

7DEOH 2I & RQWHQWV

(YDOXDWLQJ 3RVVLEOH &OHDQXS OF



,QWURGXFWLRQ %DFNJURXQG ,QIRUPDWLRQ \$VVHVVLQJ *U**R浓©62DWH**U

, Q W U R G X F W L R Q

 $\label{thm:continuity:continuit$

 $\label{lem:continuous} Vjku"Ekvk \mid gpuø" I wkfg"ku"fguki pgf"vq"jgnr"Okffng"Tkxgt." \\ Of 0."tgukfgpvu"cpf"qvjgt"kpvgtguvgf"rctvkgu"dgvvgt" \\ wpfgtuvcpf"vjg"rtqrqugf"i tqwpfycvgt"engcpwr"rncp"hqt" \\ Nqemjggf"Octvkpøu"Okffng"Tkxgt"Eqorngz0$

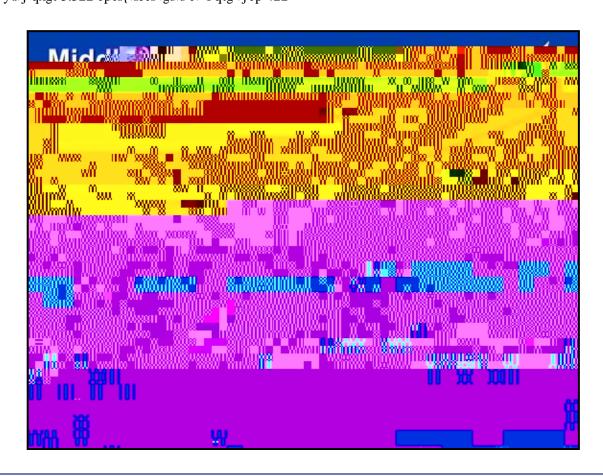
$$\label{lem:continuous} \begin{split} & Hqt"vjg"rcuv"ugxgtcn"\{gctu."Nqemjggf"Octvkp"jcu"dggp" \\ & cevkxgn\{"kpxguvkicvkpi"itqwpfycvgt."uqkn"cpf"ugfkogpv" \\ & eqpfkvkqpu"cv"vjg"Okffng"Tkxgt"Eqorngz"cpf"pgctd\{"Octvkp"Uvcvg"Cktrqtv0 \end{split}$$

 $\label{lem:curv} Qxgt"vjg"rcuv"ugxgtcn" \{gctu."vjg"Nqemjggf"Octvkp"vgco" \\ jcu"eqnngevgf"oqtg"vjcp": 22"ucorngu"cv"vjg"Okffng"Tkxgt" \\ Eqorngz"ykvj"qxgt"5.522"cpcn \{vkecn"vguvu"cv"oqtg"vjcp"422" \} \\ Qxgt"vjg"qxgt"sold find the second for the se$

 $\label{eq:continuous} i \; tqwpf \; y \; cvgt" nqecvkqpu0" E \; j \; g \; o \; kecnu" mpq \; y \; p"vq" \; j \; cxg" dggp" \\ wug \; f" \; fwtkp \; i \; "hqt \; o \; gt"kp \; fwuvtkcn" q \; r \; gtcvkqpu" \; y \; gtg" \; f \; gvgevg \; f"kp" \\ i \; tqwpf \; y \; cvgt" cv"v \; j \; g"ukvg0$

Vjg"ejgokecnu"fq"pqv"rqug"ukipklecpv"jgcnvj"tkumu"vq"
rgqrng"dgecwug"vjg"nqecvkqp"qh"vjg"ejgokecnu"ocmgu"kv"
wpnkmgn{"vjcv"rgqrng"yqwnf"dg"gzrqugf"qt"dgecwug"kp"qvjgt"
nqecvkqpu"vjg"coqwpvu"cpf"eqpegpvtcvkqpu"ctg"kpukipklecpv0

 $\label{eq:cumulative} Cu" \{qw \mbox{\sc m} \mbox{\sc m}$



% DFNJURXQG ,QIRUP: NVQ LGRROTNKHHG ODUWLQ FUHDWH

5HVSRQVH \$FWLRQ 3ODQ":KHUH LV WKH 0LGGOH 5LYHU &RPSOH["

 $\label{lem:condition} Vjg"Okffng"Tkxgt"Eqorngz"ku"nqecvgf"cv"4545"Gcuvgtp" \\ Dqwngxctf"kp"Okffng"Tkxgt."Of0"Vjg"382/cetg"eqorngz"ku"rctv"qh"vjg"Ejgucrgcmg"Kpfwuvtkcn"Rctm"cpf"kpenwfgu" \\ 34"ockp"dwknfkpiu."cp"cevkxg"kpfwuvtkcn"ctgc"cpf"{ctf."rgtkogvgt"rctmkpi"nqvu."cp"cvjngvke"Lgnf."c"eqpetgvg/eqxgtgf"xcecpv"nqv."c"vtckngt"cpf"rctvu"uvqtcig"nqv."cpf"xctkqwu"itcuu{"itggp"urcegu"cnqpi"kvu"rgtkogvgt0} \\ \end{tabular}$

Nqemjggf"Octvkp"ku"rctvkekrcvkpi"kp"vjg"Oct{ncpf"
Fgrctvogpv"qh"vjg"Gpxktqpogpvøu"Xqnwpvct{"Engcpwr"
Rtqitco"cpf"ku"tgswktgf"d{"vjg"uvcvg"vq"uwd
Fd cvkqp" _ f g"ce g

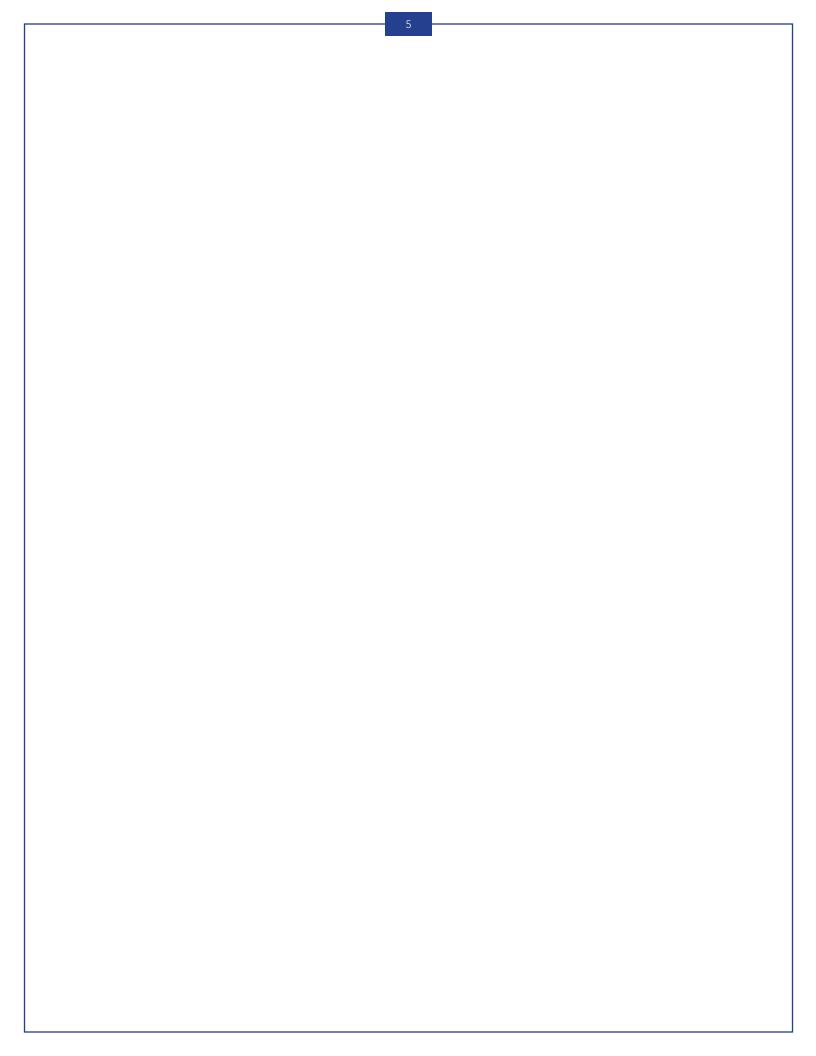
:KDW KDV /RFNKHHG 0DUWLQ¶V HQYLURQPHQWDO WHVWLQJ LQYROYHG"

:KHUH GLG WKH FRQWDPLQDWLRQ FRPH IURP"

 $\label{eq:continuous} V j g"eqpvc o kpcvkqp" o c {"jcxg"tguwnvg f"htq o "jgtkvcig"} \\ eq o rcp {"qrgtcvkqpu"cpf"fkurqucn"rtcevkegu"vjcv"ygtg"} \\ eq o o qprnceg"kp"vjg"cgtqurceg"kpfwuvt {"oqtg"vjcp"jcnh"c"egpvwt {"ciq0"Cnvjqwij"vjg"cevkqpu"ygtg"ngicn"cpf"eqpukfgtgf"uchg"cv"vjg"vkog."oqfgtp/fc{"tgugctej"jcu"ujqyp"vjcv"uqog"qh"vjg"rtcevkegu"oc{"jcxg"ngf"vq"vjg"eqpvcokpcvkqp0}\\ \end{aligned}$

:KDW LV D UHVSRQVH DFWLRQ SODQ"

 $C"tgurqpug"cevkqp"rncp"rtqxkfgu"fgvcknu"cdqwv"\\ eqpvc o kpcvkqp"cv"c"engcpwr"ukvg0"Kv"fguetkdgu"vjg" o gvjqfu"\\ wug f"vq"gxcnwcvg"vjg"eqpvc o kpcvkqp."vjg"cnvgtpcvkxgu"hqt"\\ engcpwr"cpf"vjg"tgeq o o gpfgf"yc \{u"vq"engcp"wr"vjg"eqpvc o kpcvkqp0$



Oqpkvqtkpi "qh"ckt" y kvj kp"vj g"dwknfkpi u" j cu"kpfkecvg f"vj cv" y jgtg"VEG"ku"hqwpf."kv"ku"dgnq y "vjg" O FG"uetggpkpi "ngxgn0

+DYH YDSRUV EHHQ GHWHFWHG DW WKH WUHDWPHQW DQG PRQLWRULQJ V\VWHPV"

 $Nqemjggf"Octvkp"oqpkvqtu"xcrqtu"iqkpi"htqo"dgpgcvj"vjg"\\ dwknfkpi"kpvq"vjg"vtgcvogpv"u\{uvgo."cpf"kv"jcu"hqwpf"xqncvkng"\\ qticpke"eqorqwpfu"kp"vjqug"xcrqtu0"Vjg"eqpegpvtcvkqpu"qh"\\ xqncvkng"qticpke"eqorqwpfu"jcu"ftqrrgf"ukipkLecpvn{"ukpeg"vjg"u{uvgou"Ltuv"ygtg"uvctvgf0}\\ \\$

,I WKHUH LV QR ULVN ZK\ LV /RFNKHHG 0DUWLQ FRQGXFWLQJ WKH FOHDQXS"

(YDOXDWLQJ 3RVVLEOH

S

'LG \RX IROORZ D VSHFL¿F SURFHVV WR HYDOXDWH WKH DOWHUQDWLYHV"

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qvjgt"eqtrqtcvkqpu"cu"ygnn"cu"htqo"kpukfg"Nqemjggf"
Octvkp0"Vq"jgnr"ykvj"vjg"gxcnwcvkqp."vjg"rtqlgev"vgco"
ô"yqtmkpi"enqugn{"ykvj"vjg"uvtcvgike"gxcnwcvkqp"vgco"
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qt"vjg"gpxktqpogpv"vq"dg"korcevgf0"Vjg"gxcnwcvkqp"cnuq"
eqpukfgtgf"ukvg"jkuvqt{."tgiwncvqt{"tgswktgogpvu"cpf"
gzrquwtg"tkumu"tgncvgf"vq"rquukdng"ncpf"wugu"kp"vjg"hwvwtg0

 $\label{eq:convergence} Qxgt"vjg"eqwtug"qh"qpg" \{gct."vjg"vgco"gxcnwcvgf"gcej"qh"vjg"36"cnvgtpcvkxg"engcpwr"rtqitcou"cickpuv"vjg"rtqlgev"qdlgevkxgu"cpf"etkvgtkc"hqt"uweeguu0$

 $\label{lem:convex} V\,j\,ku"gxcnwcvkqp"tg\,fweg\,f"v\,j\,g"nkuv"vq"v\,j\,tgg"\\ \&pcn"cnvgtpcvkxgu."\\ y\,j\,kej\,"\,y\,gtg"v\,j\,gp"gxcnwcvg\,f"kp"\,f\,gvckn0$

Vjg"vgco"ejqug"vjg"ogvjqf"vjcv"rtqxkfgf"vjg"oquv/ghhgevkxg"engcpwr"yjkng"cnuq"ecwukpi"vjg"ngcuv"gpxktqpogpvcn"korcev0

:DV WKH SURFHVV HIIHFWLYH"

 $\label{lem:control_vjg} Vjg"rtqeguu"ycu"gzvtgogn{"ghhgevkxg0"Vjg"uvtcvgike" gxcnwcvkqp"vgco"kpvtqfwegf"kppqxcvkxg"rtqeguugu"vq" gxcnwcvg"gcej"cnvgtpcvkxg"cpf"rtkqtkvk|g"fgekukqp"ocmkpi" etkvgtkqp0"Vjku"rggt"tgxkgy"rtqxkfgf"c"ŏhtguj"g{guö" crrtqcej"vjcv"jgnrgf"vjg"vgejpkecn"vgco"kfgpvkh{"ejcnngpigu" cpf"Lpf"uqnwvkqpu"vjcv"okijv"pqv"jcxg"dggp"eqpukfgtgf" qvjgtykug0 }$

:KDW ZHUH WKH WKUHH DOWHUQDWLYHV IRU FRQVLGHUDWLRQ RQ WKH ¿QDO OLVW"

Vjg"Lpcn"vjtgg"tgurqpug"cevkqp"cnvgtpcvkxgu"hqt"
eqpukfgtcvkqp"ygtg<
SOWHUQDWLYH "itqwpfycvgt"cpf"xcrqt" go O <

6HOHFWLQJ WKH VY/j/cv"ku"www/okptodkhkiQADWLYH

DQG ZK\"

Vjg"Nqemjggf"Octvkp"vgco"ugngevgf"Cnvgtpcvkxg"50"Vjg" cnvgtpcvkxg" y knn"eqpukuv"qh"kp"ukvw"* o gcpkpi "rgthqt o gf"kp" rnceg+"dkqtg o gfkcvkqp"qh"eqpvc o kpcvgf" i tqwpf y cvgt"kp" jkij "eqpegpvtcvkqp"ctgcu"cpf"kpuvkvwvkqpcn"eqpvtqnu0"Kp" ukvw"dkqtg o g f kcvkqp"kplgevu"c" o kzvwtg"qh" y cvgt."hqq f " i tc f g" xgigvcdng"qkn"cpf"ncevcvg"*c"pqp/vqzke"hqqf"cffkvkxg"vjcv"ku" rtqfwegf"htqo"uwictu"qh"eqtp"qt"dggvu+"kpvq"vjg"itqwpf"vq" uvk o wncvg"pcvwtcnn{"qeewttkpi"dcevgtkc"vjcv"eqpuw o g" ô "cpf" dtgcm" fqyp" ô "vjg"eqpvc o kpcvkqp0

Vjku"cnvgtpcvkxg" y knn"tgfweg"vjg"rnw o g"qh"vtkejnqtqgvjgpg"cv" $\label{eq:continuity} vjg"ukvg"d\{"wukpi"kp"ukvw"dkqtg\ o\ g\ fkcvkqp"kp"vj\ g"vj\ tgg"ctgcu"\}$ y kv j "v j g" j k i j guv"eqpegpvtcvkqpu"cpf" i tgcvguv"ceew o wncvkqpu" qh"VEG0"Vjg"jkijguv"eqpegpvtcvkqpu"ctg"hqwpf"uqwvj"qh"vjg"cevkxg"kpfwuvtkcn"hceknkvkgu" ô "qpg"ctgc"vq"vjg"yguv."cpf"vyq" ctgcu"vq"vjg"gcuv0

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:KDW LV WKH FOHDQXS VWUDWHJ\ \$OWHUQDWLYH

D

Vjg"vgcoøu"engcpwr"uvtcvgi {"kpenwfgu<

- É" Gnk o kpcvkp i "tkumu"vq" j w o cp" j gcnv j "d{"k o rtqxkp i "v j g" i tqwpf y cvgt"swcnkv { "cpf."vjwu."tgfwekpi "vjg"tkum"qh" xcrqt"kpvtwukqp"kp"dwknfkpiu"qp"ukvg=
- É" Guvcdnkujkpi"yqtmcdng"kpuvkvwvkqpcn"eqpvtqnu"uwej"cu"
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- É" Oggvkpi "uvcvg"uvcpfctfu"hqt"õtguvtkevgf"tgukfgpvkcnö" etkvgtkc"d{"korngogpvkpi"kpuvkvwvkqpcn"eqpvtqnu"uwej" cu"fggf"tguvtkevkqpu"vq"gpuwtg"vjg"itqwpfycvgt"ku"pqv" wugf"hqt"ftkpmkpi"ycvgt=
- É" Tgoqxkpi "uki pkŁecpv"eqpvcokpcpv" rnwog"*vcti gv"92'+" kp"vjg"vjtgg"ctgcu"vjcv"eqpvckp" o quv"qh"vjg"eqpvc o kpc/ vkqp="cpf
- E" Kpenwfkpi "uwuvckpcdknkv { "cu "c "fgekukqp "eqpukfgtcvkqp0

:LOO WKH JURXQGZDWHU EH IXOO\ FOHDQHG*

 $\label{eq:control_vig} V jg"engcpwr" y knn" tg o qxg"cv"ngcuv"92" rgtegpv"qh"vjg" eqpvc o kpcpv"rnw o g0"V jg"tguv" y knn" i q"c y c { "gxgpvwcnn { "cu"pcvwtcn" rtqeguugu"eqpvkpwg"vq"engcp"vjg"tg o ckpkp i "eqpvc o kpcvkqp0"V jg" Oct { ncpf"Uvcvg" Fgrctv o gpv"qh"vjg" Gpxktqp o gpv"jcu"pqvgf"vjcv"c"õtguvtkevgf"tgukfgpvkcnö" ngxgn" ô "y jkej"vjg"uvcvg"ecnnu"Vkgt"3D" ô "ku"cp"crrtqrtkcvg" iqcn"dgecwug"vjg" i tqwpf y cvgt"rtqdcdn { "yqwnf"pqv" o ggv" ftkpmkpi "ycvgt"uvcpfctfu"hqt"c"nqpi "vk o g0"V jku"ku"dgecwug" vjg" i tqwpf y cvgt"nkgu" y kvjkp"vki jv"enc { "uqknu"vjcv"unqy "fqyp" i tqwpf y cvgt" o qxg o gpv"cpf" o cmg"fkuvtkdwvkqp"qh"vjg" kplgevgf"uqnwvkqp" o qtg" fkhLewnv0"V jg"vki jv"uqknu"ctg"cnuq"vjg" rtkpekrcn"tgcuqp"vjcv."tgictfnguu"qh"swcnkv { ."vjg" i tqwpf y cvgt" cv"vjg"Okffng"Tkxgt"Eq o rngz"ku"pqv"tgcfkn { "cxckncdng"cu"c" uqwteg"qh"ftkpmkpi" y cvgt0} }$

"õVki j vö"uqknu"ecp"dg"gcukn{"

fg o qpuvtcvgf"d{"rqwtkpi" y cvgt"qxgt"

ucpf"kp"c"eqncpfgt"cpf"qxgt"enc{"kp"c"

ugeqpf"eqncpfgt0" Y cvgt"tgcfkn{"rqwtu"

vj tqwi j "vjg"ucpf." y j kej "ku" o qtg"

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kplgevgf"ocvgtkcnu"okijv"tqy0"Tguwnvu"
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I tqwpf y cvgt" o qfgnkp i "wugu"cnn"v j g" f cvc"eqnngevg f "htq o " v j g"ukvg"vq"tgrtgugpv"v j g"ukvg"cpf"rtg f kev"v j g"tguwnvu"qh"v j g" xctkqwu"cnvgtpcvkxgu0"Kv" j cu"dggp"e j gemg f "c i ckpuv" j kuvqtke" i tqwpf y cvgt"dg j cxkqt"wpfgt"Lgnf/o gcuwtg f "cxgtc i g"cpf" rw o r"vguv"eqpfkvkqpu0" Oqfgn"cuuw o rvkqpu"wug f "kp"v j g" kplgevkqp"uk o wncvkqpu" y knn"dg"e j gemg f "d { "c"rknqv"vtcegt" kplgevkqp"rtq i tc o "vq"dg"rgthqt o g f "kp"v j g"uw o o gt"qh"42330" Kh"pgeguuct { ." o qfgn"cuuw o rvkqpu" y knn"dg"c flwuvg f "cpf"v j g" e j cp i gu" y knn"dg "kpeqt rqtcvg f "kp"v j g" rtgnk o kpct { "fguk i p"vq" dg"kpkvkcvg f "chvgt" Oct { ncpf" Fgrctv o gpv"qh"v j g"Gpxktqp o gpv" cpf" rwdnke"eqpewttgpeg0"

 $I\ tqwpf\ y\ cvgt"fqgu"pqv"\ o\ qxg"s\ wkemn\{"cv"vjg"O\ kffng"Tkxgt"\ ukvg"dgecwug"vjg"uqknu"ctg"\ o\ quvn\{"enc\{0"Cu"c"tguwnv."vjg"\ o\ qfgn"\ rtgfkevgf"vjcv"kv"\ y\ qwnf"dg"dgvvgt"vq"vtgcv"vjg"\ o\ cvgtkcn"kp"\ rnceg"vjcp"vq"cvvg\ o\ rv"vq"rw\ o\ r"kv"qwv."\ y\ j\ kej"\ y\ qwnf"vcmg"c"\ xgt\{"nqpi"vk\ o\ g0\}$

'LG WKH WHDP FRQGXFW DQ\ DFWLYLWLHV WR SUHGLFW ZKDW ZRXOG ZRUN EHVW"

 $\label{eq:continuous} Vjg"vgco"eqpfwevgf"cffkvkqpcn"itqwpfycvgt"oqfgnkpi" vq"cuuguu"vjg"ghhgevkxgpguu"qh"kp"ukvw"dkqtgogfkcvkqp"wugf" cnqpg"cv"vjg"ukvg"cpf"vq"fgvgtokpg"yjgvjgt"itqwpfycvgt" gzvtcevkqp."qt"tgoqxcn."yqwnf"eqorngogpv"vjg"engcpwr" ghhqtvu0"Vjg"oqfgn"kpenwfgf"kplgevkqpu"ykvj"cpf"ykvjqwv" itqwpfycvgt"tgoqxcn"kp"c"uocnn"rqtvkqp"qh"vjg"uqwvjgcuv" ctgc"qh"vjg"ukvg0$

7KH 'HWDLOV RQ %LRUHPHGLDWLRQ

Kp"ukvw"*qt"rgthqt ogf"kp"rnceg+"dkqtg ogfkcvkqp"ku"c"rtqeguu" vjcv"kplgevu"c" o kzvwtg"qh" y cvgt"cpf"pwvtkgpvu"kpvq"vjg" i tqwpf" vq"uvk o wncvg"pcvwtcmn{"qeewttkpi"dcevgtkc"vjcv"dtgcm"fqyp" vjg"eqpvcokpcvkqp0"Pwvtkgpvu"rtqrqugf"hqt"vjku"rtqlgev"ctg" hqqf"itcfg"xgigvcdng"qkn"cpf"ncevcvg0"Kv"ku"cp"ghhgevkxg."ygnn/ rtqxgp."uchg"vgejpkswg"vjcv"gpjcpegu"pcvwtcn"rtqeguugu"vjcv" ctg"cntgcf{"qeewttkpi"kp"vjg"itqwpf0

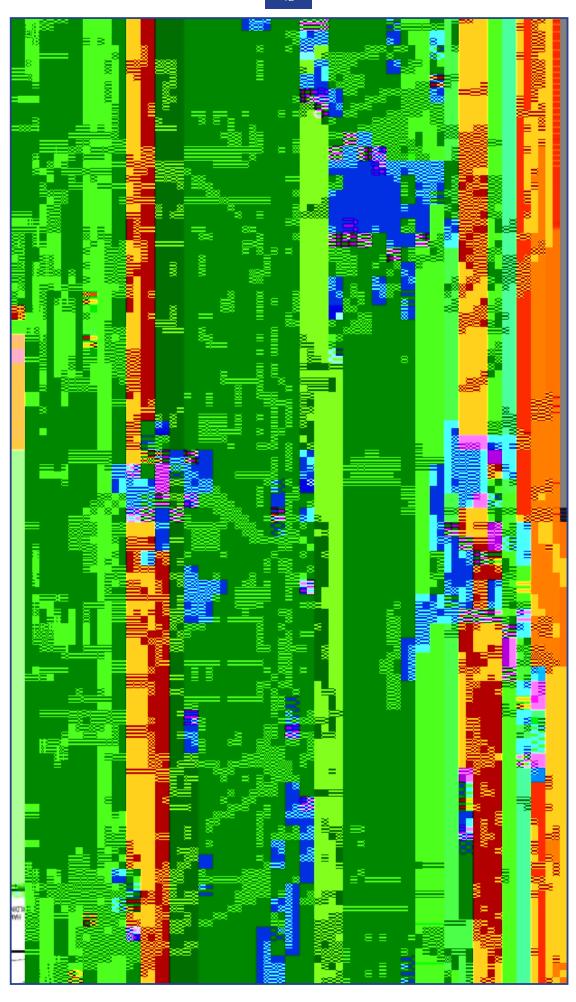
\$UH WKHUH EHQH;WV WR XVLQJ

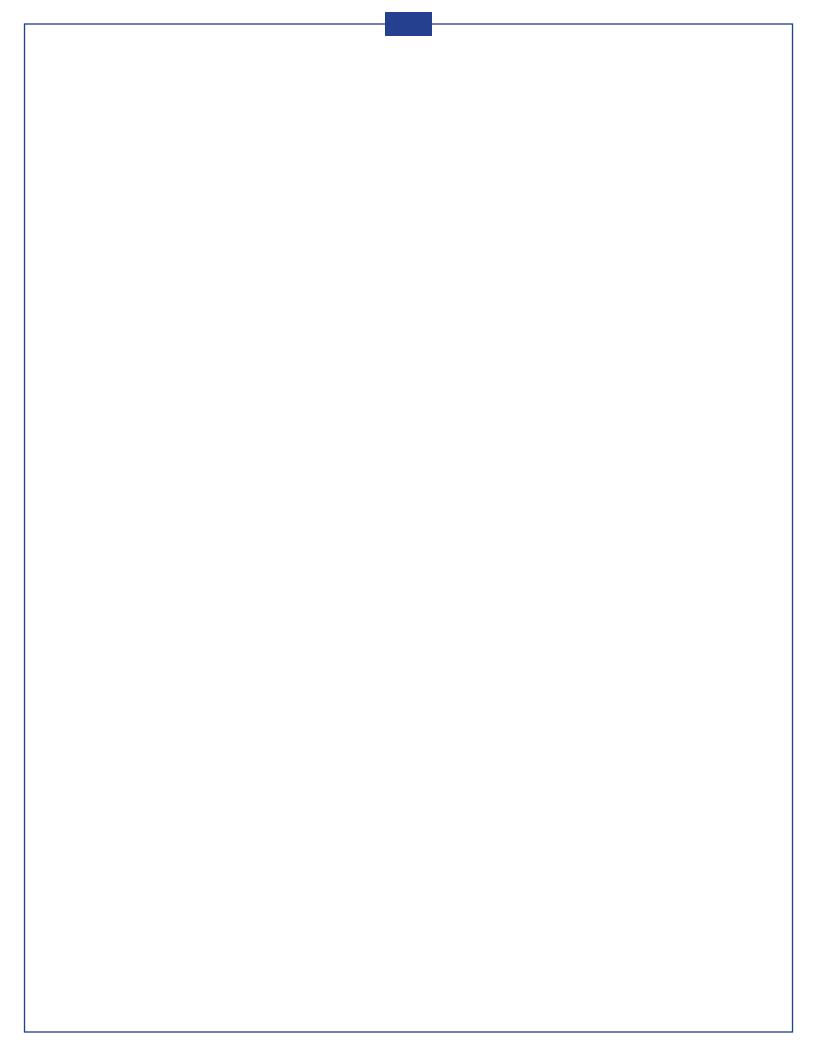
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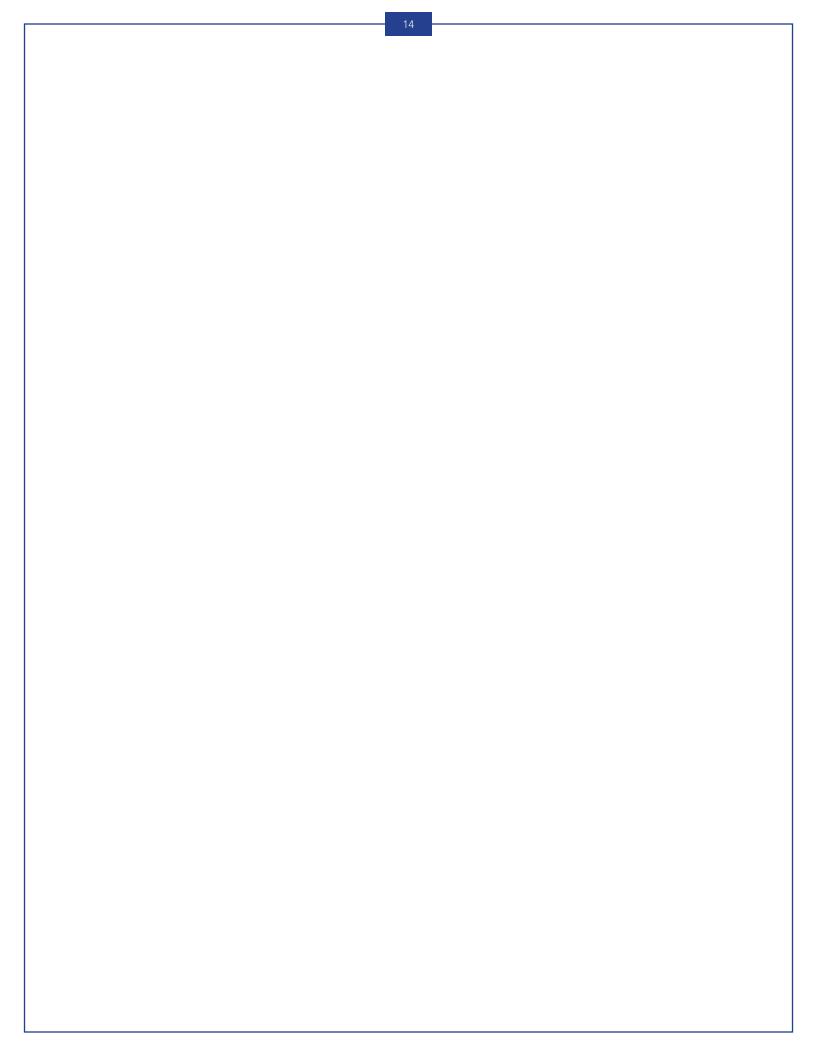
v tgc tgp tceknkv {"cpf"qvjgt"tgncvgf"kphtcuvtwevwtg" uwej"cu"nctig"pgvyqtmu"qh"wpfgtitqwpf"rkrkpi0"Kp"ukvw" dkqtgogfkcvkqp"ukipkLecpvn{"tgfwegu"kphtcuvtwevwtg" $: \texttt{KDW} \ \texttt{LV} \ \texttt{LQ} \ \texttt{VLWX} \ \texttt{ELRUHPHGLDWL} \\ \texttt{Lgswktgogpvu0"Cffkvkqpcnn} \\ \texttt{Swktgogpvu0"Cffkvkqpcnn} \\ \texttt{Swktgogpvu0"C$ rnceg"dgnqy"vjg"itqwpf"uwthceg."vjgtg"ku"nguu"rqvgpvkcn"hqt" jwocp"gzrquwtg"vq"vjg"eqpvcokpcpvu"ukpeg"vjg{"ctg"pqv" dgkpi"gzvtcevgf."vtgcvgf"cpf"fkuejctigf0

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0 ' (" ô "Oct{ncpf"Fgrctvogpv"qh"vjg"Gpxktqpogpv

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\$UPVWURQJ DQG \$VVRFLDWHV +LOOVLGH 7UDLO (GG\YLOOH .\

