Generation Interconnection System Impact Study Report

For

PJM Generation Interconnection Request Queue Position AC1-225

Marysville-Sorenson 765 kV

June 2018

Preface

The intent of the System Impact Study is to determine a plan, with approximate cost and construction time estimates, to connect the subject generation interconnection project to the PJM network at a location specified by the Interconnection Customer. As a requirement for interconnection, the Interconnection Customer may be responsible for the cost of constructing: (1) Direct Connections, which are new facilities and/or facilities upgrades needed to connect the generator to the PJM network, and (2) Network Upgrades, which are facility additions, or upgrades to existing facilities, that are needed to maintain the reliability of the PJM system. All facilities required for interconnection of a generation interconnection project must be designed to meet the technical specifications (on PJM web site) for the appropriate transmission owner.

In some instances a generator interconnection may not be responsible for 100% of the identified network upgrade cost because other transmission network uses, e.g. another generation interconnection or merchant transmission upgrade, may also contribute to the need for the same network reinforcement. The possibility of sharing the reinforcement costs with other projects may be identified in the feasibility study, but the actual allocation will be deferred until the System Impact Study is performed.

The System Impact Study estimates do not include the feasibility, cost, or time required to obtain property rights and permits for construction of the required facilities. The project developer is responsible for the right of way, real estate, and construction permit issues. For properties currently owned by Transmission Owners, the costs may be included in the study.

General

Long Prairie Wind I, LLC proposes to interconnect PJM Project #AC1-225, a 300.2 MW (39.0 MW Capacity) wind generating facility in Van Wert County, OH (see Figure 2). The point of interconnection is to AEP's Marysville – Sorenson 765 kV circuit (see Figure 1).

The requested in service date is December 31, 2019.

Attachment Facilities

Point of Interconnection (Marysville – Sorenson 765 kV)

To accommodate the interconnection on the Marysville – Sorenson 765 kV circuit, a new 765 kV switching station containing a minimum of three (3) circuit breakers physically configured in a breaker and half bus arrangement but operated as a ring-bus will be constructed (see Figure 1). Installation of associated protection and control equipment, 765 kV line risers, SCADA, and 765 kV revenue metering will also be required. AEP reserves the right to specify the final acceptable configuration considering design practices, future expansion, and compliance requirements.

<u>New Switching Station Work:</u>

- Construct a new 765 kV switching station containing a minimum of three (3) circuit breakers physically configured in a breaker and half bus arrangement but operated as a ring-bus. Installation of associated protection and control equipment, 765 kV line risers, SCADA, and 765 kV revenue metering will also be required (see Figure 1).
    - **Estimated Station Cost: $25,000,000**
    - **Additional provisions for station service may be required because of the interconnection location being remote from other Transmission facilities and will be determined during the Facilities Study.**

Direct Connection Cost Estimate

The total preliminary cost estimate for Direct Connection work is given in the following tables below.

For AEP building Direct Connection cost estimates:

Description	Total Cost
Marysville-Sorenson 765 kV T-Line Cut In	**$3,000,000**
Total	**$3,000,000**

Table 1

Non-Direct Connection Cost Estimate

The total preliminary cost estimate for Non-Direct Connection work is given in the following tables below:

For AEP building Direct Connection cost estimates:

Description	Estimated Cost
765 kV Revenue Metering	**$1,200,000**
Install line protection and controls at the new 765 kV Switching Station	**$2,000,000**
Upgrade line protection and controls at the Marysville 765 kV substation to coordinate with the new 765 kV switching station.	**$500,000**
Upgrade line protection and controls at the Sorenson 765 kV substation to coordinate with the new 765 kV switching station.	**$500,000**
Total	**$4,200,000**

Table 2

Interconnection Customer Requirements

It is understood that Long Prairie Wind is responsible for all costs associated with this interconnection. The costs above are reimbursable to AEP. The cost of Long Prairie Wind's generating plant and the costs for the line connecting the generating plant to Long Prairie Wind's switching station are not included in this report; these are assumed to be Long Prairie Wind's responsibility.

The Generation Interconnection Agreement does not in or by itself establish a requirement for American Electric Power to provide power for consumption at the developer's facilities. A separate agreement may be reached with the local utility that provides service in the area to ensure that infrastructure is in place to meet this demand and proper metering equipment is installed. It is the responsibility of the developer to contact the local service provider to determine if a local service agreement is required.

Requirement from the PJM Open Access Transmission Tariff:

1. An Interconnection Customer entering the New Services Queue on or after October 1, 2012 with a proposed new Customer Facility that has a Maximum Facility Output equal to or greater than 100 MW shall install and maintain, at its expense, phasor measurement units (PMUs). See Section 8.5.3 of Appendix 2 to the Interconnection Service Agreement as well as section 4.3 of PJM Manual 14D for additional information.

2. The Interconnection Customer may be required to install and/or pay for metering as necessary to properly track real time output of the facility as well as installing metering which shall be used for billing purposes. See Section 8 of Appendix 2 to the Interconnection Service Agreement as well as Section 4 of PJM Manual 14D for additional information.

Revenue Metering and SCADA Requirements

PJM Requirements

The Interconnection Customer will be required to install equipment necessary to provide Revenue Metering (KWH, KVARH) and real time data (KW, KVAR) for IC's generating Resource. See PJM Manuals M-01 and M-14D, and PJM Tariff Sections 24.1 and 24.2.

AEP Requirements

The Interconnection Customer will be required to comply with all AEP Revenue Metering Requirements for Generation Interconnection Customers. The Revenue Metering Requirements may be found within the "Requirements for Connection of New Facilities or Changes to Existing Facilities Connected to the AEP Transmission System" document located at the following link:

http://www.pjm.com/~/media/planning/plan-standards/private-aep/aep-interconnection-requirements.ashx

Network Impacts

The Queue Project AC1-225 was evaluated as a 300.2 MW (Capacity 39.0 MW) injection into a tap of the Sorenson – Marysville 765 kV line in the AEP area. Project AC1-225 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AC1-225 was studied with a commercial probability of 100%. Potential network impacts were as follows:

Base Case Used

Summer Peak Analysis – 2020 Case

Contingency Descriptions

The following contingencies resulted in overloads:

Contingency Name	Description
2942_C2_05KAMMER 765-PP	CONTINGENCY '2942_C2_05KAMMER 765-PP' OPEN BRANCH FROM BUS 242920 TO BUS 242925 CKT 1 / 242920 05BELMON 765 242925 05KAMMER 765 1 OPEN BRANCH FROM BUS 242920 TO BUS 242516 CKT 1 / 242920 05BELMON 765 242516 05MOUNTN 765 1 OPEN BRANCH FROM BUS 242920 TO BUS 235102 CKT 5 / 242920 05BELMON 765 235102 01BELMNT 500 5 OPEN BRANCH FROM BUS 242925 TO BUS 243188 CKT 1 / 242925 05KAMMER 765 243188 05MLG1 26.0 1 REMOVE UNIT 1 FROM BUS 243188 / 243188 05MLG1 26.0 END
37_B2_TOR12	CONTINGENCY '37_B2_TOR12' OPEN BRANCH FROM BUS 242920 TO BUS 242925 CKT 1 / 242920 05BELMON 765 242925 05KAMMER 765 1 OPEN BRANCH FROM BUS 242920 TO BUS 242516 CKT 1 / 242920 05BELMON 765 242516 05MOUNTN 765

Contingency Name	Description
	1 OPEN BRANCH FROM BUS 242920 TO BUS 235102 CKT 5 / 242920 05BELMON 765 235102 01BELMNT 500 5 END
8649_B2_TOR546	CONTINGENCY '8649_B2_TOR546' OPEN BRANCH FROM BUS 242924 TO BUS 243208 CKT 1 / 242924 05HANG R 765 243208 05JEFRSO 765 1 END

Table 3

Generator Deliverability

(Single or N-1 contingencies for the Capacity portion only of the interconnection)

None

Multiple Facility Contingency

(Double Circuit Tower Line, Fault with a Stuck Breaker, and Bus Fault contingencies for the full energy output)

None

Contribution to Previously Identified Overloads

(This project contributes to the following contingency overloads, i.e. "Network Impacts", identified for earlier generation or transmission interconnection projects in the PJM Queue)

AC1-225 Contribution to Previously identified Overloads															
	Contingency		Bus						Loading		Rating				
#	Type	Name	Affected Area	Facility Description	From	To	Cir.	PF	Initial	Final	Type	MVA	MW Con.	FG App.
1	DCTL	2942_C2_05KAMMER 765-PP'	AEP-AEP	05MARYSV-05MALIS 765kV line	242928	242926	1	AC	101.38	102.51	ER	4142	81.95	

Table 4

Steady-State Voltage Requirements

None

Short Circuit

(Summary of impacted circuit breakers)

New circuit breakers found to be over-duty:

None

Stability Analysis

No issues identified

Affected System Analysis & Mitigation

LGEE Impacts:

None

MISO Impacts:

None

Duke, Progress & TVA Impacts:

None

OVEC Impacts:

None

Delivery of Energy Portion of Interconnection Request

PJM also studied the delivery of the energy portion of this interconnection request. Any problems identified below are likely to result in operational restrictions to the project under study. The developer can proceed with network upgrades to eliminate the operational restriction at their discretion by submitting a Merchant Transmission Interconnection request.

Note: Only the most severely overloaded conditions are listed below. There is no guarantee of full delivery of energy for this project by fixing only the conditions listed in this section. With a Transmission Interconnection Request, a subsequent analysis will be performed which shall study all overload conditions associated with the overloaded element(s) identified.

	Contingency		Affected		Bus				Loading		Rating		MW
#	Type	Name	Area	Facility Description	From	To	Cir.	PF	Initial	Final	Type	MVA	Con.
1	N-1	8649_B2_TOR546	AEP - AEP	AC1-225 Tap-05Marysville 765 kV line	927280	242928	1	AC	101.51	102.37	NR	4249	168.66
2	N-1	37_B2_TOR12	AEP-AEP	05MARYSV-05MALIS 765kV line	242928	242926	1	AC	101.04	102.23	NR	4047	82.3

Table 5

Light Load Analysis - 2020

Generator Deliverability

(Single or N-1 contingencies for the Capacity portion only of the interconnection)

1. (AEP - AEP) The 05MADDOX-05E LIMA 345 kV line (from bus 246929 to bus 242935 ckt 1) loads from 99.47% to 102.18% (DC power flow) of its normal rating (897 MVA) for the single line contingency outage of '7441_B2_TOR100545_A'. This project contributes approximately 24.24 MW to the thermal violation.

CONTINGENCY '7441_B2_TOR100545_A'
OPEN BRANCH FROM BUS 242928 TO BUS 926650 CKT 1 / 242928 05MARYSV 765 246999 05SORENS 765 1
END

Multiple Facility Contingency

(Double Circuit Tower Line, Fault with a Stuck Breaker, and Bus Fault contingencies for the full energy output)

None

Contribution to Previously Identified Overloads
(This project contributes to the following contingency overloads, i.e. "Network Impacts", identified for earlier generation or transmission interconnection projects in the PJM Queue)

None

System Reinforcements

Light Load Load Flow Analysis Reinforcements

New System Reinforcements
(Upgrades required to mitigate reliability criteria violations, i.e. Network Impacts, initially caused by the addition of this project generation)

1. **To relieve the Maddox Creek – East Lima 345 kV line overload:**

   Reinforcement: Existing baseline upgrades B2833 and B2969. Re-conductor the Maddox – E Lima 345 kV line. Replace terminal equipment at Maddox -E Lima 345 kV circuit.
   New Ratings upon completion: 2433/2653 (SN/SE)
   In-service date: 2022

   Project AC1-225 will need the baseline upgrades in order to be deliverable. It will be determined during the Facilities Study Phase whether the baseline upgrades B2833 and B2969 can be advanced to 2020.

   Cost Estimate: The cost for advancement of the baseline upgrades B2833 and B2969 will be determined in the Facilities Study Phase.

Contribution to Previously Identified System Reinforcements
(Overloads initially caused by prior Queue positions with additional contribution to overloading by this project. This project may have a % allocation cost responsibility which will be calculated and reported for the Impact Study)
(Summary form of Cost allocation for transmission lines and transformers will be inserted here if any)

None

Contribution to Previously Identified System Reinforcements

(Overloads initially caused by prior Queue positions with additional contribution to overloading by this project. This project may have a % allocation cost responsibility which will be calculated and reported for the Impact Study)

(Summary form of Cost allocation for transmission lines and transformers will be inserted here if any)

1. To relieve the Marysville - Maliszewski 765 kV line overload: Replace the Maliszewski 765 kV circuit breaker 'D'. Estimated Cost is $2.5M. PJM Network Upgrade N5889. New SE rating to be 4571 MVA.
   This upgrade is driven by the AC1 queue and the AC1 queue will share this cost. The cost allocation is as follows:

Queue	MW contribution	Percentage of Cost	$ cost ($2.5 M)
AC1-002 LTF	66.9	9.666	0.242
AC1-067	170.8	24.679	0.617
AC1-153	199.9	28.883	0.722
AC1-204	172.5	24.924	0.623
AC1-225	82.0	11.848	0.296

Table 6

Schedule

It is anticipated that the time between receipt of executed agreements and Commercial Operation may range from 18 to 24 months if no line work is required. If line work is required, construction time would be between 24 to 36 months after signing an interconnection agreement.

Note: The time provided between anticipated normal completion of System Impact, Facilities Studies, subsequent execution of ISA and ICSA documents, and the proposed Backfeed Date is shorter than usual and may be difficult to achieve.

Conclusion

Based upon the results of this System Impact Study, the construction of the 300.2 MW (39.0 MW Capacity) Long Prairie Wind generating facility (PJM Project #AC1-225) will require the following additional interconnection charges. This plan of service will interconnect the proposed wind generating facility in a manner that will provide operational reliability and flexibility to both the AEP system and the Long Prairie Wind generating facility.

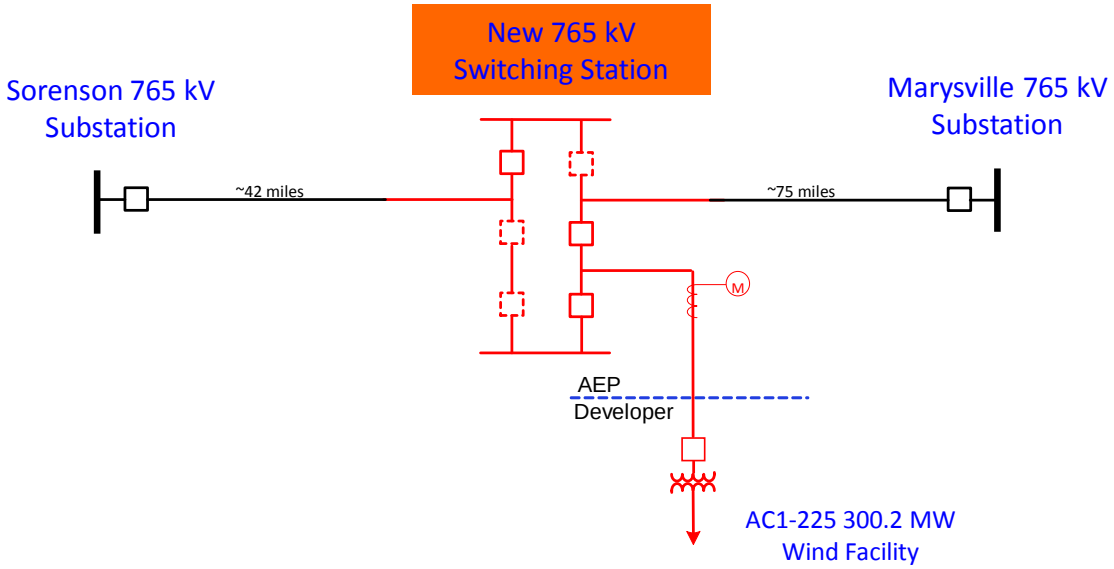
Cost Breakdown for Point of Interconnection			
Type of Network Upgrade	**Network Upgrade Number**	**Description**	**Estimated Cost**
Attachment Cost	**n5684**	New 765 kV Switching Station	**$25,000,000**
Non-Direct Connection Cost Estimate	**n5685**	765 kV Revenue Metering	**$3,000,000**
	n5686	Marysville-Sorenson 765 kV T-Line Cut In	**$1,200,000**
	n5687	Install line protection and controls at the new 765 kV Switching Station	**$2,000,000**
	n5688	Upgrade line protection and controls at the Marysville 765 kV substation to coordinate with the new 765 kV switching station.	**$500,000**
	n5689	Upgrade line protection and controls at the Sorenson 765 kV substation to coordinate with the new 765 kV switching station.	**$500,000**
	n5889	Contribution to Previously Identified System Reinforcements	**$2,500,000**
		Total Estimated Cost for Project AC1-188	**$34,700,000**

Table 7

The estimates are preliminary in nature, as they were determined without the benefit of detailed engineering studies. Final estimates will require an on-site review and coordination to determine final construction requirements.

Figure 1: Point of Interconnection (Marysville - Sorenson 765 kV)

Single-Line Diagram



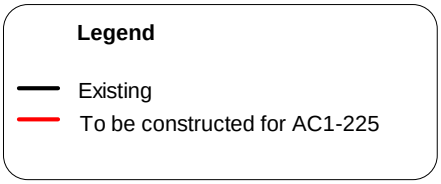
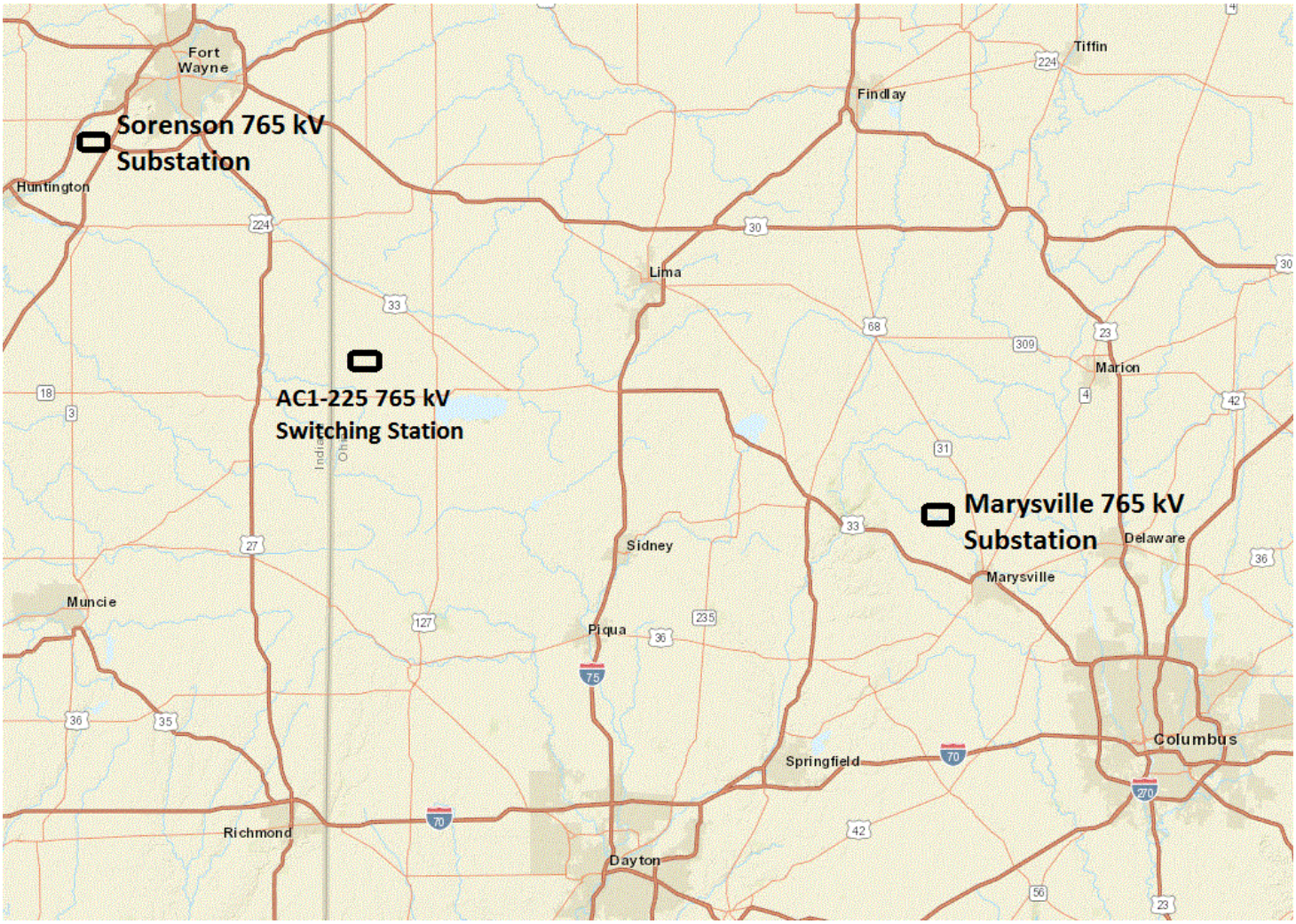


Figure 2: Point of Interconnection (Marysville – Sorenson 765 kV)



Appendices

The following appendices contain additional information about each flowgate presented in the body of the report. For each appendix, a description of the flowgate and its contingency was included for convenience. However, the intent of the appendix section is to provide more information on which projects/generators have contributions to the flowgate in question. Although this information is not used "as is" for cost allocation purposes, it can be used to gage other generators impact.

It should be noted the generator contributions presented in the appendices sections are full contributions, whereas in the body of the report, those contributions take into consideration the commercial probability of each project.

Appendix 1 – Load Flow Results

(AEP - AEP) The 05MARYSV-05MALIS 765 kV line (from bus 242928 to bus 242926 ckt 1) loads from 101.38% to 102.51% (AC power flow) of its emergency rating (4142 MVA) for the line fault with failed breaker contingency outage of '2942_C2_05KAMMER 765-PP'. This project contributes approximately 81.95 MW to the thermal violation.

CONTINGENCY '2942_C2_05KAMMER 765-PP'
OPEN BRANCH FROM BUS 242920 TO BUS 242925 CKT 1 / 242920 05BELMON 765 242925 05KAMMER 765 1
OPEN BRANCH FROM BUS 242920 TO BUS 242516 CKT 1 / 242920 05BELMON 765 242516 05MOUNTN 765 1
OPEN BRANCH FROM BUS 242920 TO BUS 235102 CKT 5 / 242920 05BELMON 765 235102 01BELMNT 500 5
OPEN BRANCH FROM BUS 242925 TO BUS 243188 CKT 1 / 242925 05KAMMER 765 243188 05MLG1 26.0 1
REMOVE UNIT 1 FROM BUS 243188 / 243188 05MLG1 26.0
END

Bus Number	*Bus Name*	*Full Contribution*
246431	*05BUCHANAN*	*0.64*
243441	*05CKG2*	*34.48*
246397	*05ELKHARTH*	*0.6*
247216	*05FLATG1*	*5.46*
247217	*05FLATG2*	*5.46*
247218	*05FLATG3*	*5.46*
247219	*05FLATG4*	*5.46*
247220	*05FLATG5*	*5.47*
246536	*05MOTTVILL*	*0.25*
247270	*05RPMNG1*	*4.82*
247271	*05RPMNG2*	*4.81*
247272	*05RPMNG3*	*4.81*
246416	*05TWIN BRCH1*	*0.15*
275149	*KEMPTON ;1E*	*21.82*
274775	*LINCOLN ;6U*	*2.33*
274776	*LINCOLN ;7U*	*2.33*
274777	*LINCOLN ;8U*	*2.33*
275148	*MILKS GRV;1E*	*21.82*
293061	*N-015 E*	*18.57*
293644	*O22 E1*	*12.48*
293645	*O22 E2*	*24.22*
294392	*P-010 E*	*23.59*
274722	*S-055 E*	*6.04*
884780	*S-058 C*	*64.44*
884781	*S-058 E*	*193.31*
247568	*V3-015 C*	*6.13*

247949	*V3-015 E*	*41.05*
274687	*WILL CNTY;4U*	*79.04*
920252	*X1-020 C*	*31.37*
920253	*X1-020 E*	*209.92*
247611	*X2-052*	*21.03*
910542	*X3-005 E*	*0.88*
920462	*Y2-103*	*55.02*
920472	*Y3-013 1*	*4.58*
920482	*Y3-013 2*	*4.58*
920492	*Y3-013 3*	*4.58*
247620	*Y3-023*	*0.15*
LTF	*Z1-043*	*38.61*
247633	*Z1-051 C*	*2.69*
247634	*Z1-051 E*	*3.2*
916502	*Z1-106 E1*	*1.54*
916504	*Z1-106 E2*	*1.54*
916512	*Z1-107 E*	*3.1*
916522	*Z1-108 E*	*3.06*
LTF	*Z1-112*	*14.85*
916651	*Z1-127 1*	*2.07*
916652	*Z1-127 2*	*1.04*
920873	*Z2-113 E*	*0.35*
920882	*Z2-114 C*	*0.08*
920883	*Z2-114 E*	*0.4*
920892	*Z2-116 C*	*0.04*
920893	*Z2-116 E*	*0.21*
LTF	*AA1-001*	*9.49*
920932	*AA1-018 C*	*2.98*
920933	*AA1-018 E*	*19.95*
LTF	*AA1-071*	*9.9*
918972	*AA1-116 E*	*3.12*
918982	*AA1-117 E*	*3.12*
921692	*AA2-035*	*158.81*
922102	*AA2-116*	*157.25*
922912	*AB1-080*	*6.49*
923022	*AB1-091 C OP*	*85.78*
930761	*AB1-122 1*	*88.61*
930762	*AB1-122 2*	*88.24*
923562	*AB1-172*	*0.96*
LTF	*AB2-013*	*22.09*
LTF	*AC1-002*	*66.92*
926661	*AC1-067 OP*	*170.79*
927081	*AC1-109*	*3.09*
927101	*AC1-110*	*4.62*
927121	*AC1-111*	*5.55*

927481	*AC1-141*	*14.37*
927501	*AC1-142A*	*9.91*
927571	*AC1-148 C*	*4.76*
927572	*AC1-148 E*	*3.17*
927621	*AC1-153 C1*	*95.91*
927623	*AC1-153 C2*	*96.32*
927622	*AC1-153 E1*	*3.84*
927624	*AC1-153 E2*	*3.85*
928141	*AC1-204*	*86.25*
928142	*AC1-204*	*86.25*
928361	*AC1-225 C OP*	*10.65*
928362	*AC1-225 E OP*	*71.31*