	Environmental Analysis Teaching and Research Laboratory	Date: 6/12/2022	SOP No. 23 v 4.2
	Standard Operating Procedure	Title: IDEXX Quanti-Tray 2000 for E. coli and Total Coliform Bacteria Enumeration	
	Approved By: Marc Los Huertos	Revised: February 20, 2025	

1. Scope and Application

- 1.1** This standard operating procedure describes the test method for the collection and analysis of water samples for the enumeration of *Escherichia coli* (*E. coli*) and Total coliform bacteria.
- 1.2** This method is applicable for analyzing drinking water, surface water, groundwater, and wastewater to assess microbial contamination levels.

2. Summary of Method

- 2.1** Surface water samples are collected in 120ml shrink-banded, sterile IDEXX bottles. An undiluted water sample will be analyzed from the sample collected. The Colilert reagent (Colilert-18) is added directly to the 100 ml undiluted sample. Both are mixed thoroughly to dissolve the reagent. The sample is transferred to Quanti-Trays/2000 and sealed using the Quanti-Tray sealer. Samples are incubated at 35.0 ± 0.5°C for 18 hours. Results are reported as MPN/100mL.
- 2.2** The detection limit for this analysis is 1 Most Probable Number (MPN) per 100mL of sample.

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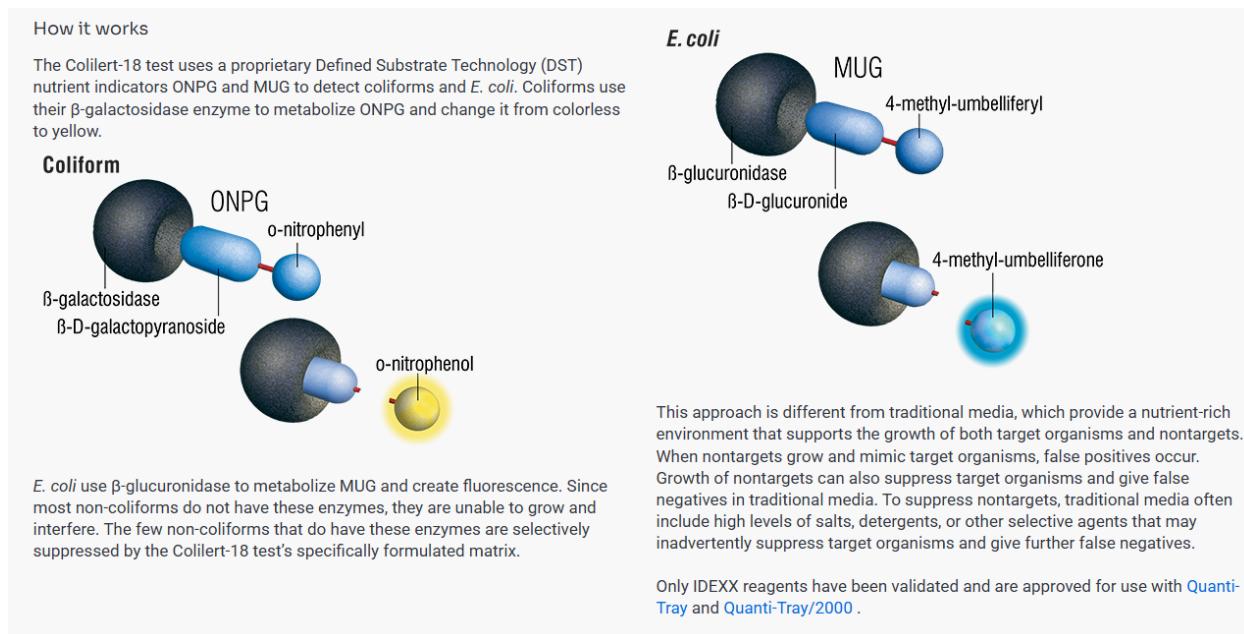


Figure 1: How Colilert works

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3. Acknowledgements

4. Definitions

4.1 Analytical batch: The set of samples processed at the same time.

4.2 Control cultures: For each lot of medium, check analytical procedures by testing with known positive and negative control cultures. For example, E.coli is a positive control for this analysis and Staphylococcus aureus is a negative control.

4.3 Field duplicate (FD): Two samples taken at the same time and place under identical circumstances and that are treated identically throughout field and laboratory procedures. Analysis of field duplicates indicates the precision associated with sample collection, preservation, and storage as well as laboratory procedures.

4.4 Laboratory reagent blank (LRB): An aliquot of sterilized water treated as a sample in all aspects, except that it is not taken to the sampling site. The purpose is to determine if the analytes or interferences are present in the laboratory environment, the reagents, or the apparatus.

4.5 Laboratory duplicate (LD): Two aliquots of the same environmental sample treated identically throughout a laboratory analytical procedure. Analysis of laboratory duplicates indicates precision associated with laboratory procedures but not with sample collection, preservation or storage procedures.

5. Biases and Interferences

5.1 Water samples containing humic or other material may be colored. If there is background color, compare inoculated trays to a control tray containing only water (SM, 9223 A.)

5.2 Chlorinated water may inhibit the growth of coliform bacteria. If the water has been chlorinated, use the sodium thiosulfate vials to neutralize the chlorine.

6. Health and Safety

6.1 The analysis involves handling of freshwater samples that may contain live microorganisms and therefore pose some threat of infection. Laboratory personnel who are routinely exposed to such water samples are encouraged to protect themselves from water borne illnesses by wearing clean disposable gloves and washing their hands frequently.

6.2 The Colilert reagent is not hazardous according to the manufacturer's material safety data sheet. The manufacturer does recommend wearing gloves and safety glasses while using this reagent and washing hands after use.

Safety and Personnel Protective Equipment

Water quality can range from high quality and even potable to very low with assorted pathogens or even toxicity. Thus, it's important to take every precaution possible to protect yourself.

7. Personnel & Training Responsibilities

7.1 Laboratory and field personnel shall have a working knowledge of this analytical procedure and will have received training from a faculty, staff, or student knowledgeable of the proper sample analysis procedures.

7.2 Laboratory personnel conducting microbial analysis must follow this SOP to ensure consistency and accuracy in results. Proper aseptic techniques and quality control measures must be observed at all times.

7.3 Researchers training is required before this the procedures in this method can be used.

7.4 Researchers using this SOP should be trained for the following SOPs:

- SOP 01 Laboratory Safety
- SOP 02 Field Safety

8. Required Materials and Apparati

8.1 Quanti-Tray Sealer® : IDEXX Laboratories, Inc., Westbrook, ME — Serial NO: QT1757, Model NO: B9-10894-04.

8.2 UV light source (365 nm)

8.3 Incubator- ($35^{\circ}\text{C} \pm 0.5^{\circ}\text{C}$)—Catalog NO: 150152632, Serial NO: IMC40490982

8.4 Comarator (Catalog NO: 2100Q-01) (Comparator is located in lab refidgerator in a red zip lock bag.)

9. Reagents and Standards

- IDEXX Colilert-18 reagent (Catalog 98-27164-00)
- Sterile, shrink-wrapped 100ml IDEXX bottles- Catalog NO: WV120SBT-200
- Sterile with sodium thiosulfate, shrink-wrapped 100ml IDEXX bottles- Catalog NO: WV120SBT-200 (if chlorinated samples)
- IDEXX Quanti-Tray or Quanti-Tray 2000

- Pipettes and sterile pipette tips
- Gloves and lab coat
- Deionized (DI) water for reagent preparation (if necessary)

10. Estimated Time

10.1 This procedure requires 12 minutes to set up and 18 hours to incubate. Enumeration of the results requires 10 minutes.

11. Sample Collection, Preservation, and Storage

11.1 Arrive at site and record site number, date and time.

11.2 Label bottle with location (geographic area name and stream or lake name), date, time, water temperature and sampler's initials. Label bottle before immersion using a black permanent marker or pre-printed labels.

11.3 Use latex gloves when handling bottles during sampling. Fingers contain contaminants such as nitrates. Bug repellents or sunscreen are particularly troublesome as contaminants. Once the gloves are on, be careful not to touch your face, the ground, or anything but the bottles.

11.4 The sample should be taken from flowing, not stagnant water, facing upstream.

11.5 Be sure to immerse the bottle completely, 10 cm (4 inches) deep, with mouth of bottle pointing upstream, so no water flows over your hand into the bottle. Be sure the bottle does not get near the bottom of the stream where sediments can be disturbed. Water samples should be collected 6-12 inches below the water surface. Fill bottle, to the 100ml line indicated, on first immersion, pour off the excess and cap. Do not under fill or over fill, do not redunk. If too much water is poured off, redo sample with new 100 ml container.

11.6 Do not touch bottle mouth or inside of cap. Be careful not to contaminate the sample with surface film, contact with human skin, breathing in/on the bottle or cap, etc. If stream is too shallow to immerse bottle fully, collect as much as possible, being very careful not to touch the bottom. Note depth on field notes.

11.7 Collect one "field duplicate" (FD) sample every two weeks (sampling frequency). Sample sites chosen for duplicate sampling are selected at random among sites sampled. When a duplicate sample is selected for the site, repeat procedures as with normal stream samples. The duplicate is the second sample when two samples are collected. Duplicates document repeatability of individual sample collections and reproducibility of laboratory results.

11.8 Samples are analyzed in the Biogeochemistry Lab. Keep samples cool while transporting. Store at 4 °C until analysis, but do not freeze. Analyze within 6 hours of collection.

11.9 For each sample, the location number, bottle numbers used and time collected will be recorded in the field sample log.

11.10 The samples will be kept in the possession of researcher personnel who both collect and analyze the samples.

QA/QC

11.11 Accuracy: Initial analyst demonstration of capability and for each new lot of Quanti-Tray/2000, analyze the following:

11.12 Check each new lot of Colilert. Shine the ultraviolet lamp on the media snap packs. If the lot is fluorescent it will be discarded.

11.13 Blank Control: Dissolve one packet of Colilert media in 100 ml distilled water. Check for fluorescence.

11.14 Positive Control: Dissolve one packet of Colilert media and 1 or 2 Control Culture vials (in Freezer) in 100 ml distilled water. Incubate for 18 hours. Check for fluorescence.

11.15 Analyze sterile reagent water blank with each batch of samples to verify that there is a negative result from 18-22 hours.

11.16 Gravimetrically check each new lot of sterile, transparent, nonfluorescing.

11.17 Review sampling and analysis procedure with Lab Manager.

12. Sample Processing Procedure

Good laboratory practices will be used for this procedure.

12.1 Turn on the Quanti-tray sealer.

12.2 Set the incubator to 35 °C.

12.3 Allow samples to reach room temperature before analysis.

12.4 Aseptically add the Colilert-18 reagent to the 100 mL water sample.

12.5 Place the lid back on the sample and shake well till the reagent has dissolved.

12.6 Use a permanent felt tip marker to label your Quanti-tray with information identifying your sample.



Figure 2: Adding Reagent

12.7 Open the Quanti-tray by holding it at the top, with the well side facing your palm. Push the top edge of the Quanti-tray in with your free hand while squeezing the tray into a circle. Open the tray by gently pulling the foil tab away from the plastic side. Be careful not to tear the tab. Do not touch the inside of the tray.

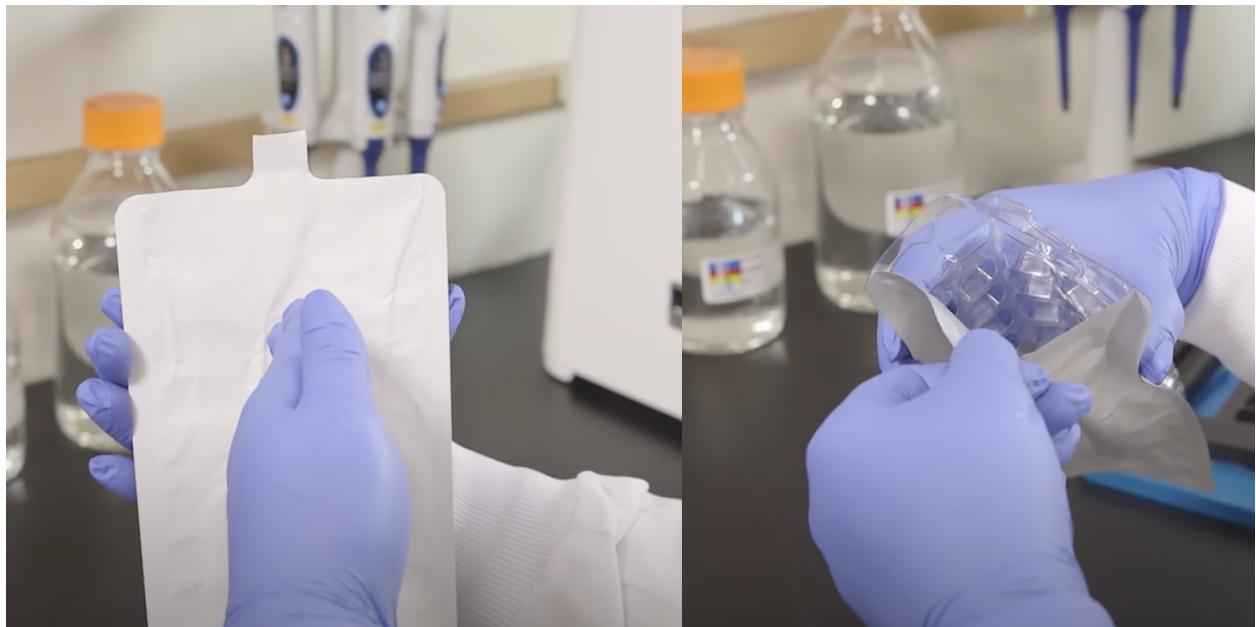


Figure 3: Opening and Pouring Sample into Quanti-Tray



Figure 4: Pouring Sampling into Quanti-Tray

- 12.8** Pour the sample mixture into the Quanti-tray, avoiding contact with the foil tab. Tap the small wells 2-3 times to release any air bubbles. Allow foam to settle. The sealer will disperse the sample mixture into the Quanti-tray wells, seal the wells, and then partially eject the sealed tray.
- 12.9** Place the filled Quanti-tray on the rubber insert, making sure each well fits its corresponding hole.
- 12.10** Push the insert with the tray into the sealer, non foil tab end first, until the sealer grabs the tray and pulls it into the slot. If you need to reverse the motor, press and hold the reverse button. However, do not reverse the motor if the rubber insert is completely inside the sealer. The sealer distributes the sample mixture into the Quanti-tray wells, seals the wells, and then partially ejects the sealed tray.

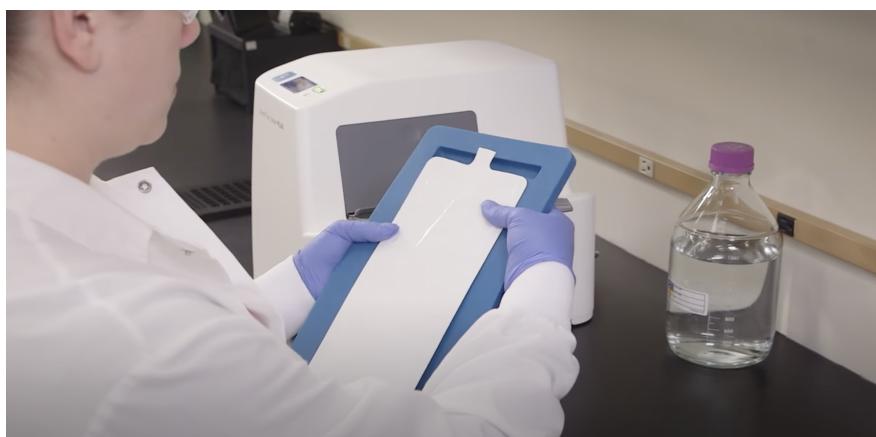


Figure 5: Pressing the Tray into the Rubber Insert

12.11 Remove the rubber insert and tray from the sealer.

12.12 Incubate the sealed tray for 18 hours at $35^{\circ}\text{C} \pm 0.5^{\circ}\text{C}$.

12.13 After incubation, count and mark the wells with a permanent marker that are equal to or greater than the comparator including the large overflow well at the top.

12.14 Record the number of small and large wells that are equal to or greater than the comparator in the lab notebook.

12.15 To determine the number of total coliforms, use the table in the appendix. We will also use the IDEXX software.



Figure 6: Counting Coliform and E Coli Wells (Be careful to avoid eye damage with the use of the UV lamp.)

12.16 To determine the number of E Coli, view the Quanta-tray under a UV lamp. Count the fluorescent wells that are equal to, or greater than the comparator.

12.17 Report results in the label with a permanent for both the small and large cells.

12.18 Use the Appendix Tables to calculate as an approximate MPN. But to generate

Table 1: The bacteria positive standards for the Quanti-Tray 2000

Organism	Result
Escherichia coli	Yellow wells, fluorescence
Klebsiella pneumoniae	Yellow wells, no fluorescence
Pseudomonas aeruginosa	Clear wells, no fluorescence
Method Blank	Clear wells, no fluorescence

the MPN, we'll need to use IDEXX software software to double check the results.

12.19 A count of 1–10 MPN/100 ml is regarded as low risk; 11–100 MPN/100 ml is medium risk. Finally, an E. coli count greater than 100 MPN/100 ml is judged high risk.

12.20 The completed bench sheet should be reviewed by the researcher, the laboratory director and the QA manager.

12.21 The Lab Director or QA Manager must sign the labbook to verify that the results are accurate.

Disposal

12.22 All materials must be autoclaved prior to disposal and workspaces thoroughly disinfected.

12.23 Dispose of media in accordance with Good Laboratory Practices.

13. Data Analysis and Calculations

13.1 For each sample analyzed, including quality control samples, record the number of small and large positive wells and the MPN in the appropriate places on the bench sheet (see below). Calculate precision for duplicate analyses using equation 1.

13.2 Equation 1.

$$Precision(asRPD) = \frac{(AB) * 100}{(A + B)/2} \quad (1)$$

Where: A = MPN from aliquot A and B = MPN from aliquot B

13.3 The following results should be observed:

14. QC/QA Criteria

Using Standards

14.1 TBD

Data assessment and acceptable criteria

14.2 The analyst should review all data for correctness (e.g., use of MPN table).

14.3 Record the precision values as RPD on the bench sheet.

14.4 The desired precision is $\pm 20\%$ (RPD).

14.5 The desired detection limit is 1 MPN/100mL

14.6 The completed bench sheet is reviewed by the analyst's supervisor or the QVIR Lab Director

Corrective actions for out-of-control or unacceptable data

14.7 The results for precision and blank data are compared to the acceptable values for this analysis; $\pm 20\%$ and 1 MPN/100mL, respectively.

14.8 If a precision value exceeds 20% then the analyst should write in the comments section of the bench sheet: These data are associated with an out-of-control duplicate analysis. The UCL = 20%. Note: "UCL" is the Upper Control Limit (i.e., 20%).

14.9 If a blank value exceeds 1 MPN/100mL then the analyst should write in the comments section of the lab notebook: "These data are associated with a blank value that exceeds the detection limit of 1 MPN/100mL."

14.10 The samples cannot be reanalyzed because the sample volume will be depleted after the initial analysis.

14.11 If data are unacceptable for any reason, the analyst should review their analytical technique prior to conducting this analysis again.

Disposal

14.12 All materials must be autoclaved prior to disposal and workspaces thoroughly disinfected.

14.13 Dispose of media in accordance with Good Laboratory Practices.

15. Trouble Shooting

TBD!!!

16. References

- 16.1** APHA, AWWA, WEF. (2012) Standard Methods for examination of water and wastewater. 22nd American Public Health Association (Eds.). Washington. 1360 pp. (2014).

IDEXX Quanti-Tray®/2000 MPN Table

# Large Wells Positive	# Small Wells Positive																									
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	
0	<1	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.1	15.1	16.1	17.1	18.1	19.1	20.2	21.2	22.2	23.3	24.3	
1	1.0	2.0	3.0	4.0	5.0	6.0	7.1	8.1	9.1	10.1	11.1	12.1	13.2	14.2	15.2	16.2	17.3	18.3	19.3	20.4	21.4	22.4	23.5	24.5	25.6	
2	2.0	3.0	4.1	5.1	6.1	7.1	8.1	9.2	10.2	11.2	12.2	13.3	14.3	15.4	16.4	17.4	18.5	19.5	20.6	21.6	22.7	23.7	24.8	25.8	26.9	
3	3.1	4.1	5.1	6.1	7.2	8.2	9.2	10.3	11.3	12.4	13.4	14.5	15.5	16.5	17.6	18.6	19.7	20.8	22.9	23.9	25.0	26.1	27.1	28.2	29.6	
4	4.1	5.2	6.2	7.2	8.3	9.3	10.4	11.4	12.5	13.5	14.6	15.6	16.7	17.8	18.8	19.9	21.0	22.0	23.1	24.2	25.3	26.3	27.4	28.5	29.6	
5	5.2	6.3	7.3	8.4	9.4	10.5	11.5	12.6	13.7	14.7	15.8	16.9	17.9	19.0	20.1	21.2	22.2	23.3	24.4	25.5	26.6	27.7	28.8	29.9	31.0	
6	6.3	7.4	8.4	9.5	10.6	11.6	12.7	13.8	14.9	16.0	17.0	18.1	19.2	20.3	21.4	22.5	23.6	24.7	25.8	26.9	28.0	29.1	30.2	31.3	32.4	
7	7.5	8.5	9.6	10.7	11.8	12.8	13.9	15.0	16.1	17.2	18.3	19.4	20.5	21.6	22.7	23.8	24.9	26.0	27.1	28.3	29.4	30.5	31.6	32.8	33.9	
8	8.6	9.7	10.8	11.9	13.0	14.1	15.2	16.3	17.4	18.5	19.6	20.7	21.8	22.9	24.1	25.2	26.3	27.4	28.6	29.7	30.8	32.0	33.1	34.3	35.4	
9	9.8	10.9	12.0	13.1	14.2	15.3	16.4	17.6	18.7	19.8	20.9	22.0	23.2	24.3	25.4	26.6	27.7	28.9	30.0	31.2	32.3	33.5	34.6	35.8	37.0	
10	11.0	12.1	13.2	14.4	15.5	16.6	17.7	18.9	20.0	21.1	22.3	23.4	24.6	25.7	26.9	28.0	29.2	30.3	31.5	32.7	33.8	35.0	36.2	37.4	38.6	
11	12.2	13.4	14.5	15.6	16.8	17.9	19.1	20.2	21.4	22.5	23.7	24.8	26.0	27.2	28.3	29.5	30.7	31.9	33.0	34.2	35.4	36.6	37.8	39.0	40.2	
12	13.5	14.6	15.8	16.9	18.1	19.3	20.4	21.6	22.8	23.9	25.1	26.3	27.5	28.6	29.8	31.0	32.2	33.4	34.6	35.8	37.0	38.2	39.5	40.7	41.9	
13	14.8	16.0	17.1	18.3	19.5	20.6	21.8	23.0	24.2	25.4	26.6	27.8	29.0	30.2	31.4	32.6	33.8	35.0	36.2	37.5	38.7	39.9	41.2	42.4	43.6	
14	16.1	17.3	18.5	19.7	20.9	22.1	23.3	24.5	25.7	26.9	28.1	29.3	30.5	31.7	33.0	34.2	35.4	36.7	37.9	39.1	40.4	41.6	42.9	44.2	45.4	
15	17.5	18.7	19.9	21.1	22.3	23.5	24.7	25.9	27.2	28.4	29.6	30.9	32.1	33.3	34.6	35.8	37.1	38.4	39.6	40.9	42.2	43.4	44.7	46.0	47.3	
16	18.9	20.1	21.3	22.6	23.8	25.0	26.2	27.5	28.7	30.0	31.2	32.5	33.7	35.0	36.3	37.5	38.8	40.1	41.4	42.7	44.0	45.3	46.6	47.9	49.2	
17	20.3	21.6	22.8	24.1	25.3	26.6	27.8	29.1	30.3	31.6	32.9	34.1	35.4	36.7	38.0	39.3	40.6	41.9	43.2	44.5	45.9	47.2	48.5	49.8	51.4	
18	21.8	23.1	24.3	25.6	26.9	28.1	29.4	30.7	32.0	33.3	34.6	35.9	37.2	38.5	39.8	41.1	42.4	43.8	45.1	46.5	47.8	49.2	50.5	51.9	53.2	
19	23.3	24.6	25.9	27.2	28.5	29.8	31.1	32.4	33.7	35.0	36.3	37.6	39.0	40.3	41.6	43.0	44.3	45.7	47.1	48.4	49.8	51.2	52.6	54.0	55.4	
20	24.9	26.2	27.5	28.8	30.1	31.5	32.8	34.1	35.4	36.8	38.1	39.5	40.8	42.2	43.6	44.9	46.3	47.7	49.1	50.5	51.9	53.3	54.7	56.1	57.6	
21	26.5	27.9	29.2	30.5	31.8	33.2	34.5	35.9	37.3	38.6	40.0	41.4	42.8	44.1	45.5	46.9	48.4	49.8	51.2	52.6	54.1	55.5	56.9	58.4	59.9	
22	28.2	29.5	30.9	32.3	33.6	35.0	36.4	37.7	39.1	40.5	41.9	43.3	44.8	46.2	47.6	49.0	50.5	51.9	53.4	54.8	56.3	57.8	59.3	60.8	62.3	
23	29.9	31.3	32.7	34.1	35.5	36.8	38.3	39.7	41.1	42.5	43.9	45.4	46.8	48.3	49.7	51.2	52.7	54.2	55.6	57.1	58.6	60.2	61.7	63.2	64.7	
24	31.7	33.1	34.5	35.9	37.3	38.8	40.2	41.7	43.1	44.6	46.0	47.5	49.0	50.5	52.0	53.5	55.0	56.5	58.0	59.5	61.1	62.6	64.2	65.8	67.3	
25	33.6	35.0	36.4	37.9	39.3	40.8	42.2	43.7	45.2	46.7	48.2	49.7	51.2	52.7	54.3	55.8	57.3	58.9	60.5	62.0	63.6	65.2	66.8	68.4	70.0	
26	35.5	36.9	38.4	39.9	41.4	42.8	44.3	45.9	47.4	48.9	50.4	50.4	52.0	53.5	55.1	56.7	58.2	59.8	61.4	63.0	64.7	66.3	67.9	69.6	71.2	
27	37.4	38.9	40.4	42.0	43.5	45.0	46.5	48.1	49.6	51.2	52.8	54.4	56.0	57.6	59.2	60.8	62.4	64.1	65.7	67.4	69.1	70.8	72.5	74.2	75.9	
28	39.5	41.0	42.6	44.1	45.7	47.3	48.8	50.4	52.0	53.6	55.2	56.9	58.5	60.2	61.8	63.5	65.2	66.9	68.6	70.3	72.0	73.7	75.5	77.3	79.0	
29	41.7	43.2	44.8	46.4	48.0	49.6	51.2	52.8	54.5	56.1	57.8	59.6	61.2	62.9	64.6	66.3	68.0	69.8	71.5	73.3	75.1	76.9	78.7	80.5	82.4	
30	43.9	45.5	47.1	48.7	50.4	52.0	53.7	55.4	57.1	58.8	60.5	62.2	64.0	65.7	67.5	69.3	71.0	72.9	74.7	76.5	78.3	80.2	82.1	84.0	85.9	
31	46.2	47.9	49.5	51.2	52.9	54.6	56.3	58.1	59.8	61.6	63.3	65.1	66.9	68.7	70.5	72.4	74.2	76.1	78.0	79.9	81.8	83.7	85.7	87.6	89.6	
32	48.7	50.4	52.1	53.8	55.6	57.3	59.1	60.9	62.7	64.5	66.3	68.2	70.0	71.9	73.8	75.7	77.6	79.5	81.5	83.5	85.4	87.5	89.5	91.5	93.6	
33	51.2	53.0	54.8	56.5	58.3	60.2	62.0	63.8	65.7	67.6	69.5	71.4	73.3	75.2	77.2	79.2	81.2	83.2	85.2	87.3	89.3	91.4	93.6	95.7	97.8	
34	53.9	55.7	57.6	59.4	61.3	63.1	65.0	67.0	68.9	70.8	72.8	74.8	76.8	78.8	80.8	82.9	85.0	87.1	89.2	91.4	93.5	95.7	97.9	100.2	102.4	
35	56.8	58.6	60.5	62.4	64.4	66.3	68.3	70.3	72.3	74.3	76.3	78.4	80.5	82.6	84.7	86.9	89.1	91.3	93.5	95.7	98.0	100.3	102.6	105.0	107.3	
36	61.7	63.7	65.7	67.7	69.7	71.7	73.8	75.9	78.0	80.1	82.3	84.5	86.7	88.9	91.2	93.5	95.8	98.1	100.5	102.9	105.3	107.7	110.2	112.7	114.6	
37	65.0	67.0	69.1	71.2	73.3	75.4	77.6	79.8	82.0	84.2	86.5	88.8	91.1	93.4	95.8	98.3	100.8	103.4	105.9	108.6	111.2	113.9	115.6	117.3	118.6	
38	66.3	68.4	70.6	72.7	74.9	77.1	79.4	81.6	83.9	86.2	88.6	91.0	93.4	95.8	98.3	100.8	103.4	105.9	108.6	111.6	114.4	117.1	122.2	125.0	127.8	
39	70.0	72.2	74.4	76.7	78.9	81.3	83.6	86.0	88.4	90.9	93.4	95.9	98.4	101.0	103.6	106.3	109.0	111.8	114.6	117.4	120.3	123.2	126.1	129.2	132.2	135.4
40	73.8	76.2	78.5	80.9	83.3	85.7	88.2	90.8	93.3	95.9	98.5	101.2	103.9	106.7	109.5	112.4	115.3	118.2	121.2	124.3	127.4	130.5	133.7	137.0	140.3	
41	78.0	80.5	83.0	85.5	88.0	90.6	93.3	95.9	98.7	101.4	104.3	107.1	110.0	113.0	116.0	119.1	122.2	125.4	128.7	132.0	135.4	138.8	142.3	145.9	149.5	
42	82.6	85.2	87.8	90.5	93.2	96.0	98.8	101.7	104.6	107.6	110.6	113.7	116.9	120.1	123.4	126.7	130.1	133.6	137.2	140.8	144.5	148.3	152.2	156.1	160.2	
43	87.6	90.4	93.2	96.0	99.0	101.9	105.0	108.1	111.2	114.5	117.8	121.1	124.6	128.1	131.7	135.4	139.1	143.0	147.0	151.0	155.2	159.4	163.8	168.2	172.8	
44	93.1	96.1	99.1	102.2	105.4																					

INDEXX Quant-Tray®/2000 MPN Table

Small Wells Positive

# Large Wells Positive	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
0	25.3	26.4	27.4	28.4	29.5	30.5	31.5	32.6	33.6	34.7	35.7	36.8	37.8	38.9	40.0	41.0	42.1	43.1	44.2	45.3	46.3	47.4	48.5	49.5
1	26.6	27.7	28.7	29.8	30.8	31.9	32.9	34.0	35.0	36.1	37.2	38.2	39.3	40.4	41.4	42.5	43.6	44.7	45.7	46.8	47.9	49.0	50.1	51.2
2	27.9	29.0	30.0	31.1	32.2	33.2	34.3	35.4	36.5	37.5	38.6	39.7	40.8	41.9	43.0	44.0	45.1	46.2	47.3	48.4	49.5	50.6	51.7	52.8
3	29.3	30.4	31.4	32.5	33.6	34.7	35.8	36.8	37.9	39.0	40.1	41.2	42.3	43.4	44.5	45.6	46.7	47.8	48.9	50.0	51.2	52.3	53.4	54.5
4	30.7	31.8	32.8	33.9	35.0	36.1	37.2	38.3	39.4	40.5	41.6	42.8	43.9	45.0	46.1	47.2	48.3	49.5	50.6	51.7	52.9	54.0	55.1	56.3
5	32.1	33.2	34.3	35.4	36.5	37.6	38.7	39.9	41.0	42.1	43.2	44.4	45.5	46.6	47.7	48.9	50.0	51.2	52.3	53.5	54.6	55.8	56.9	58.1
6	33.5	34.7	35.8	36.9	38.0	39.2	40.3	41.4	42.6	43.7	44.8	46.0	47.1	48.3	49.4	50.6	51.7	52.9	54.1	55.2	56.4	57.6	58.7	59.9
7	35.0	36.2	37.3	38.4	39.6	40.7	41.9	43.0	44.2	45.3	46.5	47.7	48.8	50.0	51.2	52.3	53.5	54.7	55.9	57.1	58.3	59.4	60.6	61.8
8	36.6	37.7	38.9	40.0	41.2	42.3	43.5	44.7	45.9	47.0	48.2	49.4	50.6	51.8	53.0	54.1	55.3	56.5	57.7	59.0	60.2	61.4	62.6	63.8
9	38.1	39.3	40.5	41.6	42.8	44.0	45.2	46.4	47.6	48.8	50.0	51.2	52.4	53.6	54.8	56.0	57.2	58.4	59.7	60.9	62.1	63.4	64.6	65.8
10	39.7	40.9	42.1	43.3	44.5	45.7	46.9	48.1	49.3	50.6	51.8	53.0	54.2	55.5	56.7	57.9	59.2	60.4	61.7	62.9	64.2	65.4	66.7	67.9
11	41.4	42.6	43.8	45.0	46.3	47.5	48.7	49.9	51.2	52.4	53.7	54.9	56.1	57.4	58.6	59.9	61.2	62.4	63.7	65.0	66.3	67.5	68.8	70.1
12	43.1	44.3	45.6	46.8	48.1	49.3	50.6	51.8	53.1	54.3	55.6	56.8	58.1	59.4	60.7	62.0	63.2	64.5	65.8	67.1	68.4	69.7	71.0	72.4
13	44.9	46.1	47.4	48.6	49.9	51.2	52.5	53.7	55.0	56.3	57.6	58.9	60.2	61.5	62.8	64.1	65.4	66.7	68.0	69.3	70.7	72.0	73.3	74.7
14	46.7	48.0	49.3	50.5	51.8	53.1	54.4	55.7	57.0	58.3	59.6	60.9	62.3	63.6	64.9	66.3	67.6	68.9	70.3	71.6	73.0	74.4	75.7	77.1
15	48.6	49.9	51.2	52.5	53.8	55.1	56.4	57.8	59.1	60.4	61.8	63.1	64.5	65.8	67.2	68.5	69.9	71.3	72.6	74.0	75.4	76.8	78.2	79.6
16	50.5	51.8	53.2	54.5	55.8	57.2	58.5	59.9	61.2	62.6	64.0	65.3	66.7	68.1	69.5	70.9	72.3	73.7	75.1	76.5	77.9	79.3	80.8	82.2
17	52.5	53.9	55.2	56.6	58.0	59.3	60.7	62.1	63.5	64.9	66.3	67.7	69.1	70.5	71.9	73.3	74.8	76.2	77.6	79.1	80.5	82.0	83.5	84.9
18	54.6	56.0	57.4	58.8	60.2	61.6	63.0	64.4	65.8	67.2	68.6	70.1	71.5	73.0	74.4	75.9	77.3	78.8	80.3	81.8	83.3	84.8	86.3	87.8
19	56.8	58.2	59.6	61.0	62.4	63.9	65.3	66.8	68.2	69.7	71.1	72.6	74.1	75.5	77.0	78.5	80.0	81.5	83.1	84.6	86.1	87.6	89.2	90.7
20	59.0	60.4	61.9	63.3	64.8	66.3	67.7	69.2	70.7	72.2	73.7	75.2	76.7	78.2	79.8	81.3	82.8	84.4	85.9	87.5	89.1	90.7	92.2	93.8
21	61.3	62.8	64.3	65.8	67.3	68.8	70.3	71.8	73.3	74.9	76.4	77.9	79.5	81.1	82.6	84.2	85.8	87.4	89.0	90.6	92.2	93.8	95.4	97.1
22	63.8	65.3	66.8	68.3	69.8	71.4	72.9	74.5	76.1	77.6	79.2	80.8	82.4	84.0	85.6	87.2	88.9	90.5	92.1	93.8	95.5	97.2	98.9	100.5
23	66.3	67.8	69.4	71.0	72.5	74.1	75.7	77.3	78.9	80.5	82.2	83.8	85.4	87.1	88.7	90.4	92.1	93.8	95.5	97.2	99.0	100.7	102.4	104.1
24	68.9	70.5	72.1	73.7	75.3	77.0	78.6	80.3	81.9	83.6	85.2	86.9	88.6	90.3	92.0	93.8	95.5	97.2	99.0	100.7	102.5	104.3	106.1	107.9
25	71.7	73.3	75.0	76.6	78.3	80.0	81.7	83.3	85.1	86.8	88.5	90.2	92.0	93.7	95.5	97.3	99.1	100.9	102.7	104.5	106.3	108.2	110.0	111.9
26	74.6	76.3	78.0	79.7	81.4	83.1	84.8	86.6	88.4	90.1	91.9	93.7	95.5	97.3	99.2	101.0	102.9	104.7	106.6	108.5	110.4	112.3	114.2	116.2
27	77.6	79.4	81.1	82.9	84.6	86.4	88.2	90.0	91.7	93.7	95.5	97.4	99.3	101.2	103.1	105.0	106.9	108.8	110.8	112.7	114.7	116.7	118.7	120.7
28	80.8	82.6	84.4	86.3	88.1	89.9	91.8	93.7	95.6	97.5	99.4	101.3	103.3	105.2	107.2	109.2	111.2	113.2	115.2	117.3	119.3	121.4	123.5	125.6
29	84.2	86.1	87.9	89.8	91.7	93.6	95.6	97.5	99.5	101.5	103.5	105.5	107.5	109.5	111.6	113.7	115.7	117.8	120.0	122.1	124.2	126.4	128.6	130.8
30	87.8	89.7	91.7	93.6	95.6	97.6	99.6	101.6	103.7	105.7	107.8	109.9	112.0	114.2	116.3	118.5	120.6	122.8	125.1	127.3	129.5	131.8	134.1	136.4
31	91.6	93.6	95.6	97.7	99.7	101.8	103.9	106.0	108.2	110.3	112.5	114.7	116.9	119.1	121.4	123.6	125.9	128.2	130.5	132.9	135.3	137.7	140.1	142.5
32	95.7	97.8	99.9	102.0	104.2	106.3	108.5	110.7	113.0	115.2	117.5	119.8	122.1	124.5	126.8	129.2	131.6	134.0	136.5	139.0	141.5	144.0	146.6	149.1
33	100.0	102.2	104.4	106.6	108.9	111.2	113.5	115.8	118.2	120.5	122.9	125.4	127.8	130.3	132.8	135.3	137.8	140.4	143.0	145.6	148.3	150.9	153.7	156.4
34	104.7	107.0	109.3	111.7	114.0	116.4	118.9	121.3	123.8	126.3	128.8	131.4	134.0	136.6	139.2	141.9	144.6	147.4	150.1	152.9	155.7	158.6	161.5	164.4
35	109.7	112.2	114.6	117.1	119.6	122.2	124.7	127.3	129.9	132.6	135.3	138.0	140.8	143.6	146.4	149.2	152.1	155.0	158.0	161.0	164.0	167.1	170.2	173.3
36	115.2	117.8	120.4	123.0	125.7	128.4	131.1	133.9	136.7	139.5	142.4	145.3	148.3	151.3	154.3	157.3	160.5	163.6	166.8	170.0	173.3	176.6	179.9	183.3
37	121.3	124.0	126.8	129.6	132.4	135.3	138.2	141.2	144.2	147.3	150.3	153.5	156.7	159.9	163.1	166.5	169.8	173.2	176.7	180.2	183.7	187.3	191.0	194.7
38	127.9	130.8	133.8	136.8	139.9	143.0	146.2	149.4	152.6	155.9	159.2	162.6	166.1	169.6	173.2	176.8	180.4	184.2	188.0	191.8	195.7	199.7	203.7	207.7
39	135.3	138.6	141.7	145.0	148.3	151.7	155.1	158.6	162.1	165.7	169.4	173.1	176.9	180.7	184.7	188.7	192.7	196.8	201.0	205.3	209.6	214.0	218.5	223.0
40	143.7	147.1	150.6	154.2	157.8	161.5	165.3	169.1	173.0	177.0	181.1	185.2	189.4	193.7	198.1	202.5	207.1	211.7	216.4	221.1	226.0	231.0	236.0	241.1
41	153.2	157.0	160.9	164.8	168.9	173.0	177.2	181.5	185.8	190.3	194.8	199.5	204.2	209.1	214.0	219.1	224.2	229.4	234.8	240.2	245.8	251.5	257.2	263.1
42	164.3	168.6	172.9	177.3	181.9	186.5	191.3	196.1	201.1	206.2	211.4	216.7	222.2	227.7	233.4	239.2	245.2	251.3	257.5	263.8	270.3	276.9	283.6	290.5
43	177.5	182.3	187.3	192.4	197.6	202.9	208.4	214.0	219.8	225.8	231.8	238.1	244.5	251.0	257.7	264.6	271.7	278.9	286.3	293.8	301.5	309.4	317.4	325.7
44	193.6	199.3	205.1	211.0	217.2	223.5	230.0	236.7	243.6	250.8	258.1	265.6	273.3	281.2	289.4	297.8	306.3	315.1	324.1	333.3	342.8	352.4	362.3	372.4
45	214.1	220.9	227.9	235.2	242.7	250.4	258.4	266.7																