Fields of Fuel: Environmental and Economic Considerations of Transitioning Boardman to Biomass Using Corn and Wheat Residue in a Three State Area

Final report of the Spring 2014 Environmental Studies Junior Seminar (ES300) at Reed College

Executive Summary

List of Figures

Table of Contents

1 Introduction

1.1 Boardman: Predicament and Possibility

Figure 1

. 6n f/cSure political landscape eloiEleaW.yp1(poli4sc)1(oli4s93.0469 74.88

1.2 Brief History of Boardman and its relationship to Utilities

1.3 Utilities in the Pacific Northwest

1.4 Oregon's Renewable Energy Structure

Figure 2

2 Policy Brief: Emissions policy relevant to Boardman's transition to biomass

2.1 Clean Air Act compliance regulations

2.1.1 Prevention of Significant Deterioration (PSD) permitting

2.1.2 Regional Haze Rule: Current BART specifications and considerations for future PSD regulations

2.1.3 Greenhouse Gas Emissions (GHG) regulation under Title V of the CAA

2.3 Biomass Energy Tax Credit

-
-

2.4 Emissions Calculations for different fuel sources

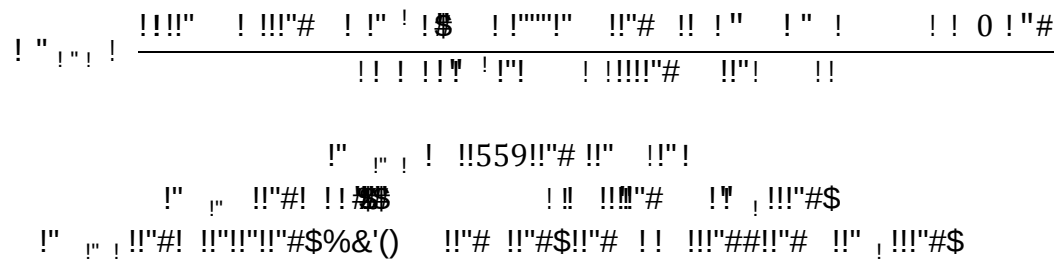
2.4.1 Units

-
-
-
-
-
-
- ! ! ! "#$! ! " #!

2.4.2 Calculation Notes

-
-
-
-
-

Wheat Straw:



Wood:[46]

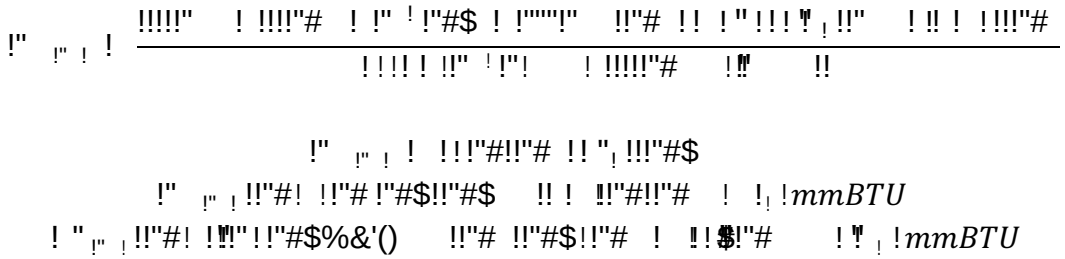


Figure 3.

Figure 4.

2.4.4 Carbon Emissions from Biomass[47]

$$!"_{!"} = !\frac{!!\ !"\#\$!!_{!}!!!!!"_{!}!!"!"!}{!!\ !} ! !""""lb!!"\#$$

Combined corn and wheat biomass:

$$!"_{!"} = \left(\quad ! \quad !"\#\$! 0 ! ! \frac{!!\ \ !"}{!"} \right)$$

Figure 5.

Figure 6.

3 Transportation and Acquiring Biomass: Costs and Carbon Implications

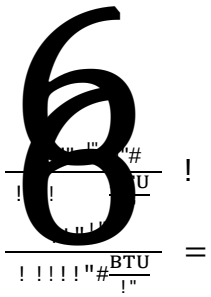
3.1 Biomass requirements

!""!"   !!"#$!%# !!"#$!!"#$! !!!" ! !" ! !!"!

!""""!!"!   !!""!!"#

!!!" ! !" ! !"!   ! ———— ! ———— ! !!!" ! !" !"! !"#

!!!"!   !"!



3.2 Crop residues

! "#!!"#$%&"! !"#$%!!"## ! !"#$%&! !"#$%&'(!!"#$%&'() ! !"#$%&'(!!"#$%&'!!"!#$!%$&

$$!"\#!"\#\$\%\&" = !"\#\$\% \quad !!"\#! \frac{0 \quad !"\#\$}{!!"} ! \frac{!"\#\$\%!}{!"\#\$\%} ! 0 \quad ! 0 !"$$

$$!"\#!"\#\$\%\&" = !"\#\$\% \quad !!"\#! \frac{0 !" !"\#\$}{!!"} ! \frac{! !"\#\$\%\&}{!"\#\$\%} ! 0 !"\#! 0 !"$$

Figure 7

Wheat Residue:	2.94 million tons dry wheat straw	(Milbrandt 2005, 12) (Ag Census 2007

Figure 8

Figure 9

3.3 Crop distance from Boardman

3.4 Transportation Costs of moving biomass to Boardman

Figure 10

3.5 Purchasing costs of crop residues

3.6 Meeting Demand

3.7 Carbon Emissions Associated with Biomass Transport

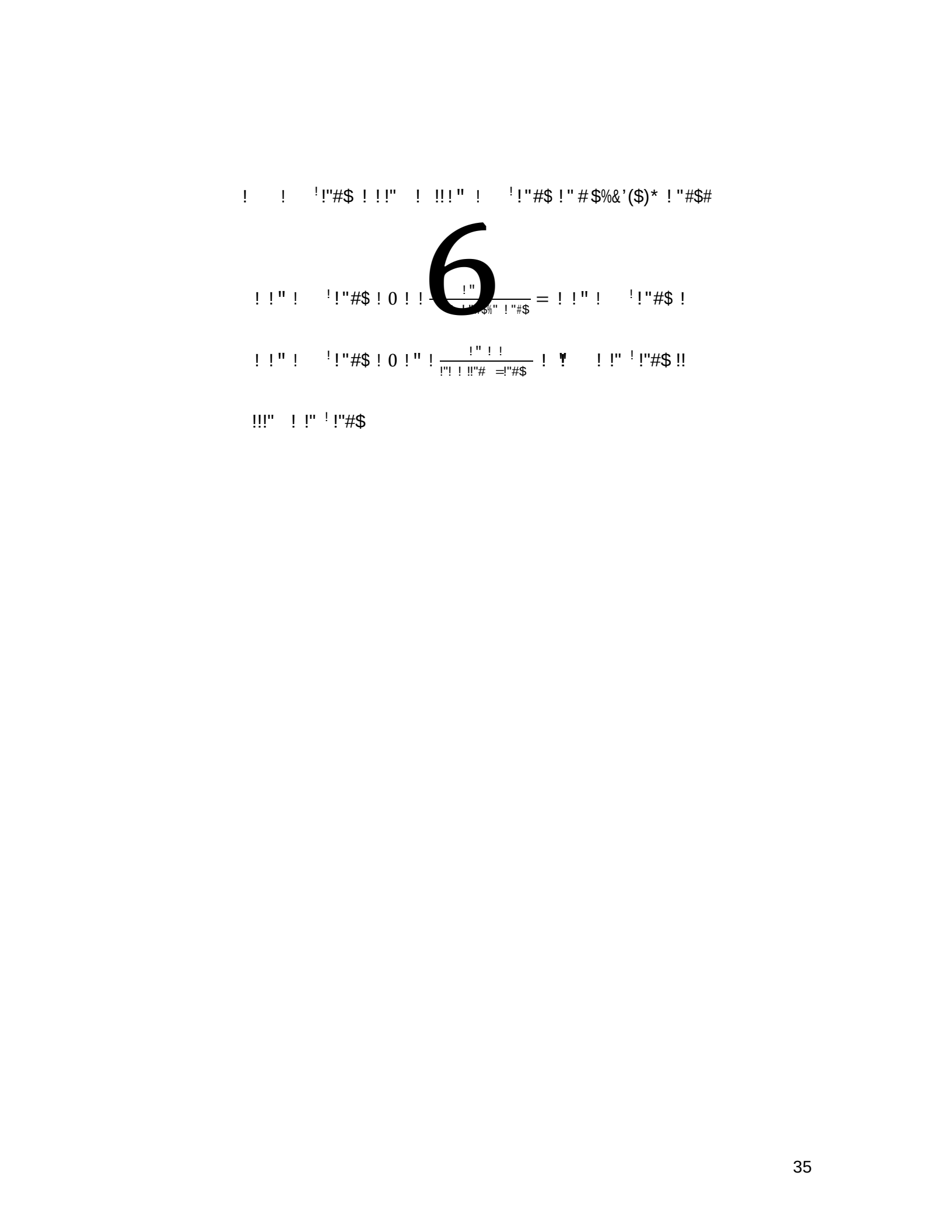
Figure 11

4 Torrefaction: Scenarios and Development

4.1 Current Torrefaction Technology

4.2 Future Torrefaction Technology

! ! ! !"#$! !!" ! !!! " ! !"#$!"#$%&'($)* !"#$#



! !" ! !"#$! 0 ! ! !" = ! !" ! !"#$!

! !" ! !"#$! 0 !" ! !" ! ! ! !" !"#$!!

!!!" ! !" !"#$

6 GIS Table Appendix

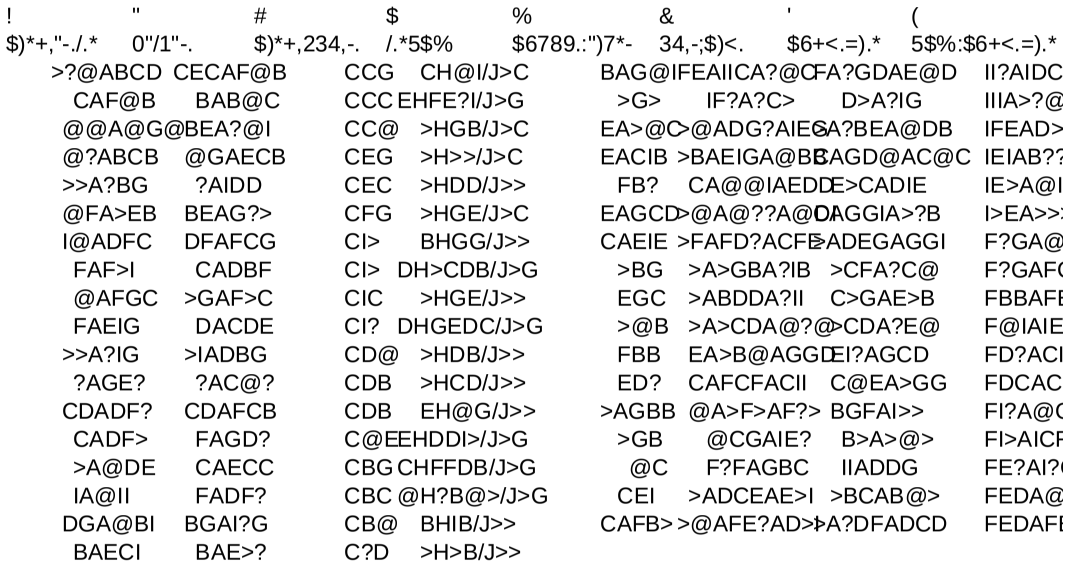
!	"	#	$	%	&	'	(
)*+,-.+/0,-/)+12	)*+,-203/.1-/)+12	)*+,-203/.1-4*,2	561/4-/)+12	7*+,892613	7*+,:12	;61/489261	;61/4:12-<
=>=?@	ABCD	ABCD	<EF>F=F	<?<=@G=	<@>=GF	=>HHI>=G<	E=><?
F	F	F	<<?>@GE	F	F	?>GH<>F<G	=G>F=
I>GG@	JF=	<<>G==	GFG>@FG@FHH=	EH	<E>FG@	<=>@JH>JE	<I@>@
ABCD	F	F	IE>E<F	F	F	G>J<G>@J?	H?>F@
F	F	F	GJ>==J	F	F	<><@=>FIG	<G>@
<@>=EA@	ABCD	ABCD	IH>@=J	@IHG<@<	@H>?<=	H>?<@><=<	?G>@
<=>G=I	=><@=	<EF>IE<	E=>J=G	GG??EH?	@E>I?G	H>?JH>E=H	?H><C
F	F	F	?=>FI<	F	F	@>G@<><JI	@E>H
H>E?A	ABCD	<>FH@	<IF>IEG	<@<F=HH	<F>FJ?	<@>==<>F<J	<HI>HI(
ABCD	F	F	EE>IEF	F	F	?>FI?>?GG	=F><=
<=>E??	@?>FHE	=EI>===	@F>H@EGHH@FHE		@J>=E@	<>?<I>=HH	<E>IH
G=<	ABCD	ABCD	@=>IGF	HEFFF	GI@	@>FJ=>I=E	@H>=
J>=FG	H>FGH	<<E>H=E	@=@><F<<=I=IHE		<H><G=	<@>E=?>GEG	<?F>E@
ABCD	ABCD	ABCD	J@=	F	F	=J>JH?	J<G
F	F	F	E>?H@	F	F	J<?>?E=	I>=GI
?E>HG@	J>GGH	@@G><GI	<H?>IEI	<<?IJ==?	I=>=<E	<F>@I?><IE	<@<>?
ABCD	@@?	H>=E@	JHG	F	F	=H>=?F	E=C
F	F	F	=J>HHE	F	F	G>HJ@>FG<	H<><<
<F<	<>=EI	G?>J=I	I>E?@	<GFHG	<FI	JI?>G@?	<F>?E
ABCD	F	F	H?E>IEG	F	F	GF>?I@>E=G	G=<>@
ABCD	ABCD	ABCD	I<<	F	F	=I>@I@	J<J
F	G=E	I>FH?	J>HJ<	F	F	EFG>JJ@	J>G<
F	F	F	<><HI	F	F	<FE>?=E	<>@E
F	F	F	J><<E	F	F	HFH>=E@	H>EE
ABCD	<>HIF	G?>J<J	@>=?J	F	F	@<F>?G?	@>H,
ABCD	G>?JH	JJ>@FE	G>EH<	F	F	@I@>@FG	G>H?
ABCD	<<?	ABCD	<HF>EH=	F	F	J><<?>?HI	I?>J@

K*4/32L @G@><H< <>?IF><IE

! " # $ % & ' (
$)*+,"-./,* 0"/1"-. $)*+,234,-. /,*5$% $6789:";7*- 34,-$)<. $6+<.=),* 5$%:$6+<.=),*
>>?@>A BBC?>BC DE BFDG/HBD A?CDG D?BID?JEC DGC?IGD

!
"
#
$
%
&
'
(
)''*%#+,$
-!.%
/+!+%0-!.%
&,1/
1)12333
/4.,
560789:;8<:
560789:;8<:0<=7
2?
@32A8B<=CB
D59E8B6:=B
FG3HG
@3@?H
2GGIJH

!	"	#	$	%	&	'	(
)*+,-.+/0,-/)+12	)*+,-203/.1-/)+12	)*+,-203/.1-4*,2	561/4-/)+12	7*+,892613	7*+,:12	;61/489261	;61/4:12-<
=	>?@A	>?@A	B<BCDD<	=	=	<ECFGDCGHG	<HFCIJI
=	JCBII	E=CJFB	JCBFD	=	=	J=HCH=<	JCDF
=	=	=	<=ECJF=	=	=	ECGI<CJEF	FFCF=
>?@A	>?@A	>?@A	<GFCIHI	=	=	ECFE=CH<=	FHCIJI
=	=	=	JGCEDJ	=	=	<C=<DCE=G	<<CHI
>?@A	=	=	H<CIBD	=	=	ECJFHC=DI	FDC<E
=	=	=	HICIEE	=	=	DCII<CHDD	GFCEI
>?@A	JBH	DC<GF	BCE<G	=	=	BFBCH=<	DCD<
=	>?@A	>?@A	HCGIG	=	=	EJECH<=	FCD=
>?@A	<CBF=	BEC=<B	DCJBD	=	=	BEICBFE	DCBC
BCI=I	GC<E<	<JHCGE<	GCBDE	F=<BHJ	GCIDB	G<FCJIF	EC<=
<CBIJ	<C=JI	JHCEBI	FCF=G	J<BIHI	<CFIJ	E<DCE<F	FCJG
=	=	=	BGCHHE	=	=	JCJGFC=B<	JECEI
=	=	=	GC<J<	=	=	JJBCEEH	


! " # $ % & ' (
$)*+,"-./.* 0"/1"-. $)*+,234,-. /.*5$% $6789.:")7*- 34,-;$)<. $6+<.=).* 5$%:$6+<.=).*
>?@ABCD CECAF@B CCG CH@I/J>C BAG@IFEAIICA?@CFA?GDAE@D II?AIDC
CAF@B BAB@C CCC EHFE?I/J>G >G> IF?A?C> D>A?IG IIIA>?@
@@A@G@BEA?@I CC@ >HGB/J>C EA>@C>@ADG?AIE>A?BEA@DB IFEAD>
@?ABCB @GAECB CEG >H>>/J>C EACIB >BAEIGA@BBBAGD@AC@C IEIAB??
>>A?BG ?AIDD CEC >HDD/J>> FB? CA@@IAEDDE>CADIE IE>A@I
@FA>EB BEAG?> CFG >HGE/J>C EAGCD>@A@??A@DAAGGIA>?B I>EA>>:
I@ADFC DFAFCG CI> BHGG/J>> CAEIE >FAFD?ACFE>ADEGAGGI F?GA@
FAF>I CADBF CI> DH>CDB/J>G >BG >A>GBA?IB >CFA?C@ F?GAF(
@AFGC >GAF>C CIC >HGE/J>> EGC >ABDDA?II C>GAE>B FBBAFE
FAEIG DACDE CI? DHGEDC/J>G >@B >A>CDA@?@>CDA?E@ F@IAIE
>>A?IG >IADBG CD@ >HDB/J>> FBB EA>B@AGGDEI?AGCD FD?ACI
?AGE? ?AC@? CDB >HCD/J>> ED? CAFCFACII C@EA>GG FDCAC
CDADF? CDAFCB CDB EH@G/J>> >AGBB @A>F>AF?> BGFAI>> FI?A@(
CADF> FAGD? C@EEHDDI>/J>G >GB @CGAIE? B>A>@> FI>AICF
>A@DE CAECC CBG CHFFDB/J>G @C F?FAGBC IIADDG FE?AI?(
IA@II FADF? CBC @H?B@>/J>G CEI >ADCEAE>I >BCAB@> FEDA@
DGA@BI BGAI?G CB@ BHIB/J>> CAFB> >@AFE?AD>I>A?DFADCD FEDAFI
BAECI BAE>? C?D >H>B/J>>
42


! " # $ % & ' (
)'*%#+,$ -!.% /+!+%0-!.% &,1/ 1)12333 /4., 560789:;8<: 560789:;8<:0<=7
?@ AA@BC5:<=D B59C8E6:=E ?F3@F AGGHAI 2AG2JB %/+%K-
?H GA*=9>LC8E>);>6=E IA3FF @?@2G AGIAJI/)M+(B%/+
?N 2@*>;=D> ,75C= AG3?F AHFI2 G3AJN)M+(O#%-+K!P
G3 F2 P8E<=QE ,75C= AG3GF I3II A23?JN)M+(O#%-+K!P
GA I2 +R8EO&5QQ5C= AG3HF GI2HI AN2HJI)M+(O#%-+K!P
G2 FI .8E87=S5 ,75C= AG3G@ 23A@I @GFJA)M+(O#%-+K!P
GF AG#59985 ,75C= AG3FA 2AIAG 2?H3JF)M+(O#%-+K!P
GA A2?'T::> G ,75C= AG32F 2HNN 22FA2G)M+(B@%2-GAGIAJI @3

!	"	#	$	%	&	'	(
)*+,-.+/0,-/)+12	)*+,-203/.1-/)+12	)*+,-203/.1-4*,2	561/4-/)+12	7*+,892613	7*+,:12	;61/489261	;61/4:12-<
=	<>?@AB	CBA?>@B	@C=	=	=	D@?D>C	DB>
>	=	=	EFGH	IDI	B	=	=
C?A>C	DB?<AD	A>D?AJI	<<?A=C	>DDJ=<	J?<BJ	<?DI@?=J>	<J?DA
D?AAD	A?@JI	D<D?JJ<	B?<J@	@@@<ID	C?A==	ACD?ADD	B?>J<
<C?@><	C@?>I=	BAB?@D@	D@?@>@	DD=CC@I	<B?CJ@	D?>J<?=D@	C<?C=
>?A<<	J?>>C	<JD?<C<	CJ?AA=	<<<CB<<	I?DAB	C?>J>?CI=	@C?<
D?J=A	D=?CII	J<D?BJI	AD?>@=	CDB@><	D?AC>	>?@=D?<DA	AJ?JID
=	EFGH	EFGH	D?DBB	=	=	D=J?D>C	D?@
@?@C@	<?D<=	C=?>B=	BB?DC<	>IIB>>	J?BC=	J?A@>?CBC	>A?B@
<?J>=	C?B@>	<=>?B=J	<<B?BI>	C=@>J=	D?JCB	<D?C>I?AA<	<@>?=,
@?@CI	B?BIB	D<A?JI@	C>?BC<	>I@J<@	J?ABJ	C?><@?D=A	@D?>
=	EFGH	EFGH	C=?JDD	=	=	<?C=C?I=B	<J?CI>
=	EFGH	EFGH	C<?J=D	=	=	B>@?=IA	<=?D=
=	EFGH	EFGH	J?CBD	=	=	J=J?<CA	J?I>@
EFGH	EFGH	EFGH	@=?ICD	=	=	C?C@@?>@I	CI?@I
<?I=J	@?D==	<=<?<JC	J<?CDD	D@ADDB	D?=JI	D?I=I?A<>	C@?C
=	EFGH	EFGH	@<?=JI	=	=	<?A<D?JJI	D=?DI
<?DAB	JBJ	<<?AIC	CC?>BI	<ICD>=	<?><=	D?DD>?IDI	D>?DI
>@@	D?@@C	JB?JBJ	<B?@J=	<=CJ<D	B>D	A=I?=C@	B?CA
=	=	=	<<?>AC	=	=	@D>?J=B	J?=C
=	=	=	J?=>C	=	=	A@?AJB	BBC

7 Bibliography