Six Sigma
Process Improvement Story

Green Belt **Project Objective:**

To Reduce Waste Transfer Costs

Last Updated: 7-19-13

Team: **The Waste Warriors**

Lourdes Avalos (Team Leader) **Michael Moore (Team Leader)**

Lou Broughton **Michael Fernandez** **Frank Gomez**

Rick Rayborn **Tom Wilfong**

Ray Scher (Sponsor) Chris Rose (Sponsor)

Six Sigma Problem Solving Process

The team utilized the 5-Step DMAIC problem solving process.

DMAIC Performance Improvement Process

Process Step		Description of Team Activities
Number	Name	
1	DEFINE	• Select Problem • Identify Project Charter • Develop Project Timeline • Establish Method to Monitor Team Progress • Construct Process Flowchart • Develop Data Collection Plan • Display Indicator Performance “Gap”
2	MEASURE	• Stratify Problem (i.e.“Gap”) • Identify Problem Statement
3	ANALYZE	• Identify Potential Root Cause(s) • Verify Root Cause(s)
4	IMPROVE	• Identify and Select Improvement(s) • Identify Barriers and Aids • Develop and Implement Improvement Plan • Confirm Improvement Results
5	CONTROL	• Standardize Improvements within Operations • Implement Process Control System (PCS) • Document Lessons Learned • Identify Future Plans

Identify Project Charter

1., 2. ☑

The team was chartered by management and developed a team Project Charter.

Project Charter		
Business Case	*Project Name:*	Reduce waste transfer operations costs.
	Problem/Impact:	Transfer Operation expenses are higher than its revenues; it is not self sufficient. The Operations are subsidized by other disposal revenue to cover its expenses.
	Expected Benefits:	Study will result in discovering financially beneficial alternatives to the way we do business now in the transfer of waste.
Objectives	*Outcome Indicator(s)*	Q1 - Waste Transfer Costs
	Proposed Target(s)	Target= 25% Cost Reduction in Transfer Operation Costs, or $4.01
	Time Frame:	March - July 2013
	Strategic Alignment:	Supports the County's Business Plan
Scope	*In Scope:*	Waste Transfer costs at North Dade Landfill, South Dade Landfill, Resource Recovery facility, and the Department's three (3) Regional Transfer Stations
	Out-of-Scope:	Disposal costs at MDC waste facilities
	Authorized by:	Ray Scher; Chris Rose
Team	*Sponsor:*	Ray Scher; Chris Rose
	Team Leader:	Lourdes Avalos, Michael Moore
	Team Members:	Lou Broughton, Frank Gomez, Mike Fernandez, Rick Rayborn, Tom Wilfong
	Process Owner(s):	Michael Moore
	Mgmt Review Team:	Ray Scher; Chris Rose; Kathleen Woods-Richardson
Schedule	*Completion Date:*	31-Jul-13
	Review Dates:	Monthly, and Final Review in July 2013
	Key Milestone Dates:	See Action Plan

Develop Project Timeline Plan

4.

The team developed a timeline plan to complete the Project.

Legend:	
	= Actual
	= Proposed

WHAT: Complete DMAIC Story Project by July 31, 2013

DMAIC Story Process Step	WHEN									
	2013							2013-14		
	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct.	Nov.	Dec.
1. Define			4/12/13							
2. Measure			4/20/13							
3. Analyze					6/30/13					
4. Improve								10/1/13		
5. Control									12/31/13	

Monitor Team Progress

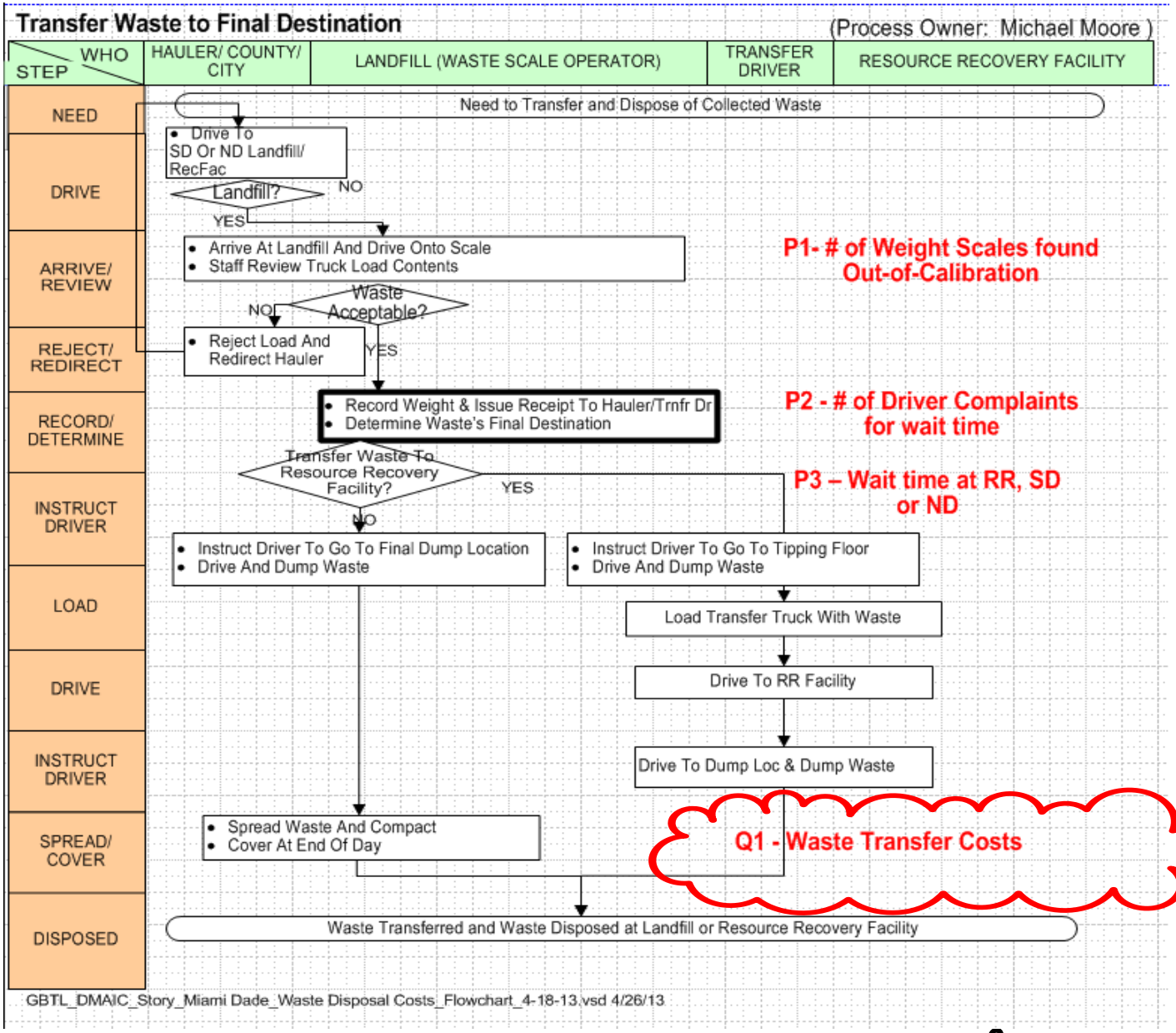
The Team and Management used a Checklist to monitor team progress.

DMAIC Story Checkpoints				
PLAN	Step 1 Define	**Objective: Demonstrate the importance of improvement needs in measurable terms.**		▪Team identified an indicator; developed a Flowchart and a Spreadsheet
		1. The stakeholders' need(s) were identified.	✓	
		2. The problem can be described as an "object" with a "defect" with unknown cause(s) that need to be identified.	✓	
		3. A line graph outcome indicator was constructed that appropriately measures the problem (or gap).	✓	
		4. A schedule for completing the five DMAIC Story steps was developed.	✓	
	Step 2 Measure	**Objective: Investigate the features of the indicator, stratify the problem and set a target for improvement.**		▪ Line Graph ▪ Paretos and Histograms
		5. Data contained or directly linked to the indicator were stratified from various viewpoints (i.e., what, where, when and who) and a significant dataset was chosen.	✓	
		6. A target for improvement was established based on the stakeholders' need.	✓	
		7. The impact of the target on the indicator was determined.	✓	
		8. A problem statement that describes the "remaining dataset" was developed.	✓	
	Step 3 Analyze	**Objective: Analyze the stratified data to identify and verify the root causes.**		▪ Fishbone ; RC ▪Verification Matrix
		9. Cause and effect analysis was taken to the root level.	✓	
		10. Potential causes most likely to have the greatest impact on the problem were selected.	✓	
		11. A relationship between the root causes and the problem was verified with data.	✓	
		12. The impact of each root cause on the gap was determined.	✓	
DO	Step 4 Improve	**Objective: Develop and implement countermeasures to eliminate the verified root causes of the problem.**		▪Countermeasures Matrix; Barriers and Aids; Action Plan
		13. Countermeasures were selected to address verified root causes.	✓	
		14. The method for selecting the appropriate countermeasures was clear and considered effectiveness and feasibility.	✓	
		15. Barriers and aids were determined for countermeasures worth implementing.	✓	
		16. The action plan reflected accountability and schedule.	✓	
CHECK		**Objective: Confirm that the countermeasures taken impacted the root causes and the problem; and that the target has been met.**		▪ Line Graph
		17. The effect of countermeasures on the root causes was demonstrated.	✓	
		18. The effect of countermeasures on the problem (or indicator) was demonstrated.		
		19. The improvement target was achieved and causes of significant variation were addressed.		
		20. The effect of countermeasures on the indicator representing the stakeholders' need was demonstrated.		
ACT	Step 5 Control	**Objective: Prevent the problem and its root causes from recurring. Maintain and share the gains.**		▪Process Flowchart; Process Control Chart
		21. A method was established to document, permanently change, and communicate the revised process or standard.		
		22. Responsibility was assigned and periodic checks scheduled to ensure compliance with the revised process or standard.		
		23. Specific areas for replication were identified.		
		Objective: Evaluate the team's effectiveness and plan future activities.		Lessons Learned
		24. Any remaining problems (or gaps) were addressed.		
		25. Lessons learned, P-D-C-A of the Story process, & team growth were assessed & documented.		

Review Process Flow Chart

The team constructed a Process flow chart describing the Process.

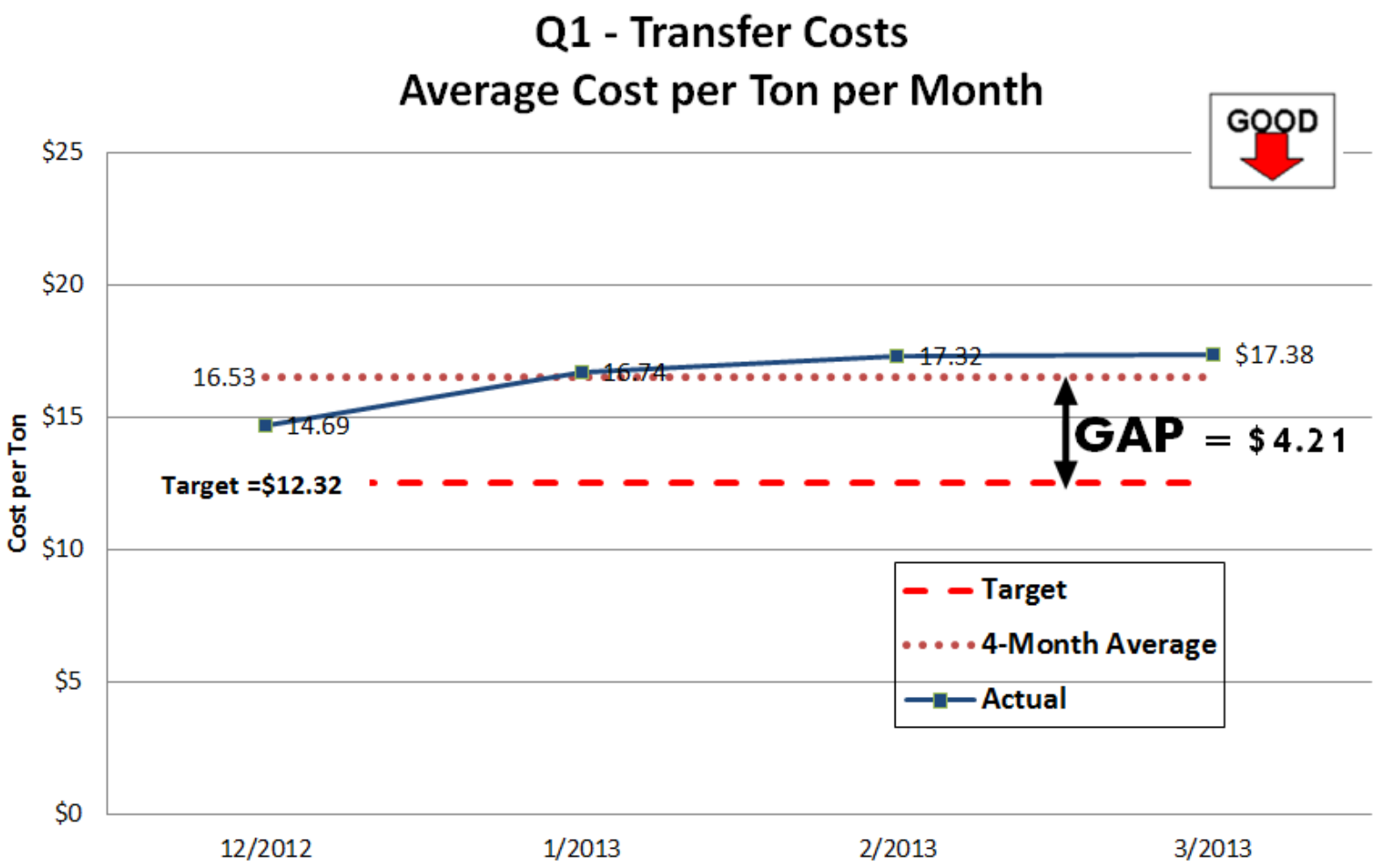
Outcome Indicators were developed from the **SIPOC** and **Customer Rqmts analysis** (see Appendix)



Review Selected Indicator

3., 6., 7.

The team calculated Q1 indicator data.



Waste Transfer Cost Factors

The team identified factors considered in gathering costs of Waste transfer trips.

Transfer Costs per Ton =

$$\frac{\text{Vehicle + Driver + OT}}{\text{(Tons per Trip) x (\# of Trips)}}$$

Fixed /controlled costs

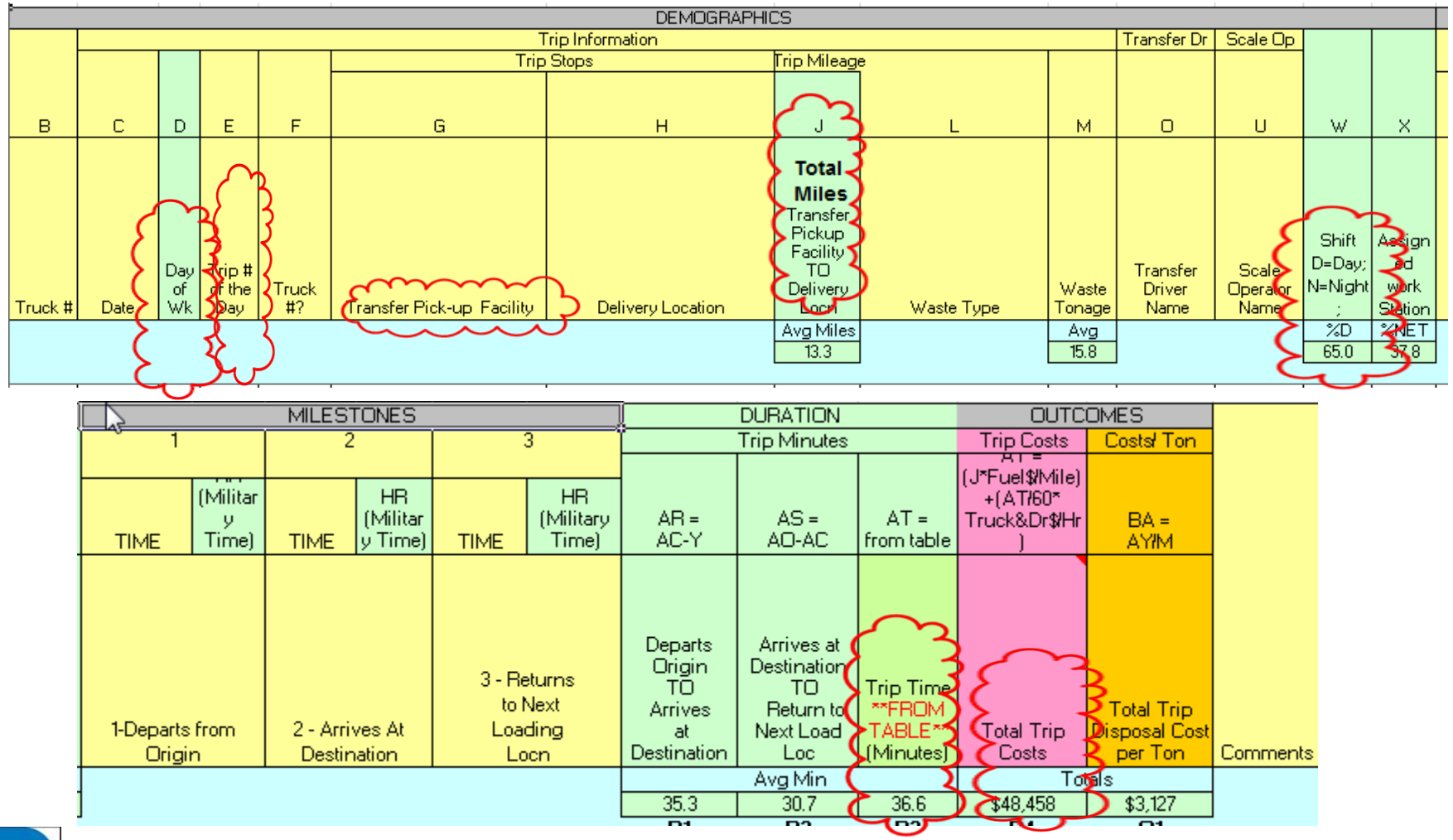
Number of trips are affected by:

• Time of Day (shift)	• Road conditions
• Traffic	• Speed
• Distance traveled	
• Driver experience	

Identify Data Collection Needs

5.

The data collection spreadsheet was developed from available electronic Trip data. The spreadsheet will help the team evaluate factors that could contribute to costs, and will allow team to focus in on those factors to validate their cause-and-effect relationship.

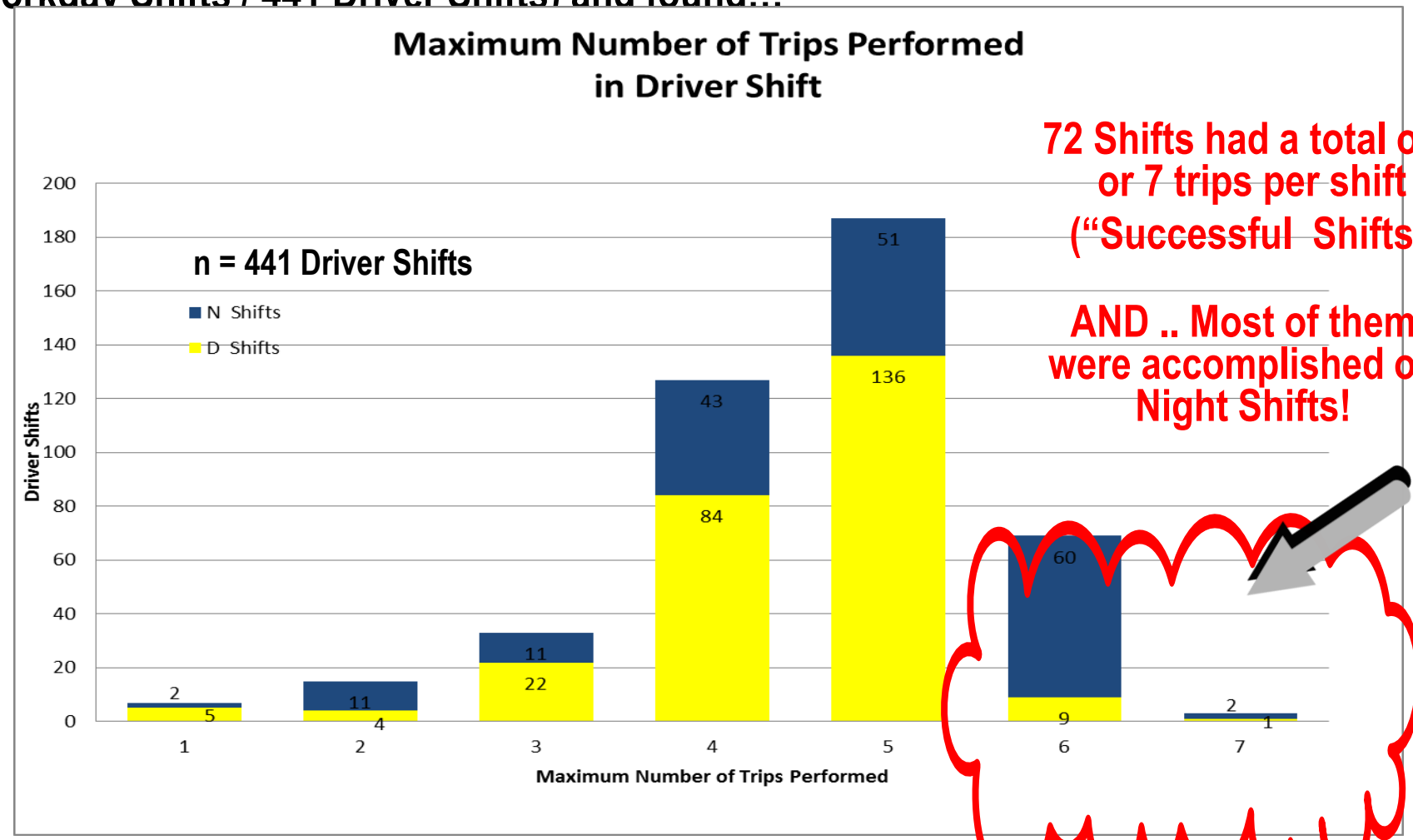


- **The team chose to analyze December 2012 trips.**

Stratify the Problem

8.

The team stratified the December 2012 weekday trips containing all needed information available - minus Residue & Overtime trips (1911 trips / 20 Weekdays / 36 Workday Shifts / 441 Driver Shifts) and found…



Problem Statement: *"Most of the Driver Shifts producing 6 or 7 Trips per Shift, were performed on Night Shifts. "*

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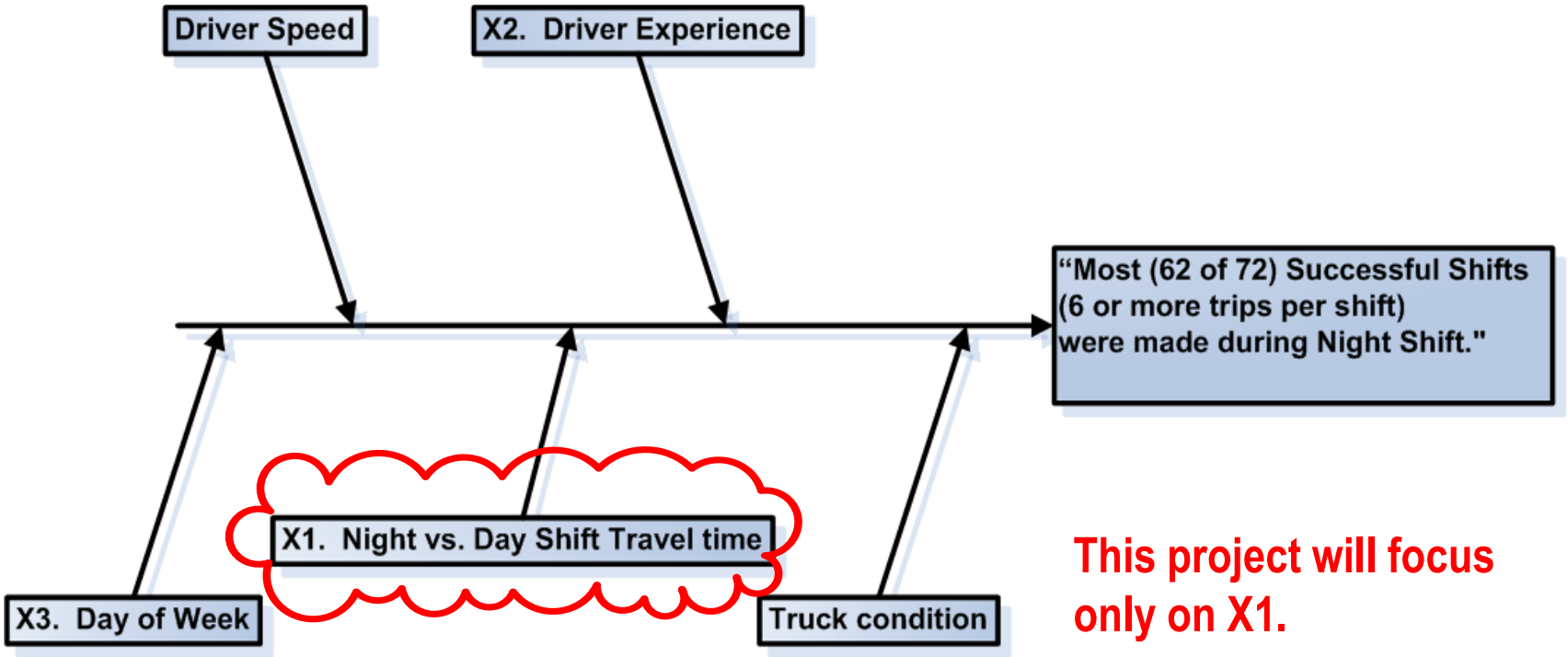
Identify Potential Root Causes

9., 10.

The team completed Cause and Effect Analysis and found…

Fishbone Cause & Effect Diagram



This project will focus only on X1.

The team next looked to verify this Potential Root Cause.

Root Cause Validation Selection Method

11., 12.

With the help of a Black Belt, the team conducted "Cause and Effect" Validation Analysis on suspected potential Cause. The team selected the appropriate Statistical Validation Method based on the Type of Data of the Potential Cause (X) and Effect (Y).

X

	Y: Discrete	Y: Continuous
X: Discrete	Chi Square	t-Test ANOVA DOE
X: Continuous	Logistic Regression	Scatter Diagram Correlation Regression

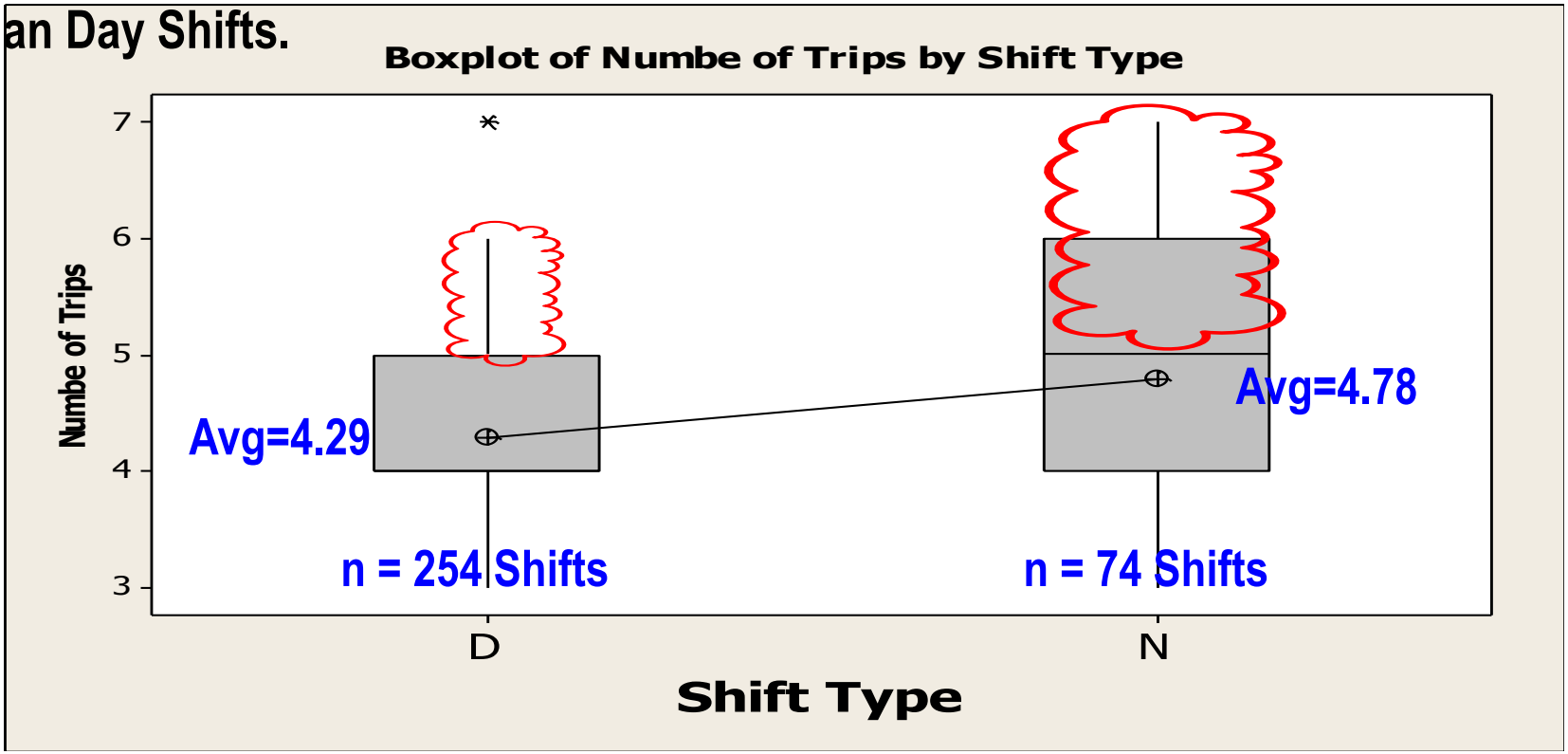
Validation Results Matrix

(Y's) Effect	(X's) Potential Cause(s)		Type Data	Statistical Validation Method	Results: P-Value	Results: Validated?
(Y1) # of Trips Per Shift (Continuous Data)	X 1	Night vs. Day Shift travel time	Discrete	ANOVA	P=.00	Yes
	X 2	Driver	Discrete	ANOVA	P=.00	Yes
	X 3	Day of Week	Discrete	ANOVA	P=.00	Yes

This project will focus only on X1. (Other projects will focus on Driver and Day of Week – see Appendix)

Validation Results

The team sampled and analyzed 328 shifts in December 2012 using ANOVA Validation and found that Night Shifts produce more trips per shift on average than Day Shifts.



One-way ANOVA: # of Trips vs. Shift Type

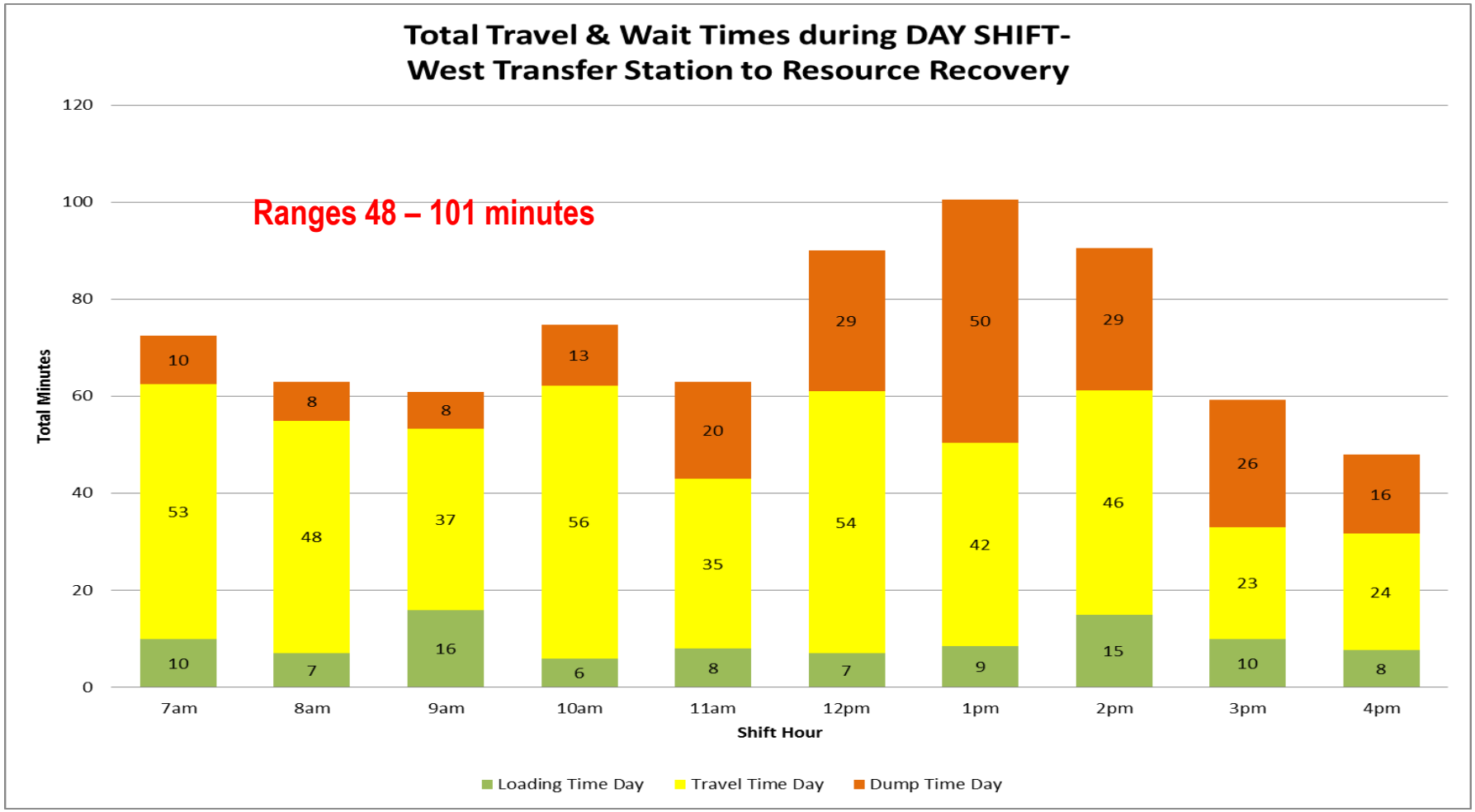
Source	DF	SS	MS	F	P
Shift Type	1	13.897	13.897	16.97	0.000
Error	326	266.981	0.819		
Total	327	280.878			

P<.05 Validates

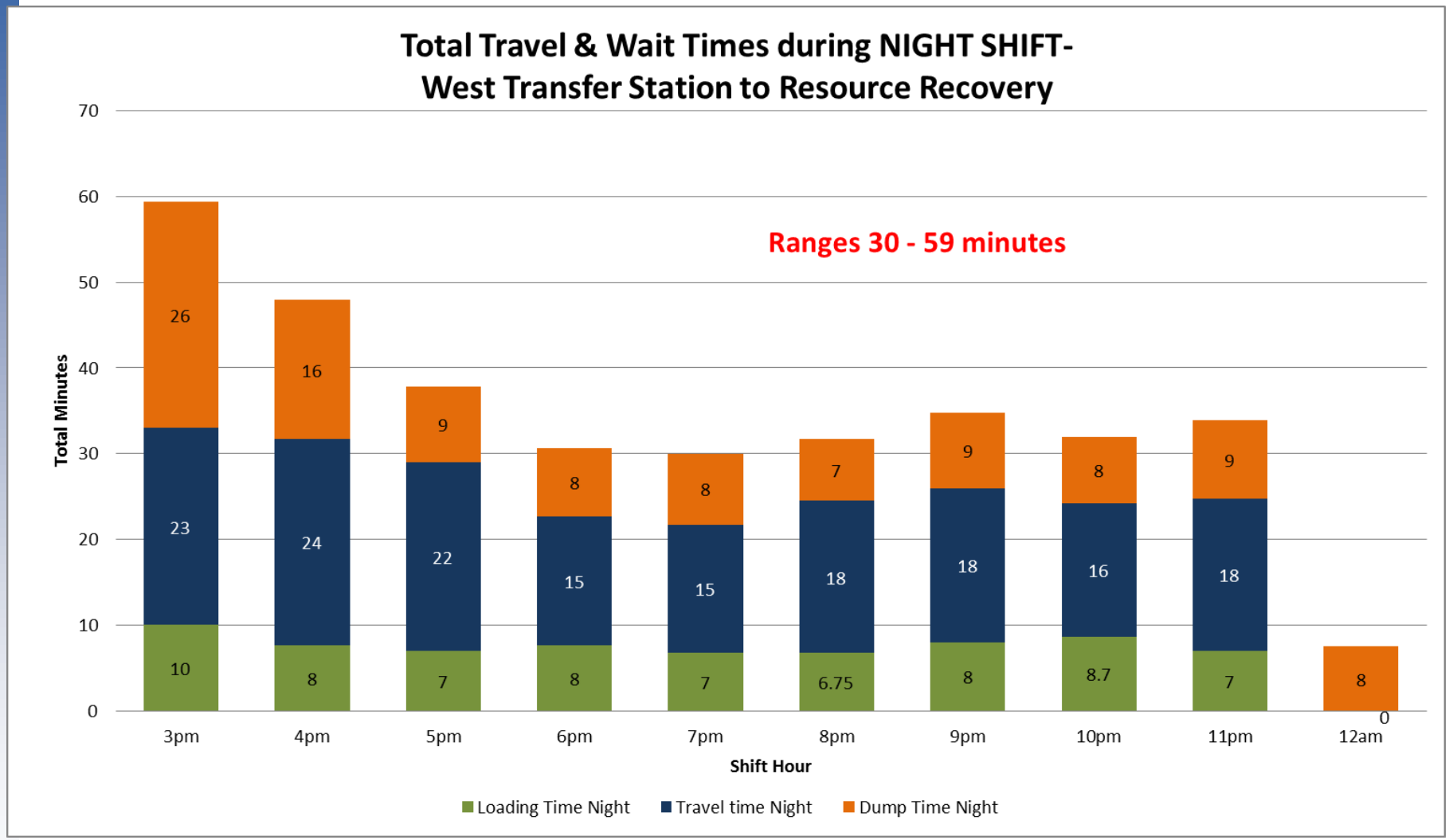
Interpretation: Night Shifts produce more Trips than Day shifts…and 50% of the Night Shifts produced 5 to 7 Trips, compared to only 25% of Day Shifts)

Validation Results

The team analyzed sample travel times in the December 2012 trips



Validation Results



and confirmed that the combination of travel and station-wait times were significantly shorter during the Night Shift hours.

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Identify and Select Countermeasures

13., 14.

The team brainstormed many countermeasures and narrowed them down to these for evaluation:

Counter/Measures Matrix

Problem Statement	Verified Root Causes	Countermeasures (So, what are we going to do about it?)	Legend: 5=Extremely 3=Moderately 1=Little or None — Ratings: Effectiveness	Feasibility	Overall	Take Action? Yes/No
"Most of the Successful Shifts (6 or more trips per shift) are Made during Night Shift."	X1- Night Shift makes a difference on the number of trips per shift.	A. -Reallocate some existing Day Shift positions to Night Shift *(attrition only – no new positions)*	5	2	15	Y
		B. -Expand schedule of the Night Shift *(currently M-Th; add schedule of M,T,Th,F)*	5	5	25	Y
		C. –Consider adding a 3rd Shift in the later hours. *(7am-5:30pm; 2:30pm-1am; 8pm -6:30am)*	5	5	25	Y

The team selected all 3 measures for implementation.

Estimated Efficiencies Due to Countermeasures 5.

The first Countermeasure…

A. Move 22 existing empty Day Shift slots to Night Shift slots… waste tonnage transferred would increase:

Current Scenario:

	Salary Cost	x # of Drivers	x Average Trips per Shift	x Average Tonnage at Capacity	.= Tons Moved per Day	x 17 Work Days a Month	x 12 Months
Day Shift	23.03	57	5	16	4,560	77,520	930,240
Night Shift	21.79	32	6.5	16	3,328	56,576	678,912
Totals:		89			7,888		1,609,152 Moved Tons

Countermeasure A:

	Salary Cost	x # of Drivers	x Average Trips per Shift	x Average Tonnage at Capacity	.= Tons Moved per Day (Day & Night)	x 17 Work Days a Month	x 12 Months
Day Shift	23.03	35	5	16	2,800	47,600	571,200
Night Shift	21.79	54	6.5	16	5,616	95,472	1,145,664
Totals:		89			8,416		1,716,864 Moveable Tons

An increase of 107,712 Tons!

Estimated Savings Due to Countermeasures

5.

The 2nd Countermeasure …

B. Expand schedule of the Night Shifts *(currently M-Th; add schedule of M,T,Th,F)* … estimated annual savings would be:

- Although no dollar savings, would allow more schedule flexibility and therefore, more choices and buy-in from staff

The 3rd Countermeasure …

C. Consider adding a 3rd Shift in the later hours. *(7am-5:30pm; 2:30pm-1am; 8pm -6:30am)*

- Will entail revisiting data to identify viable hours. Although no dollar savings, would allow more schedule flexibility and therefore, more choices and buy-in from staff

Estimated Efficiencies Due to Countermeasures

Other Intangible Efficiencies:

- Less tractor trailers on our roadways during the Day
- Reduction in street congestion
- Reduction in traffic (incl. wait times) at Res. Recovery & the landfills
- Reduced down time for fleet maintenance *(to be done during day when more trucks are available and fleet shops open)*

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Estimated Efficiencies Due to Countermeasures

FACTS:

- In FY10-11, transferred 917,485 Tons
- In FY11-12, transferred 1,111,745 Tons
- Increase in waste is expected due to population growth as well as economy upturn
- Average (5 trip) Driver Shift = 16,320 Tons annually
- 107,712 Tons represents 6.6 FTEs (although attrition runs high)
- 6.6 FTEs = $293,380.56 cost avoidance! *(don't have to create more positions to move more waste)*

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Identify Barriers and Aids

15.

The team performed Barriers and Aids analysis on the selected Countermeasures.

Countermeasure(s): Implement Countermeasures to Improve Efficiency in Waster Transfer Operation

Barriers		Aids
Impact (H, M, L)	**Forces against Implementation**	**Forces For Implementation**
H	1) Switch more day shifts to night shifts: *Union; equipment mechanic shop closed at night; external hiring delays*	A) Improved employee morale; Less employee leave usage; reduced overtime usage; less traffic congestion at transfer station; better customer service - at scale house and tipping floor; beneficial impact on cost savings; management very supportive of team's efforts in saving costs.
M	2) Add a 2nd Night Shift (M-Th) AND (M,T,Th,F) *Union; equipment mechanic shop closed at night; external hiring delays*	B) Improved employee morale; Less employee leave usage; reduced overtime usage; less traffic congestion at transfer station; better customer service - at scale house and tipping floor; beneficial impact on cost savings; management very supportive of team's efforts in saving costs; Reduced OT on Saturday (they clean the floor in prep. For Mon.) .
H	3) Create a 3rd Shift: Union; RR operating hours; equipment mechanic shop closed at night; citizen noise complaints; external hiring delays; additional supervision required; additional waste equipment operators; waste attendants	C) Allows employee flexibility; Less employee leave usage; reduced overtime usage; less traffic congestion at transfer station; improving customer service by reducing traffic during the day.

The team next sought to incorporate this analysis into the team's Action Plan.

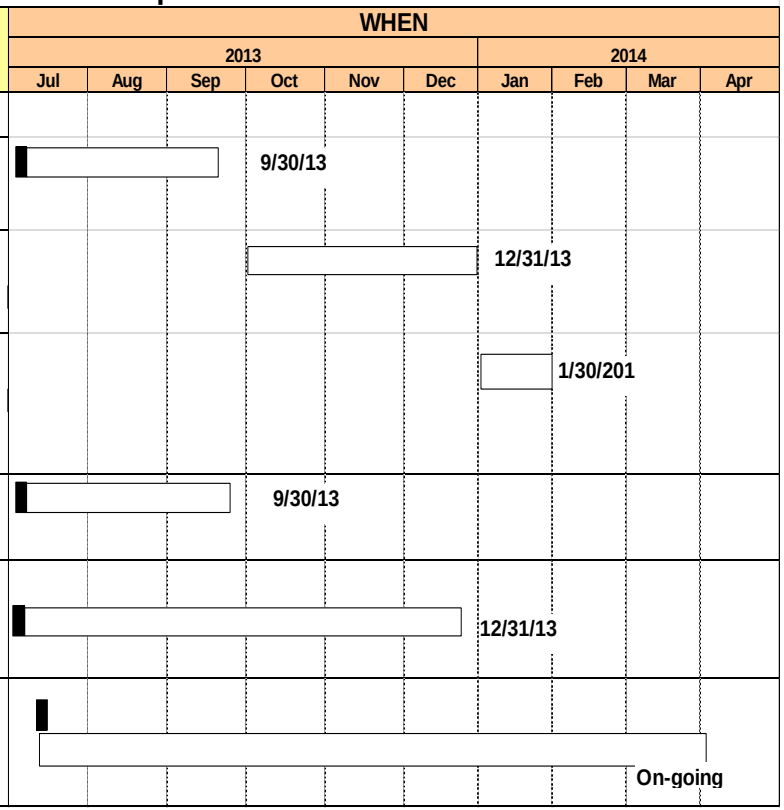
Develop and Implement Action Plan

Legend:
■ = Actual
□ = Proposed

The team implemented an Action Plan for the team's Countermeasures. 16.

WHAT: Implement 3 Countermeasures to improve efficiency in the Waste Transfer Operation.

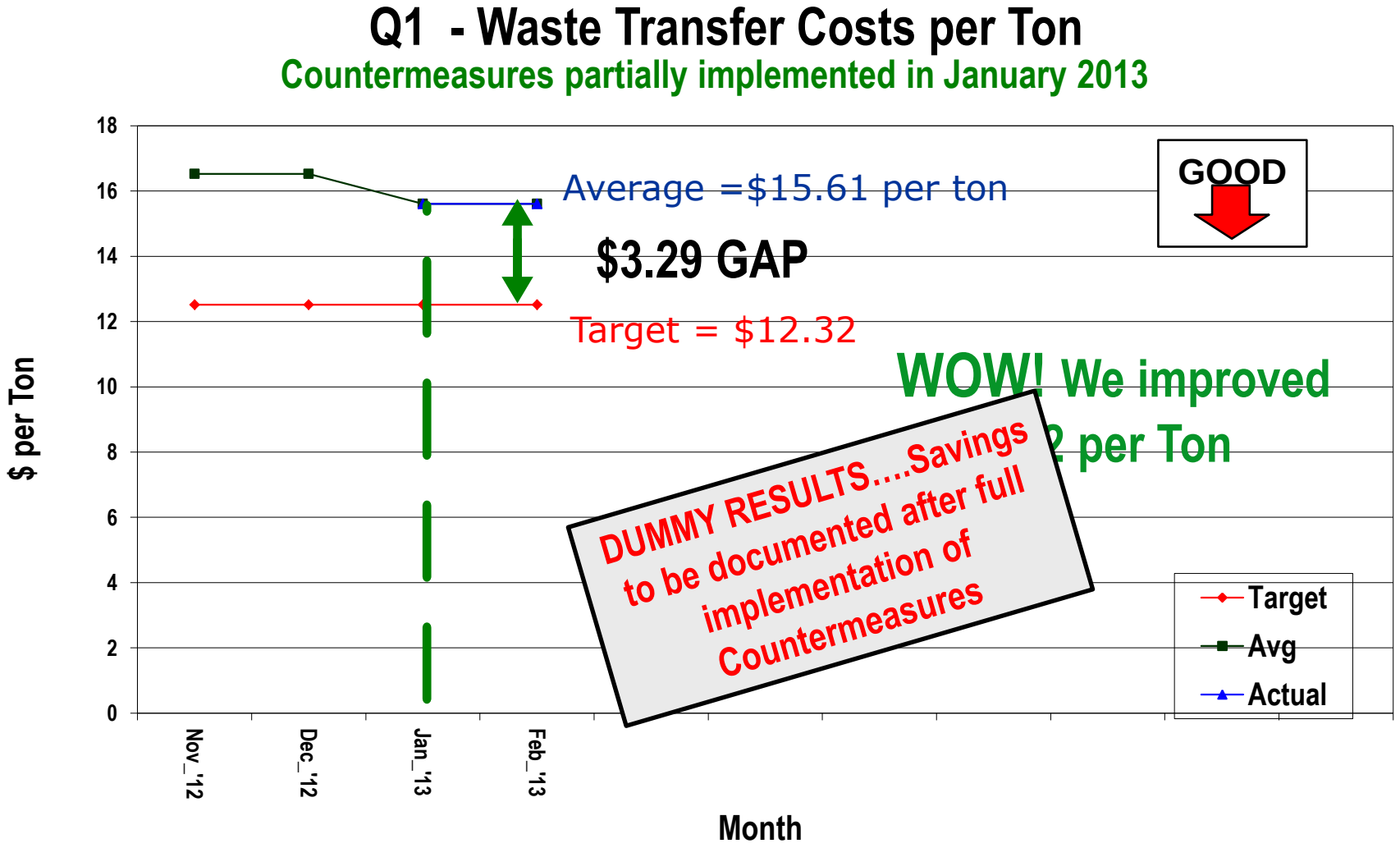
	HOW	WHO	WHEN
1.	**Develop Countermeasures:**		
	A- Reallocate 22 existing Day Shift positions to Night Shift (attrition only – no new positions)	M. Moore	9/30/13
	B- Expand schedule of the Night Shift (currently M-Th; add schedule of M,T,Th,F)	M. Moore	12/31/13
	C- Consider adding a 3rd Shift in the later hours. (7am-5:30pm; 2:30pm-1am; 8pm -6:30am)	M. Moore / Internal Team	1/30/201
2.	**Secure Management Approval of Countermeasures (share benefits)**	Team	9/30/13
3.	**Communicate Countermeasures to Stakeholders, along with related policy/procedure changes**	M. Moore/ Mngt. Team	12/31/13
4.	**Establish On-going responsibilities and standardize countermeasures into operations**	M. Moore	On-going



Review Results

17., 18., 19., 20.

The team collected indicator data and reviewed results of it's countermeasures

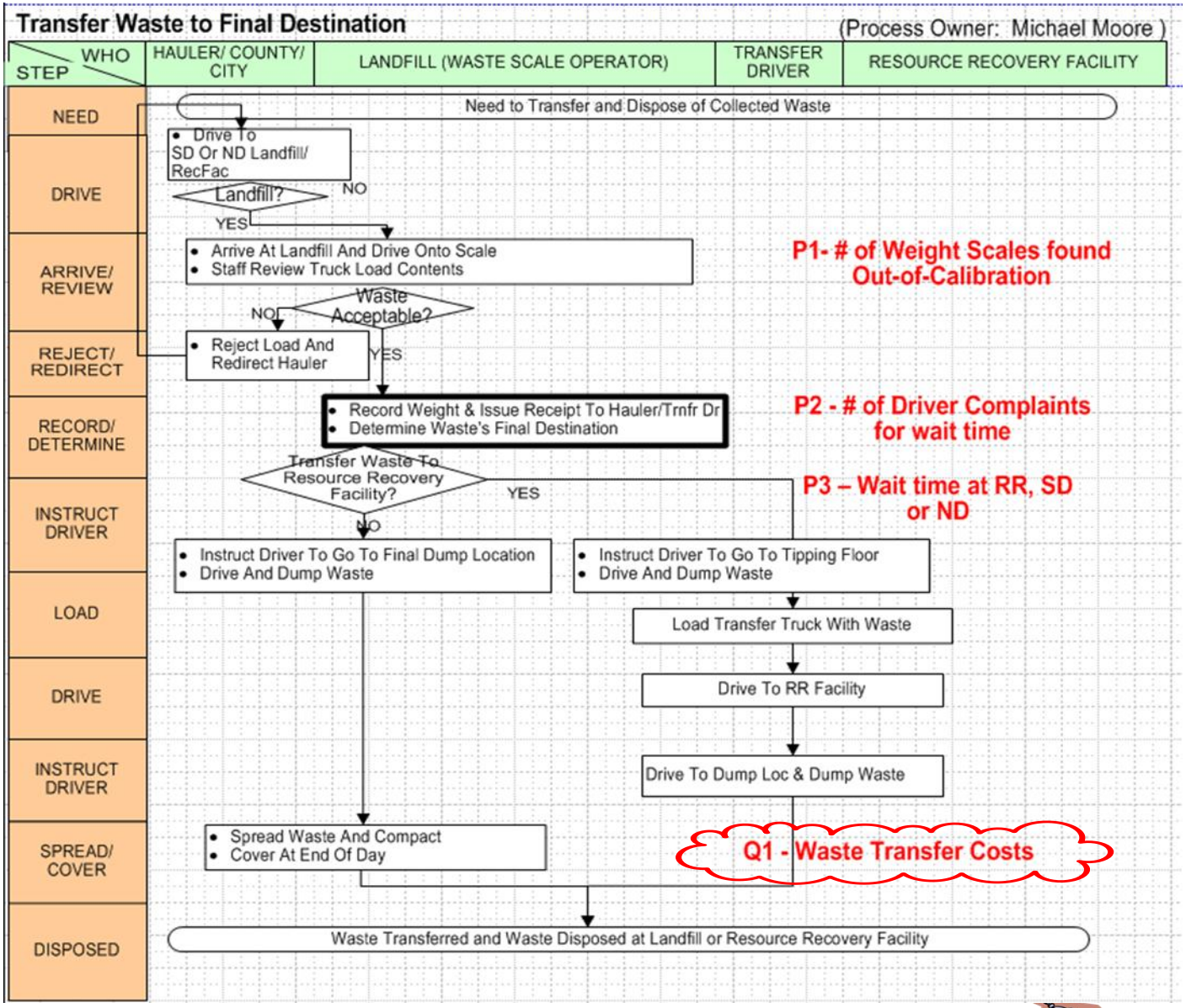


The team was encouraged by the results and will continue to monitor the countermeasures.

Standardize Countermeasures

21.

The team incorporated the countermeasures, which affects the working hours and not the process.



Standardize Countermeasures

21., 22., 23. ☑

The team Developed a Process Control System (PCS) to monitor the process on-going.

Process Control System

Process Name: Transfer and Dispose Waste	**Process Owner:** Michael Moore
Process Customer: Taxpayers; Management on behalf of Stakeholders; Other Municipalities	**Critical Customer Requirements:** Transfer Waste safely and at low cost
Process Purpose: Transfer Waste received at Transfer Stations to Resource Rec Facility	**Current Sigma Level:** TBD
	Outcome Indicators: P2, P3, Q1

Process and Quality Indicators			Checking / Indicator Monitoring			
Process Indicators And Quality Indicators		Control Limits Specs/ Targets	Data to Collect What is Checking Item or Indicator Calculation	Timeframe (Frequency) When to Collect Data?	Responsibility Who will Check?	Contingency Plans / Misc. • Actions Required for Exceptions • Procedure References
P2	# of Driver Complaints for wait time		# of Driver Complaints measure on ASE – trending data	Monthly	Division Director	• ASE Software Variance Report documentation; review Scale House Reports and address as appropriate.
P3	Wait time at Resource Recovery Facility		Wait times collected on Team Spreadsheet ("Transfer Driver Time and Production Report" form) – trending data	Quarterly	Division Director	Review Scale House Reports for possible root cause and address as appropriate.
Q1	Waste Transfer Operation Costs (*25% reduction [or $4.13] from average of $16.53)*	$12.40 - $12.32	FAMIS Report for Transfer Station Division *(captures operational expenditures)* / SWM MDFLTRAN-PWAS Report for Acct. 6999 *(captures tons transferred)*	Monthly YTD	Division Director	Review these two Reports for possible root cause and address as appropriate, or review Driver scheduling issues and address as appropriate.

Approved: _____ Date: _____ Rev #: ____ Rev Date: _____

The team looked ahead to the future.

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Define | Measure | Analyze | Improve | Control

Identify Lessons Learned

24.,25.

Lessons Learned

1) Good data is critical in problem analysis…careful identification of the poor performing outcome measure makes problem solving easier (keeps you focused).

2) Identifying Root Cause(s) by examining the data using the tools and techniques is better than guessing at what you think are the causes.

3) Having a systematic, standardized DMAIC process is essential to good problem solving.

Next Steps

Continue to monitor the countermeasures' performance results; adjust as necessary.

Appendix

S.I.P.O.C. Analysis

Process: *Dispose Waste to Final Destination*

Process Owner: *Michael Moore* Date Approved:

Suppliers	Inputs	Process	Outputs*	Customers
Waste Scale Operator Municipalities Private Haulers County Trucks	Waste Tonnage	1. Recieve Waste 2. Weigh truck 3. Determine Final Destination of Waste	- Waste Weight - Final Waste Destination	Driver County
Waste Scale Op. Driver (Mun/PH/MDC) MDC Transfer Driver	- Final Waste Destination - Waste Tonnage	4. Instruct Driver of location to Dump Waste 5a. Waste Dumped on Tipping Floor OR... 5b. Waste Taken to Landfill Area & Dumped	- Final Destination Verbal instructions	Driver
MDC Transfer Driver	- Final Waste Destination -Waste Tonnage	6. Load Waste on Transfer Truck 7. Transport Waste to Resource Recovery Facility	- Final Destination Verbal instructions	Driver
MDC Transfer Driver RR staff	- Final Waste Destination 'Waste Tonnage	8. Weigh truck 9. Dump Waste at Res. Recovery Fac. 10. Spread, Compact and Cover Waste at Landfill	- Waste Tonnage at Final Destination	County

* Outputs used to Identify Outcomes

Appendix

Customer Requirements Matrix

Process: ***Dispose Waste to Final Destination***

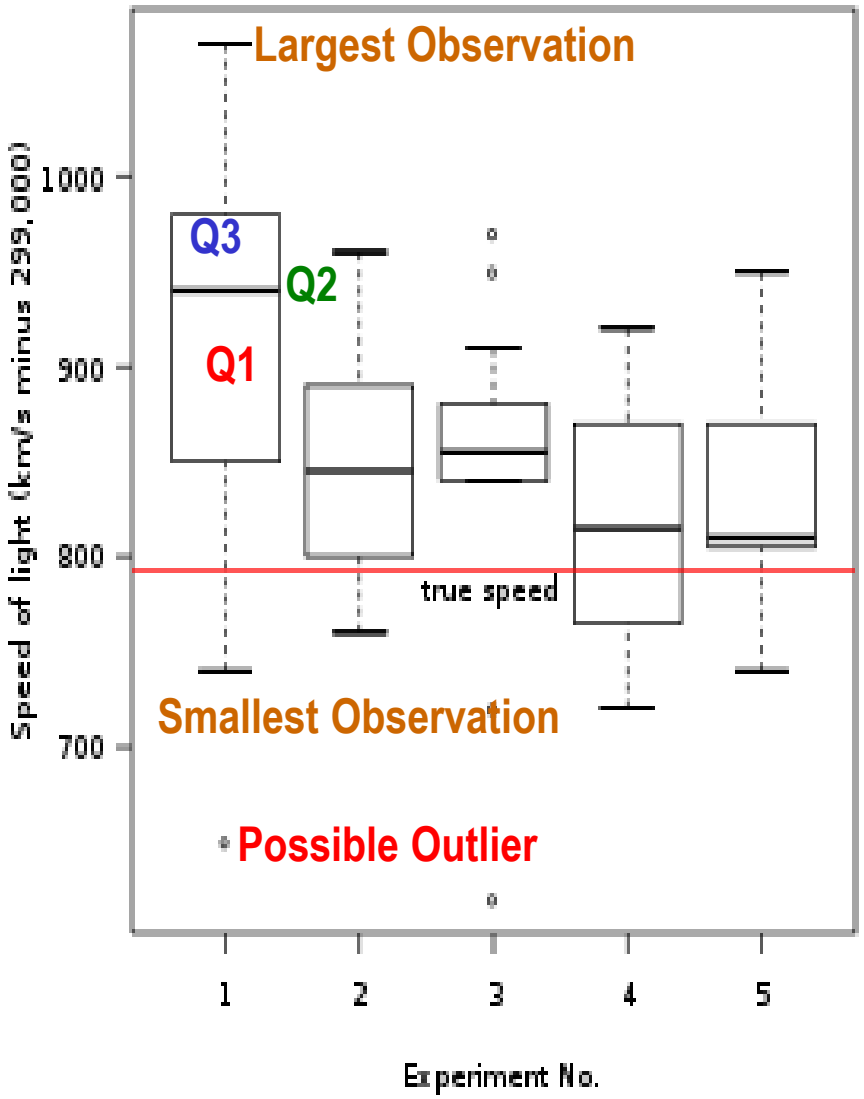
Survey Voice of Customer		Process Output(s)	Customer Valid Requirement	Outcome Indicator(s)
Quality Element	**Example Question**			
Accuracy	*How accurate do the process outputs need to be?*	Waste Weight Receipt	**Tonnage to be accurately weighed**	**P1- # of Weight Scales found Out-of-Calibration**
Timeliness	*When do customers need the process outputs?*	Waste Final Destination instructions	**Final Destination determined within 15 min of arrival**	**P2 - # of Driver Complaints for wait time** **P3 - # of Minutes from Waste Tonnage received at Landfill to sent to RR**
Cost	*What cost/resources are customers willing to pay for process outputs?*	Waste Tonnage	**Dispose Waste in most cost effective method**	**Q1 - Waste Disposal Trips-per-Driver per Shift** **Q3 – Overall Disposal $ Cost per Ton**

Appendix

Validation Box Plot Overview

A **box plot** is a convenient way of graphically depicting groups of numerical data through their five-number summaries: the smallest observation (sample minimum), lower quartile (Q1), median (Q2), upper quartile (Q3), and largest observation (sample maximum) . A box plot may also indicate which observations, if any, might be considered outliers.

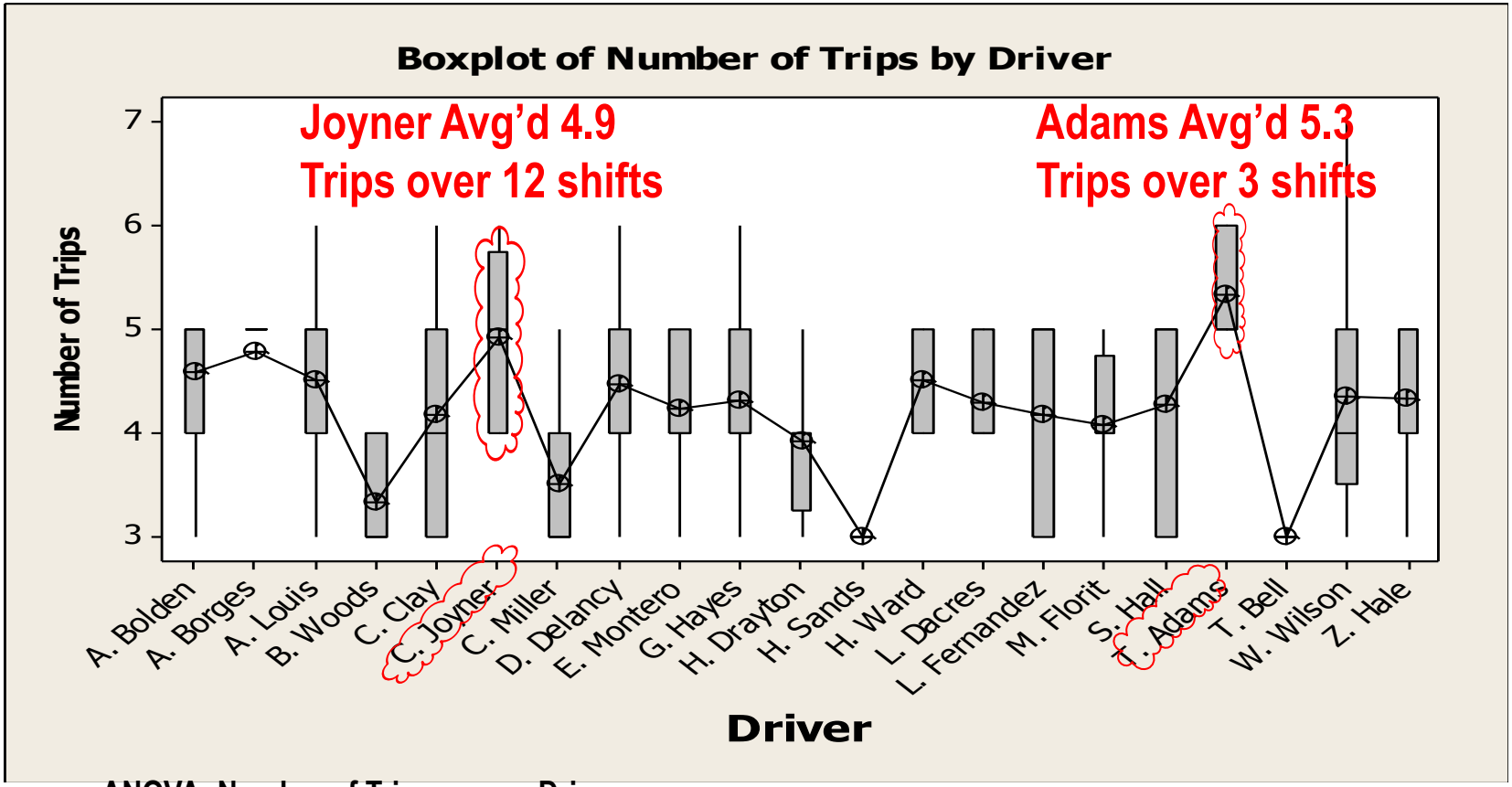
Box plots display differences between samples (i.e. Shift, Drivers, Day of Week). The spacings between the different parts of the box help indicate the degree of dispersion (spread) and skewness in the data. (*Note: Similar Box Plots aligned in a row indicate that the samples are from the same population and few, if any, differences exist. Box Plots out of alignment may indicate significant differences in samples (e.g. a root cause exists).*



Appendix

Validation Results: Drivers

The team analyzed 254 Day trips in December 2012 using ANOVA Validation and found Drivers do make a difference on Day Shifts.



One-way ANOVA: Number of Trips versus Driver

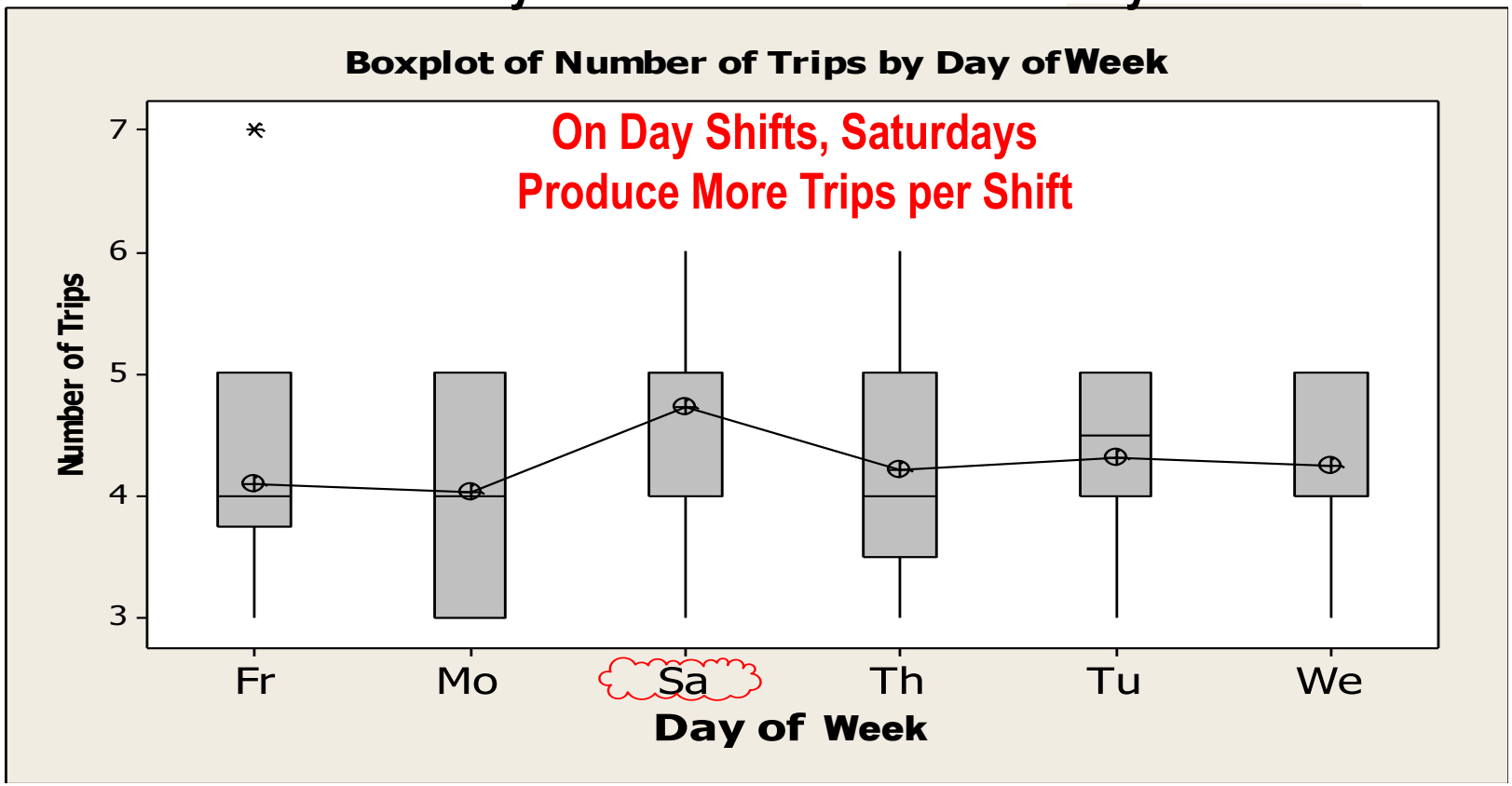
Source	DF	SS	MS	F	P
Driver	20	41.037	2.052	3.43	0.000
Error	233	139.404	0.598		
Total	253	180.441			

P<.05 Validates

***Interpretation*: Drivers make a difference on # of trips during the day shift.**

Appendix Validation Results: Day of Week

The team analyzed a sample of 254 Day shifts in December 2012 using ANOVA Validation and found Saturdays do make a difference on Day Shifts.



One-way ANOVA: Number of Trips versus Day of Shift

Source	DF	SS	MS	F	P
Day of Shift	5	15.836	3.167	4.77	0.000
Error	248	164.605	0.664		
Total	253	180.441			

P<.05 Validates

***Interpretation*: Saturdays produce more trips on average…almost one more trip per shift**

Define | Measure | Analyze | Improve | Control