REVIEW OF THE SUCCESS OF STREAM RE-ALIGNMENT PROJECTS AUTHORIZED IN ONTARIO BY FISHERIES AND OCEANS CANADA UNDER SECTION 35 OF THE *FISHERIES ACT*

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A review of stream re-alignment projects was undertaken to determine the extent to which approved and completed stream re-alignment projects meet the “no net loss of the productive capacity of fish habitat” principle of Fisheries and Oceans Canada. The role of the environmental assessment process was assessed for its ability to produce compensation plans that meet federal fish habitat objectives. Forty-four authorized project files were reviewed, with a further detailed field assessment of ten of these files.

Results indicate that, overall, the principal of “no net loss” was met for the selected case studies. There was found to be a general improvement in habitat quantity and quality in post-construction conditions. Standard information was lacking in the project files. Recommendations include developing standard protocols for rapid assessment in pre-construction conditions, as a baseline for post-construction monitoring, as well as standard design considerations.

RÉSUMÉ

On a entrepris un examen des projets de réalignement de cours d’eau afin de déterminer la mesure dans laquelle les projets approuvés et menés à bonne fin respectent le principe d’« aucune perte nette de la capacité de production de l’habitat du poisson » de Pêches et Océans Canada. On a évalué le rôle du processus d’évaluation environnementale pour sa capacité de produire des plans de compensation qui répondent aux objectifs fédéraux relativement à l’habitat du poisson. On a procédé à l’examen de 44 dossiers de projets autorisés ainsi qu’à une évaluation sur le terrain détaillée de 10 de ces dossiers.

Les résultats indiquent que dans l’ensemble, le principe d’« aucune perte nette » a été respecté pour les études de cas choisies. On a constaté une amélioration générale de la quantité et de la qualité d’habitat dans les conditions post-construction. Il manquait des renseignements normalisés dans les dossiers de projet. Les recommandations comprennent l’élaboration de protocoles normalisés aux fins d’une évaluation rapide dans les conditions pré-construction, à titre de condition de base pour la surveillance post-construction, ainsi que des considérations relatives à la conception normalisée.

1.0 INTRODUCTION

Fisheries and Oceans Canada (DFO) in Ontario reviews a large number of proposals each year requesting the re-alignment of streams. Most of these projects occur in southern Ontario and involve physically manipulating the location of watercourses or their dimensions, bank characteristics, and meander geometry. A wide range of projects require stream re-alignment, including culvert installation or removal, drainage and stormwater management, land use change (urban or agricultural development), and erosion control, among others. Between 1997 and 2001, DFO in Ontario reviewed approximately 8,569 projects; 11% (943) were authorized and 12% (117) of those projects were stream re-alignments (DFO Referrals Database 2002).

Most stream re-alignment projects result in a "harmful alteration, disruption or destruction" (HADD) of fish habitat, as defined in Section 35 of the Federal *Fisheries Act,* and are authorized under Subsection 35(2) by DFO. Any project requiring such authorization must also undergo an environmental assessment under the *Canadian Environmental Assessment Act* (CEAA) before the authorization is issued. Collectively, this process involves detailed impact analysis, and where mitigation fails to alleviate potential adverse effects through planning and design, compensation is required to replace the habitat and productive capacity lost through the project. To off-set habitat losses, and to meet DFO's guiding principal of "no net loss (NNL) of the productive capacity of fish habitat" as outlined in the *Policy for the Management of Fish Habitat* (DFO 1986), fish habitat biologists ensure that the new channel incorporates natural channel design principles, which typically improve fish habitat.

The compensation measures authorized and implemented in stream re-alignment projects often involve, to varying degrees, the creation of stream reaches that mimic or replace the natural characteristics of fish habitat altered. Principles of aquatic ecology, geomorphology, hydraulics, and landscape architecture are incorporated into the study design to ensure that the final construction will be safe, dynamically stable, and productive. Ideally, these designs either replace the habitat functions that were compromised by the in-stream works, and/or contribute to related habitat functions that improve the productivity of the principal fish assemblages present (e.g., localized nursery habitat creation for a trout population that migrates through a stream system). The final design is assessed upon completion, using a number of criteria including erosion risk, stability, dynamic geomorphic stability, habitat quality and quantity, project survival, riparian plantings, and whether or not the new channel achieves the targets set out in design.

However, follow-up assessment to determine the success of compensation is not undertaken consistently, and relatively little is known about the effectiveness of various compensation techniques for stream re-alignments. With an increasing demand for land use change and infrastructure retrofits, there is an urgent need to review the follow-up component of the federal approvals process. The follow-up assessment is required to evaluate the success of the channel re-alignment designs and to provide insight into the most appropriate design methods for various locations and conditions (e.g., Canadian Shield, sand/clay areas, rural/urban settings, etc.).

Several researchers have completed large-scale follow-up site visits to gain insight into relative success and failure of channel restoration and enhancement projects. Kondolf and Micheli (1995) reported on various studies completed by other investigators. These studies showed that out of 100 enhancement projects completed in the United Kingdom, only 5% had been re-evaluated. When 400 projects had been monitored and evaluated in southwestern Alberta, 69% were structurally stable, whereas 33% were of low or zero effectiveness in achieving habitat enhancement goals. In Oregon and Washington, 161 projects were examined and 18% had failed and 60% were damaged or ineffective. Brown (2002) examined 24 different types of stream restoration practices at 450 sites and found that less than 60% of the practices fully achieved even limited objectives for habitat enhancement.

Results such as those presented by Kondolf and Micheli, and Brown emphasize the importance of follow up monitoring and project evaluation. Insight gained from the monitoring of completed projects provides an opportunity not only to evaluate project success, but to identify which aspects of a setting, design approach, or design team may signify increased potential for the success or failure of a project. To assess whether or not a project has satisfied the “no net loss” guiding principal as outlined in the Habitat Policy, monitoring objectives need to clearly define project success or project failure (e.g., monitoring results in the presence of target species).

In 2002, DFO retained Golder Associates Limited, Aquafor Beech Limited, and ESG International Incorporated to work on a joint project to review stream re-alignment projects.

Case studies were used to determine the extent to which approved and completed stream re-alignment projects have met DFO’s guiding principal of “no net loss of the productive capacity of fish habitat”. More specific project objectives included:

1) assessing the interrelationships between predicted fish and fish habitat impacts and predicted outcomes of compensation plans (i.e., stream re-alignment designs and techniques);
2) recommending methods for improving the approvals process in achieving expected results; and
3) providing recommendations for increasing the effectiveness of monitoring practices in measuring project success. Furthermore, by examining a range of implemented plans, the role of the environmental assessment process was assessed for its ability to produce compensation plans that meet federal fish habitat objectives.

2.0 GOALS AND OBJECTIVES

There were two main objectives for the overall project:

- Determine the extent to which approved and completed stream re-alignment projects have met DFO’s guiding principal of “no net loss of the productive

capacity of fish habitat", using qualitative measurements of habitat quality and quantity as surrogates for productive capacity; and
- Assess the ability of stream re-alignment technology to improve the dynamic stability and ecological productivity of stream systems.

Other goals for the project included:

- Comparison of as-built stream re-alignments to project design and approvals requirements;
- Analysis of parameters that influence project success;
- Recommendations on methods for improving the effectiveness of the approvals process in achieving expected results.

The general intent of this study was to determine whether stream re-alignments benefit aquatic ecosystems. If projects do not consistently accomplish this, the approvals process should be reviewed to determine if the correct design was used. Further rationale for the evaluation, including objectives, physical and biological indicators, and the evaluation framework, is found in Appendix A.

3.0 APPROACH

This project was broken into two phases: 1) an office review of 44 files and 2) a detailed field assessment of ten of these files.

For the office review, the primary sources of information that were used to fulfil the study objectives were:

1. Information contained in previously authorized project files, including the types and detail of analysis undertaken and the information requested by DFO on which authorizations were based; and

2. Direct comparisons between as-built site conditions and file information of pre-re-alignment conditions and design.

To identify representative projects with sufficient information to warrant review, a stepwise procedure was developed to screen existing project files for information that would be consistently available. Projects with as-built drawings were selected for field review and these drawings were compared against the approved design and project rationale. The master list of project file data was assessed for trends such as project team composition, level of analysis utilized, rationale for fish habitat objectives in designs, etc. The general stepwise procedure is summarized below:

- Initial review of the DFO referrals database and project files;
- Compilation of key project data summaries;
- Development of screening rationale and selection criteria;

- Selection of representative candidate projects and documentation of the selection process;
- Development of an information request form that DFO staff may distribute to future project proponents;
- Development of study design for selected case study projects;
- Field assessment of selected case study projects;
- Comparative analysis of field data against information upon which design and approvals were based;
- Review of master project file summaries for additional trends in re-alignment projects; and
- Interpretation of results in order to derive recommendations to improve the DFO authorization process for consistently achieving the NNL principle in stream re-alignment projects.

As part of this project, a literature review was undertaken to review recent experience with rapid assessment indicators as well as indicators of project success and relevant project evaluation frameworks. Through this review, both the "Rehabilitation Manual for Australian Streams" (Rutherfurd et al. 1999) and the "Adaptive Management of Stream Corridors in Ontario" (Ontario Ministry of Natural Resources and Watershed Science Centre 2002) provided a valuable framework for the development of a stream re-alignment monitoring program. The monitoring strategy that has been developed for the present study was largely derived from information contained within those two reports. Rutherfurd et al. (1999) defined five groupings of project outcomes that may define the framework of post-construction project evaluation (Appendix A).

Ontario's Burlington District was chosen as the geographic area for evaluation since there was a high occurrence of the stream re-alignment projects in the area (Figure 1). Selection criteria were developed to facilitate an initial file screening and short-listing of projects for inclusion in the study. An electronic database was searched for projects involving DFO authorized stream re-alignment projects between 1996 and 2002 (Figure 2).

During the review of the selected stream re-alignment files, it became apparent that the amount of background information contained within the files was variable in quality and quantity. As a result, the project team developed a generic "Stream Re-alignment Information Checklist" (Appendix B) that could be used by DFO for dealing with the proponents of future re-alignment projects to ensure complete files, full project rationale, and a baseline for performance monitoring after construction.

A file inventory checklist was developed to assist with the file review and selection (Appendix C). Qualitative and comparative reviews of file information on physical project elements, biological data, habitat conditions, design rationale, and design data were all considered. Other key information was collected on project impetus and objectives, location and scale of projects, discipline involvement, and quality of file data to review post-construction success.

A data sheet was developed to address both the biological and geomorphologic components of a Rapid Assessment Data Collection regime (Appendix D). Key parameters focused around indicators of immediate and long term dynamic stability, morphology, habitat conditions and riparian connectedness. Descriptions of the data collection parameters are also provided in Appendix D. Data collected from the site assessments for ten selected projects were synthesized and used in comparisons between pre-construction conditions, design elements and post-construction conditions. Summary information from each project analysis was then further synthesized to assess trends across the reviewed projects.

The ten projects selected for site assessment and pre-post construction comparisons were generally the projects with relatively high quality file information (pertaining to pre-construction conditions and design rationale). The comparisons and assessments of stability from these projects could potentially be a biased representation of the nature and types of projects that DFO staff receives for review and authorization. Therefore, the project team conducted additional analyses on the master project database from which the shortlist of ten projects was selected. These analyses focused primarily on pre- and post- construction channel length (as an indicator of the range of project size and complexity in the overall database), project team composition, information completeness and quality, and presence of approval and post-construction reports. Criteria of how project success was determined are included in Appendix E.

4.0 RESULTS AND DISCUSSION

4.1 INITIAL SCREENING

Seventy-eight files were opened for review; however after an initial screening of these projects, it became apparent that some did not involve a DFO authorization for a HADD or were not stream re-alignments. As a result, 34 files were eliminated and detailed checklists were completed for the remaining 44 files. The largest proportion of stream re-alignment projects identified in the DFO referrals system queries and assessed in this study were located within the Burlington District (Figure 1).

4.2 FILE SUMMARIES

Detailed project summaries were synthesized for 44 projects and tabulated in a master database for review and comparisons (Appendix F).

Courses in geomorphology and natural channel design for practitioners were first offered in 1991. While some re-alignment projects were implemented soon thereafter, a time lag most likely occurred while approval agencies and proponents adapted to the new approach to traditional erosion control and diversion projects. As a result, proponents conducting stream re-alignments in the early to mid nineties were less likely to have incorporated geomorphology and natural channel design elements into their projects.

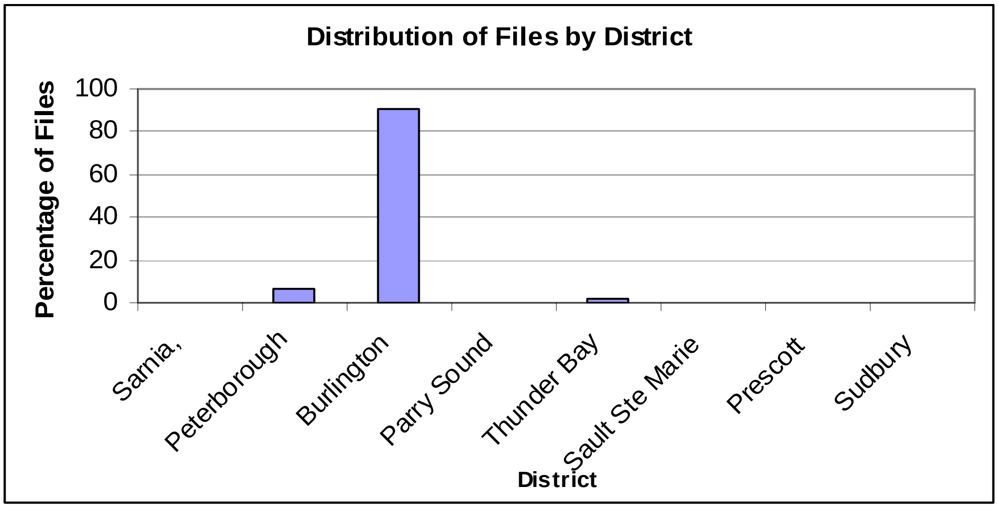

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Figure 1. Percentage of DFO- Ontario Great Lakes Area (OGLA) referral files reviewed for re-alignment data distributed by District between1997 and 2001.

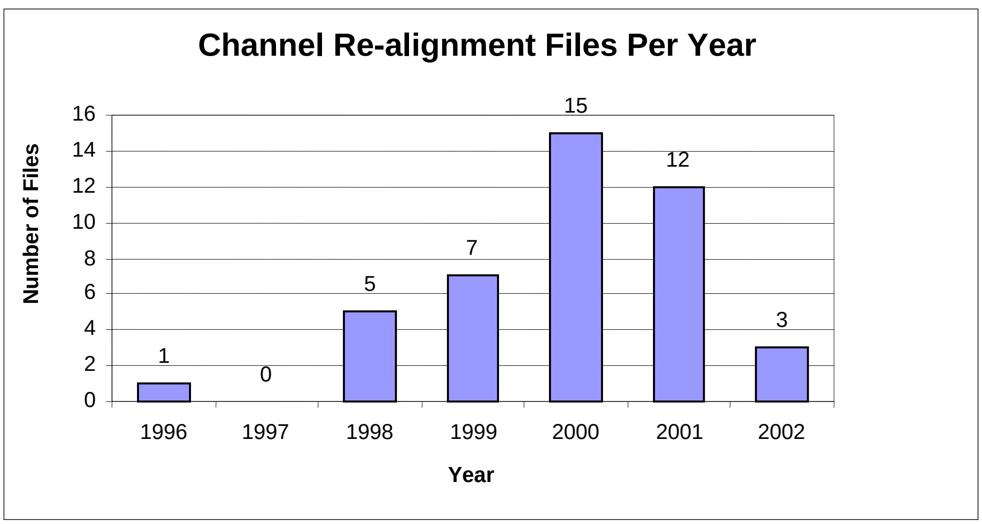


Figure 2. Number of stream re-alignment projects authorized in Ontario between 1996 and 2002.

Other summary statistics on project files were based primarily on design and approval information, as opposed to post-construction conditions on project sites. This was due to the fact that only 30% of project files contained evidence of as-built drawings or post-construction monitoring.

File summaries provided information on the impetus for proposed stream re-alignments. According to the results of this assessment, re-alignment projects are completed for a variety of reasons ranging from land development to bridge or culvert work (Figure 3).

Each of the 44 projects was examined for stream length (pre-existing stream conditions compared to the design stream), file data quality, and project design team composition. The results of these finding are summarized in the following paragraphs.

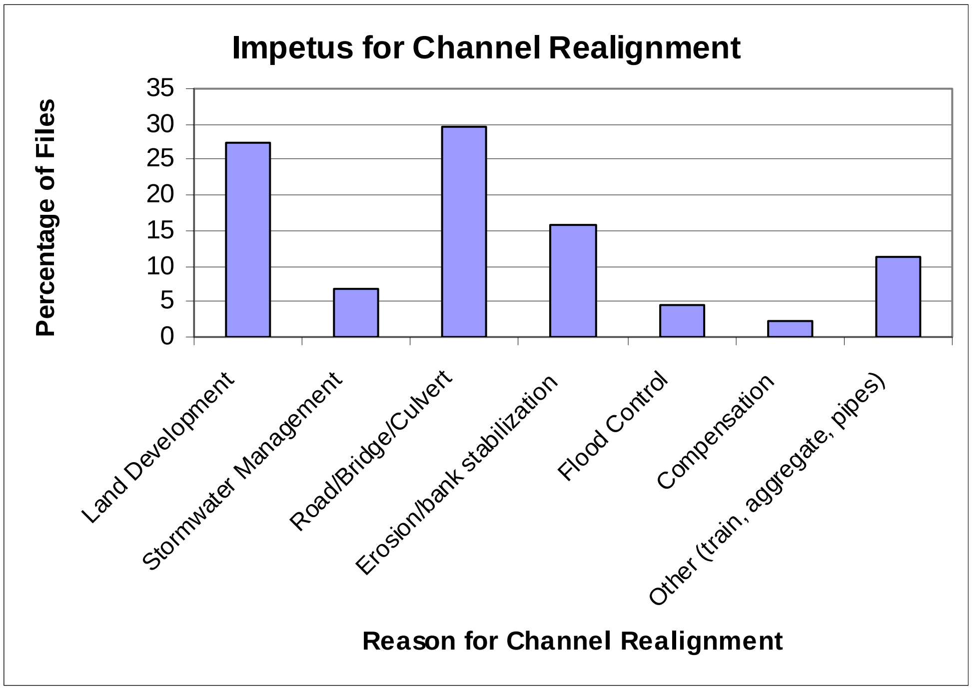


Figure 3. Rationale for channel re-alignment projects in Ontario between 1997 and 2001.

4.2.1 Project Magnitude and Net Gains in Stream Length

Based on site length comparisons of pre-existing stream conditions to the design systems in the 44 files examined, overall channel length has increased from 19.7 km to 21.9 km. Assuming that all projects were constructed as designed in the authorization, this suggests an overall gain in habitat quantity. However, this indicator should not be taken exclusively, since net gain in productive capacity is a function of designed habitat quantity and quality (which includes considerations such as the specific habitat elements in the design, net channel stability resulting from the project, and the compatibility of proposed habitat with larger scale reach characteristics or objectives).

From the outset, we hypothesized that reach length may relate to project complexity and therefore may affect project team composition, data quality, or project success. These factors may also affect fiscal resources, public profile, or accountability. Therefore, we grouped projects into length classes and found that relatively few were less than 100 m, and that most project reaches were between 100 and 500 m in length (Figure 4).

4.2.2 File Data Quality

Recognizing that 34 files were omitted from the preliminary review, partially due to lack of information, the quality of information contained in the remaining 44 files was assessed to select files with sufficient information for site assessments. We have already documented a relatively poor level of as-built and post-construction file information. The established criteria allowed a qualitative ranking based on presence and quantity of information relating to the physical, habitat, and biotic components of

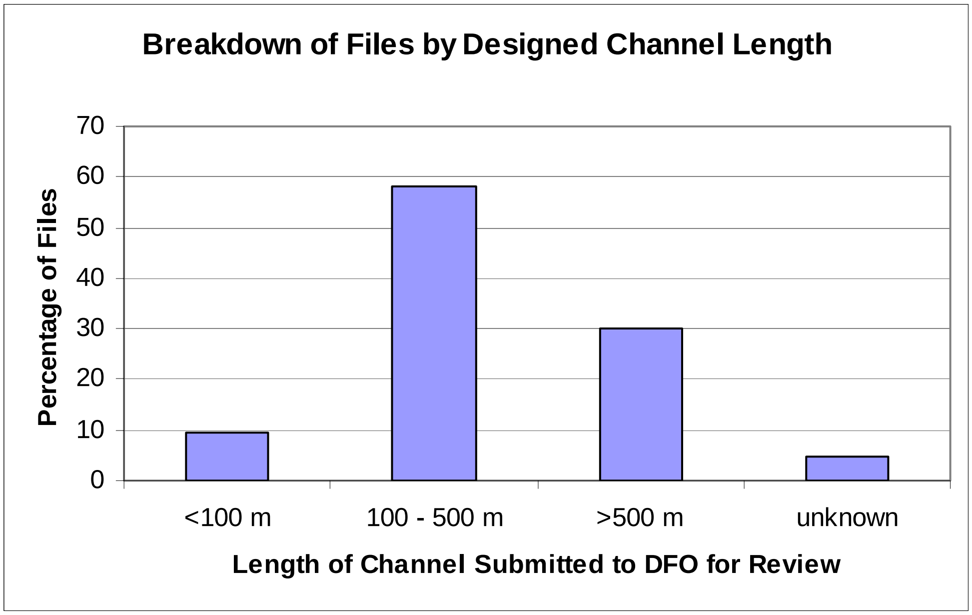


Figure 4. Channel length classes for authorized stream re-alignment projects reviewed in Ontario between 1997 and 2001.

the re-alignment projects. For example, to be ranked as having relatively high quality file data, the file would be required to contain the following information:

- a biological design rationale addressing key environmental and NNL considerations;
- geomorphologic analyses supporting the design; and
- key site and reach-level data on biological communities, habitat types and quality, and physical resource data emphasizing geomorphology and hydraulics.

Files with little information were ranked as low quality, while files containing most or all of the parameters were ranked as high, and all others were ranked as medium. Given three qualitative rankings, approximately the same proportion of files (1/3) were of low, medium, and high quality.

With respect to physical resource data, 42% of files were ranked as relatively high quality and 28% were of medium quality (Figure 5). Only 7% of files contained high quality biological data and 44% contained an obvious lack of information on which a channel design could be based. Approximately half of the files contained a medium quality of habitat information.

Results based on our assessment demonstrated that physical channel conditions are described reasonably well, while biological and habitat data are generally of medium or low quality.

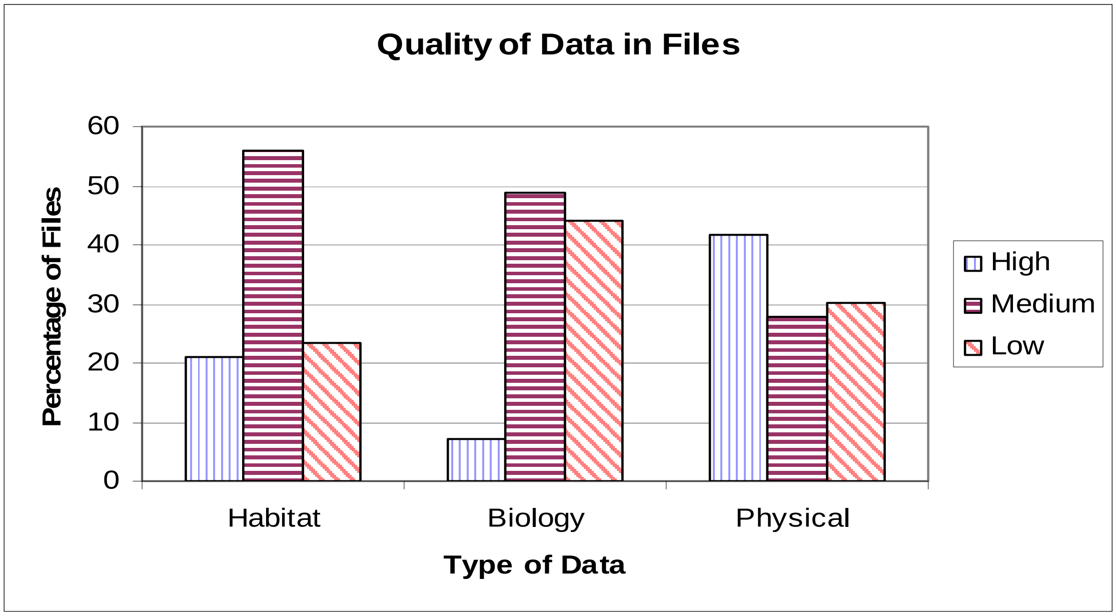


Figure 5. Quality of data assessed based on information in the files relating to habitat, biology, and physical resources for channel re-alignment projects authorized in Ontario between 1997 and 2001.

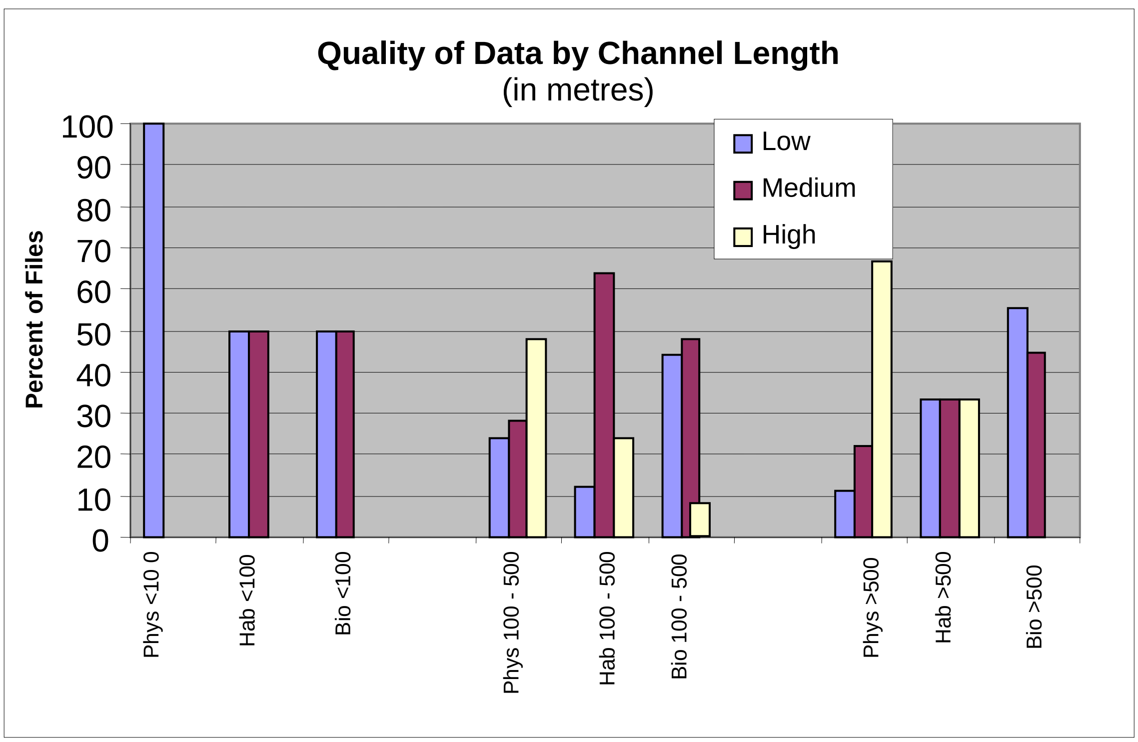
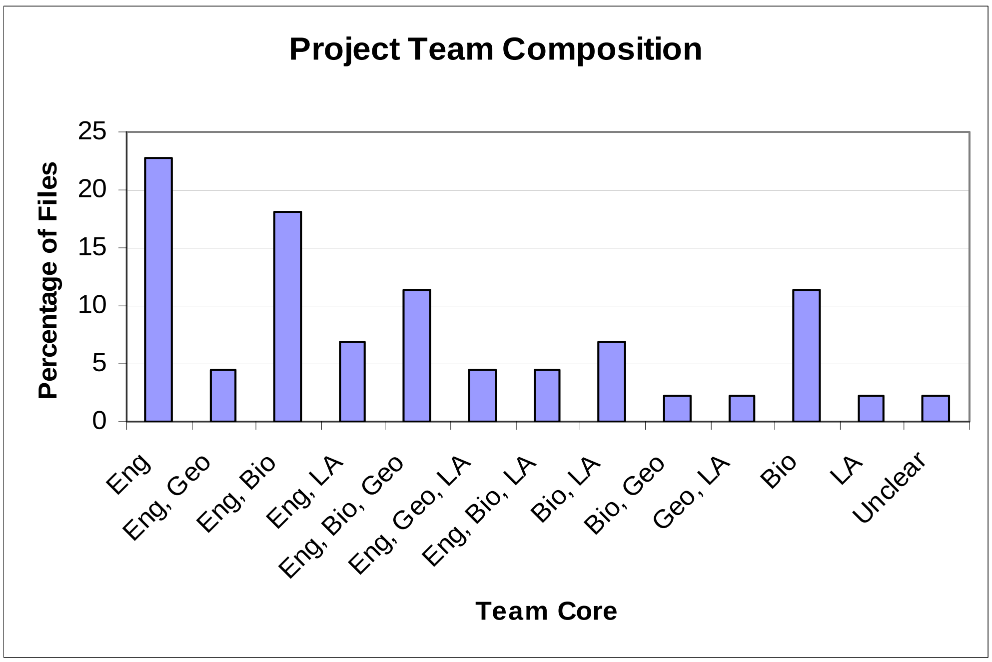


Figure 6. Percent of files in each file information quality ranking (low, medium, and high) based on increasing project scales (channel length) for channel re-alignment projects authorized in Ontario between 1997 and 2001.

Trends in the quality of data based on the scale of projects revealed that good quality file information was generally lacking in smaller scale projects (<100 m). This outcome was visible in all small project files based on physical resource information (Figure 6). The proportion of files with poor biological information did not decrease as project size increased, in contrast to the physical resource data which did improve with project size.

4.2.3 Design Team Composition

External design teams were generally comprised of various combinations of engineering, biological, geomorphologic, and landscape architectural disciplines (Figure 7). This review emphasized the supporting technical components (hydraulics, biology, and geomorphology) more than the design disciplines which may involve varying degrees of landscape architecture, engineering, and other disciplines, depending on project scale.



Note: Eng – Engineer; Geo – Geomorphologist; Bio – Biologist; LA – Landscape Architect

Figure 7. Project team composition.

A relatively large proportion of files (35%) were authorized by DFO that had only one discipline involved in the external design team (Figure 8). Forty-four percent of the projects involved two disciplines and 21% involved three disciplines.

All of the projects involving three disciplines had engineers (Figure 9). Geomorphologists and landscape architects were the least represented on design teams. Geomorphologists were represented on about 65% of three discipline teams. Biologists were represented on approximately 70% and 80% of two and three discipline projects respectively.

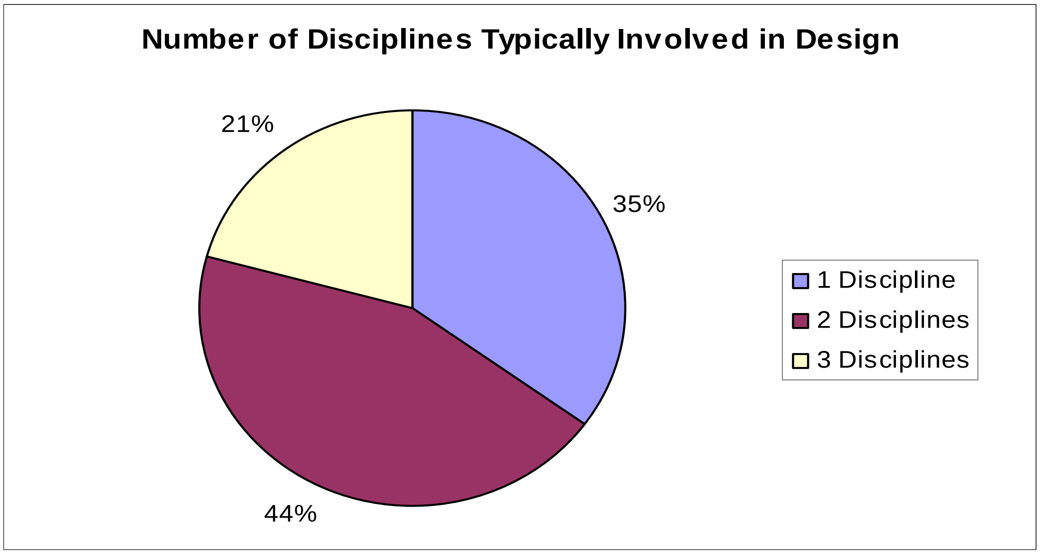


Figure 8. Number of disciplines, shown as a percentage, involved in re-alignment projects.

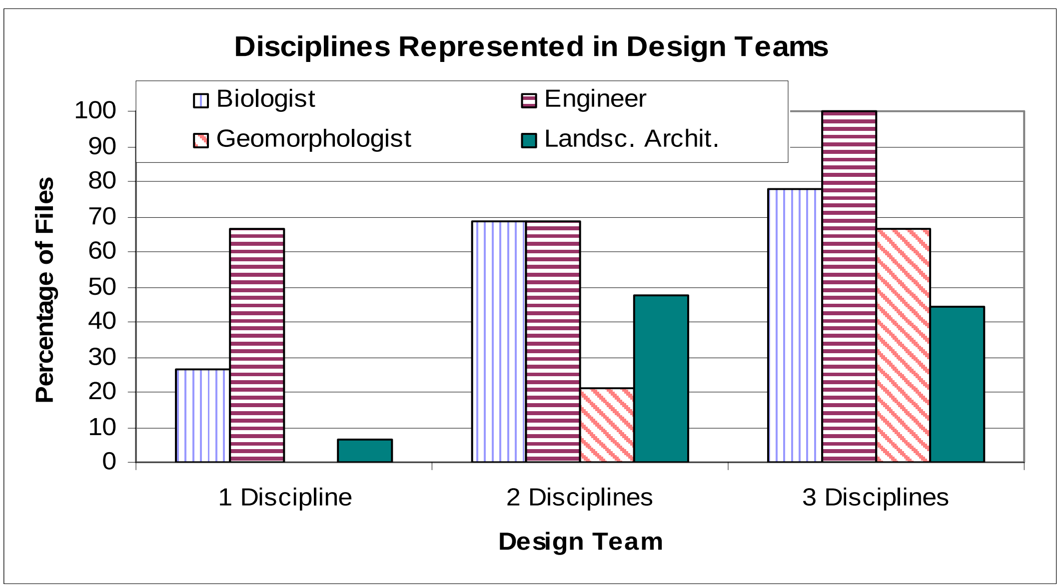


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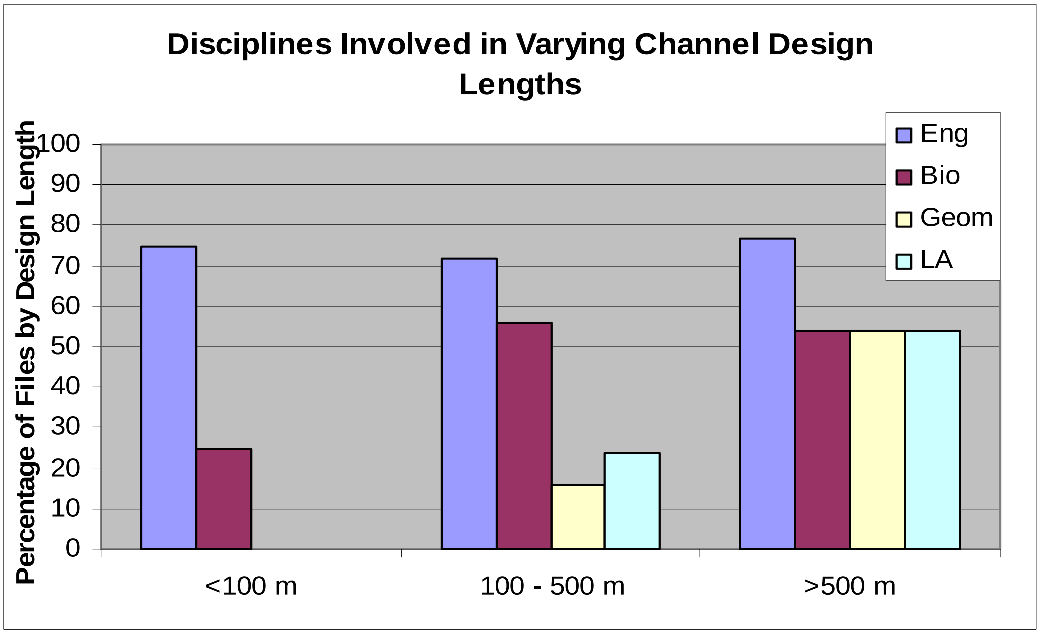
Figure 9. Disciplines represented on stream re-alignment project design teams for re-alignment projects authorized in Ontario between 1997 and 2001.

Most of the small projects were conducted with one discipline, whereas moderate and large scale projects had two and three discipline design teams. Engineering involvement was consistent at 70-75% of small, moderate, and large scale projects. Other disciplines were represented in increasing proportions as project size increased (Figure 10).



Note: Eng – Engineer; Geom – Geomorphologist; Bio – Biologist; LA – Landscape Architect

Figure 10. Disciplines involved in different sized stream re-alignment projects that were authorized in Ontario between 1997 and 2001.

4.2.4 File Review Summary

For the 44 project files that were examined as part of this study, there were significant inequalities between small and large projects. More quantitative habitat gains were achieved in larger projects, which may simply relate to the space and stream length available for re-alignments. Both the quality of data and the mix of disciplines were poorer in smaller and moderate sized projects. However, since the majority of projects were in the moderate size class and have more potential for increases in both quantity and quality of habitat, consideration should be given to criteria for ensuring appropriate interdisciplinary involvement is represented on specific projects. In addition, most files had a lack of documented or rationalized objectives. Therefore, the value and type of improvements to be realized, and the post-construction measurement of success, are not well understood.

4.3 POST-CONSTRUCTION FIELD COMPARISONS

Ten projects were selected for case study analyses which included both a detailed paper file review as well as a field assessment. One of these projects was never implemented in the field (Table 1, Project 10), leaving nine projects for post-construction field comparison. The field program was undertaken during the fall of 2003 using a modified rapid assessment technique combining geomorphologic and ecological parameters. After each individual project was assessed and compared to its respective design, approval, and pre-construction conditions, summaries of each assessment were synthesized so general trends across all nine projects could be reviewed (Table 1).

Projects were selected based on a level of file information amenable to post-construction comparisons. The post-construction time of projects ranged between 2 to 4 years since authorization. Although the project teams generally had engineering involvement (8 of 10), the other team disciplines were variable in their participation. Biologists were involved in seven projects, geomorphologists were included in three, and landscape architects in four projects (Table 1).

Qualitative assessments were made of the static, or existing, stability of each site, as well as long term, dynamic stability and erosion risk. Project sites were generally stable at the time of field observations. Parameters related to erosion risk and dynamic geomorphic stability deal more with interpretations of longer term trends in each project reach. Erosion risk reflects a combination of visible evidence and interpretation of other geomorphic variables, to predict future channel adjustments toward an unstable situation, or away from intended project outcomes. Dynamic geomorphic stability is associated partially with erosion risk and relates to long term stability with natural levels of channel adjustment within project objectives. Most projects were assessed as having relatively low erosion risk (two projects ranked in the ‘moderate-high’ category). With respect to dynamic stability, one project ranked ‘moderate-poor’, but all other projects ranked relatively well (Table 1).

Execution is a reflection of whether project components were all installed in accordance with the authorized design with consideration of seven specific project elements as follows:

- Stream configuration/geometry;
- Pools/riffles/instream structures;
- General dimension;
- Riparian plantings;
- Substrate in pools/riffles;
- Erosion control measures; and
- Bank structures.

One project fully executed all seven elements, and all projects executed at least four elements successfully (Table 1). While it is possible that some omissions resulted from projects not giving design consideration to specific elements, the analysis still assessed execution as seven elements of a complete design.

Project Survival refers to the survival of executed project features up to the point of field assessment. Project Survival was observed to be good in seven of the projects. One project was defined as moderate-poor in Project Survival and one project was classified as good-moderate. As would be expected, the project with higher erosion risk ranked lowest for project survival.

Table 1. Comparison of features between selected channel re-alignment projects.

Case Number	Age (Years)	Design Team	Erosion Risk (Post Construction)	Stability	Dynamic Geomorphic Stability	Project Execution	Project Survival	Habitat Quality	Habitat Quantity
1	2.5	Eng	Low	Good	Good	5 out of 7	Good	Improvement	Improvement
2	~3.5	Eng	Moderate-high	Good	Good-moderate	4 out of 7	Good	Improvement	Improvement
3	4	Eng, Bio, Geo, LA	Low	Good	Good	7 out of 7	Good	Improvement	Improvement
4	~3.4-4	Eng, LA	Low-moderate	Good	Good	4 out of 7	Good	Potential Improvement	Improvement
5	4	Eng, Bio	Moderate-high	Moderate	Moderate-poor	5 out of 7	Moderate-poor	Improvement	Improvement
6	2-3	Eng, Bio	Low	Good	Good	6 out of 7	Good	Improvement	Improvement
7	Unknown	Eng, Geo, Bio	Low-moderate	Good	Good	6 out of 7	Good	Improvement	Improvement
8	2.5	Bio, Eng	Low-moderate	Good	Good	Unable to Assess	Good	Potential Improvement	Improvement
9	2.7	Bio, LA, Geo	Moderate	Good	Good	5 out of 7	Good-moderate	Improvement	Improvement
10	2	Bio, LA	Project not implemented in field						

1. Design Team = Eng – Engineer; Geo – Geomorphologist; Bio – Biologist; LA – Landscape Architect
2. Erosion Risk = an overall view of the risk of erosion for the whole length of the study area. Several parameters are looked at to come up with a ranking. For example overall erosion extent, severity, bank stability and riparian vegetation robustness. Bank structures and general dimensions are also considered for the entire study area (low/moderate/high)
3. Stability = a combination of several factors including bank stability (vegetation on banks or actual bank stabilization structures), stability of prior channel, straightness of channel, low average energy grade, erosional resistance of bed and bank material, minimal channel shortening, presence of bedrock on channel bed or banks that control channel form, instream structures that control channel grade, management of flows (good/moderate/poor)
4. Dynamic Geomorphic Stability = associated partially with erosion risk and related to long term stability with natural levels of channel adjustment within project objectives.
5. Project Execution = number of elements accomplished. Seven specific elements were considered: stream configuration/geometry; pools/riffles/instream structures; general dimensions; riparian plantings; substrates in pools/riffles; erosion control measures; bank structures
6. Project Survival = refers to survival of executed project features up to the point of field assessment (good/moderate/poor)
7. Habitat Quality = includes an assessment of post construction substrate diversity, morphologic diversity and instream cover (improvement/no improvement)
8. Habitat Quantity = increase in length of stream after construction, increase in habitat volume (improvement/no improvement)

Habitat Quality was derived from the post construction assessment of substrate diversity, morphologic diversity, connectivity, and instream cover features. Habitat Quantity was derived from the assessment of changes in habitat volume and length of stream channel after construction. Changes in habitat volume reflect interpreted movements in channel cross-sections. For example, an improvement was considered when the stream profile of the re-alignment was altered from wide and shallow to deep and narrow with a more concentrated low flow channel. This newly constructed low flow channel would likely remain inundated for a longer period annually and provide better instream habitat than a relatively wide, shallow channel.

Improvements in Habitat Quantity were observed in all of the case studies, while improvements in Habitat Quality were observed in seven of the projects with potential improvements seen in two. The degree and direction of change could, however, not be definitively assessed. Pre-construction ecological conditions were documented to varying degrees, and ecological objectives for project reaches were generally poorly rationalized or documented. Additionally, all of the selected projects were in relatively disturbed or modified streams, and therefore, were more likely to exhibit improvements through the re-alignments.

5.0 CONCLUSIONS

The following general conclusions and recommendations were derived from a combination of the detailed DFO file review and the field comparison of pre- and post-construction conditions for ten case studies:

- Few projects contained design objectives or rationale for habitat improvement;
- Approximately 30% of project files contained as-built or follow-up information (monitoring reports);
- There was a general improvement in habitat quantity and quality in post-construction conditions for 10 case studies selected for relatively good quality of file information;
- Results indicate that overall DFO's guiding principal of "no net loss" of the productive capacity of fish habitat" was met for the 10 selected case studies ;
- Selected projects do not likely represent a cross-section of projects authorized and larger projects tended to contain multi-disciplinary involvement;
- Relatively few files contained good quality biological information for fisheries review despite a relatively high proportion of project teams with biologists;
- Approximately 1/3 of projects that were authorized by DFO involved a single discipline on the design team, as represented in the file information;
- The level of involvement of geomorphologists in projects was relatively low; and
- Standard information is lacking in project files, regardless of the level of detail.

6.0 RECOMMENDATIONS

- Ecosystem or fish habitat targets and rationale are necessary to direct design options and measure success in monitoring post-construction conditions;
- Consideration should be given to developing strategies to consistently monitor compliance of authorized and constructed projects, provide performance monitoring data, and contribute to the adaptive management cycle in stream management;
- Standard protocols are needed for rapid assessment in pre-construction conditions, synchronized as a baseline for post-construction monitoring, as well as for standard design considerations;
- Approval requirements should include consideration of the combination of habitat quality and quantity of assessed habitat types to produce desired post-construction conditions; and
- Consideration should be given in the approvals process to enhance the balance of disciplines required in channel re-alignment projects.

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APPENDIX A: RATIONALE FOR DESIGN EVALUATION

OBJECTIVES

Many monitoring programs have been established around the world to evaluate the success of channel restoration and enhancement works. Fisheries and Oceans Canada (DFO) recognizes the importance of monitoring and always prescribes a monitoring program as part of the *Fisheries Act* authorization for any proposed re-alignment. In general, although monitoring may be undertaken, when it lacks clear and measurable objectives the information and data that are collected may be of limited usefulness in defining whether or not the project has attained its intended objective. A successful project evaluation program must therefore clearly identify measurable goals that will determine whether or not a project has been successful. Due to the variable nature of different re-alignment projects (e.g., setting, physical constraints, aquatic habitat conditions, species diversity, target species) the measures of project success will differ among projects.

In general, success of a stream re-alignment project should be measured against the principle of “no net loss” of productive capacity. The evaluation program must therefore rely on parameters that are measurable and which provide indications of ecological function, integrity, habitat production potential, and the “no net loss” principle. In addition, the intensity of the evaluation program should be designed taking into consideration the project’s level of risk to impact fish and fish habitat. Factors such as scale of negative effect of the project and sensitivity of fish and fish habitat should be considered when determining the appropriate level of effort of the evaluation program.

Rutherfurd et al. (1999) and Kondolf and Micheli (1995) further discuss project evaluation designs in which the objectives of individual projects are key determinants of specific evaluation techniques. This project, however, will rely on more generally applicable evaluation objectives:

1) Did they build what was approved?
2) Does the project promote dynamic stability or is it failing physically?
3) Is the project achieving “no net loss” and/or specific fisheries objectives?

If projects are not consistently built according to the approvals, then there are mechanisms needed to monitor or enforce the implementation of projects. If projects were built to the requirements of the DFO authorization, but are unstable or unproductive, there are likely improvements in approval requirements (e.g., project team disciplines, levels of analytical detail, establishment of targets) that are needed.

Indicators of whether or not a re-aligned channel has resulted in a “no net loss” of productive habitat condition will be identified differently among the study disciplines represented in the project. For example, a biologist may identify the presence of target species in the re-aligned channel as indicative of project success, a geomorphologist may focus on the balance of erosion and deposition within the channel, a terrestrial

PHYSICAL AND BIOLOGICAL INDICATORS

ecologist might evaluate the rate of vegetative species survival, and an engineer might evaluate project success based on structure survival.

Reliance on physical indicators alone in determining the extent to which productive capacity has been achieved is inadequate. A recent manual, “Adaptive Management of Stream Corridors in Ontario” (Ontario Ministry of Natural Resources and Watershed Science Centre 2002), stresses the need for inclusion of biological indicators of success in project evaluations and monitoring through the following excerpt of discipline-specific indicators of success:

- *Geomorphology* – channel has achieved some form of equilibrium with appropriate movement, storage, and sorting of materials (modified or based on constraints that were inherent to the location and to the design);
- *Ecology/Biology* – protected or enhanced biological functions including fish habitat, species-specific habitat or specific life stage habitat.

Kondolf and Micheli (1995) have found that the success criteria applied during post-project evaluations have historically focused on biological more than geomorphological factors. They point out, however, that the interaction between a stream channel, floodplain, and stream flows provide the framework supporting aquatic and riparian structures and functions. Gregory et al. (1991) also indicate that geomorphological factors are primary determinants of the spatial and successional patterns of biological communities. For these reasons, determination of project success/failure with respect to evaluating whether a channel re-alignment has resulted in a “no net loss” of productive capacity condition should be based on both biological and geomorphological evaluations of the post-construction channel condition.

While not always the case, riverine aquatic communities likely have the greatest potential to achieve optimum productivity in a dynamically stable stream system/reach. Stream systems/reaches that are unstable may support more productive aquatic communities in the short term. However, such communities are typically not representative of indigenous or optimum community functions. A stable reach is also typically a prerequisite for constructing habitat enhancement measures. Subsequent failure of such measures is often the result of reach level instability (Rosgen 2001).

A key lesson from the development of the “Adaptive Management of Stream Corridors in Ontario” (Ontario Ministry of Natural Resources and Watershed Science Centre 2002) as well as the Ontario Ministry of Natural Resources Stream Assessment Protocol (Stanfield et al. 2000) is that parameters measured in the field may serve to interpret both the geomorphic stability and the biological integrity of a reach. Therefore, coordination between these two disciplines is required to establish data collection protocols. For instance, geomorphologists may measure the size and spacing of pools and riffles in the reach as part of an assessment of stability and sediment transport efficiency. Biologists often require information on the relative extent of these features, along with percent cover, in order to assess morphologic diversity or quality of a life history micro-habitat for biotic integrity.

EVALUATION FRAMEWORK

Both the "Rehabilitation Manual for Australian Streams" (Rutherfurd et al. 1999) and the "Adaptive Management of Stream Corridors in Ontario" (Ontario Ministry of Natural Resources and Watershed Science Centre 2002) provide a valuable framework for development of a monitoring program. The monitoring strategy that has been developed for this study is largely derived from the information contained within these two reports. Rutherfurd et al. defined five groupings of project outcomes that may define the framework of post-construction project evaluation (Table A-1).

Table A-1. Project Evaluation Groupings (from Rutherfurd et al. 1999).

Execution	Determine if works have been completed as designed. – Is constructed channel as shown on the design drawings?
Survival	Determine if works withstand the expected natural events (e.g., structure, vegetation). – Are in-channel habitat features in intended locations? – Are bank protection and bio-engineering structures intact or at risk of failure (e.g., through undermining, outflanking)? – Is vegetation establishing on the floodplain?
Aesthetic	Assess whether works produce a more attractive natural environment especially in park-like settings.
Physical/ Structural Outcomes	Examine if project improves habitat by increasing physical and hydraulic diversity. – Have substrates and structures remained in intended locations? – Is sediment transport (deposition or scour) efficient and stable? – Are lateral migration and bank erosion occurring as expected? – Is the project reach dynamically stable?
Ecological Outcomes	Improve population size, diversity, and sustainability of plant and animal communities. – Is the physical habitat functioning to support target species or processes? – Does the project reach contribute to improved biological stability? – Do biological production, presence of target species, life history stages, and ecological processes indicate that the "no net loss" principle has been achieved?

APPENDIX A: RATIONALE FOR DESIGN EVALUATION (Continued)

Confidence in the results of a post-construction project evaluation depends on the design of the evaluation program. Rutherfurd et al. (1999) identified five monitoring designs which provide varying levels of reliability and confidence for detecting actual change. They, and others, suggest that the choice of monitoring design should be sufficient to evaluate the success or failure of a project for the intended audience and for fulfilling objectives of the study (Table A-2). In general, the weakest evaluation program consists only of visual observations. Confidence in whether the evaluation detects actual success/failure increases when incorporating replication (i.e., multiple samples both spatially in the channel and in time), controls (e.g., reference reach upstream, downstream, or nearby), and baseline data (i.e., prior to alteration). Observations of aquatic habitat and channel conditions within a re-aligned channel do not identify whether the observations are due to the re-aligned channel or are a result of system wide/watercourse characteristics (e.g., abundance and diversity of fish species, sedimentation in channel). For this reason, confidence in results of an evaluation program increases when a similar assessment is completed in a control reach.

Table A-2. Different Levels of Monitoring Design (from Rutherfurd et al. 1999).

Plastic	anecdotal, no sampling, only observations
Tin	unreplicated - uncontrolled, sampling only after rehabilitation
Bronze	unreplicated - uncontrolled, sampling before and after rehabilitation OR unreplicated - controlled, sampling only after rehabilitation
Silver	unreplicated – controlled, sampling before and after intervention
Gold	replicated sampling – replicated sampling both before and after

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APPENDIX B: PRELIMINARY STREAM RE-ALIGNMENT PROJECT INFORMATION CHECKLIST

RE-ALIGNMENT PROJECT INFORMATION CHECKLIST- PRELIMINARY

Please insure that you complete this checklist to the best of your ability. A detailed initial application will assist in the file review process. Please fill in the appropriate blanks and check the relevant boxes.

1.0 PRE-CONSTRUCTION CONDITIONS

1.1 Physical condition

Grain size: Bed_____ Sub pavement ______
Soil type: (Circle 1): Bedrock Fine soils Clay/silt Alluvium
Channel Dimensions:
Channel width (m): Bankfull _____ Baseflow______
Channel depth (m): Bankfull _____ Baseflow ______
Channel length (m) ________
Cross-sectional configurations
Average bank slope _____ Average bank height _____
Flow Regime (Circle 1): Intermittent Ephemeral Perennial
Flow Velocity: _____ (cm/s, cfs, l/s). Please fill in and circle unit of measure
Photographic inventory of the channel (before construction) provided: □

1.2 Biological Condition

Presence of natural riparian vegetation _____ Pictures provided: □
Please provide a list of the fish community present in the watercourse:

____
____
____
____
____

Species information acquired through:
- Electro fishing survey □ Date: ________________
- Historical MNR records □
- Other documents □

Reference for documented information: _______________________________

Average stream temperature: ________ ºC
Use of impacted area as spawning, nursery, rearing, food supply or migration route

APPENDIX B: PRELIMINARY STREAM RE-ALIGNMENT PROJECT INFORMATION CHECKLIST (Continued)

2.0 PROPOSED DESIGN

2.1 Design Rationale

Please state the design rationale for this project:

____
____
____
____
____
____

2.2 Design Approach

Method(s) used to determine channel dimensions and parameters. Circle 1 or more of the following:

Reference Reach	Rosgen	Hydraulic Analysis	Geomorphologic Considerations

2.3 Design Parameters

Design discharge: __________ (Units?)
Design velocity: __________ (Units?)
Channel Slope: ____________
Channel length (m) __________
Channel width (m): Bankfull _____ Baseflow______
Channel depth (m): Bankfull _____ Baseflow ______
Please specify new substrate materials:

____
____
____

Bank treatments proposed (Please circle)
Boulder clusters Root wads Fascines Amour stone Other
Other (Please specify):

____
____

APPENDIX B: PRELIMINARY STREAM RE-ALIGNMENT PROJECT INFORMATION CHECKLIST (Continued)

2.4 Design Drawings

Locations of the pools, riffles and runs are shown □
Planform configuration drawing is included □

- Bank stabilization – temporary protection
- Revegetation plan

3.0 SUMMARY OF PROPOSED CHANGES

Please complete the following table:

	Channel Length (m)	Channel Width (m) (Bankfull)	Habitat units (Units?)
Pre-construction:			
Post- construction:			
Change:			

4.0 POST CONSTRUCTION MONITORING

As-built drawings to include: (Please check the following boxes)

- planform drawing □
- detailed profile drawing □

Positions of pools, riffles and other instream features are documented □
Typical channel section drawing is provided □
Photographs of as-built features included: □
The photographic inventory of the as-built channel must be catalogued to correspond to the as-built drawings

5.0 PROPOSED MONITORING PROGRAM

- Outline recommended monitoring strategy that will evaluate channel stability

____
____
____

APPENDIX C: PHASE 1 CHECKLIST TO INVENTORY FILES AND CONTENTS FOR SELECTION

DFO Channel Re-alignment StudyPhase 1 checklist G2353/64114

Phase 1: Checklist to inventory files and contents for selection

- DFO Project Number:
- Date of approval:
- Date of construction:

- Channel length Pre-construction: ___ m Post-construction: ___ m
- Width Pre-construction: ___ m Bkfl, Bot W, Base flow
  Post-construction: ___ m Bkfl, Bot W, Base flow

- Design flow: bankfull, 2-year, 5-year, 10 – year, 25 year, 100 year, regional

Impetus for re-alignment

- New road crossing ___
- Road widening ___
- Culvert replacement ___
- Drainage/stormwater management ___
- Land Development ___
- Wetland/pond creation ___
- Stability/erosion control ___
- Channel bed lowering ___
- Pipeline crossing ___
- In-channel works ___

Study Team Disciplines

- Biologist ___ Geomorphologist ___ Engineer ___ Landscape Architect ___ unknown ___
- Landscape Architect for riparian and floodplain vegetation ___
- What discipline was the manager? _________

Project Constraints

- Documented Y/N ___
- Valley constriction ___
- Vertical barriers or control points ___
- Structures (e.g. pipes, private property, roads, culverts, etc.) ___

APPENDIX C: PHASE 1 CHECKLIST TO INVENTORY FILES AND CONTENTS FOR SELECTION (Continued)

Pre-construction channel conditions

- Geology: Bedrock ___ Fine Soils (e.g., clays/silts) ___ Alluvium ___
- Physical channel characteristics:
    - Channel dimensions (e.g., width, depth, substrate)
    - Grade ______ % m/m other unit: ___
- Type of land use
- Rate of change of land use
- Degraded Y/N
- Natural or unnatural
- Rosgen Type ___
- Flow Regime? intermittent, ephemeral, perennial
- Bankfull flow?
- Grade?
- Channel defined, undefined, poorly defined, swale
- Habitat:
    - Presence of natural riparian/bank habitat Y/N ___
    - Warmwater or Coldwater system _____
    - Barriers Y/N ___
    - Is there information on aquatic habitat through study reach (e.g., stream morphology)? ___
    - Is there information on aquatic habitat at larger scale? ___
    - Information on habitat or water quality (e.g., temperature data) ___
- Biology:
    - Fish species information Y/N ___
    - Fish sampling done for this project Y/N ___
    - Are there target species Y/N ___
    - What species if listed ______________________
    - Benthic invertebrates Y/N ___

Design Rationale

- Documented Y/N ___
- Approach: reference reach, Rosgen, hydraulic
- Geomorphological or Biological Calculations Y/N ___
- Engineering calculations Y/N ___
- Awareness of biology?
- Awareness of geomorphology?
- Fisheries Design Targets _____________________________
- Information on scale Y/N __

APPENDIX C: PHASE 1 CHECKLIST TO INVENTORY FILES AND CONTENTS FOR SELECTION (Continued)

Channel Design

- Design Flow ______ cms, cfs, l/s
- Channel dimensions (e.g., width, depth, substrate)
  - Bankfull indicated?
- Bank treatments:
  - Concrete ___ armourstone ___ rip-rap ___
  - Gabions ___ bio-engineering ___ none ___
- Bed treatments:
  - Armourstone ___ rip-rap ___ natural materials ___
  - Riverstone ___
- Post construction grade? ___

- Fisheries Habitat Design Targets Y/N? ___ and specifics __________________
- Riparian Habitat Considerations Y/N? ___

- Monitoring Recommended by design team ___
- Compensation type – list to be created as the files are searched

Project Approval Documents

- Copy of authorization in file Y/N ___
- Copy of application ____
- Design drawings ____
- Monitoring reports ____
- # requested (in authorization document) ____ and received (in file) ____
- CEAA reports ___
- EIS or fisheries analysis report ___

- As-built sign off? ___ Construction Supervision Compliance report

Comments:

APPENDIX D: FIELD DATA SHEET AND DATA COLLECTION PARAMETERS

RAPID STREAM ASSESMENT

Name:
Project No:

Date ____________________ **Site #** __________ Reach or X-Section **Length** ____________________
Location ____________________ **Weather** ____________________________________ Pre Post Ref

Photo #	**Location**
	map? ☐

Reach Characteristics

length ___________ gradient _____________
instream cover: pool ___ boulder ___
veg ___ lg woody debris ___ overhang ___
% pool ____ % riffle ____ % run ____ % flat ____

Channel Dimensions	run	flat	pool	riffle
Bankfull depth				
Bankfull width				
Baseflow depth				
Baseflow width				
Entrenchment				

Evidence of floodplain connection:

Bars	none	seldom	consistent
medial	☐	☐	☐
lateral	☐	☐	☐
point	☐	☐	☐

Substrates

	% fines	sands	gravels	cobbles	boulders	organic	litter	bedrock	other
Pool	____	____	_____	_____	______	_____	____	______	____
Riffle	____	____	_____	_____	______	_____	____	______	____

% of reach disturbed by fines _________ Embeddedness % _____
Coarser in riffles than pools? _________
Native material exposed? ___________ Substrate Habitat Quality = G M P
Comments ____

Erosion	downcut ___ widening ___ headcut ___ bedscour ___ sloughing ___ planform __
Location	meander bend _____ straight ______ valley wall _______ structure _______

Erosion Severity: Erosion Extent:

Thalweg			
follows planform:	no	mod	yes
flow diversity	low	mod	high
directed at bank:	low	mod	high

Biota
benthos _____ algae % _______
macrophyte % _____
types __________ __________ __________
fish present? _________ source __________

Water Quality
temp.______ time_______ clarity ___

parameter	measurement

Banks	pool	riffle
% undercut	________	_________
slump	________	_________
bare	________	_________
rock	________	_________
wood	________	_________
vegetated	________	_________

Bank Stability
G M P

Bank Height:_____________
Bank Material:_____________

Riparian Vegetation
% overhead cover ____
Robustness G M P
Dominant types ____________________
% of each ____________________

Roots
shallow _______
deep _______
sparse _______
dense _______

Project Execution Data
Comments

Y/N	**Project Data**	Y/N
☐	Stream configuration / geometry?	☐
☐	Pools / riffles / instream structures?	☐
☐	General dimensions?	☐
☐	Riparian plantings?	☐
☐	Substrates in pools / riffles?	☐
☐	Erosion control measures?	☐
☐	Bank Structures?	☐

Survival Comments: (e.g., structures in place and intact)

APPENDIX D: FIELD DATA SHEET AND DATA COLLECTION PARAMETERS (Continued)

Data Collection Parameters/Rapid Stream Assessment (RSA) Parameters

Banks – The condition of the banks provide insight into channel stability, future potential stability, and channel processes (e.g., widening, migration). Observations that are indicative of stability and processes include: undercutting, condition of bank face (e.g., unvegetated, rock, woody debris), and the role/potential of vegetation to enhance the structural strength of the bank materials (e.g., relative rooting depth, rooting density, presence of grasses/herbs/forbs on the bank face). Wherever appropriate, a percentage of the banks with the above-noted characteristics will be quantified.

Bank Height and Bank Material – The height of the bank from the toe of the slope to the inflection point will be measured only if it is greater than the bankfull depth. In general, the greater the bank height, the greater the susceptibility to erosional problems. The material that comprises the bank is important in the assessment of stability as some types (e.g., silt, sand) are more prone to erosion than others (e.g., clay, bedrock). Therefore, all bank materials should be recorded in the space provided.

Bank Stability – The overall stability of channel banks will be rated as Good (stable), Moderate (local incidence of instability), or Poor (generally unstable).

Bars – Depositional features will be documented with respect to location in the channel (point, medial, lateral) and relative abundance (none; seldom – 1 or 2 per 100 m; consistent – throughout the re-aligned channel). The presence and location provide insight into the sediment transport capacity of the re-aligned channel, sediment supply, and hydraulic conditions through the cross-sections. This information will be used to identify discontinuity in sediment transport processes between adjoining channel sections and/or pre-existing channel conditions.

Biota – The presence or absence of certain types of aquatic organisms are often used as indicators of stream health. Benthos (benthic invertebrates) are commonly used in stream assessments. The presence/absence of certain taxa can be indicative of a healthy stream (e.g., mayflies, stoneflies present) or unhealthy systems (e.g., these taxa not present). If benthic invertebrate data exists for the relevant section of stream, then a check mark should be put in the appropriate space on the data sheet. Macrophyte percent cover and types (submerged, emergent, floating) should be recorded, as instream aquatic vegetation provides habitat for both benthic invertebrates and fish. The percent cover of algae within a stream can often be an indicator of nutrient enrichment and temperature. Abundant algae growth is often the result of increased nutrient loadings and high temperatures. The presence/absence of fish within the stream should be

APPENDIX D: FIELD DATA SHEET AND DATA COLLECTION PARAMETERS (Continued)

Data Collection Parameters/Rapid Stream Assessment (RSA) Parameters (cont'd)

Biota (cont'd) – recorded, as the provision of functional fish habitat is usually one objective of DFO authorizations for stream alterations. An indication of whether the fish presence/absence was a field observation or based on existing data should also be recorded.

Channel Dimensions – Channel dimensions are a product of the interaction between hydrologic regime and boundary materials. Bankfull and low-flow (baseflow) width and depth will be measured using a tape or ruler and compared to the design drawing to detect general infilling or section enlargement. Change in cross-section dimensions may have occurred during channel construction or may be a result of channel adjustments due to improper design. Other information gathered during the RSA will provide insight into the cause of changes in channel dimensions. Entrenchment refers to the relationship between a channel and its valley, and is a measure of the vertical containment of a watercourse. Entrenchment is quantified as the ratio of the flood-prone area at twice the maximum bankfull depth to the width of the bankfull channel. Measurements will be taken at riffle sections along the re-aligned channel.

Erosion – Erosion can occur anywhere along a channel (banks, bed, meander bends) and is a process that occurs in all natural watercourses. Excessive erosion may be indicative of larger scale adjustment processes. Erosion along the re-aligned channel will be classified (with check marks) with respect to dominant modes of channel change (e.g., downcutting, widening, headcutting, bed scouring, bank sloughing, and planform adjustment). The location will be marked on a copy of the design drawing and identified as meander bend, straight section, valley wall, or at a structure (e.g., culvert). Observations of erosion, along with other observations made during the RSA (e.g., substrate, thalweg), will provide insight into the processes at work in the re-aligned channel, its present stability, and its future stability.

Erosion Severity and Extent – Erosion severity and extent enables the field reviewer to document additional notes pertaining to observed erosion (e.g., if incidence was local and associated with thalweg orientation, meander migration/extension, meander cut-off processes, etc.). This information will provide further insight into the processes that are occurring in the re-aligned channel and can be used to assess channel stability.

APPENDIX D: FIELD DATA SHEET AND DATA COLLECTION PARAMETERS (Continued)

Data Collection Parameters/Rapid Stream Assessment (RSA) Parameters (cont'd)

Floodplain Connection – The floodplain connection ensures that the energy of larger than bankfull flows will be dissipated on the floodplain and therefore not be available for erosion and/or sediment transport. Connectivity will be assessed in the field through a visual examination and an estimate of entrenchment. The connectivity may account for observed instability and/or excessive erosion within the channel.

Photos – Photos will be taken to document channel and floodplain characteristics and specific indicators of instability/erosion. Photo locations will be marked onto a design drawing that shows the planform configuration.

Project Data – During the rapid reconnaissance visit, elements of the designed channel will be checked to determine if they were constructed (i.e., execution) as per the design drawings (e.g., presence and location of features) and if/how they have survived. Specific observations will include: stream configuration/geometry (e.g., planform), pools/riffles/in-stream structures (e.g., boulders, rock vanes), cross-section dimensions, riparian plantings, relative substrate distribution (pools/riffles), erosion control measures (in place/removed, functioning), bank structures (e.g., bio-engineering, rock). All observations will be made with reference to the design drawings. The condition of the features or any deviation from the design would be documented on the design drawings or noted on the RSA data sheet.

Reach Characteristics – Reach characteristics provide an overview of reach characteristics that are useful for comparison to the pre-existing reach conditions and are descriptive of the re-aligned channel. Relevant characteristics will be documented (checked) with respect to presence within the reach (large woody debris, pools, boulders, overhangs, vegetation). Percent presence of pools, riffles, runs and flat channel sections provides an indicator of hydraulic diversity and flow energy dissipation mechanisms within the channel.

Riparian Vegetation – Riparian vegetation provides stream shading (temperature moderation), a trophic link between the terrestrial and aquatic environments, and bank stability. An estimate of the percent of shading (overhead cover) will be taken. The dominant types of vegetation (trees, shrubs, grasses, emergents) will be noted along with the percent contribution of each to the reach being assessed. The general robustness, or condition, of the riparian vegetation should be recorded as good (plants appear healthy with new growth evident), moderate (stress evident, minimal growth) or poor (plants clearly

APPENDIX D: FIELD DATA SHEET AND DATA COLLECTION PARAMETERS (Continued)

Data Collection Parameters/Rapid Stream Assessment (RSA) Parameters (cont'd)

Riparian Vegetation (cont'd) –stressed or dead). If possible, the root characteristics along the banks should be described as shallow or deep and sparse or dense. This can aid in the assessment of bank stability.

Substrates - Variability in grain size naturally occurs between riffles and pools due to changes in hydraulic condition (substrates should be coarser in riffles than in pools). Estimating grain size distributions (as % composition by grain size) provides insight into design survival, channel stability and channel processes. Exposure of bedrock or underlying native materials will also be documented and may be indicative of downcutting and/or adjustments in the configuration of bed morphology. Presence of organic material, (leaf litter, small woody debris, other detrital material) will noted in comments. Percent of reach disturbed by fines refers to the abundance of fine-grained sediment throughout the reach which may be representative of natural conditions or of an excess of sediment loading/insufficient sediment transport capacity. Information on substrate conditions in a reference reach or pre-existing channel conditions is necessary for a comparative evaluation. Embeddedness is an indicator of abundant fine sediment supply and/or of insufficient sediment transport capacity (e.g., due to an over-wide channel). Embeddedness will be documented as a relative percentage based on visual estimates. Comparison to pre-existing data or reference reach data can provide an indication of whether the present substrate condition is natural for the reach or has been altered as a result of the re-aligned channel.

Substrate Habitat Quality – Substrate habitat quality will be recorded in the "substrates" section of the data sheet., marked as good, moderate, or poor for aquatic organisms (benthic invertebrates and fish), based on an assessment of the parameters discussed above. Good habitat quality refers to that which can be used by organisms for shelter, spawning, foraging, etc. This rating is dependent upon target species, or the organisms that are expected to live in the area of study. The degree of embeddedness, size, and composition of substrates all often contribute to an area's habitat quality. In riffle areas, good substrate habitat quality refers to a low percentage of fines, low embeddedness, and a diversity of grain sizes. Poor quality substrates are dominated by fines or have coarser materials embedded within the fines. Moderate quality substrates contain a mixture of good and poor characteristics. In contrast, in slow flowing areas, fine sediment with abundant vegetation growth may constitute good habitat. Therefore, the substrate habitat quality rating should be based on both

APPENDIX D: FIELD DATA SHEET AND DATA COLLECTION PARAMETERS (Continued)

Data Collection Parameters/Rapid Stream Assessment (RSA) Parameters (cont'd)

Substrate Habitat Quality (cont'd) – the existing substrate conditions and the target species or those species expected to live there. This information should be included in the comments section.

Thalweg – The position and orientation of the thalweg is indicative of the areas of flow stress during high flows and may correspond to areas of erosion (e.g., meander migration, channel adjustment). Specific observations include whether the thalweg follows the planform, flow diversity (i.e., fast and slow moving sections), and if flow is directed at the bank. The observations will be ranked into no/low (never, or seldom), moderate (occurrences observed), and yes/high (always or almost always). This information is used in conjunction with observations of other parameters to gain insight into channel stability and potential for future change.

Water quality – Water quality will be examined where appropriate (i.e., when baseline data exists). At a minimum, water temperature should be measured, as well as the time at which the measurement was taken. In addition, water clarity can be described as clear, clear but stained or turbid, but weather conditions during the previous week must also be noted since turbidity can be dependent upon run-off. The degree of turbidity can be visually estimated in the field and recorded in the appropriate place on the data sheet. Additional parameters can be measured if budgets allow (e.g., pH, conductivity, dissolved oxygen).

APPENDIX E: INDICATORS OF PROJECT SUCCESS

DETERMINANTS OF STABILITY OF RELOCATED CHANNELS

Brown (2002), in his review of more than 400 projects, found that the key factor contributing to the success of a restoration structure occurred when the design was based on an understanding of stream processes and an accurate assessment of current and future stream channel conditions. This finding confirms results reported by other researchers who indicated that channel instability may result when a proposed channel design does not account for processes operating in the channel (e.g., increasing discharge, current disequilibrium conditions) or consider appropriate long term processes that are operative upstream and/or downstream of the proposed re-alignment.

Brice (1981) identified key factors that contribute to the stability of relocated channels through completing a review of channel re-alignment projects (Table E-1). Review of Table E-1 clearly shows that numerous factors contribute to channel stability and either directly or indirectly to the productive capacity of a re-aligned stream channel. Awareness of these factors is important as they may be used to explain project success and/or failure. Isolating factors during project evaluation can be accomplished by grouping projects with similar characteristics (e.g., similar flow regime, slope, length, etc.).

Table E-1. Factors Important to the Stability of Relocated Channels (from Brookes (1988) based on Brice (1981)).

Site Factors	stream flow, habitat, drainage area, water discharge, channel width, bank height, sinuosity, stream type, valley relief, channel boundary material, incision of channel, vegetation cover along banks, prior channel stability, human works
Alteration Factors	length of relocation, slope and cross-sections of relocated channels, aspects of channel alignment, measures for erosion control and environmental purposes
Post-alteration Factors	length of performance period, streamflow during performance period, post-construction maintenance and addition of countermeasures, growth of vegetation along the channel

The productive capacity of a watercourse is, in part, determined by channel stability, although some instability and channel change may be beneficial to the aquatic community. An understanding of the factors that contribute to the stability and instability of relocated channels is beneficial when determining parameters that should be included in the post-construction project evaluation. Brookes (1988) summarized these factors, based on a review of Brice's (1981) work (Table E-2).

APPENDIX E: INDICATORS OF PROJECT SUCCESS (Continued)

Table E-2. Critical Factors Contributing to the Stability and Instability of Relocated Channels (from Brookes (1988) based on Brice (1981)).

Stability	Instability
• Growth of vegetation on banks • Bank stabilization structures (e.g., rock, bio-engineering, erosion control blankets) • Stability of prior channel • Straightness of channel • Low average energy grade (i.e., bankfull slope of channel) • Erosional resistance of bed or bank materials • Minimal channel shortening in the relocation • Presence of bedrock on channel bed or banks that controls channel form • In-stream structures that control channel grade (e.g., check dam or drop structure) • Management of flows (e.g., storm water management, dams) both within and diverted to the channel • Few floods in first few years after construction • Preservation of original channel	• Incorporation of bends in relocated channels • Floods of large recurrence interval soon after construction • Erodibility of bed or bank materials • High channel side, susceptible to slumping • Instability of prior channel • Sharp decrease in channel length • Failure of revetment • Abrupt change in channel width (e.g., increase or decrease) • Absence of vegetation along bank • Flood soon after construction • Lack of continuity in vegetation cover along banks • Turbulence at check dam or drop structure • Flow constriction at bridge • Non-linear junction with natural channel • Steep average energy grade of channel (e.g., bankfull grade; a channel is considered relatively steep at grades exceeding 1% for southern Ontario watercourses)

DETERMINANTS OF BIOLOGICAL HEALTH AND STABILITY

Using the general monitoring program objective framework recommended by Rutherfurd et al. (1999), the following example questions were identified as indicators to assess project success:

- Were objectives for execution, survival and physical conditions met?
- Has the ecological function of the stream been maintained or improved?
- Has the species richness increased?
- Is there a connection to a robust riparian system with increased potential of nutrient/energy conversion?
- Has the potential for benthic/forage production increased?
- Has the riparian wildlife community been enhanced?

APPENDIX E: INDICATORS OF PROJECT SUCCESS (Continued)

Kondolf and Micheli (1995) summarized critical aquatic habitat variables for project evaluations as follows:

- Habitat depth;
- Stream velocity;
- Percent overhang/cover/shading;
- Pool/riffle composition;
- Fish population changes;
- Invertebrate community changes; and
- Macrophytes.

These authors also related relevant riparian measures. Most of the water quality and habitat metrics could be measured with appropriate benthic community assessments. Ecological success may be measured by a combination of indicators of habitat creation, as well as indicators of biological production.

REFERENCES

Brice, J.C. 1981. Stability of relocated channels. Technical Report No. FHWA/RD-80/158, Federal Highways Administration, US Department of Transportation, Washington, DC. 177 p.

Brookes, A. 1988. Channelized rivers: Perspectives for Environmental Management. Toronto: John Wiley & Sons, 326 p.

Brown, K. 2002. Urban stream restoration practices: an initial assessment. The Center for Watershed Protection, Elliot City, MD. 8p.

Kondolf, G.M., and Micheli, E.R. 1995. Forum: evaluating stream restoration projects. Environmental Management, 19 (1): 1-15.

Rutherfurd, I.D., Jerie, K.E., and Marsh, N. 1999. A rehabilitation manual for Australian streams Volume 1 and 2. Land & Water Resources Development Corporation, Cooperative Research Centre for Catchment Hydrology. Vol. 1: 189 p., Vol. 2: 400 p.

APPENDIX F: MASTER DATABASE OF DETAILED SUMMARIES FOR ALL PROJECTS

File Location	Date of approval	Amendment	Date of construction	Channel length (m)		Channel width type	Channel width (m)		Design flow (cms)	Design slope (%)	Impetus for re-alignment	Study team	Manager	File Data Quality- Pre-construction channel conditions			Design rationale	Channel Design	Approval documents	Monitoring reports	Off Site compensation	Notes
				PRE	POST		PRE	POST						Physical	Habitat	Biology						
Harvester	21-Jun-01	Yes	Sept. 30 2002 - Nov. 30, 2002	1327	1480	Bkfl	2	4.4	1.48, 1.69	0.77, 0.25	Land Dev	Geo, Eng	P.Eng	H	H	M	Yes	H	4 of 6	0 of 3	No	This project is still on-going; works still need to be completed
Harvester	26-Mar-01	Yes - 2	Aug 28 2001 - Dec. 31, 2005	190	193	Bkfl	1	2.6, 1.3, 0.7	0.35	1.1	Land Dev	Bio, Eng	Bio	M	M	L	Yes	H	4 of 6	0 of 4	No	
Harvester	10-Jul-02	No	July 10, 2002 - Dec. 31, 2005	760	818	Bkfl	0.5	1 - 2	0.13	0.43	SW mang.	Eng, LA	P.Eng	M	L	M	Yes	M	6 of 6	0 of 3	No	
Harvester	29-Jun-00	No	June 29, 2002 - Dec. 31, 2007	1350	1700	Average	?	35	?	0.7	Land Dev	Bio, Eng, Geo	P.Eng	M	M	M	No	H	4 of 6	0 of 3	No	2 sections of channel
Harvester	08-Nov-01	No	Nov.8, 2001 - March 31, 2002	810, 270, 750	847, 371, 1005	?	1	1.3, 1.6, 1.1	- 2.8 Q2, 0.21	0.18 - 0.47	Land Dev	Bio, LA	Bio	M	L	H	Yes	H	4 of 6	0 of 3	No	V. Detailed designs in this file. Good info on the built design
Harvester	30-Jun-00	No	June 30, 2000 - Nov. 30, 2002	39	39	----	?	?	?	?	Culv. Replace	Eng	P.Eng	L	L	L	No	L	4 of 6	0 of 3	No	Has had a complaint form HRCA, plantings not complete, to much armourstone
Harvester	02-Aug-00	No	Aug 2 2000 - Dec. 31, 2001	305	335	----	?	?	?	?	Land Dev	Eng	P.Eng	L	L	L	No	L	4 of 6	0 of 1	No	
Harvester	Complicated project, review incomplete, need to talk to assessor																					
Harvester	10-Jul-00	No	Jul. 10, 2000 - Dec 31, 2002	1400	1400	----	Varies with reach			0.29-0.31	SW mang., New road	Geo, Eng, LA	P.Eng	H	H	L	Yes	M	4 of 6	0 of 2	No	2 sections of a creek being realigned
Harvester	26-Jul-00	No	Jul. 24, 2000 - Nov. 30, 2002	1523	2022	Bfl, low flow	2.5 - 4	3	0.24	0.3	Culv. Instillation	Bio	?	L	M	M	Yes	L	4 of 6	0 of 1	No	
Harvester	36760	Yes - 1	Aug 22, 2000 - Dec. 31, 2003	106	106	bfl	7 - 12		?	?	Runway extension	Bio	Bio	M	M	M	Yes	L	4 of 6	0 of 3	No	
Harvester	36682	No	36678				1	?	?	?	Train derailment	Bio, Eng	P.Eng	L	L	L	No	M	3 of 6	2 of 2	No	Train derailment, federal project
Harvester	15-Mar-01	No	Mar-01	110	110	?	gabion	8	1.2	1.136	Erosion control	LA	LA	L	M	M	Yes	H	5 of 6	2 of 3	No	
Harvester	07-Sep-00	Yes - 1	Sept. 7 2000 - Dec 31 2003	247	275	Active	2-4	0.5 - 2	1.3 - 1.8	0.42	Road widening	Bio, Geo	Bio	H	M	L	Yes	H	4 of 6	unclear	No	Bankfull grade is 0.15 - 0.25 %
Harvester	13-Jun-02	No	June 13 2002 - March 31, 2003	850	850	Bkfl	24-35	25	45.6	0.32	Erosion control	Geo, LA	LA	H	M	M	Yes	M	5 of 6	0 of 3	No	
Harvester	10-May-01	Yes-1	Nov-01	250	250	Bkfl	5	3.1	1.1	1	Flood control	Eng	P.Eng	H	H	M	No	M	4 of 6	? Of 2	No	
Harvester	06-Jul-01	No	Jul 6, 2001 - Oct. 30, 2002	100	120	----	adding pool segment		50 yr	0.08	Bridge reconstruction	Bio, P.Eng	P.Eng	H	M	M	Yes	H	5 of 6	0 of 3	No	1 pool segment added to existing
Harvester	30-Apr-01	No	April 30, 2001 - Dec. 31, 2002	98	102		2.6, 1.9		2.09	0.59	Culvert, Stormwater, Land Dev.	Bio	Bio	M	H	M	No	M	4 of 6	0 of 3	No	
Harvester	18-Jun-01	Yes-1	Nov.8, 2001 - Jan 1 2004	1832	1760	?	Variable	1.2	1.87	0.2	Aggregate expansion	Bio, Geo, Eng	P.Eng	M	M	M	No	M	6 of 6	1 of 7	No	Most mon. reports not due yet. Destruction of 1832 m. Compensation is creation of 1760 m of habitat and 2 ponds totalling 2321 m^2
Harvester	06-Mar-01	No	March 6, 2001 - Nov. 30, 2003	797	980	-----	?	?	6.86, 14.68	0.27, 10.5	Compensation project	Geo, Eng, LA	P.Eng	H	L	L	Yes	H	4 of 6	0 of 3	Yes	2 streams will be made into 1. Compensation for construction of Parkway. Rosgen used with some limitations
Harvester	03-Aug-01	Yes-1	Jul-02	400	400	Bkfl	22 - 32	12.5			Bridge replacement	Bio, Eng	P.Eng	H	H	H	Yes	M	6 of 6	1 of 3	No	being replaced now. 1022 m^2 impacted, 1198 m^2 compensated
Harvester	30-Aug-01	Yes-1	Nov-02	200	217	Bkfl	1.7	1.7	w flow, 18.81 c	0.64, 2.1, 1.4	Road widening	Eng	P.Eng	H	M	L	Yes	L	5 of 6	1 of 2	No	Post construction is 217 m of new channel and 329 m of wet meadow habitat
Harvester	01-Jul-98	Yes-2	31-Aug-01	100	150	Width is available				0.8	Road widening	Bio, Eng, LA	P.Eng	M	L	M	No	L	5 of 6	2 of 3	No	7 creek crossings, only Tributary D was redesigned
Harvester	20-Jul-00	Yes-1	Oct-01	150	150	Bkfl	1	2	1	1.56, 1.35	Land Dev	Bio, P.Eng	P.Eng	H	M	L	Yes	M	6 of 6	2 of 3	No	Final mon. report not due yet.
CCIW	13-Dec-96	No	Mid January 1997	1000	1000	Multiple sections; unclear			19.93 (2 yr - 10	2.19	Erosion control	Eng	P.Eng	L	L	L	Yes	L	3 of 6	?	No	2 stream reaches
CCIW	28-May-98	No	30-Jun-98	35	30	?	1	2	2 - 4 m/s??	?	Land Dev	Eng, Bio	P.Eng	L	M	L	No	M	6 of 6	1 of 2	No	
CCIW	28-May-98	No	?	69	40	-----	?	?	?	? No change	New road crossing	Eng	P.Eng	L	L	M	No	L	4 of 6	1 of 2	No	
CCIW	23-Jun-98	No	15-Jun-98	280	280	Bkfl	0.5-1	?	0.0019 - 0.013	1.28	New road crossing and Culvert replacement	Bio, Eng	?	M	M	H	Yes	L	5 of 6	0 of 1	Yes	Initial work unsatisfactory, More work had to be done, nat channel
CCIW	29-May-02	No	?	198	160	Bkfl		1.8-3.0	5 yr	1.3	Land Dev	Bio, LA	?	M	H	M	Yes	H	3 of 6	0 of 2	Yes	Net gain of habitat due to off site compensation, nat channel
CCIW	03-Sep-98	No	Oct-98	178	173	Bkfl	1.1	2.5	0.4/0.6, 2.8,/4.4	0.46, 0.8	Pipe replace, and lowerin	Bio, Geo, Eng	P.Eng, Bio	H	H	M	Yes	H	5 of 6	0 of 2	No	
CCIW	16-Jul-99	No	1999-2000	800	800	Bkfl	?	1.9	regional	0.25	Stormwater mangem	Eng, LA	P. Eng	M	H	M	Yes	L	5 of 6	1 of 3	No	
CCIW	26-Oct-99	No	?	232	232	Bkfl	?	6	2	low	Contaminant decommissioning	Bio, Eng	P.Eng	L	M	L	Yes	L	4 of 6	0 of 2	No	
CCIW	03-Aug-99	No	Dec, 1999	100	100	Bkfl	12.71	16.65	19.8	0.72, 1.08	Erosion control	Bio,LA	Bio	L	M	M	Yes	M	4 of 6	1 of 3	No	
CCIW	25-Jul-00	No	July 25, 2000 - Nov. 30, 2002	280	385	Bkl		3.6	?	0.7	Culvert replacement	Bio, Geo, Eng	P. Eng	L	M	L	Yes	L	5 of 6	0 of 2	No	
Harvester	18-May-99	Yes - 2	May 18 1999 - Dec 31 2004	650	1005	low-flow	?				development	Bio, Geo, Eng	Bio	H	M	L	Yes	H	4 of 6	and 2001 photographic	No	File still active
CCIW	1999	?	?	107	107	Bkfl	?	6	?	dwg	Culvert replacement	Eng	P.Eng	L	M	M	No	M	4 of 6	0 of 1	No	
CCIW	Aug 5 1999	No	Aug 5, 1999 to Dec 31, 2002	220	220	Bkfl			1.3	1.26, 0.37, 0.5	Land Dev	Eng	P.Eng	H	M	L	Yes	M	4 of 6	0 of 2	No	
CCIW	Sept, 1999	No	Sept. 22 1999 - Dec. 31, 2001	60	60	Bf	?	3	?	dwg	Bridge replacement	Eng	P.Eng	L	M	M	No	M	3 of 6	0 of 2	No	
CCIW	Feb 8 2000	?	?	250	230		0.53 - 0.73	1 or 10 m10 yr	19.26 - 10 yr	0.3	Land Dev	Eng, LA	P.Eng	H	M	M	Yes	M	3 of 6	0 of 3	No	
CCIW	Sept, 11 2000	No	Mar-02	120	120	Bkfl	1-3	4-6	?	?	Flood control	Bio	Bio	H	M	L	Yes	M	4 of 6	2 of 4	Yes	Bank stabilization project along Whisky Creek compensates for loss on Sophie's Creek, 42 m
CCIW	Feb 1 2001	No	?	200	180	Bkfl	3	3	3	?	Road crossing	Bio, Eng, LA	P.Eng	H	M	M	Yes	H	3 of 6	0 of 3	No	No profile drawing of the stream
CCIW	Feb. 18, 2000	No	Apr-00	300	300	Average	8.81	11	7	1, 1.5	Erosion control	Geo, Eng	P.Eng	H	H	L	Yes	M	4 of 6	0 of 3	No	Very detailed pre construction fluvial geo. Report done
CCIW	04-Jun-01	No	June 4 2001 - Nov 1 2003	560	700	Bkfl	?	4	1 m/s	0.16	Erosion control	Bio, LA	Bio	H	M	L	Yes	H	4 of 6	0 of 1	No	Elsie Ck - same
CCIW	Nov 1 2000	No	June - Sept 2000	120	120	?	15-20	?	?	?	Bank stabilization	eng	Township	M	L	L	No	L	4 of 6	0 of 4	No	2 of the monitoring reports are not due yet