'$7(6HSWHPEHU

1$0E(H

ILUVW ILUVW

'HSDUWPHQW &LYLO DQG (QYLURQPHQWDO (QJLQHHULQJ

&ROOHJH &RLOOHJH RI (QJLQHHULQJ

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,QIUDVWUXFWXUH (QJLQHHULQJ 0DQDJHPHQW 6\VWH

0%$)ORULGD ,QVWLWXWH RI 7HFKQ

*HQHUDO %XVLQHVV 0DQDJHPHQW 0HOERXUQH)O

06&(8QLYHUVLW\ RI ,OOL

*HRWHFKQLFDO (QJLQHHULQJ &KDPSDLJQ 8UEDQD ,OO

%6&(8 6 &RDVW *XDUG $FDGH

&LYLO 6WUXFWXUDO (QJLQHHULQJ 1HZ /RQGRQ &7

$FDGH(PLF [SHULH,QFH WDXQWLRQWLK RI

D 80DVV /RZHOOO$V\$RFLDWH 7HDFKHUV 3URIHVVRU

E 80DVV /RZHOOO 0$ /HFDUXUHU

F 0HUULPDFN &RUWKHQGGHUXQFW 9LVLWLQJ 3URI

\HDUV

G 8QLYHUVLW\ RI 1KZU KDP $1G MXQFW 9LVLWLQJ

3URIHVVRU \HDUV

H 7XIWV 8QLYHUVLW\ \HDUV 0$GMXQFW 9LVLWLQJ 3URIH

I 1RUWKHDVWHUQ 8QLYHUVLW\ 3URIHVVRU

6HSWHP

'LUHFWRU *HRWHFKQLFDO DQG 6WUXFWXUDO (QJLQH
5DQVRP (QYLURQPHQWDO &RQVXOWDQWV ,QF 2DN (
1HZEXU\SRUW 0DVVDFKXVHWWV

, ZDV VSRQVLEOH IRU DOO JHRWHFKQLFDO DQG VWUX
GHVLJQ VHUYLFHV SURYLGHG WR FOLHQWV *HRW
[illegible] GHHS IRXQGDWLRQ DV ZHOO DV YDULR
UHFRPPHQGDWLRQV , ZDV DOVR UHVSRQVLEOH IRU

VWUXFWXUHV RQ D ODUJH PLOLWDU\ WUDLQLQJ IDFLO
VL[HQJLQHHUV DQG WHFKQLFLDQV

(QJLQHHU
8 6 &RDVW *XDUG

, VHUYHG DV D FRPPLVVLRQHG RIILFHU LQ WKH 8 6 &
HQJLQHHULQJ UHODWHG IXQFWLRQV LQFOXGLQJ SOD
DQG SURMHFW PDQDJHPHQW UHODWHG WRFWPDLQHUH
LPSURYHPHQW DQG GHVLJQ RI ZDWHUIURQW VWUX
GLVSRVDO IDFLOLWLHV URDGV DQG ZDWHUZD\V

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3URIHVVLRQDO /LFHQVHV DQG $IILOLDWLRQV
x 352)(HV À RIHDÉCHU QJLQHHU 3(O (QÄ•€

x $6&(VWXGHQW PRGHO EULGJH FRPSHWLWLRQ YR

x &KDLUPDQ +%6&(3DSHU FRPSHWLWLRQ FRPPLWWHH
x -XGJH IRU 0DVV $FDGHP\ 67(0)DLU :3, :RUFHVWHU
x -XGJH IRU 1HZ +DPSVKLUH 6FLHQFH DQG (QJLQ
&RQFRUG 1+
x 7HFKQLFDO 3DSHU 5HIHUH-HRXHYDOZHU ,QIUDVWUX
6\VWHPV

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, DP LQWHUHVWHG LQ DGYDQFLQJ WHFKQRORJLHV WK
FLYLO HQJLQHHULQJ V\VWHPV RWKHUZLVH NQRZQ DV
$ &LYLO ,QIUDVWUXFWXUH 6\VWHP PD\ EH GHILQHG D
WR WKH DQVIWU RI SHRSOH DQG JRRGV ZDWHU ZDVWH F
UHVHDUFK LV GHGLFDWHG WR WKH GHYHORSPHQW R
VXSSRUW V\VWHPV WKDW DVVLVW LQ WKH PDQDJHP
GLPHQVLRQDO GHPDQGV RI ODUJH

,QYHVWLJDWHG WKH LQYHQWRU\ DQG SUHVHQW FRQG
V\VWHP RI QDYLJDEOH ZDWHUV SRUWV KDUERUV D
UHSRUW WKDW LQIRUPHG WKH VWDWH OHJLVODWLYH
QHHGV V\VWHPV

³$ 3HUIRUPDQFH&HUWDLQHG &/RVVHV 6WXG&RRQIF5HHQFH%UHGGJH
'HFNV´
8QLYHUVLW\ RI 1HZ +DPSVKLUH WR
'XUKDP 1HZ +DPSVKLUH

'HYHORSHG DEDVHOLQH GDWDEDVH IRU DVVHVVLQJ WKH SHUI
FRVWV HIIHFWLYHQHVV DQG FRQFUHWH EULGJH GHFNV LQ W
&XUUHQWO\ GHYHORSLQJ FRQGLWLRQ DVVHVVPHQW PRGHOV DQG
UHLQIRUFHG FRQFUHWH UHVXOWDQW GHYHORSPHQW RI
RWKHU SXEOLFDWLRQV DUH DQWLFLSDWHG IURP WKL

³%ULGJH 0DQDJHPHQW 6\VWHP´ 'HYHORSPHQW
&HQWHU IRU ,QIUDVWUXFWXUH5HVHDUFK 6WXGLHV
5HQVVHODHU 3RO\WHFKQLF ,QVWLWXWH 7UR\ 1<

'HYHORSHG &RQGLWLRQ $VVHVVPHQW 'HWHULRUDW
)RUHFDVWLQJ 0HWKRGRORJLHV DQG EULGJH PDQDJHP
'HYHORSPHQW LQFOXGHG DVVHVVLQJ 'HFLVLRQ\WKRGRORJ\ IRU HYDO
ODUJH EULGJH UHKDELOLWDWLRQ FRQWUDFWV
WZR RI ZKLFK DUH LQ SURJHVVLRQDO UHIHUHHG MRX

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'H6WHIDQR 3 DQG *UL\3DVRMHHYO 'HFLVLRQ $QDO
0HWKRGRORJ\ IRU /DUJH %7UDQVSRUWDEOLRQ6\VWHPV
WK $QQXDO:HWKLQJWRQ ' & -DQXDU\ 3DSHU 1R

'H6WHIDQR 3 DQG *UL\DVJH 'HFN 3HUIRUPDQFH DQG
$ 5HOLDELOLW\EDVHG6\VWHPV$QDO\VLV2I 7KH)RXUWK 0DWHU
&RQIHUHQFH:DVKLQJWRQ ' & SS

'H6WHIDQR 3 DQG *UL\5DVRO%DVHG3UHGLFWLRQ 0RG
/DUJH %ULGJH &RPSRQHQW6WUXFWXUHV5HVHDUFK %R
0HHW:DVKLQJWRQ ' & 3DSHU 1R

'H6WHIDQR 3 DQG *UL\5DVRO%DVHG3UHGLFWLRQ 0RG
/DUJH %ULGJH &RPSRQHQW6WUXFWXUHV5HVHDUFK 5H
1DWLRQDO $FDGHP\ 3UHVV :DVKLQJWRQ ' & SS

'H6WHIDQR 3 DQG *UDGXDWH 3URJUDP LQ &LYLO (QJLQHHULQJ 0
%ULGJH 0DLQWHQDQFH 3ROLF\ DQG 0DQDJHPHQW 7KH ,QIUDVWUXFW
$VVHVVPHQW &RQGLWLRQ 5DWLQJ DQG 3UHGLFWLRQ 0RGHOV

$UPLQLR 6 'H6WHIDQR 3 ³$QDO\VLV 'HVLJQ &RQVWUXFWLRQ &RQGLWLRQ $VVHVVPHQW DQG 3UHGLFWLRQ 0RGHOV IRU %
&RQGLWLRQ $VVHVVPHQW DQG 3UHGLFWLRQ 0RGHOV IRU &RQFUHWH %ULGJH 'HFN
,QIUDVWUXFWXUH &RQGLWLRQ (YDOXDWLRQ DQG 0DLQWHQDQFH &RVW 3HU

'H6WHIDQR 3 $UPLQLR 6 DQG *UL\DV ³$ 0
3UREDELOLVWLF &RQGLWLRQ 3UHGLFWLRQ 0RGHOV
7UDQVSRUWDWLRQ 5HVHDUFK :RUNLQJ 3DSHU 1R

$UPLQLR 6 'H6WHIDQR 3³$VVHVVPHQW *UDGXDWH PHQW $ &DVH
/RQJ%UDQFK %ULGJH ,QYHVWLJDWLRQ 3URJUDP 5HVHDUFK
$QQXDO 0HHWLQJ ' & 3DSHU 1R

'H6WHIDQR 3 DQG *UL\DV .RG IRU (VWLPDWLQJ 7UDQV
LQ %ULGJH 'HWHULRUDWLRQ &RVWV 6\VWHP
1R SS

'H6WHIDQR 3 ³3HUIRUPDQFH 3UHGLFWLRQ DQG
0DQDJHPHQW 7KH5HLQVVHODHU 3RO\WHFKQLF ,QVWLWX
'HSDUWPHQW 7RZ\ 1<

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6 HS WEHP

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PÐ1W%La<@D@<@G P WHIDðR ðC) 0

DFNQRZOHGJHG WKDW WKHUH LV D FULWLFDO QHH
HGXFDWLRQ WR EHWWHU VHUYH WKH SURIHVVLRQ LQ
, ZLOO VHHN RSSRUWXQLWLHV WR HQJDJH VWXGHQ
H[HUFLVH WKXLUH WKH DSSOLFDWLRQ RI HQJLQHH
FODVVURRP , ZLOO DOVR HQFRXUDJH WHDP SURMHF
OHDUQ DQG GHYHORS HIIHFWLYH OHDGHUVKLS PDQD

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8QLYHUVLW\ RI 0DVVDFKXVHWWV /RZHOO 0$

$ 8QGHUJUDGXDWH &RXUVHV

- 6WHHO 'HVLJQ DQG GHVLJQ RI %HDPV &RO
  %HDP&RORXPQ DQG 3UHVHUYH&RQG3LQQDWWWR FXUUHQW $
  'HVLJQ 6SHFLILFDWLRQV
- 6WDWLFV DQG YHFWRUV HTXLOLEULXP PRPHQW
  LQHUWLD EDVLF VWUXFWXUDO DQDO\VLV
- '\QDPL3FDUWLFOHV DQG ULJLG ERGLHV LQ PRWL
  ZRUN HQHUJ\ IRUFH DFFHOHUDWLRQ DQG YL
-)RXQGDWLRQV DQG 6RLO0 (QJLQHHULQJ D
  H[SORUDWLRQ 6HWWOHPHQW $QDO\VLV HODV
)RXQGDWLRQV %HDULQ5HWDLQLQJ6WUXFWXUHV
  0HFKDQLFDO\ 6WDELOL]HG (DUWK
- (QJLQHHULQJ (FRQRPLFV DQG %XVLQHVV PRGHOLQJ DQG
  1HW 3UHVHQW:RUWK &RVW\VLV HFRQRPLHV
  HVWLPDWLQJ LQIODWLRQ WD[HV GHSUHFLDWL
- *HRWHFKQLFDO (QJLQH*UDLQJ/DERUDWRU\ VR
  FRPSDFWLRQ SHUPHDELOLW\ IORZ QHW GL
  XQFRQILQHG FRPSUHVVLRQ WHVW
- &LYLO (QJLQHHU3UREOHP6ROYLQJ DQG 6WDWLVWLF
  /LQHDU 3URJUDPPLQJ 'LVWULEXWLRQ DQG 1HW
  0D[LPXP)ORZ DQG 'HFLVLRQ2ULQWLQJ$QDO
  SHUVRQ
- &RQVWUXFWLRQ3URMHFW0DQDJHPHQW HVWLPDWLQJ DQ
  %UHDNGRZQ&W3W U3(5W XSUHW HFW VFKHGXOLQJ SU
  PHWKRGV FRQVWUXFWLRQ FRQWUDFW DJUHHP
  GLVFRXQWHG FDVK IORZ LQFOXGLQJ GHSUHFLD
  RSWLPDO HTXLSPHQW UHSODFHPHQW
- 6HQLRU &DSVW&RQH3UHKHQVLYH0RGHOLQJ\ 0
  LQFOXGH WKHHQXGHGRGHSLQQ SUREOHPV IHDVLE
  DQDO\VLV FRPSOHWH GHVLJQ SURFHVV FR
  VROXWLRQV DQG FRVW HVWLPDWLRQ DQG VFK
  HIIRUW GHYHORSPHQW RI D VF\DWLHQSWHULSHV
  UHSRUWLQJ DQG SUHVHQWDWLRQV

6SWEHP

8QLYHUVLW\ RI 1HZ +DPSVKLUH 'XUKDP 1+

- 0HFKDQLFV 6WDWLFV DQG '\QDPLFV
- 0HFKDQLFV 6WUHQJWK RI 0DWHULDOV
- 3URMHFW 0DQDJHPHQW 3URMHFW 0DQDJHPHQW IRU (QJL &RQVWUXFWLRQ
- 6\VWHPV $QDOYHV (QJLQHHULQJ (FRQRPLFV 0RGHOLQJ /LQHDU 3URJUDPPLQJ

7XIWV 8QLYHUVLW\ 0HGIRUG 0$

- $SSOLHG 0HFKDQLFV 6WUHQJWK RI 0DWHULDOV
- &LYLO (QJLQHHULQJ 0DWHULDOV 0HFKDQLFDO 0HDVXUHU RI VWHHO FRQFUHWH ZRRG DVSKDOW DOXPL PHFKDQLFDO SURSHUWLHV 6WDWLVWLFDO GDW

1RUWKHDVWHUQ 8QLYHUVLW\ %RVWRQ 0$

- 6WUXFWXUDO &DSDVLFDO VWKHRULHV RI VWUXFWX GHWHUPLQDWH DQG LQGHWHUPLQDWH DWUXFW VWLIIQHVV DQG IOH[LELOLW\ PHWKRGV
- $GYDQFHG &RQFUHWH 6LJQDOXP %HDP7RUVLRQ WZRD\ 6ODEV DQG)RRWLQJV

5HQVVHODHU 3RO\WHFKQLF ,QVWLWXWH 7UR\ 1<

- &LYLO (QJLQHHULQJ *HRWHFKQLFDO &RQVWHFKQLFDO DGYLVRU I

<RUN &RXQW\ 7HFKQLFDO &ROOHJH :HOOV 0(

x ,QWURGXFWLRQ &RPSXWHU $LGHG 2'&$ $8 7 2'&$ UDIWLQJ
x $GYDQFHG &RPSXWHU $8 7 2&$ 'UDIWLQJ
x ,QWURGXFWLRQ)XQGDPHQWDOV RUH EXLOGLQJ OD
DQG FRQVWUXFWLRQ WHUPLQRORJ\ EOXHSULQ
WHFKQLTXHV

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D 'LVVHUWDWLRQ $GYLVRU &RQGLWLRQ GLUHFWRUVDSHUYRU
UHVHDUFK WRSLF WLWOH H[SHFWHG JUDGXDWLRQ DW
WKH UHYLHZ SHULRG QRWH SODFHPHQW FRPSDQ\ LQ

D 0DMRU DGYLVRU RQHV 2ZXVX7ZXPDHL 7KHVLV 7LW
%DVHG &RQGLWLRQ $VVHVVPHQW 2I 5HLQIRUFHG
6\QWKHWLF $SHUWXUH 5DGDU ,PDJLQJ 7HFKQLTXH
3XEOLVKHG WZR SDSHUV LQ UHVSHFWHG HQJL
0D\
E &,9(&23 &XUULFXODU 3UDFWLFDO 7UDLQLQJ
:LQWHU DQG 6SULQJ *UDGXDWHG 6SULQJ

E 7KHVLV $GYLVRU VLVXG HQWV GLUHFWRUVDSHUYRU

6 SWEHP

&ROOHJH &RPPLWWHH WHUP GDWHV DSSUR[LPDWH IUH
DFFRPSOLVKPHQWV RQ WFRPLHV RX ZHUH FRPPLWWHH FKI

D 80$66 /RZHOO 0DNHU 6SDFH UHQRYDWLRQ FRPPLWWH
PHHWLQJV WKURXJKRXW WKH \HDU ZLWK RWKHU IDFX
GHYHORS D PXOWLSXUSRVH VWXGHQW PHHWLQJ DQG
DUH FXUUHQWOR XPHQW 6SHDLQJ
E 80$66 /RZHOO 0DNHU 6SDFH UHQRYDWLRQ FRPPLWWH
FRPPLWWHH , SDUWLFLSDWHG LQ VHYHUDO PHHWLQ
\HDU DQG DVVLVWHG LQ GHYHORSLQJ6FXUULFXOXP D
SURJUDP SDUWLFXODU , GHYHORSHG 06(0 SURJUDP F
,QIUDVWUXFWXUH 0DQDJHPHQW DQG (QJLQHHULQJ 6H
SXUVXLQJ PDQDJHPHQW FDUHHUV LQ FKDVOHHQLQHH
DSSURYHG E\ ERWK *3$& DQG)DFXOWL6HQDWH)DO
DFFUHGLWHUG VWXGHQWV JUDGXDWHG IURP WKLV S
F &ROOHJH RI (QJLQHHULQJ 3URPRWLRQ &RPPLWWHH P
5HYLHZHG 177 DSSOLFDQWV IRU SURPRWLRQ 5HFRPP
SURPRWLRQ

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WRRO IRU DOO VWXGHQWV JUDGXDWLQJ IURP WKH FL
SURJUDP DWH8JUFXUUHQWOH\UDEWLYH PHPEHUV
J 3UHVHQWHG ³2UGHU RI (QJLQHHU´ FHUWLILFDWHV WR
FHUHLPHRVQ

6 IS WEHP

Ah 0 7ÂÂ//PPRED0

D ,QVWUXFWRU RI FDSVWRQH FODVV GHVLJQ
VFKRRO LQ /RZHOO 0$ 7KH SURMHFW LQFOXGHG DG
OLEUDU\ VSDFHV WR DQ H[LVWLQJ VFKRRO
E ,QVWUXFWRU RI D VHQLRU FDSVWRQH FODVV GHVLJQ
WUDIILF DQG SHGHVWULDQ WUDIILF RQ 1RUWK &DPS
F 5HSUHVHQWHG 80$66 /RZHOO DV D MXGJH IRU WKH 1
(QJLQHHULQJ ([SR DW 1+7, &DPEULGJH 1+ 0DUFK
G 5HSUHVHQWHG 80$66 /RZHOO DV D MXGJH IRU WKH 0DVVD
6FLHQFH 67(0 IDLU LQ :RUFKHVWHU 0$)HEUXDU\
H 3DUWLFLSDWHG LQ WKH &RPPXQLW\ &RQQHFWLRQV %UHD

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6+257 &2856(6

³'HVLJQ RI &RDVWDO 6WUXFWXUHV´ $6&(3RUWODQG

³'HVLJQ RI)RXQGDWLRQV IRU '\QDPLF /RDGV´ $6&(3

³26+$ +HDOWK DQG 6DIHW\ 7UDLQLQJ IRU +D]DUGRXV

&21)(5(1&(6

³1RUWKHDVW :RRG 'HVLJQ 6\PSRVLXP´ :RRG 0(

³$6&(6(, 6WUXFWXUHV &RQJUHVV´ %RVWRQ 0$

³$6&(6(, 6WUXFWXUHV &RQJUHVV´ /RV 9HJDV 19

³$6&(6(, 6WUXFWXUHV &RQJUHVV´ 2UODQGR

³$6&(6(, 6WUXFWXUHV &RQJUHVV´ $XVWLQ 7;

³0DLQH 7UDQVSRUWDWLRQ &RQIHUHQFH´ 0('27 $XJXVWD

³ UG 0DLQH 7UDQVSRUWDWLRQ &RQIHUHQFH´ 0('27 $XJ

³'HHS)RXQGDWLRQ $QDO\VLV 'HVLJQ DQG &RQVWU

³%DVLF 'HVLJQ &RQVWDQWV &RQIHUHQFH´ $,6& %RVWRQ

³&RDVWDO (QJLQHHULQJ 0DQXDO $ +LJKOLJKW RI &K
0DQXDO´ $6&(&235, :RRGV +ROH 0$

³3UDFWLFDO 6WHHO 'HVLJQ´ $PHULFDQ ,QVWLWXWH

³&RQFUHWH 6ODEV RQ *URXQG´ $PHULFDQ &RQFUHW

³6RLO 6WUXFWXUH ,QWHUDFWLRQ DQG WKH ,QWHUDFWLR
(QJLQHHUV´ %6&(6 %RVWRQ 0$

³$QFKRUHG 6XS*HR 6HPLQDU´ $'6& 7KH ,QWHUQDWL
)RXQGDWLRQ 'ULOOLQJ

³,QIUDVWUXFWXUH &RQGLWLRQ $VVHVVPHQW $UW
6RFLHW\ RI &LYLO (QJLQHHUV %RVWRQ 0$

³ VW &HQWXU\ $VVHW 0DQDJHPHQW :RUNVKRS´ $$6+
3RO\WHFKQLF ,QVWLWXWH 7UR\ 1<

³ W7KUDQVSRUWDWLRQ 5HVHDUFK %RDUG &RQIHUHQF
:DVKLQJWRQ ' &

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- 'ULOOVKHDGW IRXQGDWLRQV IRU UDLOURDG EULGJHV L
- 0LFURSLOH XQGHUSLQQLQJ SURMHFW IRU DEXWPHQW IRU LPSURYHPHQWV LQ 0DVVDFKXVHWWV 0%7$
- %XLOGLQJ IRXQGDWLRQ VHWWOHPHQW LQYHVWLJDV

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3HUIRUPHG LQYHVWLJDWLRQ DQDO\VLV GHVLJQ DQG IRU WKH UHKDELOLWDWLRQ RU FRQVWUXFWLRQ RI WK

- FRQFUHWH GDPV /DNH 1DQF\ 3URYLGHQFH 1< :U
- LQGXVWULDO HTXLSPHQW SODWIRUPV *(6LOLFRQ
- SLSHOLQH XWLOLW\ VXSSRUWV *(3ODVWLFV 'LY
- UHLQIRUFHG

x U LUSSD S VKRUHOLQH SURWHFWLRQ V\VWHP
x UHKDELOLWDWLRQ RI DQ H[LVWLQJ WLPEHU PRRULQ

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0DQDJHG D WHDP RI HQJLQHHULQJ WHFKQLFLDQV D
ô` 0

x 6XFFHVVIXOO\ QHJRWLDWHG DQG DGPLQLVWHUHG
FKDQJH RUGHUV 6XSHUYLVHG FRQVWUXFWLRQ TX
&RDVW *XDUG

x 3DUWLFLSDWHG LQ WKH SODQQLQJ GHVLJQ DQG
RXWSDWLHQW FOLQLF 86 &RDVW *XDUG

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x &LWL]HQVKLS 1DWXUDO ERUQ 8 6 FLWL]HQ
x)DPLO\ 0DUULHG ZLWK [WKUHH FKLOGUH
x 0LOLWDU\ VHUYLFH XW&RDVW *XDUG 2IILFHU
PRV 1DYDO 5HVHUYH 2IILFHU 6HDEHHV
x 5HOLJLRQ 5RPDQ &DWKROLF
x +REELHV RXWGRRU VSRUWV DQG UHFUHDWLR