

# 5DSLQ 5HVSQRVH E\ WKH (FWRP\FRUUKL]DO ( & )RUHVW WR 'LHVHO \$SSOLFDWLRQ DV ,QGLFDW

.HQ &XOOLQJV-XI@LDRQH  
1\$6\$ \$PHV 5HVHDFK &HQWHU 06 0RIIHW )LHOG &\$ 86\$  
&RUHVSRQGLQH@XW@DUQJV 1\$6\$ \$PHV 5HVHDFK &HQWHU 06 0RIIHW )LHOG &\$ 86\$ 7  
FXOOLQJV #HDUWKOLQN QHW  
5HF GDWH \$FF GDWH 3X@GD-X@  
&RSULJKW ( &XOOLQJV . HW DO 7KLW LV DQ RSHQ DFFHV DUWLFOH GLVWULEXWHG XQGHU WKH WH  
XVH GLVWULEXWLRQ DQG UHSURGXFWLRQ LQ DQ\ PHGLXP SURYLGHG WKH RULJLQDO DXWKRU DQG VRXU

\$EVWUDFW  
\$FRPELQDWLRQ EDLWLQJ DQG PROHFXODU PHWKRGV ZDV XVHG WR LGHQWL  
EORFNV ZKLFK SHQHWUDWHG WR D GHSWK RI FP \$IWHU WZR ZHHNV IXQJL WKD  
FDQ VXUYLYH DQG H[SUHVV ODFFDVH JHQHV XQGHU FRQGLWLRQV FUDWLG E\ GL  
PRGHV IRU SK\WRUHPHGLDWLRQ DQG VLWH UHVWRUDWLRQ VWUDWHJLHV WKDW XV

.H\ZRUG%LRUHPHGLDWLRQ (FWRP\FRUUKL]DO ( &XOOLQJV-XI@LDRQH )RUHVW WR 'LHVHO \$SSOLFDWLRQ DV ,QGLFDW  
3LQXV FRQWRUWD 5XVXOD 7ULFKRORPH@PH EDVHG UHPHGLDWLRQ VWUDWHJLHV  
,QWURGXFWRQ 3HWUR@RFRDUERQ FRQWDPLQDWLRQ RI  
D SHUVLVWHQW SUREOHP ZLWK VHYHUDO  
:RRG URWWLQJ DQG HFWRP\FRUUKL]DO SLSHV DQG VWRUDJH WDNV DQG VXUID  
WKH HQ]\PHV QHFHVVDU\ WR EUHDN GRZG WKH EDUERQ PKDLOV IRXOG LO  
PDQ\ W\SHV RI DQWKURSRJHQLF FRQWDPLQDWLRQ > WKHVH HFRV\VVHPV R\XU XC  
ZKLWH URW 3X@GD-X@LV LQGLFDWLRQ WKDW @LJQLQ  
GHJUDGLQJ IXQJL ZLOO GR MXVW WKDW > @ DQG FDQ UHGXFH K\GURFDUERQ  
FRQWDPLQDWLRQ LQ VRLOV E\ DV PXFK DV JHQHWLF PHWKRGV WR DYVHVW WKH @  
0XFK RI WKH ZRUN LQ WKHVH UHGXFWRQV EDVHG UHPHGLDWLRQV DFFDVH VVH  
SRO\SKHQRO R[LGDVHV WKDW XWLOL]H EDVHG UHPHGLDWLRQV DFFDVH VVH  
WKDW LQFOXGH OLJQLQ LQ ZRRG DQG LQGLFDWLRQV WR @LJQLQ DQG LQGLFDWLRQ  
SRO\FOLF DURPDWLF K\GURFDUERQV LPSDFWLRQ DQG SRO\FOLFWRQV DQG GLYHU  
E\SKHQROV 3&%dV > @ 7KH ODWHU DUH ZLGHV SUHDG VRLO DQG ZDWHU WR  
FRQWDPLQDQWV RI DQWKURSRJHQLF RULJLQ WKDW FDQ DFFXPXODWHV YL@VHYHU  
VRXUFHV LQFOXGLQJ GLHVHO VSLOOV > @KH JRDO RI WKLW HQGHYRU ZDV WR  
/DFFDVHV DUH HDVLO\ LQGXFLEOH FRPPXQLWLYH ZRXOG UHVSROG UDSLQ\ W  
XWLOL]H D EURDG UDQJH RI VXEVWUDWHV DUH RI GHWHFWLRQ DFFDVH VVH  
WR[LFLW\ RI WKHVH FRPSRXQGV YLD LPPRELOL]WLRQ WR KHV LQ ODFFDVH DQG GLYHU  
WKXV ORZHULQJ WKHLU ELRDYDLODELOLW\ > @LJQLQ DQG LQGLFDWLRQ  
XWLOL]H D EURDG UDQJH RI VXEVWUDWHV DUH RI GHWHFWLRQ DFFDVH VVH  
3KHQROLF EDVHG VXEVWUDWHV WKDW DUH SUHQRUPV ERWODVLRQV LQGLFDWLRQ  
SRO\FOLF DURPDWLF K\GURFDUERQV IXQJL DQG SRO\FOLFWRQV DQG GLYHU  
SKHQROV 3&%dV ERWK RI ZKLFK DUH ZLGHV SUHDG VRLO DQG ZDWHU  
FRQWDPLQDQWV RI DQWKURSRJHQLF RULJLQ %HFDXVH RI WKHVH XWLOLWLYH W  
UDQJH RI LQGXXWULDQ XVHV LV ZLGH DQG LQFOXGHV HQ]\PDWLF UHPHGLDWLRQ F  
VRLO DQG ZDWHU FRQWDPLQDQWV SRO\PHU V\QWKHVLV SXOS EOHDFKLQJ  
OLJQRO\WLF FHOOXORVLF ELRIXHOV SURGXFWLRQ DQG WH[WLOH G\H EOHDFKLQJ

0HWKRGV

([SHULPHQW 'HVLJQ

'LHVHO PO EORFN ZDV DSSOLHG WR D GHSWK RI FHQWLPHWHUV &0  
FRUUVSRQGLQJ WR WKH GHSWK RI WKH WKLQ RUJDQLF OD\HU WR VRLOV XVLQJ  
ZDWHULQJ FDQ LQ WKUHH UHSOLFDWH PHWHU 0 [ 0 EORFNV LQ DQ ROG  
JURZWK ORGJHSROH SLQH VWDQG QHDU <HOORZVWRQH 7KH VWXG\ VLWH ZDV  
FRPSULVHG RI \HDU ROG ORGJHSROH SLQH ZLWK VTXDUH IHHW  
DFUH EDVDO DUHD 6HYHUDO FRUHV ZHUH WDNHQ LQ WKH DUHD WR HQVXUH WH  
(& URRWV SUHVHQW LQ WKH VRLO 7UHDWPHQW SORWV ZHUH SDLUHG ZLWK  
DGMDFHQW FRQWURO SORWV LQWR ZKLFK QR GLHVHO ZDV DGGHG 7KLV  
DUUDQJHPHQW HQVXUHG WKDW WUHDWPHQW DQG FRQWURO EORFNV ZHUH LQ FOR  
SUR[LPLW\ WR HDFK RWKHU WKDQ WUHDWPHQWV WR WUHDWPHQWV FRQWUROV  
FRQWUROV PLQLPL]LQJ WKH OLNHOLKRRG WKDW DQ\ SDWWHUQV PHDVXUHG ZHU  
GXH WR UDGGRP GLVWULEXWLRQ RI IXQJDO K\SKDH LQ WKH VRLO UDWKHU WKDQ  
UHVSRQVH WR WUHDWPHQW

7ZR ZHHNV IROORZLQJ DSSOLFDWLRQ VRLO VDPSOHV VDPSOHV IURP  
ZLWKLQ HDFK RI SORWV ZLWKLQ HDFK EORFN FHQWLPHWHU FP GLDPHWHU ;  
FP LQ GHSWK ZHUH WDNHQ IURP HDFK SDLUHG WUHDWPHQW DQG FRQWURO  
SORW IRU D WRWDO RI IURP ERWK WUHDWPHQW DQG FRQWURO DQG D JUDQ  
WRWDO RI VRLO VDPSOHV

0ROHFXODU \$QDO\VLV

6RLOV ZHUH VLIWHG WR UHPRYH URRW DQG (&0 PDWHULDO '1\$ ZDV  
SUHSSHG IURP VRLOV XVLQJ 0R %LR 3RZHU6RLO '1\$ LVRODWLRQ NLW DQG  
'1\$ ZDV DPSOLILHG IURP HDFK RI WKH FRUHV E\ 3&5 XVLQJ WKH  
EDVLGLRP\FHWH VSHFLILF ODFFDVH SULPHUV &X ) U DFFRUGLQJ WR WKH

&DQWKDUHOODFHDH +\GQDFHDH 0\FHQDFHDH DQG 7KHOHSKRUDFHDH 7DEOH  
WKDW ZHUH DEVHQW IURP WKH ODFFDVH JHQH SRRO

5XVVXOD QLJLULFDQV

5XVVXODFHDH

5XVVXOD WXUFL

0XOWLSOH ODFFDVH OLNH JHGHORRBYVDEHHQ GHWHFWHG LQ  
\$WKHOLDFHDH VSHFLHV > @ %HFDXVH RI WKLV DQG EHFDXVH WKH\ DUH RIWH  
GHWHFWHG LQ RUJDQLF VRLO OD\HUV LW KDV EHHQ K\SRWKHVLJHG WKDW WKH\ I  
KDYH VRPH UROH LQ OLJQLQ GHJUDGDWLRQ SURFHVVHV > @ 2XU GDWD LQGLFDV  
WKBWORGAWDAD H[KLELW SRVLWLYH JURZWK UHVSQRVHV WR GLHVHO

&LWDW&K@OLQJV DQG 'H6LPRQH 5DSLQ 5HVSRQVH E\ WKH (FWRP\FRUUKL]DO (&0 &R  
\$\$SOLFDFWLRQ DV ,QGLFDWHG E\ /DFFDVH \*HQH )UDJPHQWR'LYHUVLW\ - %LRUHPHG %

3DJH RI

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.LP -+ .LP <6 &KDUDFWHUL]DWLRQ RI &DHRWDO%DRWQ]DFH%\$URP\DRU \$)6 &DLUQH\  
ZLOG PXVKURRP 7ULFKRORPD VDSRQDFHXPODFDFWFL O%NRWJHQQR OQ%LRWR R PFRUUKL]DO  
UHJXODWLRQ E\ QLWURJHQ LQ 3LVROLWKXV  
:DQJ +; 1J 7% 3XULILFDWLRQ RI D Q&X@OLQ]D NPLQDF %ODU P DWRP\FRUUKL]DO IX  
ODFFDVH ZLWK +,9 UHYHUVH WUDQVFULSWRQWR LQKDEILQ RURLQ FDLVLRQL DWRPG VZKWK D  
PXVKURRP 7ULFKRORPD JLJDQWHXP %LRFKH%LRZKWR QHV 18RPLXQDO 3DUN :RPLQJ %