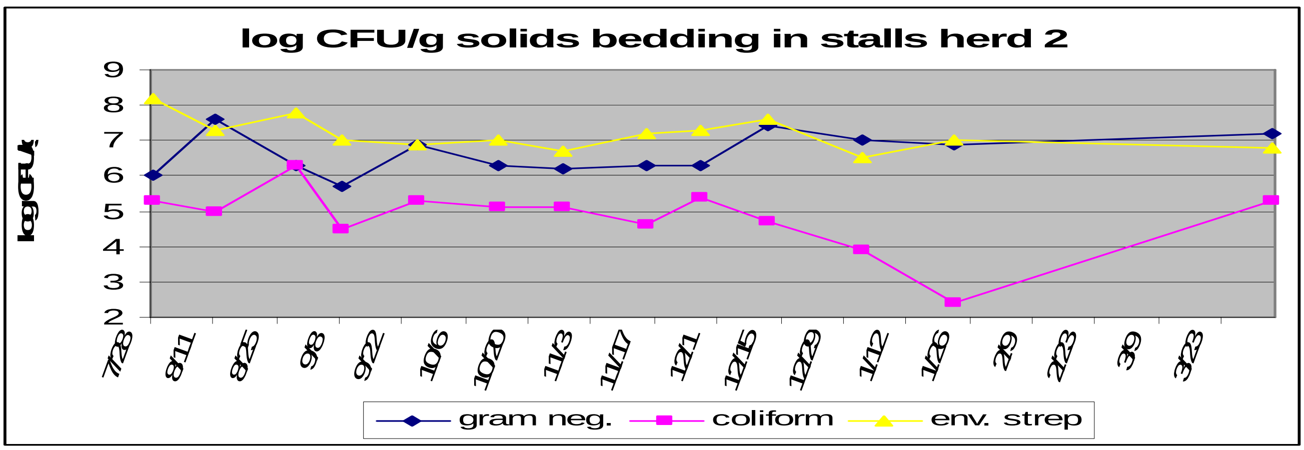

Figure 5. Log CFU/g bedding bacteria counts in freestalls of herd 2.

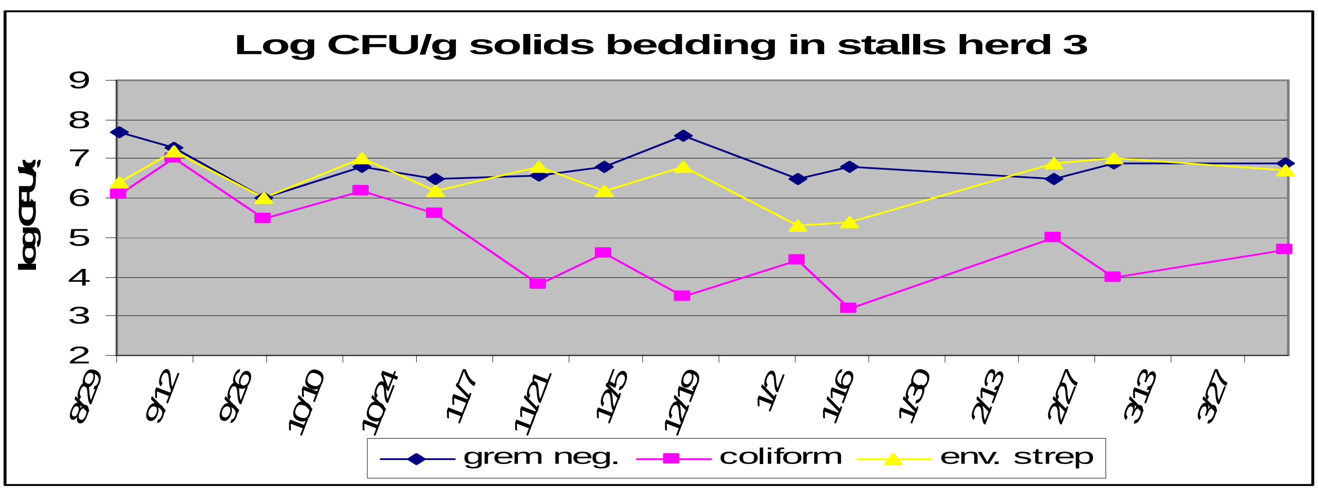

Figure 6. Log CFU/g bedding bacteria counts in freestalls of herd 3.

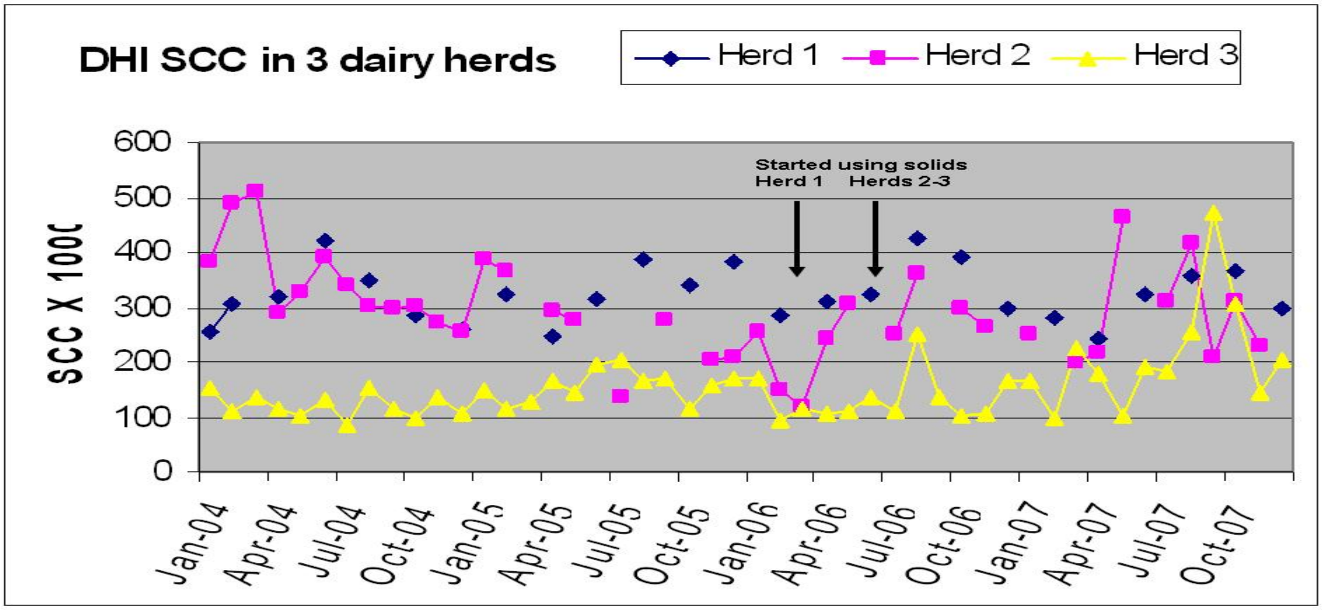

Figure 7. DHI somatic cell counts (SCC X 1000) for 4 years for three Iowa dairy herds (pre and post solids).

Table 1. Dairy Bulk Tank Milk Cultures 2006-2007

Herd	Date	St. ag	S. aureus	Coli	G- oth)	Strep	CNS	Coryn	Bac	Total
1	3/24	0	100000	10	20	100000	0	0	0	200000
1	4/7	0	3000	50	40	1000	0	0	0	4000
1	4/24	0	16000	180	0	0	0	0	0	16600
1	5/23	0	320	1140	260000	0	0	0	0	300000
1	6/5	0	40	85	0	135000	3500	0	0	135000
1	6/16	0	160	10	10	19000	190	0	0	5000
1	6/27	0	250	250	130	115000	1625	500	0	115000
1	7/14	0	0	280	260	155000	16000	0	0	155000
1	7/28	0	700	100	10	250000	1300	0	0	TNTC
1	8/11	0	70	120	330	5500	525000	0	0	TNTC
1	8/29	0	0	100	120	350000	25000	0	0	TNTC
1	9/8	0	0	590	10	70000	8000	0	0	70000
1	9/25	0	15000	50000	0	300000	0	0	0	400000
1	10/13	0	40	0	0	0	730	0	0	1000
1	10/27	0	0	735	0	1750	750	0	0	4000
1	11/15	0	100	310	0	2630	1950	0	0	5000
1	11/18	0	0	530	0	440	1050	0	0	2000
1	11/28	0	0	40	10	60000	30	0	0	60000
1	12/12	0	0	3000	500	50000	0	0	0	50000
1	1/2	0	0	0	0	600	1100	300	0	2000
2	7/28	0	2000	110	590	400	1900	0	0	5000
2	9/11	0	0	340	50	50000	3000	0	0	120000
2	10/13	0	560	270	0	560	180	0	0	2500
2	11/16	0	0	30	2000	0	60	0	0	3000

2	11/28	0	0	2930	19000	11100	0	0	0	35000
2	12/12	0	0	1000	4500	5500	0	0	0	9000
2	1/2	0	0	0	5250	0	0	2000	0	8000
2	1/22	0	0	30	3000	0	0	2000	0	5000
3	8/29	0	0	20	350	500	100	0	200	1100
3	9/7	0	0	0	60	0	220	0	0	230
3	9/25	0	0	0	0	0	300	10	0	310
3	10/13	0	0	0	0	0	30	0	0	30
3	10/27	0	10	40	0	30	0	0	0	2000
3	11/15	0	0	0	0	90	20	0	0	110
3	11/28	0	0	0	230	16000	140	0	0	20000
3	12/12	0	20	10	500	2000	20	0	0	2000
3	1/2	0	100	10	120	1500	0	0	0	1800
3	1/12	0	10	20	0	1100	700	0	0	1800
3	2/2	0	0	10	0	160	100	0	30	200
3	3/2	0	60	160	430	600	200	0	0	1400
3	4/3	0	0	2750	900	520	2500	0	0	6000