

The 17th Annual SJSU College of Science Student Research Day

!"#\$%&'() %&(*'+,++'((

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! "##\$%&'()*\$+)\$&(, - & ./&0 , 1 2 , 3 4 &
4 56&78&9:99!

"#\$%&' (#) '!*+!, - * . * / - 0% .!10-#) 0 #1!

! #! %&'!() * +, - ' . / - ' / 0! +120' 3/! 43/56'! '78,9!36! : '('665! ;!<2! != ' / 62! ; != ; / 5.6'! >2! ? 5032/13/!! "#\$%&' " () * +, - #. # / " \$, !

>5@3285!A136' / 2B! = CD& - ' . ! 45C!B!E' 12/3(5!A3B!%5/ ; 5!F; B!G&13603/5! : 7C; ' / B!H!C/5!E516&/ ' ; B!I53 ? ' 3!FC!
! >5(C80; J!! * 313!E5/ K2L' / B! * 5103/5!A1' ? ' 1B! + & 383. !K' 88' 1!

! \$! M8<5(021; != ; / 5.6'6!51' ! * 2 - C850' - ! @ ; ! M - 2! ! % 153/3/7!5/ - ! = 8' ' . ! 3/!! "#\$%&' " () * +, - #. # / " \$, !
H/31C - & ! A2DD5B!G3@' 88' ! : 5663<B! >503 ? 5! >515&B!E5/ ' 665! I3 ? ' / ' NB!H/05/5!A515 - P50B! = 515!H885 - 3/ B!E5/ ' 665!
) 51(35B!Q ? 38; != 22K22B!Q ? ? 5!M - 36&2B!450' 1; / 5!%2D58' / D2B!4 ' 883!A' / ' - ' 003!

>5(C80; J!! * 313!E5/ K2L' / B! * 5103/5!A1' ? ' 1!

G2885@215021J!! : 2' 88' !FRQ0238' !

! S! A12 ? 2. ' 12T3 - 56' ! ' T. 1' 6632/!36!5(03L50' - ! 3/! ! ' 6. 2/6' ! 02! & ; - 127' /! . ' 12T3 - ' 15/ - ! 62 - 3C ? ! @ 3(51@2/50' ! 3/!
O " I * . 2, - 1#, !

* 500&' P! + ' 11; B! >15/ (' 6(5!%211' 6!

>5(C80; J!! = 5@3/ ' !U' (&!

! 9! = 238! 6. ' (358360!2!1!7' / ' 158360V!H! ' !A5; !H! ' 5!P588<82P' 16!5 - 5.03/7!02! - 3<<' 1' / 0!62386V!

! I' 663(5!%12P!

>5(C80; J!! A' / !G510' 1!

G2885@215021J!! %15(; ! * 363' P3(N!!

! W! G303N' / != (3' / (' !X505!U' L' 58!) ' 2715. & 3(! + 500' 1/6!3/! >82P' !G282113/! Y' 60' 1/! Y 588<82P' 16!

!) 15(' !XC; 5/ ' / B! * 5835! * 38' ; !

>5(C80; J!! A' / !G510' 1!

G2885@215021J!! %15(; ! * 363' P3(N!5/ - !ZL2// ' !FC2/7!

! [! X12C7&0! \ ? . 5(06!QL28C032/!5/ - ! + 85603(30; !2<!5! : 503L' !G583<21/35! + 85/0! = . ' (3' 6!

! : 50583' ! Y 22 - ? 5/6' ' B!H88' / !F' L5/B!I' 663(5! = ? 30&B!K511362/!X' !E2; !

>5(C80; J!! = C65/!F5 ? @1' (&0!

!]! : 2L' 8!A5(0' 1358!A' 05,) 585(0263 - 56' !Q/N; ? ' !5/ - !306! + 20' / 0358!U28' !3/!KC ? 5/!%220&!X' (5; !

! * 3(&' 88' ! Y 588' 13C6B!Z366' 8!U' ; / 5B! >516&' ' - !) & 5 - 313!

>5(C80; J!! G8' @ ' 1!MCL' 1/ ' ; !

! ^! _ 0383N5032/!2<!5/! / 0' 7156' !X' <3(3' / 0!F' / 03L3158!E' (021!<2!X' 83L' 1; !2<!5!X : H!U' . 531!% ? . 850' !

! IC5/! >5/ (&' NB! + 51/30!I&C00; B!H61305!A&5 ? 3 - 3. 503!

>5(C80; J!! I' / / 3<' 1! * \$!I2&/602/!

! `! + 850' 8' 0! >5(021! \ E! 56! 5! >E \ \ \ ! = 5<' !K51@21!F2(5032/!<2!K' ? 2. & 3835!H! + 503' / 06! Y 30&! \ / & 3@30216!

! 4' / / ' ; ! % C; ' / B!G8515!I!F' ? C6B!G56' ; ! : \$!U2056B!E53@&5L3!) 5136&B! : 52 ? 3! >1' 3056B!

>5(C80; J!! I' / / 3<' 1! * \$!I2&/602/!

! #a\$! \ - ' / 03<3(5032/!5/ - !QL58C5032/!2<!GU \ = + U!G56` !67U : H6!<2!10&' ! + C1. 26' !2<!Q - 303/7! = 'L' 158!F2(3!3/!0&' !

! * ' 0& ; 82@5(0' 13C ? !QT021bC' / 6!) ' / 2 ? ' !

! U5bC' 8! * \$!K588B!H61305! = \$!A&5 ? 3 - 3. 503B!IC835/!I!K' 1 ? 3 - 5!

>5(C80; J!! Q83N5@ ' 0&! = D2L15/ B!I' / / 3<' 1! * \$!I2&/602/!

##\$! Q/13(& ? ' /0!<2!U51' !5/ -! : 2L'8!A5(0' 135!3/ !0&' !M158! * 3(12@32 ? '!C63/7!GU\=+U,G56`!Q-303/7!
! F'3<!) 1' ' / 'B! Y 38835 ? !KC5/7!
! >5(C80;J!!G8' @' 1!MCL' 1/ ' ;!
!
#"\$! =; ? .50&'03(! : 'C12015/6 ? 300' 16!X' (1'56' !=' /6303L30; !02!=01'0(&!3/! * C6(8' !=.3/-8' !H<<'1' /06!
% '2-2 ? 3!2!) 2 ? 'NB!= '1' /5!M103NB!%3 ? 20&; !H/ -15- 'B!H10&C1!K51/3(&B!H8' T5/ -15!=585N51B!=0' L' /!U\$!
E58- '6.3/2B!Q13D5! =/ ; - '1B! * 5; 5!E5883/5; 575 ? B!+&; 83(35!=5/ (&'N!
! >5(C80;J!!4.50&' 13/ ' !H\$! Y 38D3/62/!
!
#S\$! X' L'82. ? ' /0!2<15/ !M.027' / '03(!H. .125(&!02!=03 ? C850'!) 5 ? ? 5! * 2021! : 'C12/6!3/ !L3012!U' ? 3' ! * 5/ -5P' B!
H. 221L5! 4 515D' 8B! =53! 4 315/ !A; 13B!X5/30N5!G&'83/ 'B! = '1' /5!M103NB!H8; 665!M((35/2B! * 1C-C85! ; CDC85B!+1303!
+50' 8B! =&3L583!45/ P513B!H8' TC6!I5(D62/ B!X' /36' !E317' /!
! >5(C80;J!!4.50&' 13/ ' !H\$! Y 38D3/62/!
! G2885@215021J!! =&5 P /!K2(& ? 5/!
!
#9\$! X' (3-C2C6!+85/06!51' ! * 21' !K5N51-2C6!0&5/ !+1' L32C68; !>2C/ -!3/ !G583<21/35!K2 ? '! \7/3032/ !c2/ ' !
! 45/5D2!4502!
! >5(C80;J!!4.50' !Y 38D3/!
G2885@2150216J!! =D; 85!X' //36B!I21-5/ !U' -3/7B! =D; !A3@83/ B! =. ' /6' !1483/ ' <'80' 1B!H0&51L!4 '6D51B!X5L3-!
A' /0' 12CB!Q8; '6!Q665/55!B!U5(&'8! Y2/7!B!G&518200' !Y 51-B!X5L3-! Y 5/7B! !I'663(5!F' ' !
!
#W\$! G2 ? @3/5032/6!2<! * '(&5/3(58!+1' ,01'50 ? ' /0! d!+1'6(13@' -!>31' !G5C6' !=&1C@! * 2105830; !3/ !0" !I' " &* , -3* .2. " &* , !
! e(2; 20' !@1C6&f!Q/ (125(&' -!G256058!+15313' !U' 60215032/!
! I21-5/ !U' -3/7B! I'663(5!F' ' !
! >5(C80;J!!4.50' !Y 38D3/!
! G2885@2150216J!! I51' -!G&38-1'66B!X' L33!U52!
!
#[\$! \- ' /03<; 3/7!+120'3/6!0&50! * '-350' \ / (1'56' -!+1283<' 15032/ !50!K37&' 1! \ /015('88C851! . K!
! F5C15! * 5103/6B! I' //5!KC/0' 1B!X5/3'8!M12N(2B!
! >5(C80;J!!A1' ' !) 13882, K388!
!
#]\$! U'7C85032/12<!+1283<' 15032/ !5/ -!G'88!X'50&!@; !\ / (1'56' -! \ /015('88C851! . K!
! G518; ! * 2/05/ B!Q ? 3832! * 2158'6B!
! >5(C80;J!!A1' ' !) 13882, K388!
!
#^\$! Q/73/ ' ' 13/7!+120'3/6!02! * '56C1' !H(3-!F' L'86!3/ !F3L3/7!G'886!
! H/ - '85!G1/05(B!K5/ /5! = 'L' 13'003B!%136&5! * 513' !>5@388515/ B!A51@515! =5/ -2L58B!
! >5(C80;J!!A1' ' !) 13882, K388!
!
#`\$! .K! =05@3830; !2<!%&' 1 ? 2605@8' !5/ -! : 2/ ,0&' 1 ? 2605@8' !U : H!E31C6!
! Q-751!A515056B! : 3D3!+5/5&3!N5- ' &!
! >5(C80;J!! =2/35! =3/7&58!
!
"a\$! \ /L'60375032/ !5/ -!Q/73/ ' ' 13/7!2<!+&26. &50' ! * '05@2836 ? !3/ !4 #+ '5.%&2(&26-#7+%&82#\$, !<21!Q/ &5/ (' -!UQQ!
! A321' (; (83/7!
K51. 1' '0!45C1B!G285/ !%3N2/ B!%&56'8! : C ? 5/ B! * '575/ !Q/138' B! =50' - ' !U562C83B!5/ -!Q13(! =&52!
! >5(C80;J!!Q83N5@'0&! =D2L15/!
!
#" \$!) ' /03(!E5135032/ !H ? 2/7!+&3, [!G; 602L31C6'6! _ / - '1723/7!X3<<'1' /0!K'50! =&2(D!%1'50 ? ' /06!
! =5/3D5! =5 ? '8B!+15/5L!A5@CBZ5/7(&' /!F3!
! >5(C80;J!! =2/35! =3/7&58!
!
" "\$

!

"S\$! \ ? .8' ? ' /05032/!2<!GU\+=+U!G56`!) ' / '!Q-303/7!3/! * '0&;821C@1C ?!'T021bC' /6!H * #!
: 5-3;5!E;6206D5B!H61305!A&5 ? 3-3. 503B!H/0583!G&5C&5/B!U5bC'8!K588B!H&-38!K5 ? ' ' -B!IC835/!K'1 ? 3-5B!
U3(&51-! : 72!
!
! >5(C80;J!!I' / /3<'1! * \$!I2&/602/B!Q83N5@'0&! =D2L15/!
!
! "9\$! Q<<' (0!2<!H/7320' /63/!\!5/ -!G5 .02. 138!_ .2/!\<85 ? ? 5021;!U'6.2/6'6!02!H(C0'!=8' '.!>157 ? ' /05032/!3/!
* 3('
!
! U' ' ? !H8! * 5DD3!
!
! >5(C80;J!!X5L3-!G\$!Q/6 ? 3/7'1!
!
! G2885@2150216J!! : 3(&2856!X\$! Y & ' '8' 1B!4 1360' /! : \$!Q5-6B! : 25&!%\$!H6&8' ;!
!
! "W\$! X'L'82. ? ' /058!Q0&5/28!QT. 26C1'!G5C6'6!G&5/7'6!3/!0&'!QT.1'6632/!2<!K3602/ '!' * 2-3<;3/7!Q/N; ? '6!5/ -!
U'6C806!3/!F2/7,% '1 ? !G&5/7'6!3/!) ' / '!QT.1'6632/!
!
! I26&C5! * 516&B!I2-3! : 7C; ' /!
!
! >5(C80;J!!U5(&5'8!>1' / (&!
!
! "[! \$! %&'!Q<<' (06!2<!X'L'82. ? ' /058!Q0&5/28!QT. 26C1'!2/! * 51D'16!2<!H73/7!3/!9&%,%3 '* ."-6#. "\$%/ ", +#&-
: 5L/ ' '0! =5/7&'15!
!
! >5(C80;J!!U5(&5'8!>1' / (&!
!
! "]! \$! >' ? 58'! * 3(' !Y 30&!5! =310C3/!9!4 /2(D2C0!QT. '13' / (' !H(('8'150' -!H7' ,\ / -C(' -!) 8C(26'!\ /028'15/ ('15/ -!
\ /6C83/!U'63605/ ('
!
! * 575/!G\$!+ ' / / ' ;!
!
! >5(C80;J!!>15/D!4 \$!KC; / &!
!
! "^! \$! QT5 ? 3/3/7!0&'!U28'!2<! =310C3/!9!2/!0&'! =01C(0C1'15/ -!>C/ (032/!2<!% '60'6!3/! * 3('
!
! H16&35!K5 ? N' & .2C1! =B!H8@'10!H\$! : 7C; ' /B!H'2P; //!I!G25D8' ;B!%&3,%3/5! : \$! : 7C; ' /!
!
! >5(C80;J!!>15/D!4 \$!KC; / &!
!
! "`! \$! \ /L'6037503/7!0&'!U28'!2<!Q60127' /!5/ -!+127'60'12/ '13/! * ' -3503/7!0&'! \ ? .531' -! * 5 ? ? 51;!X'L'82. ? ' /0!
M@6'1L' -!3/! =310C3/!9!4 /2(D2C0! * 3('
!
! I25/ / ' !+ \$!4 &5C!
!
! >5(C80;J!!>15/D!4 \$!KC; / &!
!
! Sa! \$! * 28' (C85!\ - ' /03<3(5032/!5/ -!U'<'1' / ('!) ' / '03(!X505@56'!2<!H ? '13(5/!+3D5,5662(350' -!+85/06!
: ' &5!) C1CB! * C&5 ? ? 5-!U56&3-B! =0' .&5/3' !%&5/7!
!
! >5(C80;J!!I'663(5!G5603882!E51-512!
!
! S#! \$! X : H! * '05@51(2-3/7!U'L'586!X3<<'1' / ('6!3/!H ? '13(5/!+3D5!X3'06!
ZL2/ / ' !FC2/7B! =58L5-21! * 5103/ 'NB!G' (3835!U326!X'8!U32B!) 32L5/ /3!gC'N5-5B! * 2/3(5!E38856' /21!
I'663(5!G5603882!E51-512!
!
! !
! S" \$! H66'663/7!0&'!F266!2<!.S^! * H+!43/56'!56!5!%&'15. 'C03(!%517'0!<21!G&' ? 20&'15. ;!\ / -C(' -!+ '13. &'158!
: 'C12.50& ;!
!
! K25/7,E3!ECB! = '1' /5!M103N!
!
! >5(C80;J!!450&'13/ ' !H\$! Y 38D3/62/!
!
! G2885@2150216J!!H8' D65/ -!5!G&C-3/2L5B! * 3135 ? !A\$!) 22- ? 5/!
!
! !
! SS! \$! E36C583N3/7!&21 ? 2/58!'<<' (06!2/!(51-35(! ? C6(8'!('88!&; . '1012. &;!C63/7!-373058!&282715. &3(! ? 3(126(2. ;J!
X2'6!63N'! ? 500'1V!
!
! I5(bC'8; /! =3 ? ? 2/6!5/ -!K'1 ? 5/!KC5/7!
!
! >5(C80;J!!H8' T5/ - '1!+5;C ? 2!
!
!
!
!
!
!

S9\$! H!G&' ?3(588; ,X' <3/ ' -!H665; !02!\L' 603750' !0&' !Q<<' (06!2<!K21 ? 2/ '6!2/!K' 510! * C6(8' !G' 88!+1283<' 15032/!
: 5/5D!+5@85B! =&5/0&3!X5L' B!K5<65/221!E5/ ;5B!A' 1' /3(' !A511575/ ,U2(&5B!5/ -!H/ -1' P!G55 ? .C' -!
>5(C80; J!!H8' T5/ - '1!+5; C ? 2!

!

SW\$! +/ 'C ? 28; 63/ ,3/ -C(' -!+ * : !%15/6 ? 3715032/!5/ -!X361C .032/!2<!H31P5; !Q .30&' 83C ? !H- &' 1' /6!IC/ (032/6!
X' L2/6! * 2B!Q853/ ' !: 7C; ' /B!%51' D!I5D2C6&B!G&136035/!H6 .3156B!E3L35/! : 7C; ' /B!I56 ? 3/!X2B!>15/ (36(2!
: C/ 'NB!450&' 13/ ' !G288B!I5/ '665!G512N5B! : 3(28' !K2 ? 'N!
>5(C80; J!! Y 580' 1!H-5 ? 6!

!

G2885@2150216J! !=&C; 3/7! hCB!U2-!4!%P '0' /B!I2&/! * !F' 2/7B!IC5/!+!U265, G210' 6!

!

S[!\$! X; /5 ? 3(!+; 0&2/ ,@56' -! * '0&2-!+12L3- '6! gC5/030503L' !H/58; 636!2<!\ /0' 1('88C85!IC/ (032/!M175/3N5032/!
XC13/7! ; -3\$#26%\$*"#!\ /<' (032/!2<10&' !U' 6.315021; !Q .30&' 83C ? !
X' L2/6! * 2B!Q853/ ' !: 7C; ' /B!>15/ (36(2! : C/ 'NB! : 3(28' !K2 ? 'N!
>5(C80; J!! Y 580' 1!H-5 ? 6!

!

G2885@2150216J! !=&C; 3/7! hCB!IC5/!+!U265, G210' 6!

!

S]!\$! X' L' 82. ? ' /0!2<!Q1; 0&12(;0' !+1' (C16216!<12 ? ! ? Q=G!5/ -!A * =G!G' 88!F3/ '6!

!

+&3!+&5/B!F21' / ' !F' ' B!U55/5\$ * 27&5115@!

!

>5(C80; J!!%NL35!H@15 ? 62/B!F' 385!4&503@!

!

S^!\$! +12 ? 203/7! ? Q=G!X' 13L' -!G51-32 ? ; 2(;0' ! * 50C15032/! Y1-3!2&/! X1013/7!98 .28c#T500050(!/() 0.2(2&/! *) -(5) 0.2(1-3) 0.2

9W\$! A3/ -3/7!H/58; 636!2<!GC(C1@30j]kC138!P30&!+&' / ;8585/3/ '15/ -!%13'0&;85 ? ? 2/3C ? !C63/7!\620&'1 ? 58!%3015032/!
G58213 ? '01;!
!
! : 3/5!G&C5/7!
!
! >5(C80;J!!X51;8!Q77'16!
!
9[!\$! +1' -3(032/!<12 ? !+120'3/!= 'bC' / ('12<!5!=P30(&F3D'!U'732/!3/!&=\U%#!
U3(&51-!+'5162/B!A' /05 ? 3/!=015C66B!I2/50&5/!M13@'882B!%3<<5/ ;!%&53B!='83/5!F3 ? 5!) C5/B!A122D'!
A'883/7&5C6' /!
!
! >5(C80;J!!A122D'!FC6037!
!
! G2885@215021J!! : 3/7DC/!Y5/7!
!
9]!\$! 43/ '03(6!2<10&'!G,0'1 ? 3/58!X2 ? 53/!2<!?, #2)%6%\$", -"#&2/*\$%, "H1/H!3/!0&'!+28; ? ;T3/!U'63605/ ('!
+50&P5;!
!
! FC('12!=5/-2L58! !
!
! >5(C80;J!!F5C15!G\$! * 388'1!G2/15-!
!
9^!\$! H(;8!K2 ? 26'13/ '!'F5(02/ '!'H/58276!56!+20' /0358!\/&3@30216!2<!gC21C ? !=' /63/7!
!
! H-135/!A85/(56!
!
! >5(C80;J!!F5C15!G\$! * 388'1!G2/15-!
!
9`!\$! G&515(0'13N5032/!2<!G283603/!H-0CL5/06!3/!?, #2)%6%\$", -"#&2/*\$%, "
!
! * 5;C15!+5/0583/75 ? B!G&5-!U' '-!
!
! >5(C80;J!!F5C15!G\$! * 388'1!G2/15-!
!
Was!\$! H!U'L3' P!2<!= '8' (0!F30'150C1'!>2(C6' -!2/!0&'!_ / - '1715-C50'!G&' ? 3601; !U'6'51(&!QT. '13' / ('!
!
! =/37-&5!U5;585!
!
! >5(C80;J!!U'65! * \$!4'88;!
!
W#!\$! H/2 ? 582C6!G51@2/ ,A212/!A2/ -!>21 ? 5032/!2/! : 5/26(58'!X35 ? 2/ -! =C1<5('6!_63/7!%1372/58!A212/!
G2 ? .2C/ -6!
4136&/5!) 2L3/ -5150CB!QN&327&2- '!M\$!_ P5-358'B!X5/3'8! : \$!F5@C/6D;B!%;5//5! =C.1' ? 'B!IC5/! * 37C'8!X'8!
U265132B! =282 ? 2/!H-0'3!\B!G; /0&35! * '8' / -1'NB!
!
! >5(C80;J!!H@15&5 ? !Y28(200!
!
! G2885@2150216J!! =5/7,IC/!F' 'B!E3173/35!H802'B!4' /0!\1P3/B!X' //36! : 21-8C/ -!
!
W"\$!\$! X31' (0!A15/ (&' -!5/ -!G; (83(!H ? 3/ '!'X35 ? 2/ -!F5003('!A2/ -!>21 ? 5032/!_63/7!5!A12 ? 3/ '!' =C1<5('!
\
/0'1 ? '-350'!
%6N!G&3/7!G&'C/7B!) 15('!M83L35!X1' PB!G5 ? 12/!h\$! =02D'61B!I217'!H\$!F2. 'N,U2656B!G; /0&35! * '8' / -1'NB!
K583 ? ! * C&5 ? ? 5-!
!
! >5(C80;J!!H@15&5 ? !Y28(200!
!
! G2885@2150216J!! =5/7,IC/!F' 'B!E3173/35!H802'B! =5 ? 3! =53/32B!X' //36! : 21-8C/ -B!4' /0!\1P3/!
!
WSS!\$! +856 ? 2/3(!>8C21'6/ ('!'Q/&5/ (' ? ' /0!2<!) 28-,X35 ? 2/ -! : 5/251(&30' (0C1'6!<21!A3285@'83/7!H. .83(5032/6!
!
! U3/5!45P5 ? C15B! : 5P58! =C758B! =0'L' /!% ' -- ;B!X!Q/0283!G2T!
!
! >5(C80;J!!H@15&5 ? !Y28(200!
!
! G2885@2150216J!!X' //36! : 21-8C/ -B! =5/7,IC/!F' 'B!E3173/35!H802'!
!
W9\$!\$! Q8C(3-503/7!0&'!Q<<' (0!2<!+&26. &21;85032/!2/! * 203<!H!X' . ' / - /0!H(03L5032/!2<!=\U%#!
!
! H- -362/!G&' /B!+5013(35!X265;85B!H-213/5! =&5&@5N3B!U;5/! : &5/!
!
! >5(C80;J!! : 3/7DC/!Y5/7!
!
WWS!\$! X366' (03/7!0&'! * '(&5/36 ? !2<!H88260'13(!U'7C85032/!2<!=\U%#!
!
! Q ? 38; !F'2/7B!U' ' /5!X265/0&B!ZC03/!KC1B! * ;!EC!
!
! >5(C80;J!! : 3/7DC/!Y5/7!
!
!

W[!\$! Q<<'(06!2<!+28; ? ' !G2/<3/' ? ' /0!2/!G5058;60!H(03L30;!3/!G1266! * '050&'636!2<!H8D' / '6!
! %;'6&35!=5..B!=0'.&5/3!'E '856bC'NB! * '072/!M? 51!
! >5(C80;J!! * 5-58; /!U\$!U5-85C'1!
!
W]!\$! =0C-3'6!2<!=0!C(0C1' -! : ,\62.12. ;8!H(1;85? 3- '!e : \+H * f!+28; ? '16!56!=C. .2106!<21!%15/63032/! * '058!
G5058;606!
! * '83665!=\$!)13<<3/!
>5(C80;J!! * 5-58; /!U\$!U5-85C'1!
!
W^!\$! =; /0&'63N3/7!+28; ? '1,A2C/-!G2.. '1!G5058;606!<21!Q/N; ? ' ,F3D'!G5058;636!
! A1' / -5!FCB!=5; 2!3!%1'02B!H@37538!U5 ? 3! 'NB!F38;!%1C2/7!
>5(C80;J!! * 5-58; /!U\$!U5-85C'1!
!
W`!\$! QT.8213/7!G&' ? 3(588;!U'5(03L'!U'732/6!2<+&56'!=.5('!P30&! =C. .210!E '(021! * 5(&3/'6!
! K' 'DC/!G&2B!G58L3/! : 7C; ' /B! : 3(&2856!G&5/B!IC603/!+15-2B!45185!H1 ? ' /05!
! >5(C80;J!!) 35 / ? 51(!) 15N3283!
!
[a!\$! =3? C850' -! * ' (&5/3(58!% '603/7!2<!H ? ;823-!>3@138!=0!C(0C1'6!+1' -3(0' -!@;!h,15;!G1;605882715.& ;!
QT. '13 ? ' /06!
! H-5 ? !\ /7P '162/B!X5L3- !=5/03572!I1\$B!+5013(D!U'75/B!H/ - ;!%52B!\ /3D5!A&5035!
! >5(C80;J!!) 35 / ? 51(!) 15N3283!
!
[#!\$!!!!\ /L'6037503/7!\ / (21.2150' -!) 15.&' / ',A36? C0&!%517'06!<21! : C(8'51!U'5(032/6! !
! * '85/3'!) C'11'12B!FC(5!F' B!G; /0&35! * 5(&B!45(;! * ' / -2N5!
! >5(C80;J!! : 3(&2856!Q\$!Q6D'1!
! G2885@2150216J!!I2&/!) 1' ' / 'B! * 500&' P!) 200B!U3(&51-!>3/D!
!
["!\$! GK"!0517'06! d!63/78'!/C(8'2/11'5(032/6!
H8'T!G&C;5/2LB!IC603/!X35NB! * '85/3'!) C'11'12B!X5/3'8!H/ -1'!K'1/5/ - 'N!) 51(35B!FC5B!FETQq.24000.2418668.28cBT5000502

!
[^\$! * 58P51'!G85663<3(5032/!_63/7!) 15.&! : 'C158! : '0P21D6!
! E13/-5! * 5&&2015!
! >5(C80;J!! * 51D!=05 ? .!
!
[` \$! _ / - '1605 / - 3 / 7 ! 0 & ' ! U 2 8 ' ! 2 < ! = ' 7 ? ' / 0 5 8 ! X C . 8 3 (5 0 3 2 / 6 1 3 / ! K 3 7 & ' 1 , 2 1 - ' 1 !) ' / 2 ? ' ! M 1 7 5 / 3 N 5 0 3 2 / !
! =515!Q\$!A'88! !
! >5(C80;J!! Y ' / - ; ! F ' ' B ! Y 3 8 8 3 5 ? ! H / - 1 ' 2 . 2 C 8 2 6 !
! G 2 8 8 5 @ 2 1 5 0 2 1 J ! ! G 5 1 8 2 6 ! U 2 0 5 6 !
!
] a \$! \ / 0 ' 1 5 (0 3 L ' ! ? 3 U : H , ? U : H ! H / 5 8 ; 6 3 6 ! H . . !
! H 8 ' T 3 6 ! % 2 1 1 ' 6 B ! G 1 ; 6 0 5 8 ! K 5 / B ! X 3 D 6 & 5 ! 4 2 2 8 !
! >5(C80;J!! Y ' / - ; ! F ' ' !
!
] # \$! * 2 - ' 8 3 / 7 ! = ' b C ' / (3 / 7 ! H 1 0 3 < 5 (0 6 ! 3 / ! : ' T 0 !) ' / ' 1 5 0 3 2 / ! = ' b C ' / (3 / 7 !
! Z L 2 / / 5 ! F ' C / 7 B ! > ' 8 3 T ! * @ C 7 5 !
! >5(C80;J!! Y ' / - ; ! F ' ' !
!
] " \$! % P 3 0 0 ' 1 ! A 2 0 ! X ' 0 ' (0 3 2 / ! C 6 3 / 7 ! = 2 (3 5 8 ! : ' 0 P 2 1 D ! H / 5 8 ; 6 3 6 !
! % & 3 ! A C 3 !
! >5(C80;J!! 4 5 0 ' 1 3 / 5 ! + 2 0 3 D 5 !
!
] S \$! + 1 ' - 3 (0 3 / 7 ! Q T 0 ' 1 / 5 8 8 ; ! E 3 6 3 @ 8 ' ! % 1 5 3 0 6 ! < 1 2 ? ! X : H ! = 5 ? . 8 ' 6 !
! : 3 1 5 0 ! + 5 / - D 5 1 !
! >5(C80;J!! % ' / 7 ! * 2 & !
! G 2 8 8 5 @ 2 1 5 0 2 1 J ! ! * 5 1 D ! A 5 1 5 6 & B ! X ' . 5 1 0 ? ' / 0 ! 2 < ! I C 6 0 3 (' ! = 0 C - 3 ' 6 !
!
] 9 \$! _ 6 3 / 7 ! * 5 (& 3 / ' ! F ' 5 1 / 3 / 7 ! 0 2 ! * 5 T 3 ? 3 N ' ! > 3 1 6 0 ,) ' / ' 1 5 0 3 2 / ! = 0 C - ' / 0 ! = C ((' 6 6 !
! * C 6 0 5 < 5 ! Z ' 6 3 8 ; C 1 0 !
! >5(C80;J!! % ' / 7 ! * 2 & B ! Q 8 5 3 / ' ! G 2 8 8 3 / 6 !
!
] W \$! U ' 5 8 ! % 3 ? ' ! + 5 / 2 1 5 ? 3 (! \ ? 5 7 ' ! + 1 2 (' 6 6 3 / 7 !
! * 5 0 0 & ' P !) ' 1 8 3 0 6 !
! >5(C80;J!! % ' / 7 ! * 2 & !
!
] [\$! % 5 1 7 ' 0 ' - ! H - L ' 1 6 5 1 3 5 8 ! H 0 0 5 (D 6 ! 2 / ! = . ' ' (& ! = ' . 5 1 5 0 3 2 / ! = ; 6 0 ' ? 6 !
! 4 ' / - 1 3 (D ! % 1 3 / & !
! >5(C80;J!! * ' 8 2 - ; ! * 2 & B ! % ' / 7 ! * 2 & !
!
]] \$! A ' ; 2 / - ! W) ! Y 3 1 ' 8 ' 6 6 !
! + 2 2 0 5 ! = & ; 5 ? 6 C / - 5 1 B ! + ' 0 ' 1 ! 4 / 3 7 & 0 B ! = 1 5 0 5 / !) C . 0 5 !
! >5(C80;J!! : 5 L 1 5 0 3 ! = 5 T ' / 5 !
! G 2 8 8 5 @ 2 1 5 0 2 1 J ! ! X 1 \$! H @ & 3 6 & ' D ! U 2 ; !
!
] ^ \$!

"9: ;<=>9?=@!\$BCDEFD! ;?G!%D=<@?@>C!

!

^`\$! =3?C8503/7! * 57/ '03(!+'1 ? '5@3830;! * '56C1' ? ' /06!2<15!U'62/5/0!>'112 ? 57/ '03(!%&3/!>38 ? !3/!0&'!) KN!
U5/7'! Y 30&!5! =&210!G31(C30' -! * 3(126013 . ! _63/7!GM * =MF! * C803 .& ;63(6!

! H8'T5/ - '1!G5@20!

! >5(C80;J!!U5/D2!K'3/ -8!

!

`a\$! * 5(&3/ '!F'51/3/7!+&56'!X'0' (032/!3/! =/5 . 6&206!2<! _8015(28-!H02 ? 6!3/!M . 03(58!F5003('6!

! =0' .&5/3'! =013'7'8!

! >5(C80;J!!Q&65/!4&505 ? 3!

!

`#\$! %2 . 2827 ;!2<15!X13L' /!'X! =. 3/!%2!bC'!M6(3885021!H115;!

! =&3L5 ? !45 ? @20!

! >5(C80;J!!K3851; ! * \$!KC160!

!

`"\$! gC5/0C ? ! =050'!Q/73/ ' '13/7!P30&! _8015(28-!H02 ? 6!

! >5(C80;J!!K3851; ! * \$!KC160!

!

`\$\$! QT . 853/3/7!+&202/6!P30&!5!G85663(58!>3'8-!H(032/!+13/ (3 . 8'!

! I5 ? '6! =5682PB!A1' / -5/! =021D!

! >5(C80;J!!4' /! Y &5102/!

!

`9\$! X36(2L' 13/7!F2P! =C1<5(' !A137&0/ '66!) 585T3' 6!P30&!U3(&! =051!G8C60' 1! = ;60' ? 6!

! Q/13bC' !G5@1' 15B!HC0C ? /!) 583/6D3B!H8'T5/ - '1!K5PD68' ;!

! >5(C80;J!!H512/!U2 ? 5/2P6D;!

!

`W\$!! G85663<3(5032/!2<!G2 ? . 5(0! =0'8851! = ;60' ? 6!H12C/ -! : '51@;!) 585T3' 6!

! =503/ - '1 . 1' '0! =3/7&B!I; / '665!E5885 - 2/!

! >5(C80;J!!H512/!U2 ? 5/2P6D;!

!

!

%FH?@ IJ9GK9 >9? =D!

!

%&5/D6!02!588!2<!0&'!60C- ' /0!1'6'51(&'16!5/ -!0&'31!<5(C80;! ? ' /02!16!5/ -!(2885@2150216!<21! -36 . 85 ;3/7!0&'!1'6C806!2<!<!
0&'31!&51-!P21Dp!!!%&36!36!01C8; !5/!3 ? . 1'663L'!6&2P(56'!2<!0&'!@125-!15/7'!2<!1'6'51(&!5(03L30; !0&50!05D'6! . 85(' !
P30&3/!2C1!G288'7' \$!!!

!

+1' . 515032/!<21!0&'! =UX!3/L28L' -! ? 5/ ;!(288'57C'6!<12 ? !0&'!G288'7' \$!!!IC603/!G128; !. 13/0' -! ? 260!2<!0&'! . 260'16!0&50!
P'1'! -36 . 85 ;' -!02-5; \$!!! = '0C . B!0'51-2P/B!5/ -!1'850' -!56 . ' (06!3/L28L' -!F' ' !E'83NB! * 3D'! =0' .&' /6B! * 51(2!+51' /0!5/ -!
* 500!) '51; \$!!G&'!I2/ '6! . 1' . 51' -!0&'! /5 ? ' !0576\$!

!

>3/588; B!0&5/D6!02!X1\$! * '82- ;!Q6<5/ -3513!5/ -!60C- ' /06!2<!0&'! =I= _!G&5 . 0'1!2<!0&'! =0C- ' /0!H<<38350'6!2<!0&'!

H ? '13(5/!G&' ? 3(58! =2(3'0; !e=HHG=f!o!G&' ? 3601; !G8C@!<21! . 12L3-3/7!1'<1'6& ? ' /06!<21!0&'!60C- ' /0!5C0&216!5/ -!
<5(C80;p!

!

%&5/D6!02!'L'1; 2/ ' !P&2! . 5103(3 . 50' -!5/ -!566360' -!P30&! =UX#]p!

!

!