Design a Study for Determining Labour Productivity Standard in Canadian Armed Forces Food Services

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Abstract: Canadian Armed Forces (CAF) Food Services recently implemented a standardized menu at all static service locations. Within this new regime, CAF Food Services requires a standard against which they can measure labour performance and use to inform future rationalization of staffing. To start, a pilot study was conducted in February and March 2015 to collect labour performance data. In this paper, we review the results from the pilot study. Due to issues identified with the pilot study, this paper also proposes a revised design and analytical approach for a follow-on study.

1 INTRODUCTION

Canadian Armed Forces (CAF) Food Services is a decentralized function with an estimated value exceeding $150 Million in cost per year for fresh feeding. As functional authority for CAF Food Services, Strategic Joint Staff (SJS) Directorate Food Services recently implemented a three-week National Standardized Cycle Menu (NSCM) on all static feeding facilities, which has been rolled out across all CAF static feeding facilities since the beginning of November 2014. However, currently CAF Food Services does not have a labour performance standard that can be used to measure and compare the labour performance in CAF Food Services (Mat J4 2014).

Unlike most of other food industry, the CAF Food Services is not profit driven and fulfilling the operational needs is its first priority. Determining a CAF specific labour performance standard for CAF Food Services is significant. As a start, SJS Directorate Food Services planned a pilot study and collected labour performance data in February and March 2015. Directorate Materiel Group Operational Research (DMGOR) was later tasked to provide analytical support. The objective of this work is to review the results from the pilot study. Furthermore, due to the issues identified with the pilot study, the work is also used to provide SJS Directorate Food Services a more rigorous study design and analytical approach for a future follow-on study.

2 RESULTS FROM THE PILOT STUDY

2.1 Data Collection

It is noted here that Operational Research and Analysis was not significantly consulted to set up of the pilot study including the aspects, e.g., the target determination, sample selection, and the sample size determination. In addition, the grouping of facilities and the order of visits were determined by financial consideration, i.e., minimizing the travel cost, not by statistical consideration. Furthermore, the choices of the dates were not randomly selected and the facilities were aware of the dates of visits prior to the data collection.

An existing Excel-based Labour Performance Data Collection Tool (Whiting 2015) was used in the data collection process. Annex A Tables A1 provides a summary of data obtained from the pilot study.

2.2 Data Exploration

This section will summarize the results from the pilot study. Although the design of the pilot study is

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not ideal, it provides useful prior information needed for designing a more rigorous future follow-on study.

Volume of Activity

In CAF Food Services, Volume of Activity is used to record the number of meals (including breakfast, lunch and dinner) served in a facility during a fix time period (e.g., daily, monthly or yearly). For the pilot study, Volume of Activity records the total number of meals served during the pilot study period, i.e., a five day period. The Volume of Activity for five days ranges from 2,161, 2,335, 3,037, 4,514, 10,613 and 17,883 for Halifax, Esquimalt, Trenton, Wainwright, Gagetown and Saint-Jean respectively.

Number of Meals per Labour Hour

The number of meals per labour hour is calculated by dividing the total number of meals served by the total number of labour hours spent including labour hours spent by both military and civilian employees see eqn. (1):

$$\textit{Number of meals per labour hour} = \frac{\textit{Number of meals served}}{\textit{Total labour hours spent}} \quad (1)$$

There is a large variation on the number of meals per labour hour across facilities calculated, which are 1.8, 1.9, 3.6, 3.9, 4.3 and 5.3 for Esquimalt, Halifax, Wainwright, Gagetown, Trenton and Saint-Jean respectively (data from Table A.1).

The Volume of Activity is reported as the most important factor that has impact on the labour productivity (Tremblay 2004). The data from the pilot study also suggests that except for Trenton (Different from the other facilities, Trenton also provides flight feeding which requires less time on serving the food than the in person serving.), there is a relationship between the Volume of Activity and the Number of Meals Per Labour Hour: i.e., the greater the Volume of Activity, the greater the Number of Meals Per Labour Hour (which is consistent with the finding in Tremblay 2004) (See Figure 1).

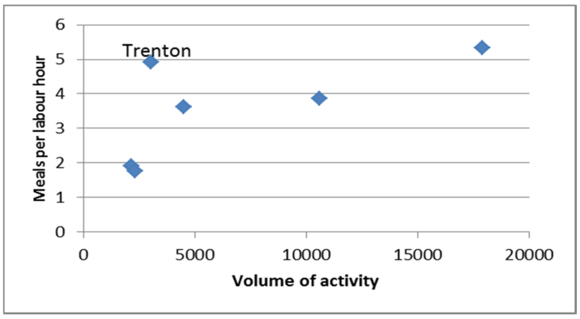

Figure 1: Volume of activity vs. number of meals per labour hour.

Labour Cost per Meal

Table 1 shows that labour cost per meal varies significantly across facilities, which is \$3.85, \$4.83, \$6.22, \$6.89, \$13.35 and \$13.57 for Saint-Jean, Trenton, Gagetown, Wainwright, Halifax and Esquimalt respectively. Some facilities have much higher labour costs per meal than the others, e.g., Halifax and Esquimalt. It needs to be noted that the food material costs and non-food costs (e.g., cost for paper plates) are not included in these figures. Therefore the total cost per meal (including all labour, food material and non-food costs) should be even higher. As such, the total cost per meal in some facilities apparently will not be recoupable by the payments from the diners.

Table 1: Labour cost per meal by facility.

Facility	# of	Total	Labour
Saint-Jean	17,883	$68,775	$3.85
Trenton	3,037	$14,678	$4.83
Gagetown	10,613	$65,972	$6.22
Wainwright	4,514	$31,117	$6.89
Halifax	2,161	$28,855	$13.35
Esquimalt	2,335	$31,686	$13.57

SJS Directorate Food Services reported that the labour rate per hour is the same across CAF Food Services facilities. Therefore, the labour cost per meal is mainly influenced by the labour productivity, i.e., the number of meals per labour hour. It is intuitive that the more meals per labour hour produced the less labour cost per meal. Figure 2 shows this negative correlation between the number of meals per labour hour and labour cost per meal.

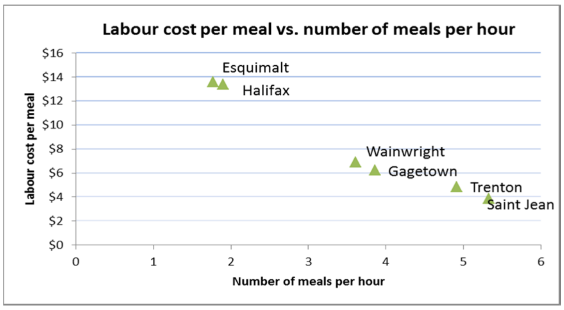

Figure 2: Labour cost per labour hour and number of meals per labour hour.

Additionally, since salary difference exists among different ranks of military cooks and between military and civilian cooks, the labour cost per meal will also be influenced by rank composition of military cooks and civilian and military labour ratio in the facility (see Figure 3).

Figure 3 shows the percentage of civilian hours versus military hours in preparing the meals across facilities. The multiple proportion test shows there is a significant difference (p-value<0.01) on civilian military hours ratios among facilities. The figures for Halifax and Saint-Jean facilities are significantly different; Halifax uses the least civilian labour (52%) and Saint-Jean uses the most civilian labour (90%) among all six facilities.

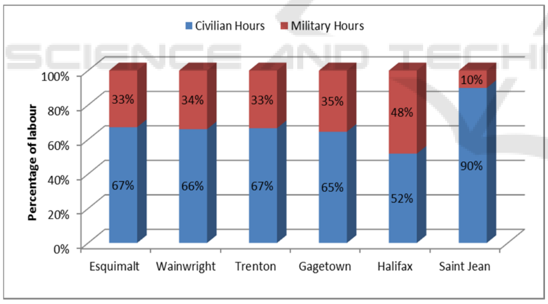

Figure 3: Percentage of civilian vs. military hours spent on preparing meals in the six facilities.

All these data have been incorporated in the calculation of the labour cost per meal in the pilot study.

3 STUDY DESIGN

Due to the issues identified about the approach taken to conduct the pilot study, a new study and its alternative details in study design and method of analysis are proposed.

3.1 Objective of the Study

The study design is driven and determined by the objective of the study. Ultimately, CAF Food Services would like to establish a labour performance standard that can be used to measure and compare the measure performance and inform food services staffing. For this study, as requested, it will only focus on the quantitative side of the labour performance, i.e., the labour productivity.

3.2 Two Labour Performance Standards Should Be Established

With regard to the labour productivity, the first question is: can we set up a uniform labour productivity standard for all facilities in CAF Food Services?

Due to the big variation currently existing on the labour productivity across facilities (as shown in Figure 1), we believe it does not make sense to establish just one labour productivity standard at this time. Based on the data from the pilot study, it is recommended two labour performance standards be established at first:

- one labour performance standard for small facilities (in terms of facilities with small Volumes of Activity); and
- one for large facilities (in terms of facilities with large Volumes of Activity)

3.3 Choice of Target Population

The target population is the population about which information is wanted (Cochran 1977). The choice of the target population should be determined by the objective of the study. The choice of target population will profoundly affect the statistics that result (Lohr & Stratton 2010). Should the target population be composed of all feeding facilities in CAF Food Services? The answer is "No". The reason is because the objective of this study is to develop a labour performance standard for the CAF Food Services not just to get an overall labour performance measure for CAF Food Services. Rogers 2014 provides a clear definition of "standard": "Standard can refer to an aspect of performance, or to the level of performance, or to a combination of both. These standards can be considered minimum levels required, or levels required to be considered best practice." In our context, the labour performance standard here refer to the aspect of labour productivity and the level of the labour productivity; and the standard is considered as the best practice in CAF Food Services. Therefore, to determine the labour productivity standard for the CAF Food Services, we do not recommend using the entire CAF feeding facilities as the target population; instead we recommend the target population consist of facilities which represent the best practice in CAF Food Services in terms of labour performance, i.e., labour productivity in this study.

Therefore, based on military knowledge about CAF Food Services, SJS Food Service provided the following seven facilities to form the target population, i.e., Saint-Jean, Gagetown, Trenton, Wainwright, Shilo, Cold Lake and Bagotville. These facilities were chosen based on the following considerations:

- examples of CAF feeding facilities with good labour performance, from which the labour performance standard can be drawn from;
- regional consideration (i.e., west, central and east); and
- choice of both operational and training facilities.

3.4 Suggested Grouping of Facilities

According to the annual Volume of Activity for FY14/15 obtained from (Whiting and St-Cyr 2015 & Whiting 2015), these seven facilities have been classified into two groups (Table 2), i.e., small and large facility groups. The facility is classified as a small facility if its annual Volume of Activity is less than 100,000 meal day (Meal day is another way to measure the Volume of Activity. One meal day is equal to three meals.); while the facility is classified as a large facility if its annual Volume of Activity is equal to or greater than 100,000 meal days (Record of Discussion May 2015). Based on these criteria, Saint-Jean, Gagetown, Trenton and Wainwright are classified as large facilities while Shilo, Cold Lake and Bagotville are classified as small facilities.

As described in Section 3.2, two labour performance standards should be established for these two groups respectively.

Table 2: Grouping of seven facilities.

Facility	Meal days	Grouping
Gagetown	267,514	Large
Trenton	127,044	Large
Wainwright	136,269	Large
Saint-Jean	347,940	Large
Shilo	57,590	Small
Cold Lake	69,180	Small
Bagotville	37,260	Small

3.5 Choice of Measure

We agree with (Tremblay 2014) that labour productivity can be used as a quantitative measure of food service performance, and the number of meals per labour hour can be used to measure labour productivity. In addition to quantitative measures, qualitative measurer should also be included in developing the labour performance standard for CAF Food Services, e.g., customer satisfaction (mentioned in CAF Food Services Menu 2013 as well). Both quantitative and qualitative measures together should form a holistic view of labour performance in CAF Food Services. However due to the scope of this study, it was agreed that only the quantitative side of the labour performance is investigated in this study.

According to (River 2000), productivity is defined as a relationship between the total amount of goods or services being produced (outputs) and the organizational resources needed to produce them (inputs). The labour productivity here, i.e., the number of meals per labour hour, is calculated (see eqn. (1)) by dividing the total number of meals by the total number of labour hours spent.

3.6 Suggested Method for Considering NSCM and How to Define the Sampling Frame

CAF Food Services cannot easily change the number of staff in facility solely when the menu changes. NSCM is a three-week cycle menu; hence each cycle is composed of 21 days. Over the span of one year, this cycle will be repeated just a bit more than 17 times. To simplify the study and to take budget constraints into consideration, it should be assumed that the 17 cycles are the same. Therefore, we should be able to focus the future labour study within one cycle. Hence, a random sample should be drawn from 21 days, just a full cycle of NSCM; and the order and dates of on-site visits should be randomly selected.

The sampling frame for this study should be a list of consecutive dates between the study starting date and the 21st date that follows the starting date. Once SJS Directorate Food Services determines the start date of the data collection for the future labour study, the sampling frame can be determined immediately.

3.7 Suggested Sampling Method

In order to reflect real operations, randomization of the dates for on-site visits is necessary and important. The dates should be randomly selected and should not be revealed to the facility in advance.

Further exploration shows the variation within each individual facility on labour productivity is smaller relatively to the variation between facilities. One-way analysis of variance (ANOVA) was used to test the between and within facility variation on labour productivity (See Table 3), i.e., number of meals per labour hour (data from Table A).

Therefore, instead of a simple random sampling, a stratified random sampling method can be used. Each facility should be treated as a stratum in both small and large facility groups. The stratified random sampling should be conducted in the following steps:

- First, clearly specify the strata (each facility is treated as a stratum);
- Then, within each stratum (i.e., each facility), use a simple random sampling method to select a random sample of days from the established sampling frame for the on-site visit;
- Collect data from each visit and calculate the labour productivity for each facility; and
- Pool the results from all facilities (i.e., all strata) within the group (large or small) to get an overall labour productivity measure for the group.

The advantages of this stratified random sampling method are:

- separate estimates can be obtained for each stratum (i.e., each individual facility) without additional sampling; and
- since the data are more homogeneous within each stratum, the stratified sampling estimator usually has smaller variance than the corresponding simple random sampling estimators from the same sample size, i.e., a stratified sample can provide greater precision than a simple random sample of the same size.

3.8 Sample Size and Sample Allocation

In order to do sampling, the sample size and sample allocation should be determined first. The following definitions are used in this determination. Noted here, as mentioned in Section 3.7, each facility is treated as a stratum in the following calculation.

T	*total number of facilities in large or small facility group*
N_i	*total number of units in the* i^{th} *facility,* $i = 1, 2, \ldots, T$
N	*total number of units in all facilities*
n_i	*number of samples for the* i^{th} *facility,* $i = 1, 2, \ldots, s$
n	*the total sample size for all facilities*
w_i	*the proportion of the sample which will be allocated to the* i^{th} *facility*
C_i	*cost of obtaining a sample from the* i^{th} *facility*
σ_i	*standard deviation for the* i^{th} *facility*
$\hat{y}$	*mean for large or small facility group*
$Var(\hat{y})$	*Variance for the mean of the large or small facility group*
$\hat{y}_i$	*mean for* i^{th} *facility in large or small facility group*
z	*the upper 0.025 (i.e., 0.05/2) critical point of the standard normal distribution*

What is the sample size for estimating mean labour productivity for the large or small facility group to within some margin of error (noted as *b*) with 95% probability? This question can be translated into eqn. (2):

Table 3: Between and within group variation.

	Sum of Square	f	Mean Square	F	Significance
Between Groups	54.228	5	10.846	35.992	.000
Within Groups	7.232	24	0.301		
Total	61.460	29			

$$z[Var(\hat{y})]^{1/2} = b \qquad (2)$$

Since the Stratified Random Sampling method is used and the samples are drawn independently from the strata, an unbiased estimator of the sample variance ($Var(\hat{y})$) for the large or small facility group can be calculated using eqn. (3) (Cochran 1977):

$$Var(\hat{y}) = \sum_{i=1}^{T}\left(\frac{N_i}{N}\right)^2\left(\frac{N_i - n_i}{N_i}\right)\frac{\sigma_i^2}{n_i} = \frac{1}{n}\sum_{i=1}^{T}\left(\frac{N_i}{N}\right)^2\left(\frac{N_i - nw_i}{N_i}\right)\frac{\sigma_i^2}{w_i} \qquad (3)$$

where $n_i = nw_i$.

Replacing $Var(\hat{y})$) in eqn. (2), eqn. (2) is changed to

$$z^2\left(\frac{1}{n}\sum_{i=1}^{T}\left(\frac{N_i}{N}\right)^2\left(\frac{N_i - nw_i}{N_i}\right)\frac{\sigma_i^2}{w_i}\right) = b^2 \qquad (4)$$

Solving this margin of error equation for n leads to:

$$n = \frac{\sum_{i=1}^{T}\left(\frac{N_i}{N}\right)^2\frac{\sigma_i^2}{w_i}}{\frac{b^2}{z^2} + \frac{1}{N}\sum_{i=1}^{T}\left(\frac{N_i}{N}\right)\sigma_i^2} \qquad (5)$$

Using this equation and based on data obtained from the large or small facility group from the pilot study, the total sample size n, required for estimating mean labour productivity to within some margin of error b with 95% probability can be calculated for the large and small facility groups respectively (see Annex B).

However, there is still one parameter w_i which needs to be determined. The variable w_i represents how the sample is allocated to the i^{th} stratum. There are several ways to allocate the sample (Cochran 1977, Lohr & Stratton 2010, Montgomery & Stratton 2010); the following allocation scheme is recommended:

$$w_i = \frac{N_i\sigma_i/\sqrt{C_i}}{\sum_{i=1}^{T} N_i\sigma_i/\sqrt{C_i}} \qquad (6)$$

$$n_i = n\frac{N_i\sigma_i/\sqrt{C_i}}{\sum_{i=1}^{T} N_i\sigma_i/\sqrt{C_i}} \qquad (7)$$

This allocation scheme was chosen based on the following considerations:

- larger sample size should be assigned to strata containing larger number of elements (i.e., larger N_i);
- larger sample on less homogeneous strata (i.e., larger σ_i); and
- smaller samples from strata with higher cost (i.e., higher C_i).

In summary, the equations above provide not only the calculation of total sample size but also the sample size allocation.

To be conservative and to consider the data obtained from a less ideally designed pilot study, the sample sizes determined based on the pilot data have been inflated to the next integer (see Annex B).

It needs to be noted in the pilot study, the small facility group was formed by two small facilities, i.e., Halifax and Esquimalt. Unfortunately, Cold Lake, Shilo and Bagotville were not included in the pilot study. Due to insufficient data for Shilo, Cold Lake and Bagotville from the pilot data and to get a more robust estimation, the pooled σ_i from the small facility group in pilot study (i.e., Halifax and Esquimalt) was used for Cold Lake, Shilo and Bagotville. The detailed sample size calculation and sample allocation can be found in Annex B. In summary, for large facility group, 16 random samples are needed in total. The number of samples allocated for Wainwright, Trenton, Saint-Jean and Gagetown are 4, 5, 3 and 4 respectively. For small facility group, 13 random samples are needed in total. The sample size for Bagotville, Shilo and Cold Lake are 5, 4 and 4 respectively.

3.9 Suggested Method to Determine the Labour Productivity

Once the data for the selected facilities are collected, the labour performance measurer (i.e., labour productivity) and its variance can be determined.

Two sets of labour productivity will be determined: one for large facility group and one for small facility group. The pooled labour productivity for the large/small facility group can be calculated using a weighted average of the labour productivities (i.e., number of meals per labour hour) across selected facilities within the large/small facility group (see eqn.(8)). The weights individual facility (i.e., individual stratum) receiving is N_i/N. As (Cochran 1977) pointed out this self-weighting scheme is time-saving. The same weighting scheme is used for calculating the variance for the estimated pooled labour productivity (see eqn. (9)).

$$\hat{y} = \frac{1}{N}(N_1\hat{y}_1 + N_2\hat{y}_2 + \cdots + N_T\hat{y}_T) \qquad (8)$$

$$\hat{V}(\hat{y}) = \frac{1}{N^2}({N_1}^2\hat{V}(\widehat{y_1}) + {N_2}^2\hat{V}(\widehat{y_2}) + \cdots + {N_T}^2\hat{V}(\widehat{y_T})) = \frac{1}{N^2}\sum_{i=1}^{T}{N_i}^2(\frac{N_i - n_i}{N_i})\frac{{S_i}^2}{n_i} \qquad (9)$$

As discussed earlier in Section 3.3, specifically in our context, the labour performance standard refers to the aspect and the level of labour productivity; and the standard is considered as the best practice in CAF Food Services. As these labour productivity measures are generated from the selected CAF Food Service facilities of best practice, the labour productivity generated from the next labour study can be considered as the initial standard. It needs to be noted that establishing the labour performance standard will be an evolving process. Although the current study does not produce a labour performance standard directly, it is significant since it is one of the building blocks in the early stage which will support the establishment of the first labour performance standard for CAF Food Services.

4 CONCLUSIONS

4.1 Summary

This paper first reviews the results from the pilot study conducted in February and March 2015 for CAF Food Services. Due to the issues identified with the pilot study, this report also proposes a revised design and analytical approach for a follow-on study.

In summary, the target population is composed of two groups, i.e., the large facility and small facility groups. The large facility group consists of Wainwright, Trenton, Saint-Jean and Gagetown; and the small facility group consists of Bagotville, Shilo and Cold Lake. These are chosen as facilities of best practice on labour performance based on military knowledge and judgement. A stratified random sampling method is suggested being used to get the random samples for the target population. With the same sample size, a study with a stratified random sampling scheme will be able to produce a more precise estimator compared to that with a simple random sampling scheme. The sample size and sample allocation have been determined based on the data obtained from the pilot study. In summary, for the large facility group, 16 random samples are needed in total. The number of samples allocated for Wainwright, Trenton, Saint-Jean and Gagetown are four, five, three and four respectively. For the small facility group, 13 random samples are needed in total. The sample size for Bagotville, Shilo and Cold Lake are five, four and four respectively. The approach for calculating weighted stratified random sample estimates and their corresponding variances are also determined for the future study.

Although according to the client's request, this study focuses only on the quantitative side of the labour performance, we believe in order to provide the labour performance standard for CAF Foods Services, not only the quantitative measure, but also qualitative measure of labour performance should be considered. Therefore, if it is financially permitted, we recommend that a social study (using techniques, e.g., customer surveys, interviews, or focus groups) be conducted to measure the qualitative aspects of the labour performance. Only focusing on the labour productivity may drive the facilities to pursue fast but not high quality food services.

4.2 Significance of the Study

Unlike most of the other food industries, CAF Food Services is not profit driven and fulfilling the operational needs is its first priority. Given that the CAF Food Services does not have a labour performance standard, establishing one is significant.

It is beneficial to provide a labour performance standard (i.e., level of labour performance of best practice here) against which a performance of a CAF Food Services facility can be measured and compared. Once developed, this labour performance standard could then be used to ensure food service facilities to provide efficient and effective food service support to the CAF and may inform future rationalization of staffing within CAF Food Services. Routine measurement of labour performance could also provide a way for CAF Food Services managers to monitor and track operational improvements over time. This study focuses on the quantitative side of the labour performance, i.e., labour productivity. As summarized in (River 2000), productivity measures can play a key role in business process redesign and optimization, assessing maximum sustainable outputs, lowering products or service unit cost, and exploring the feasibility of out sourcing.

Developing a labour performance standard will be an evolving process. Although the current study does not produce a labour performance standard for CAF Food Services directly, it outlines the requisite study design for data collection and an analytical approach for a future study, which will underpin future development of a labour performance standard for CAF Food Services.

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ANNEX A: SUMMARY OF DATA FROM PILOT STUDY

Table A: Summary statistics for Halifax obtained from the pilot study.

Facility	Day	Civilian Hours	Military Hours	Civilian Wages	Military Wages	Total Hours	Labour Costs	# of Meals	Meals/Hour
Halifax	D1	24	143	$615	$4086	167	$4701	483	2.9
	D2	120	90	$2502	$2688	210	$5191	496	2.4
	D3	152	143	$3216	$4157	295	$7373	444	1.5
	D4	144	90	$3084	$2688	234	$5773	398	1.7
	D5	136	98	$2901	$2917	234	$5818	340	1.5
Gagetown	D1	334	158	$6875	$4778	492	$11653	2180	4.4
	D2	342	203	$7058	$5977	545	$13034	2272	4.2
	D3	396	225	$8276	$6618	621	$14894	2224	3.6
	D4	348	218	$7215	$6404	566	$13619	2266	4.0
	D5	326	203	$6810	$5962	529	$12773	1671	3.2
Saint-Jean	D1	614	83	$12,122	$2,534	697	$14,656	3816	5.5
	D2	630	68	$12,130	$2,106	698	$14,236	3556	5.1
	D3	606	68	$11,640	$2,106	674	$13,747	3606	5.4
	D4	556	53	$10,523	$1,664	609	$12,187	3523	5.8
	D5	620	60	$12,057	$1,892	680	$13,950	3382	5.0
Wainwright	D1	168	90	$3,738	$2,745	258	$6,484	992	3.8
	D2	168	83	$3,738	$2,517	251	$6,255	1051	4.2
	D3	192	83	$4,269	$2,517	275	$6,786	704	2.6
	D4	136	90	$2,992	$2,617	226	$5,610	963	4.3
	D5	152	90	$3,365	$2,617	242	$5,983	804	3.3
Trenton	D1	104	30	$2,217	$799	134	$3,016	558	4.2
	D2	80	45	$1,825	$1,170	125	$2,995	715	5.7
	D3	80	53	$1,825	$1,384	133	$3,209	650	4.9
	D4	72	45	$1,610	$1,226	117	$2,836	603	5.2
	D5	72	38	$1,610	$1,013	110	$2,622	511	4.7

Table A: Summary statistics for Halifax obtained from the pilot study (Cont.).

Facility	Day	Civilian Hours	Military Hours	Civilian Wages	Military Wages	Total Hours	Labour Costs	# of Meals	Meals/Hour
Esquimalt	D1	200	60	$4,400	$1,658	260	$6,058	435	1.7
	D2	176	83	$3,870	$2,271	259	$6,141	408	1.6
	D3	176	120	$3,870	$3,267	296	$7,137	426	1.4
	D4	152	98	$3,457	$2,668	250	$6,124	365	1.5
	D5	168	90	$3,830	$2,397	258	$6,227	701	2.7

ANNEX B: SAMPLING

As we discussed in Section 3.8, the sample size and sample allocation will be determined using eqns. (5), (6) and (7).

The following sample size calculation and sample allocation are based on the information from the pilot study or provided by (Whiting June 8 2015). The number of the total observation units is 21 (a three-week full cycle of NSCM). For the large facility group:

- Wainwright $(\text{i.e.}, \text{i} = 1)$
  - $\text{N}_1 = 21, \sigma_1 = 0.71, \text{c}_1 = 2.4\text{c}$
  - Using eqn. (6), the weight for Wainwright is calculated: $\text{w}_1 = 0.33$
- Trenton $(\text{i.e.}, \text{i} = 2)$
  - $\text{N}_2 = 21, \sigma_2 = 0.58, \text{c}_2 = \text{c}$
  - Using eqn. (6), the weight for Trenton is calculated: $\text{w}_2 = 0.27$
- Saint-Jean $(\text{i.e.}, \text{i} = 3)$
  - $\text{N}_3 = 21, \sigma_3 = 0.32, \text{c}_3 = \text{c}$
  - Using eqn. (6), the weight for Saint-Jean is calculated: $\text{w}_3 = 0.15$
- Gagetown $(\text{i.e.}, \text{i} = 4)$
  - $\text{N}_4 = 21, \sigma_4 = 0.50, \text{c}_4 = 1.9\text{c}$
  - Using eqn. (6), the weight for Gagetown is calculated: $\text{w}_4 = 0.24$

In the pilot study, the small facility group was formed by two small facilities, i.e., Halifax and Esquimalt. However it was determined later that these three facilities, i.e., Cold Lake, Shilo and Bagotville would be good examples of small feeding facilities in terms of labour performance.

Although there was no data collected for these three small facilities, there is no problem to figure out the N_i and c_i for Cold Lake, Shilo and Bagotville. To get a more robust estimation, the pooled standard deviation from Halifax and Esquimalt was used for Cold Lake, Shilo and Bagotville; therefore, the standard deviation for all three small facilities are computed to be, and assumed to be identical.

For the small facility group:

- Cold Lake (i.e.,i=1)
  - $\text{N}_1 = 21, \sigma_1 = 0.58, \text{c}_1 = 1.5\text{c}$
  - Using eqn. (6), the weight for Trenton is calculated: $\text{w}_1 = 0.34$
- Shilo $(\text{i.e.}, \text{i} = 2)$
  - $\text{N}_2 = 21, \sigma_2 = 0.58, \text{c}_2 = 1.7\text{c}$
  - Using eqn. (6), the weight for Trenton is calculated: $\text{w}_2 = 0.32$
- Bagtoville $(\text{i.e.}, \text{i} = 3)$
  - $\text{N}_3 = 21, \sigma_3 = 0.58, \text{c}_3 = 1.5\text{c}$
  - Using eqn. (6), the weight for Trenton is calculated: $\text{w}_3 = 0.34$

Let $b = 0.25$ (initial determined, can be justified as required) and $z = 1.96$ (is the 97.5% percentile of the standard norm distributions, the critical value for 95%), and according to eqn. (5), the sample size required is approximate 14.59 for estimating the mean of labour performance productivity for the large facility group with 95% probability with marginal error 0.25. Applying the corresponding weights, the sample allocation is calculated for each individual facility as follows:

- Wainwright: $\text{n} \times \text{w}_1 = 3.86 \approx 4$
- Trenton: $\text{n} \times \text{w}_2 = 4.90 \approx 5$
- Saint-Jean: $\text{n} \times \text{w}_3 = 2.74 \approx 3$
- Gagetown: $\text{n} \times \text{w}_4 = 3.09 \approx 4$

It needs to be noted that to be conservative and to consider the less ideal design of the pilot study, the sample sizes determined based on the pilot data have been inflated to the next integer. Therefore, the number of samples allocated for Wainwright, Trenton, Saint-Jean and Gagetown are 4, 5, 3 and 4 respectively.

The same procedure is used for calculating the sample sizes for the small facility group. Calculating based on eqn. (5), the total sample size of 12.44 will be required. Again, for the same reason, the sample size determined based on the pilot data via optimal allocation scheme have been inflated to the next integer. Therefore, the sample size for Bagotville, Shilo and Cold Lake are 5, 4 and 5 respectively:

- Bagotville: $\text{n} \times \text{w}_1 = 4.27 \approx 5$
- Shilo: $\text{n} \times \text{w}_2 = 3.99 \approx 4$
- Cold Lake: $\text{n} \times \text{w}_3 = 4.17 \approx 5$